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Impact of fertilization on disease development and yield components

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Abstract. This paper is an attempt to determine the different foliaire diseases on the two cultivars Triomphe and Elio. Triomphe is known as a susceptible variety. Elio, the most commonly used in Morocco since 1992 is resistant to some diseases. The effect of fertilizers on diseases development and yield is also studied. Many authors showed the benefit of split applications of nitrogen fertilizers top-dressed between rows.

On the basis of soil analysis and of rice nutrient requirements, four hypotheses were tested to answer some of these questions.

F1: N-P-K+add with 141 kg/ha of urea as three split applications 20% at 4-5 leaf stage; 30% 10 days later: and 25% 20 days after the 4- 5 leaf stage.

F2: O-P-K=add with 141 kg/ha of urea as four equal split applications 25% at 4-5 leaf stage; 25% 10 days later and 25% 20 days after the 4-5 leaf stage; and 25% at panicle initiation stage.

F3: N-P-0 = add with 141 kg/ha of urea as three split applications 20% at 4-5 leaf stage; 30% 10 days later and 25% 20 days after the 4-5 leaf stage.

F4: N-0-0 + add with 141 kg/ha of urea as three split applications 20% at 4-5 leaf stage; 30% 10 days later; and 25% 20 days after the 4-5 leaf stage. Two standard formulas advocated by the main firm of fertilizers were used as a check.

A plot of 2,5 ha was cultivated with rice in 1993 in the Gharb region. The density of sowing was 200 kg/ha. Plots of 1m^2 were harvested to estimate the yield components: number of tillers in 1 m^2; number of panicules in 1 m^2: total weight of grains and weight of 1000 grains. The final harvest was realised on the 23th of November 1993. The same technics were used for Triomphe regarding sowing density and soil tilling. At variable vegetative stages, samples of diseased leaves were taken to the laboratory in order to determine the type of contaminations.

In conclusion, the highest yield was obtained by the formula F3 suggested by the litterature and tested for the first time in Moroccan conditiions. The yield of F3 was 7.6 t/ha with no N-application at sowing time and equal split applications of urea at the four critical stages. The yield component the most affected by these treatments were the number of panicles per square meter and total weight of seeds. The different formulas of fertilization did not have a significant effect on disease development. Thius study allowed a better understanding of the most prevalent rice diseases in Morocco.

I – Introduction

The rice crop was introduced in the Gharb region in the north western part of Morocco in 1949. The area suitable for rice production is now 12,000 ha, the area planted each year is about 5,000 to 6,000 ha. The average yield of paddy rice is 45 q/ha, while the maximum yield reached is about 70 q/ha.

The climate of the rice growing area of Morocco is of the Mediterranean type, with an influence of the ocean favourable for summer cropping. The amount of annual rainfall is highly variable, the mean annual rainfall varies between 450 and 600 mm with 90% concentrated between October and April. The average daily temperature varies from 11°C in the winter to 27°C in the summer. The weather is favourable to the rice crop from mid-April to the end of September. However, rice is generally sown from late June to July due to lack of water availability prior to this date.

Rice is hand or machine seeded on dry fields; many farmers seed rice, after steeping it in water, on submerged fields. The soil is plowed 1 to 2 times. It is sown at 140 to 200 kg/ha. Nitrogen fertilizers are urea and ammonium sulphate with split applications (1/3 at seeding and 2/3 at tillering stage). Phosphorus and potassium are used by most farmers although potassium is noted to have no effect on yield (Lakrimi, 1989). The rice crop is subjected to various constraints: diseases such as *Pyricularia oryzae*, *Helminthosporium sp*; insects, mostly borers like *Sesamia inferens*; weeds including the most devastating ones *Echinochloa crus gali* and *Panicum repens*; and also water management and heterogeneity of fields.

Many authors reported that the most severe rice disease is blast caused by *Pyricularia oryzae* (Ou, 1985; Tsai, 1992). Blast is severe when nitrogen is increased (Ahn, Mukelar, 1986; Hsieh, 1992; Ou, 1985). Applications of excessive rate of nitrogen should be discouraged to prevent the excessive growth of plants and attack by diseases and insects (Hsieh, 1992). We hypothesized that leaf blast is likely to be suppressed when nitrogen is not applied at planting and that an increase in the number of equal applications of a given quantity of nitrogen would reduce blast severity and most foliage diseases as had been reported for irrigated rice (Amin, Venkataro, 1979; Bernaux, 1981; Koraka, 1965; Lee E.W., Lee B.W., 1980). The split applications of nitrogen is recommended to increase its efficiency and to prevent over dosage of nitrogen supply (Cupta, O'Toole, 1986). In drought-prone upland conditions in Brazil, the application of nitrogen in a single dose at panicle initiation stage reduced leaf and panicle blast compared with nitrogen applied at planting (Dos Santos, Prabhu, De Aquino, De Cavalho, 1986). In contrast, the split application of nitrogen tends to reduce blast in irrigated rice (Amin, Venkataro, 1979; Bernaux, 1981; Koraka, 1965; Lee E.W., Lee B.W., 1980). In our study, we assessed under Moroccan conditions the effects of alternative ways of splitting and timing fertilizers applications on yield components of the rice crop.

