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Effects of Irrigation Interval, Nitrogen and Phosphorus on Grain Yield and biomass of Wheat*

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ABSTRACT

This study was conducted for two successive seasons of 1998/1999 and 1999/2000, at the Gezira Research Station Farm, Agricultural Research Corporation, Sudan, to investigate the effects of irrigation interval, nitrogen and phosphorus levels on wheat (*Triticum aestivum L.*) yield and yield components. The study consisted of three irrigation intervals (7,14,21 days), three N levels (0, 43 and 86 kg N/ha) and two P levels (0 and 43 kg P_20_5/ha). Treatments were arranged in a split-split plot design with three replications. Results showed that the irrigation intervals of 7 and 14 days had positive effects on wheat grain and total dry matter yield as compared to the 21 days irrigation interval which negatively affected these parameters. Plants of the latter treatment were dwarf with thin stems and matured earlier resulting in low grain and biomass yields. The study, also, showed that the highest wheat yield was obtained with the application of N and P at the rates of 86 kg N and 43 kg $P2O_5$/ha, respectively, with the irrigation interval of 7 days.

INTRODUCTION

Efficient water management is an important factor in enhancing crop. productivity (Rahman and Islam, 1991). Water deficit and temperature are the primary factors limiting wheat production in the Sudan. Wheat is grown under irrigation in central Sudan, where the climate is semi-arid ،the soil is heavy clay and the root system is limited to the surface layers .In the past, water was easily obtainable,

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cheap and its use was directed towards achieving maximum yield (Farah *et al.*, 1993). The frequency of irrigation of crops influences most aspects of crop growth and yield. Increased water use efficiency through efficient water management practices can be achieved by adopting the right frequency of irrigation. Increased plant height, dry matter and higher yields were obtained with higher irrigation frequencies due to increased leaf area (Cooper, 1980).

Frederik and Camberato (1995) stated that N is required in relatively higher quantities compared to other elements, by winter wheat, for optimum vegetative and reproductive growth. Nitrogen is probably the most important element to be considered in wheat production in arid zone soils of Sudan. Grasses in general, including wheat, are very sensitive to insufficient N and are very responsive to N fertilization (Quisenberry and Reitz, 1967). Khalifa (1973) indicated that N fertilization affected dry weight and grain yield of wheat through its effects on leaf area. Satti (1989)reported that application of N and P at the rates of 86 and 43 kg/ha, respectively, significantly increased grain yield of wheat. Numerous physiological processes associated with wheat growth are influenced by N. In many wheat producing areas, increasing the rate of N results in maximum leaf area. As plants mature, they translocate N from leaves and stems to the grain for protein production. Upon maturity، grains contain 60-70% of N in the plant (Hanson and Hitz, 1982) Under irrigation, high rates of N fertilizer can be economical, but they should be applied at the an optimum level Consequently, fertilizer recommendations for irrigated crops have been developed to attain the demand (Hauck et al., 1984). Little research work has been carried out in the Sudan on the combined effects of N, P and irrigation on wheat yield. The objectives of this work are, therefore, to determine the effects of irrigation regime and the levels of N and P on wheat growth and yield.

MATERIALS AND METHODS

Two field experiments were conducted during the winter seasons of 1998/1999 and 1999/2000 at the Gezira Research Station Farm of the Agricultural Research Corporation, Wad Medani, Sudan, latitude 140°

24' N, longitude 33^0 31' E. and altitude 411 m.a. s.l. The climate of the study area is classified as arid, with an average annual rainfall of 302 mm.

The soil of the experimental site is a cracking heavy clay Vertisols (Remeitab soil series), classified as fine, smectitic, isohyperthennic‹ Chromic Haplustefts (Soil Survey Staff, 1996).

The land was prepared by disc plow and disc harrow in October after the rainy season, to obtain a favourable soil environment for germination and crop growth. Leveling was done to enhance irrigation water management and crop establishment. Seeds were dressed with Gaucho (Imidacloprid) at the rate of l g/kg for protection against termites and aphids. Cultivar Elneilain was used as a test crop. Seeds were manually sown on November 21^{st} and 16^{th} for the two seasons, respectively, at the rate of 143kg/ha. Plant population was counted two weeks after sowing to determine the number of plants per unit area. The treatments were arranged in a split-split plot design with three replications. 1rrigationintervals of 7, 14 and 21 days were assigned to the main plots. Nitrogen at the rates of 0,43 and 86 kg N/ha applied as urea in two doses one at sowing and the other before the second irrigation, were assigned to the sub-plots and P was assigned to the sub-sub- plots at the rate of 0 and 43 kg P_2O_5/ha applied as triple super phosphate at sowing. Subplot area was 4x6 m^2 with a net area of 2x3 m^2 for harvest. At maturity, plants were cut at the soil surface and their biomass (stems and leaves) was weighed Data were subjected to the analysis of variance procedure.

RESULTS AND DISCUSSION

Main effects of irrigation interval, N and P on grain yield and biomass of wheat

Results showed that the main effects of irrigation interval, N and P were significant on wheat grain yield and biomass (Table l). The highest grain and biomass yields were obtained at the irrigation interval of 7 days, 86 kg/ha N and 43 kg/ha P for both seasons. The yield at 7 day irrigation interval was significantly higher than that obtained at 21 days irrigation interval. At the irrigation interval of 21

days, during both seasons, the number of grains/ spike decreased even with increasing levels of N and P fertilizer as compared to 7 and 14 days interval. This decrease in the number of grains/spike resulted in lower grain yield These results agree with those of Gajri and Prihar (1982) who showed that grain yield increased significantly with more irrigation, while stress caused considerable losses in grain yield. The growing season of 1998/1999 was characterized by high temperature, which resulted in stunted plants and reduced yield as compared to season 1999/2000.

