Paper 39

[Accueil] [Remonter] [Intro 1] [Paper 2] [Paper 3] [Paper 4] [Paper 5] [Paper 6] [Paper 7] [Paper 8] [Paper 9] [Paper 10] [Paper 11] [Paper 12] [Paper 13] [Paper 14] [Paper 15] [Paper 16] [Paper 17] [Paper 18] [Paper 19] [Paper 20] [Paper 21] [Paper 22] [Paper 23] [Paper 24] [Paper 25] [Paper 26] [Paper 27] [Paper 28] [Paper 29] [Paper 30] [Paper 31] [Paper 32] [Paper 33] [Paper 34] [Paper 35] [Paper 36] [Paper 37] [Paper 38] [Paper 39] [Paper 40] [Paper 41] [Paper 42]

Product quality and environmental impacts in rice farming : from knowledge to decision support procedures

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Abstract

Two different but complementary problems are examined in this paper : the industrial quality of the end-product and the 'quality' of the agricultural practices used with regard to their potential effects on the environment. In order to reduce the scope of the subject, two particular aspects of these problems are examined :

- the effect of environmental conditions and cultural practices (including nitrogen) on the milling yield of rice grown in the Camargue, and,
- the effects of the management of nitrogen fertiliser on production levels and environmental risks.

The common feature of the two aspects is therefore the effects of nitrogen on paddy rice yields, product quality (measured by milling yield) and the environment. Each topic is discussed using the same methodological procedure, consisting of showing the fundamental knowledge acquired on biophysical processes in the context of the natural environment in the Camargue, to indicate farmers' strategies and practices and to propose methods and results showing how to connect the two fields of knowledge that are related to scientific knowledge and farmers' knowledge. This in fact means seeing how farmers can be led to adopting cultural practices that respect a multicriterion set of specifications : yield, quality and respect of the environment. The problem is particularly difficult insofar as these criteria are not appraised by the same persons using the same scale. The yield is of interest first to the farmer who can adjust it by managing his means of production, quality depends on the rules and standards set by the industry and representations of the environment are set socially and conflicts are managed at the level of the Camargue area.

Keywords

- Rice, Camargue, cultural practices, environment, quality
- France

Introduction

Context and problematics

Applying a 'quality' approach to rice growing leads to considering two aspects of the problem that would appear to be very different : the quality of the end-product and the 'quality' of cultural operations. The former concerns the farmer directly and on a very short term basis as payment for his work depends on certain quality criteria imposed by the market and the sector. The price paid to the grower varies according to the types of grains produced (Pons et al., 1992) and, for the same type, according to the milling yield (the percentage of unbroken, whitened rice obtained from a given quantity of paddy rice). The second aspect leads to making judgements of the effects of the cropping systems used by farmers on changes in the states of the environment. These states involve the physical, chemical and biological characteristics of cultivated fields and hence their 'fertility'; they also concern the states of the environment outside the farm. Here, we address the problem of the relations between farming and the environment.

Changes in the 'fertility' of rice fields concern the farmer directly, but as perception is set against a fairly long time scale (several years) that is sometimes difficult to assess, the constraint is not always felt with the same urgency. It must always be approached in relative terms with regard to the biological components of fertility since the present virtual monocropping practised in most rice growing areas has led to a rapid increase in weed and pest pressure, calling into question the sustainability of the system and worrying professionals considerably. The changes in the characteristics of cultivated fields on a farm may affect the general evolution of the ecosystem. For example, a decrease in the biological fertility of rice fields leads the grower to make increased use of chemical control methods with increased risks for the environment.

This impact of cultural operations on the environment of the cultivated fields concerns numerous categories of persons with different interests and requirements (non-farming neighbours, nature conservationists, industrialists, livestock farmers, fishermen, hunters, etc.). It also concerns more generally the community as a whole, as this is responsible for managing for future generations a wetland heritage whose area has decreased continuously in Europe in recent years. However, it is not true to state, as some people have (Tamisier, 1994), that farmers are unaware of this aspect of the problem and that their prime concern of the economic profitability of the farm in the short term rules out any preoccupation with a certain heritage management of their working and living environment. In the Camargue, the existence of marshland used for shooting and the possible tourist development of private land are leading farmers to consider the attractiveness, the 'aesthetic aspect' of their farms in an economic context of uncertainty with regard to farm production (Sausse et al., 1993).

Finally, product quality and quality of the environment are two questions that are now merging in the efforts made by professionals to obtain quality designations (of the AOC type) that will be based on a certain image of the geographical area of production and will lead to certain specifications for rice growing. Consideration of 'quality rice growing' is thus becoming a necessity, with reference to both meanings of the word 'quality' mentioned previously. It is necessary to learn the simultaneous management of environmental and product quality (INRA-SAD, 1994).

Both aspects of the question of quality are approached in this paper. We present first of all some unpublished results from our laboratory on the subject of the industrial quality of rice measured by its milling yield** , with stress laid on little-studied aspects, i.e. the effects of fertilisation practices. In the second part, we show how to approach relations between agriculture and the environment to overcome the usual divergences between farmers and conservationists and farmers and extension agents. This is illustrated using fertilisation practices.

***Milling yield is the percentage of whole, whitened grains after winnowing and whitening in relation to the initial weight of paddy rice.*

Methodology

Study of the relations between inorganic fertilisation, the state of the plant population and the technological quality of the rice produced is based on the monitoring of cropped fields for several years. The work was performed in the Camargue from 1984 to 1987. This agronomic appraisal method (Barbier et al., 1990) makes it possible to study the relations between cultural practices and the states of soil, climate and plant population and of yields (in paddy rice and whitened whole grains) under real cropping conditions. In 1984 and 1985, for which the results are presented here, a total of 130 rice fields on 30 farms were monitored from the land preparation stage to the final yield in paddy and milled grains.

