IMPORTANCE OF COMBINED PHOSPHORUS AND NITROGEN FERTILIZATION OF BARLEY IN SEMI-ARID DEFICIENT SOILS

*J. Ryan, M. Mergoum, A. Azzaoui, K. El Mejahed, and M. El Gharous

INTRODUCTION

Much attention has been given in recent years to the issue of improving cereal output in Morocco (Shroyer **et al.,** 1990; Ouattar and Ameziane, 1989). The Dryland Applied Agricultural Research Projet at Settat has focused on the low rainfall cereal zone (250-450mm), a vast area that embraces about half of the country's cropland. As fertilizer use in this area is relatively low, the use of nitrogen has been shown to have a major impact on yields. (Abdel Monem **et al.,** 1990a; Ryan **et al.,** 1991) for wheat. Phosphorus is less frequently deficient for cereals as indicated by crop response and soil test survey data (Adbel Monem **et al.,** 1990b). Though barley constitutes the major cereal in the dryland zone, it has been neglected in terms of on-farm research.

* Contribution from INRA/MIAC, Aridoculture Center, P.O. Box 290, Settat, Morocco.

A recent trial near Settat (Ryan **et al.,** 1990) clearly demonstrated the extent to which barley responds to applied N in a shallow barley-growing soil, typical of the Chaouia region; with five cultivars, yield were mores than doubled by using 80-120 kg N/ha. Another concurrent trials at the same site indicated that barley showed an even greater relative response to applied P than either wheat or triticale (Azzaoui **et al.,** 1990). Because of the logistical difficulty of obtaining sties low in both N and P, on-farm trials in recent years have dealt with both elements separately (Ryan and Matar, 1990) using an adequate rate of the alternative element as a non-variable factor. However, in order to make efficient and economic fertilizer recommendations to farmers, it is important to know to what extent responses of one element are influenced by those of the other when both are deficient in the soil.

MATERIALS AND METHODS

The sites for this on-farm trial were adjacent to Settat in the more favorable rainfall zone (386 mm) and about 70 km south near Skhour Rehamna (270 mm). The soil types were representative of these respective cereal-growing areas. Actual rainfall for the season was lower than normal (277 mm Settat, 225 mm Skhour Rehamna) but was well-distributed, especially at critical growth periods, i.e., no rain in November, above average in December, none in January, but above average in February and March. The fields chosen were low in both N and P, i.e., 2.8 ppm NO_3-N at Settat and 2.0 ppm at Skhour Rehamna, while values for $NaHCO_3$=P were 4.0 and 3.1 ppm, respectively.

After disc-harrowing the field plots (4 x 5 m) were laid out in triplicate in a split-plot design with N the main plot and P the sub-plot. Then fertilizers were hand-broadcasted, with N (0, 30, 60, 90, 120 kg/ha) as ammonium nitrate and P (0, 10, 20, 30 kg/ha) as triple superphosphate. A barley cultivar, Arig-8, was hand-broadcasted at 132 kg/ha and mixed in with a disc harrow along with the fertilizer (Nov. 28 at Settat, and Dec. 4 at Skhour Rehamna).

During the subsequent growing period, weeds were controlled at Settat by conventional spraying with "Certrol H". The Skhour Rehamna site was practically weed-free. At maturity the crop was hand-harvested (May 24 Settat, June 4 Skhour Rehamna). Total biomass and grain yields were recorded along with grain N content and kernel weight.

RESULTS

Not surprisingly, the main factors N and P, had individual overall significant effects on yield and quality parameters for the most part at both locations. With biomass and grain yields from the unfertilized plots being the same at both Settat and Skhour Rehamna (Table 1), responses were significant up to 90 kg N/ha and of a greater magnitude at the more favorable Settat site; at both sites, each 30 kg N increment produced a significant yield increase up to 90 kg/ha. However, N had little or no effect on grain N content at Settat, but the higher N rates (90 and 120 kg/ha) significantly increased grain N% at Skhour Rehamna. Similarly, kernel weight was differentially influenced at these sites, with no effect at Settat but with a tendency for kernel weight to decrease with increasing N rates at Skhour Rehamna.

It is interesting to compare the relative (actual yield/control yield x 100) biomass responses to each element applied without the other at the two sites (Fig. 1). Nitrogen consistently increased yield at Settat to 90 kg/ha, where yields were double those of the non-fertilized control, but tended to decrease at the higher (120 kg) rate. Responses did not exceed 40% at the drier Skhour Rehamna site. Phosphorus responses at Settat were lower than those for N and were marginally higher than at Skhour Rehamna ; maximum responses were less than 40%.

Given the low levels of available P at both locations, both responded to applied P. Biomass and grain yields were increased by each 10 kg increment up to 20 kg/ha (Table 2). However, unlike N, addition of P had no effect on either grain N content or kernel weight at either location.

