NITROGEN APPLICATION TIMING FOR DRYLAND MOROCCAN CEREALS

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RESUME

L'efficacité de la fertillisation azotée des céréales en zones arides et semi-arides dépend de la quantité et la distribution des pluies. L'application des engrais azotés à un stade de croissance précoce permet à la culture de s'établir et de profiter au maximum des pluies précoces. Cependant, il est difficile de savoir jusqu'à quel stade de croissance on peut retarder l'apport des engrais azotés sans affecter le rendement. Les objectifs de cette étude étaient (i) évaluer l'effet des différentes doses et de différents temps d'apport d'engrais sur les céréales en zones arides et semi-arides. (ii) quantifier les pertes d'azote par volatilisation en cas d'un apport en surface sous forme d'urée. Les traitements un apport de N étaient à différents stades de croissance de deux variétés d'orge Arig-8 et Tamelalt, une variété de blé Juda et une variété de triticale Juanillo. L'azote a été appliqué à une dose de 60 kg/ha sous forme d'ammonitrate aux stades deux feuilles, 4 feuilles, tallage, montaison et épiaison. Pour répondre au deuxième objectif, un essai a été installé parallèlement pour quantifier les pertes d'azote par volatilisation à partir de l'urée appliquée en surface à différentes périodes avant le semis.

Le rendement en grain et en matières sèches de toutes les céréales n'était pas affecté par le temps d'apport de l'engrais azotés et ceci jusqu'au stade tallage. Une baisse de rendement de 22% et 27% a été observée lorsque l'apport d'azote a été retardé aux stades montaison et épiaison respectivement. Malgré leur différence en rendement, les variétés répondaient de la même façon aux apports d'engrais azotés. Les résultats obtenus nous permettront de conclure que l'application des engrais azotés aux céréales peut être retardé jusqu'au stade tallage sans réduire significativement le rendement.

Les rendements obtenus des traitements concernant l'application de l'urée en surface avant le semis n'ont reflété aucune perte significative de l'azote par volatilisation.

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ABSTRACT

The effectiveness of nitrogen fertilizers for cereals in the arid and semi-arid zones of Morocco is rainfall-dependent. Top-dressing during early growth stages allows for assessment of soil moisture and growing conditions. However, the extent to which it can be delayed without reducing yields is not clear. The objectives of this study were to (i) evaluate the impact of varying N application times on yield of commonly grown cereals in Morocco's arid semi-arid zone end and (ii) assess the possible loss of N as ammonia from surface-applied urea. The treatments were N fertilizer applied at different growth stages of four different crops : two varieties (Arig 8, Tamelalt) of barley (Hordeum vulgare L.), one variety (Jouda) of wheat (T. aestivum) and one variety (Juanillo) of triticale (Triticosecale). Fertilizer N was applied at 60 kg/ha as ammonium nitrate at planting, 2-leaf, 4-leaf, tillering, stem elongation, and boot-heading stages. As N may be lost by volatilisation from surface broadcasting, a parallel experiment invoved surface application of urea at varying time periods prior to planting, i. e., about every 3 days for 24 days.

The biomass and grain yields of all cereals were not affected by application time up to the tillering stage. However, when N was applied at elongation or boot stage a significant decrease in total yield occurred. The decreases in total dry matter yield were 22% and 27% for N applied at elongation and boot-stages, respectively, compared with the average yield over the other application periods. Corresponding reductions in grain yield were 19 and 26%, respectively. While cereal varieties varied in terms of yield, being highest for triticale and lowest for Jouda wheat, the pattern of response with time was similar. Therefore, top-dressing of N can be delayed until the tillering stage without any loss of efficiency. Yields from surface-brodcasting of urea did not reflect any apparent loss of N by volatilization. Thus, when urea is top-dressed in wet cool conditions, little loss of efficiency is likely to occur under dryland Moroccan conditions.

KEY WORDS : Barley, ***Triticale***, Jouda Wheat, N volatilization, N efficiency arid zone

INTRODUCTION

The success of dryland crop production is dependent on precipitation during the growing season and on plant-available water stored in the soil. The probability of achieving satisfactory and reliable dryland yield depends upon total available water for the crop. An adequately fertilized wheat crop would extract more water than N-deficient wheat. The major factors that limit cereal production in Morocco are drought and low fertilizer inputs (Shroyer et ***al.***, 1990). Nitrogen has been shown as the most limiting nutrient of grain crop yields (Abdel Monem et ***al.***, 1990 a, 1990b; Soltanpour et al. , 1989). Hessian fly (***Mayetiola destructor*** Say) is another major cause of low cereal production in the dryland areas of Morocco. However, its effect has been shown to be only slightly offset by adequate N fertilization (Ryan et al., 1991).

