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Effects of Planting Date and Levels of Fertilizer Nitrogen on the Growth and Yield of Wheat in the Eastern Region of Saudi Arabia

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ABSTRACT. Agronomic research on wheat (*Triticum aestivum* L) in the eastern region of Saudi Arabia is limited. Field experiments were conducted in Al-Hassa area to study the effects of planting date and nitrogen fertilizer on the growth and yield of the wheat variety Arz. Treatments included early and late November and early and Late December, and three fertilizer nitrogen levels, 40, 80 and 120 kgN/ha. Final plant height and weight increased with early sowing and higher fertilizer levels. Flag leaf area and concentration of chlorophyll in the leaves were indicators of higher photosynthetic activity. Grain yield increased significantly as the level of fertilizer nitrogen increased, and decreased as sowing was delayed. The number of kernels per spike was increased by nitrogen in both seasons and by early sowing in the second season. Kernel weight significantly increased with early sowing. It was concluded that early November is the optimum sowing date and nitrogen levels of 120 kg/ha or more result in high yields.

Wheat (*Triticum aestivum* L.) is an important commercial grain crop in Saudi Arabia. Its acreage and production has been increasing sharply in the eastern region and the country as a whole during the last decade. However, agronomic research on wheat in the eastern region is very limited. Most of the previous research work conducted in the region concentrated on the forage qualities of wheat as compared with various other forage legumes and grasses. Only a few experiments were conducted on wheat for grain. Due to differences in the onset and length of the winter season and other climatic factors the results obtained from other wheat growing areas can not be applicable to the eastern region.

Research on wheat in Saudi Arabia placed particular emphasis on the introduction and adaptability of different cultivars. Agronomic factors, their interactions and other attributes under-lying the growth and development of wheat received much less systematic and consistent attention.

The effect of sowing date in the central region was studied by Habib and Makki (1979) in experiments combining sowing dates, November to January, and seed rates ranging from 50 to 200 kg/ha. No significant differences in yield or yield components were obtained from the different seeding rates. The highest yields were obtained from sowing dates during the period from the 10th to the end of November. Grain yield was positively correlated with plant height, kernel weight and number of tillers per unit area.

Sayed and Al Sayed (1982) observed significant differences in root and shoot weight ratio, yield and other agronomic characters. Grain yield was reported to increase linearly with an increase in the total dry weight of shoots at heading. The upper most leaf of wheat, the last to be formed, known as the flag leaf, has been closely associated with grain yield. It is the photosynthetic activity of the last two leaves and particularly of the flag leaf that provides most of the carbohydrates which become stored in the grain. Hence, any reduction in the activity of these leaves after heading, inevitably has an adverse effect on grain yield (Arnon 1972).

Osman and Mahmoud (1981) studied the effects of nitrogen fertilizer and seed rate on wheat grain yield and its components. Positive linear relationships were established between nitrogen levels and grain yield in two out of three seasons for the variety Mexipak. Nitrogen treatments had no significant effect on the number of spikelets/spike and had a significant effect on the number of kernels per spike in two seasons. The grain weight was not affected by treatment.

Material and Methods

Experiments were conducted in the Experimental Station of King Faisal University located in Al-Hassa oasis in the eastern region of Saudi Arabia for two seasons 1982-1983 and 1983-1984. The soil of the station is light salt-affected, sandy loam. The levels of salinity in this area were determined from samples taken from each sub-plot. The conductivity of the saturation extract ranged from 3.20 to 4.10 mmhos/cm^3 indicating that the variability was not very high and that the salinity level was reasonably low to permit normal growth of the crop. The experiments followed a wheat-fallow-wheat rotation.

The treatments included four sowing dates *viz.* early November (7/11), late November (21/11), early December (7/12) and late December (21/12). The fertilizer treatments were 40, 80, and 120 kg N/ha, given in the form of urea (46%) as post-sowing application; about two weeks after sowing. The fertilizer was broadcast between the rows and watered-in by immediate irrigation.

