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Wheat (*Triticum aestivum* L. cv. Yecora rojo) Performance as Affected by Seeding Rates and Nitrogen Fertilization

O.A. AL-TAHIR and M.A. AL-ABDULSALAM
Crops and Range Science Department, College of Agric. and Food Sci., King Faisal University, Al-Hassa, Saudi Arabia

ABSTRACT. Field studies were conducted at two locations in the eastern and northern regions of Saudi Arabia during 1991, 1992 and 1993 to determine the effects of nitrogen fertilization and seeding rates on yield components and grain yield of bread wheat, cv. Yecora rojo. Nitrogen from 40 to 240 kg/ha and seeding rates from 120 to 210 kg/ha were applied. Increasing N up to 200 kg, resulted in gradual, significant and consistent increase in number of spikes/m^2, number of grains/spike, 1000-grain weight and, ultimately grain yield. A linear response of wheat to levels of fertilizer nitrogen was observed at Hail and a curvilinear response at Al-Hassa. However, yield components and grain yield decreased with increased seeding rates.

Introduction

Saudi crop production is limited to the cool season. Cereals are sown near the onset of autumn rains and fill their grains during spring when evapotranspiration increases. The two main constraints to cereal production in Saudi Arabia are water and nitrogen. Farmers in this semi-arid region therefore frequently use summer fallow systems in an attempt to simultaneously alleviate both constraints. However, this often increases soil degradation. Annual cropping with the use of adequate fertilization should minimize soil degradation (Campbell *et al.*, 1993), but available water remains yield limiting. Recent studies suggest that rapid early growth and high biomass production prior to anthesis frequently may increase cereal grain yields particularly on deep sandy soils (Turner and Nicolas, 1987; Shepherd *et al.*, 1987). Grain yields can be increased by the use of higher levels of fertilizer (Turner *et al.*, 1987; Shepherd *et al.*, 1987 and Venn *et al.*, 1987). However, the magnitude of yield increase would depend on source and level of nitrogen fertilizer as well as time of application (Ghandorah, 1986).

Rapid early growth has been shown to increase crop yield (Cooper *et al.*, 1987). However, there is a risk that high biomass production may increase water use, in arid regions, prior to anthesis and lead to reduction in grain yield because of water deficits in the grain-filling period. Plant density provides an alternative method of influencing early biomass production. Edwards (1992) indicated that wheat yields can be increased by increasing plant density. However, field studies suggest that response to seeding density varies with site and season (Anderson, 1986).

Semi-dwarf wheat cultivars are known to respond well to the application of nitrogenous fertilizers. Researchers from different agroecological regions of Saudi Arabia reported different findings for response of wheat to cultural practices. Varying seeding rates had no appreciable effect on grain yields of wheat (Briggs, 1975). The N-response of wheat cultivars varied from 100 to 240 kgN/ha, depending upon soil fertility and agroclimatic conditions (Bartholomew and Williams, 1978; Anonymous, 1983; Rawajfih *et al.*, 1985, Osman and Mahmoud, 1981; and Makki *et al.*, 1987).

With this background in view, an investigation was carried out at two locations; *viz.*, Al-Hassa and Hail, having distinct soil and climatic situations to ascertain the nitrogen and seed rate requirements of wheat.

Materials and Methods

Field studies were conducted during 1991, 1992 and 1993 at two locations; *viz.*, Al-Hassa in the eastern region and Hail in the northern region of Saudi Arabia. The soils were shallow, sandy to sandy loam and low in nitrogen. Soils at Al-Hassa were light and salt affected and winters were short. Whereas soils were more fertile and winters were longer at Hail. The monthly mean maximum and minimum temperatures ranged from 14.7 to 33.2 and – 2.7 to 19.5°C in Hail and from 14.9 to 38.1 and 6.0 to 24.0°C in Al-Hassa during the period of study. The rainfall received in Hail during the growing seasons, from December to March, was 121.6, 181.6 and 200.3 mm in 1991, 1992 and 1993, respectively. In Al-Hassa, the amount of rainfall was negligible.

The treatments covered a range of six N levels (40 to 240 kg/ha) and four seeding rates (120 to 210 kg/ha). The experiment was designed in split plots with nitrogen in the main plots and seeding rates in the sub-plots, with four replications. The net plot size was $2 \times 4 = 8$ m^2.