Time of application has received little attention in the semi-arid zone of Morocco, Nitrogen fertilizer is applied mainly at planting time. While Ryan et al, (1989) found no difference between N applied at time sowing and with split application, application at tillering was somewhat better in terms of breadwheat yield. However, delaying N fertilization may be of economic value due to the risk of crop failure. Though urea is susceptible to volatilization in calcareous soils under favorable weather conditions (Ryan et al., 1981), it is the principal N fertilizer on a worldwide basis and is being used at an increasing rate as a top-dressing source of N in Morocco. However, volatile loss of N in the field has not yet been studied in Morocco. The objectives of this study were to evaluate the impact of varying N application time on yield and quality of commonly grown cereals in Morocco's semi-arid zone and to assess possible loss of N fertilizer efficiency through volatilization of ammonia from surface-applied urea.

MATERIALS AND METHODS

The soil at the site chosen for this on-farm trial was a fine, mixed, thermic shallow Petrocalcic Palexeroll. Average precipitation in the area is 386mm/yr, while that of the current cropping season, recorded a Sidi El Aydi Agricultural Experiment Station about 15 km away, was 277 mm (Fig. 1). While no rain fell in Nov. and little in Jan., rain in Dec. was above average at 76 mm, while Feb. and March rains were also satisfactory enough to produce adequate yields. Barley was the previous crop at this site. Prior to land preparation, the soil was sampled and analyzed. The soil was deficient in N (2 ppm NO_3-N) and phosphorus (4 ppm $NaHCO_3$-P), but was well supplied with potassium (230 ppm). The soil was tilled with an offset disc or "cover-crop".

The treatments were 60 kg N/ha as ammonium nitrate applied by hand-broadcasting at different growth stages (planting, 2-leaf, 4-leaf, tillering, elongation, or boot-heading). A blanket P rate of 30 kg P/ha was applied as triple superphosphate. The experimental design was a spilt-plot with crops as main plot and time of application as sub-plots, with three replications. At the tillering stage 'Certrol-H', i.e., Isoynil (4-hydroxy-3, 5-diodobenzonitril) was applied at 0,4 kg a.i./ha to control weeds.

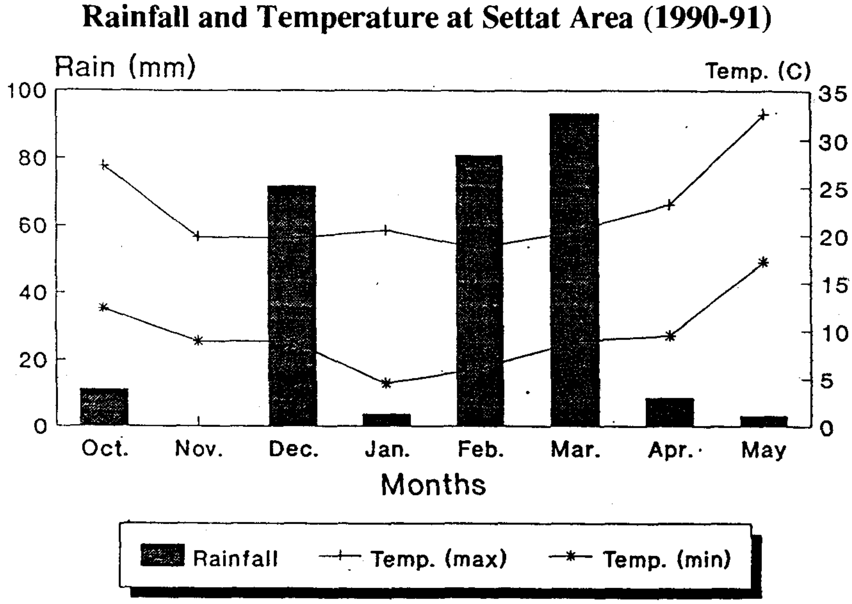

Fig. 1 : Rainfall and temperature during the 1990-91 cropping season at Settat.

