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EFFECT OF PHOSPHORUS ADDITION ON THE RESPONSE OF FOUR WHEAT CULTIVARS TO N FERTILIZATION LEVEL UNDER SANDY SOIL CONDITIONS

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ABSTRACT: *Two field experiments were conducted in sandy soil in Khattara farm, Sharkia, during two seasons (98/1999 – 99/2000) to find out the response of four wheat cultivars (Sakha 8 - Sids 1 – Sids 7 – Giza 164) to three N fertilization levels (60, 90 and 120 kg N/fad) at two P levels (0 and 23 kg P_2O_5/fad).*

Results indicated the superiority of Giza 164 followed by Sakha 8 in grain filling rate and superiority of Sids 7 and Giza 164 in the effective grain filling period. In both seasons, Giza 164 recorded the highest grain, straw and total yields / fad due to its superiority in the number of spikes/m^2 and number and weight of grains per spike. This cultivar was afforded better inter and intra row plant competitions than either Sids 1 or Sids7.

Each N increment or the addition of P had a significant effect on the grain filling rate. This was also true regarding grain yield/fad and all of its components, but the grain filling period was not affected significantly.

Addition of P increased the efficiency of added N where grain yield and all of its components could be maximized with lower N levels when P was added. Yield could be maximized to 13.4 and 15.8 ardab/fad due to addition of 134 and 113 kg N/fad in the two seasons, respectively. This yield could be optimized to 13.1 and 15.5 ardab/fad due to additions of 108 and 83 kg N/fad giving total profits of 1094 and 1386 L. E/fad in the two seasons, respectively.

Key words: *Phosphorus, Nitrogen, Fertilization, Cultivars, Wheat.*

INTRODUCTION

In the last decade of the 20^{th} era, a number of high yielding wheat cultivars were released where most of them had longer spikes, but, unfortunately they had a lower tillering capacity than the old ones. These cultivars did not express their high yield potentiality in the valley due to their low rust resistance and, also , outside the valley due to other yield limiting factors other than rust infection. The use of different wheat cultivars of different spike characteristics under different N and P levels, might help in defining tho se factors which ceil grain yield potentiality under sandy soil conditions where the soil is of a very poor fertility level and in particular from nitrogen and phosphorus.

Several workers reported significant varietal differences in yield attributes and yield potentiality among different Egyptian wheat cultivars (Essa, 1990 ;

El-Sayed *et al.*, 1992; El-Kalla *et al.*, 1994 ; Kassem and Nasr, 1995 ; Makhloof, 1996 ; El-Douby, 1997 ; Hassanien *et al.*, 1997 ; Aly, 1998 ; El-Karamity, 1998 ; Mahfouz and Gabour, 1998 ; Mowafy, 1999 ; Abdul Galil *et al.*, 2000 and Awaad , 2001).

Regarding the response of wheat to N fertilization under sandy soil conditions, several authors reported significant increase in yield of wheat due to the increase of N level up to 90 kg/fad (Moselhy, 1995 and Abdel – Messeih and Abdel-Nour 1999). However , others got similar response when they added 100 kg N/had (El–Bana and Aly, 1993 ; Attia and Aly , 1998 and Hassan and Gaballah, 2000). Moreover, Abo- Warda (1993) reported that grain yield of wheat responded to N addition of 120 kg N/fad Furthermore, Fayed (1992) and Soliman (2000) got similar response, but, to N additions of 120 and 180 kg N/fad., respectively.

Concerning the response of wheat to addition of P fertilizer , some authors reported significant increase in yield of wheat due to the increase of P level up to 16 kg P_2O_5/fad (Abd El-Haleem, 1994). Other authers reported that wheat responded to more additions of P reaching 31.0 kg P_2O_5/fad (El-Nagar *et al*, 1989) and 46.0 kg P_2O_5 (Aly, 1998; Attia and Aly, 1989 ; and El-Bana, 2000). However, Abdel – Raouf *et al.*, (1988) found that wheat did not respond to P application of 31.0 kg P_2O_5/fad.

