New approaches for grassland research in a context of climate and socio-economic changes

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SERIES A: Mediterranean Seminars
2012 – Number 102

CIHEAM

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2012

A 102

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Foreword

Grassland-based systems are no longer seen exclusively as livestock production enterprises but as multiple use systems with important consequences for the global environment. They are crucial for the protection of ecosystem goods and services, for tourism and for mitigating climate change. Well-managed grasslands provide important benefits such as increased water infiltration and retention or improved nutrient cycling, associated with organic matter accumulation in the soil, as well as increased plant growth and diversity of species. Thereby grassland management is also an adaptation strategy for climate change, as it reduces the risks associated with prolonged drought periods and unreliable rains that characterise Mediterranean regions. There is an urgent need to assess the interaction between climate change and grasslands to identify appropriate options that can help farmers to manage forage resources under increasing drought conditions and market globalisation. The challenge is then to improve grassland productivity, pasture persistence and resilience under these constraints. Scientific advances in grassland management and new strategies in plant improvement may undoubtedly contribute to this aim.

This publication is the outcome of the 14th Meeting of the FAO-CIHEAM Inter-regional Cooperative Research and Development Sub-Network on Mediterranean Pastures and Fodder Crops titled **"New approaches for grassland research in a context of climatic and socio-economic changes"** which was organised in Samsun (Turkey) from 3 to 6 October 2012, and includes the invited and selected papers presented at the Meeting. The 14th Meeting was jointly organized by the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) and the Agricultural Faculty of the University of Ondokuz Mayis (Turkey), with the collaboration of the Food and Agriculture Organisation of the United Nations (FAO), Black Sea Agricultural Research Institute (Turkey) and Fito Tohumculuk Ticaret Ltd. Şti (Fitó Seeds Company).

The seminar covered a range of topics that were allocated into four sessions, which were:

1- "Climate change and grasslands: impacts, adaptation and mitigation";

2- "Selection of pasture and forage species under climate and socio-economic changes";

3- "Role and management of permanent grasslands";

4- "Changes in Mediterranean farming systems to meet new socio-economic scenarios".

Around 100 scientific contributions were presented and discussed including introductory and invited papers, short oral communications and poster presentations. Also the contributions given from specialists coming from countries of different Mediterranean areas of the world (Africa, Middle East, Australia, Europe and South America) at the Round Table on "Mediterranean grassland research: priorities and future challenges" are included.

At this point we want to thank all authors for submitting papers, all the members of Scientific Committee that carried out the revision of the contributions and all members of the Organizing Committee for preparing this conference. Finally we express our gratitude to the Mediterranean Agronomic Institute of Zaragoza (CIHEAM-IAMZ, Spain) for the support of our Sub-Network in terms of Meeting secretariat, proceedings publication, grants, etc.

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14th Meeting of the FAO-CIHEAM Subnetwork on Mediterranean Forages and Fodder Crops (Samsun, Turkey, 3-6 October 2012)

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Introductory Session

An overview of fodder resources and animal production in Turkey

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Abstract. In this paper, roughage resources of Turkey were reviewed. Problems and recommendations were discussed for sustainable animal production in the country. Hay production and forage crops acreage have increased significantly last two decades owing to governmental incentives but there is still gap in sufficient quality forage in the country. The forage gap is mainly compensated with cereal straw which is too far to meet animal maintenance need. Some serious measurements such as regulation of grazing season, grazing capacity and selection of proper animal species for rangelands are needed. With respect to forage crops production, solving seed problems and marketing, and determining roughage prices considering feed quality are especially important challenges. Finally producers have to be trained on animal feeding and raising and rangelands management.

Keywords. Turkey – Animal raising – Rangeland – Forage production.

Une vue d'ensemble des ressources fourragères et de la production animale Turquie

Résumé. *Dans cet article, les ressources en fourrage de la Turquie ont été examinés. Les problèmes et les recommandations ont été examinées pour la production animale durable dans le pays. Les surfaces de foin et de cultures fourragères ont augmenté de manière significative ces deux dernières décennies en raison de mesures gouvernementales, mais il existe est encore une besoin de fourrage de qualité dans le pays qui n'est pas couverte. Cet écart et principalement compensée par la paille de céréales, mais ceci est trop pauvre pour répondre aux besoins d'entretien des animaux. Certaines mesures sérieuses telles que la réglementation de la saison de pâturage, la capacité de pâturage et la sélection des espèces animales appropriées pour les parcours sont nécessaires. En ce qui concerne la production des cultures fourragères, la résolution des problèmes liés aux semences et à son commercialisation, et la détermination des prix du fourrage considérant son qualité nutritive sont des défis particulièrement importants. Enfin les producteurs doivent être formés sur l'alimentation animale et élevage et sur la gestion des pâturages.*

Mots-clés. *Turquie – Élevage – Parcours – Production de fourrage.*

I – Introduction

Turkey is a country located between Europe and Asia from 26° to 45° E and from 36° to 42° N with total area is 78.35 million ha of which 76.96 million ha is land area. The distribution of land use can be summarized as follows: field crop areas are 21.4 million ha (of which forage crops reach 1.46 million ha), horticultural areas (vegetables, vine, fruit, olive, hazelnut and the other agricultural tree) are 3.0 million ha, rangelands are 13.2 million ha, meadows are 1.4 million ha, forests are 15.1 million ha, shrublands 8.3 million ha and 15.4 million ha the other areas which are mainly water surface, settlement, barren areas, and etc. (ps: some low productive areas are officially defined in this class, most of them over degraded rangelands) (TUIK, 2010).

Turkey has 750 billion dollar national gross income and 70 billion of which obtain from agriculture. The share of animal husbandry in agriculture is about 30 percent (TUIK, 2010). All small livestock and vast majority of large livestock depend on rangelands and harvest residues in agricultural areas for feeding during the grazing season (Altin *et al.*, 2011). Therefore, rangelands have crucial importance for animal husbandry, especially during crop growing season because there are no artificial pastures or feed resources for extensive animal husbandry during this period. On the other hand, intensive animal farms, which do not depend on natural pasture, especially dairy, are quite few and they are located around crowded cities in the western and central parts of the country.

The average elevation is 1100 m and annual total precipitation is 643 mm. Both the amount and distribution patterns of precipitation show great variation depending on geomorphological features. Therefore, eleven agro-ecological regions occur in the country (Fig. 1). Agricultural practices show great variation among the regions, depending on difference of topographical conditions and precipitation patterns. While plant production is the main occupation in the western part of the country, the animal husbandry is the major occupation in both East and Central Regions. This variation affects also animal type and raising system.

Fig. 1. Agro-ecological regions of Turkey.

II – Presence of animal resources

Turkey's domestic ruminant population consists of 11,555,800 cattle and 25,769,900 sheep and goats (TUIK, 2010), which are equal to 10.14 million Animal Units (AU). While cattle number has not changed significantly in the last years, small ruminant number decreased seriously, especially Angora goat, in last decades. For example, the decreases in small ruminant number from 1980 to 2010 were as follows: sheep from 48.63 to 20.88 million, ordinary goat from 15.38 to 5.53 million, Angora goat from 3.66 to 0.15 million (TUIK, 2010). During this period, the amount of cattle products increased despite the decline in the number of cattle because of replacement of local breed animals with cross-breed and pure races. The distribution of animals among agro-ecological regions is summarized in Table 1.

Due to increasing mechanization in agriculture last decades, equids number decreased seriously in the country. Nowadays, the country has 416,500 equids and its number changes from 8800 to 68,000 among agro-ecological zones. Horse power use is common to carry hay from meadows and fields in North-Eastern Anatolia agro-ecological region, while asses and mules are used to carry goods and for transportation in West Marmara and South-Eastern Anatolia regions.

Buffalo number decreased seriously in past decades because of low production capacity and decreasing demand for its power. But buffalo milk product, especially skimming and yoghurt, attain special demand with high price in Aegean and West Black Sea regions, hence, some farmers in these regions raise buffalo to meet this demand.

Table 1. **The distribution of animal presence among agro-ecological regions (x 1000) (TUIK, 2010)**

Agro-ecological regions[†]	Equids	Buffalo	Cattle			Sheep	Goat	Total (AU)[††]
			Pure	Hybrid	Local			
NE Anatolia	57.7	3.9	135.3	874.8	641.4	2323.1	194.8	1219.1
ME Anatolia	40.8	10.1	153.8	337.4	282.0	4471.2	747.0	1020.1
SE Anatolia	53.2	6.8	154.0	248.4	338.0	3586.3	1224.8	950.8
West Marmara	20.1	4.4	844.6	190.8	36.5	1349.4	451.4	960.4
East Marmara	68.0	6.3	1085.0	499.1	155.0	2275.8	764.0	1553.5
Aegean	21.5	16.0	306.4	349.4	88.2	890.3	207.0	626.1
Western Anatolia	19.6	0.7	350.2	265.2	107.2	2121.1	240.6	708.4
Mediterranean	47.8	1.3	368.7	488.2	87.1	1284.4	1476.9	926.7
Central Anatolia	23.4	6.4	372.0	537.3	226.2	1562.7	211.1	913.1
West Black Sea	55.6	27.3	345.5	671.3	390.7	691.8	134.1	961.5
East Black Sea	8.8	2.8	68.3	245.4	112.4	326.1	29.1	298.1
Total	416.5	86.0	4183.8	4707.3	2464.7	20882.2	5680.8	10138.0

[†]NE: North-Eastern, ME: Middle-Eastern, SE: South-Eastern.
[††]AU (Animal Unit): Equal to 500 kg live weight.

Cattle production is a main resource of meat and milk demand of the country. The majority of cattle is pure or cross breed but breeds distribution shows a great variation among regions. West and East Marmara region is about to have half of the pure cattle breed population of the country, since these regions are the most crowded part of the country, and the demand for milk product is very high. Local and cross breeds cattle populations are common in North-Eastern Anatolia and West Black Sea regions, regions that have hill topographical rangelands. Local breeds and their crosses are common in these regions since they perfectly match for hilly topography.

Sheep industry for milk, meat and wool is common in Middle-Eastern Anatolia and South-Eastern Anatolia regions because the rangelands in these regions have sparse and short plant cover, hence they are not suitable for cattle grazing. Stubble and fallow areas are significant feed resources for rangeland depended animal husbandry. Moreover, the vast majority of sheep flocks, especially from South-Eastern Anatolia, move to North-Eastern Anatolian highlands during hot summer period to overcome the hot weather stress and feed shortage. In addition to these regions, Central Anatolia and East and West Marmara regions are significant sheep production areas in the country; because rangeland areas are extremely restricted in Marmara and quite poor in Central Anatolia, hence, stubble grazing is the main feed resource for sheep industry in these regions. The lowest presence of sheep and goat is found in East Black Sea region because in addition of a limited rangeland area, moistly climate is not suitable small ruminant raising (Holechek *et al.*, 2004).

Goat milk product and meat have special interest in Mediterranean region. On the other hand, maquis are the most common feed resource for grazers, hence, ordinary goat (not Angora) breeding is the most common in the region. In addition to Mediterranean region, the second most important region for ordinary goat production is South-Eastern Anatolia because the northern part of the region is characterized by a sharp topography and sparse oak vegetation. Angora goat production was common in the Central Anatolia region but it is near to extinction nowadays, due to the sharp decrease of mohair demand in both national and international markets in the last decades.

III – Rangeland resource of Turkey

Although Turkey's rangelands lost true climax vegetation because they have been faced to intensive grazing since ancient civilization and plant communities show great variation among regions (Firincioglu *et al.*, 2008), the rangelands are the most important feed resource for animal husbandry in the country. Turkey has 13.17 million ha rangelands area but its distribution show great differences among the regions (Table 2). While rangelands cover large areas in the North-East Anatolia region, the West Marmara has the least rangeland area. Hence, the contribution of rangelands to animal husbandry show great variation among the regions.

The North-East and the Black Sea regions rangelands primarily are grazed with cattle herds because rangeland vegetation are consisted of better quality in these regions. Black Sea regions rangelands are characterized by forest gaps and alpine rangelands types with sharp topography, while North-East Anatolia rangelands are characterized by open vegetation with uneven topography. The rangelands in southern and central parts of the county are primarily grazed with sheep flocks and plant communities are characterized by dry steppe vegetation (sparse canopy cover and short plants) with harsh topography because all flat areas were converted to cropland during fifties. The poorest rangelands are located in South-East Anatolia region. The Mediterranean rangelands are located in forest gaps and in alpine zones with harsh topography.

In addition to true rangelands, maquis (officially registered in the forest inventory of the country) provide significant feed amounts to goat flocks in the region. Traditional goat transhumant grazing systems is generally characteristic of the region. Transhumance routes lies from coastal areas of Mediterranean Sea to inside of Central Anatolia Region.

The rangelands are insufficient to meet animal needs during the grazing season on countrywide, especially in Central Anatolia, Middle-Eastern Anatolia, South-Eastern Anatolia and West Marmara regions, thus stubble grazing after cereal harvest play a significant role in the range depending animal husbandry.

IV – Hay production in Turkey

Turkey has 1.45 million ha natural hay meadows and their production is about 5.81 million tones. More than half of the natural meadow areas are located in the North-Eastern and Middle-Eastern Anatolia regions. West Marmara region has the least natural hay meadow areas in the country. The production from natural hay meadows is not enough to meet feedlot period roughage needs in any region of the country.

In the country, total forge crop sowing areas is 1.46 million ha, which is equal to 8.6% of country croplands, and the total production is 7.48 million tones forage (Table 2). Forage crop acreage is higher in North-Eastern Anatolia, Middle-Eastern Anatolia and East Marmara regions, while it is lowest in East Black Sea region. While North-Eastern Anatolian farmers allocate about a quarter of their field areas for forage crop production, South-Eastern Anatolian farmers allocate only 1.4% of total field for forage production.

Forage crop cultivation pattern shows significantly differences among regions (Table 3). While alfalfa and sainfoin cultivation are common in North-Eastern and Middle-Eastern Anatolia regions, silage maize cultivation is important in the Marmara and Aegean regions, where milk production of the country is concentrated. Annual forage crops cultivation is generally more importante in the Mediterranean and the Aegean regions. These regions have the best climatic condition for plant growth, hence, crop diversity is very high.

Although government gives significant financial support for forage crop cultivation countrywide, forage crops are still not economically competitive with cash crops. Hence, perennial forage crops and annuals do not cover large areas during cash crop growing season, but annual legumes, primarily vetch, cover large areas during the winter season in the regions. Annual forage crops cultivation is common under dry farming conditions in the North-Eastern Anatolia and upward part of the West Black Sea regions because natural hay meadows and perennial forage crops do not meet roughage gap during the long feedlot period.

Table 2. Meadow, rangeland and forage crops covered areas and total production by agro-ecological regions. TUIK (2010) values

Regions†	Area (ha)				Production (ton)				Demands
	Meadows	Rangelands	Forage crops		Meadows	Rangelands	Forage crops	Total production	
			Area	Ratio††					
NE Anatolia	484,071	2,748,321	306,294	24.2	1,936,285	1,648,993	1,046,245	4,631,523	4,449,774
ME Anatolia	343,695	2,020,073	239,342	18.6	1,202,932	1,212,044	862,701	3,277,677	3,723,507
SE Anatolia	47,944	964,632	44,237	1.4	191,776	482,316	181,142	855,234	3,470,580
West Marmara	26,257	389,478	87,317	5.3	105,026	272,635	715,827	1,093,488	3,505,686
East Marmara	52,827	750,055	204,133	7.1	237,719	450,033	1,582,995	2,270,747	5,670,378
Aegean	51,383	544,483	98,848	7.1	231,224	353,914	654,706	1,239,844	2,285,253
Western Anatolia	75,984	1,339,556	62,679	1.8	227,952	535,822	463,170	1,326,944	2,585,740
Mediterranean	44,888	614,446	83,728	3.4	224,438	399,390	422,188	1,046,016	3,382,500
Central Anatolia	78,064	2,500,009	168,350	4.2	234,192	1,125,004	793,533	2,152,729	3,332,698
West Black Sea	42,232	740,024	146,933	6.9	211,158	592,019	701,806	1,504,983	3,509,494
East Black Sea	201,969	556,297	19,593	3.0	1,009,847	556,298	60,673	1,626,818	1,087,864
Total	1,449,313	13,167,375	1,461,454	8.6	5,812,549	7,628,467	7,483,986	20,925,002	37,003,475

†NE: North-Eastern, ME: Middle-Eastern, SE: South-Eastern.
††Share in the total sowing area.

Table 3. Forage crops sowing area (ha) and production (kg) in Turkey. TUIK (2010) values

Regions†	Alfalfa		Sainfoin		Annuals		Maize		Total	
	Sown	Product.	Sown	Product.	Sown	Product.	Sown	Product.	Sown	Product.
NE Anatolia	153,190	712,987	67,817	151,163	81,506	137,122	3,781	44,973	306,294	1,046,245
ME Anatolia	193,658	727,320	20,346	45,099	22,528	64,973	2,504	25,308	239,036	862,700
SE Anatolia	6,827	28,554	1,766	2,033	25,930	49,866	9,714	100,940	44,237	181,393
West Marmara	9,711	81,506	449	1,540	25,890	70,134	50,630	562,647	86,680	715,827
East Marmara	22,828	103,766	1,918	4,747	28,849	62,272	45,069	483,447	98,664	654,232
Aegean	40,510	323,061	3,322	9,044	67,316	199,037	91,677	1,051,853	202,825	1,582,995
Western Anatolia	24,013	251,278	3,212	9,669	21,115	42,845	14,282	159,379	62,622	463,171
Mediterranean	11,531	74,840	2,729	6,060	45,632	95,820	23,436	245,468	83,328	422,188
Central Anatolia	76,501	442,436	45,255	119,583	32,250	64,742	14,293	166,772	168,299	793,533
West Black Sea	20,780	145,825	7,880	22,360	82,755	227,717	35,399	305,905	146,814	701,807
East Black Sea	93,200	27,620	2,387	5,936	5,020	10,221	2,557	15,041	103,164	58,818
Total	568,849	2,919,193	157,081	377,234	438,791	1,024,749	293,341	3,161,733	1,458,062	7,482,909

†NE: North-Eastern, ME: Middle-Eastern, SE: South-Eastern.

V – Roughage supply and demand in Turkey

Turkey has 10.14 million AU livestock and year-round roughage demandt is about 37.0 million tones. The average altitude is about 1000 m in the country and grazing season is roughly 180 days (Altin *et al.*, 2011). About 7.5 million AU obtain their feed from rangeland and roughly their demand is 13.5 million tones roughage whereas the rangelands supply about 7.6 million tones roughage. Thus, there is a big roughage gap during the grazing season in the country as a whole. This gap is compensated with poor quality feed grazed stubble, fallow or abandoned fields and understory vegetation (orchards and forests).

Approximately, 2.64 million AU cattle are risen in intensive system or barn during the year-round in the country and their roughage needs during summer season reaches 4.75 million tones. These demand is met from forage crop production in the cropping system. In addition to summer demand, there is a 18.75 million tones roughage demand during the winter period and the total roughage needs for barn feeding is about to 25.5 million tones. The total production from hay lands (meadow plus forage crop cultivation) is about 13.3 million tons in the country. In this case, there is a 12.2 million tones roughage gap in the country. There are some alternative roughage sources, such as vegetable residues, sugar beet leaf and pulp and fruit garden understory, which account for an amount of about 5.0 million tones. Finally, 7.2 tons of roughage gap are compensated by cereal straw.

VI – The problems with animal husbandry

The problems can be summarized under three categories:

(i) Rangelands. Since the establishing of Republic of Turkey, it have been occurred a significant shrinkage of the rangelands area (from 44.50 to 13.17 million ha). As a result of this shrinkage, grazing pressure gradually increased on the rangelands because forage crops acreage has not increased in this period. Hence, overgrazing, which has been continuous for at least 5 or 6 decades (Koc *et al.*, 2000) is the main problem of the rangelands. As a result of continued overgrazing for decades, the vast majority of the rangelands in the country is poor or fair range condition class. This is not a personal or general presumption, this fact has also been estimated by a research conducted on countrywide using satellite imaginary (Avag *et al.*, 2012).

In addition to overgrazing, early and late season grazing is another problem with the rangelands. Traditionally, animal raisers tend to graze rangelands as long as climatic conditions are favorable for grazing on the rangelands and grazing season is lasted least two months. This is extremely harmful because range plants are under grazing pressure during both spring and autumn critical periods (Koc and Gokkus, 1997).

The grazing systems applied are not considering plant growth dynamics. Traditionally, herder grazing system is used in all rangelands in the country. Herder profession is generally done by uneducated and poor peoples. If herders were trained about animal feeding, and range and herd management they could take some measurements with respect to prevent overgrazing, early grazing and could practice a more skilful grazing, planning intensity and other factors.

There are 15.4 million ha areas officially classified as undefined areas. The vast majority of these areas is comprised of denuded rangeland areas due to overgrazing. These areas might be reclaimed using herbaceous plants or shrubs establishment. But there is not scientific information about this topic in the country and also seed and seedling material is lacking.

(ii) Forage crops. Forage crop sowing areas have been increased about four fold (from 2.0% to 8.6%) for last two decades due to governmental incentives. But there is still a serious forage gap in the country. In general, the farmers who are primarily interested in animal raising have not enough cultivation area and large land owners are generally not interested in animal raising and they are not willing to cultivate forage crops because they do not find a reliable market. On the other hand, plant residuals, especially cereal straws, have a good market value in the country.

Late cutting and spring grazing is the main problem with natural hay meadows. The grazing at the beginning of the growth period cause at least a decreasing of 30% of hay production in natural meadows (Gokkus, 1989). Farmers delay hay harvest date up to plant color turn from green to yellow, thus, digestibility of harvested hay decreased at least 50% (Akyildiz, 1957).

Turkey has different agro-ecological regions but there is not enough high yielding forage crop cultivars for every region because plant improvement studies are quite limited and it has been concentrated on a few plants such as alfalfa, vetch and pea.

There is not enough forage seed production in the country. Hence, forage seed demand is provided from international markets but there is not enough control. Hence, unstandard seeds are sold by seed markets, and especially, cultivar adaptation test have not done.

(iii) Animal raising. There is not domestic large ruminant breed race in the country. High yielding cattle breeds requested by the producers are provided by international markets. For example a quite big number Angus breed were introduced and distributed to farmers without performing any adaptation test during last two years.

The vast majority of our animal productions is provided by traditional animal raising enterprises. They do not aware of maintenance nutrition needs and welfare of animals. They keep their animals in unhealthy (unventilated, unlighted) barns during the long feedlot period and they use mainly straw in animal rations, which is too far to meet maintenance demand of animals, during the long feedlod period. Hence, range depending herds reach the spring under metabolically ruined conditions and the animals try to repair their metabolism in the beginning of the grazing season. As a result of this mistake, the high quality spring forage is not turned to animal product.

VII – Recommendations related to range, forage and animal production in Turkey

It is essential to determine the grazing season, the carrying capacity and suitable grazing systems to sustainably use the natural rangelands. Grazing season and carrying capacity can be determined for every rangeland sites using vegetation index values and range condition scores estimated by the National Range Management Project using satellite imaginary which are available at Ministry of Food, Agriculture and Animal Husbandry data base. The determination of suitable grazing systems and animal types for each rangeland types is a seriously necessity for Turkish rangelands.

Degraded rangelands and officially undefined areas cover a large area, hence, erosion is a serious problem in the country. Reclamation and rehabilitation of these areas are urgent and necessary to alleviate the erosion problem and overgrazing on the rangelands. For this purpose, to determine suitable rehabilitation techniques and to develop suitable plant material are priorities.

Although forage crops sowing areas increased seriously in last decades owing to governmental incentives in forage crop production, there are still serious roughage gap in some agro-ecological regions (SE Anatolia, Marmara, Mediterranean, Aegean and West Black Sea) because forage crops cannot compete economically with cash crops under current incentives in these regions. Therefore, establishing a hay stock market, which covers all around the country in trading, is crucially important for sustainable animal production. By this way, large land owners, who are not interested in animal production, can contribute to forage crop production as they can allocate large areas for forage crops in rotation systems if they find a reliable and profitable market. It is essential to determine roughage prices considering feed quality in this organization.

Seed production and seed trade problems with forage crops are to be urgently solved. Especially, it is important to be given priority to develop new cultivars for each agro-ecological region.

In natural hay meadows, spring grazing has to be stopped and the cutting stage has to be arranged considering hay quality.

In rangeland depending animal husbandry, animal producers should be trained on animal feeding, race selection and barn comfort. At least, animal producer should be aware of maintenance needs of animals and optimal barn climatic conditions. At a national scale, to develop suitable animal races, which efficiently transform rangeland resources, should be a main policy and new races should never be imported without doing adaptation tests.

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Overview on grassland and farming systems in Samsun province

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Abstract. Samsun province is one of the important provinces for its high agricultural potential in Turkey. Around 45% of the province total area is suitable for cultivation. Crop production makes 81% of the total agricultural income. However, the average farm size is very small at about 4 hectares. In order to sustain the existence of small enterprises, livestock and the cultivation of forage crops with a higher added value should be developed accordingly. For this purpose, there should be more forage plants in crop rotation systems. High yielding forage crops in irrigable lands and drought-resistant, ever green plants in summer period in non-irrigable sloping lands are necessary to provide the animal feed chain with high energy resources.

Keywords. Samsun – Turkey – Crop area – Forage – Grasslands – Feeding gap.

Vue d'ensemble sur les pâturages et les systèmes de production dans la province de Samsun

Résumé. *Samsun est l'une des provinces importantes pour son potentiel agricole élevé en Turquie. Environ 45% de la superficie totale province est cultivable. La production agricole fait 81% du total des revenus agricoles. Toutefois, la taille moyenne des exploitations agricoles est très faible, à environ 4 hectares. Afin de soutenir l'existence de petites entreprises, de l'élevage et la culture de plantes fourragères à plus forte valeur ajoutée devraient être développes. À cette fin, il devrait y avoir plus de plantes fourragères dans les systèmes de rotation de cultures. Ils sont nécessaires des cultures fourragères à haute rendement sur les terres irrigables et de plantes résistantes à la sécheresse, toujours vertes en période estivale sur les terrains non irrigables et vallonnés, pour fournir la chaîne alimentaire animale en ressources a valeur énergétique élevé.*

Mots-clés. *Samsun – Turquie – Superficie de culture – Fourrage – Pâturage – Écart d'alimentation.*

I – Introduction

Samsun Province is one of the important provinces for its high agricultural potential in Turkey. Each year, Samsun is always in the top ten of Turkish 81 provinces in terms of the value of agricultural production (TurkStat, 2010).

There is a high agricultural production in Çarşamba and Bafra Plains with 170,000 hectares area in total and also in the coastal plains and in the plains among the mountains. Samsun Province is in the leading position in rice, corn, and vegetable cultivation (Hekimoglu and Altindeger, 2007) and in water buffalo milk and milk production in Turkey.

II – Farming systems in Samsun

The total area of Samsun Province is 958,000 hectares and this area covers 1.22% of Turkey's total area. Samsun Province is in the first ranks in terms of the ratio of cultivated lands to total area, with around 45%. After agricultural lands, forest and non-cultivated lands are predominant. Meadow and pastures cover only 33,700 hectares (Table 1).

Table 1. Land use distribution in the province of Samsun

	Total cultivated agricultural lands and perennial plants		Meadow and pastures		Forest		Total land size and position in Turkey	
	ha	%	ha	%	ha	%	ha	%
Samsun	432,718	45.2	33,721	3.6	358,107	37.4	958,000	1.22
Turkey	24,437,000	31.0	14,617,000	18.6	21,390,000	27.3	78,355,700	100.00

Source: TurkStat (2010).

Table 2 shows that approximately 86,000 enterprises exist in Samsun; 85% of these enterprises are mixed enterprises with plant and animal production. However, the average farm size is at the level of 4 hectares and below the average in Turkey. Considering animal husbandry, the average number of cattle ranging from 2-4 is very common in small family enterprises. This situation makes it impossible for the continuation of efficient and competitive agricultural activity.

Table 2. Number of agricultural enterprises and their structures in Samsun and Turkey

	Number of agricultural enterprises	Average land size per enterprise (decare)	Number of livestock per enterprise
Samsun	86,381	40	2-4
Turkey	3,100,000	62	2-4

Source: TurkStat (2010).

Crop production occupies a large proportion in agricultural production in the province of Samsun. Across the province, 81% of agricultural income is provided from crop production. This value is at the level of 72% in Turkey (Table 3). High-quality plants such as rice, tobacco, corn and some vegetables are grown in Samsun (Table 4). Approximately 25% of total national production of spinach, leek, cauliflower and different types of cabbages takes place in Samsun. Therefore the percentage of crop production in Samsun is above the average of Turkey. However, small agricultural enterprises with small farm size are common in our province. In order to sustain existence of small enterprises, livestock and the cultivation of forage crops with a higher added value should be developed accordingly (Anon., 1999; Hekimoglu and Altındeger, 2007; Acar, 2008).

Table 3. The distribution of agricultural income in Samsun and Turkey

Type of income	Samsun (%)	Turkey (%)
Field crops	20.20	27.34
Vegetables	45.70	20.50
Fruits	15.10	24.40
Fishery products	0.76	2.02
Animal products	18.24	25.74

Source: Statistics from Samsun Provincial Directorate of Agriculture (2010).

Table 4. Important crops grown in Samsun and comparison with Turkey

Name of product	Samsun			Turkey	
	Cultivated area (ha)	Production (t)	% Turkey	Cultivated area (ha)	Production (t)
Soybean	2,505	8,606	9.94	23,472	86,540
Rice	14,463	125,182	14.60	99,000	860,000
Hazelnut	88,341	83,830	14.00	667,865	600,000
Tobacco	5,125	3,208	6.18	80,977	51,912
Corn	33,835	194,797	4.5	593,551	4,310,000
Vegetable	33,695	1,348,207	3.28	729,415	24,021,132
Wheat	103,090	252,039	1.30	8,103,400	19,674,000

Source: TurkStat (2010).

III – Grassland farming and animal husbandry in Samsun

Alpine meadow vegetation on the plateau has the majority of the pasture lands in Samsun. Meadow and pastures are in the public domain in Turkey. They have been given to the common use of villages and as a result, excessive and irregular grazing occur in the region. Therefore, pasture yields in Samsun and generally in Turkey are low (Sabanci *et al.*, 2010).

Forage crops are produced in about 51,000 hectares in Samsun and this value corresponds to 11% of total cultivated area. The main forage crops cultivated in our province are vetch, maize for silage, oats, sainfoin and alfalfa. Totally 1 million tonnes green forages are obtained from the cultivated lands (Table 5). The annual estimated green pasture yield is around 500,000 tonnes. Approximately 3.4 million tonnes of green fodder is required to feed farm animals in Samsun, whose numbers are shown in Table 6. The remaining portion (1.9 million tonnes) is provided from beneath orchard production, crop production residues and other roughage obtained from other regions.

Table 5. Forage crops and production in Samsun

	Cultivated area (ha)	Production (t) (fresh yield)
Fodder beet	15	750
Alfalfa	546	18,587
Sainfoin	1,078	19,257
Oats (hay)	2,755	38,174
Maize (silage)	14,590	468,400
Triticale (hay)	165	2,310
Vetch (hay)	31,756	456,394
Ustilago reiliana (hay)	80	1,562
Total	50,985	1,005,474

Source: Statistics from Samsun Provincial Directorate of Agriculture (2010).

Coastal plains are very fertile for the production of higher-yielding products such as vegetables, rice and corn. High yielding forage plants should find more place in rotation systems in these fertile irrigated lands. Extensive farming is performed inlands due to limited irrigation facilities, climatic conditions and landscape. In fact, these regions are more suitable for the production of livestock and forage crops (Acar, 2008). Indeed, livestock and dairy farming in recent years have started to develop the inland areas. In order to increase sustainability and profitability of this situation, high-quality forage production should be encouraged and supported as more than 70% of input is feed in farm management (Avcioglu *et al.*, 2009).

Table 6. Number of farm animals in Samsun and comparison with Turkey

Number of animals	Samsun		Turkey
	Number	% of Turkey	
Sheep	132,854	0.57	23,089,691
Goat	12,604	0.20	6,293,233
Cattle	282,493	2.48	11,369,800
Water buffalo	11,380	13.43	84,726
Total	439,331	1.07	40,837,450

Source: TurkStat (2010).

The two periods in a year with deficit in green forages are mid summer and winter months. In fact, during summer months, animals try to meet their feed needs by grazing on pastures. However, pastures are non irrigable lands, and pasture lands is mostly dominated by cool season plants. These plants are dried up and they are not able to meet feed gap (Tosun *et al.*, 1991). Therefore, high yielding forage crops in irrigable lands and drought-resistant, ever green plants in summer period in non-irrigable sloping lands are necessary to provide the animal feed chain with high energy resources (Acar and Ayan, 2011). Cattle are kept under shelters and silage, haylage and dry hay are used to feed them in winter period. Therefore production of silage, haylage and dry hay should increase for winter feed.

IV – Conclusion

Crop production dominates the animal production in Samsun. However, it is possible to say that crop farm is not profitable and sustainable due to the small farm size of around 4 hectares. Vegetable production, horticulture, organic agriculture, animal husbandry and forage production providing a higher gain per unit area, should be supported to sustain small enterprises in Samsun.

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Reform of the CAP:
Progress for grasslands and livestock farming?

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Abstract. The European Commission (EC) presented recently a proposition for a reform of the Common Agricultural Policy (CAP) after 2013. This proposal continues some of the present objectives and includes new ones that take into account the enlargement to new Member States. The mechanisms designed by the EC for reaching these objectives, especially for the "Greening" component of pillar 1, are though very unlikely to succeed. The definition of permanent grassland is far too restrictive and inadequate. Semi-natural grasslands and High Nature Value farmland are not specifically targeted although they are the most valuable ecosystems of the farmland area. Greening measures are too general, not targeted, not contractual and based on one-year farmers' commitments. They do not include farmers' advice and training, and a convincing control system. Most CAP expenditures should shift from pillar 1 to pillar 2 and the agri-environmental scheme. In the medium term, CAP expenditures should support the emergence of a market of public goods (biodiversity, landscape and carbon storage mainly) supported by pillar 2 budget (public money for public goods!). An increase of the grassland area and the implementation of an efficient system for biodiversity conservation in agriculture are highly desirable.

Keywords. Common Agricultural Policy – Greening – Agri-environment – Public goods.

Réforme de la PAC : Un progrès pour les prairies et l'élevage ?

Résumé. *La Commission européenne (CE) a présenté récemment une proposition pour une réforme de la Politique Agricole Commune (PAC) après 2013. Cette proposition poursuit certains des objectifs actuels et en inclut de nouveaux qui prennent en considération l'élargissement à de nouveaux Etats membres. Les mécanismes conçus par la CE pour atteindre ces objectifs sont cependant très peu susceptibles de réussir, particulièrement pour la composante « verdissement » du 1^er^ pilier. La définition des prairies permanentes est bien trop restrictive et inadéquate. Les prairies semi-naturelles et les terres agricoles de Haute Valeur Naturelle ne sont pas spécifiquement ciblées bien qu'elles soient les écosystèmes les plus précieux de la surface agricole. Les mesures du verdissement sont trop générales, non ciblées, non contractuelles et basées sur des engagements annuels des agriculteurs. Elles ne comprennent pas de conseil et de formation des agriculteurs, et un système de contrôle convaincant. La plupart des dépenses de la PAC devraient être transférées du 1er pilier au 2ème pilier et au programme agri-environnemental. À moyen terme, les dépenses de la PAC devraient soutenir l'émergence d'un marché de biens publics (biodiversité, paysage et stockage de carbone principalement) soutenu par le budget du 2ème pilier (des fonds publics pour des biens publics !). Une augmentation de la surface de prairie et la mise en place d'un système efficace pour la conservation de la biodiversité en agriculture sont fortement souhaitables.*

Mots-clés. *Politique Agricole Commune – Verdissement – Agri-environnement – Biens publics.*

I – Introduction

On 12 October 2011, the European Commission (EC) presented a proposition for a reform of the Common Agricultural Policy (CAP) after 2013 (European Commission 2011a,b). Three broad objectives of the future CAP are defined: (i) viable food production, (ii) sustainable management of natural resources, and (iii) balanced territorial development. New ideas have been introduced in the 2011 CAP reform proposals of the EC compared to the former CAP. Most changes are related to pillar 1. A new "Basic Payment Scheme" will introduce more equity in the payments per ha within and between Member States (MS). A compulsory "Greening" component will support farmers for respecting agricultural practices beneficial for the climate and the environment. MS may grant an additional payment from pillar 1 for areas with natural constraints. This support has to be limited to 5% of the national envelope. Part of the budget will target young and small farmers. MS would have the possibility to spend limited amounts of their envelope (maximum 5%) on "coupled" payments linked to a specific product. Limited transfer would be allowed between pillars 1 and 2 or pillars 2 and 1. The cross-compliance principle would be reinforced. Capping would limit payments that very large farms can receive.

More fairness in the distribution of supports is certainly something that could increase cohesion of the EU, support the income of small farmers of the new MS and of extensive farmers of all MS and could be used for enhancing the environment, protecting biodiversity and landscapes. A successful transition of the economies of the new MS is vital for all EU countries. CAP mechanisms should target farmers of these countries for helping them to develop a modern and sustainable agriculture while protecting the environment. Capping is also a tool that can contribute to distributing supports to farmers who need them the most. If one can agree on the objectives, mechanisms for reaching these objectives can be discussed!

II – Analysis of the EC proposals

There is a wide consensus that the CAP must be simplified and its efficiency increased. The recent proposals do not really go in this direction.

The "greening" component of the 1st pillar introduces confusion between the objectives of the 1st and the 2nd pillars. If the Greening component of pillar 1 is considered as a "light" version of Agri-Environmental Measures (AEM), AEM and Less Favoured Areas (LFA) programmes would have both 1st and 2nd pillar components. The articulation between the green component of pillar 1 and the environmental scheme of the Rural Development Programme (RDP) is not defined.

Even more importantly, **the CAP must demonstrate good value for money to tax payers**. That implies the delivery of public goods and the implementation of an effective system for this delivery.

The budget devoted to the greening is important (about 30% of the national envelopes of direct payments) and could triple the amount spent on agri-environment compared to the present situation if the budget of AEM is maintained. **The 3 measures of the greening component – maintaining permanent pasture, crop diversification and maintaining an "ecological focus area" of at least 7% of farmland – are welcome in their principle.**

Supporting permanent pastures is highly justified for many reasons. The environmental benefits of the measure on the maintenance of permanent pastures will though be limited because it is not targeted to precise environmental goals and in particular it does not focus on semi-natural vegetation.

The definition of permanent grassland by European Commission (2011a) – "land used to grow grasses or other *herbaceous* forage naturally (self-seeded) or through cultivation (sown) and that has not been *included in the crop rotation* of the holding for five years or longer" – does not take into account the vast grazed areas that include high proportions of trees and/or shrubs and that have been used for centuries in different areas of Europe from Sweden to the South of Spain and to Greece. Grazed woodlands, *Calluna* heather and other *Ericaceae* communities in the lowlands and in mountains, Mediterranean matorral, the Spanish Dehesa and the Portuguese Montado for instance would be excluded from supports and they are among the most precious and biologically rich, grazed ecosystems of Europe. They are also storing carbon in higher amounts than other grazed ecosystems.

On the other hand, large areas of grasslands are regularly resown without taking part in crop rotations. The soil cover is always grass but the vegetation is not permanent grassland. These grasslands provide much lower environmental benefits and are species-poor. The definition should only include grasslands that are not regularly ploughed or chemically destroyed and reseeded.

The greening measure for grassland and rangeland conservation should target specifically semi-natural vegetation, i.e. managed ecosystems dominated by indigenous or naturally occurring grasses, other herbaceous species and/or shrubs which are grazed or have the potential to be grazed (Allen *et al.*, 2011). These ecosystems are not substantially modified by fertilisation, liming, drainage, herbicide use, introduction of exotic species and over-sowing. Forestland that produces, at least periodically, understorey vegetation that is grazed should also be included. Compared to semi-natural grasslands, lower level of subsidies should support more intensively used permanent grasslands (PG). The definition of intensively used PG implies more frequent defoliations and higher stocking rates and productions than semi-natural grasslands. Simple maintenance rules should be defined in the support system and controlled by a credible monitoring and evaluation procedure. Legume-based temporary grasslands could be supported too, at a lower rate than intensively used PG.

The environmental objectives and management of the "ecological focus area" are not defined. Terms like "field margins, hedges, trees, fallow land, buffer strips, afforested area" are rather vague and the biodiversity of these areas can be of high-value, but could also be of low-value, sometimes with harmful elements. These areas should be carefully defined, in-field and on field edges, include all types of ecological infrastructures that are beneficial to biodiversity and their management should be checked and the results evaluated. That implies higher levels of control than with the present 1st pillar measures and an implementation philosophy closer to the 2nd pillar.

The greening component should support as a priority those farming systems that provide environmental public goods and services. High Nature Value (HNV) farming systems are one of them. Their persistence is threatened by a low profitability. HNV farmland is often managed by small farmers that the reform would like to support. However, the proposition of the EC insufficiently includes HNV. If it is recognised amongst the main objectives of the RDP, there is no mention of any tool specifically focused on it. This tool could possibly be integrated in a 1st pillar component (Beaufoy and Marsden, 2011). MS may grant an additional 1st pillar payment for areas with natural constraints, for a very limited amount of their national envelope, but no clear environmental objectives are associated to this measure. These payments should be merged with those of the LFA scheme of the RDP and used for financing HNV farming on a simple, clear and effective basis. That would result in giving a stronger content and a clearer environmental objective to the LFA programme (the present definition: "a broad-scale mechanism for maintaining the countryside in marginal areas" is very general and has limited environmental relevance).

All RDP programmes should have clear objectives including environmental objectives like AEM, LFA, investment in physical and human capital and the Leader axis. Special attention should be paid to the avoidance of distortion effects of these policies, especially investment supports and LEADER projects, on the environment. **The current agri-environmental scheme has had a positive effect on the environment** by slowing down the degradations, by maintaining a situation or by restoring biodiversity and landscapes. Its effect was though insufficient, as recognized in the EU Biodiversity Strategy. There are several reasons for this, including issues with national or regional scheme design, the targeting of the measures, the way they are implemented, a lack of farmer's advice, low administrative capacity, low payment levels and insufficient budget. The budget for AEM should thus not be decreased, it should increase, but the proposals of the EC do not guarantee this increase. In each country, AEM should be better targeted. Increasing farmer's advice and training on AEM and increasing monitoring and evaluation will require greater administrative efforts and a somewhat larger part of the budget, but these conditions are necessary for ensuring effectiveness, efficiency and good value for public money (Hart and Baldock, 2011).

The present proposals of greening measures will not deliver important environmental benefits because they are too general and not targeted, they will apparently not include training, monitoring and evaluation of the results. It has been shown that only targeted measures can be efficient for biodiversity restoration and conservation (for instance: Bretagnolle *et al.*, 2011). General and broad measures, like those corresponding to the management rules of pillar 1, are not. Non-contractual agri-environmental actions will thus most likely not deliver significant results! Most measures require long-term adoption for reaching consistent results. The one-year basis of the EC proposal does not fit with this criterion. Multi-annual commitments should be considered.

If all these aspects are not taken into account in the final version of the reform, the credibility of the "greening" component of the CAP and of the whole CAP will be threatened.

Independently of the reform proposals and the previous comments, a change of paradigm is needed for the CAP. **The CAP budget should move from income support to a public good market financing**. That will give a new legitimacy to this policy. The structure in two pillars should be abandoned or the largest part of the CAP budget should be transferred from pillar 1 to pillar 2, with a lowering of co-funding rates in less developed regions (which is included in the EC proposals). The remaining part of pillar 1 budget (for instance about 20% of the total CAP budget) should be mainly kept for stabilizing income in case of high price volatility (safety net). Pillar 2 budget would become the basis for creating a true market for public goods and services and in priority for biodiversity and landscape conservation, carbon storage and water quality. On the supply side, initiatives could come from farmers advised by experts (research organisations, specialized NGO, R&D offices) for proposing (offering) public goods and services. On the demand side, the 2nd pillar of the CAP would be the main source of payments but other public authorities (national, regional, local), private companies, individuals or group of individuals could evaluate these proposals and decide to pay (to buy) them or not. Improved AEM should remain the reference and a source of inspiration for this market. This system based on private initiative, creativity and efficiency would boost the protection of the environment and stimulate rural life. It would create a vibrant countryside, create new jobs and increase contacts between the agricultural sector and other stakeholder types.

III – Discussion and conclusions

The structure of the CAP budget in two pillars is no more really justified. Direct payments, even if better distributed among and within MS, cannot be socially justified anymore in a context of public expense reduction and economic difficulties. Farmers should not be paid just for farming! They should earn income from their farming activities that should be as much as possible economically viable. This viability is though not always guaranteed. It can be increased by complementary activities that must also be based on the reality of a market. Farmers should notably be rewarded for the positive actions they undertake for a sustainable management of natural resources and for the delivery of ecosystem services. A market should be initiated and organized by the CAP for the production of public goods and services. This market should be largely financed by public money (public money for public goods!). This implies a change of paradigm of the CAP. Most CAP expenditures should be redirected to this objective. That will give a long-term legitimacy to the CAP budget.

In every policy document, the support to "permanent grasslands and rangelands" should include ecosystems dominated by shrubs and/or trees and that are traditionally grazed. Given the fast erosion of biodiversity in the EU, specific measures should support the maintenance and the restoration of semi-natural grasslands, within and outside Natura 2000 areas, and the farming systems that ensure their persistence, the HNV farming systems. More intensively used permanent grasslands and, to a lesser extent, legume-based temporary grasslands should also be supported because they protect natural resources and provide ecosystems services compared with arable land, although to a lesser extent than semi-natural grasslands.

Only AEM and greening components that target a species, a group of species, or a habitat can be efficient. AEM and greening components can also be designed to support a broad farming system, e.g. extensive sheep grazing system or other HNV farming systems, that can deliver real environmental benefits. With the exception of the support of these particular farming systems, general horizontal and not targeted measures are not efficient. Farmers' advice and training are essential because they do not yet sufficiently consider themselves as providers of biodiversity and ecosystem services and they do not always have enough knowledge for this new task. Follow-up, evaluation and control systems are also necessary for achieving good value for money.

The relative importance of the EU as an exporter on the world market of meat and dairy products is decreasing. Luxury and high-quality products, like Protected Designation of Origin (PDO) cheeses, have though good chances to compete in this market. European farmers should maintain or increase their income by producing for local markets in priority and by increasingly selling their products in short-marketing chains. PDO labels and private trademarks can be efficient tools for guaranteeing the combination of local origin, better taste, and the protection of biodiversity and landscape. That requires the consideration of biodiversity in the specifications to ensure a production system that favours biodiversity. Agri-tourism can also be helpful, especially in less favoured areas.

The conclusions of the "Dillon Round" of the General Agreement on Tariff and Trade (GATT) negotiations in 1962-1963 included the acceptation by European negotiators of free-tax imports of protein-rich feedstuff for animal feeding. As a result, between 1961 and 2008, feed imports have increased in the 27 countries of the present EU by about 400% (in tonnes) (FAOSTAT). Soy became the main product of feed imports (83% in 2008). That induced a fast increase of industrial monogastric (pig and poultry) production and blocked any further development of legumes and protein crops in Europe. It induced also a decrease of the grassland area. In the EU-6 [Benelux, France, Germany (GFR), Italy], losses of the permanent grassland area are estimated at about 30% and 7 million ha between 1967 and 2007 (Eurostat). In the EU-15, losses are probably closer to 15% or 10.5 million ha in 50 years (FAOSTAT). Feed imports are now equivalent to about 10% of the total EU-27 grassland area on a ME basis, and about 27% on a CP basis (Swolfs, 2011, and own calculations). In the 1961-2009 period, the maize area more than doubled, as a complement to protein-rich feedstuff, it gained 1.2 million ha in France, Germany and Benelux while the total cereal area remained almost stable (FAOSTAT). Other reasons of the decline of the permanent grassland area are urbanization and afforestation. Very large areas were afforested from the 1990s for instance in Spain and Portugal with CAP supports. These evolutions have also consequences on human health. Compared with grain-fed (soy, cereals) beef or milk, grass-fed beef or milk are lower in total fat, lower in saturated fatty acids (Couvreur *et al.*, 2006) linked with coronary heart diseases (CHD), higher in total omega-[and has a healthier ratio of omega-6 to omega-3 fatty acids (1.7 versus 5-14)], higher in conjugated linolenic acid (CLA) (cis-9 trans-11) (Dhiman *et al.*, 1999) that is anti-cancer, and higher in vaccenic acid (which can be transformed into CLA) (Duckett *et al.*, 2009). Improving human health and achieving higher protein independence are thus desirable objectives that can be partly achieved by a better use of grasslands, by reducing the importance of monogastric meat consumption compared to beef meat, by producing meat and dairy products on the basis of grass and not on the basis of grain. More grassland in the agricultural area will also provide better landscapes and more ecosystem services.

It is estimated that 30 to 50% of the total food produced in western societies is wasted (WRAP 2009, 2010; Parfitt *et al.*, 2010). Food waste reduction should thus receive more attention than yield and production increases. Policies can in parallel reduce wastes and use them, for instance in animal feeding as sources of protein and energy. Innovative systems are needed for ensuring the respect of hygienic aspects.

Research and development are essential for developing new systems that are efficient both in terms of food and ecosystem service productions. Innovation in the bio-economy is though not restricted to biotechnologies. New solutions, combining existing knowledge and techniques, or using new techniques, can be developed at the whole farming system level. Research is notably required to define the economic value of public goods and services in different kinds of ecosystems in arable land, grassland and forest; to study the effects of agricultural techniques and systems on the delivery of these public goods and services; to support the conservation and restoration of public goods and services from the technical and economic points of view. Small and Medium Enterprises (SME) should be more intensively associated with the development of new commercial products and processes.

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Session 1
Climate change and grasslands: Impacts, adaptation and mitigation

Climate change and grasslands: impacts, adaptation and mitigation

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Abstract. The paper reviews recent evidence on climate change and the role of greenhouse gases (GHG). Historical evidence indicates that climate change is not a new phenomenon and Mediterranean ecosystems have shown considerable resilience to past climate changes. The 21st century can be regarded as an era of climate change in which concerns about climate are accompanied by other drivers relating to globalization, food security and energy and sustainability issues. Carbon dioxide enhancement can have positive and negative effects for forage production. Increased temperatures and water deficits in the Mediterranean zone are likely to impact adversely on production, based on modelled outcomes, especially on maximum-production systems, but climate-adapted and regionally diverse systems of agriculture are suggested as being more resilient to climate change impacts. A range of adaptation strategies at both farm level and at policy/ government level are considered as means of enabling grass and forage systems to be maintained in a changing climate. Livestock agriculture contributes to GHG emissions but a range of mitigation measures are considered that can help offset some of these emissions. It is concluded that an integrated approach is required to respond to climate change. Many challenges remain but there are grounds for cautious optimism for future grass and forage-based farming in the Mediterranean zone.

Keywords. Forage – Greenhouse gas emissions – Livestock farming – Climate history – Mediterranean.

Le changement climatique: les effets, les adaptations et les mesures d'atténuation

Résumé. *Cet article passe en revue l'évidence actuelle du changement climatique et le rôle des gaz à effet de serre. Les preuves historiques indiquent que le changement climatique n'est pas un phénomène nouveau et les écosystèmes méditerranéens sont, par ailleurs, montré une résilience considérable aux changements climatiques passés. Le 21ème siècle peut être considéré comme une ère de changement climatique dans laquelle les préoccupations concernant le climat sont accompagnées par d'autres préoccupations telles que la mondialisation, la sécurité alimentaire, l'approvisionnement en énergie, et la durabilité. Le dioxyde de carbone peut avoir des effets positifs et négatifs sur la production de fourrage. L'augmentation des températures et des déficits d'eau dans la zone méditerranéenne, basée sur les résultats des modèles, sont susceptibles d'avoir un impact négatif sur la production, en particulier sur les systèmes de production intensive. Au contraire, des systèmes agricoles adaptés au climat et diversifiés sont considérés comme plus résistants aux impacts du changement climatique. Une gamme de stratégies d'adaptation au niveau des exploitations agricoles et au niveau des politiques gouvernementales peut permettre aux systèmes herbager et fourrager de se maintenir malgré les changements climatiques. L'élevage contribue aux émissions de gaz, mais une série de mesures d'atténuation sont prises pour aider à compenser certaines de ces émissions. Il est conclu qu'une approche intégrée est nécessaire pour répondreau changement climatique. De nombreux défis demeurent, mais l'optimisme pour l'avenir de l'agriculture des prairies dans la zone méditerranéenne demeure.*

Mots-clés. *Fourrages – Élevage – Émissions de gaz – Histoire climatique – Méditerranéenne.*

I – Introduction

Climate change has become a topic high on the political agenda and one that has serious potential implications for agriculture and land use, particularly in zones that are already affected by seasonal high temperatures or water deficits (FAO, 2006). Climate change is not just a recent phenomenon, and during the history of human civilization there have been several alternating periods of warming and cooling of the climate. The reasons for climate change are imperfectly understood but include both natural (changes in solar radiation, volcanic activity) and anthropogenic causes (increased emissions of CO_2 and other greenhouse gases (GHG)). The Third and Fourth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC, 2001a, b; 2007) conclude that recent global warming is "unequivocal" and that most of the increase in global average temperature since the mid-20th century is "very likely" (>90% probability) due to increased concentrations of GHGs - principally carbon dioxide, methane and nitrous oxide – anthropogenic emissions of which have increased greatly since the 19th century. Carbon dioxide (CO_2) is the main GHG due to its relatively high atmospheric concentration (at the present time 390 ppmv; having increased by over 30% since the mid-18th century. Methane (CH_4) and nitrous oxide (N_2O) have also increased by similar proportions over the same period. Although they are less abundant in the atmosphere (at *ca.* 1800 ppbv and 323 ppbv) their global warming potential is respectively 23 and 296 times greater than CO_2 over a 100-year timescale; importantly, a high proportion of their emissions are derived from agriculture. Improving agricultural management to reduce emissions of these gases is therefore part of the overall package of measures to limit the extent of future climate change.

This paper first considers the historical background relating to climate and environmental change and focuses on the issues of present-day concerns as they relate to grasslands in Europe, particularly the Mediterranean zone. The potential impacts on grassland and grassland agriculture are considered in terms of the scenarios reported in *Climate Change 2007*, the Fourth Assessment Report of the UN Intergovernmental Panel on Climate Change (IPCC). At the farm scale, as well as at landscape scales and in policy development, there is scope for adapting grasslands to potential changes that might arise due to shifts in temperatures and precipitation. Grassland also has an important potential role in contributing to the mitigation of the effects of climate change – at least in terms of reducing or offsetting net GHG emissions. This paper reviews the evidence on the causes of climate change, its possible impacts on forage production, quality and utilization, and the opportunities for changes in integrated management to adapt to the effects of climate change and to reduce the emissions of GHGs associated with forage and ruminant production.

II – Historical background to climate change

Around 12000 years BP, the Northern hemisphere, and Europe in particular, experienced an abrupt and relatively brief (1000-year) cold-climate period, the "Younger Dryas", which interrupted the post-glacial warming trend than began about 20000 years BP. One consequence was the sudden onset of drought in the eastern Mediterranean (Levant). This has since been linked (though controversially) with the onset of settled farming among the Natufian culture: the "dawn of agriculture". Around 9000 years BP (onset of the Holocene Climatic Optimum) there was a widespread global warming with snowmelt and flooding in Europe on a massive scale. In the eastern Mediterranean there is evidence of climatic oscillations (wet and arid periods) coinciding with archaeological developments and adaptive strategies that transformed human cultures (Finne *et al*., 2011; Roberts *et al*., 2011). More recently, around 950 to 1250 AD, the Medieval Warm Period (MWP) led to further changes in agriculture, with Mediterranean crops like grapes being grown even in north-west Europe. The MWP may have experienced greater temperature rise (as argued by McIntyre and McKitrick, 2005) than in the late 20th century (as previously argued by Mann *et al*., 1998). The end of the MWP marked the onset of so-called Little Ice Age (LIA) which lasted until around 1850, a period that necessitated improvements in agriculture, particularly in livestock production for meat. Our present-day concerns about climate change and global warming date from only the late-1980s (previously, environmental signals were interpreted as indicating a likely future glacial period), but the end of the LIA is now taken as coinciding with the onset of industrialization, land-use change and greatly increased emissions of carbon dioxide and other GHGs (anthropogenic forcing) that are attributed, at least in part and by many scientists and politicians, as the cause of recent global warming. I have highlighted these trends (over what is a relatively short period of the history of human civilization; much greater environmental changes are evident over longer timescales ('t Mannetje, 2007)) to emphasize that (i) climate change always has been, and still is, taking place, and we have only imperfect understanding of its causes; and (ii) agriculture and land use are inextricably linked to climate and weather, and changes in climate have been important drivers of agricultural change.

III – The 21st Century – an era of climate change

Climate change has risen as a priority on the international political agenda and has entered the public consciousness as an issue of compelling global environmental importance. IPCC projections of future climate change suggest further warming (of between 1 and 3° C by 2100, but locally, as in the hinterlands of the Mediterranean zone, increases could be much higher, as reviewed by t'Mannetje, 2007). In addition, changes in the distribution of precipitation, with decreased rainfall over parts of southern and eastern Europe, and an increase in the frequency of some extreme events like heat waves and floods are also likely (IPCC, 2001a,b; 2007; Olesen *et al*., 2011). Despite measures to reduce carbon emissions, atmospheric CO_2 concentrations will increase appreciably (very high level of certainty).

Concerns about climate change also coincide with the impacts of globalization, population growth, environmental degradation and resource depletion, energy security and food security (Royal Society, 2009) and the present century has been labelled as an "era of climate change" (e.g. Winter, 2009). The term "dangerous climate change" has been used to describe possible outcomes in which ecosystems and food productions systems cannot adapt and sustainable economic development is threatened (see Schneider and Lane, 2005). Projected population and socio-economic growth is predicted to greatly increase food demand by 2050 (FAO, 2008). World prices of grain and other livestock feedstuffs have risen appreciably in recent years, propelled by rising demand from developing countries and exacerbated by production deficits linked to biofuel crops in exporting countries. In the context of European agriculture the economic value of grass and forage crops for ruminants is likely to increase, as grain and other commodities are required for human consumption or as feed for pigs and poultry. Agriculture will need to embrace new technologies and adapt to policies and practices aimed at raising production sustainably while at the same time delivering on increasing standards for environmental protection and food quality (Royal Society, 2009).

IV – Climate change impacts

1. Climate change impacts for grassland and forage production

An increase in atmospheric CO_2 concentration is one of the most certain outcomes and one that may have both positive and negative consequences. Carbon dioxide is the major resource for photosynthesis and several reviews have concluded that elevated CO_2 concentrations stimulate photosynthesis, leading to increased plant productivity and modification of water and nutrient cycles (Kimball *et al*., 2002; Nowak *et al*., 2004; Soussana and Lüscher, 2007). Experiments under optimal growing conditions have shown that doubling CO_2 concentration can lead to a 0.30-0.50 increase in leaf photosynthesis in C_3 plants, and an increase of 0.10-0.25 in C_4 plants, with above-ground canopy increases in excess of 0.17 occurring in grassland ecosystems (Soussana and Lüscher, 2007, and references therein). Plant functional groups also differ in their response to enhanced CO_2, and both legumes and non-legume forbs are reported to be more responsive than grasses and increase in abundance (Lüscher *et al*., 2005). The effects of sustained temperature increases on grasslands are less clear, as increased temperatures not only increase photosynthesis but also cell respiration and possibly the rates of loss, through respiration, of sequestered soil carbon (Parsons *et al*., 2011, and references therein).

For most parts of Europe changes in mean annual precipitation are expected to be small, and under most of the future "emissions scenarios" these are within the range of natural variability. However, shifts towards a higher proportion of the annual rainfall in winter (notably so in most of the Mediterranean area) and less rain in summer, have the potential to increase the frequency of years with summer drought stress, leading to reduced security of crop yields on non-irrigated land. This is exacerbated by higher temperatures which lead to increased evapotranspiration. Future predictions for the Middle East region (Turkey, Syria, northern Iran and northern Iraq) suggest a loss of 170,000 km^2 of rain-fed agricultural land by 2100, and reduced length of grazing season on rangeland (Evans, 2009). Perhaps of greater impact across the Mediterranean and adjacent regions is the possible increased frequency of extreme events: rainfall occurring in storms that can lead to soil erosion and flooding, and increased leaching of nutrients. At other times of year, there is an increased likelihood of more exceptional and prolonged hot, dry spells that pose risks for feed budgeting, and increased risks of wildfires, the impacts of which are potentially most serious in Mediterranean and southern Europe. These impacts present additional pressures in areas that are already affected by abandonment of marginal grazing land. The problem of supplying forage during the summer dry season in many areas of the Mediterranean region is likely to become greater. Water limitations will prevent potential benefits of CO_2 enhancement from being realized. Irrigation offers a practical measure for greatly increasing the production of grasses and forage legumes such as lucerne; however, under future scenarios with higher temperatures and more frequent droughts, combined with other demands on water supplies, this cannot be relied upon as a sustainable option. While grassland production on a Europe-wide scale is likely to be enhanced rather than reduced by ongoing climate change, the productivity in southern Europe is likely to be reduced under hotter, drier and more variable conditions ('t Mannetje, 2007; Trnka *et al*., 2011).

2. Climate change impacts for livestock production and grassland utilization

Elevated CO_2 is likely to affect feed quality for grazing, both in terms of fine-scale (crude protein concentration and C:N ratio) and coarse-scale changes (C3 species vs. C4 species) although there are strategies to overcome this particularly through the greater use of legumes (Soussana and Lüscher, 2007). At the farm scale, the consequences for feed budgeting are increased under situations of uncertainty, requiring a greater area allocated for conserved feed to support livestock during periods with little or no forage production. Heat stress affecting livestock is another serious potential impact affecting the livestock sector, as this can lead to reduced intake and liveweight gain / milk production. Changing climate also presents risks of increased spread of vectors of livestock diseases. These are important impacts in the context of seasonally hot, dry regions, like the Mediterranean (Morgan, 2005; Bindi and Olesen, 2011).

V – Adaptations to climate change

Adaptation is an important component of the response to climate change impacts, both at farm level and policy level: vulnerabilities can be reduced and potential opportunities realized (Moriondo *et al*., 2010). Farmers, assisted by governments and other supporting institutions, can plan to adapt to climate change but improved understandings of adaptation are needed to respond to future impacts through low-risk strategies (Morgan, 2005; Reidsma and Ewart, 2008). Bindi and Olesen (2011) distinguish between "autonomous adaptations", which can optimize production without major system changes, such as varying sowing dates, stocking rates or fertilizer rates, and "planned adaptations", such as land-use change, breeding new plant varieties, or installation of irrigation systems.

In the specific context of Mediterranean grass and forage situations, we can identify a number of potential adaptations to impacts on primary production and feed quality. These include: farm-scale adaptive responses of greater reliance on conserved feed for housed livestock, increased use of drought-tolerant species including C_4 grasses and maize (Morgan, 2005), greater use of forage legumes in place of N-fertilized grass (Sulas, 2005), changes in dates of sowing, improved manure storage and applications, improved soil management to increase soil organic carbon and soil structure and moisture conservation through minimum-till systems or organic amendments (Diacono and Montemurro, 2010) and provision of irrigation – although this last option may be unavailable or uneconomic in many areas (García-Ruiz *et al*., 2011).

At the scale of policy-makers and institutions, longer term adaptations can be developed through improved plant breeding to meet agronomic and other goals in response to climate change impacts. New forage resources are required that are adapted to higher temperatures, drought, and increased CO_2. This might be achieved through exploitation of traits for dehydration tolerance and summer dormancy, either in novel species or for introducing traits into existing widely used grasses and legumes (Volaire *et al*., 2009). In addition to new legumes, a shift to communities with more C_4 grass species is a likely successional outcome in semi-natural Mediterranean grasslands but their feeding value is lower than C_3 species ('t Mannetje, 2007). There is a need to develop strategies for incorporation of C_4 grasses, ideally with improved germplasm, into ruminant production systems.

An integrated land management approach will be needed to maintain agriculture in the Mediterranean zone. This will need to incorporate soil and water protection, management to reduce the risk of wildfires in shrub and browse communities, and greater use of high quality silage to support utilization of low quality forage in dry periods. The Mediterranean zone has a traditional farm management culture that is often already well adapted to climatic variability, rather than to maximizing productivity. Some authors (Blondel, 2006; Reidsma and Ewart, 2008) have argued that the view of Mediterranean agriculture being highly vulnerable to climate change, based on modelled outcomes, needs to be refined to take account of local adaptations. The existence of regional farm diversity can be developed further as a promising adaptation strategy to reduce vulnerabilities to unfavourable conditions. Reidsma and Ewart (2008) further suggest that measures such as subsidy and incentives should support the increasing diversity of farming systems. The arguments of Blondel (2006) draw on an historical perspective, and challenge the "Lost Eden" or "Ruined landscape" view of Mediterranean ecosystems. Examples of the "Sylva-Saltus-Ager" system that was widespread in the Roman Empire, and the Dehesa-Montado of the Iberian Peninsula and some islands are used to illustrate the high degree of resilience, productivity and biodiversity of farmed Mediterranean landscapes in response to continuous human disturbance of fluctuating regimes and intensity over many millennia.

VI – Management to mitigate greenhouse gas emissions

Grassland-based agricultural systems contribute to the biosphere-atmosphere exchange of GHGs, with fluxes closely linked to management practices (Soussana *et al.,* 2004). Ruminant livestock farming contributes to GHG emissions mainly through emissions of CH_4 and N_2O, and from direct and indirect use of carbon fuels, but there are opportunities for adapting management to mitigate these emissions.

1. Carbon dioxide

Long term pasture and scrub ecosystems and the maintenance of other farmland vegetation and accumulation of carbon as organic matter in soils can all contribute to the temporary removal, and in some cases to the long-term sequestration, of CO_2 from the atmosphere, thereby enabling grassland-based farming to contribute to GHG mitigation as well as improving the sustainability of the soil (Freibauer *et al*., 2004; Smith, 2004; Lal, 2010). Measures to reduce net-CO_2 emissions include improving efficiency of animal manures and crop residues, reducing soil disturbance, maximizing the C returns in manure, use of deeper rooting species, application of sewage sludge or compost to land, incorporation of biochar (Vaccari *et al*., 2011), extensification, and improved management to reduce wind and water erosion. Permanent pasture and minimum-tillage systems are favoured over annual cultivations. The increase in soil C content after a shift from arable to grassland is partly explained by a greater supply of C to the soil under grass, mainly from the roots, but also from the shoot litter (Soussana *et al.,* 2004). Whereas this rate of increase of soil C after conversion to grassland is slow, the rate of C disappearance from soil after returning grassland to arable is rapid. In terms of future research a major scientific development in the context of plant breeding in recent years has been the focus on plant functional traits (PFT) rather than on cultivars *per se*. PFTs control many terrestrial ecosystem processes including soil C storage; e.g., De Deyn *et al*. (2008) propose a trait-based approach that will help develop strategies to preserve and promote C sequestration. Kell (2011) takes this argument further and suggests that rather than focus on soil C sequestration that is happening now but might be possible through active agricultural invention and needs towards C sequestration at greater depths. Breeding crop plants with deeper and bushy root ecosystems could simultaneously improve soil structure and also its steady-state carbon, water and nutrient retention, as well as sustainable plant yields.

2. Methane

Enteric fermentation is the main agricultural source of methane in Europe, with emissions from livestock manures accounting for most of the rest. Methane is produced as a by-product of digestion of structural carbohydrates, due to the action of rumen microbes. During digestion, mono-saccharides are fermented to H_2, CO_2 and volatile fatty acids (VFAs), and as part of this stage of ruminant digestion some of the microbes (methanogens) produce CH_4. Several studies have formulated abatement strategies to mitigate CH_4 emissions. Mitigations aimed at enteric fermentation may be addressed at three different levels: livestock dietary changes, direct rumen manipulation, and systematic changes. The dietary changes involve measures which enhance the efficiency of feed energy use, and this is one area which has potential implications for forage use in the future (Cardenas *et al*., 2007). Even assuming a constant percentage of methane loss, this strategy will decrease methane loss per unit of product and probably decrease CH_4 emissions in the long term (Johnson and Johnson, 1995). The most natural way to depress CH_4 production would be to manipulate the diet to give high rates of fermentation and/or passage through the rumen, affecting rumen VFAs. These changes in VFA proportions have been associated with a decrease in the fibre content of the diet (e.g. by including maize silage). Ingestion of organic acids and yeast culture have been associated with reduced emissions in total CH_4 per cow and also with beneficial increases in animal product (Hopkins and Del Prado, 2007). The use of some plant extracts (i.e. tannins, saponins) has also been associated with CH_4 reduction. There may be considerable potential for tanniniferous legumes such as *Lotus* species, but further research is needed on their effectiveness.

There are some drawbacks to using dietary supplements. The organic acids are not yet commonly used, and they may also trigger pH problems in the rumen. Plant extracts may also have anti-nutritional effects and even be toxic (Teferedegne, 2000). For instance, in a study by Hess *et al*. (2005), extracted tannins had a positive effect on feed rates and hence a possible reduction of CH_4 per kg product, whereas the use of shrub legumes rich in tannins resulted in decreased feed rates. Yeast culture, on the other hand, although variable, may be promising as a successful mitigation option as it is already in common use. Direct rumen manipulation may offer an alternative to dietary change; for instance, defaunation of protozoa to decrease the number of methanogenic bacteria. However, there are many drawbacks including risks of metabolic disorders. Clearly, many research challenges exist before these approaches can be implemented (Hopkins and del Prado, 2007).

Systematic changes may involve identifying animal breeds which result in a reduction of CH_4 output per animal, though so far no clear evidence has been found (Münger and Kreuser, 2005). Increasing productivity per head (i.e. milk yield per cow or per ewe), or increasing the number of lactations for which the average milking cow or ewe remains economically productive, would decrease CH_4 production per unit of milk. Similarly, reducing the length of the production cycle of meat animals would also reduce the CH_4 production per kg of meat produced; thus, within the framework of production targets would decrease total CH_4 emissions. However, although more intensive forms of animal production tend to decrease total CH_4 output, they might not be compatible with other policy targets.

Mitigations aimed at manure management include opportunities to decrease total CH_4 outputs from farming systems are limited to either increasing the O_2 supply to restrict methanogenesis, minimizing the release of CH_4 to the environment (e.g. covered slurry lagoons/ manure stores) or using anaerobic digesters to produce more CH_4 in a controlled environment and hence use this CH_4 as a source of energy. This last technique could represent a sustainable option, and if the issues of high capital cost can be overcome this may become an important feature of future forage-based systems compatible with low CH_4 emissions.

3. Nitrous oxide

Nitrous oxide is formed in the soil through nitrification and denitrification and is controlled by a number of soil factors, including moisture content, temperature, fertilizer additions, pH, organic matter content, nitrate and ammonium (Hopkins and del Prado, 2007, and references therein).

Nitrate and ammonium in the soil are subject to several process dynamics. In general, N_2O emissions can be reduced by implementing practices aimed at enhancing the ability of the crop to compete with processes that lead to the escape of N from the soil-plant system (Freney, 1997). For instance, there are several methods for increasing the efficiency of the crop to remove mineral N from the soil. These include improving fertilizer efficiency, optimizing methods and timing of applications (Dosch and Gutser, 1996), using ammonium-based fertilizers rather than nitrate-based ones (Dobbie and Smith, 2003) and employing nitrification chemical inhibitors (Macadam *et al.,* 2003). Increasing the soil aeration may significantly reduce N_2O emissions. Avoiding compaction by traffic, tillage (Pinto *et al.,* 2004) and grazing livestock may help to reduce N_2O emissions. Housing system and management will also influence N_2O emissions, e.g. straw-based manures result in greater N_2O emissions than slurry-based ones (Groenestein and Van Faassen, 1996). Minimizing the grazing period is likely to reduce N_2O emissions as long as the slurry produced during the housing period is uniformly spread. Livestock diets also affect the N_2O emissions from slurry subsequently applied to land (Cardenas *et al*., 2007).

VII – Conclusions: the need for integration of actions for adaptation and mitigation

Forage-based agriculture contributes to the total of GHG emissions but there are many practical and potential solutions that can help reduce these impacts, and some of these can also help agriculture adapt to the direct impacts associated with climate change. Agriculture is also subject to other pressures, including environmental (biodiversity, eutrophication, erosion, and acidification), socio-economic and sustainability issues. Identification of “win-win” strategies requires development of appropriate modelling systems together with the acquisition of field and farm data (Scholefield *et al.,* 2005).

However, GHG and other emissions account for only a part of the whole challenge facing grassland and forage-based systems as we move into an era of climate change. Policy makers are increasingly becoming concerned with energy security, food security and management of water resources and other ecosystem services. Nevertheless, the history of farming the Mediterranean zone shows that systems have evolved in response to changing conditions, and these traditions and their diversity, coupled with technological advances, provide some grounds for cautious optimism. Many research challenges remain. At national and regional scales, policy makers need to ensure that decisions on land and environmental management, and on future food security, are based on evidence-based research and expert advice in order to ensure a sustainable balance of forages, arable crops and other land-use requirements, consistent with broader economic, social and environmental objectives. Research funders also need to ensure that climate change implications are factored into future projects.

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Developing a coherent monitoring system for Mediterranean grasslands

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Abstract. Grasslands are one of the world's most widespread vegetation types, covering nearly 20% of the land surface and represent a major source of production of agricultural products. However, grassland vegetation across the Mediterranean region is changing at an unanticipated rate. These changes are the result of climatic and socio-economic changes. Because changes in agro-ecosystems affect the livelihoods and development of rural communities, it is important that planners and policy makers be able to determine grassland condition and trend in relation to climatic and managerial factors at specific locations. Over the past decade we have been developing monitoring technologies and protocols that can be used at local scales which speed the collection, processing, and storage of indicators of grassland health. By coupling digital photography, GPS technologies, information collected with accessory devices, and computer software applied in a strict monitoring protocol, we are able to rapidly monitor grassland vegetation. Repeated measurements over time at the same locations provide information regarding environmental trend and rate of change. When we couple our local scale measurements with landscape scale remote sensing data such as satellite or high altitude aerial photography, we have a more complete picture of vegetation dynamics and system change which facilitates interpretation and development of mitigation strategies.

Keywords. Remote sensing – Vegetation dynamics – VegMeasure software – Image processing.

Développement d'un système de surveillance cohérent pour les pâturages méditerranéens

Résumé. *Couvrant environ 20% de la superficie terrestre, les formations végétales herbacées constituent le type de végétation le plus répandu dans le monde. Dans la région méditerranéenne, ce type de végétation est toutefois, en train de subir des changements quantitatifs et qualitatifs rapides résultant de facteurs d'origine climatique et anthropique. Puisque les changements dans les agro-écosystèmes influent sur les moyens de subsistance des communautés rurales, il est important que les gestionnaires et les décideurs soient en mesure de déterminer l'état des pâturages et la tendance par rapport aux facteurs climatiques et de gestion à des endroits précis. Au cours de la dernière décennie, nous avons mis au point des technologies de surveillance et des protocoles qui sont plus efficaces que les techniques traditionnelles. En combinant la photographie numérique, les technologies GPS, et les logiciels personnalisés et en suivant un protocole bien définit, nous sommes en mesure de surveiller la végétation avec une très haute précision. Ces mesures répétées aux mêmes endroits fournissent des informations utiles sur la tendance écologique ainsi que les variations inter-annuelles. Une image plus complète de la dynamique de la végétation et l'évolution du système pourrait être obtenue après association des données à l'échelle locale avec des données de télédétection par satellite telle que la photographie à haute altitude ou aérienne. Ceci facilitera l'interprétation et le développement de stratégies de mitigation.*

Mots-clés. *Télédétection – Dynamique de la végétation – Logicielle VegMeasure – Traitement des images.*

I – Introduction

Slowing grassland degradation remains an enormous challenge with concomitant social, environmental, and economic implications. Natural resource managers and ecosystem engineers are often called upon to evaluate the effects of their actions and thus are required to document changes in plant communities (Greig-Smith, 1983). Plant cover is one of the fundamental quantitative parameters measured by botanists. Cover is ecologically important because plant leaves and branches protect the soil from the damaging effects of heavy rainfall and reduce soil erosion. Agronomists, ecologists, and range scientists usually express cover as the percentage of the ground surface that is occupied by the plant crown or shoot area when it is projected vertically downward. Cover is easier to measure than biomass and if one also acquires measurements of plant height and the stratification within the vertical profile, it can be used to predict biomass. One technique that has been used in conjunction with traditional cover measurements is photographic monitoring (Bennett *et al.*, 2000).

Development of vegetation sampling protocols requires careful assessment of management goals in relation to benefits received from sampling efforts. Traditionally ecologists have employed quadrats that are sampled for plant cover, aboveground biomass, and density (Barbour *et al.*, 1987; Hill *et al.*, 2005). Also of importance is the cover of litter and percent of bare ground exposed to the erosive impact of rain. Parameters that involve cover are typically recorded by field personnel using field sampling techniques that are based on visual estimates. Advances in electronic technology have created new opportunities for vegetation and ecosystem monitoring.

II – Materials and methods

1. Apparatus

A digital charting apparatus was composed of a GPS data logger, a bubble level, and compass mounted on a wooden platform attached to a Bogen-Manfrotto 3025 3D Junior Tripod Head. The head is attached to a monopod and a digital camera as shown in Fig. 1. The camera is set at a fixed focal length and the head adjusted so the base of the monopod is just out of the field of view. The monopod is set at a fixed length so the camera is held at the same height above the ground for all photos. This setup allows the user to position the camera in a cardinal direction, in a hori-

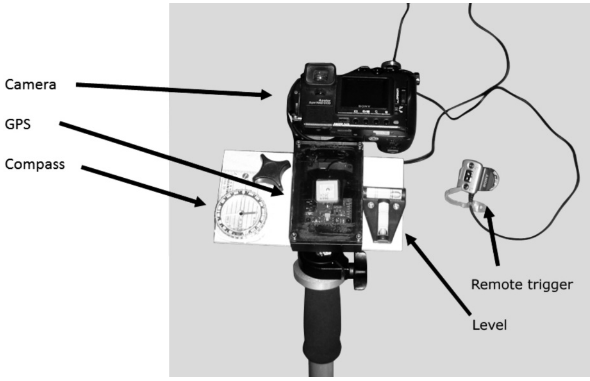

Fig. 1. This figure shows the digital charting apparatus used in this study. It consists of a digital camera mounted on a Bogen-Manfrotto 3025 3D Junior Tripod Head that positions the camera pointed vertically downward from a fixed height. The compass allows us to have the top of the camera pointed southward for each image.

zontal plane at a fixed height above the ground (Booth *et al*., 2004). We use a continuously recording GPS unit that tracks the position of the camera at 1 second intervals throughout the day.

Before we collect data in the field, we synchronize the time on the digital camera with GPS time using a hand-held GPS. Each morning before we collect data, we also take a photograph of either the hand-held GPS unit that shows the date and time or a computer screen with a master clock so any deviation of the camera time can be determined or camera time offset from GPS time corrected for. The entire apparatus allows us to know the position (latitude, longitude, and elevation) of the camera when a photograph was taken and to know the directional orientation of the image. The first photo in the field has a ruler in it so we can determine the size of each photographic pixel on the ground and scale the image.

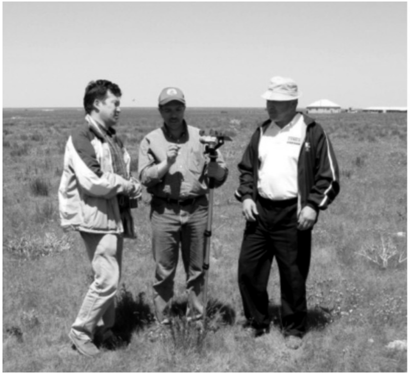

Fig. 2. The digital charting apparatus is being used in the field. Once the height of the monopod has been set it remains at that height for the sampling session. Because we work in the northern hemisphere, we usually point the camera due south which reduces shadow in the image.

Images can be positioned and tagged with geographic coordinates with the GeoAlbum software package. This program automatically assigns coordinates, rotates the image, and sets the pixel dimensions for each image. In addition it creates a world file so they can be opened and positioned in Geographic Information Systems (GIS) programs such as ArcGIS, ERDAS, or Global Mapper (Louhaichi *et al.,* 2010). As informative as photographs are, most scientists and managers would like to be able to extract quantitative measurements from the images (Louhaichi *et al*., 2001). Once they are positioned and scaled they can be used as maps and distances between points or surface areas calculated. This has been used to determine spacing between plants in desert areas and to calculate the canopy cover of shrubs.

2. Image processing

If vegetative cover is desired, image processing programs such as ERDAS Imagine®, ENVI®, VegMeasure 2®, Sample Point®, and others. We built VegMeasure2 to rapidly calculate the cover of large numbers of images quickly (Preuss *et al.,* 2012). It was originally designed to estimate the cover of green leaves, litter, and soil in digital images (Fig. 3).

III – Results and discussion

Digital charting using the apparatus and software described in this paper can rapidly collect detailed plot-level information on grassland systems that are tagged with the location, date and time. On our sagebrush grassland studies, a team of 4 trained technicians equipped with staff-mounted cameras have taken as many as 1600 geo-referenced sample images in a day. Landscapes are therefore more intensely sampled and internal variation in the system more accurately portrayed. We often couple digital charting with traditional sampling on a subset of the sample plots so we have reference values that can be compared and errors estimated. Office time on the computer can be greater but that is generally because more samples were taken.

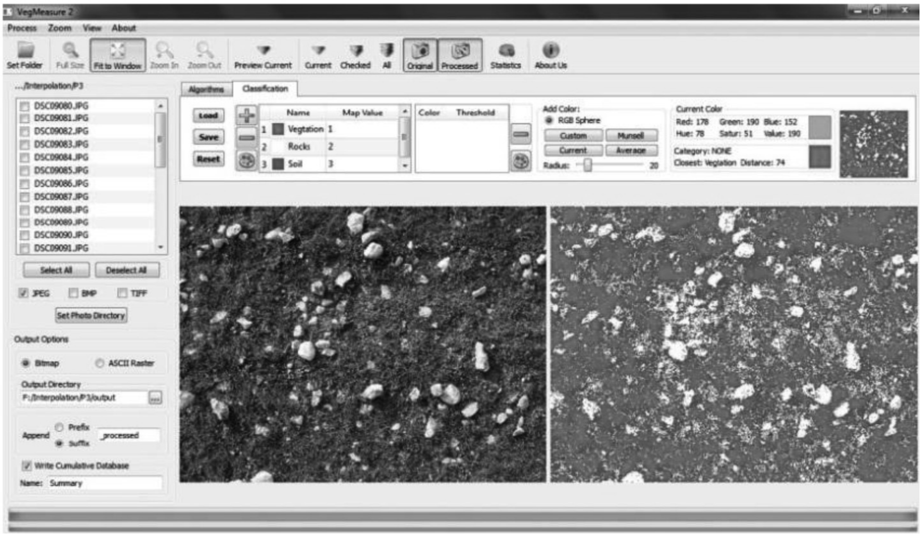

Fig. 3. This is a screen capture from VegMeasure 2 showing the classification of green leaf, rocks and soil in the digital image on the left. Each pixel in the classified image on the right has been assigned to one of these classes and colored appropriately, green for green vegetation, brown for soil, and white for rock. After the image has been classified the number of pixels in each class is counted, the surface area calculated and the relative percentage of each reported.

We suggest that with appropriately designed sampling strategies are employed using sound statistical protocols; a coherent representation of grassland ecosystem can be obtained. Because geo-referenced images can be stored on computer hard drives or optical disc storage formats (CD and DVD), storage and transfer of information is relatively easy. Once images are gathered and processed, trained botanists and vegetation ecologist find a wealth of information about conditions on the site at that point in time. Field tests of data collected using digital charting techniques compare favourably with traditional sampling.

Geo-positioned vector data (single images) would then be interpolated in GIS environment to create a raster image (Fig. 4). Repeated measurements of transects or permanent plots can be used to monitor change that results from variable weather as well as climate change. We have followed permanently positioned plots for six years and been able to document both declining and increasing plant species. It is simpler to monitor distinct, broadleaf species, but individual, perennial, bunch grasses can also be followed.

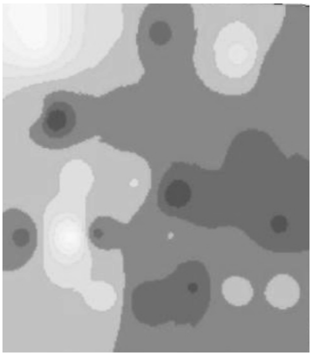

Fig. 4. Raster image generated through interpolation of vector data, greener (darker) areas have more vegetation cover.

IV – Conclusions

The overarching goal of digital charting of vegetation is to enhance our understanding of and ability to quantitative measure the condition and change in grasslands. The monitoring system evaluated in this study represents a quick and inexpensive way to obtain quantitative ground cover estimates of grasslands, while providing a temporal record of ground cover conditions. Digital photography does not require any specialized equipment and can be obtained quickly by a single person. The method also allows for the standardization of ground cover estimates between sites, something that cannot be accomplished when using visual estimates.

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Grassland management options under Kyoto Protocol Article 3.4
The Portuguese case study

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Abstract. Portugal has voluntarily committed to reporting the CO_2 emissions and removals resulting from grassland management under Kyoto Protocol Article 3.4. This commitment, together with the fact that a significant proportion of grasslands in Portugal are of low productivity and are located in the regions with higher risk of desertification, brought the context and motivation to promote the expansion of permanent sown biodiverse rich in legumes. These pastures are an innovation from the Biodiversity Engineering that promotes the increase of the soil organic matter and consequent carbon sequestration. Nowadays, this type of pasture represents more than 85 000 ha in Portugal, from which a significant percentage has been supported by the Portuguese Carbon Fund as a way of refunding farmers for the provision of an environmental service. Recently, the Portuguese Carbon Fund has also demonstrated interest in remunerating the farmers willing to control shrub encroachment at pastures through the use of non-invasive techniques that promote soil carbon sequestration. Regarding the biodiverse pastures, a 10 years model of the soil organic matter dynamic shows a carbon sequestration of about 6.5 t $CO_2.ha^{-1}.yr^{-1}$. In the case of the change of practice for shrub control, results from a preliminary model are promising in what concerns the prediction of carbon sequestration.

Keywords. Pastures – Non-tillage – Shrub control – Carbon sequestration – Land management.

Options de gestion de pâturages dans le contexte de l'article 3.4 du Protocole de Kyoto. Le cas d'étude de Portugal

Résumé. *Portugal est volontairement engagé à rendre compte du budget des émissions de CO_2 de la gestion des praires pour l'article 3.4 du Protocole de Kyoto. Cet engagement, en collaboration avec le fait qu'une proportion importante des pâturages au Portugal sont d'une faible productivité et sont situés dans les régions avec un risque plus élevé de la désertification, a introduit le contexte et la motivation de promouvoir l'expansion des pâturages biodiverses permanentes, riches en légumes. Ces pâturages, lorsqu'on les compare à celles naturelles, promeuvent l'augmentation de la matière organique du sol et la séquestration du carbone. Aujourd'hui, ce type de pâturage représente plus de 85 000 ha au Portugal, des quels une pourcentage importante est été financée par le Fond du Carbone Portugais. Ce Fond a également manifesté son intérêt pour rémunérer les agriculteurs qui acceptent de contrôler l'embroussaillement des pâturages avec l'utilisation de techniques non invasives et qui promeuvent la séquestration du carbone dans le sol. En ce qui concerne les pâturages biodiverses, le modèle de la dynamique de la matière organique du sol pendant 10 années montre une séquestration du carbone d'environ 6,5 t $CO_2.ha.^{-1}.an^{-1}$. Dans le cas du changement de la pratique pour le contrôle des arbustes, les résultats préliminaires sont promettants en ce qui concerne la prédiction de la séquestrationdu carbone.*

Mots-clés. *Pâturages – Non-travail du sol – Arbuste – Sequestration du carbone – Gestion des terres.*

I – Introduction

There are strict stipulations in the Kyoto Protocol (KP) as to how a country's emissions inventory is made, namely regarding what to account. However, there are some items that remain as an option for each signatory country. These options relate to the agro-forestry sector and are the so-called Land Use, Land Use Change and Forestry activities, now renamed Agriculture, Forestry and Other Land Uses (AFOLU), under the framework of Article 3.4 of the KP. While most sectors are net polluters, where all that can be done is to minimize CO_2 emissions, AFOLU activities are responsible for CO_2 sequestration in soils and living biomass. Therefore, AFOLU activities (IPCC, 2006) do not promote a decrease in emissions, but rather the sequestration of CO_2.

Portugal plays a leading role regarding AFOLU account in the KP, since it has decided to elect, in the framework of these voluntary AFOLU activities under Article 3.4 of the KP, the activities: "Grassland Management", "Cropland Management" and "Forest Management".

However, even using such additional measures as these, in 2006 PNAC still pointed to excess in emissions. A Portuguese Carbon Fund (PCF) was then created in order to fund and promote projects with innovative approaches to increase carbon sequestration through AFOLU activities.

Also of relevance, is the fact that historically, the most common type of pastures in Portugal are natural grasslands (NG) and fertilized natural grasslands (FNG). These are poor pastures, located in the regions with higher risk of desertification, with low productivity that support low stocking rates and require mechanical shrub control, with negative consequences regarding soil erosion. As an answer to these problems it is developed, around 1960, a new system of pastures – sown biodiverse permanent pastures rich in legumes (SBPPRL).

Within this context, Terraprima - Environmental Services, a spin-off enterprise from Instituto Superior Técnico, Technical University of Lisbon, submitted two projects related to grassland management to the Portuguese Carbon Fund that have been accepted. One regards the expansion of Sown Biodiverse Permanent Pastures rich in Legumes and the other the control of shrub encroachment at pastures through the use of non-invasive techniques. Both projects promote the increase in soil organic matter, and therefore, carbon sequestration. The sequestration of carbon is paid to farmers as an ecosystem services.

Sown biodiverse permanent pastures rich in legumes consist of diverse mixes of up to twenty different species or varieties of seeds, and are rich in legumes. Commonly SBPPRL are more productive than natural grasslands, and are also richer in number of species. There are fewer gaps in plant cover throughout the plots, since species variability ensures that the species more suited for each spatial condition will thrive. There are many studies on the role of biodiversity in productivity but SBPPRL remain the only widespread large-scale application of what may be called "biodiversity engineering".

The seed mix is designed specifically for each location after soil analysis. Species in the mix is adapted to soil physical and chemical characteristics, as well as to local climate conditions, and therefore there is no single representative mix. The higher plant productivity of SBPPRL implies increased atmospheric carbon capture through photosynthesis. Part of the biomass produced is stored in soils due to the high density of yearly-renewed roots.

If the pastures are well managed, as happens with the SBPPRL, there is no need for shrub control. However, that is not the case with the common natural pastures, fertilized or not. In these cases, there is the need to control, and the most used technique is the plow tillage. This technique causes enormous losses of soil organic carbon and N pools as greenhouse gases to the atmosphere (Blanco-Caqui and Lal, 2008). The plow tillage also decreases soil quality and increases the probability of erosion. Therefore, the change from tillage techniques to no tillage ones, presents as an important management change.

In this context, this work aims to quantify the carbon sequestration that takes place due to these management changes as well as its importance in the context of KP.

II – Method

For both projects, we are measuring the soil organic matter (SOM), but our ultimate goal is to estimate the carbon sequestration that takes place. The organic matter content is measured in percentage points, $g_{SOM}/100g_{soil}$. The average soil bulk density in Portuguese soils is 1.48 $g.cm^{-3}$, according to the Harmonized World Soil Database (HWSD; Fisher *et al*., 2008). A 1pp increase in SOM means that there is an increase of 0.0148 g $SOM.cm^{-3}$. Using the sampling depth, the SOM mass per unit may then be subsequently determined per unit area. In order to convert SOM to carbon, it is assumed that about 58% of SOM corresponds to soil organic carbon which is then converted to CO_2.

1. Sown biodiverse permanent pastures rich in legumes

As presented in Teixeira *et al*. (2011), and regarding the SBPPRL, data was obtained from rainfed pastures in eight farms in Portugal from 2001 to 2005. Plot areas ranged from 5 to 15 ha. Each plot's soil and landscape type was approximately homogeneous, in terms of soil and previous use. Samples were collected both from SBPPRL, NG and FNG.

The soil organic matter modelling considers a simple mass balance model, according to which the mass percent balance of SOM is the difference between input and mineralization. To determine the grassland system in which the increases in SOM was highest, the SOM increase was calculated in all systems starting from the same initial SOM (Teixeira *et al*., 2011).

The model is estimated using 78 observations and an Ordinary Least Squares approach.

2. Shrub encroachment

The soil samples were collected in 173 different plots each with 500 m^2, distributed by 24 farms and 10 municipalities of inland Portugal, and three soil types (derived from sandstone, schist and granite), for the year of 2011. We aimed to sample representative variability regarding climate, geology and cover. We collected samples in soils with tillage management and no-tillage.

Since, in this case, we do not have a time series, the analysis is done considering the year that the last tillage mobilization took place. We aim to understand if, for soils with current no tillage management the soil organic matter is significantly higher than for those subject to tillage control. We used an Ordinary Least Squares approach.

III – Results and discussion

1. Sown biodiverse permanent pastures rich in legumes

As shown in Fig.1, a 10 years model allows an increase in SOM of about 0.21 $pp.yr^{-1}$, equivalent to 1.78 t $C.ha^{-1}.yr^{-1}$ and to the sequestration of 6.5 tons of CO_2 per hectare per year. This increase is higher than for FNG and NG, 0.08 pp.yr-1, equivalent to 0.71 t $C.ha^{-1}.yr^{-1}$ (Teixeira *et al*., 2011).

Concerning the pastures sown in 2009 and 2010, there was a total of about 25,000 ha, 289 landowners and an additional 4 years carbon sequestration of about 475,000 t CO_2. The pastures sown in 2011 / 2012 are expected to sum up 30,000 ha, 500 landowners and an additional 4 years carbon sequestration of about 740,000 t CO_2.

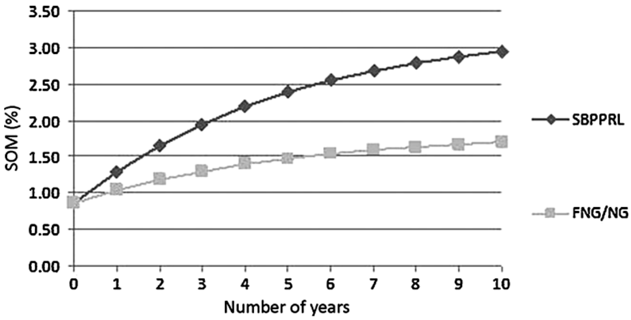

Fig. 1. 10 years model of SOM accumulation in SBPPRL, compared to FNG and NG.

2. Shrub encroachment

The results clearly indicate the presence of a higher content of organic matter in the samples associated with the no-tillage control. On average, for these samples, the organic matter is 1.1% higher. This implies a carbon sequestration of about 8.4 t $CO_2.ha^{-1}.yr^{-1}$. If the analysis is done by soil type, the carbon sequestration is about 11.2 t $CO_2.ha^{-1}.yr^{-1}$, for schist and 5.9 t $CO_2.ha^{-1}.yr^{-1}$, for sandstones. Due to the lack of representative data, it was not possible to calculate a factor for the soils derivative from granite.

In terms of field implementation, the aim is to extend this change of practices to 100,000 ha, contributing with 0.72 Mton CO_2.

IV – Conclusions

Both management changes allow an important carbon sequestration, which is accounted for in the KP and it is contributing to its fulfilment.

The sown biodiverse permanent pastures rich in legumes are currently highly implemented in Portugal, contributing, not only with carbon sequestration but also with a higher productivity and improvement of soil quality.

The change in control technique associated with shrub encroachment at pastures allows a soil carbon sequestration, associated with an increase in soil organic matter, and therefore, soil quality. This project is being currently implemented.

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Production and persistence of Mediterranean perennial grasses under contrasting climatic scenarios

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Abstract. In the current context of increasing droughts due to climate change, this study analyzed the effects of a range of severe summer water deficits (-329 to -710 mm) and summer high temperatures (+3 and +6°C than ambient temperatures for 2-3 weeks) on the persistence and production of perennial forage grasses. We compared a Mediterranean cultivar (cv) of cocksfoot (*Dactylis glomerata* L., cv Medly) and of tall fescue (*Festuca arundinacea* Schreb, cv. Centurion), in both a Mediterranean and a temperate site in France. The results show that (1) the annual production was variable but reduced on average by 40% along the range of tested water deficits; (2) the thresholds of significant increased mortality occurred at around 560 mm of water deficit; (3) deeper water uptake can be associated with the greater persistence of tall fescue at high water deficit and (4) an after-effect of summer water deficits resulted in an increase of frost sensitivity especially for cocksfoot. To cope with climate change, breeding programs for Mediterranean cultivars should aim to improve both frost tolerance and drought survival through increased summer dormancy.

Keywords. Climate change – Summer drought – Grassland – Stress survival – Plant mortality.

Production et pérennité de graminées pérennes sous sécheresses et hautes températures estivales

Résumé. *Sécheresse et évènements climatiques extrêmes risquent de survenir plus fréquemment sous l'influence du changement climatique. Nous avons testé une gamme de déficits hydriques estivaux (-329 à -710 mm) et des températures estivales élevées (+3°C and +6°C que la température ambiante pour 2-3 semaines) sur la persistence et la production de graminées fourragères pérennes. Un cultivar méditerranéen de dactyle* (Dactylis glomerata *L., cv Medly) et de fétuque élevée* (Festuca arundinacea *Schreb. cv Centurion) ont été comparés dans un site méditerranéen et un site tempéré en France. Les résultats montrent que (1) sur la gamme de traitements testés, la production annuelle a été variable mais réduite en moyenne de 40%, (2) les seuils de déficits hydriques cumulés associés à une augmentation significative de mortalité sont définis autour de -560 mm; (3) Des prélèvements en eau plus profonds peuvent être associés à la meilleure persistence de la fétuque et ; (4) la sensibilité au gel hivernal, surtout du dactyle, augmente quand les plantes ont été soumises à de forts déficits hydriques l'année précédente. Pour faire face au changement climatique, les programmes de sélection végétale de cultivars méditerranéens doivent améliorer la tolérance au gel et la survie à la sécheresse estivale par une dormance estivale supérieure.*

Mots-clés. *Changement climatique – Sécheresse estivale – Prairies – Survie au stress – Mortalité.*

I – Introduction

Although increasing droughts and extreme events are predicted to occur more often under climate change (I.P.C.C., 2007), their effects are currently poorly described by crop and pasture models (Tubiello *et al*., 2007). A decrease in summer precipitation in southern Europe, accompanied by increased temperatures would inevitably lead to more frequent and more intense droughts (Lehner *et al*., 2006) resulting in widespread mortality events. To cope with the negative effects of climate change, short-term adaptations may include changes of species or cultivars (Olesen *et al*., 2007). As summer aridity will increase, the interest of genotypes and cultivars originating from the Mediterranean basin, may extend to larger areas. We tested the responses of the two major perennial grass species adapted to drought, i.e. cocksfoot *Dactylis glomerata* L. and tall fescue *Festuca arundinacea* Schreb. at both Mediterranean and temperate sites in France. By manipulating temperatures and water availability to grass sward in the field, we aimed to define for each of the tested Mediterranean cultivars, the climatic thresholds associated with critical plant mortality and reduced resilience of these perennial forage crops.

II – Material and methods

We compared mono-cultures of perennial cultivars (cvs) of forage grasses of cocksfoot (cv. Medly) and tall fescue (cv. Centurion), in both a Mediterranean (Montpellier) and a temperate site (Lusignan) with average May-September water deficits of 289 mm and 424 mm respectively.

The temperate (46°4N, 0°1E) site (Temp-site) and the Mediterranean (43°6N, 3°8E) site (Med-site) had both a cambisoil with a depth of 1m and a comparable soil water reserve.

Over 2 years, 14 treatments combining controlled water supply and night temperature (T = +1°C and C = control low) under 6m^2 rainout shelters (throughout both years) + infra-red heating (+3°C or +6°C relatively to the temperatures of the unheated treatments) for three weeks in summer, induced a range of cumulative water deficits (Table 1). They were computed for the periods during which soil water was depleted (May to September). The main effects of heat stress were ascribed to increased soil water deficit (Poirier *et al*., 2012). Soil moisture was measured regularly with a neutron probe in all un-heated treatments in summer. Each treatment was replicated four times.

Table 1. Cumulative Precipitation-Evapotranspiration (P-ETP) from May to September for the 14 climatic treatments over two sites in France

	Temperate site (8 climatic treatments)								Mediterranean site (6 climatic treatments)					
Year	**2009**				**2009**				**2009**				**2010**	
Treat.	T	T + 3°C	C	C + 6°C	T	T + 3°C	C	C + 6°C	T	T + 3°C	C	C + 6°C	T	C
|P-ETP|	329	412	445	488	433	485	536	553	436	484	545	584	624	707

Above-ground biomass was cut when required and oven dried to assess dry biomass. The density of living plants was assessed visually after each cut and after autumn rehydration by assigning a score (0-100%) to the percentage cover by plants in each sward. Autumn survival rates after summer treatments were calculated as the ratio between the density rate of living tillers in the autumn versus the density rate of living tillers in the previous spring. Similarly, survival rates after winter frost were calculated as the ratio between the density rate of living tillers in the spring versus the density rate of living tillers in the previous autumn.

For analysis of variance, climatic treatments and cultivars were considered as fixed effects, whereas replications were considered to be random effects.

III – Results

1. Water use

The minimum soil water content at the end of the summer reached 220 mm on average for both species in Med-site whatever the treatments. Conversely, it reached significantly lower levels for tall fescue (230 mm) than for cocksfoot (249 mm) across all un-heated treatments in Temp-site.

2. Aboveground biomass production

Between 329 mm and 707 mm summer climatic deficit, the annual biomass production was reduced on average by 40% for tall fescue "Centurion". The production of cocksfoot "Medly" was as variable but less affected by the greatest summer climatic deficits (Fig. 1a).

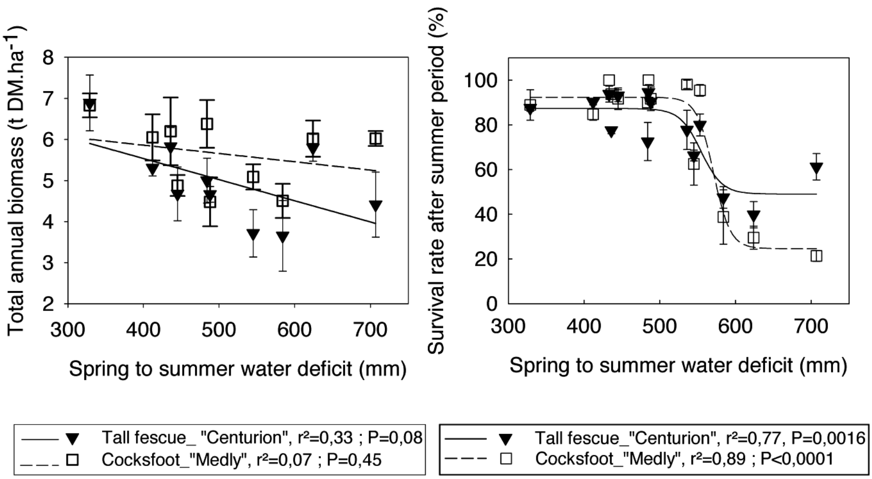

Fig. 1. (a) Total annual biomass (t DM ha^{-1}) and (b) Summer survival rates (%) of tall fescue "Centurion" and cocksfoot "Medly", under a range of water deficit from April to September (mm).

Summer survival rates were greater than 80% for both species when the maximum climatic water deficit was lower than -550 mm (Fig. 1b). 50% plant survival occurred at a water deficit of -554 mm for tall fescue "Centurion" and -571 mm for cocksfoot "Medly". At higher deficits, plant survival rates declined drastically especially for cocksfoot "Medly" that reached 20% survival at -700 mm deficit. Tall fescue "Centurion" displayed a lower plant mortality (50%) at high aridity when it could maintain higher hydration in surviving organs (not shown). Following the autumn recovery, both cultivars displayed active tillering in the subsequent seasons and the spring density rates was greater than 60% in all treatments.

3. Frost survival

In the 2009 winter, the number of degrees-days lower than -0.5°C was twice as many at Temp-site (-1882°C) than at Med-site (-914°C). Frost damage induced tiller mortality and was greater when plants (especially "Medly") had been subjected to high water deficits in the previous year. Spring survival following winter frost was decreased by 25% for fescue "Centurion" and up to 40% for cocksfoot "Medly" in Temp-Site (Fig. 2). At Med-Site, the trends of these effects were similar but less marked and spring tiller survival was unaffected (not shown).

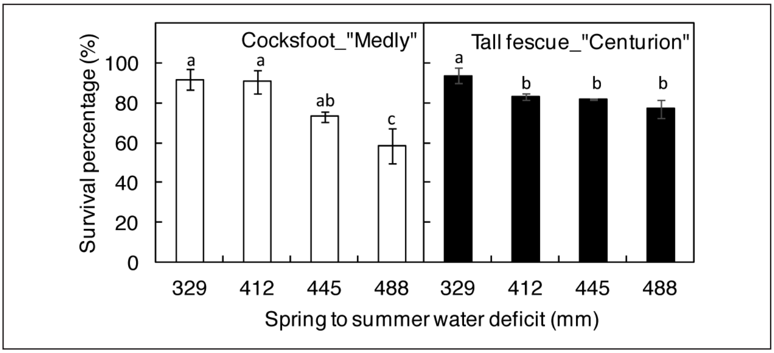

Fig. 2. Plant survival to frost (%) in cocksfoot "Medly" and tall fescue "Centurion" under a range of water deficit from April to September (mm) in the previous year. Significant differences between treatments are indicated by distinct letters a, b, c.

IV – Discussion and conclusions

We analysed the effects of a broad range of climatic treatments and extreme events that even exceed the worst cases projected by IPCC. The adaptation of tall fescue and cocksfoot cultivars had also previously been modelled appropriately as a function of spring-summer drought stress intensities at different sites across the Mediterranean basin (Annicchiarico *et al*., 2011; Pecetti *et al*., 2011). Our results show that a spring to summer- water deficit greater than -560 mm is a critical threshold for the persistence of the most Mediterranean cultivars of cocksfoot and tall fescue. Deeper water uptake and incomplete summer dormancy can be associated with the greater drought survival of tall fescue at -700 mm water deficit. The limited winter hardiness of this material questions the substantial northward expansion of their thermal suitability in Europe (Olesen *et al*., 2007), because the use of Mediterranean forage grass cultivars may well improve crop persistence under summer drought but increase the risk of frost susceptibility to the spells of extremes winter temperatures that can occur in temperate areas. To cope with climate change, breeding programs for Mediterranean cultivars should aim to improve both frost tolerance and drought survival through increased summer dormancy**.**

Acknowledgements

ANR Contract ANR-07-VULN-011- "VALIDATE" project.

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Influence of water deficit on growth parameters of perennial grass species

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Abstract. Water is one of the most important environmental factors controlling the production of perennial grass species under semi arid Mediterranean conditions. In this experiment, the influence of water deficit on the growth parameters of three perennial grasses (*Agropyron intermedium*, *Bromus inermis* and *Phalaris aquatica*) was investigated. For this reason the shoot weight, the leaf weight and the leaf area were measured every fifteen days during the growing season and the specific leaf area (SLA) was calculated. *P. aquatica* presented the highest leaf and shoot weight, leaf area and SLA while *A. intermedium* the lowest leaf and shoot weight, leaf area and SLA. *B. inermis* showed an intermediate behaviour. The results suggest a differential performance of the three species in terms of growth under water deficit conditions. *P. aquatica* showed higher tolerance under drought conditions followed by *B. inermis.*

Keywords. *Agropyron intermedium* L. – *Bromus inermis* L. – Drought – *Phalaris aquatica* L. – Specific leaf area.

L'influence du déficit de l'eau sur les paramètres de croissance des espèces graminées pérennes

Résumé. *L'eau est une des facteurs environnementaux les plus importantes pour contrôler la production des espèces vivaces d'herbe dans des conditions méditerranéennes semi arides. Dans cette expérience on a étudié l'influence du déficit de l'eau sur les paramètres de croissance de trois herbes vivaces (*Agropyron intermedium, Bromus inermis *et* Phalaris aquatica*). Pour cette raison, le poids de tige, le poids foliaire et la surface foliaire ont été mesurés tous les quinze jours pendant la période de végétation et la surface foliaire spécifique (SLA) a été calculée. Le* P. aquatica *a présenté le poids foliaire et le poids de pousse le plus élevé, la surface foliaire et le SLA tandis que l'*A. intermedium *a présenté le poids foliaire et le poids de tige le moins élevé, la surface foliaire et SLA. Le* B. inermis *a montré un comportement intermédiaire. Les résultats suggèrent que les trois espèces n'aient pas présenté la même représentation en termes de croissance dans des conditions de déficit de l'eau avec le* P. aquatica *montrant une tolérance plus élevée dans des conditions de sécheresse suivies de* B. inermis.

Mots-clés. Agropyron intermedium *L. –* Bromus inermis *L. – Sécheresse –* Phalaris aquatica *L. – Surface spécifique des feuilles.*

I – Introduction

Drought is the most important environmental stress and many efforts have been made to improve crop productivity under water-limiting conditions (Cattivelli *et al.*, 2008). It is predicted that climate of the Mediterranean region will change with prevalence of drier and hotter summers as resulting from global warming leading to significant yield losses (IPCC, 2007; Jacobsen *et al.*, 2012).

Differential ability of plant species to survive under drought conditions may be a major factor influencing plant-community composition. Thus, an appropriate study of the specific variations in drought resistance and the factors involved in its determination is of special interest in order to forecast future plant-community changes (Matías *et al.*, 2012). At the species level, changes in habitat characteristics within an ecosystem may alter growth traits such as plant size, specific leaf area (SLA) or biomass-allocation patterns, resulting ultimately in a shift in drought resistance (Lloret *et al*., 1999; Poorter *et al*., 2009). Published information suggest that annual species present higher values of SLA than the perennial ones (Garnier *et al*., 1997) while variations have been found in perennial species with different pattern of distribution (Li *et al.*, 2005). Moreover, in the Mediterranean region species belonging to the same growth form or even the same genus have been found to follow different mechanisms to cope with water deficit conditions (Corcuera *et al*., 2002; Karatassiou *et al*., 2009; Karatassiou and Noitsakis, 2010).

The aim of this work was to investigate the influence of water deficit on the growth parameters of three perennial grasses (*Agropyron intermedium*, *Bromus inermis* and *Phalaris aquatica*).

II – Materials and methods

The research was conducted in natural vegetation in the farm of the Aristotle University of Thessaloniki, Northern Greece (longitude: 40° 34‘, latitude: 23° 43‘), at an altitude of 10 m above sea-level. The climate of the area could be characterized as Mediterranean semiarid with cold winters. The mean annual precipitation is 400 mm and the mean annual temperature is 15.5°C. The monthly average precipitation (mm) and the minimum temperature (°C) during the experimental period ranged from approximately 17.02 to 55.64 mm and from 14.6 to 23.4°C respectively.

Measurements were taken in three perennial C_3 grass species: *Agropyron intermedium* (Host) Beauv, *Bromus inermis* Leyss and *Phalaris aquatica* L. These species are widespread in grasslands of the low zone of Northern Greece and their contribution to the grassland production is very important. All measurements were taken during the growing season at four different phenological stages: (i) early vegetative, (ii) vegetative, (iii) flowering, and (iv) inflorescence. Fifteen plants of each species were randomly selected along a line. Three lines and a total of 45 plant species have been considered for each species (Cornelissen *et al.*, 2003). In each phenological stage one tiller from each plant was collected; and the leaf area as well as the fresh weight of shoots and leaves were measured. Leaf area was measured using the portable leaf area measurement system Li-3000A (LiCor Lincoln, Nebraska, USA). Then to determine the dry weight the samples (leaves, stems) were placed in the oven for 48 hours at 70°C. Specific leaf area (SLA) was calculated as the ratio of leaf area to leaf dry weight.

General linear models procedures (SPSS 17 for Windows) was used for data analyses. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

During the growing season significant changes in growth and allometric parameters of the three grass species were detected. The shoot dry weight in all species (Fig. 1a) showed an increasing trend, while the leaf dry weight (Fig. 1b) a rather decreasing one over the season. In the early phenological stages, the higher dry weight of shoots and leaves was found in *P. aquatica* while in the stage of inflorescence in *B. inermis* but without significant differences between them. Throughout the growing season *A. intermedium* showed the lowest dry weight of shoots and leaves. *P. aquatica* presented the higher mean forage production and *A. intermedium* the lower under semi arid Mediterranean conditions.

As far as the LA is concerned, *P. aquatica* showed the highest average values LA (88.6 cm^2), followed by *B. inermis* (66.7 cm^2) and *A. intermedium* (22.5 cm^2). The SLA, an important trait to survive through a Mediterranan climate, is associated with relative growth rate and plant abilities to use light and soil resources (Grotkopp and Rejmánek, 2007). From the changes of SLA (Fig. 2) during the growing season it becomes apparent that *A. intermedium* and *B. inermis* presented

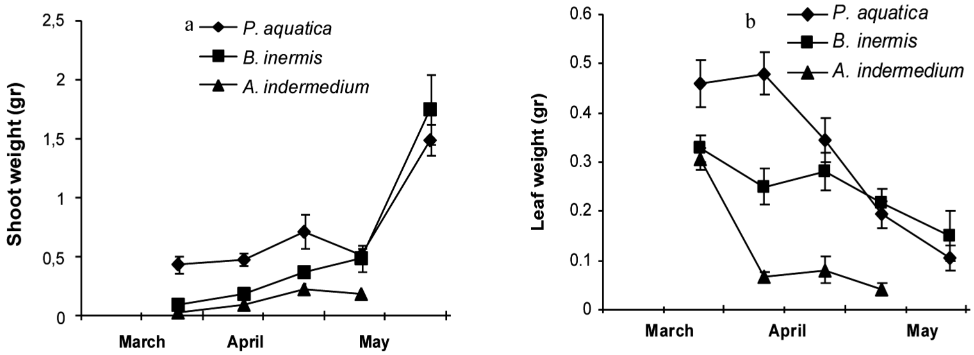

Fig. 1a,b. Seasonal changes of dry weight of a) shoots and b) leaves of three perennial grasses.

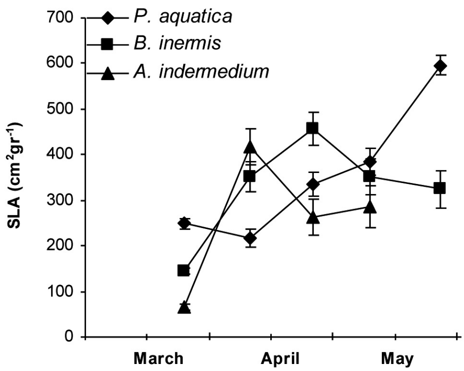

Fig. 2. Seasonal changes of specific leaf area (SLA) of three perennial grasses.

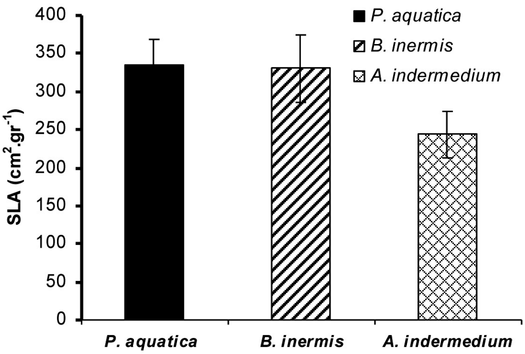

Fig. 3. Mean specific leaf area (SLA) of three perennial grasses during the growing season.

similar behaviour since they both showed an increased trend in SLA until the first days of April followed by a significant decrease from that point towards the inflorescence stage. On the other hand, SLA in *P. aquatica* followed a completely different pattern with a stabilizing trend until the first days of April that abruptly increased until the stage of inflorescence. In the inflorescence stage, when the water deficit was higher, *P. aquatica* presented the higher SLA and consequently the higher production. The increased trend in SLA and the decreasing pattern of the leaf weight of *P. aquatica* in May indicates that this species in the mature vegetative stage developed large but thin leaves to capture the available light more efficiently and continued to grow (Gurevich *et al.*, 2006). *P. aquatica* has the capacity to maintain an optimum water balance under drought conditions (Karatassiou *et al.,* 2010) exhibiting also higher productivity (Li *et al.,* 2005). Moreover, no significant differences in the values of mean SLA between *P. aquatica* and *B. inermis* were found, while *A. intermedium* showed the lowest values (Fig. 3). The three perennial grasses showed differences in their SLA and consequently in their relative growth rate and survival under semi arid Mediterranean conditions(Grotkopp and Rejmánek, 2007). It seems that *P. aquatica* and to a lesser extent, *B. inermis* showed a higher SLA because of their capacity to maintain optimum water balance under drought conditions, allowing the function of stomatal apparatus (Karatassiou *et al.*, 2010). Therefore, in the Mediterranean region *P. aquatica* could be considered as a more tolerant and productive species followed by *B. inermis.*

IV – Conclusions

Plant species with the same life form did not follow the same growth and biomass allocation patterns under drought conditions. *P. aquatica* and *B. inermis* showed higher specific leaf area index and therefore greater adaptation to drought than *A. intermedium*. These species are desirable in the vegetation of Mediterranean grasslands in order to provide high amounts of food production for small ruminants.

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Preliminary results on climate change evidence from coprolites of *Myotragus balearicus* Bate 1909 (Artiodactyla, Caprinae)

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Abstract. Plants may vary their stomata density as a function of environmental factors, such as [CO_2], drought and temperature. Under the present atmospheric conditions, it is expected that leaves have different stomata density than they had hundreds or thousands of years ago, due to the rise of CO_2 in the atmosphere. Microhistological analyses of coprolites of the extinct *Myotragus balearicus* from Cova Estreta (Pollença, Mallorca), with a radiocarbon age of 4950 ± 38 BP (3775-3640 2σ cal BC; Wk-33010), have shown a diet including an important amount of *Buxus balearica* epidermal fragments. Three of these coprolites were used to estimate the stomata density on *Buxus balearica* epidermal fragments from this period. Additionally, three samples of the endangered *Buxus balearica*, the sole species *of Buxus* currently present on Mallorca, were collected in three different localities and leaves were examined under microscopy to determine the stomata density. A significant difference between epidermal fragments from coprolites and epidermal fragments of living plants (c^2 = 34.46, P<0.0001, L-R c^2 test), with a density average of 27.21 and 19.05 stomata/mm^2 respectively, has been recorded. The current lower density of stomata could be a plant response to climatic change in the Mediterranean islands.

Keywords. Stomata – *Buxus balearicus* – Climate change – Carbon dioxide.

Résultats préliminaires sur l'évidence du changement climatique basée sur les coprolithes de Myotragus balearicus Bate (1909)

Résumé. *Les plantes peuvent varier la densité des stomates sur la base de facteurs environnementaux, tels que le CO_2, la sécheresse et de la température. Dans les conditions météorologiques actuelles sont censés avoir une densité stomatique des feuilles différente de ce qu'ils avaient pendant des centaines ou des milliers d'années auparavant, en raison de l'augmentation du CO_2 dans l'atmosphère. L'analyse des coprolithes de la disparition microhistologique de Myotragus balearicus de Cova Estreta de (Pollença, Mallorca), avec un âge radiocarbone de 4950 ± 38 BP (3775-3640 cal BC 2σ; WK-33010) ont montré une alimentation qui comprend une quantité importante fragments épidermiques de Buxus Balearica. Trois de ces coprolithes ont été utilisées pour estimer la densité des stomates dans les fragments épidermiques de Buxus balearica cette période. En outre, trois échantillons en danger d'extinction balearica Buxus, la seule espèce de Buxus opérant actuellement à Majorque, ont été recueillies à trois endroits différents et les feuilles ont été examinés au microscope afin de déterminer la densité des stomates. Il y avait une différence significative entre les fragments épidermiques de coprolithes et de fragments de l'épiderme des plantes vivantes (c^2 = 34,46, P <0,0001, test LR c^2), avec une densité moyenne de 27,21 et 19,05 stomata/mm^2, respectivement. La plus faible densité des stomates pourrait être une réponse des plantes aux changements climatiques dans les îles de la Méditerranée.*

Mots-clés. *Stomates* – Buxus balearicus – *Changement climatique – Dioxyde de carbone.*

I – Introduction

Certain plant traits, such as leaf morphology, are sensitive to climate change effects. Some works, based on exposing plant species to varying CO_2 concentrations in controlled environment experiments, demonstrated that anincrease in atmospheric CO_2 concentration causes a reduction in stomatal density (Woodward, 1987; Woodward and Kelly, 1995). In some species, stomata density also decreased in response to drought (Giordano *et al*., 2011), although this factor has a species' dependent effect (e.g. Mehri *et al*., 2009; Guerfel *et al*., 2009). Comparative studies on stomatal density, based on herbarium material, have been used to estimate the effects of a rise in atmospheric CO_2 over the past centuries (Woodward, 1987; Peñuelas and Paoletti and Gellini, 1993). Stomatal density has also been considered as an indicator of atmospheric CO_2 concentration in studies based on plant fossil material (e.g. Beerling and Chaloner, 1992; Beerling, 1993; McElwain and Chaloner, 1995).

Herbivore coprolites are potential sources of ancient plant remains as they may contain fragments of leaf epidermis from which stomatal density can be determined. Moreover, the microscopic diagnostic features of these fragments allow for the identification of plant species. As plant species recorded on recent geological periods –such as the Holocene– can be also found in the present, comparisons of their current and fossil stomatal density are feasible. These comparisons could provide evidence of atmospheric CO_2 concentration changes.

Myotragus balearicus Bate 1909 was a ruminant artiodactyl endemic to the Eastern Balearic Islands, which became extinct more than 4000 years ago (Alcover *et al*., 1999). *Myotragus* coprolites were collected from Holocene sediments in the deposit of Cova Estreta (Pollença, Serra de Tramuntana, Mallorca). Coprolite content has shown a diet with a high amount of *Buxus balearica* Lam (Alcover *et al*., 1999; Bartolomé *et al*., 2011), which is an extant species in that area nowadays.

Palynological studies on the Balearic Islands document that prior to 2880 cal BC the vegetation was very different to the of recent times (e.g., Yll *et al*., 1997). Now, the vegetation is dominated by shrub formations characteristic of xeric conditions (Yll *et al*., 1995), while prior to 2880 cal BC, it was apparently dominated by wet forests. Epidermal fragments of *Buxus balearica* contained in *Myotragus balearicus* coprolites allow us to present a paleontological proxy to relative CO_2 concentration in the atmosphere of the island c. 5700 years ago. The comparison of stomatal density of *Buxus balearica* found in the coprolites with epidermal tissues of living plants could be interpreted as possible evidence of climate change in the Mediterranean islands.

II – Materials and methods

Myotragus balearicus coprolites were collected from upper levels of the sedimentary deposits in Cova Estreta (Pollença, Mallorca) during the excavation campaigns in the nineties (Alcover *et al*., 1999). The cave is located in the Tramuntana mountains, in the North of the island, at c.350 m above sea level.

One of the coprolites was dated by the Radiocarbon Dating Laboratory of the University of Waikato (New Zealand) giving a radiocarbon age of 4950 ± 38 BP (3775-3640 2σ cal BC; Wk-33010).

Three leaves of the extant *Buxus balearica* were collected from three different sites of the Tramuntana mountains: Pollença, Escorca and Bunyola.

Three coprolites, as well as leaves samples, were used in the microhistological preparations, following the technique of Stewart (1967). The procedure includes water washing of the material, grounding in a mortar, digestion in HNO_3, water dilution, filtering at 1.0 and 0.25 mm of pore diameter, and mounting glass microscope slides. The slides were examined under a microscope at x 400 magnification. A grid of 0.2 mm square was used to count the number of stomata per unit area.

Buxus balearica is an ideal taxon for this kind of analysis as the remains of its thick cuticle are prone to be well preserved in the coprolites. Its epidermis is composed of rounded-polygonal shape cells, with thick walls. There are no trichomes in the epidermis. The stomata are only present in the abaxial face. They are circular, bigger than other epidermal cells, with two refractile C shape guard cells. These features allow their identification in the preparations. In this work, we assume that *Buxus balearica* was the only species of *Buxus* genus that *Myotragus balearicus* consumed, although there is another *Buxus* species (*B. sempervirens* L) in the Mediterranean area, with the same epidermal traits, its presence in the island has been never documented.

Several models were adjusted in data analysis. Adjust levels were submitted to verisimilitude χ^2 test (Likelihood Ratio Chi-Square). Plant or coprolite effect was firstly checked, including the sample as the only factor. Then, a model was adjusted to check possible differences between sampling sites. Finally, the model was adjusted for the entire dataset with the origin of the sample (coprolite or plant) as the only factor. All analyzes were performed using the program JMP7.

III – Results and discussion

The effect of plant or coprolite origin was not significant in any case (P> 0.07 for all models LR χ^2 test), nor was the differences between sampling sites of *Buxus balearica* (χ^2 = 2.18, P = 0.34 LR χ^2 test).

The results showed a significant difference between stomatal density in epidermal fragments of *Myotragus balearicus* coprolites and epidermal fragments of extant plants (χ^2 = 34.46, p <0.0001, LR χ^2 test), with an average of 27.21 and 19.05 stomata/mm^2, respectively (Table 1).

Table 1. Stomatal density of different tissues of *Buxus balearica*

Origin	Stomatal density (stomata/mm^2)
Coprolites of *Myotragus*	27.21a
Sant Vicenç	17.91b
Escorca	21.09b
Bunyola	19.63b

Different letters indicate significant difference (p < 0,005).

The decrease in stomatal density since middle Holocene could be due to recent increasing of CO_2 in the atmosphere, as it is suggested by other studies conducted in experiments with controlled CO_2 concentrations (Woodward, 1987; Woodward and Bazzaz, 1987; Woodward and Kelly, 1995; Ramonell *et al*., 1997; Sánchez *et al*., 2010) or with herbarium material (Woodward, 1987; Peñuelas and Matamala 1990; Paoletti and Gellini, 1993). Consequences of this change in plant physiology seem to lead to more xeric adaptations. In this sense, studies such as Ramonell *et al*., (1997) affirmed that the positive effect on stomatal density allows that the plants should live in more dry climates. In addition, Cuni *et al*., (2010) suggested that the decrease of the density stomata restricts the quantity of water steam that the plants liberate to the atmosphere.

V – Conclusions

The stomatal density found in the epidermal fragments of *Buxus balearica* from middle Holocene coprolites of the extinct *Myotragus balearicus* is greater than that found in epidermal tissues of current *Buxus balearica.* The lower density of stomata in extant *Buxus* could be the result of a plant adaptation to the current increase in carbon dioxide in the atmosphere.

Acknowledgments

This study was made possible through funding obtained from the "Ministerio de Ciencia e Innovación para proyectos" CGL2010-22116 (sub-BOS) and CGL2010-17889 and CONACyT, Mexican Institute.

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Vulnerability to Climate Change of Turkana pastoralist of dry savanna

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Abstract. Pastoralism is a dynamic grassland management system which implies complex and multiple interactions among people, livestock, environment, as well as local and traditional knowledge and formal and informal institutions. In Turkana, a region located in Northern Kenya, most of the population's livelihood depends on extensive herding. Most of them are experiencing the adverse impacts of changes in climate, particularly recurrent droughts and occasional floods. This is threatening the socio-ecological balance they are part of. Some argue that pastoralists are among the most vulnerable to climate-related hazards. However, others maintain that they are well-equipped to tackle climate change, as they have proved throughout history. What is the case in Turkana? By means of a set of interviews to Turkana pastoralists and relevant stakeholders in the region we attempt at shedding light on this question. While it is obvious that pastoralists have been adapting and trying to remain flexible for centuries, and that this has allowed them to live in the dry land ecosystems of Eastern Africa; it is also evident that several socioeconomic trends are hindering their adaptive capacity.

Keywords. Pastoralism – Dry grassland – Adaptation strategies – Vulnerability.

Vulnérabilité des bergers au changement climatique à Turkana (Kenya)

Résumé. *L'élevage pastoral est un système dynamique de gestion des pâturages, qui implique l'existence des nombreuses et complexes interactions parmi les gens, le bétail, l'environnement, ainsi que les institutions et les savoirs locales et traditionnels. À Turkana, une région située au Nord du Kenya, la plupart des gens sont éleveurs qui pratiquent un élevage pastoral. Ils sont en train d'expérimenter les mauvais effets du changement climatique, particulièrement sécheresses récurrentes et de temps en temps inondations. Ceci est en train de menacer l'équilibre socioécologique duquel ils font partie. Quelques-uns soutiennent que les bergers sont parmi les plus vulnérables aux risques du changement climatique. Toutefois d'autres maintiennent qu'ils sont très bien équipés pour faire face au changement climatique, comme ils l'ont bien démontré à travers de l'histoire. ¿Qu'est-ce qui se passe à Turkana? Moyennant des interviews à des bergers et à des acteurs concernés de Turkana on a essayé de mieux comprendre cette question. Tandis que c'est évident que les bergers ont été adaptés et ont essayé de rester flexibles, et que ça leur a permis de vivre dans les écosystèmes sèches de l'Afrique de l'Est, il est aussi évidant qu'il y a plusieurs tendances socioéconomiques, qui sont en train d'entraver les bergers de mieux s'adapter.*

Mots-clés. *Élevage pastoral – Pâturages secs – Stratégies d'adaptation – Vulnérabilité.*

I – Introduction

The effects of climate change are being felt by the populations of pastoralists worldwide. Pastoralism is a dynamic system, which implies complex and multiple interactions among people, livestock, environment, as well as local and traditional knowledge and formal and informal institutions. In Turkana, a region located in Northern Kenya, most of the population's livelihood depends on extensive raising of zebus, camels, goats and sheep. Most of them are experiencing the adverse impacts of changes in climate, principally recurrent droughts and occasional floods. This is threatening the socio-ecological balance they are part of in tropical grasslands.

It is widely spread the opinion that sees rain-fed agriculture, and particularly pastoralism, as highly vulnerable to climate-related hazards (Cooper *et al*., 2008; Thornton *et al*., 2009). Thus, some argue that pastoralists are among the most vulnerable to climate-related hazards as, for instance, rangelands and water points dry up (Calvosa, 2009). Whereas others maintain that they are well-equipped to tackle climate change, as for centuries they have been developing strategies of adaptation to mutable environmental conditions and resource scarcity (Davies and Nori, 2008; WISP, 2007). What is the case in Turkana?

II – Materials and methods

Dry and pastoral lands occupy more than 80% of Kenya, and are home to approximately 4 million pastoralists, who comprise more than 10% of Kenya's population (Kirbride and Grahn, 2008). Turkana is a semiarid region located at Northwestern Kenya. It shelters a population of one million people, who identify themselves as Turkana and also speak the Turkana language. Pastoralism is their main source of livelihood. Despite the importance of zebu raising, the Turkana also raise goats, donkeys and camels. In recent years, development aid programs have attempted at introducing fishing and irrigation schemes among the Turkana Lake, with limited success (Watson and van Binsbergen, 2008).

By means of a set of interviews conducted toTurkana pastoralists and relevant stakeholders in the region, we attempt at shedding light on the adaptation capacity of Turkana pastoralists to changes in climate. Specifically, a total of 25 interviews was conducted, 11 to male pastoralists, 6 to female pastoralists, 6 to local association members, and finally 2 to regional civil servants - veterinarians. The following groups of items were tackled extensively in the interviews: (i) main type of changes in climate being experienced; (ii) impacts of these changes on: livestock, grazing resources, agricultural practices (where relevant), water availability, state of the surrounding ecosystems, existence of conflicts over scarce resources within and among communities, implication in gender issues, state of the traditional knowledge; (iii) existence of additional socio-economic drivers exacerbating climate change's impacts; and finally (iv) the adaptation strategies being implemented to face the upcoming changes in each domain.

III – Results and discussion

Recurrent droughts, occasional floods, and increasing calendar unpredictability are the climate events that Turkana pastoralist communities have been adapting to in the past few decades (Birch and Grahn, 2007; Galvin *et al*., 2004; McCabe, 1990; Oba, 1992). Pastoralism is highly dependent on the maintenance of a sophisticated and constantly evolving balance between pastures, water, livestock, peoples and their surroundings. The following groups of adaptations strategies (Table 1) have been identified as being implemented by Turkana pastoralists to preserve such equilibrium (for a more in-depth analysis see Rivera-Ferre and López-i-Gelats, 2012): (i) enhancing mobility, what entails moving herds to areas with better grazing and water conditions and securing access to critical resources during difficult times; (ii) boosting social collaboration and reciprocity, what implies adopting strategies such as food sharing, livestock loans, joint ventures, friendly collaboration, communal planning, communal ownership, splitting the herd among different members of the family, communal grazing, and labor exchange, what strengthens the sense of belonging to a commonality and increases the resilience of the community to future changes by fostering mutual support and exchange of knowledge and capacities; (iii) favoring diversification and multi-purpose strategies, as a precautionary strategy to diminish the risk of losses in front of potential unexpected changes; and (iv) preserving and promoting biodiversity, both wild and domesticated, including shifting towards other types of livestock more adapted to the approaching new socio-ecological conditions, such as browsers – camels, goats. The anticipatory and endogenous nature of these adaptation strategies, as well as their cost-effectiveness, indicate that much can be learned from Turkana pastoralist communities to adapt to climate change in dry lands.

Table 1. Adaptation strategies to climate variability implemented by pastoralist in Turkana

Autonomous	Planned	Autonomous/Planned
Enhancing mobility Boosting social collaboration and reciprocity Favouring diversification/multi-purpose strategy Promoting biodiversity	Empowering community Schemes of sedentarisation	Adoption of fodder crops/ pasture enclosures

Other adaptation measures that have been identified as being undertaken in Turkana pastoralist communities are those promoted by external institutions. These include (v) empowering the community members by offering them services and training, such as schooling, health care, and pastoralist field schools; and (vi) offering to these communities schemes of sedentarisation, food relief and improved market access, to try to improve their livelihoods. Other strategies can be either endogenous or promoted by external institutions, depending on the particular context, such as (vii) adoption of fodder crops and pasture enclosures, what in some occasions also implies livestock corralling, to guarantee more stable feeding conditions for the livestock.

It is obvious that pastoralists have been adapting and trying to remain flexible for centuries, and that this has allowed them to live in the dry land ecosystems of Eastern Africa. However, diverse socioeconomic trends are hindering their adaptive capacity to climate change by impeding the development and promotion of this type of livestock farming. These are: (i) demographic growth, (ii) neglect of pastoralist knowledge, customary practices, and institutions, in policy-making, and (iii) increasing integration of pastoralist societies within the market economy. These drivers are impelling gradual dismissal of local traditional knowledge, abandonment of communal planning and institutions, increase in social differentiation, and overexploitation of the limited resources of rangelands. Also rising tensions, both within the community and among communities, and growing levels of malnutrition, are being witnessed in Turkana with dramatic consequences. Thus, to guarantee the endurance of pastoralist communities in Turkana, it is needed to overcome this set of socio-economic drivers. In particular, interceding to reduce the hostility among neighboring pastoral communities, and adjusting the humanitarian aid towards more restocking and training to pastoralists instead of food relief, would entail significant improve in the medium term in the livelihood of Turkana pastoralist communities.

IV – Conclusions

Pastoralism is a sophisticated - e.g. communal planning and ownership of resources, nomadism, etc. - and productive - e.g. animal source food, draught power, fiber, social status, keeping savings, etc. - use of grassland resources. It guarantees the livelihood of millions of people worldwide, while contributing at the same time to sustainable environmental management. Thus, it should be borne in mind that most of these adaptation strategies are practices that pastoralist communities have been traditionally undertaking to guarantee their livelihoods in climate margins, such as drylands, mountains and cold regions (Rivera-Ferre and López-i-Gelats, 2012). It has been only recently acknowledged the importance of these practices as adaptation strategies to changes in climate.

Results suggest that Turkana pastoralist communities are well prepared to face climatic variability. The long experience of these communities in overcoming changes is clearly shown on the fact that the majority of endogenous adaptation strategies are also of an anticipatory nature. This must be carefully considered by policy makers. On the contrary, this is not so clear in the case of those adaptation strategies being promoted by donor agencies. These planned adaptation strategies should be cautiously implemented. It should be carefully assessed if they are really empowering the community. In so doing, it is necessary to take into consideration the social, cultural, economic and geographical contexts within which these strategies are put into practice, so as to assess what unintended consequences might arise, and include pastoralists in the policy-making process. Thus, while endogenous adaptations by pastoralist communities should not be romanticized, top-down interventions should always be critically assessed.

The knowledge, institutions and customary practices of pastoralist communities, highly adapted to the local conditions and developed throughout centuries of coevolution with changing environments, can be of a great value to adapt the whole livestock sector to the current situation of increased climate variability. However, to guarantee the endurance of pastoralism and its related benefits in Turkana, there is the commanding need to overcome a set of socio-economic drivers, which are hindering the development and promotion of pastoralism.

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Economic effects of the changing regime of autumn rains onto sheep breeding farms

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Abstract. The change in the autumn rain regime can create problems for sheep breeding based on pasture or non-irrigated grass. A reduction in the useful rain hampers the growth of grass production, preventing grazing, and requiring farms to tap into the stock of hay to feed animals in the autumn-winter season. Farms may have to rent more land to produce grass in the spring in order to expand their forage production with an increase of costs that will be difficult to endure in a declining milk prices scenario. This analysis assesses whether the changes in climate variability, which are already under way, alter the probability distribution of rainfall in autumn, reducing the days of rain for the growth of grass. The economic effects of this and other changes will be evaluated by means of a Discrete Stochastic Programming territorial model that allows to represent the choices of farms under uncertainty; in this work we present a preliminary simulation concerning the effect of autumnal rainfall on sheep breeding. The analysis shows the different situation of a farm type that grows the grass completely non-irrigated, another with a limited supply of water from wells and a third that can tap into the water supply of a Water User Association.

Keywords. Sheep breeding – Rain fed grassland – Sheep livestock management – Climate change.

Les effets économiques du changement du régime des pluies d'automne sur les fermes d'élevage ovin

Résumé. *Le changement dans le régime de pluies d'automne peut créer des problèmes pour l'élevage ovin basé sur des pâturages. Une réduction de la pluie utile peut entraver la croissance de l'herbe, ce qui empêche le pâturage, et obligeant des fermes de puiser dans le stock de foin pour nourrir les animaux pendant la saison automne-hiver. Les exploitations agricoles peuvent avoir besoin de louer plus de terres pour produire de l'herbe au printemps, afin d'accroître leur production de fourrage avec une augmentation des coûts qui seront difficiles à supporter dans un scénario de baisse des prix du lait. Cette analyse évalue si les changements dans la variabilité du climat, qui sont déjà en cours, de modifier la distribution de probabilité de pluie en automne, ce qui réduit les jours de pluie pour la croissance de l'herbe. Les effets économiques de ceci et d'autres changements seront évalués au moyen d'un modèle territoriale de programmation stochastique discret qui permet de représenter les choix des exploitations agricoles dans l'incertitude. Dans ce travail, nous présentons une simulation préliminaire concernant l'effet des précipitations automnales sur l'élevage des moutons. L'analyse montre que la situation est différente selon le type d'exploitation: celles qui exploitent des pâturages sans irrigation, celles ayant un approvisionnement limité en eau à partir de puits, et finalement les fermes ayant disponibilité d'eau d'irrigation à partir d'une association des usagers de l'eau.*

Mots-clés. *Élevage ovin – Pâturages non irrigués – Gestion du bétail – Changement climatique.*

I – Introduction

The change in the autumn rain regime can create problems for sheep breeding farms that are based on pasture or non-irrigated grass. A reduction in the useful rain hampers the grass production, preventing grazing, and requiring farms to tap into the stock of hay to feed animals in the autumn-winter season. This requires these farms to expand their production of forage, by renting more land to produce spring grass, or by irrigating this crop, or by recurring to the market of fodder.

This analysis first assesses whether the changes in climate variability, which are already under way, alter the probability distribution of rainfall in autumn, reducing the days of rain for the growth of grass. Second, evaluates the possible effects of this change on different sheep farm typologies. As a next step of the research, those typologies will get plugged into a territorial Discrete Stochastic Programming model in order to evaluate the reaction of the whole agricultural sector of the area.

II – Materials and methods

This study focused on the province of Oristano in Sardinia, a major area of sheep farming in Italy. Its data source was the FADN European database on farming accounting, consisting of annual observation of 77 farms over 3 years (2005-2007). Information on structural, economic and technical characteristics of the farms were provided by the database.

The observations were clustered with K-mean, obtaining 3 homogeneous groups and the centroid of each group was deputed as representative sheep breeding farm typology. The result of this clustering process was validated by checking if the defined typologies were consistent in terms of feed balance. For this purpose an estimation of the animal requirements and the feed availability was carried out. Hence, the demographic categories making up the flock have been identified on a monthly basis and overall needs of dry matter and metabolizable energy were rebuilt, after determining the unitary milk production for productive sheep (assuming the daily production of primiparous as 75% of multiparous). The nutritional needs were determined using the equations proposed by Cannas *et al*. (Cannas *et al*. 2004, Cannas *et al*. 2005).

Also the farm fodder crops have been rebuilt on a monthly basis, taking into account the intensity of the monthly growth (kg of DM/ha/month) of pastured species and production of farm stocks (hay), based on the values of unitary production.

The balance between the needs of the flock and forage availability were found consistent: this was considered as validating the farms represented by the averages of each of the three groups identified by the cluster analysis.

Climate change for Sardinia sheep breeders acts on the likelihood of having a sufficient autumn rain for the fodder to start its cycle efficiently. It has been shown fitting probability distribution for observed current and simulated future rain condition. The variable considered is the occurrence of a sequence of at least three rainy days that sum up to 35 mm of water rained. Climatic daily data are sourced by Agroscenari research project and produced by Italian JRC CNR-Ibimet.

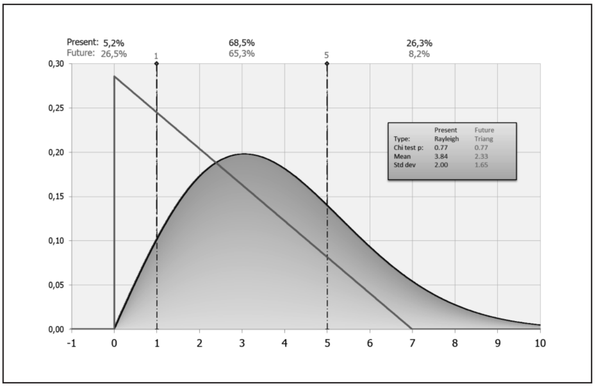

Fig. 1. Occurrence probability of 3-rainy-days sequences (∑>35 mm) over 15 October - 15 November.

III – Results and discussion

Major characteristics of the 3 farm types are presented in Table 1.

Table 1. Types of farms

Typology		OFFWUA_A	OFFWUA_B	ONWUA
Observations (no.)		38	26	9
Land (ha)	UAA	41	62	87
	UAA irrigated	0.0	1.3	5.1
Animals (heads)	Sheeps	148	355	464
	Sheeps/UAA forage	3.8	6.5	6.4
Labour (h)	Family labour	3,211	3,501	4,581
	Total labour	3,289	4,292	6,515
Capitals (€)	Total	373,439	670,888	1,386,997
	Equity	373,110	667,400	1,385,163
Milk Production	Milk (kg)	25,623	61,533	74,010
	Milk (kg) per sheep	170	170	150
	Price (€/kg)	0.628	0.621	0.606
Income statement	Gross Saleable (GDP)	34,488	82,351	110,485
	Milk GDP	16,082	38,229	44,834
	Public support	9,211	21,983	26,309
	Variable costs	9,489	26,237	41,645
	Feeds	4,269	8,934	13,120
	Gross income	25,000	56,114	68,840
	Fixed costs	8,908	13,635	25,203
	Net income	16,092	42,478	43,636
	Indirect Costs	26,149	31,506	42,248
	Comp. to the family labour	20,905	22,235	28,226
	Profit	-10,057	10,973	1,389
Indicators	Total labour per head	22.2	12.1	14.0
	Return On Equity (ROE)	-2.1%	2.1%	-0.1%

A simulation was carried out increasing the likelihood that pastures and grasslands do not produce grass for grazing in autumn, and that this failure occurs at least once every 4 years. This leads to the advanced exhaustion of stocks of hay and the need to meet the needs of the flocks in some other way. Among the various possibilities of some farms is the use of irrigation, with higher costs from the payment of certain reservations to the consortium or lifting water from wells. This solution is impractical on many farms that do not have wells or located in areas not served by community facilities for irrigation (represented by **OFFWUA_A**). Still, this solution is very expensive for farms with wells (**OFFWUA_B**). Finally, it is very expensive even for irrigation supplied by community facilities because it requires the provision of water outside the irrigation season, with high tariffs (**ONWUA**).

Then there is the possibility of renting of agricultural land to be allocated to the production of grass spring to increase the stocks available. This solution is expensive because it requires that farms take each year leased land, as a precaution about the year of crisis. Furthermore, the increased demand for land is concentrated in the territory concerned and greatly increases the cost of rent.

Finally, there is the possibility of purchase on the hay market, drawing it in the last months before the new spring production company. This possibility would lead to increased purchases of hay between different types, ranging from 25% to 75%. At current prices the budgetary impact on the farms is very limited. There would be a rather remarkable effect in the event of a price increase, and this is likely to occur because the new climatic conditions would affect simultaneously all sheep farms in Sardinia, simultaneously increasing market demand for these forages. The model used does not allow to simulate the effects on the price of the variation of this application. However, an analysis of the market and prices of these forages has shown that in the last 20 years there have been differences of 50% between the observed maximum price and the average price. If one of the most productive areas of the country simultaneously enter on feed markets, as a result of climate change, the price could plausibly increase even higher. However it was considered interesting to carry out a simulation with a price 50% higher. Under these conditions the model generated reductions in net income of 4.2%, 3.1% and 2.3%, respectively for **OFFWUA_A**, **OFFWUA_B, ONWUA** farms.

IV – Conclusions

The sheep farms are potentially exposed to multiple critical events due to the CC. They may be in trouble in the spring haying operations, due to a different distribution of rainfall at that time hindering their access into the field. There are problems of milk production in summer because of higher temperatures resulting in a stress to the sheep, and even less availability of pasture. Here was considered only one possible critical aspects of sheep farms management related to climate change: the possibility that every four years, the autumn-winter pastures are not available because the rain in October-November period was not sufficient. The effect of this phenomenon on farm income becomes relevant only if it affects large areas, pushing their farms to resort simultaneously to fodder markets. It is also differentiated by type of farm, and it is found that smaller farms without any irrigation water supply suffer a greater percentage reduction of their income.

Acknowledgments

The analysis presented in this work has been developed with financial resources of the research projects AGROSCENARI, funded by the Italian Ministry of Agricultural, Food and Forestry Policies (MiPAAF).

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Dehydration tolerance and drought survival of summer dormant Moroccan ecotypes of cocksfoot (*Dactylis glomerata* L.)

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Abstract. Summer dormancy in perennial grasses is a major trait conferring plant survival and persistence in Mediterranean areas. The aim of the present study was to characterize the effect of summer dormancy on dehydration tolerance in six Moroccan ecotypes and two cultivars "Kasbah" and "Porto" of *Dactylis glomerata* in a glasshouse experiment. Measurements included the ratio of green/senescent aerial tissues, soil water evolution, water content in survival organs and plant survival rate. D8 and D9 ecotypes showed high senescence when soil moisture was 5%, while Kasbah (dormant cultivar) was at 52% of areal senescence. Proportion of senescent tissue reached 98% for all ecotypes at soil humidity of 1.9%. Under severe drought, water content of apices decreased to reach 0.31 g H_20 g^{-1} dry weight, which was a lethal value for four tested ecotypes and cv. Porto. Except for Kasbah, D1 and D6, which remained alive with little hydrated apices. The soil moisture associated with 50% of plant mortality was 2.5% for Porto and D8 but decreased to 1.9% for D14. Kasbah, D1 and D6 could survive until 1% soil moisture. These results are ascribed to efficient strategies of both dehydration avoidance and tolerance in the best surviving genotypes.

Keywords. Cocksfoot – Drought tolerance – Dehydration – Summer dormancy.

Tolérance à la déshydratation et survie à la sécheresse d'écotypes marocains de dactyle* (Dactylis glomerata *L.) à dormance estivale

Résumé. *La dormance estivale chez les graminées pérennes est un trait majeur conférant la survie et la persistance dans les régions méditerranéennes. Le but de ce travail est de caractériser la dormance et la tolérance à la déshydratation de six écotypes marocains et de deux cultivars de* Dactylis glomerata *en conditions contrôlées. La progression de la sénescence foliaire, de la teneur en du sol, l'hydratation des organes de survie et le taux de survie des plantes ont été mesurés. La sénescence a atteint 98 % pour l'ensemble des écotypes à l'humidité de sol de 1,9 %. Sous sécheresse extrême, le contenu d'eau des apex a diminué drastiquement jusqu'à 0,31 g* H_20 g^{-1} *MS considérée comme létale pour quatre écotypes et Porto, à l'exception de Kasbah, D1 et D6, qui ont maintenu une survie avec des apex faiblement hydratés. L'humidité de sol associée à 50 % de mortalité est 2,5 % pour Porto et D8, mais seulement de 1,9 % pour D14 alors que Kasbah, D1 et D6 ont survécu jusqu'1% d'humidité du sol. Ces résultats sont attribués à une efficace combinaison d'évitement et de tolérance à la déshydratation chez les écotypes les plus résistants.*

Mots-clés. *Dactyle – Tolérance à la sécheresse – Déshydratation – Dormance estivale.*

I – Introduction

For forage plants growing in areas subject to prolonged and severe summer drought, the most important agronomic character is not the ability to produce during drought but the ability to survive, recover in autumn and grow actively during the rainy seasons (Volaire *et al*., 1998b). Different adaptations have evolved among the grasses of the Mediterranean region ensuring their survival during the arid summer. One important trait associated with remarkable persistence in perennials under arid conditions is summer dormancy, which causes a reduction in the surface area of the plant thus conserving moisture but at the same time retains sufficient living tissue for regrowth in the autumn (McWilliam, 1968). Morocco being a major center for diversity of perennials has provided a wide range of genetic variation within these species. Moroccan ecotypes of cocksfoot showed 97% drought survival, whereas ecotypes of European origin exhibited only 59% survival (Knight, 1966). While summer dormancy is common in herbaceous plants growing in semi-arid conditions, it has been shown that some of these plants are very dehydration tolerant even when not dormant (Volaire *et al*., 2001; Volaire, 2002). This study aimed to rank the Moroccan populations of cocksfoot previously characterized for summer dormancy according to their dehydration tolerance and drought survival.