Wheat cultivar, Yecora rojo, was sown in rows, spaced 20 cm apart, on Nov. 15 at Al-Hassa and Dec. 15 at Hail in all seasons. Nitrogen was applied in two equal splits in the form of urea, one-half at sowing and the other half at the stage of tillering. A basal application of 75 kg P_2O_5/ha as superphosphate and 50 kg K_2O/ha as nitrate of potash, was given to all plots at sowing. Weeds were effectively controlled and adequate basin irrigation was given at an interval of about seven days.

The observations were recorded on number of spikes/m^2, number of grains/spike, 1000-grain weight, and grain yield. Grain yield was determined from an area of two square meters of the middle rows of each plot. Yield components were determined from 25 randomly sampled spikes taken from each sub-plot. An electronic seed counter was used to obtain random 1000-grain samples, which were then weighed.

Results and Discussion

The analysis of variance (SAS program, 1986) for grain yield, number of spikes/m^2, number of grains/spike and 1000-grain weight combined over the three years is presented in Table 1. It was indicated that locations, nitrogen levels and seeding rates had highly significant effects on the traits under study. However, locations had only a significant effect on the 1000-grain weight.

TABLE 1. Analysis of variance for grain yield, spikes/m^2, grains/spike and 1000-grain weight at both Al-Hassa and Hail.

	Grain yield (t / ha)
Nitrogen (N)	**
Seeding rate (S)	**
Location (L)	**
N × S	*
N × L	*
S × L	**
N × S × L	*
	Spikes/m^2
Nitrogen (N)	**
Seeding rate (S)	**
Location (L)	**
N × S	*
N × L	*
S × L	**
N × S × L	*
	Grains/spike
Nitrogen (N)	**
Seeding rate (S)	**
Location (L)	**
N × S	*
N × L	*
S × L	**
N × S × L	*
	1000-grain weight (g)
Nitrogen (N)	**
Seeding rate (S)	**
Location (L)	*
N × S	*
N × L	**
S × L	**
N × S × L	*

*, **Significant at the 0.05 and 0.01 probability levels, respectively.

The data presented in Table 2 represent the mean effect of nitrogen on yield components and grain yield for the two locations in the three growing seasons. Seeding rate and nitrogen affected grain yield by modifying spikes/m^2, grains/spike and grain weight. These results are in accordance with the results of Ghandorah (1985) and Shehab El Din and Eissa (1992).

TABLE 2. Effects of nitrogen levels on yield components and grain yield of wheat at the two locations (three seasons).

Nitrogen (kg/ha)	No. of spikes/m^2	No. of grains/spike	1000-grain weight (g)	Grain yield (t/ha)
		Al-Hassa		
40	438	41	39.8	7.1
80	427	42	41.0	7.4
120	467	40	40.2	7.5
160	472	43	42.4	8.2
200	529	45	45.3	10.8
240	486	44	44.9	9.6
LSD (0.05)	35	0.6	2.7	0.8
		Hail		
40	401	41	40.5	7.0
80	445	42	43.3	8.2
120	443	43	44.8	8.9
160	482	43	44.9	9.1
200	590	44	46.4	11.9
240	556	43	45.1	10.8
LSD (0.05)	36	0.4	0.1	1.2

Increasing the level of N at both locations resulted in gradual and significant increases in the number of spikes/m^2, number of grains/spike and 1000-grain weight up to 200 kg/ha (Table 2). In wheat, grain weight is a function of complex source-sink phenomena because it is influenced by environmental conditions and nutrient availability as well as a tendency for the yield components to compensate for each other (Slavik, 1966). For example, if poor growth conditions during plant development suppress a yield component such as tillering but these conditions improve during seed set, then the plant may have a low number of spikes which will be compensated by producing a great number of grains. Similarly, grain weight will be dependent both on conditions that exist during grain-filling as well as conditions that existed during earlier development. Consequently, interpretation of the interactions is rarely straightforward. At both locations, there was a significant and gradual increase in grain yield with each increment in the level of N up to 200 kgN/ha, after which the yield declined. The difference in grain yield, between the 200 and 240 kgN/ha levels, was significant at Al-Hassa, but not at Hail. The latter was attributed to a gradual improvement in the nitrogen supplying power of the soil due to improved management. Campbell *et al.* (1993) reported an excellent relationship ($R^2 = 0.91$, P = 0.001) between grain yield and nitrogen level. The relative association increased with years of cropping.