The present study therefore aimed to study the effect of phosphorus addition on the response of four wheat cultivars to N fertilization level under sandy soil conditions.

MATERIALS AND METHODS

This study was carried out during two growing seasons (1998/1999 and 1999/2000) under sandy soil conditions at Khattara Experimental Station of the Faculty of Agriculture, Zagazig University.

A. Factors under study:

A-1. Wheat cultivars:

Sakha 8 , Sids 1 , Sids 7 and Giza 164.

A-2. Nitrogen levels:

60 , 90 and 120 kg N/fad were tried as ammonium sulphate (20.5% N) where 1/5 of each N level was given at sowing. The remainder amounts were given in five equal splits in 14 – days by interval from 10 days after sowing.

A-3. Phosphorus levels:

A dose of 23 kg P_2O_5/fad was given as superphosphate (15% P_2O_5) at sowing in comparison with a check (without P fertilization).

A basal dose of potassium sulphate at a rate of 24.0 kg K_2O/fad was given also at sowing in the first season, but was added in two equal splits (at sowing and at heading) in the second season. Wheat cultivars were sown in the 3rd week of November in the two seasons and harvested in the first week of May in the first season, and in the last week of April in the second season, except Giza 164 which was harvested in the first week of May. Flood irrigation was scheduled at one week by interval during winter. This interval was shortened to 4 or 5 days with the beginning of spring where irrigation was withheld two weeks before harvest. A fixed seeding rate of 400 seeds per m^2 was used from all cultivars under study. Wheat followed follow preceded, also, by wheat. The soil was sandy with a pH average of 7.6 and organic matter content of 0.14%. The average contents of available N, P and K in the upper 20 cm of soil depth were 8.7, 2.2 and 59.5 ppm., respectively.

B- Experimental design:

A split plot design of 4 replications was used where wheat cultivars occupied the main plots and the six combinations of N and P levels were allotted to the sub – plots. Each sub-plot included 20 rows of 3 m long and 15 cm apart.

C- Recorded data:

C-1. Grain filling rate and effective grain filling period:

Ten days post anthesis, seven samples of 100-grain weight were taken from five main spikes at one week by interval up to harvest. After oven drying at 70°C, for a constant weight, the grain filling rate per day per 1000 grain (GFR) and the effective grain filling period (EGFP) were calculated with the use of orthogonal polynomial Tables according to Snedecor and Cochran (1967). The grain filling rate and period were calculated as follows:

C-1.a. Grain filling rate (GFR):

The linear component of the grain weight increase from the start of grain filling up to grain maturity was calculated as it measures the constant rate of grain filling (mg/day/1000 grains).

2-1-b. Effective grain filling period (EGFP):

The effective grain filling period was calculated with help of the following equation according to AbdulGalil *et al.*, (1997):

$$\text{EGFP} = \frac{G_{w7} - G_{w1}}{GFR} \quad (Days)$$

Where G_{w7} and G_{w1} are the 100- grain weights of the seventh (final) and first grain samples, respectively. GFR is the grain filling rate (mg/day/1000 grains).

C-2. Grain and straw yields and their attributes:

From a length of 30 cm, which was labeled after seedling emergence in a bordered row, the following data were recorded:

1- Plant height (cm)
2. Number of spikes/m^2
3. Spike length (cm)
4. Number of spikelets/spike
5. Number of grains/spike
6. Number of grains/spikelet
7. Thousand grain weight (gm)
8. Grain weight / spike (gm)

The ten central rows were harvested where the following data were recorded:

2-9. Grain yield / fad (ardab / fad)

2-10. Straw yield/fad (ton/fad)

2-11. Total yield / fad (ton / fad)

2-12. Harvest index (%)

D. Statistical analysis:

Data were statistically analyzed according to Snedecor and Cochran (1967), using duncan multiple range test for comparison among treatments averages. In interaction Tables, capital and small letters were used for comparisons among rows and columns averages, respectively.