Of major concern in this study was the interaction between N and P or differential responses at varying levels of the other element. These effects were significant and are illustrated for biomass yield (Table 3) which essentially followed a similar pattern as for grain yield. Without N, the addition of increasing P levels had little effect on biomass yields at either site; with no added P, responses to N were, however, much higher. Consequently, responses to N were enhanced by increasing P levels. Thus highest yields were observed at the 120 kg N rate with 30 kg P at Settat, but with 90 kg N/ha and 30 kg P/ha at Skhour Rehamna.

Table 1. - **Mean effects of nitrogen application rates on barley parameters at two sites[2]**

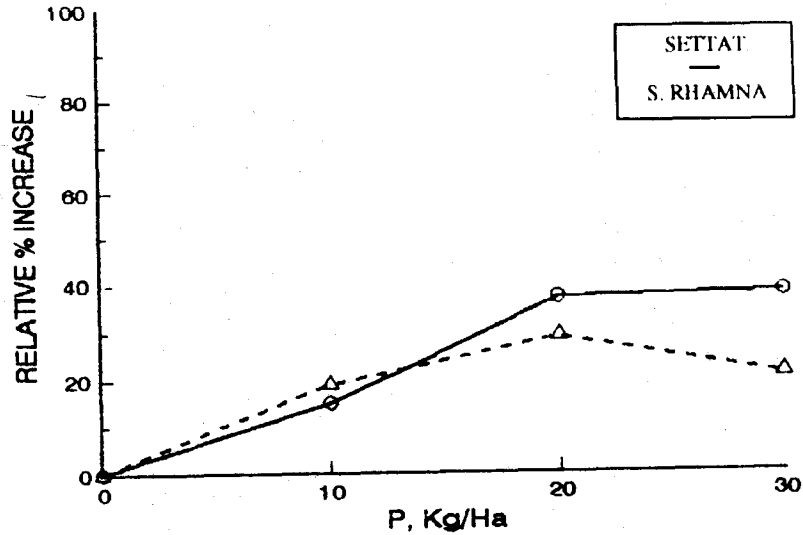
	Biomass		Grain		N Content		Kernel Weight	
Nitrogen	S.	S.R.	S.	S.R.	S.	S.R.	S.	S.R.
kg/ha	---------- tons/ha ----------				--------- % ---------		- g/1000 -	
0	2.9d	3.0d	0.9d	1.0d	1.21a	1.11b	40	44a
30	3.8c	3.8c	1.2c	1.3c	1.00b	1.21b	40	42ab
60	4.9b	4.3b	1.6b	1.4b	1.09ab	1.22b	39	37c
90	5.9a	4.8a	1.8a	1.6a	1.05ab	1.60a	40	39b
120	6.2a	4.6a	1.9a	1.5a	1.18a	1.70a	40	38bc

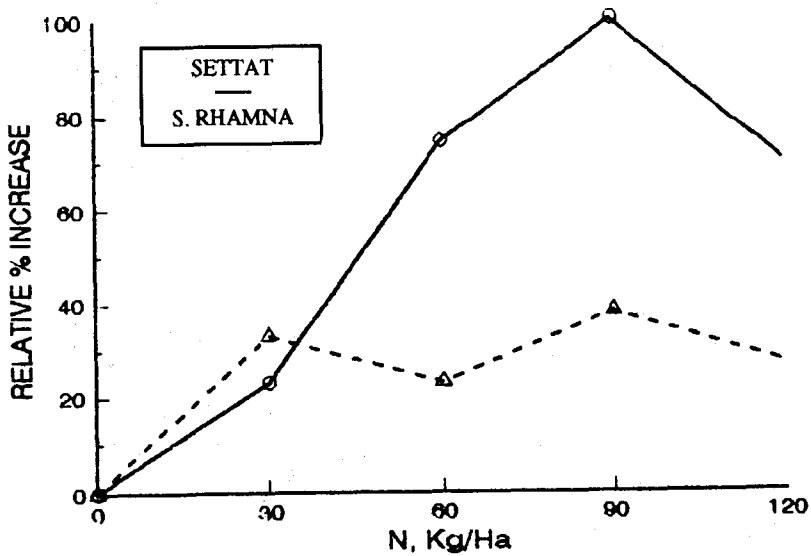
[1] Within columns, means with different letters are significantly different.
[2] S. = Settat ; S.R. = Skhour Rehamna

Table 2. - **Mean[1] effects of phosphorus application rates on barley parameters at two sites[2]**

	Biomass		Grain		N Content		Kernel Weight	
Phosphorus	S.	S.R.	S.	S.R.	S.	S.R.	S.	S.R.
kg/ha	---------- tons/ha ----------				--------- % ---------		- g/1000 -	
0	3.7c	3.2c	1.1d	1.1c	1.11ab	1.42	38b	40a
10	4.6b	4.1b	1.4c	1.4b	1.12ab	1.37	40ab	41a
20	5.2a	4.5a	1.6b	1.5ba	1.15a	1.37	41a	38a
30	5.5a	4.7a	1.7a	1.6a	1.04b	1.31	40ab	41a

[1]Within columns, means with different letters are significantly different.
[2]S. = Settat; S.R. = Skour Rehamna