II – Materials and methods

Six cocksfoot ecotypes (D1, D6, D8, D9, D10 and D14) collected in different regions of Morocco and evaluated previously for their summer dormancy (Shaimi *and al,* 2009) and two cultivars (cvs) cv Kasbah and cv Porto were tested. Cv “Kasbah” was selected in Australia from Moroccan germplasm collected in an area with 270 mm average annual rainfall. It is very summer dormant and drought resistant. The productive cultivar “Porto” was bred from Portuguese material originating from oceanic climate (Oram, 1990).

The experiment was undertaken in a glasshouse at INRA (Rabat, Morocco) in autumn, winter, spring and summer 2007, using 21-cm PVC pots containing the same quantity of substrate 70% of sand, 10% of clay and 20% of peat. Seeds of cvs “Porto” and “Kasbah” and the 6 ecotypes were sown in separate pots on 19 November (25 plants per pot). Pots of each genotype were fully irrigated and were defoliated when necessary until first of June, when the soil moisture was adjusted to 31 % and irrigation stopped. One or two pots of each genotype were successively re-watered after 7, 12, 15, 18, 21, 25, 28 and 33 days of drought and soil moisture was measured regularly by gravimetry. Two pots of each genotype were irrigated throughout the period as controls. All pots were fully randomized. For 3 weeks following each rehydration, the number of plants that regrew from the surviving plants was counted. The data were analysed using the appropriate analysis of variance and regression models in the SAS (SAS, Inc., Cary, North Carolina, USA).

III – Results and discussion

Biomass production: During spring, dry matter production differed significantly (P<0.0001) between genotypes (Fig 1). Porto exhibited the highest production; followed by D6 and D9 ecotypes. Kasbah yielded 48% less than Porto, and accumulated as much biomass as D10, D8 and D14 ecotypes, while D1 was the least productive. In the summer, biomass production of irrigated plants decreased by 43% on average (Fig. 1) with significant differences between genotypes (P<0.0001). Porto maintained the highest production and D1 had the lowest. Kasbah and D9 had the same production slightly higher than D6 and D8 (Fig. 1). After 21 days of drought, recovery yields amounted on average to 77% of those of irrigated plants. But, only Kasbah, D6 and D1 ecotypes could produce aerial biomass after a severe drought of 33 days.

Senescence: The fraction of senescent tissues varied significantly according to drought duration (P = 0·0001). Senescence reached 96% after 25 days of drought for D8, D9, D10 and D14. But since the 28th day of drought all genotypes reached full aerial senescence. D8 and D9 were faster to reach senescence. Senescence was correlated to aerial biomass produced in summer following each drought rehydratation (r = 0.226).

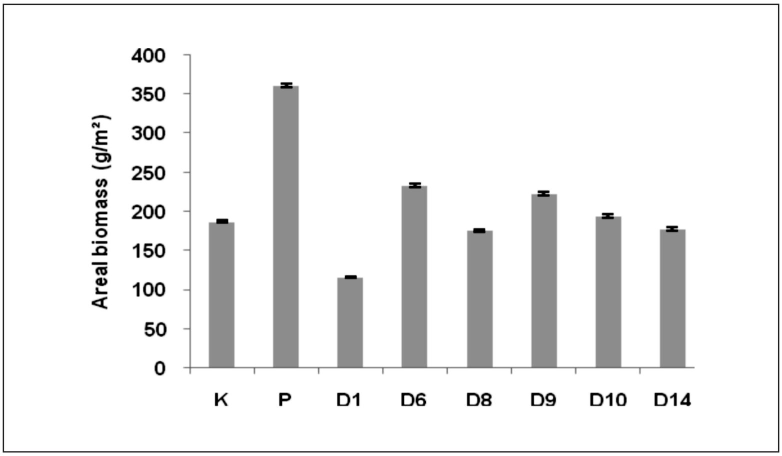

Fig. 1. Spring production of aerial dry matter (g/m²) of 6 Moroccan ecotypes and 2 cultivars Kasbah (K) and Porto (P) of *Dactylis glomerata*.

Water content of leaf bases: The water content in apices differed significantly according to drought progression (P = 0.0001), and ranged from 4.75 to 0.33 g H_20 g^{-1} d. wt. Dehydration of leaf bases progressed more quickly in ecotypes D1 and D14. Responses of the ecotypes D9 and D14 were intermediate. However, mortality was substantial in all genotypes except Kasbah and D1, especially when the last surviving leaf bases had a water content below 0.38 g H_20 g^{-1} d. wt. The water content of last surviving leaf bases were 0.48, 0.45 and 0.54 g H_20g^{-1} d wt of Kasbah, D1 and D6 ecotypes after 33 days of drought.

Plant survival: All genotypes displayed 100% survival when drought duration did not exceed fifteen days (Fig. 2). Plant mortality started after 18 days of drought and genotypes differed markedly since then. Porto had lost 40% of plants when all others genotypes survived at more than 86%. Plants of ecotypes D9, D8 and Porto died at relatively higher soil moisture than those of Kasbah, the other ecotypes being intermediate. The soil moisture associated with 50% mortality was 2.5% for D8 and Porto and 1.9% for D14 ecotype. High levels of survival was reached by Kasbah and D1 at 1.8%, soil moisture.

Dehydration tolerance: As soil water content decreased in pots, aerial tissues of D8 and D9 were faster to senesce, followed by Kasbah, D10, D6 and D14. In addition, Kasbah, D8, D9 and D10 reached almost full aerial senescence and had more hydrated tissue at soil water content of 2.5%· The dehydration of leaf bases progressed more quickly in Porto and D8, while responses of the other ecotypes were intermediate. However, mortality was substantial in D8 and Porto cv at soil moisture of 1.9%, especially when the last surviving leaf bases had a water content below 0·38 g H_20g^{-1}dw. After 33 days of drought, only Kasbah, D1 and D6 ecotypes displayed some survival (15, 15 and 5% respectively) and the water content of last surviving leaf bases were 0.48, 0.45 and 0.54 g H_20g^{-1} dw. Plants of Porto and D8 died at a higher soil water content than those of Kasbah and D1, the other genotypes being intermediate. The soil water content associated with 50 % mortality was 2.5 % for Porto and D8 ecotype and 1.4% for Kasbah and D1. Under extreme drought only D1, D6 and Kasbah exhibited some survival.

D6 and D10 leaf base water content was low (0.58 g H_20g^{-1}) but their survival rate was high (80%). Volaire *and al* (1998b) also showed that plant survival depends more on how long the surviving tissues can maintain cell integrity at given moisture content, rather than on the actual minimum threshold of dehydration reached by tissues. Under the experimental conditions tested, Kasbah, D6 and D1 were the most tolerant to tissue and soil dehydration, while able to avoid the effects of drought for longer, (Levitt, 1972; Sugiyama and Nikara, 2004). Our results show a great variability in dehydration tolerance within highly summer dormant ecotypes of cocksfoot that can be exploited for future breeding programs (Volaire and Norton, 2006).

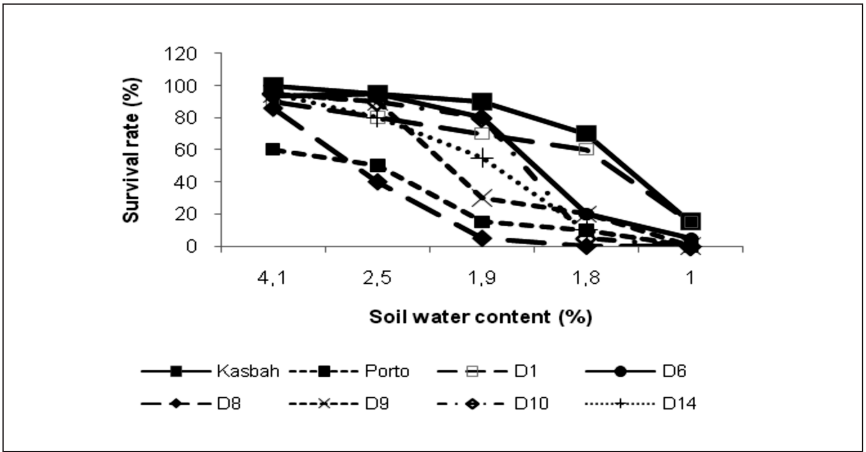

Fig. 2. Drought survival rates as affected by water soil content (%) for 6 Moroccan ecotypes and 2 cultivars Kasbah (K) and Porto (P) of *Dactylis glomerata.*

IV – Conclusions

We analyzed plant material previously characterized for its summer dormancy and showed that the ecotypes which survived best after severe drought displayed combined strategies, with both drought avoidance by senescence of aerial tissue to reduce transpiration, and dehydration tolerance in apices that can remain alive at low hydration and low soil water content. We are now investigating the genetic determination of summer dormancy in order to support plant breeding for new cultivars that would be productive and highly drought tolerant (PRAD project).

Acknowledgments

Thanks to the European Union (project INCO-MED, PERMED) and all the persons involved.

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Effect of limited water supply on *Melilotus officinalis* nutrient content

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Abstract. The aim of the present study was to investigate the influence of limited water supply on nutrient accumulation of *Melilotus officinalis* tissues. For this purpose a pot experiment was conducted, where half of the pots were fully irrigated (up to field capacity) and the rest were irrigated with half the quantity of water. Irrigation plan was applied for five weeks during the growing season. At the end of the experiment, randomly selected plant material, divided in roots, shoots and leaves, was dried and the content of K, Na, Mg, Ca, Cu, Fe, Zn and Mn was determined. The results showed that the limited water supply interacted with the mineral content of *M. officinalis* plants, increasing the concentration of K, Ca, Mg, Cu, Fe and Mn in the leaf tissues. Accumulation of these nutrients could serve as a means to alleviate the adverse impact of drought on important metabolic processes, enhancing *M. officinalis* tolerance to water stress.

Keywords. Drought – Macro-nutrients – Micro-nutrients.

***Effet de l'approvisionnement en eau limité sur le contenu en éléments nutritifs de* Melilotus officinalis**

Résumé. *L'influence de l'approvisionnement en eau limité sur l'accumulation des éléments nutritifs dans les tissus de* Melilotus officinalis *est étudiée. Un expérimente en pot a été menée, où la moitié des pots ont été entièrement irrigué (jusqu'à la capacité au champ) et le reste ont été irrigués avec la moitié de la quantité d'eau. Un plan d'irrigation a été appliqué pour les cinq semaines pendant la saison de croissance. À la fin de l'essai, la matière végétale choisie au hasard, divisée dans les racines, les tiges et des feuilles, est séché et le contenu de K, Na, Mg, Ca, Cu, Fe, Zn et Mn a été déterminée. Les résultats montrent que l'approvisionnement en eau limité a interagi avec la teneur en minéraux des plants de* M. officinalis*; les tissus foliaires indiquent une augmentation de la concentration de K, Ca, Mg, Cu, Fe et Mn. L'accumulation de ces nutriments pourrait servir comme un moyen d'atténuer l'impact négatif de la sécheresse sur d'importants processus métaboliques, cet-à-dire d'améliorer la tolérance de M.* officinalis *à un stress hydrique.*

Mots-clés. *Sècheresse – Macro-nutriments – Micro-nutriments.*

I – Introduction

Drought, a common phenomenon in Mediterranean areas especially during summer, has many adverse impacts on plants, inhibiting their growth (Asgharipour and Heidari, 2011) and affecting their mineral content (Hu and Schmidhalter, 2005). Drought is generally regarded to reduce nutrient uptake by roots and their translocation to the shoots due to its negative effect on transpiration rate, active transport and membrane permeability (Alam, 1999). Nevertheless, numerous studies have shown that many species accumulate inorganic ions as a means to adapt to water stress (Patakas *et al*. 2002; Zhu *et al*. 2005), increasing in this way their drought resistance.

Melilotus officinalis L. (yellow sweetclover) is a biennial legume species, considered as palatable forage of high quality both for livestock and wildlife (Mueggler and Stewart, 1980). In addition, this species produces strong and deep penetrating taproots that can loosen and aerate compacted soil; these characteristics make *M. officinalis* a suitable candidate as a nurse crop in revegetation of derelict land (Stevens and Monsen, 2004). Aim of the present study was to determine the changes in nutrient content of *M. officinalis* under water stress.

II – Materials and methods

The study was conducted at the farm of Aristotle University, 14 km south of the city of Thessaloniki (40°32´N, 22°59´E), at an elevation of about 5 m a.s.l. in autumn 2002. The climate of the area could be characterized as Mediterranean semi-arid with cold winters. Seeds (commercial seedlot of Spanish origin) of yellow sweetclover (*Melilotus officinalis* L.) were sown in twenty 25-liter-pots. All pots were filled with a 5:4:1:1 (on a volume basis) peat:soil:manure:sand mixture. The mixture comprised of white peat medium bedding, enriched with nutrients and trace elements (Klassmann TS1, Klassmann-Deilmann GmbH, Geeste, Germany), grassland soil (0-20 cm), collected the same year from the farm of the Aristotle University of Thessaloniki, farmyard manure and sand.

After seedling emergence, the pots were thinned to a total of 10 seedlings per pot. Then the pots were transferred to a permanent rain shelter, a wooden construction of 2.5 m height, with a transparent plastic cover on top. The rain shelter was designed in such a way as to avoid rainfall reaching the pots, while keeping the atmospheric conditions unchanged. Ten pots, randomly selected, were irrigated frequently (Full Irrigation) so that the soil in the pots was always near field capacity, as determined by tensiometers. The other ten pots received 50% less water than the fully irrigated plants (Limited Irrigation). After six weeks, plant material from both treatments was collected. Roots, shoots and leaves were first separated and rinsed with deionized water, then dried for 48 h at 60^{o}C and ground through to ≤1 mm screen. A sample of 1 g from each tissue material was dry-ashed in a HCl 2N solution at 500^{o}C for 16 h. Potassium and Na concentration was determined using a flame photometer (PFP7, Jenway, Essex, England), while Mg, Fe, Cu, Ca, Mn and Zn concentration was determined with an atomic absorption spectrophotometer (AA-6300, Shimadzu Corporation, Tokyo, Japan).

A completely randomized experimental design was followed with ten replications for each treatment. Statistical analysis of the data was performed using ANOVA with the help of the SPSS® statistical software v. 17.0 (SPSS Inc., Chicago, IL, USA).

III – Results and discussion

The water supply significantly interacted with the majority of macro-nutrients in *M. officinalis* roots, stems and leaves (Table 1). More specifically, under limited irrigation, K and Ca content decreased in roots and stems and increased in leaves (Fig. 1). Potassium plays an important role in survival of plants under environmental stress (Waraich *et al*. 2011), contributing to osmotic adjustment (Utrillas *et al*. 1995; Patakas *et al*. 2002). Leaf K increase could have contributed to the osmotic adjustment of *M. officinalis* plants, acting as a mechanism to maintain turgor pressure and stomatal conductance (Patakas *et al*. 2002) and, hence, photosynthesis under drought conditions (Waraich *et al*. 2011). In compliance with this result, Kostopoulou *et al*. (2010) in their study with the same species under similar experimental conditions found that stomatal conductance was not affected by limited irrigation. Calcium, on the other hand, has a prominent role in maintaining cell structure (McLaughlin and Wimmer, 1999) and recovery from drought (Palta 1990). Increase of Ca under drought conditions has been reported by others (Utrillas *et al*. 1995; Patakas *et al*. 2002).

Little information is available on the effect of drought on Na and Mg. Under limited water supply root Na content of *M. officinalis* plants decreased (Fig. 1), while stem and leaf content was not affected (Table 1). A decrease in sodium content of *Cynodon dactylon* was also observed under water deficit (Utrillas *et al*. 1995). On the other hand, plants of *Sorghum bicolor* grown on different irrigation regimes did not differ in the concentration of Na (Asgharipour and Heidari, 2011). Magnesium concentration decreased in stems and increased in leaves of *M. officinalis* plants (Fig. 1). Magnesium plays a significant role in reducing the generation of reactive oxygen species, protecting the chloroplasts from photo-oxidative damage under water stress (Waraich *et al*. 2011).

Table 1. Effect of irrigation treatment on nutrient content (in mg kg^{-1} dry matter) of *Melilotus officinalis* tissues

Plant part	K	Na	Ca	Mg	Cu	Fe	Zn	Mn
Roots	***	***	***	NS	NS	NS	*	NS
Stems	***	NS	***	***	*	NS	**	NS
Leaves	***	NS	*	**	**	**	NS	*

*P<0.05, **P<0.01, ***P<0.001, NS: non significant.

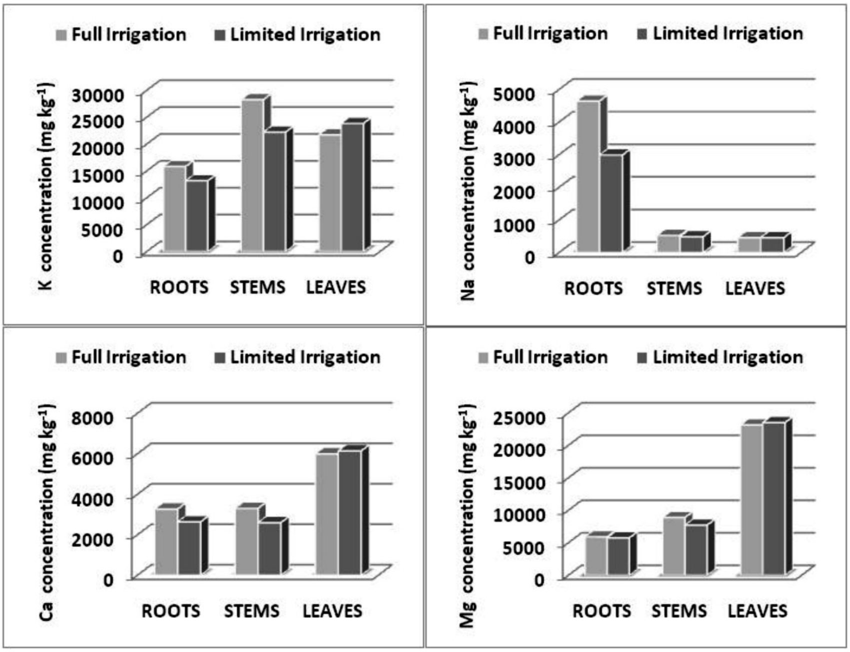

Fig. 1. Macro-nutrient content of *Melilotus officinalis* tissues under full and limited irrigation.

Information dealing with the effect of drought on the concentration of micro-minerals in plant tissues is rather scarce. In the present study, water supply significantly affected the micro-nutrient content of *M. officinalis* tissues (Table 1). Generally, drought reduces nutrient uptake by roots through the decrease in the diffusion rate of nutrients in the soil towards the absorbing root surface (Pinkerton and Simpson, 1986; Alam, 1999). According to Hu and Schmidhalter (2005) low soil moisture can induce deficiencies in Mn, Fe and Zn. In this study we found similar results for Zn, which decreased in roots and stems of *M. officinalis* (Table 2). On the contrary, Cu content increased in stems and leaves, while Fe and Mn increased in leaves (Table 2). Copper is required for lignin synthesis, needed for cell wall strength and prevention of wilting. Increase of Cu content could alleviate the adverse effects of drought by reducing dieback of stems, yellowing of leaves and stunted growth (Waraich *et al*. 2011). Further research is needed in order to determine the role of Fe and Mn in *M. officinalis* under drought conditions. Nonetheless, accumulation of inorganic ions may contribute to the adaptation of this species to drought stress.

Table 2. Micro-nutrient content (in mg kg^{-1} dry matter) of *Melilotus officinalis* tissues under full and limited irrigation. Data represent means ± standard deviation

Plant part	Irrigation	Cu	Fe	Zn	Mn
Roots	Full	9 ± 0.4	918 ± 28	66 ± 6	41 ± 3
	Limited	9 ± 0.6	972 ± 47	53 ± 4	44 ± 2
Stems	Full	8 ± 0.2	104 ± 7	56 ± 2	19 ± 1
	Limited	11 ± 1.4	114 ± 18	45 ± 2	21 ± 2
Leaves	Full	10 ± 0.9	485 ± 17	55 ± 2	68 ± 4
	Limited	14 ± 0.6	900 ± 87	61 ± 4	79 ± 3

IV – Conclusions

The results of the present study showed that water supply interacted with the mineral content of *M. officinalis* plants. Increased accumulation of K, Ca, Mg, Cu, Fe and Mn in the leaf tissues of this species under drought conditions could serve as a means to alleviate the adverse impact of drought on important metabolic processes, enhancing *M. officinalis* tolerance to water stress.

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Competition in an alfalfa-tall fescue mixture under Mediterranean conditions

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Abstract. The focus of the current study was to evaluate the competitive ability of two forage species (alfalfa- *Medicago sativa* L., and tall fescue- *Festuca arundinacea* Schreb.) grown in dry and disturbed soils either in mixture (1:1) or in monocultures, for capture of sunlight. Two levels of water regimes were used: a) frequent irrigation by sprinkler to the point of field capacity and b) no irrigation (drought) conditions. The plants were cut in about 20 day time intervals, at height of 7 cm above soil surface. Measurements of the leaf area and the dry weight of leaves and stems were conducted during two successive growing seasons, and the leaf area ratio (LAR), the leaf weight ratio (LWR) and the leaf area index (LAI) were calculated. Our results showed that: mixture reduced significantly LAR and LAI of alfalfa only under irrigation, while these indices were unaffected in tall fescue; under both water regimes, the alfalfa LAI was higher to the corresponding tall fescue LAI; drought and mixing did not affect LWR, which remained higher in tall fescue compared to alfalfa during the season of experimentation. We conclude a lower competition ability of alfalfa to tall fescue under irrigation and therefore lower productivity.

Keywords. Alfalfa – Tall fescue – Competition – Mixture – Leaf area.

La concurrence dans une mélange de luzerne et de fétuque élevée dans des conditions méditerranéennes

Résumé. *L'objectif de cette étude était d'évaluer la capacité concurrentielle de deux espèces fourragères (luzerne-* Medicago sativa *L., et fétuque élevée-* Festuca arundinacea *Schreb.) cultivées dans des sols secs et perturbés, soit en mélange (1:1) soit en monoculture, pour la capture de la lumière solaire. Deux niveaux d'approvisionnement en eau ont été utilisées: a) irrigation fréquente par aspersion au point de la capacité au champ, et b) aucune condition d'irrigation (sécheresse). Les plantes ont été coupées à un intervalle de 20 jours environ, à hauteur de 7 cm au-dessus de la surface du sol. Les mesures de la surface foliaire et du poids sec des feuilles et des tiges ont été menées au cours de deux saisons successives, et ils ont été aussi calculés le ratio surface foliaire (LAR), la proportion du poids des feuilles (LWR) et l'indice de surface foliaire (LAI). Nos résultats ont montré que: le mélange a réduit de manière significative le LAR et le LAI de la luzerne en irriguée, tandis que ces deux indices ne sont pas influencés chez la fétuque élevée; dans les deux régimes hydriques, le LAI de la luzerne était plus élevé par rapport à la fétuque, la sécheresse et le mélange n'a pas influencé LWR , qui est resté plus élevé chez la fétuque élevée par rapport à la luzerne au cours de la saison de l'expérimentation. Nous concluons que la luzerne a une capacité inférieure de concurrence par rapport à la fétuque élevée sous l'irrigation, et pour cette raison la productivité est plus faible.*

Mots-clés. *Luzerne – Fétuque élevée – Concurrence – Mélange – Surface foliaire.*

I – Introduction

In the Mediterranean areas, the use of legumes in mixtures in degraded lands and under variable conditions could be essential to achieve persistent and high quality pasture swards (Porqueddu *et al*., 2004). The long-term usefulness of a grass-legume mixture depends on the ability of each species to persist in the mixture. Compatibility of grasses with legumes depends on their morphological and physiological characteristics (Springer *et al*., 2001). Ecological conditions such as the abiotic environment, herbivory, and the presence, absence or identity of neighbors alter the morphological phenotypes of plants. This phenotypic plasticity alters the sign and magnitude of interactions among plants (Callaway *et al*., 2003).

The main resources, for which species compete, are water in dry environments and light in humid environments. Differences in the ability of the partner species to capture the sunlight could explain the competitive ability of the species in the mixture. This ability mainly depends on leaf area of the plant, which is considered an important factor of canopy photosynthesis and therefore, the main determinant of its growth rate (Barnes *et al*., 1990). Leaf characteristics are strongly influenced by neighbors. The presence of interspecific neighbors may lead to differences in growth and allocation patterns of plants in mixtures as compared with monocultures. Leaf area could be described in terms of leaf area ratio (LAR), leaf area index (LAI) and leaf weight ratio (LWR), which shows the biomass allocation to leaves (Callaway *et al.,* 2003; Poorter *et al*., 2009).

This study assesses the leaf area expansion as a response to species interactions in a field grown alfalfa/tall fescue binary mixture subjected to drought.

II – Materials and methods

The field experiment was conducted in the farm of Tobacco Institute of Drama, Northern Greece (41°09‘N, altitude 130 m above sea level. The climate of the area is semi-arid with a mean annual temperature of 15.2°C and mean annual precipitation of 589 mm. The soil was degraded, the textural class was silt loam and at establishment of the experiment the pH was 7.6. The used species were *Festuca arundinacea Schreb.* cv festorina (tall fescue), sown by seeds introduced from USA and *Medicago sativa* v. Yliki (alfalfa), sown by seeds produced in the Institute of Forages of Larisa (Greece).

Monocultures and binary mixture of the two species, in proportionality 1:1, were established in autumn. The sowing rate was 4 g m^{-2} for alfalfa, 4.5 g m^{-2} for tall fescue and the half of them for the mixture. The sowing was expanded around the plot to avoid edge effect. A fertilizer, containing 22% N and 11% P_2O_5, was applied once just before sowing. Herbicides were not used during the experiment and the weeds were removed by hand.

The experimental area was separated in two field areas in a distance of 5 meters, each of them representing one watering treatment. In both field areas the design was completely randomized with four replicates for each treatment. All stands were irrigated until the plants were well established. After the first cut in spring, two water regimes were applied: a) irrigation by sprinklers to maintain field capacity (I); b) rainfed, the most of the period the plants were grown under drought (R). The plants were cut at 7 cm from the soil surface. Cutting was applied when the first inflorescences appeared, at about 20 day intervals (four to five cuttings in the measuring season). Thus, we had the following treatments: FF I irrigated tall fescue in monoculture; MM I irrigated alfalfa in monoculture. FF R rainfed tall fescue in monoculture; MM R rainfed alfalfa in monoculture. FM I irrigated tall fescue in mixture; MF I irrigated alfalfa in mixture. FM R rainfed tall fescue in mixture; MF R rainfed alfalfa in mixture.

The cut plant material of the entire plot (1mx1m) was hand-separated in the two component species and weighed; samples of each species from monocultures and mixtures were separated in leaves and stems. The leaf area was measured by an Area Measurement System (Delta-T-Devices). The leaves and stems were oven dried at 75°C for 48 hours and weighted. The Leaf Area Ratio (LAR), as leaf area per above ground dry biomass of plant, in dm^2 g^{-1}; the Leaf Area Index (LAI), as leaf area per soil surface, and the leaf weight ratio (LWR), as leaf weight per above ground dry biomass of plant, were also calculated for each cut data.

Measurements were repeated for two successive years (1996-1997), from April to July, when yields of rainfed plots approximated zero.

III – Results and discussion

Leaf area ratio (LAR), an index of photosynthetic area to total above ground plant tissues, is illustrated in Fig. 1. Tall fescue presented higher LAR during summer in relation to spring months, which probably is associated with the leaf weight ratio (LWR) (Fig. 2). During the same period, alfalfa presented lower LAR, which contributes to transpirational surface reduction. The effect of drought (rainfed conditions) on LAR is not clear. This result differs from other publications, which report reduction of the LAR under drought (Poorter *et al.,* 2009). Moreover, in a previous publication it was shown that under the same conditions and under more intensive cutting (at 3 cm height) drought reduced LAR in both species (Lazaridou and Noitsakis, 2002).

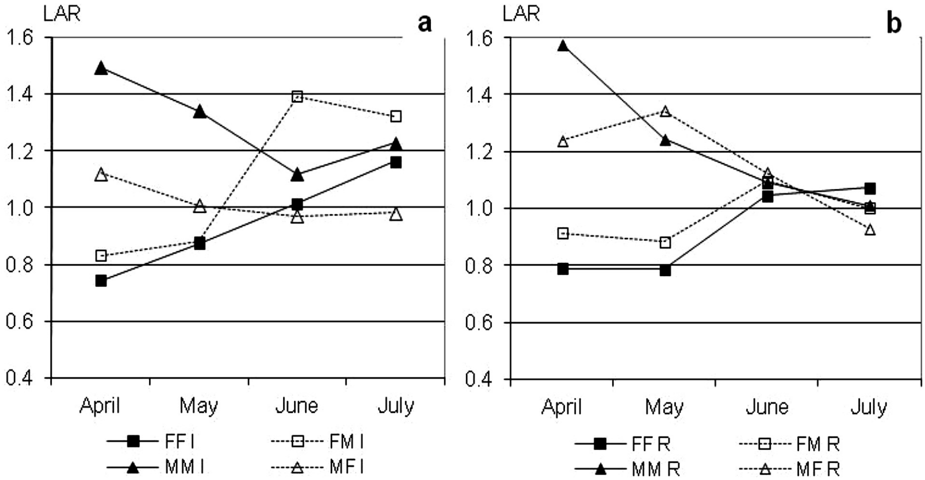

Fig. 1. Seasonal changes of leaf area ratio (LAR) of alfalfa and tall fescue, grown in monocultures or mixtures (a) under irrigation and (b) rainfed conditions. FF I irrigated tall fescue in monoculture; MM I irrigated alfalfa in monoculture. FF R rainfed tall fescue in monoculture; MM R rainfed alfalfa in monoculture. FM I irrigated tall fescue in mixture; MF I irrigated alfalfa in mixture. FM R rainfed tall fescue in mixture; MF R rainfed alfalfa in mixture. Values present means of two years.

The effect of mixture on LAR depended on species and on water regime (Fig. 1). The mixture affected the LAR only in the irrigated treatment, although in different way for the two species (Fig. 1a). The values of LAR of mixed tall fescue in relation to its monoculture were significantly higher; while the values of LAR of mixed alfalfa in relation to its monoculture were lower. This result could be attributed to shading of tall fescue from alfalfa (Poorter *et al.,* 2009).

The values of LAR depend on the leaf thickness and/or the leaf weight ratio (LWR), indicating the fraction of above ground plant weight allocated to the leaves (Poorter and Remkes, 1990).

LWR is considered being the main allometric index, affected by growth stage in grasses (Sheaffer *et al.* 2000). The values of LWR in tall fescue during summer indicate proportionally more biomass allocation to leaves, at rates higher than 95%, which explains the LAR increase (Fig. 2). This finding could be attributed to the fact that plants remain in the vegetative stage and they do not enter in the flowering stage, during which the stems elongate. In alfalfa LWR remains more or less stable during the season. Both drought and mixing did not affect the LWR of the two species. Therefore, we might conclude that changes in LAR resulted from changes in the thickness of leaves (Poorter and Remkes, 1990).

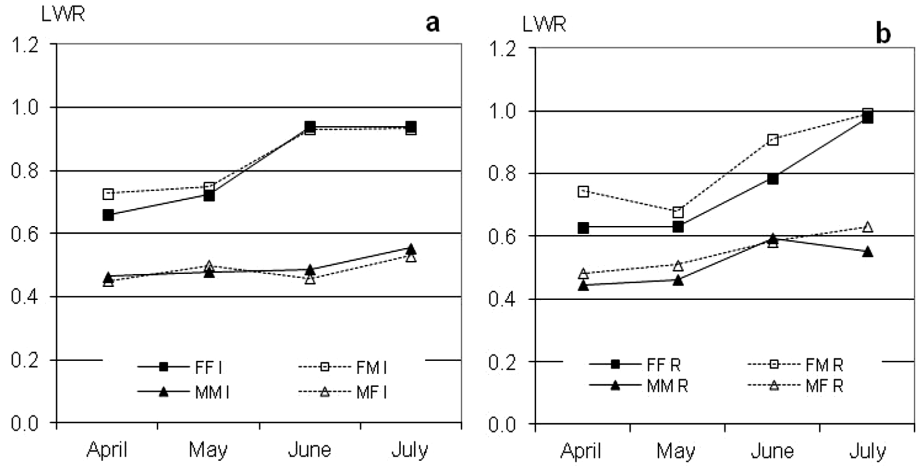

Fig. 2. Seasonal changes of leaf weight ratio (LWR) of alfalfa and tall fescue, grown in monocultures or mixtures (a) under irrigation and (b) rainfed conditions. FF I irrigated tall fescue in monoculture; MM I irrigated alfalfa in monoculture. FF R rainfed tall fescue in monoculture; MM R rainfed alfalfa in monoculture. FM I irrigated tall fescue in mixture; MF I irrigated alfalfa in mixture. FM R rainfed tall fescue in mixture; MF R rainfed alfalfa in mixture. Values present means of two years.

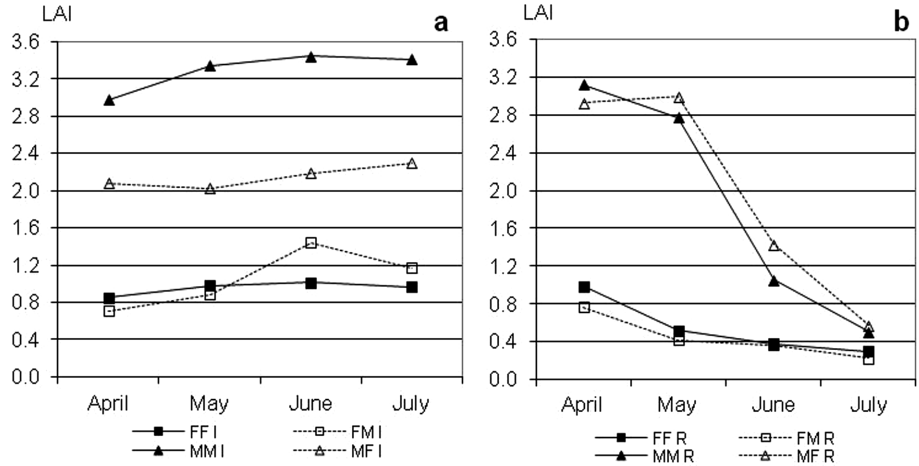

Fig. 3. Seasonal changes of leaf weight ratio (LAI) of alfalfa and tall fescue, grown in monocultures or mixtures (a) under irrigation and (b) rainfed conditions. FF I irrigated tall fescue in monoculture; MM I irrigated alfalfa in monoculture. FF R rainfed tall fescue in monoculture; MM R rainfed alfalfa in monoculture. FM I irrigated tall fescue in mixture; MF I irrigated alfalfa in mixture. FM R rainfed tall fescue in mixture; MF R rainfed alfalfa in mixture. Values present means of two years.

Leaf Area Index is as indicator of canopy density and light acquisition. As a general rule, plant canopies with high LAI absorb higher light quantities, resulting in accelerated plant growth rates and a significant competitive advantage (Barnes *et al*., 1990). LAI is illustrated in Fig. 3a for irrigated and Fig. 3b for rainfed plants. LAI of alfalfa was much higher than that of tall fescue, suggesting higher growth rate and productivity. Drought decreased the canopy density as expressed by LAI in both species. The reduction was higher in alfalfa, especially during the drought summer season. The mixture did not affect the LAI of tall fescue but the LAI of alfalfa increased under drought in relation to its monoculture, probably due to LAR reduction, as LWR was not reduced.

IV – Conclusions

In an alfalfa-tall fescue mixture, grown under Mediterranean conditions, we expect a low competitive ability of alfalfa reported to tall fescue under irrigation. It is because of lower LAR and LAI compared to its monoculture. Instead, the higher LAR and LAI values of alfalfa under drought show a higher competitive ability compared to tall fescue.

Acknowledgement

This research was funded by Kavala Institute of Technology (TEI).

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Competition for soil water among trees, shrubs and pasture in Iberian Dehesas.
Consequences for pasture and tree productivity

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Abstract. The low tree density in silvopastoral systems results in increased pasture productivity and allows remnant trees to cope with summer water deficit. However, the worldwide phenomenon of savanna shrub encroachment could compromise the benefit of wide tree spacing in these water limited forests. We analyze the effect of shrub encroachment of Iberian dehesas for soil water dynamic and tree water status. The consequences for oak tree and pasture productivity are discussed. Increased tree density resulted in a worsening of tree water status and acorn productivity. *Cistus* shrubs showed a net competitive effect for soil water which influenced negatively the pasture yield, and the functional state and acorn production of the trees. By contrast, *Retama* shrubs affected positively the soil moisture of uppermost soil layers (hydraulically lifted water) and showed a facilitative effect for pasture yield without influencing the functional tree state and acorn production.

Keywords. Competition – Facilitation – Pasture understory – Silvopastoral – Water deficit.

La concurrence pour l'eau du sol entre les arbres, les arbustes et les pâturages dans les dehesas ibériques. Conséquences pour la productivité des pâturages et des arbres

Résumé. *La faible densité des arbres dans les systèmes sylvopastoraux est compatible avec une bonne production des pâturages, et permet aux arbres résiduels faire face à un déficit hydrique en été, tout en facilitant le fonctionnement et la productivité des arbres. Cependant, le phénomène mondial de l'embroussaillement des savanes pourrait compromettre l'intérêt de l'espacement des arbres dans ces forêts* semi-arides. *Nous analysons l'effet de l'embroussaillement des dehesas ibériques avec* Cistus *ladanifer et* Retama *sphaerocarpa* sur la dynamique de l'eau du sol *et l'état hydrique des arbres. Les conséquences pour la productivité des chênes et des pâturages sont discutées. L'augmentation de la densité des arbres a entraîné une aggravation de l'état hydrique des arbres et la réduction de la productivité gland.* Cistus *a montré un effet concurrentiel net pour l'eau du sol qui a influencé négativement le production du pâturage, et l'état fonctionnel des arbres et la production de glands. En revanche,* Retama *affecté positivement l'humidité des horizons superficiels de sol (*ascenseur hydraulique*) et a montré un effet de facilitation pour la production des pâturages sans influencer l'état fonctionnel d'arbre et la production de glands.*

Mots-clés. *Concurrence – Déficit en eau – Facilitation – Silvopastoral – Sous bois.*

I – Introduction

Although forest thinning initially increases the availability of light for pasture, this clearance could have also important consequences for tree functioning, particularly in water-limited regions, as Mediterranean Basin countries. A good example is found in the scattered-trees silvopastoral system named Dehesa in the Iberian Peninsule (Moreno and Pulido, 2009). However, woody encroachment of former pasturelands and savannas have recently increased markedly worldwide (van Auken, 2000), including man-made savannas, as Iberian dehesas (Fernández-Ales *et al*., 2012; Pinto-Correia and Mascarenhas, 1999) and other Mediterranean open woodlands (Papanastasis, 2004). There is a great concern about the ecological and productive consequences of woody encroachment of pastures and savanoid landscapes. The consequences of woody encroachment of the idealized two layered dehesas are not still well known. Here, we compile data of three published studies that respond to three specific questions: (i) how do scattered-trees affect to soil water dynamic in two-layered dehesas (Cubera and Moreno, 2007); (ii) how do tree density affect to soil water reserve and tree water status (Moreno and Cubera, 2008); (iii) how do shrub understory affect to soil water reserve and tree water status (Moreno and Rolo, 2011).

II – Materials and methods

The study was conducted in 10 dehesas of Central-Western Spain under semi-arid Mediterranean climate (mean annual rainfall ranging 500-600 mm, mean annual temperature 15.5-16.5 ºC, and mean annual potential evapotranspiration above 800 mm). Soils are acid, low in soil organic matter (usually < 3%) and of moderate depth (frequently < 100 cm). The vegetation in two-layered plots was formed by scattered oaks (*Quercus ilex* L.; trunk diameter 25-80 cm; 5-200 trees ha^{-1}) plus a herbaceous understory mainly composed by annual species. In three layered-plots, a third vegetation layer (shrub understory) was present. Two contrasting shrub species, in terms of cover and rooting system, were selected for his study, the shallow rooted *Cistus ladanifer* (soil cover 60-80%) and the deep rooted *Retama sphaerocarpa* (soil cover 20-60%) (Rolo and Moreno, 2012).

In a first study, we monitored soil water content (SWC) at different distance of scattered trees in four two-layered open dehesas (Control plots). Soil moisture profile was measured in 6-16 trees per dehesa both beneath and out of the canopy (2 and 30 m from the trunk). In a second study, SWC in control plots was compared with SWC in dense forest plots (canopy cover nearby to 20 and 100%, respectively). In dense forest plots, 6 replicated profiles were monitored, while 12 replicated profiles were monitored in open dehesas (6 profiles beneath the canopy and 6 out of the canopy). In a third study, SWC of 6 control plots was compared with SWC of 6 adjacent shrub encroached plots (either with *Cistus ladanifer* or with *Retama sphaerocarpa*). Four different habitats were defined, two from control plots, beneath the tree canopy and out of the tree canopy; and two from encroached plots, beneath trees and away from the tree canopy. Four replicated profiles were monitored in each plot.

SWC was measured either with TDR-probes (Tektronic model 1502C) or the Diviner 2000 probe (Sentek Pty Ltd) at different depths, with intervals of 20 cm for the first meter and then every 50 cm up to a maximum depth of 250-300 cm. Leaf water potential of trees (Ψ_{pd}) was periodically measured before sunrise by means of a Scholander chamber (Skye Instr., UK, model SKPM 1400) once per month (around mid-month from July to September). Details on measurements conducted at each site and parameters are given in Cubera and Moreno (2007), Moreno and Cubera (2008), Rolo and Moreno (2011) and Moreno and Rolo (2011).

III – Results

As a general trend for all the experimental sites, SWC was slightly but significantly higher beyond than beneath tree canopy during both dry and wet periods. Canopy width affected significantly this trend in all sites, with higher differences among distances in the biggest trees (Cubera and Moreno, 2007). Soil recharge beneath and beyond the tree canopy generally is completed during wet season for most of the profile, with soil water content values close or even higher to field capacity irrespective of site and distance to tree. Only at the deepest layers, near 3 m depth, did soil recharge seem incomplete in some cases. At 2 m from the tree trunk, SWC values close to the wilting point were observed at the end of the dry season. However, at 30 m of distance, an important amount of available water remained unused by vegetation in the deeper layers of the soil. Throughout the year, *HD* plots (~ 100% of tree cover) showed significantly lower SWC values than *LD* plots (~ 20 tree cover) (Moreno and Cubera 2008).

SWC was significantly lower beneath *Cistus* and tree+*Cistus* than in open pasture in the three studied sites. This reduction was consistent during the entire study period in depth (Fig.3). *Retama* showed a positive effect on SWC compared to pasture areas, although the effect was not consistent across sites (data not shown). Retama played a positive role for SWC in sites with deep soils, but the contrary in shallow soils (Moreno and Rolo 2011). SWC beneath tree+shrub habitat showed intermediate values among SWC found beneath shrub habitat and tree habitat, irrespective of the shrub species (Fig. 1).

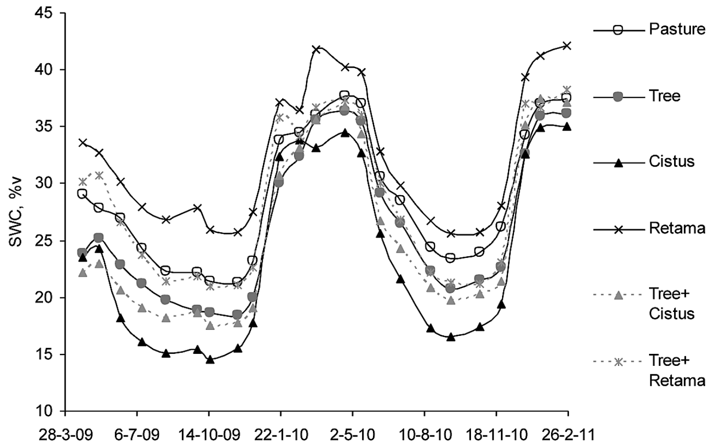

Fig. 1. Seasonal pattern of soil water content in four habitats of dehesas encroached with *Cistus ladanifer* or *Retama sphaerocarpa*. Values are average for three sites x four replicated profiles (0-250 cm depth) in each case. Adapted from Moreno and Rolo (2011).

Scattered oaks growing in open dehesas, at low density, maintained a high water potential during summer drought, with predawn leaf water potential (Ψ_{pd}) ranging from above -1 MPa or slightly below -2.0 MPa (Table 1), depending of the soil depth. When tree grew in dense stands (~ 100% tree cover) Ψ_{pd} decreased very significantly (from -0.53 to -2.77 MPa on average). The presence of a *Cistus ladanifer* understory beneath and among scattered oaks also produced a significant decrease of Ψ_{pd}, although the reduction was not so acute (from -1.74 to -2.02 MPa on average). By contrast, the presence of *Retama* sphaerocarpa did not produce a significant change in the water status of oaks.

Table 1. Monthly dynamic of ψ_{pd} for oak trees growing in dehesas at low and high tree density (adapted from Moreno and Cubera, 2008) and in open and encroached stands (with *Cistus ladanifer* or *Retama sphaerocarpa* understory; adapted Rolo and Moreno, 2011). Different letters between habitats indicate significant differences at *P* < 0.05

	July	August	September	Average
Low tree density	-0.34 ± 0.12 a	-0.66 ± 0.32 a	-0.58 ± 0.25 a	-0.53 ± 0.21 a
High tree density	-2.27 ± 0.43 b	-2.83 ± 0.52 b	-3.21 ± 0.43 b	-2.77 ± 0.64 b
Open dehesa	-0.99 ± 0.08 a	-1.92 ± 0.10	-2.32 ± 0.19 a	-1.74 ± 0.04 a
Cistus encroached	-1.34 ± 0.09 b	-2.05 ± 0.11	-2.68 ± 0.11 b	-2.02 ± 0.04 b
Open dehesa	-1.46 ± 0.06	-1.80 ± 0.04	-2.07 ± 0.14	-1.78 ± 0.03
Retama encroached	-1.28 ± 0.05	-1.51 ± 0.18	-2.19 ± 0.13	-1.66 ± 0.04

V – Conclusions

Tree thinning traditionally practiced for dehesa creation is a useful mechanism for *Q. ilex* to cope with summer drought, especially at dry sites. The improved water status of scattered trees allows them to assure an important acorn production most of the year.

The deep rooting system together with the slow-growing attitude of many oak species could determine a low competitive potential of oaks with herbaceous layer. Its low competitiveness together with its capacity to thrive in poor soils make oaks genre very suitable for long-term agroforestry systems in Iberian Peninsula. However, evergreen oaks frequently produce a diminution of soil moisture respect to open pasture. Hence, the potential benefit of trees has a small actual facilitative effect because the competitive use of soil water by trees overrides its positive effects, especially under semi-arid conditions of many Iberian dehesas and other Mediterranean open woodlands.

Encroachment of scattered-oak woodlands with *Cistus* understory produces a reduction of soil moisture, with negative consequences for both pasture and tree production. By contrast, the potential of *Retama* to use very deep water and to pump it to upper soil layers produce a significant increase of soil moisture in the pasture-rooted soil, with a positive effect on pasture understory production. By contrast the effects for tree water status and acorn production result rather negative. Although dehesa shrubs compete with trees for soil resources stronger than herbaceous plants do, the mature oaks are not substantially affected. Hence, dehesa encroachment can be recommended as mechanism to favour tree regeneration of dehesas (Pulido *et al*., 2010) without compromising the short term productivity of trees. Nevertheless, these findings should not be generalized and further studies focusing specific combination of tree-shrubs species under different edaphoclimatic conditions will be needed.

Acknowledgments

This work has been funded by the Spanish Research Program (AGL 2006-09435) and y Plan Regional de Investigación of Extremadura (III PRI + D + I, PRI07C044). V. Rolo was supported by a doctoral grant funded by the Regional Government of Extremadura (Consejería de Economía, Comercio e Innovación) and Fondo Social Europeo.

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REFORMA: a new project for identification and selection of resilient, water- and energy-efficient forage and feed crops for Mediterranean agricultural systems

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Abstract. Crop-livestock and feed systems have huge importance for Mediterranean regions to satisfy the increasing demand for animal products, increase the economic stability of smallholders and produce typical animal products with high added-value, while contributing to sustainable farming, environment protection and efficient nutrient cycling. These systems are threatened, however, by the marked insufficiency of high-protein feedstuff, the overexploitation of forage resources, the increasing costs and/or the decreasing availability of irrigation water and mineral fertilizers, and the increasing drought and heat stress arising from climate change. The development of resilient, water- and energy-efficient forage and feed legume crops could definitely alleviate these constraints. This is the objective of the ArimNet project "Resilient, water- and energy-efficient forage and feed crops for Mediterranean agricultural systems (REFORMA)", which joins nine research institutions from Italy, France, Algeria, Morocco, Tunisia and USA in an integrated manner to develop: 1) lucerne varieties with tolerance to severe drought, salinity, heat and grazing; 2) pea varieties with drought tolerance, targeted to grain and forage production; 3) cost-efficient marker-assisted selection procedures, and ecologically-based breeding strategies, for lucerne and pea; 4) lucerne-based and pea-based forage crops, taking into account the legume plant types, the associated grass or cereal species, the level of site drought stress, the acceptability by farmers, the forage quality and the target utilization.

Keywords. Marker-assisted selection – *Medicago sativa* – *Pisum sativum* – Protein feedstuff.

REFORMA: un nouveau projet pour identifier et sélectionner des espèces destinées à l'alimentation animale, résilientes, efficaces en eau et en énergie pour les systèmes agricoles méditerranéens

Résumé. *Les systèmes de culture à destination de l'alimentation des ruminants et des monogastriques sont cruciaux dans les régions méditerranéennes pour satisfaire une demande croissance en produits animaux, accroître la durabilité économique des petits exploitations et assurer la typicité des produits animaux ayant une forte valeur ajoutée, tout en contribuant à une agriculture durable, à la protection de l'environnement et au recyclage des nutriments. Ces systèmes sont menacés par une insuffisance en aliments protéiques, la surexploitation des ressources fourragères, l'augmentation des coûts et/ou la diminution de la disponibilité en eau d'irrigation et en fertilisants, et l'augmentation de la sécheresse et des stress thermiques liée au changement climatique. Le développement de fourrages et d'aliments dont la culture est résiliente, efficace en eau et en énergie pourrait définitivement lever ces contraintes. C'est l'objectif du projet ArimNet "Resilient, water- and energy-efficient forage and feed crops for Mediterranean agricultural systems (REFORMA)", qui* *rassemble neuf équipes de recherche d'Italie, France Algérie, Maroc, Tunisie et Etats-Unis pour développer de manière coordonnée: 1) des variétés de luzerne tolérantes à des sécheresses sévères, la salinité, les fortes températures et le pâturage ; 2) des variétés de pois tolérantes à la sécheresse, pour des productions de graines ou de fourrage ; 3) des procédures de sélection assistée par marqueurs économiquement rentables et des stratégies de sélection ciblant des progrès sur la durabilité des cultures; 4) des cultures fourragères basées sur la luzerne ou le pois, prenant en compte les caractéristiques des légumineuses, les espèces graminées ou céréales associées, le niveau de stress hydrique du milieu, l'acceptabilité par les agriculteurs, la valeur alimentaire et l'utilisation prevue.*

Mots-clés. *Sélection assistée par marqueurs* – Medicago sativa – Pisum sativum – *Aliments protéiques.*

I – Introduction

Crop-livestock systems play a strategic role in the Mediterranean basin. They safeguard the economic stability of smallholders in north Africa, and support local economies, which are often based on typical dairy productions, in southern Europe. These systems are threatened by the insufficiency of protein feedstuff, the overexploitation of forage resources, the increasing costs and/or decreasing availability of irrigation water and mineral fertilizers, and the increasing drought and heat stress arising from climate change. The development of resilient, water- and energy-efficient forage and feed legume crops could alleviate all of these constraints. These crops have a reported positive impact on the sustainable intensification, the productive stability and the environment protection in crop-livestock systems (Carrouée *et al*., 2003).

The limited funding available at the national and international level for forage and feed legume breeding requires, however, to carefully identify a few promising species on which concentrating joint efforts and resources. Lucerne (*Medicago sativa* L.) is the main forage crop in south-European countries and the Maghreb, while pea (*Pisum sativum* L.) is the main feed grain legume in southern Europe and is mainly grown for forage in mixture with a cereal in the Maghreb. Lucerne cultivation in north Africa is traditionally limited to frequently irrigated conditions, but recent results have highlighted the good drought tolerance of Mediterranean landraces that evolved in stressful environments (Annicchiarico *et al*., 2011). Recent pea breeding has improved the traditional drawback of this crop represented by its poor standing ability, but novel varieties have hardly ever targeted regions of the Mediterranean basin.

The on-going development of lucerne genomic resources may allow to explore association mapping for quantitative trait loci (QTL) and to develop marker-assisted selection (MAS) procedures (Li *et al*., 2011). QTL for lucerne drought tolerance have just started to be studied (Julier *et al*., 2010). Genomic resources are increasingly available also for pea genotyping aimed to define MAS procedures (Deulvot *et al*., 2010). More efficient breeding may arise not only from MAS but also from ecological and/or evolutionary approaches that exploit selection under natural (Ceccarelli *et al*., 2010) or artificially-reproduced conditions (Annicchiarico, 2007).

II – The Project REFORMA

1. Objectives

The overall aim of the project is strengthening the economic and environmental sustainability of Mediterranean crop-livestock and feed systems, also by enhancing their self-sufficiency for feed proteins and their ability to adapt to and to mitigate climate change. This is pursued by developing more resilient and more water- and energy-efficient systems based on genetically-improved forage and feed legume species. The specific objectives of the project are:

(i) enhancing the forage yield and persistence of lucerne in Mediterranean environments that are subjected to severe drought stress, high temperatures and/or salinity, by selecting stress-tolerant varieties phenotypically and by defining innovative breeding strategies based on MAS and on ecologically-based selection procedures and adaptation targets;

(ii) defining MAS procedures for enhanced grazing tolerance of lucerne targeted to extensive Mediterranean systems, and for high lucerne compatibility with grass companions;

(iii) producing drought-tolerant pea varieties for grain or forage production, by phenotypic selection in stress environments and by definition of innovative MAS procedures and ecological selection strategies;

(iv) optimizing the cultivation and use of pea- and lucerne-based forage crops with respect to legume plant types, the associated grass or cereal species, the expected level of site drought stress, the acceptability by farmers, and the target forage quality and utilization.

2. Structure of the project

The partner institutions participating to the project are: CRA-FLC (Centro di Ricerca per le Produzioni Foraggere e Lattiero-Casearie, Lodi, Italy); INRA-URP3F (Unité de Recherche Pluridisciplinaire Prairies et Plantes Fourragères, Lusignan, France); INRA-UMRLEG (Unité Mixte de Recherches en Génétique et Ecophysiologie des Légumineuses à Graines, Dijon, France); INRA-MOR (Institut Nationale de la Recherche Agronomique, Marrakesh, Morocco); INRAA (Institut National de la Recherche Agronomique d'Algérie, Alger, Algeria); ENSA (École Nationale Supérieure Agronomique, Alger, Algeria); CNR-ISPAAM (Istituto per il Sistema Produzione Animale in Ambiente Mediterraneo, Sassari, Italy); IRA (Institut des Régions Arides, Médenine, Tunisia); and SRNF (The Samuel Roberts Noble Foundation, Ardmore, USA).

The research activities are accomodated into three Work Packages (WP):

WP 1: *Ecological breeding strategies and variety selection*;

WP 2: *Genomics and definition of marker-assisted selection procedures*;

WP 3: *Assessment and optimization of innovative legume-based crops*.

The contribution of each WP in fulfilling the project objectives is shown in Fig. 1, while the roles of, and interactions among the participating institutions in the various tasks of the three WPs are illustrated in Fig. 2.

Besides achieving the targeted objectives, the project will offer the opportunity to test lucerne and pea germplasm, selection strategies and crop utilizations across a wide range of Mediterranean agricultural environments that span from climatically favourable to severely drought-prone. The emphasis on germplasm evaluation in north-African environments, which experience drought stress levels more severe than those in south-European environments, enables breeding programs in southern Europe to anticipate solutions to cope with the predicted effects of climate change, by developing germplasm and selection approaches which are already valuable for the harsher conditions of north Africa.

The transfer of know-how among partner institutions will be favoured by two final training workshops. A freely-available electronic handbook will promote optimal cultivation methods for innovative forage crops and optimal diets including these forages or pea grain. This and other dissemination actions will spread the project results among farmers and other stakeholders.

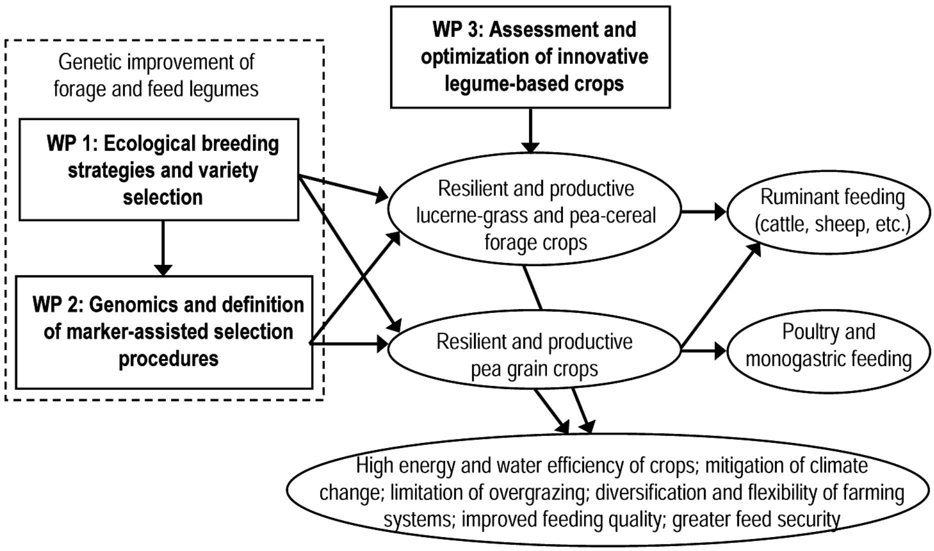

Fig. 1. Contribution of each research WP to the project objectives.

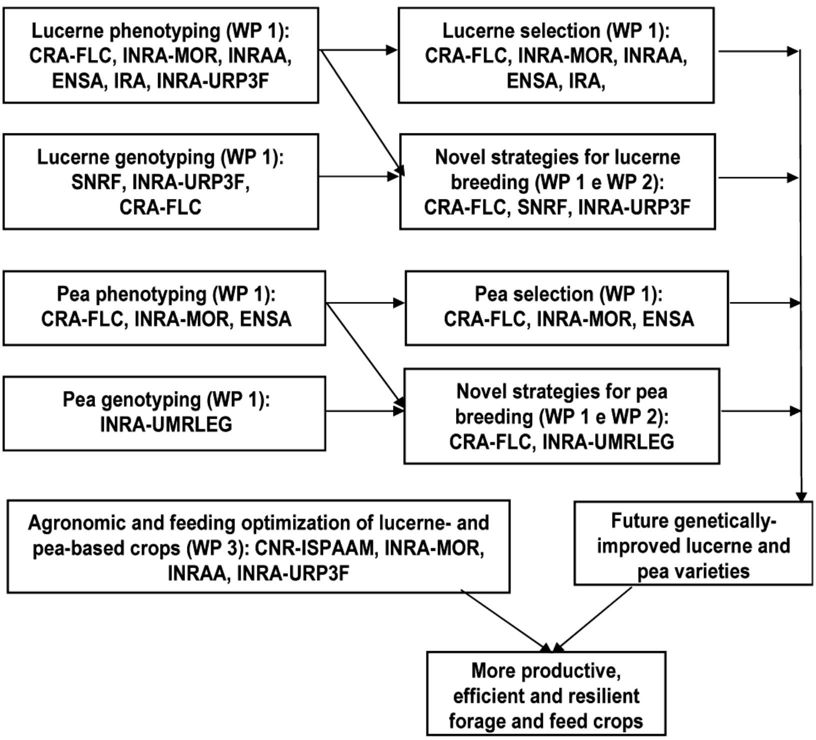

Fig. 2. Roles of and interactions among the partner institutions in relation to the project targets.

Acknowledgments

The project is funded in the framework of the 2010 Call of the Coordination of the Agricultural Research in the Mediterranean Area (ArimNet).

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The impact of climatic variations on the role and sustainable management of natural ecosystems in the Middle Atlas.
(Afenourir wetland area case)

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Abstract. The Afenourir lake (wetland area; 33° 17'N - 5° 16'W) is located in the Central Middle Atlas of Morocco south of Ifrane province about 30km south of Azrou. The lake is part of the perimeter of Ifrane National Park as established in October 2004. It belongs to the Western Palearctic biogeography region. Afennourir area has several land statutes that are subject to rights of land use and various other regulations: (i) the ethnic use tenure, under the authority of the Interior Ministry, (ii) the private domain of the State, this is the forest area which is under the tutelage of forest department, (iii) the swamp area is under the supervision of the watershed hydraulic agency of Sebou. The Afennourir site constitutes important water resources to local people in this area where the physical land characteristics do not allow the storage of rainwater and snowmelt and to develop real rivers. Therefore, the waters of the lake are highly coveted as evidenced by the large number of wells around the lake especially in the eastern part. At present, the area knows the existence of illegal forty wells. The pumping of water from these wells knows great importance.Water withdrawals, either for domestic or for watering the cattle, are valued to 180 m^3 per day. This quantity pumped at the wells has a direct effect on the lake since both are fed from shallow aquifer. This situation is more aggravated by climatic conditions which are often dry and which are favorable to the habitat establishments around the lake leading to livestock concentration in the area increasing the needs for water and forage.

Keywords. Grassland – Humid area – Water – Population pressure – Climate variations.

Impact des variations climatiques sur le rôle et la gestion durable des écosystèmes naturels au Moyen Atlas (cas de la zone humide d'Afenourir)

Résumé. *Le lac d'Afenourir (33° 17'N - 5° 16'W) se situe dans le Moyen Atlas Central marocain au Sud de la province d'Ifrane à 30km au Sud d'Azrou, dans la commune rurale d'Aïn Leuh. Le lac s'inscrit dans le périmètre du Parc National d'Ifrane créé en octobre 2004. Il appartient à la région biogéographique du Paléarctique occidental. La zone d'Afennourir connaît plusieurs statuts fonciers grevés de droits d'usage et de réglementations variés : (i) Le régime collectif : placé sous l'autorité du Ministère de l'Intérieur, (ii) Le domaine privé de l'Etat, concerne le domaine forestier qui se trouve sous la tutelle du département des eaux et forêts, (iii) Statut domanial qui couvre l'espace du marécage proprement dit et relève de la tutelle de l'agence hydraulique du bassin versant du Sebou. Le site d'Afennourir constitue une ressource en eau d'importance pour les populations locales, dans un secteur où les caractéristiques physiques ne permettent pas le stockage des eaux pluviales et nivales ainsi que le développement de véritables cours d'eau. Par conséquent, les eaux du lac d'Afenourir sont très convoitées comme en témoignent le nombre important de puits creusés autour du lac et notamment dans la partie Est. Actuellement on note l'existence d'une quarantaine de puits illégaux. Le pompage de l'eau au niveau de ces puits connait une grande importance. Les prélèvements en eau, que se soit pour des usages domestique ou pour l'abreuvement des troupeaux, sont évalués à une quantité journalière de 180 m3. Le pompage au niveau des puits est de plus en plus aggravée par les conditions climatiques souvent sèches du fait de la création des habitats fixes au tour du lac et la concentration des troupeaux dans la zone pour les besoins d'eau et d'herbe.*

Mots-clés. *Zone humide – Parcours – Eau – Pression anthropique – Variations climatiques.*

I – Introduction

Forest ecosystems of the Middle Atlas, especially cedar forest, are undoubtedly a natural heritage of exceptional richness: Biological, economic and also cultural richness. The cedar tree is a symbol with excellence of the "Mediterranean region", and also a historical symbol of North African art whose powerful roots still feed a strong traditional current. The cedar forests of the Middle Atlas are still an exemplary in Morocco and occupy a vast region in Morocco where "the forest environment" prevails over a wide range. The Atlas cedar is a species listed in the global agenda of biodiversity. A development plan of management of the Natural Park of Ifrane was established by forest services in 1995 as part of the conceptual design of a network of protected sites and areas and management plans of National Parks in Morocco (BCEOM-SECA/ISR/IBM - AEFCS-BAD). This document was the basis of the decree creating the National Park of Ifrane, promulgated in October 2004, over an area of 51,800 ha.

This study has as main objectives: (i) to implement a participatory management to make a local community as responsible of natural resources management, (ii) to alleviate the dryness of the Lake Afenourir during dry conditions, (iii) to reduce the grazing pressure of pastoral ecosystems around the wetland site.

II – Materials and methods

The national Park zone of Ifrane makes about 50,000 ha and incorporates human activities and use rights of resources and space for local communities. One of the most important wetlands of the Middle Atlas is Afenourir Lake which is located in the south of Ifrane province, 30 kms south from Azrou (Ain Leuh rural community). The Afennourir Lake is a wetland of high altitude surrounded by cedar forest. It contains ecological, landscape, socio-economic and cultural values of great interest that let it be a part of Ramsar list since 1980. Indeed, the uniqueness of its landscape character in the North African region, and its avifaunal interest, allowed it to satisfy criteria of the Ramsar Convention (signed in Iran, 1971) which requires the taking of measures to preserve values of the site.

However, no appropriate management action has yet been taken despite the diversity of threats from many anthropogenic factors (overgrazing, settlement, poaching) and natural factors (less rainfall and snowfall) that endanger the functionality of the site and its sustainability. These constraints are increasingly exacerbated by climate variations in the latest decades and agri-silvopastoral imbalance existing in the Middle Atlas region.

III – Results and discussions

1. Land tenure and use

Land tenure issues, and uses of Afennourir area has several statutes that are subject to various rights and regulations of land use:

(i) The ethnic statute: It corresponds to grazing areas in the non forest land. This land status has some problems in terms of access to resources among the beneficiaries (Ait Mouli) and non-rights holders (Oulad Khawa) and is currently at present some illegal overtaking, particularly in terms of settling permanently on this area.

(ii) The private domain of the State: It corresponds to forest area which is under the tutelage of forest department. However, people keep their rights of land use (harvesting deadwood and grazing) on this space.

(iii) The domain status: It corresponds to land covered by water (wetland) and it's under the authority of the watershed hydraulic agency of Sebou.

2. Climatic variation effects on water resources of Afenourir Lake

A. Climatic variations and drought

The climate in the Afennourir region, and more generally in this part of the Central Middle Atlas, is defined as a Mediterranean mountain climate. The altitude influences the quantity and type of precipitation that takes in the form of snow during the winter period (November-February). The Ain Leuh station, located at about 4 km north-west of Afennourir Lake has an average annual rainfall of 567.6 mm and Azrou station have 827 mm.

The quantities of rainfall for the years 2007 and 2008 have not, particularly, exceeded 300 mm while the average rainfall in normal years exceeds 800 mm / year (Ain Kahla station).The water covered area of the lake in June 2008 (dry conditions) is 11.5 ha. This show, by comparison with the maximum water level of Lake that the lake is dried to 95%.This finding was also verified by the participatory card established with the shepherds and users. Indeed, to appreciate the drying importance of the lake by the population we used the approach by asking the population users to realize the current limits of the lake, the maximum of filling level of the lake and the level reached by water during the last two dry years.

B. Uses and water withdrawals estimation

Waters collected from the site are exhausted either directly from the lake or from wells opened in the nearby grazing (none forested) area.

The livestock watering on site. To satisfy the water needs of livestock on the site, we estimated the daily taking at 125 m^3 per day by multiplying 25 thousand grazing by the daily need of each individual sheep estimated to 5 liter/day.

The off-site livestock watering. Two means of taking off are practiced: (i) Tanks towed by animals: we identified 60 users who make three to four hours drive to seek for water, and they make two round-trip travel. The size of the tank is 350 liters. So that for this category the quantity of water took off is about 42 m^3 per day, (ii) Tractor tanks: With a size of 2000 liters, the number of users is six. For this category the quantity of water took off is about 12m^3 per day.

Domestic purpose Uses. For this category we have estimated the taking of water to 1.6 m^3 per day (20 settling users consuming about 80 liters per day).

C. The settlement of transhumant breeders

This phenomenon is qualified as a major constraint, because it is considered as a generator of other constraints such overgrazing, delimbing, etc. The settlement near the Afenourir area is encouraged by the water potential existing at the wetland. At the time of the study (2008), 41 habitats have been identified and are located within or adjacent to the wetland.

These houses are ephemeral; they are built of dry stone with wood frames covered with plastic material.

D. Impact on forest ecosystem

The nearby forest of Afennourir site is characterized by cedar species (*Cedrus atlantica*), *Crataegus laciniata, Quercus rotundifolia* (green oak) and *Fraxinus angustifolia*. The forest ecosystems around the Afenourir site are characterized by a high pressure and degradation effects.

Moreover, the local populations began to practice livestock association with non legal users, with as consequence an increase in livestock number. This led to overgrazing of silvopastoral ecosystems of Central Middle Atlas. In addition, the cedar trees at forest edges are consistently subjected to pruning and topping by shepherds settled or grazing near the lake. Afennourir site situation is extremely serious because, if some broad-leaved species (*Quercus rotundifolia*) seem to be more resistant to such practices, cedrus tree can be easily negatively impacted. In fact, the physiological imbalance that occurs due to the decrease in aerial biomass, comparatively to the root system, let to reduce photosynthetic functions witch causes the dead of trees.

3. Recommendations for sustainable management of resources

For each of the above problems, we proposed a number of concrete actions that will subsequently be a possible planning action.

The main objective is to alleviate the dryness of the lake. To attend this objective we propose to do the following actions: (i) deviation of water stream to control frequencies in order to achieve an optimal level of the lake about 300 ha. This action allows to maintain the lake not dried during the summer, (ii) drilling a well to the level of the deep aquifer. By a simple calculation we can deduce that a single well of a flow rate of 5 l / sec per day (5 * 12 * 3600 = 216 000 l) can satisfy all the needs of the population with water during the summer period. The quantity needed in this period was estimated at, approximately, 180 000 l / day.

The second objective concerns the reduction of grazing pressure. To achieve this objective it is suggested the following interventions: (i) resting implementation of degraded grasslands, (ii) possibility to regulate association herds (limitation or prohibition).

IV – Conclusion

The Afenourir Lake is subject to various pressures induced by over-pumping of water resources and overgrazing of nearby rangelands. In addition the sedentarization of herders which exacerbate the imbalance between ecosystem supply and permanent demand of settled populations in water and fodder.

However, no appropriate management action has yet been established despite the diversity of threats from many anthropogenic (overgrazing, settlement, poaching, etc) and natural factors (less winter snowfall) that endanger the functionality of the site and its sustainability. The need for an appropriate management plan is essential. The analysis in this study comprises both the inventory and synthesis of knowledge (ecological, institutional and socio-economic diagnosis) in Afennourir site ecosystems. So, some proposals are made aiming sustainable management including rehabilitation and habitat restoration.

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Policy approaches to grassland in planning documents of Ministry of Food Agriculture and Livestock in Turkey in the context of climate change

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Abstract. The grassland-based policy approaches are strongly linked with the livestock management because the livestock nutrition system which is based on grazing intensively particularly on hilly and remote areas. This situation has been predominantly reflected in planning as the interventions directed to regulating the grazing intensity (over-grazing) and erosion control. The most comprehensive and concrete interventions for the establishment of policies for grassland in the context of impacts, mitigating and adapting to climate change have been seen in the Strategic Plan (2010-2014) and Performance Programmes. The needed resources for implementing the measures regarding grassland management and climate change accounts for 6.5% of total budget in Performance Programme 2012 showing significant increase of importance given to climate change when compared with the Performance Programme 2011. The measures regarding erosion control in IPARD Programme may be classified as the practices for mitigation purposes although it is not implied as a measure targeted to climate change in the Programme.

Keywords. Grassland – Climate change – Planning – Strategic Plan (2010-2014) – Performance Programme.

Approches politiques sur les pâturages dans les documents de planification du Ministère de l'Agriculture, de l'Alimentation, et de l'Élevage en Turquie dans le contexte du changement climatique

Résumé. *Les approches politiques basés sur les prairies et les pâturages sont fortement liés à la gestion de l'élévage bétail à cause du système nutrition du bétail, qui est basé sur le pâturage en particulier sur les zones montagneuses et éloignées. Cette situation a été principalement reflété dans la planification des interventions visant à réguler l'intensité de pâturage (surpâturage) et le contrôle de l'érosion. Les interventions les plus complètes et concrètes pour la mise en place de politiques sur les pâturages dans le contexte de l'impact, l'atténuation et l'adaptation au changement climatique ont été vus dans le Plan stratégique (2010-2014) et des Programmes de performance. Les ressources nécessaires pour mettre en œuvre les mesures relatives à la gestion des pâturages et le changement climatique représentent 6,5% du budget total du Programme de performance 2012 montrant une augmentation significative de l'importance du changement climatique par rapport au Programme de 2011. Les mesures concernant le contrôle de l'érosion dans le programme IPARD peuvent être classés comme des pratiques à des fins d'atténuation bien qu'elle n'est pas impliquée en tant que mesure ciblée au changement climatique dans le Programme.*

Mots-clés. *Pâturages – Changement climatique – Planification – Plan stratégique (2010-2014) – Programmes de performance.*

I – Introduction

The effects of agricultural activities to global climate change accounts to 13% (Göl, 2007) while livestock are important sources of CH_4 accounting for one-third of global anthropogenic emissions of this gas. One of the mitigation options for livestock management is improving pasture quality especially in less developed areas since there has been observed proportionally greater increase in farm gross margin and animal productivity (Alcock and Hegarty, 2006).The other mitigation practices in the context of grassland management and pasture improvement are managing grazing systems, grazing intensity and timing, increase productivity by alleviating nutrient deficiencies, fire management, species introduction with higher productivity and deeper roots and pasture rehabilitation implementations (Smith *et al*., 2007). In the case of adaptation practices to climate change, the implementations play a critical role as a key proactive measure for coping with likely impacts. Adequate policy is a prerequisite for successful preparedness (Mendelsohn and Dinar, 2009).

The great majority of Turkish livestock farming is extensive. Due to insufficient and costly domestic fodder production, farm animals' nutrient needs are mainly covered by grazing. The extensive system leads to intensive use of pastureland (overgrazing) so interacts as increased erosion (MARA 2008). Approximately 86% of land is suffering from some degree of erosion. In this context, erosion is seen on 54% of forest land, 59% of agricultural land and 64 % of pastures (MARA, 2010). Figure 1 shows the changes in land use and number of animals in Turkey between the years 2000 and 2010. The land under the permanent meadows and pastures accounts for 14.6 million ha which has increased about 2 million ha compared to year 2000. The number of bovine animals is 11.4 million and ovine animals are 29.4 million in 2010. Although there has been a decrease in the number of ovine animals, the number of bovine animals has increased compared to year 2000.

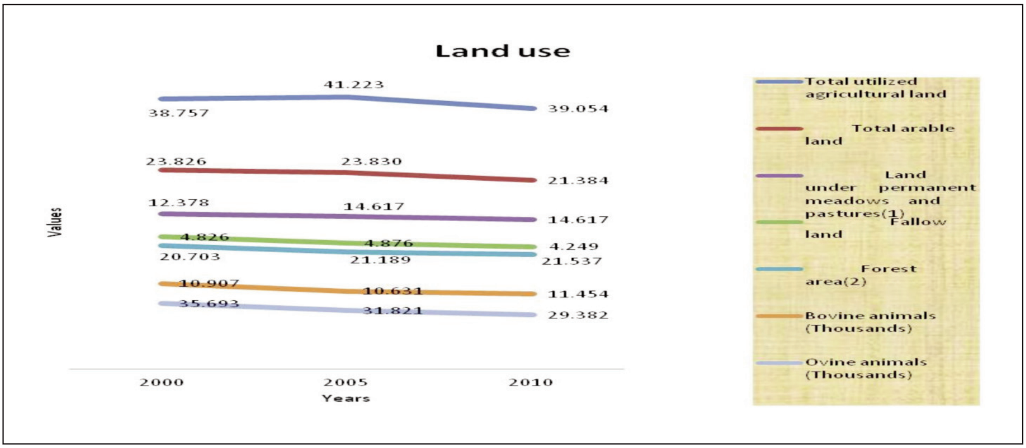

Fig. 1. The change in land use and number of animals in Turkey between 2000 and 2010. Source: The Summary of Agricultural Statistics, TURKSTAT, 2012.

The Ministry of Food, Agriculture and Livestock (MoFAL) was settled up in June 2011 following the abolishment of Ministry of Agriculture and Rural Affairs (MARA). MoFAL is the main institution responsible for making and implementing policy regarding livestock management, grazing land management and pasture rehabilitation.

In this study, it is aimed to reflect the policy approaches of the MoFAL on grassland management and pasture improvement through analysis of the planning documents by giving particular attention to climate change.

II – Policy approaches by planning

1. Rural Development Plan (2010-2013)

The Rural Development Plan (RDP) sets the priorities and policy framework for rural development in national basis. The measure "Rehabilitation and amelioration of pastures" is available under the strategic objective "Protection and Improvement of Rural Environment". The interventions are: preparation of grazing plans, raising awareness of farmers on planned grazing, natural terracing, afforestation to provide resting places for animals, weed control, supports to farmers for protection of pastures.

2. IPARD Programme (2007-2013)

Instrument for Pre-accession Assistance Rural Development (IPARD) Programme has been prepared to use the funds of European Union (EU) allocated under the fifth component of Instrument for Pre-accession Assistance (IPA). The general objectives are identified as: to contribute to the sustainable modernisation of the agriculture and food sector with improvement of EU acquis related food safety, veterinary, phytosanitary, environmental standards and to promote the sustainable development of rural areas.The priorities related to pastures/grasslands have been included in the second phase of the Programme under the preparatory actions for the implementation of agri-environmental measures (Axis 2 interventions). The preparations for the conferral of management decision from EU to implement these measures under this priority has been ongoing and is expected to start by 2013.

The programme targets the three particular problems related with agricultural activities and the use of land one of which is related to grassland is soil erosion under the measure named "Erosion Control (Measure Code 201, Sub-measure 1).

Actions targeted under erosion control have been constituted under three interventions which are: conversion of arable land to permanent extensive pasture, reduction of grazing period on eroded pastures thus giving time to grass species to complete their biological cycle and to vegetation recovery, management of soil cover and enhancement of rotation on arable land by replacement of spring crops especially on slopes by winter crops.

3. Strategic Plan (2010-2014) and Performance Programmes

Strategic Plan (2010-2014) includes the mission, vision, main objectives and priorities as well as measurable indicators of the MoFAL. The performance programmes have been prepared in yearly bases and monitors the Strategic Plan. The strategic plan refers the measures regarding grassland management and climate change under the priority axes called "protection and sustainable use of environment and natural resources".

The identified measures are: 1) protection and sustainable use of agricultural land including the activities: land evaluation studies, preparation of land use plans and consolidation of parcels, 2) development and extension of agri-environmental implementations; 3) improvement and sustainable use of pastures including the activities: formation of inventory for pastures, preparation of maps and identification of borders, raising awareness, rehabilitation of pastures, erosion control.

The measure regarding establishment of early warning system includes the monitoring of risks like drought and flood which are caused by the climate change. The measure implementation of agricultural insurance includes the support payments accounting 50 % of the insurance bills of farmers making agricultural insurance. The measure regarding providing of the losses of farmers due to natural disasters includes the payments made to farmers who suffer from the natural disasters to sustain their farming activity. The resources needed for implementation of these measures are seen in Table 1.

Table 1. The needed resources identified in Performance Programmes 2011 and 2012

Measure	Budget for 2011 (Million TL)	% in total	Budget for 2012 (Million TL)	% in total
Protection of agricultural land (Measure No 9)	0.2	0.002	321.5	3.06
Agri-environmental implementations (Measure No 13)	20.3	0.24	11.5	0.11
Improvement and sustainable use of pastures (Measure No 14)	21.9	0.26	23.6	0.22
Early warning system (Measure No 17)	0.14	0.016	50.5	0.48
Agricultural insurance (Measure No 18)	99.4	1.17	263.6	2.51
Natural Disasters (Measure No 19)	10.6	0.12	11.3	0.11
Total	152.5	1.8	682	6.5

Source: Performance Programmes 2011 and 2012.

The resources identified in Performance Programme 2011 account for 1.8% of total budget. The amount allocated for agricultural insurance is the major one which account for 1.17% of total budget. The needed resources identified in Performance Programme 2012 account for 6.5% of total budget showing significant increase of importance to climate change effects. The financing for protection of agricultural land and payments for agricultural insurance is comparably higher than the other measures.

III – Results and discussion

The policy framework in existing policy documents of the MoFAL refers mainly the structural problems of agriculture in the Country and targets generally the productivity, food quality and safety, modernisation of agriculture and food sector and integration to markets. The environment related priorities are particularly found in every policy document in which the grassland management is emphasised however the climate change policy implications have remained weak.

It is also observed in policy approaches that the grassland-based policy implications are strongly linked with the livestock management because of the livestock nutrition system which is based on grazing particularly on hilly and remote areas. This situation has been predominantly reflected in planning as the interventions directed to regulating the grazing intensity. Although the interaction between the environment and grassland management has been noted in planning, there has not been seen any evidence of obvious approaches for the establishment of policies for grassland in the context of impacts, mitigating and adapting to climate change.

Overgrazing causes destruction of the natural composition of the grassland and also decreases rangeland efficiency which is leading to erosion. The fact that pastures are faced with erosion problem more than other land which is about 64%, have resulted in policy implications to control the erosion problem which is particularly seen in IPARD Programme. Although it is not implied as a measure targeted to climate change, the measures regarding to erosion control in IPARD programme may be classified as the practices for mitigation purposes. Although the interventions under the erosion control are to be implemented at the pilot level, the implementation of this measure will be a great experience since the programme is an operational one with a budget allocated and institutional set up to be provided.

The RDP prepared in national basis includes the interventions for protection of pastures like preparation of grazing plans, raising awareness of farmers on planned grazing, natural terracing, afforestation to provide resting places for animals, weed control, supports to farmers for protection of pastures. There cannot be seen the relation between climate change and grassland management however, the interventions may be implied as for mitigation purposes.

The Strategic Plan and Performance Programmes may be considered as the most comprehensive and detailed policy documents regarding the grassland and climate change. There can be seen the measures for mitigation purposes and for decreasing the impacts of climate change (early warning system, natural disasters, agriculture insurance). The resources identified in Performance Programme 2012 account for 6.5% of total budget showing significant increase of importance to climate change when compared with the Performance Programme 2011.

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Agro-pastoral production system of Egypt. Climate change, vulnerability and opportunities for poverty alleviation

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Abstract. Agro-pastoral production system in the northwestern coastal zone of Egypt is characterized by varied agricultural activities including raising small ruminant's flocks, beside cultivation of barley and some fruits as Olives and Figs. This system has been fragilized by drought that has become more frequent and worsened by human activities. A survey study was conducted to identify and analyze the causes, impacts and management mechanisms of drought crisis in this area. The sample of the study encompassed 162 agro-pastoralists. Major findings were extracted for the causes of drought vulnerability included socio- economic, livelihood and agriculture. The annual income of the household reduced by 58.3% in the drought years. The various Bedouins coping mechanisms were inadequate to reduce the negative impact of drought. Results highlight small ruminant role on alleviating poverty and helping household to deal with climate variability. The share of small ruminant in the households economy in the dry year ranged from 60%-67%.The perception of small ruminant to escape poverty is completely linked to the flock size. Based on the findings and conclusions of this study, specific recommendations were made to reduce effects of drought crisis.

Keywords. Agro-pastoral system – Survey – Drought vulnerability – Small ruminants – Poverty alleviation.

Système de production agro-pastorale de l'Egypte. Changements climatiques, la vulnérabilité et les possibilités de réduction de la pauvreté

Résumé. *Le système de production agro-pastorale dans la zone nord-ouest de la côte de l'Egypte se caractérise par diverses activités agricoles, y compris élevage des petits troupeaux ruminants, à côté de la culture de l'orge et certains fruits comme les olives et les figues. Ce système a été fragilisé par la sécheresse qui est devenue plus fréquente et aggravée par les activités humaines. Une enquête a été menée afin d'identifier et d'analyser les causes, les impacts et les mécanismes de gestion de crise de la sécheresse dans ce domaine. L'échantillon de l'étude comprenait 162 agro-pasteurs. Les principales conclusions ont été extraites pour les causes de la vulnérabilité à la sécheresse inclus socio-économique, moyens de subsistance et l'agriculture. Les résultats mettent en évidence le rôle des animaux du ferme sur la réduction de la pauvreté et pour aider les éleveurs à faire face à la variabilité du climat. La perception de l'élevage pour échapper à la pauvreté est complètement liée à la taille du troupeau. Sur la base des constatations et des conclusions de cette étude, des recommandations spécifiques ont été faites pour réduire les effets de crise de la sécheresse.*

Mots-clés. *Système agro-pastoral – Enquête – Vulnérabilité à la sécheresse – Petits ruminants – Réduction de la pauvreté.*

I – Introduction

Egypt has poor rangelands, although vast areas of more than 10 million ha exist. According to FAO (2010) rangelands provide only 5 percent of animal feed in Egypt. Hegazi *et al*. (2005) indicate that the main areas of rangelands are distributed over the northwestern coastal zone (NWCZ), the Sinai Peninsula and the Halayeb- Shalatyin region in the South East corner of Egypt bordering the Red Sea. The NWCZ is characterized by low rainfall (<150mm) and high fluctuation of the precipitation. Pastoralists and agro-pastoralists are the dominant economic activity. Economic survival of the peoples of the region depends on management of sheep and goats, beside cultivation of barley and some fruits as Olives and Figs. The zone has witnessed major changes over the last 50 years; demographic growth, urbanization and touristic development. More recently, the zone has faced a long drought period from 1995 to 2011 that has negatively affected rangelands, agriculture, livestock production and household livelihood. An understanding of the socio-economic impact of drought and of farmers' coping mechanisms is essential in designing technological and policy interventions for more effective drought mitigation. This study was initiated to identify and analyze the causes, impacts and management mechanisms of drought crisis in this area. It also contrasts how Bedouins poor in livestock (BPL) fared compared to those wealthy in livestock (BWL).

II – Material and methods

The survey was conducted by way of personal interviewers with 162 agro-pastoralists covering three districts (Matrough, Neguila and Sidi barani). The survey was carried out over a period of two years (February 2008 to August 2010) using structure questionnaires contain a total of 90 items, grouped into Bedouins production resources, their production constrains, management practices, input and output parameters, small ruminant and agriculture production performances.

Whole farm budget was performed using Microsoft Excel spreadsheet to estimate economic losses due to drought at the Bedouins level. Families were stratified into two categories according to flock size. The gross margin is estimated for each of farm activities as the difference between total revenue and total variable costs. The costs and benefits were converted into monetary terms using farm gate prices. Least squares analyses of variance were conducted using the general linear model procedure of SAS (1990). Statistical model included drought, flock size and drought –flock size interaction. Three Bedouins coping mechanisms were relied to reduce the negative impact of drought, namely; 1- decreasing flock size, 2-selling their lambs and kids after weaning directly and 3 - move with their flocks searching for feed. Simulation techniques were used to apply the various scenarios on farm models. The model was a modified version of the Texas A &M sheep simulation model (Blackburn and Cartwright, 1987a, b, c). Detailed description of the simulation model is presented in Almahdy and Metawi (2000). Small ruminant flocks were simulated for 10 yr life-cycle production.

III – Results and discussion

Drought produces a large number of impacts that affects the social and economic standard of living. Analysis of data showed that the drop in agricultural income during a drought year was in the range of 40-80 per cent of average rainfall -year income. The effects of drought on the flock size changes and flock performance for (BWL) compared to (BPL) are presented in (Table 1). The average flock size and annual sheep and goat productivity were declined by only 12.9%, 3.2% and 4%, respectively for the (BWL). On the other hand, the drought under (BPL) conditions has leaded to reduce of sheep and goat flocks' productivity by 23.4 and 16%, respectively. Furthermore, their average flock sizes were reduced by around 47% which reflecting that sheep and goat are important physical assets, which can be liquidated at times of financial need.

Although the financial analysis of sheep and goat production gave positive return, drought greatly affected its profitability. The share of small ruminants in the household's economy in the average rainfall year were estimated as 43.6% and 47.7% among (BWL) and (BPL), respectively. The corresponding figures in the dry year were estimated as 59.8% and 67%,respectively. Shomo (2004) reported that sheep are the principal economic activity in the dry areas, contributing 57-89% of the income of small scale producers.

Table 1. The effects of drought on small ruminant flock performance

Characters	Average year		Dry year		F-test		
	BWL	BPL	BWL	BPL	D	FS	D×FS
Flock size, head	225	48.9	196	26			
Source of income:							
Crop cultivation,%	22.6	15.8	4.0	1.3			
Fruits:							
Olive,%	8.3	6.2	5.9	2.0			
Fig,%	13.9	8.4	9.8	2.8			
Small ruminants,%	43.6	47.7	59.8	67.0			
Non-farm income,%	11.6	21.9	20.5	26.9			
Productivity:							
Sheep[1]	28.2	26.5	27.3	20.3	×	NS	××
Goats[2]	19.9	18.7	19.1	15.7	NS	NS	×
Financial analysis:							
Profit / ewe, LE[3]	428	465	135	160	××	×	×
Profit / doe, LE	227	250	70	96	××	NS	×

1 = Kg lambs production/ewe/year; 2 = kg kids production/doe/year; 3 = $ = LE5.8; D = drought; FS = flock size; $^{\times}$ p<0.01; $^{\times\times}$ p<0.001; NS = non significant.

The frequent occurrence of drought results in widening the gap between the feed supply and nutrient requirements of small ruminants. The main expenses are due to the feeding when supplements are used. In addition to severe stressors like crop failures and unemployment makes (BPL) more sensitive to droughts. The annual income of the household reduced by 58.3% in the drought years. Bedouins attempted to compensate this loss by seeking additional employment in the non-farm sector. This additional income, however, was compensating the loss in farm income by only 9-16%. Bedouins relied on three main mechanisms to recoup this income loss: decreasing flock size, selling their lambs and kids after weaning directly (58% of the breeders), and move with their flocks searching for feed. Two types of movements are observed in the region i.e. within and outside the region. In average rainfall years the within movements are observed where sheep and goats move from dry areas to wet areas where natural vegetation is available. In dry years, however, flocks of sheep and goats move to adjacent provinces(e.g. Alexandria, Behaira and Fayoum) where irrigated fodder and crop residues are available.. These adjustments helped recover 19- 28% per cent of the total loss in income. Households still ended up with more than 50 per cent lower income than in a normal year, despite all these adjustments. Thus the various Bedouins coping mechanisms were inadequate to prevent a shortfall in income. Therefore, Bedouins make adjustment in their expenditure items of his budget to reduce the negative impact of drought. Household budget in an average rainfall year was spent purchase of food (36%), followed by clothing (16%), school fees (14%), medical expenses (10%), social activities (7%), and other items (17%). On the other hand, income in a drought year was spent mostly on purchase of food 78%. However, Egyptian government also intervenes to assist Bedouins, through:

(i) Distribution of subsidized feedstuffs or subsidized loans to buy feedstuffs. The objective to help smallholders to improve animal productivity and to get additional revenue through lamb and kids fattening activity.

(ii) Investments in digging of wells, cisterns and water harvesting systems.

(iii) Distributed of Damascus bucks as a tool for goat genetic improvement. The main advantages of the Damascus crossbreds were reported by Aboul-Naga *et al.*, 2008.

IV – Conclusion

It can be concluded that, the various Bedouins coping mechanisms were inadequate to reduce the negative impact of drought. On the other hand, the share of small ruminants in the household's economy in the in the dry year were ranged from 60% to 67%. So, improving small ruminant production systems can make a significant contribution to reduce the negative impact of drought. The challenge is to develop mechanisms to provide poor Bedouins with feedstuffs and Damascus goat bucks either through credit loans or through livestock breeders associations. Also, reducing animal feed cost by enhancing crop byproducts nutritive value is more recommended during drought periods. However, there are many different kinds of agro-industrial byproducts available in the region, which is seriously under exploited. Investment in rural education can increase return to labour as well as help diversify income. Using poor quality underground water and drip irrigation system is considered in drought years.

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Session 2
Selection of pasture and forage species under climate and socio-economic changes

Selection of pasture and forage species adapted to changing environmental conditions in Mediterranean climates

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Abstract. Over the last two decades, many agricultural regions of the Earth with Mediterranean climates have suffered from changing climatic conditions in the form of extended periods of intense drought. These droughts have been associated with an increasing awareness of and concern about climate change and the likely future nature of Mediterranean-type climates. Coping with climate change will be a difficult problem to address because most models for Mediterranean-climate regions predict drier and hotter environments such as for example, in south-western Australia and the western Mediterranean Basin. In south-eastern Australia, while the overall amount of rainfall is predicted to decline, summers are expected to receive more rain and winters become drier. Assuming these predictions are correct, the pastures and rangelands of these regions will experience stresses that without intervention or altered management may cause their wholesale collapse. Not only would this seriously reduce the production of food and fibre from grazing animals it would also lead to a decline in the numerous ecosystem services provided by grasslands such as the services which improve and protect soil structure contributing to the sustainability of cropping through the reduction of nitrate leaching and the maintenance of biodiversity. In Australia, pastures research to adapt to these future climate scenarios has so far primarily focussed on improving plant growth models and assessment of the ability of agricultural soils to sequester more atmospheric carbon. Around the Mediterranean Basin, forage plant research is still mainly focussed on annual crops, cereals and irrigated lucerne. In both regions the focus now needs to shift to the development of more climate resilient perennial plants and agronomic systems able to use these more resilient plants efficiently. Pre-breeding research is needed to identify germplasm resources within the major perennial pasture species with enhanced levels of drought and heat tolerance. This paper describes methods to identify and measure two of the important drought tolerance traits used by perennial herbaceous plants, dehydration tolerance and summer dormancy.

Keywords. Perennial forage species – Dehydration tolerance – Summer dormancy – Climate change – Water stress.

Sélection d'espèces fourragères pour leur adaptation aux conditions environnementales prévues sous changement climatique en climat méditerranéen

Résumé. *Durant les deux dernières décennies, la plupart des régions agricoles qui dans le monde ont un climat méditerranéen, ont subi des périodes de sécheresse intense sous l'effet du changement climatique. Ces sécheresses ont contribué à une prise de conscience croissante des risques associés aux changements globaux et notamment aux implications environnementales futures pour toutes ces zones bioclimatiques. Le défi à relever pour s'adapter aux effets du changement climatique est difficile, dans un contexte où la plupart des modèles prédisent des environnements plus chauds et plus secs comme par exemple, dans le sud-ouest de l'Australie et l'ouest du bassin méditerranéen. Dans le sud-est australien par contre, alors que le montant des précipitations devrait décliner, les étés pourraient être plus pluvieux and les hivers plus secs. En supposant que ces prédictions sont correctes, les pâturages et les parcours de ces régions seront soumis à des stress abiotiques qui, dans l'hypothèse d'aucune modification de gestion, pourraient entraîner des dégradations drastiques de la ressource fourragère. En effet, ces contraintes accrues du milieu pourraient* *affecter non seulement la productivité animale mais également les nombreux services éco-systémiques rendus par les communautés herbacées comme l'amélioration et la protection des sols contribuant à la durabilité des systèmes de culture, la protection des nappes phréatiques et le maintien de la biodiversité. En Australie, la recherche pour l'adaptation des systèmes fourragers aux futurs scénarios climatiques s'est surtout concentrée sur l'amélioration des modèles de croissance végétale et l'évaluation des sols agricoles pour séquestrer plus de carbone atmosphérique. Autour du bassin méditerranéen, la recherche en matière fourragère se consacre essentiellement aux cultures annuelles, aux céréales et à la luzerne irriguée. Dans les deux régions, il est maintenant urgent de s'orienter vers le développement d'espèces pérennes et de systèmes agro-écologiques plus résilients. Des efforts de sélection sont nécessaires pour identifier des ressources phyto-génétiques parmi les principales espèces pérennes prairiales avec des niveaux élevés de tolérance à la sécheresse et aux fortes températures. Cet article décrit des méthodes pour identifier et mesurer deux des traits les plus importants de ces espèces pérennes herbacées qui sont la tolérance à la déshydratation et la dormance estivale.*

Mots-clés. *Espèces fourragères pérennes – Tolérance à la déshydratation – Dormance estivale – Changement climatique.*

I – Introduction

World population has more than doubled in the last 50 years with much of the increase occurring in developing nations. The development of short-straw, high harvest-index cereals through the Green Revolution was instrumental in allowing the feeding of this growing population. Similar to the rest of the World, in regions with Mediterranean climates this population surge is associated with the major and ongoing relocation of people from rural to urban areas. This internal migration has resulted in governments increasingly redirecting their resources, including those associated with agricultural research, away from rural and toward urban-based objectives (Cribb, 2010).

Regions with Mediterranean-type climates have come under increasing climatic stress in the last few decades as the level of precipitation in many of these regions has undergone a decline. This drier trend, indicative of climate change, is predicted to continue (I.P.C.C., 2007) and evidence of this has been the extended droughts that have afflicted the western Mediterranean Basin and southern Australia in the decade 2000-2010. In most regions, rainfed agriculture is likely to face more climate-related risks associated with water shortages (Trnka *et al*., 2011). In the Mediterranean basin, in particular, the rate of warming may reach +4°C in the summer, leading to an additional month of summer conditions (Giannakopoulos *et al*., 2009) and greater water shortages (Bindi and Olesen, 2011; Supit *et al*., 2010). Therefore the decline of grassland production, pasture failures and long-term degradation from drought might gradually become more widespread in some regions (Briske *et al*., 2003). In some cases the predicted changes in climate are also associated with changes in the distribution of precipitation. For example, in south-eastern Australia while the overall amount of rainfall may change little it is anticipated that the cooler seasons of the year will see a decline in rainfall whereas there may even be an increase in rain over summer. Such climatic change could lead to major alterations in the botanical composition of grasslands and pastures with substantial implications for grazing animal production and the ecosystem services provided by these grasslands (Godfree *et al*., 2011).

Concerned about these trends, pasture and grassland scientists have made special efforts in the last decade to advance understanding of the traits which improve drought survival of our key pasture species and some plant breeders have begun to incorporate these traits into new cultivars to enhance the resilience of pastures to future climate changes. This paper will briefly present methods to identify and measure two of the key drought tolerance traits of temperate pasture grasses, viz. summer dormancy and dehydration tolerance, and also suggest future research directions to further improve these screening methods.

II – Traits conferring enhanced survival of drought in temperate perennial grasses

Most research studying the effects of drought on plant growth and production has concentrated on plants of an annual habit with much of it focussing on the maintenance of crop yield or production when subjected to only moderate moisture deficits (Ludlow, 1989; Blum, 2005). Indeed the study of plant response to severe drought and of traits that improve survival particularly for perennial plants has received much less attention, being a more recent development with much work having been stimulated by the droughts of the last decade which killed many plants in grasslands and forests (Volaire *et al.,* 1998a, McDowell *et al*., 2008). The drought survival enhancement traits found within perennial herbaceous plants of agricultural and industrial importance include dehydration avoidance/delay, dehydration tolerance (Ludlow, 1989; Volaire *et al.,* 2001) and summer dormancy (Volaire and Norton, 2006). Desiccation tolerance, a trait allowing some very highly specialised species termed “resurrection plants” to rehydrate and recommence growth and reproduction after desiccation to air dryness (Gaff, 1971) should be mentioned for completeness. However, it seems unlikely that this trait can by utilised in current agricultural production systems.

1. Identification of dehydration tolerance and summer dormancy

The degree that a plant controls its water potential as it experiences intensifying moisture deficit has been the primary determinant of whether it is considered to express dehydration avoidance (syn. dehydration postponement or delay) or dehydration tolerance (Levitt, 1980). Plants which respond to moisture deficit by employing traits allowing them to maintain a high water potential, e.g. extensive root development to maximise water extraction, high stomatal resistance to minimise water loss, are considered to be dehydration avoiding. Conversely, those that allow water potential to fall while continuing to maintain function are classed as following a dehydration tolerance strategy and are presumed to employ traits conferring cellular tolerance to low water status, e.g. high levels of intra-cellular fructan to maintain cell membrane integrity, enhanced dehydrin expression (Turner, 1986; Turner, 1997; Close, 1997; Demel *et al*., 1998).

The above terminology was developed primarily to describe the drought response strategies of crop plants with an annual habit, so it is not surprising that these terms become inadequate when confronted with perennial plants, not least those that express traits found solely in perennial plants such as summer dormancy. Indeed, the key factors to differentiate and identify drought response strategies of perennial plants include, season of expression and moisture environment. Thus, because summer dormancy can only ever be expressed in the field in summer it can only ever be observed in that season. Indeed, after the induction under low temperatures and short photoperiods of winter, summer dormancy is expressed under the high temperatures and long photoperiods of summer and in the genotypes which have the trait, expression will occur independent of soil moisture level (Ofir, 1975; Ofir and Kigel, 1999; Volaire and Norton, 2006).

Dehydration tolerance can be expressed in any season of the year although it is only ever expressed in response to moisture deficit. To avoid confounding with summer dormancy when testing perennial plants it is therefore advisable to test for expression of this trait in the cooler seasons of the year when photoperiods are short.

2. Measurement of dehydration tolerance

Two methods to measure dehydration tolerance will be described here. The first considers that the minimum soil moisture conditions in which the plant is just able to survive is the primary index to rate dehydration tolerance (Volaire *et al*., 2005). The second method considers that the length of time that a plant can survive after it has entered the stage when stomata are permanently closed is an important component in dehydration tolerance (Bolger *et al*., 2005) although it also includes a factor accounting for differences in final plant survival.

Within one series of testing and using a scale developed with this second method, differences in dehydration tolerance (scale of 10 to 0, where 10 is maximum dehydration tolerance) and associated plant mortality varied substantially. For example, across three cultivars (cvv) of cocksfoot dehydration tolerance ranged from 10 to 5.8, across two cvv of tall fescue ratings of 6.8 and 3.3 were measured, while across four cvv of phalaris scores varied from 4.5 to 3.5 (Norton, 2007). Within cocksfoot the different dehydration tolerance ratings equated to cultivar mortality ranging from 0 to 42%, in tall fescue from 18 to 59% and in phalaris from 18 to 38%.

Typically dehydration tolerance is measured in pots where it can be assured that plant roots have fully exploited the available soil volume prior to the imposition of the drying cycle. Ensuring full exploitation of the pot soil prior to drying cycle imposition overcomes concerns voiced about the artificial soil physical constraints associated with some pot experiments where the failure to achieve full root exploitation can compromise experimental results (Passioura, 2006).

In both methods, pot soil water content is measured by weighing at regular intervals over the duration of the drying cycle to illustrate the rate of plant water use over the period of drying. This measurement also determines the commencement of the stage (commonly termed stage 3) from which plants have permanently closed stomata to the point of plant death (Sinclair and Ludlow, 1986).

To remain alive a perennial grass plant must maintain its youngest vegetative tiller. This tissue is usually in the form of a meristem enclosed by older leaves. As a drought intensifies and lengthens it is typically difficult to determine the exact point of plant death because the youngest meristem is normally enclosed by older leaves which themselves senesce more and more as the drought progresses. This problem is addressed by undertaking sequential rehydration of certain pots assigned for this purpose at short and regular time intervals, to examine the subject plants for regrowth and thus life, while allowing the drought to continue in other pots within the trial. By this means it is possible to determine the soil moisture content and time of death of the desired proportion (usually 50% of the sample) of the test genotype.

For Method 1, the soil moisture content at which 50% of the sample of the test genotype is dead is the criterion of dehydration tolerance and this figure is simply quoted. Alternatively for method 2 (Norton, 2007),

Dehydration tolerance = Stage 3 duration (days) of cv y * (1 - proportion of y death).

Both methods rank the relative level of dehydration tolerance of one genotype with respect to the others only within the suite of genotypes being tested. A thorough measurement of environmental parameters, including ambient aerial and soil conditions should occur to enhance comparability of one series of dehydration tolerance measurements with another. Moreover, the development and use of a suite of "control" genotypes within the species being studied of high, moderate and low levels of dehydration tolerance is essential because it will further enhance the comparability of different series of assessments.

3. Summer dormancy

A. Nature and identification

Dormancy, whether expressed in the summer or winter, is an adaptive physiological response state primarily aimed at ensuring survival of perennial plants, allowing the plant to minimise exposure to the season when the most stressful, life-threatening conditions prevail (Vegis, 1964). It is therefore, a form of stress avoidance as during the period of dormancy, the metabolic rate of plants declines greatly (Volaire *et al.,* 2005) and those life processes which are most adversely affected by unfavourable environmental conditions, e.g. growth and reproduction, are halted (Hoffman and Parsons, 1993). Summer dormancy is defined as an endogenously controlled and coupled series of processes comprising the cessation or reduction of leaf growth, the complete or partial senescence of herbage and in some cases the endogenous dehydration of meristems expressed even under non-limiting moisture conditions. However, it is always expressed under the environmental conditions typical of Mediterranean summers (Volaire and Norton, 2006).

Dormancy was not observed in the earlier drought tolerance work of the annual crop physiologists (Ludlow, 1989) so that its role in enhancing drought tolerance of perennial plants has, in contrast to other strategies, been particularly neglected. The summer dormancy trait commonly occurs in those temperate perennial grass species of Mediterranean origin found in regions usually experiencing summer dry periods of four months or more (Cooper, 1963). In the Mediterranean Basin most of these regions are found in North African and Middle Eastern countries (Neal-Smith, 1955). Other research has shown that the trait also exists in North American species growing in similar environments (Laude, 1953). Observations suggest that the trait exists at least in the Australian grasses, *Austrodanthonia caespitosa* and *Elymus scaber* (C. Waters and J. Virgona pers. com.) from summer-dry environments although this still requires experimental confirmation.

Summer dormancy is a powerful trait that enhances plant survival over hot, dry summers. Several field trials conducted over a range of seasons and environments and in different continents showed that grasses with the trait had better survival invariably over dry summers than grasses of the same species without the trait (Malinowski *et al*., 2005; Norton *et al*., 2004). Other more detailed, field-based, physiological studies have quantified this advantage, showing that the highly summer-dormant cocksfoot (*Dactylis glomerata*) cultivar Kasbah had 28% greater survival than the non-dormant, Mediterranean cv Medly through a prolonged and intense summer dry period during which 913 mm of evapotranspiration accumulated (Norton *et al*., 2006a). Under similar conditions the summer-dormant tall fescue (*Festuca arundinacea*) cv Flecha had 30% greater survival than the non-dormant cv Demeter (Norton *et al*., 2006b).

Breakthroughs in our understanding of the anatomical basis of dormancy are also quite recent. These studies have focussed most intensively on birch (*Betula* spp.) expressing the trait in winter (Rinne and Schoot, 2003; Rinne *et al*., 2001) and on the herbaceous geophytes, *Tulipa* spp. and *Ranunculus asiaticus,* which express summer dormancy (Kamenetsky, 2009). The centre piece of these studies has been the microscopic imaging of dormant apical meristems. This has clearly depicted the isolation and consequent inability of adjacent cells within the apex to communicate with one another due to the plugging of inter-cellular plasmodesmata which imposes a complete absence of growth and greatly reduced cellular activity.

Although this research has not occurred in those temperate perennial grasses which express summer dormancy, the physiological nature of the trait in these species is sufficiently similar to the geophyte subjects to assume that comparable anatomical mechanisms to those observed in the geophytes operate also in the grasses. However, as the complexity of the natural world continues to astound biologists telling us that it is unwise to make too many assumptions, this is a field of research which truly beckons.

B. Measurement

Several approaches to the measurement of summer dormancy are cited in the literature. These methods are based on: (1) the level of herbage production under full, continuous irrigation over the summer (Laude 1953); (2) assessment of production of new tillers or “greening-up” after a mid-summer storm (or mid-summer irrigation) occurring in the middle of an extended summer dry period (Oram 1983), and (3) measurement of herbage senescence after an extended summer dry period (Silsbury 1961; Lorenzetti *et al.* 1981; Ceccarelli and Somaroo, 1983). This third technique has been shown subsequently to be quite unreliable often giving inconsistent results and therefore is not recommended (Norton *et al*., 2008). It was also noted that summer dormancy is most reliably expressed in the field under the correct environmental factors of both induction and expression, i.e. vernalisation followed by long days and increasing temperature (Norton, 2007). Summer dormancy has been reliably reproduced and studied in long pots (<1.1 m deep) in which substantial soil moisture tension could be developed when water was applied from the bottom of the pot (McWilliam and Kramer, 1968).

Within any temperate perennial grass species it can be difficult to differentiate the responses plants use to avoid or tolerate dehydration from those associated with the expression of summer dormancy. This is because under summer moisture deficit these traits are expressed in a similar way, viz. cessation of growth, senescence and shedding of herbage, tolerance of low tissue water potential in some species.

This superficially similar behavior under summer drought is well illustrated by comparing the response to varying levels of summer moisture of the cocksfoot cultivars Medly and Kasbah, known for their contrasting expression of summer dormancy. Indeed, in fully irrigated and summer storm trials where plants were well-hydrated, dormancy scores of cultivar (cv) Medly were quite low (range 0-2.4 where 10 is maximum dormancy) suggesting a summer-active grass able to produce new herbage whenever moisture was non-limiting (Norton *et al.,* 2008). In contrast, when the assessment was made 47 days after the commencement of a summer drought, with plants that were no longer well-hydrated, the same cultivar had a dormancy score of 6.2, a value normally indicating a moderately high level of dormancy. However, while Medly is a plant with a quite high level of drought survival ability (Volaire *et al.* 1998) this drought survival is due both to dehydration avoidance and tolerance, with avoidance expressed by the shedding of foliage (Norton *et al*., 2006a) leading to reduced transpiration with the associated conservation of soil water while dehydration tolerance expressed through tolerance of low tissue water content in its meristems increases as drought intensifies (Volaire and Lelievre, 2001). The strong growth response of Medly to non-limiting summer moisture occurring under either irrigation or in response to a summer-storm clearly shows that it is not summer-dormant. In contrast, cv Kasbah showed no growth response to non-limiting summer moisture irrespective of how the moisture was applied. In summer Kasbah expressed a consistent and similarly high level of dormancy (range of 8.7-9.9), characterised by complete cessation of growth, full senescence of herbage and substantial dehydration of meristems under either full summer irrigation or after a simulated summer storm thus confirming the strong expression of this trait (Norton *et al*., 2006a).

III – Conclusions

Substantial progress has been made recently in the characterisation and measurement of summer dormancy. The same cannot be said about dehydration tolerance and there is an urgent need for further research to compare, refine and develop methods for the measurement of this trait. Only two methods have been described here but these should not be considered as fulfilling all the potential requirements to measure this trait. Method 1 is attractive because of its simplicity, although the degree of precision that it provides would probably vary depending upon the moisture holding capacity of the soil used and it may be inadequate for some situations and depend upon the plant material being assessed. Method 2 provides potentially for a greater degree of precision but it is more complex with all the attendant technique problems that are associated with greater complexity.

The great ability of summer dormancy to improve survival over hot, dry summers makes this a potentially attractive trait even in environments where summers are only occasionally dry. However, when a summer dormant grass is removed from a Mediterranean climate, the degree of expression of the trait may be much reduced. For example, during recent abnormally cool and wet summers at Canberra in south-eastern Australia, on-going, although slow growth of cocksfoot cv Kasbah has been observed throughout the summer (Norton, 2011). Therefore, in climates where substantial summer rainfall is common it may be imprudent to use summer dormant forages because summer active weeds are likely to invade the pasture to exploit any moisture not used by the forage. Alternatively, it might be possible to develop a stable pasture comprising both summer dormant and summer active genotypes where any moisture available throughout the year can be utilised by one of the forage species. However, this “ideal” pasture needs substantial research and development input before it can be used in agriculture (Norton, 2010).

In Australia the primary selection criterion used by perennial pasture plant breeders to improve survival in hot, dry environments remains field persistence. Persistence is determined by measuring density in the field of the subject plant. The longer the subject maintains an acceptable density in the field, the more persistent it is considered. However, while persistence must always be measured it is not a trait within itself. Rather persistence is the product of a number of traits which when combined in interaction with environmental factors lead to the outcome we subsequently recognise as persistence.

Recently Australian breeders have sought to improve the tolerance to the acidic soils so widespread across south-eastern Australia particularly in phalaris and lucerne, species reputed to be acid soil intolerant (Culvenor *et al*., 2011). If this breeding objective is attained it is possible that superior drought survival will also be obtained in these species because acid soil tolerance should confer enhanced root growth and make available to plants a greater volume of soil for water extraction (Norton *et al*., 2012).

Given the major improvement that dehydration tolerance and summer dormancy can make to survival of periods of intense drought and heat together with the increasing frequency of these events we suggest that plant breeders should consider selecting for these traits, prior to field screening, as this is highly likely to improve overall persistence.

Acknowledgments

Thanks are due to Meat & Livestock Australia Ltd and to the European Union (project INCO-MED, PERMED) for financial support.

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Quality and dry matter yield of triticale forage in winter and late-spring in Southwestern Spain

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Abstract. Special soil and climate conditions of the *dehesa* ecosystem in the south west of Spain have an influence in herbaceous biomass production, causing moments with a lack of feed for extensive livestock along the year. In this paper the possibility to introduce triticale crop for a double use (by grazing or cutting in winter and cut at late spring) to cover winter and summer deficiencies in animal feed, has been studied. Triticale varieties were, var. Fronteira, var. Alter and two experimental cultivars from the Portuguese National Agricultural Research Institute, called INIA 1 and INIA 2. As control, a variety of Italian ryegrass, was used. The experiment was carried out in a *dehesa* in the SW of Spain during three years (2008-09, 2009-10 and 2010-11). On average some triticale cultivar (INIA 1 and INIA 2) biomass yields were similar to the reference treatment one, giving rye-grass the lowest biomass in dry years. Alter and INIA 2 did not show decrease in DM yield when a cut in winter was applied but show an increment in quality (high CP content and low NDF).

Keywords. Extensive pastures – Livestock – Dehesa – Silvopastoral.

Rendement en matière sèche et évaluation de la qualité à différents stades de croissance du fourrage de triticale dans le sud-ouest de la Péninsule Ibérique

Résumé. *Les conditions climatiques et édaphiques de l'écosystème de dehesa dans le sud ouest de l'Espagne ont une influence dans la production de biomasse herbacée, causant des moments de l'année avec un manque d'aliments pour l'élevage extensif. Dans ce travail la possibilité d'introduire de la culture de triticale pour une double utilisation (par le pâturage ou la coupe en hiver et coupés à la fin du printemps) afin de couvrir les carences d'hiver et d'été dans l'alimentation animale, a été étudié. Les variétés de triticale ont été, var. Fronteira, var. Alter et deux cultivars expérimentaux du National Agricultural Research Institute de Portugal, appelés INIA 1 et INIA 2. Comme traitement de référence, une variété de ray-grass italien, a été utilisé. L'expérience a été réalisée dans une dehesa dans le sud-ouest de l'Espagne pendant trois ans (2008-09, 2009-10 et 2010-11). En moyenne, certains rendements en biomasse de cultivars de triticale (INIA 1 et INIA 2) étaient similaires au traitement de référence; le ray-grass donne le plus bas rendement en biomasse dans les années sèches. Alter et INIA 2 ne montrent une baisse de rendement en MS quand un coupé en hiver a été appliqué, mais montrent une augmentation de la qualité (plus de contenu en protéines et faible en fibres).*

Mots-clés. *Pâturages extensives – Élevage – Dehesa – Sylvopastoral.*

I – Introduction

Shallow soils and erratic climatic conditions are the *dehesa* main characteristics, that make herbaceous pastures not to be enough to feed animal livestock in these areas, specially in winter and summer time (Pérez, 2005). The intra- and inter-annual irregularity involves the necessity of a good management of the dehesa by farmers, in order to avoid the disappearance of these kind of farms (Olea, 2011). All this demands the introduction of forage crops to use the biomass, either by grazing or by cutting and preserving. Commonly, to supplement summer necessities, forage crops as triticale are used (Delogu *et al.*, 2002). In this paper the possibility to cut or graze triticale in winter and cut and conserve it at the end of the spring is studied, regarding the forage quantity and quality.

II – Material and methods

The experiment was carried out in the 2008-09, 2009-10 and 2010-11 agricultural seasons, in a *dehesa* of the south west of Spain, with Mediterranean semiarid climate (Fig. 1). Each elemental plot (18 m^2 = 3 m x 6 m) was divided in 2 for the different treatment (cut in spring at grain milky stage and cut in winter before tillering, simulating grazing plus cut the regrowth in spring) and had 4 replications, with acid soils (pH 5.4) and middle organic matter (2.4%) content. The 4 triticale cultivars were; Fronteira, Alter and 2 cultivars still in study by the Portuguese National Agricultural Research Institute which were called INIA 1 and INIA 2, sown at 150 kg ha^{-1} rate. The control was *Lolium multiflorum* westerworld type (cv. Tetrawest) and was sown at 30 kg ha^{-1} rate.

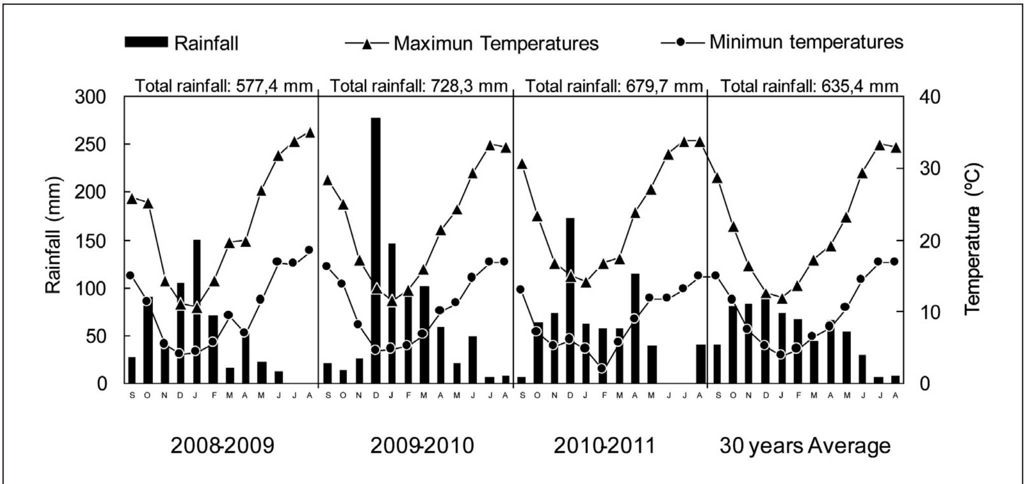

Fig. 1. Annual and monthly rainfall and temperature (monthly mean of maximun and minimun) in 2008-09, 2009-10 and 2010-2011 years and 30 years average in the experiment location.

Nitrogen fertilization was applied part in sowing moment and part after winter cut (37 + 9 kg N ha^{-1}). Dry matter yield (DM), crude protein (CP), organic matter digestibility (OMD) and neuter detergent fibre (NDF) were determined on the collected samples following the official methods. Data results from the samples were subjected to variance analysis to determine the different treatment effect on the forage parameters, using Fisher test of least significant difference (LSD) at P≤0,5, for the treatment averages.

III – Results and discussion

DM yield, CP, OMD and NDF were studied in winter and late spring cuts, having in the second date two possibilities; with or without winter cut (**b** and **a** cut respectively). In case of DM yield "with winter cut", winter DM was added to spring DM yield. No significant differences were found for CP, OMD or NDF in *year x cultivar* interaction in winter, but in DM yield. Figure 2 (right) shows higher DM yield in 2008-09 year than in 2009-10 and 2010-11 (with no significant differences between them), and how every triticale cultivar provide higher DM yield than rye-grass. INIA 2 and Alter triticales were the best cultivars regarding DM biomass in winter each year. Winter CP content ranges between 18.1 and 20.3 % with no significant differences between cultivars, either having no signification the year (16.7 – 20.5 %) (Table 1). Winter NDF (Table 1) were higher in 2008-09 (39.7%) and 2009-10 (40.9%) years than in 2010-11 (38.8%). Regarding the cultivars, Alter and INIA 2 had the higher NDF content (42.7– 41.8 %) and rye-grass the lower (34.1%). Rye-grass and triticale INIA 1 showed higher OMD (84.3 and 82.5 % respectively) than the rest of triticales, having INIA 2 and Alter the lowest OMD values (79.8 and 79.4 % respectively).

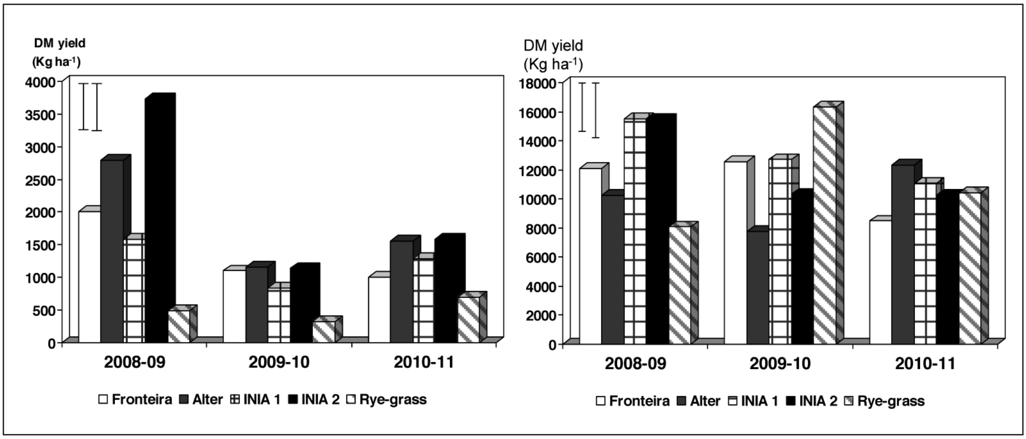

Fig. 2. Winter DM yield (RIGHT) (kg ha^{-1}) in *year x cultivar* interaction. Vertical bars show difference for the same level of year (left) and different level of year (right) and average of the spring DM yield (LEFT) (kg ha^{-1}) in *year x cultivar* interaction. Vertical bars show difference for the same level of year (left) and different level of year (right).

In winter, *year* had an important influence in DM yield; in spring DM yield had no significance, either with one or two cuts. However, significance appears when an interaction with *cultivar* is studied. Regarding the number of cuts, applying only one cut in late spring provides, on average, a significant higher DM yield (13,076 kg ha^{-1}) than adding winter and spring biomass (10,081 kg ha^{-1}). In Fig. 2 (left) it is possible to observe that INIA 1 and INIA 2 are always, even it rains a lot or not, between the cultivars with higher DM yield, while rye-grass and Alter have an important dependence of the rain; the more rain the higher DM yield in rye-grass and opposite in Alter. Similar DM yields (12,900 – 16,300 kg ha^{-1}) were referred by Delogu *et al.* (2002) for similar climate conditions. It is concluded than the more rainfall the better is the production (Peltonen-Sainio and Järvinene, 1995), but authors as Cossani *et al.* (2009) affirm that is the distribution of the rainfall the one that influences the final DM yield. That could explain the lower DM yield in some cultivars in wet years (2009-10 and 2010-11) with reference to dry year (2008-09) due to a ponding in the soil of the experiment.

Table 1 shows the differences in CP and NDF regarding the significant interaction *cultivar x number of cuts*. Study provides that means in CP are higher in 2008-09 than in other years, as well as in forage with two cuts facing one and being INIA 1 one of the cultivars with the lowest CP content. No differences were found between cuts regarding NDF content, but between years, having the lowest value of NDF, 2008-09 year. Fronteira and rye-grass showed higher NDF con-

Table 1. CP (%) and NDF (%) for one and two cuts in the four triticale cultivar and the rye-grass studied. Different letters show a significant difference

Cultivar	Cuts	CP (%)	NDF (%)
Fronteira	1 cut	10.17 abc	56.41 ab
	2 cuts	10.61 ab	56.78 a
Alter	1 cut	8.94 cde	52.90 cd
	2 cuts	11.26 a	52.38 cd
INIA 1	1 cut	8.24 e	53.38 cd
	2 cuts	8.23 e	56.66 ab
INIA 2	1 cut	8.76 de	54.46 bc
	2 cuts	10.06 abc	52.27 d
Rye-grass	1 cut	9.40 bcde	56.88 a
	2 cuts	9.77 bcd	56.97 a

tent than the rest of triticales. CP decreases in the course of plant life, according to Rojas *et al.* (2004) due to the organs differentiation (leaves, stem and spike). Carrasco López *et al*. (1999) obtained CP values near to 20% in winter time, while Lithourgidis *et al.* (2006) obtained lower CP content, due probably to the low rate of N fertilization used in that experiment (8 kg N ha^{-1}). OMD results (data not shown) had a high significant negative correlation with NDF (r = 0,90***); that it is to say that the higher fibre content the lower digestibility the forage has. Fibre results from this study are higher to the ones indicate by Maçãs (1999) (in early growth stages), but similar to the ones referred by Assefa and Ledin (2001), Delogu *et al.* (2002) and Francia *et al.* (2006). All this is not in agreement with Sinclair and Senligman (1995), who explained that the lower was the rainfall in growth stages, the faster rises the leaf/stem ratio, increasing the lignification process therefore, the amount of fibre in the forage. Anyway again the ponding conditions in wet years could explain the low quality in biomass. Nousiainen *et al.* (2003) and Kozloski *et al.* (2005) found the same correlation between NDF and OMD, and this is widely used to predict forage quality.

IV – Conclusions

Regarding the DM yield in winter, INIA 2 and Alter showed the highest values. These two triticales did not suffer a decrease in DM yield in spring facing not applying a cut in winter but the quality of their forages was better than the rest, presenting higher CP content and lower NDF than the other triticales when a cut in winter was applied. So in conclusion using INIA 2 and Alter grazed in winter and cut in late spring is the best option to cover feed deficiencies in *dehesa* farms.

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Performance of some tall fescue varieties grown under Algerian semi-arid conditions

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Abstract. Within farming systems, perennial grasslands provide numerous positive environmental effects such as improvement of soil structure, erosion decrease, control of nitrate leaching and maintenance of biodiversity. In order to develop grassland crops with improved persistence and enhanced water use efficiency, 7 cultivars of tall fescue (*Festuca arundinacea* Schreb.) were evaluated for agronomic behaviour and persistence in the semi-arid region of Setif during the 2007-08 cropping season, corresponding to the third year of production. The measured traits focused on accumulated dry matter (DM), water use efficiency (WUE), plant height (PHT), relative growth rate (RGR) sward persistence (PER) and earliness (DHE). The study revealed the existence of variability for some traits, and identified cultivars having high dry matter yield and good water use efficiency. The results indicated too that the tested genotypes differed significantly for the measured traits. Fletcha, Fletcha^{EF} and Fraydo gave the best dry matter yield, RGR, PER and WUE, while Lutine, Sisa and Centurion performed poorly under semi-arid growth conditions.

Keywords. Perennial grasses – Dry matter yield – Persistence – Water use efficiency – Semi-arid climate.

Performance de quelques variétés de fétuque élevée cultivées sous conditions semi-arides d'Algérie

Résumé. *Dans les systèmes de production agricoles, les prairies pérennes offrent de nombreux effets positifs sur l'environnement tels que l'amélioration de la structure du sol, la diminution de l'érosion, le contrôle du lessivage des nitrates ainsi que le maintien de la biodiversité. Afin de développer la culture des prairies avec une meilleure persistance, 7 variétés de fétuque élevée (Festuca arundinacea* Schreb.*) ont fait l'objet d'une 'évaluation agronomique du comportement et de la persistance dans la région semi- aride Sétif durant la campagne agricole 2007-08, correspondant à la troisième année de production. L'étude a porté sur la matière sèche accumulée (DM), l'efficience d'utilisation de l'eau (WUE), la hauteur de végétation (PHT), le taux de croissance relative (RGR), la persistance (PER) et la date d'épiaison (DHE). L'étude a révélé l'existence de la variabilité pour certaines variables et a identifié des cultivars possédant par un bon rendement en matière sèche et une bonne efficacité d'utilisation de l'eau. Les résultats indiquent aussi que les génotypes testés diffèrent significativement pour les variables mesurées. Fletcha, Fletcha^{EF} et Fraydo ont donné le meilleur rendement en matière sèche, RGR, PER et WUE, tandis que Lutine, Sisa et Centurion ont donné des performances médiocres dans les conditions semi-arides.*

Mots-clés. *Graminées pérennes – Production de matière sèche – Persistance – Efficience d'utilisation de l'eau – Climat semi-aride.*

I – Introduction

The eastern high plateaus of Algeria have a continental Mediterranean climate with variable rainfall, ranging from 168.7 to 517.3 mm, 56 to 88% of which falls in the cold period, extending from October to March (Chennafi *et al.,* 2006). Water remains the main factor limiting crop production even though cold, late spring frost hazard and terminal heat are also frequent (Bouzerzour and Benmahammed, 2009). In these conditions the lack of forage production is a major obstacle to livestock development.

Grasslands are required as sources of good quality and healthy animal fodder, they have multifunctional requirements which include environmental, social, and cultural aspects. (Humphreys *et al*., 2004). An increasing interest in perennial forages for Mediterranean environments is justified by the ability of these species to extend and regularise the feeding season relative to annuals, particularly when their winter yield can be expressed. They may provide earlier and more sustainable feeding possibilities than annuals due to rapid regrowth at the onset of autumn rains and delayed senescence that derives from better ability to exploit the residual moisture in summer (Piano *et al.,* 2005). The objective of the present study is to assess the performances of the seven tall fescue varieties grown under rainfed conditions in the eastern high plateaus of Algeria.

II – Material and methods

1. Experimental design

The field study was conducted during the 2007/08 cropping season at the Setif Agricultural Experimental Station of the Field Crop Institute (ITGC) located at 36°12'N, 5°24'E and 1023 m asl. The long term annual mean precipitation of the experimental site is 396.0 mm, recorded mainly from November to March with a winter mean temperature of 6.6°C and a spring mean temperature of 12.5°C. The climate is temperate continental, varying from arid to semi-arid. The soil is loamy clay, with a bulk density of 1.35 g cm^{-3}. Seven perennial tall fescue (*Festuca arundinacea* Shreb.) varieties were sown in October 2005 in a lattice design with four replicates and 10 row-plots of 2.5 m long x 2 m wide.

Sowing was done by hand. The plant material originated from Portugal, Italy, France and Australia, It was obtained via the PERMED project[1]. Average seeding rate was 20 kg ha^{-1}. Nitrogen fertilizer was applied at a rate of 100 kg ha^{-1} as urea 35%. No irrigation was supplied.

2. Measurements

The 6 inner rows per plot were harvested in the spring when inflorescence emerged in at least 4 entries among the tested varieties. Dry matter yield (DMY) was determined after drying a sample of 500 g in a forced air oven at 65ºC during 48 hours, Heading date (DHE) was recorded, on the outer rows, as the number of Julian days from January 1st to the date when 50% panicles fully emerged. Plant height (PHT) was measured just before harvest, using the average of the measurements per plot from the soil surface to the highest point of the vegetation. Variation in the ground cover percent of living grown tissue was used as measure of persistence (PER) according to Casler *et al*. (2002). The relative growth rate was calculated by the equation given by Wilhelm and Nelson (1978).Soil water measurements were made with neutron probe after each harvest and then water-use efficiency (WUE) was expressed according to Chen *et al.,* (2003). The collected data were statistically analyzed with STATBOX 6 Package. Differences among the entry means were separated by the test of Newman and Keuls.

III – Results and discussion

1. Plant height and dry matter

Mean plant height averaged over genotypes showed significant differences for both seasons: autumn 2007 and spring 2008. The mean value of PHT was 23.7 cm in autumn, and varied from a minimum of 20.7 cm for Flecha^{EF} to a maximum of 28.7 cm for Lutine, while in spring, the mean

[1] Work conducted under PERMED project, contract n° INCO-CT-2004-509140.

value was 18.3cm, and varied from a minimum of 14.2 cm for Centurion to a maximum of 22 cm for Fraydo. The autumn and spring yields were relatively lower than dry matter yield of the previous season, and averaged 0.45 and 0.66 t ha^{-1}, respectively. No significant differences were noted between varieties for both seasons, nevertheless, the most productive cultivars in terms of annual production were Fraydo and Flecha^{E+} with 1.27 t ha^{-1}, while sisa and Lutine were the least productive with a total DMY of 0.94 and 0.89 t ha^{-1} respectively. Spring yields are lower than expected for all cultivars due to insufficient rainfall. Duru and Ducrocq (1998) indicate that the measurement of the grass height is not sufficient to predict the amount of forage production. These authors state that for a given height, the quantity of the produced grass depends on both the horizontal structure (density of ground cover) and vertical structure (distribution of biomass in different horizons) structure of the meadow. The dry matter yield is an important characteristic in determining the choice of selected varieties. Van Wijk *et al*. (1993) mentioned that dry matter yield of the new varieties increased annually by 5%, because of greater persistence and good performance during the third and fourth years of cultivation.

2. Persistence and earliness

Row cover showed significant differences between tall fescue varieties in both seasons. Row cover means varied from 38.3 (Sisa) to 61.9 % (Flecha^{EF}) in autumn and from 29.9 (Lutine) to 53.2 % (Flecha^{EF}) in spring (Table 1). The number of days to head varied significantly between genotypes. Fecha^{EF} and Fraydo were the earliest with 98 calendar days; they headed 7 days earlier than Tanit the latest variety. According to Volaire and Lelièvre (2004) early flowering is associated with drought survival in cocksfoot. Heading spread over 30 days, clearly discriminating between the tested cultivars. Early flowering allowed a longer regrowth period, and consequently a greater allocation of assimilates to root growth before the onset of drought. Thomas, (1997) suggested that phenology interacts significantly with the plants ability to withstand drought stress. Early flowering provided an effective avoidance mechanism against summer water stress.

3. Relative growth rate and water use efficiency

The tested genotypes differed significantly for the relative growth rate based on dry matter accumulated between 14/04/2008 and 29/04/2008. The mean RGR was 22.6 g kg^{-1} d^{-1}. Centurion and Fraydo showed the poorest RGR with 13.5 and 11.4 g kg^{-1} d^{-1} respectively, while Lutine and Flecha^{EF} showed the highest RGR with 30 and 29.5 g kg^{-1} d^{-1} respectively. No significant differences between varieties were observed for water use efficiency. Flecha endophyte free and endophyte infected (E542) showed the highest water use efficiency while Lutine had the lowest WUE (Table 1). Water use efficiency (WUE), defined as the ratio between plant dry matter yield

Table 1. Genotypic means of the traits measured during the third production year (2007/08)

Name	ADM	SDM	TDM	PHT1	PHT2	PER1	PER2	DHE	WUE	RGR
Tanit	0.53	0.63	1.16	23.7ab	17.9ab	57.7a	4803a	105a	6.9	27.9a
Sisa	0.34	0.60	0.94	20.8b	18.3ab	38.3b	34.2b	101a	6.1	25.4a
E542	0.48	0.79	1.27	23.3ab	18.0ab	55.8a	50.7a	95a	8.6	20.5a
Centurion	0.45	0.58	1.03	23.5ab	14.2b	57.5a	39.8b	104a	6.3	13.8a
Flecha^{EF}	0.52	0.71	1.23	20.6b	17.0ab	61.9a	53.2a	98a	7.6	29.5a
Lutine	0.31	0.58	0.89	28.7a	20.4a.	39.1a	29.9b	104a	5.9	30.0a
Fraydo	0.55	0.72	1.27	25.3ab	22.0a	47.9ab	42.5ab	98a	7.4	11.4a
Sign.	NS	NS	*	*	*	*	*	*	NS	*

Autumn dry matter yield (ADM, t ha^{-1}), Spring dry matter yield (SDM, t/ha), Annual dry matter (TDM), Autumn plant height (PHTa, cm), Spring plant height (PHTs, cm), Persistence (PER1,2, %), Number of days to heading (DHE, days), Water use efficiency (WUE, kg ha^{-1} mm^{-1}), Relative growth rate (RGR, g kg^{-1} d^{-1}).

and transpiration is one measure of the ability of a plant to perform well under incipient drought (Thomas, 1997). The potential of breeding crop species with higher WUE to reduce water use and the approaches used have been reviewed by Condon *et al.,* (2004). Blum (2009) considers that WUE is a parameter determining the resistance of crops to drought. However, Lelièvre *et al*. (2011) suggest that WUE and drought tolerance are two distinct forms of adaptation in perennial grasses grown in semi-arid regions.

IV – Conclusion

The results of this study show that there is a quite large variability between tall fescue varieties. The drought-tolerance pattern exhibited by Flecha and Fraydo is consistent with the higher level of drought stress that characterized their selection environments relative to those of the other cultivars. In addition, there was some evidence for better drought tolerance of earlier-heading germplasm. Earliness could easily be selected for in breeding programmes, and may be useful as an indirect selection criterion especially if selection for drought-prone environments had to be performed in favourable sites or cropping years. The most adapted cultivars could now be included in our semi-arid production system in order to regenerate permanent meadows

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Bio-agronomic traits of *Psoralea bituminosa* and *P. morisiana* accessions collected in Sardinia

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Abstract. *Psoralea* genus (Leguminosae) includes some species with promising features as pasture legume in Mediterranean areas prone to drought. Eight Sardinian and 7 Spanish accessions of *P. bituminosa* were evaluated during 2009-2011. Forage production and its furocoumarin content, seed yield and mass were observed. The total forage yield ranged from 68.4 g DM plant^{-1} in Loculi to 252.6 g DM plant^{-1} in Albo-H-TolFrio, with the accessions showing differences in the seasonal production also. The 1000 seed weight varied from 15 g in Llano del Beal to 35 g in Monte Gonareddu, while Llano del Beal and Monte Rosello showed the highest seed yield (about 30 g pl^{-1} year^{-1}). A high variability was observed for furocoumarin content, too. These preliminary results are very encouraging in view of the valorisation of *Psoralea* as perennial forage legume for marginal rainfed areas.

Keywords. *Psoralea* – Seed characteristics – Forage production – Furocoumarin content.

Evaluation bio-agronomique des accessions de* Psoralea *collectées en Sardaigne

Résumé. *Le genre* Psoralea *comprend des espèces avec des caractéristiques prometteuses comme légumineuses de pâturage dans les zones méditerranéennes exposées à la sécheresse. Huit accessions de Sardaigne et 7 accessions espagnoles de* P. bituminosa *ont été évalués au cours des années 2009-2011. La production de fourrage et de son contenu de furocoumarine, le rendement grain et le poids de mille grains ont été observés. La production total variait de 68,4 g MS par plante en Loculi à 252,6 g MS par plante, pour Albo-H-TolFrio; aussi les accessions ont présentes des différences en termes de production saisonnière. Le poids de mille grains variait de 15 g en Llano del Beal à 35 g pour Monte Gonareddu. Le rendement grain était le plus élevé pour Llano del Beal et Monte Rosello (environ 30 g per plant). Une grande variabilité a été aussi observée pour le contenu des furocoumarines. Ces résultats préliminaires sont très encourageants en vue de la valorisation de le genre* Psoralea *comme légumineuse fourragère pérenne pour les zones marginales pas irriguées.*

Mots-clés. Psoralea *– Caractéristiques des semences – Production de fourrage – Contenu des furocoumarin.*

I – Introduction

Psoralea is a legume that grows in Mediterranean basin and Macaronesia and has a potential as pasture fodder for ruminants in semiarid Mediterranean environments but only few selected ecotypes are cultivated in Canary Islands and Morocco (Muñoz *et al*., 2000). In Sardinia Island two species of *Psoralea* can be found in natural stands: *P. bituminosa* (L.) Stirt. and the endemic *P. morisiana* Pignatti et Metlesics. They can be easily distinguished on the basis of some morphological traits and for the presence of a typical bitumen smell in *P. bituminosa* (Camarda, 1981). Both species have an appreciable content of furocoumarins, compounds that have been related to a low palatability of fresh fodder (Pecetti *et al*., 2007) but that can be used in PUVA therapy (Viola *et al*., 2009). In this work we describe a part of a larger screening done among Sardinian populations of *P. morisiana* and *P. bituminosa* and Spanish accessions of *P. bituminosa,* in order to discriminate within populations with low furocoumarin content useful for fodder production in Mediterranean environments or for furocoumarin extraction and pharmaceutical utilisation.

II – Materials and methods

Plant establishment. Five accessions of *P. morisiana* (Monte Gonareddu, Punta Giglio, Siliqua, Bitti, Burcei) and three accessions of *P. bituminosa* (loculi, monte Rosello, Siniscola) collected in Sardinia during 2009 were evaluated in an experimental field at the Centre for the Conservation and Valorisation of Plant Biodiversity, Alghero, Italy (40° 35' N, 8° 22' E) together with 7 accessions of *P. bituminosa* belonging to var. *albomarginata* (AlboH-TolFrio, Famara), var. *crassiuscula* (Crassiuscula, Vilaflor) and var. *bituminosa* (Calnegre, Llano del Beal, Tenerife) from Canary Islands and Spain. The site has a Mediterranean climate, with an average annual rainfall of 540 mm and a dry season during summer. The soil is alluvial and calcareous (pH 6.9). The experiment was carried out in plots with 12 plants per accession in a completely randomized design with three replicates. Plants were grown from scarified seeds sown in jiffy pots in a greenhouse then transplanted in field in February 2010. Fertilization was done before planting with 46 kg ha^{-1} of P_2O_5. Occasional irrigation was supplied to plants when necessary from late spring to early summer in the first year. The following observations and analysis were done:

Phenology. Plants were observed weekly at the beginning of the flowering, 50% flowering, 100% flowering, end of flowering, first ripe fruit, plant senescence and re-flowering stages.

Seed yield and 1000 seed weight. Seeds were collected weekly during ripening in 2010 and 2011. Seed production was observed on 3 plants per plot. The 1000 seed weight was calculated from the average weight of subsamples of 100 seeds (4 replications).

Forage production. Forage samples were collected in October 2010, December 2010, March 2011 and October 2011 from 3 plants per plot, when plant height exceeded 15 cm. Plant samples were oven-dried at 60 °C until a constant weight was achieved.

Extraction and determination of furocoumarins. In October 2011, fresh leaves (100 g) were extracted by maceration using cold MeOH/HCl 2M (800 ml) and kept under stirring for 20 hours at room temperature. The extracts were filtered and concentrated under vacuum at a temperature below 50°C in a rotary evaporator, then dissolved in distilled H_2O (250 ml) and the extraction repeated three times with 45 ml of $CHCl_3$. The organic extract was concentrated under vacuum at 30°C and the residue used for the furocoumarin analysis. Furocoumarins were analysed by a GC (Hewlett Packard 5970) equipped with a ZB5 column (Phenomenex, 60 m, 0,25 m) coupled with a MS instrument (Hewlett Packard GMD) and quantified by the Standard Addiction Method. All analysis were repeated three times.

Except for furocoumarin content, all data were subjected to ANOVA and mean values separated by LSD test. Statistical analysis were performed with the software package R.

III – Results and discussion

Flowering, seed weight and seed production. Sardinian accessions showed an earlier flowering than Spanish accessions, especially in 2010 (Table 1). Flowering was earlier and shorter for almost all populations during 2011, when plants were totally under rainfed conditions. The 1000 seed weight ranged between 15.0 g and 35.1 g and no statistical differences were found between year 2010 and year 2011. Seed production varied from 0.2 g pl^{-1} to 33.9 g pl^{-1}. Sardinian populations showed a very low production of seeds in the first year, except for Monte Rosello. In the second year, however, the seed production of the Sardinian accessions Bitti, Loculi, Monte Rosello, Siliqua and Siniscola attained the most productive Spanish accession, Llano del Beal.

Famara did not flower in the first year and the seed yield was negligible in the second year also; on the contrary, Calnegre produced a low amount of seed only in the first year.

No statistical differences were found for seed production between *P. morisiana* and *P. bituminosa* accessions, but within *P. bituminaria* some differences were found for var. *bituminosa* vs *crassiuscula* and *albomarginata*, showing a seed mean production of 16.1, 7.9 and 4.2 g pl^{-1} respectively.

Table 1. Day of first flower appearance (DoY), flowering duration (days), 1000 seed weight (g) and seed production (g pl^{-1}) in 15 accessions of *P. bituminosa* and *P. morisiana*

Species/ Variety	Population	Start of flowering (DoY)		Flowering duration (days)		1000 seed weight (g)		Seed production (g pl^{-1})	
		2010	2011	2010	2011	2010	2011	2010	2011
Albomarginata	Albo-H-TolFrio	185^{cde}	132^{ef}	48	59	24.6^{bc}	26.8^{b}	2.0^{d}	$13.9^{b\text{-}e}$
	Famara	–	175^{a}	–	14	–	17.7^{fgh}	–	1.1^{e}
Crassiuscula	Crassiuscula	196^{bc}	147^{cd}	56	44	23.2^{bc}	24.8^{bc}	4.3^{d}	6.1^{de}
	Vilaflor	190^{bcd}	150^{c}	69	44	24.3^{bc}	25.3^{bc}	14.6^{bc}	6.7^{de}
Bituminosa	Calnegre	229^{a}	–	31	–	16.2^{ef}	–	0.2^{d}	–
	Llano del Beal	156^{fg}	138^{de}	84	63	15.0^{f}	15.4^{h}	33.9^{a}	32.0^{a}
	Tenerife	210^{ab}	161^{b}	42	18	22.6^{cd}	20.4^{def}	1.1^{d}	0.6^{e}
	Loculi	126^{h}	116^{g}	98	63	16.3^{ef}	16.4^{gh}	4.0^{d}	28.2^{ab}
	Monte Rosello	153^{g}	132^{ef}	60	59	24.4^{bc}	20.6^{def}	28.0^{a}	24.6^{ab}
	Siniscola	130^{h}	125^{fg}	87	63	19.1^{de}	$18.0^{e\text{-}h}$	16.6^{b}	32.0^{a}
Morisiana	M. te Gonareddu	157^{fg}	137^{de}	90	56	35.1^{a}	32.2^{a}	2.7^{d}	8.7^{cde}
	Punta Giglio	$170^{d\text{-}g}$	146^{cd}	119	69	23.6^{bc}	21.1^{de}	16.7^{b}	$14.3^{b\text{-}e}$
	Siliqua	$177^{c\text{-}f}$	145^{cd}	78	83	26.6^{b}	23.0^{cd}	5.9^{cd}	$17.8^{a\text{-}d}$
	Bitti	165^{efg}	131^{ef}	77	84	26.9^{b}	23.2^{cd}	6.5^{bcd}	23.8^{abc}
	Burcei	154^{g}	144^{cd}	88	73	21.4^{cd}	19.1^{efg}	5.7^{cd}	$13.0^{b\text{-}e}$

Different letters in the same column indicate values statistically different at $p \leq 0.05$. Dates were expressed using the sequential Day of the Year (DoY), starting with day 1 on January 1st.

Forage production and furocoumarin content. The total forage yield per plant ranged from 68.4 g in Loculi to 252.6 g in Albo-H-TolFrio. The Sardinian accessions Monte Gonareddu, Bitti, Punta Giglio, Siliqua, and Siniscola produced a total forage yield comparable to the best Spanish accessions (Table 2). A marked seasonality in forage production was observed. Most of Spanish accessions produced a good amount of forage in autumn; on the contrary, most of Sardinian accessions produced new sprouts in spring. Calnegre, after a respectable forage production in December 2010, suffered for winter cold and showed a high plant mortality.

In the early autumn cut (Oct 2011), several accessions showed a high furocoumarin content, in particular three Sardinian population (*P. morisiana*: Monte Gonareddu, Punta Giglio, *P. bituminosa*: Monte Rosello). All accessions showed a higher angelicin than psoralen content, except for Monte Gonareddu, where psoralen prevailed. In general, Sardinian accessions of *P. morisiana* showed a low content of psoralen, as well as the Spanish accessions of *P. bituminosa* belonging to the var. *albomarginata* and *crassiuscula*. These results are similar to those reported by Pecetti *et al*. (2007) for *P. bituminosa* germplasm of Central Italy, where environmental conditions are less stressful than in Southern Italy. Among *P. bituminosa*, Monte Rosello showed the highest content of angelicin. It is noteworthy that angelicin is studied in a new application for the treatment of thalassemia (Lampronti *et al*., 2003).