We used a split-plot design replicated four times, in which the sowing dates occupied the whole-plots and the fertilizer levels occupied the sub-plots. The sub-plots (3 × 5 m) were separated by borders one meter wide and were uniformly irrigated.

Arz, one of the standard commercial varieties in the region, was sown in each sub-plot, at the rate of 100 kg/ha. The seeds were drilled by hand in rows 20 cm apart. Resowing of missing parts was done within the first week after planting. Weeds were effectively controlled by hand and waterings were given at weekly intervals. Plant stand, height, tillering, flowering date, number of spikes per plant, number of kernels per spike, 100 grain weight, chlorophyll content, leaf area, and grain yield were measured. Plant samples were taken at random from each sub-plot every two weeks. All the plants in a 50 cm length of row were cut at ground level and taken to the laboratory for the various fresh and dry weight measurements.

Concentrations of chlorophyll-A, B and total were determined on leaves obtained from the seventh sample, 15 weeks after planting. The fresh green leaves were chopped and 5 g were placed in a mortar. Forty ml of 80% acetone were added and the tissue was ground to a fine pulp. The resultant extract was filtered while the grinding was repeated until the tissue was devoid of chlorophyll. The mortar was rinsed to collect all the chlorophyll. The volume of the filtrate was then adjusted to 100 ml by adding 80% acetone. The optical density of the chlorophyll extract in a 10 mm cell was read with a spectrophotometer against a blank of 80% acetone and the amount of chlorophyll in mg per g of leaf material was calculated.

The flag leaf area of plants selected at random from the eighth and last sample before harvest was measured using a leaf area meter.

Measurements of the effect of treatments on yield components were based on random plant samples taken from each sub-plot. The grain yield of each sub-plot was obtained from the middle six rows, from which samples were not taken during the growing season. All the plants were cut at ground level, threshed and the grain and straw yields recorded.

Results and Discussion

During the first month after planting, the percentage of emergence, stand and general appearance of the crop were excellent in both seasons. Emergence and stand were almost perfect, with the exception of a few spots which required re-sowing.

Effects of Sowing Date and Nitrogen on Growth

The first sowing date started with taller plants on the first sampling occasion, indicating faster growth. Final plant height decreased significantly with a delay in the sowing date (Table 1). It is also evident that plant height increased with an increase in the level of nitrogen. In both seasons the effects of sowing date and nitrogen were similar and significant at the 0.01 level.

Table 1. The effect of sowing date and fertilizer nitrogen treatment on final plant height (cm) 1982-83 & 1983-84

Levels of fertilizer kg/ha	Sowing dates								Mean	
	Early Nov.		Late Nov.		Early Dec.		Late Dec.			
	1982-83	1983-84	1982-83	1983-84	1982-83	1983-84	1982-83	1983-84	1982-83	1983-84
40	87.2	67.2	81.8	66.2	67.2	61.7	68.2	41.8	76.1	59.2
80	89.5	73.6	86.0	72.0	78.0	63.3	72.7	45.8	81.5	63.7
120	98.5	79.1	88.5	75.4	83.3	67.3	77.5	43.1	86.9	66.2
Mean	91.8	73.3	85.4	71.2	76.2	64.1	72.8	43.6	S.E.±0.90 LSD(1%) =2.52	±1.30 LSD(1%) =3.64

S.E. (sowing dates) ± 1.31 LSD (1%) = 4.26 (82/83)
± 2.20 LSD (1%) = 7.15 (83/84)

The number of live shoots, vegetative at the early stages of growth and mainly fertile at later stages, was highest on the first sampling date and then started to decline (Fig. 1). The number of shoots per m^2 increased with an increase in the level of fertilizer nitrogen on all sampling dates. The effect of sowing date did not exhibit a consistent trend, but the final number of shoots per m^2 at the last sampling date before harvest was highest for the early November sowing date.