D-1 Response to N fertilization and total profit:

The present study seeks to find out the differential response of the four wheat cultivars to nitrogen fertilization and , as well, this response at the two phosphorus levels. For significant cultivar response to N increments and the significant N x P interactions, the response equations were calculated according to Snedecor and Cochran (1967), using the orthogonal polynomial Tables. The significancy of the linear and quadratic components of each of these equations was tested and hence the response could be described as linear (first order) or quadratic (second order). The predicted maximums (Y_{max}) and optimums (Y_{opt}) of grain yield, as well as, the predicted maximum (x_{max}) and optimum (X_{opt}) N levels were calculated according to Sukhatme (1941), as follows:

$$\hat{Y}_{max} = Y_o + \frac{b^2}{4c} \qquad \hat{Y}_{opt} = Y_o + b(X_{opt}) - c(X_{opt})^2$$

$$(X_{max}) = -\frac{b}{2c} + X_o \qquad (X_{opt}) = \frac{r-b}{2c} + X_o$$

The expected profit which could be obtained due to the addition of the first N level under study (60 kg N/fad) was calculated as follows:

$Pr_{(1)} = p\,(Y_o) - 2q$

Also, the expected profit which could be obtained due to the increase of N level to the optimum one (X_{opt}) was calculated with the help of the following equation:

$Pr_{(2)} = p\,[\,c\,(X_{opt})^2]$ (Sukhatume, 1941).

where:

Y_o = Grain yield at the lowest N level i.e. 60 kg N/fad (ardab/fad).

b = Measures the linear component of the response equation.

c = Measures the quadratic component of the response equation

r = q/p

q- Cost of N unit i.e. 30 kg N/fad = 60 L.E

p= Price of a unit yield (ardab) = 100 L.E

For all characters under study the predicted maximum averages which could have been obtained if the N level was increased to a certain maximum i.e X_{max} were also calculated in order to define the yield limiting components.

Accordingly, the total profit was calculated through summation of $Pr_{(1)}$ to $Pr_{(2)}$. It is worth to note down here that in calculation of these profits, the other spent costs for the other agronomic practices or any other related expenses were not taken in consideration as it was not under the interest of this study. However, the total profit obtained through the aforementioned calculations still gives an enough indication to the expected gain from addition of nitrogen fertilizer in presence and absence of P fertilization keeping in mind that all the other costs and expenses were the same for the all treatments under study.

RESULTS AND DISCUSSION

1- Grain filling rate and period and some yield attributes:

Table (1) shows grain filling rate (GFR) and effective grain filling period (EGFP) as well as, plant height, number of spikes/m^2 , spike length and number of spikelets/spike for the four wheat cultivars as affected by N and P levels and their interactions in the two seasons.

1- a. Cultivar differences:

It is evident from Table (1) that the four wheat cultivars varied significantly regarding GFR, EGFP, plant height , number of spikes/m^2, spike length and number of spikelets/spike in the two seasons. Regarding GFR and EGFP, Giza 164 had the highest averages with at par GFR average with Sakha 8 and at par EGFP average with Sids 7 in the first season.

Regarding plant height and number of spikes /m^2 differences were also significant, where Sids 7 had the tallest plants in both seasons with at par average with Giza 164 in the first season. However, Giza 164 followed by Sakha 8 had higher number of spikes/m^2 than either Sids 1 or sids 7in the two seasons.

Regarding spike length and the number of spikelets/spike, Sids 7 cv had longer spikes with greater number of spikelets/ spike than Sakha 8, Sids 1 and Giza 164 which had as long spikes with as much spikelets/spike as the former cultivar in the first season.

In the literature, several workers reported significant cultivar differences regarding GFR and EGFP (Aly and El-Bana, 1994 ; Aly, 1998 ; Mowafy, 1999 and Awaad, 2001), plant height (El-Douby, 1997 ; Aly, 1998 and El-Karamity, 1998), number of spikes/m^2 (Hassanien *et al.*, 1997 and AbdulGalil *et al.*, 2000), spike length (Essa, 1990 ; El-Kalla *et al.*, 1994 and Kassem and Nasr, 1995) and number of spikelets/spike (Aly, 1998 and El-Karamity , 1998).