Table 2. Dry matter yield (g DM pl^{-1}) and furocoumarin content (mg kg^{-1} leaf FW) in the various Sardinian accessions of *P. bituminosa* and *P. morisiana* and Spanish accessions of *P. bituminosa*

Species/ Variety	Accession	Yield (g DM pl^{-1})					Furocoumarins (mg kg^{-1} leaf FW)	
		Oct 2010	Dec 2010	Mar 2011	Oct 2011	Total yield	Oct 2011	
							Ang	Pso
Albomarginata	Albo-H-TolFrio	81.8^{ab}	77.1^{ab}	–	93.6^{a}	252.6^{a}	202.7	57.2
	Famara	18.8^{ef}	–	34.4^{de}	22.1^{bc}	75.3^{d}	88.4	29.0
Crassiuscula	Crassiuscula	74.0$^{a\text{-}d}$	78.2^{ab}	–	54.0^{ab}	206.2^{ab}	65.1	39.5
	Vilaflor	80.8^{ab}	46.7^{bc}	–	58.3^{ab}	185.8^{ab}	44.6	44.6
Bituminosa	Calnegre	109.2^{a}	93.8^{a}	–	3.3^{c}	206.3^{ab}	288.8	48.7
	Llano del Beal	63.9$^{a\text{-}e}$	–	51.9^{cde}	66.9^{ab}	182.7^{abc}	142.2	90.7
	Tenerife	50.7$^{b\text{-}f}$	55.7^{bc}	–	21.8^{bc}	128.1^{bcd}	70.4	37.3
	Loculi	10.4^{f}	–	25.7^{e}	32.3^{bc}	68.4^{d}	127.5	70.0
	Monte Rosello	76.1^{abc}	39.2^{c}	–	57.3^{ab}	172.5$^{a\text{-}d}$	751.8	108.7
	Siniscola	37.1$^{b\text{-}f}$	–	60.3^{cd}	50.2^{abc}	147.6$^{a\text{-}d}$	245.7	54.6
Morisiana	Monte Gonareddu	32.1$^{c\text{-}f}$	–	97.9^{a}	42.8^{bc}	172.9$^{a\text{-}d}$	154.3	339.4
	Punta Giglio	40.1$^{b\text{-}f}$	–	70.7^{bc}	39.4^{bc}	150.2$^{a\text{-}d}$	244.2	116.1
	Siliqua	36.4$^{b\text{-}f}$	–	90.0 ^{ab}	57.4^{ab}	184.8^{ab}	195.0	89.5
	Bitti	30.3^{def}	31.0^{c}	–	69.8^{ab}	131.1^{bcd}	105.7	13.7
	Burcei	21.3^{ef}	–	33.3^{e}	22.3^{bc}	76.9^{cd}	55.0	00.0

Ang = angelicin; Pso = psoralen. Different letters in the same column indicate values statistically different at $p \leq 0.05$.

IV – Conclusions

An interesting variability among the accessions of *P. morisiana* and *P. bituminosa* was found. Some of them showed an interesting seasonal distribution of forage production, especially in early autumn. These preliminary results are very encouraging in the view of the valorisation of *Psoralea* as perennial forage legume for marginal rainfed areas. Growing *Psoralea* in permanent stands may provide alternative sources of natural fodder protein, especially in late spring, early summer or early autumn, reducing costs at farm level for supplements, and also in terms of fertilizers and soil tillage. Some of the studied varieties showed interesting amounts of furocumarins, therefore it is possible consider them as a valuable sources of bioactive compounds to be used in different therapies. On the other hand, the effect of furocoumarins on animal health must be better investigated as well as their content in conserved forages.

Acknowledgements

The research was financed by the Sardinian Regional Administration (L.R. 7/ 2007 - Promotion of scientific research and technological innovation in Sardinia). The Authors wish to acknowledge Prof. Ignazio Camarda for helping in the identification of collection sites, Dr. Enrique Correal for providing seeds of Spanish accessions, Mr. D. Dettori, Mr. D. Nieddu and P. Saba for the technical help.

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Variation in seed yield and morphological traits in Turkish grass pea (*Lathyrus sativus*) genotypes

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Abstract. In this study 51Turkish landraces, 4 ICARDA lines and 1 registered variety of *Lathyrus sativus* L. were investigated for morphological characters and seed yield. The experiment was carried out in Samsun ecological conditions in 2009 with spring-sown. A high variation was determined among genotypes regarding the investigated characters, especially in seed yield and thousand seed weight. The variation among the *Lathyrus sativus* genotypes was between 2.82 g/plant and 13.64 g/plant for seed yield and between 5.10 g/plant and 22.89 g/plant for biological yield and between 91.65 g and 167.70 g for thousand seed weight. Many of the landraces had higher seed yield and thousand seed weight than registered cultivar named "Gurbuz 2001". Correlation analysis showed that biological yield, stem number, pod number per plant and petiole length highly and positively correlated with seed yield.

Keywords. Grass pea – *Lathyrus* – Landrace – Seed yield.

***Variation du rendement en graines et des caractéristiques morphologiques chez des génotypes Turques de gesse commune* (Lathyrus sativus)**

Résumé. *Dans cette étude, 51 variétés locales turques, 4 lignes de l'ICARDA et 1 variété enregistrée de* Lathyrus sativus *L. ont été étudiées pour les caractères morphologiques et le rendement en graines. L'expérience a été réalisée en 2009 dans des conditions écologiques de Samsun, en semis de printemps. Une forte variation a été déterminée chez les génotypes dans les caractères étudiés, en particulier dans le rendement en graines et dans le poids de mille graines. Les différences entre les génotypes de* Lathyrus sativus *étaient comprises entre 2,82 g/plant et 13,64 g/plant pour le rendement grainier, entre 5,10 g/plant et 22,89 g/plant pour le rendement biologique, et entre 91,65 et 167,70 g pour le poids de mille graines. Beaucoup d'entre les genotypes locales avaient un rendement des semences et un poids de mille graines plus élevé que ceux du cultivar enregistré "Gurbuz 2001". L'analyse de corrélation a montré que le rendement biologique, le nombre de tiges, nombre de gousses par plante et la longueur du pétiole sont fortement et positivement corrélés avec le rendement en graines.*

Mots-clés. *Gesse –* Lathyrus *– Genotype local – Rendement en graines.*

I – Introduction

Lathyrus sativus "LS" is an important annual legume crop used for food, feed and forage in many parts of the world especially in drought and marginal areas (Campbell, 1997). The crop is valued for its high yield, high protein content, drought tolerance, low input requirement, adaptation to diverse soils and climates, resistance to insects and pests (Yan *et al*. 2006). Recently, due to the advantageous biological and agronomic characters, LS is gaining interest as a model crop for sustainable agriculture and is considered as an important source of genes in the legume breeding for both biotic and abiotic stress resistance (McCuthan, 2003).

In spite of the importance of *Lathyrus* for human and animal nutrition, the utilization of the grain is limited due to the presence of the neurotoxic compound 3-(-N-ox-alyl)-L-2,3 diaminopropionic acid (b-ODAP), that causes Lathyrism disease when seeds are consumed as a major component of the diet (Spencer *et al.* 1986). In general, breeding programs mainly focused on improving a genotype having high seed yield and low neurotoxin level. Therefore, the aim of the present study was to determine the variation in seed yield and morphological traits of Turkish *Lathyrus sativus* landraces and ICARDA lines.

II – Materials and methods

A total of 56 genotypes of *Lathyrus sativus* were investigated relation to seed yield and some morphological traits, 51 landraces from Turkey, one released cultivar "Gurbuz-2001" and 4 ICARDA lines (Table 3). Field experiments were conducted in Agricultural Faculty experiment field of Ondokuz Mayis University, Samsun (264972 E – 4581185 N, UTM) - Turkey in 2009 spring growing season. The field experiment was established on April 4 with no fertilizer at 15 cm seed to seed and 30 cm row to row spacing. Each landrace or line was sown one plot (3 m length with 3 rows), all the traits were determined on randomly selected ten plants at the seed maturity stage between July 19 and July 26 depending on genotype. All the data were presented as a mean, minimum, maximum, and standard deviation, in addition, Correlation and Principle Component Analysis were performed by means of 13.0 Statistical Package Program.

III – Results and discussion

The results showed that there was high variation between the investigated characters among the Turkish *Lathyrus sativus* "LS" genotypes (Table 1). The range from sowing to seed maturity time among to LS genotypes was eight days (105-113). The earliest genotype was registered variety "Gurbuz 2001" while the latest genotype was landrace S. The plant height (PH) varied from 30.00 to 48.10 cm with a mean of 37.13 cm and, petiole length (PL) was between 1.46 and 4.22 cm among to LS genotypes. Campbell (1997), reported that plant height ranged from 15 to 172 cm in LS originating different countries. The highest variation among to investigated LS genotypes was observed in relation to seed yield (CV = 38.52%), ranging between 2.82 and 13.64 g/plant while the lowest variation (CV = 6.88%) was in pod length (PDL). Also the variation was very high for biological yield (BY), number of stems per plant (NSM), number of pods per plant (NPP), but it was low for seed number per pod (NSP) among to LS genotypes. The average thousand seed weight (TSW) in investigated LS genotypes amounted to 115.56 g (with a range of 91.60 – 167.70 g) (Table 1). In the previous studies, SY of LS reported between 0.5 – 21.19 g/ plant (Pandey *et al.* 1997; Polignanao *et al.* 2005). TSW is an origin-dependent trait and the genotypes collected from the Mediterranean basin have higher seed weight than genotypes collected from the Indian subcontinent (Campbell, 1997). In this respect, although Turkey located in the Mediterranean basin, relatively low TSW values observed in the present study compare to Grela *et al.* (2010) who reported TSW was between 120 and 660 g among to thirty-one European accessions.

Seed yield was positively and highly correlated with all the traits, especially with BY, NSM and NPP ($r = 0.988^{**}$, 0.658^{**} and 0.851^{**} respectively) (Table 2). In general, correlations between all the traits were positive except TSW and NSP, and in agrement with previous studies. One of the important finding of this study that is positive and high correlation between SY and PL ($r = 0.413^{**}$). It is intersting because no referans can found relation to PL for *Lathyrus sativus* in earlier studies. Moreover, this correlation indicating that PL may be used for selection of high yielding genotypes at the early stage.

Table 1. Mean, maximum and minimum values of some traits in 56 *Lathyrus sativus* genotypes

Traits	Mean ± sd	Minimum	Maximum	CV (%)
Plant height (cm)	37.13 ± 4.35	30.00	48.10	11.72
Petiole length (cm)	2.00 ± 0.41	1.46	4.22	21.00
Leaf length (cm)	6.43 ± 0.60	5.02	7.84	9.33
Biological yield (g/plant)	11.11 ± 3.95	5.10	22.89	35.55
Seed yield (g/plant)	5.97 ± 2.30	2.82	13.64	38.52
Number of the stem per plant	6.13 ± 2.14	3.00	11.80	34.91
Number of the pod per plant	17.50 ± 5.71	9.00	33.40	32.62
Pod length (cm)	3.05 ± 0.21	2.43	3.66	6.88
Number of the seed per pood	3.40 ± 0.33	2.70	4.17	9.71
Thousand seed weight (g)	115.56 ± 9.91	91.65	167.70	17.23

Table 2. Correlations between investigated traits among to 56 *Lahyrus sativus* genotypes originating Turkey and ICARDA

Traits	PH	PL	LL	BY	SY	NSM	NPP	PDL	NSP
PL	.349**								
LL	.565**	.263							
BY	.343**	.427**	.351**						
SY	.329*	.413**	.343**	.988**					
NSM	.115	.441**	.156	.682**	.658**				
NPP	.227	.467**	.236	.877**	.851**	.629**			
PDL	.369**	.295*	.100	.429**	.455**	.238	.173		
NSP	.180	.052	-.013	.096	.067	-.092	.123	.080	
TSW	.187	.151	.311*	.393**	.437**	.271*	.102	.555**	-.409**

**, *: Correlation is significant at the 0.01 and 0.05 level respectively.

PLH plant height, PL: petiole length, LL: leaf length, BY: biological yield, SY: seed yield, NSM: number of the stem per plant, NPP: number of the pod per plant, PDL: pod length, NSP: number of the seed per pood, TSW: thousand seed weight.

Principle component analysis (PCA) based on SY, NSP and TSW indicated that the first two principle components explained 87.76 % of the total variation (Fig. 1). PC1 correspond to 52.18 % of the variation and PC2 to 27.00%. In the first component, the most important contribution were related to TSW while second component was mainly loaded by SY and NSP (Table 4). The obtained scatter plot using these first two components is shown in Fig. 1. Distribution of the LS genotypes on scatter plot indicated that many of landraces especially those are BR1, BR2, BR3, BR4, D4, U7, I1, I2, S, K were clearly superior compare to registered cultivar (GR) regarding both SY and TSW, therefore, they were most promising genotypes for improving new and high yielding varieties (Fig. 1).

IV – Conclusions

Sustainable and environmentally sound agricultural systems have renewed the importance of *Lathyrus sativus* and, the lack of varieties has favored breeding programs. Local materials and old landraces are present an important and diverse gene pool to breeders. The present study showed that Turkish LS genotypes may be promising for breeding study with high variation especially in seed yield.

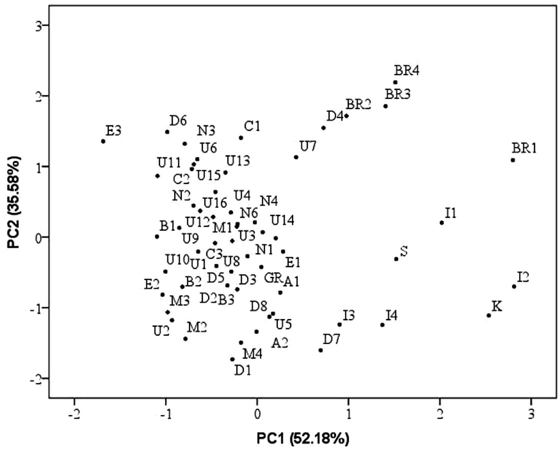

Fig. 1. PCA on seed yield, seed number per pod, TSW of *Lathyrus sativus* genotypes.

Table 3. Origin of the LS genotypes

Getp.	Origin	Getp.	Origin
A	Adiyaman	K	Kutahya
B	Burdur	M	Malatya
BR¡	Bursa	N	Nevsehir
C	Cankiri	S	Samsun
D	Denizli	U	Uşak
E	Elazıg	I	ICARDA
GR	Registered variety		

Table 4. Correlation of the analyzed three traits with the first two component

Traits	Component	
	1	2
SY	.404	.661
NSP	-.372	.707
TSW	.581	-.007

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Agronomic evaluation of introduced accessions of *Vicia narbonensis* L. under contrasting environments and two years period

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Abstract. This work aimed to evaluate agronomic and nutritive characteristics of 9 accessions of *Vicia narbnonensis* received from ICARDA under the framework of germoplasm exchange. They were evaluated in two contrasting locations (Oued Mliz, semi arid and Oued Béja, sub humid) during two cropping years (2009-2010 and 2010-2011) in comparison with two checks arranged in a randomised complete bloc design with three replications. Seed yields, pod and seed number, flowering date and winter vigour were scored. During first year, analysis of variance showed significant effects of site, accession and their interaction for all agronomic traits. Flowering and pod set are earlier in Oued Mliz while pod maturity was earlier in Oued Béja with highest number of pods. Seed number and seed weight were higher in Oued Mliz. Significant correlations were obtained between flowering and pod set and flowering and pods/plant. Among these accessions, 6 were selected and evaluated the following year. During second year, seed yield of these accessions was two times higher in Oued Béja. Based on yield and yield components, two accessions were released for cultivars registration.

Keywords. *Vicia narbonensis* L. – Agronomic evaluation – Semi-arid – Sub humid.

Evaluation agronomique d'accessions introduites de* Vicia narbonensis *L. dans deux localités et deux années

Résumé. *Ce travail a pour objectif d'évaluer les caractéristiques agronomiques et nutritionnelles de neuf accessions de* Vicia narbonensis *L. reçues de l'ICARDA. Elles ont été évaluées dans deux sites contrastants durant deux campagnes consécutives en comparaison avec deux témoins locaux. Le dispositif expérimental étant en bloc aléatoire complet à 3 répétitions. Des paramètres agronomiques, phénologiques et de rendement ont été mesurés. Durant la première année, l'analyse de variance a montré un effet hautement significatif du site, de l'accession et de leur interaction sur tous les paramètres sauf le pourcentage de gousses vides. La floraison est précoce à Oued Mliz alors que la maturité est précoce à Oued Béja. Des corrélations significatives sont obtenues entre la floraison et la formation de la 1ère gousse et la floraison et le nombre de gousses. Parmi ces accessions, 6 ont été retenues pour être ré évaluées la campagne suivante. Durant la deuxième année, le rendement grainier est deux fois plus élevé à Oued Béja qu'à Oued Mliz. En se basant sur ces résultats, 2 accessions ont été retenues et vont faire l'objet d'inscription variétale.*

Mots-clés. Vicia narbonensis *L. – Évaluation agronomique – Semi aride – Sub humide.*

I – Introduction

Vicia narbonensis L. (Narbon vetch) is a leguminous species with the potential to become an important grain and straw crop for animal feed in dry temperate areas (Bennett and Maxted, 1997). *V. narbonensis* var. *narbonensis* is currently cultivated as a minor crop in the Middle East (Maxted, 1995). It is widely distributed in Mediterranean basin where it is cultivated under rained conditions and often used to feed animals. *V. narbonensis* was found to be a widespread calcicole species in Syria and Turkey with two botanical varieties, narbonensis and salmonea; the variety jordanica was restricted to southern Syria (Enneking and Maxted, 1995). In Tunisia, only the var. *narbonensis* was found (Hassen, oral communication); it grows spontaneously on deep alkaline sandy and silty soils on low altitudes. It is often found in faba bean crops in north Tunisia as well as in protected areas and cereals crops in the centre region. Several research works have shown that Narbon vetch is a good yielding species with good tolerance to cold and drought conditions. Vetch seeds could be integrated in livestock feeding to replace some protein sources like soybean. Selection of *V. narbonensis* accessions adapted to local conditions and those that could promise to improve animal performance is targeted.

This work was undertaken to evaluate the agronomic and nutritive value of introduced accessions of Narbon vetch in order to select promising lines for cultivars registration.

II - Materials and methods

1. Trials management

The trials were conducted under rainfed conditions in two contrasting sites (Oued Béja and Oued Mliz) during two cropping years. Oued Beja has a sub humid climate with 600 mm annual rainfall, cold winter and hot summer. Oued Mliz has a semi arid environment with 460 mm rainfall, cold winter and hot dry summer. The rainfall during the two cropping seasons is shown in Fig. 1.

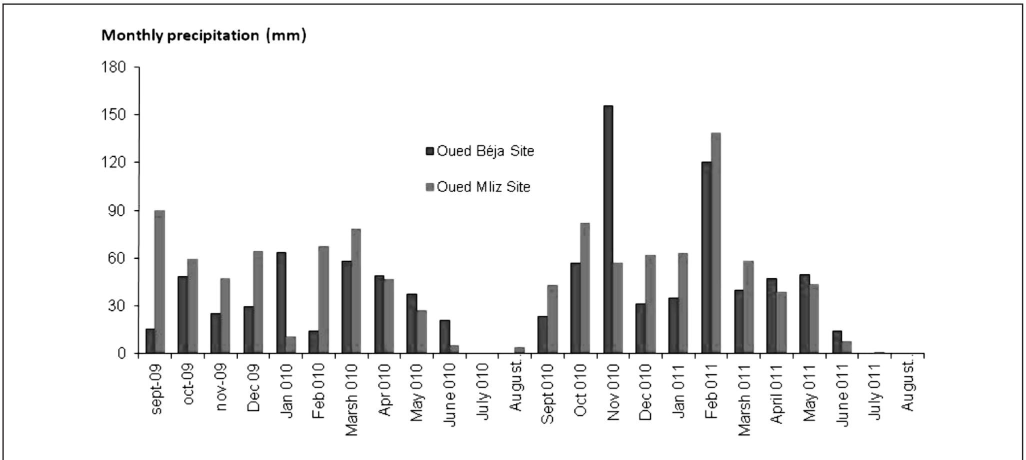

Fig. 1. Monthly precipitation recorded in Oued Béja and Oued Mliz sites during the two cropping years (2009-2010 and 2010-2011).

2. Plant material

In 2009-2010, nine accessions received from ICARDA in the frame of germoplsam exchange were evaluated in comparison with two local checks (acc. P1 and acc. 545). These accessions are originated from different Mediterranean countries. In 2010-2011, only 6 accessions were selected for a new evaluation. For each year and site, a complete bloc design with 3 replications was used. Each accession was sown in a plot of 4 rows of 4 m long and 30 cm intervals.

3. Measurements

Agronomic potential was determined during the first year in both locations by measuring seed yield and biological yield as well as phenological and agronomic traits such as seed and pod weight, percentage of shattering and empty pods. The second year, phenological traits, vigour and seed yield were measured in both sites. Yield components as pods plant^{-1}, seeds pod^{-1}, percentage of empty pods and percentage of shattering were evaluated at Oued Béja only and that on 20 plants taken randomly from each plot. The remaining plants in the plot were cut for seed yield evaluation in addition to the seeds of the 20 plants used for the other traits. Nutrient contents of Narbon vetch accessions seeds and straw are under analysis.

4. Statistics

Analysis of variance was performed on seed yield where year and site are regarded as random effects while accessions and replication are considered as fixed. For the other agronomic traits (phenological and yield components), ANOVA was performed on one year (random effect) and accessions and replications are fixed effects. Means was compared using Duncan test at 5% level.

III – Results and discussion

1. Seed yield

Seed yield is the only trait that was recorded in two sites during two years. Oued Béja site was more favourable for seed yield of Narbon vetch accessions than Oued Mliz (Table 1). This result was in agreement with that reported by Orak and Nizam (2009) in which, environmental factors strongly affect seed yields of Narbonne vetch.

Table 1. Seed yield (kg ha^{-1}) of Vicia narbonensis accessions evaluated in two sites during two cropping years (2001 & 2011)

	Oued Béja				Oued Mliz			
Accession	**2010**		**2011**		**2010**		**2011**	
	Mean	**SD†**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
1	5019	523	6488	634	4939	762.7	3000	511.6
10	6750	995	6218	261	5529	847.5	2347	843.1
12	4307	679	–	–	4181	1617	–	–
13	4227	1202	–	–	4846	788.5	–	–
14	5138	90	5011	1875	5784	741.2	2278	685.3
7	5348	886	5619	1219	5891	1081	1946	1094
8	5395	661	4582	424	5933	996.3	2181	126
9	5982	904	5956	2970	4662	2550	2139	1143.9
Local check (P1)	5329	3401	3694	2813	4845	301	2458	448
Local check (545)	234	35	–	–	4213	2967	–	–
Mean year	4943a		5367a		5082a		2336b	
Mean site		5117a			3951b			

–: Not included in the trial; values covered by the same letter are not significantly significant at P<0.05.
SD†: Standard deviation.

Average seed yield of all accessions not differed significantly from site to site (4943 kg ha^{-1} vs. 5082 kg ha^{-1}) during the first year (2010), despite the large difference in total amount of seasonal rainfall between sites. This proves that this legumes species is well adapted for a wide range of bioclimatic conditions. During the second year (2011), high significant effect of site was observed on seed yield (P<0.0001) while accession and site by accession interaction effects were not significant. Average seed yield was two times higher in Oued Béja than in Oued Mliz (5367 kg ha-1 vs. 2336 kg ha-1) despite the favourable rainfall conditions in both sites. Seed yield increased between 2010 and 2011 in Oued Béja while it decreased in Oued Mliz. This trend may be related to environmental conditions rather than genotypic effect. This was also noted by Ücel (2003) on *V. narbonensis* lines evaluated in southern Turkey for seed yield components. According to this author, as low temperature delays the date of flowering, seed yield and major yield components decrease.

3. Phenological traits and yield components

During the first cropping year (2009-2010), all traits measured on 10 accessions differed between sites. Most accessions set flowers and pods earlier in Oued Mliz than in Oued Béja (109 days vs. 102 days and 114 days vs. 123 days, respectively) while pods mature earlier in Oued Béja (154 vs. 164 days) and were higher in this site (76 pods vs. 36). Seed number and 100 seeds weight were higher in Oued Mliz. The ranking of accessions for these traits is given in Table 2.

Table 2. Means of all accessions for the phonological traits and yield components measured in 2009-2010 in both sites

Accession name	Origin	Days to flowering	Days to pod set	Days to pod maturity	Pods $plant^{-1}$	Seeds pod^{-1}	1000 seed weight
8	Lebanon	108a	118.7ab	160abc	55.22abc	4.02a	228.2a
12	Lebanon	107.8a	119ab	160abc	73.78a	4.45a	168.2cd
545†	Tunisia	107.8a	120.4a	162.4a	41.9c	3.88a	143.2d
P1†	Tunisia	106.8ab	120a	157.9c	54.57bc	3.98a	190.5abcd
1	Lebanon	106.6abc	118.6ab	158.8bc	51bc	4.73a	221.1ab
7	Lebanon	106.5abc	118.8ab	158.7bc	57.08abc	5.2a	180.2bcd
13	Lebanon	104.5bc	118.3ab	158.5c	54.7bc	4.74a	171.7cd
10	Turkey	104.5c	118.2ab	158c	58.05abc	4.53a	211.7abc
9	Syria	104.2c	118.7ab	160.7abc	66.1ab	4.41a	174.8cd
14	Iraq	104c	117.3b	161.1ab	61.36ab	4.33a	201.3abc
Average		106.1	118.8	159.5	57.8	4.41	189.7
SE		0.61	0.61	0.67	3.57	0.14	6.3

[A,b,c,d] Different letters in the same Colum denote significant difference (P<0.05) between means.
†: local checks.

Significant correlations were found between flowering and pod set (r^2 = 0,88; P<0,001; n = 60) and flowering and pods/ plant-1 (r^2 = 0,61; P<0,001; n = 60). Seed yield was positively correlated to seed weight (r^2 = 0,65; P<0,001; n = 59). Based on seed yield and yield components, acc. 1 and acc. 9 were selected as promising lines that deserve registration in the national catalogue. Both accessions had low percent of empty pods. Acc. 1 had prostrate growth habit with low lodging susceptibility while Acc. 9 is early flowering and is having an erect growth habit.

IV – Conclusion

The evaluation of Narbon vetch under contrasting environments has demonstrated interesting grain yield under semi arid conditions. Seed weight is an important criterion for selecting high yielded accessions. In semi-arid conditions, earliness is important for selecting material having the ability to complete life cycle before the spring drought. The integration of Narbon vetch seeds in livestock feeding to replace some protein sources like soybean meals still depending on future nutritive values under evaluation.

Acknowledgements

The authors wish to acknowledge the support of the Oued Béja and Oued Mliz research and technical staff who contributed to the success of this work.

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Messina (*Melilotus siculus*) – a new annual pasture legume for Mediterranean-type climates with high tolerance of salinity and waterlogging

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Abstract. Messina (*Melilotus siculus*) is a new annual pasture legume with high waterlogging tolerance and much higher salt tolerance than other legumes. Glasshouse and laboratory studies have identified several mechanisms for both salt and waterlogging tolerance that explain its adaptation to saline, waterlogged soils. Field trials are underway to select the best adapted line for release as a new cultivar. Selection is also being conducted for an adapted salt tolerant *Rhizobium* strain. This paper discusses the ecology, physiology and agronomy of messina and progress towards its release as a new pasture species for saline, waterlogged soils in Mediterranean-type climates.

Keywords. Salinity – Waterlogging – Fodder – Cultivars – Plant breeding – Rhizobia – Nitrogen fixation.

Messina* (Melilotus Siculus) *– une nouvelle légumineuse fourragère annuelle pour de climats de type méditerranéen avec une grande tolérance à la salinité et l'engorgement

Résumé. *Messina* (Melilotus Siculus) *est une légumineuse fourragère annuelle tolérante à l'égorgement et ayant une tolérance à la salinité beaucoup plus élevé que d'autres légumineuses. Des études sous serre et en laboratoire ont identifié plusieurs mécanismes à la fois pour la tolérance à la salinité et à lengorgement qui expliquent son adaptation aux sols salins et détrempés. Essais sur le terrain sont en cours pour choisir la meilleure ligne adapté pour son lancement comme un nouveau cultivar. La sélection est également en cours pour une souche de* Rhizobium *adapté et tolérante à la sel. Cet article traite de l'écologie, la physiologie et l'agronomie de messina et des progrès vers sa sortie comme une nouvelle espèce fourragère pour des sols salins et gorgés d'eau en climats de type méditerranéen.*

Mots-clés. *Salinité – Saturation en eau – Fourrage – Cultivars – Amélioration des plantes – Rhizobia – Fixation d'azote.*

I – Introduction

Approximately 400 million ha throughout the world are affected by salinity (FAO, 2005). In southern Australia around 1.5 million ha of agricultural land in Australia is currently affected by dryland salinity, with this area predicted to increase to 1.7-2.3 million ha by 2020 (National Land and Water Resources Audit, 2001). Such areas are often subject to winter waterlogging. The combination of these stresses severely affects plant growth and survival (Barrett-Lennard, 2003).

Self-regenerating annual pasture legumes are widely used in the farming systems of southern Australia (Nichols *et al.*, 2007), which has a Mediterranean-type climate. However, currently used pasture legumes, particularly subterranean clover (*Trifolium subterraneum* L.), are very sensitive to salinity, particularly as germinating seedlings (Nichols *et al.*, 2009; Rogers *et al.*, 2011). This is a problem in the years following sowing, as soil surface salinity levels are generally highest at this time (Nichols *et al.*, 2008). There is clearly a need to find an annual legume adapted to the combined stresses of salinity and waterlogging on saline soils to provide nitrogen for salt tolerant grasses and improve pasture quality.

Melilotus siculus (Turra) Vitman ex B.D. Jacks (syn. *M. messanensis* (L.) Mill.), given the common name of "messina" (Rogers *et al.*, 2011), is a very promising annual pasture legume for saline, waterlogged soils. This paper summarises the results of studies on messina and its rhizobia and prospects for their commercialisation.

II – Adaptation of messina to saline, waterlogged soils

Messina is native to saline, marshy areas of the Mediterranean basin, Iberian peninsula and east Asia (Marañón *et al.*, 1989). Initial interest in messina came from a series of trials conducted across southern Australia, in which herbage production and persistence of 42 annual pasture legumes were measured over three years at five sites that varied in extent of both salinity and waterlogging (Nichols *et al.*, 2008). Messina is the only species that regenerates on waterlogged sites with surface (0-10 cm) electrical conductivity (EC_e) >8 dS/m in summer and persists on sites with EC_e >30 dS/m (Nichols *et al.*, 2008; Nichols and Craig, unpublished data). This compares with burr medic (*Medicago polymorpha* L.), which can be productive on soils with summer surface EC_e >8 dS/m, but only when they are well-drained, while balansa clover (*Trifolium michelianum* Savi) is productive on soils subject to waterlogging, but will not persist when summer surface EC_e is <8 dS/m.

1. Salinity tolerance and avoidance mechanisms at germination

Messina has a range of salinity tolerance and avoidance mechanisms at germination. It has higher salinity tolerance *per se* as a germinating seedling than other pasture legumes. Nichols *et al.* (2009) showed messina germination was not reduced by 300 mM NaCl (equivalent to 30 dS/m), while significant reductions occurred for burr medic cv. Scimitar at 240 mM and balansa clover cv. Frontier at 120 mM NaCl. Significant variation for salinity tolerance at germination was also found amongst messina accessions by Rogers *et al.* (2011). Messina also has an ability to recover germinability after exposure to high levels of salinity. Nichols *et al.* (2009) showed messina was able to recover 31% of its potential germinability upon transfer to non-saline solution after 21 days in 600 mM NaCl, while Jeffery (2011) found variation amongst 21 messina accessions for germination recovery following 14 days at 600 mM NaCl, with four recovering full germinability and seven with >70% germination. This compared with no germination of burr medic cv. Scimitar or *Melilotus albus* cv. Jota.

Seed coat impermeability (hard seeds) was shown by Nichols *et al.* (2009) to protect the seed against the toxic effects of salinity over summer. They also showed messina had a delay in the timing of hard seed breakdown (seed softening) over the summer-autumn period, compared to *T. subterraneum* and *T. michelianum*. This delay acts as a salinity avoidance mechanism to defer germination until late autumn-early winter, when reliable rainfall, capable of flushing salts from the surface, is more likely to occur. Jeffery (2011) found variation in the timing of seed softening amongst 21 messina accessions.

2. Tolerance to salinity and waterlogging in the vegetative stage

Glasshouse experiments have demonstrated the high salt tolerance of messina. In a study of 19 *Melilotus* species Rogers *et al.* (2008) found 2-month old messina plants subjected to 28 d in an aerated solution of 240 mM NaCl had 89% the shoot biomass of non-saline controls, compared to 31% for balansa clover cv. Paradana. Rogers *et al.* (2011) found variation for salinity tolerance amongst 29 messina accessions, with ten having >80% the shoot biomass of non-saline controls after 21 d at 300 mM; no plants of balansa clover cv. Frontier survived. In another experiment shoot biomass of messina was 30% that of non-saline controls after 21 d at 450 mM, compared to 15% for both balansa clover cv. Paradana and burr medic cv. Scimitar (Teakle *et al.* 2012).

The waterlogging tolerance of messina has been confirmed in glasshouse studies. Rogers *et al.* (2008) found messina shoot biomass after 28 d in stagnant solution (designed to emulate the hypoxic conditions of waterlogged soils) was 102% of aerated controls, compared with 99% for balansa clover cv. Paradana and only 29% for lucerne (*Medicago sativa* L) cv. Sceptre. Root biomass of messina in the stagnant solution was 119% that of the aerated solution, compared with 144% for balansa clover and only 32% for lucerne. Rogers *et al.* (2011) examined 23 messina accessions and found none had shoot growth reductions >20% in stagnant solution, compared with aerated controls, while root biomass increased by as much as 41%. Teakle *et al.* (2011) and Verboven *et al.* (2011) showed that waterlogging tolerance of messina is aided by a highly porous form of aerenchyma, termed “phellem”, which develops around the roots under stagnant conditions and enables O_2 transport from the hypocotyls.

A recent study by Teakle *et al.* (2012) showed that messina is very tolerant to the combined stresses of salinity and waterlogging. New leaves were produced in messina after 14 d in stagnant nutrient solution with 550 mM NaCl (~ sea water salinity), while both balansa clover cv. Paradana and burr medic cv. Scimitar died after 5 d in a 400 mM NaCl stagnant solution

III – Commercialisation of messina and an adapted *Rhizobium*

Initial field trials on saline, waterlogged soils showed that while messina was able to set seed and regenerate, the vast majority of regenerating seedlings failed to nodulate and grow (Nichols *et al.*, 2008; Bonython *et al.*, 2011). This was shown to be due to the inability of the commercial *Rhizobium* strain (*Sinorhizobium medicae* strain WSM 1115), used to inoculate annual medic (*Medicago* spp.) seed, to persist over summer in the highly saline soil surface. Field screening has identified several *S. medicae* strains with much greater ability to nodulate regenerating messina plants on saline soils (Bonython *et al.*, 2011). This now paves the way for development of messina as a new species for agriculture.

Field trials are currently underway to evaluate 21 accessions of messina over a 3-year period on saline, waterlogged sites in southern Australia. Measurements include biomass production, seed production, seedling regeneration densities and nodulation ability. It is intended that the best adapted variety will be released to the seed industry in 2014, along with the best adapted salt-tolerant *Rhizobium* strain.

IV – Further research

Before messina can be released as a new species for agriculture, duty of care trials need to be conducted to ensure there are no risks to animal health. Messina has negligible levels of the chemical coumarin, found in other *Melilotus* species (Nair *et al.*, unpublished data; Stevenson, 1969), which can taint the flavour of meat, milk and flour and cause a haemorrhagic condition in livestock if fed mouldy hay (Masters *et al.*, 2001). Messina also has similar nutritive value to other pasture legumes (Rogers *et al.*, 2008). However, animal feeding trials need to be conducted to confirm its lack of anti-nutritional factors and its value as a stock feed.

Once the best adapted accession has been selected as a new cultivar, agronomic and grazing management packages need to be developed to optimise pasture performance and animal production. Factors include establishment methods, mixtures with salt tolerant grasses, fertiliser rates, broadleaf herbicide options and grazing strategies. Seed production strategies also need to be devised. A preliminary seed harvesting trial produced seed yields of over 1,500 kg/ha (A.D. Craig, unpublished data), indicating the high yield potential of messina and its potential for seed harvesting with a conventional cereal harvester. This should make possible the provision of inexpensive seed for sowing.

Acknowledgments

We are grateful for the technical support of Brad Wintle, Darryl McClements, Stephen Biggins and Tammy Closter. We wish to thank John South, Twynam Cunningham, Bob and Craig Lubcke, Neville and Gordon Stopps, Duck Island Partners, Trevor Egel, Kym Herriot and Greg Vickers for their support and allowing us to conduct field trials on their properties.

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Comparative estimation of crude protein, phenols and tannins concentration of *Lotus corniculatus* growing in different habitats

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Abstract. *Lotus corniculatus* is a temperate perennial legume that contains condensed tannins which increase the animal production and decrease bloating in ruminants. The aim of this study was to investigate differences in crude protein (CP), total phenols (TPH), total tannins (TT) and condensed tannins (CT) concentration of *L. corniculatus* individuals growing in oak forest and in open grasslands. The collection of plant material was conducted in Taxiarchis area, Chalkidiki, Northern Greece from four sites in an oak forest and four sites in adjacent open grasslands. Twenty individual plants of *L. corniculatus* were randomly collected at the flowering stage in summer 2011 from each of the eight sites and were analysed for CP, TPH, TT and CT concentration. According to the results, the CP concentration was significantly higher in individuals from the forest in comparison to individuals from the open grasslands. Inversely, the individuals from the open grasslands had significantly higher concentration of TPH, TT and CT compared to those from the forest.

Keywords. Legumes – Condensed tannins – *Lotus corniculatus.*

Estimation comparative des concentrations de protéines brutes, de phénols et de tannins de* Lotus corniculatus *provenant de différents habitats

Résumé. *Lotus corniculatus est une légumineuse vivace, tempérée, qui contient de tanins condensés qui augmentent la production animale et diminuent le météorisme chez les ruminants. L'objectif de cette recherche était d'étudier les différences de protéines brutes (CP), des phénols totaux (TPH), des tanins totaux (TT) et la concentration des tanins condensés (CT) de génotypes de* L. corniculatus *qui poussent dans la forêt de chênes et dans les prairies ouvertes. La collection de matériel végétal a été réalisée dans la région de Taxiarchis, à Chalkidiki, en Grèce du nord à partir de quatre sites d'une forêt de chênes et de quatre sites des prairies ouvertes adjacentes. Vingt plantes individuelles de* L. corniculatus *ont été prélevées au hasard au stade de la floraison en été 2011, de chacun des huit sites et ont été analysées pour le CP, TPH, TT et la concentration de CT. Selon les résultats, CP était significativement plus élevée chez les individus de la forêt par rapport aux individus des prairies ouvertes. Inversement, les plantes provenant des prairies ouvertes avaient des concentrations de TPH, TT et TC significativement plus élevées par rapport à ceux de la forêt.*

Mots-clés. *Légumineuse – Tanins condensés –* Lotus corniculatus.

I – Introduction

Lotus corniculatus is a widely distributed legume of high nutritive value (Escaray *et al*., 2012) with good adaptability to different soil and climatic conditions, fact that results in its genetic diversity (Steiner *et al*., 2001). It contains phenolic compounds and especially proanthocyanidins, also known as condensed tannins (CT), which prevent bloating and allow the control of internal parasite infections, without using anthelmintic drugs (Aerts *et al*., 1999, Min and Hart, 2003). However, depending upon its CTs concentration (Marshall *et al*., 2010) it could have a beneficial or detrimental effect on ruminant production. Marshall *et al*. (2010) found significant variation in CT within and between varieties of *Lotus*. It is known, that CT concentration is affected by genetic and environmental variables (McMahon *et al*., 2000). Therefore, the knowledge of germplasm diversity in response to environmental condition is a useful tool for its utilization in breeding efforts.

The objective of this research was to estimate the variation in phenols, tannins, condensed tannins and crude protein (CP) content among *L. corniculatus* individual plants growing under two different environmental conditions, namely in forest and in open grassland.

II – Materials and methods

The study was conducted in the area of Cholomontas, Chalkidiki prefecture, northern Greece (40°23'N, 23°28'E) at 800 m a.s.l. The climate of the area is classified as subhumid Mediterranean, with a mean air temperature of 11.1°C and an annual rainfall of 767 mm. The area is situated in the *Quercion confertae* subzone of the *Quercetalia pubescentis* (sub-Mediterranean) zone (Athanasiadis, 1986). The whole forested area was grazed by goats and sheep.

Table 1. Description of collection sites

Site Nr.	Altitude	Aspect	Dominant herbaceous species	Description
Forest				
1	852 m	East	*Vicia* sp*, Platango* sp.	Beech forest
2	867 m	North-west	*L. corniculatus, Cynodon* sp.	Oak forest
3	780 m	West	*Brachypodium* sp.*, Trifolium sp.*	Oak Forest
4	815 m	South	*Trifolium sp., Brachypodium* sp.	Oak forest
Grassland				
1	792 m	North-west	*Cynodon* sp.*, Cinosurus* sp.	Not grazed grassland
2	799 m	South-east	*Agrostis* sp.*, Cynodon* sp.	Grazed grassland
3	765 m	North-east	*Agrostis* sp.*, Chrysopogon* sp.	Grazed grassland
4	812 m	West	*Cynodon* sp.*, Hieracium* sp.	Heavily grazed grassland

Twenty individual plants were collected at the flowering stage in August 2011 from each of four different sites in the forested area and in the open grasslands (Table 1), i.e. total of 160 plants and oven-dried at 50^{o}C for 48h. All the samples were ground through a 1 mm sieve and analysed for N using the Kjeldahl procedure (AOAC, 1990). Crude Protein (CP) concentration was then calculated by multiplying the N content by 6.25. Samples were analysed for total phenols (TPH), total tannins (TT) and CT assays according to Makkar (2003). Three replicates of 200 mg samples were extracted in 10 ml aqueous acetone (acetone: water, 7:3) twice in an ultrasonic water bath for 20 min. The extracted samples were centrifuged at 3,000 g at 4°C for 10 min and the supernatants were used for tannin analysis on the same day Makkar (2003). Total phenols (TPH) and total tannins (TT) in the extract were determined by a modification of the Folin-Ciocalteu method using polyvinylpolypyrrolidone (PVPP) to separate tannin phenols from non-tannin phenols (Makkar *et al*., 1993). Concentration of TT (mg/g DM) was calculated as follows: TT conc. = (conc. of TPH) - (conc. of TPH remaining after PVP treatment). Both total phenols and total tannins were expressed as tannic acid equivalent (mg/g TAE). Condensed tannins (CT) were determined according to the method of Porter (*et al*., 1986), using purified quebracho CT as the reference standard. The CT contents are therefore expressed as quebracho equivalent.

One-way ANOVA of the data was performed using SPSS® statistical software v. 18.0 (SPSS Inc., Chicago, IL, USA), in order to determine differences among the habitats and collection sites in each habitats. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

The individuals originated from the forest had significant lower TPH, TT and CT and higher CP concentration compared to those from grassland (Table 2). Iason and Hester (1993) have also reported that shading reduced TPH. According to Jantineke *et al*. (2009) shading reduced the TPH, TT and CT respectively. It is well known that shade improves the nutritive value of the herbage vegetation as the maturity stage is delayed compared to open field conditions (Burner and MacKown, 2006, Parissi and Koukoura, 2009). The increase of crude protein content in legumes species under shade has also been reported by Kyriazopoulos *et al*. (2012).

Table 2. Means and Coefficient of Variation (CV) of TPH (mg/g DM TAE), TT (mg/g DM TAE), CT(mg/g DM QE) and CP(%) concentration of *L. corniculatus* individual plants from forest and grassland

	TPH		TT		CT		CP	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Forest	5.5	25.1	2.4	35.3	20.3	36.3	19.0	19.0
Grassland	6.6	22.3	3.0	34.8	25.5	24.6	13.7	6.7
F-value/Sign.	5.848	**	4.322	**	5.939	**	40.446	**

** (P ≤ 0.05).

Table 3. TPH (mg/g DM TAE), TT (mg/g DM TAE), CT (mg/g DM QE) and CP(%) concentration of L. corniculatus individual plants from the collecting sites in forest and grassland

	Forest				Grassland			
	1	2	3	4	1	2	3	4
TPH	4.3b	6.8a	4.7b	6.1a	5.1b	6.4ab	7.7a	7.0a
TT	1.7b	3.3a	1.9ab	2.6a	1.6c	2.8b	4.0a	3.6a
CT	15.2b	26.0a	14.2b	25.5a	24.9	24.7	28.2	24.3
CP	21.0a	21.0a	19.4a	14.7b	13.3	14.3	13.6	13.7

* Means in the same row followed by the same letter are not significantly different (P ≤ 0.05).

Significant differences were detected for TPH, TT, CT and CP in forest and for TPH in grassland among the collecting sites (Table 3). Significantly higher TPH, TT, and CT concentration was observed in forest habitat at site 2 where *L. corniculatus* was one of the dominant species (Table 1). On the other hand, the ungrazed grassland (site 1 of grasslands) (Table 1) had significant lower TPH and TT compared to the others (Table 3). It is well documented that plants-herbivores interactions led to the development of defence mechanisms of plants against herbivores such as tannins (Barroso *et al.,* 2001). Thus, ungrazed plants had lower content of tannins compared to the grazed ones).

The higher variability in terms of CV estimation was observed for TT and CT among the individuals from both forest and grassland. The CP concentration revealed the lowest variability among the individual from both forest and grassland.

IV – Conclusions

The habitat ecology and management seems that affect the concentration of crude protein, phenols and tannins in individual plants of *L. corniculatus*. The arising question is whether this variation is a result of genetic or environmental effect, in order to use in future breeding efforts.

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Agricultural traits of blue grass accessions in Black Sea Region of Turkey

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Abstract. Breeding of blue grass (*Poa* sp.) is a very important issue in Turkey and seed collections play a key role in enhancing the genetic pool. For this reason, blue grass seeds were collected from Northern Anatolian Region in 2007, and were subsequently characterized. Accessions were sown in seed trays and then seedlings were transplanted to field. At the end of the measurements and observations, the results were: (i) plant heights ranged between 22 and 100 cm; (ii) internode distance between 2.5 and 25.0 cm; (iii) main stem diameter between 0.10 and 1.38 mm; (iv) number of internode between 2 and 3; (v) flag leave blade length between 1.2 and 23.9 cm; (vi) flag leave blade width between 0.10 and 0.50 cm; (vii) panicle length between 3.10 and 16.60 cm. Number of spikelet in *Poa sp*. was found between 15 and 207, number of tiller per plant was between 19 and 382, number of fertile tiller per plant was between 0.11 and 15.6 g, dry matter yield per plant was between 10.03 and 27 g, 1000 seed weight was between 0.10 and 0.70 g.

Keywords. Diversity – Natural vegetation – Agricultural characters – Blue grass.

Caractéristiques agricoles des accessions d'herbe bleu dans la région de la mer Noire de la Turquie

Résumé. *La culture de l'herbe bleue (*Poa *sp.) est très importante en Turquie et les collections de semences jouent un rôle clé dans l'amélioration du pool génétique. Pour cette raison, des graines d'herbe bleu ont été recueillies au Nord région d'Anatolie en 2007, et ont ensuite été caractérisées. Les accessions ont été semées dans des plateaux de semences et de plants ont été transplantés ensuite au champ. A la fin des mesures et des observations, les résultats étaient les suivants: (i) la hauteur des plantes varie entre 22 et 100 cm ; (ii) la distance internodale entre 2,5 et 25,0 cm ; (iii) le diamètre de la tige principale entre 0,10 et 1,38 mm ; (iv) le nombre d'entrenœuds entre 2 et 3 ; (v) la longueur de la feuille drapeau entre 1,2 et 23,9 cm ; (vi) la largeur de la feuille drapeau entre 0,10 et 0,50 cm ; et (vii) la longueur de la panicule entre 3,10 et 16,60 cm. Le nombre d'épillets a été trouvée entre 15 et 207, le nombre de talles par plante était comprise entre 19 et 382, le nombre de talles fertiles par plante était comprise entre 0,11 et 15,6 g, le rendement en matière sèche par plante était comprise entre 10,03 et 27 g, et poids de 1000 grains était comprise entre 0,10 et 0,70 g.*

Mots-clés. *Diversité – Végétation naturelle – Caractéristiques agricoles – Herbe bleu.*

I – Introduction

Nearly half of the fodder production in Turkey is provided from ranges and pastures. The botanical composition of these lands has negatively been affected by early grazing and overgrazing. Consequently, their yields have rapidly declined.

It is essential to determine the suitable species and varieties in a certain region to improve ranges and pastures. The most efficient short-term way to cover feed deficiency is to increase the cultivation and yields of forages. Blue grass (*Poa sp*.) is inarguably an important plant for the Black Sea region since it is highly consumed by grazing animals. There is a wide range of variation among the blue grass plants raised in different areas of Mid-Black Sea Region in terms of examined traits in a study. This case is of great importance with respect to genetic diversity. Genotypic features of plants should be determined by eliminating the effects of environmental factors, which might be succeeded by raising plants in similar environmental regions (Acar et *al.,* 2009). *Poa species,* which are significant pasture plants, could grow in well drained lands, humid and cool regions with regular rainfall and in the soils with 6 and 7 pH values (Açıkgöz, 2001). *Poa species* show a large variation in terms of biotype characters due to their spreadable characters. Although most of the species are located in the native pastures; some are used in forage production and establishment of green lands (Manga *et al*., 2002). Davis (1985) conducted an experiment on *Poa species*, and determined some agricultural characters of some *Poa species*. For example, in *Poa infirma,* plant height was between 5 and 20 cm, leaf blade width was between 0.5 –2 mm; in *Poa annua*, plant height was between 7 and 40 cm, leaf blade width was between 0.8 – 3.5 mm, panicle length was between 3.5 and 10 cm, in *Poa trivialis,* plant height was between 25 and 90 cm, leaf blade width was between 2 and 3.6 mm, panicle length was between 4 and 13 cm; in *Poa pratensis*, plant height was between 20 and 80 cm, leaf blade width was between 1.5 and 4 mm, panicle length was between 3.5 and 12 cm; in *Poa angustifolia,* plant height was between 20 and 80 cm, leaf blade width was between 0.8 and 2 mm, panicle length was 20 cm; in *Poa longifolia,* plant height was between 30 and 100 cm, leaf blade length was 5 cm, leaf blade width was between 1.5 and 4.5 mm, panicle length was between 7 and 15 cm; in *Poa compressa,* plant height was between 30 and 55 cm, leaf blade width was between 2 and 4 mm, panicle length was between 3 and 7 cm; in *Poa nemoralis*, plant height was between 25 and 60 cm, leaf blade width was between 1 and 3 mm; in *Poa sterilis*, plant height was between 15 and 40 cm, leaf blade width was between 1 and 1.8 mm, panicle length was between 12 and 15 cm; in *Poa alpine*, plant height was between 8 and 35 cm, leaf blade width was between 1.5 – 3 mm; in *Poa bulbosa*, plant height was between 9 and 55 cm, leaf blade width was between 0.5 and 1.5 mm, panicle length was between 2 and 7 cm.

In different resaerches, many characters were determined in *Poa pratensis.* For example, plant height was found as 120 cm in a study (Anon., 2011a). Brede (2001) also measured some characters of *Poa pratensis.* Plant height was found between 45-60 cm, leaf blade length was between 7-10 cm. Clayton (2010a) found the leaf blade length as 5-30 cm, leaf blade width as 2-4 cm number of internod as 2-4, panicle length as 2-20 cm. According to a research (Anon. 2011b), plant height was found between 20-80 cm and leaf blade width was found between 2 and 4 cm. Zylk and Pronczuk (2000) recorded that 1000 seed weight was between 0.245 and 0.425 g.

In the present study, *Poa sp.* seeds were collected from natural flora of Samsun, Sinop and Ordu provinces. Firstly, some morphological and agricultural traits of the plant genotypes were characterized and after that, the usage potentialities of these materials will be set up in improvement of pastures, forage and green area in the region.

II – Materials and methods

Seeds were collected from natural flora of Ordu, Samsun and Sinop provinces located in the Middle Black Sea Region in the period of June and September 2007-2008. The collected 292 seed samples from 62 different locations were sown in seed trays in January 2009 and seedlings were transplanted to field at 70 cm row spacing 70 cm plant spacing within the rows (70 x 70 cm) at the end of March and at the beginning of April in Samsun, Turkey. The experimental area has the typical Mediterranean climatic conditions. All observations and measurements (plant heights, internode distance, main stem diameter, number of internode, flag leave blade length, flag leave blade width, panicle length, spikelet number in a panicle and fertile tiller number, dry matter yield per plant, seed yield per plant) were performed in the second year of the study at blossoming stage and the obtained data were analyzed using SPSS 11.0 program (SPSS, 2002).

III – Results and discussion

At the end of the two-year study, totally 75 accessions in different 11 *Poa* species were collected from Samsun (36), Sinop (24) and Ordu (15) provinces. The most samples in total samples belong to *Poa angustifolia, Poa pratensis* and *Poa trivialis*. The species and the number of collected samples for each species as *follow: P. pratensis* 19, *P. sterilis* 5, *P. trivialis* 11, *P. compressa* 3, *P. nemoralis* 4, *P. annua* 3, *P. angustifolia* 22, *P. infirma* 3, *P. longifolia* 2, *P. bulbosa* 1 and *P. alpina* 2. *Poa alpina* was only found in high plateu of Ordu province. *P. bulbosa* and *P. annua* were only found in Sinop province. Plant height of all *Poa* species varied between 22 and 100 cm and general average was calculated as 58.21 cm. Coefficient of variation was found 34.58% as the variation was large concerning plant heights of *Poa* species (Table 1).

There was no a large variation regarding the internod number of all *Poa* species and samples and number of internod was found between 2 and 3 in all samples. However, there was a large variation in internod length and varied from 2.5 to 25 cm. Coefficient of variation was found as 34.99%. Main stem diameters of the samples were between 0.10 and 1.38 mm. (Table 1).

The variation was also large in leaf blade lengths of the samples and recorded between 1.2 and 23.9 cm. The coefficient of variation was calculated as 53.89 in terms of leaf blade length. Yet, the coefficient of variation was found as 29.55% regarding leaf blade width. It was recorded between 0.10 and 0.50 cm (Table 1). Panicle lenghth changed from 3.10 to 16.60 cm and coefficient of variation was 27.44%.

Table 1. Some statistical data on *Poa* species

Characters	Number of population	Number of sample	Average	Minimun	Maximum	CV (%)	Sx
Plant height (cm)	75	379	57.42	22.00	100.00	22.71	1.03
Internode distance (cm)	75	379	11.84	2.50	25.00	34.99	0.21
Main stem diameter (mm)	75	379	0.93	0.10	1.38	19.28	0.01
Number of internode	75	379	2.39	2.00	3.00	20.43	0.02
Flag leave blade length (cm)	75	379	3.61	1.20	23.90	53.89	0.10
Flag leaf blade width (cm)	75	379	0.25	0.10	0.50	29.55	0.25
Panicle length (cm)	75	379	7.98	3.10	16.60	27.44	0.11
Spikelet number in a panicle	75	379	81.77	15.00	207.00	37.15	1.54
Fertile tiller number	75	379	81.07	10.00	382.00	57.12	2.38
Tiller of number	75	379	86.78	19.00	382.00	51.36	2.29
Seed yield per plant (g/ plant)	75	379	2.05	0.11	15.60	86.39	0.10
Dry matter yield per plant (g/ plant)	75	75	16.91	10.03	27.00	19.73	0.39
1000 seed weight (g)	75	75	0.27	0.10	0.70	50.56	0.02

Number of spikelet per panicle was between 15 and 207 and coefficient of variation was 37.15%. Number of tiller was found between 19 and 382; fertile tiller number was counted between 10 and 382 and coefficient of variation was found 51.36% and 57.12%, respectively. Seed yield per plant was 2.05 g as average of all populations (0.11 and 15.60 g). Coefficient of variation was found as 86.39%. 1000 seed weight of the samples were found between 0.10 and 0.97 and average was 0.27 g. Coefficient of variation was 50.46%. Dry matter yield per plant was between 10.03 and 27 g. Average of all populations was 16.91 g.

There was a statistically significant and positive relation between dry matter yield and plant height, internode length and internode number ($P \leq 0.01$). There was also statistically significant and positive relation between dry matter yield and number of tiller and number of fertile tiller ($P \leq 0.05$). There was a statistically insignificant and positive relation between dry matter yield and internode length, panicle length and seed yield. However there was a statistically insignificant and negative relation between dry matter yield and leaf blade length & width, number of panicle and 1000 seed weight. There was a statistically significant and positive relation between seed yield per plant and number of tiller and number of fertile tiller ($P \leq 0.01$).

IV – Conclusions

At the end of the study, a large gene pool was obtained from *Poa* genus. In this material, samples were classified regarding forage production, pasture establishment and establishing turfs. Breeding studies should continue to release cultivars for the purposes.

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The determination of pasture type alfalfa lines

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Abstract. The objective of this research was to characterize 56 collected alfalfa populations growing with two experiments from clones and from seeds in 2010 and 2011. Collected alfalfa populations were affected significantly in most observed traits over two years period. The populations of Akyurt 1.2.3, Kizilcahamam 1.2., Gudul 1, Kazan 1.2., Cankaya 1, Sincan 2, Çubuk 2, Pursaklar 1, Şereflikochisar 1. 2. 3., Nallıhan 1 had erect growing habit and their annual dry matter yield/plant were very high over the two years. They are going to be evaluated for forage-type alfalfa breeding. Apart, all the other populations are going to be subject to a graze-type alfalfa breeding program in near future, because they showed perfect results when investigate of their pasture characters. The first cut dry matter yield/annual dry matter yield (%) was highest on the population of Kalecik 1 (82%). Some of them also had high forage yields, as Golbası 1.2. and Kizilcahamam 1, as well as forage-type. They were growing horizontal, they spread on the surface and under the soil, some of them had rhizomes and they have so many tillers on their crown.

Keywords. Alfalfa-*Medicago sativa* L. – Characterization – Forage type – Grazing type.

La détermination des lignes de luzerne aptes pour le pâturage

Résumé. *L'objectif de cette recherche est de caractériser une population de 56 luzernes qui a été cultivée et rassemblée en réalisant deux essais en les années 2010 et 2011 à partir de clones et de graines. Les populations de luzerne recueillies ont été affectés de manière significative dans la plupart des traits observés sur la période de deux ans. Les populations de Akyurt 1.2.3, Kizilcahamam 1.2, Gudul 1, Kazan 1.2, Cankaya 1, Sincan 2, Çubuk 2, Pursaklar 1, Şereflikochisar 1. 2. 3., Nallıhan 1 on montré une croissance dressée et leurs rendements annuel de matière sèche / plante étaient très élevés au cours des deux années. Ils seront évalués pour la culture de luzernes fourragères. En outre, toutes les autres populations vont constituer en une proche période l'objet d'un programme d'amélioration de luzernes pour le pâturage. Car ils ont montré de résultats parfaits lors de l'examen des caractéristiques au pâturage. Le rapport de rendement en matière sèche à la première coupe / rendement annuel en matière sèche (%) était le plus élevé pour la population de Kalecik 1 (82%). Certaines d'entre elles, tels que Golbasi 1,2. et Kizilcahamam 1, ont eu également des rendements fourragers élevés, ainsi qu'ont présenté un type fourrager. Ils ont grandis de à l'horizontale, ils se sont propagés sur la surface et le sous sol, certains d'entre eux ont des rhizomes, et ils possédent de nombreuses talles sur leur couronne.*

Mots-clés. *Alfalfa-*Medicago sativa *L. – Caractérisation – Type fourrager – Type pour pâturage.*

I – Introduction

Turkey is the gen centre for a lot of quality forage plants including alfalfa species (Davis, 1970). Wild alfalfa species (*Medicago sativa* L.) can be seen often in our vegetation (Sabancı and Ozpinar, 2001). Pasture type alfalfa is generally spread under the ground, horizontal growing and it has rhizomes. And these plants are very persistent to cold and drought. Because of that, they are also very persistent to grazing and they can be used for natural pastures for over seeding and for establishing artificial pastures (Aydın *et al*., 2010). There is no still certificated pasture-type alfalfa cultivar, even they are our nature plants. But, some institutes have carried out breeding research with them nowadays. There is urgent need for these types of alfalfa species in our country. The objective of this research was to characterizee 56 alfalfa populations which were collected in the location of Ankara province as clones and seeds.

II – Materials and methods

In province of Ankara with 24 towns (about 31 km^2), wild alfalfa stems and seed pods were collected as total 56 populations from the nature during the spring and summer of 2009 and seedlings were grown in the greenhouse. Two field trials were established with all of these seedlings on 2th May of 2010 in experimental land of Agricultural Faculty on Ankara University (39º57'N, 32º53'E, 894 m altitude). One of them has 38 populations which were obtained from collected alfalfa seeds, and the other one has 20 populations which were obtained from collected alfalfa clones. These seedlings were planted in a clay loam, classified slightly alkaline (pH 7.8), rich in potassium (1400 kg ha^{-1}), poor in phosphorus (69 kg ha^{-1}) and containing 1.15% organic matter. According to State Meteorology Department, long-term observations (1975-2010) in Ankara showed that average precipitation, mean temperature and relative humidity were 403 mm year^{-1}, 12.1ºC and 61%, respectively. Corresponding values in 2010 were 594 mm, 14.5ºC and 59%, however they were 436 mm, 12ºC and 62% in 2011. In both experiments, the seedlings of each population were planted into one row with 80x80 cm apart. The number of plant in each row were divided to 3 as replications. 9 phenologic and morphologic observations and measurements were done and forage yields were determined for characterization on collected alfalfa plants in 2010 and 2011. The data were analyzed by GLM at the 5 and 1 % levels of significance. When a significant differences was found, a protected Duncan test was applied at the p=0.05 level for comparisons between means (SAS, 1985).

III – Results and discussion

Averaged over two years (2010 and 2011) 9 observations of 56 collected alfalfa populations were analyzed and the Duncan results were given in Table 1 and 2. According to the 36 population results which were grown from collected alfalfa seeds, average of both years, there were significant population effects on all observed traits as the level of 1% except the structure of root crown. It was not significant. However, on the results of other 20 populations which were obtained from collected alfalfa clones, population effects were significant on all observations for the mean of two years as the level of 1 %, except the rhizome number on plants which was no significance among the populations and the first cut dry matter yield/annual dry matter yield (%) that significance level is 5% among the populations.

Average of two years, the plants were grown from the seeds, the highest annual dry matter yield were obtained from the population of Akyurt 3 as 259 g/plant and the populations of Kizilcahamam 1., Kazan 2, Golbasi 2., Cankaya 1 and Golbası 1 fallowed it (Table 1). When the plants were grown from collected alfalfa clones, Şereflikochisar 1 had the highest dry matter yield as 295 g/plant and the others were Şereflikochisar 3, Kizilcahamam 1, Nallihan 1, Akyurt 1, Cankaya 1, Çubuk 1 and Pursaklar (Table 2). These high yielding alfalfa populations were mostly erect grown and they seem as forage-type. However, first cut dry matter yield/annual dry matter yield was highest on Kalecik 1 population as 82 %, which is horizontal growing graze-type population (Table 1). Our main objective was to collect and evaluate breeding material for graze-type alfalfa in this research. After field trials over 2 years, collected populations showed mostly horizontal growing and when investigated for their pasture characteristics, they were perfect on them (Van Keuren and Marten, 1988). Their first cut yields were high, their growing was horizontal, they spread on the surface and under the soil, some of them had rhizomes and they have so many tillers on their crown (Prosperi *et al*. 2006). They are good for resistance to graze and to hard environmental conditions (Aydin, *et al*. 2010). However, the populations of Akyurt 1, 2, 3, Kizilcahamam 1,2., Gudul 1, Kazan 1,2., Cankaya 1, Sincan 2, Çubuk 2, Pursaklar 1, Şereflikochisar 1, 2, 3. Nallıhan 1 had erect growing habit and their annual dry matter yield/plant in 2010 and

Table 1. The mean of some observations from seed growing alfalfa populations averaged over two years (2010 and 2011)

Populations	1*	2	3	4	5	6	7	8	9
Kalecik 1	8.0a-g**	1.3h-j	17.1h-n	99.9ab	141.4c-h	0.8a	1.0	4.7a-e	18.5j-l
Kalecik 2	8.9a	1.8c-j	16.2i-n	67.0lm	83.0e-h	0.6f-j	1.0	3.9f-h	19.6h-l
Kalecik 3	6.8 g-l	2.0a-h	20.1e-j	94.6a-d	110.8c-h	0.7a-f	1.0	4.6a-e	17.8k-m
Güdül 1	5.6 l-o	1.2h-j	27.1b-d	89.5a-g	144.9c-g	0.7a-j	1.0	5.0a	20.7g-l
Gölbaşı 1	7.2b-j	2.1a-g	23.6c-h	98.3ab	181.7a-d	0.8a-c	1.0	4.7a-e	21.8e-k
Gölbaşı 2	7.1c-j	2.3a-c	25.3b-g	102.6a	192.4a-c	0.8ad	1.0	5.0a	20.3h-l
Gölbaşı 3	7.5b-i	2.2a-e	18.6g-l	96.4a-c	150.0c-f	0.7a-g	1.0	4.9a-c	22.2d-k
Haymana 1	7.2b-j	1.3g-j	19.3f-k	93.2a-e	105.6c-h	0.8ab	1.0	4.6a-e	15.5lm
Haymana 2	7.1c-j	1.1ij	19.7e-j	92.8a-f	69.6f-h	0.7a-g	1.0	4.9ab	12.9m
Haymana 3	8.5ab	1.4e-j	19.1f-k	87.7b-h	97.7d-h	0.7a-i	1.0	4.8a-d	15.4lm
Beypazarı 1	8.0a-g	1.9a-i	14.5i-n	87.6b-h	128.0c-h	0.7a-i	1.0	4.2e-g	19.3i-l
Beypazarı 2	6.9g-i	1.4f-j	17.6h-m	88.4a-g	158.6b-f	0.8a-e	1.0	4.5a-e	21.3f-k
Beypazarı 3	6.3i-n	1.4d-j	19.9e-j	88.4a-g	155.7b-f	0.7a-i	1.0	4.5a-e	22.9d-k
Ayaş 1	7.0e-j	1.6c-j	16.3i-n	83.2c-j	112.5c-h	0.5h-j	1.0	4.6a-e	21.4f-k
Elmadă 1	7.2c-j	1.2h-j	16.6h-n	75.6g-m	153.7c-f	0.7a-i	1.0	4.5a-e	17.8k-m
Elmadă 2	7.8a-h	1.6c-j	11.0mn	82.1c-k	70.5f-h	0.7a-g	1.1	4.6a-e	18.9i-l
Elmadă 3	8.4a-c	1.7c-j	10.2n	80.3d-l	104.4c-h	0.8ab	1.2	4.3d-f	18.5j-l
Akyurt 1	5.2no	2.7a	26.4b-e	81.9c-k	169.1b-e	0.7a-g	1.0	4.4b-f	23.7b-j
Akyurt 2	6.1j-n	2.7a	18.2g-l	78.3f-m	158.1b-f	0.7a-h	1.0	5.0a	24.1a-j
Akyurt 3	5.2no	1.8b-i	26.0b-f	85.4b-i	259.0a	0.6b-j	1.0	4.4c-f	28.9a-c
Çamlıdere 1	7.1d-j	2.2a-f	12.2k-n	67.6k-m	86.6e-h	0.6b-j	1.0	4.9a-c	23.4c-k
Çamlıdere 2	6.6h-m	2.6ab	13.6j-n	68.8j-m	144.5c-g	0.5h-j	1.0	4.7a-e	29.4a
Çamlıdere 3	7.1d-j	2.6ab	18.9g-k	70.8j-m	127.5c-h	0.6c-j	1.0	4.9a-c	23.7a-j
Kızılcahamam 1	6.0j-n	2.7a	31.6b	89.5a-g	241.7ab	0.6e-j	1.0	4.9a-c	28.6a-c
Kızılcahamam 2	5.7k-o	1.4f-j	28.3bc	86.1b-i	164.3b-e	0.6c-j	1.0	4.6a-e	24.4a-i
Kızılcahamam 3	7.7a-h	1.4f-j	17.8h-m	71.6i-m	56.4gh	0.8a-d	1.0	3.5h	19.3 i-l
Çubuk 1	8.2a-f	1.3g-j	13.9j-n	50.5n	52.5h	0.6d-j	1.0	4.8a-c	19.8h-l
Çubuk 2	5.9j-n	2.3a-d	21.4d-i	68.5k-m	127.8c-h	0.5ij	1.0	4.9a-c	29.2ab
Çubuk 3	6.9f-k	2.3a-e	19.1f-k	65.1m	108.4c-h	0.7a-h	1.0	4.9a-c	26.3a-g
Bala 1	8.3a-d	1.7c-j	13.3j-n	78.2f-m	107.3c-h	0.6c-j	1.0	4.7a-e	25.3a-h
Bala 2	8.3a-e	2.1a-g	11.7l-n	64.8m	97.4d-h	0.6b-j	1.0	4.9ab	27.8a-d
Bala 3	8.3a-e	2.0a-h	10.8mn	70.8j-m	104.6c-h	0.5ij	1.0	5.0a	26.9a-f
Mamak 1	7.2b-j	1.7c-j	19.7e-j	73.5h-m	116.1c-h	0.7a-i	1.1	4.6a-e	27.2a-e
Sincan 2	6.8g-l	1.0j	26.9b-d	73.2h-m	137.2c-h	0.7a-h	1.0	4.9ab	25.3a-h
Kazan 2	4.5o	1.0j	39.6a	85.8b-i	196.8a-c	0.6g-j	1.0	4.7a-e	28.9a-c
Çankaya 1	5.5m-o	1.1ij	30.2bc	78.7e-m	192.2a-c	0.5j	1.1	3.7gh	21.9e-k

1[*1]: Growth habit (1-erect, 2-lateral), 2: The rhizome number on plants (1: none, 9: too much), 3: Natural plant height (cm), 4: Main stem lenght (cm),5: Annual dry matter yield (g/plant), 6. First cut dry matter yield/annual dry matter yield (%), 7. The structure of root crown (1:too much fine tillers, 2: fine tillers on main stem), 8. The depths of root crown (1: on surface, 5: on deep of soil), 9. Cutted area of plants (cm). [**]Means of each populations in a column followed by the same lower case letters are not significantly different ($p<0.05$).

2011 were very high. They are going to evaluate for forage-type alfalfa breeding. Apart then, all other populations are going to be subject for graze-type alfalfa breeding program in near future. Some of them also gave high forage yield as Golbası 1,2 and Kizilcahamam 1. Their performances are given in Table 1 and 2.

Table 2. The mean of some observations on clones of alfalfa populations averaged of two years

Populations	1*	2	3	4	5	6	7	8	9
Pursaklar 1	4.8f	1.0	35.3a-c	87.9ab	255.1ab	0.5b-e	1.5b	3.9b-f	23.0a-d
Evren 3	6.4de	1.0	23.2e-h	78.6b-d	103.8c-f	0.6ab	1.0c	4.6a-c	16.8cd
Keçiören 3	7.8a-d	1.3	16.9g-i	73.9b-d	127.2c-f	0.5a-e	1.2c	3.3f	20.1b-d
Ayaş 2	8.5ab	2.2	11.8i	60.4d	96.6c-f	0.6a-c	1.1c	3.4f	16.7cd
şereflikoçhisar 1	3.2g	1.0	42.7a	90.3ab	295.6a	0.4d-e	1.0c	4.5a-c	23.4a-c
şereflikoçhisar 2	3.2g	1.0	40.7ab	75.5b-d	164.5b-f	0.5a-e	1.1c	4.3a-e	19.2b-d
şereflikoçhisar 3	3.0g	1.0	41.1a	80.6a-d	267.7ab	0.5a-e	1.0c	4.7ab	23.0a-d
Polatlı 1	7.7a-d	1.3	17.8f-i	72.8b-d	115.6c-f	0.4c-e	1.0c	4.4a-d	17.1cd
Çubuk 1	5.3ef	1.1	26.8c-f	64.8cd	194.7a-f	0.5a-d	2.4a	4.6a-c	19.3b-d
Haymana 1	7.9a-d	1.0	12.2i	70.8b-d	71.7f	0.5a-e	1.0c	3.5e-f	18.2b-d
Kızılcahamam 1	7.0b-d	1.0	20.7e-i	84.8a-c	208.7a-e	0.6a-c	1.2c	3.7d-f	20.2b-d
Mamak 1	8.7a	1.0	14.5hi	74.4b-d	81.5ef	0.6a-d	1.0c	4.4a-d	16.6d
Bala 1	6.5c-e	1.0	23.9d-g	86.1ab	93.4d-f	0.7a	1.1c	3.3f	18.0b-d
Güdül 1	8.6a	1.0	11.6i	69.7b-d	94.8c-f	0.6ab	1.0c	3.8c-f	17.6cd
Çankaya 1	4.0fg	1.0	37.4ab	83.3a-c	215.7a-d	0.4c-e	1.0c	2.5g	24.5ab
Nallıhan 1	3.0g	1.0	32.3b-d	73.6b-d	224.7a-c	0.3e	1.1c	4.3a-e	20.4b-d
Kalecik 1	8.2ab	2.3	17.0g-i	84.4a-c	160.5b-f	0.5a-e	1.0c	3.7d-f	22.7a-d
Elmadă 1	8.0a-c	1.5	20.0e-i	72.8b-d	110.3c-f	0.5a-e	1.0c	4.5a-c	20.0b-d
Akyurt 1	7.5a-d	1.0	27.5c-e	87.0ab	185.3a-f	0.5a-e	1.0c	5.0a	28.5a
Sincan 1	7.5a-d	1.0	18.5e-i	100.0a	166.0b-f	0.5a-e	1.0c	5.0a	23.0a-d

1*1: Growth habit (1-erect, 2-lateral), 2: The rhizome number on plants (1: none, 9: too much), 3: Natural plant height (cm), 4: Main stem lenght (cm),5: Annual dry matter yield (g/plant), 6. First cut dry matter yield/annual dry matter yield (%), 7. The structure of root crown (1:too much fine tillers, 2: fine tillers on main stem), 8. The depths of root crown (1: on surface, 5: on deep of soil), 9. Cutted area of plants (cm). **Means of each populations in a column followed by the same lower case letters are not significantly different ($p<0.05$).

IV – Conclusions

After the trials over two years for 56 collected alfalfa populations, mainly graze-type and forage-type alfalfa lines were characterized. Except the populations of Akyurt 1,2,3, Kizilcahamam 1,2, Gudul 1, Kazan 1,2, Cankaya 1, Sincan 2, Çubuk 2, Pursaklar 1, Şereflikochisar 1, 2, 3, Nallıhan 1 which were forage-types and their forage yields were high, all the other populations shown graze-type characters when regard the all observed traits. For further breeding programme, selected populations are going to be used for obtaining of forage-type and graze-type alfalfa varieties.

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Technical culture of kenaf produced under Tunisian semi arid conditions

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Abstract. Kenaf, *Hibiscus cannabinus L*, is a warm-season annual fiber crop. The stem is a source of fibre production. In Tunisia, kenaf production was introduced in the humid and saharian regions since 1998. Possibility of its culture in Zaghouan, a Tunisian semi arid region, and the optimal density for a higher yielding and nutritive value was our main objective. Three seeding densities (seeds/m²) were used: 27 (D1); 13 (D2) and 5 (D3) seed/m^2. Harvesting was at 75 days age. The highest yield (11.6 t/ha) in terms of edible dry matter (DM) was recorded for D1 and the lowest (6 t/ha) for D3. Protein content was higher (>17%) in leaves and lower (<12%) in stems. The main handicap of its production is water resource. Agricultural companies should be carried out to well introduce this plant in the agriculture systems since it can be a good precursor for some cereal culture due to its capacity to incorporate a high organic matter amount in the soil.

Keywords. Kenaf – Nutritive value – Seeding density – Maturity stage.

Technique cultural du kenaf produit en Tunisie sous des conditions semi-arides

Résumé. *Kenaf, Hibiscus cannabinus est une culture annuelle de saison chaude destinée à la production de fibres utilisée dans l'industrie de textile. En Tunisie, la production du kenaf a été introduite dans les régions humides et sahariennes depuis 1998 dans le cadre des projets agro-industriels visant essentiellement la production de fibre. La possibilité de sa culture dans le gouvernorat de Zaghouan, une région semi-aride en Tunisie, et la détermination de la densité optimale pour un meilleur rendement fourrager et une bonne qualité nutritionnelle étaient notre objectif dans ce présent travail. Trois densités de semis (semences/m^2) ont été utilisées: 27 (D1); 13 (D2) et 5 (D3). La récolte a été effectuée vers les 75ièmes jours après le semis. Le rendement fourrager le plus élevé a été observé avec la densité D1, soit 11.6 t/ha et le plus faible avec la densité D3, soit 6 t/ha. La teneur en protéine en protéine a été élevée (>17%) au niveau des feuilles et faible au niveau des tiges (<12%). Néanmoins, cette culture prometteuses reste tributaire des ressources en eau. Des campagnes agricoles pour la vulgarisation devraient être assurées pour sensibiliser les agriculteurs de l'importance de cette culture fourragère et l'introduire systèmes agricoles puisque elle peut être considérée un précurseur aux cultures céréalières grâce à son pouvoir d'apporter au sol une quantité importante en matière organique.*

Mots-clés. *Kenaf – Valeure nutritive – Densité de semis – Stade de maturité.*

I – Introduction

Kenaf (*Hibiscus cannabinus* L., Malvaceae) is a warm season annual fiber crop closely related to cotton (*Gossypium hirsutum* L., Malvaceae) and okra (*Abelmoschus esculentus* L., Malvaceae) that can be successfully produced in a large portion of the world, particularly in Africa. This annual specie is characterized by its 3- to 4-m height and high production of biomass which is composed primarily of cellulose-rich stalk (Webber, 1993) from which the fiber is extracted. Kenaf requires less than 6 months for attaining a size suitable for practical application. For industrial purposes, the apical part of the plant rich in protein and low in cellulose, may be considered a by-product potentially suitable for livestock production. As the commercial use of kenaf continues to diversify from its historical role as a cordage. Based on the optimum of forage quality and quantity, kenaf was best harvested between 10 and 12 weeks after planting, when CP is approximately 15% (Phillips *et al*., 1999). The ground leaves of kenaf have high digestibility and can be used as a source of roughage and protein for cattle and sheep (Webber, 1993) especially when harvested early (González-Valenzuela *et al*., 2008). Little information is available regarding kenaf forage response to population density, which affects plant morphology, dry matter (DM) accumulation, and susceptibility to lodging. Information of potential yield and chemical composition of kenaf as fodder for ruminants in the Mediterranean areas, especially under semi arid conditions, is presently insufficient. Therefore, the objective of this study was to assess the technical culture of kenaf under Tunisian semiarid conditions, determine the influence of population density on kenaf dry matter (DM) and fresh matter (FM) yields, and forage quality at 75 days after sowing (DAS).

II – Material and methods

1. Kenaf growth and harvest

The kenaf was grown on land owned by the Agricultural High School of Mograne, government of Zaghouan (center east of Tunisia). The experimental field area covered 1000 m^2 (20x50) and divided into height plots. Plots were 2 m spaced and had a 69 m^2 surface (23 x 3 m). They were sown at different seed densities (seeds/m^2). In our present study we focused our aim on only three densities: 27 (D1); 13 (D2) and 5 (D3). The crop was sown in June 2011 and harvested at 75 days age at a height of 180 to 190 cm. The soil was loamy clayey and its pH was 8. Prior to planting, plots were ploughed and fertilizer was applied at a rate of 50 kg/ ha N and 150 kg/ ha P. No K was supplied, as its status was already adequate in the soil. All plots were kept weed-free by hand weeding throughout the growing season.

During growth, the plots were managed as irrigated crops receiving a daily irrigation. At 75 days after planting, kenaf was harvested by hands at approximately 5 cm above ground level using a 1x1m quadrant (three replicates for each plot). Plants within the quadrant were immediately weighed to determine fresh weight. Leaves and stems of the whole plant from each plot were manually separated and dried at 60ºC to constant weight.

2. Chemical analysis and in sacco dry matter degradability

Dried samples of young stems and leaves were ground through a 1 mm screen and analyzed for the contents of crude protein (CP), ash (AOAC, 1990), neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Robertson and Van Soest, 1981) and Van Soest *et al*. (1991). For the determination dry matter degradation, samples of leaves and young stems were ground through a 3mm sieve and two replicate samples of each, weighing about 3g, were placed into nylon bags and incubated in the rumen of fistulated heifer. Elapsed the incubation time (48 h), bags were gently rinsed with tap cold water, oven dried (60ºC, 48 h) and weighed to calculate the degradability of the dry matter as the difference between the initial vegetal material (3 g) and the residual of the incubation. The fistulated heifer was fed on concentrate (4 kg/d) and alfalfa hay (8 kg/d).

III – Results and discussion

1. Vegetative growth of kenaf and biomass production

It is well reported that biomass production is influenced by vegetative and growth rate of the plant, population density. In our present study three plant densities were examined: 27 (D1), 13 (D2) and

5 (D3). At very low planting densities (<20 plants/m^2) kenaf produces multiple branches, which renders harvesting more difficult (Massey, 1973). Nevertheless stem diameter decreased as population density increased resulting from intraspecific competition among plants (Acreche *et al*., 2005, Reta *et al*., 2010). This fact can explain partly the lowest DM contents (21.2 %) reported in this present study when plant density is the lowest (5 plants/m^2). Similar DM contents were recorded earlier (19.1%) by Rude *et al*., (2002) when kenaf was harvested at 42 DAS. In relation with plant density, an opposite trend was observed for fresh and dry matter yields of the whole plant (Table 1). The highest yields of fresh (51.9 t/ha) and dry matter (11.6 t/ha) corresponded to the highest density (27 plants/m^2). These DM production yields were dramatically higher than that reported by Chantiratikul *et al*., (2009) who recorded 0.12-0.95 t/ha DM yield harvested 75 DAS.

It appears therefore that DM yield of kenaf do depend upon plant variety, seeding rate, maturity stage (Bañuelos *et al*., 2002) and other agronomic factors.

Table 1. Dry matter (DM) contents (%) and biomass production (Fresh matter, FM; and dry matter, DM) (t/ha) of kenaf at different seeding densities

Plant density	D1	D2	D3
% DM	22.3	22.7	21.2
FM (t/ha)	51.9	39.9	29.2
DM (t/ha)	11.6	9	6.2

2. Chemical composition and in sacco DM degradability

Data on chemical composition and in sacco DM degradability of leaves and stems of kenaf harvested at 75 DAS are presented in Table 2. Mineral contents varied between 6.7 and 12.6% corresponding the lowest values to stems (D1) and the highest to leaves (D3). Kenaf leaves contain a higher concentration of CP (>22%) and in sacco DM degradability (>70 DM) than the stems (Table 2) which are less digestible (36-40% DM) due to their high NDF(54-65%) and ADF (42-50%) contents and poor levels of CP (7.5-11.5%). This was expected because mature tissues (at the base) accumulate higher amounts of metabolic products than the younger parts at the top. With respect to plant density, increases in population density were not related to kenaf nutritive value in terms of crude protein (CP) and fiber concentrations as was suggested earlier by Reta *et al*. (2010). This response is probably predictable when considering that density increase did not modify the forage leaf and stem proportions, which are related to forage quality in terms of CP and fiber concentrations (Swingle *et al*., 1978). The average CP, NDF and ADF concentrations were slightly higher than those reported either by Reta *et al*. (2010) who recorded 177, 453, and 524 g/kg respectively for the whole plant harvest at 87 DAS or by Muir (2002) with a population density of 16 plants/m^2 and harvested at 83 DAS during its flowering phase. When compared with leaves, this author reported lower CP concentrations (192 g/kg) and higher ADF (280 to 290 g/kg) and NDF (350 to 380 g/kg) concentrations. The higher CP and lower NDF and ADF concentrations reported in our study, as compared with those of the other authors can be probably due to an earlier phonological phase at harvesting.

To optimize forage quality and quantity, kenaf should be harvested between 60 and 80 days after planting since the proportion of leaf in the total DM decreases dramatically at about 80 days after planting (Phillips *et al*., 1999). Crude protein content at this time would be >15% and in situ OM disappearance could be >69% (Phillips *et al*., 1999). These findings justify partly the successful use of kenaf to replace Alfalfa as a crude protein supplement for lambs fed Bermuda grass or Fescue hay.

Table 2. **Chemical composition (g/kg DM) and in sacco dry matter degradability (%) at 48h incubation of leaves and stems of kenaf grown at different plant densities**

	Density	MM	CP	NDF	ADF	D48
Leaves	D1	11.1	23.1	26.8	19.9	70
	D2	12.0	22	28.9	22.4	73
	D3	12.6	22.5	27.0	20.5	75
stems	D1	6.7	7.5	65.8	50.4	36
	D2	9.4	11.5	54.9	42.1	40
	D3	7.2	9.1	61.7	47.1	41

It has also been determined that chopped kenaf (29% dry matter, 15.5% crude protein, and 25% acid detergent fiber) is a suitable feed source for Spanish (meat-type) goats.

IV – Conclusion

This research further supports the feasibility of producing kenaf not only for fiber, but also for a livestock feed. The greater water requirement of kenaf could be a problem in areas where irrigated water is limited. An optimum population density for DM production corresponded to 27 plants/m^2. However, for an optimum nutritive value in terms of CP and DM degradability a density of 13 plants/m^2 was accepted. Future research should focus on cultural methods to maximize kenaf's nutritive value and total dry-matter production.

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A new annual summer forage crop: Cowpea

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Abstract. Four cowpea genotypes (YBS1, YBS2, YBS3, YBS4), were evaluated for forage yield and related parameters at two locations (Samsun and Suluova) in Turkey during 2011 summer growing season. The effects of genotype, location and GxL interaction on 50% flowering stage, fresh and dry forage yield were significant. Average value of the 50 % flowering period and dry forage yield were 49 days and 688 kg/da over the locations and genotypes. The period of 50% flowering among genotypes was longer, however, forage yield was higher at Suluova than Samsun. The highest dry and forage yield was obtained from genotype YBS3 which is also latest in flowering at both locations.

Keywords. Cowpea – Flowering period – Forage yield – Genotype.

Une nouvelle culture annuelle fourrage d'été : la niébé

Résumé. *Quatre génotypes de niébé (YBS1, YBS2, YBS3, YBS4), ont été évaluées pour le rendement en fourrage et les paramètres associés à deux endroits (Samsun et Suluova, en Turquie) au cours de la saison de croissance estivale de 2011. Les effets du génotype, de l'emplacement et de l'interaction GXL sur le rendement en fourrage frais et sec à 50% de floraison, étaient significatives. Les valeur moyennes de la période de floraison à 50% et du rendement en fourrage sec étaient 49 jours et 688 kg/da comprises tous les emplacements et les génotypes. La période de floraison à 50% chez était plus longue chez les génotypes, et cependant, le rendement en fourrage était plus élevé à Suluova qu'à Samsun. Le rendement le plus élevé en fourrage sec a été obtenu à partir du génotype YBS3 qui est aussi de floraison tardive sur les deux sites.*

Mots-clés. *Niébé – Période de floraison – Rendement fourrager – Génotype.*

I – Introduction

Cowpea *(Vigna unguiculata. L),* in Turkish "*Borulce"* is an important tropical and subtropical annual legume. White seeded and black-eyed types are generally grown for grain or vegetable while viny varieties are preferred for forage (Ali *et al*., 2004). Cowpea is heat- and drought- tolerant crop and it tolerate alkaline soil conditions and has a high potential of biological nitrogen fixation. Cowpea fodder is rich in crude protein up to 18.4% (Khan *et al.*, 2010).

The biggest technical constraint in livestock production in Turkey is forage deficiency especially during summer period when pasture vegetation is dry. Cowpea can make a significant contribution to the forage production and to close forage gap during the summer period, however, its uses as forage has been neglected and, progress in breeding cultivars for forage purposes has been slow in Turkey. This crop is grown only for human consumption with production of 2200 tons grain and 26.000 tons fresh pod in the country. Therefore our knowledge on the forage performance of cowpea is insufficient and the present study was conducted to determine forage yield and yield-related parameters of four cowpea genotypes at two locations in Turkey.

II – Materials and methods

Four cowpea genotypes (YBS1, YBS2, YBS3, YBS4), were evaluated for forage yield and related parameters at two locations (Samsun and Suluova) in 2011. General properties of the experimental soil were given in Table 1. Experiments were arranged in randomized complete block design with five replicates and, established on June 8 in Samsun and on May 9 in Suluova. Both experiments were irrigated five times when plants need water.

Table 1. General properties of the experimental area soil

Location	Property						
	Clay (%)	Sand (%)	Silt (%)	OM (%)	pH	K (ppm)	P (ppm)
Samsun	53.74	24.83	21.43	2.87	7.08	31	26.61
Suluova	43.05	29.78	27.53	3.28	7.52	132	82.54

Plant height, main stem diameter, branch number and forage yield were determined at 50% flowering stage. For the dry forage yield fresh plant samples were oven-dried at 60° during 48 hours. The data were subjected to analysis of variance and Duncan's complementary test by means of SPSS 10.0 V.

III – Results and discussion

Average performance of cowpea genotypes for the yield and the other investigated traits over two locations are given in Table 2. The analysis of variance for combined locations showed that the effects of genotype (G), location (L) and GxL interaction on the investigated traits were generally significant ($P<0.05$, $p<0.01$). Therefore the results were given separately for Samsun (Table 3) and Suluova (Table 4) locations as well. Average value of the days to 50% flowering (DFL) among genotypes ranged from 45 to 55 days with the earliest genotype YBS4 over the locations,(Table 2). Average fresh forage yield (FFY) and dry forage yield (DFY) over the locations and genotypes were 3513 and 688 kg/da. The DFY determined in present study was higher than reported by Eskandari and Ghanbari (2009), who is obtain 613 kg/da DFL from cowpea. As a mean of two locations, the highest plant height (PH), FFY and DFY were deteremined in genotype YBS3 (Table 1). Average DFL was markedly earlier at Samsun location than Suluava, however, average FFY and DFY were higher at Suluova location (Table 2). Higher forage yield at Suluova than Samsun location might be due to high organic matter, sand and silt contents in the soil (Table 1) and aslo due to late flowering (Table 2). Highest yields of forage are obtained in sandy loam soils with high nitrogen rates resulting in excessive vegetative growth (Ali *et al*., 2004).

At Samsun location, DFL among genotypes ranged from 35 days (YBS4) to 46 days (YBS3). Main stem diameter (STD) and branch number was between 8.07-8.70 mm and 4.02-4.62 respectively with no significant differences among to genotypes at Samsun location (Table 3). The differences among genotypes for FFY and DFY were significant ($p<0.05$) and the high yielding genotype was YBS3 with 4128 kg/da fresh and 804 kg/da dry forage yield in this location (Table 3). At Suluova location, the genotypes took significantly longer period for the DFL compare to Samsun ranging between 54 and 63 days with the latest genotype YBS3 (Table 4). The effects of genotype were significant on PH, BRN, FFY and DFY and, genotpye YBS3 had a highest PH, BRN, FFY and DFY at Suluova location. The fresh and dry forage yield of genotype YBS3 were 4666 and 948 kg/da, respectively. Aravindan and Das (1996) found that forage yield was significantly and positively associated with branch number.

Table 2. Average performance of cowpea genotypes over the locations

Genotype	DFL (day)	PH (cm)	STD (mm)	BRN	FFY (kg/da)	DFY (kg/da)
YBS1	48ab	136ab	8.77	4.00	3478b	687b
YBS2	48ab	130ab	8.26	3.73	3140c	606c
YBS3	55a	147a	8.74	4.22	4397a	876a
YBS4	45b	118b	8.57	3.73	3038c	586c
SAMSUN	41	155	8,36	4,28	3413	650
SULUOVA	56	110	8.80	3.57	3613	727
Average	49	133	8.58	3.92	3513	688
Genotype (G)	**	**	**	**	**	**
Location (L)	**	**	*	**	**	**
G x L	**	**NS**	**NS**	*	**	**

*P<0.05, **P<0.01, NS: no significant. There are no significant differences (p<0.05) among mean indicated by the same letters. DFL; days to 50% flowering, PH, plant height, STD; stem diameter, BRN; branch number, FFY; Fresh forage yield, DFY; dry forage yield.

Table 3. Average performance of cowpea genotypes at Samsun location

Genotype	FLW	PH	STD	BRN	FFY	DFY
YBS1	42	155ab	8.70	4.26	3276b	631b
YBS2	42	155ab	8.07	4.24	3142b	581b
YBS3	46	170a	8.28	4.62	4128a	804a
YBS4	35	140b	8.40	4.02	3107b	585b

There are no significant differences (p<0.05) among meand indicated by the same letters DFL; days to 50% flowering, PH, plant height, STD; stem diameter, BRN; branch number, FFY; Fresh forage yield, DFY; dry forage yield.

Table 4. Average performance of cowpea genotypes in Suluova location

Genotype	FLW	PH	STD	BRN	FFY	DFY
YBS1	54	117a	8.84	3.78a	3680b	742b
YBS2	54	104b	8.45	3.22b	3138c	631c
YBS3	63	125a	9.19	3.82a	4666a	948a
YBS4	54	96b	8.73	3.44ab	2969c	587c

There are no significant differences (p<0.05) among meand indicated by the same letters DFL; days to 50% flowering, PH, plant height, STD; stem diameter, BRN; branch number, FFY; Fresh forage yield, DFY; dry forage yield.

Overall, at both location, genotype YBS3 was a latest for DFY and also superior for PH and yield. This results clearly showed that YBS3 is a superior genotype for forage production at both location. In addition present results indicated that long DFL period promoted the vegetative growth and resulted high forage yield. Similar results reported by Latif (1993). Also, Khan *et al*. (2010) observed high variation for PH in 24 genotypes ranging between13-236 cm and reported that there is a positive relationship between plant height and maturity period. It is meaning that earliest genotypes produced dwarf plants having low vegetative growth and forage yield.

IV – Conclusions

This study showed that the performance of cowpea as a forage crop is very high and it can take a significant role in closing the forage gap occurring especially during summer period. According to the differences between locations and genotypes for yield we suggest that there is need more study to determine superior genotypes for different conditions and also breeding studies to improve new varieties for target ecological zones.

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Selection of two triticale varieties for forage-end use in Tunisia

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Abstract. Two new released triticale varieties (one spring type Tcl821 and one winter type, G41) were evaluated for their dry matter yield and nutritive value at three harvesting stages (first node detectable, Z31, late boot, Z50 and soft dough stag, Z85). Both genotypes confirmed their high dry matter yield potential at all stages. The winter triticale was more productive than the spring genotype at all growing stages. G41 presented a prostrate growth habit from emergence to first node detectable stage (Z31) and took much more time to reach that stage. Among the two cultivars, it was the best to be used by grazing or in dual-purpose system at early vegetative growth. At late boot stage (Z50), the winter type produced 9 T DM ha^{-1} of a high quality forage (CP = 15%; ADL = 3.8%, dOM = 60%). The spring triticale Tcl821 produced an equivalent forage quality but with half the yield potential (5 T DM ha^{-1}). At soft dough stage, the spring triticale Tcl821 was as much productive as the winter genotype G41, but it produced a forage with much higher quality as expressed in terms of CP, ME and fibers. The agronomical meanings of the three key harvesting stages were discussed.

Keywords. Triticale – Forage – Nutritive value – Winter type – Spring type.

Développement de deux variétés de triticale pour une utilisation fourragère en Tunisie

Résumé. Deux variétés de triticale nouvellement inscrites (un triticale de printemps Tcl821, et un triticale d'hiver, G41) ont été évaluées pour leur production fourragère et valeur nutritionnelle à 3 stades de croissance (premier nœud, début épiaison, et pâteux mou désignés respectivement Z31, Z50 et Z85). Les deux génotypes ont confirmé leur haut potentiel de rendement en MS à tous les stades de croissance, avec une nette supériorité de G41 particulièrement aux stades précoces (Z31 et Z50). Ce dernier a présenté une croissance plagiotrope depuis la levée jusqu'au stade Z31 qu'il atteint 3 semaines après Tcl821. Il est le génotype susceptible de mieux valoriser une exploitation du triticale par pâturage ou dans le cadre d'un système de double exploitation. Au stade début émergence des barbes (Z50), G41 a produit 9 T MS ha^{-1}, et donné lieu à un fourrage de très bonne qualité fourragère (MAT= 15%; ADL = 3.8%, dMO = 60%). Tcl821 a également un fourrage d'aussi bonne qualité mais avec moitié du rendement potentiel (5 T MS ha^{-1}). Au stade pâteux mou (Z85), le triticale de printemps Tcl821 a été aussi productif en MS que le triticale d'hiver G41, mais il donne lieu à un fourrage de bien meilleure qualité en terme de MAT, teneur en énergie métabolisable et de lignine. Les significations agronomiques des trois stades clé de récolte ont été discutées.

Mots-clés. *Triticale de printemps – Triticale d'hiver – Fourrage– Valeur nutritionnelle.*

I – Introduction

Oat constitutes more than 65% of annual forage cultivated area in Tunisia (Chakroun, 2000). It is grown wrongly at all Tunisian environments from the North to central Tunisia although this species performs well only under favorable environments (over 450 mm of well partitioned annual rainfall) or under irrigation and needs deep and fertile soils. In order to diversify forage resources while taking account of climate change and high farmers skill in growing cereals, our choice was made on triticale species which may constitute a part of forage calendar under less favorable bioclimatic zones. To valorize the triticale as an alternative forage resource to fodder oat, a national breeding program have been initiated since 2005. It aimed to select triticale genotypes targeted for animal use as a green fodder resource and not as a grain. As other forage cereals; triticale may be used at all stages of growth, from the grazing of small plants early in the grazing season, to harvest of mature whole plant for hay, or silage at the end of the season (Mergoum *et al*., 2009). The diversity of types and uses of triticale complicates the choosing of varieties and decisions about the crop management. To choose such a genotype for such use, it is necessary to know perfectly the growth mode of the triticale, its forage potential yield, nutritive values at different growth stage and specific crop management needed to harvest the maximum value of the genotype (Fohner, 2002).

This program initiated in 2005 with more than 100 spring, facultative and winter type triticale accessions originated from CIMMYT, and have led to the registration of two genotypes which are described here.

II – Materials and methods

1. Selection procedure

As for our short term breeding strategy we select varieties from the CIMMYT triticale nurseries. The approach adopted was the selection of lines from genetic material, more or less homogeneous, received from the CIMMYT since 2005. Selection criteria included agronomic traits in addition to dry matter yield at soft dough stage. Six years selection has led to the release of two cultivars which are being registered in Tunisian national catalogue. In this paper we would try to characterize these two new genotypes in the aim to choose the type and form in which they are the best to be used.

2. Plant material

Main characteristics of two selected triticale genotypes are presented in Table 1.

Table 1. Main characteristics of two selected triticale genotypes

Genotype	Origin/nurseries	Pedigree	Seed weight (g)	Type
G41	CIMMYT/ TW05M_LAWIN-INC	AN-31	32	Winter
Tcl821	CIMMYT/40 ITYN	ARDI_1/TOPO 1419// ERIZO_9/3/LIRON_1-1/4/ FAHAD_4/FARAS_1/5/ CT775.81/ARDI_1//ANOAS_1..	55	Spring

3. Measured parameters

Agronomic measured traits were: days to each targeted growth stage, plant height in cm (distance from soil surface to spike tips at cutting), dry matter yield at several phonological growth stages: first node detectable, late boot, anthesis, soft dough and seed maturity stages designed in Zadoks scale (Zadoks *et al*., 1974) as Z31, Z50 and Z85 and Z95, respectively. At each stage, forage yield is measured by cutting 6 x 0.25 m² quadrate from each plot and a sample of 500 g was dried at 50°C then milled. Samples were analyzed for crude protein, neutral detergent fibers (NDF), acid detergent fibers (ADF) and acid detergent lignin (ADL) content (AOAC, 1984). Metabolic energy (ME) and digestible organic matter (dOM) were determinate by gas production technique (Menke and Steingass, 1988).

III – Results and discussion

Dry matter yield (DMY). DMY was measured as a function of growing degrees days (GDD) calculated with a base temperature of 0°C (Fig. 1). For each genotype, there was a strong quadratic relationship between DMY and GDD as revealed by high R^2 coefficient. For both genotypes maximum dry matter was reached at soft dough stage. G41 produced its dry matter yield on a more extended period of time (175 days *vs* 141). It exhibited a prostrate growth habit from emergence to Z31 and an erect growth habit thereafter. At first node detectable stage (Z31), the winter type triticale (G41) produced 30% more DYM than the spring triticale Tcl821 and took much more time to reach that stage. It should be advantageous to be used by grazing at early stage. At late boot stage, the winter triticale out-yielded spring triticale by 30% (90 *vs* 52 g DM m^{-2}) and was much more later to reach this stage (a gap of 54 days separated the dates on which late boot stage is attained). The stage Z85 is reached one month earlier by the spring triticale, but, both genotypes produced significantly the same DYM of 170 g DM m^{-2}. DYM of triticale for all harvesting stages was high and was superior to those found in other studies on forage triticale in Spain (Royo and Tribo, 1997) Italy (Delogu *et al.*, 2002) or USA (McCormick *et al.*, 2006).

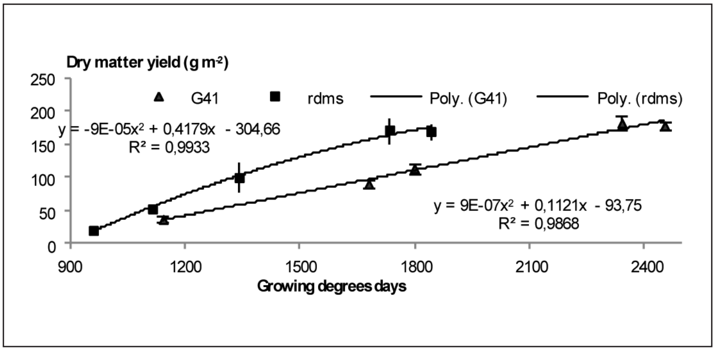

Fig. 1. Variation of dry matter yield with growing degree days.

Crude protein. Maximum crude protein content is registered in Z31 stage for both varieties, and averaged 25.3 and 23.9 for the spring and winter triticale, respectively. At Z50 stage, both genotypes showed significantly the same CP content. In late season, Tcl821and G41 showed a drastic decrease in their crude protein content which reached 10.3 and 5.2, respectively (Table 2).

Table 2. Chemical composition (CP, NDF, ADF and ADL), ME and dOM of two triticale varieties (G41 and Tcl821) at first detectable node (Z31), late boot stage (Z50) ant at soft dough stage (Z85)

		CP (%)		ME (Mj kg^{-1} MS)		dOM (%)		NDF (%)		ADF(%)		ADL (%)	
Stage		**G41**	**Tcl821**	**G41**	**Tcl821**	**G41**	**Tcl821**	**G41**	**Tcl821**	**G41**	**Tcl821**	**G41**	**Tcl821**
Z31	Average	23.9	25.1	23.8	25.0	61.1	58.3	53	59.5	22.1	29.7	1.52	–
	SD	0.8	0.6	1.7	0.9	1.7	4.3	24.3	2.5	9.0	0.7	1.0	–
Z50	Average	14.3	15.6	11.8	13.3	49.1	50.7	59.4	55.9	37.1	35.5	4.17	3.8
	SD	2.3	2.5	1.9	2.2	5.1	2.3	1.6	0.7	1.6	0.6	1.09	1.42
Z85	Average	6.5	9.2	6.8	9.2	42.4	49.1	71.5	56.9	40	34.1	6.89	6.06
	SD	1.3	1.8	0.7	4.8	2.7	4.4	9.68	5.69	3.76	4.86	3.6	0.21

Digestible organic matter (dOM). dOM averaged 60%, 50% and 45% at Z31, Z50 and Z85 stages. Both genotypes showed significantly the same dOM at both first node and late boot stage. At soft dough stage, the spring triticale tcl821 presented a significantly higher dOM than the winter triticale variety (G41).

Fibers. Whatever the genotype, both NDF, ADF and ADL content showed a notable increase between Z31 to Z85 stage. The spring triticale showed a much higher quality indicated by lower NDF, ADF and ADL over all harvesting stages (Table 2). Fibers values still comparable to those obtained by Delogu *et al*. (2002).

Metabolic energy (ME). In general, with respect to the first harvesting stage (Z31) there was an expected drop in the values of metabolic energy registered in Z50 and at Z85 thereafter. At all stages Tcl821 showed the highest ME values (Table 2). However, regarding to dry matter yield, the winter triticale G41 out yielded Tcl821 at all stages in term of energy production per ha. In another hand, the different measures of ME along the lifecycle showed that after a linear decrease began from early vegetative stage, the ME marked a small increase at soft dough stage which is likely to be related to the storage of starch at the grains level (Fohner, 2002). This trend was less obvious for the winter triticale genotype (data not presented).

Although its high cold temperature requirement to initiate heading, G41, showed a good adaptation to local bioclimatic conditions. However, It presented weak grain yield potential (< 200 g m^{-2}, data not presented). Regarding to its high dry matter yield, G41 should constitute an interesting alternative ressource to fodder oat. First node detectable stage, or Z31 is considered as a key stage for using forage cereals by grazing or in dual-purpose system (Royo *et al*., 1993; Ben Youssef *et al*., 2000b). It is generally recommanded to not exceed this stage to cease grazing or to make forage cut, otherwise, a severe grain or forage yield decrease would be obtained on regrowth. At this stage, G41 showed a great forage yield potential (over 3.6 T DM ha^{-1}) with a high nutritive value and allowed a long grazing period as it reached Z31 in late February after a seeding in november. This yield level is superior to that obtained at the same stage for barley (Ben Youssef *et al*., 2001); oat (Ben Youssef *al*., 2000a) and spring triticale (Benyoussef *et al*., 2000b). In addition to its initial vegetative prostrate growth habit, G41 seemed to be predestinated for the use by grazing better than the spring triticale Tcl821. Further investigations still be needed to study the genotype behavior under grazing animals. Late boot stage (Z50) marks for cereal species, the limit between vegetative and reproductive growth (Fohner *et al*., 202). Using triticale in this stage may constitute a compromise between an acceptable level of dry matter yield, and high forage nutritive value. In our study, G41 showed a superiority upon spring genotype concerning all yield and nutritive value traits at this harvesting stage: more forage yield (10 *vs* 6 T DM ha^{-1}), leafier forage (leaf to stem ration equal to 70% *vs* 40%); richer in dry matter content (22% *vs* 15%), longer crop height (133 *vs* 88 cm), more productive in energy (120 000 *vs* 84 000 Mj ha^{-1}) and crude protein (1460 *vs* 990 kg CP ha^{-1}). It had significantly the same CP content and dMO and ADL as the spring triticale Tcl821. At our knowledge, none of the other forage cereals have been recommended for such end-use in Tunisia. With G41 selection, we have developed a variety which can produce a high dry matter yield of high quality forage at late April which means at a time favorable for hay or silage making. That compromise could not be obtained with the spring type triticale. For cereals, soft dough stage Z85 corresponds to grain physiological maturity. Grains are completely constituted, and rich in starch which constitute an important energetic source while the plant still yet green. As mentioned in figure 1 and table 2, the winter triticale genotype maintained its dry matter yield superiority over Tcl821 (18 T MS *vs* 16 T MS ha^{-1}). However, its nutritive value is subjected to a great depletion at this stage in comparison to that of the spring type. It is less digestible, poorer in CP (5.5% *vs* 9.1) and ME (6.8 *vs* 9.2 Mj kg^{-1} DM), presented a very higher level of NDF and ADL and seemed to enter in a senescence more precociously than the spring triticale variety. That senescence was evidenced by a very high dry matter content averaging 47%. That's why, it is strongly recommended not to use this cultivar at this late stage. In general, as regard to its nutritive value, the spring triticale presented a typical chemical analysis constitution as found in other studies (Delogu *et al*., 2002; Mc Cormick, 2006). Dry matter yield is superior to those commonly found in bibliography suggesting that spring triticale valorize better hotter Mediterranean-type climate. Using the Tcl821 cultivar for silage or hay making at soft dough stage allowed taking maximum value of its nutritive value and forage yield.

IV – Conclusions

Evaluation of forage yield and nutritive value of two triticale genotypes over 3 key harvesting stages allowed to better understanding how to take maximum value of them and to decide the best way in which they should be managed for forage production.

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Growth rates, biomass yield and forage quality of three local Poaceae in Annaba's region, North East Algeria

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Abstract. In the Algerian context, the development of durable fodder agriculture and breeding require complex strategies of which one of the elements consists in developing the use of fodder species adapted to the local biotope characteristic of Mediterranean climate. The aim of this work consisted to study and cultivates 3 Algerian varieties of Poaceae fodder, reed canary grass *Phalaris arundinacea*, rye grass *Lolium multiflorum* and tall fescue *Festuca arundinacea* in order to evaluate their agronomic performance; the growth rates and the field biomass output. The obtained results showed that the biomass production was more important for the reed canary grass in compete cycle than in incomplete cycle of vegetation, contrary to rye grass and tall fescue. Moreover, the analysis of growth kinetics showed that it is the spring growth which presented the best characteristics of the plant development and dry matter (DM) yield production. From fodder value, the reed canary grass and the tall fescue are well provided in Total Nitrogen Matter (TNM) and relatively low in Fodder Units (FU). Contrary, the rye grass is rich in energy compounds (EU) but contains low protein content.

Keywords. Poaceae – Fodder-growth – Kinetics-biomass – Yield-fodder value.

Le taux de croissance, le rendement en biomasse et la qualité fourragère de trois Poaceae locales dans la région de Annaba, Nord-Est algérien

Résumé. *Dans le contexte algérien, le développement d'une 'agriculture fourragère et d'un l'élevage durables exigent des stratégies complexes dont l'un des éléments consiste à développer l'utilisation d'espèces végétales adaptées aux biotopes locaux à climat Méditerranéen. Le but de ce travail a consisté à étudier et cultiver 3 variétés algériennes de Poaceae fourragères, l'alpiste Phalaris arundinacea, le ray-grass Lolium multiflorum et la fétuque élevée Festuca arundinacea, afin d'évaluer leurs performances agronomiques, les rythmes de croissance et le rendement de la biomasse aérienne.. Les résultats obtenus ont montré que la production de biomasse a été plus importante chez l'alpiste en en cycle complet qu'en cycle incomplet de végétation, contrairement au ray-grass et à la fétuque élevée. Par ailleurs, l'analyse de la cinétique de croissance a montré que c'est la croissance printanière qui a présenté les meilleures caractéristiques du développement des plantes et la production de matière sèche (MS)). Concernant la valeur fourragère, l'alpiste et le fétuque élevée sont bien pourvues en matière azotée totale (MAT)) et relativement faible en unités fourragères (UF). Contrairement, le ray-grass est riche en composés énergétiques (UF)), mais contient une faible teneur en protéines.*

Mots-clés. *Poaceae – Fourragères – Croissance cinétique-biomasse – Rendement-valeur fourragère.*

I – Introduction

In Algeria, the fodder forage deficit is still pronounced and chronic, as feeding of livestock is mainly based on grazing and natural fodder resources (Adem and Ferrah, 2001). Indeed, studies of prospecting collection and evaluation were interested in these local forage species that are already adapted to our climate and local environment (Boudelaa, 1992; Abdelguerfi and Laouar, 2001).The aim of this work is to evaluate the potential production of DM biomass of three species (*Lolium multiflorum* Lamk, *Festuca arundinacea* Schreb and *Phalaris arundinacea* L). The objective was to determine i) the growth rates of DM in these species based on local climatic conditions, ii) the potential production of DM over several years in complete and incomplete cycle of vegetation and iii) the nutritive value of forage species.

II – Materials and methods

Trial was performed at the Fetzara station, situated at around 36°46'North latitude and 7°36'East longitude (North East Algeria). The study was carried out from September 2007 to June 2011 in four years. The experiment was set up on a balanced soil texture (sandy clay loam) with a seedling density of 940 plants/m^2. The soil chemical characteristics were pH: 7, N: 0.10% (relatively poor), P_2O_5: 20 ppm (poor in P), K_2O: 30 ppm (poor in K), organic matter (OM): 2.5% (medley relatively rich). The experiment was arranged in completely randomized block design with three replication. Parcel dimension was 4 m by 4m with seven lines and 80 cm row spacing. The climate is Mediterranean, characterized by an annual rainfall between 600 and 700 mm and an average yearly temperature of 17.5°C. Two experiments were conducted, one in an annual cycle of growth from seedlings (October), until the final harvest in (June) and the other in cutting cycle by making three cuts per year (i.e. incomplete cycle of vegetation). The yields of fresh material (FM), dry matter (DM) were calculated by cuts of plots. Parcel weight was geren matter yield. The plants sampled were then placed in an oven at 80° C for 48 hours; their weight after this period was dry matter yield, DM yield, (Cornet, 1984). Specific leaf weight was determined from the ratio dry weight / leaf area of a subsample of 20 leaves per species (Araus *et al*., 1998). for forage analysis, the total nitrogen content is determined by the method of Kjeldahl nitrogen digestible matter are determined by the formula of Demarquilly. For energetic value, the approach is to estimate digestibility of organic matter (OM) and then to calculate according to Leroy formula. Les FUMi and FUMe are calculated sequentially from the estimated gross energy (EB), the digestible energy (DE) and metabolizable energy (ME) and net energy (NE) (Andrieu *et al*., 1988).

III – Results and discussion

1. Biomass production, DM yield

Dry matter yields varied s among the species studied. In annual cycle of vegetation, it is the canary grass that produced the largest production (223 q.ha^{-1}). Ryegrass and tall fescue performed almost similarly 164 and 154 quintals per hectare respectively (Table 1). In Incomplete cycle of vegetation, i.e. operating section and three sections produced during the four years from 2007 to 2011 (Table1), red canary grass gave the highest production (327.5 qx.ha^{-1}), followed by ryegrass (305 q.ha^{-1}). Fescue produced a low yield equal to nearly half of the two before mentioned species with a value of 164 quintals per hectare. However, the DM production of the year 2009/2011 by cutting (Table 2) showed that this was the second cut that produced the most DM for ryegrass and canary grass and subsequently decreased in the third cut. The other species, fescue had a constant production of DM and a marked increase from the first to the last cut with a highest peak of 70 quintals per hectare. The results of DM showed that the canary grass produced more biomass in the annual cycle than the incomplete cycle of vegetation, in contrast to ryegrass and tall fescue. The dry matter accumulation of plant cover or species can be represented as a function of absorbed radiation useful for photosynthesis (Eckardt *et al*., 1977). Indeed, this incident radiation absorbed varies from one species to another and at the vegetation itself. It also depends, leaf area index and the angle of insertion of the leaves and also the structure of the foliage, which is very different in species of the architectural and optical point of view (Gosse *et al*., 1986). In incomplete cycle of cutting operation of plant, we note that is the second cut, which gave a high yield in the red canary grass and ryegrass. This cut was made in the period were climatic conditions are again favorable (good rainfall and adequate temperatures). It is the spring growth (Ollerenshaw *et al*., 1982; Kemp, 1988; Kemp 1989; Duru *et al*., 1995; Kyle 2006). The drop in biomass in the third cut is explained by Gillet (1980) by "cutting effect", depletion of root reserves in response to repeated cuts made or overexploitation.

Table 1. Dry matter yields of species over four years (q.ha^{-1})

Species	DM in complete cycle Value ± SD	DM in incomplete cycle Value ± SD
Ryegrass	164 ± 46.3	305 ± 100.8
Tall fescue	154 ± 57.3	164 ± 15.7
Canary grass	223 ± 24	327.5 ± 100.6

SD: Standard deviation.

Table 2. Dry matter yields of species according to cuttings in incomplete cycle of vegetation during the 2009/2010 year in (q.ha^{-1})

Species	1th cut	2nd cut	3th cut	Total yield Mean value ± SD
Rye-grass	100	150	70	320 ± 33
Tall fescue	24	50	70	144 ± 18.83
Canary grass	27	80	13	120 ± 28.85

SD: Standard deviation.

2. The fodder value of forage

The analysis of the feed value was made at the heading stage of the complete cycle of vegetation. The results showed that ryegrass was more energy-rich compounds (FU 0.94, 0.81 and 0.77 FUMi, and FUMe) (Table 3). Reports TNM/FU and L/S respectively 54.8 and 0.22 are relatively small compared to the other two species. In contrast, tall fescue and reed canary grass are poor in crude FU but filled with respective values of 73 and 39.5 g.kg^{-1} of DM and an L/S is 0.4 and 0.3 in the fescue in the canary. Moreover, the best leaf specific weight (LSW) is observed in ryegrass with an average weight of 0.52 g.cm^{2}.Tall fescue introduced through a LSW. By cons, the LSW the lowest was recorded in the canary with 0.3 g.cm$^{.2}$.From fodder value point of view, the red canary grass and tall fescue are well provided in Total Nitrogen Matter (TNM) and relatively low in Fodder Units (FU). Contrary, the ryegrass is rich in energy compounds, but contains low protein content report by the ratio TNM/FU and L/S, which are indices of forage quality.

Table 3. Forage quality parameters of species

	Ryegrass	Tall fescue	Red canary grass
FU in (g.kg^{-1}of DM)	0.94 ± 0.02	0.7 ± 0.08	0.55 ± 0.1
FU milk	0.81 ± 0.02	0.68 ± 0.07	0.52 ± 0.07
FU meat	0.77 ± 0.02	0.65 ± 0.04	0.07
TNM in (g.kg^{-1} of DM)	51.5 ± 7.5	73 ± 12	39.5 ± 2.5
Ratio TNM/FU	54.8	110.6	71.8
LSW in (g.cm^{-2})	0.5 ± 0.01	0.4 ± 0.01	0.3 ± 0.15
Ratio L/S	0.2	0.4	0.3

IV – Conclusion

These studied species, appear to have interesting characteristics in biomass production. In optimum conditions and proper, they can increase forage production and there by improve the livestock feed, but, they can never by themselves solve the problem of feeding in Algeria.

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Behaviour of some alfalfa populations from algerian oasis

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Abstract. Surveys carried out between April and December 2006 at several Saharan farms showed that farmers continue to use local alfalfa seed they buy from other neighbouring farmers even with higher prices than those of introduced varieties. Thus, we have implemented a behaviour test (March 2008) at Hassi Ben Abdallah (800 km Southeast of Algiers) with a Lattice device with 4 blocks (repetitions) for 20 Saharan populations and 13 biometrical parameters (fresh and dry yields, dry matter content, height and diameter of the main stem, number of mowing, …) considered for about three years. The first observation is that nineteen alfalfa populations continue growing in the winter and just one (Guemar) which stop its growing when it's cold. After an ANOVA test, all parameters have shown a significant or high significant difference except the number of mowing which revealed a non significant difference. Using an ascending hierarchical classification, we obtain three groups of alfalfa populations from algerian oasis according to our biometric parameters.

Keywords. Alfalfa – Oasis – Algerian oasis – Behaviour.

Comportement de populations de luzerne provenant des oasis algériens

Résumé. Des prospections menées entre avril et décembre 2006 au niveau de plusieurs exploitations sahariennes ont montré que les agriculteurs persistent à utiliser des semences de luzerne locale qu'ils se procurent chez d'autres agriculteurs voisins même avec des prix plus élevés que ceux des variétés introduites. Ainsi, nous avons mis en place essai de comportement (Mars 2008) à Hassi Ben Abdallah (800 km au Sud-Est d'Alger)) avec un dispositif en Lattice comprenant 4 blocs (répétitions) portant sur 20 populations sahariennes et 13 paramètres biométriques (rendements frais et sec, taux de matière sèche, hauteur et diamètre de la tige dominante, nombre de coupes, …) ont été pris en considération pendant près de trois années. Le premier constat est que 19 populations de luzerne continuent leur développement en hiver et une seule (Guemar) qui arrête sa croissance quand il fait froid. Suite à une ANOVA, tous les paramètres ont montré une différence significative à l'exception du nombre de coupes. En utilisant une classification ascendante hiérarchique, nous avons obtenus trois groupes de populations de luzerne des oasis algériennes d'après nos paramètres biométriques.

Mots-clés. Luzerne – Oasis – Oasis algérienne – Comportement.

I – Introduction

In Algeria, the area devoted to perennial alfalfa (*Medicago sativa* L.) is between 0.37 and 0.71% of the area devoted to fodder crops. In the Sahara, alfalfa is the main forage species grown. Farmers in the region have shaped populations which come to equal and sometimes exceed widely the varieties introduced for some characters (Chaabena and Abdelguerfi, 2001). Surveys carried out between April and December 2006 at several Saharan farms showed that farmers continue to use local alfalfa seed they buy from other neighboring farmers even with higher prices than those of introduced varieties. The morphological and botanical composition of alfalfa has a great influence on the parameters of nutritional value (Marble, 1993). However, the influence of climatic conditions, soil, water, and more genetic variability was very clear on the morphology and anatomy of different populations and varieties of alfalfa.

This work follows those of Chaabena (2001) and Chaabena et *al.* (2004). Thus, the objective of this work is to assess some agronomic characters and behavior of this saharan collection alfalfa.

II – Materials and methods

During our surveys, we collected seeds of alfalfa from seed producer and have appointed the population, as do farmers, with the name of the locality of the place of harvest. We sowed 20 populations: Aoulef 1, Aoulef 3, Blidet Amor, Chott, Ghardaïa, Hassi Ben Abdallah, Hassi Laabid, In Salah, Janet, Lioua, Meggarine 1, Meggarine 2, Nezla, Ouargla, Taghit, Tamantit, Temacine 1, Temacine 2, and Touijine; at March 2008 and monitor their development until April 2011, by some biometrical parameters: Green yield (q/ha), Dry yield (q/ha), Dry matter rate (%), Stem height at mowing (cm), Number of ramifications by plant, Dominant stem diameter (mm), Leaf length (mm), Leaf width (mm), Fresh ratio Leaf/Leaf+Stem, Dry ratio Leaf/Leaf+Stem, Total green production (q/ha), Total dry production (q/ha), and Number of mowing. We have implemented performance test (March 2008) in Hassi Ben Abdallah (25 km northeast of Ouargla) with a Lattice plan with 4 blocks (replicates). All data were analysed by ANOVA. Analyis of variance than an Ascending hierarchical classification analysis were undertaken using the XLSTAT statistic package (XLSTAT, 2009).

III – Results and discussion

The number of mowing does not show significant differences between the populations and ranges from 20 cuts for Nezla, Aoulef 1, Meggarine 2, Ghardaïa, and Aoulef 3 to 16.5 cuts for Guemar. All the 12 other parameters differed significantly between populations (Table 1 and Fig. 1). For the stem height at mowing, all populations except one (Guemar with 29.6 cm) are grouped together. This population show the shows lowest values for most variables: Green yield (51.337 q/ha), Dry yield (11.607 q/ha), Stem height at mowing (29.6 cm), Dominant stem diameter (2.07 mm), Leaf width (30.173 mm), Total green production (866.141 q/ha), and Total dry production (194.089 q/ha); and the best for one parameter: Dry ratio leaf/leaf+stem (0.694). Best values are presented by Meggarine 2 for Green yield (147.044/ha) and Total green production (2940.882 q/ha); Blidet Amor for Dry yield (51.296 q/ha), Dry matter rate (39.585%), and Total dry production (992.811 q/ha); Ghardaïa for Stem height at mowing (53.302 cm), Dominant stem diameter (4.963 mm), and Leaf width (55.917 mm); Chott for Number of ramifications (6.75); Aoulef 1 for Leaf length (56.094 mm); and Ouargla for Fresh ratio leaf/leaf+stem (0.724).

Some of these results are slightly higher, lower or similar than those obtained by Chaabena (2001). Slightly higher for stem height at mowing we obtain values 53.302 - 29.600 cm against 45.82 - 26.75 cm; for Dominant Stem Diameter, 4.963 -2.070 mm against 3.15 - 2.03 mm; for Leaf length, 56.094 – 35.094 mm against 26.5 - 17.8 mm; for leaf width, 55.917 – 30.173 mm against 17.1 - 8.0 mm; for dry matter rate, 39.585 – 14.961 % against 32.11 - 21.60%. Lower for number of ramifications, 6.75 – 3.75 against 8.60 - 2.92. And similar for fresh ratio leaf/leaf+stem, 0.724 – 0.500 against 0.701 – 0.552; and dry ratio leaf/leaf+stem, 0.694 – 0.467 against 0.697 - 0.531.

To synthesise all data an ascending hierarchical classification analysis was undertaken on all 13 factors (Fig. 2).

This classification highlighted three groups (classes) populations:

– Class 1: Guemar, In Salah, Aoulef 3, and Lioua

– Class 2: Temacine 2, Tamantit 2, Hassi Ben Abdallah, Meggarine1, and Blidet Amor

Table 1. Average values and average groups of 12 variables for the 20 populations of alfalfa studied in Ouargla

Parameters / Population	Average Green Yield (qx/ha)	Average Dry Yield (qx/ha)	Average Dry Matter Rate (%)	Average Stem Height at Mowing (cm)	Average Number of Ramifications by plant	Average Dominant Stem Diameter (mm)	Average Leaf Length (mm)	Average Leaf Width (mm)	Average Fresh Ratio Leaf/Leaf+Stem	Average Dry Ratio Leaf/Leaf+Stem	Average Total Green Production (qx/ha)	Average Total Dry Production (qx/ha)
Aoulef 1	143.047	34.559	24.205	47.639	5.75	3.963	56.094	46.917	0.6	0.563	2860.942	691.184
	a	bcde	ef	a	ab	bcdef	a	a	gh	g	a	bcd
Aoulef 3	98.65	31.079	32.618	44.659	3.75	3.163	35.094	39.917	0.7	0.616	1973	621.586
	ab	bcde	bc	a	b	ef	g	bc	b	b	ab	bcd
Blidet Amor	130.252	51.296	39.585	48.436	4	2.963	49.094	38.917	0.655	0.56	2521.928	992.811
	a	a	a	a	ab	f	bc	cd	d	g	a	a
Chott	109.816	17.857	17.19	49.479	6.75	4.463	40.094	45.917	0.5	0.467	2175.565	353.804
	ab	ef	h	a	a	abcd	f	a	j	n	ab	de
Ghardaïa	110.947	25.579	23.414	53.302	5.75	4.963	52.094	55.917	0.589	0.534	2218.943	511.587
	ab	cdef	ef	a	ab	a	ab	a	h	j	ab	bcde
Guemar	51.337	11.607	24.025	29.6	5.5	2.07	36.651	30.173	0.62	0.694	866.141	194.089
	b	f	ef	b	ab	g	g	f	f	a	b	e
Hassi Ben Abdallah	133.54	40.392	31.145	43.335	5.75	3.463	41.094	45.917	0.603	0.6	2649.424	801.157
	a	abc	cd	a	ab	def	f	a	gh	d	a	abc
Hassi Laabid	118.788	29.994	25.995	44.117	4.75	3.963	56.094	35.917	0.576	0.598	2326.528	587.394
	ab	bcde	e	a	ab	abcdef	a	e	i	d	ab	bcd
In Salah	114.291	28.31	25.61	43.043	3.75	3.163	51.094	49.917	0.639	0.612	2219.431	549.069
	ab	bcde	ef	a	b	ef	ab	a	e	c	ab	bcd
Janet	116.078	25.521	22.954	47.281	6.75	3.563	47.983	52.733	0.602	0.534	2276.393	499.558
	ab	cdef	f	a	a	cdef	cde	a	gh	j	ab	bcde
Lioua	104.095	23.099	23.615	50.557	3.75	3.063	46.094	41.917	0.683	0.55	2041.659	453.167
	ab	def	ef	a	b	f	de	b	c	hi	ab	cde

abcdefg: averages with different letters on the same column are significantly different at 5%.

Table 1 (cont.). Average values and average groups of 12 variables for the 20 populations of alfalfa studied in Ouargla

Parameters / Population	Average Green Yield (qx/ha)	Average Dry Yield (qx/ha)	Average Dry Matter Rate (%)	Average Stem Height at Mowing (cm)	Average Number of Ramifications by plant	Average Dominant Stem Diameter (mm)	Average Leaf Length (mm)	Average Leaf Width (mm)	Average Fresh Ratio Leaf/Leaf+Stem	Average Dry Ratio Leaf/Leaf+Stem	Average Total Green Production (qx/ha)	Average Total Dry Production (qx/ha)
Meggarine 1	125.516	42.176	33.799	49	3.75	3.763	54.094	45.917	0.607	0.487	2483.021	834.24
	ab	ab	b	a	b	bcdef	a	a	g	k	a	ab
Meggarine 2	147.044	21.199	14.961	46.597	4	4.563	45.094	41.917	0.708	0.547	2940.882	423.976
	a	def	i	a	ab	abc	e	bc	b	i	a	de
Nezla	137.537	21.407	16.377	49.434	4.75	3.963	51.135	50.917	0.655	0.576	2750.747	428.14
	a	def	hi	a	ab	bcdef	ab	a	d	f	a	de
Ouargla	102.301	23.435	23.57	50.278	5.75	4.763	53.114	46.917	0.724	0.551	2029.382	464.736
	ab	def	ef	a	ab	ab	a	a	a	h	ab	cde
Taghit	122.331	24.495	20.933	48.312	4	3.763	49.094	45.917	0.65	0.599	2387.488	477.334
	ab	cdef	g	a	ab	bcdef	bcd	a	d	d	ab	bcde
Tamantit 2	122.304	35.758	30.322	51.605	4.75	3.463	37.094	44.917	0.608	0.471	2416.448	706.247
	ab	bcd	d	a	ab	def	g	a	g	m	ab	bcd
Temacine 1	139.697	31.82	23.063	50.73	5	4.163	46.094	46.917	0.63	0.588	2751.815	626.186
	a	bcde	f	a	ab	abcde	de	a	f	e	a	bcd
Temacine 2	107.725	31.936	30.166	46.062	6.75	2.963	41.094	36.917	0.597	0.478	2136.291	633.271
	ab	bcde	d	a	a	f	f	de	gh	l	ab	bcd
Touijine	115.287	21.046	19.658	51.061	5.5	3.85	41.094	38.917	0.655	0.589	2261.446	412.068
	ab	def	g	a	ab	bcdef	f	cd	d	e	ab	de

abcdefg: averages with different letters on the same column are significantly different at 5%.

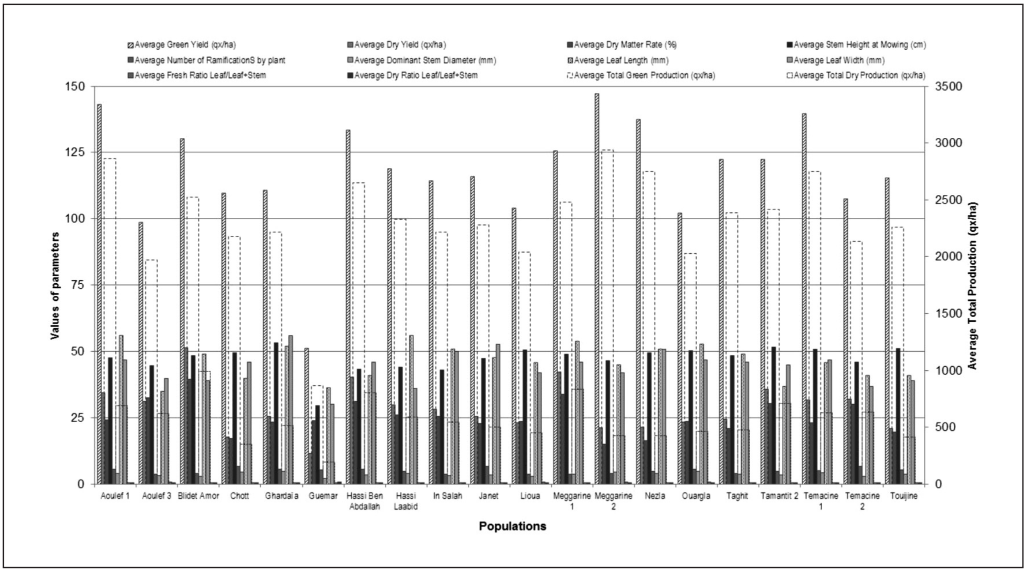

Fig. 1. Average values of 12 parameters for 20 populations of oasis populations of alfalfa.

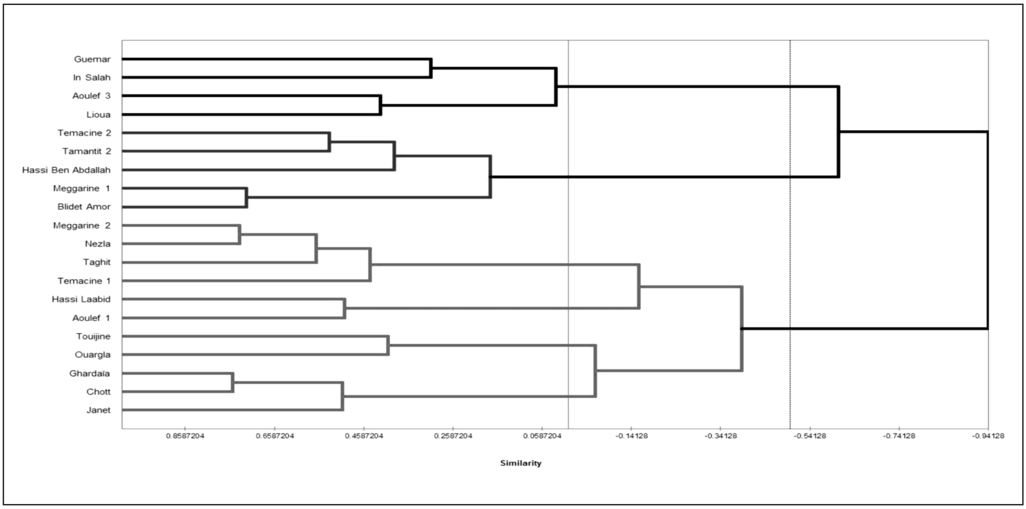

Fig. 2. Ascending hierarchical classification analysis of some alfalfa populations from algerian oasis.

– Class 3: Meggarine 2, Nezla, Taghit, Temacine 1, Hassi Laabid, Aoulef 1, Touijine, Ouargla, Ghardaïa, Chott, and Janet

The first class includes populations of alfalfa with the worst results (globally), and the third class takes in the best ones. The second class go-between the two.

IV – Conclusion

The four year assessment of some agronomic characteristics of alfalfa oasis collection confronted us to a wide range of variation in all observed traits. Population and local climate influenced the biometric values of this fodder. Principal component analysis helped to integrate all data and eventually to select several varieties of interest, both commercial accessions and landraces, on agronomic criteria.

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Evaluation of lambs propensity towards different accessions of *Psoralea*

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Abstract. Animal propensity towards a food is mainly based on pre-ingestive stimuli, and could be measured by the intake rate. A short-term test, using the micro-swards method, was carried out to measure lambs propensity for different accessions of *Psoralea* genus, a perennial legume widely distributed in Mediterranean regions. The following 4 accessions of *Psoralea* were evaluated: *Psoralea bituminosa crassiuscula* Vilaflor; *Psoralea bituminosa bituminosa* Llano del Beal; *Psoralea bituminosa bituminosa* Monte Rosello; *Psoralea morisiana* Punta Giglio. The forages were offered, in a 4x4 latin-square design with 3 replicates, to 12 Sarda lambs, first adapted to the test routine with *Hordeum vulgaris* L.. Fresh matter intake (FMI) and DM intake (DMI, g head^{-1}), number of bites (NB, n.), eating time (ET, min), bite frequency (BF, n. min^{-1}) and intake rate (IR, g min^{-1}) were measured in 5 min sessions. Overall, lambs showed a low propensity for all accessions of *Psoralea* with a slightly higher DM IR for Vilaflor (P≤0.05).

Keywords. Feeding behaviour – Intake rate – Sheep – *Psoralea*.

***Évaluation de la propension des agneaux vers différentes accessions de* Psoralea**

Résumé. *La propension des animaux vers un aliment est principalement basée sur la stimulation pré-ingestive, et pouvait être mesurée par le taux d'ingestion. Un essai à court terme, en utilisant la méthode de micro-swards, a été réalisé pour mesurer la propension des agneaux pour différentes accessions du genre* Psoralea, *une légumineuse pérenne largement distribuée dans les régions méditerranéennes. Les 4 suivantes accessions de* Psoralea *ont été évalués:* Psoralea bituminosa crassiuscula *Vilaflor;* Psoralea bituminosa bituminosa *Llano del Beal;* Psoralea bituminosa bituminosa *Monte Rosello;* Psoralea morisiana *Punta Giglio. Les fourrages ont été offerts, dans un 4x4 carré latin avec 3 répétitions, à 12 agneaux de race Sarde, d'abord adaptée à la routine de test avec* Hordeum vulgaris *L.. L'ingestion de matière fraîche (FMI) and sèche (DMI, g tête^{-1}), le nombre de préhensions (NB, n.), le temps d'ingestion (ET, min), la fréquence de préhensions (BF, n. min^{-1}) et le taux d'ingestion (IR, g min^{-1}) ont été mesurés pendant 5 min d'observation. Dans l'ensemble, les agneaux ont montré une faible propension pour toutes les accessions de* Psoralea, *avec une faible préférence pour Vilaflor qu'a montré un plus haut DM IR (P≤0.05).*

Mots-clés. *Comportement alimentaire – Taux d'ingestion – Brebis –* Psoralea.

I – Introduction

Psoralea bituminosa C.H. Stirton (syn. *Bituminaria bituminosa* L.) is a perennial legume widely distributed in the Mediterranean Basin, and it grows and remains green all-year-round even during summer and autumn. *Psoralea* genus has a large diversity with 3 varieties of *P. bituminosa* found in the Canary Islands (*albomarginata, crassiuscula,* and *bituminosa*) and an endemic species (*P. morisiana*) present in Sardinia (Porqueddu *et al*., 2011). *P. bituminosa* is usually considered of low palatability because of the strong smell that can be emitted by oil glands located on its foliage. However the nutritive value of *P. bituminosa* in terms of forage composition and digestibility was proven similar to or even better than that of other legumes. However, the aerial part of this species may contain a high concentration of furanocoumarins, out of which psoralen and angelicin are the most abundant (Pecetti *et al*., 2007). These substances could be harmful to animals, being responsible for contact photodermatitis, in addition to possibly limiting forage intake. Nevertheless *P. bituminosa* is traditionally used for feeding goats in the Canary Islands (Ventura *et al*., 2009), and is assumed to be tolerant to heavy grazing with cattle (Sternberg *et al*., 2006). The potentiality of *Psoralea* as forage species for dairy sheep is less known. For that reason an experimental test was carried out to evaluate the propensity of Sarda lambs towards different accessions of *Psoralea*.

II – Materials and methods

A short-term test was carried out to measure lambs propensity for 4 accessions of *Psoralea*. These were: *P. bituminosa crassiuscula* Vilaflor; *P. bituminosa bituminosa* Llano del Beal; *P. bituminosa bituminosa* Monte Rosello; *P. morisiana* Punta Giglio. The forages were sown separately in thirty replicate plastic boxes (46.5 cm, 28.5 cm, 14 cm) per accession (120 boxes in total) to establish micro-swards (Orr *et al*., 2005). The seeds were sown on average at a rate of 20 g m^{-2}. The boxes were hand-watered when the soil surface was deemed dry. Each accessions was offered in a 4 x 4 Latin-Square design with 3 replicates to a total of twelve Sarda lambs, aged 126 ± 2 days (mean ± SE), with a live weight of 23.4 ± 0.8 kg. No lamb had previous experience of grazing *Psolarea*. In a pre-experimental period of 10 days the lambs were adapted to individual boxes with concrete floor and fed with ryegrass hay and a commercial concentrate. Since then they were familiarized to the propensity test routine using micro-swards sown with *Hordeum vulgaris* L. (training period, 4 days). After this they were submitted to the experimental treatments (experimental period, 4 days). During this period, between 10 and 12 a.m., the lambs were daily exposed in a random sequence to one of the treatments (two paired boxes of one accession) for about 5 min. During the test the behaviour of the lambs was video-recorded. The micro-sward boxes were weighed before and after each test in order to determine the biomass removed, corrected for evapotranspiration losses (ET), measured using micro-swards of the same accession. Every day the sward surface height (SSH) of each micro-sward was measured by a sward stick before and after grazing. On 2 occasions during the experiment one micro-sward per accession not offered to the animals, was cut at the root-shoot interface after SSH measurement. The samples were freeze-dried and submitted for DM, CP, EE, NDF, ADF, ADL (AOAC, 1990), N fractions (Licitra *et al*.,1996), water soluble carbohydrates (WSC, Martillotti *et al*., 1987) determinations. Non fiber carbohydrates (NFC) were then calculated. Total (Tot. Ph.) and tannic phenols (Tan. Ph.), using Folin Ciocalteu's reagent, and condensed tannins (CT), using the butanol–HCl method and expressing the concentration as leucocyanidin, were also determined. On the basis of weight and chemical measurements and video analysis, the following behavioural parameters were calculated with reference to each 5 min propensity test: intake on fresh (FMI) and on dry matter (DMI) basis (g $head^{-1}$); eating time (ET, min); number of bites (NB, n.); bite mass (BM, g); bite frequency (BF, n min^{-1}) and intake rate (IR, g min^{-1}). Acceptability index was also calculated for each accession as proportion of lambs with minimum intake on total lambs exposed (%). Chemical parameters were analysed with GLM procedure using forage treatment as fixed effect. SSH and behavioural parameters were analysed with mixed procedure, using forage treatment as fixed effect and animal, day and replicate as random effects. Treatment means were separated by Tukey test ($P<0.05$). Chi-Square analysis was performed on acceptability index. Regression analyses were also performed to explore relationships between behavioural data and chemical parameters using daily accession values averaged across replicates (SAS, 2001).

III – Results and discussion

The chemical composition of the different accessions is reported in Table 1. *Llano del Beal* showed the highest level of CP followed by *Monte Rosello*, *Vilaflor* and *Punta Giglio* ($P<0.05$). On the contrary *Punta Giglio* presented the highest level of EE ($P<0.03$) and higher NFC than all the other accessions (P<0.02) with the exception of *Vilaflor*. Fibre fractions were greater in *Monte Rosello* in particular ADF (P<0.01) and ADL (P<0.03). *Punta Giglio* showed lower level of fibre fractions as already observed by Porqueddu *et al*. (2011). No difference was found in N fractions (not shown) and in total phenols and tannic phenols (Table 1). No condensed tannin was detected in any accession.

Table 1. Chemical composition (% DM) of different accessions of *Psoralea* offered to lambs during the propension test (Lsmeans ± SE)

	Llano del Beal	Monte Rosello	Punta Giglio	VilaFlor	P≤
DM	14.1 ± 1.0	13.3 ± 1.0	17.3 ± 1.0	18.5 ± 1.0	0.06
OM	86.2 ± 0.5 c	86.9 ± 0.5 bc	89.2 ± 0.5 a	88.6 ± 0.5 ab	0.05
CP	18.8 ± 0.9 a	17.1 ± 0.9 ab	13.6 ± 0.9 c	14.2 ± 0.9 bc	0.05
EE	4.0 ± 0.2 b	3.7 ± 0.2 b	4.7 ± 0.2 a	3.4 ± 0.2 b	0.03
NFC	26.5 ± 1.8 bc	20.5 ± 1.8 c	34.1 ± 1.8 a	31.6 ± 1.8 ab	0.02
WSC	2.6 ± 0.1	3.3 ± 0.1	5.1 ± 0.1	4.2 ± 0.1	0.18
NDF	43.5 ± 2.2	52.2 ± 2.2	41.8 ± 2.2	45.0 ± 2.2	0.09
ADF	28.1 ± 0.8 b	35.0 ± 0.8 a	22.7 ± 0.8 c	27.5 ± 0.8 b	0.01
ADL	4.8 ± 0.3 b	6.1 ± 0.3 a	4.5 ± 0.3 b	6.0 ± 0.3 a	0.03
Tot. Ph.	1.8 ± 0.1	1.6 ± 0.1	2.1 ± 0.1	1.6 ± 0.1	0.29
Tan. Ph.	0.4 ± 0.1	0.5 ± 0.1	0.6 ± 0.1	0.4 ± 0.1	0.37

Values in the same row with different letters differ significantly (P<0.05).

The highest pre- and post-grazing sward height was found in *Monte Rosello* (35.9 ± 1.0 and 34.3 ± 0.7 cm respectively) whereas the lowest in *Llano del Beal* (16.1 ± 1.0 and 14.4 ± 0.7), being *Vilaflor* (26.7 ± 1.0 and 25.1 ± 0.7) and *Punta Giglio* (24.3 ± 1.0 and 22.4 ± 0.7) intermediates (P<0.001). Overall feeding behaviour variables parameters measured (Table 2) showed very low values as compared to those found in similar experiments with adult dairy sheep (Giovanetti *et al*., 2011). This could be expected, considering the role of learning in feeding behaviour expression (Villalba and Provenza, 2009).

Table 2. Behavioral parameters of lambs fed with different accessions of *Psoralea* (Lsmeans ± SE)

	Llano del Beal	Monte Rosello	Punta Giglio	VilaFlor	P<
Eating time (min)	2.46 ± 0.5	2.66 ± 0.5	1.88 ± 0.5	2.95 ± 0.5	0.22
FM bite mass (g)	0.38 ± 0.06	0.41 ± 0.05	0.41 ± 0.06	0.35 ± 0.05	0.81
DM bite mass (g)	0.05 ± 0.01	0.05 ± 0.01	0.07 ± 0.01	0.06 ± 0.01	0.38
Bite rate (n. min^{-1})	14.6 ± 3.2 ab	11.9 ± 3.2 ab	9.5 ± 3.2 b	16.6 ± 3.2 a	0.05
FM intake rate (g min^{-1})	5.14 ± 1.0	4.91 ± 1.0	3.34 ± 1.0	5.83 ± 1.0	0.17
DM intake rate (g min^{-1})	0.69 ± 0.1 ab	0.67 ± 0.1 ab	0.57 ± 0.1 b	1.08 ± 0.1 a	0.03

Values in the same row with different letters differ significantly (P<0.05).

The intake rate, often regarded as a gauge of forage immediate palatability showed higher level on DM basis in *P. bituminosa crassiuscula Vilaflor* than *P. morisiana Punta Giglio* (P<0.03). This fact was also confirmed by the acceptability index since comparing the accessions, *Vilaflor* showed higher acceptability index than *Punta Giglio* (P<0.03, Fig. 1). Using daily mean accession values, a negative relationship was detected between FMIR and total phenols (FMIR = + 13.0 ± 3.9 - 4.66 ± 2.2 Tot.Ph; R^2 = 0.25, P<0.05, RMSE = 2.0, CV = 42.0) indicating a probable effect of these compounds in reducing palatability.

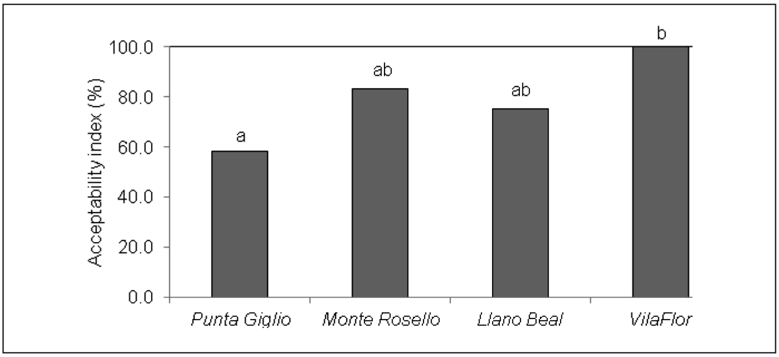

Fig. 1. Acceptability index of *Psoralea* accessions as proportion of lambs with a minimum intake (% of exposed lambs).

V – Conclusions

The results of the experiment indicate that the propension of naïve lambs towards the studied accessions of *Psoralea* is very low in particular for P. *morisiana*, probably because of its content of secondary compounds (e.g. fouranocumarins). Further studies are warranted to evaluate ingestive response in adult sheep featured by greater foraging experience and higher feeding requirements than lambs.

Acknowledgements

The Government of Sardinia (Italy) for the financial support (Projects CRP2_235, PO Sardegna, FSE 2007-2013 L.R. 7/2007). Dr. L. Bertuolo for the help in micro-sward establishment. Mr. S. Picconi, Mr. S. Mastinu, Mr. A. Pintore, Mr. G. Beccugna, Mr. G. Scanu, Ms. M. Niolu, Mr. M. Delrio, Ms. M.A. Sanna for their technical help.

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Options available for improved forage production under highland conditions. The Pakistan experience

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Abstract. The forage production and availability were affected by single cut *vs*. multi-cut, hybrid *vs*. varieties, legumes *vs*. cereal crops, sole cropping *vs*. intercropping, altering planting dates, different types and doses of chemical fertilizer. Non winter dormant/ improved alfalfa and Egyptian clover varieties were 2-3 times more productive than the local landraces commonly cultivated in the region. The improved forage production techniques also provided forage during the deficit periods. Improving the performance of the high-altitude summer pastures being difficult and time-consuming task and would not alleviate the winter forage scarcity problem. Main emphasis should therefore, be put on improving fodder production and conservation on the agricultural holdings. Since holding size is minute, the aim must be to maximize production per unit of area. Fodder production in these isolated, high areas had been little studied. The population has had no easy access to the technology and seed supplies available in the plains and, for the higher areas, technology from lower down is not appropriate.

Keywords. Forage production – Sole cropping – Inter-cropping – Multi-cut – Single cut – Legumes – Cereal crops.

Les options disponibles pour l' amélioration des productions fourragères dans les Hautes Terres : Cas du Pakistan

Résumé. *La production et la disponibilité de fourrage ont été affectés par la coupe simple* vs *multi-coupe, hybride* vs *variétés, les légumineuses* vs *cultures céréalières, la monoculture* vs *cultures intercalaires, les dates de plantation, les différents types et les doses d'engrais chimiques. Les variétés améliorées de luzerne et de trèfle d'Alexandrie étaient 2-3 fois plus productives que les variétés locales couramment cultivées dans la région. Les techniques améliorées de production de fourrage ont également fourni du fourrage pendant les périodes de déficit. Améliorer la performance des alpages est une tâche difficile et de longue haleine et ne résout pas le problème de la rareté du fourrage d'hiver. L'accent doit donc être mis sur l'amélioration de la production fourragère et de conservation sur les exploitations agricoles. Puisque la taille des exploitations est infime, l'objectif doit être de maximiser la production par unité de surface. La production fourragère dans ces régions isolées et élevés a été très peu étudiée. La population n'a pas eu un accès facile aux technologies et semences disponibles dans les plaines et, pour les zones les plus élevées, la technologie de zones plus bas n'est pas approprié.*

Mots-clés. *Production fourragère – Monoculture – Cultures intercalaires – Multi-coupe – Coupe simple – Légumineuses – Cultures céréalières.*

I – Introduction

Lack of quality fodder throughout the year and especially during winter is the major limiting factor for livestock production in the mountain areas of Pakistan. Most of the rangelands are overgrazed and poorly managed. Most of the irrigated area is planted with cash crops such as orchards, vegetables, staple food crops, etc. Therefore, intensification of improved fodder production near villages as a sole crop as well as intercropped in the orchards would be of great economic benefit in order to produce more feed of better quality, for maintaining animals over winter and for weight gains in spring. Under the present situation insufficient fodder with poor quality is available in the area and hence the animals are underfed, lean, and less productive. Traditional systems of farming will not be adequate for a changing human population.