The results concerning the frequential analysis of probable rice sowing and harvesting dates were obtained by very close monitoring of farming operations at three farms. On the one hand the structural characteristics of the farm were identified (labour, equipment, soil type and irrigation system) and on the other the decision-making rules used by the farmer to allocate his labour and equipment resources in the fields and in time were recorded. These resources and rules were then entered in a work organisation simulation program such as OTELO (*Organisation du Travail Et Langage à Obje*t). This enabled us to calculate the dates of performance of certain cultural operations (sowing, harvesting, etc.) on the base of climatic scenarios drawn from meteorological records over the past twenty years. It is thus possible to appraise the risks taken by the farmer (the risk of sowing too late, of harvesting too late, etc.).

The industrial quality of rice

Existing knowledge

We now possess fairly good knowledge of the main factors that affect the industrial quality of rice. Studies carried out in the Camargue (Cornet 1964; Grillard and Séguy, 1972; Laignelet and Marie, 1983; Barbier and Mouret, 1986; Clément and Séguy, 1994) have shown the importance of post-flowering climatic conditions on the milling yield and the determinant nature of grain form in susceptibility to these events. They have also shown the effect of pest attacks at the end of the cycle (stem-borers, Sclerotium sp.) and of lodging on production quality. When lodging, which may be caused by pathogenic fungi such as Sclerotium, occurs early on in a field that is still flooded, yield and quality are strongly affected, as in the Camargue in 1994.

The relation between milling yield and grain moisture at harvesting is shown in Figure 1 for all varieties for two successive years with very contrasted climatic features. It can be seen that in 1985 there was a very rapid fall in milling yields when the grain moisture content at harvesting was lower than 20-21%. A somewhat slighter decrease occurred in 1984 below the same moisture level.

Figure 2 shows the relation between milling yield and the average temperature during the 30 days preceding harvesting (grain maturation period). It can be seen that milling yields were high and displayed little variability in 1984. The grain maturation period was thus relatively cool with moist atmospheric conditions (low evapotranspiration and slow, regular grain maturation). In 1985, maximum and mean milling yields were lower and above all more variable; air temperatures were much higher during the grain maturation period (the atmosphere was hot and dry and the grain dried more rapidly). Very low milling yields (20 to 25%) were recorded in 1985. In these cases, rice was harvested at very low moisture contents of between 15 and 18%. In 1984, harvesting at very low moisture contents did not result in such low milling yields; the effect of strong alternance of drying and remoistening under 1985 weather conditions should be noted here (potential evapotranspiration during the maturation phase was 5.5 mm per day in 1985 and only 3 mm per day in 1984).

The relations between milling yield and fertilisation practices are less well known and have been studied less. Our work has shown links between plant nitrogen and phosphorus levels and milling yield (Barbier and Mouret, 1986).

A strong nitrogen concentration at the end of the cycle results in a higher percentage of immature kernels. In fact, the effect of nitrogen is fairly complex and the repercussions on milling yield are generally indirect. Excessive nitrogen fertiliser combined with mediocre rice emergence increases the rate of individual tillering of the plants and the production of vegetative biomass (stems and leaves). When a certain tillering rate is exceeded (> 4-5 tillers per plant), the staggering in phenological stage remains and it is rare for all the tillers to be mature at harvesting, whence the increase in the percentage of immature kernels. The grain maturation phase lengthens when the biomass content and plant nitrogen level are high at flowering; when the harvesting date is a set one, the average grain moisture content is higher, as is the percentage of immature kernels. It should be mentioned that excess nitrogen and biomass at flowering have many frequently correlated consequences (Durr, 1984): a higher sterility rate, a higher percentage of poorly filled grains, a higher percentage of immature kernels and lower average grain weight. Although nitrogen enables—during the vegetative and reproductive phase—a steady increase in the yield potential established at flowering (through abundant tillering and the differentiation of a large number of spikelets), this potential is often poorly used at the end of the cycle. In most cases, although the paddy yield is lower than the potential yield at flowering, it remains correlated with it. However, study is rarely pursued as far as the industrial yield for which the farmer is paid. Full examination of the yield build-up of milled rice would enable true analysis of the economic profitability of the procedures for applying nitrogen fertiliser (doses, type and dose splitting).

The effect of phosphorus is opposite to that of nitrogen. A highly significant correlation is observed between the phosphorus content of the plant at flowering and grain breakage. When the plant phosphorus content increases, the following features are observed simultaneously :

- shortening of the flowering to maturity time,
- a decrease in the percentage of cargo rice in relation to the weight of paddy rice (spikelets are less well filled),
- a higher breakage percentage.

It were as if by accelerating the grain maturation phase phosphorus were to reduce the milling yield by affecting its two components : the percentage of cargo rice and breakage.

Given the combined but antagonistic effects of N and P on industrial rice yields, we examined the effects of the plant N:P ratio on milling yield. It was found that the highest values observed increased with the N:P ratio, while the latter varied fairly broadly (from 10 to 17). This would seem to indicate that under the conditions of the Camargue, analysis of the balances between nutrient elements and their effects on the industrial quality of rice should be focused on the N:P ratio as the effects of potassium did not appear to be determinant.

Improvement of product quality at farm level

At holding scale, the farmer must determine a cropping plan at the beginning of the season and, for his rice fields, a sowing plan with the allocation of varieties and (planned) sowing dates to batches of fields. This allocation takes many factors into account : the cycle length of the variety, known ecological requirements and susceptibility to lodging and pests, the sensitivity of milling yield to pre-harvest climatic conditions, the field characteristics (soil type, preceding crop, ease of irrigation and drainage, etc.) and the type of harvesting planned (a contractor or the holding's own machines). These decisions taken at the beginning of the season, the progress of the season (and especially emergence), crop management methods (fertilisation) and the weather conditions at the end of the cycle will result in a certain final product quality.