1-b. Nitrogen level effect:

In both seasons, each increase of N level up to 120 kg N/fad reflected significant increase in each of GFR, plant height, number of spikes /m^2, spike

Table (1) : Grain filling rate (GFR), effective grain filling period (EGFP) and some yield attributes of the four wheat cultivars as affected by N and P levels and their interactions in the two seasons.

Main effects and interactions	GFR (mg/day/1000-grain)		EGFP (day)		Plant height (cm)		Spikes/m^2 (No)		Spike length (cm)		Spikelets/spkie (No)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Cultivar effect: (C)												
Sakha 8	890.54a	900.62b	34.51c	34.54b	73.14c	74.39c	430.25b	434.67a	7.90c	8.03c	14.19b	14.45c
Sids 1	844.87b	855.79c	34.72bc	34.35b	77.93b	78.55b	327.37d	336.79c	9.00b	9.11b	16.29a	16.61b
Sids 7	849.91b	898.08b	34.97a	34.52b	78.80a	80.24a	342.79c	350.16b	9.31a	9.27a	16.56a	17.90a
Giza 164	894.91a	914.95a	34.82ab	34.95a	78.82a	78.55b	442.00a	435.00a	9.10ab	9.17b	16.09a	16.50b
F. test	*	*	*	*	**	**	**	**	**	**	**	**
Nitrogen level effect: (N)												
60 kg N/fad	833.75c	840.34c	34.71	34.58	74.57c	75.34c	357.18c	358.93c	8.17c	8.24c	13.86c	14.53c
90 kg N/fad	870.87b	896.93b	34.78	34.58	78.06b	78.85b	394.18b	400.71b	9.02b	9.09b	16.42b	16.95b
120 kg N/fad	905.25a	939.81a	34.77	34.60	78.88a	79.61a	405.43a	407.84a	9.29a	9.36a	17.06a	17.62a
F. test	*	*	N.S	N.S	**	**	**	**	**	**	**	**
Phosphorus level effect: (P)												
Check	815.18b	817.85b	34.73	34.60	74.52b	75.06b	349.16b	355.50b	7.95b	7.94b	13.62b	14.16b
23 kg P_2O_5/fad	924.72a	966.87a	34.79	34.58	79.82a	80.81a	422.04a	422.83a	9.70a	9.85a	17.94a	18.57a
F. test	*	*	N.S	N.S	**	**	**	**	**	**	**	**
Interaction effects:												
C X N	N.S	N.S	N.S	N.S	*	*	N.S	N.S	N.S	*	**	N.S
C X P	N.S	N.S	N.S	N.S	*	*	N.S	*	**	*	*	*
N X P	*	N.S	N.S	N.S	**	*	**	**	*	*	*	*

*, ** and N.S indicate significant at 0.05, 0.01 and insignificant, respectively.

length and the number of spikelets /spike. However, the EGFP was not significantly affected by the increase of N level.

These data clearly indicate that N was badly needed by wheat plants to increase their elongation and tillering. This favourable effect was reflected in more elongation by wheat spike and hence a significant increase in the number of spikelets/spike. The data further indicate that grain growth was also favoured by the increase of N level as expressed in higher GFR without significant effect on EGFP. The increase of GFR refers to a long acting effect of N on grain growth and strengthen the view that it had a favourable effect of leaf area and its duration since both are the main contributing factors of post-anthesis assimilates for grain filling in wheat (Gallagher *et al.*, 1976). Certainly the role of N in internode elongation is extensively reported in the literature (Milthrope and Moorby , 1979). Also , N was found to be indispensable for tillering of wheat as expressed herein in a significant increase in the number of spikes / m^2. This indicates that the increase of N level up to 120 kg N/fad, kept the produced tillers against death and hence mortality (Rawson and Donald, 1969).