These paper reports results of on-farm evaluations conducted in higher-altitude maize-wheat based farming systems in the Northern areas of Pakistan and options available to enhance forage production.

1. Enhance fodder yields, quality and soil fertility per unit area per season

In order to obtain early and good yields on small holdings in winter, compatible fodder crops may be sown in mixture to produce higher fodder yields and quality per unit area per season. Low growing leguminous fodders such as lucerne, berseem, and vetch can be mixed with oats, barley, ryegrass, brassica etc. Lucerne + oats, berseem + oats and shaftal +oats combinations produced 190, 130 and 80 t/ha of green material compared with 120, 89, 45, and 90 t/ha Lucerne, berseem, shaftal, and oats pure stands respectively (Table 1).

Table 1. Yields (tonnes/ha) of some leguminous forage crops

Variety	Green forage	Air dry matter
Local lucerne	55	19
Sunder lucerne	120	45
Sunder + oats	190	58
Shaftal	45	14
Shaftal + oats	80	25
Berseem	89	28
Berseem + oats	130	47
Oats	90	38

Source: Dost, 1997.

Jefferson and Zentner (1994) reported that lucerne sown alone produced much less than oat sown with Lucerne or oat sown alone in the establishment year. In contrast, Brink and Marten (1986) showed that oat as a companion crop to Lucerne had inferior forage quality compared with barley when the mixture was harvested in the sowing year.

2. Non winter dormant *vs*. winter dormant lucerne varieties

Several non winter dormant and winter dormant varieties of lucerne were evaluated at three sites during 1993-95. The details are presented in Table 2. Non winter dormant lucerne variety Sundar has been extremely successful at all three sites. They may suffer some frost damage at high altitudes but grow throughout the year and yield more than twice as much as the winter dormant landrace in double crop areas below 2,000 m. They also provided maximum green feed in the critical December-January forage deficient period.

Table 2. Green and dry matter yields (t/ha) of lucerne varieties at three sites

Varieties	Sites					
	Chilas		Gilgit		Skardu	
	Green fodder	Dry matter	Green fodder	Dry matter	Green fodder	Dry matter
Sundar	165	50	174	52	90	26
Misasirsa	98	32	117	34	74	20
Pioneer	92	29	95	30	86	22
Sanora	90	27	84	24	73	20
Illunico	71	22	68	22	70	19
Type 8/9	100	32	96	30	74	21
Powera	58	19	61	19	68	18
Local	55	16	60	18	57	17
Average	91.13	28.38	94.38	28.62	73.25	20.38

Source: Dost, 1995.

1.3. Forage availability through manipulation of planting seasons

Supply of forage mainly depends on the time of sowing. In developing countries where fodder is very scarce, the time of fodder availability during deficit or lean periods is more important than the total quantity of fodder available. Sowing date trials on high forage yielding oat cv. Scott were conducted at research institutes throughout the country under various agro-ecological environments. The results obtained are presented below.

At Gilgit and Chilas, the 15 October sowing, and the 15 November sowing at Juglot, provided maximum forage in December-January, the fodder deficit period. September sown crops provided acceptable yields in November at all sites, time of fodder availability is directly correlated with sowing time (Table 3).

Table 3. Green yields (t/ha) of oat cv S-81 at various sowing dates at three sites during 1995

Treatments	Gilgit	Chilas	Juglot
September 20	74	55	25
September 27	65	53	27
October 1	62	50	29
October 7	80	60	30
October 15	88	78	30
October 22	70	55	35
November 1	60	52	37
November 8	55	40	39
November 15	51	43	47
November 22	48	35	36
November 29	40	58	31

Source: Dost, 1997.

1.4. Increased forage production through fertilization

Different doses of nitrogenous and phosphatic fertilizer produced substantially higher yields at five locations in Pakistan than using no fertilizer or farmyard manure alone, especially on seriously depleted soils that had been mono-cropped for many years with cereals. Maximum forage yields were obtained through application of 150-75 N-P kg/ha at most sites, followed by 150-25 N-P kg/ha (Table 4). However, increased use of fertilizer could not be justified in many instances for economic and environmental reasons.

Table 4. Green yield (t/ha) of oat cv. Scott under different fertilizer doses and sites in 1999-2000

Fertilizer (N-P kg/ha)	Green fodder yield				
	Islamabad	Tandojam	Tarnab	Sariab	Faisalabad
100-25	74.69	59.56	30.78	46.00	96.29
50-50	61.11	52.16	28.01	42.33	79.32
50-25	56.79	57.40	25.23	40.33	70.37
50-75	61.11	55.24	28.94	47.33	101.23
150-25	80.86	74.99	29.40	45.33	98.45
150-75	87.04	74.09	30.78	56.66	112.04
100-50	74.69	62.34	31.95	50.00	99.38
00-00	37.65	44.13	27.78	32.00	52.16

Source: Annual Report 2000, Fodder Research Programme, NARC, Islamabad.

1.5. Single cut *vs*. multi-cut forage varieties

Compared with wheat and barley in Pakistan, oats provide multiple cuts, tiller profusely, yield more, and are of higher nutritional value (Table 5). Standing oats can be cut progressively, releasing land earlier than normal for follow-on crops or relay cropping. Any remaining oats can be dried as hay. This coincides with optimum soil moisture for land cultivation and sowing of the following crop, and also allows small areas or peripheral lines on terraces to be saved for seed. In many, but not all instances, more recently bred cultivars out-yield older ones (Dost, 1994).

Table 5. Average plant height (PH), tillers per plant (TL), leaves per tiller (LV), green fodder yield (GY), dry matter yield (DY), seed yield (SY), Crude protein content (CP), and crude fibre contents (CF) of oats cv. S-81 in Islamabad, 1991-92

Treatments	PH	TL	LV	GY	DY	SY	CP	CF
CT 1	63.63	6.18	4.89	13.59	2.07	0.85	12.29	22.32
CT 2	83.70	6.80	5.89	16.92	2.57	0.54	12.25	22.94
CT 3	90.06	6.89	6.26	23.46	4.08	0.48	8.68	24.50
CT 4	94.74	7.07	6.59	33.33	6.60	0.46	8.46	25.58
CT 5	134.78	6.46	6.56	54.99	12.99	–	7.94	25.60
CT 6	–	–	–	–	–	1.34	–	–
LSD (P = 0.01)	10.70	0.54	0.63	4.73	1.24	0.24	0.34	0.36

CT 1: Cut for fodder 70 days after sowing and then for seed, CT 2: Cut for fodder 85 days after sowing and then for seed, CT 3: Cut for fodder 100 days after sowing and then for seed, CT 4: Cut for fodder 115 days after sowing and then for seed, CT 5: Cut at 50% flowering for fodder only, CT 6: No fodder cut but left for seed only.
Source: Dost, 1994.

Although the use of oats as a multi-cut crop is common in Pakistan, relatively limited research data are available in Pakistan on forage quantity in crops harvested at various stages of maturity, so studies were carried out to determine the ideal stage to obtain a compromise between maximum forage yield and reasonably good forage quality. Hussain *et al*., (1998) evaluated oats, barley, and wheat for forage yield and quality at nine growth stages at Islamabad during 1990-1992. Oats harvested at head emergence stage and barley and wheat at full flowering produced maximum green yields. In all three crops, the highest dry matter yield was recorded at early dough stage. The maximum crude protein content was recorded at four leaf stage repeatedly, whereas minimum protein content was recorded in the early dough stage. Oats, barley, and wheat harvested at boot stage provided a good compromise among green fodder yield, dry matter yield, and forage quality. At this stage, a sufficient quantity of fodder with moderate forage quality was obtained (Table 6).

Table 6. Green and dry matter yield and crude protein content of oats, barley, and wheat under various cutting regimes

Cutting stage	Green fodder yield (t/ha)				Dry matter yield (t/ha)				Crude protein (%)			
	Oats	Barley	Wheat	Mean	Oats	Barley	Wheat	Mean	Oats	Barley	Wheat	Mean
CS 1	37.66	33.15	21.73	30.84	5.81	4.80	3.93	4.85	14.93	13.47	12.56	13.65
CS 2	40.43	35.74	26.26	24.15	7.13	5.75	4.78	5.89	14.07	12.78	11.97	12.34
CS 3	56.45	44.77	24.49	41.90	10.68	7.49	4.67	7.61	12.65	11.70	11.53	11.36
CS 4	67.16	51.30	28.80	49.09	12.41	9.21	6.52	9.39	10.80	9.85	10.21	10.28
CS 5	69.44	48.45	31.78	49.89	12.15	8.05	7.41	9.21	8.75	8.42	8.15	8.44
CS 6	64.60	56.39	30.66	50.55	11.43	10.26	7.08	9.59	8.10	7.72	7.50	7.77
CS 7	68.21	58.42	40.51	55.71	13.35	11.17	9.83	11.44	7.63	7.54	7.32	7.50
CS 8	64.27	53.93	33.95	50.72	13.99	13.40	10.83	12.74	7.50	7.02	6.96	7.16
CS 9	51.21	42.52	33.72	42.52	17.17	14.67	12.23	14.69	7.15	6.85	6.75	6.92
Mean									10.17	9.22	9.48	

CS 1: Repeated cutting at 4 leaf stage, CS2: Repeated cutting at tillering, CS 3: Repeated cutting at jointing, CS 4: Repeated cutting at boot stage, CS 5: Harvesting once at head emergence, CS 6: Harvesting once at 50% flowering, CS 7: Harvesting once at 100% flowering, CS 8: Harvesting once at early milk stage, CS 9: Harvesting once at early dough stage.

Source: Hussain et al., *1998.*

1.6. Hybrid *vs*. varieties

Local maize and millet are dual purpose crops extensively grown in North Pakistan. Multi-cut hybrid sorghum could ensure maximum tonnage of green as well as dry matter well distributed throughout the summer growing period.

Overall hybrid sorghums provided four cuttings in Gilgit and Chilas and two in Skardu and Khaiber. At all the locations, all the hybrids produced 2-3 times more green fodder and dry matter yields well distributed over the entire growing period as compared to the traditional local maize and millet cultivars. Due to higher temperatures in Gilgit and Chilas, maximum forage yields were recorded as compared to Skardu and Khaiber (Table 7).

Table 7. Green and dry matter yields (t/ha) of different sorghum hybrids and local maize and millet cultivars

Varieties	Sites							
	Gilgit		Chilas		Skardu		Khaiber	
	Green fodder	Dry matter	Green fodder	Dry matter	Green fodder	Dry matter	Green fodder	Dry matter
LS-4000	117	34	109	32	68	26	62	22
S.S.G.988	141	42	92	30	60	20	53	18
Forage sorghum	125	37	75	28	66	24	58	20
Sordan-91	138	45	102	30	75	29	66	23
S.S.G-1	110	33	95	26	64	23	56	19
Average	126.20	38.20	94.60	29.20	66.60			
Local Maize	38	13.23	41	15	33	12.49	30	9
Local Millet	35	12	33	11	30	9	28	8

Source: Dost, 1998.

II – Conclusions

It was observed that the hybrid multi-cut hybrid sorghums which were scarcely known in the area have produced 100-125 tones/ha green fodder yields as compared to 25-30 tones/ha fodder yields by local maize. The improved varieties of maize were superior in grain yields, stover yields, and green fodder yields as compared to local landraces. However, improved varieties were 20-30 days late in grain maturity. Also the improved oats and lucerne varieties produced 2-3 times more yields as compared to local varieties.

The improved berseem clover varieties produced 132-140 tones green fodder yields in six cuts as compared to 80-85 tones by shaftal clover in three cuts. Although there is no tradition of applying chemical fertilizers to the forage crops, maximum forage yields were obtained through application of 150-75 N-P kg/ha at most sites. However, increased use of fertilizer could not be justified in many instances for economic and environmental reasons.

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Locations and some agricultural properties of *Medicago orbicularis* L. genotypes present in Antalya flora

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Abstract. Turkey, which is at the intersection of three gene centers, and especially Mediterranean basin, is the gene centre of many legumes used in agriculture. There are more than 900 legumes species and most of them are annual plants. 30 of these species are medic (*Medicago* L.) species. Annual medics originated from Mediterranean. 13 of them, which also have high adaptation capacity, have economic importance. With regards to contribution of the length of vegetative period, annual medics have great importance. Thus, some of the annual medics reach the grazing maturity in early spring and some of them develop after the unsuitable conditions of summer season and provide significant contribution to grass yield of pasture in late autumn. In general, despite the use of perennial plants in the world, annual medics are much more promising than perennials in the pasture with limited rainfall in summer. The ecological conditions of our country are very similar to the region where annual medics have importance in the grass yield. Annual medics have great importance for the improvement of roughage production in our country. In this study, the coordinates of spread areas of *Medicago orbicularis* L., which is one of the species of annual medics, were determined with GPS in Antalya natural flora. Also in natural flora, development shapes of plants, leaflet width and length, hairiness of leaf surface, flower color, plant length, amount of fruits in plant and hairiness in bean were analyzed.

Keywords. Annual Medic – Natural Flora – *Medicago orbicularis* L.

Localisations et certaines propriétés agricoles des génotypes de* Medicago orbicularis *L. présents dans la flore d'Antalya

Résumé. *La Turquie, qui est à l'intersection de trois centres de gènes, est le centre gène de beaucoup de légumineuses utilisées dans l'agriculture. Il existe plus de 900 espèces de légumineuses et la plupart sont des plantes annuelles. 30 de ces espèces sont medics* (Medicago *L.) espèces. Les medics annuels proviennent de la Méditerranée. 13 d'entre eux, qui ont aussi la capacité d'adaptation élevée, ont une importance économique. En ce qui concerne la contribution à la longueur de la période végétative, les médicagos annuels ont une grande importance. Ainsi, certains d'entre eux atteignent la maturité pour le pâturage au début du printemps, et certains d'entre eux se développent après les mauvaises conditions de la saison estivale et fournissent une contribution significative à la production d'herbe de pâturage en fin d'automne. En général, malgré l'utilisation de plantes parenes dans le monde, les médecins annuels sont beaucoup plus prometteuses pour les zones à faibles pluies d'été. Les conditions écologiques de notre pays sont très similaires à la région où les médics annuels ont une importance dans la production d'herbe. Les médics annuels ont une grande importance pour l'amélioration de la production de fourrage dans notre pays. Dans cette étude, les coordonnées des zones de distribution de* Medicago orbicularis *L., qui est l'une des espèces de médics annuels, ont été déterminées avec GPS dans la flore naturelle d'Antalya. Également dans la flore naturel, les formes, la largeur et longueur des feuilles, la pilosité de la surface foliaire, la couleur des fleurs, la longueur des plantes, la quantité de fruits dans la plante et la pilosité des gousses, ont été analysés.*

Mots-clés. *Médic annuel – Flore naturel –* Medicago orbicularis *L.*

I – Introduction

Diversification and development of fodder crops is important to meet forage gap in our country. Fodder crops production can be increased by using both perennial and annual forage crops and annual legume forage crops in the fallow system (Al and Baysal, 1996; Ekiz, 1995, Andic *et al*. 1996).

Pasture area of our country is about 12.3 million hectares and dry matter yield is approximately 1000 kg/ha. This low yield shows that our pastures do not have enough productivity. However, yield can be improved by breeding studies. With high adaptation capabilities, the ability to compete, rapid grow and the nutritional value the annual medics can be used in breeding pasture.

In general, despite the use of perennial plants in the world, due to the limited amount of rainfall during the summer annual medics are more promising than the perennial (Ocumpaugh *et al*., 1998). Annual medics have Mediterranean origin and can be found nearly in every region of Turkey. Annual medics has a high potential to increase forage production of our country.

II – Materials and methods

In the study, an annual medic species, button clover (*M. orbicularis* L.) were collected from the natural flora of Antalya. A random sampling method which covers the entire area of the species was used during the collections. This method is advantageous because it is possible to take samples in a wider area in less time and enable a collector to see the entire area.

Visiting dates are arranged according to the altitudes and flowering time of species in the flora. GPS values (height and coordinates) of the species are determined. To determine the characteristics of the species, growth form, flower color, plant height, number of fruits per plant, leaf width-length and hairiness on the leaf and pod values were taken.

III – Results and discussion

Location, height, and the coordinates of *M. orbicularis* L. genotypes collected from natural flora of Antalya are given in Table 1. It can be seen from table that genotypes are available from west to east area of Antalya province naturally. When we look at the altitudes, genotypes were found between 6 m and 1223 m which shows *M. orbicularis* L. can be found from the coast to the high plateaus. These findings indicate that *M. orbicularis* L. has the ability of a wide range adaptability and Mediterranean region is the native land of this species.

Some characteristic values of *M. orbicularis* L. genotypes are given in Table 2. Horizontal growth form and yellow flower color was determined. Leaf width 2.5-11.0 mm, leaf length 4.0-16.5 mm, leaf hairiness and pod hairiness 1.0-3.0, plant height 18.0-72.0 cm, and the number of fruits per plant were recorded between 2.5-46.0.

Aydin *et al*. (2010), in a study on *M. orbicularis* L. found plant height between 24.33-71.33 cm, leaf width of the 0.84-1.6 cm, leaf length and 0.7-1:58 cm. In addition, they found the status of development the genotypes as horizontal, semi-horizontal, semi-erect and observed low hairiness. These findings were similar to our data.

Karadağ (1994) also observed *M. orbicularis* L. genotypes and similar results were presented. In the mentioned study, genotypes were horizontal and different in terms of hairiness. Stem length was recorded between 16.6 - 49.2 cm.

Crawford (1985), emphasized that annual medics *Medicago lupulina* L., *Medicago arabica* L., *Medicago orbicularis* L. and *Medicago polymorpha* L. are the most economically important species.

Table 1. Location, height, and the coordinates of *M. orbicularis* L. genotypes

Genotype No	Location	Altitude	Coordinates	
1	Aksu merkez	35	36 S 0308832	UTM 4092669
2	Nebiler – Yeniköy	301	36 S 0284735	UTM 4096555
3	Akseki merkez	1053	36 S 0391923	UTM 4100520
4	Gündoğmuş	915	36 S 0399982	UTM 4074404
5	Akseki	946	36 S 0389435	UTM 4099616
6	Garipçe köyü	796	36 S 0264847	UTM 4131127
7	İbradı – Derebucak	1099	36 S 0374740	UTM 4107215
8	Korkuteli-Büyükköy	922	36 S 0259909	UTM 4114104
9	Zeytintaş mağarası	60	36 S 0332115	UTM 4091902
10	Akseki-Cevizli	1097	36 S 0393296	UTM 4114095
11	Elmalı-Finike	1037	36 S 0760941	UTM 4067773
12	İbradı-Emiraşık köyü	494	36 S 0380367	UTM 4104317
13	Kaş – Dirgenler Köyü	207	36 S 0751965	UTM 4027843
14	Kaş – Kasaba	209	36 S 0747799	UTM 4023347
15	Akçay yolu-Elmalı	1045	36 S 0753609	UTM 4059041
16	Düden	60	36 S 0304916	UTM 4097758
17	Elmalı-Finike yolu	1025	36 S 0761324	UTM 4060627
18	İbradı	949	36 S 0388869	UTM 4098920
19	Kaş - Dağbağ köyü	234	36 S 0759858	UTM 4034355
20	Elmalı-Finike yolu	1024	36 S 0764431	UTM 4055925
21	Akseki-Dikmen	884	36 S 0389957	UTM 4093797
22	Yukarı seki	13	36 S 0352399	UTM 4081207
23	Kurşunlu	69	36 S 0306068	UTM 4094547
24	Dağbeli	798	36 S 0277540	UTM 4119104
25	Kaş – Kasaba	335	36 S 0744108	UTM 4026305
26	Gündoğmuş	1002	36 S 0406799	UTM 4075668
27	Ormana-İbradı	1057	36 S 0371691	UTM 4106951
28	Çandır	6	36 S 0325424	UTM 4091391
29	Korkuteli	924	36 S 0263736	UTM 4100016
30	Çığlık – Yeniköy	298	36 S 0282818	UTM 4102750
31	Karaman köyü	135	36 S 0305529	UTM 4107502
32	Korkuteli – Büyükköy	941	36 S 0260204	UTM 4118035
33	Karaöz – Ekşili	76	36 S 0301406	UTM 4114801
34	Nebiler	273	36 S 0283929	UTM 4095758
35	Gündoğmuş-güzelbağ	676	36 S 0409262	UTM 4067566
36	Karaöz	62	36 S 0306372	UTM 4092880
37	Çandır	6	36 S 0325424	UTM 4091391
38	Evrenseki	8	36 S 0352327	UTM 4078586
39	Güloluk – Aksu	57	36 S 0334274	UTM 4121840
40	Akseki	1223	36 S 0392083	UTM 4107316
41	Ormana – Başlar	1045	36 S 0372113	UTM 4106349
42	Gündoğmuş -köprülü	515	36 S 0422884	UTM 4070055
43	Kızılkaya köyü	884	36 S 0259974	UTM 4124864
44	Alanya – Burçaklar	237	36 S 0401276	UTM 4059417
45	Akseki – Sadıklar köyü	993	36 S 0393216	UTM 4089072

Table 2. Some agricultural properties of *M. orbicularis* L. genotypes

Genotype	Growth form	Flower color	Leaf width	Leaf length	Leaf hairiness	Pod hairiness	Plant height	Fruit per plant
1	Horizontal	Yellow	6.5	8.0	2.0	2.0	57.5	46.0
2	Horizontal	Yellow	7.0	11.0	1.0	1.0	39.0	13.0
3	Horizontal	Yellow	7.2	10.1	1.0	1.0	41.0	32.5
4	Horizontal	Yellow	8.0	10.0	1.0	1.0	55.5	19.5
5	Horizontal	Yellow	6.5	9.5	1.0	2.0	34.2	14.4
6	Horizontal	Yellow	7.5	11.0	1.0	1.0	30.5	13.0
7	Horizontal	Yellow	7.2	9.5	1.0	1.0	27.4	18.6
8	Horizontal	Yellow	6.0	9.0	2.0	2.0	40.5	12.0
9	Horizontal	Yellow	7.5	9.0	2.0	1.0	30.5	15.0
10	Horizontal	Yellow	6.2	8.5	1.0	1.0	37.8	22.4
11	Horizontal	Yellow	10.5	14.0	1.0	1.0	46.0	10.0
12	Horizontal	Yellow	6.5	9.0	2.0	2.0	22.5	31.0
13	Horizontal	Yellow	7.2	9.2	2.0	3.0	32.0	16.5
14	Horizontal	Yellow	8.5	12.0	1.0	1.0	44.0	13.0
15	Horizontal	Yellow	7.0	11.0	2.0	1.0	56.0	8.5
16	Horizontal	Yellow	7.0	10.5	1.0	1.0	42.0	27.0
17	Horizontal	Yellow	8.0	10.0	1.0	1.0	47.0	39.0
18	Horizontal	Yellow	6.5	9.5	1.0	1.0	30.5	14.5
19	Horizontal	Yellow	7.0	8.8	2.0	1.0	34.2	18.4
20	Horizontal	Yellow	8.0	9.0	1.0	1.0	45.0	20.0
21	Horizontal	Yellow	5.5	8.0	2.0	1.0	18.0	2.5
22	Horizontal	Yellow	6.0	8.2	2.0	1.0	39.8	12.6
23	Horizontal	Yellow	5.3	7.7	1.0	1.0	24.0	6.5
24	Horizontal	Yellow	4.0	5.5	2.0	2.0	26.0	18.5
25	Horizontal	Yellow	10.5	12.0	1.0	1.0	30.0	20.0
26	Horizontal	Yellow	7.0	10.5	1.0	1.0	30.0	15.0
27	Horizontal	Yellow	8.2	10.4	1.0	2.0	42.2	25.3
28	Horizontal	Yellow	5.6	8.0	1.0	1.0	27.4	18.5
29	Horizontal	Yellow	6.3	10.0	1.0	1.0	40.5	29.0
30	Horizontal	Yellow	10.0	14.5	1.0	1.0	72.0	30.5
31	Horizontal	Yellow	8.4	11.2	2.0	1.0	39.8	25.6
32	Horizontal	Yellow	6.0	10.5	1.0	1.0	38.0	27.5
33	Horizontal	Yellow	7.2	9.6	1.0	1.0	42.2	21.3
34	Horizontal	Yellow	8.0	9.5	1.0	1.0	31.5	20.0
35	Horizontal	Yellow	5.0	8.0	2.0	1.0	51.0	7.0
36	Horizontal	Yellow	11.0	16.5	3.0	2.0	51.5	13.0
37	Horizontal	Yellow	8.0	10.5	1.0	1.0	35.0	11.5
38	Horizontal	Yellow	7.5	9.0	1.0	1.0	31.0	32.0
39	Horizontal	Yellow	6.0	8.5	1.0	1.0	24.0	17.5
40	Horizontal	Yellow	2.5	4.0	1.0	1.0	34.0	28.5
41	Horizontal	Yellow	6.4	8.2	2.0	2.0	33.5	22.8
42	Horizontal	Yellow	6.0	8.0	1.0	2.0	34.5	6.5
43	Horizontal	Yellow	7.6	10.2	1.0	1.0	44.6	24.0
44	Horizontal	Yellow	7.2	9.8	2.0	1.0	38.6	19.4
45	Horizontal	Yellow	8.2	12.0	2.0	2.0	58.4	30.6

Average plant height was 20.64 cm, leaf length was 11.8 mm and leaf witdh was 12.40 mm in the study of Sayar *et al.* (2010) which was carried out in a east province of Turkey. Hairiness leaves, yellow color and semi-horizontal growth form was stated. These findings were similar to our study except plant height. This difference can be attributing to the different ecological conditions of the locations.

IV – Conclusions

There is a demand for roughage in Turkey. In order to meet this need it is important to increase fodder plants production. Besides, we need to find more efficient ways to use our pastures. In the pastures breeding studies high feed value is required. Therefore, annual medics can be used in this manner.

Horizontal or semi-horizontal structure, hard seed, high adaptation ability, usable in the sub-cultivation systems and the other important characteristic of the annual medics provide many advantageous. *M. orbicularis* L. can be thought as an alternative to species which have been used in the pastures breeding programs. Because this species is naturally available in our flora and has many advantageous.

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Preliminary selection of *Lolium perenne* L. natural populations for pasture improvement purpose in rainfed Mediterranean conditions

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Abstract. Previous researchs have established how *Lolium perenne* L. genetic conservation, evaluation and development have priority for Mediterranean permanent pasture sustainability, and how new persistent and drought tolerant varieties could contribute to mixtures of annual and perennial legumes for pasture improvement purpose. Nevertheless, scarce is the availability of perennial ryegrass cultivars responding to semi-arid climates adaptation criteria; their persistence being reduced by incidences of summer droughts. The attempt to extend this availability has been started through a collection of germplasm and consequent field evaluation of natural populations, originating from different pedo-climatic sites of Corsica and Sardinia islands in the Mediterranean Sea, in terms of productive parameters, habit, phenology and persistence. The field evaluation trial was carried out at the Ottava experimental station of the Sassari University (570 mm average annual rainfall, North Sardinia, Italy). Starting from initial 30 natural populations, 11 preliminarily selected accessions were compared over three years, under rainfed conditions, following the UPOV rules for the identification of new cultivars, with the purpose to estimate the potential inclusion of most interesting accessions in programs that lead to varietal certification.

Keywords. *Lolium perenne* – Rainfed conditions – Semi-arid climate – Persistence.

Sélection préliminaire des populations naturelles de* Lolium perenne *L. dans le but de amélioration des pâturages dans les conditions non irriguées méditerranéens

Résumé. *Recherches antérieures ont établi comment la conservation génétique, l'évaluation et le développement des graminées pérennes, ont la priorité pour la durabilité des pâturages permanents méditerranéens, et comment de nouvelles variétés, persistantes et tolérantes à la sécheresse, pourraient contribuer aux mélanges de légumineuses annuelles et pérennes pour objectif d'amélioration des pâturages. Cependant, la disponibilité de cultivars de ray-grass pérennes répondant à des critères de l'adaptation au climat semi-aride est rare, leur persistance étant réduite par l'incidence des sécheresses estivales. La tentative d'étendre cette disponibilité a été démarré à travers une collection de matériel génétique et par l'évaluation morpho-agronomique des populations natives, provenant de différents sites pédo-climatiques sur les îles de Corse et de Sardaigne dans la mer Méditerranée, en termes de paramètres productives, de phénologie et de persistance. L'étude de évaluation sur le terrain a été réalisée à la station expérimentale de Ottava de l'Université de Sassari (570 mm précipitations annuelles moyennes, du Nord Sardaigne, Italie). A partir de 30 initiales populations naturelles, 11 accessions persistantes ont été comparés sur trois ans, dans des conditions non irriguées, suivant les règles de l'UPOV pour l'identification de nouveaux cultivars, dans le but d'estimer l'inclusion éventuelle de des accessions plus intéressantes dans les programmes qui mènent à la certification variétale.*

Mots-clés. Lolium perenne *– Conditions non irriguées – Climat semi-aride – Persistance.*

I – Introduction

The maintenance of ecosystem services is becoming one of the most important component of European farm income, through the subsidies introduced by the European Union's common agricultural policy (Lelièvre and Volaire, 2009); in this new contest, it is clear that semi-permanent improved pastures based on multifunctional mixtures of annual and perennial species may have a positive role (Franca *et al*., 2007). In recent years, there have been advances in the availability of annual pasture species in the Mediterranean seed market, while progress remains to be made in selecting perennials useful for this purpose. Commercial perennial grasses, and even drought tolerant perennial ryegrass varieties, often do not persist, being not able to survive to hot and dry summer in Mediterranean environment (Franca *et al.*, 1995). Through the years, various germplasm collection campaigns were carried out in the Mediterranean Basin. Regional genepools of perennial ryegrass were established in France (Charmet and Balfourier, 1990), a core germplasm collection was carried out in Tunisia (Chakroun *et al*., 1995) and a germplasm collection for breeding purpose was concluded in Italy (Falcinelli *et al.*, 1988). But, nevertheless, no selection process was completed and it is still difficult to find a perennial ryegrass variety able to compose a balanced and persistent multifunctional mixture for pasture improvement purpose. So, research programs should ensure a diversification of available perennial grasses germplasm for phenology, drought tolerance, summer dormancy levels, and dehydration tolerance.

The attempt to extend this availability has been started through a collection of germplasm and consequent field evaluation of natural populations, originating from different pedo-climatic sites of the islands of Corsica and Sardinia in the Mediterranean Sea, in terms of productive parameters, habit, phenology and persistence. In this paper, coverage values at the autumn establishment were used for observing the persistence capability of the populations, while data on plant morphology and productivity were utilized for clustering the persisting populations for similarity.

II – Materials and methods

The 30 populations used in this experiment were sourced from a collection carried out in 2004 within the Vegetatio Interreg III A programme by ISPAAM (Sardinia, Italy) and ODARC (Corsica, France). On autumn 2005, collected seeds were sown in a experimental field in Sassari (Italy), 80 m a.s.l., average annual rainfall 547 mm, average annual temperature 16,2°C, on a calcareous sandy-lime soil. Seeds were sown in rows, 20 cm distant. Plots (1 m x 3 m) were arranged in a randomized block design with three replications.

The persistence of each population from autumn 2005 to spring 2008 was determined visually estimating the coverage percentage of the population in autumn. Only 11 populations re-established for three years and were included in the analysis. Also, with the aim of studying the morphological variability of the persisting populations, the following morphological characters were observed: tiller length, flag leaf length and width, spike length; number of sterile and reproductive tillers per plant, number of spikelet per spike, plant habit. In terms of productivity, dry matter yield and potential seed yield of the persisting populations were determined. Cluster analysis was performed on average values of morphological and productive data per population, only using data of the second year. Statgraphics Centurion (StatPoint Inc.) multivariate procedures (Squared Euclidean distances and Nearest Neighbour Method) were performed.

III – Results and discussion

Data are referred to the 11 of the 30 collected populations that persisted for three years in the field in dry conditions. Cantoniera Atzeni is the only Sardinian population that persisted, the other 10 populations are original of Cap Corse (Corsica, France) (Fig. 1). All the populations improved their coverage in the second year, compared with the sowing year, and seven populations have followed the same trend even in the third year, reaching in most of the cases coverage percentages higher than the 50%. Only two populations, RG17 and RG6, decreased their re-establishment at the first year level (about 20% of coverage). The field trial concluded in June 2008; however, observations on persistence made in October 2008 showed that all the 11 populations re-established for the fourth year.

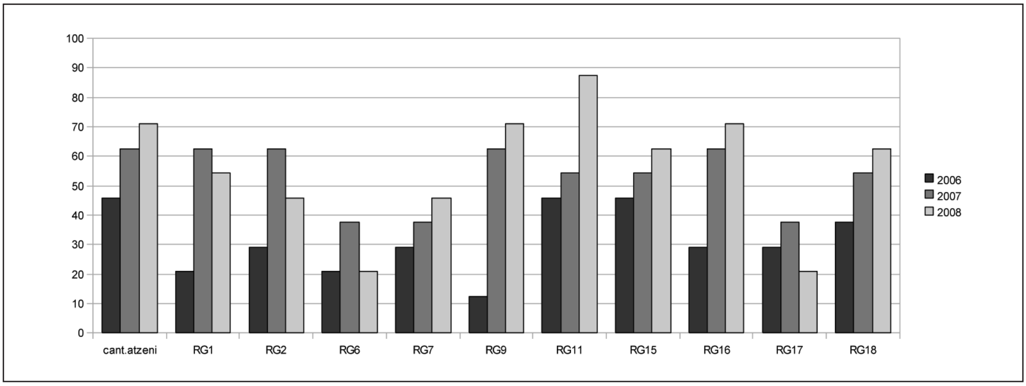

Fig. 1. Percentage coverage in late autumn of each population in the three years of the trial.

The correlation matrix (Table 1) shows a positive correlation between seed yield and dry matter yield, in opposition to results of previous breeders' studies on Mediterranean perennial grasses (Falcinelli *et al*., 1988). Seed and dry matter yield are also significantly correlated with the number of reproductive tillers. Also, higher the plant height, higher the size of the vegetative traits, like tiller length and flag leaf length and higher the number of spikelets spike^{-1}. Tall plants showed also higher number of reproductive tillers.

Table 1. Correlation matrix between the main observed characters of the 11 persisting populations, for the 2nd year of the trial

TL	**TL**							
SL	0.893 ***	**SL**						
FL	0.872 ***	0.749 **	**FL**					
SPT	0.814 **	0.656 *	0.886 ***	**SPT**				
RT	0.591 n.s.	0.453 n.s.	0.585 n.s.	0.504 n.s.	**RT**			
TT	0.541 n.s.	0.319 n.s.	0.632 *	0.571 n.s.	0.908 ***	**TT**		
PH	0.920 ***	0.709 *	0.892 ***	0.793 **	0.714 *	0.731 *	**PH**	
SEED	0.612 *	0.441 n.s.	0.370 n.s.	0.373 n.s.	0.780 **	0.665 *	0.590 n.s.	**SEED**
DMY	0.739 **	0.502 n.s.	0.721 *	0.584 n.s.	0.908 ***	0.880 ***	0.885 ***	0.765 **

TL	**Tiller length**
SL	**Spike length**
FL	**Flag leaf length**
SPT	**Spikelets spike^{-1}**
RT	**Reproductive tillers**
ST	**Sterile tillers**
TT	**Total tillers**
PH	**Plant height**
SEED	**Seed yield**
DMY	**Dry matter yield**

* = P≤0.05; ** = P≤0.01; *** = P≤0.001.

Cluster Analysis (Fig. 2) showed that Cantoniera Atzeni and RG17 had peculiar traits that made these two populations dissimilar to the others. In Table 2, the average values of the observed morphological and productive traits which characterize each cluster are reported.

The populations grouped in clusters 1 to 3 are more productive for seed yield and DMY. Cantoniera Atzeni is characterized by the elongation of the tiller and the spike, the erect habit and the early flowering. Cluster 2 groups five populations which differ from Cantoniera Atzeni mainly for shorter tiller and spike. Cluster 3 is composed by two populations (RG16 and 18), which are characterized by an high incidence of sterile tillers on the total number of tillers per plant. RG17 is constituted by very short plants, producing the lowest DMY. Cluster 5 is composed by two populations having short plants, but with a good tillering and late flowering.

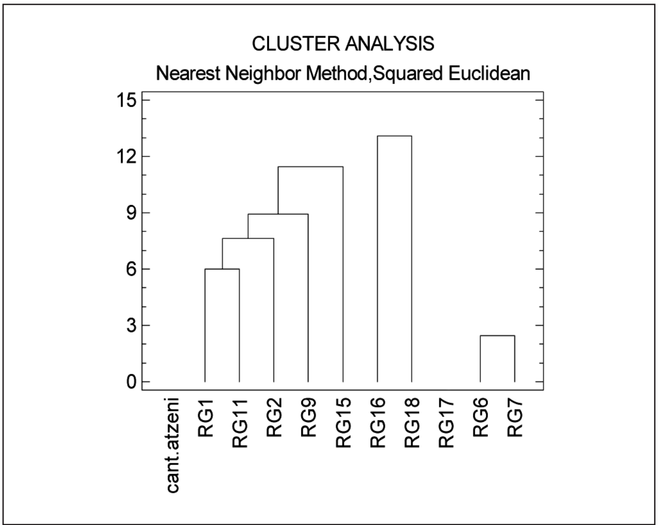

Fig. 2. Cluster Analysis of the 11 persisting populations for the main observed morphological and productive characters in the second year of the experimentation.

Table 2. Average values of the observed traits characterizing each cluster resulted from multivariate analysis

Cluster	Population	TL cm	SL cm	FL cm	SPT nr.	RT nr.	TT nr.	PH cm	SEED g m^{-2}	DMY g m^{-2}	FLOWERING
1	CANT.ATZENI	61	39	17	29	234	291	39	24	1032	EARLY
2	RG 1-2-9-11-15	51	27	14	28	212	289	32	25	984	MID
3	RG 16-18	41	22	12	25	236	327	28	20	1043	MID-LATE
4	RG 17	34	23	7	21	130	146	8	15	179	MID-LATE
5	RG 6 - 7	35	20	11	25	133	227	14	10	284	LATE

IV – Conclusions

Between the 11 persisting populations, a great variability of the morphological and productive characters was observed. The preliminary results of this research permits to show that is possible to develop a valorization program of different morphotypes of perennial ryegrasses, persistent in semi-arid rainfed conditions. Cantoniera Atzeni will represent the basic genotype for selecting a productive, erect and early flowering perennial ryegrass to be used for forage/hay production. Populations from Corsica RG 6 and 7 will be multiplied to be used in multifunctional mixtures with annual and perennial grasses and legumes, with cover crop purposes.

An investigation is being carried out currently on these 11 persistent populations of *L. perenne* for studying physiological drought resistance mechanisms on leaves and root, phenologic adaptations.

In conclusion, the results of this trial are preliminary and preparatory to the development of a research aimed at identification of new *Lolium perenne* varieties, persisting to Mediterranean semi-arid rainfed conditions and suitable for forage/hay production rather than for cover crops management.

Aknowledgements

The trial has been funded by the PIC Interreg IIIA "VEGETATIO" Sardinia-Corsica-Tuscany.

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Morphological characterization within some Algerian populations of *Trifolium striatum* L. (Fabaceae)

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Abstract. Within the framework of the evaluation and utilization of the plant genetic resources having a fodder and pastoral interest in Algeria, a morphological characterization was done on three Algerian populations *Trifolium Striatum* L. This species is regarded as quite scarce in Algeria. Several characteristics relating to plant vegetative and generative such as, fruiting heads, pods and seeds were studied. The ecological factors (rainfall, altitude) as well as geographical coordinates (latitude and longitude) of the population natural environment were taken into account during the statistical analysis. Preliminary results showed the existence of an intraspecific variation. Width of the fruiting heads characteristic was found to be particularly interesting for the taxonomic level and should deserve a special attention. The variation noticed in some characteristics of the plant, maximum height, maximum width, winter daily growth rate, length of the fruiting heads, would be linked to longitude and latitude parameters of the natural habitat of the populations. The conservation, the valorization and the development of this fodder legume, adapted to humid regions with a lot of rainfall in Algeria, could contribute towards the natural enrichment of soils with nitrogen fixation and the improvement of the living standards of the local communities through the expansion of livestock farming.

Keywords. Clovers – Ecology – Fodder legume – Morphology – Natural habitat.

Caractérisation morphologique chez quelques populations Algériennes de* Trifolium striatum *L. (Fabaceae)

Résumé. *Dans le cadre de l'évaluation et de la valorisation des ressources phytogénétiques d'intérêt fourrager et pastoral en Algérie, une caractérisation morphologique a porté sur trois (03) populations Algériennes appartenant à* Trifolium striatum *L. Cette espèce est considérée comme assez rare en Algérie. Plusieurs caractères relatifs à la plante, aux infrutescences, aux gousses et aux graines ont été étudiés. Les facteurs écologiques (pluviométrie, altitude) et les coordonnées géographiques (latitude et longitude) du milieu d'origine des populations ont également été pris en compte lors des traitements statistiques. Les résultats préliminaires obtenus, indiquent l'existence d'une variabilité intraspecifique. Le caractère "largeur des infrutescences" se révèle particulièrement intéressant sur le plan taxonomique et mérite une attention toute particulière. La variation observée chez certains caractères de la plante (hauteur maximale, largeur maximale, vitesse de croissance journalière hivernale, longueur des infrutescences), serait liée à deux paramètres (longitude et latitude) de l'habitat naturel des populations. La conservation, la valorisation et le développement de cette légumineuse fourragère, adaptée aux régions fortement arrosées et humides de l'Algérie, permettraient de contribuer à l'enrichissement naturel des sols en azote et à l'amélioration du niveau de vie des communautés locales, à travers le développement de l'élevage.*

Mots-clés. *Ecologie – Habitat naturel – Légumineuse fourragère – Morphologie – Trèfles.*

I – Introduction

In Algeria, the genus *Trifolium* L. comprises 37 species, amongst *Trifolium striatum* L. (Quézel and Santa, 1962). This fodder legume, quite scarce in Algeria (Abdelguerfi *et al*., 2006), is present in pasture and scrub (Quézel and Santa, 1962). It is adapted to poor soils or containing little total limestone and bearing acid to neutral pH of the heavily watered and humid regions (Abdelguerfi *et al*., 2006). Coste (1983) reported its presence in lawns and sandy areas in almost all France and Corsica. *T. striatum* is an exceedingly polymorphic species (Zohary and Heller, 1984). Only a critical (experimental) study of the wealth of forms included in the discussed species will finally determine their constancy and taxonomic value (Zohary and Heller, 1984). The present study is in line with the evaluation and development of the plant genetic resources bearing a fodder and pastoral interest in Algeria and follows on the several studies carried out on spontaneous fodder legumes (Issolah, 2006; Issolah and Abdelguerfi, 2010; Issolah *et al*., 2011).

II – Materials and methods

A behavioral preliminary study was carried out about 13 species and 144 populations of the genus *Trifolium* in Algeria. The number of populations varies from 2 to 31 according to the frequency of the species (Issolah, 2006). Three populations belong to *Trifolium striatum* L.. The trial was conducted at the experimental station of Guelma (East of Algeria), located at 227 m above sea level. The zone of study is subhumid. The average yearly pluviometry is 678.6 mm. The temperature is 11°C (mean minimum temperatures) and 23.8°C (mean maximum temperatures). The soil texture was clayey. The pH was 7. The populations were sown (07/11/1990), in total randomization, on 1m long rows (Issolah *et al*., 1993). The phenological characteristics observed were: H1 (24/03/91) : maximum height at the row; W1 (05/05/91) : maximum width at the row; S1: winter daily growth rate (from 11/02 to 24/03/91) (cm/day) ; S2: spring daily growth rate (from 24/03 to 05/05/91) (cm/day) ; 1F: Appearance of the first inflorescence; BF: Beginning of the flowering (one inflorescence per plant).

This work was followed up by a biometrical study on the fruiting heads, the pods and the seeds of *T. striatum* (03 populations). For each population, 30 fruiting heads were chosen randomly. The studied characteristics were as follows: size of fruiting heads (cm) : length (LF) and width (WDF) ; number of pods per fruiting head (PF) ; number of seeds per pod (SP) ; number of seeds per fruiting head (SF) ; seed size (mm) : length (LS), width (WS) at the rate of 3 seeds per fruiting head (90 seeds per population) ; weight (g) of 30 fruiting heads (WF) ; the weight of a thousand seeds (WTS) ; ratio for weight of seeds / weight of fruiting heads (RW) (Issolah, 2006).

Following the analysis of the morphological variation, relations between the phenological and biometrical characteristics were studied by taken into account, some ecological factors (altitude (ALT), annual rainfall (R) according to Gaussen and Bagnouls (1947)) as well as the geographical coordinates (longitude, latitude) of the natural habitat of the populations.

III – Results and discussion

The variance analysis showed that the characteristics of number of pods per fruiting head and width of fruiting heads were those that varied most, compared to the whole characteristics, and respective variation coefficients of 7.6 % and 8.7 % (Table 1).

Concerning the number of seeds per pod, Zohary and Heller (1984) reported 1 seed per pod in *T. striatum*. 1 to 2 seeds per pod were found in this study. However, 2 seeds per pod were rarely encountered. Length of fruiting heads varied between 1.23 and 1.29 cm with average 1.25 cm. A previous study indicated that the size of heads varies between 0.6 and 1.5 cm (Zohary and Heller, 1984). Our results indicated that the width of fruiting heads varied between 1.16 and 1.36 cm, with an average of 1.29 cm. We note that the difference between the two extremes as far as "length of fruiting heads" is concerned, is very limited, insignificant, hence the lack of homogeneous groups, and this contrary to "the width of fruiting heads" which put forward a very highly significant difference between populations. This would probably be linked to the fruiting heads

Table 1. **The fruiting heads, pods and seeds characteristics of some Algerian populations of *Trifolium striatum* L.**

Characteristics	Min	Max	Mean	Standard deviation	Coefficient of variation (%)
LF (cm)	1.23	1.29	1.25	0.03	2.8
WDF (cm)	1.16	1.36	1.29	0.11	8.7
PF	22.53	26.23	24.39	1.85	7.6
SP	1	2	1-2	–	–
SF	21.37	24.5	22.98	1.57	6.8
LS (mm)	1.88	1.90	1.89	0.01	0.5
WS (mm)	1.28	1.37	1.32	0.05	3.4
WF (g)	2.81	3.14	3.01	0.18	5.8
WTS(g)	2.65	2.99	2.81	0.17	6.1
RW	0.61	0.66	0.63	0.02	4.0

Min: Mean of a population. Max: Mean of a population. Mean: Mean of the species.

morphology. Indeed, we note that, within the same population, the fruiting heads are either lone or in pairs made up of two fruiting heads firmly assembled, nearly mixed up. Zohary and Heller (1984) informed that the heads are solitary or in pairs due to spurious dichotomy whereas Coste (1983) speaks about usually lone inflorescences in *T. striatum*. Thus, the characteristic «width of the fruiting heads» proves to be particularly interesting on the taxonomic point of view and deserves a special attention.

A biomerical study conducted on 139 algerian populations of 12 species of the genus *Trifolium* L. indicated that *T. spumosum*, *T. repens*, *T. bocconei, T. fragiferum* and *T. resupinatum* presented a large size (lenght) of fruiting heads (Issolah, 2006). This also study signalized that *T. repens, T. spumosum, T. bocconei, T. glomeratum* were characterized, by a high number of seeds per fruiting head (Issolah, 2006). The discriminant factorial analysis, applied on seven species of *Trifolium* (*T. campestre*, *T. scabrum*, *T. tomentosum*, *T. glomeratum*, *T. fragiferum, T. resupinatum, T. striatum*), revealed that the biometical characteristics (width of fruiting heads, weight of a thousand seeds, weight of fruiting heads, number of pods per fruiting heads and the number of seeds per fruiting head) were the most discriminant, comparing to the bloom and particularly to the vegetative growth ones (Issolah, 2006).

Concerning the matrix of correlations (Table 2), certain characteristics (H1, W1, S1) relating to the vegetative growth of the plants were noticed to be positively correlated to the longitude and negatively to the latitude of the natural habitat of the populations. Concerning the fruiting heads, only the characteristic "length of fruiting heads" proved to be positively correlated with the longitude of the natural habitat of the populations. Thus, the efficient populations, for some characteristics, come from the eastern regions located inland. There were found not to be relations either between the phenological and biometrical characteristics on the altitude and/or rainfall of the natural habitat of the populations (Table 2).

Previous studies conducted on several species of clovers in Algeria indicated that the altitude was the factor that had affect on the size of fruiting heads (lenght), specially in *T. scabrum* and *T. campestre* (Issolah, 2006). The number of pods per fruiting heads was negatively linked to the altitude in these two species (*T. scabrum* and *T. campestre*). Within *T. campestre*, the vegetative growth (width), was positively linked to the altitude (Issolah, 2006). This factor (altitude) also had affect on the bloom within *T. tomentosum* and *T. glomeratum* (Issolah, 2006). In *T. bocconei,* the number of pods per fruiting head was positively linked to the latitude of the natural habitat of the populations (Issolah and Abdelguerfi, 2010).

Table 2. **Relations between the morphological characteristics and the ecological factors within some Algerian populations of *Trifolium striatum* L.**

	Morphological characteristics								
Ecological factors	**H1**	**W1**	**S1**	**S2**	**1F**	**BF**	**LF**	**PF**	**SF**
Altitude	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rainfall	NS	NS	NS	NS	NS	NS	NS	NS	NS
Longitude	**1*** **	**1*** **	**0.998***	NS	NS	NS	**0.997***	NS	NS
Latitude	**-0.999***	**-1*** **	**-0.999***	NS	NS	NS	NS	NS	NS

Characteristics : see Materials and methods for details.
*P<0.05, **P<0.01, ***P<0.001, NS: no significant.

IV – Conclusions

The obtained results showed the existence of a certain variation within *T. striatum*. The characteristic of the fruiting heads width have been found to be particularly interesting for the taxonomic point of view and deserves a special attention. For some characteristics, the observed variation would be related to the longitude and the latitude parameters of the natural habitat of the populations. Taking into account the number of populations being restricted, a larger number of individuals and populations could reveal more information on the behaviour and morphological characteristics of *Trifolium striatum* L.

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Landraces of forage maize as source of genetic variability for organic farming

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Abstract. Concern for the preservation of the environment is a constant at present. The European Commission has developed specific directives to prevent pollution and degradation of the environment. In agriculture, organic farming is presented as an alternative to intensive agriculture that is more polluting and straining on natural resources. Most of the maize breeding materials currently commercialized are not adapted to organic farming conditions and the gene pool has been shrinking after years of genetic selection. Therefore, the landraces used in breeding programs could introduce new genes to obtain materials adapted to new agriculture systems. The aim of this work was to evaluate forage maize hybrids developed at Centro de Investigaciones Agrarias de Mabegondo (CIAM) under Organic Farming. These hybrids were obtained by crossing different Galician landraces with an inbred line which has Galician landrace background. These hybrids have shown good levels of genetic diversity of all studied traits. They were more vigorous and earlier than commercial ones. They had variability of fiber and lignin content but similar digestibility of *in vitro* organic matter, thus breeding programs could discern and exploit these traits. Therefore, landraces could provide new genes to current breeding programs in order to obtain materials more suited to new agricultural conditions.

Keywords. Forage maize – Hybrids – Landraces – Organic Farming.

Les variétés locales de maïs fourrager en tant que source de variabilité génétique pour l´agriculture écologique

Résumé. *Le souci de la préservation de l´environnement est actuellement une constante. La Commission européenne a développé des directives spécifiques pour la prévention de la pollution et la dégradation de l´environnement. Dans le domaine de l´agriculture, l'agriculture écologique se présente comme une alternative à l'agriculture intensive, plus polluante et consommatrice de ressources. La plupart des matériaux d'amélioration du maïs actuellement commercialisés ne sont pas adaptées aux conditions de l'agriculture écologique. Le pool génétique a été raccourci après des années de sélection génétique. Par conséquent, l'usage de variétés locales dans programmes d'amélioration pourrait introduire de nouveaux gènes pour obtenir des matériaux adaptés aux nouveaux systèmes agricoles. Le but de ce travail a été d´évaluer les hybrides du maïs fourrager développés au Centro de Investigaciones Agrarias de Mabegondo (CIAM) sous conditions d´agriculture écologique. Ces hybrides ont été obtenus par croisement de différentes variétés locales galiciennes avec une lignée pure, qui possède un fonds génétique de variétés galiciennes. Ces hybrides ont présenté de bons niveaux de diversité génétique pour tous les caractères étudiés. Ils étaient plus vigoureux et plus précoces que les hybrides commerciaux. Ils ont montré une variabilité dans le contenu de fibre et lignine mais la digestibilité* in vitro *de matière organique a été similaire pour tous, ainsi donc les programmes d'amélioration génétique pourraient séparer les génotypes avec meilleurs résultats pour ces caractères. Par conséquent, les variétés locales pourraient fournir de nouveaux gènes aux programmes d'amélioration en cours pour l'obtention de matériaux plus adaptés aux nouvelles conditions de l'agriculture.*

Mots-clés. *Maïs fourrager – Hybrides – Variétés locales – Agriculture écologique.*

I – Introduction

Forage maize is one of the most important sources of roughage for animal feed in Europe, thus its production area exceeded 5 million hectares in 2009 (Eurostat, 2012). The Northwest of Spain concentrates 72% of the global Spanish production which represents 2,500 Megatons of fresh matter (MARM, 2011). During the 80s, landraces were disappearing and were replaced by maize selected hybrids due to their economic advantages. Currently, most of the cultivated maize is hybrid materials from breeding programs, this breeding process being characterized by a shrinking of the genetic background due to the limited number of materials used as parental lines (Barrière *et al.*, 2004).

The increase of organic farming importance in the last decades is causing the demand of new materials adapted to these low input conditions of cultivation. The aim of this work was to evaluate the ability of new hybrids improved from landraces for organic farming use. The narrow genetic background of breeding materials could not be sufficient for obtaining such new materials; moreover the characteristics required for organic or low input farming might have disappeared by selection under high input conditions. Thus a broadening of the genetic base of maize breeding though introduction of new germplasm is necessary. Landraces appear as a good source of new genes and they are earlier, more vigorous, more adapted to environmental conditions and richer in variability making them very useful for breeding programs.

II – Materials and methods

Four maize hybrids were evaluated for agronomic and forage traits under organic farming conditions. During 2008 crosses between inbred line EC49A and landraces 85022, 85042, 85020 and 85040 collected at different Galician sites were made to obtain maize hybrids. Line EC49A was previously obtained at CIAM´s breeding programs and has Galician landraces background. Commercial hybrids Nkthermo and Anjou290 (official testers at Spanish Office of Vegetable Varieties - OEVV) were sown too as control.

Field trials were conducted in two years (2009-2010) at four locations: Sobrado (43º0’N, 7º5’W), Baralla (42º5’N, 7º2’W), Pacio (42º6’N, 7º5’W) and Eirexafeita (42º4’N, 7º4’W). The selection of locations was made according to forage maize demand. Experimental design was a randomized block with 8 m^2 plots and three replications and the final plant density was 90,000 plants per hectare. The agronomic traits that were evaluated were early crop vigour (EV) (subjective ascending scale from 1 to 5) and flowering time (FT) (days from sowing to tasseling). At the silage stage entire plants per plot were cut, weighted and chopped. Samples of 300 g were taken and dried in a ventilated oven at 80ºC over the course of 16 hours for the determinations of dry matter yield (DM) and then dried samples were ground in a Christy Norris 8 mill (mesh size= 1mm). Forage quality was determined by near infrared reflectance spectroscopy (NIRS) according to Campo *et al.* (2010) equations. Estimated parameters were *in vitro* organic mater digestibility (IVOMD), crude protein content (CP), acid detergent fiber content (ADF), neutral detergent fiber content (NDF) and lignin content (LIG).

Four experimental environments were taken into account and combined analysis was performed using PROC GLM of the SAS statistical package (SAS, 2008). Hybrids were considered as fixed effects and the Duncan´s multiple range test of the LSMEANS statement was used to generate differences among least square means.

III – Results and discussion

Statistical significance of the main effects and means of agronomic, yield and quality traits evaluated in hybrids and controls are shown in Tables 1 and 2, respectively. Highly significant environmental effects were found for all evaluated traits, thus there was an important environmental compound in the observed differences. This shows the different productive ability of the evaluation environments. Different studies have shown the important impact of environmental conditions on the plant fiber content and forage quality, so temperature or radiation exerts stronger impact than the genotype does (*Kruse et al.*, 2008). Genotype effects were also highly significant for evaluated traits (except for DM, IVOMD and LIG). Environment*Genotype interaction was not statistically significant for all traits except for CP, thus the differences between genotypes had remained stable through out the environments so the best genotypes in an environment will be the best on another one.

Hybrids were more vigorous than controls (Table 2). Early crop vigour is associated with higher competitive ability (Pester *et al.*, 1999), so in this way they had better ability to compete with weeds which ensures a better development. This is an important aspect in organic farming where use of inorganic herbicides is not allowed. Among all of the hybrids, 85040 x EC49A and 85020 x EC49A were the most vigorous, not to mention that hybrids were also earlier than controls (74 days vs. 76.6 days), 85022 x EC49A being the earliest within its group. The average DM of hybrids' group was 12.71 t/ha which is slightly higher than the control group, although no significant differences were found between these two groups. Hence, landracexEC49A hybrids could be as productive as commercial hybrids.

Table 1. Statistical significance of main effects of hybrids and controls evaluated at four environments

SV[†]	EV	FT (days)	DM (t/ha)	IVOMD (%)	CP (%)	ADF (%)	NDF (%)	LIG (%)
Environment (E)	*	***	***	***	***	***	***	***
Rep	*	*	ns	**	**	ns	ns	ns
Genotype (G)	***	***	ns	ns	**	*	**	ns
E*G	ns	ns	ns	ns	**	ns	ns	ns
CV	14.6	2.5	16.3	3.9	10.0	7.6	6.5	9.4

[†] SV: source of variance; rep: replicate within environments; CV: coefficient of variation.

* P<0.05, ** P<0.01, *** P<0.001, ns: non significant.

Table 2. Means of agronomic, yield and quality traits of hybrids and controls evaluated at four environments

Means	EV	FT (days)	DM (t/ha)	IVOMD (%)	CP (%)	ADF (%)	NDF (%)	LIG (%)
85020 x EC49A	4.58ab[†]	73.92b	13.69a	65.83b	4.82b	27.55a	53.98a	2.56a
85022 x EC49A	4.08bc	70.92c	11.12b	65.46b	5.10ab	25.46b	50.76bc	2.39bcd
85040 x EC49A	4.33ab	77.83a	12.93ab	63.79b	4.81b	27.48a	54.05a	2.57ab
85042 x EC49A	4.63a	73.68b	12.83ab	66.12b	5.01b	26.12ab	51.70ab	2.50abc
Anjou 290	3.34c	75.16b	12.05b	67.93a	5.46a	24.36b	48.41c	2.26d
Nkthermo	2.50d	78.00a	12.21ab	66.19b	5.56a	25.95ab	50.21bc	2.38cd
Means by group								
Hybrids	4.40	74.06b	12.71	65.29	4.94	26.54	52.49	2.50
Controls	2.92	76.58a	12.13	67.06	5.51	25.16	49.31	2.32
	***	**	ns	*	***	*	**	**

[†] Means with the same letter were not statistically different.

* P<0.05, ** P<0.01, *** P<0.001, ns: non significant.

The average CP content used to be nearly 8% in silage maize (Barrière *et al.*, 1997). The observed significant reduction in CP content is in agreement with the negative correlation between CP and nitrogen availability found by other authors under low input nitrogen conditions (Lawrence *et al.*, 2008; Li *et al.*, 2010). Lignin content is the primary determinant in cell wall digestibility and hence in organic matter digestibility (Riboulet *et al.*, 2008). Lignin and fiber content were higher in the hybrids group than in control group, although digestibility of the hybrids group was slightly less than that of the control group. Relationship between ADF and NDF is an important trait because it is correlated with NDF digestibility. Thus high feeding value hybrids should have a low ADF/NDF content (Riboulet *et al*., 2008). ADF/NDF ratio was the same in the hybrids as in control group (ADF/NDF = 0.51). Lignification pattern and biochemical composition of lignin have also an important effect on digestibility, minor variations of these traits could cause an important effect on fiber digestibility, although not on fiber content (Moore and Hatfield, 1994). Despite lignin and fiber content showing great variability among hybrids, IVOMD had similar values and only Anjou 290 showed a significantly different digestibility percentage. The rest of the hybrids had percentages similar to NKthermo control.

IV – Conclusions

Among studied hybrids genetic variability has been observed for all characters except for DM. Landrace x EC49A were as productive as controls for DM but in average they showed better performance of agronomic traits. Of all the hybrids, 85022 x EC49A was the best for FT and quality traits, had the best CP content and had similar values of ADF and NDF to Anjou 290. 85042 x EC49A showed interesting characteristics, having the best EV and values of ADF, NDF and LIG similar to those of Nkthermo.

Landrace hybrids proved themselves to be as good as controls; hence a selection program could separate the best genotypes to obtain parental lines from these landraces. Crosses between current inbred lines and these parental lines could very well provide new hybrids better fitted for new agricultural requirements.

Acknowledgments

This study was financially supported by Council for Rural Development, Galician Government, project FEADER 2008/25. The authors acknowledge the collaboration of Consello Regulador de Agricultura Ecolóxica de Galicia (CRAEGA) and Calfensa Proyectos S.L.

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Characterization of a local germplasm of sulla (*Hedysarum coronarium*) in the north of Morocco

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Abstract. In the west-northern region of Morocco, the sulla (*Hedysarum* spp) an endemic forage plant is subject to severe genetic erosion that needs a special attention to preserve and to valorise this patrimony. In this context this study was carried out to collect and characterize local germplasm. Thirty ecotypes were collected and compared with Italian and Spanish varieties. Agronomic assessment showed that 80% of collected ecotypes were creeping types and 20% were upright ecotypes. They were conducted as monocropping and gave yield exceeding 10 tons per hectare of dry matter. Plant chemical analysis indicated that the local germplasm showed a higher protein content than Italian and Spanish varieties: 25.9, 23.1, and 14.1%, respectively. For the cellulose content, no significant differences were found among ecotypes (20% of DM). As conclusion, since local germplasm presented better productivity indexes it is evident to conduct a breeding program for development of this crop as strategic feed resource for the region.

Keywords. Evaluation – Sulla – Northern Morocco – Chemical composition – Dry matter yield.

Caractérisation du germoplasm local de sulla (*Hedysarum *spp) dans le Nord ouest du Maroc

Résumé. Dans la région du nord ouest Marocain, le sulla (Hedysarum *spp*) plante fourragère endémique est soumise à une forte érosion génétique qui nécessite une attention particulière à la préservation et à la valorisation de cette ressources Dans ce contexte, cette étude a été réalisée pour collecter et caractériser le germoplasme local de cette espèce. Vingt-cinq écotypes ont été collectés et comparés avec des variétés italiennes et espagnoles. L'évaluation agronomique a montré que la plupart des écotypes collectés sont de types rampants (80%) et quelque uns de types verticaux (20%). Les rendements du Sulla en monoculture ont été généralement supérieurs à 10 tonnes de matière sèche par hectare. L'analyse chimique a indiqué que le matériel génétique local montre une teneur en protéines plus élevée que les variétés italiennes et espagnoles respectivement (25,6%, 23,1% et 14,1% de MS). Pour la teneur en cellulose, les trois origines ont un niveau identique (20% de MS). En conclusion, le matériel génétique local montre une meilleure productivité en termes de rendement en matière sèche et de composition chimique ce qui appelle à la mise en place d'un programme de sélection pour l'exploitation de cette ressource et son intégration dans l'amélioration du calendrier alimentaires des troupeaux dans cette région.

Mots-clés. *Evaluation – Sulla – Nord du Maroc – Rendement en biomasse – Composition chimique.*

I – Introduction

Phytogenetic resources are valuable assets necessary to maintain the ecological balance. In this context, natural populations of sulla (*Hedysarum* spp) are of great interest that can be exploited in the recovery of degraded areas in the northwest region of Morocco. In order to preserve this important genetic potential, a program of exploration and collection of local sulla was initiated in 2009 in Tangier, which houses a large genetic diversity of this species but is under strong and continuous genetic erosion (Triffi-Farah *et al*., 2002, Noutfia *et al*., 2010). The use of sulla by small ruminants showed good performance by either pasture in monoculture or in mixtures with other legumes for use as hay or silage (Leto *et al*., 2002; Moll *et al*., 2008). Used as hay or silage, sulla showed no difference in production performance or quality of milk and sheep's and goat's cheese (Leto *et al*., 2002 and Molle *et al*., 2003). This performance is due firstly to its moderate content of condensed tannins and its relatively high content of energy (Molle *et al*., 2008). Also, the sulla is well known for its high nutritional value especially its protein content. In order to characterize and preserve the local sulla germplasm, a collection and assessment were conducted during the campaigns 2009 and 2010 through the following steps: (1) Collection and characterization of the genetic diversity of local sulla ecotypes; (2) agro morphological and chemical characterization by comparison with Spanish and Italian varieties.

II – Material and methods

1. Agro morphological assessment of the collection

Surveys and collections have to be spread over the two crop years 2009 and 2010. The methodological approach adopted is to cover a greater morphological diversity based on criteria related to earliness, size of pods and the vegetation bearing. The accessions collected in 2009 were sown (September 2010) in the field of experimental station Bougdour in Tangiers for an initial assessment. This was made on the basis of morphological criteria, DNA extraction and biomass yield in comparison with some Italian varieties.

2. Chemical composition

The studied collection consists in 30 different entries of sulla from two years of collections in the area, five Spanish varieties of the species flexusum and three Italian varieties. Each entry is sown in a plot of 9 square meters. The initial nutrient applied prior to sowing 0-100-100 consists of units of nitrogen, phosphorus and potassium respectively. The analysis concerned the determination of the composition of different forage ecotypes by analysis of crude protein (CP), crude fiber (CB), mineral matter (MM) and fat (MF).

III – Results and discussion

1. Agro morphological assessment of the collection

Following the various outputs of exploration undertaken in the area, we could classify this collection in three groups (Table 1).

Table 1. Characteristics of different collected accessions of sulla in the North west of Morocco

Group	Number of accessions	Description of collection sites
Group 1	11	Moderately deep heavy textured soils in flat topographys
Group 2	13	Roughed topography
Group 3	6	Eroded roughed topography
Group 4	8	–

In fact, the sulla feared poor drainage and research ecotypes tolerant of such conditions would be of great importance for some marginal sites in the area. Accessions of Sulla showed a fairly large morphological variability as shown in Table 2. The level of dry matter yield obtained is comparable to variety Irpina with 7.5 tons/ha dry matter, but it is significantly lower than the Carmen variety with about 9 tons of dry matter per hectare.

Table 2. Morphological characteristics of local ecotypes of sulla

Main criterion choice	Accession number	Main stem height (cm)	Main plant height (cm)	Leaflets number per sheet	Internodes number of the main stem
Spreading habit	13	< 5	<10	5 - 7	3
Broad panicle	2	30.09	35.11	7 - 9	7 - 9
Late flowering	13	28.17	32.12	7 - 9	5
Waterlogging tolerance	2	42.71	52.7	7 - 9	9

Spanish ecotypes, whose seeds were shelled (naked), showed a fairly homogeneous lifting while several local ecotypes presented a very low or no emergence. And seven local entries and the variety of Tunisia were eliminated by their very low rates emergence. So we raised the lack of nodulation in all ecotypes (observation made on several plants). This problem was partially solved by the application of nitrogen to the branching point. The observations have shown a healthy behaviour of all ecotypes especially against the attacks of the powdery mildew widespread in the area. The flowering period started early for the ecotypes in the beginning of the second decade of April and lasts until late May. The different ecotypes showed a bloom over several weeks. The high density observed in two fields of sulla (in the area) has hinted that it would be determinant in the regulation of plant growth in height (erect) while low densities favour the lateral growth. To elucidate the issues and the lack of nodulation on the low germination of some ecotypes, an investigation should be undertaken by studying the possible effect of decortications pods on seed germination and dormancy of the event of some seeds and ways to overcome this dormancy for a better crop establishment. Moreover, the on going work on the isolation and characterization of strains of Rhizobium inoculating sulla in this region (El Mourabit *et al*.; 2010) may soon shed light on the reasons for the absence of nodulation in the experimental site Bougdour.

2. Chemical composition

From these results, we see that except the crude protein content, different ecotypes showed similar values for MM, CB and MG. These levels are comparable to those advanced by Leto *et al*. (2002). For nitrogen content, local ecotypes showed values comparable to Italian varieties and those reported by Molle *et al*. (2008). However the Spanish varieties have recorded the MAT value significantly lower and close to the sulla-oat mixtures. For local ecotypes, there is considerable variability in the CP content ranging from 10 to 30% of MS reflecting genetic variability within this collection.

Table 3. Chemical composition of different entries of sulla in Tangier in% DM

	CP	MF	MM	CB
Local ecotypes	25.95 ± 6.84	3.58 ± 1.83	11.57 ± 3.25	22.00 ± 4.40
Italian varieties	23.14 ± 1.56	4.48 ± 1.28	10.16 ± 0.91	22.73 ± 3.83
Spanish varieties	13.88 ± 3.16	6.54 ± 7.48	10.60 ± 1.71	20.71 ± 3.74

CP: crude protein; MF: fat; MM: minerals; CB: crude fiber.

III – Conclusion

The two years evaluation of the plant material of local sulla show a great production level of this species closely similar to some Italian varieties. They indicate also the existence of significant variability of the CP content of different ecotypes that deserves to be confirmed by further analysis and reflecting significant genetic variability. The results also highlight the technical requirements for the conduct of the culture of sulla including low or no emergence of some ecotypes, the absence of nodulation of different ecotypes in some areas that are searchable as constraints in order to better exploit this resource

Acknoweledgement

Our sincere thanks to Dr. M. Chentouf, Head of the Animal Production Research Unit of Tangier, for his contributions made in revising the manuscript.

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Selection of oat varieties to the North of Morocco
Need of diffusion and renewal of the varieties

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Abstract. Oat is the main fodder culture in the Northern West region of Morocco where it is used as green, hay, silage or grain. However, the improvement of this culture faces several constraints related to the unavailability of varieties adapted to local conditions characterized by a long rainy period and development of many leaf diseases. This study summarizes the efforts in the selection and dissemination of high yielding varieties with a long development cycle and good resistance to foliar diseases. Five varieties namely Ghali, Tissir, Zahri, Amellal and Nasr, have been selected and recommended for the area. In experimental station, these varieties reach yields of 12 tons of dry matter (DM) and 4.5 tons of grain per hectare while some imported varieties capped at 6 and 3 tons per hectare of DM and grain respectively. In the field, new varieties record yields of 10 tons and 2.4 tons per hectare of DM and grain respectively, against only 6 tons of DM and 0.6 tons of grain per hectare for local seed widely used in the region.

Keywords. Selection – Oat – North of Morocco – Leaf diseases – High yield – Dry matter – Grain.

Sélection de variétés d'avoine pour le Nord ouest du Maroc: diffusion et renouvellement des variétés

Résumé. *L'avoine est la principale culture fourragère dans le nord ouest marocain où elle est exploitée soit en vert, en foin, par ensilage ou en grain. Cependant, le développement de cette culture a été confronté à plusieurs contraintes dont en particulier l'indisponibilité de variétés adaptées aux conditions de la région caractérisées essentiellement par une longue période pluviale et les attaques fréquentes de maladies foliaires. La présente contribution met en évidence les résultats des programmes de sélection de variétés performantes adaptées à la région. Au moins cinq variétés, Zahri, Amellal, Tissir, Nasr et Allal sont actuellement recommandées pour la zone en raison de leur cycle de développement assez long et leur résistance à la rouille brune et au mildiou. En station expérimentale, ces variétés atteignent des rendements en biomasse de 12 tonnes de matière sèche (MS) et 45 quintaux de grains par hectare alors que certaines variétés importées plafonnent à 6 tonnes MS et 30 quintaux de grains par hectare. Au champ, les nouvelles variétés enregistrent des rendements de 10 tonnes et 24 quintaux par hectare de matière sèche et de grains respectivement contre seulement 6 tonnes et 6 quintaux par hectare pour la semence locale largement utilisée par les agriculteurs.*

Mots-clés. *Sélection – Avoine – Nord du Maroc – Rendement – Biomasse – Grain – Maladies foliaires.*

I – Introduction

The improvement of oat (*Avena sativa* L.), started in Morocco from the 80's years of the last century, have led to the selection of a panel of high yielding varieties adapted to soil and climatic conditions of different agro-ecological regions of the kingdom. For the North West region where the oats are the main crop of the forage sole (Noutfia, 1994), the selection criteria apply, in addition to the biomass and grain productivity, other criteria specific to the region. These criteria are mainly related to relatively late growth cycle, covering the period of late rains between November and mid-May. This period corresponds to the best time for the preparation of hay. Also, tolerance or resistance to leaf diseases including leaf rust, powdery mildew and viral budding barley are also important in breeding programs for the northern area saw the importance of damage caused annually on susceptible varieties (Alfaiz *et al*., 1990 and 1997; Noutfia *et al*., 2003 Noutfia *et al*., 2003). The selected varieties were also tested in several sites in the region with farmers during the last years. They are conducted and compared with local seeds widely used by farmers and with some imported varieties. The production potential of these varieties, in experimental station and in farms, go well beyond the local varieties and the imported variety. However, some of these varieties showed some fairly significant damage caused by attacks due to leaf rust *(Puccinia coronata fsp avenae*) that happens every year in the area. Indeed, it is well accepted that the varietal resistance of oats to rust can be broken by more virulent strains of the pathogen (Alfaiz, 1997). Therefore, updating and renewal of the panel of varieties is essential to overcome these risks and cope with the varietal degeneration which gradually reduces the performance of the varieties. This contribution aims to show the potential production of new varieties with the aim to extend the range of recommended varieties for the northern zone.

II – Material and methods

1. Diffusion of new varieties in the region

Two varieties (Tissir and Zahri) were tested with producers in four localities in the region (Chefchaouen (35°06 N; 5°30 W), Asjen (34°57N; 5°35W), Bouhmed, and Had Gharbia (35°12N; 6°09W)). Demonstration plots were installed for comparison with an imported variety (Hamel) and local seed. The monitoring was conducted during the 2005, 2006 and 2007. The comparison was made on the basis of dry matter and grain yields and resistance to rust.

2. Comparison with other varieties

Five new varieties of oats have been tested in comparison with two control varieties namely Amellal and Zahri in Tangier. The trial was installed in the experimental domain of INRA Tangier (Bougdour 35°45 N and 5°45 W) in a clay loam soil, under rainfed conditions. The climate of the locality corresponds to a sub-humid Mediterranean type with mild winters and with mean temperatures of 10.0°C min and 27.5°C max and total precipitations of 755 mm. Sowing was done on large plots of 100 square meters per variety on the 10 of December 2007. The basic fertilizer 30-80-60 corresponds to units of nitrogen, phosphorus and potassium respectively. Coverage fertilization, focused on the addition of two doses of nitrogen of 30 units each at tillering and heading stages. The comparison between varieties was made on criteria related to vegetation height measured on 10 plants per plot and three replicates and determined between the first node and the output of the last sheet. Biomass yield is determined by the harvest of three square meters per plot in full bloom and the determination of dry matter content of three samples of 500 g per plot after oven drying at 70°C for 48 hours. Behavior with respect to foliar diseases is scored on a graduated scale ranging from 5 in the absence of any attack to 1 when the attack is spread over the entire plant. Earliness is approximated by observing the flowering date of each variety representing 50% of flowering plants. Analysis of the results for the yield and the height of plants was made by analysis of variance while the earliness and disease resistance were compared with controls.

III – Results and discussion

1. Diffusion of varieties in the region

Performance levels achieved in the different localities in the area show a marked improvement over the local seed used by farmers and the imported variety (Hamel). Thus, at experimental stations an average yield of 12 tons of dry matter and 4.5 tons of grain per hectare were obtained with the new varieties Tissir and Zahri. By cons, the variety Hamel recorded yields per hectare of

6 tons of dry matter and 3 tons of grain due to a widespread attacks of brown rust. The new varieties allow some production stability due to their tolerance to disease and better response to improved technology led. Thus, in a wet year on relatively heavy soil, the variety Tissir reached a yield of UF 3443 against just UF 2795 for the variety Hamel. Similarly, among the producers of the four localities in the region (Chefchaouen, Asjen, Bouhmed, and Had Gharbia), these new varieties have recorded average yields of 2.4 tons of grain and 10 tons of dry matter per hectare. In similar circumstances, the yields obtained with local seeds did not exceed an average of 0.6 tons of grain and 6 tons of dry matter per hectare (El Mourabit *et al*., 2007). Therefore, a producer has been chosen for the multiplication of two varieties (Tissir and Zahri) since 2006 with an improved technical conduct which enables him to achieve average yields of 3.0 tons of grain per hectare. (El Mourabit *et al*., 2007). Concerning the attacks of rust, the variety Hamel and local seeds were devastated every year. For the improved varieties, even the variety Zahri shows moderate attacks estimated at 50% in the locality of Asjen, it is free like the other variety Tissir in other localities.

2. Comparison with other varieties

The installation and removal of varieties has been good and consistent. Vegetative development of plants showed that three of the new varieties (5, 9 and 8) are more vigorous than the control varieties and have a late development cycle of about one week compared to control Zahri. Flowering period was distributed over the second decade of April with a gap of two weeks between the early varieties and the later one (var. 8). The levels of dry matter yields obtained are less than the usual potential due probably to that the seeding was done with a delay of about one month reducing the growth period which could affect negatively the final yield. Two new varieties have recorded dry matter yields significantly higher than the others (8-9 ton DM ha^{-1}) but not different from the control Amellal (Table 1). Thus, the higher yield of dry matter made by both varieties 5 and 9 is related more to the strength of the plant, the cycle length and the absence of fungal diseases. The variety 5 which registered the best performance has also the highest finesse rods with an abundance of foliage. This variety because of its morphology characterized by abundant foliage will have a great asset to farmers for the preparation of the hay.

Table 1. Characteristics of different oat varieties tested

Variety	Plant height (cm)	Flowering date (*vs* control 1)	Rust level	Dry matter content (%)	Dry matter yield (ton ha^{-1})
Var.5	117.3a	+ 6 days	4	26b	8.15a
Var.6	86.7b	+ 6 days	4	28ab	5.89b
Var.7	88.9b	0 day	4	25b	4.91b
Var.8	105.7a	+ 8 days	5	23b	6.07b
Var.9	115.9a	5 days	5	27ab	9.48a
Zahri (Control 1)	95.6ab	16 april	5	28ab	7.26ab
Amellal (Control 2)	98.9ab	11 april	5	30a	9.03a
	$P<0.05$			$P<0.05$	$P<0.05$

IV – Conclusion

The selected varieties recorded higher dry matter and grain yields than local seed and imported variety. During this period, these new varieties have been spared rust except the variety Zahri which was substantially attacked in the Asjen locality. For local seeds, the attacks were systematic and rust damage usually compromise the production. These results highlight the importance of the introduction of suitable varieties for higher yields and therefore farmers' incomes. Moreover, the multiplication of these varieties by the farmers themselves can contribute greatly to their dissemination in the area. Finally, the attacks of rust on the control Zahri, demonstrates the need for continuous renewal of the range of varieties to escape the attacks of the diseases. This objective was reached with two new varieties that showed performance beyond the control varieties known for their adaptation to the area. These two new varieties in addition to their vegetative state comparable to that of controls have a longer growing cycle and a vigorous vegetative aspect and are more suitable for the preparation of better hay.

Acknoweledgement

Our sincere thanks to Dr. M. Chentouf, Head of the Animal Production Research Unit of Tangier, for his contributions made in revising the manuscript.

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The effect of seed size and some priming method on germination of *Vicia sativa* L.

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Abstract. The sudty was conducted to determine the effect of seed size and some priming methods on germination of common vetch. Seed was fractionated into two classes "small or large seed". The seeds for each seed size were primed in different priming medium. Germination performance of large seed is higher than small seed. PEG solution is suitable for common vetch.

Keywords. Germination – Priming – Seed size – *Vicia sativa* L.

L'effet de la taille des graines et une méthode d'amorçage sur la germination de* Vicia sativa *L.

Résumé. *L'étude a été menée afin de déterminer l'effet de la taille des graines et une méthode d'amorçage sur la germination de la vesce commune. Les semences ont été divisées en deux classes de "taille petite ou grande". Les graines de chaque taille ont été amorcées en milieux d'amorçage différents. Les performances germination des graines grandes sont plus élevées que celles de petites graines. La solution de PEG est appropriée pour la vesce commune.*

Mots-clés. *Germination – Amorçage – Taille des graines –* Vicia sativa *L.*

I – Introduction

Both increased feed requirements for an expanding Turkish livestock population and sustainable agriculture necessitate the introduction of forage legumes into crop rotations (Fırıncıoglu *et al*., 2009). Common vetch (*Vicia sativa* L.), a major annual forage legume in Turkey, is grown over a large area 500 000 ha (TUIK, 2009). It is grown under both arid and wet conditions in every region of Turkey. It is exposed to different stress factors depending on its growing environment. For example, waterlogging damage to fall sown common vetchs can be a serious problem in North part of Turkey (Manga *et al*., 2003). In arid environments, freezing temperatures in winter, low and inconsistent distribution of annual rainfall, and high temperatures at maturity are all important abiotic stres (Fırıncıoglu *et al*., 2009).

Succesful stand establishment of common vetch depends on seed germination and seedling growth (Samarah, 2006). Pod shattering has been a major constraint to seed production of common vetch (Acıkgoz, 2001). Delayed seed harvest may increase seed losses due to pod shattering; however, early harvest may influence seed weight and germination. Samarah (2006) reported that germination of immature seeds of common vetch differed mature seeds depend on drying method of seeds. Also Acıkgoz and Rum-Baugh (1979) determined that large-seeded cultivars of common vetch tended to produce larger and more rapidly growing seedlings.

Seed priming is a tecnique which involves uptake of water by the seed followed by drying to iniate the early events of germination up to the point of radicle emergence (Varier *et al*., 2010). Its benefits include rapid, uniform and increased germination, improved seedling vigour and growth under a broad range of environments resulting in better stand establishment (Varier *et al*., 2010).

Priming can be accomplished through different means such as hydropriming (soaking in water), osmopriming (soaking in osmotic solution such as polyethyle glycol (PEG), mannitol, sodium and potassium salts) (Elkoca *et al*., 2007; Tiryaki *et al*., 2009). Although there is some information about the effects of seed priming on germination of some forage legumes in the literature (Gullap *et al*., 2007; Tiryaki *et al*., 2009; Rouhi *et al*., 2010), seed priming was not reported for common vetch.

The objective of the present work was to determine the effects of some priming treatments on seed germination of common vetch (*Vicia sativa* L.).

II – Materials and methods

Seed of common vetch (*Vicia sativa* L.), cultivar Albayrak, was obtained from Black Sea Agriculture Research Station, Samsun, Turkey. Seed was fractioned into two classes "small or large seed". While small seeds were those that passed through a 4 mm slotted sieve, large seeds were those retained on it. Subsequent to fractionation, all physically damaged seeds were manually removed. Thousand seed weight (TSW) was determined for each fraction by counting and weighing 8 samples of 100 seeds (ISTA, 1993). It varied between 76 and 54 g. Moisture content of each seed size was determined by grinding the seeds and then drying at 130 ºC for 4 h and they were found to be 10.5 % and 10.4 % on a fresh weight basis (respectively, small and large seeds).

The seeds for each seed size were divided into lots. In osmopriming treatments, the seed lots were fully immersed in different osmopriming medium at various concentrations: 1, 2 or 3% of KNO_3, KH_2PO_4, NaCl or boric acid, 10, 20 or 30% of PEG 6000 or 4% mannitol. The seed lots were imbibed in distilled water in hydropriming treatments. The ratio of seed weight to priming solution volume was kept 1:5 (g ml^{-1}) (Ghiyasi *et al*., 2007). The seed lots were primed in darkness in an incubator at 25 ± 1 ºC (Kaur *et al*., 2002) for 3 days (altough seed coat began to break down, radicle did not prosturated, hence, priming got through). Following priming, seeds were rinsed under running top water for 2 minutes to remove the priming agent (Tiryaki *et al*., 2009) and dried on filter paper at 25 ± 1 ºC for 24 h (Elkoca *et al*., 2007). Seeds whose seed coat began to break down during priming were eliminated before the germination test. Untreated (non-primed) seeds were used as the control.

Germination test were completed in darkness in an incubator at 25 ± 1ºC (Akhtar and Hussain, 2009). 20 seeds were placed on 2 layers of filter paper moistened with 10 ml of deionised water in covered 9 cm petri dishes replicated four times for each treatment. Captan (1 g /litre) was added into the deionised water to prevent fungal development. Germinated seeds, which the radicle was approximately 3 mm length (Killi and Erol, 2006), were recorded and removed from petri dishes daily until the number stabilized (for 9 days). The percentage of germinated seeds was calculated as formula. The percentage of germinated seeds = (total germinated seed number/20) x 100.

Four replicates of 20 seeds for germination were arranged in split plot design. Seed size was main plot, priming agent was subplot. Seeds in KNO_3, NaCl and boric acid and in higher concentrations (>1%) of KH_2PO_4 did not germinate, thus, these priming treatments did not participate in the statistical analysis. Before analysis, arcsine transformation was used. Analysis of variance of data was done by SPSS 10.0 V. The means were ranked according to LSD test.

III – Results and discussion

Seed size, as a characteristic of seed quality, influences seedling growth and establishment (Nik *et al*., 2011). There were significant differences ($P \leq 0.01$) between seed size regarding germination percentage. As predicted, the highest germination percentage (18.8 %) was obtained from large seed. In the present study, large seeds exhibited two times greater germination than small seeds, regardless of priming. With increased seed size, higher germination percentage was determined in triticale (Kaydan and Yagmur, 2008) in oat (Mut *et al*., 2010). Because delayed seed harvest in common vetch can increase seed losses due to pod shattering; harvest is done before all seeds are mature, thus, small seeds may be immature.

Priming media significantly (P≤ 0.01) altered germination performance of *Vicia sativa* L. While 20 % PEG 6000 enhanced germination percentage in both seed size, 4% mannitol enhanced germination percentage in large seeds (Fig. 1). PEG is commonly used as osmotic priming material because it is readily available and has no physiological reaction with seed. Very large molecules of this substance do not pass through seed cell membranes but control diffusion of water through the seed coats by providing lower osmotic potential in the seed environment (Pill, 1995). The other priming treatments reduced germination. Moreover seeds in KNO_3, NaCl and boric acid and in higher concentrations (>1%) of KH_2PO_4 did not germinate. The effect of priming can change depending on chemical, duration time and plant species. For example, 1% KNO_3 and KH_2PO_4 enhanced germination percentage of *Lolium multiflorum*, higher concentrations (> 1%) of the same solutions had an adverse effect on seed germination (Tiryaki *et al*., 2004). Additionally priming seeds in 3% boric acid significantly improved germination rate and uniformity of *Amaranthus caudatus* L. At 15°C (Tiryaki, 2009). Contrary to present result, 2% NaCl and KNO_3 enhanced germination percentage of white clover when seed were primed in 2 days (Tiryaki *et al*., 2009). It may be toxic ion effect of NaCl, rather than osmotic effect, which has been reported that salt concentration did not affect the proprotion of seed imbibing of red clover (Onal Asci, 2011).

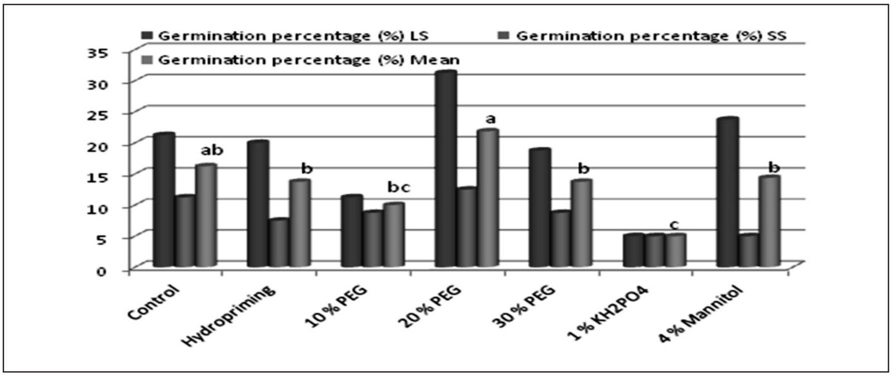

Fig. 1. Germination percentage of *Vicia sativa* L. seeds in different priming treatments. (LS: Large seed, SS: Small seed).

The results of this study confirmed that the selection of larger seed is suitable for much germination percentage. The resultant effect of priming depends on the used method. Altough 20 % PEG seems to be useful to increase germination percentage, time of treatment must be investigated to learn the most effective method.

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Prediction of the nutritive value of annual forage clovers and serradella by near infrared spectroscopy (NIRS)

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Abstract. Near infrared reflectance spectroscopy (NIRS) was evaluated as a tool to estimate organic matter (OM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), water soluble carbohydrates (WSC), ether extract (EE) contents and in vitro organic matter digestibility (IVOMD) in samples of six annual legumes species (*Trifolium incarnatum*, *T. michelianum*, *T. resupinatum* –ssp. *resupinatum* and *majus*–, *T. vesiculosum* and *Ornithopus sativus*) grown as winter crops and harvested in different dates in spring. After selecting a collection of 316 samples, calibration equations were developed by modified partial least square regression of the reference values on the spectra records. The best coefficient of determination in cross validation (r^2) and range to error ratio (RER) values for OM, CP, ADF, NDF, WSC, EE and IVOMD were 0.71 and 11.8, 0.88 and 12.7, 0.91 and 15.3, 0.97 and 26.0, 0.91 and 20.6, 0.75 and 9.7 and 0.81 and 11.0, respectively. It is concluded that NIRS analysis is an useful tool for the prediction of the nutritive value of the annual forage legumes studied.

Keywords. Forage legumes – Chemical composition – Digestibility – NIRS.

Prédiction de la valeur nutritive des trèfles fourragères annuelles et de la serradelle par spectroscopie proche infrarouge (NIRS)

Résumé. *L'objectif de ce travail a été d'évaluer l'utilité de la technique de la spectrométrie dans le proche infrarouge (SPIR) pour la prédiction de la composition chimique et de la digestibilité de six espèces de légumineuses fourragères annuelles (*Trifolium incarnatum, T. michelianum, T. resupinatum *–ssp.* resupinatum *et* majus*–,* T. vesiculosum *et* Ornithopus sativus*) cultivées en cultures d'hiver et récoltées à des dates différentes au printemps. Des équations de calibrage SPIR ont été développées (méthode de «modified partial least squares») pour prédire des paramètres tels que : la matière organique (OM), protéines (CP), fibres (ADF, NDF), sucres solubles (WSC), lipides (EE) et la digestibilité in vitro de la matière organique (IVDMO), à partir d'une collection de 316 échantillons. Les meilleures valeurs de coefficients de détermination en validation croisée (r^2) et de rapports de la plage de valeurs à l'erreur de prédiction (RER) pour l'OM, CP, ADF, NDF, WSC, EE et IVOMD ont été 0,71 et 11,8, 0,88 et 12,7, 0,91 et 15,3, 0,97 et 26,0, 0,91 et 20,6, 0,75 et 9,7 et 0,81 et 11,0, respectivement. On en conclut que l'analyse SPIR constitue une méthode très utile pour la prédiction de la valeur nutritive des légumineuses fourragères annuelles étudiées.*

Mots-clés. *Légumineuses fourragères – Compositon chimique – Digestibilité – SPIR.*

I – Introduction

Galician dairy cow farms (located in the NW atlantic-humid corner of the Iberian peninsula) produce 2.2 million of tonnes of milk, accounting for about 40% of total dairy production and more than half of dairy cow producers in Spain (MARM, 2010). About half of dairy milk produced in Galicia comes from 2,000 farms (owning more than 300 tonnes of milk quota per holding) in which the typical winter daily ration fed to the lactating cows (in a DM basis) includes 30-40% of maize silage and 15-25% of grass silage (Flores *et al*., 2011). Most of these farms follow an intensive forage rotation system of two crops per year in the arable land with maize and italian ryegrass as summer and winter silage crops, respectively, although more than one third of them practise the monoculture of maize, leaving the land uncultured during the winter between successive maize crops (Fernández-Lorenzo *et al*., 2009). The low protein content of the forage produced in this system, coupled with the increasing prices of the nitrogen and growing environmental concerns has led to a recent farmer's interest in the inclusion of legume forages in the rotation. Following some promising results arising from the evaluation of some new annual forage legume species as winter crops for silage (Resch-Zafra *et al*., 2010) a number of farms have began to grow annual *Trifolium* and *Serradela* species, arising the need of having reliable methods for the routine evaluation of its nutritional value for both research and advisory purposes.

NIRS is an alternative to standard analytical methods for determining nutritive value of forages and has become widely recognized as a valuable tool in the accurate determination of the chemical composition of a wide range of forages (Shenk and Westerhaus, 1985). The key to successful use of the NIRS technique is to develop a calibration model, based in a large calibration database which adequately represents the characteristics of the forage problem samples to be predicted.

In the present study, it is evaluated the potential use of NIRS to predict chemical composition and in vitro digestibility of species of new annual forage legumes grown for silage as the first step in providing a robust, fast and inexpensive laboratory method for estimating the nutritional value of these species.

II – Materials and methods

This work was carried out with samples of six annual forage legume species which were harvested at six different dates during the first and second spring growth (15 March-24 May and 26 April-5 July, respectively) in an experiment carried out at the Centro de Investigacións Agrarias de Mabegondo (A Coruña, Galicia, Spain) in year 2010. The species studied were Crimson clover (*Trifolium incarnatum* L. cv Viterbo), Balansa clover (*T. michelianum* Savi. cv. Bolta), Persian clover (*T. resupinatum* L. ssp. *resupinatum* cv. maral and ssp. *majus* cv. Kyambro), Arrowleaf clover (*T. vesiculosum* Savi. cv. Zulu) and French serradella (*Ornithopus sativus* Brot. cv. Margurita). Dry matter (DM) content of fresh samples was determined by oven-drying at 80ºC for 16 hours and the spectra of dry samples (n=545), ground in a Christy-Norris hammer mill to pass a 1 mm screen, were registered in a Foss NIR Systems 6500 monochromator (spectofotometric NIRSystems 6500 (FOSS NIRSystems, Inc., Silver Spring, Washington, USA).

Two aliquots of each sample were scanned in a spinning circular cup with a quartz window of 37.5 mm diameter, at 2 nm intervals (1050 data points) in the wavelength range of 1100-2500 nm. The spectrum of each sample was the average of the two sub-samples. Initially, all spectral data were recorded as the log 1/reflectance (log 1/R values). Samples with extreme (i.e. outliers) or very similar spectra (Mahalanobis distance H of >3.0 and a minimum standardized distance NH <0.6, respectively) were excluded from the calibration data set, unless they were thought to provide relevant information (Shenk and Westerhaus, 1996). Data were processed using the software WinISI Version 1.5 (Infrasoft International, Port Matilda, USA, 2000).

Wet chemistry of selected samples (n = 316) was carried out by reference methods, which included the determination of organic matter (OM) by ignition in a muffle furnace overnight at 500ºC, crude protein (CP, as total Kjeldahl N x 6.25, being N the nitrogen content) following Castro *et al*., (1990), acid detergent fiber (ADF) and neutral detergent fiber (NDF) by procedure of Goering and Van Soest, (1970), water soluble carbohydrates (WSC) by colorimetry (Castro, 2000) and ether extract (EE) by the Soxtec method (AOAC official method 2003.06). *In vitro* organic matter digestibility (IVOMD) was performed by the procedure described by Tilley and Terry (1963), modified by Alexander and McGowan (1966). All parameters were reported on a dry matter basis and analysed in duplicate.

Calibration equations were obtained using a Modified Partial Least Squares (MPLS) regression technique (Martens and Naes, 1987). This regression technique requires cross-validation to prevent overfitting, obtaining validation errors by partitioning the calibration set into several groups and pooling them into a standard error of cross-validation. MPLS of reference values on the second derivative of standard normal variate (SNV) and de-trended spectra (Barnes *et al*. 1989) was the best regression method for all the determinations. The statistics parameters used to test the performance of the calibration equations were the standard errors (SEC and SECV) and coefficients of determination (R^2 and r^2) obtained in the calibration and cross validation steps, respectively. The range error ratio (RER) of cross validation, as defined by the range of the population's reference values divided by the corresponding SECV was also considered since it is an useful statistic to test the accuracy of the calibration models (Williams and Sobering, 1996).

III – Results and discussion

The characteristics of the reference values of the calibration data set and the statistics to describe the quality of NIRS calibration and prediction equations selected are shown in Table 1. Both the number of samples and the variability in their chemical composition and *in vitro* digestibility were found to be adequate for developing initial NIRS calibrations. The values obtained for the coefficients of determination ranged from 0.85 (EE) to 0.98 (NDF) in the calibration step, and from 0.71 (OM) to 0.97 (NDF) in the cross validation step, showing a high proportion of variability in the reference data accounted for by the regression equation (except for OM and EE). These values, together with SEC and SECV are within the acceptable range cited by other authors which developed NIRS calibrations for estimating the nutritive value of temperate forages (Murray, 1993). On the other hand, the values of the RER statistic confirms the apparent good precision of the equations developed, according with Williams and Sobering (1996) who suggest a minimum RER value of 10 for an adequate estimation quality in NIRS calibrations. These results are also in agreement with those reported by Li *et al*. (2011) for the prediction of nutritive values of annual *Trifolium* species.

Table 1. NIRS statistics of the calibration equation used for the prediction of organic matter (OM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), water soluble carbohydrates (WSC), *in vitro* organic matter digestibility (IVOMD) and ether extract (EE) of the annual forage legume species

Variable	N	Mean	SD	Range	SEC	SECV	R^2	r^2	RER
Chemical composition (%DM)									
OM	316	88.24	1.77	82.05 - 93.32	0.47	0.95	0.91	0.71	11.83
CP	315	18.21	4.20	9.26 - 28.13	0.87	1.48	0.96	0.88	12.73
ADF	316	28.64	7.08	11.55 - 44.35	1.41	2.13	0.96	0.91	15.37
NDF	316	33.54	7.87	14.54 - 51.58	1.01	1.42	0.98	0.97	26.03
WSC	316	12.27	4.09	3.81 - 29.36	0.61	1.24	0.97	0.91	20.66
EE	242	1.75	0.42	0.91 - 2.95	0.17	0.21	0.85	0.75	9.71
In vitro OM digestibility (%)									
IVOMD (%)	308	75.20	6.50	54.69 - 86.05	1.98	2.84	0.90	0.81	11.05

N = number of samples, SD = standard deviation, SEC = standard error of calibration, SECV = standard error of cross validation, R^2 and r^2 = coefficient of determination in calibration and cross validation, RER = Range/SECV.

IV – Conclusions

This work demonstrates the promising potential of NIRS for assessing the nutritive value of annual forage legumes, showing a good performance in the prediction of crude protein, cell-wall components, water-soluble carbohydrates and *in vitro* OM digestibility. It is nevertheless advisable to check the equation in blind tests on open sets into the future and include new samples from different years and environments to increase the robustness of the predictions.

Acknowledgments

The authors wish to acknowledge the financial support received from the INCITE of Xunta de Galicia (Project PGIDIT09MRU012E) and the dairy company Leyma Central Lechera, S.A.

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New annual legumes as winter crops for intensive forage rotations in Galicia (NW Spain). I – Dry matter yield

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Abstract. It is presented in this paper the dry matter yield results obtained in an experiment where six species of annual legumes were sown in small plots in mid-October 2009 as a winter monoculture crop and harvested in the next spring following a silage-cutting strategy. Legume species were: Crimson clover; Balansa clover; Persian clover (ssp. *resupinatum* and ssp. *majus*); Arrowleaf clover and French serradella. Forage was given a first cut at two weeks intervals in six harvest dates beginning at mid-march, and a second cut was taken after six weeks of regrowth. Sown legume dry matter yield varied broadly among species across cutting dates (from 3.3 to 6.6 t ha^{-1} and from 0.8 to 3.4 t ha^{-1} in first and second cycles, respectively) and among cutting dates across species (from 1.5 to 8.5 t ha^{-1} in the first cycle and from 3.7 to 0.2 t ha^{-1} in the second). In spite of the good average productivity of most of the legume species studied, their low dry matter (DM) content in spring (from 9.8 to 19.0% DM) could make difficult to obtain and adequate fermentation quality of silage harvested by the end of April to fit in the rotation with maize.

Keywords. Forage potential – Monoculture crops – Serradella – Clovers.

Les neuvelles légumineuses annuelles utilises comme des cultures d'hiver pour les rotations fourragères intensives en Galice (NO Espagne). I – Rendements en matière sèche

***Résumé**. Ces travaux présentent des résultats sur la production observée au cours d'un essai qui a évalué six espèces de légumineuses annuelles semées à l'automne 2009 et soumises à une stratégie de coupe pour ensilage au printemps suivant. Les espèces étaient: le trèfle rouge (*Trifolium incarnatum* L.), trèfle migueliano (*T. michelianum* Savi), trèfle de Perse (*T. resupinatum* L.) ssp. resupinatum et ssp. majus, trèfle vésiculeuse (*T. vesiculosum* Savi) et serradelle (*Ornithopus sativus* Brot.). La récolte s'est effectuée à six dates différentes à intervalles de deux semaines à partir de mi-mars, avec une deuxième utilisation de la repousse à six semaines. La production de matière sèche (MS) a montré une variation considérable entre les espèces (de 3.3 à 6.6 t MS ha^{-1} en moyenne sur les différentes dates sur la première coupe), et également entre les dates de coupe (1.5 à 8.5 t de MS ha^{-1} entre la première date et la dernière, en moyenne sur toutes les espèces). Malgré les bons rendements obtenus pour la plupart des espèces évaluées, leur utilité en tant que fourrage pour ensilage de printemps, en rotation avec le maïs, pourrait s'avérer délicate en raison de la faible teneur en matière sèche atteinte dans le fourrage, entre 9.8% et 19.0%.*

***Mots-clés.** Potentiel fourragère – Cultures pures – Serradelle –Trèfles.*

I – Introduction

Crimson clover and Serradella were used in the traditional livestock farming systems of the coastal zone of Galicia as winter forage in rotation with maize. Although previous studies (Lloveras,1987) showed that it was possible to obtain a good quality forage for silage in spring from these species, they did not find a place in the modern dairy farms which use predominantly the Italian ryegrass for this purpose. The emerging concern about the rising costs of inputs and environmental issues of agriculture production have led to a renewed interest about the inclusion of forage legumes in the livestock farming systems in Europe. New species of forage legumes have emerged in the last ten years as a consequence of the re-examination of the pasture legumes used in Australian ley-faming. Among the new traits sought in these species are deeper root systems, acid-tolerant rhizobial symbioses and tolerance to pests and diseases (Loi *et al*., 2008). In conditions of mid-mountain pastures in the Mediterranean area of the south of Galicia, with acid soils of medium-low fertility, Piñeiro *et al*., (2008) found good results in sward establishment and performance for grazing and a summer hay cut in beef production systems, concluding that the recommended species were Crimson clover, Balansa clover, Persian clover, Arrowleaf clover and French Serradela. Until the date there is not local information available about the forage potential and nutritive value of these new species in the context of intensive double-cropping systems of Galician dairy farms, with maize as the summer crop. The objective of this study was to evaluate and compare the forage potential of different cultivars of annual legumes, grown as winter fodder crops for silage production in spring, assessing their utility to be included in the intensive double cropping forage rotation systems with maize, typical of many of the Galician dairy farms.

II – Materials and methods

A field experiment was performed from October 2009 to July 2010 in the research station farm of the Centro de Investigacións Agrarias de Mabegondo, (Galicia, NW Spain, 43º 15´ N, 8º 18´ W, 100 m altitude) on a silt loam soil, with marine Mediterranean climate, under rain fed conditions.

The legume species evaluated were Crimson clover (*Trifolium incarnatum* L.) cv. Viterbo; Balansa clover (*T. michelianum* Savi.) cv. Bolta; Persian clover (*T. resupinatum* L.) ssp. *resupinatum* cv. Kyambro and ssp. *majus* cv. Maral; Arrowleaf clover (*T. vesiculosum* Savi.) cv. Zulu II and French serradella (*Ornithopus sativus* Brot.) cv. Margurita. In the first growth, a harvest schedule of six cutting dates, one cut every two weeks from 15 March to 24 May, was imposed. The regrowth was harvested six weeks later, following the same schedule, from 26 April to 5 July.

The experimental lay out was a split plot with ten blocks where the species (sown as monocultures) were assigned to the whole-plots and the harvest dates, to the subplots. The plots were sown with inoculated seed broadcasted on 13-16 October 2009, using a seed rate of 30 kg ha^{-1} for French serradella and crimson clover, and 10 kg ha^{-1} for the rest. The size of individual plots was 1.3 m x 6.0 m. The herbage was cut to a 10 cm stubble height, using a reciprocating mower, and the whole production was measured on a strip of 5.0 x 0.9 m per plot. The samples were weighted in the field using a portable scale and a representative sample (1.0 kg) was taken per plot and immediately sent to the laboratory for the determination of dry matter content (DM) and botanical composition. Data were subjected to ANOVA and multiple comparison of means by Fisher’s Least Significant Difference procedure using Proc GLM of SAS (SAS Institute, 2000).

III – Results and discussion

Climate characteristics (monthly rainfall and mean temperature) of the experimental site during growing season (October 2009 to July 2010) are shown in Table 1.

Table 1. Monthly rainfall and average temperature over the experimental period

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Mean temperature (ºC)	16.4	12.5	8.3	7.9	7.7	9.6	12.7	14.1	16.8	18.9
Rainfall (mm)	127.4	276.2	214.8	184.0	159.6	84.0	44.6	84.5	117.0	38.1

Forage production depended significantly ($p<0.001$) on the legume crop used, both in first and second growth. Dry matter yield of sown legume (DMY) was also affected ($p<0.001$) by harvest dates and a significant interaction ($p<0.001$) between legume specie and harvest dates was observed. As shown in Table 2, in the first growth, average DMY, DM content and percentage of sown legume (in DM basis) were, respectively, 5.35 (±3.26) t ha^{-1}, 12.1% (±2.8%) and 86.5% (±13.3%), and in the re growth, 1.81(±2.13) t ha^{-1}, 11.8% (±2.8%) and 88.2% (±11.9%). French serradella was the earliest flowering specie (29 March), followed by Balansa clover (12 April), Persian clover ssp. *resupinatum* (23 April), Crimson clover (26 April), Arrowleaf clover (5 May) and Persian clover ssp. *majus* (22 May).

Table 2. Dry matter yield (DMY), dry matter content (DM) and percentage of sown legume species (DM basis) averaged by species across harvest dates and by harvest dates across species

Species†	DMY ($t\ ha^{-1}$)	DM (%)	Sown species (%)	Harvest dates††	DMY ($t\ ha^{-1}$)	DM (%)	Sown species (%)
			First cycle				
French serradella	5.42	11.8	87.3	15 March	1.57	15.8	73.4
Crimson clover	6.24	11.9	88.5	29 March	2.54	10.4	82.6
Balansa clover	6.68	11.6	95.1	12 April	4.38	10.8	87.6
Persian clover *resupinatum*	4.92	12.1	88.9	26 April	6.65	10.5	91.0
Persian clover *majus*	3.39	12.8	72.2	10 May	8.41	9.8	94.0
Arrowleaf clover	5.48	12.6	86.7	24 May	8.59	15.4	90.1
l.s.d.	*0.59*	*0.3*	*3.7*	*l.s.d.*	*0.56*	*0.7*	*3.9*
			Regrowth				
French serradella	0.87	11.3	80.2	26 April	3.76	10.5	89.7
Crimson clover	2.40	11.2	93.7	10 May	3.52	10.2	89.9
Balansa clover	0.92	10.6	88.6	24 May	1.92	14.0	84.2
Persian clover *resupinatum*	1.29	11.9	86.7	7 June	0.70	12.2	92.9
Persian clover *majus*	3.41	12.7	88.0	21June	0.64	15.4	92.1
Arrowleaf clover	1.96	12.1	90.7	5 July	0.27	19.0	70.6
l.s.d.	*0.35*	*1.0*	*3.2*	*l.s.d.*	*0.46*	*0.8*	*3.0*

† Mean values across harvest dates for each species; †† Mean values across species for each harvest date. *l.s.d.*: least significant difference between two means in the same column at $p<0.05$.

When sown legume yield was averaged across harvest dates it was observed differences among species, being Balansa clover and Crimson clover (6.68 and 6.24 t DM ha^{-1}, respectively) more productive in the first cycle than the rest of species, and Persian clover ssp. *majus* (3.39 t DM ha^{-1}) the least productive. The latter species was the most productive in the second cycle (3.41 t DM ha^{-1}), given its high capacity of regrowth. DM content remained very low in all species along the different harvest dates, ranging from 11.6% to 12.8% in the first growth and from 10.6% to 12.7% in the second growth.

Averaged among species, legume DM yield increased in the first cycle from 1.57 t ha^{-1} by 15 March (first harvest date) to 8.59 t ha^{-1} by 24 May (sixth harvest date). Daily forage growth rate in the five intervals between harvest dates was 69.2, 131.4, 162.1, 125.7 and 12.8 kg DM ha^{-1} day^{-1} indicating a high growth potential of these species that, in the conditions of the experiment, concentrates between the beginning of April to mid-May, reaching a ceiling by the second half of

April. A regrowth was observed for all species until the third harvest date of the first cycle. From this time on, only the Persian clover ssp. *majus* showed an appreciable growing capacity and consequently this species was the most productive, on average, in the second cycle (3.41 t DM ha^{-1}). In spite of this, in the regrowth of the first and second harvest dates forage production of Crimson clover (5.70 and 5.78 t DM ha^{-1}) and Arrowleaf clover (4.99 and 4.68 t DM ha^{-1}) clearly outyielded that of Persian clover (2.28 and 3.96 t DM ha^{-1}).

Table 3 shows the mean values of the DM yield of each species along the six harvest dates in the first cycle. Whilst Balansa clover and Crimson clover were the most productive species from the beginning of April to the fifth harvest date (10 May), Arrowleaf clover significantly outyielded the rest of legumes in the last cut (24 May). Although a maximum of DM yield was observed for all species by 10 May, this was not the case for Arrowleaf clover, which maintained a fairly high growing rate (180 kg DM ha^{-1} day^{-1}) during the second half of May.

Table 3. Interaction of Species x Harvest date for dry matter yield (t ha^{-1}) of sown legumes

	Harvest date (First cycle)					
Species	**15 March**	**29 March**	**12 April**	**26 april**	**10 May**	**24 May**
French serradella	2.2	3.3	4.8	6.8	8.1	7.1
Crimson clover	1.1	2.2	5.0	7.7	10.8	10.4
Balansa clover	2.6	4.0	5.9	8.7	9.1	9.1
Persian clover *resupinatum*	1.4	2.6	4.1	5.6	7.7	7.9
Persian clover *majus*	1.2	1.4	2.4	3.7	5.4	5.7
Arrowleaf clover	0.7	1.5	3.8	6.9	8.6	11.1

Least significant difference between two means in the same row or column ($p<0.05$): 0.92.

Little information can be found in the literature on productive performance of these legumes as monocrops. In the research station farm Mabegondo, Iglesias and Lloveras (1998) reported yields of 5.8 and 6.2 t DM ha^{-1} at the third week of May for local ecotypes of French serradela and Crimson clover. In Australia, Loi *et al.*, (2000) indicate values of 5 t DM ha^{-1} for French serradela and Balansa clover in spring at flowering stage. Other studies have reported yields up to 6 t DM ha^{-1} for Crimson clover harvested at flowering stage in EEUU, and about 4 t DM ha^{-1} for a cultivar of Persian clover ssp. *resupinatum* under irrigation conditions in Italy (Hoveland and Evers, 1995, and Martiniello, 1999, respectively, cited by Frame, 2005).

IV – Conclusions

The preliminary results showed a high productivity of the annual legumes studied, indicating that they could fit in the rotation with maize. Crimson clover and Balansa clover seem the most promising species for harvesting by the end of April. However, their low DM content could make it difficult to obtain a satisfactory silage quality with these species.

Acknowledgments

The authors wish to acknowledge the financial support received from the INCITE of Xunta de Galicia (Project PGIDIT09MRU012E) and the dairy company Leyma Central Lechera, S.A.

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New annual legumes as winter crops for intensive forage rotations in Galicia (NW Spain). II – Nutritive Value

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Abstract. The digestibility and chemical composition values of six species of annual legumes (Crimson clover, Balansa clover, Persian clover –ssp. *resupinatum* and ssp. *majus*–, Arrowleaf clover and French serradella) sown in small plots as a winter monoculture crop in the CIAM research station farm (coastal zone of Galicia, NW Spain) and harvested in the next spring following a silage-cutting strategy is presented in this paper. Forage was given a first cut at two weeks intervals in six harvest dates beginning at mid-March, and a second cut was taken after six weeks of regrowth. Nutritive value, estimated by NIRS, was high in average, and was affected by species and harvest date. For the first and second growth cycles the mean values of *in vitro* organic matter digestibility (IVOMD, %) and crude protein content (CP, % dry matter) were, respectively, 73.0±3.7% and 71.7±2.9% for IVOMD and 17.8±3.8% and 18.4±2.7% for CP. Forage quality, whilst reducing from the first harvest date, showed a more marked decline after the third harvest date (mid-April). This date could be adequate for ensiling, providing a high-digestibility, protein-rich forage and would fit into an intensive two crops per year rotation with maize as the summer crop.

Keywords. Digestibility – Crude protein – Serradella – Clovers.

Les neuvelles légumineuses annuelles utilises comme des cultures d'hiver pour les rotations fourragères intensives en Galice (NO Espagne). II – Valeur nutritive

Résumé*. L'objectif de ce travail a été de comparer l'évolution de la composition chimique et la digestibilité de six espèces de légumineuses fourragères annuelles (*Trifolium incarnatum, T. michelianum, T. resupinatum *–ssp.* resupinatum *et* majus*–,* T. vesiculosum *et* Ornithopus sativus*) cultivés en cultures d'hiver et récolté à des dates différentes au printemps suivant d'une stratégie pour l'ensilage. Les résultats, obtenue par SPIR, montrent en moyenne une haute valeur nutritive, qui est significativement affectée par les espèces, les dates de récolte et leur interaction. Pour les premier et deuxième cycles, respectivement, la valeur moyenne de la digestibilité in vitro de la matière organique était de 73,0 ± 3,7% et 71,7 ± 2,9, tandis que la protéine brute (% matière sèche) était de 17,8 ± 3,8% et 18,4 ± 2,7%. Dans le premier cycle a montré une baisse de la qualité plus marqué à partir de la coupe de la mi-Avril, par conséquent cette date pourrait être indiquée pour l'ensilage, en fournissant un fourrage hautement digestible, riche en protéines, qui s'intègrent bien dans la rotation de deux récoltes par an avec le maïs comme culture d'été.*

Mots-clés. *Digestibilité – Protéine brute – Serradelle –Trèfles.*

I – Introduction

In recent years different cultivars of annual legumes adapted to areas with mild winters have appeared in the market. These new pasture legumes have been selected, among other characters, based on the depth of their root system, large growing season, tolerance to pests and diseases and symbiotic association adapted to acid soils (Loi *et al.*, 2008). Some of these forage species were of common use, no many years ago, in Galician farms, as it is the case of crimson clover and serradella (Lloveras, 1987) and in a recent study about the improvement of pasture systems in suckler-cow hill farms in the SE of Galicia (NW Spain) Piñeiro *et al*. (2010) reports about the good performance, in terms of sward establishment and yield of Crimson clover, Balansa clover, Persian clover, Arrowleaf clover and French Serradella in a grazing-summer hay cut system.

There is no detailed information, at the present, about the comparative nutritive value of the cited species when grown for silage in lowland situations. In order to asses their utility in the Galician dairy farms as winter crops in intensive forage rotation systems with maize, it is the objective of this study to assess the evolution of the *in vitro* organic matter digestibility and chemical composition of the first cycle of these annual legumes under a strategy of different cutting dates for silage in spring.

II – Materials and methods

This work was carried out with six annual forage legume species sown in monoculture in the autumn of year 2009, which were harvested at six different dates the next spring during the first growth cycle (15 March-24 May) at two weeks intervals. The species studied were Crimson clover (*Trifolium incarnatum* L. cv Viterbo), Balansa clover (*T. michelianum* Savi. cv. Bolta), Persian clover (*T. resupinatum* L. ssp. *resupinatum* cv. Maral and ssp. *majus* cv. Kyambro), Arrowleaf clover (*T. vesiculosum* Savi. cv. Zulu) and French serradella *(Ornithopus sativus* Brot. cv. Margurita). The experiment was carried out at the Centro de Investigacións Agrarias de Mabegondo (CIAM, A Coruña, Galicia, NW Spain, 43º 15´ N, 8º 18´ W, 100 m altitude) following a split-plot design with species as the main plot and harvest date as the subplot, with ten blocks. Other details of the experiment can be found in Valladares *et al*. (2012).

Dry matter (DM) content of fresh samples (n=360) was determined by oven-drying (80 ºC, 16 hours) and dry samples were ground in a Christy-Norris hammer mill to pass a 1 mm screen. The chemical composition and digestibility of ground samples was estimated by NIRS using a calibration equation obtained at the CIAM for fresh annual legume species (Pereira-Crespo *et al*., 2012). Estimated quality parameters were: organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), water soluble carbohydrates (WSC), and *in vitro* organic matter digestibility (IVOMD). Data were subjected to ANOVA and multiple comparison of means by Fisher’s Least Significant Difference procedure using Proc GLM of SAS (SAS Institute, 2000).

III – Results and discussion

Species and harvest dates significantly affected ($p<0.001$) all the parameters of chemical composition and the *in vitro* organic matter digestibility. Mean values of all samples in the first cycle of growth (n=360) were: IVOMD (%) 73.0 ± 3.7 (range 61.9 to 80.9), OM (% DM) 90.0 ± 1.4 (range 87.6 to 94.3), CP (% DM) 17.8 ± 3.8 (range 8.0 to 26.2), WSC (% DM) 12.1 ± 2.2 (range 6.8 to 18.1) and NDF (% DM) 35.8 ± 6.0 (range 24.2 to 52.4), showing a good average nutritive value.

As can be seen in Table 1, where the average values for the main effects are shown, Crimson clover, Persian clover ssp. *resupinatum* and Balansa clover were the most digestible species, with IVOMD (%) values of 74.9, 74.6 and 74.0% respectively, whilst the French serradella showed the lowest value (70.4%). The variation in OM (%DM) content among species was quantitatively small, ranging between 91.3 and 89.1 % for Persian clover *majus* and French serradella, respectively. Crude protein content (%DM) of Persian clover *majus* was superior, on average, compared with the rest of species (19.1 %DM), whilst Arrowleaf clover showed the lowest CP value (16.6 %). Regarding to WSC (%DM) content, Crimson clover showed the highest value (14.1 %) followed by Arrowleaf clover (13.7 %), being observed the lowest values for the Persian clovers (ssp. *resupinatum* 10.8% and ssp. *majus* 10.5%). Cell-wall content of French serradella and Arrowleaf clover were, respectively, the highest and lowest values compared with the rest of species, with NDF values of 41.8% and 33.6%DM for both species.

Table 1. Effect of species and harvest date on chemical composition (%DM) and *in vitro* organic matter digestibility (%) of annual legumes

Species†	OM	CP	WSC	NDF	IVOMD	Harvest date††	OM	CP	WSC	NDF	IVOMD
French Serradella	91.3	18.2	11.5	41.8	70.4	15 Mar.	89.2	20.6	14.5	31.6	77.5
Crimson clover	90.5	18.1	14.1	35.3	74.9	29 Mar.	89.1	22.7	10.7	31.6	74.3
Balansa clover	89.8	17.0	12.4	35.6	74.0	12 Apr.	89.7	19.6	13.1	31.1	74.6
Persian clover *resup.*	89.3	17.9	10.5	34.8	74.6	26 Apr.	89.9	17.0	11.7	36.7	72.2
Persian clover *majus*	89.1	19.1	10.8	33.9	72.1	10 May	90.0	14.6	11.5	40.5	71.0
Arrowleaf clover	90.1	16.8	13.7	33.6	71.8	24 May	92.1	12.5	11.5	43.5	68.3
l.s.d.	*0.19*	*0.22*	*0.14*	*0.29*	*0.21*	*l.s.d.*	*0.20*	*0.41*	*0.29*	*0.32*	*0.16*

† Mean values for each species across harvest dates. †† Mean values for each harvest date across species.
l.s.d.: least significant difference between two means in the same column at p<0.05.

Species digestibility, crude protein and sugar content declined with advancing maturity, with mean values in first (mid-March) and last cutting dates (late May) for IVOMD (%), CP (%DM) and WSC (%DM) of, respectively 77.5 and 68.3%, 20.6 and 12.5% and 14.5 and 11.5%. As expected, NDF (%DM) increased clearly from 31.6 to 43.5% between these dates, and OM content (%DM) also increased slightly from 89.2 to 92.1%. As indicated by Valladares *et al*., (2012), legume DM content remained low along the spring, with overall mean values of 12.1 ± 2.8 (range 5.2 to 21.3). The ratio WSC/N remained fairly low, on average, all along the season, ranging from 2.9 to 5.8. It has been suggested that WSC/N ratio values less than 6 are indicative of a risk of deficient fermentation in the silo (Braithwaite, 1987). This fact, together with the very low DM content of these species in the spring, which ranged from 9.8 to 15.8 % (Valladares *et al*., 2012) highlights the need of wilting in order to succeed in the ensiling of these annual legumes.

Table 2 reflects the interaction effect (p<0.001) of species x harvest date for the digestibility of annual legumes. Comparing the first and the last harvest dates, Crimson clover and the two cultivars of Persian clovers (*resupinatum* and *majus*) showed a lower rate of IVOMD decrease (-0.79, -0.69 and -0.80 percent units per week, respectively) whilst the two early-flowering species (French serradella and Balansa clover) and Arrowleaf clover showed a faster rate (IVOMD decrease of -1.15, -1.05 and -1.02 percent units per week, respectively). With regard to the reduction of protein content with advancing maturity of forage, there is also significant differences among species although this effect is less marked (p<0.05). To this regard, the Persian (ssp. *resupinatum*), Balansa, Arrowleaf and Crimson clovers showed the highest average rate of decrease between mid-March and late-May, with values of -0.96, -0.95, -0.93 and -0.92 units of CP (DM basis) whilst Persian clover (ssp. *majus*) and Serradella values were -0.67 and -0.43 units. It is to be noted that, for all species in general, both IVOMD and CP of legumes remains fairly high up to mid-April, and from this date on a more marked decline in quality was observed in the experiment.

These results are in agreement with previous works cited in the literature, indicating the good nutritional quality of annual legumes and its decline with advancing maturity, although we found differences in the behaviour of different species. For example, Lloveras and Iglesias (2001) observed a rapid drop in quality of Crimson clover after flowering; in contrast, our results showed that this specie was one of the highest quality, according IVOMD and CP contents. Also in contrast to our findings, Akin and Robinson (1982) reported a lower digestibility for Crimson clover

Table 2. Interaction of Species x Harvest date on crude protein (CP, %DM) and *in vitro* organic matter digestibility (IVOMD, %) of annual legumes

Species	Crude protein (%DM)						*In vitro* OM digestibility (%)					
	15 Mar.	29 Mar.	12 Apr.	26 Apr.	10 May	24 May	15 Mar.	29 Mar.	12 Apr.	26 Apr.	10 May	24 May
French Serradella	19.5	21.6	19.2	17.2	16.3	15.2	76.1	72.9	72.8	69.5	66.8	64.6
Crimson clover	21.2	23.6	20.1	17.2	14.7	12.0	78.2	75.3	76.7	75.5	73.3	70.3
Balansa clover	20.6	21.9	19.3	15.7	13.5	11.1	79.0	76.5	75.9	72.8	71.5	68.2
Persian clover *resup.*	21.6	23.3	19.6	16.9	13.8	12.0	78.7	75.5	76.1	74.0	72.7	70.7
Persian clover *majus*	20.6	23.6	21.0	19.2	16.1	13.9	76.7	71.9	71.3	70.3	73.0	69.8
Arrowleaf clover	20.0	22.5	18.4	16.0	13.4	10.7	76.4	73.6	74.7	71.1	68.8	66.2

l.s.d.: least significant difference between two means in the same column at p<0.05 CP 0.72, IVOMD 1.05.
Flowering date: Serradella 29 Mar., Balansa clover: 12 April, Persian clover *resupinatum*: 23 April, Crimson clover 26 April; Arrowleaf clover 5 May, Persian clover *majus*, 22 May.

that Arrowleaf clover, at similar stages of maturity, which is not observed in our study. The use of different varieties and their interaction with environmental conditions of each case may be one reason to explain these differences, thus reinforces the need for evaluation of different species and varieties locally and keep them updated in time.

IV – Conclusions

It is confirmed the good overall nutritional quality of the annual legumes evaluated, and Crimson clover, Balansa clover and Persian clover ssp. *resupinatum* showed advantages, in terms of IVOMD and CP content, for a harvest in the last half of April, compatible with the usual maize seeding time in Galician dairy farms conditions. Since silage fermentation can be compromised by the low dry matter and WSC/N ratio of these species, it seems obligated and adequate wilting of forage before ensiling.

Acknowledgments

The authors wish to acknowledge the financial support received from the INCITE of Xunta de Galicia (Project PGIDIT09MRU012E) and the dairy company Leyma Central Lechera. S.A.

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Searching for new annual legumes suitable for pasture establishment in Southern Europe

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Abstract. The high plant biodiversity of Mediterranean basin, shaped from both the millennial agro-pastoral activity and the pedo-climatic variability, has produced a natural selection of pasture species, suitable for several uses in farming systems. Many of the recently released Australian annual legumes varieties are not always suitable for pasture establishment in southern Europe, mainly because of their early flowering and high hardseededness, which affect the persistence capability. In order to clarify the low persistence of the Australian varieties and to identify new interesting materials for the Mediterranean forage scene, ten accessions of *Lotus ornithopodioides*, *Ornithopus compressus*, *O. sativus*, *Trifolium hirtum*, *T. mutabilis* and *T. spumosum* were compared in North-Sardinia. These accessions, were evaluated for bio-agronomic traits as vigour, phenology, seed production and hardseedness breakdown. Results revealed the potential suitability of many of tested materials for both Mediterranean pasture improvement purposes and multifunctional uses.

Keywords. Persistence – Hardseededness – Annual legumes – Pasture establishment.

Recherche des nouvelles légumineuses annuelles adaptées à l'établissement de pâturages dans l'Europe du Sud

Résumé. *La grande biodiversité de la communauté végétale du bassin méditerranéen, façonnée par la millénaire activité agro-pastorale et par la variabilité pédo-climatique, a produit une sélection naturelle des espèces, adapté à plusieurs buts dans les systèmes agricoles. La plupart des variétés australiennes des légumineuses annuelles, disponibles sur le marché, ne sont pas toujours adaptées à l'établissement de pâturages dans le sud de l'Europe, principalement en raison de leur précoce floraison et de la haute dureté des semences, qui affectent la capacité de persistance. En conditions semi-arides Méditerranéennes, les traits distinctifs du idéotype des légumineuses annuelles sont la capacité de persistance et la gestion durable des cultures. Dans ce contexte et afin d'identifier matériaux potentiellement intéressants pour les systemes fourragèrs méditerranéens, treize différentes accessions de* Lotus ornithopodioides, Ornithopus compressus, O. sativus, Trifolium hirtum, T. mutabilis *et* T. spumosum *ont été comparés dans l'essai expérimental avec plantes espacées réalisée dans le nord-Sardaigne. Ces accessions ont été comparés pour la vigueur, la phénologie et la dureté des semences. Les résultats ont révélé la pertinence potentielle de beaucoup des matériaux testés pour l'amélioration des pâturages Méditerranéens et les usages multifonctionnels.*

Mots-clés. *Persistance – Dureté des semences – Légumineuses annuelles – Établissement de pâturages.*

I – Introduction

The native flora of the Mediterranean basin represent a rich source of legumes' germplasm and their root-nodule bacteria, for purposes of cropping, pasture and forage (Howienson and Loi 1994; Loi *et al.*, 2005). This is due to the high biodiversity of vegetal community, shaped from both millennial agro-pastoral activities and pedo-climatic variability, which have produced a natural selection of species suitable for several aims. Subterranean clover and annuals medics played an important role in the Australian wheat belt area in supplying nitrogen and sustaining the animal productions in both ley-farming and phase-farming systems. In the last decade, the high cost of seed production, the dependence from herbicides, the diffusion of new pests and diseases impacted on their popularity (Loi *et al.* 2005). In this contest, a second generation of legumes was released and introduced in the seed market by Australian researchers. In a recent multisite experiment in Sardinia, several of these new varieties showed difficult establishment and persistence and low forage productions. Despite good agronomic performances in the first year, the low autumn re-establishment of the sown varieties reduced the competitiveness against native species, depressing any attempt of pasture improvement (Porqueddu *et al*., 2010). This behaviour suggested their use in mixtures and highlighted the need to identify new pastures species more suitable to the local conditions. The existence of a variability in hardseededness among species in a mixture is a favourable trait, as advantages may be achieved combining seeds with different hard seeds levels and softening pattern for reducing inter- and intra-annual fluctuations (Porqueddu and González, 2006). For this aim, ten accessions of annual self-reseeding legumes, collected in different areas of Mediterranean basin, were compared for vigour, phenology and hardseededness in North-Sardinia.

II – Materials and methods

The trial was carried out in Surigheddu (North Sardinia, 40°35'38,21'N – 8°22'49,21'E, 26 m a.s.l.) at the Centre for the Conservation and Valorisation of Plant Biodiversity of the University of Sassari. The climate is typical of the central Mediterranean basin with long-term average annual rainfall of 540 mm and dry summer. The soil is calcareous alluvial, with a pH (water) of 6.9. Ten accessions of *Lotus ornithopodioides* (2), *Ornithopus compressus* (2), *O. sativus* (1), *Trifolium hirtum* (2), *T. mutabilis* (1), and *T. spumosum* (2) were compared in a completely randomized block experimental design with 3 replications. *Medicago polymorpha* Anglona, *T. subterraneum* Antas, *T. spumosum* Bartolo were used as tests. Preliminarily, seeds of all accessions were germinated in Petri dishes on tissue paper in a germinator at constant temperature (20°C). Seedlings were first transferred in Jiffy pots and after few months transplanted in spaced rows (0,6mx1.80m) on the December 7th, 2010. No herbicides were used, weeds having been controlled by mulching films. Data on plant vigour, cold damages, phenology and hardseededness were collected. Plant vigour and cold damages were estimated by assigning visual scores between 1 (low) and 5 (high). Phenology was recorded indicating the date at which each plant reached the following four phenological phases: 1st opened flower, 1st green pod, end of flowering and complete plant senescence. To investigate on hardseededness, 100 seeds for each accession were wrapped in fly-wire envelopes to form a strips. Three replicate strips were placed on the soil surface and then buried at 1 cm deep in a randomized block design. On 30th of July, 30th August and 30th September, the seeds were taken off and placed directly onto moist filter paper in Petri dishes at 20 °C for 20 days. Germinated and hard seeds were counted at in each of the three dates.

III – Results and discussion

In the period of the trial from transplantation to senescence (June), the total rainfall was 330 mm, mainly concentrated in December (50% of total rainfall) and the remaining one homogeneously distributed between March and June. No rainfall during the summer months occurred. *T. spumosum* WCT showed more vigorous plants than most of the accessions, but was not significantly different from the test variety *M. polymorpha* Anglona. *T. spumosum* Bartolo and most of the other native accessions formed a group of low vigor materials (Table 1). Cold damages were insignificant in *T. spumosum* WCT, but were more evident in less vigorous accessions. All accessions showed a high variability in phenology. Significant differences were found in all the observed phases; flowering began earlier in *T. spumosum* Bartolo (110 days from transplantation), which was significantly earlier than the other two *T. spumosum* WCT and VCD, with 124 and 130 days, respectively. *O. sativus* Soft and *T. mutabilis* showed late flowering (142 and 170 days, respectively,) but the latter was very fast ending its reproductive cycle after only 43 days from the first flower appearance. In *T. subterraneum* Antas, *O. compressus* Pabarile, *L. ornithopodioides* LA, *O. compressus* GEH and *T. spumosum* Bartolo, the duration of the flowering cycle were longer than 70 days (70-84 day). *T. spumosum* VCD, *T. spumosum* WCT, *M. polymorpha* Anglona and *T. hirtum* NA completed the flowering between 60 and 64 days, *L. ornithopodioides* LB and *T. hirtum* NB between 56 and 59 days.

Table 1. Bio-agronomic traits of the accessions: plant vigour and cold damages (score 1-5) and phenology phases (days from, December 7th 2010)

	Vigour	Cold damage	1° flower open	1° pod green	End flowering	Senescence
T. subterraneum Antas	2.7^{cd}	3	133^{d}	141^{d}	200^{bc}	206^{bcd}
T. hirtum NA	2.4^{bc}	4	126^{bcd}	165^{e}	189^{ab}	194^{a}
T.hirtum NB	1.4^{ab}	4	128^{bcd}	165^{e}	187^{ab}	194^{a}
T. mutabilis	2.0^{abc}	4	172^{f}	194^{f}	215^{c}	216^{bcd}
T. spumosum Bartolo	2.0^{abc}	3	110^{a}	124^{a}	190^{ab}	194^{a}
T. spumosum WCT	4.0^{e}	2	124^{bcd}	138^{bcd}	190^{ab}	194^{a}
T. spumosum VCD	2.3^{bc}	3	130^{cd}	134^{bcd}	190^{ab}	194^{a}
O. compressus Pabarile	1.7^{abc}	3	130^{cd}	139^{cd}	202^{bc}	213^{bc}
O. compressus GEH	1.1^{a}	4	117^{ab}	136^{bcd}	190^{ab}	193^{a}
O. sativus Soft	1.7^{abc}	4	142^{e}	165^{e}	202^{bc}	210de
L. ornithopodioides LA	1.6^{ab}	4	119^{abc}	133^{bc}	203^{bc}	212^{e}
L. ornithopodioides LB	2.2^{abc}	3	127^{bcd}	132^{b}	183^{a}	193^{a}
M. polymorpha "Anglona"	3.7^{de}	3	120^{abc}	132^{b}	184^{a}	194^{a}

The pattern of hardseed breakdown (Fig. 1) was quite homogeneous for all of the accessions, except for *O. sativus* Soft, which showed to be clearly softseeded (95% soft seeds on 30th of July). For this reason, *O. sativus Soft* was excluded from the statistical analysis.

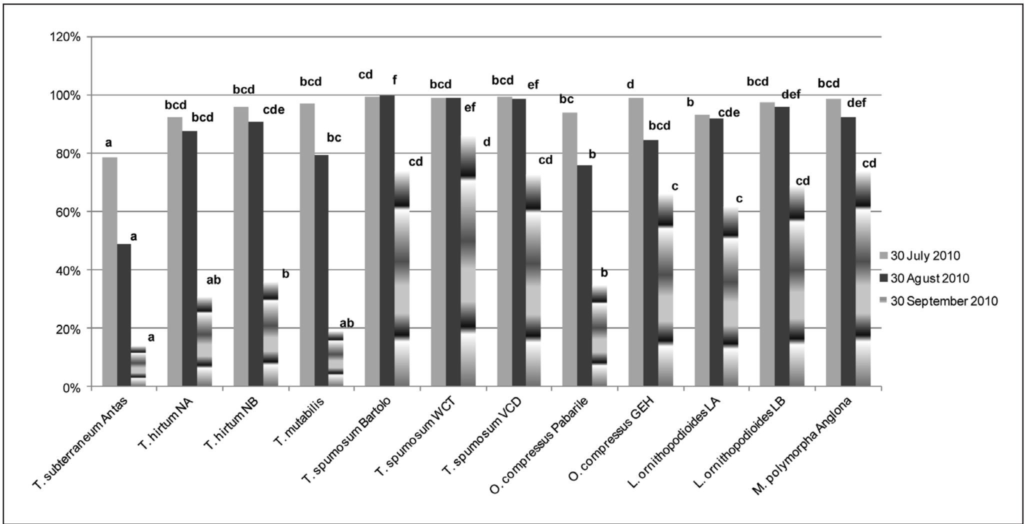

Fig. 1. Percentage of hard seeds at three different dates.

In the other accessions, hard seeds ratio exceeded 90% in early summer except for T*. subterraneum* Antas. In general, the percentage of hard seeds was stable in mid-summer. A slight decrease was observed in the two accessions of *O. compressus* and *T. mutabilis* while *T. subterraneum* Antas dropped from 80% to 50% hard seeds. Significant differences in hardseededness were also shown among accessions at the end of summer. *T. subterraneum* Antas, *T. mutabilis*, *T. hirtum* and *O. compressus* Pabarile, strongly reduced the hard seeds level up to 15%-35%. The remaining accessions maintained hard seed percentages between 60% (*L. ornithopodioides* LA) and 85% (*T. spumosum* WCT).

IV – Conclusions

The late flowering of a pasture crop in Mediterranean environments is a factor that promotes the extension of the grazing calendar and guarantees the lasting preservation of forage quality, as well as the regenerative capacity ensures the plant persistence. *O. sativus* Soft, which is late maturing and fully soft-seeded at the beginning of summer, satisfies both phenology and persistence requirements. However, it could be sensible to false breaks in case of summer rainfall. The same considerations are also valid for *T. mutabilis*. As regards *T. hirtum*, both genotypes showed interesting traits, with a flowering time similar to that of the well adapted tests. *T. spumosum* VCD and *O. compressus* Pabarile represented a promising alternatives to the commercial varieties of the same species, being late-maturing. Although the results are partial and site-specific, some accessions showed to be suitable for the inclusion in valorisation programs. In particular their erect habit that set heads on the top of the plants may avoid the use of suction harvesting (indispensable for the traditional pasture legumes as subterranean clovers and medics) making easier and cheaper the harvesting with conventional cereal harvesters.

Acknowledgements

The authors wish to acknowledge the Fondazione Banco di Sardegna for the financial support, Prof. Ignazio Camarda for hosting the trial at the Centre for Plant Biodiversity, Mr Daniele Nieddu and Mr Piero Saba for their technical help.

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Drought and high temperature resistance evaluation of *Dactylis glomerata* L.

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Abstract. With the aim to identify cultivars characterized by high drought and temperature resistance and high water use efficiency a study was carried out on 1 accession (Jana) and 4 Sardinian ecotypes of orchard grass (*Dactylis glomerata* L.) (Bolotana, Bonorva, Bonnanaro, Platamona). To evaluate the adaptive responses of different *D. glomerata* ecotypes, two trials were carried out in order to evaluate drought resistance under rain proof shelter and controlled water supply, and to evaluate high temperature resistance in a greenhouse where high summer temperature (daily maximum temperature > 50 °C) were monitored. On December 2010 seeds were sown in seed benches at the beginning of March the plants were transplanted at the 5th leaf stage in 45 litres pots, utilized in the drought resistance trial, and in a container (25 x 0.8 m), utilized in the high temperature resistance trial. In drought resistance trial, two water regimes were applied: 1) Control, soil humidity was kept at the field capacity, 2) W1, pots water losses were reintegrated at 80%. Above ground plant biomass, net photosynthesis, transpiration rate, stomatal conductance, leaf relative water content (RWC) were monitored throughout both trials.

Keywords. Drought resistance – Relative water content – Net photosynthesis – *Dactylis glomerata*.

L'évaluation de la résistance de* Dactylis glomerata *L. à la sécheresse et aux hautes températures

Résumé. *Dans le but d'identifier des cultivars caractérisés par la résistance à la haute température, à la sécheresse et avec une grande efficacité dans l'utilisation de l'eau, on a réalisé des expériences sur 1 cultivar (Jana) et 4 écotypes sardes de* Dactylis glomerata *L. (Bolotana, Bonorva, Bonnanaro, Platamona). L'évaluation des réponses adaptatives des différents écotypes a été effectuée lors de deux expériences: la première menée à l'abri de la pluie et avec un régime d'eau contrôlé, pour vérifier la résistance à la sécheresse; la deuxième conduite dans des serres avec températures estivales élevées enregistrées (journellement > 50 °C), pour évaluer la résistance à la haute température. En décembre 2010 on a semé les grains dans des plateaux. Au début de mars les plantes au stade de la 5ème feuille ont été transplantées dans des pots de 45 litres pour la première expérience et dans un bac (25 x 0,8 m) pour la deuxième. Pendant le test de résistance à la sécheresse, on a appliqué deux régimes hydriques: 1) Contrôle, en gardant l'humidité du sol au niveau de la capacité au champ, 2) W1, en réintégrant 80% d'eau des pots perdue dans le procès d'évapotranspiration. Lors des deux expériences on à observé aussi la biomasse aérienne, la photosynthèse nette, le taux de transpiration, la conductance stomatique et la teneur relative en eau dans les feuilles.*

Mots-clés. *Résistance à la sécheresse – Teneur relative en eau – Photosynthèse nette –* Dactylis glomerata*.*

I – Introduction

Forage species have a strategic importance in semi-arid and arid regions. In Mediterranean areas, dry matter production of pastures and its seasonal distribution are strongly related to the meteorological pattern. The choice of suitable forage species and varieties, taking into account their growth behaviour and their adaptation to drought conditions, represents one of the main strategies to improve forage production in semi-arid areas. Drought resistance is generally defined as the maintenance of plant production during moderate or severe water deficit. Several studies have been carried out on drought resistance in annual forage species while less experimental results are available on perennial forage grasses (Sanderson *et al*., 1997; Ledda *et al*., 2002; Volaire *et al*., 2009). To identify the main ecophysiological characteristics of *Dactylis glomerata* L. conferring drought survival and high temperature resistance, as the ability to survive at low soil moisture under Mediterranean summer high temperature and drought, an experiment on one accession and four ecotypes of *Dactylis glomerata* L. was carried out.

II – Materials and methods

A study was carried out on 2010-2011 growing season at the Experimental Farm of the Agricultural Research Council in Sanluri (Sardinia, Italy, 39°31'N; 8°51'E, 60 a.s.l.). Five genotypes of *Dactylis glomerata* L. (one accession "Jana" and four Sardinian ecotypes "Ottava", "Bolotana", "Bonnanaro", "Bonorva") were compared in a drought resistance trial in a pot experiment under rain out shelter and in a high temperature resistance trial in a greenhouse. At the beginning of March 2011, after seed germination in seed benches, plants at the 5th leaf stage were transplanted in a container (25 x 0.8 m) arranged in a complete randomised design with five replication and utilized in the high temperature resistance trial (without water limitation). At the same time 2 plants per pot (45 litres each), utilized in the drought resistance trial, were transplanted using a horticultural substrate:soil:sand mixture (40:40:20) and well irrigated until the drought treatment started. In drought resistance trial, two water regimes were applied: 1) Control treatment, soil humidity was kept at the field capacity, 2) W1 treatment, the plants were exposed to progressive drought by restoring only 80% of soil water losses. In this second trial pots were arranged in a factorial complete randomised design with three replicates. Two times per week, pots were weighed to determine water losses and water volumes for irrigation. In greenhouse trial, temperatures (maximum and minimum) were daily recorded. Leaf Relative Water Content (RWC) were determined as the ratio between (leaf fresh weight – leaf dry weight) and (leaf rehydrated weight – leaf dry weight) expressed as a percentage; net photosynthesis, transpiration rate and stomatal conductance were monitored at leaf scale on young fully expanded leaves (one leaf x plant x pot) 4 times in pots trial and 5 five times in greenhouse trial by using a gas analyser (CIRAS-2, PP Systems International, Inc., MA, USA). Above ground plant biomass was observed too in both trials.

III – Results and discussion

Water content at field capacity was constantly maintained in the Control treatment, while W1 treatment reached the wilting point at the end of June (Fig. 1).

Inside the greenhouse the daily maximum temperature was higher than 50°C almost all days in July and August.

The above ground dry matter production results (Table 1), in drought resistance trial, showed a significant reduction due to the imposed water stress. Among genotypes, "Platamona" and "Jana" produced the highest dry matter amount.

In the high temperature resistance trial, the genotypes "Jana" and "Bonorva" showed the highest dry matter productions, while the lowest values have been observed in the ecotype "Bolotana".

In mid-July, in pots trial, leaf RWC was about 55% in the control treatment and decreased accordingly to water stress imposition at 29% in the W1 pots (Table 1). The accessions "Jana", "Bonnanaro" and "Bonorva" showed the highest RWC.

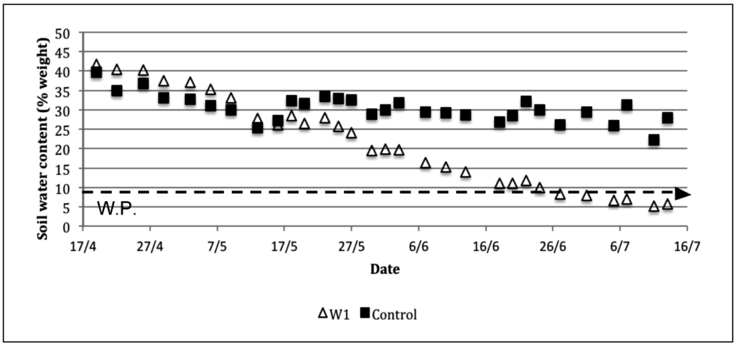

Fig. 1. Evolution of soil water content (% weight in two water regimes).

Table 1. Above ground dry matter production (DM) at the end of trials and relative water content (RWC) at 04/08/11 in greenhouse trial and at 14/07/11 in pots trial in relationship to ecotypes and water regimes

	DM (g pot^{-1})			DM (g plant^{-1})	RWC (%)			
	Pots			Greenhouse	Pots			Greenhouse
Genotypes	**Control**	**W1**	**Means**	**Means**	**Control**	**W1**	**Means**	**Means**
Jana	33.4	21.7	26.7a	61.3a	59.9	38.6	49.3a	74.0a
Bolotana	25.8	19.0	21.8b	25.3c	50.1	26.5	38.3ab	44.9b
Bonnanaro	24.6	23.7	24.2ab	37.0bc	72.2	25.2	48.7a	70.6ab
Bonorva	32.9	24.3	28.6ab	49.4ab	53.7	36.3	45.0a	59.1ab
Platamona	33.4	30.7	32.0a	37.4bc	41.5	20.2	30.8b	74.8a
Means	29.9a	23.9b			55.5a	29.4b		

Means followed by the same letter within each column are not significant different at P≤0.05.

In early August, in the greenhouse trial, the genotypes “Jana”, “Bonnanaro” and “Platamona” showed the highest RWC values (> 70%).

Regarding transpiration, no significant differences were observed among genotypes in drought resistance trial (data not shown), while W1 treatment showed significantly lower values than Control treatment between water regimes.

Similarly, stomatal conductance and net photosynthesis (Table 2) resulted higher in the Control treatment. Among genotypes, “Bonorva” showed the lowest stomatal conductance and net photosynthesis values, while the other ecotypes did not showed significant differences among their, for both parameters.

In the high temperature resistance trial, the ecotypes “Bolotana” and “Platamona” showed the lowest transpiration values, 2.8 e 2.7 mmoli (H_2O) m^{-2} s^{-1} respectively, with statistic differences from accession “Jana” (3.6 mmoli (H_2O) m^{-2} s^{-1}) (data not shown).

The genotypes “Jana”, “Bonnanaro” and “Bonorva” showed higher stomatal conductance values than 70 mmol (H_2O) m^{-2} s^{-1}, whereas “Bolotana” and “Platamona” showed about 53 mmol (H_2O) m^{-2} s^{-1} values (Table 2). The lowest net photosynthesis values (4.3 µmol (CO_2) m^{-2} s^{-1}) were observed in the ecotype “Platamona”.

Table 2. Stomatal conductance (GS) and net photosynthesis (PN) in both trials in relationship to ecotypes and water regimes

	GS (mmol (H_2O) m^{-2} s^{-1})				PN (µmol (CO_2) m^{-2} s^{-1})			
	Pots			Greenhouse	Pots			Greenhouse
Genotypes	Control	W1	Means	Means	Control	W1	Means	Means
Jana	110.0	66.6	88.3ab	75.8a	7.9	5.5	6.7ab	6.1ab
Bolotana	92.0	77.9	85.8ab	53.0b	6.4	6.2	6.4ab	6.3a
Bonnanaro	113.8	78.9	96.3a	74.3a	8.2	5.2	6.7ab	6.5a
Bonorva	78.8	60.4	69.6b	70.6ab	6.9	4.7	5.8b	5.5ab
Platamona	105.7	88.1	97.4a	53.3b	9.4	7.1	8.3a	4.3b
Means	100.0a	73.9b			7.8a	5.7b		

Means followed by the same letter within each column are not significant different at $P \leq 0.05$.

IV – Conclusions

The drought resistance experiment allowed a complete control of the drought imposition by pots water content monitoring and by a progressive soil water deficit simulation in late spring. At the beginning of the drought, in pots trial, and with maximum daily temperature lower than 40 °C, in greenhouse trial, plants maintained a high photosynthetic activity (data not shown), in order to accumulate carbohydrates used for the autumn vegetative re-growth (Volaire and Lelièvre, 1997).