Helping farmers to improve this quality consists of using existing technical references to design, at the beginning of the season, cropping plans for varieties that ensure paddy rice and milling yields that come up to their expectations, given the climatic risks and the characteristics of the farm. For this, it is necessary to construct models for aid in decision-making that incorporate existing agro-physiological knowledge and the constraints of work organisation on the farm (Legal, 1994).

Figure 3 shows the simulation results for a typical farm in the Camargue. The risks of late harvesting can be appraised with the farmer; late harvesting increases the risk of poor product quality as it increases the probability of harvesting under poor conditions (Figure 4): flooded fields, lodging or poor grain maturity.

Cultural practices and respect of the environment

This chapter is based on work carried out in close collaboration with P.Y. LEGAL of CIRAD/SAR (Montpellier) and the help of INA-PG (M.H. CHATELAIN, F. PAPY).

'You can just...', 'you have to...': the downward model of diffusion of knowledge

Many rice growing procedures are known that are potentially less aggressive for the environment. We can mention several here without pretending to provide exhaustive coverage :

- pre-irrigation with mechanical weeding to control wild rice and other weeds (Catala, 1992),
- leaving little time between the final soil preparation work and sowing so that, similarly, weed emergence is reduced and delayed,
- the use of crop rotation to reduce pest and weed pressure and hence limit the use of agricultural chemicals,
- dry seeding with no submersion while the rice begins to grow; this avoids the use of algicides, vermicides and fungicides at the beginning of the cycle,
- the chopping and ploughing in of rice straw to improve mineral nutrition of rice and reduce the doses of fertiliser placed in the soil or distributed in water during cultivation. This way of using straw also avoids delicate burning operations near urban areas (in Italy),
- shortening the interval between application and ploughing in of fertiliser and flooding the fields,
- the possibility of nitrogen management with better allowance for the real crop requirements with applications split during cultivation when uptake by the plant is at maximum.

In the absence of recent scientific references concerning the effects of rice growing and rice production procedures on the environment, we have considered here as alternatives any technique that replaces the use of a synthetic substance by any mechanical or biological action and any technique that uses new knowledge to perform more rational management of inputs (and hence improve their effectiveness).

The generally beneficial effect for the environment of some alternative practices is still uncertain. Although the ploughing back of crop residues avoids burning and improves the mineral nutrition of rice, it may have negative secondary effects. For farmers, burning is a means of controlling pests and weeds; if this is true, abandoning burning might be accompanied by increased use of agrochemical applications for control purposes. Research station trials are therefore not sufficient for judging the benefit of a given technique. Complementary knowledge must be gained to achieve better understanding of the many interactions under real conditions. A cultivated field should be considered as a complex system.

The reproaches made concerning rice growing do not all concern the use of chemicals but also include criticism of spraying techniques (helicopters for example), the simple presence of flooded rice fields and their extension : changes in the landscape, fewer trees and hedges, decrease in 'natural' environments, change in surface and underground hydraulics (in particular, in the Camargue, saline ground water rises in the peripheral zones because of the pressure of the fresh water used) and competition for the use of areas by many different categories of people.

It would seem clear that the latter features are central to the debate. These conflicts are the result of both the play of social relations in the area, the economic context and the adaptation/innovation capability of the professional setting in the broad sense. Rice has gained ground once again in the Camargue because rice growing techniques (and hence yields) have progressed in parallel with economic support for the crop, but also because the recent fall in rice prices has led farmers to seek to reduce production costs through a reduction in labour costs and subcontracting (helicopter spraying, subcontracted harvesting).

Rice growers pride themselves on being the cause of a certain ecological equilibrium because of the fresh water that they bring to the environment because of their farming activities and whose cost they cover.

Finally, at research and development level, it is often regretted that there is a lack of comprehension between the external 'experts' who conceive and develop new techniques (see the list above) and farmers, described as being conservative or even ignorant because they do not adopt them on a large scale. The problem should be considered from a different angle in order to overcome this two-fold lack of understanding between farmers and conservationists and farmers and technical consultants. The components of this approach are presented here, illustrated by examples drawn from the case of the Camargue.

Better understanding farmers' choices : an interactive procedure of decision support and guidance of research

This goes beyond the framework of agronomic research stations and cultivated fields and focuses on the actual farming activities performed on a farm (as part of networks of relations in parallel or not with activities that are not directly agricultural : farm tourism, tertiary rearing, etc. Two main basic principles guide analysis at farm level :

- a farmer always has 'good reasons' to do what he does and the objective then becomes that of understanding these 'good reasons', in other words analysing the determinants of the farmer's cultural choices and his cultural practices (Landais and Deffontaines, 1989),
- farms possess a diversity of structures, activities and modes of operation related to their geographical position, the diversity of the environments that they exploit, their history and the projects and objectives of the farmers who manage them. It is necessary to understand this diversity because farmers do not display the same receptiveness to the different technical themes extended.

These two principles should make it possible not to substitute but to complete external appraisal (or appraisal by an expert who judges the effectiveness of the cultural practices used in relation to standards and a theoretical field of external knowledge) by an internal appraisal performed from the farmer's point of view : has the farmer attained the objectives that he set? It can be understood that if the farmer attains his objectives every year and is satisfied with his situation, there is little likelihood that he will be interested by modifications to his farming system.

It is not easy to understand why a farmer does what he does, because asking him is not enough. The reasons are often implicit. They must therefore be explained and a model of general action — little or not questioned each year — separated from adaptations related to uncertainties, and mainly climatic and technical uncertainties (Sebillotte and Soler, 1988).