Table l. Main effects of irrigation interval, N and P on wheat grain yield and biomass (kg/ha) 1998/1999 and 1999/2000 seasons.

	Season		Season	
	1998/1999	1999/2000	1998/1999	1990/2000
Irrigation interval(days)	Grain yield (kg/ha)		Biomass yield (kg/ha)	
7	926a	2832b	3083a	7186a
14	662b	2270a	2566b	5758
21	375C	1545c	2513b	4231c
Significance level N (kg/ha)	***	***	***	***
0	482b	1664c	2226c	4430c
43	702a	2323b	2697b	6059b
86	779a	2659a	3239a	6686a
Significance level P_2O_5 (kg/ha)	***	***	***	***
0	627b	2100b	2547b	5550b
43	682a	2331a	2895a	5900a
Significance level	*	*	***	*
C.V.(%)	14.7	19.3	15.4	14.9

* **Significant at the P=0.05 and 0.001 levels, respectively.

Means followed by different letters are significantly different according to Duncan's Multiple Range Test.

Interaction effects of irrigation interval, N and P on wheat grain and biomass yields

The interaction of irrigation, N and P were significant on grain and biomass yields as shown in Tables 2 and 3, respectively. Fisher *et al*. (1977) and Steynberg *et al.* (1989) showed that cereals were generally more sensitive to water stress during their reproductive growth. Therefore, if yields are to be maximized, water stress should be avoided during these critical stages (Nel and Berliner, 1990). It is clear that the efficiency of N and P fertilizers depends on water

availability, which is a major limiting factor. Hence, it is not advisable to extend irrigation intervals of wheat when N and P fertilizers are applied. Extending irrigation intervals results in low grain and biological yields even if N and P are applied.

Results of this work showed that the irrigation interval of 7 days positively affected grain and biomass yields of wheat. Also, the results showed that at the irrigation interval of 21 days, the grain and biomass yields of wheat were low even at the application of N and P at high doses, this might be due to soil moisture stress. It is clear that frequent irrigation is necessary to delay leaf senescence, which causes reduction in grain yield(Thompson and Chase, 1992).

Table 2. Interaction effects of irrigation interval, N and P on wheat grain yield (kg/ha) 1998/1999 and 1999/2000 seasons.

Fertilizer rate(kg/ha)		1998/1999			1999/2000		
		Irrigation intervals (days)					
N	P	7	14	21	7	14	21
0	0	385.44 ^{fg}	572.03 ^{cde}	287.26 ^{g}	2080.89 ^{g}	1806.89 ^{j}	1343.00 ^{n}
0	43	487.40 ^{def}	736.81 ^{bc}	425.48 ^{efg}	1841.55 ^{ij}	1810.33 ^{j}	1107.11 ^{o}
43	0	1170.67 ^{a}	637.02 ^{bcd}	368.54 ^{fg}	2846.44 ^{d}	1875.00 ^{i}	1608.77 ^{l}
43	43	1102.55 ^{a}	593.83 ^{bcde}	342.40 ^{fg}	3294.44 ^{b}	2645.00 ^{e}	1669.77 ^{k}
86	0	1177.36 ^{a}	674.00 ^{bc}	370.80 ^{fg}	3284.66 ^{b}	2549.55 ^{b}	1505.66 ^{m}
86	43	1237.46 ^{a}	761.12 ^{b}	457.11 ^{defg}	3649.11 ^{a}	2933.22 ^{c}	2036.66 ^{h}

Means followed by different letters are significantly different according to Duncan's Multiple Range Test.

Table 3. Interaction effects of irrigation interval, N and P on wheat biomass yield (kg/ha) 1998/1999 and 1999/2000 seasons.

Fertilizer rate(kg/ha)		1998/1999			1999/2000		
		Irrigation intervals (days)					
N	P	7	14	21	7	14	21
0	0	1407.00 ^{l}	3265.33 ^{de}	2547.33 ^{de}	5555.33 ^{j}	4555.33 ^{l}	3610.66 ^{u}
0	43	2091.66 ^{de}	2257.33 ^{de}	2690.00 ^{de}	5194.0 ^{k}	4388.33 ^{n}	3277.33 ^{r}
43	0	2600.00 ^{de}	2080.00 ^{def}	2411.66 ^{de}	7555.33 ^{d}	5833.00 ^{i}	4277.33 ^{o}
43	43	4814.33 ^{a}	2374.00 ^{de}	1906.33 ^{ef}	8360.66 ^{b}	6444.33 ^{f}	3888.33 ^{p}
86	0	3966.66 ^{b}	2806.66 ^{cd}	2739.66 ^{cd}	7733.00 ^{c}	6388.33 ^{gp}	4444.00 ^{m}
86	43	3621.33 ^{b}	3515.33 ^{bc}	2785.66 ^{cd}	8722.00 ^{a}	6944.33 ^{e}	5888.33 ^{h}

Means followed by different letters are significantly different according to Duncan's Multiple Range Test.

Phosphorus application significantly increased the grain yield. This might be due to an increase in number of heads/m^2 and hence grain yield, according to Omer (1989) and Ibrahim and Adlan (1989).

In conclusion, more frequent water supply throughout the growing season with optimum levels of N and P are necessary to obtain high wheat yields.

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