In this report, we present first the results of a survey of diseases in Morocco and then the effect of nitrogen fertilization on rice yield and blast development.

II – Assessment of rice diseases through surveys

In 1955, Ringuellet reported the existence of blast on rice in Morocco. Others, pointed that the severity of this disease might be important when August and September are rainy, and that an early planting will decrease the incidence of blast (ORMVA, 1988a). Brown spot, Helminthosporium, and leaf smut were also reported in this region but none of these diseases was fully described by the authors (Lakrimi, 1989,15,16). The ways cited to avoid the diseases were the use of certified seeds, crop rotation, the burning of the straw after harvest, early planting, and the use of a balanced fertilization (Lakrimi, 19891; ORMVA, 1988a; ORMVA, 1988b; Ringuellet, 1955). We surveyed the rice area of Morocco for diseases since 1993 starting mid July to harvest. The objective of the surveys is to determine the nature and the distribution of the prevalent rice diseases in this region. During the surveys, leaf and panicles were collected to be analysed in the laboratory for pathogen identification and also to make a relationship between the type of symptoms and the related pathogens.

1. Materials and methods

Fields were surveyed in the various rice growing zones of the area. The observations were made at random. Diseased samples with different types of symptoms were analysed in the laboratory. Leaves, stems and nodes were washed with water then sterilised superficially for ten seconds in alcohol at 70%, followed by a second dip in sodium hypochlorite at 2%. After one more wash with sterilized distilled water, the samples were put in culture media of rice flour. The petri dishes were then incubated at 28°C. After 5 to 7 days, we checked the samples under the microscope for fungal spores. We transfer the spores under microscope to get pure cultures of the isolated fungal organisms.

2. Results

During our surveys, the severity of foliage diseases was low due to the drought conditions. The rainfall was lower than the normal since 1991 in the rice growing area. Given that the symptoms caused by different diseases were largely described by many authors (Ou, 1985), we compared the observed and the described types of spots found on rice foliage. However, we observed non typical spots in surveyed fields. The leaves of rice cultivars present different types of spots. They differ by their size, shape and colour. They usually appear first on the lower leaves. At tillering, they appear as small brown spots of 1 to 4 mm in size. Some elliptical spots have a light colour on their center. The spots enlarge and collapse to become a large brown area. Other oval spots collapse to give big and irregular spots. When the attack is severe, the leaves may dry out and die. Spots are also found on kernels. Sometimes, the stem is attacked under the panicle which will die or fall off at the point of attack. The stems show also some black large spots often near the nodes. The kernels presented dark spots at their base.

A. The mycoflora associated to the leaves of rice

The isolated fungal species from leaf lesions of rice according to their abundance were:

Helminthosporium sp.	Brown spot
Fusarium sp.	Scab
Alternaria sp.	Stackburn disease
Cercospora oryzae	Narrow brown leaf spot
Curvularia sp.	Black kernel
Pyricularia oryzae	Blast

B. The mycoflora associated to rice seeds from the collected panicles during surveys

We characterized the parasites on seeds of different rice cultivars by the method of "blotter test". *Pyricularia oryzae* was not isolated from any of the seed samples that we tested. Eleven fungal species were isolated. The saprophytes were the most abundant with a percentage of isolation of 85%; 67% and 44% for *Alternaria* sp., *Epicoccum* sp. and *Cladosporium* sp. respectively. The other fungi were essentially, *Helminthosporium* sp., *Fusarium* sp., *Curvularia* sp. and *Cephalosporium* sp.. The percentage of isolation of *Helminthosporium sp.* was about 14%, but it did not exceed 2% for *Cephalosporium sp*. Other saprophytic fungi were found at low frequencies such as *Ulocladium* sp., *Trichothecium* sp., and *Nigrospora oryzae*.

C. Relationship between field symptoms and the isolated organisms

The isolation of the pathogens associated to leaf spots indicated that:

❏ spots described as characteristic of *Pyricularia oryzae* yielded *Helminthosporium* sp. or *Curvularia sp.* instead of *P. oryzae*;

❏ *Pyricularia oryzae* may be isolated from spots other than those described as typical of blast and also from spots reported to be describing *Helminthosporium* sp. attack;

❏ the lesions on stems, yielded either *Helminthosporium* sp. or *Pyricularia oryzae*.