The following can be identified among the reasons for farmers to use certain cultural practices (ranging from the choice of variety and its siting in the farm field structure to harvesting by way of the various cultural operations such as tillage, fertilisation, seeding, phytosanitary treatments, fertilisation and water management) :

* the main and subsidiary objectives, that he sets himself at certain key moment. A farmer for whom high yields are not an objective will set the completion of seeding on 20 May as a subsidiary objective whereas another, who aims at high yields, aims at competing the sowing of the earliest varieties on 5 May and that of the latest on 30 April. These deadlines allow for the risks of fall of yield with late sowing (sterility at flowering, lodging and harvesting in water, poor quality of the final product). The different programmes can be related to the importance of rice crop for the farm and the farmer's dislike of risk. As this aversion varies in intensity according to the economic situation of the person concerned (e.g. a high level of debt), previous remarks concerning farm diversity apply again, with the important aspect then being to possess a typology of farms in the region drawn up from criteria that are pertinent with regard to the purpose of the work (in this case drawing up technical advice for rice growing);

*the indicators used by the farmer to decide on the performance of certain technical operations, in other words the indicators used in rules for operation of the 'if... then...' type. These indicators incorporate a whole field of knowledge possessed by the farmer and that result from his experience, his network of neighbours and advice from various bodies. For example, one farmer might use the average air temperature measured on his farm to decide whether to begin seeding operations (he will only begin at over 13°C) whereas another will use as reference the irrigation water temperature measured in an irrigated field.

Little research has been performed and little aid has been provided for farmers with regard to the choice and analysis of the pertinence of these indicators that are nevertheless central to decision-making concerning farming. Knowledge of these indicators and rules is nonetheless of great importance for improving fertilisation and weed management practices to achieve better effectiveness of the chemicals used (making it possible to avoid excessive dosage or catching up operations). How does the farmer identify weeds? How does he appraise their importance? How does he identify the stage of plant development to decide on the most appropriate treatment? The corollary to this question is knowing how a farmer incorporates and uses messages like 'to be used at 1.5 leaf stage of barnyard grass (Echinochloa sp.)'.

*The spatial nature of farming activities and structural constraints. At field scale, agricultural activity is essentially perceived in its temporal dimension; the concept of crop management sequence exists as a reminder of logical, ordered succession of technical operations. At farm scale, agricultural activity becomes spatialised. Operations must follow each other in space and time according to the different crops and varieties and their requirements, the states of vegetative growth, the field structure, the type and state of the soil and also the human resources and the equipment available and its capacity (rate of progress of the work). It is essential to make a spatial representation of the sequence of the various operations in order to understand the constraints to which the farmer is exposed. This approach and the use that can be made of it is illustrated in Figure 5 (Keda, 1994).

Tillage on this farm always starts in the low-lying parts; these clayey soils drain slowly and even light rain delays the work considerably and they must therefore be awarded priority to avoid seeding too late in case of rainfall. In contrast, flooding starts with the higher fields and moves towards the low part. There are two major reasons for this : because of its topographical position and the soil type, irrigation of some of the higher land is difficult and long and the greatest advantage must be drawn from the head of water. The irrigation stations are at the high points of the farm and leakage from defective channels is avoided by first irrigating the fields that are nearby and hence on the higher fields. The result of this two-fold set of constraints is that the time elapsing between the spreading and ploughing in of fertiliser and submersion varies considerably according to the position and may be very long and not very suitable for the good use of nitrogen fertiliser (substantial loss by nitrification-denitrification). In such a situation, the farmer may express interest in operations aimed at modifying fertilisation plans for the lowest fields (where the gap is longest), in particular by abandoning basal nitrogen fertilisation; in this case, he will use a simple PK fertiliser and apply all the nitrogen required during the rice growing period.

The second solution also makes it possible to seed at the best dates since P and K fertiliser can be applied from February onwards and thus no longer risk delaying seeding.

The results of seeding date simulation are shown in Figure 6 for a comparison of the two management sequences mentioned, i.e. (a) application of NPK fertiliser ploughed in before seeding, and (b) application of PK fertiliser in February-March and nitrogen application after seeding. It is verified that the second procedure enables earlier seeding likely to give better yields and better grain quality.

Conclusion

In the last example mentioned, the farmer may not wish to modify his fertilisation plans. For reasons of simplicity, he may not wish to have to apply two different formulas. In this case, one is led to examine with him the pertinence of the orders of priority that he awards to his fields for starting cultural operations.

It can be seen that the procedure is aimed at reconsidering his choice and decision-making procedures with the farmer, to design others and to reformulate the problem. It is therefore an interactive process for aid in decision-making at farm scale. However, this advisory procedure should nevertheless go beyond individual cases and be of benefit for all farmers who experience the same type of problem.

Implementation of the procedure involves a number of concepts, a theoretical model of representation of the organisation of work on the farm and simulation tools that can test the consequences of the farmer's mode of organisation for the procedure of operations (Papy, 1993). The use of simulation software makes it possible to deepen discussion with the farmer by introducing inter-annual climatic variation and its effects in production build-up and thus to see the risks involved in a certain type of organisation or a certain farm structure.

The aim here is not to perform in-depth development of the methodology but to show how it is possible to go beyond certain arguments and certain cleavages in relations between farmers and conservationists and between farmers and agricultural advisers.