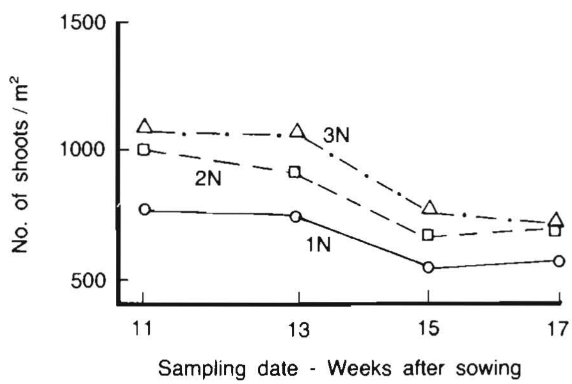

Fig. 1. Effect of level of nitrogen on the number of shoots per square meter, averaged over sowing date treatments

The four samples taken from the different treatments for fresh and dry weights during the 1982-1983 season indicated a general trend of higher weights for the earlier sowing dates and higher levels of nitrogen. The effect of sowing date, howevdr, was not consistent in all the sampling occasions. The final fresh and dry weights, however, showed a general decreasing trend with a delay of the sowing date.

The effect of nitrogen on the fresh and dry weight of plants showed consistency in all the sampling dates. The dry weight values obtained in the last sampling date before harvest, 17 weeks afterplanting, showed a clear and consistent increasing trend with an increase in the level of nitrogen (Fig. 2).

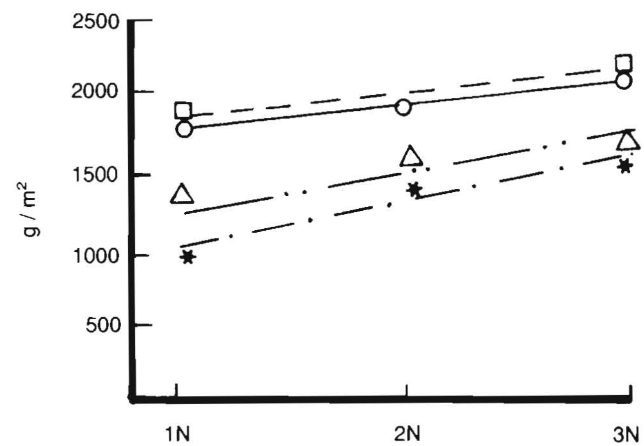

Fig. 2. Dry weight g/m^2 as influenced by nitrogen level increase.

Early Nov. □	Y = 1729 + 2.5 ×	r^2 = 0.92
Late Nov. ●	Y = 1684 + 2.65 ×	r^2 = 0.51
Early Dec. ∗	Y = 752 + 7.6 ×	r^2 = 0.87
Late Dec. △	Y = 1123 + 5.8 ×	r^2 = 0.90

Flag leaf area which has been reported (Arnon 1972) to be closely associated with grain yield exhibited very clear and consistent trends with sowing date and fertilizer nitrogen treatments. The area of the flag leaf (Table 2) decreased significantly with a delay in the sowing date at every level of fertilizer used. It also showed a non-significant trend of increase with an increase in the level of nitrogen from 40 to 120 kg/ha for every one of the four sowing dates.

Table 2. The effect of sowing date and fertilizer nitrogen on flag-leaf area (cm^2), 1982-1983

Level of fertilizer	Sowing dates				Mean
	Early Nov.	Late Nov.	Early Dec.	Late Dec.	
40	89.6	54.4	38.2	20.5	50.7
80	97.9	65.5	53.9	47.5	66.2
120	127.2	85.1	67.6	42.9	80.7
Mean	104.9	68.4	53.2	37.0	

S.E. ± 5.20 LSD (5%) = 11.76

The effects of the date of sowing and the level of fertilizer nitrogen on the concentration of chlorophyll in the leaves was in agreement with the effects observed on flag leaf area, height and other growth attributes. The data presented in Table 3 for chlorophyll A and B, clearly show an increase in concentration with earlier sowing and with higher nitrogen level. The results were highly significant, at the 0.01 level in all cases, and the trend was consistent for all sowing dates and all levels. Coupled with the results obtained for flag leaf area, the effect on chlorophyll concentration presents clear evidence of higher photosynthetic activity as a result of early sowing and higher level of fertilizer nitrogen.