In a drought resistance experiment (Salis *et al*., 2006) "Jana" showed a similar RWC and *Dactylis glomerata* above ground dry matter production genotypes confirming results of the present study in relation to the water imposition treatments.

Plant responses to high temperatures stresses was not always consistent with plant responses to water stresses.

Further investigations are still in progress on abscisic acid content (ABA) and on post-summer survival.

Acknowledgements

The work was funded by Regione Autonoma della Sardegna (PO Sardegna FSE 2007-2013) on L.R.7/2007 "Promozione della ricerca scientifica e dell'innovazione tecnologica in Sardegna".

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Adaptation of Australian self-reseeding forage legumes to three environments of Sardinia

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Abstract. The important role of annual self-reseeding legumes is well known and their use in livestock systems is consistent with low input agriculture trend. Australian commercial varieties of self-reseeding legumes mainly derive from Mediterranean basin germplasm. They have been selected for environmental conditions of southern Australia where they are cultivated. Each year a large amount of seed of Australian varieties is imported to southern Europe. Therefore it is necessary to investigate their adaptation and yield capacity to local environmental conditions. A two years trial was performed in three Sardinian sites with different pedoclimatic characteristics, with the aim to compare the agronomic performances of Australian self-reseeding legume varieties belonging to *Biserrula*, *Ornithopus*, *Medicago* and *Trifolium* genera. Earliness of flowering, forage yield and variety persistence in the second year were evaluated. Varieties of *Trifolium* spp. had the best productive performances, coupled with the highest persistence in subterranean clovers. Varieties of *Biserrula* and *Ornithopus* spp. proved to be not well adapted to the three sites and showed low herbage mass production.

Keywords. Self reseeding legumes – Forage yield – Persistence – *Trifolium* spp.

Adaptation de légumineuses fourragères auto-réensemençantes australiennes à trois environnements de la Sardaigne

Résumé. *Le rôle important des légumineuses annuelles auto-réensemençantes est bien connu et leur utilisation dans les systèmes d'èlevage est compatible avec une agriculture à faible input. Les variétés commerciales de légumineuses auto-réensemençantes australiennes dérivent principalement de matériel génétique du bassin méditerranéen. Elles ont été sélectionnèes pour le milieu du sud de l'Australie. Tous les ans une grande quantité de semences de variétés australiennes est importée dans l'Europe du Sud, par conséquent c'est nécessaire de vérifier leur capacité d'adaptation et de production de fourrage dans les environnements locales. Une expériméntation de deux ans a été réalisée dans trois localités sardes avec différentes caractéristiques pédoclimatiques, dans le but de déterminer la réponse agronomique des variétés australiennes de légumineuses auto-réensemençantes appartenant aux genres* Biserrula, Ornithopus, Medicago *et* *Trifolium. La phénologie, la production fourragère, et persistance dans la deuxième année ont été évalues. Les variétés du genre* Trifolium *spp. ont montré la meilleure réponse productive, et la plus élevée persistance pour le trèfle souterrain. Bien différent a été la réponse des genres* Biserrula *et* Ornithopus *spp. dans les trois localités, avec une production fourragère réduite.*

Mots-clés. *Légumineuses auto-réensemençantes – Production de fourrage – Persistance –* Trifolium *spp.*

I – Introduction

The benefits of forage legumes, as nitrogen fixation capacity, high nutritive value and voluntary feed intake, are well known and economically exploited in animal production systems (Rochon *et al*., 2004; Frame, 2005). The use of annual self-reseeding legumes is consistent with low input agriculture trend. Their ability to produce a variable quantity of hard seed allows them to persist several years without annual sowing, reducing costs for soil cultivation and seed purchase. This peculiarity is exploited in short (1 or 2 years) and long (3-6 years) crop rotation systems such as performed in many Australian farms (Nichols *et al*., 2007). Despite most of annual self-reseeding legumes have their origin in Mediterranean basin, Australian commercial varieties, that have been selected to mach the needs of Australian agriculture, sometimes proved to be unsuitable for local pasture improvement (Sulas, 2005). Therefore the aim of this work is to assess in different locations of Sardinia (Italy) some agronomic performances of several annual self-reseeding legume cultivars imported from Australia.

II – Materials and methods

The trial was carried out from October to June in 2009/10 and 2010/11 in 3 different locations of Sardinia, Bolotana, Olmedo and Ussana. The pedo-climatic characteristics of experimental site and their meteorological condition during the trial period are showed in Table 1 (meteorological data were provided by Sardinia Environmental Agency, ARPAS). Bolotana has a sub acid soil whereas Olmedo and Ussana have a sub alkaline soil. The latter has the highest values of assimilable phosphorus and exchangeable potassium. Seventeen Australian genotypes were compared: *Biserrula pelecinus* L. Casbah and Mauro, *Medicago polymorpha* L. Cavalier, *M. sphaerocarpus* Bertol. Orion, *Ornithopus compressus* L. Santorini, *O. sativus* Brot. Cadiz and Margurita, *Trifolium dasyurum* L. Sothis, *T. glanduliferum* Boiss. Prima, *T. hirtum* All. Hykon, *T. michelianum* Savi Paradana, *T. resupinatum* L. Prolific and Turbo Plus, *T. subterraneum* L. Antas and Denmark, *T. spumosum* L. Bartolo, *T. vesiculosum* Savi Zulu. The sown in each location was in October 2009. The adopted experimental design was a randomised block with 3 replications and 10 m^2 plots size. All species were inoculated with their specific rhizobia. In the two years total dry matter (DM) production of each variety was evaluated by cutting two 0.5 m^2 samples per plot at vegetative and full flowering stage. Fresh forage was completely dried in an oven-dryer at the temperature of 65°C. Moreover, to asses species earliness, the number of days between sowing and the first open flower were recorded. All data were analysed by ANOVA procedure using forage species and location as fixed effect (SAS, 2002).

Table 1. Main pedo-climatic characteristics of the three experimental locations

	Bolotana		Olmedo		Ussana	
Lat, Long	40°16'N, 8°58'E		40°40'N, 8°22'E		39°10'N, 3°20'E	
Altitude (m a.s.l.)	200		40		150	
Texture	sandy clay loam		sandy clay loam		sandy loam	
pH	6.1		7.8		7.9	
Organic C (g kg^{-1})	10.0		9.5		7.3	
Total N (g kg^{-1})	0.7		0.9		0.8	
Assimilable P (mg kg^{-1})	3.5		7.3		18.6	
Exchangeable K (mg kg^{-1})	141.6		81.7		204	
Climate	**Climatic mean**	**2009-11**	**Climatic mean**	**2009-11**	**Climatic mean**	**2009-11**
Min temperature (°C)	9.4	9.9	11.5	9.4	10.7	9.9
Max temperature (°C)	23.5	24.9	20.4	21.2	22.8	22.7
Rainfall (mm)	580	480	582	774	434	540

III – Results and discussion

During the years of the trial temperatures didn't differ from long term values and Bolotana showed the highest maximum temperatures (Table 1). Annual rainfall was above climatic mean in both Olmedo and Ussana and below in Bolotana. Overall genotypes belonging to *Trifolium* genus had the highest DM production in both years whereas *Biserrula* and *Ornithopus* spp. had the lowest (4.2 *vs* 1.6 and 1.1 t ha^{-1} in the first year, 1.3 *vs* 0.5 and 0.3 t ha^{-1} in the second year for *Trifolium*, *Biserrula* and *Ornithopus* spp respectively, P<0.05). In the first year, in Olmedo and Ussana, *T. vesiculosum* Zulu and *T. resupinatum* Turbo Plus and Prolific had the best performances, with more than 8 t ha^{-1} of DM production (Table 2). In Bolotana the Australian species had the lowest productions with a maximum of 4.8 t ha^{-1} in *T. vesiculosum* Zulu. In the second year *T. subterraneum* Antas showed the highest forage production in all sites, but *T. vesiculosum* Zulu, *T. michelianum* Paradana, *T subterraneum* Denmark in Ussana and *T. hirtum* Hykon and *T. subterraneum* Denmark in Olmedo produced over 2 t ha^{-1} of DM. Subterranean clovers performed well in all locations, confirming previous results obtained in Sardinia (Porqueddu *et al.*, 2010). Despite the species with high level of hardseedness had not relevant yield in the second year, *B. pelecinus* Casbah and Mauro produced in Ussana 2.1 and 1.2 t ha^{-1} respectively.

Table 2. Total dry matter (DM) production in the first and second year at the three locations Bolotana (BO), Olmedo (OL) and Ussana (US)

	DM yield 2009-10				DM yield 2010-11			
	BO	OL	US	spxlo LSD=	BO	OL	US	spxlo LSD=
Specie and cultivar	**t ha^{-1}**	**t ha^{-1}**	**t ha^{-1}**	**1.9 t ha^{-1}**	**t ha^{-1}**	**t ha^{-1}**	**t ha^{-1}**	**0.8 t ha^{-1}**
B. pelecinus Casbah	0.0e	1.8de	3.5de	*	0.0c	0.0f	2.1bc	*
B. pelecinus Mauro	0.0e	2.2de	2.0ef	*	0.0c	0.0f	1.2c-e	*
M. polymorpha Cavalier	0.2e	5.2c	4.5bd	*	0.0c	0.0f	0.0f	ns
M. sphaerocarpus Orion	0.2e	3.7dc	5.7b	*	0.1c	0.0f	0.0f	ns
O. compressus Santorini	0.4e	0.4e	1.7f	ns	0.0c	0.0f	0.0f	ns
O. sativus Cadiz	1.1de	1.7de	1.7f	ns	0.1c	0.5ef	0.7d-f	ns
O. sativus Margurita	1.1de	0.2e	1.1f	ns	0.2c	0.3f	0.9d-f	ns
T. dasyurum Sothis	1.0de	5.8c	4.7b-d	*	0.0c	1.3c-e	0.0f	*
T. glanduliferum Prima	3.4a-c	4.0dc	3.9cd	ns	0.1c	1.0c-f	0.8d-f	*
T. hirtum Hykon	1.2c-e	4.6c	3.5de	*	0.4c	2.4b	1.5cd	*
T. michelianum Paradana	3.2a-d	4.8c	3.8cd	ns	0.1c	1.9bc	3.0b	*
T. resupinatum Prolific	1.3c-e	9.3a	5.6bc	*	0.1c	0.7d-f	0.9d-f	*
T. resupinatum Turbo Plus	3.9ab	6.2bc	8.1a	*	0.0c	0.8d-f	0.4ef	*
T. subterraneum Antas	2.2b-e	5.2c	3.9cd	*	2.0a	5.0a	4.8a	*
T. subterraneum Denmark	1.3c-e	1.6de	1.4f	ns	1.5b	2.4b	2.6b	*
T. spumosum Bartolo	1.0de	5.1c	4.9b-d	*	0.0c	0.0f	0.0f	ns
T. vesiculosum Zulu	4.8a	8.2ab	8.1a	*	0.5c	1.6bd	2.5b	*
Average	1.5	4.1	4.0		0.3	1.1	1.3	
		P				P		
Specie		<0.001				<0.001		
Location		<0.002				<0.002		
Specie x location		<0.001				<0.001		

In the column of locations means followed by the same letter are not different at P = 0.05 (Duncan's test).
In the rows interaction specie x location least significant difference (spxlo LSD) is calculated at P = 0.05 (Duncan's test); * = significant; ns = not significant.

However in both years 11 species showed significantly interactions with the locations in forage production (Table 2). Flowering time highlighted wide differences of earliness in the studied species ranging from 118 to 196 days in *M. polymorpha* Cavalier in Bolotana and *T. resupinatum* Turbo Plus in Ussana, respectively (Fig. 1).

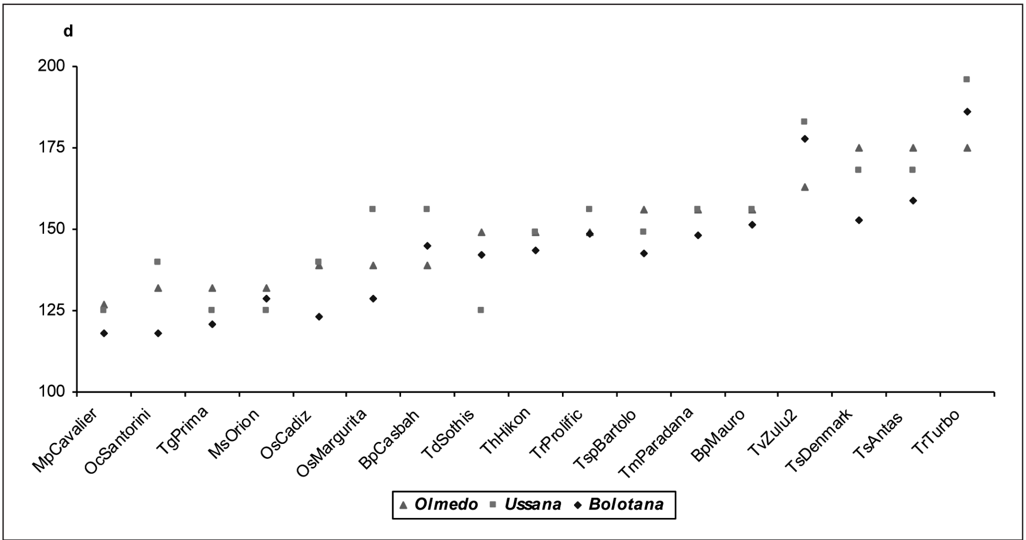

Fig. 1. Days between sowing and the first open flower of the forage species in the three locations.

IV – Conclusions

The different pedo-climatic characteristics of the locations strongly influenced the performances of the Australian species. Some species showed high level of hardseedness, up than 90% (data not shown), that could permit the regrowth in the subsequent years, adapting to ley farming systems. However the different behaviour of these species in such different environmental conditions allows a wide range of varieties choice for pasture establishment in the Mediterranean farming system. More studies should be necessary, in various pedo-climatic environments, to evaluate the suitability to grazing pressure with different animal species.

Acknowledgements

The authors wish to acknowledge Mr. G. Becugna, Mr. G. Casula, Mr. D. Dettori, Mr. S. Mastino, Mr. S. Nieddu, Mr A. Pintore and Mr. P. Saba for their collaboration in field activity and ARPAS for the provision of meteorological data.

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The fluoride effect (NaF) on germination and yield production of three local species of Poaceae fodder

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Abstract. The effect of fluoride (NaF) of three local species of rye grass (*Lolium multiflorum* Lamk***.,*** tall fescue *(Festuca arundinaceae*) and red canary grass (*Phalaris arundinaceae*) was analyzed at the concentration of 0; 10^{-1}M; 10^{-2} M and 10^{-3}M. The results showed that germination was effected by fluoride pollution. In fact, applying constant level of NaF caused considerable decrease in germinal capacity and power. At the concentration level of NaF solution over 2.33 g.l^{-1}. The process of germination was completely inhibited in the three studied species. Moreover, it is worth mentioning that fluoride was found to greatly affect fescue growth. In contrast, fluoride had a favorable effect on rye grass and reed canary grass growth. Such growth stimulation is explained by an elevation in the respiratory activity. On the other hand, biochemical estimations show that fluoride treatment disturb biosynthesis of both photoreceptor pigments and sugars. Finally, we can conclude that the response of these ecotypes to fluoride pollution seems to be relatively resistant to this type of pollution.

Keywords. Fluoride pollution – Germination – Growth – Chlorophyll – Sugars – Toxicity.

L'effect du fluorure (NaF) sur la germination et le rendement de trois espéces fourragères locales (Poaceae)

Résumé *Les effets de fluorures (NaF) sur trois graminées fourragères locale*s Lolium multiflorum *Lamk.,* Festuca arundinacea *Schreb.,* Phalaris arundinacea *L., ont été analysés aux concentrations suivantes: 0, 10^{-1}M, 10^{-2}M et 10^{-3}M. Les résultats obtenus montrent une réelle sensibilité de la germination à la pollution fluorée. En effet, l'application de doses croissantes de fluorures diminue considérablement la faculté et l'énergie germinative. Au delà de la concentration 2,33 g.l^{-1} de NaF, l'inhibition du processus de germination est totale chez les trois espèces. Par ailleurs, le fluor a affecté sensiblement la croissance de la fétuque et favorisé légèrement celle du ray-grass et l'alpiste, mais ces variations ne sont pas significatives. Concernant les paramètres biochimiques, on note que le fluor a nettement perturbé les voies de biosynthèse des sucres et les pigments photorécepteurs. Enfin on peut conclure que la réponse de ces écotypes au fluor se révèle relativement résistante à ce type de pollution.*

Mots-clés. *Pollution fluorée – Germination – Growth – Chlorophylles – Sucres-toxicité.*

I – Introduction

Fluoride is a phytotoxic pollutant. Its accumulation by plants and its migration to the periphery of the organs and the appearance of apical leaf necrosis are well known phenomena (Stevens *et al*., 1998; Fornasciero, 2001). This element will accumulate in the cytoplasm of plant cells and is up to 200 mg. kg^{-1} in dry tissue (Mezghani *et al*., 2005). The Annaba's region is an important industrial pole which rejects waste nature and many air and waste gas including fluorine fall out to the soil surface causing serious disturbances in the plant and animal communities (Semadi, 1989; Miller, 1993; Tsiros et Haidouti, 1998; Salesse, 2008) such as fluorosis poisoning (Cerklewski, 1997). The purpose of this study is to assess the effect of fluorine on i) germination and growth of plants with certain biochemical markers and ii) the phytotoxity by accumulation to preserve the cattle from poisoning.

II – Materials

Germination test: The germination test was conducted under standard laboratory conditions and he soaked seeds were grown in Petri dishes of 8.5 cm on two pieces of filter paper (Whatman 5). The experiment was set up in a completely randomized design with 3 replications of 20 seeds per variety, and 4 concentrations of NaF was added to the germination medium (0, 10^{-1}M, 10^{-2}M, 10^{-3} M). Treatment with solutions containing fluoride was made at a rate of 25ml per concentration. The germination rate (GR) is expressed as percentage of seeds (Shirafew and Baker, 1996).

Trial biomass production: Sowing was carried out in pots containing soil with sandy clay loam texture. Mineral fertilization was made to correct the defect in fertility with an NPK (15-5-15). Treatment with fluoride solutions was made from the 50th day of growth with three sprays of 25 ml per week. The plant biomass was harvested twice, first cut was made at the 80th day of growth and a second cut at the 150th day of cycle. After the second harvest, the roots also were cut and separated from the soil by washing with water. For biochemical assays, chlorophyll was measured by method of Hicox and Israelsam (1979). Soluble sugars were measured using the method of Schields and Burnett (1960) and fluoride in the leaves using the ionometric T.IS.A.B-C.D.T.A amended method (Devilliers, in Semadi, 1989). Data from germination and dry matter yield was statistically analyzed by ANOVA 2 (Minitab Inc., 2003).

III – Results and discussion

1. Rate and speed of germination

The results (Table1) showed that seed treatment with fluorides at 10^{-1}M level inhibited completely the rate and speed of germination of three studied species. The canary grass was the most sensitive to fluoride since concentration10^{-2}M also inhibited germination, while the other two species (rye-grass and fescue) had the most sensitive to fluoride since concentration10^{-2}M also inhibited germination, while the other two species (ryegrass and fescue) had their germination rate reduced by 50%. A second germination test showed that the toxic threshold of inhibition was 33 g.l^{-1}.

Table 1. Rate and speed of germination

	Rye-grass		Tall fescue		Red canary grass	
	RG (%)	Vm (seed/day)	RG (%)	Vm (seed/day)	RG (%)	Vm (seed/day)
Control	100	11.1	59.7	5.4	50.0	3.1
10^{-1}M	–	–	–	–	–	–
10^{-2}M	33.30	3.70	20.0	2.1	–	–
10^{-3}M	83.30	9.2	31.1	3.5	31.7	1.7

2. DM biomass yield

The results showed that the biomass yield did not seem to be affected significantly (NS) neither the first cut nor the second cut by fluorine treatment (Table 2). Moreover, species responded differently to this type of pollution ($P<0.05$). On root biomass, the same observation was reported; fluorine did not exert significant negative effect from the statistical point of view. The content of 10^{-1}M had no effect on ryegrass root but reduced the weight of fescue and stimulated that of the canary grass. The doses of fluoride used did not exert any significant effect on the performance of dry matter (DM). The decreased biomass in the second cut was due to “cutting effect” and the low yield was explained by the negative fluorine action on hormone and enzymatic systems (Deruelle and Lallemant, 1983).

Table 2. DM production of biomass and belowground (g. pot^{-1})

	Rye-grass		Tall fescue		Red canary grass	
	1st cut	**2^{ed} cut**	**1st cut**	**2^{ed} cut**	**1st cut**	**2^{ed} cut**
Aerial biomass						
Control	2.1 ± 0.1	1.0 ± 0.2	1.7 ± 0.3	1.0 ± 0.4	1.8 ± 0.3	1.0 ± 0.4
10^{-1}M	2.1 ± 0.3	1.1 ± 0.1	0.7 ± 0.3	1.2 ± 0.3	2.9 ± 0.5	0.3 ± 0.1
10^{-2}M	2.8 ± 1.3	0.9 ± 0.3	1.2 ± 0.1	1.3 ± 0.5	2.2 ± 0.4	0.6 ± 0.2
10^{-3}M	2.9 ± 0.5	0.9 ± 0.3	1.4 ± 0.5	0.7 ± 0.1	2.0 ± 0.2	0.4 ± 0.2
Belowground biomass						
Control	0.4 ± 0.1		1.3 ± 0.1		0.4 ± 0.1	
10^{-1}M	0.4 ± 0.1		1.2 ± 0.2		0.5 ± 0.1	
10^{-2}M	0.7 ± 0.1		1.3 ± 0.2		0.4 ± 0.1	
10^{-3}M	0.5 ± 0.1		1.2 ± 0.1		0.4 ± 0.0	

3. Chlorophyll content

The effect of fluoride on chlorophyll content of leaves was observed. The results (Table 3) showed that the total amount of chlorophyll increased in all treated plants of rye grass. However, tall fescue showed reduced chlorophyll content in leaves was in canary grass, low doses of fluoride (10^{-2}M and 10^{-3}M) stimulated chlorophyll synthesis in leaves while the high dose (10^{-1}M) inhibited. During the second cut, it was observed that the fluorine always tend to raise the chlorophyll content. In fact, fluoride distrupted the synthesis pathways of chlorophyll. It was responsible for the content reduction by inhibition of the synthesis or by conversion into the corresponding pheophytins.

Table 3. Chlorophyll content in leaves (mg.g^{-1} of FM)

	Rye-grass		Tall fescue		Red canary grass	
	1st cut	**2^{ed} cut**	**1st cut**	**2^{ed} cut**	**1st cut**	**2^{ed} cut**
Control	1.07	6.35	1.61	0.93	1.65	1.30
10^{-1}M	0.13	1.01	0.67	1.30	0.81	4.20
10^{-2}M	0.70	1.20	1.07	1.54	1.08	1.60
10^{-3}M	0.74	1.93	1.13	1.25	1.12	4.95

4. Soluble sugar content

During the first period of growth, ryegrass contained more soluble sugars than the fescue and canary grass in the control plants (Table 4). In contrast,, fully grown this species first undergoes a drastic reduction and ends up with a rate two times lower than the other two species (tall fescue and red canary grass). However, in treated groups, fluorine distrupted metabolism carbohydrates. The highest concentration (10^{-1}M) causeda stimulation of the sugars synthesis. Carbohydrate metabolism was also affected by fluoride. At low doses, fluoride can stimulate soluble sugar content, while high concentrations of fluorine reduce the sugar content (Garrec *et al.*, 1981).

Table 4. **Soluble sugar content in leaves (mg.g^{-1} of FM)**

	Rye-grass		Tall fescue		Red canary grass	
	1st cut	2^{ed} cut	1st cut	2^{ed} cut	1st cut	2^{ed} cut
Control	97.72	10.80	68.62	20.50	81.13	24.14
10^{-1}M	37.42	6.40	39.80	14.60	55.20	24.20
10^{-2}M	43.12	4.50	67.82	11.80	78.82	21.65
10^{-3}M	72.80	17.90	92.80	33.70	90.97	22.80

5. Leaves fluoride content

Fluoride content in the leaves (Table 5) showed that ryegrass and canary grass accumulate constant to relatively low levels during the two cuts. These vary between 17.5 and 21.04 µg.g^{-1} DM for the respective concentrations of Co (control) and 10^{-1}M. In contrast, fescue seems accumulate more fluoride (1.5) than the other species (34.80 µg.g^{-1}) with the treatment dose of 10^{-1}M. Fluoride accumulated in the leaves of the three species was greater than 10 µg.g^{-1}of DM. They were considered phytotoxic and can induce serious metabolic disturbances (chlorosis, necrosis). Furthermore, the ingestion of these forage by cattle would not cause the fluorosis disease, because the observed levels were below 40 µg.g^{-1}, threshold toxic to animals (Plebin and Garrec, 1986).

Table 5. Leaves fluoride content in (µg.g^{-1}of DM)

	Rye-grass		Tall fescue		Red canary grass	
	1st cut	2^{ed} cut	1st cut	2^{ed} cut	1st cut	2^{ed} cut
Control	–	–	–	–	–	–
10^{-1}M	18.80 ± 0.2	18.70 ± 0.1	34.8 ± 0.3	16.5 ± 0.3	21.04 ± 0.5	19.90 ± 01
10^{-2}M	18.12 ± 0.1	18.12 ± 0.3	29.6 ± 0.1	16.7 ± 0.5	20.60 ± 0.4	15.40 ± 0.2
10^{-3}M	17.50 ± 0.4	17.50 ± 0.3	26.2 ± 0.5	16.2 ± 0.4	20.20 ± 0.2	20.20 ± 0.2

IV – Conclusions

This work shows that fluoride reduces germination by acting on the system involved enzyme (degradation of reserves and production of the energy required for this phenomenon). The dose-effect is important. Growth biomass, production of DM was also weakened by fluoride, disrupting photosynthesis by inhibiting the metabolism of chlorophyll and sugars. Moreover, the accumulation of fluoride in the leaves shows that these levels are phytotoxic causing chlorosis and necrosis but below threshold (<40µg.g^{-1}DM) can cause fluorosis disease to cattle.

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Yield and nitrogen fixation capacity by inoculated white lupin (*Lupinus albus* L.)

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Abstract. White lupin (*Lupinus albus* L.) crop can gain a renewed interest due to its higher crude protein yield than other rainfed grain legumes, and for the request as an ingredient of functional or healthy food products. It is a new crop in Sardinia (Italy) and very few studies provide information about the N fixation ability of this species which needs to be preferably evaluated at local level from direct measurements. This study was aimed at quantify the DM yield and the N fixed by white lupin, using the Isotopic Dilution method, in three Sardinian sites. Grain dry matter yield and its N proportion did not differ between sites whereas the proportion of N derived from the fixation showed a wider variation. The aerial DM of white lupin fixed from 140 to about 270 kg ha^{-1} of N. Even if results differed among sites, very high percentages of N derived from the atmosphere were found and a relationship of 53.7 kg of fixed N per tonne of grain DM produced by this legume was established.

Keywords. Legumes – % Ndfa – Fixed N – Straw – Grain yield.

***Rendement et capacité de fixation d'azote par le lupin blanc inoculé* (Lupinus albus)**

Résumé. *La culture du lupin blanc (*Lupinus albus *L.) peut trouver un nouveau intérêt en raison de son rendement de protéine brut plus haut que celui d'autres légumineuses de grain et pour la requête comme un ingrédient de produits alimentaires fonctionnels ou sains. C'est une nouvelle culture en Sardaigne (Italie) et très peu d'études fournissent des informations sur la capacité de fixation de l'azote (N) de cette espèce qui doit être de préférence évaluée au niveau local avec des mesurages directs et une méthodologie appropriée. Cet étude concerne la quantification du rendement de matière sèche et de N fixé donné par le lupin blanc, en utilisant la méthode de Dilution Isotopique, dans trois localités sardes avec des caractéristiques du sol différentes. Le rendement de matière sec du grain et sa proportion de N ne diffèrent parmi les localités tandis que la proportion de l'azote provenant de l'atmosphère a montré une variation plus large. La matière sèche aérien de lupin blanc a fixé de 140 à environ 270 kg ha^{-1} de N. Même si les résultats ont différé parmi les localités, des pourcentages très élevés de N provenant de l'atmosphère ont été trouvés et une relation de 53.7 kg de N fixé par t de grain produit par cette légumineuse a été établie.*

Mots-clés. *Légumineuses – % Ndfa – N fixé – Paille – Rendement en grain.*

I – Introduction

Leguminous crops can contribute to a more sustainable agriculture in both traditional and organic farming systems. White lupin (*Lupinus albus* L.) is an interesting crop due to its low alkaloid lines, higher crude protein yield than other rainfed legumes such as pea, faba bean and narrow leafed lupin, and for the request as an ingredient of functional or healthy food products (Annicchiarico, 2008; Annicchiarico *et al.,* 2010; Chiofalo *et al.*, 2012). White lupin is an old species mainly distributed around the Mediterranean and cultivated for thousand years. There is renewed interest in it in southern Europe, where this crop is mainly grown in France, Spain and Portugal

(Huyghe, 1997). White lupin is a new crop in Sardinia (Italy), where information on its adaptation and N fixation ability is almost absent. As a general rule, legumes can fix from 1.5 to 2.5 kg of shoot N per 100 kg of shoot dry matter. However such relationship, arisen from Australian works, represents a gross generalization that cannot be considered for a widespread application. In fact, specific information concerning the effects of crop genotype and environmental conditions on legume N fixation can come only from direct measurements of N fixation, preferably at local level, using an appropriate methodology (Unkovich and Pate, 2000). This study was aimed at quantify the DM yield and the N fixed by white lupin crops in Sardinia, using the Isotopic Dilution method. The paper reports the main results obtained in the first year of the experiment.

II – Materials and methods

The field experiments were conducted during 2009-10 in Sardinia at three locations, with different soil types and rainfall amounts (Table 1). The total rainfall from September 2009 to August 2010 were 27, 9 and 44% greater than the long-term means for the Stintino, Chilivani and Sanluri sites, respectively.

Table 1. Main pedo-climatic characteristics of the three experimental locations

Location	Stintino	Chilivani	Sanluri
Latitude/longitude	40° 52' N, 8° 15' E	40° 36' N, 8° 58' E	39° 31’ N, 8° 51’ E
Altitude (m.a.s.l.)	6	200	60
† Avg. temp. (°C) /rainfall (mm)	15.2/590	15.2/560	17.6/430
†† Rainfall (mm)	752	612	618
Soil series (FAO, 1988)	*Haplic Nitosols*	*Lithic leptosols*	*Eutric fluvisuols*
Sand/ silt/ clay (%)	81/9/10	81/11/8	45/ 25/30
pH	6.0	6.6	7.6
Total N (g kg^{-1})	1.7	1.3	1.2
P (mg kg^{-1})	2.6	8.3	16.2

† Long-term year means.

†† From September 2009 to August 2010.

At each locations, where this crop had not been sowed before, stands of white lupin cv Multitalia were established in Autumn by sowing 60 kg ha^{-1} of viable seed. Seeds were inoculated with *Bradyrhizobium lupini* (Souche LL13). Native annual grasses and wheat, sown at a seed rate of 190 kg ha^{-1} were used as non fixing reference species. Plots were arranged in a complete randomized design with four replicates. The size of each experimental unit was 4.5 x 7.5 m. All plots were fertilized with about 100 kg ha^{-1} P_2O_5 using triple superphosphate before seeding. Seedbed was prepared using conventional tillage consisting of 30-cm depth ploughing and superficial harrowing. No irrigation, fertilizer, or herbicide was applied after sowing. A rate of 4 kg N ha^{-1} of enriched ^{15}N fertilizer (10 atom %^{15}N enriched ammonium sulfate) was applied to a 3 m^2 area of non-fixing reference species and white lupin. At maturity, dry matter production was determined by cutting the aerial biomass at 5 cm above ground level over the same 3 m^2 ^{15}N enriched area within each experimental unit, subdividing into grain and straw, and drying the material at 65°C in a forced-air oven until it reached a constant weight. Dry samples of grain and straw were ground finely enough to pass through a 1 mm mesh and subjected to elemental analyzer isotope ratio mass spectrometry at the laboratory Iso-Analytical Limited (Cheshire, United Kingdom) to determine both N and the atom%^{15}N content. The proportion of white lupin N derived from atmosphere (%Ndfa) was calculated by the ^{15}N dilution method, as described by Warembourg (1993) and the ^{15}N excess of each different legume plant portion was compared with the corresponding value of the reference non-fixing crop. The amount of N fixed was calculated by multiplying white lupin N yield (kg ha^{-1}) per %Ndfa/100. All data were analysed by ANOVA and separation of mean values by least significance difference (LSD) test at 5% probability.

III – Results and discussion

Straw dry matter yield differed significantly between sites; it ranged from 3.4 t ha^{-1} at Chilivani to 8.5 t ha^{-1} at Stintino where stems were as tall as Chilivani (Table 2). The higher straw yield was probably caused by the mild weather conditions of this site very close to the sea. Grain yield ranged from 2.2 to 2.9 t ha^{-1}. Nitrogen content of grain was from three to more than six times higher than that of the straw. Grain yields were lower to those obtained in other Italian environments (Annicchiarico, 2008).

Table 2. White lupin plant height, straw and grain dry matter yield and its N concentration at the three locations during 2009-10

	Height (cm)	Dry matter yield (kg ha^{-1})			N concentration (%)	
Location	Plant	Straw	Grain	Total	Straw	Grain
Stintino	124a	8.5a	2.2a	10.7a	1.8a	5.4b
Chilivani	80b	3.4c	2.4a	5.8c	1.1b	5.8ab
Sanluri	119a	5.5b	2.9a	8.4b	0.8b	6.1a

Means followed by the same letter within each column are not significant different at P≤0.05.

The atom%^{15}N excess in each legume biomass component was overall significantly lower than that in the corresponding component of the reference species at each locations (data not shown), due to its dilution with atmospheric N. The Ndfa of white lupin (Table 3) reached about 95% at Stintino for both biomass components, it was slightly lower at Chilivani and significantly lower at Sanluri (-40%), indicating a reduced N fixation activity at this site. The Ndfa percentages at Stintino and Chilivani sites were quite similar to those reported by Carranca *et al.* (2009) for the same legume species grown in central Portugal.

Table 3. Nitrogen yield, proportion of N derived from the atmosphere (Ndfa) and amount of fixed N in straw and grain of white lupin at the three locations during 2009-10

	Nitrogen yield (kg ha^{-1})		Ndfa (%)		Fixed N (kg ha^{-1})	
Location	Straw	Grain	Straw	Grain	Straw	Grain
Stintino	162.3a	124.5a	94.6a	95.1a	153.7a	118.4a
Chilivani	40.6b	143.1a	87.2a	90.2a	35.5b	129.7a
Sanluri	48.9b	182.2a	54.2b	59.3b	27.7b	112.6a

Means followed by the same letter within each column are not significant different at P≤0.05.

The amount of fixed N in straw exceed 150 kg at Stintino whereas it was significantly lower at the remaining locations. The fixed N in the grain was similar among locations and it was on average 120 kg ha^{-1}. Nevertheless, considering the total N in grain, which is the component usually removed from the field, the proportion of grain N derived from the soil represented only 5% at Stintino and about 41% at Sanluri due to its lower Ndfa percentage. Even if below ground pool N is not considered in this work, the N balance remained positive at Stintino after grain harvesting and removal (+35 kg ha^{-1} of N), whereas it was negative at the remaining locations. The total N fixed by white lupin in its aerial biomass (straw + grain) ranged from 140 (Sanluri) to about 270 kg ha^{-1} (Stintino). It is worth noting that the lowest value reached those recorded for annual and perennial forage legumes in previous experiment carried out in Sardinia (Sulas and Sitzia, 2005; Sulas *et al.*, 2009). Considering the data from the two locations where % Ndfa for grain reached on average 92.6%, the regressions of the fixed N for white lupin grain on the corresponding DM yield (Fig. 1) showed a relationship of 53.7 kg of N per tonne of grain DM.

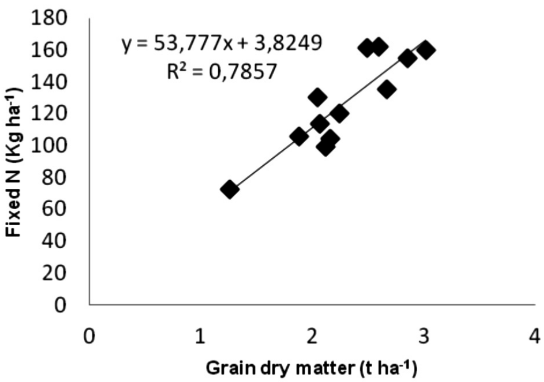

Fig. 1. The relationship between fixed N and dry matter yield in white lupin grain.

IV – Conclusions

White lupin crop showed good adaptation and performances. However, the range of Ndfa percentage was wide and a high capacity of white lupin to fix N was recorded in two of three locations under study. An interesting relationship for fixed N per tonne of grain produced by this legume was established.

Acknowledgements

The authors wish to thank Dr. Antonio Demelas from LAORE Agency of Sardinia for his collaboration, Dr. Stefano Taras for hosting the experimental trial in his farm and Mr. Piero Saba at CNR ISPAAM and Mr. Maurizio Pitzalis at CRA-AAM for their technical assistance in field.

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Session 3
Role and management of permanent grasslands

Role and management of permanent grasslands

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Abstract. Permanent grasslands are open areas covering nearly one fourth of the total land area in the world. Temperate grasslands such as prairies, pampas, steppes or paramos have hot and dry summers, and rainy cool winters. Grasslands are vitally important for livestock as a feed source, environmental protection, conservation of genetic resources, preservation of natural resources, sustainable agriculture, wildlife habitat, tourism and leisure. As a science and technique, the grassland management provides the maximum production with the conservation of vegetation, soil and the other natural resources. The effective management of grasslands depends on a number of different factors such as the characteristics of grassland, plant species, livestock type and environmental sources. Use of proper grazing system is the most important practice in management. The main principles of grazing management are grazing capacity in relation to the number and kind of animals, grazing period and grazing distribution. Grassland management also involves weed control, fertilization, burning, and seeding with natural grasses or other plants.

Keywords. Pasture – Meadow – Livestock – Grazing.

Rôle et gestion des pâturages permanents

Résumé. *Les pâturages permanents sont des espaces ouverts qui représentent presque le quart de la surface totale des terres du monde. Les pâturages tempérés tels que prairies, pampas, steppes ou "paramos" ont des étés chauds et secs, et des hivers froids et pluvieux. Les pâturages sont d'une importance vitale pour le bétail comme source d'aliment, protection environnementale, conservation des ressources génétiques, préservation des ressources naturelles, agriculture durable, habitat pour la vie sauvage, tourisme et loisirs. Du point de vue scientifique et technique, la gestion des pâturages permet un maximum de production tout en conservant la végétation, le sol et les autres ressources naturelles. La gestion efficace des pâturages dépend de plusieurs facteurs différents tels que caractéristiques des pâturages, espèces végétales, type de bétail et sources environnementales. L'utilisation d'un système approprié de pâturage est la pratique la plus importante en matière de gestion. Les principes essentiels de la gestion de la paissance sont la capacité de paissance liée au nombre et au type d'animaux, et la période et distribution de la paissance. La gestion des pâturages implique également le contrôle des mauvaises herbes, la fertilisation, le brûlage, et l'ensemencement avec des graminées naturelles ou d'autres plantes.*

Mots-clés. *Pâturage – Prairie – Bétail – Paissance.*

I – Introduction

Grasslands are wide and open areas where grasses and other herbaceous plants are dominant. They exist on every continent except Antarctica. The major units in vegetation are grasses with few or no trees. Grassland was defined by UNESCO as “land cover with herbaceous plants with less than 10 percent tree or shrub cover (White, 1983; cited in Anonymous, 2011a). In the same source, wooded grassland is explained as “the vegetation with grasses and grass-like plants with 10-40 percent tree or shrub cover”.

Worldwide agricultural area is 13 billion hectares. Grasslands as permanent meadows and pastures cover nearly 25.8 % of the land area with 3.355 million ha (FAO, 2011). The area covers 68.6% of total agricultural land. In contrast, permanent meadow and pastures (14.6 million ha) cover nearly 19 % of the total land area and 37.4 % of total utilized agricultural land in Turkey (TurkStat, 2012).

The grasslands are grouped into two categories, tropical and temperate grasslands. Tropical grasslands called as savannas being hot all year with wet seasons are located between the Tropic of Cancer and the Tropic of Capricorn. Temperate grasslands having hot summers and cold winters are in the north of the Tropic of Cancer in Northern Hemisphere, and in the south of the Tropic of Capricorn in Southern Hemisphere.

There are different names for temperate grasslands scattered around the world such as prairies, pampas, campos, paramos, steppes and veldts (Anonymous, 2011b). Prairie refers to the grasslands located interior parts of North America. Pampas are the lowlands in Argentina, South America. Campos meaning field in Spanish lies in Uruguay and Brazil with few trees or shrubs. Paramo is high, tropical, mountainous vegetation above the continuous timberline located in “the northern Andes of South America and adjacent southern Central America. Veldt refers to the wide open rural spaces in South Africa covered in grass or low scrub. Steppes occurring in Europe and Asia have semi-arid and continental climate. A great amount of these grasslands have been transformed to fields for agriculture.

In 1998, Allaby stated that grassland occurs where there is sufficient moisture for grass growth, but where environmental conditions prevent tree growth. Its occurrence, therefore, correlates with a rainfall intensity between that of desert and forest (Anonymous, 2011a). Anderson (2012) reported that there is not a single climate for all grasslands, and they occur in the areas of the earth that receive as little as 200 mm of precipitation annually to areas that have 1300 mm annually while mean temperatures vary from 0 to 30^{o}C.

Permanent grasslands are located between upper parts of the cultivated fields and lower zones of the forests (Altın *et al*, 2005). Upland grasslands, Subalpine and Alpine pastures, having a shorter vegetation period occur above the forests. In many areas, grasslands separate forests from deserts. Tropical savannah occurs in Africa, Australia, South America and Indonesia with a yearly rainfall of 50-130 cm. Some temperate grasslands have less rainfall, 25-90 cm, than tropical ones (Anonymous, 2011b).

The Mediterranean basin covering some parts of three continents lies west to east from Portugal to the shores of Lebanon, north to south from Italy to Morocco. The region has Mediterranean climate meaning rainy, mild or cool winters with hot and dry summers. The Mediterranean topography consists of high mountains, long beaches, intensive scrubs, grasslands as semi arid steppes or coastal wetlands (Sundseth, 2000). Knight (1983) described the region as an extensively modified environment, coastal land is modifying by cool or warm sea currents, some areas by the mountainous systems, others having continental climates due to distance from the oceans.

II – Role of permanent grasslands

The importance and roles of the permanent grasslands were grouped in 5 categories: feed source for livestock, conservation of genetic resources, sustainable agriculture, preservation of natural resources, and wildlife habitat.

1. Feed source for livestock

Grasses are the main component of grasslands. There are also sedges, rushes with some trees and shrubs that vary in number dependent upon the ecological conditions. Pasture and meadows are essential feed source for livestock, and provide forage for a certain period of the year.

The cost of grassland management is lower than that of growing crops which requires several operations every year such as tillage, sowing, harvesting, etc. Grasslands provide more benefits to the farmers in terms of income from the unit area than the cultivation of field crops, especially on marginal lands. They can occur on these marginal areas that are unsuitable for proper cultivation of crops in consideration with soil, slope or topography. In comparison with fodder crop production, grasslands have more nutritious and palatable plants and are more resistant or tolerant to the stress conditions such as drought or flooding than crops. Besides grazing animals are healthy and strong in addition to being resistant to diseases.

On the other hand, it is necessary to produce hay or silage to feed the animals during the winter. Farmers need available fields or they must use some parts of grasslands to grow forage crops. In fact, as Carlier *et al* (2009) emphasized, grasslands have been converted into cropland which caused reduction of grassland area and overgrazing the remaining parts in Western Europe. Similar event occurred in Turkey resulting in a serious decrease of permanent pasture and meadows from approximately 37 million hectares in 1950's to 14 million hectares in 2000's. Grassland area declined from 48.7% to 19% of total land area (Öğüt and Eryılmaz, 1991).

2. Conservation of genetic resources

Genetic resources are vitally important for the agricultural production. Breeders need a wide range of germplasm existing in the nature to improve crops. Hawkes (1981) said that such a large germplasm including cultivars, breeding lines and also wild species is necessary. As the world's population increases, the food requirement largely depends on the conservation and utilization of plant genetic resources.

Grassland plants have evolved under the influence of periodic droughts, frequent burning, and grazing animals and adapted to all of them (Anderson, 2012). This evolution together with so many different ecological conditions created a great biodiversity. Alrababah *et al* (2007) stated that biodiversity has become a very important issue recently in arid and semi arid ecosystems and grasslands, and conservation of these systems is more important in terms of species richness. Grasslands having many different plant and animal species as well as other organisms are important reserves for genetic resources and biodiversity.

The Mediterranean region is the centre of origin and diversity of many crops, especially cereals and legume species such as wheat, barley, oats, chickpeas, lentils etc. with a large number of endemics (Robertson and Bounejmate, 1999). The region also has a lot of wild species related to those crops.

Reid and Bennett (1999) defined genetic erosion as the loss of genetic material (genes, genotypes) and also the habitat of a specific taxa. The main causes of genetic erosion are changes of production systems, replacement of old local varieties with high yielding varieties, excessive use of chemicals, urban expansion and industrial development. Carlier *et al* (2009) emphasized the disappearance of many species through the conversion of native grasslands into monocultures of forage crops causing deterioration of biodiversity. They also cited that grasslands for summer grazing and maize silage for winter feeding are the only processes in modern dairy farms in EU.

Overgrazing is another reason for the loss of genetic resources, which makes the proper management and conservation of permanent grasslands more important.

3. Sustainable agriculture

Grasslands are an important factor for sustainable agriculture. Well managed grasslands and rangelands can promote sustainable agriculture (Anonymous, 2011a). Potter and Paulette (2004) pointed out some criteria for the conservation and sustainable management of forests, which can be applied to the grasslands: conservation of biological diversity, maintenance of productive capacity, health and vitality of the ecosystems, conservation and maintenance of soil and water resources, maintenance of contribution to global carbon cycles, maintenance and enhancement of long term multiple socio economic benefits to meet the needs of societies.

They defined ecological sustainability as the maintenance and restoration of the composition, structure, and processes of ecosystems over time and space. Grassland vegetation also has a vital role for erosion control in consideration with sustainability.

4. Preservation of natural resources

Grasslands are a mixture of different grass species, legumes and herbs, and act as carbon sinks, erosion preventives, birds sanctuary areas, habitats for small animals, and nitrogen fixation sources. They are able to sequester about double the quantity of carbon in comparison to arable land. Prevention of erosion and the immobilization of leaching minerals are interesting additional effects in the frame of a sustainable agriculture and development of the countryside areas (Carlier *et al*, 2009).

Pasture and meadows preserve natural resources and the environment, maintain high micro and macro flora activity in the soil, and increase soil porosity. Grasslands provide carbon and water storage, recreation and watershed protection. Most grasslands are important catchment areas for the water resources. Grazing mismanagement damages the grassland and also causes serious damage to agricultural land and siltation of irrigation systems and reservoirs because of increased erosion and run-off. Minahi *et al* (1993) state that they are almost as important as forests in the recycling of greenhouse gasses and that soil organic matter under grassland is of the same magnitude as in tree biomass (Anonymous, 2011a).

Sperling (2011) indicates that healthy rangelands capture, store, and safely release water from rainfall and snowmelt. Industrial development, tourism and leisure facilities such as swimming pools and water parks cause excess consumption of water. From this point of view, grasslands have become more important.

Grasslands are important for tourism and leisure in some areas, some may have sites of religious significance (Anonymous, 2011a). They are not only furnishing a habitat for wildlife, both flora and fauna, but also contributing to the attractiveness of the landscape. Pasture and meadows are generally colourful and aesthetic appearance. They have an aesthetic role and recreational function as providing public access that other agricultural areas usually do not allow (Carlier *et al*, 2009).

5. Wildlife habitat

Sperling (2011) classified the biotic components of grasslands as producers (plants), consumers (animals) and decomposers (microorganisms and insects), and indicated that grasslands throughout the world are essential to the survival of plants, animals, and bird species. Grasslands provide important breeding grounds for many bird species. Grasslands support a variety of wildlife species. In fact, some kinds of birds cannot live in any other ecosystem (Anonymous, 2012a). Grasslands are also primary food resources for wild herbivores.

Farrel (2006) listed grasslands and wildlife relationships. According to the writer, grasslands provide habitat for many animals, provide food for wildlife at different times of the year, form a cover for small animals, especially the birds, hiding from predators, protect them from bad weather, and make up a nesting habitat for them

III – Grassland management

There are a lot of factors causing the degradation of grasslands (Carlier *et* al, 2009; Anonymous, 2011a); converting the grasslands into cropland, grazing heavily by livestock, fire whether spontaneous or arson, subdivision with or without fencing, and provision of water points to extend the grazing area or season.

Grassland management deals with the conservation and utilization of pastures and meadows. A good management produces grass for the livestock, maintains wildlife habitats, conserves the soil and other natural sources, and preserves the landscape.

Grassland management's goal is to maximize the production and utilization of grasslands as much as possible without any damages to the environmental sources such as soil and water, and living organisms. Gençkan (1985) defines the grassland management as "a science of utilization of grasslands to get maximum animal production together with the conservation of vegetation, soil and the other natural resources".

Grassland ecosystem consists of plants, animals and the environmental conditions with the interactions among them. The production capacity of grasslands depends on these factors. (Anonymous, 2011c). For a better understanding and efficient management of the grasslands, it is important to have sufficient knowledge on these components and the interactions between them. The first step for good management is to define objectives in consideration with all components concerned and then to make decisions about how to manage the grassland. Proper grassland management not only increases the amount and quality of feed, but also improves growth rate of the livestock.

Grazing is the most important issue in the management. The main factors that provide maximum utilization of the grasslands are grazing capacity, grazing period, uniform distribution and, kind and class of animals. Grassland management also involves some cultural techniques such as weed control, fertilization, seeding with natural species, and preventing the growth of shrubs.

1. Grazing capacity

Grazing capacity is the maximum number of animals on a given management unit without any damages to vegetation and other environmental resources such as soil and water for a period of time. Stocking rate refers the number of animals concerned. If stocking rate is above the capacity, it means overgrazing which causes deterioration of the grasslands. This happens in vast majority of pasture and meadows in some countries including Turkey.

Animal unit, size of the grassland and available forage yield are used to calculate grazing capacity. Animal unit (AU) is one mature bovine weighing 500 kilograms with a dry matter intake of 12.5 kilograms per day. If the vegetation is uniform, overall size of pasture can be used for calculations. When the pasture has different types of vegetation, size of each is determined separately. Available forage yield is half of the actual yield of the grassland.

Grazing capacity (GC) is equal to:

GC = [Size (ha) x Available yield (kg ha^{-1})] / [Dry matter intake per AU (kg day^{-1}) x Grazing period (day)]

Grazing period is about 150 days in East Anatolia and 200 days in coastal areas. The area per Animal Unit equals to:

Area (ha) / AU = [Dry matter intake per AU (kg day^{-1}) x Grazing period (day)] / [Available yield (kg ha^{-1})]

The area per animal unit was 4.45 hectares in Turkey in 1940's. It was much higher than the present day's value of 0.85 hectares (Yavuz, 2011).

Grazing pressure is the relationship between the number of animal units and forage dry matter production per a management unit at a certain point in time. Overgrazing is concerned if the animals consume more than 60% of total forage produced by the management unit in a grazing season. The desirable plants disappear or lose their vigour by grazing too many animals or heavily grazing by a few animals (Heady and Child, 1994). Less valuable forage species replace those desirable plants. If overgrazing continues for a long time, it results in serious deterioration of the grassland.

For the improvement of grasslands and implementation of other management practises, grazing pressure should be moderate, with the consumption of 40-60 % of total forage production. In that case there is no change in botanical composition. This utilization reflects maximum use of grassland with the maintenance of productivity. Light grazing expresses a consumption of less than 40 percent.

2. Grazing period

Grazing period is the time span during which grazing occurs. Throughout the Mediterranean region the grazing season is the whole year (Heady and Child, 1994). In permanent pasture and meadows grazing initiates at a certain level of the growth when the plants mature for proper grazing. Plant height is one of the control factors. Generally accepted plant height for initiation is between10 to 30 cm. If the grassland consists of tall plants higher than 120 cm, grazing may start when the plants reach 30 cm height. Pastures with short species are grazed when the plants reach the minimum height of 10 cm. Grazing should be stopped at least 3-4 weeks before winter cold weather. The period depends on the ecological conditions, for example in Mediterranean climate the length of grazing period is six months from spring to autumn, while it is about five months in eastern part of Turkey.

The governors in each county in Turkey announce the beginning and ending dates of grazing. The basic problem for grasslands is that the farmers adhere those dates. Grazing starts as soon as snow cover disappears in Central and East Anatolia, and lasts when the winter temperatures begin.

3. Animal distribution

One of the grassland management practices is to distribute the animals uniformly throughout the pasture for maximum use without damages to soil and vegetation. Livestock feeding, handling, and watering facilities should be designated and installed in a manner to improve and/or maintain animal distribution. These facilities should also be designated and installed to minimize stress, the spread of disease, parasites, contact with harmful organisms and toxic plants (NCRS, 2006).

When left to natural habitats, cattle graze readily accessible areas first and forage may be underutilized on less accessible range. Unless these habits can be overcome, preferred areas may be overused while other areas are passed up (Anonymous, 2011c). Topography also influences the use of forage plants, the steepness and length of slope are important for the distribution of cattle. They generally prefer the least slope gradient or flat lands where heavy grazing occurs. Animals tend to graze near the streams where plants are green and more palatable for a longer period than those on the other places, especially on slopes.

Heady and Child (1994) listed some management practices to spread animals in accordance with the herbage resources such as development of water, fencing, roads and trails, herding, salting. Water sources provide a better distribution of the animals and utilization of the land. Availability of water on non grazed and/or lightly grazed areas also determines the grazing season and the number of livestock.

Well established fences are useful tools to control cattle and make them graze in a particular part of the pasture for an appropriate time. Fences divide the grasslands into different parts to let different classes graze separately. They also provide animals certain areas and keep them away from the others. Roads and trails simplify the use of pastures.

Herding is also a useful tool to increase efficiency in use of the grasslands. Cattle can be removed from preferred areas to less utilized areas. Animal movement may be adjusted by proper use of salting. Placement of salt in such locations that animals are encouraged to be away from sensitive areas.

Water, salt or other tools such as construction of the material for shade and fertilization make the animals move to preferred areas and stay out of overgrazed or heavily trampled parts.

4. Animal type

The effective management of grassland involves different livestock grazing the same grassland in a complementary manner. All animal species prefer certain types of vegetation. Dairy cows need young and nutritious plants for milk production; in contrast beef cattle prefer more mature and less palatable plants.

Sheep graze with their narrow muzzles and select individual leaves and other parts of the plant of a wide range of plant species(Frame, 1992). Sheep graze the grassland efficiently if the grass is short, they cannot use properly if the stand has grasses taller than 5-10 cm (Anonymous, 2011d). Cattle tear off the plants with their tongues and prefer tall grasses.

When compared with the grazing of either cattle or sheep separately, mixed grazing with cattle and sheep can improve pasture utilisation and maintain sward quality, increase growth rates in livestock, and reduce internal parasite burdens (Anonymous, 2012b). Different kind of animals can also be used for weed control, for example ragwort may be reduced by sheep, thistles and rushes may be grazed by goats (Frame, 1992).

5. Grazing systems

Proper grazing management maintains wildlife habitats, conserves the soil, and preserves the natural beauty of grassland landscape. A well planned grazing system provides forage as much of the year as possible to minimize supplemental feed cost without resources degradation. (NCRS, 2006; Anonymous, 2011d).

For the implementation of a grazing management plan, the factors to be considered are types of animals, dominant plant species, availability and distribution of water, and topography. There are three main grazing systems, continuous, seasonal and rotational grazing (Frame, 1992; Heady and Child, 1994; Anonymous, 2011b,c; HRWC, 2012).

A. Continuous grazing

Continuous grazing refers the utilization of a management unit for the whole year. The cost of this system is less than the other in consideration with labour, fencing, watering, etc. Continuous grazing is widely used and provides forage during the grazing period, but it is very difficult to achieve optimum grazing pressure. It often causes overgrazing or non grazing on some parts of the pastures unless carefully managed.

B. Seasonal grazing

Animals graze on some pastures for only part of the year. The land is not grazed for a certain period to allow the plants to rest and grow. For example many grasslands in British Columbia are grazed by cattle in spring or fall months. Lands in higher elevation ranges are used for late spring and summer grazing.

C. Rotational grazing

The pasture is divided into several parts and each part is grazed in sequence throughout the grazing period. Animals are regularly moved to fresh sections and previously grazed one is left for regeneration. Types of rotational grazing include daily strip grazing in pastures, short rotations with two or three pastures, and complementary rotations with different species. The advantages of this system are to improve livestock distribution, allow resting periods for preferred areas, and utilize forage efficiently on ungrazed areas. Rotational grazing limits soil compaction, encourages root growth, and reduces fertilizer leaching. The system also provides a continuous ground cover throughout the year reducing erosion, improves nutrient intake by evenly distribution of manure, and extends grazing season. Rotational grazing has different types of applications.

Rest rotation grazing: The grassland is divided into four or more pastures. One of them is rested throughout the year, and the others are rotationally grazed. This system is useful for the pastures having sensitive plant species which need a long period of recovery.

Deferred rotational grazing: Deferred rotational grazing consists of two or more pastures, one of which is not grazed until seed production. After grazing whole season one of the others is left for resting. The system allows the plants to reach maximum growth level and produce seed. This grazing system needs long periods of rest and grazing.

6. Fodder crop production

Production of pastures is as important as the production of crops to increase farm income and security, to improve efficiency of fertilizers, and to provide sustainable agriculture without tillage (Anonymous, 2011a). In order to use the grassland efficiently, it is necessary to produce hay or silage to feed the animals in the winter. The farmers need available fields to do it, or they must use some parts of the grassland.

Supplemental feed and/or mineral requirements should be balanced with the forage consumption to meet the desired nutritional level for the kind and class of grazing livestock (NCRS, 2006). Annual forage crops and crop aftermath extend rest periods and grazing season, and provide feed during periods of slow forage growth.

7. Other management practices

Grassland management also involves some other practices such as burning, fertilization, weed control, seeding with natural plants, and clearing or discouraging the growth of invasive shrubs and brushes.

Grasses being dominant in many grasslands are able to withstand grazing and fire. When burned grasses can grow again because the growing point of most plants is at the base, close to the ground (Anonymous 2011c). If the area is not grazed or mowed, grass stands may need periodic renovation to remove excess litter which may reduce the quality of wildlife habitat (NCRS, 2001).

Controlled fire can stimulate grass and wild flowers to reproduce, allow germination of seed bearing annuals, increase plant species diversity, control unwanted woody vegetation, open up the stand for movement of small animals and birds, reduce competition from weeds, discourage the development of shrubs and trees, recycle the nutrients tied up in old plants, improve poor quality forage, increase plant growth, and reduce the risk of large wildfires (NCRS, 2001; Anonymous, 2012a).

Fertilizer application increase forage production. Species composition can be readily manipulated by specific fertilizer treatments (Fenner and Palmer, 1998). The efficient use of on-farm manures and slurry maximize output from grassland system and minimize the environmental impact (Anonymous 2012b).

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The effect of soil microtopographic gradients on dry matter yields and species richness in two Mediterranean pastures

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Abstract. The Sown Biodiverse Permanent Pastures Rich in Legumes (SBPPRL) mix a large number of species and cultivars of improved annual pasture species adapted to Mediterranean climate, with a predominance of *Trifolium subterraneum*. On a commercial mixed farm were explored the effects of soil microtopographic gradients on dry matter (DM) yields and species richness in two intensively grazed nearby pastures – a stabilized SBPPRL and an old seminatural annual pasture (SNP) – established in the same soil catena, with a high P_2O_5 and K_2O availability. As expected the SBPPRL had higher DM yields than the SNP, more stable along the slope system, and with a larger legume fraction. The indigenous genotypes of the SNP seemed unable to translate into biomass soil fertility improvement. SBPPRL improved pasture species depressed significantly pasture species diversity and species spatial turnover. In the SBPPRL legumes mainly substituted many short living low productivity autochthonous species common in the SNP. The buffering of soil ecological gradients is probably important in the explanation of the superior agronomic performance of SBPPRL. SOM accumulation is certainly involved in this process.

Keywords. Permanent pastures – Sown pastures – Subterranean clover – Species diversity.

Effets des gradients microtopographiques du sol sur la production de matière sèche et la diversité spécifique sur deux pâturages méditerranéennes

Résumé. *Les Pâturages Permanents Biodiverses Riches en Légumineuses (PPBRL) mélangent un nombre élevé d'espèces et cultivars de plantes fourragères améliorées adaptées au climat méditerranéen, avec une prépondérance de* Trifolium subterraneum*. Dans une exploration agricole on a exploré l'effet de gradients microtopographiques sur la production de matière sèche (MS), la diversité spécifique et le turnover d'espèces dans deux pâturages adjacents intensément broutés – l'un, un PPBRL et l'autre un pâturage seminaturel annuel (PSN) – installés dans la même catena de sol avec niveaux de* P_2O_5 *and* K_2O *élevés. Comme il était prévue, le PPBRL a montré des productions de MS plus hautes et plus stables au long du gradient microtopographique que le PSN, et une composante supérieure en légumineuses. Les génotypes indigènes apparemment n'ont pas été capables de convertir en biomasse l'amélioration de la fertilité du sol. Les espèces améliorées du PPBRL ont réduit significativement la diversité spécifique, surtout d'espèces annuelles de cycle de vie court, et le turnover spatial d'espèces. L'atténuation des gradients écologiques au nivaux du sol est probablement importante pour expliquer la performance agronomique des PPBRL. La accumulation de matière organique au sol est probablement associée avec ce processus.*

Mots-clés. *Pâturages permanents – Pâturages semés – Trèfle souterrain – Diversité de plantes.*

I – Introduction

The Sown Biodiverse Permanent Pastures Rich in Legumes (SBPPRL) are a well known sown pastures system in many Mediterranean countries. Seed mixtures with a high species and cultivars diversity, with a predominance of *Trifolium subterraneum,* are their main characteristic. They often involve 10-12 improved cultivars of 6-7 pasture species with a

Mediterranean optimum, the majority of them self-regenerating winter annuals (only grasses are perennial). The SBPPRL address a classical subject in community ecology: the effects of species richness on ecosystem function. Recently we have been able to corroborate the hypotheses that SBPPRL species/cultivars richness track interannual climate fluctuations and slope system microenvironments arrays (Aguiar *et al*., 2011). Sown species and *T. subterraneum* cultivars richness are complementary in this process; they promote, respectively, interannual climatic fluctuations and microtopographic gradients tracking. These abilities are central to explain the SBPPRL superior agronomic performances.

Three hypotheses were tested in this article. 1) If SBPPRL's species and cultivars can track microtopographic ecological gradients, biomass yields should be higher in SBPPRL than in semi-natural pastures (SNP), in all slope positions. 2) In heterogeneous herbaceous plant communities the relationship between productivity and species richness generally follows a unimodal curb (Grime, 1973); consequently, if SBPPRL species inhabit soils with improved chemical fertility, and are substantially more productive than autochthonous biotypes, species richness at the local scale (alfa-diversity) is probably lower in SBPPRL than in SNP. 3) If a limited pool of improved species substitute indigenous species in fertilized soils, and SBPPRL's cultivar richness is fundamental in microtopographic ecological gradients tracking, then, species spatial turnover should be smaller in SBPPRL than in SNP.

II – Materials and methods

Two nearby pastures, a SNP and a SBPPRL, were selected on a private farm – Quinta da França (Covilhã, Portugal), 40º16'N7º30'W, ca.425m MSL. The SBPPRL was sown in arable land in 2001 with a commercial seed mixture. Since then it has been intensely grazed with cattle and sheep and annually fertilized with ca. 27 kg P_2O_5 ha^{-1}. Grazing management led to a *T. subterraneum* absolute dominance; its sown grasses biomass is irrelevant. The SNP was also fertilized with phosphorous and intensively grazed, and wasn't yet invaded by SBPPRL genotypes. The studied pastures are located on a gentle slope of a granite hill with 30 m elevation and 380 m length. Three microtopographic positions were identified: hill shoulder, backslope and footslope. In the springs of 2008 and 2010 four quadrats were randomly located on each slope position. Each of the quadrats was protected with an exclosure cage three weeks before measurements to allow species identification. Species richness and relative cover was evaluated in the third week of May of 2008 and 2010, with the point-quadrat method (frame of 70x70 cm with 49 points). The 2009 spring was exceptionally dry and the pastures were impossible to sample. DM yields were evaluated in the agricultural year of 2007-2008 in exclosure cages around the previously described quadrats. Soil samples were collected nearby the quadrats of 2010. 2007-2008 and 2009-2010 agricultural years were, respectively, moderately dry (589 mm) and moderately wet (1023 mm). Temperature integrals in the two growing seasons were close to the mean year.

Two explanatory variables were considered in the ANOVA analysis: SLOPE (three levels, Hill shoulder, Backslope and Footslope); and PTYPE (two levels, SBPPRL and SNP). In the "within subject effects" ANOVA (Table 1) the YEAR explanatory variable (two levels, 2008 and 2010) was taken as repeated measures. The species turnover (beta diversity) was indirectly evaluated through the "Lengths of gradient" (Lepš and Šmilauer, 2003) available in the output of Detrended Correspondence Analysis performed in the CANOCO program (Ter Braak and Šmilauer, 2002). The assessment of outcompeted species by the SBPPRL was done, indirectly, with a principal component analysis (PCA) ordination diagram with passively projected variables. Besides the variables used in the ANOVA, four new variables were created for the PCA adding the relative cover of sown species (SOWN SPECIES), annual oligotrophic species (HELIANTHEMETEA GUTTATI), species adapted to trampled soils (POLYGONO-POETEA ANNUAE), and annual species of temporary wet soils (ISOETO-NANOJUNCETEA). The plant species autoecology was indirectly assessed through the phytosociological optimum (Rivas-Martínez *et al.*, 2001).

III – Results and discussion

Soil P_2O_5 and K_2O (mean 135 mg.kg^{-1}, Egner-Riehm) availability in the two studied pastures was elevated and quite homogenous. Anyway, P_2O_5 levels were significantly higher in the SNP (142 *vs* 90 mg.kg^{-1}, Egner-Riehm, p<0.001), and in backslope positions (mean 141 mg.kg^{-1}). Biomass yield was much higher in the SBPPRL, consequently, in spite of the cyclical soil disturbance that occurred before 2001, SOM content was significantly higher in this pasture type then in the SNP (2.76 *vs* 2.12%, p<0.001). In 2007-2008 the DM production was 250% higher in SBPPRL than in the SNP (6151 *vs*. 1752 DM kg.ha^{-1}, p<0.001). PTYPE had a statistically significant effect in all DM yield fractions (grasses, legumes and others). In the SNP occurred a severe reduction of DM yields uphill: hill shoulder DM yield was almost an half (55.5%) of the footslope DM yield (1355 *vs* 2451 kg.ha^{-1}, p<0.001). Inversely, SBPPRL had a much higher legumes content and proportion (3031 [49.3%] *vs* 248 kg.ha^{-1} [14.2%] in SNP, p<0.001), and buffered DM yields along the slope system (the SLOPE effect in total DM yield and in DM fractions of the SBPPRL was always insignificant). The higher grass biomass in the SBPPRL (1304 *vs* 681 kg.ha^{-1} in SNP) means that this yield fraction, almost only composed of indigenous plants, benefited from the legume presence.

In Table 1, the between subjects (both years together) ANOVA shows that PTYPE and SLOPE had a significant effect on species richness. Species number per 0.49m^{-2} was higher in SNP (13.09 *vs* 10.56) and on hill shoulders (13.81 *vrs*. 10.38 and 11.31). The higher species richness in the hill shoulder was constant between years and between pasture types. In the within subject effects ANOVA only PTYPE effect was significant. In 2008, the SBPPRL had a higher species richness than the SNP (12.08 *vs* 11.25), but SNP had a much higher species richness peak in 2010 (14.92 *vs* 9.03) that explains its higher species richness in the between subject effect ANOVA.

Table 1. Local species richness. ANOVA. Tukey's HSD test (P<0.05)

	Between subject effects			**Within subject effects**			
	Mean†	**p-value**	**Error**	**Mean 2008†**	**Mean 2010†**	**p-value**	**Error**
PTYPE		0.001	5.319			**<0.001**	5.847
SBPPRL	10.56			12.08	9.03		
SNP	13.09			11.25	14.92		
SLOPE		0.002	5.319			0.318	5.847
Hill shoulder	13.81a			14	13.63		
Backslope	10.38b			10.63	10.13		
Footslope	11.31b			10.38	12.25		
PTYPE X SLOPE		0.491	5.319			0.935	5.847

†Number of species per 0.49m^{2}.

The species turnover (beta-diversity) was much higher in the in SNP (DCA "Lengths of gradient" 3.791 in 2008 and 3.476 in 2010) then in SBPPRL (DCA "Lengths of gradient" 1.687 in 2008 and 1.733 in 2010).

The first axe of the PCA diagram of Fig. 1 is correlated with the pasture types (r=0.80). The second axe probably reflects a water gradient; is highly correlated with ISOETO-NANOJUNCETEA (r= 0.93) and less with the year of sampling and the slope position. The direction of the ISOETO-NANOJUNCETEA arrow indicates that wet years and footslope positions promote temporary wet soils adapted species (e.g. *T. cernuum*). The PCA diagram also shows that sown species are a characteristic of SBPPRL, together with some undesirable nitrophilous species (e.g. *Bromus hordeaceus* and *Sysimbrium officinale*) and of trampled soils plants. A large number of well fitted species inhabit the SNP. The majority of them are oligotrophic, ephemeral, annual plants of the *Helianthemetea guttati* vegetation class. This phytosociological group is the most prone to be outcompeted by SBPPRL improved species. *Aira caryophyllea*, *Logfia minima*, *Tolpis barbata* and *Crassula tillaea*, among other species, were not detected in the SBPPRL.

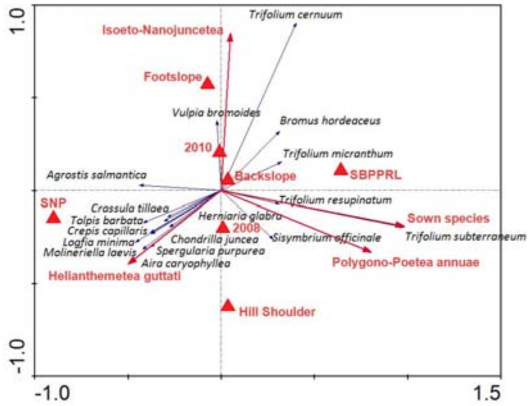

Fig. 1. PCA biplot with the 20 species with the highest fit with the first two axes.

IV – Conclusions

The studied pastures shared similar soil chemical fertility conditions. Our experiment was based in pseudoreplications. Although the sampled agricultural years 2007-2008 and 2009-2010 represent climatic extremes, the number of studied years was small. Anyway, the gathered experimental data is congruent with the three hypotheses formulated in the introduction. The 2007-2008 total biomass yield, and its fractions, were higher in the SBPPRL than in the SNP, in all slope positions. The higher grass biomass in the SBPPRL means that this yield fraction, almost totally composed of indigenous species, was beneficiated by the legume presence. Nevertheless the indigenous pasture flora was unable to convert into biomass the improved fertility soil conditions, has SBPPRL legumes did. DM yield and its fractions variation along the slope system were buffered in the SBPPRL. This characteristic helps to explain the superior agronomic performance of the SBPPRL pasture system. SOM accumulation is certainly one of its causes. Species richness maxima occurred in SNP and in hill shoulder positions. SBPPRL improved pasture species outcompeted indigenous species – especially oligotrophic, ephemeral, unproductive annual plants – and depressed significantly pasture species richness. SBPPRL also reduced species turnover along the slope system.

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Effects of juniper encroachment on herbage production and biodiversity in a natural grassland: Preliminary results

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Abstract. The encroachment of woody species in natural grasslands has recently increased, especially in arid and semi-arid environments. In the Mediterranean region, this is mainly attributed to the dramatic decrease of the traditional human activities such as pastoral management and fuelwood collection, which controlled the encroachment of woody species. The purpose of this study was to investigate the effects of *Juniperus oxycedrus* encroachment on herbage production and floristic diversity in a natural grassland. The research was conducted in the area of Megalo Dereio, which is located in Evros region, in north-eastern Greece in 2010. Herbage production was measured and ecological diversity indices were determined at three different shrub cover regimes (open, moderate, dense). Herbage production decreased progressively as juniper cover increased. Floristic diversity was significantly higher in the moderate shrub cover regime, while it was dramatically reduced in the dense shrub cover regime.

Keywords. Forage – Shrubs – Floristic diversity – Invasion.

Les effets d'empiètement de genièvre sur la production d'herbage et la diversité biologique dans un pâturage naturel : Résultats préliminaires

Résumé. *L'empiètement d'espèces boisées dans les pâturages naturels a récemment augmenté, surtout dans les environnements arides et semi-arides. Dans la région Méditerranéenne, c'est surtout attribué à la diminution dramatique des activités humaines traditionnelles comme l'administration pastorale et la collection du bois de chauffage, qui a contrôlé l'empiètement d'espèces boisées. L'objectif de cette étude était d'enquêter sur les effets de l'empiètement de* Juniperus oxycedrus*, sur la production d'herbage et la diversité floristique dans un pâturage naturel. La recherche a été réalisée dans la région de Megalo Dereio, qui se trouve dans la région d' Evros, au nord-est de la Grèce, en 2010. La production d'herbage a été mesurée et les indices de la diversité écologique ont été déterminés à trois différents régimes de couverture de buisson (ouvert, modéré, dense). La production d'herbage a diminué progressivement à mesure que la couverture de genièvre a augmenté. La diversité de Floristique était de façon significative plus haute dans le régime de couverture de buisson modéré, pendant qu'il a été radicalement réduit dans le régime de couverture de buisson dense.*

Mots-clés. *Fourrage – Buissons – Diversité floristique – Invasion.*

I – Introduction

The invasion and/or the encroachment of woody species in rangeland ecosystems is increasing in many regions, especially in arid and semi-arid environments (Van Auken, 2000; Van Auken, 2009). In the Mediterranean region, this phenomenon is attributed to major socioeconomic changes of the past few decades (Seligman and Perevolotsky, 1994), which have led to a dramatic decrease of traditional human activities such as pastoral management and fuelwood collection, which controlled the encroachment of woody species (Watkinson and Ormerod, 2001; Papanastasis and Chouvardas, 2005).

Shrub encroachment suppresses grasses and other herbaceous species (Knapp *et al.,* 2008). Many of the encroaching woody species are often unpalatable to livestock, even to browsers. Thus, shrub encroachment may reduce the carrying capacity for livestock (Ward, 2005) and consequently it may no longer support the pastoral economy (Reynolds *et al.,* 2007).

Moreover, shrub encroachment is widely recognised as one of the major threats to biodiversity in rangeland ecosystems (Bartolome *et al.,* 2005; Dalle *et al.,* 2006), as these communities are composed of a few dominant woody species (Rousseau and Loiseau, 1982). Papadimitriou *et al.* (2004) reported that floristic diversity reduced progressively as shrub density increased.

The purpose of this study was to investigate the effects of *Juniperus oxycedrus* encroachment on herbage production and floristic diversity in a natural grassland.

II – Materials and methods

The study was conducted in the area of Megalo Dereio which is located in Evros prefecture, northeast Greece at 380 m a.s.l. The climate of the area is classified as sub-Mediterranean, with a mean air temperature of 13.7° C and an annual rainfall of 560 mm. The grasslands of the study area are composed of herbaceous vegetation, while some woody species such as *Juniperus oxycedrus* subsp. *oxycedrus* and *Cistus incanus* subsp. *creticus* are also present. The area is grazed mainly by goats and cattles.

Three experimental areas with different shrub cover regimes were selected in early June 2010: (i) open shrub cover (10%), (ii) moderate shrub cover (25%) and (iii) dense shrub cover (50%). The dominant shrub species was *Juniperus oxycedrus* subsp. *oxycedrus*. Four permanent transect lines of 20 m long were established in every shrub cover regime. The plant cover and the floristic composition were measured by using the line-point method (Cook and Stubbendieck, 1986) with contacts obtained every 20 cm. The sampling of herbage yield was carried out in two 0.5 m x 0.5 m quadrats in every permanent transect established in each shrub cover regime. All samples were oven dried at 60ºC for 48 h and weighed.

The nomenclature of the recorded taxa follows Strid and Tan (1997, 2002) and Tutin *et al.* (1968-1980; 1993). Floristic diversity was determined by the number of species (N), the Shannon-Wiener diversity index (H'), the Simpson diversity index (D) and the Berger-Parker dominance index (d). The formulae of the indices are given below (Henderson, 2003):

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \qquad D = 1 - \sum_{i}^{S_{obs}} p_i^{\,2} \qquad d = \frac{N_{\max}}{N_T}$$

where S is the maximum recorded number of taxa, pi is the proportional abundance of the i-th taxa, N_{max} is the number of records of the dominant taxon and N_T is the total number of records.

The obtained data were analysed with SPSS 18 for Windows. One-way ANOVA was used to analyse the effect of juniper encroachment on herbage production and on floristic diversity indices. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980).

III – Results and discussion

Herbage production was gradually reduced as shrub cover increased. It significantly decreased by 37% and 58% in the moderate and the dense cover regimes respectively (Fig. 1) compared to the open one. This reduction could be attributed to the dominance of the more competitive woody species which shaded herbaceous vegetation away. Similar findings have been reported by many other researchers (Platis and Papanastasis, 2003; Kesting *et al.,* 2009).

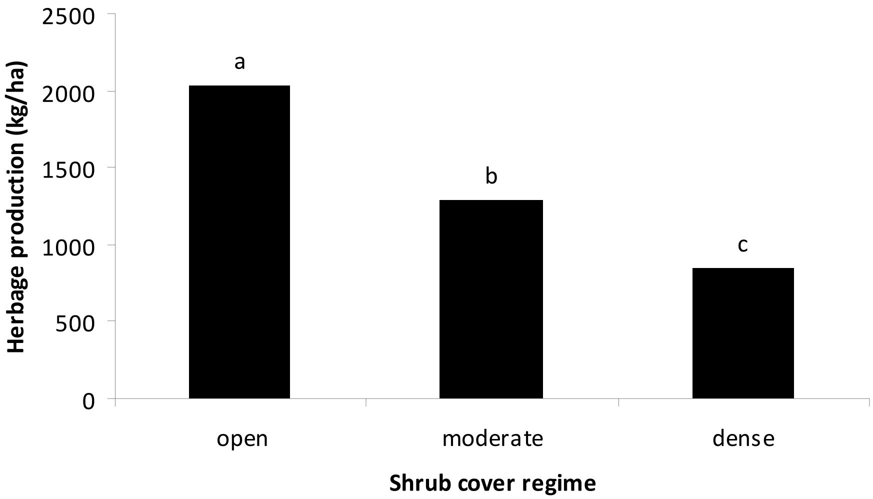

Fig. 1. Herbage production for the three shrub cover regimes. Means followed by the same letter are not significantly different (P≤0.05).

Species richness and floristic biodiversity, as described by the diversity indices, were significantly lower in the dense shrub cover regime in comparison to the moderate one (Table 1). Floristic diversity tends to be higher in the moderate shrub cover regime compared to the open one, although this increase did not produce significant results. No significant differences were detected among the shrub cover regimes for the Berger-Parker dominance index.

Table 1. Floristic diversity indices for the three shrub cover regimes

Shrub cover regime	Diversity Indices			
	N	H’	D	d
Open	15 ab*	2.05 ab	5.66 b	0.40 a
Moderate	20 a	2.46 a	9.16 a	0.29 a
Dense	12 b	1.71 b	4.06 b	0.48 a

*Means in the same column followed by the same letter are not significantly different (P≤0.05).

Shrub encroachment is generally assumed to have negative effects on floristic diversity. On the contrary, Duelli (1997) supports that shrub encroachment leads to higher habitat heterogeneity and consequently to higher biodiversity. The results of the present study confirm that up to a certain degree shrub encroachment leads to higher floristic diversity, but after it reaches that critical point, biodiversity is dramatically reduced.

IV – Conclusions

Juniper encroachment resulted in a progressive reduction of herbage production. The moderate juniper cover regime enhanced floristic diversity, but at the dense juniper cover regime biodiversity depleted. Therefore, shrub encroachment control is required either by browsing livestock or by clearing.

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Effect of herd mobility on the species composition and productivity of plant communities in the northern Mediterranean region of Morocco

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Abstract. The study was conducted in two pasture areas in the Moroccan Rif mountains (Akoumi and Bettara) exclusively used by goat's herds to assess biomass production and botanical composition of major species. To measure plant biomass we used the method of the reference module. Breeders use pasture throughout the year, except on rainy days where they resort to limbing. The shrub, mainly *Erica arborea* and *Arbutus unedo,* is the main diet used by goats. In Bettara, breeders are becoming sedentary, where the pastures are overgrazed and dominated by unpalatable plant species, and biomass production is estimated to 934 kg DM/ha. In Akoumi, where breeders are still transhumant, plant biomass largely exceeds that of Bettara (2256 kg DM/ha). A seasonal movement alleviates anthropozoic pressure on pastoral land and allows restoration of palatable species. In fact due to climate change, silvopastoral resources will be less available and of lower quality, mobility of herds is a necessary adaptation strategy to insure sustainability of pastoral resources.

Keywords. Pasture – Rif – Biomass – Mobility – Adaptation.

Effet de la mobilité des caprins sur la composition et la production des espèces végétales dans la région Méditerranéenne au nord du Maroc

Résumé. *Cette étude a été menée dans deux sites de pastoraux dans les montagnes Rifaines (Akoumi et Bettara), exclusivement utilisés par les troupeaux caprins, afin d'évaluer la production en biomasse et la composition botanique des principales espèces pastorales. Pour mesurer la biomasse végétale la méthode du module de référence a été utilisée. Les éleveurs utilisent les pâturages tout au long de l'année, sauf les jours pluvieux où ils ont recours à l'ébranchage. Les arbustes, principalement Erica arborea et Arbutus unedo sont les principaux sources alimentaires utilisés par les caprins. A Bettara, les éleveurs sont de plus en plus sédentaires, ce qui explique la surexploitation des pâturages. Ces espaces sont dominés par des espèces végétales non appétibles et la production de biomasse y est estimée à 934 kg MS/ha. A Akoumi, les éleveurs gardent leur tradition de transhumance, ce qui explique que la biomasse végétale dépasse largement celle observé à Bettara (2256 kg MS/ha). Le déplacement saisonnier allège la pression humaine et animale sur les terres pastorales et permet donc la restauration des espèces les plus appétibles. En fait, en raison du changement climatique les ressources sylvopastorales seront moins disponibles et de qualité inférieure, de ce fait pour assurer la durabilité des espaces pastorales, il faut adopter une stratégie de mobilité des animaux afin de restituer les ressources pastorales et fourragères.*

Mots-clés. *Pâturage – Rif – Biomasse – Mobilité – Adaptation.*

I – Introduction

Moroccan Mediterranean forests are increasingly under pressure due to uncontrolled goat grazing. This traditional system, inheriting to Rif society, is becoming vulnerable due to reduced forage and pastoral production (FAO, 2009). This vulnerability may increase further in response to climate change variability and population growth.

Mobility, as an ecological rationality in arid and semi-arid lands, is a response of herders to unexpected variability in pasture production and/or animal nutritional needs. It relies on herder's knowledge and local institutions in decisions making. It's part of the society's culture. Herd mobility under traditional land use systems is mainly based on a comprehensive knowledge of rangelands, where the stocking rates vary with land potential seasons (Oba, 2011).

However, breeder's sedentarization is becoming a widespread practice, especially among poor pastoral households especially in Rif Mountains.

This study was carried out in two contrasting pastures of the Moroccan Rif mountains (Akoumi and Bettara) exclusively used by goat's herds to assess the effect of herd mobility on biomass production and botanical composition.

II – Material and methods

The area of study is part of the valley of Oued Laou which is located between the provinces of Tetouan and Chefchaouen north of Morocco. The climate is Mediterranean type, with mean min and max temperatures of 3°C and 41°C respectively. Total annual precipitation is 500 mm. Oued Laou valley, a dominantly forest area, is occupied up to 30% by agriculture.

The study concerned two sites: Akoumi and Bettara. These are forest rangelands exploited mostly by goat breeders. In both sites, the species composition and productivity of plant communities were realized by assessing vegetation qualitatively and quantitatively.

For qualitative evaluation of vegetation we studied the floristic diversity of the forest grazing area. A herbarium was collected to determine the floristic composition.

For quantitative evaluation and in order to control spatial heterogeneity, we used the stratification method as proposed by Qarro (1996), Kouraimi (1997), Chebli and Mrabet (2010). In each site we identified the number of quadrats needed to control heterogeneity of silvopastoral area (3 in Akoumi and 4 in Bettara). The size of the quadrats adopted for measurement of biomass is 2 m x 5 m for shrubs strata and 1 m x 1 m for herbaceous strata. Plant biomass was measured using non-destructive method known as the reference module.

Measurements were conducted during eight months period. Quantitative evaluation was performed during May, which correspondent to vegetative peak (Qarro 1996, Kouraimi 1997, Chebli and Mrabet, 2010). Flora composition was determined during April, May and June 2011. Several surveys were conducted during the study period to gather information on modalities of pastures grazing and to complete database on species characterization.

III – Results and discussion

The area of study is characterized by a relatively rugged topography. The vegetation structure is mainly shrub-dominated.

1. Botanical composition

In Akoumi and Bettara, 125 plant species were determined. The most dominant species, which constitute the staple diet of goats in the valley of Oued Laou, are presented in the Table 1.

Table 1 expresses the floristic control between Akoumi and Bettara sites. In Akoumi sites, palatable species are relatively more abundant and diversified while in Bettara site the qualitative evaluation shows the abundance of unpalatable species. This differences in flora can be explained by high population pressure in Bettara and the dominantly transhumant population in Akoumi. In other term, biodiversity in Bettara sites is under intense degradation compare to Akoumi site. Especially, we observed species with low pastoral interest invading Bettara site, such as *Daphne gnidium* and *Arisarum vulgare*.

Table 1. Principal botanical composition of palatable and unpalatable flora in the Oued Laou valley

Plant	Akoumi	Bettara
Palatable species		
Arbutus unedo	++	+
Cistus crispus	+++	+
Cistus monspeliensis	++	+
Erica arborea	+++	+
Quercus canariensis	+	+
Quercus suber	++	+
Lavandula stoechas	++	+
Pistacia lentiscus	+	+
Zizyphus Lotus	-	++
Unpalatable species		
Anagallis arvensis	-	+
Arisarum vulgare	+	++
Coriaria myrtifolia	-	+
Daphne gnidium	+	++
Ranunculus sardous	-	+
Urginea maritima	-	+

+ + + Species very abundant.
++ Moderately abundant species.
+ Weakly abundant species.
- Absent species.

According to observations and surveys conducted with breeders, plant species that dominate the valley and who constitute over 50% of the forage species are *Erica arborea, Cistus crispus Arbustus unedo, Lavendula stoeches* and *Cistus monspeliensis*. These species are mostly abundant in Akoumi site.

2. Biomass production

Biomass production has mainly concerned the Biomass of palatable species in the two silvopastoral area of Oued Laou Valley.

A. Akoumi site

The Akoumi pasture is located at 35°24' N 5°17' W and between 450 to 755 meters above sea level. This pasture is characterized by dense vegetation mainly dominated by shrub strata. The pastoral feed offer is very high compared to surrounding areas. The site is used by breeders of Akoumi village which has a goat herd of 350 heads.

Grazing occurs throughout the year, from 9 am until 5 pm, with a reduced frequency during winter (2-3 hours per day). From survey’s data, goat breeders in this site are practicing mobility in order to maintain natural regeneration of vegetation. This local strategy has helped to conserve palatable species.

Biomass production of palatable species is important; it's estimated at 2259.52 kg DM per hectare, consisting mainly of *Cistus crispus* (49%) and *Erica arborea* (45%).

B. Bettara site

This pasture is located at 35°33' N 5°27' W. This is a much degraded scrubland with vegetation consisting mainly of shrub strata and tree in poor state.

It is operated by four breeders who own a goat herd estimated at 348 heads. Grazing is practiced throughout the year except during rainy days where breeders use delimbing. The grazing time does not exceed 6 hours a day. The herd mobility is very low and breeders are becoming sedentary. The pastures are overgrazed and dominated by unpalatable plant species (Table 1).

The site is under degradation spiral where low pastoral (unpalatable) species are dominating (*Asphodelus microcarpus* and thorny species)

Biomass production of palatable species is estimated to 934.04 kg DM per hectare, which is low for a silvopastoral area. It is composed mainly of *Arbutus unedo* (36%), *Zizyphus Lotus* (35%) and *Quercus canariensis* (26%).

IV – Conclusion

The pastures in the Oued Laou valley remain a large area for forest grazing. Biomass production varies greatly from an area to another. *Erica arborea* and *Arbutus unedo* are species most consumed by goats. In Bettara, breeders are becoming sedentary, where the pastures are overgrazed and dominated by unpalatable plant species, and biomass production does not exceed 934 kg DM/ha. In Akoumi, where breeders are still transhumant, plant biomass largely exceeds that of Bettara (2256 kg DM/ha).

A seasonal herd movement alleviates anthropozoic pressure on pastoral land and allows restoration of palatable species. In order to reduce further vegetation degradation in Rif Mountain and to adapt to climate change, a strategy based on herd mobility should be central to silvopastoral management.

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Effects of grazing on the traits of a potential fire in a Sardinian wooded pasture

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Abstract. Mediterranean rural landscapes are often characterized by a complex matrix of grasslands, open wooded pastures, shrubland and broadleaf forests, and are affected by a considerable frequency of fire ignitions. Whatever the causes and the interested landscape structure, the risk of burning is related with the fuel biomass. This paper would clear the role of grazers in reducing the fire risk within 2000 ha of a typical Mediterranean *Quercus* spp. forest, by a modelling approach, based on FARSITE simulator, able to estimate the probability of burning, and the severity of the fires. Fuel biomass samples were collected at the start and the end of the fire season in 23 representative sites, in order to define the spatial variation of the herbaceous fuel model in grazed and non grazed conditions. Ungrazed conditions were simulated placing exclosure cages in each site. The study allowed to assess the effect of the grazing abandonment on the fire behavior. Fuel reduction strategies tested by the simulator permitted to define the role of grazers in the fire prevention plan.

Keywords. Grazing – FARSITE – Fuel management.

Effets du pâturage sur les caractéristiques d'un incendie potentiel dans des prairies boisées en Sardaigne

Résumé. *Les paysages ruraux méditerranéens sont souvent caractérisés par une matrice complexe de prairies, pâturages faiblement boisés, buissons et forêts de feuillus, et sont très fréquemment touchés par des démarrages d'incendies. Quelles que soient les causes et la structure paysagère concernée, le risque d'incendie est lié à la biomasse combustible. Cet article vise à éclaircir le rôle des animaux brouteurs en vue de réduire le risque d'incendie dans 2000 ha d'une forêt typique méditerranéenne d'espèces de Quercus, par une approche de modélisation, basée sur le simulateur FARSITE, capable d'estimer la probabilité du feu et la sévérité des incendies. Des échantillons de biomasse combustible ont été collectés au début et à la fin de la saison des incendies dans 23 sites représentatifs, afin de définir la variation spatiale du modèle de combustible herbacé selon que les terrains étaient pâturés ou non pâturés. L'état de non pâturage a été simulé en plaçant des enclos de mise en défens dans chaque site. L'étude a permis d'évaluer l'effet de l'abandon du pâturage sur le comportement du feu. Les stratégies visant à réduire le combustible testées par le simulateur ont permis de définir le rôle des animaux brouteurs en matière de plan de prévention des incendies.*

Mots-clés. *Broutage – FARSITE – Gestion du combustible.*

I – Introduction

The demographic dislocation and the displacement of richest and most appealing economies to urban centers and coastal areas, are inexorably leading to the abandonment of Mediterranean inland areas, giving rise to a number of socio-economic and environmental risks (PASTOMED, 2007). According to a complex study advanced by Weissteiner *et al.* (2011), based on multi-source spatial data, abandonment is more advanced in areas of direct (open spaces in sparse vegetation, pastures) or indirect (forests) pastoral relevance. In these conditions, the fire danger is the most relevant environmental risk, related with the biomass fuel, whose quantity is limited by the animal grazing. This paper tried to investigate the relationships between grazing and fire behaviour, using the FARSITE fire behaviour simulator (Finney, 1998) in order to map the fire probability and severity at landscape scale. The aims of this study were (i) to estimate the modifications of fuel biomass as a consequence of grazers presence and (ii) to estimate the effect of grazing on the spread and behaviour of the potential fires.

II – Materials and methods

The trial was carried out in the Forest of Monte Pisanu, Central Sardinia, Italy, during five years (2007-2011). It's a public forest, property of government since 1886, of about 2000 ha, identified as Site of Community Importance (SIC) by European Union (ITB001102 Mountain range of Marghine-Goceano). The vegetation is characterised by woods of *Quercus ilex* and *Quercus pubescens*, individuals of *Taxus bacata*, *Ilex aquifolium, Quercus suber* and *Castanea sativa*. Grazing is rotational heavy for dairy sheep and continuous light for cattle, with an estimated livestock of 650 L.U. per year.

On 23 representative areas with low tree cover density (gaps, cleared areas, thinned wood), where grazing activity is performed, reliefs on grazed fuel biomass were carried out over five years in late spring and summer; in 2009, exclosure cages of 4 m^2 were placed in each site, in order to simulate the exclusion of grazers and the consequent response of the herbage accumulation. On each site, four herbaceous biomass samples at ground level within a sample area of 0.25 m^2 site were collected. Ungrazed fuel biomass was estimated cutting the herbaceous layer in two sample areas of 0,25 m^2 within each exclosure cage. All biomass samples were dried at 80°C for 12 hours and weighted for estimating dry matter production and fuel moisture.

Potential fires were simulated identifying 30 ignition points randomly distributed across a buffer area of 10 meters round the roads. Starting from the ignition points, several simulations were conducted in order to predict the fire behaviour for the two different fuel management scenarios. We used a Geographic Information System (GIS, ArcGIS 9, ESRI Inc.) in order to manage the spatial information of the project area, and to obtain input layers needed to execute the model simulations. The grid resolution of all spatial information was 15 m. A digital elevation model (DEM) was used to produce the maps of slope and aspect required as input by the simulator. Data on wind speed and direction were provided as raster maps with a grid resolution of 50 m, as calculated by a mass-consistent model. FARSITE simulator were run using two custom fuel models for herbaceous vegetation, respectively under grazed and non grazed conditions. The data provided by FARSITE (fire perimeter, rate of spread, fireline intensity) were used in order to describe the fire behavior.

III – Results and discussion

The identified sites are located in an altitude comprised between 600 m and 1200 m a.s.l.. 18 of 23 are located within the altitude range 600-800 m a.s.l. (Table 1). Data of ungrazed and grazed biomass (dry matter, t ha^{-1}) are expressed as the average values in, respectively, three and five years of the trial. As expected, fuel biomass accumulated within the exclosure cages was higher than the grazed conditions. On average, ungrazed biomass resulted of 2,5 t ha^{-1} of dry matter, ranging between 0.7 up to about 8 t ha^{-1}, with a wide variability due to the inter-annual (rainfall distribution and totals) and intra-site (microhabitat conditions) sources of variation. Average grazed biomass was about 1 t ha^{-1}, tendentiously lower in the top position sites ($r = -0.67$ between altitude and grazed biomass, $n = 23$). Regarding the assessment of fire probability and severity, the fire information provided by FARSITE were transformed into raster format and reclassified in order to provide, for the whole extension of the project area, (i) the number of times in which the simulated fires affected each pixel of the project area (burn probability), and (ii) the distribution of the values of both rate of spread and fireline intensity for the different scenarios. In the ungrazed scenario (Fig. 1A) maximum probability of fire propagation (15-25%) are referred to two large areas on the north west and south east flank (4800 ha); several sections of the latter area (about 4000m) regarded a wildland urban interface. Strong reduction (-86%) of the area covered by the same classes was observed in the grazed scenario (Fig. 1B), also characterized by a strong reduction (-77%) of the burned area. The rate of spread (ROS, m/min, Fig. 1C, 1D) was characterised by a general lower magnitude in the grazed scenario, where the highest values (>36 m/min) can be observed only in the north-west upland and in the steeper areas near the south-east flank. Regarding the fireline intensity, the grazed scenario (Fig. 1E, 1F) was characterised by about the 90% of the burned area with fireline intensity values under 1700 kw/m, which can be considered a critical threshold in order to establish effectiveness and feasibility of the methods of direct attack.

Table 1. Average values of fuel biomass (dry matter, t ha^{-1}) in the three years of the trial. Each value represents the mean of the 4 samples per site

Site	Coordinates		Altitude	Fuel biomass (t ha^{-1})			
	Latitude	Longitude		Ungrazed		Grazed	
				Mean	StDev	Mean	StDev
MP2	40°25 463	9° 00 395	1172	2.4	0.78	0.3	0.27
MP3	40°25 738	9° 00 461	1080	5.3	1.94	0.5	0.73
MP4	40°25 192	9° 00 186	1195	3.3	1.66	0.7	0.58
MP6	40°25 477	8° 58 982	946	1.3	0.17	0.7	0.43
MP7	40°25 114	9° 00 056	972	0.7	0.56	0.3	0.22
MP10	40°25 887	8° 58 250	781	3.8	1.94	0.8	0.39
MP13	40°26 285	8° 57 875	705	3.9	2.09	0.8	0.5
MP14	40°26 287	8° 57 976	739	7.9	7.85	0.8	0.65
MP15	40°26 562	8° 57 576	683	1.8	0.59	1.7	0.88
MP17	40°26 605	8° 58 052	727	1.5	0.45	0.5	0.32
MP18	40°26 809	8° 57 614	693	2.9	0.35	1.3	1.12
MP19	40°26 936	8° 57 276	670	2.2	0.17	1.2	0.78
MP20	40°27 027	8° 57 815	601	1.2	0.64	1.1	0.63
MP21	40°27 239	8° 57 296	727	2.8	0.82	1.1	0.55
MP22	40°27 509	8° 57 511	725	2.2	0.88	1.6	0.93
MP24	40°27 153	8° 56 812	736	2.7	1.04	1.3	0.63
MP25	40°27 432	8° 56 505	736	2.0	0.77	1.7	0.91
MP26	40°27 625	8° 57 214	722	2.1	0.6	1.2	0.64
MP27	40°27 628	8° 56 613	726	1.8	1.59	1.1	0.59
MP28	40°28 069	8° 56 485	752	2.8	0.59	1.3	0.75
MP29	40°28 412	8° 56 548	697	2.4	1.81	0.8	0.4
MP30	40°28 754	8° 56 573	690	1.5	0.75	0.9	0.32
MP31	40°28 814	8° 56 435	689	1.5	0.60	1.3	0.62

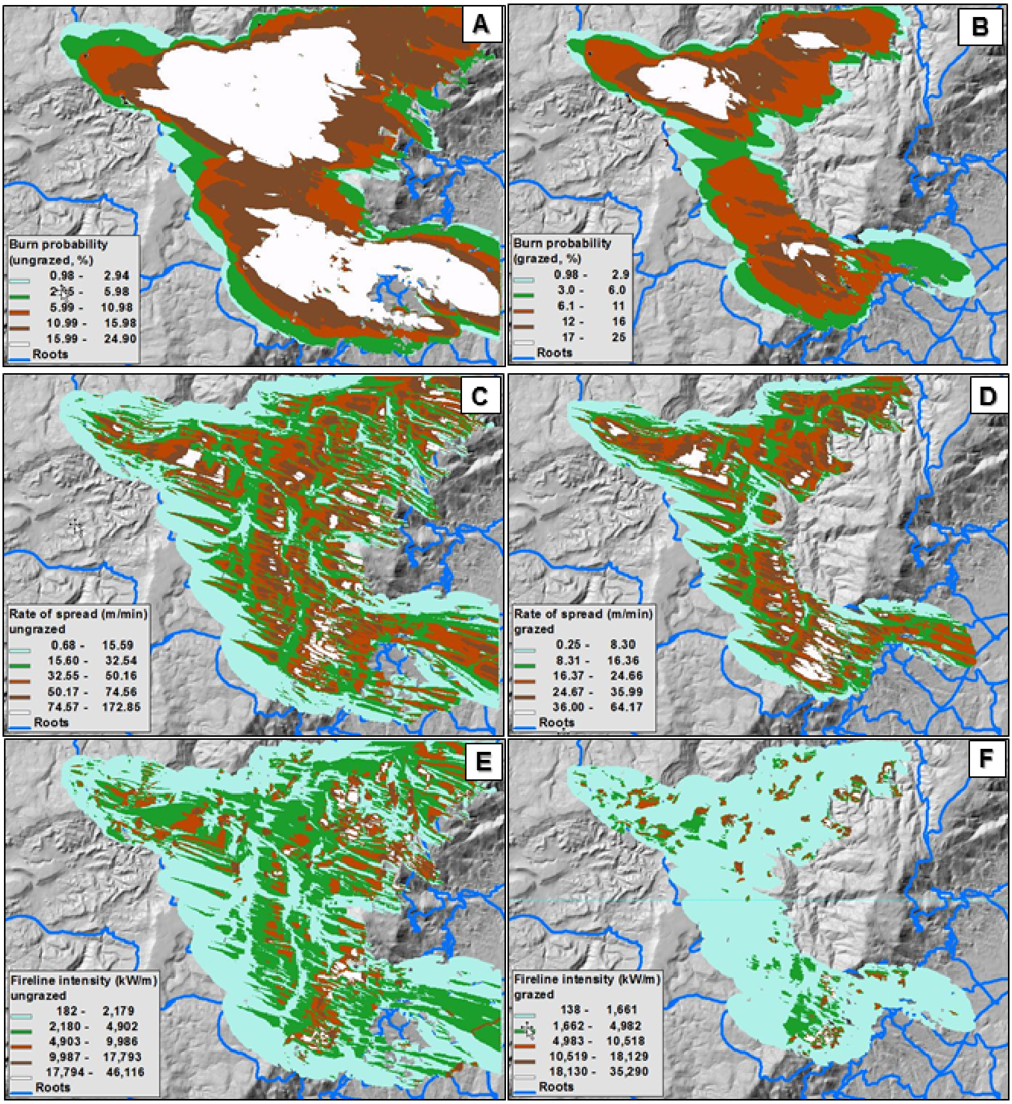

Fig. 1. Values of the propagation probability, rate of spread and fireline intensity calculated for grazed (A, C, E) and ungrazed (B, D, F) conditions by FARSITE simulator.

IV – Conclusions

The results provided by FARSITE simulator in the high natural value forest environment of Monte Pisanu, highlights the strategic importance that can be attributed to the control of herbaceous biomass in fire prevention and management. In Sardinia, as well as in many other Mediterranean forest and sylvopastoral systems, fire prevention is carried out only through the sighting and the timely involvement of fire-fighting interventions, in an attempt to contain the caused damages. In contrast, results obtained from the data collected during the trial, clearly show that the pastoral activity, playing an active role in limiting the fuel biomass, has a positive impact in containing the fire danger level. The use of pastoral activities regulated and weighted on the real potentialities of the natural pastures within the forest areas, could be a valuable support in the prevention of forest fires, involving farmers in the garrison and prevention plans of the area, possibly supporting this role with specific subsidies

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Evolution of the floristic diversity of an artificial mixture meadow under semi-arid climate in Algeria

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Abstract. In Algeria, the restoration and the creation of meadows on hydromorphic grounds of the wadi bed fields constitute a major issue of agricultural and environmental development of the semi-arid zones of altitudes which farming systems are mixed: agriculture-livestock. Within a site of this area, the diversity and frequency of the vegetable species were measured during 4 successive years on a long duration created mixture meadow and on a natural control one. Results were compared in the aim to understand the dynamics of these two types of vegetable formations subjected to traditional management practices. The results made possible to learn several lessons as for the productive provisions of the sown mixture meadow like on the fodder species having shown the best provisions of adaptation.

Keywords. Sown meadow – Natura medadow – Evolution – Floristic – Legumes – Grasses – Phenology.

Evolution de la diversité floristique d'une prairie artificielle de mélange sous climat semi-aride en Algérie

***Résumé.** En Algérie, la restauration et la création de prairies sur les terres hydro morphes des lits d'oueds constitue un enjeu majeur de développement agricole et environnemental des zones semi-arides d'altitudes à systèmes mixte : agriculture-élevage. Au sein d'un site de cette région, la diversité et la fréquence des espèces végétales, mesurées pendant 4 années successives ont été comparés sur deux parcelles de prairies, l'une naturelle et la seconde ressemée à base d'un mélange composé d'espèces introduites. Le but étant de comprendre la dynamique des ces deux types de formations végétales soumises à des pratiques traditionnelles de gestion. Les résultats ont permis de tirer plusieurs enseignements quant aux dispositions productives du mélange prairial semé ainsi que sur les espèces fourragères ayant montré les meilleures dispositions d'adaptation.*

***Mots-clés.** Pairie semée – Prairie naturelle – Evolution – Floristique – Légumineuses – Graminées – Phénologie.*

I – Introduction

Algerian agriculture is dominated by arid and semi-arid climate with low and very irregular rainfall. The most important part of agricultural systems are mixed: livestock-agriculture, and strongly including pastoralism. PERMED project (WP6 INCO project) has taken in charge a field research on natural meadow improvement as a part of multiple degraded pastures. The aim is to test behaviour of lastly selected fodder mixture under semi-arid climate and local practices. This innovation could reduce cereal crop pressure on fragile soils and provide livestock with more feeding resources. The present paper expose establishment, phenology and botanical diversity evolution of new mixture meadows in comparison with a natural control one.

II – Material and methods

The experiment has been carried out on a real farm situated in eastern high plains of the

Algerian region of Setif. Rainfall is about 400 mm/year. Agricultural system combines livestock and cereal production. Soils are profound and of silt-loam type. The pH is basic (8.2). Seeds utilized are a perennial and annual fodder mixture (Table1).

Table 1. Botanical composition of the used mixture

Component	Weight (kg/ha)	%
Medicago sativa cv. Genesis	2	6.67
Onobrychis viciifolia Scop.	2	6.67
Trifolium pratense cv. Atlaswede-	2	6.67
Trifolium fragiferum cv. Palestinel-	2	6.67
Lotus corniculatus cv. San Gabriel, L. Glaber cv. Estero	1	3.33
Lotus subbiflorus cv. Mediterraneo-	1	3.33
Trifolium mchelianum cv. Frontier, Pradana	3	10.00
Trifolium resupinatum cvs. Prolific,Nitro Plus-	4	13.33
Medicago polymorpha cvs. Santiago, Scimitar-	3	10.00
Medicago truncatula cvs. Parabinga, Jester-	2	6.67
Lolium perenne cvs. Victorian, Vitoca-	2	6.67
Dactylis glomerata cv. Currie-	2	6.67
Phalaris aquatica cv. Atlas Landmaster-	2	6.67
Festuca arundinacea cv. Demeter	2	6.67
Total	30	100.00

The experimental design was installed on 2005 November. Two closed plots of 1 ha each have been fenced and the first, the degraded one, supported the new tested meadow. The second have been followed like a control. After "Glyfosat" treatment, superficial tillage was done with a cover crop. 220 kg/ha de superphosphate (0.46 P_2O_5) was brought (46 kg P_2O_5/ha). Material used for seeding is a cereal seedier. Dose is 30 kg /ha with depth of 0.5cm. A smooth roller has been used to improve seed-soil contact. Mowing was done at 4 cm from ground. For botanical diversity asses, mowing was done in cages. Forage drying was realized in "Memert" oven under 75°C during 72 hours. 8 samples of 1 m^2 are collected in the five cages for botanical diversity assessment. From each 1 m^2 fresh biomass; 300 g are randomly extracted and served to identify different botanical components. Another 200 g are also extracted from the 1 m^2 biomass to effect DM percentage measure. Traditional flood submersion method permits to use river water when possible to irrigate the two meadows. During the experiment 4 years, rainfall average registered levels less than 400 mm. Winter and spring rain (between 16-148 mm, and 89-146 mm) varied more than the autumnal (between 104 and 143 mm). Temperatures are very high in summer (40°C) and fall in winter under 0°C. Autumnal and spring temperature is generally merciful. Low winter temperatures could often persist in earlier spring reducing vegetative plants period to less than 1.5 months (April 15 to may 30). Results are presented to facilitate botanical diversity trends analyzing during the four years of experiment. No statistical tests were done in reason of the strong annual variability and the unnecessary comparison between natural and artificial meadow types.

III – Results

Emergence (Table 2) was quite effective with 96 plants / 25 cm^2 (38400 plants/m^2). For trifolium cultivars, percentage respect seeding rate but for medics we observe a low emergence percentage. Not seeded (indigenous) plants appear very soon and show strong resistance capacity.

Table 2. Number of plants emerged per 25 cm^2 quadrates in created meadow

Species	*Trifolium*	Medics	*Lolium*	Other seeded	Not seeded	Total
Average	32.33	4.67	9.33	42.00	7.67	96.00
SD	31.34	3.27	4.46	28.87	5.82	62.84
% of total	33.68	4.86	9.72	43.75	7.99	100.00
Seeding rate	36.67	23.34	6.67	20.01		

Establishment year phenology shows that emergence occurred first in grasses (beginning of February; Fig. 1). Legumes emerged in the second half of the same month. Inversely, beginning of flowering and flowering occurred sooner in legumes than grasses in March and April successively. Senescence was observed in the first half of June.

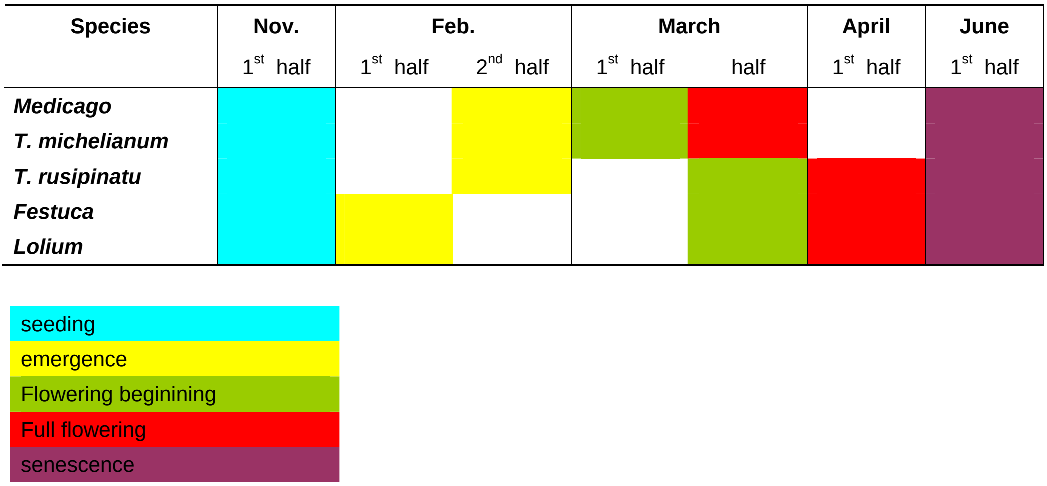

Fig. 1. New meadow establishment year species phenology.

Variation of the botanical composition (Table 3) is very important. Cultivars witch shows acceptable places in the canopy are grasses (*Lolium*, *Dactylis* and *Festuca*). From Legumes, *Medicago* species appears less frequents and met difficulties to maintain its establishment level. *Trifolium* species seems however, more adapted in particular *T. pratens*. Autochthonous species, especially weeds (*Hordeum vulgare*), are important and its level is increasing.

In the control natural meadow (Table 4), we observe less diversity but more persistence of different species. Mixture is dominated by *Festuca* species; *Lolium* and weeds (*Hordeum vulgare*) in grasses. Legumes contain more often *Trifolium* than medics. In spite of the important variation *Trifolium* species appears more persistent in the natural meadow than in the created meadow. The determinants of the plant species richness are often mutually related (Lorenzo, 2007). Phenology study shows that disconcordance of flowering stages of mixture could negatively affect some component of the species mixture. Moreover local conditions, in particular the important variability of rainfall and the spring persistence of very cold temperature could explain the observed phenomena (Wright *et al.,* 2003).

Table 3. New meadow average weight of different species in g DM / 300g fresh sample and in percent of total DM / 300g fresh sample

Species	2006		2007		2008		2009	
	g	%	g	%	g	%	g	%
Lolium perenne	7.90	9.75	8.51	8.73	10.35	**12.31**	**18.00**	**22.22**
Phalaris	5.18	6.40	4.27	4.38	7.24	8.61	**15.00**	**18.52**
Dactylis	**17.35**	**21.42**	**17.90**	**18.36**	**12.00**	**14.27**		0.00
Festuca	6.17	7.61	9.17	9.40	**11.00**	**13.08**		0.00
Medicago sativa	3.67	4.53		0.00		0.00		0.00
Other medics	4.33	5.34		0.00		0.00		0.00
Trifolium rusipinatum	3.16	3.91	**7.54**	**7.73**		0.00		0.00
Trifolium michelianum	1.17	1.44	**7.53**	**7.72**		0.00		0.00
Trifolium fragif	0.74	0.91	**4.98**	**5.11**		0.00		0.00
Trifolium ptatens		0.00		0.00	**12.50**	**14.86**	**13.52**	16.69
Lotus subiflorus		0.00	4.63	4.74		0.00		0.00
Hordeum vulgare	**12.40**	**15.31**	**10.80**	**11.08**	**18.28**	**21.73**	**22.50**	**27.78**
Other grasses	7.83	9.66	5.10	5.23		0.00		0.00
Ranunculus officinalis	**5.22**	**6.44**	**5.21**	**5.34**		0.00		0.00
Others	5.90	7.28	11.88	12.18	0.00	0.00	0.00	0.00
Total (DM of 300g)	**81.00**	**100.00**	**97.50**	**100.00**	**84.10**	**100.00**	**81.00**	**100.00**

Table 4. Natural meadow average weight of different species in g DM / 300g fresh sample and in percent of total DM / 300g fresh sample

Species	2006		2007		2008		2009	
	g	%	g	%	g	%	g	%
Lolium perenne	**26.73**	**33.02**	**10.85**	**15.15**	**23.83**	**26.89**	**10.21**	**10.02**
Phalaris	3.33	4.11	6.48	9.04	**27.09**	**30.56**	**28.49**	27.96
Dactylis	3.66	4.52	8.05	11.24	3.33	3.76	12.94	12.70
Festuca	**16.21**	**20.02**	**21.50**	**30.02**	**23.83**	**26.89**	**15.54**	**15.25**
Medics	4.79	5.92	7.02	9.80		**0.00**		**0.00**
Trifolium	**8.11**	**10.02**	**5.47**	**7.64**	**8.62**	**9.72**	**7.58**	**7.44**
Hordeum vulgaris	**15.84**	**19.57**	**5.08**	**7.10**		**0.00**	**12.84**	**12.60**
Others	2.30	2.84	7.17	10.01	1.95	2.20	14.29	14.02
Total (DM 300g)	**80.97**	**100.00**	**71.62**	**100.00**	**88.64**	**100.00**	**101.89**	**100.00**

In the new meadow; autochthonous invasive plants appear in the other hand very resistant and during the four years their parts represents mostly more or less 30% (Table 5).

Table 5. Evolution of seeded and autochthonous species average DM / 300g fresh sample in the created meadow

Species groups	2006		2007		2008		2009	
	g	%	g	%	g	%	g	%
Seeded species	49.66	61.30	64.52	66.15	53.09	67.46	46.52	59.93
Autochthonous species	31.35	38.70	32.99	33.82	18.28	23.22	22.50	28.99
Total	81.00	100.00	97.53	100.00	78.71	100.00	77.62	100.00

IV – Conclusion

Results obtained showed that the use of mixtures to create new pluriannual meadows in altitude semi-arid zones of Algeria must be studied during a long period to evaluate significantly its dynamics and performances. Trends in four successive years indicate that grasses like tall fescue and perennial ray grass are successful, however legumes, in particular *Medicago species* seems less performing. In the other hand *Trifolium* had a better dynamic. Weeds plants reinfest the created meadow quickly and reach an important level. The control of these plants should be studied in other researches.

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Development of agro forestry areas in Northern Algeria to improve pastoral production

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Abstract. In Algeria, the exploitation for livestock breeding of grazing land sloping, gaps in the forests, and some marginal lands, can be of substantial interest. Indeed, these spaces, including catchment areas of dams extending over 3 million hectares, can improve feed production. Currently, forage productivity of scrubs and forest rangelands varies from one region to another depending on environmental conditions (rainfall, exposure, soil, etc.), animal pressure and botanical composition of vegetation. Considering the chronic deficit of forage, and to improve pastoral production, we propose the development of some agro-forestry areas in northern Algeria with natural re-seeding of legumes, such as annual *Medicago*, some *Trifolium, Hedysarum*, *Onobrychis,* and *Scorpiurus* species. The choice of species and mixtures of species should take into account the ecological conditions and the adaptation of plant species. In this context, a list of suitable plant species is proposed according to soil and climatic conditions.

Keywords. Development – Agroforestry – Reseeding – Legumes – Algeria.

Aménagement des espaces agro-forestiers d'Algérie du nord pour l'amélioration de la production pastorale

Résumé. *En Algérie, l'exploitation par l'élevage de terres en pente, des vides en forêt et de certaines terres marginales, peut représenter un intérêt très important. En effet, ces espaces, dont les bassins versants des barrages ont une superficie d'environ 3 millions d'hectares, peuvent rendre un service énorme à notre élevage. Actuellement, la productivité fourragère des maquis et des parcours forestiers est très variable d'une région à l'autre en fonction des conditions du milieu (pluviosité, exposition, sol...), de la charge animale et de la composition botanique des formations végétales. Compte tenu du déficit fourrager chronique et afin d'améliorer la production pastorale, des aménagements de certains espaces agro-forestiers du Nord de l'Algérie sont proposés par l'utilisation des légumineuses à resemis naturel, tels les* Medicago *annuels, certains* Trifolium*, les* Hedysarum*, les* Onobrychis *et les* Scorpiurus*. Le choix des espèces et des mélanges d'espèces doivent tenir compte des conditions écologiques et de l'adaptation des espèces végétales. Dans ce cadre, une liste d'espèces végétales adaptées est proposée selon les conditions édaphiques et climatiques.*

Mots clés. *Aménagement – Sous-bois – Agroforesterie – Résemis – Légumineuses – Algérie.*

I – Introduction

The small agricultural area of Algeria, with 8.5 million ha, of which only 4% is irrigable and 75% receives less than 400 mm/year of rain, for 36 million inhabitants, makes it difficult to establish an agriculture capable of ensuring maximum food safety. Indeed, to promote optimal use of agricultural land, the valuation of fallow (3.5 million ha) is imperative. Moreover, the exploitation for breeding purposes of sloping land, empty tillable areas in forests and some lands classified as non-agricultural areas, may be very important. Indeed, these spaces, including catchment areas of dams with an area of nearly 3.6 million hectares, can be valuable for our agriculture.

Based on this observation, we propose to conduct an innovative approach to increase food and pastoral resources of areas classified as non- agricultural ones, including sloping land, some dam catchment areas, empty arable areas of forestlands and some degraded scrubs. We consider that large forest areas, especially in eastern Algeria, can provide considerable extra fodder units. In this respect, we propose the development of undergrowth, some forest areas, forest enclaves, and sloping grounds. Through research findings, proposals are made in favor of better preservation and enhancement of natural resources (soil, water) and biological resources with a view to improving animal production and sustainable development.

II – Materials and methods

The mountain is commonly defined as an area that includes all lands above 12% slope, i.e. 43% of the Tell region (Khelil, 2000). In Algeria, mountain areas cover a total area of 7.56 million hectares. Distribution by slope class is as follows (Table 1).

Table 1. Distribution of mountain areas depending on the slope

Slope	Name	Area (ha)	% Total area
<12%	Lower piedmont	615,000	8
12.5 to 25%	Higher piedmont	5,078,000	67
>25%	Mountain	1,872,000	25
Total	–	7,565,000	100

Source: Bureau National d'Études sur le Dévelopement Rural in Khelil (2000).

Forage productivity of scrublands and forest rangelands is highly variable from one region to another depending on environmental conditions (rainfall, exposure, soil, etc.), the stocking rate and botanical composition of plant communities.

Pastoral production in mountainous sloping areas, scrubland and some forest areas is very low. It is essential to improve the management of these environments and/or vegetation. In this perspective, we will address opportunities for improvement of pastoral and/or forage production in: sloping land in mountainous areas, enclaves, clearings and firebreak strips, oleaster (wild olive tree) and mastic; scrubs and forests.

III – Results and discussion

1. Soils on slopes in mountainous areas

The steep sloping soils of many catchment areas are affected each year, usually toward the slope. The phenomenon has increased in recent years with access to land ownership and the sharing of land among heirs (Abdelguerfi and Laouar, 1997; Laouar and Abdelguerfi, 1997). Cultivation of these soils not only causes strong degradation of the soil but also the siltation of dams downstream, which reduces the possibilities of irrigation and intensification in the lowlands. Already, in 2000, according to Khelil (2000), the total area of catchment areas of dams in operation was estimated at 2.56 million hectares, i.e. 34% of the total area of mountain areas. It is essential to use these soil types differently, while preserving the land and avoiding the siltation of dams. The use of forage and/or pastoral species with natural reseeding is one of the few solutions for the development and preservation of these soils. The annual herbaceous and/or perennial species of legumes and/or grasses, as well as trees and shrubs of forage interest should be enhanced in this type of situation. Given the usual practice around the world, it is possible to use woody species (forage and/or fruit) in strips following level curves and to seed inter-strips in annual and/or perennial herbaceous species crops (legumes and/or grasses). In this context, we can mention, for example, the following species:

- Annual species: *Hedysarum coronarium*, *H. flexuosum*, *H. aculeolatum*, *H. glomeratum, Medicago polymorpha*, *M. truncatula*, *M. orbicularis, M. aculeata*, *Trifolium pallidum*, *T. lappaceum*, *T. glomeratum*, *T. isthmocarpum*, *T. subterraneum*, *Onobrychis caput-galli*, *Scorpiurus muricatus* (the two taxa) and *S. vermiculatus.*

- Perennial species: *H. naudinianum*, *H. pallidum*, *M. sativa subsp. tunetana*, *O. argentea*, *O. alba*, *T. fragiferum*, *T. pratense* and *T. repens.*

The choice of species and species mixtures should take into account environmental conditions and adaptation of plant material.

2. Enclaves, clearings and firebreak strips

Forest enclaves, clearings and firebreak strips should be seeded with species of pastoral and/or forage interest. The use of natural re-seeding legumes, such as annual *Medicago*, some *Trifolium*, *Hedysarums, Onobrychis* and *Scorpiurus*, is widely recommended (Abdelguerfi, 1993; Abdelguerfi and Laouar 1999a,b; Abbas *et al*., 2006). Bätke (1994) obtained yields of about 5 to 7 t DM/ha in favorable years with subterranean clover in the Middle Atlas region (cold winter) in Morocco.

3. Oleaster and mastic

These plants are quite widespread in northern Algeria and their pastoral production is quite low. As part of the National Program of Agricultural Development and to reduce unemployment and create jobs, the grafting of oleaster is strongly encouraged. Given the alternating production of the olive tree and its effect on beneficiaries' income, it is essential to diversify sources of income. In this perspective, the introduction of local breeds of livestock (goats, sheep, and cattle) will develop available feed units. Besides the use of grass production, livestock will also add value to all byproducts of the olive tree (branches, grounds, etc.). The installation of some trees and forage shrubs such as ash, elm, white poplar, shrubby alfalfa and carob shrub will allow the establishment of balanced agro-silvopastoral systems.

4. Scrubs and forests

Flat and/or low slope terrain of scrubs and forests of northern Algeria should be developed to allow the increase of pastoral production while reducing grazing pressure on the remaining forests. These agro-silvopastoral and/or silvopastoral developments may be part of land development and access to land ownership. The use of annual species with natural reseeding and perennial herbaceous species should be strongly encouraged. The introduction of *Hedysarum* throughout the north central (from Chlef to Kabylia) and northeastern (from Skikda to Souk-Ahras) part of the country is necessary. Moreover, the use of ash, shrubby alfalfa, the carob tree, the spineless cactus and other species (for their leaves and/or fruit), is indispensable for tough times (off-season, inter-year).

The forests of evergreen oak (*Quercus ilex*) are often subjected to significant pressure of use (wood, grazing, etc.). Intensive exploitation has generally transformed these forests into low grade forest stands where the presence of sub-shrubby and bushy strata is remarkable. The clearing of bushes and possibly the sub-shrubby strata on flat and/or low sloping terrain will facilitate the development of an herbaceous layer of pastoral interest.

Algeria is one of seven Mediterranean countries with forests of cork oak (*Quercus suber*). Oak trees cover 450,000 ha, but true cork forests spread over only 150,000 ha. The flat and low slope terrain of the Algerian cork forests should be developed. Cork oak stands should be preserved and the undergrowth should be seeded with subterranean clover (*T. subterraneum*) in particular. The establishment of *dehesas*-type vegetation allows the increase of the production of cork oak while providing significant animal production. The *dehesas* is a sylvopastoral feature of west-central Spain. This technique is also practiced in some regions of Portugal. In Spain, the management of *dehesas* is eco-friendly: its natural components (soil, grass, tree, herbivores, and predators) can be preserved while achieving maximum economic benefit (Gómez-Gutiérrez and Pérez-Fernández, 1996).

In forest clearings of cedar, the species most common are clover and certain grasses. Different cedar groves should be given special attention and rigorous development that should enable both the regeneration of tree species and provide some pastoral production for livestock in neighboring communities. At a clearing in the cedar forest of Teniet El Had, we found more than a dozen species of *Trifolium* and four species of *Medicago*.

The forests of Aleppo pine should also be developed. Several species of the genus *Hedysarum* grow mainly in open forests of Aleppo pine and during the various surveys; we repeatedly found *H. naudinianum* and *H. glomeratum* under Aleppo pine; H*. boveanum* (*H. humile*) and some *Onobrychis* reported in these vegetations. It is therefore possible to improve pastoral production under Aleppo pine by overseeding of certain species of *Hedysarum* and *Onobrychis*.

IV – Conclusion

Currently, the lack of a significant program of development and management of pastures (broadly defined) causes their degradation and clearance. It is essential to properly manage these areas, not only to preserve biodiversity but also to better take advantage of them. Moreover, given the limited agricultural area, it is essential to reclaim pastoral lands in mountainous areas, scrubland, and forests through adequate development.

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Fodder trees and shrubs in range and farming systems in semi arid regions of Tunisia

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Abstract. Five cultivated shrub species endemic to the semi arid regions of Tunisia, *Acacia fimbriata, Allocasuarina verticillata, Medicago arborea, Anthyllis barba-jovis L* and *Opuntia ficus-indica*, were studied as a source of animal forage. The experiment was carried out in an experimental land in Mograne (Zaghouan, *East central* Tunisia). Plants were on average 4 years old conducted without irrigation. Sampling was made at the end of autumn (November) 2008. By the exception of *O. ficus-indica* all studied species had high crude protein content (>15%). *An. barba-jovis* followed by *M. arborea* had the highest N contents (>22%). Cultivated *Al. verticillata had* the highest ADF and ADL contents, 50% and 32.8%, respectively. By the exception of *A. verticillata* and *A.barba-jovis*, *in vitro* dry matter digestibility (IVD) was higher (>80%). It was concluded that some of these cultivated shrub species is compared with some leguminous forages and convenient even in dairy farms as a source of nitrogen. Moreover, the choice of alternate feed resource should not be restrictive but must fit within the existing farming systems, and be adapted to the economic realities of the farmer.

Key words. Browse – Nutritive value – Digestibility – Farming system.

Les arbustes fourragers dans les systèmes de production en zones arides et semi-arides de la Tunisie

Résumé. *Cinq arbustes fourragers endémiques aux régions semi-arides de la Tunisie, nommées* Acacia fimbriata, Allocasuarina verticillata, Medicago arborea, Anthyllis barba-jovis L *et* Opuntia ficus-indica*, ont été étudiées pour leurs valeurs nutritionnelles. Ces espèces sont cultivées dans l'exploitation de l'Ecole Supérieure d'Agriculture de Mograne (Zaghouan, centre est de Tunisie). Les plantes étaient âgées de 4 ans conduites à sec. L'échantillonnage des feuilles des différents arbustes thème de notre étude a été effectué à la fin de l'automne (Novembre) 2008. A l'exception de* O. ficus-indica *toutes les espèces étudiées ont présenté des teneurs élevées en protéines brutes (>15%) dont les feuilles de* An. barba-jovis *suivie par* M. arborea *ont les teneurs les plus élevées (>22%). Cependant les teneurs les plus élevées en ADF (50%) et ADL(32,8%) étaient observées au niveau des feuilles de* Al. verticillata*. A l'exception de* Al. verticillata *et* An.barba-jovis*, la digestibilité* in vitro *de matière sèche (IVD) était très élevée (> 80%). Il a été conclu que la valeur nutritionnelle de certaines espèces arbustives cultivées est comparée avec celle des légumineuses fourragères ce qui pourrait justifie son intégration dans les fermes laitières comme source d'azote pour les bétails. En outre, le choix de la ressource alimentaire à intégrer ne doit pas être restrictif, mais doit s'inscrire dans les systèmes agricoles existants, et être adaptées aux réalités économiques de l'agriculteur.*

Mots-clés. *Arbuste – Valeur nutritionnelle – Digestibilité – Système d'élevage.*

I – Introduction

In Tunisia, rangelands represent one-third of the total land (5,413,000 ha) widespread mainly in the arid and semi-arid regions and distributed in forest and forest pasture (970,000 ha), *Stipa tenacissima*-based steppe (743,000 ha), communal and state rangelands (2,500,000 ha), and private rangelands (1,200,000 ha). In these areas, a major constraint to livestock production is the scarcity and fluctuating quantity and quality of the year-round feed supply. Therefore, the contribution of rangelands to the needs of livestock decreased from 80 to 30% during the last three decades. Thus, to reduce the increasing deficit of feed resources and to preserve the rangelands large scale plantations of the most promised browse species were established among the last two decades. About 600,000 ha area was planted with Acacias, Saltbushes and Spineless cactus. The benefits of these species include high biomass yield, evergreen character, drought resistance, high nutritive value. Even though plantations of fodder shrubs are relatively a recent phenomenon in Tunisia. The main reason of this slow development is the abundance of natural shrub lands for livestock feeding. Plantation of these species, a standing reserve for unusual periods of drought, was first established alone on rangeland and marginal area but recently on mixed crop/livestock farms and private land. This study was designed to determine the chemical composition and in vitro digestibility of foliage collected from five cultivated Tunisian shrub species.

II – Material and methods

1. Source of shrubby samples

Samples of cultivated browse from five shrub species (4 years old) were collected in November 2008 from the land owned by the Agricultural High School of Mograne, government of Zaghouan (center east of Tunisia), Shrub species were *Acacia fimbriata, Allocasuarina verticillata, Medicago arborea, Anthyllis barba-jovis L* and *Opuntia ficus-indica* These species were planted alone on 1ha area and conducted under dry conditions. A mixture of leaves/pads and fine green stems (diameter < 2 mm) from species were sampled. In the laboratory, leaves were manually separated from the original samples and immediately oven-dried at 60ºC and subsequently, ground to pass a 1-mm screen.

2. Chemical analysis and in vitro dry matter degradability

Dry matter (DM, method ID 934.01), ash (method ID 942.05) and crude protein (CP, method ID 984.13) contents were determined following the methods of AOAC (1999). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and sulphuric acid lignin were determined with the ANKOM fibre analyser using the reagents described by Roberston and Van Soest (1981) and Van Soest *et al.* (1991).

Rumen fluid was obtained from the rumen of four Merino sheep (body weight 49.4±4.23 kg) fitted with rumen fistula, fed 1 kg alfalfa hay daily and with free access to water and mineral/vitamin licks. The in vitro dry matter digestibility (IVD) was determined following the approach proposed by Van Soest et al. (1966) and using the ANKOM-DAISY procedure. The procedure followed as described in detail by Ammar *et al.* (2004). After 48 h of incubation, samples were gently rinsed in cold water followed by an extraction with a neutral detergent solution at 100 º C during 1 h as described by Van Soest *et al.* (1966). Each sample was incubated in duplicate and two incubation runs were carried out in different weeks, giving four observations per sample.

III – Results and discussion

Chemical composition of the leaves of browse collected from the different species is shown in Table 1. The CP content varied widely, being particularly high in *An. barba-jovis* (256 g/kg DM) and low in *O. ficus-indica* (99 g/kg DM). The low CP contents in this latter species can be probably due to high proportions of mature pads in the sample. However, the nitrogen richness of *M. arborea* and *An. barba-jovis* (leguminous shrubs) is mainly attributed to the ability of these plants to fix atmospheric nitrogen (Ammar *et al.*, 2004).

Table 1. Chemical composition (g/kgDM) and in vitro dry matter digestibility (IVD, %DM) of leaves/pads of cultivated shrubs

Species	MS	MM	CP	NDF	ADF	ADL	IVD
A. fimbiriata	954	86	159	342	258	108	86
Al. verticillata	951	98	118	472	328	138	59
M. arborea	932	93	226	344	212	69	86
An. barba-jovis	961	69	256	500	300	129	70
O. ficus-indica	962	2486	99	239	117	17	97

The NDF content ranged from 239 g/kg DM in *O. ficus-indica* to 500 g/kg DM in *An. barba-jovis*. The highest ADF (328 g/kg DM) and lignin (138 g/kg DM) contents were for *Al. verticillata*. *Opuntia* pads had the highest mineral (24.76%) and lowest NDF (239 g/kg DM), ADF (117 g/kg DM) and ADL (16.9 g/kg DM) contents. These results are in agreement with those reported by Ben Salem *et al.* (2002a) on other Tunisian planted shrubs. When compared with spontaneous species of natural shrub lands cultivated fodder shrubs revealed a higher nutritive value (Ammar *et al.*, 2005). Compared with forbs and grass, browse species have the highest content in crud protein (Ammar *et al.*, 2011). Therefore browse species generally and cultivated ones particularly are admitted to represent an important fodder reserve for livestock in harsh conditions that can be used by grazing ruminants in periods of feed scarcity, especially during severe droughts. A part heir high nutritive value, cultivated shrubs are assumed to provide high biomass production depending on species, cultivar, environmental conditions, phonological stage and plant part. Forage production from a 2 year old *Atriplex* plantation was 625 and 1125 kg DM/ ha under 150 and 200 mm rainfall, respectively. Under annual rainfall of 350-400 mm, established *M. arborea* proved to be able to produce 3.5 t/ha/year (Le Houérou, 1975) and *O. ficus-indica* produced 30 t/ha green matter.

In vitro digestibility (IVD) was variable across the shrub species examined (Table 1). The highest values (97%) were observed in *Opuntica* pads, whereas the lowest (59%) was observed in leaves of *Al. verticillata*. The large differences among shrub species in digestibility may be partly attributed to the variations in chemical composition (mainly cell wall content and composition). In particular, the lignification of the cell wall of *Al. verticillata* (42%) appears to be one of the main constraints of its low digestibility. Based on the in vitro digestibility data, the shrub species can be clustered into two groups, one of low digestibility comprising the species *Al. verticillata and An. barba-jovis* (browse with high lignin contents) and the other one of high digestibility (>80%) including all the other browse species.

Some of the ligneous species studied herein are consumed to a certain degree by small ruminants grazing in Mediterranean rangelands (Ben Salem et al., 2002b). These shrub species may be complementary either to the annual herbaceous vegetation or complement each other. Cactus pads due to their high soluble carbohydrates they make better use of the high amount of soluble nitrogen in *M. arborea* and *An. barba-jovis* (leguminous species) foliage. It is well established that poor quality diets may be correctly supplemented with cactus (Ben Salem et al., 2002 b). It can be resumed from our results on the nutritional value of the cultivated shrubs that *Opuntica*, rich in water and carbohydrates, gives sufficient energy, *M. arborea and An.barba-jovis* provide protein and *Al. verticillata* is a fibre source.

For a good management options, *Opuntia* and shrubs are recommended to be planted in wide rows allowing cereal cropping (mainly barley) in between. Animals may therefore graze the increased herbaceous biomass between the rows during spring, and stubbles during the summer time. The seasonal supply of feed is then better adjusted to the animals' needs, and livestock feeding is based more on farm resources than on commercial feeds. The management of these plantations depends on many factors such as species, nature of production (leaves, pads or fruits) and utilization (picking or gathering by man or direct browsing by animals or combined solution such as trimming) and whether the production system is intensive or extensive. The species used for direct grazing generally need a periodic cutting back either for the purpose of rejuvenating and revigorating of aging plantations or else to bring the consumable biomass within reach of the animals, this is the case of *Al. verticillata* and *An. barba-jovis*. *O. ficus-indica* is either grazed directly by animals, when fruits fall to the ground, or cut back and stall feeding to remain young pads within reach of the animals.

IV – Conclusion and recommendations

Because of their roles, shrub plantation requires careful management to maximize the production of both shrubs and land. This implies that shrub plantation should be well integrated into arid and semi-arid production systems and considered as a permanent fodder resource. *O. ficus-indica* pads should play a significant role in providing valuable nutrients to small ruminants when associated with other shrub species. Therefore, avoid planting single shrub species will promote the availability of feeds during all seasons and will help to provide better balanced diets. Cactus can be used all year around and *A. fimbriata can be* mainly used during autumn and winter, while *M. arborea and An.barba-jovis* can be exploited during the winter and summer seasons. Actually, shrub plantations in Tunisia are not well developed, thus farmers should be encouraged to adopt this new strategy. Plantations should be established in alley cropping where barley (the main cereal sown in arid zones) is planted between lines of shrubs. This will help to give better barley yields and will help to make better use of cereal crops. In fact, barley stubble may be grazed directly and supplemented with *M. arborea* / *An.barba-jovis* (a protein source) or *O. ficus-indica* (energy source). This option will facilitate the management of shrubs in a sustainable way.

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Effect of deficit irrigation on dry matter and sheep production from permanent sown pastures

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Abstract. A three year study compared pasture and sheep production from permanent sown pastures that were irrigated at four levels in Konya, the Central Anatolia Region of Turkey. Pastures were established in 2007 with *Festuca rubra*, *Poa pratensis*, *Lolium perenne*, *Trifolium repens* and *Lotus corniculatus*, and irrigated at 100%, 75%, 50% or 25% of field capacity (FC). Established pastures were grazed rotationally by flocks of weaned lambs between 2008 and 2010. The total annual dry matter production (DMP) (kg/ha) was reduced (P<0.01) by decreasing levels of irrigation in each year. Averaged across the years, mean annual DMP was 9.59, 8.78, 7.21 and 4.86 t/ha for FC 100%, 75%, 50% and 25%, respectively. Pastures irrigated at FC 100% and 75% provided equal animal production but total liveweight production (LWP)/ha decreased (P<0.01) when pastures irrigated at FC 50% or at lower level in a similar manner in each year of the study.

Keywords. Pasture production – Deficit irrigation – Grazing – Irrigation efficiency – Lamb production.

Effet de l'irrigation déficitaire sur la production de matière sèche et la production ovine à partir des pâturages permanents semés

Résumé. *Une étude de trois ans ayant pour objectif de comparer la production ovine et celle du pâturage sur de différents niveaux d'irrigation a été conduite dans la région de Konya de l'Anatolie Centrale en Turquie. Les parcelles ont été semées en 2007 avec du* Festuca rubra*,* Poa pratensis*,* Lolium perenne*,* Trifolium repens *et* Lotus corniculatus *et ont été irrigués a de doses calculées á raison des % de capacité au champ de 100%, 75%, 50% et 25%. Ces prairies ont été pâturées en rotation par des troupeaux d'agneaux entre 2008 et 2010. La production annuelle totale en matière sèche (MS) (kg/ha) a été réduite chaque année en diminuant les niveaux d'irrigation (P<0.01). Ainsi, la moyenne de production en matière sèche était de l'ordre de 9,59, 8,78, 7,21 et 4,86 t/ha pour la capacité au champ de 100%, 75%, 50% et 25%, respectivement. Les pairies irriguées à capacité au champ de 100% et de 75% fournissent une production animale équivalente. Cependant, le gain en poids vif GPV/ha est diminué (P<0.01) quand les pâturages sont irrigués a une capacité au champ de 50% ou a un niveau inferieur.*

Mots-clés. *Production de pâturages – Déficit d'irrigation – Pâturage – Efficacité d'irrigation – Production ovine.*

I – Introduction

The erratic and low precipitation often causes feed shortages and variations in forage production in most dry areas (Ates *et al.,* 2010). Irrigation can increase reliability and pasture persistence to attain desirable forage and animal production (Jensen *et al.,* 2001). However, animal production that relies on irrigated pastures is subject to water scarcity the same as irrigated field crops in dry areas. Thus, low water resources force farmers to grow more with less water (Postel, 1998). Nevertheless, the highest amount of water required for optimal crop production has been recorded in Turkey, Egypt, India, Pakistan, Iraq and Uzbekistan, reflecting the ineffective use of irrigation in these countries (Doell and Siebert, 2002). The negative impact of this inefficient use of scarce water resources on agricultural production and the environment is projected to be exacerbated by climate change (IPCC, 2007). Deficit irrigation has been promoted as one of the primary means of increasing efficiency of production and coping with scarce water resources (Oweis and Hachum, 2008). Thus, this study evaluated the impact of strategic use of deficit irrigation on animal production, in permanent pastures.

II – Materials and methods

The study was conducted in Bahri Dagdas International Agricultural Research Institute (37° 51' N, 32° 33' E, 1008 m a.s.l.), Konya, the Central Anatolia Region of Turkey. The soil is a clay-loam with slightly alkaline characteristics. The climate is continental type with mean temperatures of -0.3°C min and 23.6°C max and total annual precipitation of 322 mm. A pasture seed mixture of *Trifolium repens* (3 kg/ha), *Lotus corniculatus* (3 kg/ha), *Festuca rubra* (9 kg/ha), *Poa pratensis* (5 kg/ha) and *Lolium perenne* (6 kg/ha) was sown in 0.2 m row spacing on 4 April 2007. N-P fertilizer, 100 kg/ha N and 100 kg/ha P_2O_5, was uniformly applied at sowing and repeated in October 2008 and 2009. The paddock was divided into three blocks, each containing four fenced plots (45 × 25 m) in March 2008. Each of these blocks represented one replicate of four individually grazed pasture treatments. Within each block the four irrigation treatments were designed to maintain the soil moisture at 100% (FC 100%), 75% (FC 75%), 50% (FC 50%) or 25% (FC 25%) of field capacity. Irrigation treatments began in April 2008. No irrigation was applied during the late autumn-winter periods. The irrigation schedule was designed around daily monitored soil tensiometers placed to 0-30 and 30-60 cm depths in FC 100% plots and gravimetric soil moisture measurements. Water was applied to each treatment as required to maintain the prescribed FC% on each occasion. Total precipitation and supplementary irrigation throughout the experiment are given in Table 1.

Table 1. The amount of total and supplementary irrigation in pastures irrigated to 100, 75, 50, 25% of field capacity (FC) in Konya, Central Anatolia in 2008, 2009 and 2010

Level of irrigation	Supplementary irrigation (mm)			Total irrigation (mm) (precipitation + irrigation)		
	2008	2009	2010	2008	2009	2010
FC 100%	867	760	816	1122	1170	1102
FC 75%	650	570	612	905	980	898
FC 50%	433	380	408	688	790	694
FC 25%	217	190	204	472	600	490

Konya merino weaned lambs were stratified according to their liveweights (mean LW=41±2.6 kg in 2008, 43±1.8 kg in 2009 and 39± 1.3 kg in 2010) and allocated randomly to treatment groups. All treatments were rotationally grazed with one flock of sheep grazing one plot and the other two plots spelled. The rotation length was about 20 days with an average grazing duration of 8-12 days. The average grazing intensity with FC 100%, 75%, 50% and 25% was 107, 89, 62 and 45 lambs/ha respectively. In each year, grazing began on 24 April for each treatment and ended on 20 October. Dry matter production (DMP, kg DM/ha) from each treatment was measured by quadrat cuts. Samples from the quadrat cuts were dried in an oven (65°C) until constant weight. Live weight gain per hectare (LWG, kg DM/ha) was determined by weighing the lambs prior to and after each grazing period. LWG was calculated by multiplying LWG/head by the number of lambs/ha. Total annual DMP (kg DM/ha) and LWP (live weight production, kg/ha/d) were analyzed by ANOVA with three replicates for each measurement period as a randomized complete block design. However the LWG (g/head/d) was analysed using a completely randomized design model. The data were analyzed by analyses of variance (ANOVA) of unbalanced design (due to differences in the number of lambs per treatment) with repeated measures for each LWG measurement period. This was due to the fact that blocks were no more segregated since they were rotationally grazed with the same flock. It was assumed that the pooled data from the three replicates were random samples within the same population of lamb grazing under a given irrigation level. The interaction between irrigation level and grazing period was analyzed using repeated measures under a completely randomized design model. Significant differences among treatments means were compared by Fisher's protected LSD at α=0.05. All analyses were done using Genstat version 8.1 (GenStat, 2005).

III – Results and discussion

The highest DMP (kg/ha/y) was obtained from the pastures irrigated at FC 100% in each year. DMP (kg/ha/y) of pastures were reduced (P<0.01) by at each decreasing level of irrigation to an extent by 50% lower production from pastures irrigated at FC 25% compared to pastures irrigated at FC100% (Table 2).

Table 2. Annual dry matter (kg DM/ha) and mean liveweight production (kg/ha/d) from pastures irrigated to 100, 75, 50 and 25% of field capacity (FC) in Konya, Central Anatolia

Production	Year	Level of irrigation				SEM	P	LSD
		FC 25%	FC 50%	FC 75%	FC 100%			
DMP (kg DM/ha/y)	2008	4069d	7117c	8733b	9665a	233	0.01	806
	2009	5724d	7058c	9055b	9801a	298	0.01	1031
	2010	4774d	7457c	8572b	9311a	155	0.01	537
LWP (kg/ha/d)	2008	0.87c	1.67b	1.93ab	2.14a	0.21	0.01	0.36
	2009	0.95c	1.74b	1.97ab	2.24a	0.16	0.01	0.32
	2010	0.92c	1.87b	2.27a	2.54a	0.13	0.01	0.38

LWG per lamb (g/day) did not differ (P=0.35) among irrigation treatments in 2008, 2009 and 2010 (Fig. 1 a, b, c). However, the LW gains of animals were affected (P<0.01) by seasonal shifts with the lambs growing the fastest in the spring the slowest in summer. Over three years, LWG per hectare of pastures irrigated to FC 100% gave over 2 kg/ha/d (Table 2). This was similar to the LWG per hectare obtained from pastures irrigated to FC 75% that ranged between 1.9 and 2.3 kg/ha/d. The lower levels of irrigation resulted in reductions (P<0.01) in LWGs. Average total annual animal LW production was 198, 380, 445 and 498 kg/ha for FC 25%, 50%, 75% and 100% respectively. Over three years, LWP was the most consistent in the spring and the early summer and averaged over treatments and years, these months accounted for 51% of total annual LWP. In general, supplemental irrigation during the summer and the autumn months could not provide as high LWGs of weaned lambs as in the spring period even at the FC 100% and 75% levels. This was probably due to the slower growth of the new plant tissues and the lower nutritive values of these grasses which typically occur at high and low air and soil temperatures (Waghorn and Clark, 2004).

The irrigation efficiency (a unit of water to produce a unit of LW) was reduced dramatically during summer (Fig. 2). This situation questions the benefit of applying high amounts of water to pastures in dry areas during the summer months when the efficiency of irrigation is low (Moot *et al*., 2008). The focus of production should be on lamb fattening in spring while managing pastures for the maintenance of dry ewes, and using a lower amount of water during the summer period when the water use efficiency of plants is low due to high soil evaporation and high night time temperatures (Moot *et al*., 2008). Deficit irrigation between 50% and 75% FC may also be used in spring when evapotranspiration rates are lowest. The Inclusion of annual legumes to pasture mixtures may help improving the efficiency of water use in sown pastures. It was reported in Australia where the total water use of pastures containing annual clovers was substantially lower than for perennial pastures as irrigation was not applied during the summer months when evaporation was high, although overall production was lower than for pastures established with perennial species (Stockdale, 1983). Annual legumes in permanent dryland pastures can also promote high lamb growth rates in early spring when they have high dry matter production due to their lower temperature requirements compared with perennial legumes (Ates *et al*., 2010).

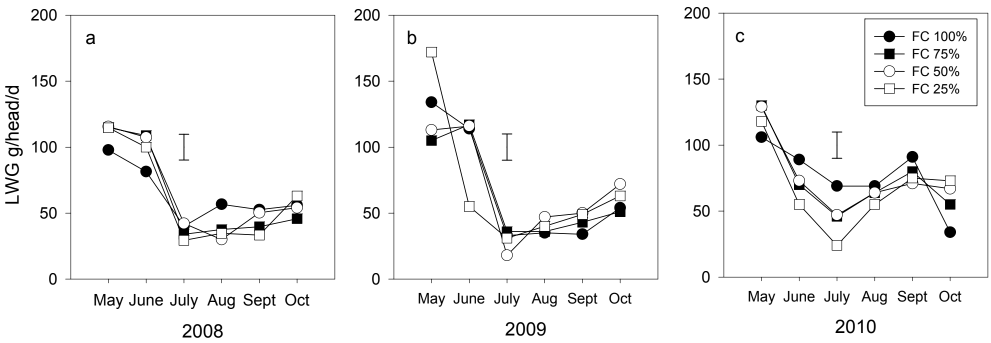

Fig. 1. Liveweight gain per head (g/head/d) in (a) 2008 (b) 2009 and (c) 2010 from pastures irrigated to 100, 75, 50 and 25% of field capacity (FC) in Konya, Central Anatolia. Bars represent SEM.