III – Impact of rice fertilization on yield components and blast development

In our study, we assessed under Moroccan conditions the effects of alternative ways of splitting and timing nitrogen applications on yield components of the rice crop.

1. Materials and methods

The experiments were conducted in the Gharb. The soil has a very light texture with relatively high amount of limestone. The analysis of soil indicated sufficient amount of nutrients that are available for rice crop.

The trial was cultivated with the rice cultivar Elio in 1993 with density of sowing of 200 kg/ha of rice directly seeded.

Six treatments in which the timing and splitting of fertilizers were utilised (Table 1). A randomized complete block design with three replications was used, in which the treatments were combined with replications for a total of 18 units. Plots were 33,3 x 41 m. One square meter was harvested from each experimental unit to assess the yield components.

Table 1. Experimental design of the trial on the effect of nitrogen fertilizer on rice yield and blast development

Cultivar: Elio
Sowing time: 8 June 1993

	F. Sowing	Split applications
T1	4- 12-4,5 + add	33 - 20 - 0 Urea 46%
T2	N - P - K + add **25%**	Urea 46% **20% 30% 25%**[a]
T3	0 - P - K + add	Urea 46% **25% 25% 25% 25%**[b]
T4	N - P - 0 + add **25%**	Urea 46% **20% 30% 25%**[a]
T5	N - 0 - 0 + add **25%**	Urea 46% **20% 30% 25%**[a]
T6	6,6-19,80 -7,8+ add	31,7-18,5-0 Urea 46%

a. 25% at sowing; 20% at 4 to 5 leaves stage; 30% ten days later and 25% twenty days after 4 to 5 leaves stage.
b. 25% at 4 to 5 leaves stage; 25% ten days later; 25% twenty days after 4 to 5 leaves stage and, 25% at panicle initiation stage.

2. Results

The blast development was in general very low in 1993. Therefore, we did not have enough disease level to make an assessment of the effect of nitrogen supply on blast severity. This hypothesis requires further testing.

On the effect of nitrogen fertilization on rice yield (Table 2), the two checks gave different yields. The best one can be used as a basis of comparison for the other treatments. The highest yield, 77 q/ha, was obtained by the third treatment. It is used commonly in Asia for irrigated rice with no nitrogen at sowing and equal split of urea top dressed between rows at the four critical stages noted before (Hsieh, 1992). Using nitrogen at sowing and only three split applications of urea without fertilizers at panicle initiation stage gave a lower yield, 69 q/ha, than the third treatment. Thus, the use of nitrogen at panicle initiation stage is an important factor for yield improvement. Plots with no potassium supply gave 65 q/ha. The lowest yield was however obtained in plots without any potassium and phosphorus supply to test the hypothesis according to which rice culture in Gharb do not need these two elements because of the richness of soil and also the irrigation water supplies the field sufficiently with these two elements (El Bouanani, 1992). Among the yield components, only the number of panicles was significantly different between treatments (Table 2), indicating that the filling capacity was higher for the second and third treatments.

Table 2. The six treatments yield for the cultivar Elio

Elio	**Number** (panicles per m^2)	**1000 kernels weight** (g)	**yield** (q)
T1	386c	28a	73
T2	429b	27a	69
T3	469a	28a	76
T4	366d	26a	65
T5	359d	27a	62
T6	355d	29a	69

Test Student-newman-keul's multiple range at alpha = 0,05.
NB: the yield is round up to the nearest digit.

IV – Conclusion

The development of foliage diseases was not important during our surveys mostly due to the drought conditions. The symptoms found on rice plants are not specifically associated to a given pathogen. The same pathogen may give different symptoms on the same cultivar depending on the environmental conditions. Thus, when disease severity is low, the observed symptoms do not allow a good identification in the field without an analysis in the laboratory. Since rice is late planted, environmental conditions can also be less conducive to disease development, especially in dry years. In contrast with other authors (Lakrimi, 1989; ORMVA, 1988a; ORMVA, 1988b; Ringuellet, 1955), we think that an early sowing will induce more diseases since moisture conditions favourable for disease development occur more likely in April and May than later in the growing season.

Concerning the fertilization, nitrogen supply can be omitted at sowing time, because the seeds have enough reserves to germinate. The need for nitrogen starts at 4 to 5 leaf stage and equal splits of it up to panicle initiation stage are the most profitable ways to fertilize rice crop. The phosphorus need to be added at sowing time to assure a good root development. It enhances the tillering and good flowering and, grain filling. The potassium increases the vigour and the resistance of the plant to stress; it fortifies the straw; increases the quality of grains and helps the transfer of starch, sugars and, oils. We reccomended four applications of nitrogen to optimize rice yield. However, the effect of this type of supply on blast needs to be further assessed.

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