BARLEY AND NITROGEN FERTILIZATION IN MOROCCO'S SEMI-ARID ZONE

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ملخص

زراعة الشعير تلائم المناطق الجافة وشبه الجافة بإفريقيا الشمالية وآسيا الغربية. وفي المغرب، هذه الزراعة تغطي المناطق ذات التربة السميكة والتساقطات المطرية ما بين 200 ملم و 350 ملم سنويا وبدون تسميد في غالب الأحيان، لذا أقيمت هذه التجربة لدراسة تأثير التسميد على زراعة الشعير وإنتاجه.

خمسة أصناف من الشعير استعملت في هذه التجربة وهي كما يلي أركي 8، أسني، تاسلوت، أكساد 60 و زكساد 176 مع أربع مستويات من الآزوط والأمونيطرات : 80،40،0 و 120 كلغ / هك هذه المقادير من الآزوط استعملت في وقت الزرع.

التسميد بالآزوط كانت له فعالية على جميع أصناف الشعير والزيادة في الإنتاج بما قدره 200 إلى 250 ٪ مقارنة مع زراعة الشعير بدون تسميد.

أما الصنف الذي كانت له مؤهلات ورنتاج كبير في هذه التجربة هو أركي 8 على عكس صنف تاساوت المبكر الذي كان أقل إنتاج.

تتجلي نتيجة هذه الدراسة في إمكانية تحسين إنتاج الشعير باستعمال الأسمدة الأزوطية في المناطق الجافة وشبه الجافة.

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RESUME

La culture de l'orge est bien adaptée aux zones arides et semi-arides de l'Afrique du Nord et l'Asie occidentale. Au Maroc. L'orge est la culture dominante en zones à sols peu profonds et ayant une pluviométrie annuelle de 200 à 350 mm. En plus, c'est une culture qui ne fait pas l'objet de fertilisation. Cette étude a été donc menée pour déterminer les effets de la fertilisation sur cette culture. Une combinaison de cinq variétés améliorées de l'orge: Arig--8. ASNI. Tassaout. Acsad-60 et Acsad-176 et de quatre doses d'azote:0, 40, 80. et 120 kg/ha: a été utilisée. L'azote a été appliqué à la vellée sous forme d'ammonitrate au moment de semis. L'azote avait un effet très apparent sur toutes les variétés même à un stade de croissance précose (tallage). L'augmentation du rendement due à l'engrais azoté a été quantifiée de 200 à 250% plus que celui du témoin. En ce qui concerne les variétés. la variété Arig-8 a montré qu'elle a un potentiel de rendement élevé, alors que Tassaout, variété précoce avait le rendement le plus bas. Cette étude a montré que le potentiel d'augmentation du rendement de l'orge en zones arides et semi-arides par l'application des engrais azotés existe.

ABSTRACT

Barley is well adapted for either grain or forage in the rainfed Middle East-North Africa region.

In Morocco, barley predominates in the 200-350 mm/yr range and on shallow soils, generally without fertilizers. Responses of barley in this zone to nitrogen have been ambiguous. In this field trial of barley varieties(Arig 8, Asni, Tassaout, ACSAD-60, and ACSAD-176) grown on a shallow soil (Pertrocalici Palexeroll) in the Settat area of Chaouia, N was broadcasted at 0, 40, 80, and 120 kg/ha as ammonium nitrate at planting. The 370 mm rainfall during the season coincided with the 50-yr average for the area. Marked responses were evident even at tillering. All varieties responded with increasing N to 120 kg/ha, where yields were 200 to 250% higher than the controls. At any N level, the six-row variety, Arig 8, was better than the others, while the earliest cultivar, Tassaout, tended to yield lower than the others.These differences were generally reflected in grain yield. The study showed the potential of increase barley output in dryland Morocco.

Key Words: Barley cultivars, nitrogen fertilization, dryland cereals.