Grain yield response curves for plots receiving different nitrogen levels show a definite nonlinear component in Al-Hassa while the response in Hail was linear (Fig. 1). The linear relationship between yield and levels of N in Al-Hassa was highly significant. The results confirmed the finding that grain yield of wheat increased sharply in both locations up to the 200 kgN/ha and, then, declined slightly in Al-Hassa data. It is logical to assume that, if more higher levels of N were used, the decline would have extended and that was expressed by the curvilinear relationship. The levelling of the yield response curve at higher N addition rates was in part due to lodging, which occurred in a few of the plots receiving 200 kgN/ha. It is, also, evident in Fig. 1 that Hail exhibited a higher response to the successive increases in fertilizer N than Al-Hassa.

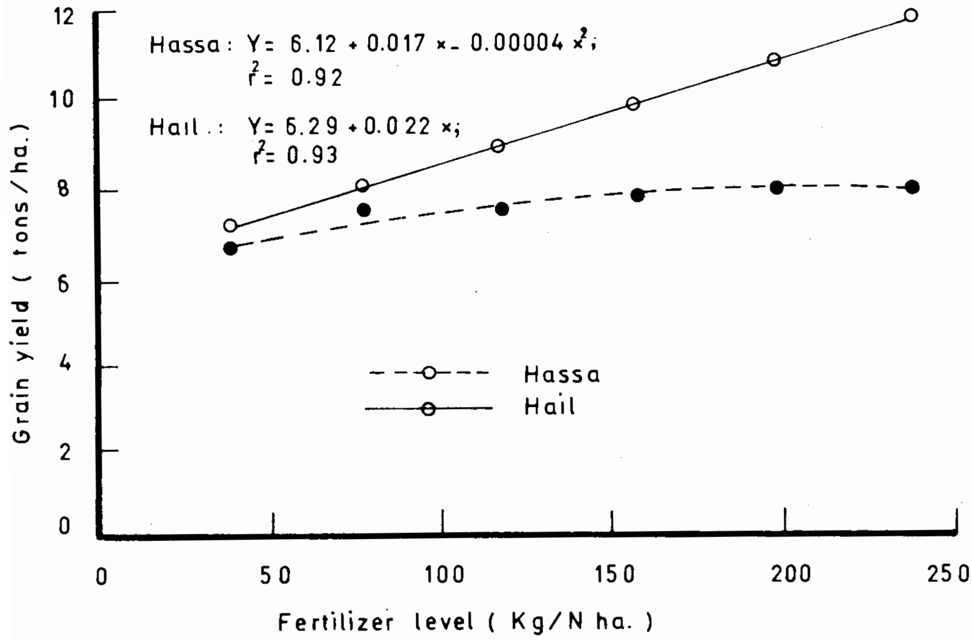

FIG. 1. The response of wheat to fertilizer N at two locations (3 seasons).

The effects of seeding rates were statistically significant on means of yield components and grain yield at both locations over the three seasons (Table 3). The general trend was a gradual decrease in yield components and grain yield as a result of increased seeding rates. This trend was consistent at Al-Hassa, but at Hail, the yield components and grain yield were increased by an increase in seeding rate from 120 to 150 kg/ha and, then, declined with further increases beyond these rates. These results were in conformity with the findings of Kobata *et al.* (1992) and Palta *et al.* (1994) who showed that increasing the seeding rate caused a reduction in the number of grains per spike and reduced the average grain weight. Soetono and Puckridge (1982) in a study on the influence of density and plant arrangement on the performance of wheat, reported longer spikes and heavier grains as a result of low seeding rates. Previous work has shown that later-formed tillers transfer assimilates to the mainstem and first tiller in wheat (Kobata *et al.*, 1992 and Palta *et al.*, 1994), and this may be the cause of smaller grain weights in later-formed tillers.

TABLE 3. Effects of seeding rates on yield components and grain yield of wheat at the two locations (three seasons).

Seed rates (kg/ha)	No. of spikes/ m^2	No. of grains/ spike	1000-grain weight (g)	Grain yield (ton/ha)
		Al-Hassa		
120	480	41	45.6	8.8
150	460	40	43.3	8.0
180	422	35	42.5	6.4
210	399	36	38.6	5.8
LSD (0.05)	31	3	1.7	0.4
		Hail		
120	535	42	44.0	9.2
150	616	44	45.1	12.2
180	498	40	42.2	8.4
210	481	39	41.0	7.7
LSD (0.05)	14	4	1.3	0.3

