Paper 26

[ 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 ]

# Effect of preseeding nitrogen fertilization on rice yield components and leaf nitrogen content under salty and non salty watering conditions in Southern Spain

**Authors :**

**AGUILAR M**
**GRAU D.**
**ESPINOZA M.**
**CONTREPAS M.**
Dirección General de Investigación Agraria. CIFA Las Torres y Tomejil. Apartado Oficial
41200 Alcalá del Río. Sevilla. SPAIN.
Tel : +34 565 08 08
Fax:+34 565 03 73

## Abstract

The effect of eight rates of preseeding nitrogen fertilization on yield components and leaf nitrogen content of two rice varieties (Indica and Japonica subspecies) in both normal and salty conditions in Guadalquivir Valley (Seville, Spain) was studied. Japonica cultivar reached a maximum yield with 120 kg/ha whereas Indica ones with 120-150 kg/ha. Japonica cultivar showed more tolerance to salty watering than Indica ones. There is a significant relationship among fertilization rate, leaf nitrogen content and grain yield. In no salty conditions leaf nitrogen content evolution was studied. Adequate and critical leaf nitrogen content values was obtained in order to avoid excessive nitrogen fertilization and negative environmental impact.

## Keywords

- Rice, nitrogen fertilization, grain yield, leaf nitrogen content, salty watering
- Spain

# Introduction

In Southern Spain, Andalucía, the acreage of rice growing is about 35.000 ha, except in years of water shortage. Seville is the only province in Andalucía where rice is grown.

The rice area is situated in the final stretch of the Guadalquivir river, between Seville and the river mouth, covering both banks, in the "Marismas" marshlands. The soil, clayey and saline, has a sedimentary origin.

Over the last decade, there have been severe irrigation problems in the andalusian rice area (Fig. 1). The salty tidal sea water tends to flow upstream while the fresh water flows in the opposite direction. Water for irrigation is pumped up from de river. In the central rice zone, at least a 25 $m^3/s$ caudal of fresh water is necessary to avoid a saline content above 0.8 g ClNa/l which carries out a reduction in rice yield. Rice paddies are irrigated under a continuously flooding system.

Thaibonnet, a long grain indica type cultivar, is sown on the 95% of the rice surface, while Thainato, the most used japonica type, occupies the rest of the rice area. Both are Californian-originated varieties. Nitrogen fertilization is only applied before rice seeding.

This rice area borders on the Wildlife National Park "Doñana" where environmental impacts caused by nitrogen pollution must be especially avoided. In this way, leaf nitrogen content analysis would be an appropriate fertilization helping method as described under Californian conditions (Aguilar, Grau, 1994; 1995).

This paper studies the relationship among nitrogen application, leaf nitrogen content and grain yield in Southern Spain in order to recommend a correct rice nitrogen fertilization under no-salty conditions. Fields studies were also conducted to know the performance of the two rice cultivars when irrigated with salty water.

# Material and Methods

Two experiments were carried out during 1994 and 1996 on a typical alluvial rice soil (Table 1) in Villafranco del Guadalquivir (Seville).

The salinity evolution of the irrigation water in both experiments is shown in Fig. 2. The experimental design adopted was a complete randomised split-plot with 3 replications, corresponding the sub-plot to the varieties. The elemental plot size was 15 x 2 $m^2$.

Eight nitrogen rates : 0-30-60-90-120-150-180-210 kg N/ha (urea 46 %) were applied and incorporated into the soil before seeding. No other fertilizers were applied. The varieties used were Thaibonnet, an early indica type cultivar, and Thainato, an early cycle japonica cultivar.

In both years, the seeding was performed by hand during mid-may and the harvest during early-October by plot-combine.

During the whole crop cycle the paddy was kept submerged all the time, except for four days in order to apply chemicals to control sedges and broadleaves weeds.

The rest of cultural procedures were as standard in the area. Observations included the following agronomic parameters :

- Cycle to heading : number of days from sowing to 50 % heading.
- Cycle from sowing to maturity (20 % humidity)
- Plant height : average of 10 plants taken at random. The length between the ground and the tip of the panicle in flowering.
- Lodging : an estimation (de visu) of the percentage of the lodging area in harvest time.

- Number of panicles per square meter : mean of four samples, each sample being taken from an area of 0.25 $m^2$.
- Number of grain per panicle mean of 40 panicles, considering the sum of blank and filled grains.
- Percentage of blank grains.
- Weight of 1000 grains (filled and blank).
- Grain yield : the whole plot was harvested.
- Leaf nitrogen content : According to the methodology described by Mikkelsen, Evatt (1973) and Miller (1983), Sampling 150 "Y" leaves (the most recently mature leaf).