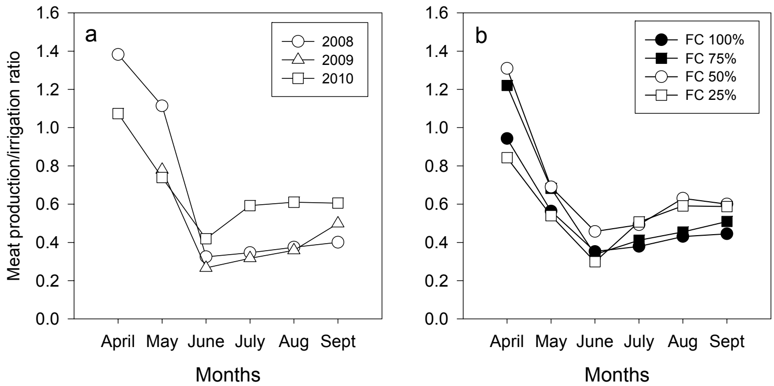

Fig. 2. The efficiency of irrigation per unit of meat produced (kg/ha-cm): (a) in 2008, 2009 and 2010, (b) from pastures irrigated to 100, 75, 50, 25% of field capacity (FC) in Konya, Central Anatolia.

IV – Conclusions

Lamb production (kg/ha) in the spring and early summer was the most consistent and thus the focus should be on fattening lambs during these periods. The irrigation efficiency (units of water to produce a unit of forage to produce a unit of LW) was low during summer months. Including annual legumes that commence growth earlier in spring than perennial legumes to pasture combinations in dry areas may provide higher water use efficiency.

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Effects of nitrogen and phosphorus fertilization on dry matter yield and quality of an abandoned rangeland

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Abstract. The object of this study was to determine the effects of nitrogen and phosphorus fertilization on dry matter yield, crude protein content, ADF, NDF and total digestible nutrient of an abandoned rangeland in Bursa-Turkey in 2008 and 2009 years. Nitrogen was applied as urea (46 % N) at 0, 50, 100, 150, 200 and 250 kg ha^{-1}rates. Phosphorus was applied as triple super phosphate (42-44 % P_2O_5) at 0, 50, 100 and 150 kg ha^{-1} rates. Fertilizers were broadcasted by hand. All of nitrogen rates increased dry matter yield and the yield reached the peak value at 200 kg ha^{-1} rate, followed by 150 and 250 kg Nha^{-1}rates, but the differences among rates were not so great. All but 50 kg ha^{-1} nitrogen level increased crude protein content, but no differences among their effects. The effects of nitrogen rates on NDF values were the same and positive when compared with the NDF value of unfertilized range. All phosphorus rates did affect only the crude protein content of hay, indicating similar effects as a result; to produce higher and quality forage from abandoned rangelands like in the experimental region the 150 kg N ha^{-1}rate can be recommended with economical considerations.

Keywords. Nitrogen – Phosphorus – Dry matter yield – Crude protein – ADF – NDF.

Titre. Effets de la fertilisation azotée et phosphorée sur le rendement en matière sèche et la qualité d'un parcours abandonné

Résumé. *Résumé. L'objet de cette étude était de déterminer les effets de la fertilisation azotée et phosphorée sur le rendement en matière sèche, la teneur en protéine brute, ADF, NDF et nutriments digestibles totaux d'un parcours abandonné situé à Bursa, Turquie, en 2008 et 2009. L'azote a été appliqué sous forme d'urée (46 % N) à raison de 0, 50, 100, 150, 200 et 250 kg/ha-1. Le phosphore a été appliqué sous forme de triple super phosphate (42-44 % P2O5) à raison de 0, 50, 100 et 150 kg/ha. Les fertilisants étaient épandus à la main. Tous les niveaux d'azote ont augmenté le rendement en matière sèche, qui a atteint une valeur maximale au taux de 200 kg ha-1, suivi de 150 et 250 kg N/ha, mais les différences entre taux n'étaient pas très élevées. Tous les niveaux d'azote sauf celui de 50 kg ha-1 ont accru la teneur en protéine brute, mais sans différences entre leurs effets. Les effets des taux d'azote sur les valeurs NDF, positifs, étaient les mêmes lorsque comparés à la valeur NDF du parcours non fertilisé. Tous les taux de phosphore ont affecté seulement la teneur en protéine brute du foin, indiquant des effets semblables comme résultat; pour produire plus de fourrage et de meilleure qualité à partir des parcours abandonnés tels que ceux de la région d'expérimentation, le taux de 150 kg N ha-1 peut être recommandé d'après les considérations économiques.*

Mots-clés. *Azote – Phosphore – Rendement en matière sèche – Protéine brute – ADF – NDF.*

I – Introduction

The growing medium in rangelands must have appropriate conditions in order that the plants should indicate their yielding power in present conditions. One of the most important factors that limits the plant production in the world is the insufficiency or inbalance of plant nutrients. Fertilization of range lands is necessary and useful when the nutrients required by plants are deficient in soil (Altın *et al*., 2005). Generally, the response of rangelands to fertilization is positive and quite high. For this reason, the fertilization is a common practice on rangelands in order to enrich plant cover or increase hay yield. Indeed, fertilizing rangelands has a lot of useful effects such as; (i) to increase hay yield and quality, (ii) to distribute hay production evenly throughout the grazing season, (iii) to ease the seedlings and (iv) to increase the palatability of hay (Altın, 1992; Heady and Child, 1994). Therefore, most practical and effective method to increase dry matter yield and quality and to improve botanical composition in rangelands is to fertilize these areas with appropriate and adequate fertilizers (Frame 1992). Fertilization, especially with N and P can increase dry matter production upto two- to three-fold from rangelands depending on the annual rainfall and moisture in the region(Aydın and Uzun, 2005). Increased N application generally increases hay production and crude protein content (Gokkus and Koc, 1995; Aydın and Uzun, 2005; Polat *et al*., 2007; Turk *et al*., 2007a; Turk *et a*l., 2007b; Balabanlı *et al*., 2010; Celebi *et a*l., 2011; Dascı and Comaklı, 2011). However, inconsistent results have been reported on the effects of fertilization on crude protein, NDF and ADF contents. Some researchers reported that there were positive effects of nitrogen on crude protein content of rangelands (Turk *et al*., 2007b; Balabanlı *et al*., 2010; Dascı and Comaklı, 2011). Balabanlı *et al*. (2010) reported that NDF peaked at the low fertilizer rates and then decreased with increasing fertilizer rates. On the other hand, Balabanlı *et al.* (2010) reported that phosphorus rate had no effect on crude protein content and ADF of rangeland. Dascı and Comaklı (2011) found that effects of phosphorus fertilization on NDF were no significant.

The objective of this study was to evaluate the responses of dry matter yield, crude protein content, ADF, NDF and TDN of an abandoned rangeland to different rates of nitrogen and phosphorus fertilization.

II – Materials and methods

This study was conducted for two years (2008 and 2009) on an abandoned rangeland in Bursa (40° 11´ N, 29° 04´ E), located on the Southern Marmara Region of Turkey. Data evaluated in this article include the results of 2008 and 2009. Total precipitation and average temperature were found as 577.9 mm and 9.9°C in 2007-2008; 579.7 mm and 7.8°C in 2008-2009; while long years average (1975-2008) were 499.6 mm and 9.7°C respectively. Soil test values indicated a pH of 7, none saline, low values in lime and organic matter and rich in potassium.

Nitrogen was applied as urea (46% N) with 0, 50, 100, 150, 200 and 250 kg ha^{-1}rates. Phosphorus was applied as triple super phosphate (42-44% P_2O_5) with 0, 50, 100 and 150 kg ha^{-1} rates. Fertilizers were broadcast by hand. Half of N and the entire of P_2O_5 were applied at the beginning of November. The rest half of N was applied at the beginning of rapid growth period of vegetation (mid-March). Fertilizer treatments were applied randomly in complete block experiment design with three replications. The dimensions of each plot were 2 m x 1 m (width and length). The distance between adjacent plots was 1 m. Harvest of plots were made at mid-May in each year when the dominant grass species reached about 50% flowering stage. After harvest, green forage samples were taken randomly from harvested green forages of each plot and put in cloth bags. They were oven-dried at 78 ºC for 48 hours and weighed, then dry weight percentages were calculated. Dry matter yield of each plot was calculated by multiplying the fresh weight of plot with its dry weight percentages. Then, oven-dried samples were ground and 1 g ground sample was used for the total nitrogen determination and 0.5 g for ADF and NDF. ADF and NDF were analyzed by sequential detergent analysis method (Van Soest *et al*., 1991) and total nitrogen by Kjedahl method. Crude protein content was calculated by multiplying total nitrogen with 6.25 constant. Total digestible nutrient (TDN) was determined by equation of TDN% = 88.9-(0.779xADF%) (Linn and Martin 1999).

Variance analysis was evaluated over two-year data. Variance analysis of components such as of dry matter yield, crude protein content, ADF, NDF and TDN were made by using MINITAB and MSTAT-C programs. The LSD was used to group the means of nitrogen, phosphorus and their interactions for each component determined when the F-test was significant.

III – Results and discussion

The response of range to nitrogen fertilizer was more evident than that of phosphorus fertilizer in respect of all components determined in the experiment. The effects of nitrogen rates on dry matter yield was found significant and the highest yield (10431 kg ha^{-1}) was produced at 200 kg N ha^{-1} level. On the other hand, the lowest dry matter yield (7725 kg ha^{-1}) was produced at plots without nitrogen (Table 1). Numerous workers have determined different nitrogen rates for maximum dry matter yield (Aydın and Uzun, 2005; Polat *et al*., 2007; Balabanlı *et al*., 2010; Celebi *et al*., 2011; Dascı and Comaklı, 2011). These are natural results due to the different ecologies and range vegetations. Response of crude protein content to nitrogen fertilization was statistically significant. Crude protein content increased up to 100 kg N ha^{-1} and then stayed stable at 150, 200 and 250 kg N ha^{-1}. These results coincide with the findings of most workers (Turk *et al*., 2007a; Balabanlı *et al*., 2010; Dascı and Comaklı, 2011). Nitrogen rates had no effects on ADF that ranged from 34.14 to 37.39 (Table 1). Nitrogen application affected also NDF content of forage. The lowest NDF value was determined at untreated plots, and the plots treated with any rates of nitrogen produced the highest NDF values, but no differences among themselves. Nitrogen rates had no effects on TDN ranging from 59.77 to 62.31 (Table 1). There were reverse results reported by other workers (Dascı and Comaklı, 2011).

Table 1. Effects of nitrogen and phosphorus rates on dry matter yield (kg ha^{-1}) and the contents of crude protein (%), ADF (%), NDF (%) and TDN (%) in an abandoned rangeland (average of two years)

	Dry matter yield (kg ha^{-1})	Crude protein (%)	ADF (%)	NDF (%)	TDN (%)
Nitrogen rate (kg ha^{-1})					
0	7725c	12.17b	37.39	49.48b	59.77
50	9004b	12.29b	36.81	50.58a	60.23
100	9030b	13.44a	36.29	52.82a	60.63
150	9448ab	13.41a	36.45	51.56a	60.51
200	10431a	13.58a	35.88	53.31a	60.95
250	9723ab	13.67a	34.14	53.37a	62.31
Phosphorus rate (kg ha^{-1})					
0	8600	12.89b	36.12	52.51	60.77
50	9213	13.48a	36.15	52.33	60.74
100	9809	13.76a	36.10	51.57	60.78
150	9551	13.59a	36.27	50.99	60.65
Years (Y)	ns	ns	**	*	**
Nitrogen (N)	**	*	ns	*	ns
Phosphorus (P)	ns	*	ns	ns	ns
Y x N	ns	ns	ns	*	ns
Y x P	ns	ns	ns	ns	ns
N x P	ns	ns	ns	*	ns
Y x N x P	ns	ns	ns	*	ns

Means of the same column followed by the same letter were not significantly different at the 0.05 level using LSD test.
*, **: F-test significant at $p \leq 0.05$, and $p \leq 0.01$, respectively. ns: not significant.

The effects of phosphorus rates on dry matter yield were insignificant (Table 1). Similar results for phosphorus fertilization were reported by Dascı and Comaklı (2011). However, some workers reported reverse results (Aydın and Uzun, 2005; Balabanlı *et al*., 2010). Crude protein content of forages was affected by phosphorus fertilization and all rates of phosphorus increased crude protein content, but there were no differences among themselves (Table 1). Polat *et al*. (2007) reported similar results for phosphorus fertilizing however, Balabanlı *et al*. (2010) reported results indicating no effects of phosphorus fertilizer on crude protein content of rangeland. The effects of phosphorus rates on ADF, NDF and TDN were found insignificant (Table 1). Dascı and Comaklı (2011) found that effects of phosphorus fertilization on NDF were no significant; which is consistent with our results. Balabanlı *et al*. (2010) reported that ADF contetnt of rangeland did not vary significantly with the phosphorus rates. All of these results, consistent or inconsistent with each other, indicated that many factors may interfere in the effects of phosphorus to occur.

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Effect of *Bacillus* sp. on P uptake in *Vicia sativa*, *Vicia ervilia*, *Medicago sativa* grown in greenhouse conditions

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Abstract. *Bacillus* sp. MK4 isolate was isolated from Şanlıurfa soils, Turkey. MK4 isolate was biochemically characterized. MK4 isolate was evaluated in vitro for plant promoting traits like ammonia (NH_3) production, antifungal activity, phosphate solubilization. In addition, the effect of *Bacillus* sp. MK4 on P uptake by *Vicia sativa, Vicia ervilia* and *Medicago sativa* under greenhouse conditions was studied. Seed inoculation of this bacterial isolate resulted in significant increases in shoot and root weight of *Vicia sativa, Vicia ervilia, Medicago sativa* with or without added P source.

Key words. *Vicia sativa* – *Vicia ervilia* – *Medicago sativa* – *Bacillus* sp. – Inoculation.

Effet de* Bacillus *sp. sur l'absorption de P dans* Vicia sativa, Vicia ervilia *et* Medicago sativa *cultivées dans de conditions de serre

Résumé. Bacillus *sp. MK4 a été isolé à partir de sols de Şanlıurfa, en Turquie. L' isolat MK4 a été caractérisé biochimiquement. MK4 isolat a été évaluée in vitro pour des traits importants pour la promotion des la croissances des plantes, tels que la production d'ammoniac (NH3), l'activité antifongique, et la solubilisation du phosphate. En plus, l'effet de* Bacillus *sp. MK4 sur l'absorption de P par* Vicia sativa*,* Vicia ervilia *et* Medicago sativa*, dans des conditions de serre a été étudiée. L'inoculation des semences avec cet isolat bactérien a entraîné des augmentations significatives dans des pousses et le poids des racines de* Vicia sativa*,* Vicia ervilia *et* Medicago sativa*, avec ou sans source de P ajoutée.*

Mots-clés. Vicia sativa – Vicia ervilia – Medicago sativa – Bacillus *sp. – Inoculation.*

I – Introduction

Plant growth bacteria are of great agronomic importance. They produce metabolite such as plant growth regulators that directly promote growth and nutrient uptake by plants (Krey *et al.,* 2011). Solubility of phosphorus is very low in most of the agricultural soil of the world (Kaçar and Katkat, 2008). Application of phosphate fertilizers is therefore essential to increase crop yields. However, availability of phosphorus is a serious problem because it is fixed in the soil (Schiling *et al.,* 1998). The use of phosphate solubilizing microorganisms has been previously tested (Lugtenberg and Kamilova, 2009).

The rhizosphere of cereal crops was found to harbor a great number of phosphate solubilizing bacteria (Krey *et al.,* 2011). The bacterial genus *Bacillus* group plays important roles in the agricultural ecosystems (Lugtenberg and Kamilova, 2009). Specificially it is involved in disease suppression in many crops (Krey *et al.,* 2011; Khalafallah *et al.,* 1982; Kumar and Narula, 1999) and enhanced plant growth and development (Kumar and Norula, 1999; Lugtenberg and Kamilova, 2009). The main objectives of this research were to isolate the *Bacillus* isolates from rhizosphere soil and determine their effect on P uptake of *Vicia sativa, Vicia ervilia* and *Medicago sativa.*

II – Materials and methods

Bacillus sp. B14, B9, B21 and MK4 were isolated from the rhizosphere soil of maize grown in vicinity of Şanlıurfa, Turkey.

NH_3 production: Isolates were tested for the production of ammonia in peptone water. Nessler`s reagent (0.5ml) was added in each tube. Development of brown to yellow colour was a positive test for ammonia production (Cappucino and Sherman, 1992).

Phosphate solubilization: All isolates were tested on Pikovskaya`s agar plates for phosphate solubilization as described by Haripsavad and Niranjana (2006).

Antifungal assay: Bacterial isolates were tested on growth plates on peptone agar. Isolates were streaked on the test plates perpendicular to pathogen fungi. The isolates were tested for antagonistic activity as described by Idriss *et al.,* 2007.

Plant and soil: The soil for pot experiment was collected from a non-fertilized field site near Osmanbey, Şanlıurfa. The soil chemical and physical properties are presented in Table 1.

Table 1. Soil some chemical properties

EC	pH	% CaCO3	P_2O_5 (kg da^{-1})	K_2O (kg da^{-1})	Organic matter %
1.65	7.66	20.8	34.5	207.5	22.1

Total nitrogen content was determined by the Kjeldahl method (Bremner, 1965). Potassium was determined by the Flame photometric method (Riehm,1985). Soil pH volue was measured by pH meter. *Vicia sativa, V.ervilia* and *Medicago sativa* seeds were obtained from the Ege University, Faculty of Agriculture.

Pots experiment: The inoculation treatment was set up in randomized design with four replicates.The day before sowing pots were filled with 1000 g soil. Ten seeds of *V.sativa, V.ervilia* and *Medicago sativa* were sown per pot. Isolates were grown in Nutrient broth. Treatments for the greenhouse experiments were: Untreated control, bacterial isolate and P, P treatment. The crops were harvested 60 days after sowing. Plant parameters studied were P uptake (mg plant^{-1}), root and shoot biomass (mg plant^{-1}).

III – Results and discussion

B14, B9, B21 and MK4 were identified as *Bacillus* sp. on the basis of morphological and biochemical tests and also on the basis of description given in Bergey`s manual of systematic Bacteriology (Holt *et al*.,1994). B14, B9, B21 and MK4 are Gram positive. They are also motile. MK4 isolate gives positive tests in nitrate and ammonia production. *Fusarium* species are the most destructive pathogen in most agricultural crops in all around the world (Idriss *et al.,* 2007). The antagonistic properties of *Bacillus* isolates against *F.moniliforme*, *F.solani* and *F.oxysporium* were shown in Fig. 1.

The metabolites produced by phytopathogenic fungi have been postulated as responsible for the increased plant growth and nutrient uptake (Haripsavad and Niranjana, 2006; Krey *et al.,* 2011). As *Pseudomonas* sp., *Bacillus* sp. increase the uptake of P, they may also increase the plant growth. In this study, it was observed the production of clear zone in Pikovskaya`s medium obtained in MK4 isolate. And this also indicated that the P uptake was improved by MK4 isolate.

Isolate MK4 inoculation affected the growth of tested plants. The inoculation of *V.sativa* with MK4 increased the shoot dry weights by 50% as compared to the control (Fig. 2). The inoculation of *V.ervilia* with MK4 increased the root dry weight 66.7% as compared to the control (Fig. 3).

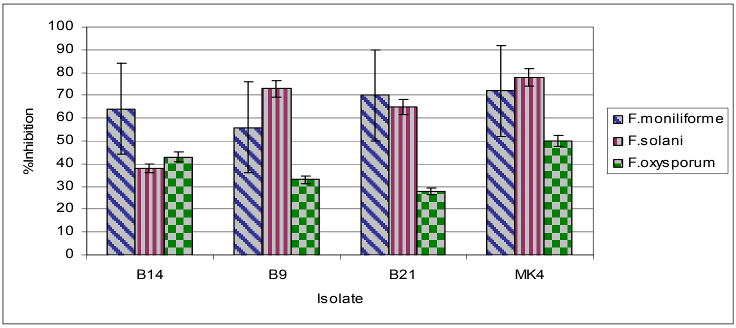

Fig. 1. Inhibition of pathogenic fungi by isolates (%).

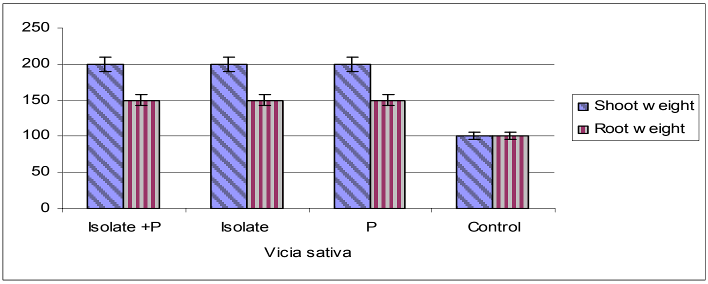

Fig. 2. The influence of isolate MK4 on shoot and root weight (mg plant $^{-1}$) on *Vicia sativa* (p< 0.01).

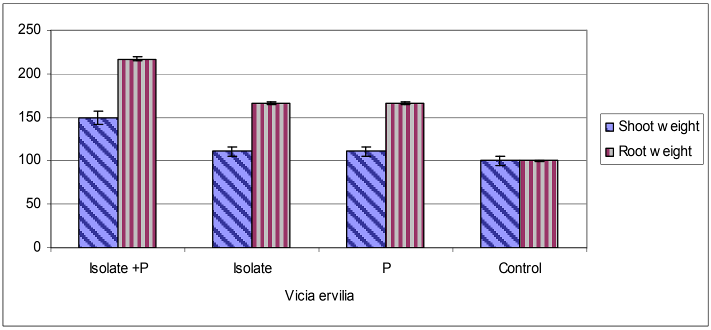

Fig. 3. The influence of isolate MK4 on shoot and root weight (mg plant $^{-1}$) on *Vicia ervilia* (p< 0.01).

Shoot and root growth increased more than control in *V.sativa* and *Medicago sativa* with isolate + P treatment (Fig. 4).

Seed inoculation with various bacterial isolates was reported to improved yield and nutrient uptake of various crops (Linu *et al.*, 2009; Lugtenberg and Kamilova, 2009). The inoculation of

Vicia ervilia, *Vicia sativa* and *Medicago sativa* grown with bacterial isolate MK4 increased the P uptake 58.4 %, 24.5 % and 37.1 %, respectively as compared to the control (Fig. 5). Similar results were reported by Kumar and Narula (1999), Linu *et al.* (2009), Krey *et al.* (2011), *Pseudomonas* sp. and *Bacillus* sp. isolates significantly enhancing plant growth and nutrient uptake.

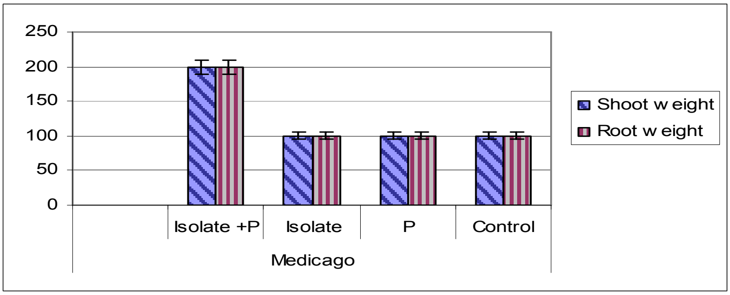

Fig. 4. The influence of isolate MK4 on shoot and root weight (mg plant^{-1}) on Medicago sativa (p< 0.01).

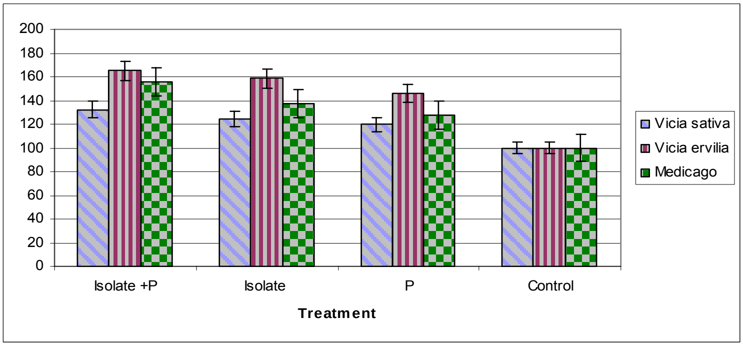

Fig. 5. The influence of isolate MK4 on P uptake (mg plant^{-1}) of *V.sativa*, *V.ervilia* and *Medicago sativa* (p< 0.01).

IV – Conclusion

Four isolates isolated from rhizospheric soil of maize were characterized as *Bacillus* sp. *Bacillus* sp. MK4 isolate showed beneficial effects on *Vicia sativa, V.ervilia* and *Medicago sativa* growth in greenhouse experiment. The favourable effect of the inoculation on plant growth may be due to growth promoting subtances by isolates.

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Pasture improvement programs carried out on some coastal pastures and highland ranges of Antalya

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Abstract. A great portion of the grassland in Antalya is in poor condition due to long dry period in summer season and improper range management practices. In this work three highland pastures, 3800 ha in total, and three coastal pastures 175 ha in total were studied, and hay yield improvement was aimed. At the beginning all coastal pastures and highland ranges were covered with fences, to control grazing periods. All pastures were fertilized in different seasons during program. In some parts of controlled pastures, seed mixtures were sown. The first year of the study all pastures were closed for grazing animals. The following years animals were grazed from May-October. Bushes and unflavoured plants were cut to give a better growing chance to favour grasses. Loop and 1 m. frame methods were used to obtain, hay yields, average plant covered areas %, and botanical composition in all coastal pastures and highland ranges. As a result, all data were shown improvement of all pastures were satisfactory, but coastal pastures observed better behaviour than highland ranges in all determined characteristics.

Keywords. Coastal pastures – Highland ranges – Hay yield - Botanical composition – Plant-covered area.

Programmes d'amélioration des pâturages menés sur des prairies côtières et des parcours montagneux d'Antalya

Résumé. *Une grande partie des pâturages d'Antalya sont en mauvais état dû à une longue période de sécheresse en été et à des pratiques peu appropriées de gestion des parcours. Dans ce travail, trois pâturages de montagne d'une surface totale de 3800 ha, et trois pâturages côtiers d'une surface totale de 175 ha, ont été étudiés en vue d'améliorer le rendement en foin. On a commencé par poser des clôtures dans tous les pâturages côtiers et parcours de montagne afin de contrôler les périodes de pâturage. Tous les pâturages ont été fertilisés à différentes saisons au cours du programme. Un mélange de semences a été semé dans certaines parties des pâturages contrôlés. Pendant la première année de l'étude, tous les pâturages étaient interdits aux animaux brouteurs. Lors des années suivantes on faisait paître les animaux de mai à octobre. Les buissons et les plantes non appétentes étaient coupés afin de favoriser la croissance des graminées. Les méthodes de la boucle et du cadre de 1 m étaient utilisées pour étudier les rendements en foin, le pourcentage moyen de couverture végétale des zones, et la composition botanique sur tous les pâturages côtiers et les parcours de montagne. Comme résultat, toutes les données ont montré une amélioration satisfaisante pour tous les pâturages, mais on a observé pour les pâturages côtiers un meilleur comportement que pour les pâturages de montagne pour toutes les caractéristiques déterminées.*

Mots-clés. *Pâturages côtiers – Parcours de montagne – Rendement en foin – Composition botanique – Zone couverte de végétation.*

I – Introduction

For the animal production, livestock enterprises basically are in need of quality roughage, which is the cheapest source of animal feed. Moreover, keeping pastures and meadows in good condition prevent water and wind erosion of soil.

Lacking of an independent pasture law, pastures areas could not be well controlled and most of pastures and meadows were sown for producing cereals during the last decades. Finally 44 million hectares of pasture land has dropped dramatically to 12.3 million hectares in Turkey.

In addition, early and excessive grazing practices for many years have impoverished pastures. So as a result of this practices hay yields of meadows and pastures were decreased.

At the year of 1998 a detailed pasture law was accepted at Turkish National Assembly. Firstly, the process of characterization and determination of pastures is important for keeping them safe and implement some necessary processes for increasing their production. Protecting pastures can help decreasing effects of global warming (Anonymous, 2010).

Pasture improvement and management activities in Antalya (5 in 2004, 1 in 2006, 1 in 2007 and 2 in 2009), continues with a total of 9 projects. This projects are implemented on the pastures of the villages of Yenidumanlar, Yurtpınar, Aşağıoba, Yağca, Kovanlık, Imırcık, Eymir, Eynif and Küçükköy.

The better parts of pastures were planted mixture of legumes and grasses. Suitable and grazing resistant, productive legumes and grasses were chosen for grazing of cattle and sheep. Fertilizers were used, and grazing period were limited.

In this study pastures conditions were determined at three coastal pastures and tree highland pastures of Antalya.

II – Materials and methods

Rangelands and pastures located in Antalya Province were surveyed for vegetation cover, botanical composition and forage yield. Six rangelands (three rangelands to represent coastal zone and three rangelands to represent highland zone) were chosen for the improvement program.

Rangelands chosen to represent coastal zone are Yenidumanlar, Aşağıoba and Yağca rangelands. Eymir, Eynif and Küçükköy rangelands were selected to represent highland zone. Yenidumanlar is located in Aksu district approximately 25 km east of Antalya. Aşağıoba and Yağca rangelands are located in Döşemealtı district approximately 20 km north of Antalya. Eymir is located in Elmalı district, 120 km west of Antalya and at a location of 1000 m above sea level. Eynif is located in İbradı district 180 km North-east of Antalya and 1050 m above sea level. Küçükköy is located in Korkuteli district, 85 km west of Antalya and at 1400-1500 m above sea level. Antalya has a Mediterranean climate, with mild, rainy winters and hot, dry summers. According to climate data, coastal zone has typical Mediterranean climate but highland zone has typical continental climate. Main winds flow from south and north directions. Wind speed is the highest in winter. Average temperature is 18°C and average relative humidity is 60,6% in Antalya.

Rangeland improvement studies were conducted for four years (2004-2008). Treatments applied in rangelands are presented below for each rangeland, separately.

Yenidumanlar. Rangeland was fenced wit wire completely and grazing was stopped. Drainage system was cleaned and renewed. Bush and shrubs were removed in certain parts of meadow. These areas were tilled and prepared seedbed and seed were sown. Soil was cultivated with minimal tillage techniques in other part of rangelands. Sprinkler irrigation system was established on rangeland. A seed mix including smooth brome (*Bromus inermis* Leys), Kentucky bluegrass (*Poa pratensis*), Bermuda grass (*Cynodon dactylis*), alfalfa (*Medicago sativa* L.), bird's-foot trefoil (*Lotus corniculatus*) and red clover (*Trifolium pratense*) was sown in 2005 autumn. 170 kg/ha diammonium phosphate (DAP) was applied during the sowing. 100 kg/ha ammonium nitrate was applied in early spring (Gençkan 1985). Yenidumanlar rangeland was not used in the first year of improvement study. The rangeland was opened to grazing in order to grazing plan and other management rules in the second year of improvement study.

Aşağıoba. Rangeland was fenced completely, an irrigation pond was made and sprinkler irrigation system was established on rangeland. Weeds were cleaned with hoe and seedbed prepared. Seed mix including smooth brome, Kentucky bluegrass, orchard grass (*Dactylis glomerata*), crested wheatgrass (*Agropyron cristatum*), sheep's fescue (*Festuca ovina*), çayır düğmesi (*Potaryum songisorba*), bird's-foot trefoil, red clover and crimson clover (*Trifolium incarnatum*) was sown. Seeding rate was 21.9 kg/ha (Bakır 1985). 170 kg/ha DAP was applied during the sowing, and 100 kg/ha ammonium nitrate was applied in early spring.

Yağca. Rangeland was fenced completely. Bushes were removed from a part of rangeland and over-seeded in that site. Soil was cultivated in a part of meadow, and a seed mix was sown in that site. The rest of the rangeland was left in natural state as a goat rangeland. Sprinkler irrigation system was established on rangeland. The seed mixture included red clover, bird's-foot trefoil, alfalfa, smooth brome, orchard grass and perennial ryegrass (*Lolium perenne*). Seeding rate was 22 kg/ha. 170 kg/ha DAP fertilizer was applied during the sowing and 100 kg/ha ammonium nitrate was applied in early spring.

Eymir. Rangeland was fenced completely and separated to three paddocks for rotational grazing. Weed control was done with chain and cutting. Soil was cultivated with minimal tillage techniques and a seed mixture (13,7 kg/ha) was sown in 2006. Seed mixture included red clover, bird's-foot trefoil, alfalfa, smooth brome, orchard grass and sheep's fescue. 220 kg/ha DAP fertilizer was applied during the sowing and 120 kg/ha ammonium nitrate was applied in early spring. Rangeland was not used in the first year of study and opened to grazing in order to grazing plan and other management rules in the second year.

Küçükköy. Broadcasting seeding was done on 750 ha existing vegetation in Küçükköy rangeland. The seed mixture included red clover, bird's-foot trefoil, sainfoin, smooth brome, crested wheatgrass and sheep's fescue. Seeding rate was 13.7 kg/ha. 120 kg/ha DAP fertilizer was applied during the sowing and 60 kg/ha ammonium nitrate was applied in early spring.

Eynif. A Grazing plan was prepared for rotational grazing and the rangeland was used in order to this plan.

All of the seed mixtures used in improvement studies were selected to suit for existing species on natural vegetation.

Vegetation cover percent, botanical composition and forage yield were determined for each rangeland in second year of rangelands improvement program.

Vegetation cover was recorded at five sites along three loops for each rangeland (Avcıoğlu, 1983). The identified species were classified according to their families: legumes, grasses and other plant species for botanical composition. Vegetation in a 1 x 1 m frame was clipped at 3 to 5 sites and weighed for forage yield determination. Forage samples were dried at 65ºC for 48 hours and were weighed for dry matter yield.

III – Results and discussion

Vegetation covered area, botanical composition and forage yield were recorded using loop method and 1 x 1 m frame method in order to determine effects of improvement practices and management on rangelands during the grazing season (Table 1).

According to results of improvement studies, vegetation covered area ranged from 77.4% to 95%. However, vegetation covered area ranges from 10% to 27% on not improved rangelands in Turkey (Bakır ve Açıkgöz, 1979). These results show that improved rangelands were better situation after improvement studies.

Forage yields were higher in coastal zone rangelands than in highland rangelands. The highest forage yield was obtained from Yağca (30,400 kg/ha) and the lowest forage yield was obtained from Eynif (8500 kg/ha). Tung *et al.* (1991) compared 5 different improvement methods in Doğanbey and the highest forage yield was obtained from Çıfıt Castle I (2720,7 kg/ha) and from Payamlı region (6645 kg/ha). Tetik *et al.* (2002) compared different rangeland improvement methods and the highest forage yield was 8741.9 kg/ha. These results agree with our result obtained from Eynif.

Table 1. Vegetation covered area, botanical composition, yield and quality traits of rangelands

Regions	Rangelands	VCA (%)	BC (%)	FY (kg/ha)	DMY (kg/ha)	Lgm/DMY (kg/ha)	Grs/DMY (kg/ha)	OPS/DMY (kg/ha)
Coastal Zone	Yenidumanlar	95.0	Lgm:13 Grs:39 OPS:48	18100	5340	580	2000	2760
	Aşağıoba	77.4	Lgm:19 Grs: 46 OPS:35	27670	9545	951	1852	6743
	Yağca	90.4	Lgm:51 Grs:16 OPS:33	30400	7803	3425	439	2802
Highland Zone	Eymir	79.4	Lgm:36 Grs: 34 OPS:30	14830	4399	1491	1496	1412
	Küçükköy	92.3	Lgm:13 Grs:59 OPS:28	21500	5122	849	2703	1570
	Eynif	79.4	Lgm:55 Grs:10 OPS:35	8500	1940	889	324	820

VC: Vegetation Covered Area; BC: Botanical Composition; FY: Forage Yield; DMY: Dry Matter Yield; Lgm: Legumes; Grs: Grasses; OPS: Other Plant Species.

Hay yields determined in our study were higher than average hay yields (300- 900 kg/ha) of Turkey rangelands (Bakır ve Açıkgöz, 1979). The highest hay yield was determined in Aşağıoba (9545 kg/ha) and lowest hay yield was obtained from Eynif (8500 kg/ha). Yılmaz *et al.* (1999); conducted a research to determine yields of a heavy grazing and a light grazing rangeland in Van. They obtained 1741.4 kg/ha hay from light grazing rangeland and 630.8 kg/ha hay from heavy grazing rangeland. Tükel *et al.* (1991); obtained 1096.1 kg/ha hay from protected rangeland from grazing and 534.6 kg/ha hay from grazing rangeland in early summer in Çukurova University Campus. Polat *et al.* (1996) conducted a rangeland improvement study and they determined hay yield of protected rangeland as 1531.7 kg/ha in Tektek Mountains in Şanlıurfa.

IV – Conclusions

The results of the study showed that breeding studies carried out on pastures of Antalya increased quality and yield. It is also important for the sustainability of the vegetation to take into account the natural vegetation available in the target pasture, when deciding the composition of seed mixtures in the over seeding system.

As a result, determination of the plant species in the target pasture and organizing breeding studies according to the natural vegetation should be used.

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Daily growth evaluation of an irrigated lucerne crop

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Abstract. The daily growth of a lucerne cv 'Aragón' crop was determined under irrigated conditions in Zaragoza (Spain) during the period 2006-2009. Forage yield and crude protein percentage were evaluated every eight days as average on seven vegetation cycles per year applying the method of Corrall and Fenlon. The productive period of lucerne was from the beginning of March to the end of November. The annual maximum dry matter yield was 15.901 kg ha^{-1} in the third year, and the maximum growth was reached on 30 June 2008, 119.5 kg ha^{-1} day^{-1}. The crude protein percentage decreased from 22.9% at mid-April to 15.5% at mid-July; later, it increased up to 24.5% at the middle of November. These results represent a contribution to the optimization of lucerne crops management.

Keywords. *Medicago sativa* L. – Daily growth – Harvest – Dry matter – Irrigation.

Évaluation journalière de la croissance d'une culture de luzerne en conditions d'irrigation

Résumé. *La croissance journalière d'une culture de luzerne cv 'Aragón' a été déterminée dans des conditions d'irrigation à Saragosse (Espagne) lors de la période 2006-2009. La production fourragère et la teneur en matières azotées totales ont été évaluées avec une périodicité moyenne de huit jours sur sept cycles de végétation par an en utilisant une adaptation de la méthode de Corrall et Fenlon. La période productive de la luzerne est comprise entre début mars et fin novembre. La production annuelle maximale de matière sèche a été de 15.901 kg ha^{-1} la troisième année. La croissance journalière maximale a été atteinte le 30 juin 2008, 119,5 kg ha^{-1} $jour^{-1}$. Le pourcentage de matières azotées totales a diminué de 22,9 % en mi-avril à 15,5 % en mi-juillet. Plus tard, il a augmenté jusqu'à 24,5 % en mi-novembre. Ces résultats représentent une contribution à l'optimisation de la gestion des cultures de luzerne.*

Mots-clés. Medicago sativa *L. – Croissance journalière – Récolte – Matière sèche – Irrigation.*

I – Introduction

Lucerne (*Medicago sativa* L.) is the second forage crop in Spain in terms of surface and the first one in terms of yield. In 2009, 159,014 irrigated ha and 86,952 rainfed ha were cultivated producing more than 10,000,000 t fresh forage yield. The main use of forage (94% of surface) was for hay or dehydrated purposes (MAPA, 2009).

The importance of this crop is due to its high dry matter (DM) and crude protein (CP) yield under irrigation conditions. In addition, it is a crop with a high capacity for fixing nitrogen and improving soil structure. For this reason, lucerne is frequently used as an alternative to other crops in basic pH soils.

Studies aiming to the improvement of this crop such as a better understanding of the distribution of forage yield and its CP contents along the harvesting time will benefit its efficiency. This work studies the evolution of daily growth and CP contents according to the date of cutting in an irrigated lucerne stand.

II – Materials and methods

The study was carried out in a flood irrigated plot in Zaragoza (Spain) in the period 2006-2009. The annual mean temperature of the test period was 14.4 ºC and the extreme monthly mean temperatures 0.3 ºC and 33.3 ºC, remarking the absolute daily minimum, -8.6 ºC. The annual mean rainfall was between 241.1 and 450.6 mm. The plot was located on an alluvial, loamy, non saline soil, 0.24 dS m^{-1} (CE 1:5); pH in water (1:2.5), 8.20; organic matter, 1.99%; P Olsen 7.03 mg kg^{-1} and K (ammoniac acetate extract) 134 $mgkg^{-1}$.

Daily growth of lucerne was evaluated according to the Corrall and Fenlon method (1978). This method developed in grasses establishes the daily growth curve using four plots rotationally harvested every week. Corral and Fenlon (1978) assume that the daily growth corresponding to week t is presented by the formula $(A_1Y_t+ A_2Y_{t+1}+ A_3Y_{t+2}+ A_4Y_{t+3})/28$, where Y_t, Y_{t+1}, Y_{t+2} e Y_{t+3} are the forage yield at the end of the weeks t, t+1, t+2 y t+3, and $A_1= A_2=A_3= A_4=1/4$ when a lineal growth rate was assumed. However if a simple quadratic approximation was assumed, the A coefficients used by these authors are: $A_1=7/16$, $A_2=5/16$, $A_3=3/16$ y A_4 =1/16. Cuts were performed every eight days in the first five productive cycles and every ten days in the sixth and seventh cycles, according to previous studies (Delgado *et al*., 2011).

Four 10 m^2 plots (2 x 5 m) distributed in random blocks with three replications were used. Sowing took place on 4 October, 2006, using the cv. 'Aragón' at 30 kg ha^{-1} sowing dose. As basic dressing 600 kg complex 8-24-8 ha^{-1} were applied the first year and 500 kg ha^{-1} of the same complex in winter in the following years. The plot was flood irrigated at a minimum rate of 12 days in the summer months.

The average cut date for the beginning of the study was 11 April and for the end was 20 November. The estimation of DM yield was made by cutting two 0.5 m^2 per plot. The cut forage was dried at 60ºC in a forced ventilation stove till reaching a constant dry weight. Then samples were ground and their CP contents evaluated by Dumas method (AOAC, 1990).

The statistical analysis to compare DM weekly yield was made using the ANOVA procedure of SAS statistical package (SAS, 2003), considering the cutting date as treatment. The comparison of means was made by the LSD test.

III – Results and discussion

Seven cuts per plot were performed along the year. The lucerne daily growth in the three years of study is shown in Fig. 1. When analysing the curves designed assuming a lineal growth, we can observe that growth started at the beginning of March and stopped at the end of November, the daily maximum being reached on 30 June 2008, and 119.5 kg DM ha^{-1} day^{-1}. Growths higher than 90 kg DM ha^{-1} day^{-1} appeared between 10 April and 27 July. The curve designed assuming a simple quadratic growth was very similar to the lineal one, reaching the daily maximum on 30 June 2008, that is 126 kg DM ha^{-1} day^{-1} and growths higher than 90 kg DM ha^{-1} day^{-1} took place from 10 April to 1 August.

Annual yield was significant ($P<0.001$) between years, outstanding the third year with 15,901 kg DM ha^{-1}, followed by the second one with 14,702 kg DM ha^{-1}, and lastly, the first year with 12,354 kg DM ha^{-1}.

These results differ from others in the bibliography under similar conditions (Hidalgo, 1966; Lloveras *et al*., 1998; Delgado, 2003; García Criado *et al*., 2010), where the highest annual yields were obtained the second year after sowing. In general, there were six productive cycles in previous studies. In this study there were seven due to the close cutting dates, cuttings being performed some times at early phenological stages, thus increasing one cycle.

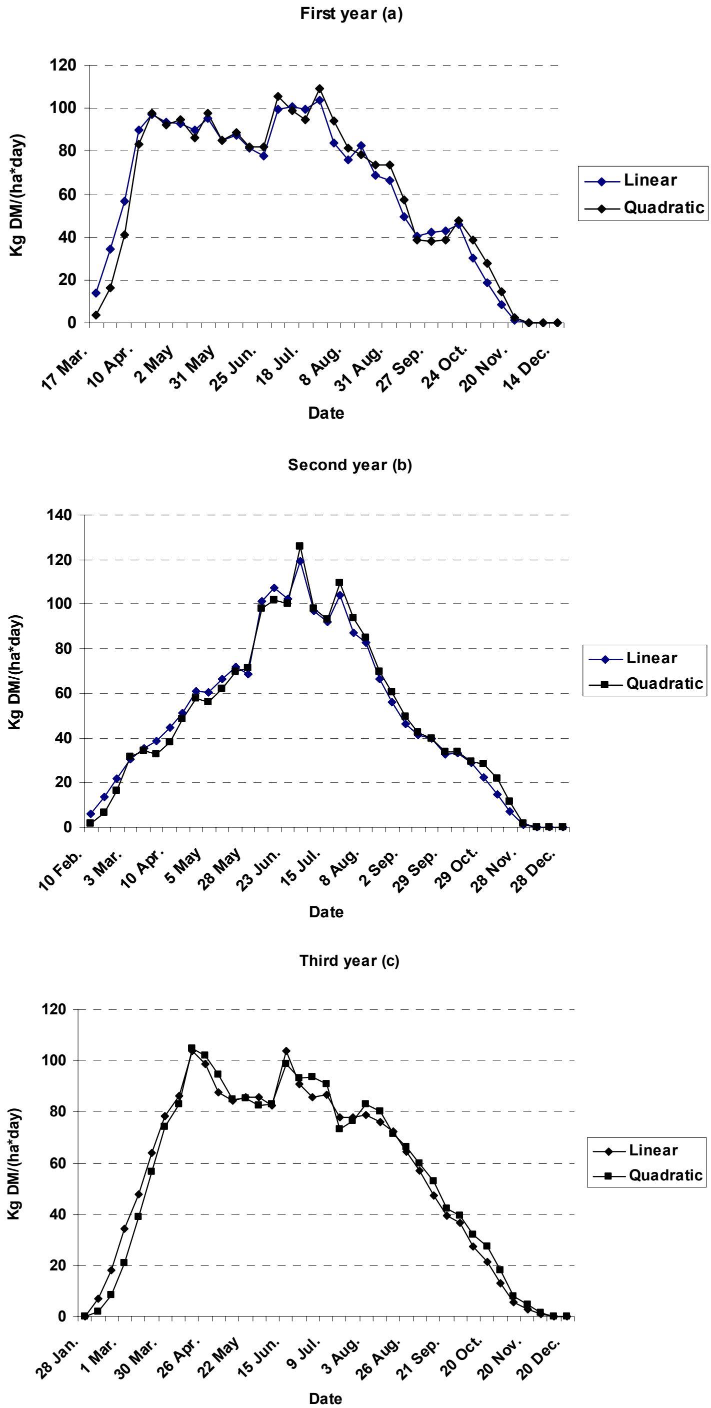

Fig. 1. Daily growth curves of lucerne cv 'Aragón' (a, b, c) and evolution of the CP contents (d) at cutting (mean of three years) under irrigation, Zaragoza (♦, lineal; ■, quadratic).

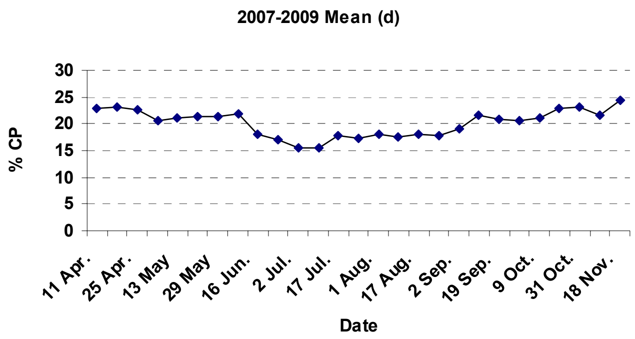

Fig. 1. (Cont.) Daily growth curves of lucerne cv 'Aragón' (a, b, c) and evolution of the CP contents (d) at cutting (mean of three years) under irrigation, Zaragoza (♦, lineal; ■, quadratic).

The evolution of the CP mean contents in the three years of the study is shown in Fig. 1. It decreases from 22.9% in the first cut at the middle of April to 15.5% at the beginning of July. Then it increases to 24.5% at the middle of November. This fact could be related to the phenological stage at cutting time, vegetative or flower bud at the beginning of the spring and at the end of summer, and between 10% and 50% flowering along the summer. This response was similar to other studies (Andueza et al., 2001).

IV – Conclusions

In the conditions of this study, the productive period of lucerne took place between the beginning of March and the end November. The maximum DM annual yield was obtained the third year, 15,901 kg ha^{-1}, and daily growths were higher than 90 DM kg ha^{-1} day^{-1} in spring, reaching the maximum one on 30 June 2008, 119.5 kg ha^{-1} day^{-1}. The CP contents decreased from 22.9%, analysed at the beginning of April to 15.5% at the beginning of July, increasing afterwards till reaching 24.5% at the middle of November.

Acknowledgements

This study has been supported by the projects RTA2005-105-C2 and RTA2009-63-C2.

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Seasonal change of the mineral concentrations of gall oak (*Quercus infectoria*) and Christ's-thorn (*Paliurus spina-christi*)

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Abstract. Gall oak and Christ's-thorn are common in the Mediterranean flora of Turkey and significant forage source for goats in spring, summer and fall. Both species are consumed preferably by the goats. Therefore, to obtain information about the feeding values of these species and reveal cause of the goats preferred primarily these species were aimed in this study by determining the change of nutrient and non-nutrient minerals in these species. In the samples macro and micro elements were determined. Results were analyzed statistically by repeated experimental design. Generally, seasonal variation of minerals of both shrubs was similar. While N, P, K, S, Cu and Zn decreased regularly from spring to fall, Ca, Mn and Na increased. Mg did not alter significantly. In gall oak, B increased from spring to fall and decreased in Christ's-thorn from spring to summer. Although Zn amount of gall oak had non-significant change seasonally, it was high for Christ's-thorn in spring but low in the other seasons. The shrubs contained sufficient macro and micro nutrients, except for S, Cu and Zn, to supply the needs of the goats in every season.

Keywords. Gall oak – Christ's thorn – Macronutrient – Micronutrient.

Variations saisonnières des concentrations en minéraux chez Quercus infectoria et Paliurus spina-christi

Résumé. Quercus infectoria *et* Paliurus spina-christi *sont des espèces courantes de la flore méditerranéenne de Turquie et constituent une importante source de fourrage pour les caprins au printemps, en été et en automne. Ces deux espèces sont consommées de préférence aux autres par les caprins. Ainsi, pour obtenir de l'information sur la valeur alimentaire de ces espèces et révéler pourquoi les caprins les préfèrent, nous avons cherché dans cette étude à déterminer les modifications des minéraux nutritionnels et non nutritionnels chez ces espèces. Les macro et micro-éléments ont été dosés dans les échantillons. Les résultats ont été analysés statistiquement par dispositifs expérimentaux répétés. Généralement, la variation saisonnière des minéraux était semblable chez les deux arbustes. Tandis que N, P, K, S, Cu et Zn baissaient régulièrement du printemps à l'automne, Ca, Mn et Na augmentaient. La valeur de Mg n'a pas été modifiée significativement. Chez* Quercus infectoria*, la valeur de B a augmenté du printemps à l'automne tandis qu'elle a baissé chez* Paliurus spina-christi *du printemps à l'été. Bien que la teneur en Zn chez* Quercus infectoria *n'ait pas subi de variations significatives au cours des saisons, elle était élevée chez* Paliurus spina-christi *au printemps mais faible lors des autres saisons. Les buissons contenaient suffisamment de macro et micro-nutriments, sauf pour S, Cu et Zn, afin de couvrir les besoins des caprins pendant toutes les saisons.*

Mots-clés. Quercus infectoria – Paliurus spina-christi – *Macronutriment – Micronutriment.*

I – Introduction

Shrubs are considered as natural forage sites for goats especially in maquis lands with dry summers. Therefore, goats are mostly raised over these sites (Rogosic *et al.*, 2006). Grazing researches carried out over shrubby rangelands of Mediterranean Region revealed that shrubs constituted more than 60% of goat forage (Papachristou *et al.*, 2005). Although shrubs generally have low forage quality and have secondary metabolites decreasing the succulence (Bartolomé *et al.*, 1998), leaves and fresh shoots have higher protein rates and lower fiber contents than grasses (Bartolomé *et al.*, 1998). Deciduous shrubs like gall oak and Christ's-thorn have higher nutritional values than the other shrubs and herbaceous species (Temel and Tan, 2011). Nutrients usually constitute the structural members of significant compounds in plants, play a role in enzyme activity and form complexes with organic molecules (Whitehead, 2000). However, these nutrients do not present at constant rates in plants. Most of them (N, P, K, S, Cu) significantly decrease with the maturation. As leaves senescence, nutrient losses are observed through remobilization and washout by precipitations (Whitehead, 2000).

Shrubs cover about 8.5 million hectare land area in Turkey (Anon., 1978) and significant part of these lands is located in Mediterranean zone. On the other hand, goats constitute 15.3% (6.3 million) of total 41.4 million livestock assets of Turkey (Anon, 2010). The research activities on shrubs of Marmara Region are not sufficient. Therefore in this study, year-around variation in macronutrient, micronutrient contents of gall oak and Christ's-thorn were observed. In this way, the significance of shrubs for goats was put forward.

II – Materials and methods

The research was carried out over shrubby rangelands located within Ağaköy, 85 km from Çanakkale Province between the dates October 2006 and November 2007. Monthly average temperatures (15.1°C) during the research period were higher than the long-term averages (13.9°C).Winter, spring and summer precipitations were lower than long-term averages. Soils of research site are sandy-loam, neutral, unsaline with high organic material content, sufficient available P and sparse K content. Exchangeable Ca, Mg, K, Na and CEC were 13.42, 2.64, 0.17, 0.07 and 16.42 meq/100 g, respectively.

In this research, gall oak (*Quercus infectoria* Oliv.) and Christ's-thorn (*Paliurus spina-christi* Miller) were used as the plant material. During the research period, plant samples were taken from the shrubs in the middle of each month. Leafy young shoots (twigs), grazable by animals, were cut and collected. Ten samples were taken from each species in each sampling. Since the investigated shrubs are deciduous shrubs, samples were not taken during the period from defoliation in fall to leaf-turn in spring. Samples were placed into cloth bags, they were dried and grinded. Macro and micronutrients were analyzed in these samples. Total nitrogen was determined by Kjeldahl method and other elements (P, K, Ca, Mg, S,Fe, Mn, Cu, B, Na, Zn) were determined by ICP-AES. Research was established using the repeated measurement design and data was statistically analyzed by SPSS statistical software. LSD Multiple Comparing Test was used to compare the averages.

III – Results and discussion

While the seasonal variations in Mg and Zn were found to be insignificant, variation of other elements were found to be significant. The highest N, P, K, S and Cu contents of gall oak were observed in spring and the values decreased in summer and fall. On the other hand, Ca, Fe, Mn, B, Na contents were at the lowest levels in spring and the values were generally higher in other seasons. Seasonal variations in Cu, B, Se content of Christ's-thorn were found to be significant. While N, P, K, S, Zn were higher during the plant growth in spring than the other seasons, Ca, Mn and Na increased in fall. Mg, Fe increased both in spring and fall seasons. Mineral content of Christ's-thorn generally decreased in summer (Table 1).

There are close relationships between N, P, K and S concentrations and physiological activities of plants. Nitrogenous compounds act as biocatalyst enzymes in plants, P plays a role in energy systems (ATP) and exists in structure of nucleic acids together with nitrogen, K regulates the osmotic potentials of the cells and S exists in structures of proteins (Kacar and Katkat, 2007).

Therefore, most of these elements exist within cell protoplasm (Spears, 1994). Although young cells in plants have high protoplasm rates, the value decreases and rate of cell wall increases as the plant maturates and dries out. Therefore, the highest N, P, K and S ratios in gall oak and Christ's-thorn were observed in spring and the lowest levels were observed in summer and fall. Similarly, Mountousis *et al.* (2008) observed the highest N ratio of the shrubs in spring and decreased values with plant maturation. Also, El Aich (1991) indicated decreasing P concentrations with maturation and Fleming (1973) reported unchanged Ca content and significantly decreased P and K ratios.While Ca contents of shrubs decreased distinctively in spring, the value increased in other seasons. Ca usually exists in hard tissues of the plants (Spears, 1994). Current results were mostly due to high protoplasmic compound levels and low wall compound levels at the beginning of growth.Variation in Mg content of gall oak was found to be significant and the values for Christ's-thorn increased significantly in spring and fall. Although most of Mg exists in protoplasm (Spears, 1994), a regular seasonal variation was not observed in plants. Researchers reported different results with regard to variation of Mg in plants. For instance, Ramírez-Orduña *et al.* (2005) reported insignificant seasonal variations in Mg contents of shrubs and Ramírez *et al.* (2001) determinate significant variations in Mg contents.

Table 1. Mineral concentrations of gall oak and Christ's-thorn

Season	**Gall oak**					
	N	**P**	**K**	**Ca**	**Mg**	**S**
Spring	23.33±4.8a	3.24±1.1a	9.65±2.7a	5.32±2.2c	3.44±0.4	1.34±0.3a
Summer	15.97±2.2b	2.12±0.2b	6.15±0.4b	12.46±2.6b	3.33±0.3	0.94±0.1b
Fall	14.68±3.9b	2.18±0.3b	4.40±1.3c	16.16±1.8a	3.46±0.6	0.93±0.1b
Mean	*17.99*	*2.51*	*6.73*	*11.31*	*3.41*	*1.07*
Significance	*0.000*	*0.002*	*0.000*	*0.000*	*0.755*	*0.000*
	Fe	**Mn**	**Cu**	**B**	**Na**	**Zn**
Spring	130.4±29.2b	590.0±156.6b	10.24±3.4a	22.5±2.7c	730.7±109.4b	27.7±6.8
Summer	277.0±68.7a	1234.8±259.0a	7.10±0.8b	46.1±10.5b	773.3±65.8b	25.0±4.2
Fall	309.4±66.6a	1342.8±220.5a	6.89±1.0b	62.0±13.6a	1201.9±281.5a	26.6±3.7
Mean	*238.9*	*1055.9*	*8.08*	*43.6*	*902.0*	*26.4*
Significance	*0.000*	*0.000*	*0.002*	*0.000*	*0.000*	*0.402*
	Christ's-thorn					
	N	**P**	**K**	**Ca**	**Mg**	**S**
Spring	25.30±8.6a	4.73±0.9a	16.87±1.3a	10.40±2.0c	3.08±0.8a	1.81±0.2a
Summer	19.36±4.9b	2.18±0.4b	13.65±1.9b	16.07±4.7b	2.36±0.4b	0.91±0.01c
Fall	14.14±2.1b	1.78±0.2b	10.05±3.2c	23.25±6.2a	2.85±0.9a	1.04±.004b
Mean	*19.60*	*2.90*	*13.52*	*16.57*	*2.76*	*1.25*
Significance	*0.003*	*0.000*	*0.000*	*0.000*	*0.001*	*0.000*
	Fe	**Mn**	**Cu**	**B**	**Na**	**Zn**
Spring	133.8±24.9a	627.3±127.4b	7.61±1.3	65.6±5.6	660.2±65.8b	40.4±9.7a
Summer	87.0±22.4b	592.0±319.7b	6.71±1.9	51.4±4.2	663.8±98.4b	24.8±3.9b
Fall	130.9±30.2a	961.0±355.5a	6.38±1.3	51.4±7.2	813.0±238.9a	23.7±4.3b
Mean	*117.2*	*726.8*	*6.90*	*56.1*	*712.3*	*29.6*
Significance	*0.000*	*0.000*	*0.080*	*0.060*	*0.003*	*0.000*

Higher Fe concentrations in gall oak were observed in summer and fall and higher ratios in Christ's-thorn were observed in spring and fall. Fe contents of plants are affected by soil conditions and changes in climate and growth seasons (Macpherson, 2000). Different results might be attributed to these issues. Fe is closely related to enzyme systems of the plants. It plays an activating role in biochemical processes like photosynthesis, respiration and N fixation (Kacar and Katkat, 2007). Therefore, higher Fe concentrations, were expected to be observed in spring, as it occurred in the case of Christ's-thorn. This expectation was also supported by Ramírez-Orduña *et al.* (2005). Mn contents of gall oak increased in summer and fall and the value of Christ's-thorn increased in fall. Most of Mn exists in cell wall of the plants (Spears, 1994). Therefore, higher rates are expected especially in summer and fall. On the other hand, insignificant seasonal changes in Mn contents were reported in the research carried out in Mexico (Ramírez-Orduña *et al.*, 2005). While higher Cu ratios of shrubs were observed in spring, the values decreased with maturation. Decrease in Cu content usually occurs with maturation, changes in climate and seasonal variations (Spears, 1994). Since Cu takes place into protein synthesis of plants, it generally exists intensively in physiologically active cells. Therefore, higher Cu contents are observed in spring (Ramírez *et al.*, 2005). Boron concentrations of gall oak increased from spring to fall and significant variations were not observed in Christ's-thorn. B plays a role in sugar synthesis and transport, in synthesis of nucleic acids and plant hormones (Kabata-Pendias, 2001) and in cell membrane processes (Kacar and Katkat, 2007). Even being insignificant, these roles may explain the high B ratios of Christ's-thorn in spring. Since B is also bound to cell wall with weaker bonds than Ca (Kacar and Katkat, 2007), B content of gall oak might increase during the maturation. Na contents of shrubs increased in fall. Na contents of plants vary based on plant species, growth stages, climate and soil conditions. Higher Na rates are observed especially in dry sites and dry years (Ramírez-Orduña *et al.*, 2005). In current study, lower precipitations in fall and winter than long-term averages might be effective to have such findings. Zn content of Christ's-thorn increased in spring and decreased in summer and fall. The variation in gall oak was found to be insignificant. Zn constitutes especially the basic structure of some enzyme systems participating into protein synthesis (Kacar and Katkat, 2007). Increasing Zn contents of Christ's-thorn in spring may be tied to high protein rates in plants at the beginning of growth (in spring).

IV – Conclusions

Evaluations made by taking the goats into consideration revealed that only S, Cu and Zn were found to be insufficient for goats during the growth seasons of both shrubs.

Acknowledgements

This research was supported by TÜBİTAK (Project No. 106O458).

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Evaluation of *Rhizobium* isolates from *Melilotus officinalis* nodules at various stress conditions

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Abstract. Pasture are an important part of agricultural systems and to increase their productivity and quality persistent forage legumes are needed. *Melilotus officinalis* is an important forage legume. *Rhizobium* bacteria can form nitrogen fixing nodules on legume roots. In this study, we phenotypically characterized 17 *Rhizobium* isolates from *Melilotus officinalis* nodules. About 47% of isolates were resistant to pH 8, 27% were resistant to 40^{o}C temperature and 17.6 % were resistant to 2-2.5 % NaCl concentrations.

Key words. *Melilotus officinalis – Rhizobium* – Isolate.

Résumé. *Les pâturages sont une partie importante des systèmes agricoles, et pour accroître leur productivité et leur qualité, des légumineuses fourragères persistants sont nécessaires.* Melilotus officinalis *est une espèce fourragère légumineuse. Les bactéries* Rhizobium *fixatrices d'azote forment des nodules sur les racines légumineuses. Dans cette étude, nous avons caractérisé phénotypiquement 17* Rhizobium *isolés de nodules de* Melilotus officinalis. *Environ 47% des isolats étaient résistants à un pH de 8, 27% étaient résistants à températures de 40°C et 17,6% étaient résistants à des concentrations de 2-2,5% de NaCl.*

Mots-clés. Melilotus officinalis – Rhizobium – *Isolat.*

I – Introduction

Rhizobium species are soil bacteria, which display a symbiotic interaction with specific legume hosts and most of these are sensitive to fluctuations of environment factors in the rhizosphere and effect the growth and productivity of the whole plant (Hungria and Vargas, 2000). Among several environmental conditions which are limiting factor such as salinity, temperature and pH are probably the most problematic (Hungria and Vargas, 2000).

The effects of varying pH levels on the growth of *Rhizobium* bacteria have been recorded by some authors (Ali *et al*., 2009; Graham *et al.;* 1994; Zerhari *et al*.; 2000). Hashem *et al*. (1998) and Lloret *et al.* (1995) have shown that changes in osmotic potential exerted by salt concentration alter the structure rhizobial cell in response to salt stress. Rhizobial isolates vary in their tolerance to major environmental factors (Rodrigues *et al.,* 2006). This study aimed to isolate and collect *Rhizobium* isolates from *Melilotus officinalis* nodules and to characterize their performance at various stress conditions.

II – Materials and methods

Rhizobium isolates were obtained from the root nodules of *Melilotus officinalis* growing at Şanlıurfa, Turkey. Nodules were disinfected, crushed in a small amount of saline (0.85 % NaCl) suspension and streaked on yeast extract mannitol (YEM) agar plates. The cultures were streaked of plates onto YEM agar for purification and isolation. Cell shape was determined by microscopy (Holt *et al*., 1994).

Stress tolerance. Aliquots of 0.1ml cultures were inoculated into 15 ml YEM broth and incubated at 25, 30, 35, 40 and 45ºC in a shaker incubator (200 rpm) for 48 h. The tolerance to salinity was tested by inoculating the cultures into YEM broth containing NaCl (w/v) (0.1, 0.5, 1, 1.5, 2, 2.5 and 3%). To determine the pH tolerance, the cultures were grown in YEM broth and pH was adjusted 3.5, 4, 4.5, 5, 8, 9 and 10 and incubated at 28°C (Zerhari *et al.,* 2000; Graham *et al*., 1994).

Hydrolysis of urea. Isolates were inoculated on a YEM agar containing yeast extract instead of urea and 0.012% phenol red as nitrogen source (Zerhari *et al.,* 2000).

Carbohydrate assimilation. The filter sterilized solutions of the carbon sources (10 % (w/v)) (glucose mannitol, galactose, sucrose, fructose, inositol, xylose) were added to YEM broth (Holt *et al.,* 1994).

The nodulation assays. The nodulation assays were performed in sterilized soil. Seeds of the *Melilotus officinalis* were surface sterilized and inoculated by adding 1 ml of isolate. Plants were cultivated in a controlled growth chamber with 15 h of light at 25 °C. Fifty days after the start of treatment, plants were harvested and separated into roots and shoots and nodulation measured.

III – Results and discussion

Seventeen isolates isolated from root nodule of *Melilotus officinalis*. Seventeen isolates showed highest growth at 35°C, five isolates (Mo1, Mo2, Mo3, Mo6, Mo7) at 40°C and two (Mo6 and Mo7) at 45 °C (Table 1). All of the isolates were catalase and urease positive. Temperatures of semi-arid soils usually exceed 40 °C at 5 cm. Although the high temperature tolerance of *Rhizobium* isolates was not correlated with nodulation capacity (Hungria and Vargas, 2000), in general , the tolerance to high temperatures among the species of *Rhizobium* has been recognized as criteria for the selection of local isolates (Hungria and Vargas, 2000; Rodrigues *et al.,* 2006). On the other hand, Meghvansi (2006) reported that the growth and survival of *Rhizobium* bacteria in soil are adversely affected by high soil temperatures. Isolate adaptation to high temperature has been reported and it was suggested that *Rhizobium* isolates from hot dry areas are more temperature and desiccation tolerant than isolates from cooler, more humid regions and that temperature and desiccation tolerance may be related to geographical origion (Hansen, 1994). Isolates were able to catabolize a great variety of carbon sources (Table 1). All of isolates also utilized a wide variety of carbohydrates such as glucose, mannitol, galactose, fructose, inositol, sucrose, xylose. Growth in carbohydrate media was accompanied by copious extracellular polysaccharide slime. Hansen (1994) has reported the importance of exopolysaccharide in nodulation on the growth of *Phaseolus vulgaris*.

The growth of isolates at various pH treatments was different (Table 1). The optimum growth temperature is 25 to 35°C (Table 1); most isolates grow at 35°C. Five were tolerant of 40°C. For most *Rhizobium* isolates the temperature of growth in culture ranges from 28°C to31°C, with many unable to grow below 10° C or at 37°C (Hungria and Vargas, 2000; Zerhari *et al.,* 2000). The most of cowpea root nodules isolates isolated from the hot dry environment of the Sahel savannah of west Africa grew at 40°C (Eaglesham and Ayanaba, 1984). None of the isolates grew at pH 3.5, 4.0, 4.5 and 10.0. Mo3, Mo6, Mo8, Mo11, Mo12, Mo13, Mo14, Mo15 and Mo16 isolates did not growth at pH 8. Similar observations were recorded by Rodrigues *et al.* (2006) and Graham *et al.* (1994). It is probable that an organism challenged at extreme pH will be less tolerant to toxic substances than under at pH regime that is close to the optimum conditions. Graham *et al.,* 1994 and Zerhari *et al.,* 2000, who recorded that the optimum pH of the growth of *Rhizobium* isolates is between 6 and 7 pH. Lipopolysaccharide are known to play a key role in the pH tolerance of *Rhizobium* species (Zahran *et al.,* 1994). Eight isolates (Mo1, Mo2, Mo4, Mo5, Mo7, Mo9, Mo10 and Mo17) grew at pH 8.0. The isolate Mo1 growth at pH 9.0. The effects of the salt concentrations were variable depending on the salt concentrations used and the isolates tested (Table 2). Generaly, *Rhizobium* isolates are more tolerant of osmotic stress than their leguminous host (Hashem *et al.*, 1991). The different *Rhizobium* species or isolates vary in their sensitivity to salt (Barnet and Catt, 1991). Although salinity is usually not a problem soils, salt concentration of 2% and 2.5% (w/v) NaCl were tolerated by a few isolates (Mo1, Mo3, Mo4) of *Rhizobium* (Table 2).

Table 1. Utilization of carbohydrate sources, growth at pH and temperature of isolates

Isolate	Utilization of carbohydrate sources†	Growth at pH							Growth at °C				
		3.5	4.0	4.5	5.0	8.0	9.0	10.0	25	30	35	40	45
Mo1	+	-	-	-	-	+	+	-	+	+	+	+	-
Mo2	+	-	-	-	-	+	-	-	+	+	+	+	-
Mo3	+	-	-	-	-	-	-	-	+	+	+	+	-
Mo4	+	-	-	-	-	+	-	-	+	+	+	-	-
Mo5	+	-	-	-	-	+	-	-	+	+	+	-	-
Mo6	+	-	-	-	-	-	-	-	+	+	+	+	+
Mo7	+	-	-	-	-	+	-	-	+	+	+	+	+
Mo8	+	-	-	-	-	-	-	-	+	+	+	-	-
Mo9	+	-	-	-	-	+	-	-	+	+	+	-	-
Mo10	+	-	-	-	-	+	-	-	+	+	+	-	-
Mo11	+	-	-	-	-	-	-	-	+	+	+	-	-
Mo12	+	-	-	-	-	-	-	-	+	+	+	-	-
Mo13	+	-	-	-	-	-	-	-	+	+	+	-	-
Mo14	+	-	-	-	-	-	-	-	+	+	+	-	-
Mo15	+	-	-	-	-	-	-	-	+	+	+	-	-
Mo16	+	-	-	-	-	-	-	-	+	+	+	-	-
Mo17	+	-	-	-	-	+	-	-	+	+	+	-	-

†Glucose, galactose, fructose, xylose, mannitol, sucrose, inositol.

Table 2. Some characteristics of isolates

Isolate	Catalase	NaCl tolerance %							Mobility	Hydrolysis of urea
		0.1	0.5	1	1.5	2	2.5	3		
Mo1	+	+	+	+	+	+	+	-	+	+
Mo2	+	+	+	+	+	-	-	-	+	+
Mo3	+	+	+	+	+	+	+	-	+	+
Mo4	+	+	+	+	+	+	+	-	+	+
Mo5	+	+	+	+	+	-	-	-	+	+
Mo6	+	+	+	+	+	-	-	-	+	+
Mo7	+	+	+	+	+	-	-	-	+	+
Mo8	+	+	+	+	+	-	-	-	+	+
Mo9	+	+	+	+	+	-	-	-	+	+
Mo10	+	+	+	+	+	-	-	-	+	+
Mo11	+	+	+	+	+	-	-	-	+	+
Mo12	+	+	+	+	+	-	-	-	+	+
Mo13	+	+	+	+	+	-	-	-	+	+
Mo14	+	+	+	+	+	-	-	-	+	+
Mo15	+	+	+	+	+	-	-	-	+	+
Mo16	+	+	+	+	+	-	-	-	+	+
Mo17	+	+	+	+	+	-	-	-	+	+

These results can be explained in this way; the growth inactivated by increased NaCl concentration of same isolates and this may be consistent with the life cycle characteristics of the tested isolates. All of the isolates grewth at 0.1%, 0.5, 1.0, 1.5% (w/v) NaCl (Table 2). Isolates were obtained from root nodules of *Melilotus officinalis*, were gram negative, non-spore forming rod-shaped bacteria. After 3 day the colonies formed on YEM agar plates were circular, convex. All of the isolates were motile in agar (0.3 %). *Rhizobium* isolates capable of growing at NaCl concentration of up to 0.500 M have been isolated from a *Melilotus* plants (Lloret *et al.,* 1995). In this study all the isolates of *Rhizobium* showed confluent growth at a salt concentration of 0.1%. Salt concentrations of 2-2.5% were tolerated by only a three isolates of *Rhizobium*, while others were sensitive (Table 2). The results of Ali *et al.* (2009) agree with the above finding. They reported that root nodule isolates of *Leucaena leucocephala* could tolerate NaCl concentration upto 4.5 %. In our study, 3 % of salt concentration was found to be inhibitory to all of the isolates.

The symbiotic performance of isolate Mo4 was determined with *Melilotus officinalis*. Results in Table 3 summarize the nodulation parameters of isolate with *Melilotus officinalis*. Shoot dry weights were greater with isolate Mo4 than in the non-inoculated and non-N fertilized control. However, the non-inoculated N-fertilized control resulted in greater shoot weight then all other treatments.

Table 3. Nodulation and shoot weight of selected *Rhizobium* isolate with *Melilotus officinalis*

Treatments	No. of nodules per plant	FW of shoot (g plant^{-1})
Control	0	3.2
Inoculated with isolate	5	4.6
Isolate and N	2	5.2
N fertilized	0	4.3

IV – Conclusions

The phenotypic studies were necessary for the characterization and selection of isolates provided information about their genetic diversity and adapted to climatic conditions. Rhizobium isolates with tolerance stress factors for increased tolerance to temperature on salinity could enhance production of forage in legume in semi-arid regions. Further studies are in progress to characterize plasmids. Understanding to contribution of plasmids to the overall symbiotic potential of isolates will allow the development of improved isolates better adapted to the plant, soil and climate conditions in Şanlıurfa, Turkey.

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Management of common pool resources: Cases of collective grasslands, inventory and characterization of their management in the region of Hadj Mechri, Laghouat (Algeria)

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Abstract. The aim of this study is to identify collective grasslands in the region of Hadj Mechri (in Laghouat region, Algeria) and to characterize their operating modes. The results showed different legal status (Arch, domanial and municipal) and different degradation levels of collective grassland managed by two operating modes, namely the collective mode and individual mode. The use of these collective grasslands was limited only to sedentary agro-pastoralists which are installed in the periphery. When operating mode is individual, it means that there was a tacit division of the collective grassland between the agro-pastoralists concerned.

Key words. Collective grasslands – Operating modes – Levels of plant degradation – Legal status – Hadj Mechri.

La gestion des parcours steppiques collectifs : État des lieux et caractérisation de leur gestion, cas de la région de Hadj Mechri, Wilaya de Laghouat (Algérie)

Résumé. *L'objectif de cette étude est l'identification des parcours collectifs de la région de Hadj Mechri (Laghouat, Algérie) et la caractérisation de leurs modes d'exploitation. Les résultats montrent que des parcours collectifs existent sous différents statuts juridiques (Arch, domanial et communal), différents niveaux de dégradation et sont gérés par deux modes d'exploitation, à savoir l'exploitation collective et l'exploitation individuelle. L'exploitation de ces parcours collectifs est limitée seulement aux agropasteurs sédentarisés en périphérie. Quand l'exploitation est individuelle, cela signifie qu'il y a eu un partage tacite du parcours entre les agropasteurs concernés.*

Mots-clés. *Parcours collectifs – Modes d'exploitation – Niveaux de dégradation végétale – Statuts juridiques – Hadj Mechri (W. Laghouat).*

I – Introduction

After the independence, the legal status of steppe lands was obtained from application of the Act of April 22, 1863 (*Senatus consults*) who shared the steppe in public land (JO, 1938), Arch[1] and lands which are collectively owned by the tribes. Since then, collective grasslands have suffered the adverse effects of recurrent drought, a growing population and failures of various policies of common pool resources (CPR) management. Because legal status of some grasslands remains unclear, a process of private appropriation of those lands was initiated by the agro powerful. So they became collective grasslands in a transition situation.

[1]Arch: group of tribes.

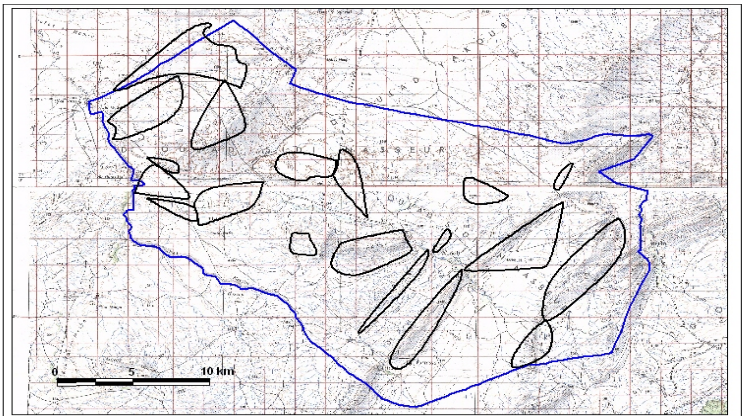
Currently, what are the management methods of those grasslands? How is the legal status of the land through the agropastoralists? What are their operating strategies? We aimed in this paper to answer those questions.

II – Methodology of conducting the survey

With the aim to understand collective management of grasslands in Hadj Mechri (HM) region (Laghouat, Algeria), a survey by questionnaire and interview has been achieved from 7/25/2009 to 8/8/2009. A rational classification is used for data analysis. It is based on two variables that are: methods of grassland management (collective or individual) which is the functional variable and overall recovery of vegetation (RGV)[2].

III – Results and discussion

First survey result indicated 19 existing collective grasslands (Fig. 1). Areas used exclusively for breeding are called *Chabka*. Those used as glazes are, called *Gaadat*. Adjacent grasslands are separated by a river, stream, trail, or simply by boundaries drawn by men.



Carte.1: les parcours collectifs de la commune de HADJ Mechri

Fig. 1. Localisation of the 19 collective grasslands in the survey area.

Total population living around grasslands was 2 794 peoples gathered in 349 households. This population represented 43% of the total population of HM (DPAT, 2008). Almost all people surveyed around the grasslands are residents.

1. The legal status of grasslands

Collective grasslands are located on land whose legal status varies from domanial[3] lands, municipal lands and Arch[3] lands (Table 1). Grasslands have a total area of 16665 ha.

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[2]The RGV data used are from a research conducted by Hammouda (2009), who worked on the same study area. The author has established 5 classes that are; Class 1 (RGV <12.5%), class 2 (12.5% <RGV <25%), class 3 (25% <RGV <50%) Class 4 (50% <RGV <75%) and class 5 (75%<RGV).
[3]Domanial land: public property; Arch land: tribe land.

Table 1. Total area of grasslands.

Legal status	Total area (ha)	%
Arch	2 918	18
Domanial	6 735	40
Municipal	7 013	42
Total	16 665	100

This distribution has been inherited from an application of the law of *Senatus Consults*, in 1863. As a result, the colonial administration monopolized the majority of grasslands and confined spaces of tribes in reduced areas (Boukhabza, 1982).

2. The grasslands and vegetation cover (RGV %)

Through the RGV, we obtain 3 separate classes (Table 2). Taken together, half of grasslands are in an average degradation situation. But if we consider the legal status, we noted that in Arch grasslands, half of them are quite good.

Table 2. The overall vegetation cover (RGV) of grasslands (%)

Legal status	Relatively bad	Average	Relatively good	Total
Arch	33	17	50	100
Domanial	33	50	17	100
Municipal	0	71	29	100
Total	21	47	32	100

For the grasslands state ownership, a third was considered bad, and half was in average condition, while 17% represent the good grasslands.

3. Access to grasslands and their tacit sharing among agropastoralists

Access to the grasslands is not free. It is limited only to residents. Because of traditional cultural considerations[5], this tradition is called "*The Horma*". Another cultural and traditional value is that called "*Rih Bladi*". Thus, in all the collective grasslands there is a partition of collective grasslands (Bédrani and Mouhous; 2008). However, when there are conflicts, for resolve, the community appealed to a committee of wise (*Djemaa*). Arch grasslands are shared between the two modes of exploitation. However, on collective grasslands, we see two situations: first, on nearly 80% of collective grasslands, agropastoralists report that they can graze their animals on any part of the grassland. Second, only 20% of the agropastoralists indicated they exploit the whole space of these grassland.

4. Types of actions contributing to assert ownership of grasslands

Certain actions confirm a form of private ownership. This is the renting of land and ploughing. Generally, grasslands are rented to anyone, including foreigners. Ploughing is also affects the collective grassland. The objective of ploughing is to assert ownership under the right to use the land. The total area ploughed is estimated to 1715 ha (10% of the total area of grasslands) (Table 3).

It must be pointed out that tillage of grasslands has been signalled in 32% of questioned agropastoralist, whereas, 37% declare that they till 10 to 60 ha.

Table 3. Estimation of total area ploughed (%)

Legal status	RGV	Area ploughed (ha)					
		0	(10 - 20)	(40 - 60)	(100 - 250)	500	Total
Arch	Rather bad	5	5	0	0	0	11
	Rather medium	5	0	0	0	0	5
	Rather good	0	5	0	11	0	16
Domanial	Rather bad	5	0	0	5	0	11
	Rather medium	0	5	0	5	5	16
	Rather good	0	0	0	5	0	5
Municipal	Rather bad	0	0	0	0	0	0
	Rather medium	11	5	11	0	0	26
	Rather good	5	0	5	0	0	11
Total		32	21	16	26	5	100

IV – Conclusion

The collective grasslands still exist in the study area. Using some social values (*Horma* and *Rih Bladi*) a new organization of the exploitation of collective grasslands has erected. This excludes any agropastoralist that has no direct access to the grasslands. To bolster the claim of ownership of grasslands, agropastoralists use practices such as ploughing or renting. However, collective management of grasslands exist but are still operating rules more stringent. When family ties are strong, grassland management becomes collective with a few stipulations. When family ties are weak, collective management tends to individually by the application of rules and social organizations already mentioned.

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Secondary compounds characterization in some autochtonous species from a North-Eastern region of Tunisia

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Abstract. Several native species were collected in the region of Zaghouan (eastern-north of Tunisia, semi-arid) in order to evaluate their chemical diversity for an eventual animal use context, during the period of spring 2011. Some secondary compounds were determined by colorimetric quantification in leaves and twigs. Essential oils from these species were extracted by hydro-distillation and then analyzed using gas chromatography technique, coupled with mass spectrometry (GC/MS). Results showed that among the studied species, *Myrtus communis* presented the highest total polyphenol (101.3 mg GAE/g DM), while *Artemisia herba-alba* and *Ruta Chalepensis* were the lowest ones (13.2 and 13.7 mg GAE/g DM respectively). Condensed tannin content in *Juniperus phoenicea* (43.8 mg CE/g DM) was largely higher than in all the other species, in which it ranged approximately between 1 and 5 mg/g DM. In addition, saponin content was the utmost in *J. phoenicea* (25.2 mg/g DM) as compared to the others species, where it varied between almost 6 and 13 mg/g DM. The amount of flavonoids varied widely between 28.6 and 5.1 mg/g DM in *Mentha pelagium* and *M. communis* respectively. Essential oils of all species were composed of wide pools of identified components. For instance, the main compounds were 1.8-cineol in *Rosmarinus officinalis* (39%), thymol (61.3%) in *Thymus vulgaris*, and carvacrol (64.8%) in *A. herba-alba*. It was concluded that the vegetal diversity in the studied area presented a consequent chemical diversity, available for animals as fed in grazing or in housing conditions. These bioactive molecules, mainly essential oils, may be used for their antimicrobial actions to improve animal health and performance. In this connection, *in vitro* studies are currently carried out in our laboratory.

Keywords. Secondary compounds – Polyphenols – Condensed tannins – Saponins – Flavonoids – Essential oils.

Caractérisation des composés secondaires de certaines espèces autochtones d'une région du Nord-Est de la Tunisie

Résumé. *Plusieurs espèces natives ont été recueillies dans la région de Zaghouan (nord-est de la Tunisie, semi-aride) au cours de la période de printemps 2011, afin d'évaluer leur diversité chimique pour une éventuelle utilisation dans un contexte d'alimentation animale. Certains composés secondaires dans les feuilles et les brindilles ont été déterminés par quantification colorimétrique. Les huiles essentielles de toutes les espèces ont été extraites par hydro-distillation puis analysées à l'aide de la chromatographie en phase gazeuse, couplée à la spectrométrie de masse (GC/MS). Les résultats ont montré que, parmi les espèces étudiées, la teneur en polyphénols totaux était la plus élevée chez* Myrtus communis *(101,3 mg/g MS), tandis qu'elle était la plus basse chez* Artemisia herba-alba *et* Ruta chalepensis *(13,2 et 13,7 mg/g MS, respectivement). La teneur en tanins condensés chez* Juniperus phoenicea *(43,8 mg/g MS) a été largement supérieure à celle de toutes les autres espèces et variait approximativement entre 1 et 5 mg/g MS. La teneur en saponines étaient la plus basse chez* J. phoenicea *(25,2 mg/g MS) et variait entre près de 6 et 13 mg/g MS chez les autres espèces. Les flavonoïdes variaient considérablement entre 28,6 et 5,1 mg/g MS dans* Mentha pelagium *et* M. communis*, respectivement. Toutes les huiles essentielles sont composées d'une large gamme de composants identifiés. Les principaux d'entre eux étaient, par exemple, 1.8-cinéole dans* Rosmarinus officinalis *(39%), le thymol (61,3%) dans* Thymus vulgaris *et le carvacrol (64,8%) dans l'*A. herba-alba*. Il a été conclu que la diversité végétale dans la zone étudiée a présenté une diversité chimique considérable, disponible pour les animaux nourris que ce soit au pâturage ou dans des conditions de stabulation. Ces substances, principalement des huiles essentielles, peuvent être utilisées pour leurs actions antimicrobiennes pour améliorer la santé des animaux et leurs performances. À cet égard, des études* in vitro *sont actuellement menées dans notre laboratoire.*

Mots-clés. *Composés secondaires – Polyphénols – Tannins condensés – Saponines – Flavonoides – Huiles essentielles.*

I – Introduction

The interest for secondary metabolites (tannins, essential oils...) in native plants is more and more growing in animal production, particularly after the removal of antibiotic growth promoters. This led to an increased interest in alternative means of manipulating rumen fermentation. Indeed, recent researches showed several secondary metabolites, such as tannins and saponins, to improve feed nutritional value, digestion, production and reproduction of ruminants (Min *et al.*, 2003; Makkar *et al.*, 2007; Mao *et al.*, 2010) when used in particular doses. For essential oils, their main effects were to reduce protein and starch degradation and to inhibit the amino acid degradation due to selective action on certain rumen microorganisms (Benchaar *et al*., 2008). The aim of this work was to determine, as a first step, the content of secondary compounds (some secondary metabolites and essential oils) in some of these native species from a North-Eastern region of Tunisia, in order to study at a second step their effects in small ruminant nutrition, mainly in extensive conditions.

II – Material and methods

Leaves and stems of 9 native species (*Rosmarinus officinalis, Thymus vulgaris, Mentha pelagium, Myrthus communis, Juniperus phenicea, Ruta chalepensis, Pistacia lentiscus, Lavandula stoechas*, and *Artemisia herba-alba*) were collected from the region of Zaghouan (North-East of Tunisia, semi-arid) during the period of spring 2011.

For secondary compounds determinations, each specie sample was dried at 40°C during 48 h and then ground and stored in obscurity. Extracts were obtained by using methanol/water (80v/20v). Methanolic secondary metabolites were analyzed for their total phenolic, flavonoid, condensed tannins and saponin contents.

Total phenolic, flavonoid, condensed tannin and saponin contents were determined as described by Dewanto *et al.* (2002), Zhishen *et al.* (1999), Sun *et al.* (1998) and Hiai *et al.* (1976), respectively.

Essential oils from the studied species were extracted using hydro-distillation on 10-days air-dried biomass. Their chemical composition was assessed using gas chromatography coupled with mass spectrometry (GC/MS). This analysis was performed on an HP 5972 mass spectrometer (Agilent technologies, Palo Alto, California, USA) with electron impact ionization (70 eV). An HP-5MS capillary column (30 m-0.25 mm coated with 5% phenyl methyl silicone, 95% dimethylpolysiloxane, 0.25 lm film thickness) was used.

III – Results and discussion

1. Secondary metabolites

Secondary compounds contents are given in Table 1. *Myrtus communis* was the highest in polyphenols (101.30 mg GAE/g DM) while *Ruta chalepensis* and *Artemisisa herba-alba* were the lowest (about 13 mg GAE/g DM). Condensed tannins content in *Pistacia lentiscus* (56.82 mg CE/g DM) and *Juniperus phoenicea* (43.75 mg CE/g DM) were largely higher than in all the other species, where the proportion ranged approximately between 1 and 6 mg CE/g DM. *Juniperus phoenicea* exhibited the highest saponin content (25.17 mg DE/g DM), which varied in the other species between 6 and 19.5 mg DE/g DM in *Artemisia herba-alba* and *Pistacia lentiscus,* respectively. Flavonoïds concentrations were comprised between 28.6 and 5.1 mg CE/g DM in *Mentha pelagium* and *Myrtus communis* respectively.

When compared with literature, Gardely *et al.* (2008) mentioned 352 mg and 588 mg GAE/g DM of total phenolic for *Myrtus communis* and *Pistacia lentiscus* respectively, while Abidi-Wannes *et al.* (2010) found a variation between different myrtle parts ranging from 33.67 and 11.11 mg

GAE/g for flower and steam respectively. The authors found that for flavonoids and condensed tannin, the highest values were observed in steam (5.17 and 1.99 mg GAE/g respectively).

Table 1. Secondary compounds contents of the studied species

Species	Vegetative stage	Total polyphenols mg GAE†/g DM	Flavonoïds mg CE††/g DM	Condensed tannins mg CE/g DM	Saponins mg DE†††/g DM
Rosmarinus officinalis	Flowering	22.74	22.40	1.37	7.85
Thymus vulgaris	Flowering	20.50	10.71	1.34	7.18
Mentha pelagium	Flowering	56.20	28.56	2.18	7.01
Myrtus communis	Flowering	101.30	5.14	6.39	7.84
Juniperus phenicea	Fruiting	47.42	14.37	43.75	25.17
Ruta chalepensis	Fruiting	13.68	6.50	1.41	12.36
Pistacia lentiscus	Fruiting	95.19	13.85	56.82	19.46
Lavandula stoechas	Flowering	23.10	25.78	3.30	12.01
Artemisia herba alba	Flowring	13.20	15.41	1.91	6.37

†GAE: gallic acid equivalent.
††CE: catechin equivalent.
†††DE Diosgenin equivalent.

2. Chemical composition of essential oils

A wide variety of components was identified for the different substrates. As an example, for *Ruta chalepensis,* more than 70% of EO was composed of 2-undecanone. Carvacrol and thymol represented a mean of 63% of *Artemisia herba-alba* and *Thymus vulgaris* EO. Finally, about 30% of essential oils consisted of α-pinene for *Myrtus communis* and *Pistacia lentiscus* species.

When compared to earlier studies, our results concerning rosemary, confirmed those of Moujahed *et al.* (2010) and Zaouali *et al.* (2008) about the presence of 1-8 cineol, camphor, and α-pinene. For *Thymus vulgaris,* our results are on line with several other findings in which thymol was the chimiotype (about 45%), with the abundance of Q-terpinene, b-cymene, and b-caryophyllene (Hudaib *et al.,* 2002; Ozcan and Chalchat, 2004). Our finding relative to *Myrtus communis* confirmed those of Yadegarinia *et al.* (2006) and Gardely *et al.* (2008) who found that α-pinene, limonene and linalool are the major molecules in the EO of this specie. In connection with the studies of Mansouri *et al.* (2011) on *Juniperus phenicea*, we found α-pinene to largely dominate the composition of *Juniperus* EO. In other studies (Mejri *et al.*, 2010), the analysis of *Ruta chalepensis* EO showed that 2-undecanone and 2-decanone exhibited the highest rate, confirming thereby our findings. For *Pistacia lentiscus*, our results are similar to those of Gardely *et al.* (2008) concerning the abundance of α-pinene. Simultaneously, the last authors mentioned a higher rate of limonene (17.8%).

IV – Conclusions

The vegetal diversity in the studied area presented a consequent chemical diversity, available for animals as fed in grazing or in housing conditions. These substances, mainly essential oils, may be used for their antimicrobial actions to improve animal health and performances. In this connection, *in vitro* studies are currently carried out in our laboratory.

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Importance of *Kochia prostrata* (L.) Schrad in arid and semi arid regions for livestock feeds

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Abstract. The limiting factor in primary productivity in arid and semi arid regions is precipitation. So, selected forage species that are tolerant to drought and salinity are very important for livestock production. Forage kochia [*Kochia prostrata* (L.) Schrad.] which grows in unsuitable conditions, is important plant in desert and semi-desert regions. Forage kochia is a perennial xerophyte and semi-shrubby plant which grows up to 30-100 cm tall. The root system of forage kochia may extend to a depth of 10 m or more. *Kochia prostrata* is very variable and there are a lot of eco-types in the world and particularly in Turkey. Forage kochia is especially important for artificial dry land pastures (100-350 mm rainfalls per years). Forage kochia has been used as a year around grazing forage plant and when properly managed survives long years (average: 15 years).

Keywords. *Kochia* – Arid land – Livestock – Pasture.

Importance de* Kochia prostrata *(L.) Schrad dans les régions arides et semi arides pour l'alimentation du bétail

Abstract. *Le facteur limitant la productivité primaire dans les zones arides et semi arides est la précipitation. Ainsi, les espèces fourragères sélectionnées qui sont tolérantes à la sécheresse et à la salinité sont très importantes pour la production animale. Le fourrage kochia [*Kochia prostrata *(L.) Schrad.] qui se développe dans des conditions sévères, est une plante importante dans les régions désertiques et semi-désertiques. Il est une plante vivace, xérophyte et semi arbustive qui grandit à 30-100 cm de hauteur. Son système racinaire peut s'étendre à une profondeur de 10 m ou plus. Kochia prostrata est très variable et il y a beaucoup d'éco-types dans le monde et particulièrement en Turquie. Kochia est particulièrement important pour les pâturages artificiels en terres arides (100-350 mm annuels). Kochia a été utilisée comme plante fourragère à pâturer pendant toute l'année et lorsqu'elle est bien gérée, elle survit longues années (moyenne: 15 ans).*

Mots-clés. Kochia *– Zone aride – Bétail – Pâturage.*

I – Introduction

It is very difficult find enough to feed the animals from herbaceous plants at adversely pasture areas places arid soil and climate conditions as Karapınar in Turkey. The plant should be given priority form the alternative methods in these areas especially the drought-resistant shrubs and plants (Acar and Dursun, 2010). Forage kochia [*Kochia prostrata* (L.) Schrad is very resistant to drought and heat, it may grow even easily in regions with 160-200 mm rainfall. It endure up to -2, -4°C during the germination period. It can live comfortably between -40°C and +40°C (Kerimbekov, 1994). The Forage kochia is found in many parts of the world, and is located in different provinces (Kastamonu, Sivas, Erzurum, Kars, Konya, Kayseri, Erzincan, Van, Ağrı) in Turkey (Davis, 1967; Anonymous, 2012) (Fig. 1).

Kochia prostrata (L.) is a perennial, xerophyte plant and its height is between 30-120 cm. Forage kochia can grow at the dry steppe and desert conditions with roots that can go down deep. When the Forage kochia is mown or grazed, new shoots grow from the lower stems. Stalk colour varies from green to red-brown. The lower branches become a woody structure. The leaves of the forage kochia are small. Flowers shapes looks like to clusters or clusters complex. Flowers constitute a flowers ball coming together. Generally forage kochia being in the foreign offspring, pollens is transferred by wind. Seeds of forage kochia are oval or round shaped. The diameter of the seed is about 2 mm. Seeds do not store for a long time. Seed or embryo is interior, with 5 perigone leaves as like beet seeds (Fig. 2) (Davis, 1967; Tokluoğlu, 1979; Kerimbekov, 1994; Anonymous, 2010; Dzyubenko and Dzyubenko, 2010). Weight of the 1000 seeds is about 0.6-1.5 g (Kerimbekov, 1994). Trials for plant yield and seed germination of kochia were conducted in Konya in 2010 and 2011.

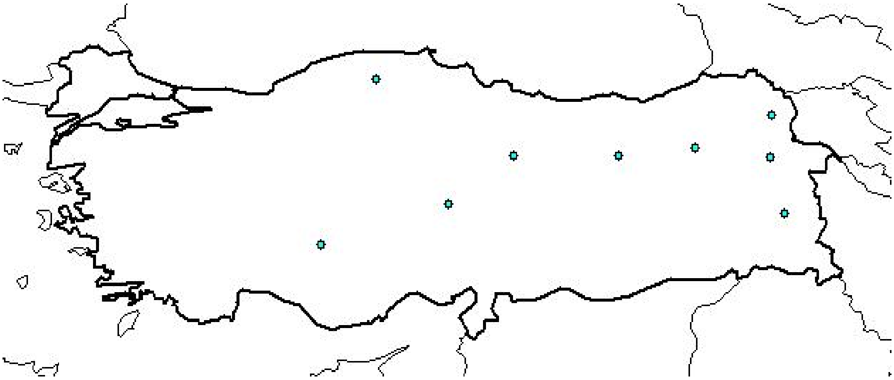
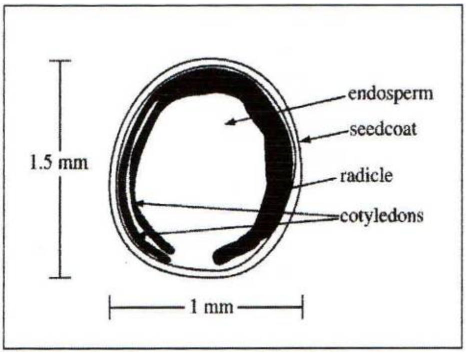
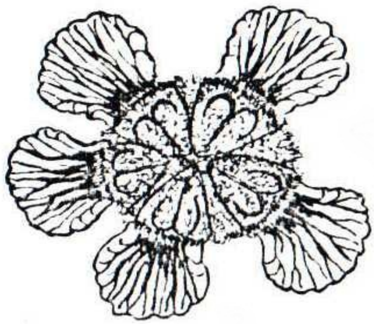


Fig. 1. Geographic distribution of *Kochia prostrata* in Turkey (Anonymous, 2012).



A



B

Fig. 2. A: longitudinal section of a seed of *Kochia prostrata* (Kitchen and Monsen, 2008). B: flower of *Kochia prostrata* (Davis, 1967).

II – Materials and methods

Yield of kochia in natural areas in Konya and germination of kochia seeds were measured in 2010 and 2011. *Kochia prostrata* seeds collected from pasture in October and November (2009) months in Konya and sown in May (2010), but germination was not achieved (Acar and Dursun, 2010). In 2010, *Kochia prostrata* seeds were collected from pasture in October and November months in Konya and sown in January (2011), and germination was achieved in greenhouse. It is very important to sown after harvesting for germination of Kochia (Fig. 3).

Fig. 3. Kochia seedlings was grown in the greenhouse.

In the other research, forage kochia has been obtained from natural habitat in Selcuk University (kochia is found in natural areas within the Selcuk University campus area) on 1 September 2010 with relating data in the field. Some plant characteristics and green and dry forage yield of forage kochia were determined. The data were obtained from two locations (A and B), and four plants from each plant type were measured.

III – Results and discussion

The obtained data can be seen in Table 1 and Fig. 4. As shown in Table 1, some differences have been detected between green and red colour plants (Acar and Dursun, 2011). Kerimbekov (1994) exposed that, there are three different types of forage kochia; these are sandy, clay and mountain, depending if Forage kochia grows at sandy, clay and stony places. Forage kochia grown in clay soils was red, and forage kochia grow where it vary depending stated. Differences noted by researchers were also suggested in our study. Again plant height given by researchers (Dzyubenko and Dzyubenko, 2010; Tokluoğlu,1979), were in harmony with their findings.

Table 1. Some features of the *Kochia prostrata* found in natural areas and with the different colours

Parameters	Green colour stem			Red colour stem		
	A	B	Average	B	A	Average
Plant high (cm)	71.20	69.60	70.40	90.60	90.40	90.50
Plant diameter (cm)	98.30	74.10	86.20	108.10	101.00	104.50
Main rood diameter (cm)	6.10	7.00	6.50	6.30	5.40	5.80
Main stem amount	13.40	10.30	11.80	8.40	7.20	7.80
Fresh forage yield (g/plant)	520.20	1100.40	810.30	902.60	509.80	706.20
Hay ratio (%)	73.10	66.76	69.93	61.55	51.38	56.46
Hay yield (g/plant)	380.10	734.30	557.20	555.10	261.50	408.30

Source: Acar and Dursun (2011).

A: Forage kochia with the green colour stem

B: Forage kochia with red colour stem

Fig. 4. An image of *Kochia prostrata* in the natural growing habitat with different stem colours (Acar and Dursun, 2011).

In a study in the United States, *Elytrigia elongate* and *Kochia prostrata* were used mixture in different proportions for animal nutrition and *Kochia prostrata* increased digestibility of low-quality feed, and could be usable for livestock feed in winter period. Nevertheless, in this study, dry matter ratio of *Elytrigia elongata* and *Kochia prostrata* were found as 91.4% and 93.6% respectively, the resulting the CP, NDF and ADF rates for *Elytrigia elongata* are 3.6%, 77.7% and 50.6% DM whereas 9.6%, 53.8% and 32.2% were found for *Kochia prostrata* (Stonecipher *et al.*, 2004). Waldron *et al.* (2010) indicated that *Kochia prostrata* is a C4 plants with 6.5 m deep roots, tolerance to heat and drought an also salt resistant, and 1000 to 1800 kg/ha yield was reported depending on subspecies with annual rainfall of 100-200 mm. In addition it was indicated that especially during late summer and winter, it has nutritious and highly efficient nutritive value, with low tannin and oxalate, without nitrate accumulation.

IV – Conclusion

Forage kochia can be found a peculiarity at the natural pasture in many places of Turkey. It may be adequate for rehabilitation of the disrupted natural balance resulting of i global warming, water resources reducing and improper usage and it is important to gain marginal areas and rangelands. At the same time it is a plant that can be used for erosion prevention works. Due to its resistance, this plant could have advantages for the use of waste water for its production. For these reasons, we have to give the necessary importance to the this plant. If it is necessary, seedling production may be raised in greenhouse conditions for production of seed germination and seedling formation, that are difficult tasks for forage kochia (Acar and Dursun, 2011).

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Effect of component ratios and management of an annual ryegrass/burr medic mixture on the forage quality

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Abstract. A trial was carried out to evaluate the benefits of grass-legume mixtures in terms of sward establishment, dry matter yield, self-reseeding ability and unsown species control. In this paper we present the aspects related with the forage quality. Two annual self-reseeding species coming from Sardinian candivars *Lolium rigidum* Gaudin NURRA (L) and *Medicago polymorpha* Anglona (P) were used. The trial was carried out in Sardinia (Italy) comparing two pure stands (L100P0 and L0P100) and three mixtures (L75P25, L50P50 and L25P75), where 100 represented the standard dense sowing rate of each component in pure stand. Two different cutting treatments were compared: two cuts *vs* three cuts. Crude protein, NDF and ADF of the different treatments were determined. Mixtures assure a more seasonally-balanced quality of forage respect to the pure stands; two cuts achieve a higher CP content. Results are important for defining suitable strategies at farm level, in terms of grazing techniques.

Keywords. Annual self reseeding species – Mixtures – Forage quality.

Effet des ratios de composition et de la gestion d'un mélange ray-grass et medicago annuel sur la qualité du fourrage

Résumé. *Un essai a été réalisé pour évaluer les avantages de mélanges graminées-légumineuses en termes de mis en place du gazon, du rendement en matière sèche, du réensemencement naturel et de la capacité de contrôler les espèces non semées. Dans cet article nous présentons les aspects liés à la qualité du fourrage. Deux espèces annuelles à réensemencement naturel, candivars* Lolium rigidum *Gaudin Nurra (L) et* Medicago polymorpha *L. Anglona (P) provenant de la Sardaigne, ont été mis en place pour étudier les effets des différents rapports de mélange et de la coupe sur la qualité du fourrage. Le test a été effectué en Sardaigne (Italie) comparant deux* (L100P0 et L0P100) *semis purs et trois mélanges* (L75P25, L50P50 et L25P75) *où 100 représente la densité agronomique standard pour la culture de chaque espèce en pur. Deux différent traitements de coupe ont étés comparés: deux coupes* vs *trois coupes. La teneur en protéines brutes, NDF et ADF a été déterminée sur des échantillons de fourrage. Les mélanges fournissent un fourrage de meilleure qualité par rapport aux semis en pur; une teneur plus élevée en CP est assurée avec deux coupes. Les résultats sont importants pour définir les stratégies les plus optimales de production de fourrage au niveau des exploitations, en termes de valeur nutritive et les techniques de pâturage.*

Mots-clés. *Espèces annuelles à réensemencement naturel – Mélange – Qualité du fourrage.*

I – Introduction

Native and improved pastures and mixtures of annual legumes with winter cereals, used as short annual forage production, represent the most important feed resources for extensive or semi-extensive Mediterranean farming systems. The higher the forage quality, the more efficient is the forage consumption by grazers, so the availability of good quality fodder is ever more a pressing pre-requisite to better manage the livestock farming and its economy. Almost 8% of protein is necessary in the feed rations to meet the protein requirements of ruminants (Qamar *et al*., 1999). So, it is very important to ensure a minimum level of protein in the rations based on the association of forage legumes with grasses; as well as it's relevant the stage at which forage plants are utilized. Two Sardinian candivars of annual self-reseeding species, *Lolium rigidum* Gaudin Nurra and *Medicago polymorpha* Anglona were selected by CNR-ISPAAM in Sardinia. Both species are widespread in the Sardinian pasturelands and have a potential important role in the qualitative and productive improvement of marginal pastures of Mediterranean areas (Franca *et al.*, 1998; Sulas and Sitzia, 2004).

II – Materials and methods

The trial was carried out under rainfed conditions in the North-West Sardinia at the Ottava research station (80 m a.s.l. 40°46'28'',66 N, 8°29'17'',88 E). The climate is typical of the central Mediterranean basin with long-term average annual rainfall of 540 mm and mean annual temperature of 16.2°C. The soil is clay-loam calcareous, with pH 7.5, low N and P_2O_5 content and adequate K_2O content. The species used in the experiment were *L. rigidum* Gaudin Nurra (L) and *M. polymorpha* Anglona (P). Five plots of 20 m^2 each (5m x 4m) were sown in autumn 2002 in a split-plot randomized block design with four replicates. The plots included two pure stands (L100P0 and L0P100) and three mixtures (L75P25, L50P50 and L25P75) where 100 represented the standard dense sowing rate of each component in pure stand (25 kg ha^{-1} and 20 kg ha^{-1} for L and M, respectively). The five plots were compared with a commercial mixture, constituted by Australian varieties of annual legumes as *M. truncatula* 'Paraggio', *M. rugosa* 'Sapo' and *Trifolium brachycalycinum* 'Clare' (M100) well suited for sub-alkaline/alkaline soils. After the late winter cut, each plot was splitted in order to apply two cutting treatments in relation to the burr medic phenological stage: two cuts T1= Early Flowering (EF) and Pod Maturing (PM) *vs* three cuts, T2= Early Flowering (EF), Full Flowering (FF) and Pod Maturing (PM). Before sowing all plots were fertilized with 36 kg ha^{-1} of N and 92 kg ha^{-1} of P_2O_5. No weeding was applied. Plots were mowed at 5 cm above ground. Forage quality was evaluated by drying samples of biomass in oven at 80°C for 48 h, then milling the samples for chemical traits determination. Total N was determinate using Kjeldahl method and crude protein (CP) was calculated by multiplying the N content by 6.25. Neutral and acid detergent fibres (NDF and ADF), were determined by te Van Soest (1994) procedure. Total digestible nutrients (TDN), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV) and net energy for lactation (Ne_l) were estimated according to the following equations adapted from Horrocks and Vallentine (1999): TDN=(-1.291xADF)+101.35, DMI=120/%NDF dry matter basis, DDM=88.9-(0.779x%ADF) dry matter basis, RFV=%DDMx%DMIx0.775, NE_l= (1.044-(0.0119x%ADF))x2.205.

III – Results and discussion

Significant differences for all quality parameters both between thesis and between treatments were observed. The potential yield of CP, NDF and ADF for the different phenological phases and treatments is summarized in Table 1.

Values at EF are common for T1 and T2. In general, mixtures give better responses than pure stands for CP production, especially for L25P75.

On average, annual CP was higher in T2 than T1 while NDF and ADF contents were higher in T1 than T2 due to the lower cut frequency and also for the drop of quality of the grass component CP annual production ranged from 533 kg in L100P0 to 1308 kg in L25P75 for T1. The CP content was higher in pure stands than mixtures, with L0P100>M100 (Fig.1). A similar range was observed for T2.

A positive interaction mixture x phenological stage of utilization was observed. The TDN concentrations were higher than those found for vetch and oats in pure stand or in mixtures by Carr *et al.* 2004 and Lithourgidis *et al.* 2006 (Table 2).

Table 1. CP, NDF, ADF production (kg ha^{-1}) in the pure stands, the grass-legume mixtures and the commercial legume mixture in relation to the phenological stage of utilization

	Crude protein (kg ha^{-1})				Neutral detergent fiber (kg ha^{-1})				Acid detergent fiber (kg ha^{-1})			
Thesis	T1=T2	T1	T2		T1=T2	T1	T2		T1=T2	T1	T2	
	EF	PM	FF	PM	EF	PM	FF	PM	EF	PM	FF	PM
L_0P_{100}	358^c	639^c	550^c	223^{nc}	293^a	2206^{ab}	444^a	727^a	176^a	1471^{ab}	277^{ab}	464^a
$L_{25}P_{75}$	448^d	860^d	481^c	292^{nc}	528^b	3047^{bc}	741^c	1523^b	311^c	1833^{bc}	397^{bc}	974^b
$L_{50}P_{50}$	270^b	583^{bc}	332^b	275^{nc}	484^b	3827^c	655^{ab}	1624^b	238^b	2172^c	337^{abc}	814^b
$L_{75}P_{25}$	256^b	551^{abc}	444^{bc}	241^{nc}	322^a	3614^c	691^c	1930^b	166^a	1848^{bc}	373^{bc}	1108^b
$L_{100}P_0$	105^a	428^{ab}	167^a	276^{nc}	355^a	2908^{bc}	447^a	1824^b	174^a	1762^{bc}	428^c	965^b
M_{100}	296^{bc}	366^a	499^c	257^{nc}	296^a	1603^a	647^{ab}	768^a	174^a	1133^a	223^a	269^a

EF = early flowering; FF = full flowering; PM = pod maturing; for EF: T1 = T2.
Different letters in a column mean significant differences at P≤0.05.

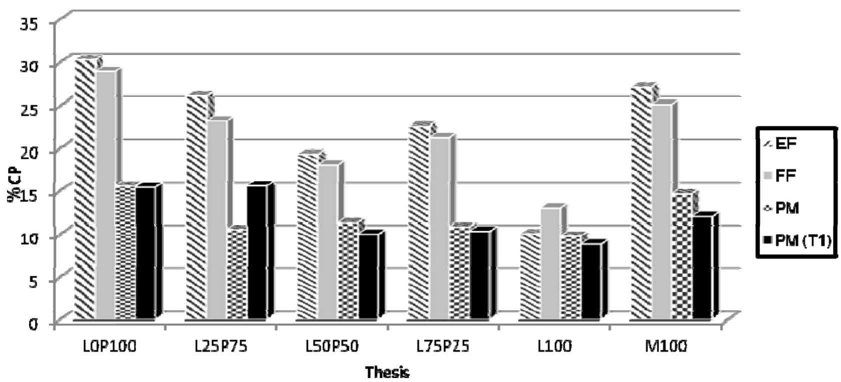

Fig. 1. CP content (%) in the pure stands, the grass-legume mixtures and the commercial legume mixture for the different phenological stages. EF = early flowering; FF = full flowering; PM = pods maturing; for EF: T1 = T2.

Table 2. TDN, DMI, DDM content in the pure stands, the grass-legume mixtures and the commercial legume mixture in relation to the phenological stage of utilization

	Total digestible nutrients %				Dry matter intake %				Digestible dry matter %			
Thesis	T1 = T2	T1	T2		T1 = T2	T1	T2		T1 = T2	T1	T2	
	EF	PM	FF	PM	EF	PM	FF	PM	EF	PM	FF	PM
L_0P_{100}	82.1	55.5	82.6	59.5	4.9	2.3	5.1	2.4	77.3	61.2	77.6	63.6
$L_{25}P_{75}$	78.0	58.4	76.7	56.0	3.9	2.2	3.4	2.0	74.8	63.0	74.3	61.5
$L_{50}P_{50}$	78.5	53.3	76.0	58.1	3.5	1.8	3.2	1.8	75.1	59.9	73.6	62.8
$L_{75}P_{25}$	82.5	56.7	76.8	56.0	4.2	1.8	3.4	2.0	77.5	62.0	74.1	61.5
$L_{100}P_0$	79.9	54.4	78.8	57.3	3.5	2.0	3.4	1.8	75.9	60.6	75.1	62.3
M_{100}	80.8	53.3	73.5	64.0	4.4	2.3	3.7	2.6	76.5	59.9	72.1	66.4

EF = early flowering; FF = full flowering; PM = pod maturing; for EF: T1 = T2.

Being the TDN negatively related with ADF, as ADF increases animals are less capable to utilize the forage. Relative Feed Value provides a fast interpretation to evaluate the forage quality because it combines potential intake and digestibility (Table 3). Forage with RFV >151 is classified as “first-class” (Horrocks and Vallentine, 1999) as shown at EF and at FF cuts. L0P100 reached the highest RFV, above 33% more than M100 confirming the high quality of *M. polymorpha* Anglona. Also NE_l its an important factor formulating a balanced diet and it is a more comprehensive measure of energy than TDN. For all treatments, NE_l was higher than NE_l described for vetch and triticale or oat in pure stands or in mixture (Lithourgidis *et al*. 2006). Average NE_l PM T2 treatments is higher (about 10%) than T1 treatments.

Table 3. RFV value and Net energy for lactation in the pure stands, the grass-legume mixtures and the commercial legume mixture in relation to the phenological stage of utilization

	Relative feed value N°				Net energy for lactation Mcal kg^{-1}			
Thesis	**T1=T2**	**T1**	**T2**		**T1=T2**	**T1**	**T2**	
	EF	**PM**	**FF**	**PM**	**EF**	**PM**	**FF**	**PM**
L_0P_{100}	291	107	305	116	1.912	1.369	1.920	1.451
$L_{25}P_{75}$	226	106	193	95	1.828	1.429	1.801	1.381
$L_{50}P_{50}$	202	85	180	88	1.837	1.326	1.788	1.423
$L_{75}P_{25}$	254	85	196	94	1.918	1.394	1.804	1.380
$L_{100}P_0$	208	94	201	89	1.865	1.347	1.844	1.408
M_{100}	263	106	206	136	1.885	1.326	1.737	1.543

EF = early flowering; FF = full flowering; PM = pod maturing; for EF: T1 = T2.

IV – Conclusions

In the search for solutions able to maximize the environmental resources such as water, nutrients and light to productivity aims, the mixtures are an important alternative to the pure stands. The positive grass/legume interaction on the efficiency dynamics of Nitrogen as mutual stimulatory effects on the N acquisition is important for sustainable agricultural systems (Nyfeler 2011). The results show that mixtures with *M. polymorpha* and *L. rigidum*, besides to forage production (data not showed) assure a more seasonally-balanced quality of forage with respect to the pure stands. Positive effects are obtained thanks to the different complementary functionality of the two species ensuring appreciated CP productions in winter when the legume components exhibit slow of growth rate and in late spring, when the grass quality drops quickly.

Acknowledgements

The authors wish to acknowledge Mr Salvatore Nieddu, Mr Daniele Dettori, Mr AntonPietro Stangoni and Mrs Maddalena Sassu for their technical help.

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Forage production of the drought tolerant Mediterranean forage legume tedera (*Bituminaria bituminosa* var. *albomarginata*) in the medium-rainfall zone of south Western Australia as affected by plant density and cutting frequency

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Abstract. The Mediterranean perennial forage legume tedera (*B. bituminosa* var. *albomarginata*) remains green all-year-round, reducing the summer/autumn feed gap, providing high quality forage when most other pasture options have senesced. At Mount Barker Research Station in south Western Australia (annual rainfall 2010/11 of 445 mm), the forage production of two tedera accessions (T1 and T6) was studied under densities of 1, 2, 4, 8 and 16 plants m^{-2} and cutting frequencies of 1, 2, 3 and 4 times yr^{-1}. The experimental design was a split-split-plot with 4 replicates. The first two years of the experiment were kept weed-free and results are presented for the second year. The density and cutting frequency were the only highly significant effects. Densities of both 8 and 16 plants m^{-2} provided the greatest forage yield of 5.8 tonnes DM $year^{-1}$, while densities of 1, 2 and 4 plants m^{-2} produced 2.1, 2.4 and 4.5 tonnes DM $year^{-1}$ respectively. The cutting frequency of 1 yielded best with 5.8 tonnes DM $year^{-1}$ followed by 2, 3 and 4 cuttings with annual productions of 4.1, 3.7 and 2.8 tonnes DM respectively. In this environment, forage produced using densities of 8 to 16 plants m^{-2} can be accumulated and used at strategic times of the year to reduce the costs associated with supplementary feeding.

Keywords. *Bituminaria* – Tedera – Cutting frequency – Plant density.

Production de fourrage d'herbe au bitume (*Bituminaria bituminosa var. albomarginata*), légumineuse vivace méditerranéenne résistante à la sécheresse, dans la zone à précipitations moyennes d'Australie Occidentale, en fonction des facteurs de densité et de coupe

Résumé. *L'herbe au bitume (*Bituminaria bituminosa var. albomarginata*), légumineuse méditerranéenne vivace, reste verte toute l'année, assurant la transition entre les fourrages d'été et d'automne, et fournissant un fourrage de très bonne qualité, une fois épuisées la plupart des autres plantes fourragères. A la station de recherche de Mount Barker au sud de l'Australie Occidentale (pluviométrie annuelle pour 2010/11: 445 mm) la production de fourrage de deux obtentions d'herbe au bitume (T1 et T6) a été étudiée avec des densités de 1, 2, 4, 8 et 16 plantes au* m^2 *et des fréquences de récolte de 1, 2, 3 et 4 fois par an. Le modèle expérimental était un plan à sous-sous parcelles partagées (split-split-plots) avec 4 réitérations. Les parcelles ont été désherbées pendant les deux premières années de l'expérience et les résultats sont présentés pour la deuxième année. La densité et la fréquence de coupe étaient les deux seuls facteurs significatifs. Les densités de 8 et 16 plantes au* m^2 *ont produit le plus fort rendement de fourrage avec 5,8 tonnes MS par an, tandis que les densités de 1, 2, et 4 plantes par* m^2 *ont produit respectivement 2,2, 2,4 et 4,5 tonnes MS par an. La fréquence d'une récolte par an a été la meilleure, avec 5,8 tonnes MS annuelles, suivie de 2, 3 et 4 récoltes annuelles donnant des productions de 4,1, 3,7 et 2,8 tonnes MS par an respectivement. Dans cet environnement, le fourrage produit avec des densités de 8 ou 16 plantes par* m^2 *peut être gardé en réserve et utilisé à des moments stratégiques au cours de l'année, pour réduire les coûts de fourrage supplémentaire.*

Mots-clés. Bituminaria *– Tedera – Fréquences de récolte – Densités.*

I – Introduction

After a worldwide search for perennial forage legumes adapted to Mediterranean environments typical of much of southern Australia, Real and Verbyla (2010) and Real *et al.* (2011) concluded that the outstanding candidates were tedera plants (*Bituminaria bituminosa* var. *albomarginata* and var. *crassiuscula*). *Bituminaria bituminosa* (L.) C.H. Stirton is widely distributed in the Mediterranean Basin and Macaronesia. A large diversity exists in the Canary Islands in habitats ranging from the coastal semi-arid areas (annual rainfall 150-300 mm; var. *albomarginata*) to the high elevation sub-humid zones [up to 500 mm annual rainfall; var. *crassiuscula*; (Méndez *et al.* 2006)]. For centuries in these regions, tedera has been one of the preferred choices by farmers for feeding dairy goats (Méndez and Fernández 1990; Real *et al.* 2009).

In Australia, the potential value of tedera for livestock production has been confirmed in preliminary agronomic and animal house studies. In south Western Australia, we studied thousands of single-spaced plants established from seedlings, rows established by seeds, and plants in small plot trials in three low rainfall sites (approx. 350mm) established in 2006. Most survived, even those sown in drought years, grew significant biomass and remained green and leafy year-round – most importantly, during summer and autumn with minimal leaf shedding since 2006 despite regular and severe defoliation by grazing or cutting. This remarkable year round growth and retention of green feed has previously only been seen in a few shrubs and can provide a strategic fodder supply over the traditional summer/ autumn dry period, a major advantage over lucerne (Real *et al.* 2008; Real and Verbyla 2010). Preliminary results of a PhD student at the University of Western Australia confirmed that tedera is able to tolerate drought conditions by applying several physiological and morphological mechanisms. These mechanisms allow high water use efficiency in comparison with lucerne which has a deep root system and sheds its leaves to cope with drought. Tedera has proven to be a very drought tolerant plant even in pot trials where access to stored moisture is not possible.

The objective of this study was to evaluate the dry matter production of tedera accessions at five plant densities and four cutting frequencies in a Mediterranean medium rainfall zone.

II – Materials and methods

1. Site description

The experiment was conducted at the Department of Agriculture and Food, Western Australia (DAFWA) Research Station at Mount Barker, Western Australia, Australia (Lat. -34.627735; Long. 117.550880). The soil is a coarse loam with $pH_{(CaCl2)}$ = 4.4 on the surface and $pH_{(CaCl2)}$ = 5.4 from 10 cm to 20cm deep. The annual rainfall is winter dominant with a 100 year average of 733.2 mm. Summers are hot and autumn and winters mild with no below zero temperatures.

2. Field design, site preparation, plant material and management

The trial consisted of a split-split-plot design with 4 replicates. Two accessions of *B. bituminosa* var. *albomarginata* (T1, T6) were used. Accessions were assigned to main plot, density (1, 2, 4, 8 and 16 plants m^{-2}) and cutting frequency (1, 2, 3 and 4 cuts yr^{-1}) were considered as split-plot and split-split-plot respectively. Each experimental unit was 1 m^2. Inoculated 6-week old seedlings were transplanted at a uniform spacing within each split-split-plot on 17th June 2009. Once plants were established, they were cut to 2-4 cm from the ground in November 2009, January 2010, April 2010, August 2010, November 2010, January 2011, April 2011 and/or August 2011 depending on the cutting frequency treatment allocation. The experiment was kept weed free during the experimental period. For the densities of 8 and 16 plants m^{-2} only the four central plants of each plot were cut, dried and weighed. Remaining plants were cut and discarded. For the densities of 1, 2 and 4 plants m^{-2}, where it was assumed that competition among plants within a plot would be negligible; all plants within a plot were cut, dried and weighed. All samples were dried at 60 °C for 4 days and DM is expressed on a per plot (1 m^2) basis.

3. Statistical analyses

Dry Matter weight was analysed using Genstat 14th Edition (2011). The design was a split-split-plot design considering accession, density and cutting frequency as the main-plot factor, split-plot factor and split-split-plot factor, respectively. ANOVA was conducted to study the significance of all effects and their interactions and LSD were used at a 5% significance to compare means of significant effects.

III – Results and discussion

Results are presented only for the second year of the experiment from August 2010 to August 2011. The density and cutting frequency were the only highly significant effects with accessions T1 and T6 having overall non-significantly different means of 4102 and 4108 kg DM ha^{-1} respectively. The mean annual yield for each cutting regime and the five plant densities is presented in Fig. 1.

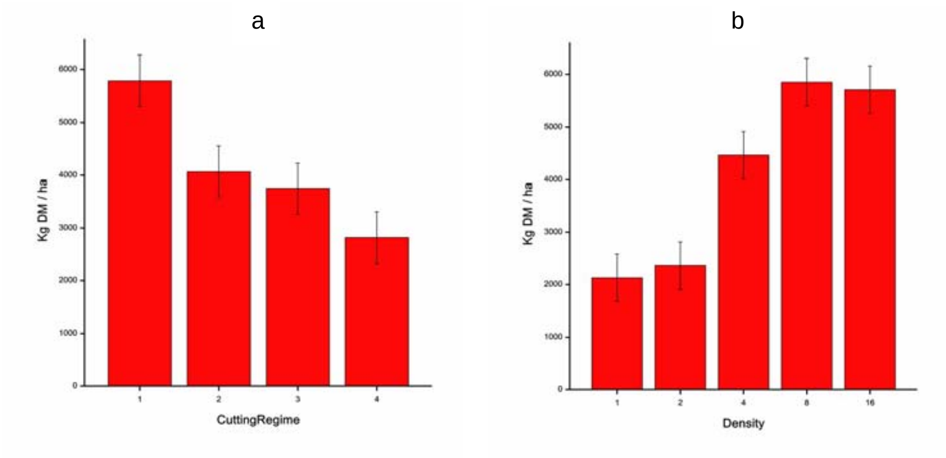

Fig. 1. Mean annual yield for four cutting regimes (a) and five plant densities (b).

Densities of both 8 and 16 plants m^{-2} provided the greatest forage yield of 5.8 tonnes DM $year^{-1}$, while densities of 1, 2 and 4 plants m^{-2} produced 2.1, 2.4 and 4.5 tonnes DM $year^{-1}$ respectively. The cutting frequency of 1 yielded best with 5.8 tonnes DM $year^{-1}$ followed by 2, 3 and 4 with annual productions of 4.1, 3.7 and 2.8 respectively. In this environment using densities of 8 to 16 plants m^{-2} tedera forage can be accumulated and used at strategic times of the year when other forages may be limiting. Similar results were obtained by Suriyagoda et al. (2012a, b) using a similar field design with the same two tedera accessions in three low rainfall sites in Western Australia evaluated from 2008 to 2010. Again plant densities of 8 to 16 proved the most productive however in these drier environments, three cuttings per year were concluded to be the optimum to have a good balance of production with forage quality. More cutting times per year resulted in leafier vegetative growth and better nutritional quality when compared with those cut less often.

IV – Conclusions

Forage production of *B. bituminosa* var. *albomarginata* was determined by plant density and cutting frequency. Plant densities of 8 to 16 plants / m^2 maximise productivity, while a reduced number of cuttings per year maximize production.

Acknowledgments

This study was supported by Future Farm Industries Cooperative Research Centre. The authors would like to thank Mount Barker research station manager, Mr. Ross Ramm for his valuable support in the project.

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Nutrient and tannin content of browsing shrub legumes informally used for small ruminant feeding in Canary Islands, Spain

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Abstract. The objective of this study was to contribute to the characterization of nutritional potential, with special attention to the profiles on phenolic compounds and condensed tannins, of some native browsing shrub legumes informally used for ruminant feeding in Canary Islands. The species selected for this study were *Bituminaria bituminosa* var. *bituminosa, Bituminaria bituminosa* var. *albormaginata, Chamaecytisus proliferus* var. *palmensis, Chamaecytisus proliferus* var. *canariae and Adenocarpus foliosus.* Crude protein (CP) ranged from 10.6% (*Bituminaria b. bituminosa*) to 18.5% (*Adenocarpus foliosus*) whereas neutral detergent fibre (NDF) was between 39.9% (*Chamaecytisus p. canariae*) and 51.6% (*Bituminaria b. albormaginata*). Condensed tannins expressed as catechin equivalent ranged from 0.1% (*Bituminaria b. albormaginata*) to 0.5% (*Bituminaria b. bituminosa)*, and total phenols expressed as tannic acid equivalent ranged from 0.9% (*Bituminaria b. albormaginata*) to 3.5% (*Chamaecytisus p. palmensis*). The organic matter digestibility (OMD) ranged from 51.9% (*Bituminaria b.albormaginata*) to 71.5% (*Chamaecytisus p. canariae*). Current results support the thesis that, according to the more local empiric practices, native flora of Canary Islands have an under exploited potential with the capacity to assist eventual changes in ruminant feeding systems strategies. Nevertheless, deeper characterization and in vivo evaluation studies of the species covered in this study are required at different seasons and vegetative stages (e.g. digestibility *in vivo*, palatability, voluntary intake, productive response).

Keywords. Total phenols – Condensed tannins contents – Browsing shrub legumes – *Bituminaria bituminosa* sp. – *Chamaecytisus* sp. – *Adenocarpus foliosus* – Tedera – Tagasaste.

Le potentiel nutritionnel et la composition en composés phénoliques et en tannins condensés, de arbustes fourragers locaux utilisés dans l'alimentation des ruminants dans les îles Canaries

Résumé. *L'objectif de cette étude était de contribuer à caractériser le potentiel nutritionnel et en particulier la composition en composés phénoliques et en tannins condensés, de certain arbustes fourragers locaux utilisés dans l'alimentation des ruminants dans les îles Canaries. Les espèces étudiées étaient :* Bituminaria bituminosa *var.* bituminosa*,* Bituminaria bituminosa *var.* albormaginata*,* Chamaecytisus proliferus *var.* palmensis*,* Chamaecytisus proliferus *var.* canariae *and* Adenocarpus foliosus*. Les teneurs en matières azotées totales (CP) s'étendaient de 10,6% (*Bituminaria b. *var.* bituminosa*) à 18,5% (*Adenocarpus foliosus*) et celle en neutral detergent fibre (NDF) de 39,9% (*Chamaecytisus pr. *var.* canariae*) à 51,6% (*Bituminaria b. *var* albormaginata*). Les teneurs en tannins condensés exprimés en équivalent catechine variaient de 0,11% (*Bituminaria b. *var* albormaginata*) à 0,51% (*Bituminaria b. *var.* bituminosa*), et les phénols totaux exprimés en équivalent acide tannique, de 0,92% (*Bituminaria b. *var.* albormaginata*) à 3,57% (*Chamaecytisus pr. *var.* palmensis*). La OMD variait de 51,95% (*Bituminaria b. *var* albormaginata*) à 71,55% (*Chamaecytisus pr. *var.* canariae*). Nos résultats montrent que la flore native des îles Canaries utilisée de manière empirique par les éleveurs, est une source fourragère sous-exploitée qui pourrait être utilisée dans le cadre de nouvelles stratégies de systèmes d'alimentation. Cependant une caractérisation* in vivo *à différentes saisons et stades physiologiques (digestibilité, appétence, ingestibilité, niveau de production permis) est nécessaire.*

Mots-clés. *Phénols totaux – Tannins condensés – Arbustes légumineuses –* Bituminaria bituminosa *sp. –* Chamaecytisus *sp. –* Adenocarpus foliosus *– Tedera – Tagasaste.*

I – Introduction

Browsing legume plants have been largely reported to be used for small ruminant feeding (i.e. sheep and goats) as feed resources in tropics, subtropics, arid and dry regions, during dry seasons, mainly. They are known to be tolerant to drought having the ability to accumulate green fodder over several seasons, controlling erosion, providing fodder reserves for times of dearth and contributing, as legumes plants, for positive impacts on soil fertility with organisms which fix atmospheric nitrogen (Le Houérou, 2000). Nevertheless their use has been limited by scant research on their nutritional and chemical properties, in particular on anti nutritional factors. The presence of tannins in browsing legumes plants is normally associated with limiting factor to the utilization as feedstuffs (Mangan, 1988; Kumar and Vaithiyanathan, 1990). In Canary Islands there are some native and endemic shrub legumes, which grow spontaneously and traditionally, that have been used by local goat and sheep keepers as feed resources. However, there is still scarce literature about their particular characteristics which had lead to a poor promotion at local and regional level. The objective of this study was to assess the nutritive value of some of these legumes shrub, specially taking into account their profiles on phenolic compounds and condensed tannins for select properly the species and the variety of the legumes shrubs for animal nutrition.

II – Materials and methods

1. Experimental material, site and chemical analysis

The species used in this study were *Bituminaria bituminosa* var. *bituminosa (B. b. bituminosa), Bituminaria bituminosa* var. *albormaginata (B. b. albormaginata), Chamaecytisus proliferus* var. *palmensis (Ch. p. palmensis)*, *Chamaecytisus proliferus* var. *canariae (*Ch. p. *canariae)* and Adenocarpus *foliosus (A. foliosus*), all of them are shrub or "semi-shrub" legumes, native (endemic) from Canary Islands, specifically from different localities in Gran Canaria (latitude 27° 55' 45"; longitude 15° 23' 20"). The original plants were randomly selected from spontaneous populations which have been developed without irrigation or fertilization during May 2009. Thin stems (less than 3 mm diameter) of mature shrubs with their leaves, steams and flowers were collected. Ash (ASH), organic matter (OM) and crude protein (CP) were determined in duplicated samples according to standard methods as described in AOAC (2000). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined following the procedure of Van Soest *et al.* (1991). Condensed tannin analysis and total phenolic content were performed by the vanillin-HCL method of Burns (1963) and the technique of Makkar *et al.* (1993) respectively; *in vitro* dry matter digestibility (DMD) and organic matter digestibility (OMD) was determined according to the two stage pepsin-cellulase method (Pepcel) (Aufrere, 1982). To assess the content of nutrients according to the type of plant, an analysis model of variance with a factor of variation (ANOVA-1) was used (SAS, 2000).

III – Results and discussion

The chemical composition, OMD, DMD are seen in Table 1, CP, ranged from 10.6% (*B. b. bituminosa*) to 18.5% (*A. foliosus*) and were significantly different in all the species, a exception of *Ch. p. palmensis* and *Ch. p. canariae*, which have similar CP content. NDF ranged between 39.9% (*Ch. p. canariae*) to 51.6% (*B. b. albormaginata*), from which NDF of *Ch. p. canariae* and *A. foliosus* were both, significantly similar and also NDF, were similar in *B. b. albormaginata* among *B. b. bituminosa*. The ASH ranged between 3.9% (*Ch. p. canariae)* to 6.9% *(B. b. albormaginata)*, there are a significantly similar ASH content between *Ch. p. palmensis* and *Ch. p. canariae* and between *A. foliosus* and *B. b. bituminosa* too. OMD (Table 1) ranged between 51.9% *(B. b. albormaginata*) to 71.5% (*Ch. p. canariae*), all the values were significantly different from each other. Although OMD and DMD of *Chamaecytisus proliferus* sp. were higher than from *Bituminaria b.* sp. and *A. foliosus.*

Table 1. Chemical composition (% DM), total phenols (% of tannins as tannic acid equivalent), condensed tannins content (%of tannins as catechin equivalent), organic matter digestibility (% OMD) and dry matter digestibility (% DMD)

Species	DM	OM	CP	NDF	ADF	ADL	Ash	CT	Total phenols	DMD	OMD
Bituminaria bituminosa											
var. *albormaginata*	63.5	88.7	11.9^{a}	51.6^{a}	37.4^{a}	9.7^{a}	6.9^{a}	0.1^{a}	0.9^{a}	55.4^{a}	51.9^{a}
var. *bituminosa*	40.7	87.7	10.6^{c}	49.0^{a}	33.5^{a}	7.6^{b}	5.2^{b}	0.5^{c}	1.4^{b}	61.6^{c}	59.4^{c}
Chamaecitysus proliferus											
var. *palmensis*	41.5	89.8	16.0^{b}	45.2^{c}	25.5^{a}	8.8^{c}	4.1^{c}	0.3^{b}	3.5^{c}	67.9^{b}	66.4^{b}
var. *canariae*	49.7	90.2	15.7^{b}	39.9^{b}	29.9^{a}	11.8^{d}	3.9^{c}	0.3^{b}	2.8^{d}	72.5^{d}	71.5^{d}
Adenocarpus foliosus	43.5	89.1	18.5^{d}	40.3^{b}	24.6^{a}	7.9^{b}	5.2^{b}	0.4^{b}	2.0^{e}	64.7^{e}	63.4^{e}
P			<.001	<.001	.031	.002	<.001	<.001	<.001	<.001	<.001

DM: dry matter; OM: organic matter; CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; CT: condensed tannins; DMD: dry matter digestibility; OMD: organic matter digestibility.

The results of total phenols and condensed tannins are in Table 1; condensed tannins ranged between 0.1% (*B. b. albormaginata*) to 0.5% (*B. b. bituminosa*) and showed a significantly similar content between *Ch. p. palmensis, Ch. p. canariae* and *A. foliosus*. Total phenols ranged from 0.9% (*B. b. albormaginata*) to 3.5% tannic acid equivalent on (*Ch. p. palmensis*) and there were significantly different between all of them. In Fig. 1 we can see the correlations between chemical compositions and OMD of the different species, exist a negative correlation between mean value of ASH, FND, FAD among OMD while there is a positive correlations between total phenols and OMD. Probably this fact is explained but the ability of the tannins to combine with dietary proteins, minerals and polymers such as cellulose, hemicellulose, pectin and minerals thus retarding their digestion (McSweeney *et al.*, 2001). Thus tannins can reduce nitrogen availability to rumen microorganisms and they may be advantageous by protecting dietary protein from digestion in the rumen and thus increasing total supply of protein for absorption (D'Mello, 1992).

	OMD	T_Phenol	Tannin
ASH	-.580*	-.842**	-.467
CP	.434	.477	-.018
NDF	-.82**	-.330	.035
ADF	-.594*	-.565	-.302
ADL	-.336	.102	-.316
OMD		.621*	-.126
T-Phenol			.342

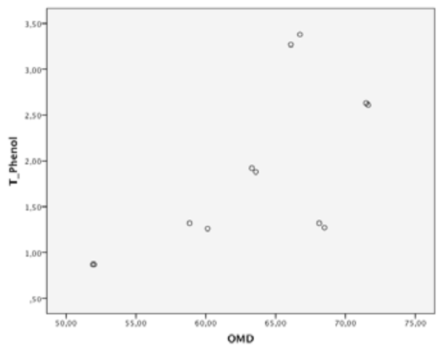

Fig. 1. Matrix and correlations of Spearmean between chemical compositions. *P < 0.05; **P < 0.01.

IV – Conclusions

The value of forages as supplements is mainly depending on their capacity to provide essential nutrients to the rumen microbial population and/or critical nutrients (anti-nutritive factors) to meet the host animal requirements, thus increasing or reducing the efficiency of feed utilization

(Elliot and McMeniman, 1987). In this study we can see that there is a positive correlation between total phenols and OMD of the canary shrubs, but also there are many differences of total phenols within the shrubs species and their variety. Although the fact that the tannins content present in tropical shrubs is now a days associated with beneficial properties in the context of ruminant nutrition (Barry *et al.*, 1986; Mangan, 1988) due to the prevention of bloat in cattle and sheep, protecting the leaf protein from the rumen digestion and increasing the supply of high quality protein for absorption; more research should be done on the relation between the quantity of total phenols and tannins and the possible toxic effects on animals, the reduction on voluntary dry matter intake, palatability and productive response. For this reason, the quantification of tannins is important to properly select the species and the variety of the legume shrubs for animal nutrition according to their effect on browsing animals.

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Sustainability of a beef cattle production system in Mediterranean marginal areas

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Abstract. The aim of this work was to evaluate the strategic role of Sardinian marginal areas in the sustainability of beef cattle production systems. The study was conducted between April and November 2011 in an experimental area (24 ha, 670 m a.s.l.) of North-West Sardinia, dominated by woody vegetation, mainly oak species, with an herbaceous cover limited to the 12% of the surface. Twenty-four calves, divided in 4 groups according to the breed: Sarda, castrated Sarda, Sardo-Modicana and a progeny by Charolaise bull and Sarda cow, were used. The animals after weaning, at 6 month of age and 168.5 kg ± 16.2 of live weight (LW, means ± SE), were raised at pasture (0.4 LU ha^{-1}) receiving a supplementation from the end of summer. Monthly animals were weighted and the herbage availability was monitored. The farm meteorological data were registered daily. The pattern of LW and growing rate (kg $head^{-1}day^{-1}$) show a strong dependence from herbage availability, the latter becoming negative during the summer. The studied system shows a shortness of feed during summer and beginning of autumn, due to the delay of autumn rain, confirming the strong relationship between animal performance and seasonal changes in Mediterranean conditions.

Keywords. Beef cattle – Grazing system – Low input agriculture.

Durabilité d'un système de production de bovins à viande dans les zones marginales Méditerranéennes

Résumé. *Le but de ce travail était d'évaluer le rôle stratégique des zones marginales dans la durabilité de systèmes de production de bovins à viande en Sardaigne. L'étude a été réalisée entre Avril et Octobre 2011 dans une zone expérimentale (24 ha, 670 m d'altitude) du Nord-ouest de la Sardaigne, dominée par une végétation ligneuse, chêne principalement, avec une couverture herbacée limitée à 12% de la surface. Vingt-quatre veaux, répartis en 4 lots selon la race: Sarde, Sarde castrés, Sarde-modicaine et un croisement (taureau Charolaise x vache Sarde), ont été utilisés. Les animaux après le sevrage, à 6 mois d'âge et 168,5 kg ± 16.2 de poids vif (moyenne ± ES), ont été maintenus au pâturage tout le temps (0,4 UGB ha^{-1}) et ont reçus une supplémentation de la fin de l'été. Le poids vif des animaux et la disponibilité d'herbe ont été mesurés chaque mois. Les données météorologiques ont été enregistrées quotidiennement. Le poids vif et le taux d'accroissement (kg $tête^{-1}$ $jour^{-1}$) des veaux montrent une forte dépendance de la disponibilité herbe, ce dernier devenant négatif au cours de l'été. Le système étudié montre une pénurie de l'alimentation pendant l'été et au début de l'automne, en raison du retard des pluies d'automne, ce qui confirme la forte relation entre la performance des animaux et les changements saisonniers dans les conditions méditerranéennes.*

Mots-clés. *Bovin a viande – Système de pâturage – Agriculture à faibles intrants.*

I – Introduction

Beef cattle production system in Mediterranean marginal areas is an important activity and represents an ancestral tradition. The typical raising system is based on grazing areas where the animals, suckler cattle and their calves, are free to graze and receive a small amount of supplements. At weaning, at 8 months of age, calves are sold to be fattened in specialized areas where they lost the specificity of the product in the fattening centres (Ligios *et al.*, 2005). For economic reasons the rural population have abandoned the typical raising system exposing the environment at risk of fire and desertification, encroachment of scrubland and woods, erosion and flooding. The sustainable use of the pasture and forestland could represent a development opportunities for the systems: the utilization of these resources by cattle can be beneficial in reducing the production costs; for the conservation of landscape; for the prevention of forest fire; and can also contribute to the maintenance of human local populations. As shown by Scotti *et al.* (2005) cattle can covered their annual energetic requirement up to 80%, grazing in wooded areas in Mediterranean environment, when a rational management is applied. The aim of this work was to evaluate the role of Mediterranean marginal area, represented by pasture based on oak tree forest, in the feeding sustainability of beef cattle production system during the spring-autumn period.

II – Materials and methods

The experiment, still ongoing, is conducted at the Experimental Farm of Agris Sardegna located in Macomer (Sardinia, Italy; lat 39°N, long 9 °E, 670 m a.s.l.). Data are referred to the spring-autumn period of 2011 (from April to November). The studied area is characterized by Mediterranean climate with hot, dry summers and mild and rainy winters (Tmax = 28.1ºC; Tmin = 3.3ºC; total annual rainfall = 905 mm). Meteorological data were recorded daily, by an automatic weather station located in the experimental site. The experimental area (24 ha), is dominated by woody vegetation, represented by *Quercus pubescens*, with open glades limited to the 12% of the total surface.

Animals: twenty-four calves, divided in 4 groups according to the breed: Sarda (S), castrated Sarda (Sc), Sardo-Modicana (SM) and a progeny by Charolaise bull and Sarda cow (F1), were used. The animals after weaning, at 6 month of age and 168.5 kg ± 16.2 of live weight (LW, mean ± SE st.dev.), were raised at pasture (0.4 LU ha^{-1}) receiving a supplementation from the end of summer to the beginning of autumn (1.70 kg $head^{-1}$ day^{-1} of a commercial concentrate and 3.0 kg DM $head^{-1}$ day^{-1} of natural pasture hay). Calf live weight (LW, kg) was recorded monthly and calf growing rate (CGR, kg $head^{-1}day^{-1}$) was calculated.

Pasture: herbage on offer (HO, t DM ha^{-1}) was monitored monthly by cutting 40 stripes (0.10 m x 5 m) randomly selected throughout the experimental area. Sward height (SWH, cm) was also measured with weighted plate (150 records per ha). In the forage samples were determined fresh and dry weight (oven dried at 60°C until constant weight) and chemical composition, evaluate on dry matter (% DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL). The samples were analysed using a Foss NIRSystems (Hoganas, Sweden) model 5000 NIR reflectance monochromator spectrometer, after calibration with traditional chemical analysis (NIRS, Shenk and Westerhaus, 1994).

Statistical analysis: HO, SWH and chemical composition of herbage on offer were analyzed with the GLM procedure of SAS using the experimental period as fixed effect; LW were analyzed with the GLM procedure of SAS using the breed as fixed effect and the pre-experimental LW as covariate; CGRs were analyzed with Mixed procedures of SAS using breed, period and their interaction as fixed effect and animal as random effect.

III – Results

During the experimental period, air mean temperature increased from Spring (Tmean = 14.3°C) to Summer (Tmean = 21.4 °C), and gradually decreased afterwards. Rainfall decreased notably from spring (April-June = 130 mm) to summer (July-August total = 22 mm) and increased only in late autumn (November = 204 mm)

The patterns of herbage on offer (HO, t DM ha^{-1}) and sward height (SWH, cm) are consistent with herbage growth trend in Mediterranean natural pasture, that is, also, clearly reflected by the pasture quality (Table 1). HO resulted very low, also in spring. The quality on offer resulted good, with high CP due to the high incidence of legume species in HO (data not shown). HO had an upward trend in quality and quantity only in late November, as consequence of late autumn rain, nevertheless it remained still very low. Overall the pasture under study is characterized, in particular in spring, by an amount of HO lower than those measured by other authors. In Mediterranean mountain conditions Acciaro *et al.* (2011) found HO = 4.9 and 3.6 t DM ha^{-1} in April and June, respectively and, in the same site, Sitzia and Fois (2008) found HO = 2.3 and 1.7 t DM ha^{-1} during two spring seasons characterized by very different amount of rainfall (160 mm *vs* 60 mm, respectively).

Table 1. Pasture sward height (SWH, cm), herbage on offer (HO, t DM ha^{-1}) and its nutrient content (% DM) during the trial (Lsmeans ±SE)

	April	May	June	July	September	October	November
SWH	6.3± 0.32d	9.6±0.52 b	11.0±0.55 a	7.8±0.62c	2.5±0.21e	1.3±0.13 f	2.8±0.10 e
HO	0.93±0.09 bc	1.11±0.09 b	1.4±0.09 a	0.88±0.06 c	0.29±0.05 d	0.07±0.02 e	0.29±0.03 d
DM	21.8±0.94e	22.8±0.63e	33.4±1.6d	65.0±2.57b	70.9±1.85a	50.9±6.40c	24.8±1.39e
CP	16.9±0.76a	14.0±0.34b	9.9± 0.39c	6.0± 0.29de	4.3±0.57f	4.6± 0.73ef	7.2±0.82d
NDF	41.0±1.40d	48.6±0.93c	58.9±1.28b	63.5±0.33ab	68.6±2.73a	66.6±4.03ab	58.2± 3.50b
ADF	23.0±1.09e	27.8±0.52d	35.5± 0.54c	40.9±1.05b	46.5±1.24a	46.4±1.89a	40.7±2.49b
ADL	4.4± 0.52e	4.8±0.23e	6.8± 0.46d	8.7± 0.61c	10.7± 0.66b	12.5±0.51ab	13.3±1.19a

Values in the same row with different letters differ significantly (P<0.001).

Average calf live weight increased from 168.5±5.26 in April to 193.1±4.97 kg per head in July. In September and October the animals lost weight (LW=178.5±4.45 in October). In November S and F1 (LW=198.4 and 200.4 kg respectively, P>0.05) recovered their weight faster than Sc (169.4 kg; P<0.05) being SM (180.5 kg) an intermediate (Fig. 1).

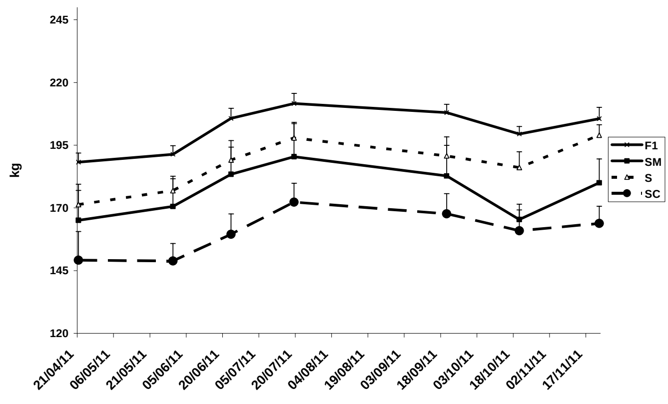

Fig. 1. Calf live weight pattern (kg LW) during the experimental period (Lsmeans ±SE).