SETTAT
S. RHAMNA
RELATIVE % INCREASE
100
80
60
40
20
0
0
10
20
30
P, Kg/Ha


SETTAT
S. RHAMNA
RELATIVE % INCREASE
100
80
60
40
20
0
0
30
60
90
120
N, Kg/Ha

DISCUSSION

Since the mid 1980's applied field research in the Settat area of Chaouia has consistently demonstrated marked yield responses of wheat to N (Abdel Monem **et al.,** 1990A ; Ryan **et al.,** 1991). This trial underlined the responsiveness of barley as well. It also demonstrated that substantial yield increases can be obtained by using N in lower rainfall areas such as at Skhour Rehamna. However, the response curves suggest that N rates of 90 to 120 kg/ha could be profitably used in the Settat area. Considerably less would be advisable for the Skhour Rehamna area. Given the unreliability of rainfall with decreasing mean annual rate (Watts and El Mourid, 1988), responses to N in the lower rainfall areas are less predictable. While higher N rates may not always evoke yield responses, the extra N may improve grain quality in terms of increased protein. Fertilization, however, seems to have no consistent effect on grain size thus test weights.

Given the fact that both soil were low in available P, the consistent response to applied P was not surprising. Responses generally coincided with those observed for a range of cereals at a deficient site near Settat (Azzaoui **et al.,** 1990). However, there was little disparity between the sites with respect to P as opposed to N. Thus, the latter element is more sensitive to rainfall variation. Unlike N, the addition of P had no effect on grain protein, and similar to it, there was no effect on grain test weight.

The essence of this field study are found in Table 3, which illustrate clearly how response to N can be increased by adequate P fertilization when both are deficient. The key to profitable cereal production is judicious use of N and P based on soil tests and on potential yields and crop responses in different zones through the dryland area. Identifying these zones or recommendation domains is an essential step in efficient fertilizer management. While appropriate testing procedures are established for dryland Moroccan soil conditions, what is now needed is a system of laboratories - public or private - to service the increased farmer demand for such services.

Table 3. **Interactions between N and P levels on barley biomass at two sites.**

Nitrogen	Settat				Skhour Rehamna			
	P, kg/ha							
kg/ha	0	10	20	30	0	10	20	30
	t/ha							
0	2.4	2.8	3.3	3.3	2.6	3.1	3.4	3.2
30	2.9	3.8	3.9	4.6	3.4	3.4	4.2	4.3
60	4.2	4.4	5.2	5.7	3.2	4.4	4.6	5.0
90	4.8	5.9	6.3	6.7	3.6	4.7	5.2	5.7
120	4.1	6.2	7.2	7.4	3.3	4.8	4.9	5.6

RESUME

La majorité des sols des zones arides et semi-arides ont été identifiées déficients en azote. Des sols deficients en phosphore sont aussi présents mais à une fréquence moins. Les essais sur la calibration des analyses du sol ont mis le point sur la réponse du blé aux engrais azotés at phosphatés en zones semi-arides, laissant la culture de l'orge avec moins d'essais de ce genre. Cependant, cette étude a été conduite pour déterminer l'effet des engrais azotés et phosphatés sur la culture de l'orge en zones arides et semi-arides. Cinq doses d'azotes (0, 30, 60, 90, et 120 kg N/ha) et quatre doses de phosphore (0, 10, 20, et 30 kg P/ha) ont été testées sur la variété d'orge Arig-8 dans deux sites différentes, (Settat et Skhour Rehamna). Les deux éléments et leur interraction avaient un effet significatif sur tous les paramètres du rendement. Ces résultats montrent l'importance de ces deux éléments dans la nutrition de la culture de l'orge en zones arides et semi-arides. Cependant, l'azote a été l'élément nutritif principal, limitant le rendement après l'eau dans la plupart des sols sauf dans les sols ayant une légumineuse comme précédent culturale et/ou contenant plus de 10 ppm NO_3-N avant la mise en place de la culture.

ABSTRACT

Most soil test calibration studies in the Dryland Applied Agricultural Research zone have addressed crop responses to nitrogen and phosphorus in separate trials. Suitable on-farm sites which are deficient in both N and P are difficult to find due to natural soil enrichment or buildup of residual available P from fertilizer use. Nevertheless, deficient fields in Settat and Skhour Rehamna involved combined N (0, 30, 60, 90, 120 kg/ha) and P (0, 10, 20, 30 kg/ha) with a high-yielding barley cultivar (Arig-8) sown at 132 kg seed/ha. Both N and P effects were significant for yield parameters. However, the effect of one was accentuated by that of the other. Yields were higher at the more favorable Settat site. There was no obvious effect on grain N and kernel weight. The results highlight the need for both N and P if both are deficient. While N is normally needed in most soils except those previously cropped to legumes and testing high in N, i.e., above 10 ppm NO_3-N, soil testing can reliably indicate the status of P in any field before fertilizing decisions are made.

Key Words : Dryland Cereals, Soil Testing

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