The combined analysis of variance for the data at both locations (Table 1) showed that, for grain yield, the interactions NXS, NXL and NXSXL were significant at the 5% significance level. This indicates that the response of wheat to N-fertilization was neither the same at varying seeding rates nor in the two locations. In other words, a change in the seeding rate and/or location was likely to result in a different response to N. There was, also, a highly significant SXL interaction for grain yield. This implies that the response to the seeding rate treatments was not the same in the two locations. Realizing that the trend of increase in the different traits with increased level of N was the same in both locations, the explanation offered is that the interaction was a result of the difference in the magnitude of treatment effects. As far as seeding rate is concerned, it is noteworthy to state that, at Hail the greatest response was associated with the 150 kg/ha seeding rate, while at Al-Hassa, 120 kg/ha resulted in the highest values of all traits. It is evident that Hail, which is characterized by better soil and suitable climatic factors (*i.e.* longer growing season and cooler filling period etc.) provided conditions which were more conducive to better responses from increased

N and seeding rates (Table 4). This is, also, reflected in the high grain yields obtained from Hail as compared with Al-Hassa.

TABLE 4. Effects of nitrogen fertilization and seeding rates on grain yield (tons/ha) of wheat at the two locations in the three seasons.

Nitrogen (kgN/ha)	Seeding rates (kg/ha)			
	120	150	180	210
Al-Hassa				
40	6.4	6.3	4.6	4.2
80	6.7	6.5	5.2	4.7
120	8.2	7.7	6.2	5.5
160	9.2	8.2	6.6	5.9
200	11.0	10.9	8.8	8.2
240	10.4	8.4	7.0	6.3
LSD (0.05)	1.3	1.2	1.2	0.9
Hail				
40	8.4	10.3	6.8	5.7
80	8.6	11.6	7.5	6.8
120	9.0	22.7	7.9	7.7
160	9.2	12.7	8.4	8.0
200	10.6	13.8	10.1	9.8
240	9.5	13.2	9.7	8.6
LSD (0.05)	1.2	1.1	1.5	1.3

Conclusions

The study, conducted on sandy soils, indicates that there is a low potential for wheat receiving low levels of nitrogen even with high seeding rates, at the two locations under study and other similar ones. Under Al-Hassa conditions, high seeding rates and nitrogen levels are required to obtain maximum grain yields of wheat. The present study on sandy soils with low inherent fertility showed that under increased plant density, nitrogen level is a useful way to improve wheat growth and yield and is consistent with the conclusion of Fukai *et al.* (1990) working with barley.

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References

Anderson, W.K. (1986) Some relationships between plant population, yield components and grain yield of wheat in a mediterranean environment, *Aust. J. Agric. Res.* **37:** 219-233.

Anonymous (1983) *Effect of sowing date and nitrogen on the yield of wheat.* Ann. Report, Al-Kharj Exp. Stat. 1980-1981 season, Saudi Arabia.

Bartholomew, P.W. and **Williams, R.J.** (1978) *The response to nitrogen Mexipak wheat grown for forage.* Joint Agric. Res. and Dev. Project, Riyadh, No. 131: 6 p.

Briggs, K.G. (1975) Effects of seeding rate and row spacing on agronomic characteristics of Glenlea, Pitic 62 and Neepa wheats. *Can. J. Plant Sci.* **55:** 363-367.

Campbell, C.A., Zentner, R.P., Selles, F., McConkey, B.G. and **Dyck, F.B.** (1993) Nitrogen management for spring wheat grown annually on zero-tillage: yields and N use efficiency. *Agron. J.* **85:** 107-114.

Cooper, P.J.M., Gregory, P.J., Tully, D. and **Harris, H.C.** (1987) Improving water use efficiency of annual crops in the rainfed farming systems of West Asia and North Africa. *Exp. Agric.* **23:** 113-158.

Edwards, I. (1992) Farming duplex soils: a farmer's perspective. *Aust. J. Expl. Agric.* **32:** 811-814.

Fukai, S., Searle, C., Baiquini, H., Choenthong, S. and **Kywe, M.** (1990) Growth and grain yield of contrasting barley cultivars under different plant densities. *Field Crops. Res.* **23:** 239-254.

Ghandorah, M.O. (1985) Response of certain wheat varieties to N-fertilization, *J. Coll. Agric., King Saud Univ.*, **7**(1): 125-133.

——— (1986) Response of wheat cultivars to seeding rates and mixed fertilizer levels using municipal waste water, *J. Coll. Agric., King Saud Univ.*, **8**(2): 347-366.

Kobata, T., Palta, J.A. and **Turner, N.C.** (1992) Rate of development of postanthesis water deficits and grain filling of spring wheat. *Crop Sci.* **32:** 1238.