Although farmers can pollute the environment (and this has by no means been proved for rice growing), their are not intentional polluters. They are involved in an economic logic and a set of technical constraints that, given the level of knowledge available, oblige them to use techniques considered to be reliable, relatively simple and profitable. This logic must be explained to the other persons concerned. However, within this framework, that may change as a result of regulations, it is possible to move towards different technical models. Certain procedures must nevertheless be set in motion for these to be achieved :

- objective analysis of the effects of the cropping systems on the states of the environment (soil, water, climate); this leads to the demonstration of cultural situations (soil conditions x cropping system) that incorporate risks (Capillon, 1992; Sausse et al., l993); the frequency of the appearance of these can then be discussed,
- testing the very different cultural intervention programmes that exist to broaden the range of possibilities, showing that one can cultivate in a different way and thus change certain representations. Experimental work serves not only to provide the proof of some agronomic superiority of one technique over another but also to open up scope for reflection. In the Camargue, demonstration that it is possible to grow rice

without water at the outset has helped to decrease water consumption in the rice fields. Demonstration that rice can be grown without application of nitrogen before seeding has made it possible to make working calendars more flexible on certain farms and to change the modes of representation of the effect of nitrogen, while this practice is not agronomically better than the others (CFR, 1993),

- working in direct contact with farmers : understanding what they do and why, discussing with them the novelties that they may be able to incorporate in their farming systems and reconsidering the information systems used in their decision-making processes. It also means that new ideas emerge and new methods to be tested. In addition, farmers experiment on their own. They innovate and accumulate knowledge and know-how; it is important to make the most of this and accompany this spontaneous dynamics,
- completing knowledge when this is insufficient. It is not enough to understand what the farmer is doing. An external appraisal is still necessary and the basic knowledge for this is often lacking. This is the case for the relations between cultural practices and product quality and the analysis of the real effects of cultural practices on environmental changes on and off the farm.

Figure l. The relation between milling yield and grain moisture content at harvesting (1984 and 1985)

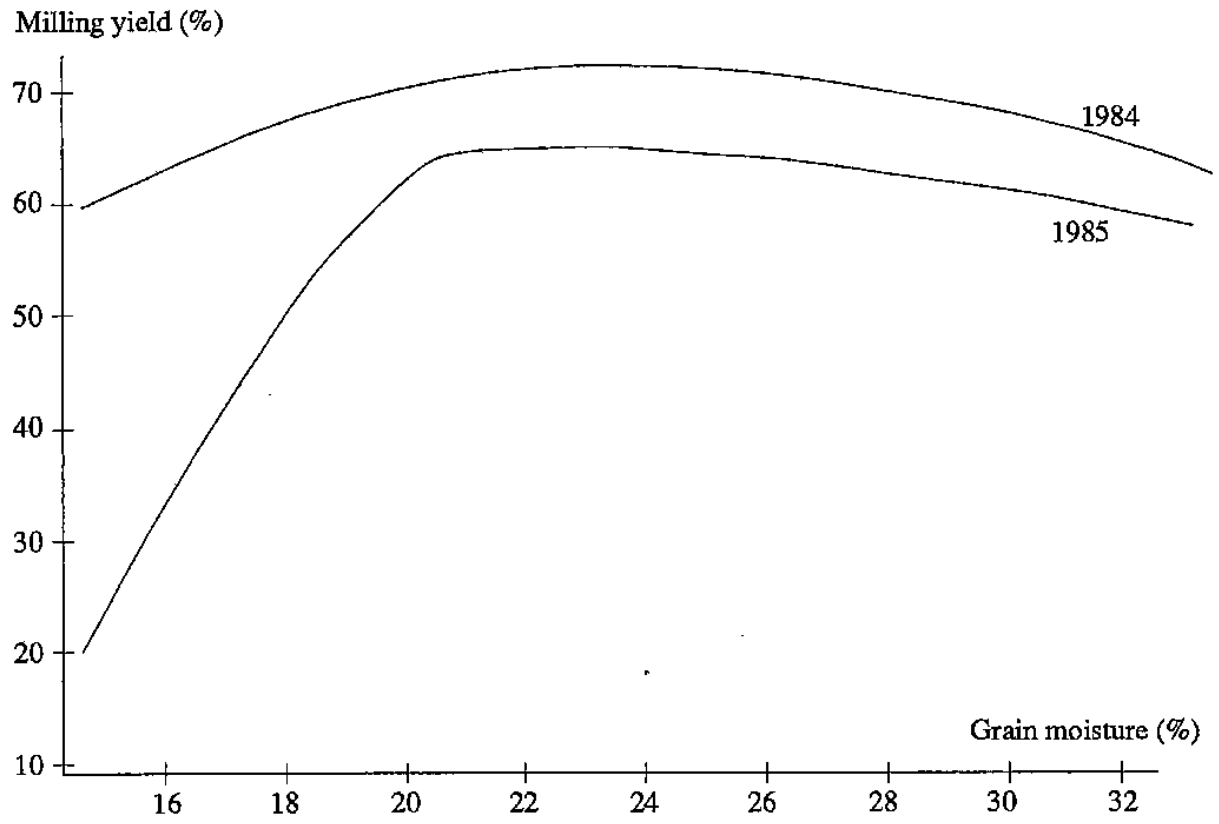


Figure 2.The relation between milling yield and average temperature during grain maturation (1984 and 1985)