It is worth to note down here that most of the increase of either plant height or the number of spikes/m^2 was due to the addition of the first N increment i.e. the increase of N level up to 90 Kg N/fad. The further N increment produced a significant increase but of lower magnitude, indicating that the response of the aforementioned characters to the increase of N level was diminishing. This subject will be discussed in details when presenting the interactions.

1-C. Phosphorus level effect:

It is quite clear from Table (1) that addition of P increased each of GFR, plant height, number of spikes/m^2, spike length and number of spikelets/spike, but was without significant effect of EGFP, in both seasons. The soil of the experimental sites was very poor in available P level (Less than 3 ppm) and hence the response of the aforementioned characters to added P was rather expected. Certainly this addition increased root extension rate through an increase in root multiplicate rate (Milthrope and Moorby, 1979). The improved root growth enabled wheat plants to seek more available plant nutrients and soil moisture. Therefore, most of the improved wheat growth observed in Table (1) could be ascribed to more use of N rather than phosphorus. Certainly, the role of P in enhancing the activity of nitrate reductase and hence the more efficient use of added N cannot be denied or neglected in this respect (Mengel, 1973).

1-d. Interaction effect:

Data in Table (1) clearly indicate that there was significant cultivar response to the increase N level in plant height (in the two seasons) , spike length (2nd season) and number of spikelets/spike (1st season). A significant cultivar response to addition of P was observed in plant height (in the two seasons), number of spikes/m^2 (2nd season) as well as spike length and number of spikelets/spike (in the two seasons). However, there was no significant cultivar response to the increase of N level on the number of spikes/m^2 indicating that the four wheat cultivars were in an almost similar need for N to maximize this number.

Data in Table (1-a) regarding the CxN interaction on plant height, clearly indicate that each N increase of N level was followed by a significant increase but with different magnitudes in the four wheat cultivars. This differential response is expressed in the response equations of plant height to the increase of N level where the response was quadratic but with different linear and quadratic constants. It was clear that with about 114 kg N/fad in the first season and 112 kg N/fad in the second season Giza 164 could reach higher plant height (80 cm) than sakha 8 (75 cm).

Table (1-a) : Plant height (cm) as affected by C x N interaction, as well as, response equations and predicted maximum plant height (Y_{max}) and N level (X_{max}) in the two seasons.

Cultivars	N levels (kg N/fad) 60	90	120	$\hat{Y} = a + bx - cx^2$	Y_{max} (cm)	X_{max} (kg N/fad)
			First season			
	C	B	A			
Sakha 8	70.43(c)	74.05(c)	74.93(b)	$70.43+4.99x-1.37x^2$	74.97	114.6
	C	B	A			
Sids 1	74.93(b)	79.01(b)	79.86(a)	$74.93+5.71x-1.62x^2$	79.96	112.8
	C	B	A			
Sids 7	76.46(a)	79.55(ab)	80.38(a)	$76.45+4.22x-1.13x^2$	80.39	116.1
	C	B	A			
Giza 164	76.47(a)	79.63(a)	80.35(a)	$76.47+4.38x-1.22x^2$	80.40	114.0
			Second season			
	C	B	A			
Sakha 8	71.86(c)	75.32(c)	75.98(c)	$71.87+4.86x-1.40x^2$	76.09	112.2
	C	B	A			
Sids 1	75.98(b)	79.40(b)	80.27(b)	$75.99+4.71x-1.28x^2$	80.32	115.2
	C	B	A			
Sids 7	77.28(a)	81.26(a)	82.17(a)	$77.28+5.53x-1.54x^2$	82.24	114.0
	C	B	A			
Giza 164	76.22(b)	79.41(a)	80.02(b)	$76.22+4.48x-1.29x^2$	80.11	112.2

Regarding the CxP interaction on the number of spikes/m^2 (Table 1-b) it was clear that Sakha 8 showed higher response than the other cvs in the 2nd season. Since this cultivar had the shortest plants, it had higher chance for more tillering due to its lower apical dominance (Friend, 1965).

Table (1-b) : Number of spikes/m^2 as affected by C x P interaction in the second season.