# Results and discussion

## Rice irrigated under no salty conditions (water salinity about 0,8 g ClNa/l)

The main results are shown in Table 2 and can be summarised as follows :

- Nitrogen lengthened rice cycle and increased rice plant height in both varieties.
- Thaibonnet achieved higher values of both panicles/$m^2$ and blank percentages than Thainato. On the contrary the japonica variety reached higher values of 1000 grain weight and number of grains per panicle.
- In both varieties panicles/$m^2$ was the yield component more affected by nitrogen dose. Regarding Thainato it has been found a significant increase of the number of grains per panicle as nitrogen dose rises.
- There is a significant relationship between panicles/$m^2$ and grain yield in both varieties.
- The grain yields picked at 150 kg N/ha in Thaibonnet and at 120 kg N/ha in Thainato (Fig. 3).
- It seems to appear an increase, not significant, of the percentage of blanks in the case of no nitrogen application (0 kg N/ha) and with the highest nitrogen dose (210 kg N/ha).

### Relationships among nitrogen rate, leaf nitrogen content and grain yield

The increase of nitrogen fertilizer boosted the nitrogen content of the leaf in the two varieties. The evolution of the content in foliar nitrogen, show as a percentage of the total dry matter of the leaf, for the optimum recommended dose in each one of the varieties tested (150 kg/ha in the case of Thaibonnet and 120 kg/ha in Thainato) is shown in Fig. 4. Here, one can observe that the nitrogen content in the leaf steadily decreased as the vegetative cycle of the plant advanced.

For the optimum dose of ferlitizer, the corresponding critical levels and adequate intervals of the percentage of nitrogen in the leaf in the phases of maximum tillering (59 days after sowing) and at the start of the panicle initiation (67 days), have been determined (Table 4).

These two phenological stages in the rice plant are the most recommended for the sample taking in order to obtain precise determinations about the nitrogen content in the leaf. The lesser value of the adequate interval corresponds to that obtained with the optimum dose of nitrogen fertilizer for each variety (150 and 120 kg N/ha for Thaibonnet and Thainato respectively) and the greater value is the result of boosting the first by 15 % in the phase of maximum tillering and by 10 % in the initiation of the panicle (Miller, 1983). The critical level corresponds to the fertilizer dose with which 90 % of the maximum yield in grain is obtained in theory. These results are similar to those obtained in test of equal characteristics carried out in California, where the climatic conditions are similar to ours. These results may help in the handling of nitrogened fertilizer in rice both in the possible contribution to aid in the topdressing during the same year and also in subsequent years. The maximum value of the adequate interval can serve as an extremely useful references in the avoidance of nitrogen fertilizer excess which may cause a negative environmental impact.

This method of recommendation of nitrogen fertilizer based on the reference values of the nitrogen content in the leaf of the rice plant can serve as a complementary help to other more commonly used and fully valid methods like the traditional soil analysis.

## Rice irrigated under salty conditions (water salinity about 3,2 g ClNa/l)

When the salinity in the water irrigation gets very high values a significant, general decrease appears for the following yield components : panicles/$m^2$, grains/panicle and 1,000 grain weight (Table 5), compared with no salty conditions. On the contrary the number of blanks is higher. Therefore grain yield decreased significantly for both varieties (Fig. 5). Despite this, Thainato behaves much better than Thaibonnet in these salty conditions.

No nitrogen effect on yield is shown for Thaibonnet. Only a little increase can be observed for Thainato.

From an economic point of view rice crop is not profitable in these extreme conditions.

### Figures and tables

**Table 1 :Some physical and chemical characteristics of experimental soil**

| Components | Depth: 0 - 20 cm |
|---|---|
| Clay (%) | 46 |
| Loam (%) | 36 |
| Sand (%) | 18 |
| pH | 7,90 |
| Organic matter (%) | 1,96 |
| Total nitrogen (‰) | 1,23 |
| Total phosphorous (‰) | 1,16 |
| Exchangeable potasium (ppm) | 367 |