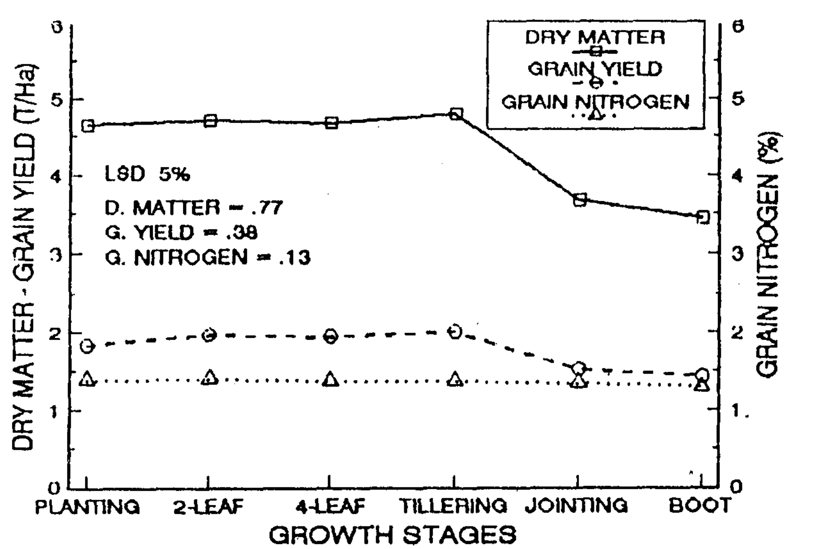

Fig. 2 : Mean effect of N application time on total dry matter and grain yields.

Table I : **Effect of varging N application time on cereal biomass and grain yield.**

	Growth Stage-Application N											
	Planting		2- leaf		4-leaf		Tillering		Stem Elongation		Boot	
	B	G	B	G	B	G	B	G	B	G	B	G
Cultuvar	t/ha											
Tamellalt	3.9	1.7	5.1	2.1	3.8	1.6	4.0	1.7	3.7	1.5	2.8	1.2
Arig-8	5.0	2.3	5.4	2.6	5.4	2.6	6.1	2.9	3.9	1.9	3.8	1.8
Jouda	3.6	1.4	3.0	1.1	2.8	1.1	3.2	1.2	2.1	0.8	2.2	0.8
Juanillo	6.0	2.1	5.4	2.1	6.7	2.6	5.9	2.2	5.0	1.9	4.9	1.8

LSD (5%) Biomass (B) = 1.886; Grain yield (G) = 0.765

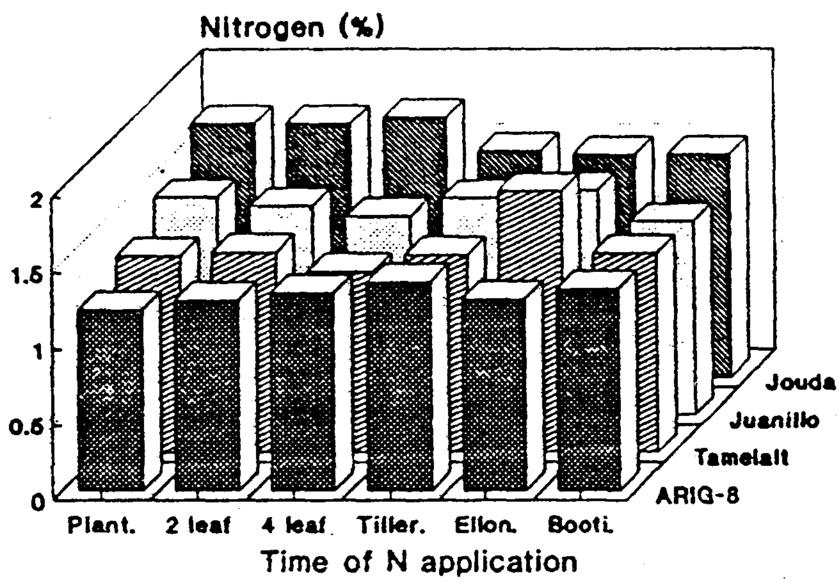

Fig. 3 : Impact of varying N application time for individual cereals.