Calf growing rate (CGR, kg $head^{-1}day^{-1}$) was strongly affected by herbage availability and quality (Fig. 2). During late spring, with an herbage allowance per day of 1.7 kg DM $head^{-1}$, the highest growing rate have been recorded: 0.530±0.06 and 0.330±0.06 kg $head^{-1}day^{-1}$ (LSmeans±SE) in June and July, respectively, (P<0.05). This is confirmed by Acciaro *et al.*

(2011) that found a higher growth rate (0.78±0.06 kg day^{-1}) in Sarda calves raised at pasture when herbage availability was 4.7 t DM ha^{-1}.

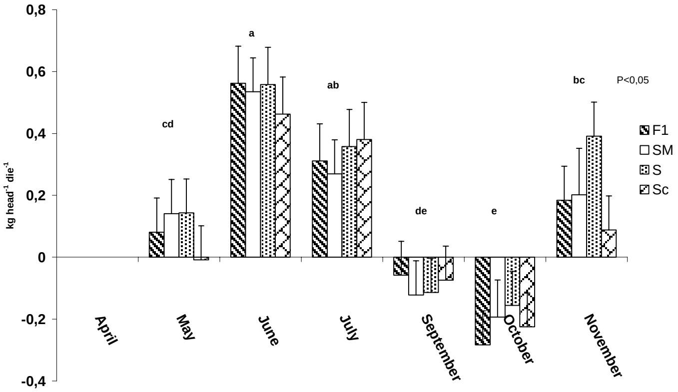

Fig. 2. Calf growing rate (kg head^{-1} day^{-1}) during the experimental period (Lsmeans ±SE). Different letters above the bars show significant difference between data.

After July HO drastically decreased and calves tended to lost weight until a supplementation was offered. No significant difference was found on CGR between the breeds studied.

IV – Conclusions

The studied system showed a shortness of feed during summer and beginning of autumn, because of the delay of autumn rain, confirming the strong relationship between animal performance and seasonal meteorological pattern in Mediterranean conditions. The important lost of weight recorded during the summer in all tested breed demonstrated that the feed production in marginal areas could be insufficient to assure an economical return in cattle meat farming system when based completely on grazing forage. More studies need to identify and quantify other services provided to the ecosystem in order to consider the beef cattle farming system not only as an exclusively economic activity.

Acknowledgments

The “PO Italia-Francia Marittimo 2007-2013” for the financial support (Projects MARTE+ SC Prot. n.AOO-GRT 109013/F.45.60 of 21/04/2010). Mr. G. Meloni, Mr. S. Mastinu, Mr. A. Pintore, Mr. G. Beccugna, Ms. R. Coinu, Mr. Giuseppe Testoni, Mr. A. Carboni, Mr. M. Pintore, Mr. G. Scanu, Mr. M. Delrio for their technical help.

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Session 4
Changes in Mediterranean farming systems to meet new socio-economic scenarios

Changes in North Africa production systems to meet climate uncertainty and new socio-economic scenarios with a focus on dryland areas

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Abstract. Production systems in North Africa are typically marked by the scarcity of water resources throughout the region. This scarcity is expected to worsen and to negatively affect food security under the grim scenarios of climate change with a predicted 20% reduction of precipitation by the end of the century and 0.2°C temperature increase per decade in the coming 2 decades. Most affected areas are those of the pastoral and agro-pastoral systems where rainfall is both low and highly variable, and productivity is continuously threatened and indeed negatively by the unfavorable changing climate. A clear change is being witnessed through the evolving livelihood pattern, marked by a more sedentary living of local populations and a strong preference for more remunerating and less-labor intensive activities, including high value animal and plant products, such as niche products, honey, aromatic and medicinal plants, and off-farm derived income including handicraft and eco-tourism. In areas less affected by drought, lowland cereal-based systems including integration of intensive livestock production are dominant. In those areas farmers are more benefiting from technological advances including mechanized farming operations, supplemental irrigation of cereal and forage crops and occasional full irrigation of high value commodities, including fruits, vegetables, and highly nutritious forage crops for animal fattening and intensive dairy production. Mountainous regions have been traditionally neglected despite their rich biodiversity and more abundant water resources. Nonetheless, local populations in all regions are more and more proactively involved in deciding on the strategies to address the dilemma of securing better livelihood and conserving natural resources in a global environment marked by a relentless climate change.

Keywords. Production systems – Agropastoral system – Cereal based system – Ruminant feeds – Climate variability.

Changement des systèmes de production face aux incertitudes climatiques et aux mutations socio-économiques des zones arides de l'Afrique du Nord

Résumé. *Les systèmes de production en Afrique du Nord sont marqués par la rareté des ressources hydriques qui est appelée à s'aggraver et à affecter négativement la sécurité alimentaire de l'ensemble de la région. Les différents scenarii de changement climatique prévoient une réduction de la pluviométrie de 20 % et un réchauffement moyen de 0.2 °C par décade. Les systèmes pastoraux et agropastoraux sont les plus touchés à case de la rareté et la variabilité de la pluviosité et les maigres opportunités de diversification des sources de revenus. La productivité de ces systèmes diminue significativement par l'effet des changements climatiques. Les systèmes pastoraux et agropastoraux vivent de véritables mutations aussi bien sur le plan sociologiques qu'économiques. Les populations essayent de développer d'autres activités plus rémunératrice, telle que le commerce transfrontalier ou des activités à caractère sédentaire (produits de terroirs, plantes médicinales, miel, écotourisme, activité non agricole, etc.). Dans les zones plus favorables où le système de production céréale-élevage domine, les agriculteurs bénéficient des avancées technologiques (mécanisation, irrigation complémentaire des céréales, production fourragère, élevage intensif, etc.). Dans les zones montagneuses du Nord où la pluviométrie est élevée et où les conditions de production sont plus difficiles à cause de la fragilité du milieu, l'activité de l'élevage extensif dans les clairières forestières demeure la principale source de revenu des populations démunies.*

Mots-clés. *Système agropastoral – Système céréale-élevage – Alimentation des ruminants – Fluctuations climatiques – Afrique du Nord.*

I – Introduction

North Africa typically is a dry region, comprising the countries of Algeria, Morocco and Tunisia, where four subregions may be easily distinguished, namely (i) a northern subhumid coastal subregion, bordering the Mediterranean sea (and the Atlantic Ocean for western Morocco), where average annual rainfall is relatively high, generally above 500 mm and where soils are relatively good for farming; (ii) a semi-arid elevated subregion flanking the first subregion from the southern side, from which it is separated by the Atlas mountains and where rainfall is around 300-500 mm, and soils are light calcareous silt-loam; it is bordered on the southern side by (iii) an arid, lower-altitude subregion, with silt-sandy soils and an average rainfall of 100-300 mm; and (iv) Sahara desert subregion covering the largest part of the countries (Nefzaoui *et al.*, 2012)

North Africa is marked by an acute water scarcity, combined with a highly variable Mediterranean climate. While the average world per capita share of fresh water is 7000 cubic meter (m^3), all three North African countries are below the water poverty threshold of 1000 m^3 (Table 1). Agriculture uses the largest share (up to 80%) of available water resources where rainfed cropping predominates. The scarcity of natural water resources, combined with the highly variable and generally very low rainfall in most of the region explain in part the low agricultural productivity, especially of key crop commodities, and the reliance of North African countries on food imports to meet their growing national demands; this is especially true for Algeria that has the largest population, and the lowest agricultural contribution to country GDP and to total employment. Water scarcity is further exacerbated by the competition for water from domestic and industrial uses, and the increasing population and urbanization. Cereal crops, mainly wheat and barley, are the major crop commodities grown in North Africa, but their contribution to national food security and household income remains low (Table 1) (Nefzaoui *et al.*, 2012)

Table 1. Selected agricultural characteristics for three North African countries

Characteristic	Algeria	Morocco	Tunisia
Population (million)	34.4	31.6	10.2
Total area (million ha)	238.1	71.0	16.4
Cultivated area (million ha)	8.4	9.0	5.0
Contribution of agriculture to GDP (%)	8.0	17.0	10.0
Rural population (% total population)	35.0	44.0	33.0
Employment in agriculture (% total employment)	14.0	45.0	18.0
Irrigated area (% cultivated area)	6.9	16.6	8.0
Total annual renewable water resources (km^3)	11.7	29.0	4.6
Annual per capita renewable water resources (m^3)	339.5	917.5	451.9
Wheat self-sufficiency (%)	29.0	58.0	50.0

To lessen their dependence on highly unpredictable cereal harvests, small-scale farmers may also maintain a small-ruminant (sheep and goats) raising activity that provides them a buffer against poor crop harvest or crop failure in severe-drought years. In fact, the cereal-livestock system forms the backbone of agriculture in the semi-arid zones in contrast to the arid regions where small ruminant raising is the major agricultural activity. Horticultural crops and specific high value fruits (citrus fruits, grapes, etc.) are produced under moisture-favorable conditions in subhumid areas or under irrigation in other areas. Extensive cultivation of olives and other drought tolerant trees are generally produced under rainfed conditions in semi-arid and arid areas (Nefzaoui *et al.*, 2012). The future of agriculture in North Africa is further threatened by unfavorable climate change that is expected to drastically affect agriculture productivity and people’s livelihoods.

II – Climate change in North Africa

North Africa is widely known for its aridity and dry climate and for rainfall variability. Severe drought indeed has been common in the region, although the causes of such drought were not well understood (El Mourid *et al.*, 2010).

In 2007, The Intergovernmental Panel on Climate Change (IPCC) confirmed(IPCC, 2007) that North Africa is among the regions most affected by climate change (CC) with a temperature rise of 1-2^oC during the past period 1970-2004, and that it will continue to be affected by global warming at the average rate of 0.2^oC per decade for the coming 2 decades. In fact, anthropogenic greenhouse gas (GHG) emissions from within North Africa are very low (Table 2) in comparison to developed countries that have an average emission rate of 14.1 ton CO_2 equivalents (TE-CO_2) and the climate change impacts in North Africaare essentially the result of global GHG emissions. According to the IPCC report, the winter season in North Africa will be shorter, leading to reduced yield and increased diseases and insect outbreaks. Precipitation will undergo a 20% drop by the end of the century, which would reduce crop yield and increase livestock losses. Heat waves also would reduce yield, while expected intense storms will cause soil erosion and damage the crops. High sea level rise will lead to salt water intrusion and salinization of irrigation water (IPCC, 2007). In fact, the frequency of drought in Morocco, for example, has been independently reported (Magnan *et al.*, 2011) to have increased from 1 in 8 years during the period 1940-1979, to 1 in 3 years during 1980-1995, and to 1 in 2 years during 1996-2002. Also, North Africa has been identified as a hot-spot for vulnerability to climate change, based on the analysis of NDVI (Normalized Difference Vegetation Index) data for the period 1982-2000 (De-Pauw, 2008).

Table 2. Greenhouse gas (GHG) emissions in North African countries (2000)

GHG emissions	Algeria	Morocco	Tunisia
Total emissions (million TE-CO_2)	103.1	63.3	20.8
Annual per capita emissions (TE-CO_2)	3.0	2.0	2.1
Emission composition (%):			
Carbon dioxide (CO_2)	64.5	67.0	72.0
Methane (CH_4)	29.7	18.0	14.0
Nitrous dioxide (N_2O)	5.9	14.0	14.0
Agriculture contribution to total emissions (%)	5.9	25.0	20.0

The livestock sector has been described as a major contributor to global warming, accounting for 18% of the world anthropogenic GHG emissions, namely carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Steinfeld *et al.*, 2006). Such large contribution of livestock to global warming is primarily the result of the highly intensive livestock system in well endowed, temperate regions of the world. In contrast, the livestock system in North Africa is primarily extensive in nature, where the dominant animals are sheep and goats, essentially raised in open rangeland fields, within the arid and semi-arid areas receiving less than 200 mm of rainfall and no fertilizer, apart from grazing animal manure. Such livestock contributes comparatively little to GHG emissions as compared to intensive livestock systems found in Europe and similar regions. However, rangelands in North Africa are subject to severe degradation, primarily because of cropping encroachment, which is responsible for 50% of rangeland degradation, *versus* 26% accounted for by overgrazing and 21% by fuel wood utilization. This trend opposes clearly that of the temperate areas, where overgrazing accounts for 70% of land degradation (Le Houérou, 2000).

The food commodity crisis of 2008 brought-up awareness of the serious threat to food security in many of the world areas, including North Africa, where policy makers realized the importance of food production uncertainty imposed by the vagaries of changing climate and the repercussions it may impose on social and political stability. In all North African countries, swift decisions were taken to encourage farmers and other food producers assure the highest degree possible for self-sufficiency in strategic food commodities. All countries prepared a multi-year plan to boost local agriculture production, taking into consideration climate change and necessary mitigation and adaptation measures.

III – Constraints and opportunities in North Africa major production systems

Major production systems may be clustered under two main agro-ecologies, i.e. vulnerable agro-ecology and favorable agro-ecology with two important production systems per agro-ecology (Table 3).

1. Vulnerable agro-ecologies

Vulnerable agro-ecologies correspond to the driest areas of North Africa and embrace more than 60 % of the arable land in the region. They include two predominant production systems, the pastoral system and the agropastoral system. These vulnerable areas are characterized by a high population growth rate, large and rapidly increasing food and feed deficits, low and highly variable income levels, and limited natural resources, especially water. In addition to being the main locus of rural poverty, they are severely degraded. The rural livelihoods are based on production systems in which small ruminants represent the principal economic output. These systems are in transition and vary both within and between countries, from nomadic or semi-nomadic rangeland-based (pastoral system) to mixed crop-livestock smallholder systems (agropastoral system).

Rural populations in these fragile environments are often forced to pursue production strategies that, while meeting short-term requirements, are in the long-term destructive and unsustainable. Inappropriate policies of land use, incentives and the absence of secured property rights have exacerbated the problem. In most countries of the region, the traditional local institutions governing access to grazing lands have been disrupted, resulting in a system of "open access", without a regulatory mechanism to control the extent and intensity of grazing.

More frequent and prolonged droughts associated with global warming have worsened the vulnerability of agropastoral societies which forced governments in the region to intervene with various forms of drought assistance. Most of these interventions have encouraged farming practices that could increase both the extent of future drought losses and the dependence of local people on government assistance. However, empirical studies have revealed that although the rural poor may have limited resources, they still have considerable capacity to adapt to environmental degradation and to rehabilitate degraded resources (Nefzaoui *et al.*, 2012).

Experience showed that neither technical interventions nor policy adjustments alone will solve the problems. An innovative program of research for development integrating policy and institutional alternatives with research on technologies and management practices is capable of enhancing the resilience of the production systems and livelihoods in these regions (Nefzaoui *et al.*, 2012).

2. Favorable agro-ecologies

Two major production systems are located within these favorable agro-ecologies, the cereal-based production system and the mountain production system. The cereal-based system, generally concentrated in lowland plains, is often rainfed and is suitable to sustainable intensification for more productive, profitable and diversified dryland agriculture. Wheat is the dominant crop that could generate income if competitively produced. Farm size varies considerably with large farms well exceeding 100 ha and others not reaching 1/10th of this. The small farms cannot benefit from economies of scale such as effective mechanization, and lack opportunities of capitalization and access to input markets. These small farms offer bleak prospects for future generations of farmers. Youngsters are increasingly looking for alternative opportunities in the cities where employment is getting scarce. The result is unbridled urbanization with slums and social unrest.

North Africa countries are increasingly aware of this rural dilemma and are seeking ways to support the development opportunities in these rural areas in a two-pronged approach: aggregate the smaller units while retaining the work force on the farms or develop alternative production systems that can be competitive on a world market through high-value crops or animal products.

The mountains production system hosts the highest poverty rates (more than 40%). Mountain zones cover about 25 million hectares, of which 60%, 32% and 8% are located in Morocco, Algeria, and Tunisia, respectively. These areas have different geographical characteristics (extent, altitude, landscape etc.) and the climate is highly diverse ranging from humid in the north to desert in the south with arid and semi-arid climates in between, but in all cases with high variability in rainfall and prevailing droughts. In this paper, a special focus will be put on humid areas. Mountain zones are endowed with important natural resources and account for 30% of the arable land in Morocco, 12.5% in Algeria and 10% in Tunisia. They are also the main preserve of forestry resources, accounting for 65% of the forested area in Morocco, 31% in Algeria and 60% in Tunisia. Moreover these zones host most of the region’s biodiversity and water resources. However, they face severe degradation and a high risk of loss of biodiversity (El Mourid, 2012).

The highlands of the Maghreb countries are well populated. They host 30%, 20% and 10% of the total populations of Morocco, Algeria and Tunisia, with population densities of 46, 150 and 100 inhabitants/km^2, respectively. These densities are higher than the national averages and are variable, ranging from 10 habitants per km^2 in the High Atlas of Morocco to more than 250 inhabitants per km^2 in Kroumirieof Tunisia and in the Rif of Morocco.

The prevailing production systems, consisting mainly of cereals, fruit trees and livestock, contribute significantly to domestic agricultural production in the respective countries. In these zones the average size of farms is generally small and cropped land is fragmented. Farms with less than five hectares of land represent 80% of mountain farms, and make up about 25% of total small farms nationwide.

The economy of mountain areas is poor and fragile. Per capita income represents, on average, half the per capita urban income, and poverty is high in most zones leading to high rates of emigration to other regions of the country and overseas.

When compared to other agro-ecosystems, mountains-based systems have not received adequate attention from research and development, despite their importance and the constraints they are facing. The social and economic development policies that have been implemented in the three countries did not address these zones until the early 1980’s when a few integrated development projects were initiated. However, the impact of these projects was very limited, as they did not account for the specificity of these areas in terms of approach and technical and social recommendations.

In fact, the development of the highland areas has been based almost entirely on productivity concerns, relying on the excessive use of external (purchased) inputs and mechanization. This approach has been targeted at relieving constraints impeding the conventional intensification of production systems by the adoption of technologies and crop management practices initially developed for high potential (lowland) areas. It omitted to take into account the mountain context and the distinctive characteristics of the highlands. The appropriateness of this approach to the mountain context has often been questioned because of the resulting pressure on the natural resource base and its limited impact on poverty reduction.

Table 3.Characteristics of major production systems in North Africa

	Vulnerable agro-ecosystems		Favorable agro-ecosystems	
	Pastoral system	**Agropastoral system**	**Cereal-based system**	**Highland system**
Constraints	- Very low and highly variable rainfall, short growing season with high temperature, and a trend of increasing aridity and desertification (CC) - Encroachment of rangelands by barley and olive crops, - Natural resources degradation and overgrazing especially around watering points - Problems of livestock watering, and water points management - Conflicts on grazing lands - Animal health problems - Rejection of pastoral work by youngsters - Scarce opportunities for attractive employment and high poverty rates (outmigration of young people) - Lack of investments - Difficult access to credits	- Low and irregular, rainfall and scarce water resources - Limited available lands for cropping expansion, - Degradation of grazing lands - Land tenure problems - Marginal and variable farm incomes - Low level of exploitation of natural and cultural patrimony - Pressure on natural resources (overexploitation) - High unemployment and poverty rates (outmigration of young people) - Lack of investments and diversification - Difficult access to credits	- Low soil fertility - Monocropping and lack of diversification - Increasing biotic stress favored by CC (new races and strains of diseases and pests) - Low input use: seeds, fertilizers, pesticides - High harvest and post-harvest losses - Low adoption of improved cultivars and production package - Production uncertainty (occasional low-rainfall seasons, or floods, heat, frost) - Increasing production cost (mainly driven by higher fuel cost) - Unfavorable market/add value/ Insurance - Socio-economic constraints to specify) - Lack of economic scale - Land fragmentation	- Harsh environmental conditions, especially in winter - Highest illiteracy and poverty rates - Subject to severe natural resource degradation with a high risk of loss of biodiversity. - Highly populated (above the national average), - Limited arable land, - High rate of soil erosion - Land fragmentation - Fragile economy - High outmigration rate - Low investment for development - Government interventions focusing on productivity concerns with little attention to natural resources conservation and development

Table 3 (cont.). Characteristics of major production systems in North Africa

	Vulnerable agro-ecosystems		Favorable agro-ecosystems	
	Pastoral system	**Agropastoral system**	**Cereal-based system**	**Highland system**
Opportunities	- Important pastoral reserve for the region - Community-based rangeland management efficient & well accepted - Relatively important pastoral infrastructures - Local know-how for rangeland management and animal breeding	- Important public and private agricultural development programs - Specific agricultural products (sheep and goat meat, dry figs, olive oil, honey, etc.) - Important aromatic and medicinal plants and fruit trees, biodiversity - Well preserved local know-how (agriculture, etc.)	- Availability of improved technologies and associated tools (both locally and thru international market) - Relatively easier access to credit (as opposed to drier, high-risk areas) - Mechanization is possible despite land fragmentation, through service providers-cooperatives de service) - Better opportunities for learning of new technologies, especially through farmer-to-farmer dissemination	- Favorable climate especially with respect to rainfall and water resources - Promising results on pasture and livestock - Endowed with important natural resources - Main preserve of forestry resources - Host most of the region's biodiversity and water resources
Major changes	- Dismantlement of traditional institutions managing natural resources - Drastic reduction of nomadism and development of "mechanized" transhumance - Important increase of use of purchased feeds (supplementation) - Diversification of income sources (eco-tourism, small scale irrigation for high value crops including indigenous herbal aromatic and medicinal species, and , trans-boundary activities)	- Development of irrigated agriculture (vegetables, fruits, cash crops, forages) - Intensification of livestock activity (fattening, dairy cattle) - Privatization and cropping of collective rangelands	- Decrease of fallow practicecrop diversification including the use of improved species/varieties of food legumes in rotation with cereals - Development of supplemental irrigation leading to high cereal yields - Development of forage market with transfer to less favorable areas - Renting cereal stubble for animal grazing (between cereal harvest and soil preparation for the following crop)	- Quasi disappearance of animal traction and its replacement by inappropriate mechanization - Diversification of income sources (ecotourism, niche products, including local honey and high-value plant species) - Advanced land fragmentation

IV – Options to mitigate risk in vulnerable agro-ecologies and to improve sustainable productivity in favorable areas

1. Soil and water conservation and use

In the past, cereal-based cropping systems in North Africa were dominated by the cereal-fallow rotation and the continuous mono-cropping. While the cereal-fallow rotation in semi-arid areas has the advantage of storing some moisture in the fallow season for use by the cereal crop in the following season, the system is inefficient, especially in favorable or moderately favorable environments. ICARDA researchers have advocated and shown the benefits of replacing the fallow with a legume crop, such as vetch, lentil, or faba bean (Ryan *et al.*, 2008). Research results indeed show a favorable effect of legume-based rotations on crop yield and water use efficiency. The introduced legume crop also leads to a beneficial build up of soil N, thus improving soil quality and contributing to sustainability of land use in the semi-arid regions. Cereal-legume crop rotation is now widely adopted by North Africa farmers, especially where annual rainfall is about or above 350 mm.

Because of the dominant aridity and fragile nature of land resources in North Africa, National Agricultural Research Systems (NARS) and ICARDA researchers developed efficient technologies for soil and water conservation and management to minimize runoff and soil erosion and improve water retention and infiltration. In arid areas, rainfall is rare, unpredictable, and sometimes comes in unexpected violent bursts causing erosion and floods, and quickly evaporating under the dry and hot conditions of the arid environment. ICARDA has revived, enhanced and promoted old indigenous practices of collecting (harvesting) the runoff water for subsequent use (Oweis *et al.*, 2001). To retain water, farmers generally use small circular or semi-circular basins or bunds around the trees or the plants. Soil is assembled and raised in such a way as to make a barrier to hold the water, which is therefore collected and made available for agricultural or domestic uses. Water harvesting (WH) proved effective for replenishing the soil water reserve and for the establishment and maintenance of vegetation cover, trees, shrubs or other crops for various uses. Larger catchments are similarly arranged to harvest water and exploited in arid areas by sheep herders to sustain rangeland species. Water harvesting not only provides a much needed additional source of water for drinking or growing plants for feed and food, but it also raises soil moisture, reduces soil erosion and contributes to C sequestration and improved soil quality. In more favorable, semi-arid or wetter regions, and where topography allows, large sloping areas of a few hundred hectares may be targeted for catchments to collect large amounts of water into large ponds or hill reservoirs (or lakes), with a capacity of up to hundreds of thousands cubic meters, requiring more solid, locally-made structures to retain the water (Ben Mechlia *et al.*, 2008). In Tunisia alone, there are about 1,000 hill lakes across the country, contributing to the shrinking water resources. Such large hill lakes are managed with the participation of local communities or organizations for an equitable water distribution among farmers.

2. Irrigation

Although water resources in North Africa do not allow full-scale irrigation of water-demanding crops (food crops, forage crops, vegetables, etc.), research has shown that supplemental irrigation (SI), applied as 1-3 irrigations at dry periods in the season, not only improves and stabilizes grain yield of major food crops, but it also gives “more crop per drop”, i.e. it has a good water return or high water-use efficiency (WUE) or, equivalently, high water productivity (WP), both terms referring to crop return, such as grain yield or value, per unit of consumed water (Oweis, 2010). In cereal-based cropping systems of semi-arid areas, WP of wheat is generally around 0.35-1 kg grain/m^3 water, but may reach up to over 2.5 kg grain/m^3 water under SI (Oweis, 2010). Therefore SI is a water saving procedure that effectively reduces the impact of drought on farmer’s livelihood. However, certain farmers tend to over-irrigate and waste valuable water resources, thinking "the more water, the better". In fact, results of wheat research show that WP is maximum for an optimum level of SI, beyond which it starts decreasing; the optimum SI level is about 1/3-2/3 the level of full irrigation (FI), the latter being equal to the full crop water requirement. Full irrigation is not as efficient as supplemental irrigation in using the water resources (Oweis and Hachum, 2006; Shideed *et al.*, 2005). In fact, in wheat WP for FI is 1 kg/m^3 but it is 2.5 kg/m^3 for SI. In scarce-water conditions, it is therefore more rewarding for the farmer to use SI to optimize WP rather than maximize yield. This approach saves water to grow the crop on a larger area and the farmer ends up with a larger total output, while using water sustainably (Oweis&Hachum, 2006). Also, water productivity can be further improved through proper crop management, including early planting, weed control, fertilizer application, and irrigation at critical times to avoid or minimize detrimental water stress, e.g. at flowering time and fruit or grain formation. For example, supplemental irrigation of wheat, combined with early planting in the Tadla region of Morocco hastened maturity, enabled the crop to escape terminal drought and heat stress, and doubled grain yield and WP (Karrou and Oweis, 2008) The beneficial effect of SI is further enhanced when SI is combined with the use of adapted varieties (Karrou and Boutfirass, 2007).

Brackish water and saline water have been used in irrigation with disappointing results in all three countries (ICID, 2003) primarily because of very high evaporative demand in desert or arid regions, and the lack of fresh water and adequate drainage for leaching the salts away. The dry environments in such areas preclude the normal growing of regular crops, but special-purpose, halophytic crop species may be grown successfully, to provide essential oils, folk medicine, biofuel, fodder, shade for animals, or to retain soil and arrest desertification (Neffati *et al.*, 2007; Qadir, 2008). In more favorable semiarid or subhumid areas, brackish water may be successfully used to grow tolerant plants (such as barley) where both fresh water and drainage facilities are more readily available.

3. Conservation agriculture

In North Africa, conservation agriculture (CA), based on the no-till system, maintenance of crop residues and crop rotation, was introduced about 30 years ago in both Morocco and Tunisia where it now covers 6,000 ha and 12,000 ha, respectively. Algeria's work in CA started only 7 years ago and is gaining momentum (Zaghouane *et al.*, 2006). In addition to the obvious benefits of reduced labor and energy cost, and some yield advantage (generally realized a few years from the start), the most striking effects in semi-arid regions of North Africa is the reduced erosion, especially in sloping areas. CA also presents the advantage of flexibility for the implementation of field crop management that allows timely planting and input application, despite unfavorable field conditions that do prevent such operations in conventional agriculture (e.g. wet soil at planting time). CA prevents soil plowing which has been identified as a major cause for CO_2 emission. Cover crops, residues and crop roots contribute to better soil structure and composition with enhanced buildup of organic matter, while crop residues protect the soil and minimize soil evaporation (Angar *et al.*, 2010; Mrabet, 2006, 2008). CA therefore contributes both to CC mitigation through reduced GHG emissions and enhanced C sequestration, and to adaptation through soil water retention and infiltration, and increased water use efficiency. Therefore, CA based on the NT system is an effective technology to conserve natural soil and water resources while minimizing the drought effect on crop production and contributing to better food security in North Africa.

Major challenges to adoption of CA technology in North Africa are posed by severe drought of rainfed arid regions and the consequent need for fodder resources during the dry season, both of which threaten the maintenance of crop mulch, a key component of CA. In such a situation, partial stubble grazing could offer a compromise. Results in Tunisia indeed show beneficial effects of CA (improved soil organic matter, better soil infiltration, higher wheat yield) despite the low amount of crop residues (1-2 t residue/ha). Another solution will be some sort of compensation to farmers for environmental services (Lal, 2010) and sustainability of natural resources that will help farmers secure alternative feed resources for the dry season. Other challenges to CA adoption in North Africa are (i) high weed infestation at the initial stage of CA adoption (Dridi *et al.*, 2010), and (ii) the unavailability of suitable CA-ready seed-drills. In fact, the adoption of NT technology in Tunisia is limited to farms of size ≥100 ha, where farmers could afford a high investment for the purchase of NT equipment. ICARDA and collaborating partners are pursuing efforts in North Africa to promote local manufacturing of low-cost NT drills, which will expand CA adoption to small-scale farmers who represent the majority of North African farmers. Here is another opportunity for policy makers to encourage farmers reduce the impact of CC, by promoting CA through reduced cost of NT drills.

4. Integrated crop-livestock-rangeland production systems

Although the dominant production systems in North Africa are based on livestock and crops, livestock is still the main source of income of rural populations in the North African countries. Sheep and goat make up the major portion of livestock in North Africa with 30 million and 10 million heads, respectively. Several factors including climate change threaten the sustainability of the production systems. There are considerable gaps in our knowledge of how climate change will affect livestock systems and the livelihoods of these populations. Management of the production risk caused by the fluctuation of feed availability is the main problem hampering the development of livestock production in North Africa. Under the framework of research for development project, the Mashreq/Maghreb project, NARS and ICARDA developed over a decade sound technical, institutional and policy options targeting better crop/livestock integration, community development and improvement of the livelihoods of agropastoral communities in 8 countries (Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, and Tunisia). These options include (i) organization of local institutions to facilitate both collective and individual adaptation and response to climate change, (ii) an innovative approach to their sustainable improvement and management including institutional solutions for access to communal/collective rangelands, (iii) better use of local natural resources with an emphasis on water harvesting and appropriate use of adapted indigenous plant species, such as cactus and fodder shrubs, and (iv) efficient animal feeding involving cost-effective alternative feeds including feed blocks, and nutrition and health monitoring (Nefzaoui *et al.*, 2012).

Two critical trends prevail in the current production context:

(i) The first trend involves a crisis in the feed supply reflecting water scarcity, exacerbated by the progressive decline of rangelands' productivity due to overgrazing, cultivation encroachment, or the disruption of institutional arrangements for resource utilization. Moreover, very low ratio of cultivated forages prevails in the cropping systems.

(ii) The second trend involves the expansion of market demand for livestock products leading to opportunities for productivity and income improvement.

5. Participatory management of communal rangelands

The pastoral and agropastoral societies in North Africa went through deep mutation during the past few decades. In the mid-20th century, the mobility pattern of the pastoralists was dictated by accessibility and availability of forage and water. With the mechanization of water transportation and the reliance on supplemental feed, animals can be kept continuously on the range, which disturbs the natural balance and intensifies range degradation (Nefzaoui, 2002, 2004). Mechanization profoundly modified rangelands' management in the steppes of North Africa. Water, supplements and other services are brought by trucks to flocks. As a result, families settle close to cities for easier access to education, health, and other services, with only sheepherders moving flocks to target grazing areas (transhumance). Production systems are intensifying and it is nowadays possible to find in the steppe a continuum between intensive fattening units that are developing in peri-urban areas and along the main transportation routes, mixed grazing-fattening systems, and purely intensive systems based on hand feeding only to provide feed supplements to animals. Agropastoral societies have developed their own strategies for coping with drought and climate fluctuation. These strategies include (Hazell, 2007; Alary *et al.* 2007):

- mobile or transhumant grazing practices that reduce the risk of having insufficient forage in any location;
- feed storage during favorable years or seasons;
- reciprocal grazing arrangements with more distant communities for access to their resources in drought years;
- adjustment of flock sizes and stocking rates as the rainy season unfolds, to best match available grazing resources;
- keeping extra animals that can be easily sacrificed in drought conditions, either for food or cash;
- investment in water availability (wells, cisterns, and water harvesting);
- diversification of crops and livestock (agropastoralism), especially in proximity to settlements, and storage of surplus grain, straw and forage as a reserve in good rainfall years;
- diversification among animal species (sheep, goats, cattle, camels, donkeys) and different breeds within species;
- income diversification into non-agricultural occupations, particularly seasonal migration for off-farm employment in urban areas.

However, recent infrastructural and demographic changes as a result of urbanization have made such strategies less effective. In a recent study conducted within the Mashreq/Maghreb project in Chenini agropastoral community, in Southern Tunisia, perception of drought and livelihood strategies to mitigate drought has been investigated using a “sustainable livelihood approach”.

The perception of pastoralists of drought and climate change during the past decades, as well as the tools used to adapt to or mitigate climate fluctuation has been investigated using a sustainable livelihood approach (Nori *et al.*, 2009). Indeed, while in the thirties, there was self-reliance on drought coping mainly through transhumance, food and feed storage and goat husbandry, these options shifted gradually towards a significant reliance on government intervention mainly through subsidizing feeds and facilitating feed transport from the North to Southern arid areas. However science and technology, including climatic adaptation and dissemination of new knowledge in rangeland ecology and a holistic understanding of pastoral resource management are still lacking. Successful adaptation depends on the quality of both scientific and local knowledge, local social capital and willingness to act. Communities should have key roles in determining what adaptation strategies they support if these have to succeed. The integration of new technologies into the research and technology transfer systems potentially offers many opportunities to further contribute to the development of climate change adaptation strategies. Geospatial information, spatial analysis tools, and other decision support tools will continuously play a crucial role in improving our understanding on how climate change will affect livelihoods of pastoral communities. Climate change also offers the opportunity to promote payment to pastoralists for environmental services, as in the case of some livestock keepers in Europe. These services could include watershed management, safeguarding biodiversity, landscape management and carbon sequestration (MacOpiyo *et al.*, 2008).

6. Efficient animal feeding using cost-effective alternative feeds

Managing the production risk caused by the variability of feed availability is the central issue in the small ruminant (SR) production system in the North Africa region. Desertification, increased drought frequency and duration, greenhouse emissions, and decreased livestock performance, justify the need for a serious understanding on the readjustment and or the establishment of new feeding strategies targeting the improvement of animal production without detrimental effects on the environment. Moreover, the development of simple and cost-effective techniques such as feed blocks, pellets, and silage (Ben Salem and Nefzaoui, 2003) to valorize local feed resources (e.g. agroindustrial byproducts) help smallholders to better manage livestock feeding throughout the year. Main benefits from these options for the animal, the environment and their impact on farmers' livelihoods are reported in Table 4. Overall the interesting results on the positive effect on animals of tanniniferous (e.g. *in situ* protection of dietary proteins, defaunation, reduced emission of methane, anthelmintic activity) and/or saponin (e.g. increased absorption rate of nutrients, defaunation, decreased production of methane) containing forages to improve feed efficiency and to control gastrointestinal parasites, and thus improve the productive and reproductive performance of ruminants should promote plants rich in secondary compounds in grazing systems. These options offer promising solutions to reduce the use of chemicals in livestock production systems to enhance livestock productivity and to decrease emission of methane (Nefzaoui *et al.*, 2011).

Table 4. Productive, environmental and social benefits from some alternative feeding options (Nefzaoui *et al.*, 2011)

Options	Impact on the animal	Impact on the environment	Impact on farmers livelihoods
Feed blocks	- Improved digestion of low quality diets and increased growth and milk production - Improved health conditions due to decreased parasiticload (use of medicated FBs)	- Decreased pollution with perishable AGIBs (olive cake, tomato pulp, etc.) - Decreased pressure on rangelands - Better quality manure	- Decreased feeding cost, increased animal performance and hence higher income - Diversification of farmers' income (sale of FBs) - Employment generation through mechanized unit for FBs making
Cactus (*Opuntia* spp.)	- Improved digestion of low quality forages - Improved animal performance	- Improved soil condition - Decreased pressure on primary resources (water and rangelands)	- Added value cash crop (fruit and cladodes sale), and increased animal performance result in increased income
Shrub mixing	- Complementarities between shrub species (nutrients and secondary compounds) increased animal performances	- Combat desertification - Soil protection	- Reduced budget allocated for feedstuffs purchasing
Rangelands resting	- Increased feed intake and digestion - Increased productive and reproductive performances	- Reduces degradation risk - Protection of plant and animal biodiversity (domestic and wildlife animals)	- Reduced feeding cost and increased performances resulting in increased income

A. Feed blocks (FBs) technology

Cold-processed feed blocks are made of a mixture of one or more agro-industrial by-products (e.g. olive cake, tomato pulp, etc.), a binder (e.g. quicklime, cement and clay), water and common salt, as well as urea with or without molasses. The technique of FB making is well described in the literature (e.g. Ben Salem and Nefzaoui, 2003; Ben Salem *et al.,* 2005a). Some variations in the blocks include the incorporation of polyethylene glycol as a tannin-inactivating agent, which has increased the utilization of tanniniferous browse foliage in ruminant feeding (Ben Salem *et al.,* 2007). Mineral enriched FBs (e.g. phosphorus, copper, etc.) are distributed to animals to mitigate deficiency and improve reproduction in ruminants. Benefits from the integration of FBs in the diet of sheep and goats are reflected by data compiled in Table 5. It is clear that depending on the formula, FBs can partially or totally replace concentrate feeds, thus reducing feeding costs without detrimental effects on livestock performances.

Table 5. Compiled data on the potential use of feed blocks as alternative feed supplements for sheep and goats in the Mediterranean area (Ben Salem *et al.*, 2005a)

Basal diet	Supplement†	Animals	Growth rate (g/day)	Feeding cost variation	Country
Stubble grazing	Concentrate (250 g/d)	Lambs	95		Algeria
Stubble grazing	Conc. (150 g/d) + FB1	Lambs	136	-81%	Algeria
Wheat straw *ad lib*	Conc. (500 g/d)	Lambs	63		Tunisia
Wheat straw *ad lib*	Conc. (125 g/d) + FB2	Lambs	66	-11%	Tunisia
Acacia leaves	FB4	Lambs	14		Tunisia
Acacia leaves	FB5 enriched with PEG	Lambs	61		Tunisia
Rangeland grazing	Conc. (300 g/d)	Kids	25		Tunisia
Rangeland grazing	FB4	Kids	40		Tunisia

†FB1: wheat bran (10%), olive cake (40%), poultry litter (25%), bentonite (20%), salt (5%); FB2: wheat bran (25%), wheat flour (15%), olive cake (30%), rapeseed meal (10%), urea (4%), quicklime (8%), salt (5%), minerals (1%); FB4: wheat bran (28%), olive cake (38%), wheat flour (11%), quicklime (12%), salt (5%), minerals (1%), urea (5%); FB5: wheat bran (23%), olive cake (31.2%), wheat flour (9%), quicklime (9.9%), salt (4.1%), minerals (0.8%), urea (4.1%), PEG (18%).

B. Fodder shrubs and trees (FST) in the smallholders farming systems

Trees and shrubs are part of the Mediterranean ecosystem. They are present in most natural grazing lands of the North Africa region. Some species are high in essential nutrients and low in anti-nutritional factors (e.g. *Morus alba*), some others are low in nutrients but high in secondary compounds (e.g. *Pistacia lentiscus*) while some shrubs are high in both nutrients and secondary compounds (e.g. *Acacia cyanophylla*, *Atriplex* spp.). Such characteristics enable the plants to withstand grazing and to provide ground for selective grazing. In arid and semi-arid North Africa regions where available forage species cannot grow without irrigation, FST could be used as feed supplements. Saltbushes (*Atriplex nummularia*, *Atriplex halimus* and *Salsola vermiculata*) are planted in dry zones in North Africa and have many advantages because of their wide adaptability to harsh agro-climatic conditions and ability to grow for a longer period. As trees require little care after establishment, the production cost is low (Nefzaoui *et al.*, 2011).

C. Alley-cropping

This technique consists of cultivating herbaceous crops of both graminae and legumes species between rows of trees or shrub species. Among the reasons for the low adoption of pure shrubs planting are the technical design of plantation, mismanagement, and competition for land often dedicated to cereal crops. Alley cropping overcomes some of these disadvantages because it (i) improves soil, (ii) increases crop yield, (iii) reduces weeds, and (iv) improves animal performance. Properly managed alley-cropping allows diversification to benefit from several markets. It also promotes sustainability in both crop and livestock production. Benefits from cactus-barley alley cropping system were evaluated in Tunisia (Alary *et al.,* 2007; Shideed *et al.*, 2007). Compared to barley alone, the total biomass (straw plus grain) of barley cultivated between the rows of spineless cactus increased from 4.24 to 6.65 tones/ha and the grain from 0.82 to 2.32 tones/ha. These results are due to the change of the micro-environment created by alley-cropping with cactus, which creates a beneficial ‘wind breaking’ role that reduces water loss and increases soil moisture. The barley crop stimulated an increase in the number of cactus cladodes and fruits, while the cactus increased the amount of root material contributing to the soil organic matter. The alley-cropping system with *Atriplex nummularia* proved efficient in the semi-arid regions of Morocco (annual rainfall 200-350 mm). Barley was cropped at a seeding rate 160 kg/ha, between atriplex (333 plants/ha) rows. Compared to farmers’ mono-cropping system, dry matter consumable biomass yield of atriplex was significantly higher in the alley-cropping system. The latter system was more profitable than mono-cropping. Indeed, Laamari *et al.* (2005) determined the net benefit *from atriplex* monocropping and barley-atriplex alley cropping over 15 years. The cumulative net benefit was 732.18 $/ha and 3,342.53 $/ha, respectively. The economic and agronomic assessment of alley cropping shows that this technology is economically profitable. Therefore, it should be extended on a large scale in the agro-pastoral areas of the North Africa region.

D. Shrub mixing technique

Most Mediterranean fodder shrubs and trees are either low in essential nutrients (energy and/or digestible nitrogen) or high in some secondary compounds (e.g. saponins, tannins, oxalates). These characteristics explain the low nutritive value of these fodder resources and the low performance of animals. For example, *Acacia cyanophylla* foliage is high in condensed tannins but low in digestible nitrogen. *Atriplex* spp. are low in energy and true protein although they contain high levels of crude protein, fibre and oxalates. Cactus cladodes are considered an energy source and are high in water but they are low in nitrogen and fibre. Moreover, they are remarkably high in oxalates. A wealth of information on the complementary nutritional role of these three shrub species and the benefit of shrub mixing diets for ruminants, mainly sheep and goats are reported in the literature (Ben Salem *et al.,* 2002, 2004, 2005b). This technique permits to balance the diet for nutrients and to reduce the adverse effects of secondary compounds and excess of minerals including salt. The association cactus-atriplex is a typical example of shrub mixing benefits. The high salinity and the low energy content of atriplex foliage are overcome by cactus. Some examples of the effects of shrub mixed diets on sheep and goats performance are reported in Table 6. In summary, diversification of shrub plantations should be encouraged to improve livestock production in the dry areas of North Africa.

Table 6. Effect of shrub mixed diets on sheep and goat growth (adapted from Nefzaoui *et al.*, 2011)

Basal diet†	Supplement††	Animal	Daily gain (g)
Acacia (417 g/d)	Atriplex (345 g/d); Barley (280 g/d)	Lambs	54
Cactus (437 g/d)	Atriplex (310 g/d); Acacia (265 g/d)	Lambs	28
Cactus (499 g/d)	Straw (207 g/d); Atriplex (356 g/d)	Lambs	81
Atriplex grazing	Cactus (290 g/d)	Lambs	20
Native shrubland grazing	Cactus (100 g/d); Atriplex (100 g/d)	Kids	60

†Acacia: *Acacia cyanophylla*; Cactus: *Opuntiaficusindicaf. inermis* (cladodes); Atriplex: *Atriplexnummularia*.
††Values between parentheses are daily dry matter intake.

7. Ley farming

Carter (1974,1978) reviewed the potential for ley farming in Algeria and Tunisia and strongly supported the concept of introducing clovers and medics in place of fallow. He estimated that a potential area of 23 million hectares existed in nine countries and suggested that this should lead to large increases in crop yield and feed supply.

Some of the earliest Australian work on ley farming in the region was in Tunisia (Doolette, 1976) and Algeria (Saunders, 1976). John Doolette worked with Australian cultivars of barrel medic (*Medicago truncatula*) in Tunisia and David Saunders started selecting locally adapted medic ecotypes to suit the cold winter conditions he encountered in Algeria. Although there has been a continuing interest in the use of medics, neither project led to widespread commercial adoption of the system.

The non-adoption of this technique is due to several constraints, including biological/ technical difficulties, land tenure of grazing lands and government policies. Biological constraints include the lack of adapted legume cultivars, the need for inoculation with rhizobia, the need to apply phosphorus and inappropriate sowing methods (Halse, 1989). Technical constraints are well documented (Riveros *et al.*, 1989) and probably the easiest to solve. At the forefront of these constraints is the inability of farmers and technicians of North Africa to master the sensitive techniques of sound pasture establishment and management, which are essential to the self-regeneration of full stands of medics during a good number of years. Seed drills suitable for medic seeds are not readily available to farmers. Another major constraint to the adoption of the ley farming system is management of the medic pastures. Correct management is supposed to regulate the stocking rate so that maximum biomass is produced and grazed by animals, while ensuring sufficient seed production for subsequent regeneration. Farmers, even when they own the grazing livestock, have been unable to adjust stocking rates to plant growth and development.

In North African countries, bloat of animals (sheep) grazing on annual medics (native or introduced) was, on many occasions, mentioned by farmers. This problem seems to stem from the intermittent grazing of the annual legume pastures. Reports suggest that animal deaths could occur very rapidly even after a very short (15 minutes) grazing period. Farmers who have suffered animal losses from bloating are not likely to continue with the legume pastures of the ley farming system. Another important drawback to the adoption of the cereal/medic ley farming system is the lack of locally produced, inexpensive medic seed. Some attempts were made by government agencies to produce seed (multiply local ecotypes and introduced ones) in a few countries (e.g.Tunisia and Morocco). However, seed yields were low and land leveling and management of the production fields and harvesting were major limiting factors. The recent trend of more remunerating intensification led to the complete abandon of ley farming in North Africa.

8. Forage crops

Major forage crops in Morocco and Tunisia (Tables 7 and 8) include grass species with a dominance of oats, followed by barley, as a dual purpose grain-forage crop.

Table 7. Importance of forage crops in Morocco (Adapted from Balafrej, 2012)

Species	Cropped area, ha	% irrigated	Yields, t/ha		Use (G, H, S)†	Availability
			Rainfed	Irrigated		
Barley	117800	11	12	36	G	G: March-May)
Lucerne	111580	97	41	62	H, G	G: April-Nov H: All year
Oat	65310	1	23	49	H, G	G: Feb-April H: Oct-Feb
Berseem	63580	99	36	63	G	Rainfed: Jan-March Irrigated: Nov-May
Maize	39302	81	38	47	G, S	G: June-Agust S: All year
Oat-vetch	5800	2	17	27	G, H, S	G: March-April H: All year

†G: Green, H: Hay, S: silage.

Table 8. Importance of forage crops in Tunisia (adapted from Chakroun, 2012)

Species	Cropped area, ha	% irrigated	Use (G, H, S)†	Availability
Oat	190000	7	S, H	S, H: All year
Barley	60000	75	G, S	G: Nov-April; S: all year
Triticale	6000	33	G, S	G: Dec-March; S: all year
Oat-vetch	3500	100	H	All year
Sulla	7000	100	G, S	G: Nov-May; S: all year
Lucerne	7500		H, G	G: 9 months per year; H: all year
Ray-grass	2500	20	H, G	G: Winter/spring; H: all year
Medicago	2000	100	G	Nov-March
Berseem	5500		G	Nov-March
Sorghum	14000		G	July-Nov
Maize	4000		G, S	G: Aug-Sept; S: all year

†G: Green, H: Hay, S: silage.

Oat can produce high forage yield, usually as hay, but suffers from low protein value, which is improved by growing oat in combination with vetch, a legume crop adapted to semiarid conditions. Barley is a fast growing and early maturing species that can provide 3 or more cuts for herbage production plus some grain feed. Other grass forages include Italian ryegrass (*Lolium multiflorum*) particularly adapted to wetter areas where it outyields oats, and maize (*Zea mais*), and sorghum (*Sorghum sudanese*), a summer species grown under irrigation and used mainly as silage for dairy cattle. Alfalfa (*Madicago sativa*), a perennial legume species can grow in semiarid areas (rainfall of 400-500 mm/year), but performs better under irrigated light soil conditions. Berseem (*Trifolium alexandrinum*), a winter legume is also known in North Africa, where it is confined to well-watered or irrigated areas. Forage crops area did not increase in Tunisia during the last 3 decades and remains below 10% of total cropped area. In Morocco, forage crops area has been increasing during the last decade and even though remains around 4% of total cropping area. With the exception of barley, forage production in North Africa is constrained by irrigation water availability and costs and seeds availability. In particular, farmers have to rely on seed imports of species and varieties often bred and tested in environments different from the North African environments. On the other hand, farmers seek more income and prefer using available water to produce high-value cash crops (vegetables, fruit trees) rather than forage crops.

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An evaluation of overall fodder production in extensive silvopastoral systems with different cover of shrub understory. The case of Iberian dehesas

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Abstract. Grazed Mediterranean open woodlands, as the Iberian dehesa, are an outstanding example of silvopastoral system where shrub encroachment has been proposed as an effective means to facilitate tree seedling recruitment and ensure the system persistence. The aim of this essay is to test the effects of different intensity of shrub encroachment on different fodder components of the system: acorn production, forage shrub and grassland yield. Metabolic Energy (ME) was increased by *R. sphaerocarpa* due to the increase of grass production and the contribution of shrub fodder in addition to the supply of acorns. Instead, the ME supplied by *C. ladanifer* layer, did not compensate the reduction in grassland and acorn production because of the low metabolic energy that *C. ladanifer* canopy provides.

Keywords. Forage shrub – Acorn production – *Cistus ladanifer* – *Retama shaerocarpa* – Pasture yield.

Une évaluation de la production fourragère globale dans systèmes sylvo-pastoraux avec de différents types de sous-étage arbustif. Le cas des dehesas Ibériques

Résumé. *Dans plusieurs systèmes sylvopastoraux méditerranéens, tels que la dehesa ibérique, la gestion de la végétation arbustive est considéré de plus en plus comme un moyen effectif pour faciliter la régénération naturelle des arbres et assurer la persistance des agrosystèmes. Nous avons testé les effets de différents types de couvert arbustif sur le rendement en glands, en fourrages arbustifs et en pâturage herbacé. Deux espèces arbustives présentant des traits fonctionnels contrastés ont été utilisées comme modèles d'étude :* Cistus ladanifer *et* Retama sphaerocarpa*. L'énergie métabolique était supérieure dans le système intégrant* R. sphaerocarpa*, notamment en raison d'une augmentation du rendement du pâturage herbacé. L'énergie métabolique apportée par la couverture de* C. ladanifer *n'a pas compensé son effet négatif sur le rendement du pâturage herbacé et sur la production de glands.*

Mots-clés. *Arbuste fourrager – Production de glands –* Cistus ladanifer *–* Retama sphaerocarpa *– Rendement.*

I – Introduction

The Iberian dehesa is usually defined as a two-layered silvopastoral system, where native grasses cohabit with a scattered widely-space tree layer, usually belonging to *Quercus* genus. In dehesas, livestock production is characterized by its diversified diet that is made up mainly of grassland, fruits and shrub browse. In the last decades, the intensification have led to a progressive increase of stocking rate, mechanisation of dehesa farming and tree clearance, with special attention to pasture improvement. In consequence, most of dehesas have an even aged tree population, with a minimal incorporation of new trees (sexual precedence) (Pulido and Díaz, 2005). Recently, several authors have shown different positive effects of encroachment on the silvopastoral systems functioning: tree natural regeneration (Pulido and Díaz, 2005) or diversification of animal diet. However, shrubs strata could produce a competitive effect to trees and pasture respect to nutrient and water. The aim of this study is to investigate the effects of the dehesa encroachment on whole productivity.

II – Materials and methods

The experiment was carried out in several dehesas of Spain between 2007 and 2010. They presented two kinds of shrubs: *Retama sphaerocarpa* (L.) Boiss (20 dehesas) and *Cistus ladanifer* L (20 dehesas). *C. ladanifer* forms extensive and mostly aggregated populations and shallow, dense root systems that retain water in the upper soil layers. *R. sphaerocarpa* is a leguminous shrub with N_2-fixing capabilities that generally grows scattered and has long and very deep roots that allow the plant to tap deep-water sources.

The mean tree diameter at breast height (dbh) was 45 and 49 cm in the dehesas with *C. ladanifer* and *R. sphaerocarpa*, respectively. The crown diameter and the density of the trees were 9.93 m and 29 trees ha^{-1}, respectively, in the dehesas with *Cistus ladanifer*, and 12.3 and 24 trees ha^{-1} with *Retama sphaerocarpa.*

For determining acorn production, four randomized quadrats (0.25x0.25 m) were sampled (one in each orientation) per tree. Respect to shrub browse production, it was determined measuring the annual sprouts (*C. ladanifer*) and fruit biomass (*R. sphaerocarpa)*, which are considered the browse production of both shrubs. There were taken along three transects (50x4 m) randomly in each dehesa, where shrub height (each meter) and cover were measured. Moreover, three plants from each transect were measured and weighed. After that, annual sprouts (in *C. ladanifer*) and fruit (in *R. sphaerocarpa*) were weighed.

For determining pasture production, in each dehesa with *C. ladanifer*, 12 trees were selected, with (six trees) and without (six trees) shrubby understorey. In each tree, pasture exclusion cages (1x1 m) were located beneath and beyond (10 m out of the tree crowns) tree canopy for collecting pasture. In the dehesas with *R. sphaerocarpa*, the design of the experiment was changed because there was not shrub presence beneath trees. In this case, eight trees were selected and pasture exclusion cages were situated in three different positions: beneath crown and out of the trees in areas without shrub and out of the trees in areas with shrubby layer. It was considered that tree influence to pasture production was limited to the area under crown (Rivest *et al*., 2011). In the same dehesas, another sampling was carried out for determining the surface of grassland which is influenced by shrub plants. In spring 2010, nine (*C. ladanifer*) and ten (*R. sphaerocarpa*) herbage samples were taken using hand clippers at different distances respect to shrub plants. The difference of sample number is due to the differences between size species. It was observed that, in each *C. ladanifer* plant, there was not pasture production in the innermost circle of the crown which accounts for 25% of total (i.e. trunk surface). In both cases, the first sample was taken cutting just below shrub crown periphery, that corresponded with third (0.30-0.45 m) and four (0.45-0.60 m) sample in *C. ladanifer* and *R. sphaerocarpa*, respectively. Next, two (*C. ladanifer*) and three samples (*R. sphaerocarpa*) were cut under plant cover. The remainder samples were located from peripheric crown position to outside. Respect to *R. sphaerocarpa*, it was assumed that the pasture production in the innermost surface (a circle which is 35% of the crown, approximately) was similar to the first sample (0-0.15 m).

A non linear least square fit to a Bolztman function was realized for distinguishing different types of influence surface around shrubs. Shrub encroachment effects on acorn yield and grassland production were determined using repeated-measures ANOVA, with two between-subject factors (site and shrub understorey presence) and one within-subject factor (year). We used LSD test to separate treatment means when ANOVA showed significant effects ($p<0.05$). All statistical analyses were performed using Statistica 7.0 (StatSoft, Inc., OK, USA).

III – Results and discussion

The results obtained in Fig. 1 indicate that we can establish two zones according to the influence of shrub plants (which mean crown surface was 1.09 m^2 for *C. ladanifer* and 2.60 m^2 for *R. sphaerocarpa*) on grassland production: the zone with the highest influence in pasture production below shrub (B) are 0.6927 m^2 $plant^{-1}$ (*C. ladanifer*) and 0.724 m^2 $plant^{-1}$ (*R. sphaerocarpa*) which suppose the highest influence was detected at 0.49 m and 0.48 m respect to plant center. The zone with an intermediate influence (I) are 1.7341 m^2 $plant^{-1}$ (*C. ladanifer*; 0.89 m radio respect to plant center) and 1.1487 m^2 $plant^{-1}$ (*R. sphaerocarpa*; 0.77 m radio respect to plant center). In *C. ladanifer* plants, the total influence surface (B+I) was greater than the mean crown size, whereas this effect did not exceed their crown in *R. sphaerocarpa* plants. This figure allows us to know the percentage of variation between the grass production of the intermediate influence (I) and beyond shrub.

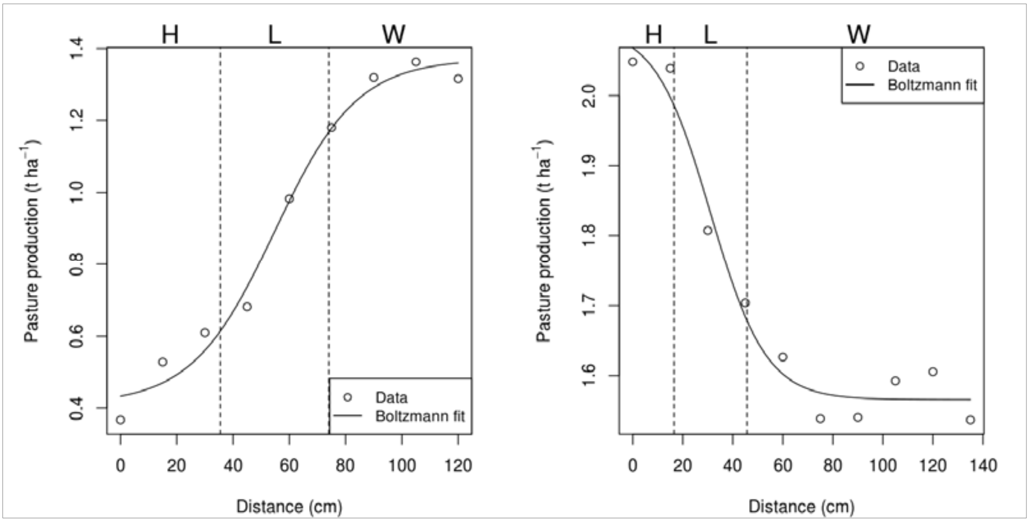

Fig. 1. Pasture production at different distances respect to *C. ladanifer (*left*)* and *R. sphaerocarpa* (right) plants. The origen of x-axis = the beginning of the samplings. Surface with the highest influence in pasture production below shrub (B); intermediate (I); and without shrub influence (O).

In Table 1, acorn, pasture and shrub browse production variation respect to *C. ladanifer* and *R. sphaerocarpa* presence are shown. The mean shrub canopy, height and crown radio were 53.65%, 2.25 m and 0.59 m, respectively, in *Cistus ladanifer*, and 37.85%, 1.7 m and 0.91 m in *R. sphaerocarpa*. Moreover, browse production was directly proportional to shrub cover as indicate: *C. ladanifer*: sprouts production (kg ha^{-1}) = 13.1278 x % shrub cover; R^2= 0.78; *R. sphaerocarpa:* fruits production (kg ha^{-1}) = 1.5307 x % shrub cover; R^2= 0.63. One of the most important parameters used to determine the quality of food is Metabolic Energy. Different authors have analyzed the ME of acorns (9.5-11.1 MJ kg^{-1} MS; Robles *et al*., 2008), *C. ladanifer* sprouts (6.59 MJ kg^{-1} MS; Patón *et al*., 2004), and *R. sphaerocarpa* (10.4 MJ kg^{-1} MS; Robles *et al*., 2008) fruits and natural grassland of dehesa (7.6-10 MJ kg^{-1} MS; Martín Polo *et al*., 2003). Table 1 shows that the obtained ME was increased by the presence of *R. sphaerocarpa.* It is due to the increase of grass production and the contribution of shrub fodder in addition to the supply of acorns, which did not change significantly with the shrub encroachment. Instead, the ME supplied by the *C. ladanifer* strata did not compensate the reduction of grassland and acorn production, because of the low metabolic energy (6.59 MJ kg^{-1} MS; Patón *et al*., 2004) that this shrub provides.

Table 1. Acorn, grassland and shrub browse production (kg ha^{-1}) and Metabolic Energy (ME; MJ ha^{-1} $year^{-1}$) variation respect to *C. ladanifer* and *R. sphaerocarpa* presence. Ns: not-significant, **: *P*<0.01, *: *P*<0.001.**

	Year	Control	*Cistus*	Sign.	Control	*Retama*	Sign.
Acorn	2007	363.78	211.3	**	339.86	276.98	ns
	2008	150.99	141.30	ns	133.74	120.96	ns
	2009	325.25	198.48	***	183.26	216.34	ns
Shrub	2008	0	704.3		0	57.9	
Grassland	2007	2732	1461	***	2354	2553	ns
	2008	2342	1412	ns (0.07)	2376	2483	ns
	2009	991	470	ns	359	403	ns
	2010	1837	1198	**	1576	1672	ns
ME		20370	15903		17884	18765	

IV – Conclusions

The presence of *C. ladanifer* reduces the overall productivity of the dehesa system, due to negatively effect of its presence on acorn and grass production which is not compensated by shrub fodder production. In contrast, the facilitation effect of *R. sphaerocarpa* increases the productivity of the system. We recommend that future research be guided towards determining whether or not the management of shrub cover (e.g., promoting *R. sphaerocarpa* understorey and clearing *C. ladanifer*, while retaining only some patches of the latter) may aid early tree recruitment without compromising overall productivity of the system.

Acknowledgments

The project was supported financially by Junta de Extremadura (III PRI+D+I, PRI07C044). The authors would like to acknowledgements by mathematical support to Dr. Rafael Benítez Suárez.

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Impacts of climate change on the small ruminants farming systems in north western Tunisia and adaptation tools

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Abstract. Studies on the national adaptation strategy of Tunisian agriculture to climate change reveal that this phenomenon will have serious implications on water resources, ecosystems and agro-systems by 2030. Successive droughts will reduce livestock numbers by 80% in central and southern regions and 20% in the North. In this context, we studied the reaction of the small ruminants farming systems to this critical situation. An investigation has been carried out in the north west of Tunisia (240 small ruminants farms in Jendouba governorate and 151 in Kef governorate). Farms typology results (by PCA) indicate the presence of three farms groups in Kef and three in Jendouba with different farm sizes and flock numbers. The common problem is feed availability. Frequent droughts and over-grazing explain why the involvement of natural pastures and rangelands in animal feed calendars are declining noticeably, justifying the frequent use of transhumance. Large amounts of concentrates are used especially in summer, reducing farmers' incomes improved by other activities. In forest zones, twigs of trees and shrubs constitute a very good food resource. Farmers practice late weaning to reduce the quantities of concentrates presented to the lambs in order to preserve their farm's sustainability.

Keywords. Climate change – Small ruminants – Farming system – Adaptation – Sustainability.

Impacts des changements climatiques sur les systèmes d'élevage des petits ruminants au nord-ouest de la Tunisie et moyens d'adaptation

Résumé. *Des études sur la stratégie nationale d'adaptation de l'agriculture tunisienne aux changements climatiques ; ont révélé que ce phénomène aura de graves répercussions sur les écosystèmes, les ressources en eau et les agro-systèmes d'ici 2030. La succession d'années sèches réduira l'effectif des petits ruminants de 80% dans les régions du centre et du sud et de 20% dans le Nord. Dans ce contexte, nous avons étudié la réaction des systèmes d'élevage des petits ruminants à cette situation critique. Une enquête a été réalisée dans le nord-ouest de la Tunisie (240 exploitations d'élevage de petits ruminants) à Jendouba et 151 au Kef). Les résultats de la typologie (par ACP) indiquent l'existence de trois groupes d'éleveurs au Kef et à Jendouba avec des superficies d'exploitations et des effectifs d'animaux différents d'un groupe à l'autre. Le problème de disponibilité d'alimentation, les fréquences de sécheresses et le surpâturage expliqueraient la participation limitée des pâturages naturels et des cultures fourragères dans l'alimentation des petits ruminants justifiant ainsi le recours fréquent à la transhumance. De grandes quantités de concentrés sont utilisées, dépassant parfois 1 kg) surtout en été ce qui diminue les revenus des agriculteurs. Dans les zones forestières, les animaux valorisent les brindilles des arbres comme ressource alimentaire alternative. Les éleveurs pratiquent le sevrage tardif pour réduire les quantités de concentrés présentés aux agneaux et assurer la durabilité de leurs exploitations.*

Mots-clés. *Changement climatique – Petits ruminants – Systèmes d'élevage – Adaptation – Durabilité.*

I – Introduction

Sustainable agriculture and rural development are certainly the answer to Word's food security concerns. However, today's choices and development paths are closely linked to climatic conditions (Mohamed, 2009). In fact, climate change will have far-reaching consequences on dairy, meat and wool production, mainly arising from its impact on grassland and rangeland productivity. Heat distress suffered by animals will reduce the rate of animal feed intake and result in poor growth performance (Rowlinson, 2008). Pastoral systems occupy two thirds of global dry land areas having a higher rate of desertification than other land uses (Neely *et al.*, 2009). In Tunisia, the livestock sector contributes by 35 to 40% of agricultural GDP in the national economy (Ben Salem, 2011). Small ruminant farming is an ancestral tradition. It plays an important economic, social and ecological role, not only in the central and southern parts of the country, but also in the north-west regions. However, agriculture has been and will, certainly, be affected by the negative impacts of climate change. Indeed, this phenomenon will have serious implications on water resources, ecosystems and agro-systems. The expected succession of dry years will cause the decline of livestock numbers (sheep, cattle and goat) by 80% in the centre and south of the country and 20% in the North (GEREP-Environnement, 2009). Therefore, the objective of this work is to carry out a typology of the small ruminants breeding systems in north-west Tunisia, to study the impacts of climate change on their functioning and the simple adaptation tools used by farmers in order to limit the effect of this phenomenon.

II – Materials and methods

This study was carried out in the governorates of Kef and Jendouba located in the north-west part of the country. The present work was focused on representative samples in each area: 151 small ruminants farms in the governorate of Kef spread over 11 delegations and 240 small ruminants farms in the governorate of Jendouba spread over eight (08) delegations. The observations covered sheep farms structural parameters (herd, agricultural surface), sheep reproduction, animal feeding and the farms economic results. Tools used by farmers to cope with the impacts of climate change were also discussed. Multivariate analysis were made only on 235 farms in Jendouba and 150 farms in the Kef area in order to elaborate a final distribution of farms into homogenous groups using STATBOX (software from GRIMMER).

III – Results and discussion

In the governorate of Kef, a total of 151 farms were investigated. The surveys' compiling results showed that the small ruminants farms are more specialized in meat sheep production with a total number of 7830 ewes which are mainly of the Thin Tailed Breed. The small ruminants farming system in the Kef governorate could be considered generally extensive depending largely on climatic conditions. During the dry years, farmers decrease their herd's size through the sales process. Three groups of farmers were selected using a principal components analysis (Fig. 1).

The first group (35 farms especially located in Nebber, Dahemni and Essers), interpreted from typological studies, is characterized by the presence of small farms (≤ 5 ha and ≤ 30 female units). Forage and pasture land areas are very low, which explains the high price of "achaba", a technique of leasing a land for grazing. These breeders do use neither animal feed complementation in flushing and steaming nor the ram effect. Many breeders use a gradual weaning method to decrease the amount of concentrate feed presented to the lambs. The average suckling period in the case of this group is medium (4 months) and farmers do not practice lamb fattening in order to reduce costs related to this operation to ensure the sustainability of their activity as the only source of income. The second group (69 farms located mainly in Sakiet Sidi Youssef and ElKalaa khesba) is essentially characterized by good flock management and medium flock size (30<TT≤100 female units). They use the flushing and steaming technique. These breeders have intermediate average total agricultural area (5<SAT≤100 ha).This constraint obliges them to use transhumance to other regions with high rental prices. Flocks are characterized by a higher prolificacy rate than in the first group. The breeders of this group also practice better organized lamb marketing using sale contracts. The wool sale constitutes an additional source of income. The third group (46 farms located mainly in Kalaat Senan and Tajerouine) is characterized by large flocks (> 100 female units) and large agricultural land area (≥ 100 h). Farmers in this group devote large agricultural area to dairy cattle forage. The main problem in the small ruminants farms in the governorate of Kef is primarily the animal feed availability related to the scarcity of rain water.

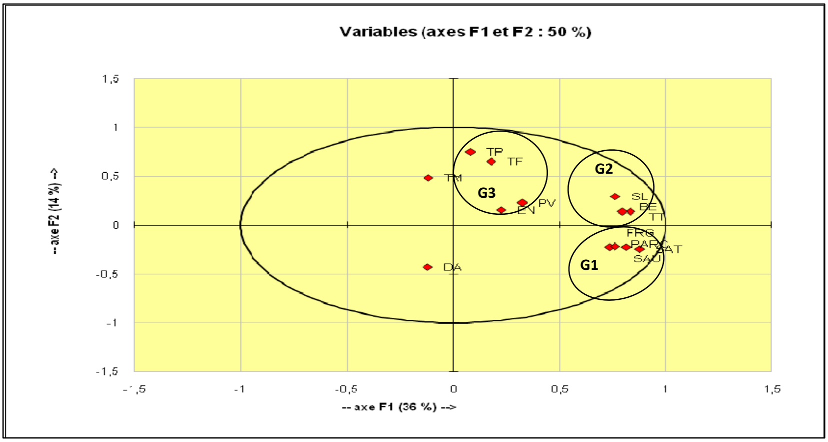

Fig. 1. Spatial localization of the farms according to the two principal components obtained from the multivariate analysis (case of the Kef governorate).

In the governorate of Jendouba, a total of 235 farms were investigated. Average parameters describing the sampled small ruminants farms in Jendouba area, mostly specialized in sheep meat production. The PCA results (Fig. 2) shows the existence of three farming systems: the traditional extensive system, the integrated intensive and rarely, the intensive system. The first system is represented by the majority of farmers relying mainly on grazing in the mountain areas of Gare de Maoi, Fernena, Tabarka and Ain Drahem. In the irrigated areas and plains, the identified breeding system is the semi-intensive which is based on grazing and food supplementation (hay, barley, concentrates, etc…) especially during the fall period when grazing land decreases. Sheep breeds reared in this area differ between regions. In fact, in lowland areas, small ruminants systems are dominated by pure breeds: Barbarine, Black of Thibar and the Thin Tailed Breed, while in mountainous regions, the presence of crossbred and mixed breeds is very common.

In this region, the majority of small ruminants farmers are private breeders and the main constraints facing this sector are the rising price of concentrates feed and forage seeds. The irrigated areas devoted to this farming system are very limited because of the importance of the dairy cattle in this region. In the mountainous areas, sheep and goat farming is based generally on limited forest path areas and feed supplementation is mostly absent.

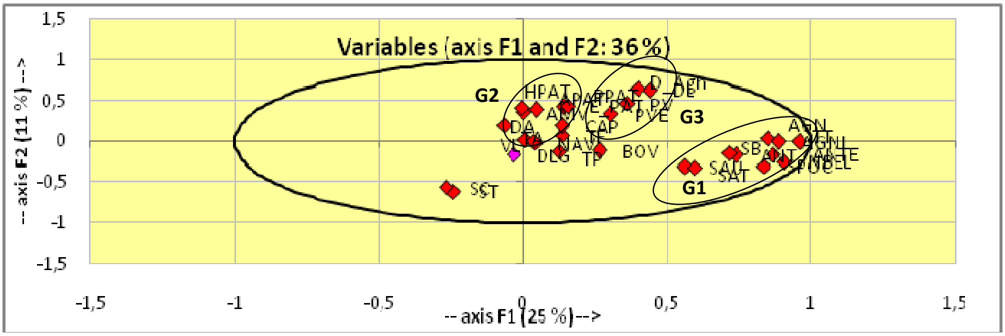

Fig. 2. Spatial localization of the farms according to the two principal components obtained from the multivariate analysis (case of the governorate of Jendouba).

IV – Adaptation tools to climate change

Global climate change is becoming a substantial reality. Tunisia is one of the most susceptible countries to the risks of these alterations particularly on the agricultural level. The major problem common to the majority of small ruminants farmers in Kef and Jendouba is feed availability. Indeed, the involvement of natural pasture and rangelands in the feed calendar is declining noticeably because of frequent droughts and over-grazing. In order to cover animal feed needs, large amounts of feedstuffs are imported which puts pressure on the national balance of payments. Small ruminants breeders in these regions are trying to find solutions which will help them to deal with the climate change problems and preserve their farms' sustainability such as the use of barley as a local feed resource. In forest zones and especially when it's summer, animals are fed on tree twigs and shrubs as a substitute for using concentrates. They also use a late weaning method in order to reduce the quantities of concentrates presented to the lambs.

In northwest Tunisia, small ruminants farms are better able to adopt the organic farming system and to adapt to warming or precipitation increases by switching to heat tolerant animals as goats or crops such as Sulla (*Hedysarum coronarium* L.), Perennial crops, such as *Festuca arundinacea* Schreb. and *Dactylic glomerata* L. would be used to valorize the marginal lands and glade forests (Chakroun, 2011).

V – Conclusions

The meeting point of climate change and livestock and especially small ruminants systems in developing countries is a pretty ignored research area. Little is known about the interactions of climate and increasing climate variability and the small ruminants farming systems evolution. There is a need to more fully understand the role that grazing areas plays in maintaining small ruminants breeding in favorable condition in north west Tunisia where feed and water resources availability at acceptable prices is the main constraint limiting the development of these breeding systems in the region.

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Determination of the socio-economic factors that affect the sustainable pasture management in Central Anatolia region of Turkey

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Abstract. According to the pasture law and regulations, the responsibilities of the farmers on pasture management have increased since 2004. Therefore, the farmers' attitude and behavior in this subject have gained importance on pasture management. The aim of this study is to present the pasture management methods of farmers in the pastures areas where rehabilitation and amelioration process are completed, and to present the factors that affect farmer's behavior on sustainable pasture management. The data used in the study were obtained by a survey among 271 farmers who live in 18 villages of 3 provinces (Ankara, Kayseri and Konya). The chi square, regression analysis and multiple correspondence analysis methods were used in evaluation of the data obtained. The significant variables that come from 40 variables used in the study were subjected to multiple correspondence analyses. As a result of the regression analysis, it is found that there is a significant relationship ($p<0.05$) between the sustainable use of the pastures and: the educational level of farmers, their living places, the use of fodder seeds that are provided for them, the participation in pasture rehabilitation activities, the utility found on the rehabilitation activity, the sustainability of the increase in fodder quantity obtained from the rehabilitation project, the use of the pastures out of purpose, whether or not the farmers are willing to rent pastures, the complying with the plan of grazing and the willingness to belong to a pasture management union. To define which categories of the variables found statistically significant in regression analysis were effective, a multiple correspondence analysis method was used. As a result of this analysis it was found that there is a significant relationship between the variable groups that comply with the grazing plan, use of fodder crops seeds, declare willingness to participate in pasture management unions and rehabilitation activities and the sustainable pasture management.

Keywords. Pasture – Rehabilitation and management – Sustainable – Socio-economic factors – Adoption.

Détermination des facteurs socio-économiques qui affectent la gestion durable des pâturages dans la région centrale d'Anatolie de la Turquie

Résumé. *Selon la loi et les règlements concernant les pâturages, les responsabilités des agriculteurs sur la gestion des pâturages a augmenté depuis 2004. Par conséquent, l'attitude des agriculteurs et son comportement vis à vis ce sujet a gagné en importance sur la gestion des pâturages. Le but de cette étude était de présenter les méthodes de gestion de pâturages dans les zones où leur processus de réhabilitation et d'amélioration est accompli et de présenter les facteurs qui affectent le comportement des agriculteurs sur la gestion durable du pâturage. Les données employées dans l'étude ont été obtenues à partir de 271 fermiers dans 18 villages de 3 provinces (Ankara, Kayseri et Konya) en employant une enquête. L'analyse chi carré, la régression et les méthodes d'analyse de correspondances multiples ont été employées dans l'évaluation des données obtenues. Les variables trouvées significatives sur un total de 40 variables utilisées dans l'étude, furent soumises à l'analyse de correspondances multiples. En raison de l'analyse de régression, on a constaté qu'il y a un rapport significatif ($p<0,05$) entre l'utilisation durable des pâturages et : le degré d'instruction des fermiers, leurs lieu de résidence, l'utilisation des semences fourragères livrées par les projets d'amélioration, la participation dans les activités de réhabilitation des pâturages, le niveau d'utilité trouvé dans l'activité de réhabilitation, la durabilité de l'augmentation de la quantité de fourrage obtenue par le projet de réhabilitation, l'utilisation des pâturages hors du but, la disposition à louer des pâturages, l'acquiescement au plan du pâturage, et la volonté de participer dans des syndicats de gestion. Pour déterminer quelles catégories des variables sont efficaces d'entre celles qui ont été trouvées statistiquement significatives dans l'analyse de régression, une analyse de correspondances multiples fut employée. En raison de cette analyse on constate qu'il y a un rapport significatif entre les groupes qui se conforment au plan de pâturage, qui utilisent des semences de fourrages, qui sont disposés à participer* *dans des syndicats de gestion et dans des activités de réhabilitation des pâturages et la gestion durable des pâturages.*

Mots-clés. *Pâturage – Réhabilitation – Gestion – Durabilité – Facteurs socio-économiques – Adoption.*

I – Introduction

Turkey must manage pastures, hayfields, mountain pastures and grasslands in terms of sustainable agriculture. These areas are main elements for developing animal husbandry and producing agricultural products with lower costs. Sustainable development should be based on the economical and ecological factors. Therefore, pastures must not be seen only as a soil protection element. However, pastures have to be developed, protecting them on account that they have many benefits for country development and be evaluated as a producing area since they are the source of animal feed. Turkish Republic has the proprietary right of pastures in Turkey. The usages of pastures belong to one or more than one municipality. 33% of pastures are in Central Anatolia region. The activities of pastures rehabilitation and amelioration are main subjects dealt with in the region agricultural development plans: 18 projects out of 79 are integral pasture rehabilitation and amelioration projects. The present project has been promoted by Republic of Turkey Ministry of Food, Agriculture and Livestock (Project number: **TAGEM/TA/11/11/03/001**). The aim of this study is to present the pasture management methods of farmers in the pastures areas where rehabilitation and amelioration process are completed, and to present the factors that affect farmer's behavior on sustainable pasture management. The project duration is 22 months.

II – Materials and methods

The farmers who live in the villages where a pasture rehabilitation project is carried out are the subjects of the study. The farmers who live in 18 villages in Ankara, Kayseri and Konya provinces where rehabilitation projects are carried out were stratified into layers according the area sizes. Sample size was determined taking into account farmers' land size. The sampling volume was calculated by using Neyman method. As a result of this calculation 271 farmers were selected (Esin *et al.*, 2010). The survey form consisted of 40 questions. Sustainable pasture management (grazing adjusted to the amount levels of forage provided by pasture lands) was the dependent variable in the study. The independent variables are characteristics of individual farmers, agricultural enterprise characteristics, the sustainability of pastures and communication behaviors of farmers. Regression analysis and (logistic) correlation coefficient are used to determine the structural relationship between dependent and independent variables. Logistic regression analyses are carried out by using *Eviews* and *MiniTab* package programs. As a result of these analyses, a multiple correspondence analysis method is used to determine which categories of the variables are found significant statistically.

III – Results and discussion

72% of farmers has a degree of primary education, 8.8% of them middle school and 19.2% of them high school and above. 88.2% of the farmers live in rural areas and 11.2% of them in cities. 21.3% of farmers live in Konya province, 9.5% in Ankara and 7.8% in Kayseri. In the project framework, it is aimed to increase fodder crops production in order to reduce grazing pressure on pastures. In this context fodder crops seeds are provided for farmers. 16.2% of the total farmers use these seeds. When carrying out pasture rehabilitation activities, the participation of farmers is intended to be assured. 60.9% of the farmers directly participated in pasture rehabilitation activities and 39.1% of them did not. It was asked to the farmers what the benefits of pasture rehabilitation activities are in the region. 79.7% of the farmers answered to this question "our animals feed better", 11.4% of them "they contributed to prevent soil and water erosion" and 8.9% of them "we learned the pasture rehabilitation process". In the case that government lease out its lands for farmers, 57.9% of the total farmers will not rent land because they think the lands belong to the village so they must be in the hands of all farmers. 42.1% of farmers stated that they wanted to rent the pasture. The ratio of the farmers that graze according to the plan for pastures is 53.1%; the other 46.9% of farmers stated that they did not want to graze according to the grazing plan. According to the 11th code of Turkish pasture regulation, members of pasture management unions are chosen from the farmers who live in the concerned villages. In this context, it was asked to farmers who live in the region whether they want or not to participate in pasture management unions. 61.6% of the total farmers stated that they would participate and 38.4% of them that they would not.

1. Results of the regression analysis

In the regression analysis, the dependent variable and the indicator of sustainable pasture management was whether or not the present rough feed quantity in pasture areas is sufficient. The independent factors were related to the individual characteristics of farmers, farm infrastructure, the farmer's behavior of pasture use, and the farmer's behavior related to pasture management and rehabilitation issues. Data of the regression analysis are given in Tables 1, 2, 3 and 4.

Table 1. The results of logistic regression for individual characteristics

Variables	Coefficient	St. Error	Z- Value	P value
Age	-0.121411	0.121326	- 1.000.700	0.3170
Education	**-0.393461**	**0.174470**	**- 2.255.176**	**0.0241**
Living Place	**1.190.082**	**0.436537**	**2.726.189**	**0.0064**
Having off-farm job	-0.084004	0.290123	-0.289546	0.7722
Income level	0.174250	0.241616	0.721186	0.4708
Membership for Non-Governmental Organizations	0.345013	0.256858	1.343.205	0.1792
Whether or not dealing with animal breeding	0.417760	0.280063	1.491.664	0.1358
Log likelihood		-178.7558		

Table 2. The results of logistic regression for pasture areas improvement

Variables	Coefficient	St. Error	Z- Value	P value
The factors for increasing productivity of pastures	-0.667761	0.196137	-3.404.566	0.0007
Demanding for pasture rehabilitation activity	0.143344	0.396531	0.361495	0.7177
Taking fodder plant seeds distributed	1.056.498	0.427548	2.471.062	0.0135
Grazing after producing fodder crops	0.108519	0.184006	0.589757	0.5554
Participation in pasture rehabilitation activity	0.851985	0.301185	2.828.782	0.0047
The utility with pasture rehabilitation activity	-0.498524	0.250608	-1.989.255	0.0467
The success of pasture rehabilitation activity	0.600309	0.335863	1.787.362	0.0739
Factors that affect sustainability	-0.393781	0.274781	-1.433.070	0.1518
Factors that ensure sustainability	0.338070	0.170910	1.978.065	0.0479
Rough feed increase after pasture rehabilitation	-0.058764	0.102274	-0.574573	0.5656
Log likelihood		-155.5617		

Table 3. The results of logistic regression for the use of pastures

Variables	Coefficient	St. Error	Z- Value	P value
Using pastures out of purpose	**-0.222504**	**0.081686**	**-2.723.885**	**0.0065**
Willingness of farmers to rent pasture	**-0.599086**	**0.263375**	**-2.274.649**	**0.0229**
Renting pastures for Non Governmental Organizations	-0.848560	0.540162	-1.570.937	0.1162
Complying with pasture grazing season	**1.100.566**	**0.263259**	**4.180.544**	**0.0000**
Participation in pasture management union	**0.496199**	**0.270334**	**1.835.505**	**0.0664**
Who must make pasture management	0.071833	0.116767	0.615184	0.5384
Log likelihood		-169.2527		

Table 4. The results of logistic regression for communication behaviors

Variables	Coefficient	St. Error	Z- Value	P value
Knowing about pasture regulation	0.123284	0.301915	0.408341	0.6830
Information level about pasture	-0.135635	0.203678	-0.665930	0.5055
The importance of pasture for animal breeding	-0.363718	0.413978	-0.878593	0.3796
Participation in pasture training activities	0.630502	0.429105	1.469.342	0.1417
Satisfaction from pasture training activities	0.284993	0.268255	1.062.398	0.2881
The frequency of purchasing newspaper	-0.050175	0.049692	-1.009.726	0.3126
Solving the problems faced with pasture	-0.094189	0.230269	-0.409037	0.6825
Taking information from agricultural advisors	0.514890	0.298312	1.726.010	0.0843
Log likelihood		-183.3536		

From Table 1 it is determined that there was a statistically significant (significance level of 5%) relationship between farmers education level and place of residence and the sustainable use of rangelands.

It was determined that there was statistically significant relationship among the sustainability of pastures and the factors: taking fodder plant seeds distributed, the participation in pasture rehabilitation activity, the utility with pasture rehabilitation activity and the factors that ensure sustainability.

It was determined that there was statistically significant relationship among the sustainable use of rangelands and the factors: using pastures out of purpose, the willingness of farmers to rent pasture, the complying with pasture grazing season and the participation in pasture management unions.

It was determined that there was no significant relationship among variables in Table 4 with sustainable use of rangelands.

2. The result of multiple correspondence analyses

In this chapter, the level of relationship between the variables of farmer's education level, their living places, the compliance with the grazing plan, the willingness to rent pastures, the participation in pasture management unions and the sustainable pasture management were analyzed by the multiple correspondence analysis method.

It was pointed that there was a relationship among the sustainable use of the pastures and the subjects who take forage plant seeds, not rent pastures and accept the grazing plans (Fig. 1).

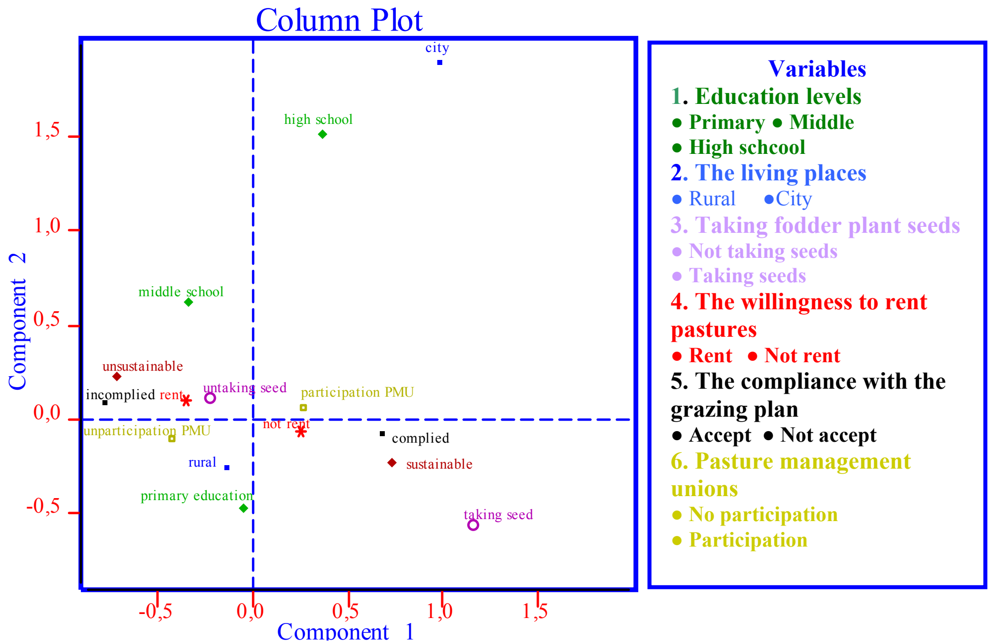

Fig. 1. The relationship between variables of sustainable use of pastures, level of education, living place, complying with grazing plan, whether or not farmers are willing to rent pastures, and participation in pasture management union.

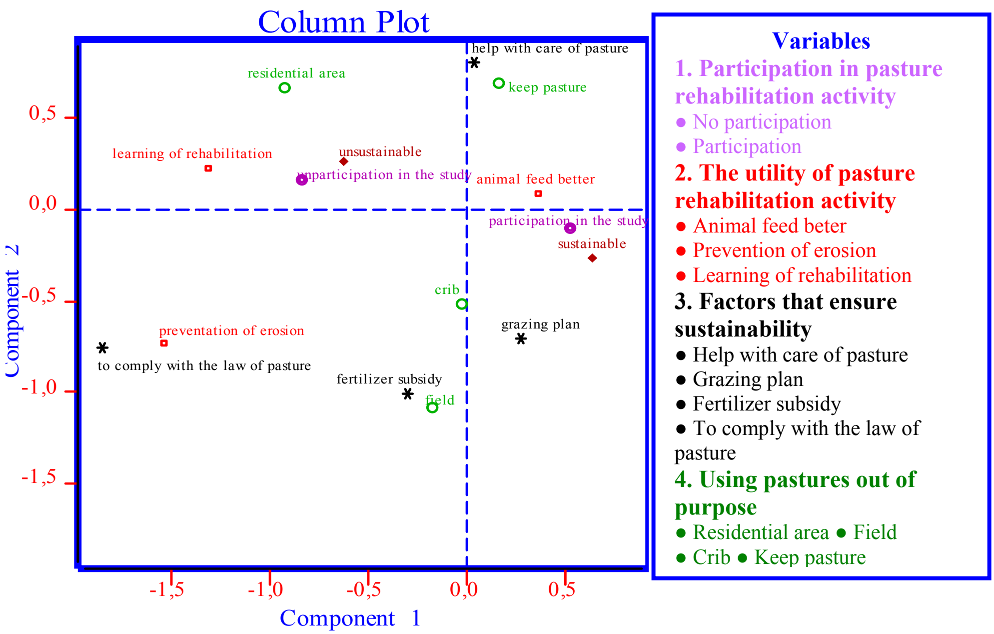

Fig. 2. The relationship between the variables of using pastures out of purpose, the utility level of pasture rehabilitation activity, participation in pasture rehabilitation activity, the factors that ensure sustainability, and sustainability of pastures.

As seen in Fig. 2, the farmers that are for sustainable pasture management are the ones who participate in pasture rehabilitation activities, who state that they comply with the grazing plan and that their animals feed better in the pastures.

IV – Conclusion and recommendations

In the study, the factors that affect sustainable pasture management are analyzed by multiple correspondence analysis method. It is determined that most of the individualistic and farm characteristics of farmers or pasture use practices and communication behavior are not factors affecting effectively the adoption of sustainable pasture management measures by the farmers. On the contrary, farmers participation in rehabilitation activities, use of offered forage seeds, and the compliance with grazing plans are factors having a relation with the sustainability of pastures use. The results of multiple correspondence analysis show that the extension services working on fodder crops cultivation should continue. It should be ensured that farmers who have already participated in pasture rehabilitation activities, adopt grazing plans and use the given fodder crops seeds are the target group for the extension activities. The studied area has a rich crop production pattern, an soils with low slopes an good productive characteristics. In this area, fodder crops production was increased by irrigation and by using fertilizers in pasture rehabilitation programs. The active farmer participation in the programs was significant.

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Effects of the economic crisis on sheep farming systems: A case study from the north Evros region, Greece

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Abstract. Extensive and semi-extensive sheep farming constitute the traditional farming systems in the Mediterranean region. These systems are predominantly labor-intensive with relatively low capital requirements, where an essential part of the animal feeding requirements are based on grazing in natural rangelands. The increased market demand for sheep milk and modernization in life-styles has recently resulted in an increase in the intensive sheep farming. The sheep are fed indoors only on purchased or harvested forages produced on-farm and concentrates. Therefore, fixed and variable costs of this system are high. Moreover, the semi-intensive sheep farming system is characterized by grazing in artificial pastures, which reduces the feeding cost. The purpose of this paper is to study the sustainability of the above three sheep farming systems. Technical and economic data from a sample of sheep farms in the north Evros region of Greece were collected in 2011 and analyzed in order to evaluate advantages and disadvantages of each system. The results provide strong evidence that the intensive system has been more adversely affected by the current economic crisis and it is more vulnerable to the potential negative effect of continued volatility of the economy than the semi-extensive ones. This is because the intensive system requires higher variable costs of purchasing harvested forage and concentrates. Although the semi-intensive system exhibits high variable costs, its feeding costs were significantly lower than the intensive.

Keywords. Dairy sheep – Farming system – Variable cost – Grazing – Artificial pasture – Feeding cost.

L'effet de la crise économique sur des systèmes ovins : Le cas de la région d'Evros du nord, Grèce

Résumé. *Les systèmes ovins extensifs et semi-extensifs sont typiques dans la région méditerranéenne. Ces systèmes utilisent le travail intensivement bien qu'ils demandent peu d'investissements de capitale, alors qu'une part essentielle de l''alimentation des animaux se basse sur le pacage des pâturages naturels. La demande accrue du lait de moutons et la modernisation des sociétés ont eu comme conséquence l'émergence de systèmes ovins intensifs qui sont basses sur la provision des fourrages, provenant du marche ou produits dans la ferme, et des concentrés. Entre ces deux systèmes, le système semi-intensif ovin est caractérisé par l' utilisation des pâturages artificiels,ce qui réduit le coût de alimentation. Cet article examine les perspectives de durabilité des ces trois systèmes ovins. Des données techniques et économiques des fermes ovins situées dans la région d'Evros du nord, en Grèce, ont été rassemblées en 2011 et analysées afin d'évaluer les avantages et les inconvénients de chaque système. Les résultats montrent que les systèmes intensifs ont été affectés par la crise économique courante plus que les systeme semi-extensifs, car la provision du fourrage et des concentrés du marche élèvent considérablement les coûts variables des fermes en intensif. Bien que le coût variable du système semi-intensif soit élevé, le coût de alimentation est moindre que dans le cas du système intensif.*

Mots-clés. *Ovin laitièr – Système de production – Coût variable – Pacage – Pâturage artificiel – Coûts d'alimentation.*

I – Introduction

Evros Prefecture, in north-eastern Greece, covers an area of 424,800 ha of which 42.3% is arable land, 32.3% are forests and rangelands and 10.6% are pastures and grasslands (HSA, 2000). Sheep farming is an important part of the local economy in this region. Particularly, in the northern part of the Prefecture, there are 442 farms rearing 51,357 sheep. Pastures and natural grasslands are limited in this area and crop production includes mainly winter cereals (wheat, barley), maize and lucerne.

Sheep farming systems in the area can be categorized in three types: intensive, semi-intensive and traditional semi-extensive. Within intensive systems, no grazing is applied, automated milking equipment is used and dairy sheep breeds are raised (De Rancourt *et al.*, 2006). Sheep rations are based on lucerne hay and corn silage, mainly produced locally. Recently, the number of intensive dairy sheep farms has increased in the north part of the Prefecture as in many other places in Greece (Tsiboukas, 2006). On the other hand, feeding in the semi-intensive system is based on pasture grazing and harvested forages. Generally, this system is not common in Greece. Finally, in the traditional semi-extensive systems, grazing is applied in communal natural grasslands and on stubble after harvest (Hadjigeorgiou *et al.*, 1999).

The purpose of this paper is to study the sustainability of the above three sheep farming systems in view of the current economic crisis and, in particular, their vulnerability to volatile economic conditions due to their dependence on capital and especially purchased inputs (forage and concentrates, fertilizers, fuel) (FAO, 2008).

II – Materials and methods

Technical and economic data from 57 sheep farms (12 intensive, 4 semi-intensive, 41 semi-extensive) located in the northern Evros area in Greece were collected in early 2011. The intensive and semi-extensive farms were randomly selected using the simple random sampling technique, while the four semi-intensive farms are the only ones existing in the area, hence they constitute the population. The majority of these farms grow maize, lucerne, wheat and barley mainly for the production of animal feedstuff.

A questionnaire-based survey with in-person interviews was conducted in order to collect data concerning infrastructure (buildings, machinery equipment), land, livestock capital, human labour and variable capital (forages and concentrates, veterinary services, fuel etc.) (Zioganas *et al.*, 2001). Moreover, the quantities of crop and animal products are recorded as well as the producer prices.

The collected data were analysed in order to evaluate advantages and disadvantages of each system. The technical and economic indicators presented in the remainder of this paper were calculated using the primary data of the survey. They are more reliable as they take into account differences in flock sizes among farms (Papadimitriou, 2005) and they readily permit comparisons among the different production systems under consideration.

An one-way weighted ANOVA was used to analyse the data using version 8.0 of the JMP software (SAS Institute Inc, Cary, North Carolina). A multiple comparisons for all pairs of means were performed using Tukey–Kramer HSD. The significance level was set to $P<0.05$ (Steel and Torrie, 1980).

III – Results and discussion

Capital expenses of the intensive and the semi-intensive system were significantly higher than those of the semi-extensive (Table 1). For the semi-extensive system they were only 166.8 €/ewe while they were calculated to 309.8 €/ewe for the semi-intensive and to 285.9 €/ewe for the intensive one.

Table 1. Capital cost shares per sheep by farming system

Capital costs	Farming system						
	Semi-extensive		Semi-intensive		Intensive		p-value
	€/ ewe	SD	€/ ewe	SD	€/ ewe	SD	
1.Fixed capital	61.9[b]	33.1	137.0[a]	51.3	116.3[a]	45.2	***
2.Variable capital	104.9[b]	26.0	172.8[a]	69.4	169.6[a]	61.9	***
Purchased feedstuff	39.3[b]	29.0	15.7[b]	10.7	80.0[a]	45.5	***
Veterinary expenses	7.5[b]	5.7	8.8[ab]	2.9	12.3[a]	5.2	*
Crop production expenses	41.8[b]	26.2	127.8[a]	70.2	56.3[b]	48.5	***
Other expenses	16.3	7.1	20.5	7.8	21.0	11.7	NS
Total	166.8[b]	49.8	309.8[a]	98.3	285.9[a]	83.6	***

*P<0.05, **P<0.01, ***P<0.001, NS: not significant. SD: standard deviation.
Means in the same column followed by the same letter are not significantly different (P≤0.05).

A similar trend was found for both constant and variable capital expenses (Table 1). Fixed capital costs account for 37.1%, 44.2% and 40.7% of the total costs of the semi-extensive, semi-intensive and intensive farming systems respectively. Differences in fixed capital are related to the considerably higher investments in infrastructure and equipment of the intensive and semi-intensive systems (De Rancourt *et al.,* 2006). This finding was expected, as these systems use modern building infrastructure for their flocks and state-of-the-art machinery equipment (milking machines, etc).

Intensive and semi-intensive farming systems also exhibit significantly higher variable costs, 169.6 €/ewe and 172.8 €/ewe respectively, compared to the semi-extensive farming system (104.9 €/ewe). Variable costs of the former system are heavily burdened with purchased feedstuff (80.0 €/ewe, 47.2% of total variable costs) (Table 1), while the variable costs of crop production for forages (seeds, fertilizers, pesticides, fuel) (127.8 €/ewe, 73.9%) constitute the main factor accounting for the total variable costs of the semi-intensive system. Note, however, that only a part of crop products is consumed on-farm as feedstuff; the remaining quantities are sold in markets.

Taking into account that feeding expenses constitute the major part of the variable costs for the semi-intensive and the intensive sheep farming systems, it is interesting to examine the sources of these costs (Table 2). Intensive farms base animal diet mainly on concentrates (67.7%) and other purchased feedstuff, which increase feeding costs. According to Morand-Fehr *et al.* (2007) this is the usual feeding practice in the intensive sheep farming systems. On the other hand, cost of purchased feeds is found to be significantly lower in both the semi-extensive and the semi-intensive systems than that of the intensive one, as sheep feeding requirements are covered partially by grazing (De Renobales *et al.,* 2012). Furthermore, the high percentage of on-farm produced forages further reduces the feeding cost in the semi-intensive systems.

IV – Conclusions

Considering the findings of the descriptive analysis presented above, it can be argued that the semi-extensive sheep farming system is less vulnerable to volatile conditions in the general economic environment, as it is less capital-demanding than the other two under consideration. Comparing the remaining two systems, variable capital costs of the intensive farming system are high mainly because of the high cost of purchased animal feeds. Similarly, the variable cost of the semi-intensive farming system is high but this is due to the high production costs of fodder crops. However, the feeding costs of the semi-intensive system are lower compared to those of the intensive one. Consequently, the sustainability of the intensive system is limited, as funds continue to be scarce. Hence, it seems that the current economic crisis affects mainly the intensive system, as farms of this type are more dependent on capital. A general recommendation for all three systems would be to rationalize the management of feeding.

Table 2. Feeding cost per sheep by farming system

Animal feeds	Farming system						
	Semi-extensive		Semi-intensive		Intensive		p-value
	€/ ewe	%	€/ ewe	%	€/ ewe	%	
Roughages	29.2[b]	38.3	29.6[ab]	37.8	39.9[a]	32.3	*
Concentrates	47.0[b]	61.7	44.1[b]	56.4	83.6[a]	67.7	***
Forages	0.0	0.0	4.5	5.8	0.0	0.0	***
Total	76.2[b]	100	78.2[b]	100	123.5[a]	100	***

*P<0.05, **P<0.01, ***P<0.001, NS: not significant.
Means in the same column followed by the same letter are not significantly different (P≤0.05).

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Exploring the use of alternative forage legume crops to enhance organic livestock farming in a context of climate and socio-economic changes

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Abstract. Organic livestock farming is going through notable growth in the Mediterranean Europe. This increase is being sponsored by the EU agri-environmental schemes, but also by the rising interest of consumers. However, constraints exist that threaten to curb the present trend. One of them is the lack of good quality forage. There is thus a need to investigate if unusual forage crops could produce good harvests under organic management in Mediterranean conditions. Accordingly, we have conducted an initial exploration on the nutritional value of alternative forage legume crops that organic farmers are growing in Catalonia (Spain), specifically: sainfoin (*Onobrychis sativa*), fenugreek (*Trigonella foenum-graecum*), Narbon vetch (*Vicia narbonensis*) and bitter vetch (*Vicia ervilia*). These forage crops are well adapted to poor soils, harsh weathers, and low water, fertiliser and phytosanitary applications. They have been traditionally cultivated in the Mediterranean region, but they have been gradually dismissed due to the spread of high-yielding forage varieties. The preliminary results indicate that not only these crops are forages of an excellent nutritional value, but they show similar or even superior nutritional values when cultivated organically. However, further research is required in this domain to gather further evidences.

Keywords. *Onobrychis sativa – Trigonella foenum-graecum – Vicia narbonensis – Vicia ervilia.*

Exploration de l'utilisation des cultures alternatives de légumieuses fourragères pour l'amélioration de l'élevage biologique dans le contexte présent de changements climatiques et socio-économiques

Résumé. *L'élevage biologique est en train d'expérimenter une croissance remarquable à l'Europe Méditerranéenne. Cet agrandissement est commandité par les mesures agroalimentaires, mais aussi par l'intérêt en augmentation des consommateurs. Cependant, il y a des limitations qui menacent la tendance actuelle. C'est le cas du manque de fourrages de bonne qualité. Donc on a besoin d'enquêter si cultures fourragères inhabituelles pourriez produire des bonnes récoltes sous une gestion biologique et dans les conditions Méditerranéennes. En conséquence, nous avons effectué une exploration initiale sur la valeur nutritionnelle de cultures alternatives de légumineuses fourragères qui sont encore cultivés à la Catalogne (Espagne), spécialement: sainfoin (*Onobrychis sativa*), fenugrec (*Trigonella foenum-graecum*), vesce de Narbonne (*Vicia narbonensis*) and ers (*Vicia ervilia*). Ces cultures fourragères sont très bien adaptées aux sols pauvres, conditions météorologiques difficiles, et apports faibles d'eau, fertilisant et produits phytosanitaires. Ces fourrages ont été cultivés traditionnellement à la région Méditerranéen, pourtant ils ont été progressivement abandonnés à cause de l'expansion des variétés fourragères à haut rendement. Les résultats préliminaires montrent que pas uniquement ces cultures sont des fourragères avec valeurs nutritionnels excellents; mais ils exhibent souvent meilleurs valeurs nutritionnels sous une gestion biologique. Cependant, on doit poursuivre avec la rechercher pour recueillir plus d'évidences.*

Mots-clés. Onobrychis sativa – Trigonella foenum-graecum – Vicia narbonensis – Vicia ervilia*.*

I – Introduction

Organic livestock farming is going through notable growth in the last decades in the Mediterranean Europe. This increase is being sponsored by the EU agri-environmental schemes, but also by the rising interest of consumers in organic meat and dairy produce. The market of organic food in Europe was 19.6 billion € in 2010. This supposes an increase of approximately five percent in comparison with 2009 (Willer and Kilcher, 2012) and represents a share of 44% of the turnover of organic products worldwide. However, constraints exist that may curb the present trend (López-i-Gelats and Bartolomé, 2010). One of them is the lack of forage of good quality, particularly for winter feeding (López-i-Gelats *et al.*, 2009). There is thus a need to explore options about alternative forage crops capable of yielding good harvests, both quantitatively and qualitatively, in organic conditions, and which are also well adapted to Mediterranean regions and the typical changes these regions undergo, which are being intensified lately be the effects of climate change, such as irregular rainfall and increasing shortage of irrigation water. In order to fill this void, we have conducted an initial exploration on the nutritional value of alternative forage legume crops that organic farmers are growing in Catalonia (Spain). Particularly, we have focused on the followings: sainfoin (*Onobrychis sativa*), fenugreek (*Trigonella foenum-graecum*), Narbon vetch (*Vicia narbonensis*) and bitter vetch (*Vicia ervilia*). These crops have been traditionally cultivated in the Mediterranean region, but they have been gradually dismissed in the last decades as a consequence of the upcoming of high-yielding forage varieties with the modernisation of agriculture. We have also added alfalfa (*Medicago sativa*) in order to have a reference point of a more conventional fodder crop.

II – Materials and methods

Two methodologies have been applied to assess the nutritional values of these fodder crops. To obtain the nutritional values of the forages under conventional management, literature review has been conducted. In the case of the nutritional values of these forages under organic management, sampling in farms growing organic fodder crops in Catalonia (Spain) was implemented between May and June 2011. The sampling process consisted of mowing 0,25 m^2 of the fodder crop in the middle of the plot. Two samples were taken in each plot. A total of 24 samples were taken, that is, 12 farms were finally included in the analysis. The samples were distributed as follows: 6 in alfalfa plots, 10 in sainfoin plots, 2 in bitter vetch plots, 4 in Narbon vetch plots, and finally 2 in fenugreek plots. The uneven distribution reflects the uneven cultivation of these crops in Catalonia. It should be stated that we are always referring to non-irrigated plots.

Given the availability of good NIRS calibration curves, to determine the nutritional values of the forages, conventional laboratory analysis were not needed. Thus the NIRS method was implemented to examine the following parameters: Ash, indicating the mineral content; Crude Protein, being the total nitrogenised fraction; Degradable Protein, which means the feed protein that can be broken down by microbial enzymes in the rumen; Neutral Detergent Fibre, which includes cellulose, hemicelluloses and lignin; Acid Detergent Fibre, containing cellulose and lignin; Lignin; Starch, entailing the non-fibrous carbohydrates; Ether Extract, which mainly consists of fats and fatty acids; Net Energy of Lactation, which is an estimation of the quantity of energy available for milk production; and Organic Matter Digestibility, which indicates the fraction of the nutrients that can be used by the animal. These analyses were undertaken between the laboratories of the Food and Animal Science Department in the Universitat Autònoma de Barcelona and the Laboratori Agroalimentari of the Departament d'Agricultura, Ramaderia, Pesca, Alimentació i Medi Natural of the Catalan Government.

III – Results and discussion

Despite the high variance observed in the data available, as may be observed in Table 1, particularly remarkable is the high nutritional values registered in the organic samples of sainfoin, bitter vetch and Narbon vetch. These show similar records to the ones of alfalfa. In general, as also remarked in Table 1, and despite the high dispersion of the data, a general trend is observed that points that the nutritional values of sainfoin, bitter vetch, Narbon vetch, fenugreek, and alfalfa, tend to perform better under organic management. The content in protein in the organic samples tends to be higher than in their conventional counterparts. While in the case of fibre it tends to be the other way around. On the contrary, the digestibility of the organic matter is in general larger in samples in conventional farming. As regards the energy available in the forages, not much difference is appreciated among organic and conventional samples. This results go in line with others in the specialised literature that remark the notable nutritional values of the sainfoin, bitter vetch, Narbon vetch, and fenugreek (Acharya *et al.*, 2006; Angeles Garcia *et al.*, 1989; Billaud i Adrian, 2001; Mir *et al.*, 1997); and the higher nutritional values of organically-produced food in comparison with its conventional counterparts (Davies *et al.*, 2004; Worthington 2001). However, further research is required in this domain to provide more evidences, particularly in Mediterranean regions and under changing climatic conditions.

IV – Conclusions

The sainfoin, the fenugreek, the Narbon vetch, and the bitter vetch, are forages that offer excellent nutritional value under Mediterranean conditions. The sainfoin, the fenugreek, the Narbon vetch, and the bitter vetch, show similar and even better nutritional values when cultivate organically in comparison with a conventional management. They are also well-adapted crops to thin soils, harsh weathers, and low water, fertiliser and phytosanitary applications. Consequently they could not only become a sound organic alternative to replace more resource-demanding protein sources for animal feeding, such as soya or maize; but also provide a good alternative to face the upcoming climate change impacts in Mediterranean regions, such as lack of water and irregular rainfall (IPCC, 2007).

The utilisation of these alternative forage legume crops could make an important contribution to deal with one of the main constraints that organic livestock farming encounters nowadays, particularly in the Mediterranean regions, that is, the lack of winter feeding. In addition, this would also support the adoption of livestock fattening among organic livestock keepers, what would enhance the on-farm income generation.

Table 1. Levels of nutritional values of sainfoin (*Onobrychis sativa*), fenugreek (*Trigonella foenum-graecum*), Narbon vetch (*Vicia narbonensis*), bitter vetch (*Vicia ervilia*), and alfalfa (*Medicago sativa*), under organic farming, according to farms sampled in Catalonia (Spain), and under conventional farming, according to references from the specialised literature.

	Organic farming					Conventional farming				
	Alfalfa n=3	Sainfoin n=5	Bitter vetch n=1	Narbon vetch n=2	Fenugreek n=1	Alfalfa n=3*	Sainfoin n=4**	Bitter vetch n=4*****	Narbon vetch n=5****	Fenugreek n=2***
ASH	8.9-12.4	8.0-11.6	7.9-12.8	6.4-12.4	8.2-12.6	10.2-11.1	10.4-11.5			
CP	14.8-26.4	17.8-26.1	15.6-24.7	13.2-23.1	15.2-18.8	16.8-22.4	13.1-17.5	14.0-19.6	14.9-21.8	17.2-17.8
DP	9.0-17.6	10.9-18.9	10.2-17.2	8.0-16.6	9.0-13.3	12.2-18.8	8.1-10.6	12.1-16.9		11.7
NDF	25.0-54.5	30.8-47.7	31.1-47.9	28.9-50.6	30.2-47.9	46.4-52.5	45.1-53.6	25.4-42.8	38.1-42.1	
ADF	16.8-35.4	21.1-35.4	22.7-31.7	20.6-36.0	21.4-35.6	29.4-34.4	27.6-36.3	28.5-31.2	20.6-28.9	
LIGNIN	4.0-6.4	4.3-7.9	4.7-5.6	4.2-7.6	2.7-5.8					
STARCH	1.0-5.6	3.4	1.0-11.0	9.9-14.1	6.5					
EE	1.9-2.0	1.5-2.4	1.8	1.5-2.8	1.8					
NEL	1.3-1.9	1.3-1.7	1.3-1.6	1.2-1.7	1.2-1.7	1.2-1.3	1.3-1.6	1.6-1.7	1.65	1.19
OMD	55.7-80.8	55.0-72.0	60.2-76.1	52.1-75.4	55.8-79.0	60-66	67.0-76.0	77.8-79.2	81.5	66.4-67.4

Where ‘n’ is the number of sampled sites of organic farming and the number of references from conventional farming found in the specialised literature; ‘ASH’ is the mineral content; ‘CP’ is crude protein; ‘DP’ is degradable protein; ‘NDF’ is neutral detergent fibre; ‘ADF’ is acid detergent fibre; ‘LIGNIN’ is lignin; ‘STARCH’ is starch; ‘EE’ is ether extract; ‘NEL’ is net energy of lactation; and ‘OMD’ is organic matter digestibility. * INRA (2007, 1990); ** Alibes and Tisserand (1990); INRA (2007, 1990); *** Darby (2004); Alibes and Tisserand (1990); **** Otal *et al.* (2009); Confalone *et al.* (2006); Alibes i Tisserand (1990); ***** Otal *et al.* (2009); Alibes and Tisserand (1990).

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Alley cropping as a durable alternative for pasture land development in the drought prone region of Eastern Morocco

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Abstract. Eastern region of Morocco, which is under permanent water shortage and recurrent drought, is facing problems of pastoral land degradation that threaten economic livelihoods of resource-poor farmers. In order to diversify the productivity and meet livestock nutritional requirements during feed gap periods, saltbush (*Atriplex nummularia*) was planted in association with barley (alley cropping). This study was conducted in Tancherfi area in order to assess the socio-economic impact of changes in farming systems using alley cropping. The vegetation parameters (shrub biomass and canopy cover) were measured during three periods. The results showed that biomass and canopy cover of *Atriplex nummularia* increased by 15% and 10% respectively due to the inclusion of barley. This association had positive effects on soil properties, which improved soil water status. Farmers expressed their satisfaction with this technique that allowed a 38.9% increase in barley grain yield. This result could be explained by the microclimate created by fodder shrubs that benefited barley growth and development. As a conclusion, with active involvement of community alley cropping should be introduced in any policy related to development of pasture lands in eastern region of Morocco.

Keywords. Mediterranean region – Pasture – Alley cropping – *Atriplex nummularia* – Barley.

L'alley cropping : Alternative durable pour le développement des pâturages dans les régions sèches de l'Orientale du Maroc

Résumé. *L'Oriental du Maroc, qui est sous la pénurie d'eau et une sécheresse permanente, est confronté à des problèmes de dégradation des terres pastorales qui menacent les moyens de subsistance économiques des agriculteurs à faibles ressources. Afin de diversifier la productivité et répondre aux exigences alimentaires du bétail pendant les périodes de disette, l'Atriplex nummularia a été planté en association avec l'orge. Cette étude a été menée dans la région de Tancherfi afin d'évaluer l'impact socio-économique des changements dans les systèmes agricoles utilisant l'alley cropping. Les paramètres de la végétation (biomasse arbustive et recouvrement) ont été mesurés pendant trois périodes. Les résultats ont montré que la biomasse et le recouvrement végétal d'Atriplex nummularia a augmenté de 15% et 10% respectivement en raison de l'introduction de l'orge. Cette association a eu des effets positifs sur les propriétés du sol ce qui a permis d'améliorer son état hydrique. Les agriculteurs ont exprimé leur satisfaction pour cette technique qui a permis une augmentation de 38.9% du rendement en grain d'orge. Ce résultat pourrait s'expliquer par le microclimat créé par les arbustes fourragers qui a fait bénéficier la croissance et le développement de l'orge. En conclusion, la participation active de la population par l'introduction de la culture intercalaire devrait être envisagée dans toutes les politiques de développement des terres de pâturage dans l'oriental du Maroc.*

Mots-clés. *Région méditerranéenne – Pâturage – Culture intercalaire –* Atriplex nummularia *– Orge.*

I – Introduction

Pastoral lands in Eastern Morocco are facing a myriad of problems (i.e. water shortage, recurrent drought and desertification). In order to restore these lands, alley cropping was proposed as an alternative technology for rebuilding soil fertility and enhancing crop and forage production (Kang *et al.,* 1985; Lal, 1989; Kang and Ghuman, 1991).

Alley cropping is an agroforestry practice where trees or shrubs are grown on single or multiple rows simultaneously with a crop between the rows. This technique can benefit from the use of agricultural by-products and dispose of green fodder during the feed gap seasons (USDA, 1999).

This technique is rather advised in areas where the complementarily between animal and plant production is strong, and who present poor soils in terms of quality and structure.

In Eastern Morocco, *Atriplex nummularia* is used in alley cropping. It can play an important role as animal feed; the *Atriplex* have high content of crude protein and mineral contents throughout the year (Franclet and Le Houérou, 1971; Otsyina *et al.*, 1982).

This paper attempts to assess the impact of using alley cropping as an agroforestry practice on productivity of fodder shrubs and barley crop.

II – Materials and methods

The study was carried out in the east of Morocco (Tancherfi site). It is located at 34°21' N 2°37' W and 980 meters above sea level. The lands are mainly cropped for cereals; although originally they were pastoral areas dominate by esparto grass (*Stipa tenacissima*). The climate of the area corresponds to a semi-arid Mediterranean type with mean minimum and maximum temperatures of 1.5°C and 44°C respectively. Total annual precipitation is 200 mm.

In order to diversify feed resources and meet livestock nutritional requirements during feed gap periods, *Atriplex* was planted in association with barley in dry areas (alley cropping). This plantation was performed on an area of 30 ha. In order to harvest most rainfall and runoff for shrub and barley growth, contour planting was practiced. The space between the shrubs with the same line is 1.5 m and 5 m between rows, therefore planting density is 1333 plants per hectare. For the control plot (without alley cropping) *Atriplex* and barley were planted in separate plots.

The vegetation parameters of *Atriplex* (shrub biomass and canopy cover) were measured during three periods (February, April and June), while the interviews with breeders were conducted during June. The barley yield was recorded at the end of the cropping season.

To measure biomass of *Atriplex* "Reference Module Method" was used. Andrew and Lange (1979) suggest that the preferred size of the reference module be 10-20% of the foliage weight. Fifteen branches (modules) were selected randomly, these modules were defoliated and weighted (leaves and wood) to determine the average weight by module. After, we counted the number of modules on the basis of 50 shrubs (5 shrubs per line transect selected randomly). Thus, the mean individual shrub biomass is obtained by multiplying average number of modules per shrub by the average weight of module. Plant material is oven dried (68°C for 48 h) to obtain Dry Matter (DM). The canopy cover was determined by measuring the surface area of each clump of shrubs within quadrats 20m x 20m. Data presented as percentages underwent angular transformation prior to statistical analysis.

III – Results and discussion

1. Seasonal variation of consumable biomass

Biomass of *Atriplex* gradually changed with the advancement of the season, from 1.453 kg DM per hectare in February, 1.613 kg DM per hectare in April to 2.053 kg DM per hectare in June, which gives an average of 1.706 kg DM per hectare. This latter exceeds *Atriplex* production without alley cropping (1.450 kg DM per hectare) (Fig. 1).

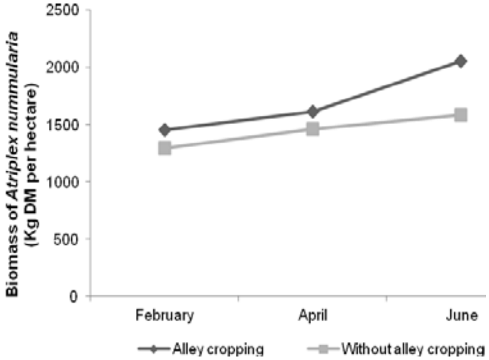

Fig. 1. Seasonal variation of consumable biomass of *Atriplex nummularia*.

Alley cropping has permitted better productivity due to possible soil restoration within rows by barley cultivation. It is also important to consider that alley cropping was applied for 3 to 4 years. Mulch from barley and *Atriplex* occurs naturally; it's a nutrient rich, moisture absorbent bed of decaying leaves, twigs and branches, teeming with fungal, microbial and insect life. Natural mulch serves as a nutrient element. Mulching improves nutrient and water retention in the soil, encourages favorable soil microbial activity and worms, and suppresses weed growth. In addition to the other benefits of alley cropping, planting the furrows along the contour helped to maintain moisture.

In fact, contour planting has allowed to increase rainfall capture and improving soil moisture condition which benefited *Atriplex* and barley.

2. Seasonal variation of canopy cover

The canopy cover of *Atriplex nummularia* increased from 13.5% in February, 18.3% in April to 20.7% in June. In areas without alley cropping, the average canopy cover of *Atriplex* doesn't exceed 7.5% (Fig. 2). This trend results from the development of the aerial part of *Atriplex* favored by microenvironment within the canopy, rainfall and temperature. To limit risk of tree competition with barley for light, farmers prune the *Atriplex* to increase solar penetration and rainfall reception to the alley.

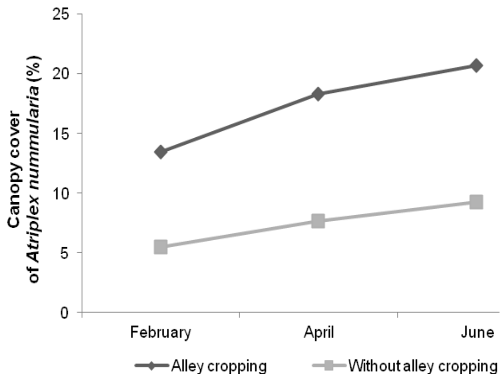

Fig. 2. Seasonal variation of canopy cover of *Atriplex nummularia*.

3. Socio-economic impacts

A. Feed cost

In area of study, farmers have noticed that before alley cropping was applied, the cost of feeding was approximate 250 Dh/year/head. After alley cropping adoption, farmers have noticed a reduction in annual expenses by 50%. In the same areas, the feeding costs were reduced by 30% for those with small flocks, and by 70% for those with large flocks (ICARDA, 2005).With alley cropping; farmers can also benefit from barley grain and straw and green fodder from of *Atriplex*.

B. Barley grain yield

With alley cropping we noticed an increase in barley grain yields, which reached 15 quintals per hectare against a production of 10.8 quintals per hectare in a control plot without *Atriplex*. This high production of barley would be linked to the positive effect of furrows that helped to retain water runoff and improve soil water status, in addition to effect of *Atriplex* shading that could limit evaporation from the soil and creates a microclimate favorable to the development of barley.

C. Fuel wood production

In Tancherfi, *Atriplex* has allowed producing 3.200 kg / ha of wood, which allowed to reduce costs of firewood used mainly for cooking and heating in cold season.

IV – Conclusion

Alley cropping has positive impact on farming system. This study showed that biomass and canopy cover of *Atriplex nummularia* increased by 15% and 10% respectively as compared to monoculture of *Atriplex*. Farmers expressed their satisfaction with the alley cropping system mainly due to 38.9% increase in barley grain yield, a significant reduction in feed cost and an important production of fodder and fuel wood.

It is recommended that rangeland strategic policy for Eastern Morocco includes large diffusion of alley cropping.

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Assessing grazing animal production systems on large Greek islands: A case study on the island of Crete

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Abstract. Greece has a long history of breeding sheep and goats utilizing the indigenous vegetation, under a system of free ranging or shepherded grazing, which in combination to some shepherds' practices formed the present land cover and biodiversity. Islands present an interesting model for animal farming activity. The study area was the island of Crete in the South Aegean Sea. The land area covers some 825,000 ha and officialy holds a population of 600,000 inhabitants, while considerable numbers of sheep and goats (1,270,000 and 580,000 respectively) are raised. These animals produce 88,000 tonnes of sheep milk and 52,000 tonnes of goat milk, together with 14,300 tones of sheep and 6,600 tonnes of goat meat. Production systems applied in this island, were investigated and flocks were divided in semi-intensive and extensive. However, since pedoclimatic conditions vary widely, in order to advise grazing management rules in the different areas, a combination of National Statistics, CORINE and field data was used to define system dependence on local grazing resources. Subsequently grazing capacities were determined and advised to the local authorities together with management guidelines with the aim of maintaining the preserved areas under moderate grazing activity.

Key words. Production systems – Rangeland management – Biodiversity – Islands – Greece.

L'évaluation des systèmes de production animale sur les grandes îles grecques : Une étude de cas sur l'île de Crète

Résumé. *La Grèce a une longue histoire d'élevage des ovins et des caprins en utilisant la végétation indigène, en vertu d'un système de pâturage libre ou avec des bergers, qui, en combinaison à des pratiques des bergers a conformé de la couverture du sol et la biodiversité présentes. Les îles sont un modèle intéressant de l'activité élevage. La zone d'étude était l'île de Crète dans la mer Égée du Sud. La superficie couvre quelque 825.000 ha et occupe officiellement une population de 600.000 habitants, tandis que le nombre d'ovins et de chèvres (1.270.000 et 580.000 respectivement) est élevé. Ces animaux produisent 88.000 tonnes de lait de brebis et 52.000 tonnes de lait de chèvre, avec 14.300 tonnes de viande de moutons et 6.600 tonnes de viande de chèvre. Les systèmes de production suivis dans cette île, ont été étudiées et les troupeaux ont été divisés en semi-intensives et extensives. Cependant, les conditions pédo-climatiques sont très variables, et afin de conseiller les règles de gestion des pâturages dans les différents zones, une combinaison de statistiques nationales, données CORINE et données de terrain a été utilisé pour définir la dépendance des systèmes sur les ressources pâturables locales. Par la suite les capacités de pâturage ont été déterminées et conseillés aux autorités locales ainsi que des directives de gestion dans le but de maintenir les zones préservées sous une activité de pâturage modéré.*

Mots-clés. *Systèmes de production – Gestion des pâturages – Biodiversité – Îles – Grèce.*

I – Introduction

Greece has a long history of breeding sheep and goats utilizing the indigenous vegetation, under a system of free ranging or shepherded grazing, which in combination to some shepherds' practices, formed the present land cover and biodiversity (Hadjigeorgiou *et al.*, 2005). Written evidence, testifying to the existence of pastoral stockfarming, is to be met with from as early as the Mycenean era (XVI-XIII c. B.C.). In the surviving corpus of Linear B inscriptions found in palaces of Knossos (Crete) and Pylos (Peloponesse), records relating to sheep farming form the largest single component (Halstead, 1990). The great majority of these sheep records were concerned with the administration of flocks, which in some sense belonged to the palaces (Halstead, 1990). Islands present an interesting model for land biodiversity evaluation studies, since transfering of terrestrial organisms is minimal and management effects on biota more prominent.

The multifunctional role of grazing systems is widely recognized today, since not only production and economic objectives can be met, but cultural, social and environmental dimensions are also covered. In this sense, pastoral livestock systems are thought as cost-effective instruments to modulate the strong inclination of Mediterranean vegetation development towards shrub invasion (Sternberg *et al*., 2000) and the accumulation of plant biomass. If adequately implemented, grazing management can be a suitable tool to maintain traditional complex landscapes and sustain biodiversity (Flamant *et al*., 1999; Rook *et al.*, 2004).

II – Materials and methods

The objective of this study was to depict the systems of grazing animal farming in the study area of Crete island and define management rules aiming to maintain current situation in vegetation cover. Sheep and goat farming systems were investigated at the farm scale and farms were classified according to structure and management, with special focus on the utilization of grazing areas, but also considering socio-economic factors. Subsequently, an appropriate structured questionnaire was completed by 96 animal farmers interested in collaborating, always with the assistance of an expert. The survey principally recorded basic farm data i.e. number of animals per category, production output, available grazing areas, available arable areas, as well as fencing, housing and machinery infrastructure. Moreover, the survey included questions designed to collect information on farm management practices, feeding programmes for the different classes of animals, rations used, rangeland management (calendars, animal types, areas and location), stock hygiene, preventive treatments, farm economics (values of inputs and outputs), commercialization of products, social characteristics of farmers etc.

At the regional scale, existing data (CORINE land cover, on farm statistics and animal census, etc) were combined with vegetation sampling to determine the areas available for grazing and their potential. Exclusion cages were erected in autumn to study vegetation dynamics, where for herbaceous vegetation available biomass at the start of summer, species composition and chemical composition were recorded. Shrub vegetation was clipped at the same time to estimate the biomass available for grazing and chemical composition was analyzed. Finally nutritional value of the vegetation was defined according to existing equations (Van Es, 1978). The above data were co-investigated in order to facilitate management decisions. The study area was divided on a Prefecture territory level and boundaries of the study area were described on the map at the same level.

III – Results and discussion

The study area of the Crete island (35^{o} N, 25^{o} E) as part of the Southern Aegean complex of islands is covering a significant area of 831,290 ha. The island shows a large variety of ground relief and ecological niches and hosts 34 “Natura 2000” sites, with a total surface area of 277,850 ha (33.4% of the island). These sites are hosting many important plant, mammal, reptile, fish and invertebrate species which are declared “endangered” and put under many protection statuses, through E.U. Directives 79/409 and 92/43. Furthermore, a wealth of endemic and rare species, have been identified on the island.

The island holds a population of 600,000 people, who by majority (49.6%) are employed in the "services" sector, which is mainly tourism. However, a total of about 94,000 agricultural holdings are officially registered on this island utilizing an area of 396,673.8 ha (NSSG, 2004). Moreover, a total of 1,270,000 sheep, 580,000 goats, 2,200 cattle, 61,000 pigs and 2,300 equines are farmed on the island, at an average flock size of 79 sheep, 27 goats, 9,7 cattle, 19,7 pigs and 1,1 equines per farm (NSSG, 2004). On average, annual productivity of livestock in this area according to official census is 69 kg milk and 12.5 kg meat per ewe; 89 kg milk and 11.8 kg meat per goat; 1,100 kg milk and 165 kg meat per cow (NSSG, 2004). However, field data produced in this study demonstrated these figures might be even lower (Tables 1 and 2).

Table 1. Basic characteristics of the sheep and goat farms investigated in Crete island (n=96)

System	Farms N°	Ewes in total	Purchased forages (kg/head/year)	Purchased concentrates (kg/head/year)	Cultivated land for forages (ha/head)	Utilized grazing land (ha/head)
Extensive	48	15,392	56.1	204.5	0.005	0.48
Semi-intensive	48	10,950	125.0	266.2	0.100	0.26

Table 2. Basic production characteristics of the sheep and goat farms investigated in Crete island (n=96) and the respective gross income

System	Farms N°	Milk per ewe (kg/head/ year)	Lambs per ewe/year	Energy requirements through feeds	Energy requirements through grazing	Gross income (€ ewe/year)
Extensive	48	89.4	1.26	53.5%	46.5%	37.6
Semi-intensive	48	143.7	1.43	78.5%	21.5%	43.6

According to CORINE land cover data, the study area had a total of 28 different land cover classes. Assuming that areas under CORINE codes 211, 212, 221, 223, 242 and 243 correspond to cultivated land, areas under codes 231, 321, 322, 323 and 324 correspond to the potential grazing land and areas under codes 311, 312 and 313 include all forestry land, it was estimated that cultivated land of the island amounted 273,280.8 ha (33.2%), rough grazing land 444,140.8 ha (53.9%) and forestry land 59,507.6 ha (7.2%).

The representative samples collected, according to geographical location and the land cover types provided data on vegetation productivity. Therefore, by combining the vegetation biomass available for grazing, its nutritional value and the nutritional requirements of the breeding animals in the study area, the grazing capacity of the rough grazing lands was assessed and defined at 0.25 LU/ha. Although this figure was comparable to the calculated grazing load of the area, an appreciable deviation from the mean was observed among the different municipalities, indicating the uneven distribution of the animals within the island, which should be rectified. However, abandonement of agricultural activity and in particular animal farming in the island poses a threat in these marginal areas and risks the stability of the whole ecosystem (de Rancourt *et al.*, 2006). Therefore, efforts should be made to secure the continuation of these activities possibly through correct marketing of local products.

IV – Conclusions

This study dealt with the important interrelationship of small ruminants with the islands vegetation. It was concluded that current grazing load would maintain land cover at its present form, therefore supporting biodiversity. Proper management directions should be applied and farmers should be actively encouraged to follow them, towards a wider societal benefit.

Acknowledgments

This study was financed by the Hellenic Ministry of Rural Development and Food. The authors express their thanks to the many people who helped in the preparation of this study.

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Use of front face fluorescence spectroscopy to identify sheep milk from different feeding diets

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Abstract. The present study aimed to determine the potential of front face fluorescence spectroscopy (FFFS) to discriminate between milk samples belonging to Sicilo-Sarde ewes fed with three different feeding groups –named control, scotch bean meal and soybean meal– throughout the lactation stage (11 weeks). Milk samples were classified by factorial discriminant analysis. Similar results were obtained by separately applying factorial discriminant analysis (FDA) on each intrinsic probe [aromatic amino acids and nucleic acids (AAA + NA), tryptophan, vitamin A and riboflavin]. In a second step, concatenation technique was applied to FFF spectra. Results obtained showed a good discrimination among milk samples with regard to lactation periods and diet compositions. These results showed that spectroscopic techniques may provide useful fingerprints and allow the identification of milk samples according to the feeding systems given to the ewes throughout the lactation periods.

Keywords. Ewe's milk – Lactation – Soybean meal – Broad bean – Front face fluorescence spectroscopy – Factorial discriminant analysis – Concatenation.

Utilisation de la spectroscopie de fluorescence frontale pour identifier le lait des brebis alimentées de différents régimes alimentaires

Résumé. *L'objet de la présente étude est de tester le potentiel de la spectroscopie de fluorescence frontale (SFF) à discriminer le lait des brebis Sicilo-Sarde selon la nature de la source azotée (tourteau de sja ou féverole) utilisée en complémentation et ce durant les onze premières semaines de lactation. Afin de déterminer le pouvoir discriminant des données de fluorescence, des AFD ont été réalisées sur de spectres des quatre sondes intrinsèques utilisées (Trp, AAA et AN, riboflavine et vitamine A). Une meilleure discrimination des laits, selon la nature du concentre et le stade de lactation, a été obtenue en étudiant conjointement les différentes régions spectrales. Cette analyse combinée a été réalisée en utilisant la technique de concaténation. Les résultats obtenus ont montré que les techniques spectroscopiques peuvent fournir des empreintes digitales utiles et permettre l'identification d'échantillons de lait selon la nature du concentré utilisé en complémentation des brebis durant la période de lactation.*

Mots-clés. *Brebis – Lactation – Tourteau de Soja – Féverole – Spectroscopie de fluorescence frontale – Analyse factorielle discriminante – Concaténation.*

I – Introduction

In Tunisia, Sicilo-Sarde dairy sheep feeding is based on grass grazing and forage, as a basal diet, and concentrate complementation all through the year (Rouissi *et al.* 2008). However, during the last years, the worldwide overall economic situation resulted in an increase in the price of raw materials used for livestock concentrate formulation (corn and soya). In this way, the search for other alternatives such as their entire or partial replacement by local food resources (barley, faba bean…) is still imperative. Milk contain several intrinsic fluorophores, which represent the most important area of fluorescence spectroscopy .These last years several authors (Karoui *et al.*, 2005; Boubellouta and Dufour, 2008) used the spectroscopy of fluorescence tool to discriminate between milk and between the dairy products of various origins and / or having sudden various treatments. The objective of this study was to evaluate the effect of the partial substitution of faba bean for soya in concentrate formulation on milk production by Sicilo-Sarde dairy ewes during the suckling period using front face fluorescence spectroscopy coupled with chemometric tools.

II – Materials and methods

1. Animals

Forty-five Sicilo-Sarde ewes were divided into three homogenous groups according to their weight: 51.3 ± 4.9 kg for the control (C) ; 51.9 ± 4.9 kg for the soybean meal (S) and 52 ± 5.4 kg for the scotch bean meal (F), the litter size :1.47 ± 0.5 for (C) ; 1.4 ± 0.5 for (S) and 1.5 ± 0.5 for (F) and the rank of lactation : 2.4 ± 0.9, 2.6 ± 0.9and 2.6 ± 0.8 for the control, soybean and scotch bean groups, respectively.

2. Diets

Ewes received a ration commun base (oat hay) at 1.5 kg DM/ewe/day and each group of animals was supplemented by a 500g / ewe / day of one of three iso-energetic and similar protein concentrates named: control, soybean rich and scotch bean rich diets during the lactation period (11 weeks). Ingredients (%) and chemical composition (% DM) of concentrates and roughage are presented inTable 1.

Table 1. Ingredient proportions and chemical composition of aliments (% DM)

	Concentrates			Oat hay
	Control	Soy bean meal	Scotch bean meal	
Ingredients (%)				
Barley	35	82.5	71.5	-
Corn	30	-	-	-
Soybean meal	15	13.5	7	-
Scotch bean meal	-	-	17.5	-
Wheat bran	15	-	-	-
VMC sheep	5	4	4	-
Chemical composition				
DM (%)	90	89	89	84
Organic matter	93.6	88.9	92.7	92.2
Crude protein	15.8	16.8	16.2	5.2
Crude fiber	5.1	9.4	7.6	39.7

3. Sampling and preservation of milk

Individual milk yield was recorded one day a week on one milking during the whole suckling period (11 weeks). For each group, the milk samples collected from the different ewes (n = 15 per group) were mixed and an aliquot of 100 ml was taken and kept in a freezer at -20°C until analyses. Before each analyses, milk samples were thawed during one night at +4°C in a refrigerator. All the analyses were made in triplicate (n = 11 samples x 3 repetitions = 33 analyses).

4. Fluorescence spectroscopy

Fluorescence spectra were recorded using a FluoroMax-2 spectrofluorimeter (Spex-Jobin Yvon, Longjumeau, France). The incidence angle of the excitation radiation was set at 56° to ensure that reflected light, scattered radiation and depolarisation phenomena were minimised. for each milk sample, three spectra were recorded.

5. Mathematical analysis of data

In a first step, Principal Component Analysis (PCA) was applied to the normalised spectra to investigate differences between the samples. In a second step, Factorial Discriminant Analysis (FDA) was performed on the first 10 Principal Components (PCs) resulting from the PCA applied to the fluorescence spectral data. Finally, the first 10 PCs of the PCA performed on each data set were pooled into one matrix and this new table was analysed by FDA. Chemometric analyses were performed in MATLAB (The Mathworks Inc., Natic, MA).

III – Results and discussion

The emission spectra (400 – 640 nm) of riboflavin spectra are depicted in Fig. 1. Interestingly, Fig. 1 showed two spectral regions: the broad peak at about 520 nm is due to riboflavin as has been reported by Miquel Becker *et al.* (2003). A difference in the fluorescence intensity at 520 nm was observed among controls and treatments (ewe's milk fed with soybean or scotch bean meals). In addition, milks collected from ewes fed scotch bean appeared to be less oxidised than those collected from ewes fed soybean meal during the studied lactation periods. That could be due to the presence of antioxidants (e.g. tannins) present only in milk collected from ewes fed scotch bean meal. The emission spectra of AAA + NA and tryptophan recorded after excitation at 250 and 290 nm (data not shown). As most of the spectra presented very similar shapes and can, therefore, visually hardly be distinguished.

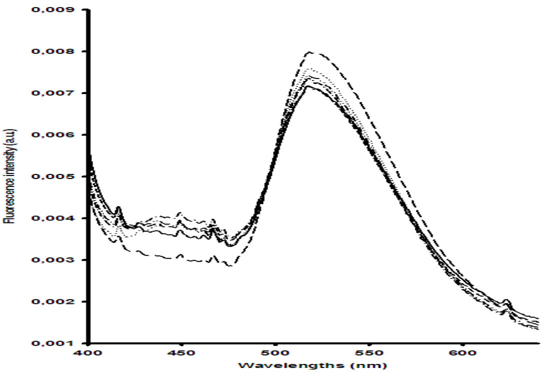

Fig. 1. Normalised fluorescence emission spectra of riboflavin fluorescence spectra recorded following excitation at 380 nm on Sicilo- Sarde ewe's milk fed scotch bean after 1 (—), 11 (…), soybean after 1 (– – –), 11 (—..—..) or control after 1 (— —) and 11 (— ···—) weeks of lactation, respectively.

In order to compare the results obtained from the different intrinsic probes, concatenation technique was applied to the AAA + NA, tryptophan, vitamin A and riboflavin spectra. The resulted similarity map of the concatenation technique is illustrated in Fig.2. The similarity map allowed a good discrimination of milk samples according to the feeding systems. Indeed, the three groups were well discriminated: control ewe's milk gave negative scores according to the discriminant factor 1 and positive scores according to discriminant factor 2; milk samples fed scotch bean meal had negative scores according to both discriminant factors 1 and 2. Finally, milk samples of ewes fed soybean meal exhibited positive scores according to discriminant factor 1 and scores close to zero according to discriminant factor 2.

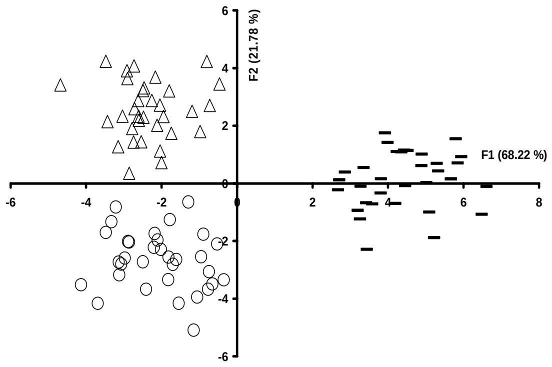

Fig. 2. Discriminant analysis similarity map determined by discriminant factors 1 (F1) and 2 (F2). (FDA) was performed on the 40 concatenated PCs corresponding to the PCA performed on the emission spectra of aromatic amino acids and nucleic acids, tryptophan fluorescence spectra , riboflavin and vitamin A fluorescence spectra of Sicilo-Sarde ewe's milk fed scotch bean meal (o), soy bean meal (–) or control (Δ).

IV – Conclusions

The results obtained in this study demonstrated that front-face fluorescence spectroscopy in combination with chemometrics can be considered as a fast, non-destructive and innovative technique to differentiate between ewe's milk samples originating from different feeding systems. The concatenation technique of the aromatic amino acids and nucleic acids (AAA + NA), tryptophan, vitamin A and riboflavin acquired by using FFF technique allowed a good discrimination of ewe's milk from the different feeding system.

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The hydrodynamic relationships of two herbaceous species in a grazed *Morus alba* L. silvopastoral system

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Abstract. In most Mediterranean areas water is one of the major determinants of plant growth. The water relations of herbaceous species was studied in a *Morus alba* L. silvopastoral system under moderate grazing. The experimental area was divided into six fenced plots in order to exclude uncontrolled grazing. Three of them were randomly assigned to be grazed (0.9 sheep/ha/year) while the other three remained ungrazed. Half of every plot was ploughed and seeded with *Trifolium subterraneum* cv Mt. Barker while the other half remained with the natural herbaceous vegetation. The water potential (Ψ) and relative water content (RWC) of *T. subterraneum* and of the dominant native grass *Poa bulbosa* were measured. Although grazing does not modify the internal water status of *T. subterraneum* and *P. bulbosa*, both species seem to have the ability to control their water balance probably by pathetic regulation of osmosis.

Keywords. Water potential – Relative water content – *Trifolium subterraneum* – *Poa bulbosa*.

Les relations hydrodynamiques de deux espèces herbacées dans un système sylvopastoral de* Morus alba *pâturé

Résumé. *Dans la région méditerranéenne, l'eau est une des déterminants majeurs de la croissance des plantes. Les paramètres hydriques de la végétation du sous-étage herbacée ont été étudies dans un système sylvopastoral de* Morus alba *L. sous pâturage modéré. La surface expérimentale a été séparée dans six parcelles clôturées afin d'exclure le pâturage non contrôlé. Trois d'entre elles ont été aléatoirement assignés pour être pâturées tandis que les autres trois restaient non pâturées. Dans toutes les parcelles de terrain* Morus alba *a été planté. La moitié de chaque parcelle de terrain a été labourée et semée avec* Trifolium subterraneum *L. cv. Mt. Barker tandis que l'autre moitié demeurait avec la végétation herbacée naturelle. Le potentiel hydrique (Ψ) et la teneur en eau relative (RWC) du* Trifolium subterraneum *et* Poa bulbosa *L. ont été mesurés. Les résultats ont prouvé que le pâturage ne modifie pas le statut hydrique de* T. subterraneum *et* P. bulbosa*. Cependant, ces deux espèces semblent avoir la capacité de régler leur balance hydrique probablement par règlement pathétique de l' osmose.*

Mots-clés. *Potentiel hydrique – Teneur en eau relative –* Trifolium subterraneum – Poa bulbosa.

I – Introduction

The analysis of hydrodynamic relationships at leaf level provides preponderant information for understanding the water economy of plant vegetation (Larcher 1980, Schopfer 1995). One of the best indicators of water balance is the changes of Ψ and RWC (Kramer 1983, Nobel 1991). These elements are crucial especially for the arid and semiarid areas where water availability is the most limiting factor for plant growth (Karatassiou *et al*., 2009). Plants in such environments have developed drought adaptation mechanisms to avoid or tolerate water stress by modifying their morphological and physiological characteristics (Arndt *et al.,* 2001, Gurevich *et al.,* 2006). Establishing a silvopastoral system in degraded Mediterranean semiarid grassland, to fill up the feed gap of the grazing animals during summer (Ainalis and Tsiouvaras 1998), should take into consideration the drought tolerance of C_3 perennial species (Sklavou *et al*., 2011). However, there is limited information regarding drought tolerance and the water relations of herbaceous species in *Morus alba* L. silvopastoral systems.

The aim of this paper was to investigate the water relations and the ecophysiological mechanisms of *Trifolium subterraneum* (seeded) and *Poa bulbosa* (natural) grown in a *Morus alba* silvopastoral system under moderate sheep grazing.

II – Materials and methods

The experiment was conducted at a low altitude Mediterranean grassland in Northern Greece. The experimental area ($40^{o}41'$ north latitude, $23^{o}14'$ east longitude) was located 45 km east of Thessaloniki, at Scholari village, at an altitude of 100 m. a.s.l. The climate of the area according to the bioclimatogram of Emberger (1942) could be characterized as Mediterranean semiarid with cold winters. The mean annual precipitation is 454.5 mm and the mean annual temperature is 15.7^{o}C (Sklavou, 2002).

The experimental area was separated into six plots (0.141 ha each plot), which were fenced in order to control the grazing. Three of the plots were randomly assigned to be grazed by sheep at a stocking rate of 0.9 sheep/ha/year while the other three remained ungrazed (control). In all plots *Morus alba* was planted. Half of every plot was ploughed and seeded with *Trifolium subterraneum* cv. Mt. Barker (*T. subterraneum)* while the other half remained with the natural herbaceous vegetation. Leaf water potential (Ψ) and relative water content (RWC) were measured in *Trifolium subterraneum* and in the dominant native grass *Poa bulbosa* L. (*P. bulbosa*)

The measurements during the experimental period were obtained on clear sunny days at midday every 15 days. All measurements were obtained on a sample of four mature and intact, fully expanded, upper leaves in both grazed and non grazed plots. Leaf water potential (Ψ) was obtained with the pressure chamber technique (Koide *et al.*, 1991). Relative water content (RWC) was determined on 4 mm discs from leaves similar in age and orientation, and from the same plant to those used for the Ψ determination, according to the procedure described in Iannucci *et al.* (2002).

General linear model procedure of the SPSS statistical software v. 17.0 (SPSS, Chicago, IL, USA) was used for ANOVA. The LSD at the 0.05 probability level was used to detect the differences among means (Steel and Torrie, 1980). Non-linear regressions of varying Ψ in respect to RWC were fitted per species and grazing treatment using a quadratic function at $p<0.05$.

III – Results and discussion

Seasonal changes of Ψ, in the non grazing treatment were significantly different between *T. subterraneum* and *P. bulbosa* (Fig. 1). So, on the same date during the growing season Ψ was higher in *T. subterraneum* in relation to *P. bulbosa*. Therefore, *T. subterraneum* seems to have the ability to maintain internal water balance (Karatassiou *et al*., 2009). Nevertheless, seasonal changes of RWC between *T. subterraneum* and *P. bulbosa* were rather similar except for the period from middle March to the end of April (Fig. 2). During this period the VPD (Vapor pressure deficit) was relatively low (1.3 kPa) and seems to be related with higher RWC values in *T. subterraneum* compared to *P. bulbosa* (Medrano *et al*., 2002, Karatassiou *et al*., 2009). In the grazing treatment, seasonal changes of Ψ in the two species were similar for most part of the growing season. It seems that grazing tends to diminish the hydrodynamic differences between *T. subterraneum* and *P. bulbosa*. Seasonal changes of Ψ for the two species differentiated in middle April, with higher values recorded in *P. bulbosa* compared to *T. subterraneum*. Seasonal changes of RWC in the grazing treatment were proportional, showing that RWC was different between the two species after middle April, which was expected from the corresponding difference of Ψ. Also, fluctuation of Ψ in relation to RWC (Fig. 3) in the two treatments (non grazing, grazing) was similar for the two species. Thus, assuming that the water use is an important factor for herbaceous production the *T. subterraneum* introduction to silvopastoral system can efficiently work.

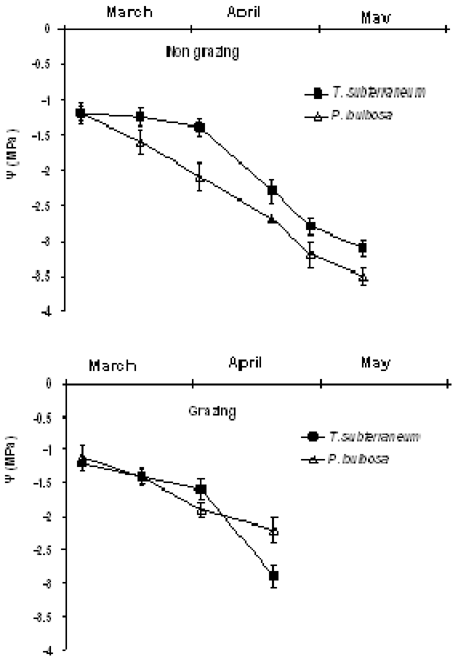

Fig. 1. Seasonal changes of water potential (Ψ) in *T. subterraneum* and *P. bulbosa* at non grazing and grazing treatment. Values present means ± SE of four replicates per species.