**Table 2 : Effect of preseeding nitrogen rate on several agronomical parameters and yield in rice. Sevilla 1996.**

| Cultivar | Nitrogen Rate (kg/ha) | Cycle 50% heading | Cycle Maturity | Plant height cm | Lodging % | Panicles /m2 | Grains /panicle | Blank grains % | 1000 grain weight (g) | Yield kg/ha, 14 % moisture |
|---|---|---|---|---|---|---|---|---|---|---|
| **Thaibonnet** | **0** | 75 | 120 | 59,8 | 0 | 567 | 40 | 10,8 | 27,6 | 3764 |
| | **30** | 75 | 120 | 63,3 | 0 | 646 | 40 | 7,9 | 28,4 | 4422 |
| | **60** | 75 | 120 | 65,8 | 0 | 758 | 37 | 5,7 | 28,8 | 5473 |
| | **90** | 76 | 123 | 71,3 | 0 | 760 | 44 | 12,5 | 27,6 | 5747 |
| | **120** | 76 | 125 | 72,1 | 0 | 808 | 51 | 8,3 | 28,3 | 7244 |
| | **150** | 77 | 125 | 73,4 | 0 | 794 | 52 | 12,0 | 28,7 | 7600 |
| | **180** | 77 | 130 | 73,4 | 0 | 827 | 59 | 10,1 | 28,2 | 7610 |
| | **210** | 79 | 130 | 77,3 | 0 | 882 | 50 | 13,3 | 28,7 | 7570 |
| **Thainato** | **0** | 76 | 123 | 71,9 | 0 | 472 | 54 | 4,2 | 31,3 | 4313 |
| | **30** | 76 | 123 | 73,9 | 0 | 580 | 56 | 3,8 | 31,7 | 5178 |
| | **60** | 78 | 123 | 81,9 | 0 | 534 | 60 | 3,5 | 31,7 | 5910 |
| | **90** | 78 | 125 | 83,4 | 0 | 540 | 62 | 3,5 | 31,6 | 6623 |
| | **120** | 78 | 125 | 87,7 | 0 | 666 | 66 | 5,0 | 31,8 | 8069 |
| | **150** | 84 | 130 | 90,2 | 0 | 603 | 75 | 4,7 | 31,5 | 8082 |
| | **180** | 84 | 130 | 91,2 | 3 | 626 | 73 | 4,8 | 31,9 | 7441 |
| | **210** | 86 | 135 | 94,5 | 13 | 597 | 83 | 6,1 | 30,4 | 7377 |
| **Nitrogen dose mean** | **0** | 76 | 122 | 65,8 | 0 | 520 | 47 | 7,5 | 29,4 | 4038 |
| | **30** | 76 | 122 | 68,6 | 0 | 613 | 48 | 5,8 | 30,0 | 4800 |
| | **60** | 77 | 122 | 73,9 | 0 | 646 | 49 | 4,6 | 30,2 | 5692 |
| | **90** | 77 | 124 | 77,3 | 0 | 650 | 53 | 8,0 | 29,6 | 6185 |
| | **120** | 77 | 125 | 79,9 | 0 | 737 | 59 | 6,7 | 30,1 | 7656 |
| | **150** | 81 | 128 | 81,8 | 0 | 699 | 63 | 8,4 | 30,1 | 7841 |
| | **180** | 81 | 130 | 82,3 | 2 | 727 | 66 | 7,4 | 30,0 | 7525 |
| | **210** | 83 | 133 | 85,9 | 7 | 740 | 66 | 9,7 | 29,5 | 7473 |
| **Cultivar mean** | Thaibonnet | 76 | 124 | 69,5 | 0 | 755 | 47 | 10,1 | 28,3 | 6179 |
| | Thainato | 80 | 127 | 84,3 | 2 | 577 | 66 | 4,4 | 31,5 | 6624 |
| *General Mean* | | *78* | *125* | *76,9* | *1* | *666* | *56* | *7,3* | *29,9* | *6401* |
| *C.V. (%)* | | - | - | *2,3* | - | *11,45* | *11,1* | *27* | *2,5* | *7,0* |
| *LSD (P<0.05) cultivar* | | - | - | *2,1* | - | *90,3* | *7* | *2,3* | *ns* | *533* |
| *LSD (P<0.05) N rate* | | - | - | *2,6* | - | *42,8* | *13* | *4,5* | *0,9* | *ns* |
| *Interaction* | | - | - | ** | - | *ns* | *ns* | *ns* | *ns* | *ns* |

**Table 3 : Effect of preseeding nitrogen rate on leaf nitrogen content (dry matter percentage) of two rice cultivars. Sevilla 1996.**