Table 3. The effect of sowing date and fertilizer nitrogen treatment on chlorophyll A and chlorophyll B concentration in leaves (mg/g), 1982-83

Levels of fertilizer kg/ha	Sowing dates (S.E.)								Mean	
	Early Nov.		Late Nov.		Early Dec.		Late Dec.			
	A	B	A	B	A	B	A	B	A	B
40	0.89	0.42	0.35	0.23	0.45	0.27	0.27	0.20	0.49	0.28
80	1.20	0.53	1.68	0.36	0.46	0.28	0.34	0.24	0.67	0.35
120	1.60	0.71	1.25	0.57	0.51	0.31	9.48	0.30	0.96	0.48
Mean	1.23	0.57	0.76	0.39	0.47	0.28	0.37	0.25	S.E.±0.10	±0.02
									LSD(1%)	LSD(1%)
									=0.28	=0.06

S.E. (sowing dates) ± 0.09 (A) LSD (1%) = 0.29
± 0.03 (B) LSD (1%) = 0.10

Effects on Yield and Yield Components

The mean grain yields obtained in the two seasons for the different sowing date and fertilizer nitrogen treatments are given in Table 4. The analysis of variance of the data obtained in the two seasons showed a significant effect of the different levels of nitrogen at 1% level. The grain yield was increased significantly by an increase in the level of nitrogen from 40 to 120. However, the rate of increase in yield tended to diminish gradually. The extra grain yield corresponding to each successive N level were 0.72 and 0.33 t/ha for the increase to 80 and 120 respectively in 1982-1983 and 0.57 and 0.55 t/ha in 1983-1984. This indicated that the response of yield to nitrogen was curvelinear; an expression of the law of diminishing returns.

Table 4. The effect of sowing date and fertilizer nitrogen treatment on grain yield of wheat (t/ha), 1982-83 and 1983-84

Levels of fertilizer kg/ha	Sowing dates (S.E.)								Mean	
	Early Nov.		Late Nov.		Early Dec.		Late Dec.			
	1982-83	1983-84	1982-83	1983-84	1982-83	1983-84	1982-83	1983-84	1982-83	1983-84
40	3.82	3.67	3.43	3.99	2.42	2.88	2.57	1.16	3.06	2.92
80	4.13	4.74	4.22	4.70	3.40	3.20	3.37	1.32	3.78	3.79
120	4.68	5.08	4.61	5.06	3.63	3.87	3.52	2.18	4.11	4.04
Mean	4.21	4.49	4.09	4.58	3.15	3.31	3.15	1.55	S.E. ±0.17	±0.17
									LSD(1%)	LSD(1%)
									=0.48	=0.48

S.E. (sowing dates) ± 0.23 LSD (1%) = 0.75 (82-83)
± 0.32 LSD (1%) = 1.04 (83-84)

The grain yield of wheat was decreased by a delay in the date of sowing in both seasons (Table 4). In seasons 1982-1983 early November sowing resulted in a significantly higher yield than late November which was, in turn, better than early December. The difference in yield between early and late December was not significant.

In the second season, late November sowing gave the highest yield, but the difference from early November was not significant. November sowings were significantly better than early December which was, in turn, significantly better than late December. The effects of treatments on yield components are presented in Table 5. Nitrogen treatments and sowing dates had no significant effect nor a consistent trend on the number of spikelets per spike in the two seasons. The number of kernels per spike showed a significant (5% level) increase with the increase in the level of nitrogen in both seasons. It was not affected by the differences in sowing dates in the first season but showed a consistent and significant decrease with delayed sowing in the second season.