Crops used were two varieties for barley, Arig-8 as a late barley and Tamelalt as an early one, one variety of breadwheat (Jouda), and one variety of triticale (Juanillo). These were hand-broadcasted at 160 kg/ha and subsequently worked in with the "covercrop". The volatilization study involved surface broadcasting of urea at 60 kg N/ha at 3-day intervals for 24 days prior to sowing on Dec. 16. The test crop in this case was ACSAD 176 barley at 160 kg/ha broadcast. Management for this trial was similar to that of the time-of-application one. At harvest, both trials were hand-harvested, weighed, threshed, straw and grain weights recorded, and grain N analyzed.

RESULTS AND DISCUSSION

While yields of grain and straw followed a similar pattern and there were no differences between cereals, the effect of N application time was constant. Thus, total dry matter yield were in the order of Juanillo triticale = Arig-8 barley > Tamelalt barley> Jouda wheat. The overall impact of varying N application time (Fig. 2) indicated significant decreases in grain and straw after the tillering stage. Though % in the cereal grain considerably decreased with delay in N application after sowing? the effect was not significant. Thus, delaying N application until stem elongation or even the boot stage reduces the efficiency of application with consequent lower resultant yields. These patterns are exhibited for individual cereals in Table I for dry matter and grain yields.

While the concentration varied between cereals (Fig. 3), there was an apparent relationship with absolute yield levels. Thus, Jouda, with lowest yield, had the highest N concentration, i. e., 1.59% while those of the higher-yielding barleys were lowest (Talekakt, 1,23%, Arig-8, 1,28%) with Jouda wheat intermediate (1,39%). Despite the lower yields of cereals when N was applied at stem-elongation and boot stages, no compensatory % N increase occurred in the dry matter. This probably reflected a reduced physiological capacity to absorb and translocate N at such advanced growth stages.

This study of the effects of N application time on dryland cereals conforms, in principle, with results obtained in Morocco and elsewhere. This not only corroborated the previous report of Ryan ***et al.*** (1989) but added to it by extending the range of application times, measured parameters, and crops involved. That N top-dressing should not be delayed beyond the tillering stage for any cereal was clearly demonstrated. That no differences between application from sowing to tillering coincides with most reports on winter rainfed fertilization (Dey Sarker ***et al.***, 1990; Christiansen and Meints, 1982). One can thus conclude that any N applied is not lost, and can be utilized by the crop up to tillering stage. As rainfall during the sowing to tillering stage is normally not sufficient to move N as mobile NO_3 below the root zone, this loss mechanism is not significant.

The other possible loss mechanism, volatile N loss, while theoretically occurring in calcareous soils, is obviously of minimal field importance in Morocco, since there were no differences in yields or indeed % N from varying pre-plant urea application time (Table II).

Table II : **Impact of varying N application dates prior to sowing on parametra of ACSAD-176 barley.**

Urea Application Date	Yield		Grain N
	Dry Matter	Grain	%
	......................t/ha......................		
Dec 15	5.53	2.49	1.22
Dec 13	5.93	2.67	1.18
Dec 9	5.47	2.46	1.16
Dec 6	5.28	2.36	1.20
Dec 3	5.40	2.43	1.67
Dec 1	6.05	2.72	1.25
Nov. 29	5.53	2.49	1.17
Nov. 26	5.47	2.46	1.24
Nov. 22	5.35	2.41	1.21
LSD (5%)	1.37	0.62	0.12
Coefficient of Variation	14.3	12.3	5.9

That the site was N-deficient was indicated by mean response to 60 kg N in the order of 50% over the control. The relatively low temperatures occurring in Nov.-Dec. reduce this temperature-dependent process, and the periodic rainfall which occurred at that time wash into the soil surface-applied urea where it is held on the exchange clay complex. Indeed, the pre-plant period was characterized by persistent rainfall, i.e., a total of 77 mm fell in 13 rainfall events over the preplant period, including four showers of 2 to 8 mm in late Nov., which were not recorded at Sidi El Aydi. With unusually high temperatures and no rainfall after surface-applied urea, some losses of volatile N may occur. In such cases, dew at nightfall is sufficient to promote dissolution and enzymatic hydrolysis.

CONCLUSION

This study has shown that there appears to be no agronomic advantage of deviating from the traditional practice of fertilizer application at or prior to planting by delaying it. However, applying some fertilizer N at tillering will have an economic advantage since it will allow assessment of crop stand and stored soil moisture. Where prospects for rain are low, farmers may reduce or eliminate N fertilizer, or indeed graze the crop if adequate grain or straw yield is unlikely.

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