| Cultivar | Nitrogen Rate (kg/ha) | Leaf nitrogen content Days after seeding: 30 | 50 | 65 | 85 | 108 |
|---|---|---|---|---|---|---|
| Thaibonnet | 0 | 3,26 | 2,98 | 3,06 | 2,27 | 1,25 |
| | 30 | 3,76 | 2,88 | 3,06 | 2,15 | 1,27 |
| | 60 | 4,23 | 3,09 | 3,06 | 2,23 | 1,34 |
| | 90 | 4,61 | 3,15 | 2,99 | 2,45 | 1,47 |
| | 120 | 4,69 | 3,28 | 3,22 | 2,61 | 1,57 |
| | 150 | 5,21 | 3,66 | 3,33 | 2,71 | 1,84 |
| | 180 | 5,06 | 3,75 | 3,41 | 2,75 | 1,72 |
| | 210 | 5,11 | 3,82 | 3,38 | 2,79 | 1,86 |
| Thainato | 0 | 3,25 | 3,13 | 3,01 | 2,18 | 1,37 |
| | 30 | 3,58 | 2,88 | 2,99 | 2,06 | 1,30 |
| | 60 | 3,96 | 3,05 | 3,11 | 2,30 | 1,34 |
| | 90 | 4,38 | 3,20 | 3,20 | 2,42 | 1,42 |
| | 120 | 4,53 | 3,44 | 3,18 | 2,66 | 1,56 |
| | 150 | 5,05 | 3,65 | 3,37 | 2,75 | 1,80 |
| | 180 | 5,21 | 3,85 | 3,39 | 2,95 | 1,91 |
| | 210 | 5,29 | 3,99 | 3,63 | 2,94 | 1,64 |
| Nitrogen dose mean | 0 | 3,25 | 3,06 | 3,04 | 2,22 | 1,31 |
| | 30 | 3,67 | 2,88 | 3,02 | 2,10 | 1,29 |
| | 60 | 4,10 | 3,07 | 3,09 | 2,27 | 1,34 |
| | 90 | 4,50 | 3,18 | 3,10 | 2,44 | 1,45 |
| | 120 | 4,61 | 3,36 | 3,20 | 2,64 | 1,57 |
| | 150 | 5,13 | 3,66 | 3,35 | 2,73 | 1,82 |
| | 180 | 5,14 | 3,80 | 3,40 | 2,85 | 1,81 |
| | 210 | 5,20 | 3,91 | 3,51 | 2,86 | 1,75 |
| Cultivar mean | Thaibonnet | 4,49 | 3,33 | 3,19 | 2,49 | 1,54 |
| | Thainato | 4,41 | 3,40 | 3,23 | 2,53 | 1,54 |
| *General Mean* | | *4,45* | *3,36* | *3,21* | *2,51* | *1,54* |
| *C.V. (%)* | | *3,7* | *4,1* | *4,4* | *4,5* | *10,7* |
| *LSD (P<0.05) cultivar* | | *0,2* | *0,16* | *0,17* | *0,14* | *0,19* |
| *LSD (P<0.05) N rate* | | *ns* | *ns* | *ns* | *ns* | *ns* |
| *Interaction* | | *ns* | *ns* | *ns* | *ns* | *ns* |

**Table 4 :Critical and adecuate concentration of leaf nitrogen content in two rice cultivars. Sevilla 1996.**

| PLANT GROW STAGE (days after seeding) | Thaibonnet critical[2] | Thaibonnet adequate | Thainato critical | Thainato adequate |
|---|---|---|---|---|
| Maximun tillering (59) | 3,2 | 3,5 - 4,0 | 3,0 | 3,2 - 3,7 |
| Panicle initiation (67) | 2,9 | 3,2 - 3,4 | 2,7 | 2,9 - 3,2 |

1. Analysis on dry weigth basis of most recently matured leaves for Kjeldahl.
2. Plants with a critical level of nitrogen produce approximately 90 % of maximun yield

**Table 5 : Effect of preseeding nitrogen rate on several agronomical parameters and yield in rice irrigated under salty conditions. Sevilla 1994.**

| Cultivar | Nitrogen Rate (kg/ha) | Plant height cm | Lodging % | Panicles /m2 | Grains /panicle | Blank grains % | 1000 grain weight (g) | Yield kg/ha, 14 % moisture |
|---|---|---|---|---|---|---|---|---|
| Thaibonnet | **0** | 56,0 | 0 | 446 | 32 | 26,3 | 22,3 | 1685 |
| | **30** | 55,8 | 0 | 554 | 29 | 22,4 | 21,7 | 1759 |
| | **60** | 56,5 | 0 | 588 | 29 | 30,4 | 22,9 | 1819 |
| | **90** | 57,8 | 0 | 465 | 28 | 27,1 | 23,8 | 1901 |
| | **120** | 57,6 | 0 | 533 | 27 | 24,9 | 24,1 | 1820 |
| | **150** | 58,1 | 0 | 545 | 25 | 27,1 | 23,0 | 1895 |
| | **180** | 57,0 | 0 | 565 | 28 | 27,2 | 23,4 | 1823 |
| | **210** | 58,4 | 0 | 580 | 27 | 32,4 | 23,6 | 1691 |
| Thainato | **0** | 66,1 | 0 | 441 | 38 | 16,5 | 25,3 | 1990 |
| | **30** | 65,4 | 0 | 517 | 37 | 17,0 | 25,5 | 2401 |
| | **60** | 67,3 | 0 | 476 | 37 | 14,9 | 25,7 | 2381 |
| | **90** | 67,7 | 0 | 517 | 37 | 17,3 | 25,9 | 2329 |
| | **120** | 66,7 | 0 | 542 | 36 | 15,6 | 25,9 | 2517 |
| | **150** | 69,8 | 0 | 550 | 35 | 14,7 | 26,0 | 2727 |
| | **180** | 69,8 | 0 | 461 | 35 | 19,5 | 26,1 | 2444 |
| | **210** | 70,5 | 0 | 555 | 36 | 14,7 | 26,4 | 2666 |
| Nitrogen dose mean | **0** | 61,0 | 0 | 444 | 35 | 21,4 | 23,8 | 1837 |
| | **30** | 60,6 | 0 | 536 | 33 | 19,7 | 23,6 | 2080 |
| | **60** | 61,9 | 0 | 532 | 33 | 22,7 | 24,3 | 2100 |
| | **90** | 62,7 | 0 | 491 | 32 | 22,2 | 24,9 | 2115 |
| | **120** | 62,2 | 0 | 538 | 31 | 20,3 | 25,0 | 2169 |
| | **150** | 64,0 | 0 | 547 | 30 | 20,9 | 24,5 | 2311 |
| | **180** | 63,4 | 0 | 513 | 31 | 23,4 | 24,7 | 2133 |
| | **210** | 64,4 | 0 | 568 | 32 | 23,5 | 25,0 | 2178 |
| **Cultivar mean** | Thaibonnet | 57,1 | 0 | 535 | 28 | 27,2 | 23,1 | 1799 |
| | Thainato | 67,9 | 0 | 508 | 36 | 16,3 | 25,8 | 2432 |
| *General Mean* | | *62,5* | *0* | *521* | *32* | *21,7* | *24,5* | *2115* |
| *C.V. (%)* | | *2,3* | - | *11,2* | *12,1* | *13,9* | *2,2* | *7,9* |
| *LSD (P<0.05) cultivar* | | *1,7* | - | *ns* | *8* | *2,4* | *0,7* | *273* |
| *LSD (P<0.05) N rate* | | *4,2* | - | *68* | *ns* | *ns* | *0,6* | *198* |
| *Interaction* | | *ns* | - | *ns* | *ns* | * | *ns* | * |