Makki, Y.M., Burhan, H.O., Al-Tahir, O.A. and **Mustafa, A.I.** (1987) Effects of planting date and level of fertilizer nitrogen on the growth and yield of wheat grown in the eastern region of Saudi Arabia. *Arab-Gulf J. Scient. Res. Agric. Biol. Sci.* **B5**(2): 175-184.

Osman, A.M. and **Mahmoud, S.M.** (1981) Yield and yield components of wheat (*Triticum aestivum* L.) and their interrelationships as influenced by nitrogen and seed rate in the Sudan. *J. Agric. Sci. Camb.* **97:** 611-618.

Palta, J.A., Kobata, T., Turner, N.C. and **Fillery, I.R.** (1994) Remobilization of carbon and nitrogen in wheat as influenced by postanthesis water deficits. *Crop Sci.* **34:** 118-124.

Rawajfih, Z., Mazroa, M., Ali, S.K. and **As-Soud, A.A.** (1985) The response of wheat to N, P and K fertilizers in a sandy soil in Unizah. *8th Symp. on the Biol. Aspects of Saudi Arabia, Al-Hassa* (Abstract): 71-72.

Shehab, El-Din, T.M. and **Eissa, A.M.** (1992) Response of bread wheat to nitrogen fertilization levels in Al-Qassim Region, Saudi Arabia, *JKAU: Met., Env., Arid Land Agric. Sci.* **3:** 69-76.

Shepherd, K.D., Cooper, P.J.M., Allan, A.Y., Drennan, D.S.H. and **Keatinge, I.D.H.** (1987) Growth, water use and yield of barley in Mediterranean type environments. *J. Agric. Sci.* **108:** 365-378.

Slavik, B. (1966) Response of grasses and cereals to water. In: **F.L. Milthorpe** and **J.D. Ivins** (ed) *The growth of cereals and grasses.* Butterworths, London, pp. 227-240.

Soetono, and **Puckridge, D.W.** (1982) The effect of density and plant arrangement on the performance of individual plants in barley and wheat crops. *Aust. J. Agric. Res.* **33:** 171-177.

Statistical Analysis System Inc. (SAS) (1986) *SAS User's Guide.* 6th edition. SAS Institute Incorporation, Cary, North Carolina, U.S.A.

Turner, N.C. and **Nicolas, M.E.** (1987) Drought resistance of wheat for light-textured soils in a mediterranean climate. In: **J.P. Srivastava** *et al.* (ed.) *Drought Tolerance in Winter Cereals.* John Wiley & Sons, Chichester, U.K., pp. 203-216.

———, **Tennant, D., Hamblin, A.P., Henson, I.E., Jensen, C.R.** and **Perry, M.W.** (1987) Influence of nitrogen on the yield, water use and water deficits of wheat grown in a mediterranean climate. In: *Proc. Australian Agronomy Conference 4th, Melbourne. Aug. 1987.* Aust. Soc. Agron., Parkville, Melbourne, p. 254.

Venn, N.R., Turner, N.C. and **Fillery, I.R.P.** (1987) Influence of post-seeding application of nitrogen on grain yield and water stress of wheat in a mediterranean climate. In: *Proc. Australian Agronomy Conference 4th, Melbourne, Aug. 1987.* Aust. Soc. Agron., Parkville, Melbourne, p. 255.

أثر معدلات التقاوي والتسميد النيتروجيني على سلوك القمح الربيعي (*Triticum aestivum* L.)

عثمان أحمد الطاهر و محمد عبدالعزيز العبدالسلام
كلية العلوم الزراعية والأغذية – جامعة الملك فيصل – الاحساء – المملكة العربية السعودية

المستخلص . أجريت البحوث الحقلية في موقعين بالمنطقتين الشرقية (الاحساء) والشمالية (حائل) بالمملكة العربية السعودية خلال الأعوام ١٩٩١ ، ١٩٩٢ ، و ١٩٩٣م لدراسة أثر معدل التقاوي (٤٠ إلى ٢٤٥ كجم / هكتار) والتسميد النيتروجيني (١٢٠ إلى ٢١٠ كجم / هكتار) على إنتاجية المحصول ومكوناته بالصنف « يوكورا روجو » . أدت زيادة النيتروجين حتى ٢٠٠ كجم إلى زيادة تدريجية ومعنوية في عدد السنابل / م^{٢} وعدد الحبوب بالسنبلة ووزن الألف حبة والإنتاجية . وقد كانت استجابة القمح لمعدلات التسميد خطية بالاحساء ومنحنى خطي بمنطقة حائل إلا أن الإنتاجية تدنت مع زيادة معدلات التقاوي .