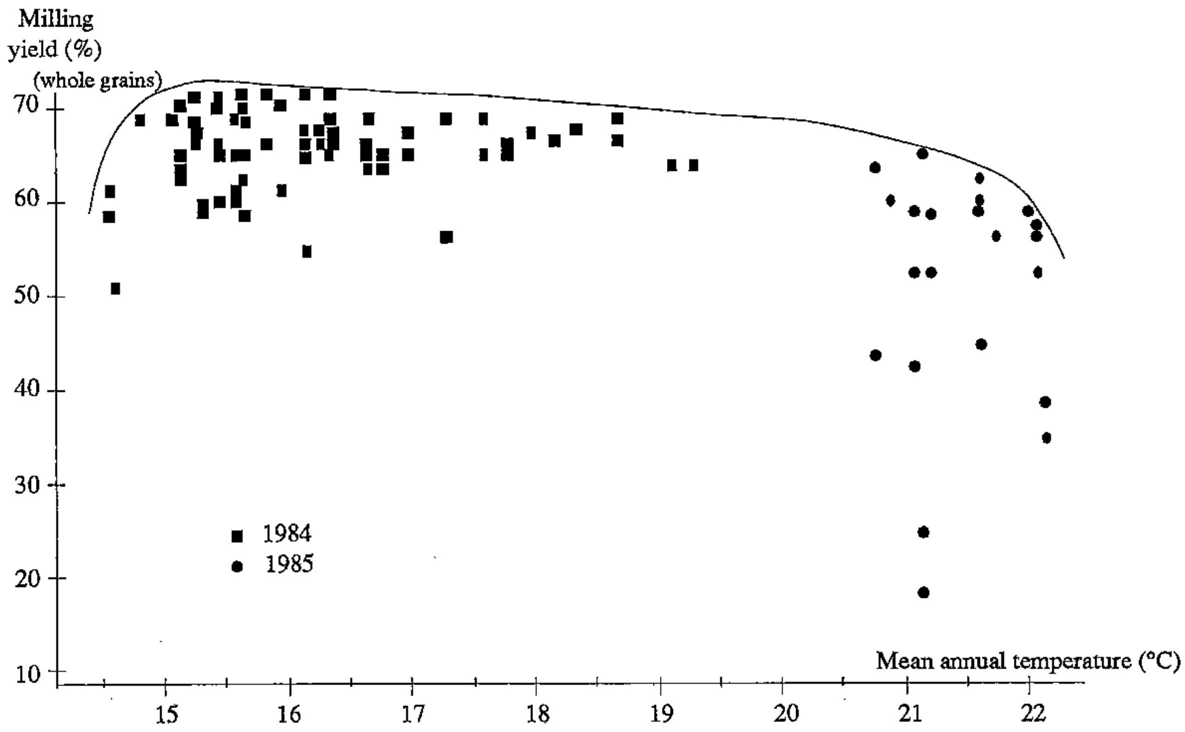
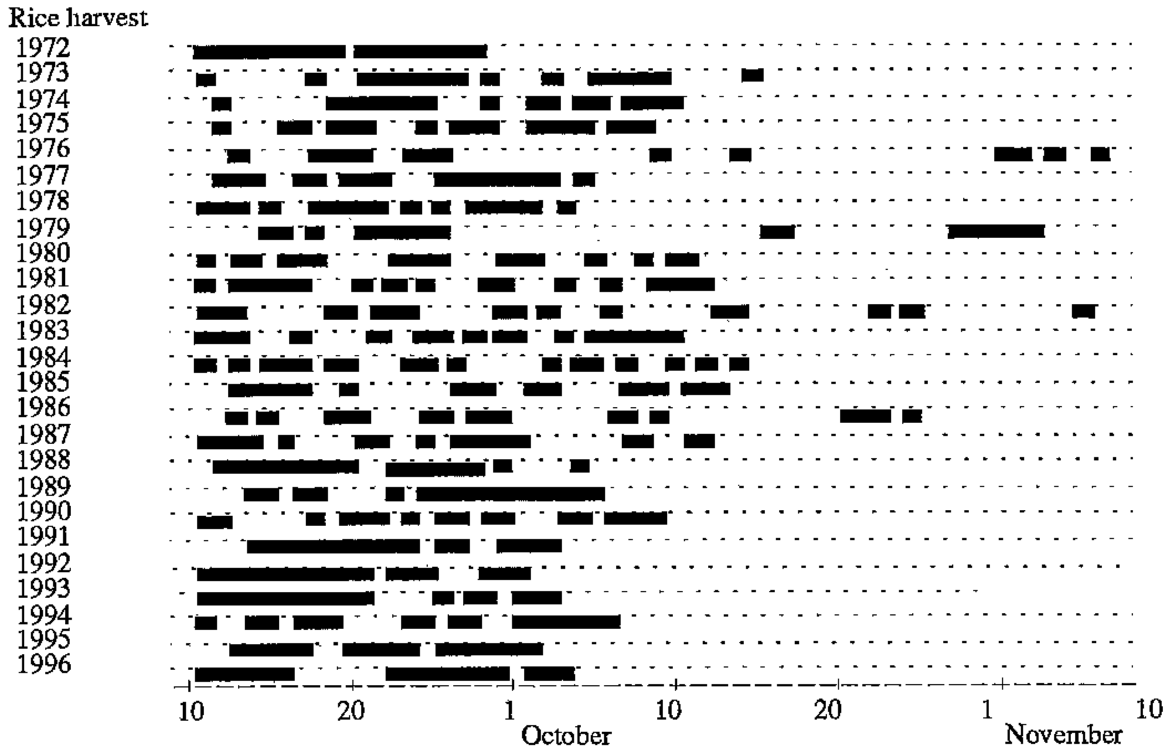


Figure 3. The result of the simulation of a rice harvest according to a mode of work organisation observed in 1996 and according to the climatic scenarios of 1972 to 1996