**Fig 1 : Rice surface evolution (1987-1997)**

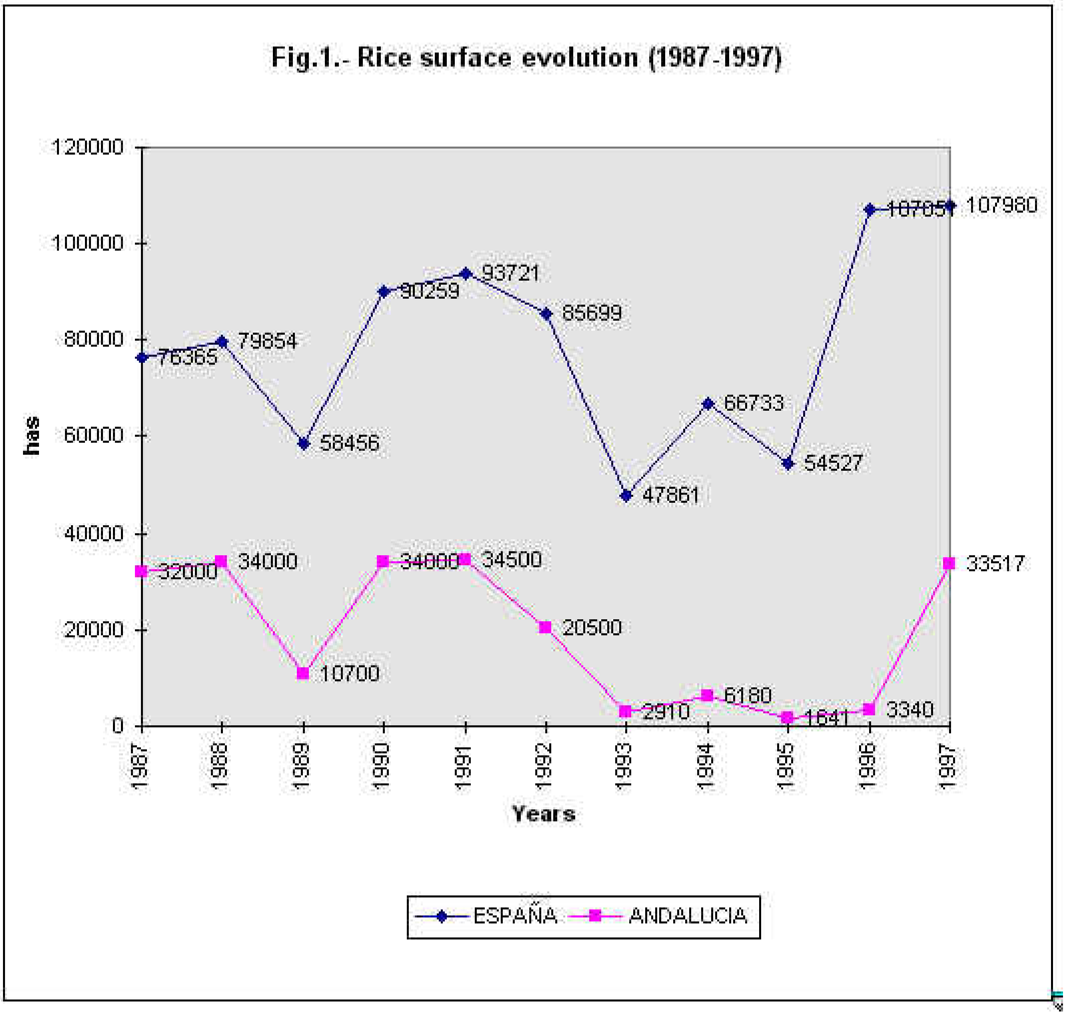



**Fig 2 : Evolution of water salinity in rice area. Sevilla 1994 and 1996.**

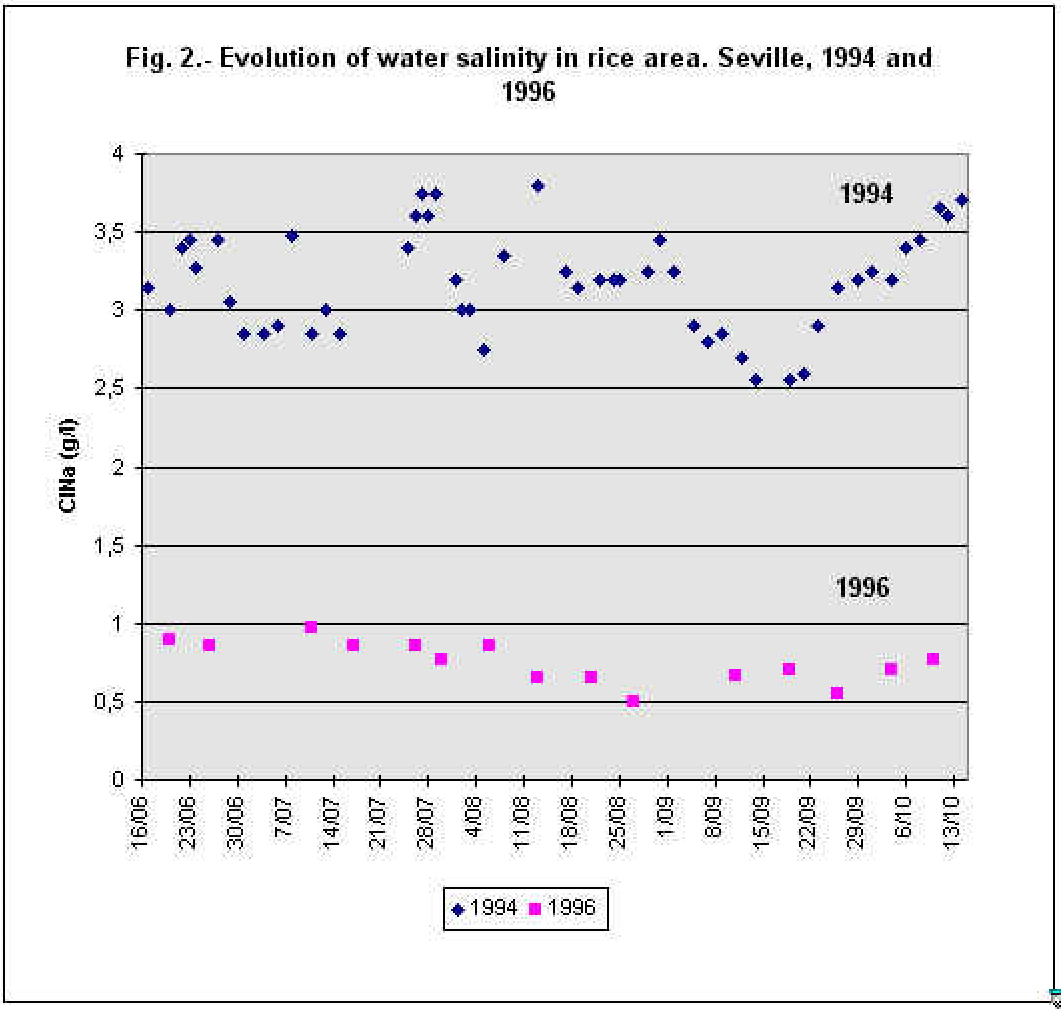



**Fig 3 : Effect of preseeding nitrogen rate on grain yield (at 14% moisture) in rice. Sevilla 1996.**

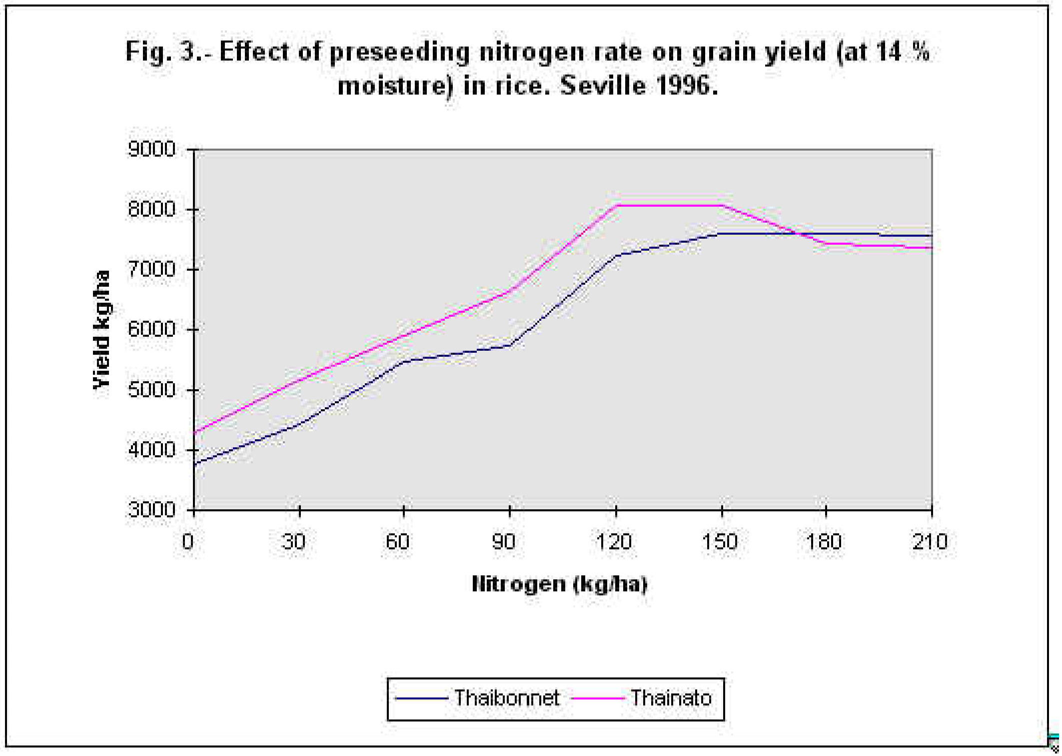



**Fig 4 :Evolution of leaf nitrogen content in two rice cutlivars. Sevilla 1996.**

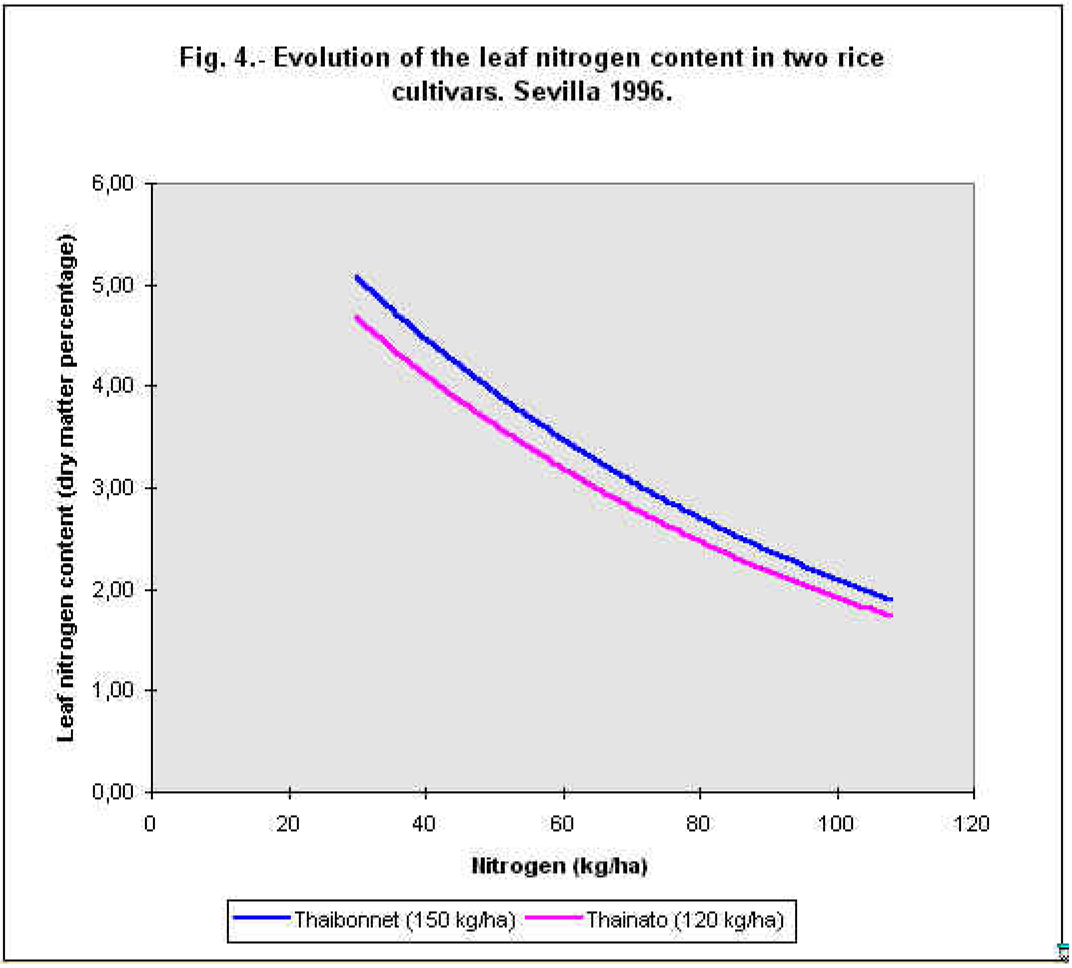