INTRODUCTION

Barley, ***(Hordeum vulgare L.)*** the fourth most important cereal crop in the world, has been cultivated as a food source from the dawn of settled agriculture. It is grown in a broader range of environments than any other cereal, including wheat. Poehlman (1985) attributed the global importance of barley to wide ecological adaptation, utility as a feed and food grain, and suitability of barley malt for brewing. An important aspect of its versatility is drought resistance or avoidance; its water requirement per unit cereal grain production is lower than for other cereals due to its relatively low transpiration rate. As it matures earlier than wheat, it is more adaptable to lower rainfall environments. Poehlman (1985) also pointed out that where soils are shallow and drought-prone, barley is more likely to produce tolerable yields of forage, and grain, if year is favorable. than wheat (***Triticum spp.***). Such characteristics explain its ubiquity in the semi-arid areas of the world.

The West Asia-North Africa (WANA) zone is a marginal rainfall area adapted to barley growing (Cooper et al.,1987). Despite the normally narrow mean annual rainfall range, the region is characterized by wide ecological diversity and indeed considerable inter-regional and inter-annual climatic variation. As a consequence of such ecosystems, a large range of cultivars has evolved. Within this rainfall range, barley tends to be grown in areas below 350 mm/yr. and wheat in the 350-450 mm zone (Anderson, 1985a); over 90% of both crops are rainfed. As with cereals in general, barley output in the region is low, ranging from 0.6 tons/ha (Jordan and Iraq) to 1.8 tons/ha (Turkey). Low fertilizer input, poor weed and disease control, and use of unimproved varieties are believed to be the main reasons for such yields.

Despite efforts to intensify output in the past two decades, the WANA area is still a food-deficit one. Due to rapid population growth rates, this projection is likely to increase for the foreseeable future. The deficit for barley is likely to increase from 5 million metric tons in 1983 to 11.3 in significant response of barley to N (ACSAD, 1986a). Similarly, unpublished work by Troeh (1984) at Aridoculture Center found no N response with barley at Sidi El Aydi station. In on-farm trials, no response was observed at three locations: Ben Guerir, Berrechid, and Khouribga (Karrou et al., 1987).

However, El Mourid et al. (1986) found a 27% increase on yield to applied N at one site (Ould Said), but none at two others. In view of the fact that no soil test data were provided for any of these on-station or on-farm trials, it is possible that the lack of response may be due to adequate levels of N°3 in the sites prior to cropping. Indeed, Ryan et al. (1990) showed that many plots at experiment stations were adequate in $N0_3$ due to previous excessive fertilizer use. Therefore, the foregoing trial, conducted on-farm at a site low in $N0_3$, evaluated of several introduced barley varieties.

MATERIALS AND METHODS

Based on adaptability and yield potential, five important barley cultivars were chosen : Tassaout, Asni, Arig 8, ACSAD - 60 and ACSAD - 176 (Table I). They varied in origin, adaptation, and days to heading. The site was a shallow (< 35 cm) Petrocalcic Palexeroll, near Settat, representing a widespreaed soil type in the Chaouia region (Stitou, 1985) and typical of shallow soils devoted to barley; wheat rather than barley is mainly grown on deeper soils. The site was cropped the previous year to barley and, as a consequence, was low in NO_3, (2 ppm). Other relevant soil properties were: texture, clay; CaCO3, 31%; organic matter, 4.3%; and available or NaHCO3-extractable P, 4 ppm (low) and available K 230 ppm (adequate).

The site was prepared using an offset tandem tractor-drawn disc or "covercrop". Plots (1.8m wide x 5m long) were then marked out with flags and fertilizers applied broadcast by hand from previously weighed bags. Triple superphosphate was applied at 30 kg/P ha to all plots, with N, as ammonium nitrate at 0, 40, 80 and 120 kg/ha. These were incorporated by the "covercrop", this time at right angles to the first run.

The seeding rate, using a wintersteiger experimental plot planter , was 100 kg/ha for each variety (Nov. 15, 1989). After crop emergence, the plants were sprayed with "Cetrol H" (4 1 a.i/ha) at about the leaf stage to control weeds. Subsequently, following the onset of net blotch and rust attack , a spraying of "Tilt" was applied. The season' s rainfall of 370 mm was equal to the area' s 50-year average, but was somewhat erratically distributed, being below normal in the Dec.-Jan. period.

Harvesting took place in May and June; one early variety, Tessaout, was harvested on May 4, and the others on June 12. The procedure involved hand-cutting two 5-m iniside rows from each plot. A separate 1-m row section was taken for N analysis in order to measure crop N uptake and estimate N-use efficiency, i.e., apparent crop N uptake. Subsequently, all samples were weighed and threshed using a stationary thresher.