Harvest: day of rain (storm) ⇒ lodging
performance halved

Figure 4. Average ten-day rainfall observed in the Camargue from 1971 to 1996

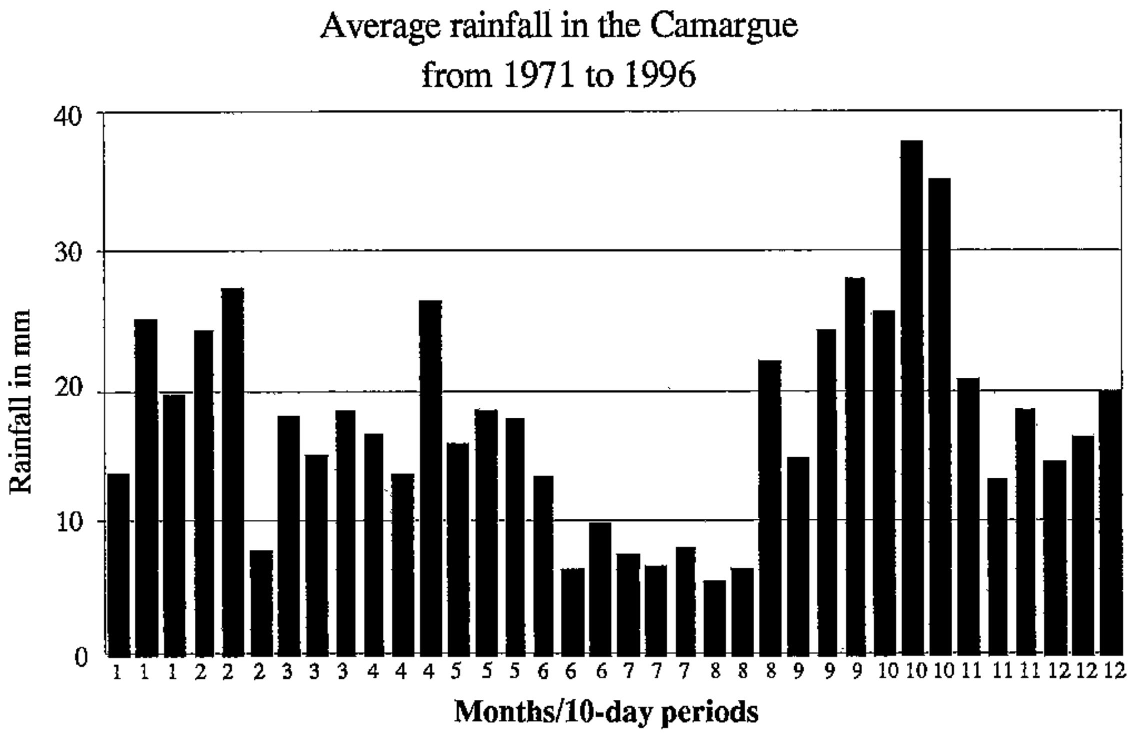


Figure 5.Field layout of a rice farm showing differences between fertiliser (N-P-K) application dates and the dates of the start of submersion for the 1994 season

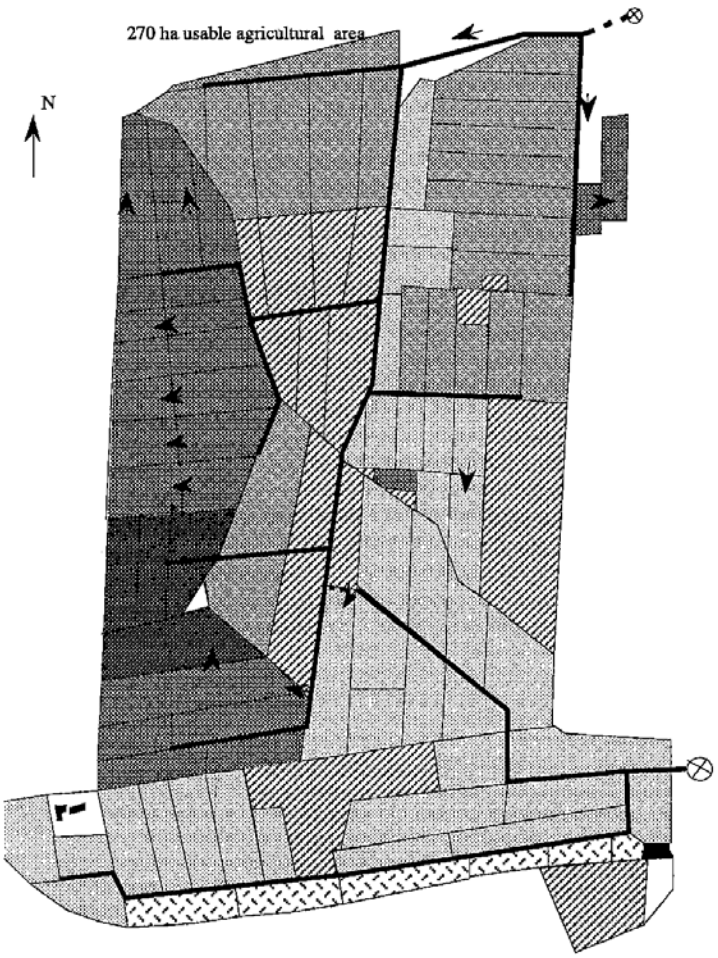
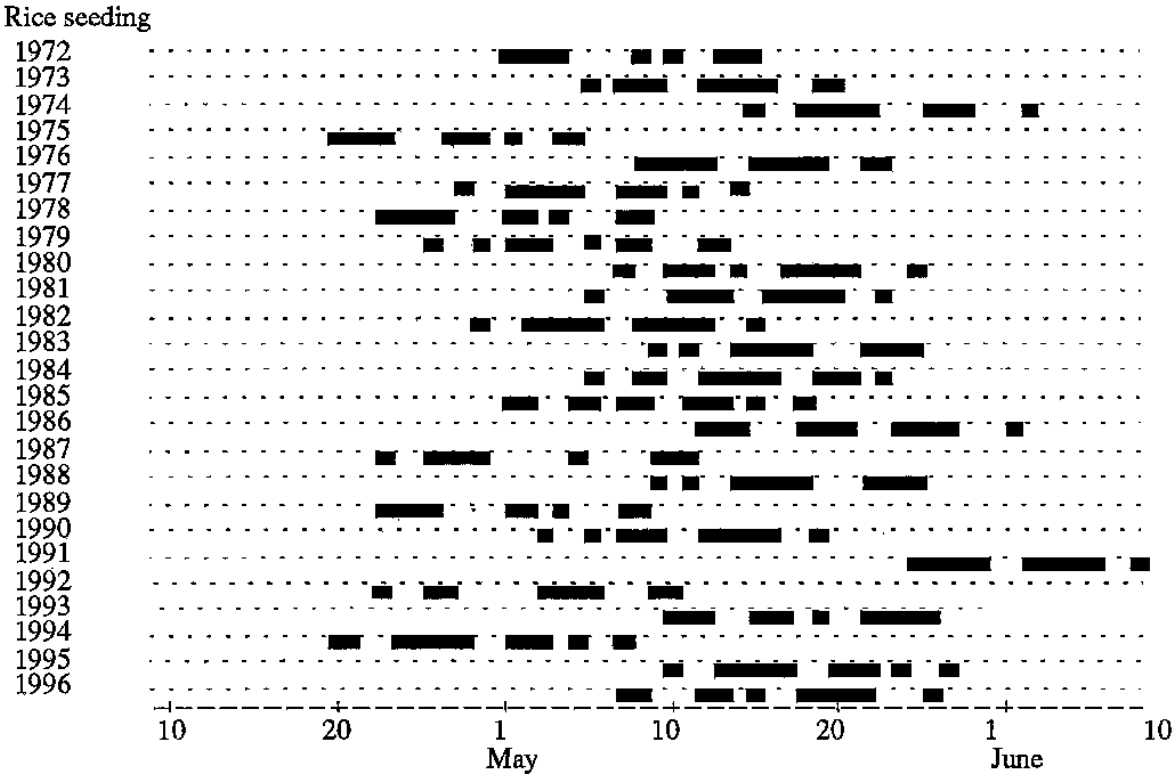