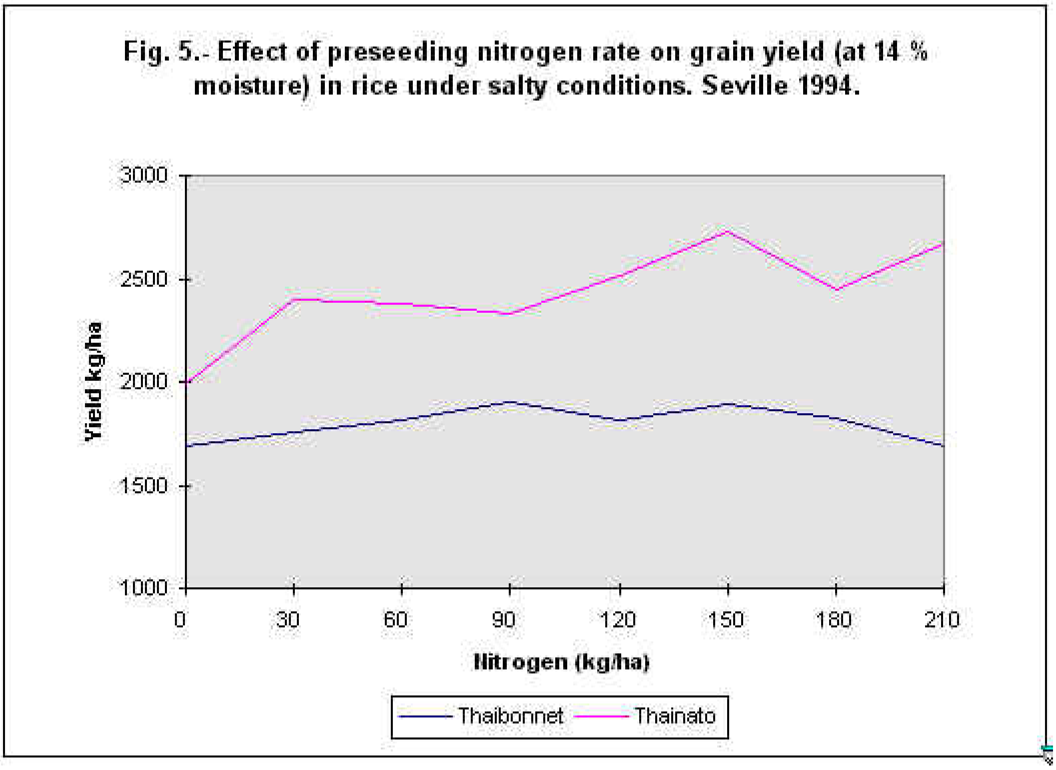



**Fig 5 : Effect of preseeding nitrogen rate on grain yield (at 14% moisture) in rice under salty conditions. Sevilla 1994.**



## References

*Aguilar M., Grau D., 1994. Influencia de la dosis de abonado nitrogenado de fondo sobre los componentes del rendimiento y el comportamiento agronómico del arroz. Investigación Agraria, Serie Producción y Protección Vegetales. Vol. 9 (1)*

*Aguilar M., Grau D., 1995. Nota sobre el efecto del abonado nitrogenado en el contenido de nitrógeno foliar en arrozal. Investigación Agraria, Serie Producción y Protección Vegetales. Vol. 10 (3).*

*Mikkelsen D. S., Evatt N. S. 1973. Soil and fertilizers : Rice in the United States : Varieties and production, Agriculture Handbook Nº. 289, Agricultural Research Service, US Department of Agriculture, pp 76-87.*

*Miller M. D. 1983. Integrated pest management for rice. University of California. Division of Agricultural Sciences Publication. 3280 p.*



Cahiers Options Méditerranéennes, Vol.24, n°3, **"Rice quality : a pluridisciplinary approach"**,
Proceedings of the international Symposium held in Nottingham, UK, November 24-27, 1997



EU Concerted Action for "Quality and Competitiveness of European Rices", EC-DG VI, AIR3-PL93-2518