Cultivars	P levels (kg P_2O_5/fad) 0	23	Percentage increase (%)
Sakha 8	B 392.57(a)	A 477.50(a)	21.6
Sids 1	B 307.58(c)	A 366.00(c)	19.0
Sids 7	B 325.08(b)	A 375.25(b)	15.4
Giza 164	B 396.83(a)	A 472.50(a)	19.1

The most interesting significant interaction was the NxP one which affected all the characters presented in Table (1) except GFR and EGFP. Table (1-c) indicate the effect of this interaction on plant height , number of spikes/m^2, spike length and number of spikelets/spike where the interaction was significance in both seasons.

It is quite clear from Table (1-c) that the increase of N level at both P levels, was followed by a significant increase in all tabulated characters, but with different magnitudes. The response equations, clearly, show that the response to the increase of N level was qudratic when P was added whereas its was linear or quadratic when P was not added. In both cases, the linear component of these equations, indicated higher response to the increase of N level when P was added compared to the check P level. It is evident that about 110 kg N/fad were quite enough to maximize plant height to more than 80 cm and spike length to more than 10 cm, number of spikes/m^2 to about 440 and number of spikelets to 19 when P was added compared with 120, 183, 142 and 123 kg N/fad needed to maximize height to 76 cm, spike length to 9cm, number of spikes/m^2 to 375 and number of spikelet /spike to 15 , in respective order when P was not added. These data clearly indicate that added P increased the efficiency of added N. This as aforementioned could be attributed to the direct and indirect roles of P on wheat growth and development. The role of P on root multiplication and extension had greater contribution than its direct role in synthesis of ATP and activation of nitrate reductase in this respect.

Table (1-c):Plant height,number of spikes/m^2, spike length and number of spikelets/spike as affected by NxP interaction, as well as, response equations and predicted maximum (Y_{max}) and N level (X_{max}) in the two seasons.

Phosphorus levels (kg P_2O_5/fad)	N levels (kg N/fad) 60	90	120	$Y^\wedge = a + bx - cx^2$	Y_{max}	X_{max} (kg N/fad)
			Plant height			
			First season			
0	C 71.96(b)	B 75.25(b)	A 76.36(b)	$71.96+4.38x-1.09x^2$	76.36	120.0
23	C 77.19(a)	B 80.87(a)	A 81.40(a)	$77.19+5.27x-1.58x^2$	81.61	110.1
			Second season			
0	C 73.20(b)	B 75.50(b)	A 76.47(b)	$73.20+2.98x-0.67x^2$	76.51	126.6
23	C 77.48(a)	B 82.20(a)	A 82.75(a)	$77.49+6.82x-2.09x^2$	83.05	108.9
			Number of spikes /m^2			
			First season			
0	C 322.50(b)	B 353.81(b)	A 371.18(b)	$322.50+38.28x-6.97x^2$	375.06	142.5
23	C 391.87(a)	B 434.56(a)	A 439.69(a)	$391.87+61.49x-18.79x^2$	442.18	109.2
			Second season			
0	C 326.31(b)	B 364.31(b)	A 375.87(b)	$326.31+51.22x-13.22x^2$	375.92	118.2
23	C 391.56(a)	B 437.12(a)	A 439.81(a)	$391.57+67.01x-21.44x^2$	443.93	106.8
			Spike length (cm)			
			First season			
0	C 7.37(b)	B 6.01(b)	A 8.48(b)	$7.37+0.74x-0.09x^2$	8.89	183.3
23	C 8.97(a)	B 10.04(a)	A 10.10(a)	$8.97+1.59x-0.51x^2$	10.20	106.1
			Second season			
0	C 7.36(b)	B 8.02(b)	A 8.46(b)	$7.35+0.78x-0.11x^2$	8.73	166.4
23	C 9.12(a)	B 10.18(a)	A 10.26(a)	$9.12+1.55x-0.49x^2$	10.35	107.4
			Number of spikelets/spike			
			First season			
0	C 11.73(b)	B 14.11(b)	A 15.03(b)	$11.73+3.11x-0.73x^2$	15.04	123.9
23	C 15.99(a)	B 16.74(a)	A 19.09(a)	$15.99+3.95x-1.20x^2$	19.24	109.4
			Second season			
0	C 12.48(b)	B 14.50(b)	A 15.51(b)	$12.48+2.54x-0.51x^2$	15.64	134.7
23	C 16.58(a)	B 19.40(a)	A 19.72(a)	$16.58+4.07x-1.25x^2$	19.89	108.8