In order to economically evaluate the response of barley to N fertilization, information was obtained on fertilizer prices (i.e., 124 Dh per 100 kg ammonium nitrate, 33.5% N) and market value of both grain (1 Dh/kg) and straw (0.25 Dh/kg). Subsequently, revenue for both yield components were calculated along with benefit-cost (B/C) ratios. A B/C of 2.0 or above is the normal criterion for profitability.

RESULTS

As anticipated from growth observations, responses to applied N were significant and consistent. However, there was no significant variety x N interaction for grain or total dry matter yield. Consequently, the mean effect of N over all five varieties is depicted in Table II. In terms of total harvested dry matter-grain and straw-each increment of N produced a significant and positive effect. The highest N rate of 120 kg/ha produced about a threefold yield increase compared with the unfertillized control. Grain yield essentially followed the same N reponse pattern as dry matter. Here, the first and second 40-kg increment of N had a significant effect. However, though the 120 kg level produced the highest grain yield, the effect was not significantly different from the 80 kg level. Though N increased grain yield over twofold, i.e., from 0.72 to 1.62 ton/ha, N at the higher rate tended to have a greater effect on straw than grain. This was

Table I : **Characteristics of barley cultivars.**

Cultivar	Row Number	Release Year/ Origin	Type of Adaptation	Days to Heading
Arig 8	6	1976 INRA	General	105
Asni	2	1984 INRA	General	100
ACSAD-60	2	1983 ACSAD	Semi-arid	85
ACSAD-176	6	1983 ACSAD	Semi-arid	95
TESSAOUT	2	- INRA	Arid	72

INRA : Institut National de la Recherche Agronomique, Rabat.
ACSAD : Arab Center for the Studies of Arid Zones and Dry **Lands Damascus.**

Table II : **Mean barley response to applied N rates.**

Nitrogen kg/ha	Yield		Harvest Index
	Dry Matter	Grain	
	........................ton/ha........................		
0	2.26 (-)	0.72 (-)	0.32
40	3.61 (60)	1.14 (58)	0.32
80	4.36 (83)	1.55 (115)	0.35
120	6.40 (183)	1.62 (125)	0.25
L.S.D. 5%	0.62	0.17	

Percentage increases in parenthesis.

Table III : **Mean effects of barley cultivars over N treatment.**

Nitrogen Cultivar	Yield		Harvest Index
	Dry Matter	Grain	
	........................ton/ha.........................		
ACSAD-60	4.08	1.41	0.35
Tessaout	3.08	1.14	0.37
Asni	3.76	1.16	0.31
Arig 8	5.07	1.37	0.27
ASCAD-176	3.66	1.22	0.33
L.S.D. 5%	0.69	0.31	

Table IV : **Fertilizer response parameters at 40 kg N/ha application rate.**

Variety	Yield		Harvest Index
	Dry Matter	Grain	
	........................kg/ha.........................		............%.............
ACSAD-60	1754	16.4	41.0
Tessaout	890	8.1	20.3
Asni	1373	14.1	35.3
Arig 8	1840	18.4	42.5
ASCAD-176	866	6.5	16.3

Based on total N uptake from 40 kg N-uptake from control/40 kg N x 100 reflected in a somewhat lower harvest index (HI), i.e., from 0.32 to 0.25.

The mean effect of N on yield components raises the question of variety effects (Table III). Total dry matter, over all N treatments, ranged from 3.08 tons for Tesssaout to 5.07 tons for Arig 8. The latter variety was significantly better than the other four varieties. While the next highest yielding variety, ACSAD-60, was better than either Asni and ACSAD-176, this effect was not significant. However, it significantly outyielded the lowest yielder - Tessaout. In terms of grain yield, there were no significant differences between varieties, although both ACSAD-60 and Arig 8 tended to yield higher than the other three varieties. Harvest index varied little between varieties except a relatively lower figure of 0.27 for Arig 8. This reflected the high straw yield of this variety.