Table 5. Effects of sowing dates and levels of nitrogen on yield components of wheat, 1982-83 and 1983-84

Treatments	Spikelets/spike		Kernels/spike		Kernel wt.(g)	
	1982-83	1983-84	1982-83	1983-84	1982-83	1983-84
Early Nov.						
40	20.6	16.7	29.7	35.4	45.4	51.0
80	19.2	17.6	29.4	37.9	45.1	49.8
120	15.8	17.5	37.7	40.2	46.5	48.0
Mean	18.5	17.3	32.2	37.8	45.6	49.6
Late Nov.						
40	17.0	16.8	28.1	33.9	41.1	43.7
80	16.1	18.7	28.2	34.9	43.0	42.7
120	19.6	19.4	38.0	38.7	41.8	39.3
Mean	17.6	18.3	32.4	35.8	42.0	41.9
Early Dec.						
40	18.0	15.8	27.3	28.5	38.4	42.7
80	18.2	16.6	30.7	28.7	35.8	41.6
120	18.6	16.9	29.9	33.4	36.4	40.4
Mean	18.3	16.4	29.3	30.2	36.9	41.5
Late Dec.						
40	17.8	15.4	28.5	24.7	37.2	38.2
80	18.3	15.8	30.0	27.5	36.3	38.3
120	18.3	16.8	34.3	29.0	37.1	38.6
Mean	18.1	16.0	30.9	27.1	36.9	38.3
Means						
40	18.3	16.2	28.4	30.6	40.5	43.9
80	17.0	17.2	29.6	32.2	40.1	43.1
120	18.0	17.6	34.9	35.3	40.5	41.6
LSD (nitrogen) (5%)			3.18	1.16		0.78
LSD (sowing) (5%)					0.90	1.47

Kernel weight showed a clear and significant tendency to increase with early sowing in both seasons. In the first season, however, there was no significant difference between the weight of kernels obtained from early and late December. The different levels of fertilizer nitrogen had no effect on kernel weight in the first season. In the second season the effect was significant but not consistent. In fact the kernel weight showed a decrease with increased level of nitrogen.

The results of this study lead to the general conclusion that early November is the optimum date of sowing of wheat in Al-Hassa area of the eastern region of

Saudi Arabia. The short duration of the winter season in the eastern region as compared with other wheat growing areas, supports the need for early planting. Grain yield was increased by increasing the amount of nitrogen and levels of 120 kg N/ha or more are needed for obtaining high yields under the conditions of the eastern region.

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أثر مواعيد الزراعة ومعدلات التسميد الآزوتي على نمو وإنتاج القمح في المنطقة الشرقية للمملكة العربية السعودية

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إن الأبحاث في مجال زراعة القمح في المنطقة الشرقية للمملكة العربية السعودية ما زالت محدودة، لذلك فقد أجريت تجارب حقلية في منطقة الأحساء لدراسة أثر مواعيد الزراعة والتسميد الآزوتي على نمو وإنتاج القمح من الصنف «أرز». واشتملت المعاملات على أربعة مواعيد زراعة، أوائل وأواخر تشرين ثاني (نوفمبر) وأوائل وأواخر كانون أول (ديسمبر)، وثلاثة معدلات تسميد، ٤٠ - ٨٠ - ١٢٠ كيلو جرام آزوت للهكتار.

دلت النتائج على أن طول النباتات والوزن يزدادان مع التبكير في الزراعة وزيادة معدلات التسميد. كما أن مساحة ورقة الراية وكذا تركيز الكلوروفيل في الأوراق أعطت مؤشرات على زيادة نشاط التمثيل الضوئي. وكانت هنالك زيادة جوهرية في إنتاج القمح من الحبوب بزيادة معدل السماد في الموسمين وبالتبكير في الموسم الثاني. كما زاد وزن الحبوب مع التبكير في الزراعة. وخلاصة البحث أن أوائل تشرين ثاني (نوفمبر) هو الميعاد الأمثل لزراعة القمح وأن التسميد في حدود ١٢٠ كيلو جرام آزوت للهكتار يعطي إنتاجاً أوفر.