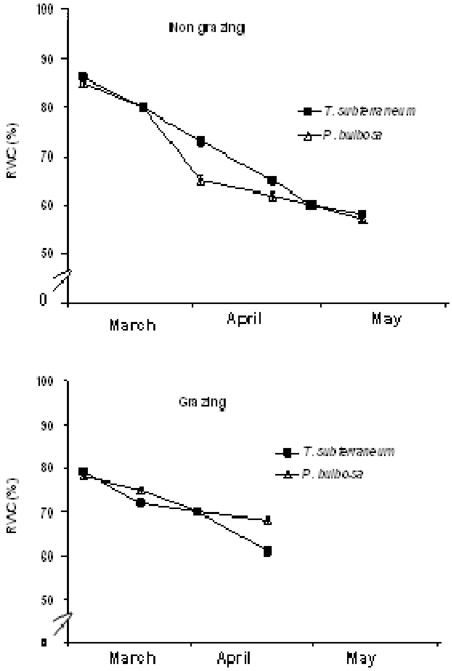

Fig. 2. Seasonal changes of relative water content (RWC) in *T. subterraneum* and *P. bulbosa* at non grazing and grazing treatment. Values present means ± SE of four replicates per species.

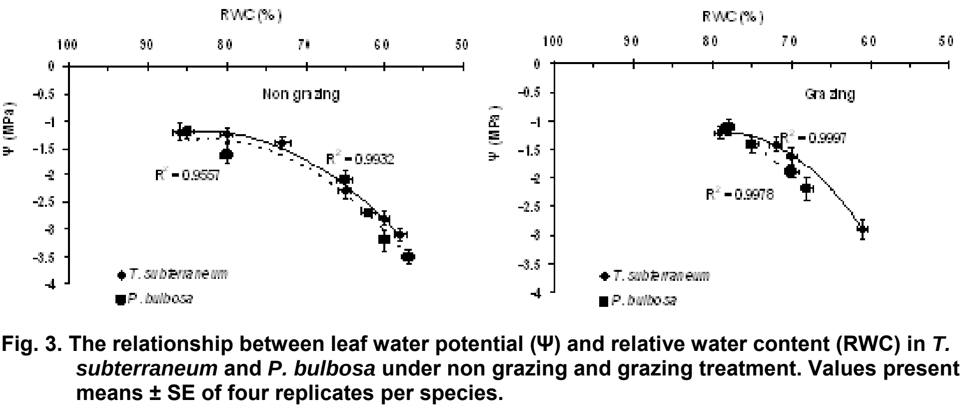

Fig. 3. The relationship between leaf water potential (Ψ) and relative water content (RWC) in *T. subterraneum* and *P. bulbosa* under non grazing and grazing treatment. Values present means ± SE of four replicates per species.

IV – Conclusions

These results suggest that *T. subterraneum* establishment can be implemented in such silvopastoral system, since the differences observed at the two species are not so much considerable. The fact indicates that the two species use water resource at different soil deep. Additionally the slow decrease of Ψ in respect to RWC in both treatments makes us think about a pathetical regulation of osmosis.

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Change in milk composition and fatty acid profile of dairy ewes depending on nature of two annual grasses species in sub-humid region of Tunisia

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Abstract. The objective of this synthesis is to investigate the forage production of two annual grasses species (green barley and triticale) and their effects on milk production, composition and fatty acid profile of dairy ewes in the Tunisian sub-humid area. The first regimen was based on green barley (GB) and the second regimen was based on triticale (T). The concentrate supply was 300 g/day/ewe for each group. The dry matter forage production was 2.4 and 5.4 t/ha for green barley and triticale respectively. Milk production was significantly higher for T group than GB one (540 *vs* 460 ml/day). Fat and protein content (g/kg) were higher for ewes fed triticale pasture than ewes fed green barley pasture (39.1 *vs* 33.6 g/kg of milk fat and 26 *vs* 24 g/kg of milk protein for T group and GB one respectively). Milk of ewes fed triticale had a higher percentage on poly unsaturated fatty acid (PUFA) than ewes fed green (6 *vs* 2.9% for T and GB respectively), on total unsaturated fatty acid (UFA) (28.7 *vs* 26.3% for T and GB respectively), on C18:0 (11 *vs* 8.5% for T and GB respectively), on C18:1 (23 *vs* 21.4% for T and GB respectively) and on C18:2 (3.5 *vs* 1.7% for T and GB respectively). Milk from ewes fed triticale had a higher linolenic acid (C18:3) proportion than milk from ewes of GB group (0.9 *vs* 0.5 % respectively). The milk CLA content was significantly higher for GB group than for T group (7.3 *vs* 3.2 % respectively). In conclusion, the cultivated triticale pasture seems conduct to higher production and healthier ewe's milk comparing to green barley except CLA percentage which the highest value was found in ewe's milk fed green barley.

Keywords. Grasses – Milk yield – Milk fatty acid profile – Sicilo-Sarde ewes.

Changement dans la composition du lait et le profil en acides gras de brebis laitières en fonction de la nature de deux espèces de graminées annuelles dans la région sub-humide de la Tunisie

Résumé. *L'objectif de cette synthèse est d'étudier la production fourragère de deux espèces de graminées annuelles (l'orge et le triticale) et leurs effets sur la production laitière, la composition chimique et le profil des acides gras du lait de brebis laitières dans la région sub-humide de la Tunisie. Le régime (GB) est basé d'orge en vert et le régime (T) est à base de triticale. L'apport en aliment concentré est de 300 g/jour/brebis pour chaque groupe. La production de matière sèche de fourrage a été de 2,4 et 5,4 t/ha respectivement pour l'orge en vert et le triticale. La production de lait était significativement plus élevée pour le groupe (T) que le groupe (GB) (540* vs *460 ml/jour, respectivement).Les teneurs en matières grasses et en protéines (g/kg) étaient plus élevés pour le lait de brebis sur pâturage de triticale que le lait de brebis sur pâturage d'orge vert (39,1* vs *33,6 g/kg de matière grasse du lait et 26* vs *24 g/kg de protéines de lait pour le groupe (T) et (GB) respectivement). Le lait de brebis sur pâturage de triticale a un pourcentage plus élevé que les brebis sur pâturage d'orge verte en acides gras poly insaturé (AGPI) (6* vs *2,9% pour le groupe (T) et le groupe (GB) respectivement), en acides gras insaturés (AGI) (28,7* vs *26,3% pour le groupe (T) et le groupe (GB) respectivement), en acide stéarique (C18:0) (11* vs *8,5% pour le groupe (T) et le groupe (GB) respectivement), en C18:1 (23* vs *21,4% pour le groupe (T) et le groupe (GB) respectivement) et en C18:2 (3,5* vs *1,7% pour le groupe (T) et le groupe (GB) respectivement). Le lait de brebis sur pâturage de triticale (T) a la plus grande teneur en acide linolénique (C18:3) que le lait de brebis de groupe (GB) (0,9* vs *0,5% respectivement). La teneur du lait en CLA était significativement plus élevée pour le groupe (GB) que pour le groupe (T) (7,3* vs *3,2% respectivement). En conclusion, le pâturage sur triticale semble conduit a une amélioration de la production et de la qualité diététique du lait de brebis en comparaison avec la lait des brebis pâturant l'orge en vert, à l'exception de la teneur en CLA du lait laquelle a été plus élevée dans le lait de brebis conduite sur pâturage d'orge vert.*

Mots-clés. *Graminées – Production laitière – Acides gras du lait – Brebis Sicilo-Sarde.*

I – Introduction

Due to the evolution of consumers' demand, more attention has been given to traits related to food safety, health and nutritional value. Animal products like milk play an important role given the impact of its fatty acid (FA) content on human health. In fact, fat nutritional aspects have been assuming an increasing importance as positive or negative predisposing factors for human health. Many others research showed that dietary factors such as the nature of forages, including pasture, and the supplementation of dairy rations with protected or unprotected vegetable or fish oil can substantially increase CLA content in milk of ruminants (Chilliard *et al.*, 2001). Compared with total mixed ration (TMR) diets, pasture-based diets have resulted in higher concentrations of unsaturated long-chain FA and CLA in milk (Kelly *et al.*, 1998). A substantial increase of milk fat CLA contents in dairy cattle after turning out to pasture were showed later in a series of experiments (Stockdale *et al.*, 2003; Kay *et al.*, 2004). Dhiman *et al.* (1999) observed a highly positive effect of fresh lush green pasture on CLA content.

The objective of this synthesis is to investigate the forage production of two annual grasses species (green barley and triticale) and their effects on milk production, composition and fatty acid profile of dairy ewes in the Tunisian sub-humid area.

II – Materials and methods

The experiment was carried out in the dairy experimental farm of the National Institute of Agricultural Research of Tunisia (INRAT) on 40 Sicilo-Sarde breed ewes. The average date of parturition was January 17th; lambs were weaned at 45 days of age. At this stage, ewes were divided into two homogeneous groups, 20 ewes each, according to age, parity and milk production (560 ml/day). Ewes of two groups were conducted during the day (from 10:00 to 15:00) on triticale and green barley pasture with rotational grazing system with a stocking rate of 20 ewes/ha. Indoors, ewes were lodged per groups which were complemented with 300 g of concentrate. The experiment lasted 70 days.

Ewes were milked daily at 06:30 and 16:30. Individual milk yield was recorded twice a month during the whole experimental period and individual milk samples (20 ml) were taken and kept (4°C) for analysis. Other milk samples were used for analysis of fatty acids composition. Grass weight was determined before entering each paddock by cutting 5 quadrates ($1m^2$) of pasture at 6 cm above the ground; total grass production was calculated according to sample weights and the paddock area. This operation occurred 5 times during the experimental period. After desiccation, the samples for each month were pooled and two sub-samples were taken for chemical analyses. The mean daily grass availability was calculated as the ratio of paddock grass production by ewes' number and by number of days spent in the paddock. Milk fat and protein were analyzed using a MilkoScan 4000 (Foss Electric, integrated Milk Testing). Methyl esters of FA were analyzed by gas chromatography (GC) (Shimadzu, Japan). The GC was equipped with flame ionization detector (FID) and Omega Wax fused silica capillary column (30 m × 0.25 mm i.d); (Omega Wax; temperature limits: 50°C - 280°C; Oven: 50°C (2 min) to 250°C at 4°C/min, hold 15 min). Chemical composition of foods was determined. Grass and concentrate samples were dried at 60 8C in a forced-air oven, ground through a 1-mm screen, and analyzed for DM (105ºC in a forced-air oven for 24 h) mineral content (450ºC for 8 h), crude fiber (Weende) and CP (Kjeldahl).

Data of milk yield, composition and fatty acid profile (twice a month for two and a half months), were analyzed as repeated measures using the mixed procedure of SAS (2000). The statistical model included: experimental diet, time of sampling and their interactions as fixed effects. Data recorded during pre experimental period (milk yield and composition) were used as covariates and included in the model.

III – Results and discussion

1. Forage production and chemical composition

Herbage production, chemical composition and nutritive value of green barley and triticale were reported in Table 1. The grass amount produced by the green barley during the first month of trial was 13.27 t fresh matter or 2.35 t DM/ha, while the triticale production was higher with 23.9 t fresh matter or 5.1 t DM/ha. For both species, an increase in herbage production was noted for the second month of trial with 24.2 t fresh matter, which corresponds to 5.7 t DM/ ha and for the green barley grass production was 14.3 t of fresh mater or 2.5 t DM/ha. The dry matter forage production average was 2.4 and 5.4 t/ha for green barley and triticale respectively.

Organic matter (%) was higher for triticale than green barley with 93% *vs* 88.3% respectively. The crude fibre content was slightly higher for triticale than green barley (27.2% *vs* 26.3% respectively). While crude protein content was higher for green barley with 13.4% in comparison with triticale grass with a respective content of 10%. The crude protein was not below the level at which it could be considered deficient for ruminant nutrition (Norton, 1994).

Table 1. Forage production and chemical composition of diets

	Triticale	Green barley	Concentrate
Forage production (t DM/ha)	5.4	2.4	-
Dry matter (%)	23.7	22	93.5
Organic matter (%)	93	88.3	96
Crude fibre (%)	27.2	26.3	7.4
Crude protein (%)	10	13.4	15.8
Ash (%)	7	11.7	4
UF (kg/ DM)	-	-	1

2. Milk yield, composition and fatty acids profile

Milk yield per ewe per day, milk composition and fatty acids profile are reported in Table 2. Milk production was significantly higher for (T) group than (GB) one (540 *vs* 460 ml/day). Fat content (g/kg) was significantly higher for ewes fed triticale pasture than ewes fed green barley pasture (39.1 *vs* 33.6 g/kg respectively). While milk protein content didn't differ significantly between groups. In fact respective protein content was 26 *vs* 24 g/kg for (T) group and (GB) one respectively. These results may be explained by the fact that fat milk content depends of grass fibre which is digested in the rumen and which is directed towards the production of acetic acid which is the precursor of the milk fat. But for milk protein content, it depends of energy intake which was similarly for the two groups (Bocquier and Caja, 2001). For milk fatty acids profile. Stearic acid (C18:0) was significantly higher for (T) group than (GB) one (11 *vs* 8.5% respectively). Oleic acid (C18:1) was also higher for (T) group with 23% in comparison with (GB) one with 21.4%. The same tendency was observed for linoleic acid (C18:2 (n-6)) and linolenic acid (C18:3 (n-3)). In fact, C18:2 (n-6) content was significantly higher with 3.5% *vs* 1.7% for (T) group and (GB) one respectively. Milk from ewes fed triticale have a higher linolenic acid (C18:3 (n-3)) proportion than milk from ewes of (GB) group (0.9% *vs* 0.5 % respectively). Milk from ewes fed triticale have a higher percentage than milk from ewes fed green barley on poly unsaturated fatty acid (PUFA) with 6% *vs* 2.9% for (T) and (GB) respectively. Total unsaturated fatty acid (UFA) also was higher for (T) group than (GB) one with 28.7% *vs* 26.3% respectively. Conversely, CLA content was significantly higher for milk ewes fed green barley (GB) than for milk fed triticale pasture (T) one (7.3% *vs* 3.2 % respectively).

Table 2. Effect of grass species on milk yield, composition and fatty acids profile

	T	GB	ESM	Pr.>F
Milk yield (ml/day)	540	460	36	*
Fat yield (g/kg)	39,1	33,6	3	*
Protein yield (g/kg)	26	24	2	NS
C18:0	11	8,5	0,3	*
C18:1	23	21,4	0,6	*
C18:2 (n-6)	3,5	1,7	0,03	**
C18:3 (n-3)	0,9	0,5	0,02	**
UFA	28,7	26,3	0,7	NS
PUFA	6	2,9	0,5	***
SFA	64,5	66,8	1	NS
CLA	0,32	0,73	0,08	***

*P<0.05, **P<0.01, ***P<0.001, NS: non significant.

IV – Conclusions

The cultivated triticale pastures lead to a higher forage production during vegetative period in comparison with green barley. Besides triticale pastures seems conduct to produce healthier ewe's milk with higher content of PUFA, linoleic acid (n-6) and linolenic acid comparing to green barley except CLA percentage which the highest value was found in ewe's milk fed green barley.

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Challenge the roots. Moving toward a sustainable agriculture

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Abstract. The research would demonstrate how to reduce the total input in a forage system (i.e. fuel, pesticides, chemical nutrients), as well as in any other agricultural system, without decreasing the production. Since 2009 the field test has been carrying out in Sardinia, Italy. An integrated forage system, including leguminous and cereals, deals with minimum and no tillage techniques. The collected data, such as chemical and physical characteristics of the soil, forage quality and quantity at various steps (pasture, hay and grain) represents the input to develop and calibrate a model, or to extend the results to a large scale, in a similar environment. The results determine the feasibility to extend this approach, in several agricultural areas, characterized by a Mediterranean climate, and similar pedological feature

Keywords. Forage system – Leguminous – Minimum tillage – Modelling.

Défier les racines. Évoluer vers une agriculture durable.

Résumé. *La recherche a montré comment réduire les entrées totales dans un système fourrager (combustible, pesticides, nutriments chimiques) ou dans n'importe quel autre système agricole, sans diminuer la production. Depuis 2009, des essais sur le terrain ont été effectués en Sardaigne, Italie, sur un système fourrager intégré, incluant les légumineuses et les céréales, avec des techniques de non-labour et de labour réduit. Les données recueillies telles que les caractéristiques chimiques et physiques du sol, la qualité de forage et des quantités aux différents stades (pâturage, foin et grain) représentent l'information permettant de développer et de calibrer un modèle, ou pour étendre les résultats à une plus grande échelle, dans un environnement similaire. Les résultats déterminent la faisabilité de l'application de cette approche à plusieurs autres regions agricoles bénéficiant d'un climat méditerranéen et ayant des caractéristiques pédologiques similaires.*

Mots-clés. *Système de fourrager – Légumineuses – Labour réduit – Modelisation.*

I – Introduction

The total decoupling application to the aids for the farmers, ratified by the EU CAP (Common Agricultural Policy) in 2003 mid-term review, caused, in Italy, a progressive reduction of the cultivated areas and a progressive land quitting. Moreover, the new European CAP is oriented toward a conversion of the extensive agricultural systems and toward cropping techniques with a lower input and more sustainable from the environmental point of view (Carboni *et al.*, 2007).

Nevertheless an increasing employ of the tillage techniques with a reduced energetic input as the "minimum tillage" or the "no tillage" all over the world, in Europe and especially in Italy, these techniques do not seem to have the same extension and impact (Carboni *et al.*, 2006).

The goal of the research project, started in 2010, is to demonstrate that it is possible to reduce the total inputs (i.e. fuel, pesticides, chemical nutrients) in a forage system, managed both in an integrated and in an organic way, with techniques of minimum or no tillage. This without having a production decrease and, at the same time, reducing the agriculture pressure on the environment. Moreover, the role of the soil as "carbon sink" and its chemical and physical modifications under a correct land-use change will be investigated.

The experimental data will be used to develop a simulation model by which verify the efficacy, or the potential efficacy, of some actions made in the local Rural Development Plan. The model calibration, based on the soil characteristics of the experimental plots, will allow, with the aid of a GIS analysis, to predict the efficacy of the interventions made in areas with the same pedological characteristics (Carboni, 2010).

II – Materials and methods

The field tests, in plots of 150 m^2 adopting a randomised block experimental design with 3 replications, are carried out in Sardinia. An integrated and an organic forage system with leguminous and cereals (self-seeding annual alfalfa, barley, consociation of vetch grass and oat) is managed using both the minimum and the no tillage techniques in two identical grounds placed one near the other with the purpose of making the comparison more efficient. The soil of the whole plots will be sampled at the beginning of each cropping cycle as vegetal samples, during their life cycle, for the quali-quantitative determinations on forages and grains.

The activity has been studying the potential impact on the soils, determining which are most important chemical-physical characteristics, of the different agronomic techniques. The research started from the soil classification, according with the Soil Taxonomy (Soil Survey Staff, 2010), made with the execution of some pedological profiles, and a contemporary sampling of the soil in each plots in order to know the “point zero” of their chemical-physical characteristics. The monitoring of the leading soil physical characteristics: structure stability, bulk density, infiltration capacity, penetrometric tests will be made every 2-3 years.

Yearly soil sampling will be executed with the purpose of studying: the evolution of the organic matter content in the soil, the allotment of the major nutritive elements, the pH modifications and the cation exchange capacity (Ministero Risorse Agricole, Alimentari e Forestali, 1994). These sampling will be made at two different depths: 0-5 cm and 5-20 cm, to satisfy two different research objectives:

(i) to underline the chemical modifications of the soil system that being a “buffer system” needs years to show some substantial modifications, starting from the surface and moving toward the deepness,

(ii) the collected data: chemical and physical characteristics of the soil, forage quality and quantity at various steps (pasture, hay and grain) will be used to develop and calibrate a mathematical model to extend the results to a large scale.

Following the soil evolution under different cultural systems, we will try to answer to the exigency of recovering the fertility, compromised by years of a non-sustainable and unguarded agriculture, and to verify its resiliency capacity. Finally the role of the soil being one of the major “carbon sink” especially under a correct land-use that allows it to accumulate organic matter will be also studied.

III – Results and discussion

The analytical data of the first year of trials are: the physical chemical data of soil profiles, the physical chemical data of soil samples at the “point zero”, the productive data of the various cuttings simulating the pasture or the hay, the productive data of the barley grain and the quality data of the barley grain.

The first approach was to apply a cross tabulation matrix to understand the relationship among the soil constituents. This analysis reveals interesting values, bringing to the attention the correlation between components, sometimes not clear. For instance in the first profile, the correlation between the pF4.2 and Ca and Mg, is pretty tight and the Sodium and Copper. While in the profile 2 the Zn is strongly associated with the pF4.2. Weak correlation is listed for exchange Mg against Bore. These preliminary results confirm that a further analysis is expected to better investigate in the relationship among matrix components.

All productive data were analysed by ANOVA. The qualitative data of the forages productions are, at the moment going on and will be analyzed in the next months. As a first comment, and synthetically, examining the productive data (see the following tables) it could be observed that they seem to be quite good both in the integrated plots and in the organic ones (with the exception of the barley in the organic trial because of a fungal pathology caused by an excess of humidity). Moreover the organic plots have productions very similar to the integrated ones and this result could allow us to suppose that during the years it will be possible to improve them and to clean the grounds without weed killing actions and to avoid the use of chemical fertilizer.

Table 1. Self/seeding annual alfalfa productivity as forage

	Integrated management DM q/ha	Organic management DM q/ha
No tillage and disk seeding machine	49.8 a	48.1 a
No tillage and seeder blade seeding machine	53.8 a	52.3 a
Minimum tillage	38.2 b	48.6 a

In the column means followed by the same letter are not different at P=0.05 (Duncan's test).

Table 2. Barley total productivity as forage and hay

	Integrated management DM q/ha	Organic management DM q/ha
No tillage and disk seeding machine	45.1 a	17.9 a
No tillage and seeder blade seeding machine	39.8 a	21.7 a
Minimum tillage	39.6 a	14.4 a

In the column means followed by the same letter are not different at P=0.05 (Duncan's test).

Table 3. Consociation vetch-oat total productivity as forage and hay

	Integrated management DM q/ha	Integrated management only for hay DM q/ha	Organic management DM q/ha
No tillage and disk seeding machine	33.0 a	47.4 a	25.8 a
No tillage and seeder blade seeding machine	30.4 a	55.4 a	25.3 a
Minimum tillage	34.0 a	81.5 b	39.6 b

In the column means followed by the same letter are not different at P=0.05 (Duncan's test).

Table 4. barley grains productivity and quality parameters

	q/ha	Proteins (%)	Moisture (%)	Hectoliter weight (kg/100 l)	1000 seeds weight (g)
No tillage and disk seeding machine	47.6 a	10.0	13.2	59.20	36.3
No tillage and seeder blade seeding machine	41.3 b	9.9	13.1	59.50	36.0
Minimum tillage	42.0 b	10.7	13.0	58.40	34.3

In the column means followed by the same letter are not different at P=0.05 (Duncan's test).

IV – Conclusions

The fact that the minimum tillage techniques do not compromise a harvest good result if made promptly and with the proper variety should be underlined. As an example the barley grain harvest data, of about 4.8 tons for hectare, is absolutely relevant for our area (south Sardinia) and for the cropping technique. The results are also analysed through the cross tabulation function to put in result the correlations among the components. As expected, the correlations are tight for those elements conditioning the fertility of the soil, weak for those threatening the soil depletions.

Further investigation will be carried out through statistical analysis and data mining.

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Current trends in the transhumant sheep and goat sector in Greece

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Abstract. The transhumant sheep and goat farming system is mainly characterized by the sustainable use of pastures for animal nutrition, low fixed capital endowments and intensive use of human labor. The system is typical for Greece, although it exhibits a constant decline during the last 30 years. The purpose of this study is to provide a thorough presentation of the current situation of the transhumant sheep and goat farming sector in Greece. Through a survey of all relevant public services, data concerning the number of transhumant farms and animals as well as their movements in 2011 are presented. The survey reveals that transhumant flocks are present in the lowlands of most of the regions in Greece and move towards mountainous rangelands of less favored areas (particularly in Macedonia and Epirus). The distances of the movements vary considerably and can be classified as small (within the boundaries of Prefectures), relatively large (mainly within the boundaries of Regions) and large (mainly intra-regional movements).

Keywords. Transhumance – Greece – Movements of transhumant flocks – Sheep and goat farming.

La dynamique et les tendances courantes du secteur ovin et caprin transhumant en Grèce

Résumé. *Le système transhumant ovin et caprin est principalement caractérisé par l'utilisation durable de pâturages et l'utilisation intensive du travail humaine. Il s'agit bien d'un systéme typique pour la Grèce, quoique on constate une diminution pendand les 30 derniers ans. L'objectif de cette étude est la présentation détaillée du secteur transhumant en Grèce. A travers d'une enquête de tous les services publiques relevants, le nombre d'élevages transhumants caprins et ovins, le nombre d'animaux et leurs déplacements principales pour 2011 sont présentés. L'enquête révèle que des élevages transhumants se trouvent presque toutes dans des differentes plaines des régions grecques, et qu'ils se déplacent pendant l'été vers les parcours des montagnes des régions moins favorisées (particulièrement en Macedoine et dans l'Epire). Les distances des déplacements sont classifiées en petites (dans les Prefectures), relativement larges (dans le cadre des régions) et larges (parmi des régions).*

Mots-clés. *Transhumance – Grèce – Déplacements de troupeaux transhumants – Élevages ovins et caprins.*

I – Introduction

Transhumant sheep and goat farming is an extensive animal breeding system, which is typical in Greece. Although historical evidence shows that the rural economy in Greece has been linked to the functionality of this system for centuries, the objective of raising productivity in the sector and changes in the structures of rural societies led to a shift to intensive animal breeding systems in the country, thus seriously constraining the social, economic, environmental and cultural role that transhumance played (Tzanopoulos *et al.,* 2011). Nowadays, tranhumance points towards animal farms which use land and inputs efficiently, in order to produce high quality edible products, which cover for emerging issues among consumers, such as food safety, health and animal welfare, and simultaneously minimize threats on the environment and safeguard resources for the future. Transhumance also constitutes a particularly suitable activity for the development of less-favored areas (Cournut and Dedieu, 2004; Dubeuf *et al.*, 2004; Holeckek *et al.*, 2004) and creates cultural linkages among winter and summer domiciles.

The purpose of this study is to provide insights of the dynamics of the transhumant sheep and goat sector in Greece, through the results of a survey of the records kept by veterinary services throughout the country. Based on the collected data, the main structural characteristics of the sector, the winter and summer domiciles of flocks and their main movements are presented.

II – Materials and methods

The licenses issued by local veterinary services for transhumant farmers in the year 2011, without which flock movements are prohibited, were gathered and analyzed in order to account for the number of transhumant farms, the number of reared animals and their main movements. The Greek Payment and Control Agency for Guidance and Guarantee Community Aid (OPEKEPE) also keeps yearly records of transhumant sheep and goat flocks, however in several cases the data were incomplete or did not account for all transhumant farms. The lack of a consistent database of transhumant flocks does not currently permit the examination of the timely development of the sector or comparisons between transhumant and other sheep and goat breeding systems. Note that the true number of transhumant farms is smaller than what is revealed through the descriptive analysis presented here (approximately 30%), due to the fact that almost all members of farm families are declared as heads of farms, although, in practice, their flocks are under the common management of the farm family.

III – Results and discussion

Table 1 shows the main structural characteristics of the transhumant sheep and goat sector in Greece. In 2011, there were 4252 transhumant sheep and goat farms in the country, which rear 1.14 mil. animals or approximately 7,5% of the total sheep and goat population in Greece. Their vast majority is situated in Thessaly (30.1%) and Central Greece (19.8%). These two regions account for more than half of transhumant sheep and goats (51.6%). The mean size of transhumant flocks in the northern part of the country (Macedonia, Thessaly) is considerably higher than the respective flock sizes in southern regions (Central Greece and Peloponnese).

Table 1. Structural characteristics of transhumant sheep-goat farms in Greece (2011) (winter domiciles)

	Transhumant farms (number)	Reared animals (number)	Mean farm size (number of animals)	Classification of farms					
				Reared animals					
				<100	101-200	201-300	301-400	401-500	>500
Western Macedonia	25	8741	349.6	1	3	5	6	7	3
Central Macedonia	249	72371	290.6	18	40	76	77	21	17
Eastern Mac.-Thrace	150	50220	334.8	14	18	32	38	26	22
Thessaly	1311	401366	306.2	182	222	269	320	160	158
Epirus	451	103806	230.2	102	142	98	60	23	26
Central Greece	844	188659	223.5	148	286	197	151	37	25
Peloponnese	608	143515	236.0	77	219	175	71	41	25
Crete	614	173888	283.2	134	134	128	112	57	49
TOTAL	4252	1142566	268.7	676	1064	980	835	372	325

An examination of the geographical dispersion of the winter domiciles of transhumant farms (Table 2) reveals considerable differences in the composition of transhumant flocks between Regions. Almost 42.5% of the transhumant farms under consideration are engaged in sheep rearing; these farms prevail mainly in Central Greece and Thessaly, where they account for 53.9% and 47.5% respectively. On the other hand, goat farms are abundant in Central Macedonia (41.8% of transhumant farms in the Region) and Peloponnese (35.2%). Sheep and goat transhumant farms are more typical for Epirus (50.3% of transhumant farms in the Region) and Crete (45.4%). On-field experience and discussions with local veterinary services revealed that most of these flocks consist mainly of sheep; nonetheless, it is not yet possible to make accurate calculations using the available data.

Table 2. Winter domiciles of Greek sheep-goat transhumant farms (2011)

	Transhu-mant farms (number)	Sheep		Goats		Sheep and goats	
		Farms	Animals (number)	Farms	Animals (number)	Farms	Animals (number)
Western Macedonia	25	6	1951	14	4459	5	2331
Central Macedonia	249	81	20482	104	32425	64	19464
Eastern Macedonia-Thrace	150	13	2466	55	17305	82	30449
Thessaly	1311	623	190002	293	84383	395	126981
Epirus	451	159	32458	65	15076	227	56272
Central Greece	844	455	92395	85	20112	304	76152
Peloponnese	608	216	39421	214	53869	178	50225
Crete	614	254	56960	81	14564	279	102364
TOTAL	4252	1807	436135	911	242193	1534	464238

Table 3 presents the summer domiciles of transhumant flocks in the country. Apart from Crete Island, where all movements take place on the island, Epirus is the region which accommodates the majority of flocks in the summer (16.9%), followed by Western Macedonia (16.6%).

Table 3. Summer domiciles of Greek sheep-goat transhumant farms (2011)

	Transhu-mant farms (number)	Sheep		Goats		Sheep and goats	
		Farms	Animals (number)	Farms	Animals (number)	Farms	Animals (number)
Western Macedonia	708	319	111331	244	70661	145	59739
Central Macedonia	234	93	23533	78	22719	63	18318
Eastern Macedonia-Thrace	157	13	2466	62	20975	82	30449
Thessaly	545	223	51284	87	25081	235	59636
Epirus	717	341	82942	70	16644	306	85669
Central Greece	639	330	65302	72	16640	237	56145
Peloponnese	638	234	42317	217	54909	187	51918
Crete	614	254	56960	81	14564	279	102364
TOTAL	4252	1807	436135	911	242193	1534	464238

An examination of Table 4 yields information concerning the main movements of transhumant flocks. Small within-Prefecture movements prevail in the summer, as they stand for 44.7% of all movements; they can be detected in almost all Greek Prefectures. Movements which do not exceed 50 km concern neighbouring Prefectures of Thrace (from Rodope to Xanthi) and Central

Greece (from Aitoloakarnania to Fokida and Evritania). The third category includes movements of 51-100 km, particularly from Thesprotia to Ioannina (Epirus), from Aitoloakarnania and Fthiotida to Evritania (Central Greece) and Arta (Epirus) and movements from lowlands to semi-mountainous areas of the island of Crete. Movements from 101-200 km occur from the lowlands of Larisa (Thessaly) to Grevena (Western Macedonia) and Ioannina, from Aitoloakarnania to Ioannina as well as movements from Preveza to Ioannina in Epirus. Finally, titneraries over 200km include those from Thessaly to the northern parts of Western Macedonia and Ioannina, as well as from Fthiotida to Trikala (Thessaly) and from Thesprotia to Western Macedonia.

Table 4. Categorization of movements of transhumant flocks according to distance in 2011. Number of flocks

Winter domiciles	Range of movements					Total
	Small within-Prefecture	<50 km	51-100 km	101-200 km	>200 km	
Western Macedonia	17	0	8	0	0	25
Central Macedonia	187	17	10	27	8	249
Eastern Macedonia-Thrace	115	35	0	0	0	150
Thessaly	342	6	215	513	235	1311
Epirus	210	31	125	65	20	451
Central Greece	227	220	149	199	49	844
Peloponnese	405	44	145	11	3	608
Crete	396	2	186	30	0	614
TOTAL	1899	355	838	845	315	4252

IV – Conclusions

The transhumant sheep and goat farming system in Greece is a dynamic animal breeding activity. The descriptive analysis of the current situation in the sector, presented above, illustrates its dynamics and reveals its potential for the future. Nonetheless, in order to fully comprehend its current role in the Greek rural economy and to formulate integrated strategies for the sector, a multi-dimensional approach is necessary. This would include the examination of transhumant farms from a social and economic perspective, by combining the results with an examination of the ecological effects of transhumant flock movements, especially on rangelands in winter and summer domiciles, and of the quality of relevant milk and dairy products.

Acknowledgments

The authors gratefully acknowledge the financial support of the European Union through the Action “THALIS” of the Programme “Education and Life-long learning”

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Root colonization of hybrid maize cultivars by mycorrhizal and pathogenic fungi at establishment in an acid soil with high phosphorus content

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Abstract. The formation of arbuscular mycorrhizas (AM), a symbiosis between roots and Glomeromycetes that improves P nutrition, health and stress tolerance of plants, can be important for establishment of maize in acid soils. In this work, a field experiment was set up in a limed acid soil with high Olsen-P content to study the colonization of roots by AM fungi and/or other soil borne fungi in 48 maize hybrid cultivars. Plants were under a severe drought at establishment. One month after sowing, AM fungi colonized over 40% of the root length of most cultivars, suggesting a mycorrhizal dependency of these plants to withstand water stress conditions. Ten cultivars presented less than 20% of AM root colonization. As determined by molecular methods, the most frequent AM fungi were *Gigaspora decipiens* and *Glomus* spp. Roots were also colonized by *Pythium* spp., *Fusarium solani*, and *F. oxysporum*.

Keywords. Arbuscular mycorrhizas – AM fungi – *Fusarium oxysporum* – *Pythium* sp. – *Zea mays*

Colonisation des racines des cultivars hybrides de maïs par les champignons mycorhiziens et pathogènes à l'établissement dans un sol acide avec haute teneur en phosphore

Résumé. *La formation des mycorhizes arbusculaires (MA), une symbiose entre les racines et Glomeromycetes qui améliore nutrition phosphorée, la santé et la tolérance au stress des plantes, peut être importante pour leur mise en place dans les sols acides. Dans ce travail, une expérience sur le terrain a été mis en place dans un sol acide chaulées à haute teneur en P Olsen-pour étudier la colonisation des racines par les champignons MA et/ou d'autres champignons du sol transmises dans 48 cultivars hybrides de maïs. Les plantes étaient en vertu d'une grave sécheresse à l'établissement. Un mois après le semis, les champignons AM colonisé plus de 40% de la longueur de la racine de la plupart des cultivars, ce qui suggère une dépendance mycorhizienne de ces plantes à résister à des conditions de stress hydrique. Dix cultivars présenté moins de 20% de colonisation MA des racines. Comme déterminé par des méthodes moléculaires, les champignons MA les plus fréquents étaient* Gigaspora decipiens *et* Glomus *spp. Les racines ont également été colonisés par* Pythium *spp.,* Fusarium solani*, et* F. oxysporum*.*

Mots-clés. *Mycorhizes arbusculaires – Champignons MA –* Fusarium oxysporum *–* Pythium *sp. –* Zea mays.

I – Introduction

In Galicia, a cattle-rearing region in NW Spain, 62,426 ha of maize are grown annually, producing 2,528,334 t of forage mainly used for silage, particularly in intensive dairy farms. The cultivated area and production have almost doubled in the last 10 years, in part as a result of the use of new hybrid cultivars with better productivity and quality.

Phosphorus promotes the initial development of maize, but maize hybrids in general are not efficient at extracting the nutrient (Kaeppler *et al.*, 2000). Also, differences in P uptake efficiency exists among maize genotypes, that can be explained by morphological and physiological plant traits, by environmental conditions, and by interactions of plants and microbes (Zhu and Lynch, 2004; Rosolem *et al.*, 2008; Gautam *et al.*, 2011).

The ability of maize hybrids to form arbuscular mycorrhizas (AM), a symbiosis between the roots and Glomeromycetes that improves P nutrition, health and biotic and abiotic stress tolerance of plants (Smith and Read, 1997), can be important to use more efficiently soil available P and to enhance plant establishment. Arbuscular mycorrhizas also alter the pattern of root exudates, resulting in differences in the microbial composition of the rhizosphere (Linderman, 1992) that could affect root invasion by fungal pathogens. The aim of this work was to study the colonization of roots by AM fungi and/or other soil borne fungi in 48 maize hybrids at establishment in an acid soil with high Olsen-P content.

II – Materials and methods

A field trial was carried out in a 0.3 ha plot located in Mazaricos (A Coruña, NW Spain). The soil was acidic (pH 4.8), and with high Olsen-P (46 mg/kg) and available K (220 mg/kg) contents. Forty eight commercial cultivars of forage maize hybrids were planted in a randomised block experiment with three replicates. In May 2011, after tillage, 150 kg N/ha, 175 kg P_2O_5/ha, and 250 kg K_2O/ha were applied. To prevent cutworms and wireworms, chlorpyrifos (5%) was applied in the furrow line at planting and, for the control of spontaneous vegetation, a pre-emergence herbicide consisting of acetochlor (45%) and terbuthylazine (21.5%). On May 18th, 2011, in each block, each forage maize cultivar was planted in three 4 m long rows. The planting density was 90,000 plants/ha.

One month after planting, in each block, three plants (shoot and roots) of each cultivar were carefully removed from soil in every replicate. The shoots were dried at 80ºC in an oven to determine dry weight. For each plant, a sample of the roots was cleared and stained with trypan blue (Phillips and Hayman, 1970) to estimate the percentage of root length colonized by AM fungi (Giovannetti and Mosse, 1980). Data on shoot dry weight and AM root colonization were subjected to a one way ANOVA. Means were compared by the Duncan test at $P<0.05$.

For detection and identification of pathogenic fungi, pieces of roots were placed in Petri dishes with Komada medium and in Petri dishes with V8 medium. The plates were incubated at 24°C. *Fusarium* colonies were transferred to PDA medium (Potato Dextrose Agar), to obtain monosporic cultures, and *Pythium* colonies were subcultured in V8 medium at 22-24ºC. Both *Fusarium* and *Pythium* species were initially identified by observing macroscopic and microscopic characteristics.

Identification of AM and pathogenic fungi in roots was also carried out by molecular methods. Fungal DNA was extracted from pieces of roots with the EZNA Fungal DNA Mini Kit (Omega Bio-tek). For AM fungi, a region of approximately 550 bp in the SSU rDNA gene was amplified using primers NS31 and AM1 (Helgason *et al.,* 1998). For *Fusarium* species, the ITS region of rDNA and a portion of the gene sequence of the elongation factor 1 α (gene EF-1 α) were studied. DNA was extracted from mycelium of monosporic cultures and amplified with primers ITS1-ITS4 and EF1-EF2, following the methods of White *et al.* (1990) and O'Donnell *et al.* (2000), respectively. For *Pythium* isolates, DNA was amplified by a semi-nested PCR using primers DC6-ITS4 in the first round and ITS6-ITS4 in the second (Cooke *et al.*, 2000). The amplified products from all fungal species were purified and sequenced on a ABI PRISM 3130 (Applied Biosystems), comparing the obtained sequences with those deposited in GenBank and, for *Fusarium* species, in the *Fusarium* comparative database of the Broad Institute.

III – Results and discussion

At establishment, plants were under severe water stress. There was no rainfall after planting and the initial plant growth was supported by the soil water reservoir, which was soon depleted since the water balance in the first months growth was highly negative (-89 l/m^2 and -121 l/m^2 in May and June, respectively). Together with the acid pH, low soil moisture probably resulted in a low availability of nutrients in the rhizosphere, particularly phosphorus (Gahoonia *et al.,* 1994).

Maize cultivars significantly differed in growth, ranging from 240 mg DM/plant for 'Jumbo 48' to 950 mg DM/plant for 'Automat' (average 548 mg DM/plant) (data not shown). These differences might be partly explained by different morpho-physiological responses to deficient water and P availability, but also to the ability of cultivars to form arbuscular mycorrhizas (Boosma and Vyn, 2008). Modern maize genotypes have been selected under conditions of good soil P fertility, what explains that, when no other factors are limiting, under high soil P conditions the percentage of root length colonized by AM fungi (below 20%) and plant growth are lower than at low P (Kaeppler *et al.,* 2000). In our work, all cultivars formed the mycorrhizal symbiosis, although not with the same AM fungus. Molecular analysis showed that the most frequent AM fungi colonizing roots were *Gigaspora decipiens* and *Glomus* spp. (data not shown).

AM fungal colonization ranged from 3.8 % (cultivar Jumbo 48) to 75 % (cultivar DKC 4888) of total root length. Ten maize hybrids presented less than 20% of AM root colonization, but most of them (thirty one cultivars) showed over 40% of the root length colonized, suggesting a mycorrhizal dependency of these plants to obtain water and nutrients, particularly P, under soil moisture stress and acidic conditions. AM fungi have been shown to enhance early maize P nutrition and growth at low fertility conditions, but also in drought environments with high soil P levels (Sylvia *et al.,* 1993). Fungal contribution to water and nutrient uptake is done through mycorrhizal hyphae, that extend far beyond the rhizosphere and act as an extension of the root system (Ruiz-Lozano and Azcón, 1995; Smith and Read, 1997).

The major effect of the AM symbiosis is to enhance uptake of P, and also other scarcely mobile nutrients and water, but AM fungi can also play an important role in the control of root fungal pathogens (Linderman, 1992). In our work, morphological and molecular analysis demonstrated that roots from all maize cultivars were colonized by *Pythium* spp., *Pythium irregulare*, *Fusarium solani*, and *F. oxysporum* (Table 1), independently of the AM fungus found in their roots was *Glomus* spp. or *Gigaspora* spp. and of the percentage of AM root colonization. This is in contrast with the results of Maherali and Klironomos (2007), who concluded that fungi in the Glomeraceae colonize more extensively plant roots, form less external hyphae, and are more effective at reducing infection by either *F. oxysporum* or a *Pythium* sp. in *Plantago lanceolata* that fungi in the Gigasporaceae.

IV – Conclusions

Soil low pH and water shortage may have resulted in difficulties in uptake of P and other poorly mobile nutrients by commercial hybrid cultivars of forage maize in the high-P cultivated soil, which led to extensive colonization of roots by AM fungi. Differences in AM root colonization and plant growth at establishment suggest differences in mycorrhizal dependency of the maize hybrids under water and nutrient stress conditions. Arbuscular mycorrhizas did not prevent invasion of roots by species of *Fusarium* and *Pythium*, although it cannot be discarded an increased tolerance of maize hybrids to these pathogenic fungi mediated by the symbiosis.

Table 1. Co-occurrence of pathogenic fungal species in roots of 48 maize cultivars

Pythium sp.	*Pythium irregulare*	*Fusarium solani*	*Fusarium oxysporum*	Nº maize cultivars	Maize cultivars
				11	Alexxandra, Amanatidis, Anjou 456, Atlético, DKC 4372, DKC 4608, Gladi, GW 001, Happy, Marcello, Organza
				15	Altius, Bonpi, Columbia, Francisco, Ginko, Goldigest, Jennifer, Lucan, LG 33.85, Manacor, LG 32.76, Pesandor, Rulex, ZP 305, ZP 409
				14	Automat, Bora, Brandy, Delli, Dixxmo, DK 315, DKC 4888, Stern, Fortim, ES Sigma, Es Fortress, Lemoro, LG 32.77, Mass 33.A
				5	BC 244, ES Sensor, Josquin, Mamilla, Phileaxx
				1	Jumbo 48
				1	Castelli
				1	Mas 23.B

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Irrigated fodder as the pillar of cattle products' supply chains in the South Mediterranean area: present situation and future prospects

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Abstract. Recent evolutions of livestock systems in the South Mediterranean area converge towards an intensification of production. Rangeland systems located in rain fed areas may not be sufficient to ensure the supply of animal proteins. As a consequence, increased efforts are needed to get more milk and meat from irrigated areas, which imply a steady output of high quality forage. The study of water uses by livestock in irrigation schemes requires a complex methodology, which has to take into account various functions of production: (i) from water volumes of different sources to fodder (quantity of biomass and its distribution throughout the seasons) and then (ii) from forage to cattle products (both milk and meat at the same time as farms are often not specialised). Moreover, climate change affects water availability and intense pressure on groundwater may put at risk many livestock systems. In this study, we take the example of the Tadla large scale irrigated scheme (105,000 ha) to present the issue of water productivity through cattle. Then, we discuss the future prospects of this topic, given the possibilities of on-farm intervention to achieve a "Livestock Revolution": improving farms' income with a sustainable use of the available water resources.

Keywords. Cattle systems – Forage – Groundwater – On-farm intervention – Water productivity.

Les fourrages irrigués en tant que pilier des chaînes d'approvisionnement en produits bovins dans le Sud de la Méditerranée : situation actuelle et perspectives

Résumé. *Les évolutions récentes des systèmes d'élevage dans le Sud de la Méditerranée montrent une intensification de la production. En effet, les systèmes pastoraux situés dans les zones pluviales ne peuvent plus assurer l'approvisionnement en produits animaux. Par conséquent, davantage d'efforts seront nécessaires pour obtenir plus de lait et de viande à partir des zones irriguées, ce qui induit une production stable de fourrage de bonne qualité. L'étude des usages d'eau par l'élevage dans les zones de grande hydraulique requiert une méthodologie complexe, qui doit intégrer différentes fonctions de production : (i) des volumes d'eau aux fourrages (quantité de biomasse et sa distribution au cours des saisons) et (ii) des fourrages au lait et à la viande, car les exploitations d'élevage bovin ne sont pas spécialisées. En outre, les changements climatiques affectent la disponibilité en eau et la pression sur les nappes peut compromettre la durabilité de nombreux systèmes d'élevage. Dans cette étude, le périmètre de grande hydraulique du Tadla (105 000 ha au centre du Maroc) est pris en exemple pour présenter la problématique de la valorisation de l'eau par l'élevage. Puis, nous discutons des conséquences de cette thématique, sous l'angle de l'intervention dans les exploitations agricoles afin de réaliser une « Révolution de l'Elevage » : améliorer les revenus avec un usage durable des ressources.*

Mots-clés. *Eau souterraine – Fourrage – Intervention – Systèmes bovins – Valorisation de l'eau.*

I – Introduction

Since the early 1950s, the South Mediterranean area has been experiencing important shifts in its food supply. For instance, the Maghreb (Algeria, Morocco and Tunisia) countries used to be net exporters of agricultural goods, mainly cereal grains and livestock products (Miège, 1961).

However, they have become importers of food, due to a rapid demographic growth. In fact, the case of Morocco clearly illustrates this food dependency, even though ambitious agricultural policies have been implemented. In the specific field of livestock products, there has been a marginalisation of range land systems and a trend of intensification, through two complementary directions: (i) the emergence of modern poultry facilities, based on totally imported inputs, and (ii) the settlement of dual purpose (milk and meat simultaneously) cattle smallholder farms, using imported breeds (Sraïri, 2011). In less than 40 years, a dairy chain has been entirely set-up, based on a fragmented offer (almost 700,000 farms which often have less than 5 cows), with more than 60% of milk originating from large scale irrigated schemes. Therefore, the supply of cattle products is largely dependent on irrigated fodder. In the near future, such a phenomenon is expected to develop, due to climate changes and the increase in milk and meat demand, which might put pressure on groundwater resources (Wada *et al.*, 2012). As a consequence, there is a need to assess more precisely the intervention possibilities to improve water productivity through cattle (Le Gal *et al.*, 2009). This might also assist farmers and the operators in the supply chains to think to sustainable ways to use water and to increase their incomes.

II – Materials and methods

A close monitoring of six smallholder farms' cropping and rearing practices has been implemented to assess water productivity through cattle (Table 1). The study sample was representative of the farms located in the Tadla (105,000 ha centre east of Morocco) irrigation scheme, with none of them having access to groundwater. The protocol consisted in an analysis of a chain of production functions: (i) from water volumes (rainfall and irrigation network) to forage biomass, and (ii) from forage and other feed complements to cattle products (milk and live weight gain).

Table 1. Characteristics of the sample study farms in the Tadla irrigated scheme

Farms	1	2	3	4	5	6
Arable land (ha)	5.0	6.3	6.5	1.4	1.6	1.8
Total fodder crops area (ha)	2.7	3.4	2.6	0.8	0.8	1.0
Alfalfa (ha)	2.0	2.0	2.2	0.8	0.8	1.0
Herd characteristics (Unit)						
Lactating cows	6.5	7.0	6.4	2.0	2.0	3.0
Growing cattle	5	7	6	2	2	3

A further reflection on the intervention possibilities to enhance water productivity through cattle farming in irrigated schemes was initiated. It consisted in testing balanced dietary rations to feed lactating cows. Its effects on milk yield were assessed. A final discussion on the means to achieve a "Livestock Revolution" was elaborated: getting more milk and meat and improving farms' incomes in semi arid irrigated areas, with a sustainable use of water resources.

III – Results and discussion

Results show that the overall performances of cattle farms are widely variable (Table 2). For example, the mean annual output of alfalfa dry matter was only 9.09 ± 0.75 tons/ha, far from its potential. Similarly, the mean annual milk yield per cow did not exceed 2,170 kg. Indeed, from irrigated fodder to cattle products, evident losses appear, due to inappropriate farming practices, like insufficient water availability, imbalanced cattle feeding and poor hygiene. As a consequence, the average profitability per cow is weak (less than 230 € per year including the value of calves' sales), because the price cost of milk is often higher than farm gate milk price. In fact, only the calf crop allows a majority of farms to reach an economic equilibrium. Therefore, live animals' sales represent a strategic income for farms, whereas milk enables them to get a steady cash flow to face daily expenses. These trends result on a highly perfectible water productivity through cattle: 1.8 m^3 per kg of raw milk and 10.6 m^3 per kg of live weight cattle. All together, these results imply that measures are needed to ensure the competitiveness of dairying with irrigated fodder in irrigated schemes, with regard to other agricultural (fruits, vegetables, etc.) or non agricultural (tourism or industry) activities. This happens at a time where water scarcity is becoming a priority item for Morocco, as rhythms of water consumption are not sustainable, having resulted in the depletion of many aquifers.

Table 2. Technical performances of irrigated cattle farms: from water productivity to profitability

Farms	1	2	3	4	5	6
Alfalfa yield (tons of dry matter/ha)	7.97	9.17	9.58	9.82	9.62	8.40
Milk						
Milk output (kg)	14,820	11,900	13,310	6,800	3,800	4,950
Total water used (m^3)	31,170	25,950	22,200	7,750	5,740	8,970
Water productivity through milk (m^3/kg of milk)	2.1	2.2	1.7	1.1	1.5	1.8
Meat						
Total live weight gain (kg)	2,100	1,740	1,770	430	710	1,290
Total water used (m^3)	19,710	22,500	9,980	3,820	6,720	10,800
Water productivity through meat (m^3/kg of milk)	9.4	12.9	5.6	8.9	9.4	8.4

As the diagnosis of water productivity through cattle revealed wide margins of intervention, a protocol was planned to promote lactating cows' milk yield, by the adoption of balanced dietary rations. It consisted in comparing the cows' true dietary rations with their total optimal requirements, in five farms with cows of different genetic (purebred Holstein or crossbred cows). The potential energy and protein requirements for milk production were determined using models describing variations in daily milk yield during lactation (Wilmink, 1987). These were related to the herds' genetic merit and their average monthly lactation stage.

At each farm visit, the correspondence between cows' nutritional requirements and the true ration was evaluated. A supplementation was suggested to the farmer when a gap was detected. The acceptance of the suggested dietary rations was tested by monitoring cows' average milk yield and noting the farmers' opinion about the changes that were made.

The effects of the continuous correction of the dietary rations according to potential milk yield in a farm with Holstein cows are shown in Fig. 1.

In this farm, characterised by a lactation potential of 23 kg of milk daily at the beginning of the monitoring period, the strategy was adopted in less than two months. In other farms, mainly with crossbred cows (Holstein x local), it took more time to bridge the gap. All together, the results demonstrate the possibility to promote cows' milk yield by a close follow-up of their dietary rations. This requires a relationship of confidence and proximity with the farmers.

The previous results, though achieved with a limited sample of farms, could be of a significant interest if applied to the whole population of herds (almost 55,000 cows) in the irrigated scheme. They would increase the milk output as they would contribute to improve the water productivity through cattle, enhancing its overall competitiveness. Questions remain on the organisation of such an intervention at this scale, due to the withdrawal of State agricultural extension services.

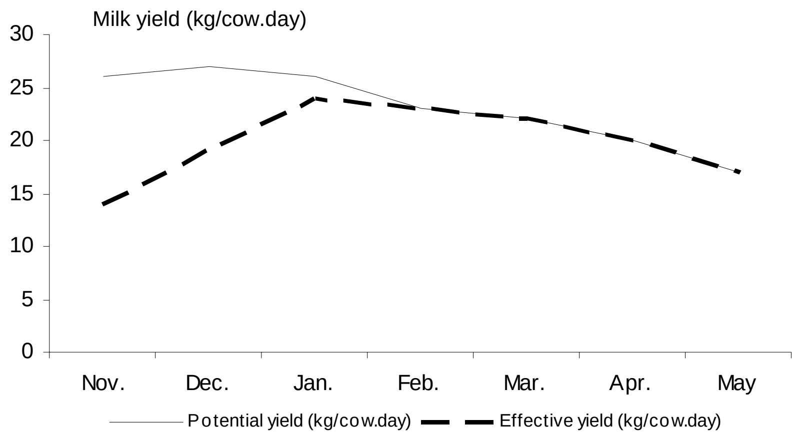

Fig. 1. Effects of the support programme on the average milk yield for Holstein cows.

Another way to improve the water productivity of the dairy chain may be achieved by an enhanced raw milk quality. This topic represents a collective challenge for all the operators of the chain due to the fragmented offer of milk. As a consequence, milk deliveries can only be organised in a two stages process (from farms to collection centres, then to milk plants) which constitutes a significant constraint to assess the quality of each single batch. The set-up of models linking milk quality parameters (fat and protein contents and microbial contamination) in relation to herds' management practices could be useful to avoid costly analyses. Such models would allow designing a grid of milk quality payment, just by the assessment of cattle rearing (feeding, hygiene, etc.) practices. This process has however to be collectively validated by the stakeholders within the dairy chain to improve the quality of milk deliveries (Sraïri *et al.,* 2009).

IV – Conclusions

Recent evolutions in food prices have implied major difficulties to secure the supply. In the Maghreb (Algeria, Morocco and Tunisia) area, which is currently facing a severe water stress, this has led to the increase of food imports, with marked consequences on the balance of trade. Therefore, these countries have to concentrate their efforts on the improvement of their food security, particularly by promoting the domestic output. In the specific field of animal products, the only way to achieve that goal is to promote a "Livestock Revolution": more products with a rationale use of resources. This article deals with that topic, and explores ways to get more milk in semi arid irrigated schemes, with the same amount of water, through a regular production of high quality forage. It shows that the adoption of an on-farm good management practices, like cattle balanced feeding may provide a solution. Another way of intervention consists in improving raw milk quality by the design of grids of payment linking on-farm practices with expected indicators. As the contribution of range land systems is in a steep decrease, the improvement of the supply of milk and meat necessarily requires a better water productivity through herds. Given the numerous roles of forage within agricultural systems (providing cheap nutrients to herds, contributing to the management of soil fertility, etc.), their production and utilization deserve to get more attention from all the stakeholders in the cattle products' chains.

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Legume-cereal mixtures ensiling in Sardinia

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Abstract. Animal feeding accounts more than 50% of farm production costs, often principally due to the protein component acquisition. Cereals and legume mixtures silage could represent an interesting source of high nutritive value forage in non-irrigated lands. Mixtures can provide an adequate proportion of nitrogen and carbohydrates in the ensiling substrates, needed to help lactic fermentation and pH reduction, essential to the conservation process. The aim of this trial was to compare silage of three leguminous-triticale mixtures, in order to obtain a preliminary evaluation for high quality and stable forages production, destined to ruminant feeding in Mediterranean areas. The trial was carried out in Sardinia between autumn 2010 and spring 2011. Mixtures of Triticale (*Triticosecale* WittMack)-white lupin *(Lupinus albus* L.), triticale-pea (*Pisum sativum* L.) and triticale-faba bean (*Vicia faba minor* L.) were evaluated. After six months of ensiling process in glass jars, silage was analyzed, by determining: pH, dry matter, fibrous fractions, crude protein, ash content, NFC+lipids and estimated DM digestibility. Mixtures with pea and triticale Amarillo reached the highest content of DM. When used in mixtures with triticale and in respect to lupin and pea, faba bean obtained the lowest values of NDF, ADF, and ADL and the highest content of NFC+lipids. Faba bean was also able to maintain the highest protein content. Considering the CP content of silage, the 30:70 seeding ratio resulted the more convenient. A more detailed evaluation of obtained results should be performed also considering the biomass production per hectare at farm level.

Keywords. Legume silage – Triticale – *Lupinus albus* L. – *Pisum sativum* L. – *Vicia faba minor* L.. – Small ruminants.

L'ensilage des mélanges légumineuses-céréales en Sardaigne.

Résumé. *L'alimentation animale représente plus de 50% des coûts de production des exploitations, souvent dû à l'acquisition des protéines. L'ensilage de mélanges de céréales et de légumineuses pourraient constituer une source intéressante de fourrage de haute valeur nutritive dans les terres non irriguées. Les mélanges peuvent fournir une proportion adéquate d'azote et de glucides dans les substrats d'ensilage, ce qui est essentiel pour la fermentation lactique, la réduction du pH et la conservation du fourrage. Le but de cet essai était de comparer l'ensilage de trois légumineuses avec triticale, afin d'obtenir une évaluation préliminaire de ces fourrages destinées a l'alimentation des ruminants dans les régions méditerranéennes. Les essais ont été réalisés en 2010/2011. On a testé trois différents mélanges : triticale (*Triticosecale *Wittmack) - lupin blanc (*Lupinus albus *L.); triticale-pois (*Pisum sativum *L.) et triticale-fève (*Vicia faba minor *L.). La qualité des ensilages a été évaluée en déterminant le pH, la matière sèche, les composants fibreuses (NDF, ADF, ADL), les protéines brutes, les cendres, NFC + lipides et digestibilité. Les mélanges avec de petits pois et le triticale Amarillo atteignent le plus haut contenu de MS. La fève a obtenu les plus faibles valeurs de NDF, ADF, ADL et la plus forte teneur en NFC + lipides par rapport au lupin et au pois. La fève était également en mesure de maintenir la teneur en protéines plus élevée. Compte tenu de la CP de l'ensilage le taux d'ensemencement 30:70 était le plus efficace. Une évaluation plus détaillée des résultats obtenus doit être également effectuée pour tenir compte de la production de biomasse par hectare au niveau des exploitations.*

Mots-clés. *Ensilage de légumineuses – Triticale –* Lupinus albus *L. –* Pisum sativum *L. –* Vicia faba minor *– Petits ruminants.*

I – Introduction

Animal feeding represents more than 50% of farm production costs. The biggest nutritional expense is often attributable to the protein component acquisition. Mixtures with legume silage could be a good source of forage of high nutritive value and make a significant contribution to farm economy; specially if it could maintain an high content of protein (CP), high content of non-fibrous carbohydrates (NFC), and low content of neutral or acid detergent fiber (NDF; ADF) and lignin (ADL). In optimal conditions sugars are mainly fermented to lactic acid, required for the indispensable pH decrease and fermentation stabilization. The main problem linked to the ensilage of high protein raw material is to reach a quick biomass pH reduction and rapid protein degradation in non-protein nitrogen (NPN) (Cavallerin et al., 2007). This issue can be solved combining legumes with the cereals, providing adequate quantity of soluble sugars to lead fermentations to lactic. This trial was aimed to identify an ensiling system of Triticale-legume mixture in order to obtain forages with proper chemical characteristics for animal nutrition.

II – Materials and methods

The trial was carried out in Sardinia at Agricultural Research Council experimental fields (Sanluri 39° 31' N, 8° 51' E) between autumn 2010 and spring 2011. White lupin (*Lupinus albus* L; var. 'Multitalia' (L)), pea (*Pisum sativum* L.; var. 'Attika' (P)), and faba bean *(Vicia faba minor* L.; var. 'Prothabat 69' (F)) crops were evaluated in mixture with Triticale (*Triticosecale* WittMack). Two triticale cultivars, var. 'Amarillo 105' (T1) and var. 'Oceania' (T2), were tested with each legume species. Was experiment arranged in completely randomised design (plot size 3000 square feet) with two replication and Triticale-legume mixture proportion were compared: 50:50% (50:50) and 30:70% (30:70); the mixture ratio was defined as seeding ratio. The forages were harvested in two different periods, according to triticale flowering and with a difference of 15 days between Early and Late harvesting. The forages were ensiled in 5-liter capacity glass jars. Thus, after six months of storage, jars were opened and a silage sample was collected from each jar; pH was measured and samples were then dried and milled with 1 mm grid. Chemical composition was determined for: dry matter content, crude protein, fiber components (NDF, ADF, ADL), and ashes. The NDF was determined using the method of Mertens (2002), ADF e ADL as suggested by Van Soest et al. (1991), while Crude Protein (CP) using the AOAC (1990); ashes were determined for incineration at 550°C. The content of non-fibrous carbohydrates and lipids was obtained by difference as NFC+lipids = 100 – (PG + NDF + Ash); the silage digestibility (DMDig) was estimated using the summative equation of Goering and Van Soest cited by Van Soest (1994). Statistical analysis were performed using the Minitab software package (Minitab Inc., 2003). The obtained dataset was analysed using descriptive statistics and Pearson correlations; a General Linear Model (GLM) was also used considering the Triticale variety, leguminous species, mixture proportion, and harvesting period as fixed factors and replication as a random factor, to evaluate differences in chemical composition; interactions were not included in the model and Tuckey test was preferred for comparisons between factors.

III – Results and discussion

Table 1 reports reported the mean values of silage chemical composition observed in the collected samples, while in Table 2 are reported the results of the GLM with the comparisons between the experimental factors. The pH was on average 4.83±0.24 units resulting higher than values of Kriszan *et al.* (2007); however the observed pH in this trial are included in the medium class of pH range observed in Italy (Crovetto, 2008) for cereal and legume silages.

Also according with Crovetto (2008) the pH was positively correlated with the DM ($r = 0.42$; $P < 0.05$), with the NDF ($r = 0.51$; $P = 0.01$), the ADF ($r = 0.38$; $P = 0.07$) and negatively correlated with the NFC+lipids ($r = -0.56$; $P < 0.01$). A significant difference for pH was observed between T1 and T2 (4.92 and 4.75 respectively; $P<0.05$); it was probably due to the higher content in NFC+lipids ($P<0.05$) and the lower DM ($P < 0.05$) of T2 with respect of T1. A big variation in DM was observed ranging from 17.5% to 45.6% (Table 1). Significant differences in DM were observed between mixtures, the highest values mixtures including T1 and Pea; no differences were observed for seeding ratio or harvesting time for DM.

Table 1. Mean chemical composition of silage samples collected in the experimental trial

	pH	DM†	CP††	NDF††	ADF††	ADL††	NFC+ lipids††	ASH††	DM Dig.††
Mean	4.83	29.35	13.10	57.26	37.45	5.35	22.36	7.28	68.61
SD	0.24	7.11	2.26	4.10	3.18	1.01	3.60	0.65	5.46
Max value	5.28	45.61	17.62	65.49	45.34	8.08	29.04	8.62	78.67
Treatment with the max value	T1L 30:70 Early	T1P 30:70 Early	T1F 30:70 Early	T1L 50:50 Early	T1P 30:70 Late	T1P 50:50 Late	T1L 50:50 Late	T2L 30:70 Early	T1L 30:70 Early
Min value	4.31	17.54	9.20	48.23	31.18	3.53	13.61	5.72	56.14
Treatment with the min value	T2P 30:70 Early	T1L 30:70 Early	T2L 30:70 Early	T1F 50:50 Early	T2P 50:50 Early	T2P 50:50 Early	T2F 50:50 Late	T1P 50:50 Late	T2F 50:50 Late

†% AF; ††% DM.

Table 2. Estimated means (LMSE) of silage chemical composition by the 4 fixed factors included in the GLM. Standard deviations from the mean are reported in italic

	Triticale		Legume			Seeding ratio T:L†		Harvesting††	
	$T1_{Amarillo}$	$T2_{Oceania}$	Faba	Lupin	Pea	30:70	50:50	Early	Late
pH	4.92a	4.75b	4.80	4.83	4.86	4.84	4.82	4.88	4.79
	0.47	*0.47*	0.06	0.06	0.06	0.05	0.05	*0.05*	0.05
DM	32.30^{a}	26.40^{b}	27.26^{b}	26.92^{b}	33.87^{a}	29.44	29.26	28.60	30.10
	1.20	*1.20*	*1.47*	*1.47*	*1.47*	*1.20*	*1.20*	*1.20*	*1.20*
CP	13.48	12.72	15.19^{Aa}	11.36^{Bc}	12.75^{Bb}	13.61^{a}	12.59^{b}	13.43	12.77
	0.30	*0.30*	*0.36*	*0.36*	*0.36*	*0.30*	*0.30*	*0.30*	*0.30*
NDF	58.15	56.36	54.46^{b}	58.30^{a}	59.01^{a}	56.80	57.22	57.88	56.63
	0.73	*0.73*	*0.09*	*0.09*	*0.09*	*0.73*	*0.73*	*0.73*	*0.73*
ADF	38.25	36.65	35.41^{b}	38.21^{a}	38.74^{a}	37.38	37.52	37.51	37.40
	0.59	*0.59*	*0.72*	*0.72*	*0.72*	*0.59*	*0.59*	*0.59*	*0.59*
ADL	5.71	4.98	5.28	5.02	5.75	5.34	5.36	4.98	5.72
	0.17	*0.17*	*0.21*	*0.21*	*0.21*	*0.17*	*0.17*	*0.26*	*0.17*
NFC +lipids	21.16^{b}	23.57^{a}	22.92	22.63	21.54	22.19	22.53	21.17^{b}	23.55^{a}
	0.66	*0.66*	*0.81*	*0.81*	*0.81*	*0.66*	*0.66*	*0.66*	*0.66*
Ash	7.20	7.35	7.43^{B}	7.70^{A}	6.70^{B}	7.40^{*}	7.15^{**}	7.51^{A}	7.04^{B}
	0.08	*0.08*	*0.10*	*0.10*	*0.10*	*0.08*	*0.08*	*0.08*	0.08
DM Dig.	72.7^{A} *0.66*	64.50^{B} *0.66*	68.93^{ab} *0.80*	70.27^{a} *0.80*	66.62^{b} *0.80*	69.00 *0.66*	67.72 *0.66*	68.23* *0.66*	67.72** *0.66*

†Seeding ratio (triticale:legume).
††Late was delayed by 15 days from Early.
†††DM digestibility estimated with summative equations (Van Soest, 1994).
A, B, C = P<0.001; a, b, c = P<0.05 ; *,** =P<0.1: within rows of the same factors, different superscripts indicate significant differences.

Protein content of silages varied from 9.2% to 17.6% of DM with an average value of 13.1±2.26%; it varied principally with the legume species used (P < 005); the highest CP was achieved using Faba instead Pea or Lupin (Table 2). Faba bean, was also able to maintain the highest protein content; considering the soybean grain price of 2011 in Italy (about a value of 8 € per % of DM per ton) the value of the Triticale-Faba silage was 30 and 20 €/ton higher than the value of Lupin and Pea mixtures. As expected, the use of more legume in the seeding ratio increased the percentage of CP in the silage, an increase of 1% of CP, from 12.6 to 13.6%, was observed for 30:70 in respect to 50:50 ($P < 0.05$), while no differences were observed for harvesting time.

The NDF of silages varied from 48.9 to 65.5% of DM with an average value of 57.3±4.1% of DM; on average, the lowest values of NDF were observed using Faba instead Lupin or Pea ($P < 0.05$). Similar results were also observed for ADF, while no differences were observed for effects of the other experimental factor. No significant differences were observed for ADL content. NFC+lipids varied from 13.61 to 29.04% of DM with an average value of 22.4±3.6% of DM. The NFC+lipids content was higher with the use of Oceania instead Amarillo and in Late with respect to Early harvesting. Estimated digestibility varied from 56.1 to 78.7% of DM, with an average vale of 68.6±5.5% of DM. The highest DM digestibility was observed in mixtures with T1 ($P< 0.001$ from T2) or with Faba or Lupin ($P < 0.05$ from peas;); it showed also high significant differences between legume species used in the mixture, different seeding ratio and harvesting time.

IV – Conclusions

In respect to the chemical characteristics of Triticale-legume silages, two cultivars of triticale, three legume species, two levels of seeding ratio and two harvesting times were evaluated. Relatively to the triticale, and in respect with Amarillo, the cultivar Oceania reached a lower pH of the silage biomass during the storage period, an higher content of NFC+lipids, higher digestibility, and also reached a lower content in DM, indicating a probable more aptitude to ensiling process. Relatively to the legumes used in mixtures with triticale and in respect to Lupin and Pea, Faba bean obtained the lowest values of fibrous components, the highest content of protein and the highest values of energy related compounds. The 30:70 seeding ratio resulted the more favorable for silage CP content. Delayed harvesting (15 days) resulted in an increase of NFC+lipids content of the silage. However, in order to estimate the economic convenience of a mixture of triticale-legume choice at farm level, a more detailed evaluation of obtained results should be performed also considering the biomass production per hectare.

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The quantity and quality of different forage resources (fallow land, grassland and stubble) in the semi arid area of Sétif

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Abstract. This work aims at the knowledge of the pastoral resources productivity and quality used in the Sétifan High Plains. During one year (2003), monitoring the production and the nutritional value of natural pastures, fallow and stubble was conducted in seven farms. This study allowed us to move to the farm plot, specifying the feeding system characteristics; the floristic composition and the resources energetic value studied so far (fallow land, pastures and stubble). The results showed significant differences and varied according to the different seasons. For the grassland, the productivity is 11t/ha. It is of 3 to 4t/ha for stubble and mown fallow; while the production of grazed fallow is of 2t/ha.

Keywords. Productivity – Nutritional value – Forage resources – Semi arid area.

Production quantitative et qualitative des différentes ressources fourragères (jachères, prairies et chaumes) dans la région semi-aride de Sétif

Résumé. *Ce travail vise la connaissance de la productivité et de la qualité des ressources pastorales utilisées dans les hautes plaines Sétifiennes. Le suivi durant une année (2003) de la production et de la valeur nutritive des prairies naturelles, des jachères et des chaumes a été réalisé dans sept exploitations. Cette étude nous a permis de passer du niveau exploitation au niveau parcelle en précisant les caractéristiques du système d'alimentation, en déterminant le niveau de productivité, la composition floristique et la valeur énergétique des ressources étudiées (jachères, prairies et chaumes). Les résultats obtenus ont présenté des différences significatives et ont été variables selon les différentes saisons d'une compagne. La productivité est de 11 t/ha pour les prairies, de 3 à 4 t/ha pour les chaumes et pour les jachères fauchées, alors que la production des jachères pâturées est de 2 t/ha.*

Mots-clés. *Productivité – Valeur nutritive – Ressources fourragères – Région semi aride.*

I – Introduction

By the nature of its climate, its terrain and its vegetation, by the habits and agricultural practices, Algeria is a country with pastoral and forage (Abdelguerfi and Laouar, 2003). However, forage production is limited compared to the needs of existing livestock. So the low interest shown by governments in the development of pastoral resources has led to inefficiencies in land management and environmental degradation, resources are increasingly uncertain. An analysis of the forage balance reported by SI Ziani (2001) helped to highlight the persistence of a fodder deficit estimated at 4 million forage units (UF)/year. Forage production provides local coverage of the needs of livestock by 52%, but the contribution of stubble and straw (3 million of UF) can increase the coverage rate to 82%. This situation arises because the sole forage is limited to low value and relatively low food resources. Our study is the evaluation of the nutritional value of key resources available for livestock grazing (productivity, species composition, and energy) in the Sétif High Plains at key moments of the operating cycles of farming systems and vegetation.

II – Materials and methods

Sétif region is characterized by a Mediterranean climate, the level of rainfall increases from south to north and is between 300 and 600 mm. Thus the study was conducted on seven representative farms in a north-south axis corresponding to the gradient of aridity, having all of them fallow (mowed or grazed), natural grasslands and stubble of barley or wheat. Monitoring was conducted over a year, the series of surveys carried out on major food resources was determined using the operating period of each resource, the sampling method used is the square sets (Bellon and Guérin, 1992). The species collected were divided into three groups: grasses, legumes and other categories of plants, identified following the nomenclature of new flora and Santa Quézel Algeria (1962-1963). The nutritional value of forage harvested from different resources is determined by chemical analysis to evaluate dry matter (DM), the total nitrogenous matter (TNM), mineral matter (MM), crude fiber (CF) the organic matter digestibility (OMD) and the energy in unit of forage (UF).

III – Results and discussion

The results of the forage productivity of different resources studied are estimated by the dry matter yields (Table 1). Significant variations are induced by factors of resource type and level of aridity, which fall into two relatively homogeneous groups; grasslands produce the highest yields with an average of 11.01 t DM/ha. Regarding the level of aridity, significantly higher yields are obtained in the north of the region where rainfall is high and the management style is different. Indeed, the enclosure for hay in early winter, fertilizing, weeding and irrigation can permanently yield higher returns compared to farms in the South, with a difference of 4.9 t/ha. The lower yields in the South can be explained by lower levels of rain and the late enclosure (early spring) practice. In fact, the mixed farming of these resources (pasture/hay), although they enjoy a fertilization and irrigation comparable to the North limit forage productivity. Stubble of barley or wheat and mowed fallow, recorded similar yields of about 3 t/ha. Grazed fallow, characterized by the early beginning of use, before the spring plowing, recorded the lowest dry matter yield.

Table 1. Production and nutritional value of different resources considered

Type of resource	Production (t DM/ha)	Chemical composition (%DM)			Digestibility (%)	Energy value (UF/kg DM)
		MM	TNM	CF		
Grasslands						
Semi-arid higher	13.59	9.45	12.19	20.33	53.5	0.34
Semi-arid lower	8.69	8.7	7.71	26.60	51.98	0.33
Grazed fallow	1.74 ± 1.12^{b}	15.86 ± 5.45^{a}	10.68 ± 2.18^{a}	23.28 ± 8.04^{a}	60 ± 4.87^{a}	0.45 ± 0.09^{a}
Barley stubble	3.32 ± 0.57^{b}	5.89 ± 1.54^{cb}	4.59 ± 0.56^{B}	37.52 ± 4.68^{a}	41 ± 2.99^{c}	0.25 ± 0.25^{c}
Wheat stubble	3.19 ± 1.2^{b}	4.94 ± 0.54^{c}	3.48 ± 0.79^{B}	41.01 ± 3.53^{ba}	42 ± 1.83^{bc}	0.16 ± 0.098^{d}

Concerning the quality forage, hay meadows are composed of 89.34% of grasses, 4.83% legumes and 5.30% of other plants (mainly Compositae, crucifers, buckwheat, and Ranunculaceae).

Regarding the chemical composition and energy content, the results obtained (Table 1) are related to the gradient of aridity. Northern grasslands exhibit higher performance compared to the southern grasslands for all parameters investigated: MM and TNM. However on the membrane constituents, the average CF contents are higher in southern than in northern grasslands with a difference of 6.27%. The same trend is observed for the energy that depends strongly on the OMD, and the average energy value of grassland is 0.33 UF/kg DM (UF: forage units), and is similar in both regions.

The grazed fallow species composition is more balanced. It is characterized by the presence of grasses, legumes and other plants (Compositae), which account for 39.66%, 9.44% and 50.91% respectively, and vary in relation to the previous crop, the fertilization and the phytosanitary treatments. Grazed fallows are used at early stages, and are higher in TNM, MM and are among the most digestible forage due to the high percentage of OMD and the energy value of about 0.45 UF/kg MS (Table 1). Culms of barley and wheat showed low MM and TNM (Table 1), where as the level of CF registered, limits the digestibility of organic matter (41 and 42% respectively for barley and wheat), but the energy value is significantly different between the two types of resources.

However, there is variability in relation to the level of aridity: the stubble of barley in the North record higher levels of OMD (45%) compared to the South (38%). But the stubble of wheat again record similar levels, not depending on the region

IV – Conclusion

From the results, it appears that there is a marked quantitative and qualitative variability between the different sources studied, and the same variation is observed between bioclimatic zones. It also appears that the fields are of great interest as important resources to feed supplies. From the perspective of production, grasslands of the North produce higher quantities compared to the South, while the nutritional values are comparable between the two regions, due to the delay in the operations of mowing.

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Enhancement of agro-pastoral productions in the rural community of M'Nahba (Wilaya of Marrakech – Morocco)

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Abstract. Livelihood in rural communities of Morocco is based primarily on breeding of meat sheep in agro-pastoral systems where forage resources are scarce and mainly represented by cereal residuals and fallow. Intensive sheep grazing and frequent agricultural tillage on cereals, practiced by rural population as a consequence of the abandonment of nomadic life, have progressively contributed to serious soil degradation and erosion. This degradation of the ecosystem has been leading a rural exodus towards urban areas within and outside the country. The present contribution is devoted to illustrate the holistic approach and activities carried out by a bilateral cooperation project Sardinia-Morocco aimed at the rehabilitation of degraded pastures by means of alley cropping, the enhancement of socio-economic conditions and the exchange of knowledge and know-how between Sardinian and Moroccan stakeholders.

Keywords. Mediterranean pasturelands – Self-reseeding forage species – Rehabilitation of degraded soil – Rural development.

Valorisation des productions agro-pastorales dans la commune rurale de M'Nahba (Wilaya de Marrakech – Maroc)

Résumé. *L'économie rurale dans les communautés rurales du Maroc est basée traditionnellement sur l'élevage de moutons pour la production de viande effectué dans des systèmes agro-pastoraux dynamiques et très fragiles. Les ressources fourragères sont rares et essentiellement représentées par les résidus des céréales ou des mauvaises herbes sur la jachère: intense et irrationnel pâturage des animaux et fréquents travaux du sol pratiqués sur les céréales contribuent à la dégradation des sols et à l'érosion. En ce contexte, les conditions de vie des populations locales résultent difficiles et l'exode rural est en cours. La présente contribution est consacrée à illustrer l'approche holistique et les activités menées par le projet de coopération international "Valorisation des productions agro-pastorales dans la commune rurale de M'Nahba (Wilaya de Marrakech - Maroc), à travers la réhabilitation des pâturages dégradés et l'échange de connaissances et de savoir-faire entre les stakeholders de Sardaigne et Maroc".*

Mots-clés. *Pâturages méditerranéens – Plants fourragères à ressemis naturelle – Réhabilitation des sols dégradés – Développement rural.*

I – Introduction

The rural area of *M'Nahba* features a Mediterranean climate, characterized by an alternation of hot and dry weather during spring and summer and mild temperatures during the winter months. The annual rainfall is scarce, with an average of 150-200 mm, and concentrated between November and March. The landscape is characterised by a highly-degraded and fragile hilly profile, exposed to water and wind erosion which led to progressive desertification processes seriously compromising soil fertility (UNCCD, 2008).

The primary agricultural activity in the area is the breeding of meat-sheep and the production of heavy lamb, highly demanded by local communities during the Eid al-Adha, the Muslim festivity celebrated at the end of Ramadan. Considering the scarcity and the poor quality of forage resources, mostly represented by cereal residuals and fallow, there is a considerable gap between the flock feed demand and the actual availability of forage production in the area. At present farmers are increasing the stocking rate and extending crop cultivations in marginal lands, often with unsuitable species, varieties and crop management practices. In order to stimulate re-vegetation and enhance the scarcity of fodder production, the EU cooperation project SMAP II (http://www.uniss.it/nrd/smap/) promoted the use of drought-resistant forage shrubs, such as *Atriplex nummularia* and *Opuntia ficus-indica*, in highly degraded extensive pasturelands, positively impacting in the status of the ecosystem and partially fulfilling the feed requirements of the flocks. Nevertheless, the surface between rows of the shrubs planted in the framework of SMAP II project is yet nearly unproductive, recording a low grass coverage (<20%), a low plant diversity and a scarce nutritive value of the herbaceous species grazed by flocks. Consequently, a deficit in forage production still exists, remarkably during drought years (DPA, 2009). In similar conditions, the "alley cropping" with understorey species planted among shrubs showed to be a profitable practice in bettering animal performances, economic return for farmers and in offering environmental benefits (Norman *et al*., 2008).

At present, rural population involved in agricultural activities lacks technical knowledge concerning dietary requirements of sheep and feed nutritional properties. Sheep diets are rather unbalanced in terms of both energy and protein intakes, so that local farmers purchase expensive concentrates from external markets to feed fattening lambs during the last stage before selling. Moreover, the lack of genetic selection and the high inbreeding level within sheep flocks cause a decreasing fertility and a low vitality of lambs (ICARDA, 2007). With reference to the social life within this rural community, a high rate of illiteracy and a low level of professional knowledge and skills occur among women, who at present do not perceive any salary for their work inside and outside their homes. This lack of skills and opportunities urge people, especially the young ones, to emigrate from these rural areas towards cities, especially the nearby Marrakech, and also abroad, particularly to Europe, causing a gradual abandonment of rural environments (UNCCD, 2005).

The present contribution is devoted to illustrate the approach and activities carried out so far by the cooperation project "Enhancement of agro-pastoral productions in the rural community of M'Nahba (Wilaya of Marrakech – Morocco) through the rehabilitation of degraded pastures and the exchange of knowledge and know-how between Sardinian and Moroccan stakeholders".

II – The Project "PROAGRO - Enhancement of Agro-Pastoral Productions in the Rural Community of M'Nahba (Wilaya of Marrakech – Morocco)"

The general objective of the project aims at decreasing the highly advanced desertification processes and soil degradation while enhancing social and economic conditions of local communities. In particular, the project aims at restoring degraded rangelands, diversifying the agro-pastoral production and developing income-generating activities for the local population, thus enhancing natural and human resources. The project actions are also expected to promote the sustainable management of agro-pastoral resources through an active participation of local stakeholders.

The specific objectives of the project are:

- Increasing the quantity and quality of fodder resources available in local pastures;
- Transferring knowledge and know-how to Moroccan stakeholders concerning both

exploitation of diversified plant resources, such as shrubs and pastures, and requalification of the local sheep meat chain;
- Promoting the social and economic role of women in the rural society;
- Creating a network among Sardinian and Moroccan stakeholders with the aim of identifying market opportunities to stimulate socio-economic development of the area mainly within the agro-pastoral sector, addressed to the outcast groups of the rural society, such as women and young people.

Started in October 2011, the project is characterized by a multidisciplinary approach, as the project *consortium* is formed by agronomists, animal scientists, ecologists, agricultural extension services and rural communities populations, belonging to several institutions, namely: Institute for Animal Production System in Mediterranean Environment (ISPAAM–CNR, Sassari), as project coordinator; Desertification Research Group of the University of Sassari (NRD-UNISS); Municipality of Seneghe (Sardinia); Municipality of Santulussurgiu (Sardinia); Sardinian Organisation of Christian International Volunteers (OSVIC); Sardinian Regional Agency in Agriculture Research (AGRIS); Sardinian Regional Agency for the Implementation of Regional Programs in Agriculture and Rural Development (LAORE); and last but not least, the Agricultural Provincial Direction of Marrakech (DPA), belonging to the Moroccan Ministry of Agriculture and Fisheries.

III – Structure of the project

The project is being implemented with four workpackages:

WP1: Enhancement of local plant genetic resources

1.1 Inclusion of native self-reseeding forage species between the rows of *A. nummularia* (alley cropping).
1.2 Renewal pruning and management of existing plantations of *A. nummularia*

WP2: Empowering technical knowledge of rural population

2.1 Sharing of successful initiatives experienced in Sardinia in the field of pasture improvement and enhancement of the meat chain. This activity will involve Moroccan stakeholders and immigrants living in Sardinia and small Sardinian associations and cooperatives operating in the agro-pastoral sector.
2.2 Strengthening skills and knowledge of Moroccan farmers and technicians through training sessions concerning feed rationing and meat production techniques, addressed to rural farmers and local extension service agents, carried out by Moroccan and Italian trainers.
2.3 Genetic improvement of livestock in the local community through the introduction of new selected rams, in order to improve the fertility of the flock and to increase the meat production, impacting positively on farmers' income.

WP3: Improving social condition of rural women. The project will strengthen the knowledge of women in craft techniques, such as weaving, knitting, sewing and embroidery, along with the promotion of female literacy and basic accounting. In this manner, women will learn the management of family budget and will generate additional income by alternative activities.

WP4: Transfer of successful entrepreneurship cases. The project will stimulate a series of exchange meetings involving Project partners and Moroccan actors (institutions, cooperatives, Moroccan immigrants in Sardinia, local community representatives) to identify successful entrepreneurship experiences carried out in the Sardinian agro-pastoral communities which could be replicated in the project area, giving a concrete and immediate response to the needs of the Moroccan communities.

The experimental trial designed for the enhancement of forage resources and planned in the action 1.1 of WP1 began in November 2011. The inter-rows of two fields of *A. nummularia*, planted at 3.5 m x 3.5 m, located in the *douar* of Ouled Ayyachi and in the *douar* of Ouled Aliate respectively, were sown with different mixtures of native self-reseeding forage species. These species were locally produced at the *"Centre de Production des Semences Pastorales Khemiss Mtouh"* (CPSP) of El Jadida (Morocco).

In each field, seven different plots were identified and seven mixtures (T) were tested:

T1: *Medicago scutellata* (25 kg ha^{-1}) + *Lolium rigidum* (4 kg ha^{-1}) cultivated in 3 ha;

T2: *Medicago polymorpha* (25 kg ha^{-1}) + *Lolium rigidum* (4 kg ha^{-1}): 3 ha;

T3: *Medicago scutellata* (12.5 kg ha^{-1}) + *Medicago polymorpha* (12.5 kg ha^{-1}) + *Lolium rigidum* (4 kg ha^{-1}): 3 ha;

T4: *Medicago scutellata* (8 kg ha^{-1}) + *Medicago polymorpha* (8 kg ha^{-1}) + *Medicago truncatula* (8 kg ha^{-1}) + *Lolium rigidum* (4 kg ha^{-1}): 1 ha;

T5: *Lolium rigidum* (35.5 kg ha^{-1}): 2 ha;

T6: Control (natural vegetation covering): 1 ha;

T7: no seeding and phosphate fertilization: 1.5 ha.

Fertilization was applied in all plots, except for the control, and consisted in the distribution of diammonium-phosphate 18-46-0 (100 kg ha^{-1}) scattered on the soil after the passage of a chisel plow. Broadcast seeding was executed by hand by local farmers in absence of a precision seeding machine in the area. Seeds were covered with branches of *Zizyphus vulgaris* dragged by a tractor.

The measurements to be done are: seedling establishment, inter-row soil covering, forage dry matter production, phenology and seed yield.

IV – Preliminary results and discussion

Because of the irregular and scarce precipitation (104 mm), much below the average of last thirty years (250 mm), and an extraordinary frost during the month of February 2012, the establishment and performances of the self-reseeding species was low. However, some differences were shown among the four tested species with M. *polymorpha* and *M. scutellata* showing a better adaptation to the climate conditions of the area. Some differences were found between the experimental fields, too, and it is likely that the earlier sowing carried out in the *douar* of Ouled Ayyachi favoured a higher seedling establishment than in *douar* of Ouled Aliate, thanks to a higher rainwater availability. Further investigations are needed and the effective contribution of our field research is expected to be reached in next project years, testing alternative techniques (i.e. summer sowing) to introduce the legumes into the pastures (Loi and Nutt, 2010).

The actions promoted by the project are working synergically to lay the basis for an immediate social and economical development of the community and assure a long-term sustainability that will last long after the project's completion. It is worth highlighting that one of the peculiar aspects of this project is the promotion and the creation of entrepreneurial perspectives in the agro-pastoral sector.

Acknowledgements

The research was financed by the Sardinian Regional Administration under the Regional Law n. 19, 11th April 1996, "Rules for International Cooperation in Developing Countries".

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Increasing production and improving quality of lamb's meat through grassland cultivation and rotational management

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Abstract. The objective of this study was to evaluate lamb's growth and carcass characteristics on grazed-grassland compared to feedlot (FL) system. The grassland consists in two separate plots of green barley (GB) and perennial ryegrass (RG). Forty five lambs (14.8 ± 2.9 kg live weight (LW)) were divided into three groups. Two groups were conducted on rotational grazing with a stocking rate of 60 lambs per ha, one on GB and the other on RG and received daily 350 g of concentrate per lamb. The last group was conducted on FL with ryegrass hay and the same concentrate *ad-libitum*. The whole grass yield was higher for RG grassland than for GB one. The crude protein content of grass was higher for both species (14%) than ryegrass hay (8.5%). The mean daily herbage availability was 0.850 and 0.720 kg DM per lamb of RG and GB, respectively. Indoor daily intake was 450 g of hay and 650 g of concentrate per lamb. For 60 lambs, the owner needs 2.76 *vs* 2 ha in FL and grassland grazing system, respectively. Lamb's final LW and average daily gain were higher for grassland lambs (28.3 kg and 140 g) than FL ones (26.9 kg and 121 g). The whole LW gain was 176, 200 and 210 kg for FL, GB and RG treatments; which equivalent to 254, 399 and 420 kg LW gain per ha in FL, GB and RG, respectively. Furthermore, grassland lamb's carcasses were less adipose (18%) and contain more muscle (57%) than that of FL (26% fat and 51 % muscle). Grazing grassland with rotational management leads to higher lamb production with higher muscle and lower fat carcass concentrations than FL system. This production system is more economic and resulted in lamb meat with high nutritional characteristics.

Keywords. Grassland – Feedlot – Lamb's growth – Carcass traits.

Augmentation de la production et amélioration de la qualité de la viande des moutons à travers la culture des prairies et le pâturage rationnel

Résumé. *L'objectif de cette étude est d'évaluer la croissance et les caractéristiques des carcasses des agneaux conduits sur pâturage de prairie ou en bergerie (B). Deux types de prairie ont été utilisés, une parcelle d'orge en vert (OV) et une parcelle de prairie permanente de ray-grass (RG). Pour ce faire, 45 agneaux (14,8 ± 2,9 kg de poids vif (PV)) ont été répartis en 3 lots. Deux lots ont été conduits en pâturage rationnel avec un chargement de 60 agneaux à l'ha, un sur OV et l'autre sur RG et reçoivent en bergerie 350 g de concentré/j/tête. Le troisième lot a été maintenu en bergerie avec du foin de ray-grass et du même concentré à volonté. La production totale de biomasse de la parcelle de RG a été plus élevée que celle de l'OV. La teneur en protéines brutes a été plus élevée pour les deux espèces d'herbe (14 %) que pour le foin de ray-grass (8,5 %). La quantité moyenne d'herbe quotidiennement disponible a été de 0,850 et 0,720 kg MS par agneau respectivement pour RG et OV. L'ingestion quotidienne des agneaux en B a été de 450 g de foin et 650 g de concentré par tête. Pour 60 agneaux, la surface nécessaire est de 2,76* vs *2 ha respectivement en bergerie et en prairie. Le PV final et le gain moyen quotidien ont été plus élevés sur pâturage d'herbe (28,3 kg et 140 g) qu'en bergerie (26,9 kg et 121 g). Le gain total de PV était de 176, 200 et 210 kg en bergerie, OV et RG, soit 254, 399 et 420 kg gain de PV à l'ha respectivement de B, OV et RG. En outre, Les carcasses des agneaux de prairie étaient moins grasses (18 %) et contenaient plus de muscle (57 %) que celles des agneaux de la bergerie (26 % gras et 51 % muscle). Le pâturage rationnel des prairies avec de faibles quantités d'aliment concentré engendre une production plus élevée d'agneaux avec plus de muscle et moins de gras que l'engraissement en bergerie avec des quantités importantes d'aliment concentré. Le premier système de production est ainsi plus économique et résulte en une viande de meilleure qualité nutritionnelle.*

Mots clés. *Prairies – Bergerie – Agneau – Croissance – Carcasse.*

I – Introduction

The humid and sub-humid regions of Mediterranean area present an important fodder potential and could play a determining role in ruminants feeding. Traditionally in these areas especially In Tunisia, oat and barley are the most immature cereals used in sheep nutrition. They are generally exploited as green fodder during 3 to 5 months between December and April. The perennial ryegrass (*Lolium perenne*) could be produced for 4 to 6 months; it is more productive (160 %) and has a better nutritive value than oat (Ben Jeddi *et al.*, 1992), and however it is still timidly cultivated in South Mediterranean. Lambs reached slaughter age with a higher weight and less carcass fat when grazing green barley or natural fallow (Atti and Abdouli, 2001) than in feedlot (FL) system. Grazed ryegrass has relative superior nutritional value than grass silage (Kennedy *et al.*, 20005) and than grass hay (Nefzaoui and Chermiti, 1989). Moreover, lambs finished on concentrate were fatter than lambs grazed on perennial ryegrass forage (McClure *et al.*, 1994). Despite these potentialities, information on the effects of this system, compared to FL, on Mediterranean meat sheep production and quality is very scarce. The objective of this study was to compare the growth and carcass characteristics of lambs produced in feed lot system (FL) and on grassland pasture based on green barley (GB) and ryegrass (GR).

II – Material and methods

1. Experimental design and treatments

The experiment was conducted at Lafareg, experimental farm of the National Institute of Agricultural Research of Tunisia (INRAT). The region has a sub humid climate with 650 mm annual precipitation. The experiment was carried out between February and May and lasted 97 days. Forty five lambs (14.8 ± 2.9 kg live weight (LW)) were randomly divided into 3 groups. Two groups were conducted on rotational grazing with a stocking rate of 60 lambs per ha in separate pastures of GB or perennial RG. At the beginning of the experiment, the sward height was 20 cm; when it becomes 7 cm, lambs have been changed for the following paddock and so forth. All grazing groups received a daily supplementation of 350 g/lamb of concentrate. The third group was conducted during the same period on FL and fed individually ryegrass hay (8.5% CP) and the same concentrate, both *ad libidum*. The concentrate was composed by barley (85%), soya bean (17%) and mineral and vitamin complement (3%).

2. Control and measurements

A. Feed collection and analyses

Indoors, uneaten feed were removed daily at 09:00 before supplying fresh feed. Herbage yield was determined before entering each paddock by cutting 15 quadrates (0.25 m^2/ quadrate) of pasture at 8 cm above the ground; the whole dry matter (DM) grass production was estimated according to this sample weight and the paddock area. This permitted the calculation of the herbage level production (mass of DM/ ha). The samplings were pooled and then a sample of approximately 0.1 kg of the collected herbage was dried and preserved for chemical analysis. The mean daily grass availability was calculated as the ratio of paddock grass production by lambs' number and by number of days spent in the paddock. Grass samples were dried, ground through a 1-mm screen, and analyzed for mineral content by ashing at 600°C for 8 h, crude fiber according to Weende method and crude protein according to Kjeldahl method.

B. Animal Measurements

Animals were weighed weekly just prior to feed distribution. At the end of the growth trial, all lambs were slaughtered. Lambs LW before slaughter were recorded. Carcasses were stored for 24 h at +4°C. Cold carcass weights (CCW) were then recorded, tails were removed and each carcass was split longitudinally in two halves. The left half-carcass was cut into six joints. Every joint was weighed and dissected into muscle, fat and bone.

3. Statistical analysis

Statistical analysis was performed by analysis of variance using the GLM procedure of SAS (SAS, 1987).

III – Results and discussion

1. Forage production, diet intake and lamb growth

Herbage production and chemical composition of barley grass and ryegrass were reported in Table 1. The grass amount produced by the whole ryegrass plot during all grazing period was higher than the barley one. The whole grass yield was 1240 and 1050 kg DM, which equivalent to 4.96 and 4.20 tons of DM per ha of ryegrass and barley, respectively. These values confirmed other results on higher production of ryegrass (Ben Jeddi *et al.*, 1992). In respect to stocking rate (60/ha) and experiment duration (97 d), the mean daily herbage availability was 0.850 and 0.720 kg DM per lamb of ryegrass and barley, respectively. The mean CP content of grass was high for both species (Table 1); they contained more CP and less crude fibre than ryegrass hay. The ryegrass plot was grazed twice and there was still herb for the third one. However, the barley growth allowed just 2 grazing periods then the herb became hard and no palatable; the experiment was stopped at this stage. These results suggested, for humid and sub-humid regions of South-Mediterranean, the extension of areas reserved to ryegrass culture instead of barley and oat in the aim to produce more grass for sheep and cattle feeding.

Table 1. Chemical composition of barley and ryegrass cultivate in humid and sub-humid areas in Tunisia

	Barley		Ryegrass	
	Mean	SD	Mean	SD
Dry matter (g/kg)	226	59.3	247	57.3
Organic matter (g/kg DM)	888	8.0	889	7.7
Crude Fiber (g/kg DM)	244	13.4	242	2.0
Crude protein (g/kg DM)	137	9.7	138	5.1
Ash (g/kg DM)	113	9.3	111	8.7

For FL lambs, mean daily DM intake was 1.100 kg as 0.450 kg of hay and 0.650 kg of concentrate. Total intake during the whole period was 655 and 949 kg for hay and concentrate, respectively. The hay and concentrate amounts necessary to 60 lambs would be 2620 and 3780 kg, which equivalent to the production of 0.66 ha (4000 kg/ha) for hay and 2.1 ha (1800 kg/ha) for concentrate. So to produce 60 lambs in FL system, the owner would need 2.76 ha against only 2 ha (1 ha for concentrate and 1 for grass) in grassland grazing system. Hence, the last feeding system constitutes an economic way of producing meat lamb in these areas. Moreover, rearing animals on grassland (more than 70 % water content) would result in a reduction of water consumption. The reduction of water intake by animals should be considered as an important aspect which would resolute the problem of animal watering given the dispersion of watering points in rural areas.

The average daily gain (ADG) was 144, 137 and 121 g for RG, GB and FL treatments, respectively. The low difference between the grazing and FL systems is explained by the high intake of concentrate in the FL system. Consequently, slaughter LW was higher for GB and RG lambs (28.3 kg) than for FL ones (26.9 kg), but it did not differ among GB and RG treatments (Table 2). The higher nutritive quality of the fresh herbage (14 *vs* 8.5% CP for hay) offered in grazing system could engender higher ADG of the lambs in the grazing system. Many studies showed that daily gain of concentrate fed lambs was lower compared to grass ones (Atti and Abdouli, 2001; Nuernberg *et al.*, 2005). Also for dairy cattle and ewes (Kennedy *et al.*, 2005; Atti *et al.*, 2006), milk yield and quality were higher for grass than FL system.

Table 2. Mean live weight (LW), average daily gain (ADG), and cold carcass weight (CC) in feedlot or grazing lambs

	GB	RG	FL	P
LW (kg)	28.0	28.6	26.9	0.06
ADG (g)	137ab	144a	121b	0.07
CC (kg)	11.6	12.4	11.4	ns

The whole LW gain was 210, 200 and 176 kg for RG, GB and FL treatments, respectively; which equivalent to 840, 798 and 702 kg LW gain by 60 lambs for the respective treatments. In relationship with the crop and forage surface necessary to produce 60 lambs, the FL system permits only 254 kg LW gain per ha while grassland grazing system results in 420 and 399 kg LW gain for RG and GB, respectively.

2. Carcass composition

All animals had the same bone but different fat and muscle proportions (Table 3). Bone is a tissue with early development in all-animal species and does not depend on regimen at older ages. However, grass (GB and RG) regimens resulted in a decrease in the fat tissue weight and proportion (18 *vs* 26%) and an increase in muscle proportion (p<0.001). So, carcasses of grazing grass lambs were leaner than carcasses produced on hay and concentrate diets, which confirmed our anterior results (Atti and Abdouli, 2001). Hence and for the similar amount of muscle, the mean fat weight of grass grazing sheep represented 0.71 times of fat weight for FL groups; which equivalent to a reduction of 80 g of fat per kg of carcass. Increased fat deposition in concentrate fed animals compared to those on pasture has been reported by several authors (Borton *et al.*, 2005; Nuerberg *et al.*, 2005).

Table 3. Carcasses composition of lambs in feedlot or grazing system

	GB	RG	FL	SEM	P
Muscle % (CW)	56.7a	57.6a	50.7b	0.76	0.001
Bone (% CW)	23.3b	22.7b	21.1a	0.99	0.01
Fat (% CW)	17.7b	17.7b	26.0a	0.32	0.001

IV – Conclusion

This study showed that lamb's growth was higher for grass grazing system and small concentrate quantity than conventional FL diet (hay and concentrate ad-libitum). The LW gain on RG pasture was particularly interesting. This management system can be used to reduce the concentrate feeds and feeding cost and, hence, increase farmer's income. Grass pasture resulted on a similar amount of muscle with only 0.7 fat mass of that produced by FL lambs. So, grazing grass could be a simple feeding strategy to naturally manipulate dietetic characteristics of sheep products; the carcasses of grassland lambs, being leaner, will be in demand by the consumers and may be recommended by the nutritionists.

Acknowledgments

The authors gratefully acknowledge the technical assistance of Dr M. H. Othmane and general Lafareg farm staff in the conduct of this study, and Dr Soufia with her team from Beja slaughtering house for their assistance. They are indebted to Z. Taghouti and J. Khlil from INRAT- PAF Laboratory for technical help during this work.

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Round Table

Reflexions on agro-pastoralists in the WANA region: Challenges and future priorities

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Abstract. Rangeland resources are among the most important – and almost certainly the most neglected – agro ecosystem component in dry areas. They are the largest land-use category, home to the poorest segment of the population, and crucial for millions of small-scale livestock producers. The availability of grazing resources for livestock in the world's drylands is low and erratic due to the recurrent droughts in which animals can often fall victim. The insufficient feed supply has been in decline with widespread degradation of rangelands arising from overgrazing, loss of biodiversity, and human induced global warming. Moreover, the feed gap today is more pronounced as the livestock population has increased substantially as a result of growing demand for animal products in West Asia and North Africa (WANA) region. An important option to compensate the shortage of feed from rangelands is to grow more forage without compromising food security. It is evident that the livestock keepers in the drylands of WANA region can only attain the goal of desirable animal production if the rangelands are adequately managed. However, protection and rehabilitation of degraded rangelands depend upon complicated factors such as land tenure, control of grazing, intensified forage production, and recurrent droughts.

Keywords. Agro-pastoralists – Food security – Diversification – Production system – Resilience.

Réflexions sur les agro-éleveurs de la Région WANA : Défis et priorités pour l'avenir

Résumé. *Malgré être largement négligés, les ressources pastorales sont parmi les plus importantes composantes de l'écosystème agricole dans les zones arides. Les pastures sont la catégorie d'occupation des terres la plus répandue, constituent le foyer de la catégorie la plus pauvre de la population et sont considérées déterminants pour des millions de petits éleveurs. La disponibilité des ressources pastorales pour le bétail dans les zones arides du monde est faible et irrégulière en raison des récurrentes sécheresses dans lesquelles les animaux peuvent souvent être les plus affectés. Cependant, l'approvisionnement insuffisant en alimentation animale a été approfondi avec une ample dégradation des terres de parcours résultant du surpâturage, de la perte de biodiversité et du réchauffement de la planète induit par l'être humain. Dans la région d'Asie occidentale et de l'Afrique du Nord (WANA), cette insuffisance en ressources alimentaires pour le bétail est plus prononcé aujourd'hui qu'auparavant aussi par l'augmentation considérable du cheptel en raison à une demande croissante de produits animaux Ainsi, une option pour compenser la pénurie d'aliments dans les parcours est de accroître la production des fourrages sans compromettre la sécurité alimentaire. Il est évident que les éleveurs dans les zones arides de la région WANA ne peuvent pas atteindre l'objectif d'une production animale souhaitable que si, et seulement si, les parcours sont gérés d'une façon adéquate. Toutefois, la protection et la réhabilitation des parcours dégradés dépendent de certains facteurs complexes tels que la propriété foncière, le contrôle du pâturage, la production intensifiée des fourrages et la persistance de la sécheresse.*

Mots-clés. *Agro éleveurs – Sécurité alimentaire – Diversification – Systèmes de production – Résilience.*

I – Introduction

Agro-pastoralists in the West Asia and North Africa (WANA) region depend upon crop-livestock production for their livelihoods. Livestock is an important element of the dryland ecosystem and play a major role in alleviating rural poverty. It is the primary form of savings, as living assets for the poor, and livestock products are an important source of income for rural women, who rank among the poorest livestock keepers. Livestock help to reduce vulnerability to external shocks, increase smallholder resilience and improve livelihoods.

Over the last three decades, there have been significant increases in both the small ruminant population and production in the WANA region, all associated with the growing demand for animal products that has risen from increases in per capita real income, urbanization and population growth (Aw Hassan *et al.*, 2010). This in turn has caused unrelenting pressure on natural resources, primarily on rangelands that are gradually giving way to the desertification. At present, it is generally considered that the WANA region does not contain any terrestrial ecosystems that are unaltered by human activity (Aronson *et al.*, 1993). Together with the negative impacts of increasing temperatures and hydrological cycle disruptions arising from lower and more erratic rainfall, the degraded condition of rangelands will likely get worse (ICCP, 2007). With the gloomy predictions of high population growth in these developing countries, it is likely that constraints on both the land and food supply will become increasingly evident in both the mixed crop/livestock and grazing systems (World Bank, 2008). On the other hand, projected increases in the demand for livestock products in these countries (Delgado *et al.* 1999; Aw Hassan *et al.*, 2010), presents significant opportunities for poor livestock keepers to increase incomes and build assets to improve their livelihoods. However, meeting the developing world's increasing demand for animal production from the limited, but degraded resources is a major challenge. Nevertheless, the animal feed deficits in the WANA region is already widespread and prevents resource poor livestock keepers from taking advantage of the growing market for animal products that would improve their livelihood. This is primarily linked to limited access to land, water, improved fodder production and livestock feeding technologies, input and output markets, pro-poor policies, effective institutions, and various forms of environmental degradations. Thus, reversing the negative trends of resource degradation requires better management and enforcement of appropriate pro-poor institutional and policy measures. The purpose of this paper is to offer an analytical review of the main constraints and opportunities faced by the agro-pastoralists in WANA region.

II – Challenges

Mediterranean grasslands face a range of global challenges that constitute serious concerns for food security, rural poverty and environmental degradation. In most cases, the vicious circle of poverty and degradation of the natural resource base are often compounded by mismanagement, weak institutions, lack of capacity, and unsustainable economic and political systems. Usually these factors lead to overgrazing which results from rangeland area loss (cultivation and ploughing impact) and the increasing number of animals (Louhaichi *et al.*, 2012). Conversion of natural ecosystems to cropland and, exploitation through selective harvesting, fuel wood removal, charcoal production and overgrazing are the major causes of degradation, habitat change and biodiversity loss (Reyers, 2004). In addition the widespread shortage of fodder exacerbates the pressure on rangelands. Disturbances arising from these activities influence ecosystem dynamics, structure and composition at the local and regional scales and are important in structuring plant communities (Sumina, 1994). Hence fodder availability becomes limiting for herbivores, resulting in a regular loss of herds during droughts and rendering livestock a driven rather than driving variable in the system. This situation, the so-called non-equilibrium conditions, also known as "New Rangeland Ecology", is expected to occur under dry climates (Sullivan and Rohde, 2002; Vetter, 2005; Gillson and Hoffman, 2007). These trends are expected to be further exacerbated by current and projected climate change scenarios.

Disruption of traditional grazing system. The traditional pastoral system of "nomadism", which evolved over hundreds of years, contained strategies for coping with various climatic, physical, and biological environments. The free movement of livestock was severely restricted through the creation of international boundaries, which cut across pastoral routes. Furthermore, the administrative boundaries set by governments during the post colonization period did not match tribal boundaries (Abu-Zanat, 2005). This mismatch accentuated the sedentarisation of herders, overgrazing, and destruction of woody plant species through burning for fuel and contributed to land degradation.

Encroachment of agricultural practices into traditional rangeland. The change from nomadism (pastoral) to agro-pastoral systems has lead to the conversion of the best rangeland (deeper soils with higher nutrient status) to cropland (Dixon *et al.*, 2001). Cultivation of rangelands using unsound practices such as ploughing down slopes and the use of heavy farm machinery have accelerated the rate of soil erosion and lowered land productivity (Abou-Sharar, 2008). Many of these more productive rangeland sites were genetic reservoirs of beneficial range plants during times of prolonged drought. Because of conversion to cropland these safe sites or “refugia” for native plants no longer exist (Louhaichi and Johnson, 2008).

Individualism. Unfortunately, this shift from the pastoral to the agro-pastoral way of life was accompanied by a different attitude of the farmer/pastoralists towards the land, with an erosion of traditional values and a lack of respect towards nature (competition for forage and land resources). Thus, early grazing and overgrazing has become a common problem (Kisamba-Mugerwa, 1995).

Dilemma of governmental policies. Both colonial and post-colonial governments have invested funds in rangeland development with particular emphasis on rational pastoralism, but in many cases these efforts have failed to achieve sustainable results due to high livestock density. For instance, the policy to protect livestock during harsh times pushed governments to intervene with various forms of assistance to farmers and herders, including distribution of subsidized animal feed, rescheduling of loans, investments in water development, and expansion of animal health programs. Although they helped limit production losses caused by drought, the drought management programs have also had negative impacts. These include the following:

(i) Accelerated rangeland degradation over the long term by undermining the traditional process of adjusting flock size to inter-annual climatic variations. Herd sizes have increased sharply in recent years, and grazing practices have changed such that many of the animals no longer leave the rangeland areas during the bad years (low rainfall) but have their feed and water trucked in. This practice leads to overgrazing, reduces the natural seeding of annual pasture species, disturbs the soil, and contributes to wind erosion, particularly in areas near water and feed supply points;

(ii) Inappropriate signals to the agro-pastoral communities have encouraged continued dependence on support programs, leading to “subsidy hunters”, unsustainable farming practices, and environmental degradation (Louhaichi, 2005).

Lack of trust between the authority and the rural community. Social organizations and relationships are also disturbed by some administrative considerations. In many cases, the delineation of the rural communes (administrative entities) does not always correspond to tribal land boundaries. In this regard, whatever the proposed institutional option, the execution of the project, the effective participation, and the sustainability, can be guaranteed only if beneficiaries are given security in terms of duration of grazing, and protection from intruders and other users of the rangeland resources (Louhaichi, 2005).

Lack of grazing policies and law enforcement. The main issues in these pastoral and agropastoral systems that need to be addressed, such as grazing rights and access to water, are often policy or institutional ones (FAO, 2009). Pastoral communities, however, are often socially and politically marginalized. Their livelihoods are undermined by inappropriate policies and laws. Although, several countries have already established pastoral codes that help manage these natural resources, unfortunately, in many cases these regulations are not widely enforced.

III – Future priorities (opportunities)

Recent advances in dryland research for development (R4D) show that strategies that integrate agro-ecosystem approaches can deliver international public goods (IPG) that can be applied and up-scaled globally to improve the livelihoods of the 2.5 billion people living in the dry areas, while safeguarding biodiversity and protecting the environment. Several mechanisms and tools are available to alleviate natural resources degradation and enhance agro-pastoralist livelihoods through productive and sustainable production systems that conserve the natural resource base.

Resilience: (harsh environment) well adapted to climate variability. In the dryland areas, pastoral communities have a close relationship with the natural environment. Pastoralists and agro-pastoralists have been adapting to extremes of climatic variability for centuries. Often conditions are harsh and natural resources are scarce. Therefore, communities must use the resources carefully and manage them wisely to ensure their continued sustainability. Pastoral communities living within rangelands have adopted a combination of livelihood options to ensure their survival. Drought in the pastoral areas is not an unexpected event but is instead a common characteristic of these ecosystems. In the past, pastoralists were able to withstand the effects of drought and other environmental stresses by applying coping strategies that have evolved over time. These coping strategies have lead to the development of customary early warning systems, resource tracking strategies, and so on.

Ecosystem services. Historically, the primary use of rangeland was to provide forage for livestock and wildlife. However, this vision of considering rangelands as solely grazing lands is narrow. Today, rangelands are recognized for their importance and value in providing a much wider variety of services and ecosystem functions. In fact, these lands also provide society with valuable products and services that support the standard of living and quality of life. These products include ecosystem services such as mitigating climate change via carbon sequestration, purifying water via bioremediation, and storing genetic diversity within the flora and fauna of these environments. Rangelands also provide natural beauty, a diversity of wildlife, recreational opportunities such as hunting, hiking, and camping, as well as economic values such as ranching and mining. Rangeland watersheds are important for clean and abundant water production. Rangeland soils, vegetation, and water are important for sustaining ecological and economic health of the world. Therefore, rangelands should be managed under principles of multiple-use, where these resources are simultaneously cared for to prevent overuse or destruction of natural resources. Proper management of rangelands is imperative to the social, economic, and political development of not only pastoral communities but the whole humanity.

Livestock mobility. Pastoralists traditionally relied on herd mobility to cope with unpredictability and risk on arid and semi-arid lands. With increased temperature and more variable rainfall in response to a changing climate, whose occurrence and variability is predicted to increase, mobility is a key strategy for mitigating the negative impacts of climate change. Seasonal movements are vital for pastoralists to make use of the scattered rangeland resources on a large scale while enabling rangeland auto-regeneration during certain times of the year (Dutilly-Diane, 2008).

Intensification of forage production. A possible strategy to overcome the widespread feed shortages and to reduce the pressure on rangelands is the intensified forage production through more integrated crop/livestock farming practices. Intensification of forage production may help farmers grow greater amounts of fodder for the livestock and help meet the feed gap. However, the unrelenting pressure on land and water due to increasing human and animal populations, and intensifying forage production without compromising food security, pose a significant challenge. Historically, in the WANA region, the effort to increase food and cash crops, arising from food security concerns, has caused conversion of large areas of rangelands to crop lands (Dixon *et al.*, 2001; Nefzaoui, 2004).Crops for grain and forage for animals compete for land and water use. Thus it is not an easy task to increase the area dedicated to cultivated fodder production and to allocate water for the irrigation of these forages. However, as well as the provision of food for humans, adequate supply of feed for livestock today is more pronounced than before as the animal population has increased in the WANA region (Le Houerou, 2000). It is evident that an implementation of trade-offs among the production systems that utilize forages, more often as supplementary and complementary to the rangelands in WANA region, is crucial to improving animal production without degrading the natural resource base.

Diversification of production systems. Diversification of agricultural production systems as a means of reducing the risk of failure may have a significant agro-socio-economic impact for smallholders in the WANA region, in the face of climate change. Diversification of production with the use of water use efficient crops, moving from cereal-based systems to cereal-legume rotations may increase the efficiency and the resilience of crop/livestock productions. At ICARDA long-term cereal based rotation trials have demonstrated the importance of forage legumes as a means of a diversification strategy in improved farming systems of the WANA region (Al Moneim and Ryan, 2004). However one of the major constraints to diversifying and improving forage production is the lack of improved high yielding varieties and poor access to locally adapted germplasm (Pecetti *et al.*, 2011). Thus, the development of locally adapted and higher drought and salinity tolerant germplasm is of paramount importance for the diversification purposes of fodder production.

Market trends. There is an increasing trend in consumption of animal products that results from increases in per capita real income, urbanization and population growth in the WANA region. The projected consumption growth rate for the livestock products is 2.4% for the period of 2000-2020 (Aw Hassan *et al.*, 2010). This growing demand for livestock products present livestock producers with a significant opportunity to increase benefits from their livestock and to raise income through participating in livestock-related markets (Delgado *et al.*, 1999). However, the small producers in the WANA countries who are often the poorest in the region may not be able to exploit the potential benefits of this growing market. Livestock producers and traders in these WANA countries face a challenge in maintaining their share of export markets due to structural and technical limitations that hinder their competitiveness (Aw Hassan *et al.*, 2010). The inability of small-scale farmers to feed their livestock adequately remains among the most widespread global technical constraints and removing it would enable smallholder livestock producers to improve their livelihoods by taking advantage of market opportunities and building assets.

Institutional and policy support. It is evident that technological progress and technical solutions are of paramount importance for a more efficient livestock production system in the WANA region. Improved animal health and nutrition, provision of locally adapted forage and range species, better integrated crop/livestock production systems, genetic enhancement and better post-harvest handling are essential for achieving higher livestock productivity. However without proper backstopping and improved efficiency in animal production, producers in WANA may not be able to compete with the more efficient foreign producers in either the domestic or export markets. Policies both at regional and national levels to promote the adoption of productivity-enhancing measures that will help improve the management of natural resources are needed (Aw Hassan *et al.*, 2010; Louhaichi, 2011).

IV – Conclusions

Reversing the trend of degrading natural resources, and increased forage production in a sustainable manner require better management. If management and rehabilitation are to be sustainable in the long-term they must also be conducted in a participatory manner; involving the agro-pastoralists in the restoration and management of the resources they depend upon. In the past the focus was geared toward the technical aspects, however, the results clearly demonstrate that institutional and policy support is urgently needed for the sustainability of the natural resource base.

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Silvopastoralism in Mediterranean Basin:
Extension, practices, products, threats and challenges

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Abstract. Ranching generally causes a progressive deforestation. Nevertheless in Mediterranean countries trees are still present in many pastoral systems, here referred to as silvopastoral systems (SPs). Trees provide products as fruits as human food, fruits or leaves as fodder, wood and firewood, environmental services like patches of soil fertility and shelter for animals, and environmental goods such as carbon sequestration, water yield and quality and reinforced biodiversity. However, most of the SPs locate in marginal areas, have low commercial profitability and are subject to two divergent trends, intensification and extensification or abandonment that compromise their long-term persistence. Here we analyzed current threats/constraints and new challenges for the future of SPs based on experience gained in Iberian dehesas. We stress the need of a comprehensive and categorized map of SPs and a database of management practices as adaptive solutions to environmental and socioeconomical contexts. We propose a set of topics for future research projects that should integrate traditional and scientific knowledge favoring innovative techniques for production of timber and non-timber forest products, livestock, and cultural and environmental values.

Keywords. Dehesa – Encroachment – Environmental goods and services – Regeneration – Scattered trees.

Sylvopastoralisme dans le bassin méditerranéen : Extension, pratiques, produits, menaces et défis

Résumé. *L'élevage provoque généralement une déforestation progressive. Néanmoins dans les pays méditerranéens les arbres sont présents dans de nombreux systèmes pastoraux (systèmes sylvo-pastoraux ; SPs). Les arbres fournissent des produits tels que des fruits pour l'alimentation humaine, fruits et feuilles utilisés comme fourrage, bois et bois de chauffage, des services environnementaux, comme la fertilité des sols et des abris pour les animaux, et des biens environnementaux comme la séquestration du carbone, le rendement et qualité de l'eau, et le renforcement de la biodiversité. Cependant, la plupart des SPs se localisent dans les zones marginales, ils ont une faible rentabilité commerciale et ils sont soumis à deux tendances divergentes, l'intensification et l'extensification, qui compromettent leur persistance à long terme. Ici, nous avons analysé les menaces et contraintes actuelles et les nouveaux défis pour l'avenir des SPs sur la base de l'expérience acquise dans les dehesas ibériques. Nous soulignons la nécessité d'une carte complète et classée par catégorie de SP, d'une base de données de produits et de pratiques de gestion et d'adaptation à des contextes environnementaux et socio-économiques. Finalement, nous proposons un ensemble de sujets pour futurs projets de recherche qui devraient intégrer les connaissances traditionnelles et scientifiques visant à faciliter l'élaboration de techniques innovatrices pour la production de produits forestiers ligneux et non ligneux, produits de l'élevage, produits culturelles et biens et services environnementaux.*

Mots-clés. *Dehesa – Buissonnement – Biens et services environnementaux – Régénération – Arbres disséminés.*

I – Pastoralism, deforestation and scattered trees landscapes

Orography, low soil fertility and climate constraints have hampered the development of large-scale agriculture in many Mediterranean region, where ranching have predominated among land uses (Pardini, 2007). However, grazing in Mediterranean countries and beyond is mostly a long way of deforestation. Grazing mostly cancels opportunities of tree regeneration (Pulido *et al*., 2010) and periodical fires have been a common management practices, especially in

Mediterranean countries (Grove and Rackman, 2001). Nevertheless, in more marginal, stress-prone regions, different landscapes dominated by scattered trees as grazed forests, anthropogenic savannas, wood pastures (trees as fodder) and grazed plantations still extant (the assemble is here referred to as silvopastoral systems; SPs).

SPs have evolved through centuries and millennia in the Mediterranean Basin, where they currently occupy vast areas in most countries (Papanastasis, 2004). Indeed, scattered trees are still a prominent element of many human-modified landscapes around the world (Gibbons *et al*., 2008). Cultural savannas could occupy more than 5 million km^2 in the Mediterranean, North and South America, Central Asia, South Africa and South Australia (Pulido, unpublished). Oak savannas extend over millions hectares in the Iberian Peninsula (Marañon *et al*., 2009).

A major challenge that grazing systems will face in the coming decades is the need to provide sustainable pasture yields while conserving ecosystem services. The capacity of SPs to sustain multiple functions and products has been emphasized as new needs and challenges have emerged in modern society (Manning *et al*., 2006; Moreno and Pulido, 2009). However, most of SPs are currently facing both environmental and economic threats that might compromise their long-term persistence. Changes in the technological and socio-economic conditions, current agricultural trends and policies are imposing a loss of traditional empirical knowledge, a continuous decrease of profitability of SPs and their products, and system degradation (Pereira *et al*., 2004). SPs need, therefore, of specific policies to solve those threats and reinforce their economical, social and ecological roles. However, there is a complete lack of systematic and detailed knowledge on the extent and constraints of most of these systems. No official data or maps are available on these multilayered systems, resulting in an information failure that precludes the elaboration of specific proposals for management and policy to face current threats.

II – The role of trees in pastoral systems

Scattered trees have been designated as "keystone structures" due to the disproportional large ecological values and ecosystem services they provide relative to the small area they occupy in landscapes. Trees provide multiple woody and non-woody plant products, high-quality food, livestock and game products, recreational or cultural services through multiple activities conducted with a comparatively low environmental impact. SPs supply us also with important ecosystems goods and services such as biodiversity maintenance, carbon sequestration, soil fertilization, microclimate amelioration, shelter for livestock, control against erosion and desertification, increased local water balance (Manning *et al*., 2006; Wallace, 2007).

The consequence of low tree density for tree functioning and productivity of Mediterranean SPs have been evidenced in Iberian dehesas, where scattered trees exhibit much higher water potential, photosynthetic activity and acorn yield than trees growing in dense forest (Moreno and Cubera, 2008; Carevic *et al*., 2010). Indeed, reduced tree density of SPs has been interpreted as a practical management strategy to cope with foreseen aridification of Mediterranean ecosystems (Joffre *et al*., 1999; Manning *et al*., 2006). The positive role of trees for soil fertility in SPs and agroforestry systems is very well documented (see Young, 1997 for a review), as it is the importance of trees on the build up of the soil carbon stock (e.g. Howllet *et al*., 2011) and on the mitigation of deep nutrient leaching (e.g. López-Díaz *et al*., 2011). Finally, the importance of SPs, and more specifically of scattered trees for the maintenance of high levels of biodiversity have been repeatedly reported in Iberian dehesas (Marañon *et al*., 2009).

In spite of the large number of scientific evidences of the positive role of trees in SPs, trees rarely have been actively favored in pastoral systems. The net effect of trees on understory and *vice versa* can vary according to different ecological factors. For instance, trees can favor pasture production through the improvement of soil physical and chemical fertility, but trees and pasture also compete for soil water and light (Moreno *et al*., 2007). A good knowledge of the effects of mature trees on forage production and the effects of understory structure on tree production (e.g. acorn production) is critical for ranchers to determine the optimal design and management of the system (tree density, thinning and pruning, canopy form and size, fertilization, pasture improvement, encroachment control, grazing regime, periodical cropping…). Similarly, the effects of understory structure on tree recruitment must be taken into account to ensure the stability (long persistence) of the system (e.g. tree regeneration). Pasture production, tree growth and/or fruit production and tree regeneration need be analyzed taking into account the complexity of the overstory-understory.

III – Current trends, threats and challenges

Over the last decades most Mediterranean SPs have faced several threats that compromise their long-term persistence. Changes of the technological and socio-economic conditions and common agricultural policies, with the concomitant lost of profitability, are leading to two divergent trends, intensification of land use in some areas, and land abandonment-encroaching in others (Pinto-Correia, 2000; Papanastasis, 2004). Intensification has resulted in a shift from the traditional farming systems with very low external inputs to a much more simplified system involving intensive management techniques, with partial substitution of extensive, low-intensity grazing for semi-intensive management regime, and decreasing diversity of land uses (Plieninger and Wilbrand, 2001). These authors have denounced a dramatic lost of soil quality and biodiversity, overageing of oak stands due to a prolonged lack of regeneration on SPs, trends intensified with the recent increment of livestock rate or grazing pressure.

Extensification results on woody encroachment of SPs all over the world (e.g. Asner *et al*., 2004; Archer, 2010), and notably in Mediterranean countries (Mazzoleni *et al*., 2004) with important changes on their functioning and productivity. Although in the last two decades an intense debate has been developed on the sustainability of SPs in view of the lack of tree regeneration, it seems that they are resilient enough able to recover to a natural stand structure after set-aside of several years (Pulido *et al.,* 2010). It seems that the trend toward tree loss in SPs is more than compensated by recovery in areas that have been abandoned, protected or devoted to big game hunting in Iberian Peninsula. The true challenge is to integrate the dual objectives, pasture improvement that could play against tree regeneration, and woody encroachment that guarantees soil and tree regeneration and thus, sustainability of the system.

IV – Future prospects

Explicit long-term strategies should be designed to promote management practices that ensure SPs conservation. However, in order to convince landowners, administration and policy-makers a better knowledge is still needed. For instance, studies focusing the conditions under which net balance of trees is positive (facilitation) or negative (competition) for pasture understory are still needed. Similarly, the optimal tree density of SPs under different uses and ecological constraints (namely water shortage) has not been adequately afforded yet. The analysis of consequences and opportunities of woody encroachment of extensive pastoral systems and landscapes also deserve more attention. SPs encroachment could be favorable for regeneration, but it is doubtful whether shrub encroachment would keep stand functioning (e.g., hydric and nutritional tree status, biodiversity) and profitability (e.g., livestock carrying capacity).

From the lessons learned across three decades of scientific studies in Iberian dehesas, but also from the realization of the lack of parallel studies in other SPs across Mediterranean countries, we estimate as priority (i) the elaboration of a comprehensive and categorized map, and the associated database of pastoral systems and grazing strategies within forest and woodland; (ii) compilation of traditional and modern management practices as adaptive solutions to environmental and socioeconomical contexts; (iii) scientific evaluation of environmental services, as reducing forest fires, C storage reinforcements, control of water loss and quality, and biodiversity preservation, under different environmental and management context; (iv) identification of synergies and trade-offs occurring among products, and among livestock production, ecosystem services and biodiversity; (v) diversification and increment of forage offer (mitigating seasonal shortages) and other marketable products of Mediterranean SPs; (vi) economical evaluation of SPs including environmental goods and services (green accounting).

Research projects should integrate traditional and scientific knowledge to facilitate (i) the elaboration of innovative techniques for the long term production of timber and non-timber forest products; (ii) the elaboration of policy proposals to reinforce the public environmental goods and services provided by SPs; and (iii) the development of effective institutions and governance structures for a effective take-up of the body of knowledge on SPs functioning and valorisation.

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Research priorities for grassland science in the Eastern Mediterranean Region

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Abstract. Grasslands and rangelands have long been solely considered as a place for livestock grazing with no regard to the many other ecosystem goods and services that they provide. Mismanagement affects significantly the forage production and the biodiversity in the Mediterranean grasslands. The study of functional traits of plant species related to their response to grazing or other agronomic practices could contribute to the further understanding of various management effects on these ecosystems. For the appropriate management techniques to be applied, the multifunctionality of these ecosystems and the climatic change should be taken into account.

Keywords. Climatic change – Functional traits – Mismanagement – Rangeland.

Les priorités de recherche pour la science des prairies dans la région de la Méditerranée orientale

Résumé. *Les prairies et les pâturages ont longtemps été considérés seulement comme des endroits pour le pâturage du bétail, sans tenir compte d'autres nombreux biens et services écosystémiques qu'ils fournissent. La mauvaise gestion affecte de manière significative la production de fourrage et de la biodiversité dans les prairies méditerranéennes. L'étude des traits fonctionnels des espèces végétales liées à leur réponse au pâturage ou d'autres pratiques agronomiques pourrait contribuer à une meilleure compréhension des effets de la gestion sur ces écosystèmes. Pour que les techniques de gestion appropriées soient appliquées, la multifonctionnalité de ces écosystèmes et le changement climatique doivent être prises en compte.*

Mots-clés. *Changement climatique – Traits fonctionnels – Mauvaise gestion – Parcours.*

I – Introduction

Mediterranean grasslands and rangelands are important natural resources with an area covering up to 48 per cent of the whole Mediterranean region (Le Houerou, 1981). Although these ecosystems have traditionally played an important role in the evolution of human societies (Jouven *et al.,* 2010), and are still the key element in the production of high quality animal products (Boyazoglu and Morand-Fehr, 2001) have been considered merely as a mean for providing feed for domestic ruminants. The significance of these ecosystems has not been fully acknowledged.

The fact that the Mediterranean basin is a global biodiversity hotspot with an extremely high number of endemic plant species (13,000) (Myers *et al.,* 2000) is strongly related to the long-time management practices, including grazing. Livestock grazing is the major factor in these ecosystems which besides quantity and quality of forage (Henkin *et al.*, 2011), strongly affects vegetation dynamics, species, and landscape diversity (Olff and Ritchie, 1998; Perevolotsky, 2005).

Grasslands and rangelands are essentially providing ecosystem services such as forage production, biodiversity conservation, habitat for wildlife, carbon fixation, prevention of erosion and nutrient storage. Despite their ecological, economic and social importance they received limited scientific and media attention on their conservation merits. This is mainly because they are widely perceived as degraded land suitable only for grazing. However, recently they are recognised for contributing to the quality of life (Arabatzis and Kyriazopoulos, 2010).

A major shift in grassland science has to occur, from considering their main function as pastures with a specific focus on livestock production to a much broader concept of natural resource management. Sustainable management should be about striking a balance among environmental conservation, livestock production and socio-economic development. The objective of this paper is to present some new aspects of grassland science focusing in the eastern Mediterranean region.

II – Research priorities

Grassland and rangeland ecosystems have to be managed with multi-purpose objectives corresponding to the different functions assigned to grassland: environment, biodiversity, landscape ecology, and livestock production with socio-economic outputs (Dahlberg, 1986). Predicting trade-offs between sustainable forage production and impacts on other ecosystem services, such as biodiversity, remains a challenge to grassland scientists.

Communal uncontrolled grazing which is predominant in the eastern Mediterranean region (Redman and Hemami, 2008; Papanastasis, 2009a; Pasho *et al.*, 2011) is often associated with the absence of monitoring and planning of stocking rates and leads to overgrazing and degradation of grasslands and rangelands, due to mismanagement. It is also connected with land abandonment (Hadjigeorgiou and Zervas, 2009) which is also widely recognized as a serious problem of grasslands and rangelands in the Mediterranean region and elsewhere, especially in semiarid environments. Undergrazing or the total abandonment of grasslands leads to heavy encroachment of woody vegetation (usually shrub species). It has to be noted that this phenomenon has been related to overgrazing by non browsing herbivores (Archer *et al.,* 1995), however in the eastern Mediterranean region is strongly related with the significant decrease of goats browsing in rangelands (Landau *et al.*, 1995; Kyriazopoulos *et al.*, 2012). Woody species encroachment in the Mediterranean grasslands is associated with an increase in wild fires (Papanastasis, 2009b) and it might threaten to decrease biodiversity (Perevolosky and Seligman, 2008). The effects of grassland abandonment on plant community composition and standing biomass have become the object of a few studies on Eastern Mediterranean (Papanastasis, 2007) but gaps in knowledge concerning the overall impact on grassland structure and regeneration remain.

Several grazing behaviour studies have documented a positive effect of browsing of goats on the control of woody vegetation encroachment (Aharon *et al.*, 2007). These studies in the future should include two key aspects: a) the nutritional, which examines the ability of the goat to collect sufficient nutrients to meet requirements for maintenance, growth, reproduction and lactation and b) the ecological, which examines the impact of the goat on the plant community or other organisms that are part of the ecosystem (Glasser *et al.*, 2012). Furthermore, future grazing behaviour studies should take into account the floristic composition of grasslands, the stage of maturity and their impact on animal products (Goetsch *et al.*, 2011).

Grazing and other management practices alter floristic composition and consequently affect compositional diversity (Belsky, 1992; Mishaud *et al.*, 2012). Changes in floristic composition reflect intra- and inter-specific competition and are caused by environmental and management influences. Grassland science has tried to understand the mechanisms of competition by focusing mainly on species adaptation (Woodard *et al.*, 1997). Diversity of grassland and rangeland vegetation has been described in terms of species number and botanical composition. Only recently, attempts have been made to explain diversity of grassland vegetation by functional traits (Lavorel and Garnier, 2002). Functional traits are plant characteristics that respond to the dominant ecosystem processes (Keddy, 1992). The advantage of such an approach in comparison to the taxonomic one is the fact that it manages to link floristic diversity to the different functions the plants have to play within the ecosystem (primary production, competition for light and for soil resources, and interactions with herbivores). So, the study of functional traits of species related to their response to grazing or other agronomic practices contribute to further understanding of various management effects on these ecosystems. This procedure is essential to promote sustainable management. Furthermore, limited information is available on the relationship of species diversity with the diversity of the functional traits within species (Gubsch *et al.*, 2010). Future studies in vegetation dynamics need to include information on temporal and spatial heterogeneity which is a dynamic component of the grassland ecosystem.

Climate change is a major environmental concern. It is predicted that in the Mediterranean region precipitation will significantly reduce (Bates *et al.*, 2008). The predicted warmer and drier climate conditions will considerably affect the grassland ecosystems' goods and services, such as fodder production, CO_2 sequestration, soil nutrient cycling and biodiversity (Cheddadi *et al.*, 2001). Thus, significant reductions in productivity as well as in biodiversity are expected rendering studies of the grassland vegetation response to climate change necessary in order to adopt appropriate management techniques. Testing new drought tolerant grass and legume species or genotypes (Gulumser *et al.*, 2010; Basaran *et al.*, 2011) will be a helpful tool to maintain forage production.

III – Conclusions

Grasslands and rangelands have to be considered not only as grazing areas for producing forage for livestock, but also for providing a variety of ecosystem goods and services. Consequently, multi-disciplinary research and multi-scale approaches are required. Grassland science needs to carry on long term experiments for monitoring all the environmental outputs and ecological goods and services associated to grassland management allowing for the ramifications of the climate change.

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Advances in grassland research in the Mediterranean region of Chile

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Abstract. The Central Zone of Chile, the only part of South America that presents a Mediterranean climate, has about 5 million hectares of pasture. A large proportion are annual species from the Mediterranean Basin. This article presents a summary of the results of 20 years of research carried out in order to improve productivity of livestock production systems and contribute to the rehabilitation of these degraded agroecosystems. The studies have considered both the collection and domestication of naturalized annual legumes in Chile (*Medicago polymorpha*) and the assessment of several accessions and cultivars of annual legumes of the genus *Trifolium, Medicago, Ornithopis* and *Biserrula*. The works have also considered the design and assessment of pasture mixtures, the evaluation of N fixation in addition to the integration of legumes in crop rotations and as cover crop in vineyards and orchards. Evaluations were performed in a gradient of rainfall between 600 and 1000 annual rainfall on volcanic soils (Andisols) and Entisols derived from granitic rocks. The productivity and persistence of *B. pelecinus* in the interior dryland and *O. compressus* in the Andean foothill are clearly superior to other annual legumes (*M. polymorpha* or *T. subterraneum*) seeded in those areas. The use of legume mixture is also highly recommended due to their higher productivity and persistence compared to monospecific pastures. The amount of N_2 fixed by annual legumes is closely related to the shoot dry matter production of the pasture, and the rate is 18-20 kg shoot N fixed per ton shoot DM accumulated. Finally, annual legumes contribute to the N nutrition of wheat or grapevines in a Mediterranean environment.

Keywords. Pastures – Legumes – Mixtures – Productivity – Persistence – N fixation– Rotations – Cover crops.

Progrès dans la recherche sur les pâturages et les prairies dans la région méditerranéenne du Chili

Résumé. *La zone centrale du Chili, la seule partie de l'Amérique du Sud qui présente un climat méditerranéen, a environ 5 millions d'hectares de pâturages. Une grande partie sont des espèces annuelles du bassin méditerranéen. Cet article présente un résumé des résultats de 20 années de recherches menées dans le but d'améliorer la productivité des systèmes de production animale et de contribuer à la réhabilitation de ces agro-écosystèmes dégradés. Les études ont porté sur la collecte et la domestication des légumineuses annuelles naturalisées au Chili (*Medicago polymorpha*) et sur l'évaluation de plusieurs accessions et cultivars de légumineuses annuelles des genres* Trifolium, Medicago, Ornithopis *et* Biserrula*. Les travaux ont également examiné la conception et l'évaluation des mélanges de pâturages, l'évaluation de la fixation d'azote en plus de l'intégration de légumineuses dans les rotations de cultures et comme plante de couverture dans les vignobles et les vergers. Les évaluations ont été réalisées dans un gradient de pluviométrie d'entre 600 et 1000 mm annuelles sur les sols volcaniques (Andisols) et entisols dérivés de roches granitiques. La productivité et la persistance de* B. pelecinus *dans les terres arides de l'intérieur et d'*O. compressus *dans les contreforts des Andes sont nettement supérieurs à d'autres légumineuses annuelles (*M. polymorpha *ou* T. subterraneum*) ensemencées dans ces domaines. L'utilisation d'un mélange de légumineuses est aussi fortement recommandé en raison de leur plus grande productivité et de leur persistance par rapport aux pâturages monospécifiques. La quantité de N_2 fixé par les légumineuses annuelles est lié à la production de matière sèche des pousses du pâturage, et le taux est de 18-20 kg N pousses fixé par tonne DM accumulé. Enfin, les légumineuses annuelles contribuent à la nutrition azotée du blé ou de la vigne dans un environnement méditerranéen.*

Mots-clés. *Pâturages – Légumineuses – Mélanges – Productivité – Persistance – Fixation de N – Rotations – Cultures de couverture.*

I – Introduction

More than 5 million ha of natural grassland are found in the Mediterranean climate region of Chile, most of them in advanced stages of degradation. According to the last agriculture census (INE, 2007), about 58% of these natural grasslands are in the arid (150-250 mm), 8% in the semiarid (300-450 mm), 23% in the subhumid (400-700 mm) and 11% in the humid-perhumid (800-1200 mm) regions. The area of improved (i.e. regenerated or managed with fertilization) and new established grasslands are only 0.24 and 0.20 million ha, respectively.

Natural grasslands are dominated by annual composites and grasses, mostly introduced intentionally or accidentally from Eurasia (Ovalle *et al.*, 2006). The diversity and abundance of annual legumes is low being *Trifolium glomeratum*, *T. dubium* and *Medicago polymorpha* the most frequent species (del Pozo *et al.*, 2006; Ovalle *et al.*, 2006). In order to improve grassland productivity and persistence, as well as soil fertility, a R&D program has been developed during the last 15 years in order to select nitrogen-fixing legumes adapted to the various agro-ecological conditions of the Mediterranean region of Chile. In this article we report the potential and multiple uses of legumes species in agro-ecosystems, as permanent pasture, in rotation with wheat and as cover crops.

II – Productivity and persistence of annual legumes species

Annual legumes are typically from Mediterranean grasslands and there are a number of species that can be used as a forage crops. Initially, we collected and characterized a large number of accessions on *M. polymorpha*, which is a naturalized species distributed in the whole Mediterranean region of Chile (del Pozo *et al.*, 2002). Then we explored other annual legumes species, particularly those containing small and hard seeds, and which are relatively ease to harvest, like *Ornithopus compressus*, *Biserrula pelecinus* and *T. micheleanum* (Ovalle *et al.*, 2003). The productivity of these legumes was evaluated in two Mediterranean environments in Central Chile, the interior dryland (Cauquenes: 35°58' S, 72°17′ W, mean annual precipitation 695 mm) and Andean foothills (Yungay: 37°10' S, 71°58' W, mean annual rainfall is 1200 mm). *B. pelecinus* showed high dry matter production and a remarkable seed yield in the interior dryland but not in the Andean foothill, whereas *O. compressus* had a high productivity in both environments (Table 1). On the third growing season, the regeneration, production and persistence of *B. pelecinus* (in the interior dryland) and *O. compressus* (in both environments) was much higher than that of *M. polymorpha* or *T. subterraneum*. Another good option for the Andean foothill is *T. vesiculusum* (Table 1), which has deeper root system and longer growing period than *T. subterraneum*.

Table 1. Days to first flower (DF) , hard seedness (HS), cumulative above-ground dry matter of three growing seasons (2000-2002) and seed yield (SY) of annual legumes growing in two Mediterranean environments of central Chile, interior dryland and Andean foothill

Species	DF†	HS†† (%)	Dry matter (g/m^2)		Seed yield (g/m^2)	
			Interior dryland††	Andean foothill†††	Interior dryland††	Andean foothill†††
M. polymorpha	97	95	909±136	116±54	137±24	28±8
T. subterraneum	118	67	932±108	802±57	95±11	194±11
B. pelecinus	123	100	1222±406	225±72	265±70	57±19
O. compressus	112	99	1251±389	872±225	143±45	80±12
O. sativus	135	4	912±289	576±33	153±56	94±10
T. micheleanum	136	43	537±204	570±90	99±29	101±12
T. vesiculosum	160	89	347±65	942±223	67±22	209±20

†From Ovalle *et al*. (2003).
††From Ovalle *et al.* (2005b) and del Pozo and Ovalle (2009).
†††From Ovalle *et al.* (2005a).
Data are from the highest productive cultivar of each species and environment.

III – Mixtures of annual legumes to improve productivity and persistence

The use of annual legume mixtures could improve pasture production, quality and persistence of Mediterranean pastures. Also, the length of the grazing season can be expanded when different legume species are combined in mixtures. In a study conducted in the interior dryland (Cauquenes, Chile) mixtures of 2 (M2) to 5 (M5) legume species were evaluated; the control was a pasture of 100% of *T. subterraneum* (Avendaño *et al.*, 2005). Dry matter production was increased at the third growing season in mixtures compared to the monospecific pasture (Fig. 1); pasture with 2 or more species were dominated by *M. polymorpha*, and the proportion of *O. compressus* and *B. penicilus* were very low in M5, despite the species where sown in equal proportion (20% each).

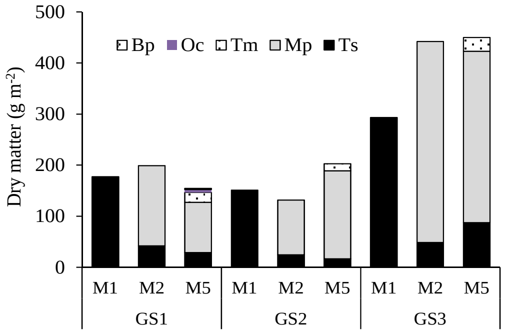

Fig. 1. Dry matter production of annual legume pastures with one (M1), two (M2) or five species (M5), during three growing seasons (GS). M1: 100% *T. subterraneum* (Ts); M2: 50% of Ts and 50% of *M. polymorpha*; M5: is 20% of Ts, Mp, *T. micheleanum* (Tm), *O. compressus* (Op) and *B. pelecinus* (Bp). Data from Avendaño *et al.* (2005).

IV – Annual legumes in rotation with cereals

Legumes can play a major role in: (i) providing additional N into cropping soils, (ii) increasing the soil N availability, and (iii) improving the grain yield of following cereal crops. Grain yields achieved by wheat in the absence of fertilizer N following annual legume mixtures (of three species) or the unfertilized oat crop, were compared to the current farmer practice of supplying N fertilizer to wheat grown after oats, during four growing seasons (2008-2011). Wheat yields following two different annual legumes mixtures of 1, 2 or 3 years old were on average 65, 98 and 63%, respectively, of the 3.4 t/ha of grain harvested in the oat-wheat with N fertilizer (160 kg N/ha) in the interior dryland, and 78, 93 and 73%, respectively, of the 6.0 t/ha attained by the N fertilized (207 kg N/ha) wheat crops in the Andean foothill. Grain yield attained in the oat-wheat rotation without N fertilization was on average 1.4 and 3.8 t/ha.

V – Nitrogen fixation

The capacity of N_2 biological fixation (NBF) by annual legumes has been evaluated by the ^{15}N natural abundance technique using four non legumes species as references plants. In granitic soils of the interior dryland the percentage of legume N derived from air (%Ndfa) of *M. polymorpha*, *T. subterraneum*, *O. compressus*, *O. sativus* and *T. michelianum* was high (74.3 to 93.9%); *O. compressus* presented the greatest N content in dry matter and the amount of N fixed was 91 kg N/ha (Ovalle *et al.*, 2006). In Alfisols of the Andean foothill the amount of N fixed by four legumes (*T. subterraneum*, *O. compressus*, *T. vesiculosum* and *T. incarnatum*) ranged between 43 and 147 kg N/ha (Espinoza *et al.*, 2011). In legume mixtures of 2 to 4 legume species, the amount of N fixed varied between 97 and 214 kg N/ha (Espinoza *et al.*, 2011). There is a close relationship between shoot dry matter and the amounts of N_2 fixed by all legume species across sites; between 18 and 20 kg shoot D/ha were fixed on average for every ton of shoot DM accumulated (Fig. 2). These values are similar to those found in grain legumes in the same environments (Espinoza *et al.*, 2012).

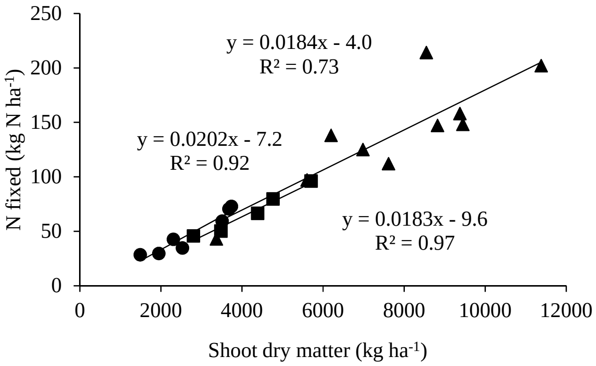

Fig. 2. Relationship between shoot dry matter (DM) and amounts of shoot N fixed by annual legumes in granitic (●) and clay (■) soils of the interior dryland, and in alfisols (▲) of the Andean foothill. Data from Ovalle *et al.* (2006) and Espinoza *et al.* (2011). In the Andean foothill the highest dry matter and N fixed by attained by legume mixtures.

VI – Cover crops

Cover cropping with nitrogen (N) fixing annual legumes is a technology increasingly being used in grapevine and orchards production systems in various Mediterranean regions. Among the benefits of using cover crops are the reduction of soil erosion, the enhancement of the soil biological activity, the increase of soil organic matter content and nutrient availability, and improvements in soil porosity and aggregate stability, and increase of soil water holding capacity. In grapevine, average inputs of annual legume N represented 112-161 kg shoot N/ha/y, respectively, grape dry matter production was increased significantly by 48-61% and the amount of N accumulated in grape bunches was enhanced by 74-105% after 2 years of legume cover crop (Ovalle *et al.*, 2010).

VII – Conclusions

The productivity and persistence of *B. pelecinus* in the interior dryland and *O. compressus* in the Andean foothill are clearly superior to other annual legumes (*M. polymorpha* or *T. subterraneum*) seeded in those areas. The use of legume mixture is also highly recommended due to their higher productivity and persistence compared to monospecific pastures. The amount of N_2 fixed by annual legumes is closely related to the shoot dry matter production of the pasture, and the rate is 18-20 shoot N fixed per tonne shoot DM accumulated. Finally, annual legumes contribute to the N nutrition of wheat or grapevines in a Mediterranean environment.

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OPTIONS méditerranéennes

SERIES A: Mediterranean Seminars
2012 – Number 102

New approaches for grassland research in a context of climate and socio-economic changes

Edited by:
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Grassland-based systems are no longer seen exclusively as livestock production enterprises but as multiple use systems with important consequences for the global environment. They are crucial for the protection of ecosystem goods and services, for tourism and for mitigating climate change. Well-managed grasslands provide important benefits such as increased water infiltration and retention or improved nutrient cycling, associated with organic matter accumulation in the soil, as well as increased plant growth and species diversity. Thereby, grassland management is also an adaptation strategy for climate change, as it reduces the risks associated with prolonged drought periods and unreliable rains that characterise Mediterranean regions. There is an urgent need to assess the interaction between climate change and grasslands to identify appropriate options that can help farmers to manage forage resources under increasing drought conditions and market globalisation. The challenge is then to improve grassland productivity, pasture persistence and resilience under these constraints. Scientific advances in grassland management and new strategies in plant improvement may undoubtedly contribute to this aim.

This publication is the outcome of the 14th Meeting of the FAO-CIHEAM Inter-regional Cooperative Research and Development Sub-Network on Mediterranean Pastures and Fodder Crops titled **"New approaches for grassland research in a context of climatic and socio-economic changes"** which took place in Samsun (Turkey) from 3 to 6 October 2012, and includes the invited and selected papers presented at the Meeting.

ONDOKUZ MAYIS ÜNİVERSİTESİ

ONDOKUZ MAYIS ÜNİVERSİTESİ ZİRAAT FAKÜLTESİ

CIHEAM
MAI ZARAGOZA

ISBN: 2-85352-490-6
ISSN: 1016-121-X

Prix: 83,85 Euro

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