Following the overall responses to N and differences between barley varieties, it is pertinent to look at responses of individual varieties to applied N rates. Thus, grain yield data are presented as a function of treatment and variety in Fig. 1. Without N, grain yield for Arig 8 was almost a ton (970 kg/ha), in contrast to low yields of 560 kg for both Tessaout and Asni. With the first addition of N, i.e., 40kg/ha, significant grain yield increases occurred. However, this time ACSAD-60, instead of Arig 8, outyielded the other varieties. Further yield increases were achieved by the 80 kg rate, with ACSAD-60 and Arig 8 being the best varieties. With the highest N level, i.e., 120 kg/ha, there was generally no further increase in grain yield. This was in contrast to the effect of the high N rate on total dry matter. Therefore, high N influenced straw yield more than grain.

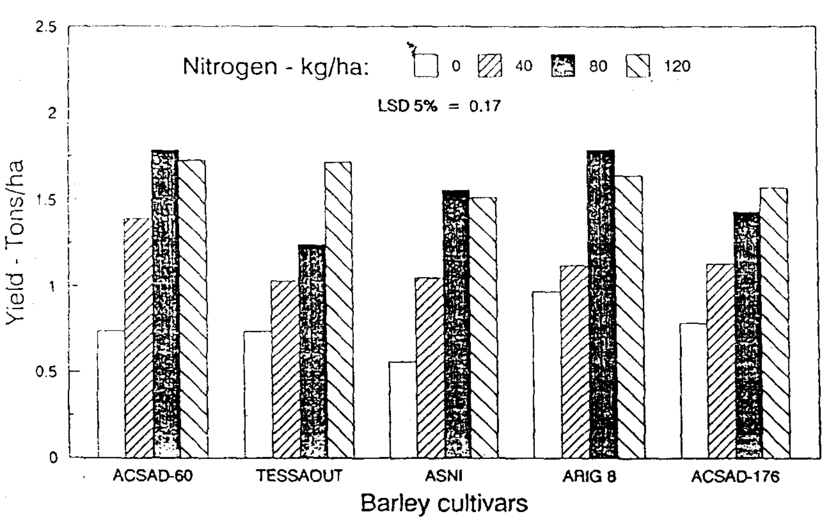

Fig. 1: Grain yield responses of barley cultivars to applied N fertilizer application rates.

A measure of the efficiency of utilization of applied N at 40 kg/ha illustrates the differential impact of N on yield increases (Table IV). Responses ranged from a low of about 0.9 tons/ha dry matter for Tessaout and ACSAD-176 to 1.84 tons/ha for Arig 8. Net N uptake ranged from 6.5 kg for ACSAD-176 to 18.4 kg for Arig 8. Percentage-wise, the apparent N recovery varied from 16.3 to 42.5. Thus, less than 50% of the added N was apparently used by the crop.

The economic data presented in Table V indicate a similar disparity between varieties. Though revenues from grain and straw, are shown, the key indicator is the B/C ratio. This, in most cases, was above 2.0, indicating an economic response at that level. With increasing N rates, the B/C values decreased, The data suggest that 120 kg N could be economically used on ACSAD-60, ASNI, and Tesssaout, while 80 kg N was economically optimum for Arig 8 and ACSAD-176. Overall B/C values, averaged over all varieties, were 3.2, 2.8 and 2.2 for the 40, 80 and 120 kg N levels, respectively.

DISCUSSION

Despite the fact that the response of barley to applied N is lower under rainfed than irrigated conditions (Baldridge et al., 1985), responses under the present limited moisture regime were significant, with consistent yield increase up to 120 kg/N ha. Similarly, Anderson (1985a) found that responses to N varied from 40 to 120 kg/ha depending on site, season, seed rate and variety. The stepwise increase in dry matter yield (Table II) suggests that further responses in dry matter yield might be achieved using even higher N levels. However, it seemed that this was about maximum for grain yield since there was no significant difference between the 80 and 120 kg N rate. The differential effect of N on grain was reflected in a lower HI at the highest N rate. However, as N response is season-specific, i.e., depending on rainfall, responses to higher N levels would occur if rainfall had been higher and better distributed. These responses were, however, in contrast to Anderson (1985a) who found that N increased grain production more than dry matter in local syrian varieties. However, the differential effect of N on straw and grain is a function of seed rate.