Figure 5. Field layout of a rice farm showing differences between fertiliser (N-P-K) application dates and the dates of the start of submersion for the 1994 season

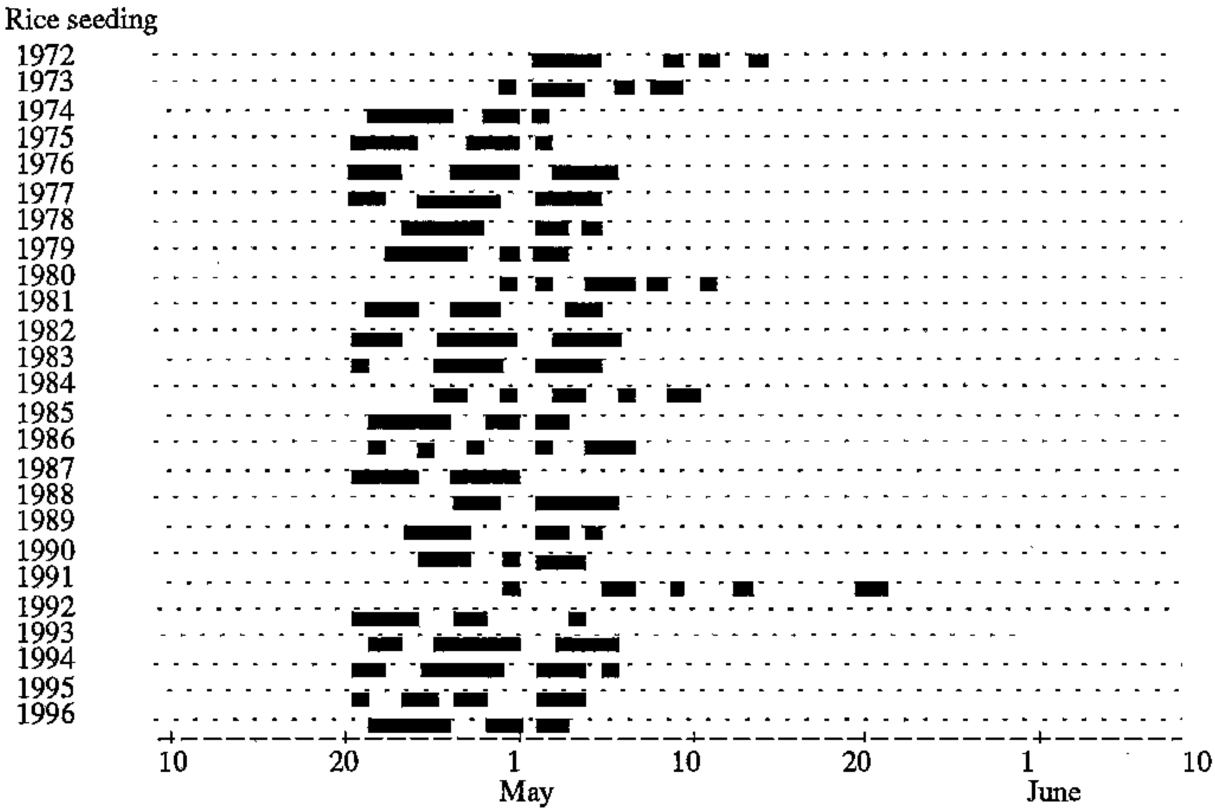
differences in days
- 0 to 5
- 6 to 10
- 11 to 15
- 16 to 20
- 21 to 25
- fields under wheat

Figure 6. The results of simulation of rice sowing dates according to two modes of application of nitrogen fertilisation.



Top : application and ploughing in before sowing

bottom : application after sowing



Areas: 205 ha of rice
16 ha of wheat

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Figures and tables summary

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