The marked response of all varieties to N was not surprising in view of trial results from the rainfed Mediterranean region (Anderson, 1985b; Brown et al., 1987; Sakhal and Sukkar, 1983). Work at ICARDA has demonstrated that, irrespective of the year's rainfall, responses of barley to N are related to the initial NO_3 levels in the rooting volume, i.e., to a depth of 60 cm (Jones et al., 1987). A critical level of 40 kg NO_3-N (14.4 ppm) was identified in these trials. In view of the extremely low value of 2 ppm NO_3-N prior to this study, the magnitude of the N response was not surprising.

The apparent contrast between our results and those reported for barley trials in this area of Morocco have to be reconciled in terms of initial soil NO_3 levels. Prior to the initiation of soil test calibration studies, few, if any field trials reported soil nutrient analyses. The most plausible reason for this absence of an N response at experiment stations (Karrou et al.,1987) was a build-up of NO_3. This was recently documented for several stations in the region by Ryan et al. (1990). Indeed, the variable response to N with barley on farmes' fields (El

Table V : **Revenue and benefit-cost (B/C) ratio from N fertilization of barley.**

Variety	N kg/ha	Revenue				B/C
		Grain	Straw	Gross	Net	
		....Dh....				
ACSAD-60	0	736	356	1092	1092	-
	40	1399	628	2027	1879	5.3
	80	1776	859	2635	2339	4.2
	120	1715	829	2544	2100	2.3
Tessaout	0	737	168	905	905	-
	40	1027	323	1350	1202	2.0
	80	1244	377	1621	1325	1.4
	120	1710	955	2665	2221	3.0
Asni	0	557	351	908	908	-
	40	1046	571	1617	1469	3.8
	80	1547	676	2223	1927	3.4
	120	1507	963	2470	2026	2.5
Arig 8	0	970	573	1543	1543	-
	40	1121	995	2116	1968	2.9
	80	1766	911	2677	2381	2.8
	120	1626	1221	2847	2403	1.9
ACSAD-176	0	785	431	1216	1216	-
	40	1129	563	1692	1544	2.2
	80	1431	692	2123	1827	2.1
	120	1555	748	2304	1860	1.5

USD. 1 = 8.0 Dh (Dirhams)

Mourid et al., 1986) may be explained based on the previous crop. Where a legume was previously grown, soil N levels may be adequate for maximum yield without the addition of fertilizer (Abdel Monem et al., 1990). Had soil samples been analyzed for N, this would have been easily detected. It can be safely assumed that if a cereal crop had been planted the previous year, a response to N would be likely. However, most Moroccan dryland barley farmers achieve tolerable yields without fertilizer or by rotation with fallow or legumes.

The study highlighted significant differences between barley varieties. Brown et al. (1987) also highlighted varietal differences; they found no difference in dry matter response to for a two-row local landrace and a six-row improved variety, but the local one had higher grain yield. In our study, the short-season variety, Tessaout, did not take advantage of late season rains and therefore yielded poorty while the longest season one, Arig 8, did so and yielded highest.

The N uptake data (Table IV) sèrve to illustrate differences in efficiency of N utilization among varieties. Average apparent N recovery was about 31%. In other words, 69% of the N was not used by that year's crop. Most of it was probably still in the soil in organic form in the roots or microbial biomass or as NH_4 and/or NO_3. Losses of N are likely to have been low. As NH_4 NO_3 is not very prone to volatile loss and was incorporated immediately, and as rainfall was not sufficient to leach NO_3 from the root zone, little actual loss could have occurred. Thus the unused N could be used by succeeding crops.

In summary, this was first researcher-managed on-farm trial in Morocco's dryland zone to clearly demonstrate barley response to N, in contrast to previous on-station trials. Fortunately, as the year's rainfall coincided with the long-term average for the area, the validity of this conclusion is enhanced. As little fertilizer is used on barley in semi-arid areas of Morocco (Crawford and Purvis, 1986), these results suggest that output could be considerably increased by general use of N fertilizers. The economic analyses support the conclusion that N use is also profitable for the farmer when used at the normally recommended range of application rates. As crop N response is obviously affected by rainfall and soil type, i.e., water-holding capacity, an expanded multi-site, multi-year barley fertilization study is warranted throughout Moroccan dryland cereal zone.The present study serves as a cornerstone for this effort.

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