2- Spike grain weight and its components:

Data in Table (2) show the number of grains/spike, number of grains/spikelet, 1000-grain weight and grain weight/ spike for the four wheat cultivars as affected by N and P levels and their interactions in the two seasons.

2-a. Cultivar differences:

Significant cultivar differences could be detected among the four wheat cultivars in the number of grains / spike, 1000–grain weight (second season) and hence grain weight / spike , as well as, the number of grains / spikelet in both seasons. Regarding the number and weight of grains / spike the four wheat cultivars could be arranged in descending order as follows. Giza 164, Sakha 8, Sids 7 and Sids1. This was almost true regarding the 1000 – grain weight in the second season but the two Sids cultivars had at par lower averages than Giza 164 and Sakha 8. An opposite trend was observed regarding the number of grains / spikelet where the two Sids cultivars had lower averages than Sakha 8 and Giza 164 in the both seasons.

These data are quite interesting as they ascertain the spike grain weight superiority of Giza 164 followed by Sakha 8 over the two Sids cultivars where Sids 7 was relatively better than Sids 1 in this respect. The data further indicate that grain weight/spike followed exactly the trend of the number of grains/spike rather than the 1000–grain weight. Also, it was evident that the increase of grain number / spike was not on the expense of 1000–grain weight. Moreover, the decrease observed herein in the number of grains / spikelet of Giza 164 was compensated by the increase of the number of spikelets / spike by this cultivar. This was not true with the two Sids cvs, which had the lightest grain weight / spike though they had larger number of spikelets / spike but with fewer grains / spikelet. This indicate that the two Sids cvs, suffered from more intensive inter and intra spikelet, competitions and hence had fewer number of grains / spikelet with lighter 1000 – grain weight (2nd season) than either Sakha 8 or Giza 164. Though the latter wheat cultivar had as long spikes with as much spikelets / spike as the two Sids cvs it had as much grain number / spikelet as Sakha 8 which had the shortest spikes with the fewest number of spikelets/spike.

According to these data, Giza 164 had higher floral fertility and lower shortfall percentage than the two Sids cultivars. In this respect, Rawson and Evans (1971) reported differences in floral fertility of a number of wheat cultivars due to differences in the tolerance of distal florets to the inhibition effect induced by grain set of the lower florets along rachilla. Also, Peterman et al., (1985) reported significant differences in shortfall percentage among ten winter wheat cvs due to differences in plant height where semi – dwarf cvs had lower shortfall than long old types ones due to more availability of photosynthates for the formers than for the latters.

It could be concluded that the two Sids cvs, with their longer plants and spikes might had have suffered from shortage of photosynthates which

Table (2) : Spike grain weight and its components of the four wheat cultivars as affected by N and P levels and their interactions in the two seasons.

Main effects and interactions	Number of grains/spike		Number of grains/spikelet		Thousand grain weight (gm)		Grain weight/spike (gm)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Cultivar effect: (C)								
Sakha 8	33.64b	34.83b	2.37a	2.41a	40.56	41.12b	1.40b	1.43b
Sids 1	31.62d	32.76d	1.94c	1.97c	40.33	40.10c	1.33d	1.38d
Sids 7	32.50c	34.10c	1.96c	1.91c	40.81	41.05b	1.38c	1.41c
Giza 164	36.03a	36.90a	2.24b	2.24b	41.00	42.00a	1.49a	1.46a
F. test	**	**	*	*	N.S	**	**	**
Nitrogen level effect: (N)								
60 kg N/fad	32.00c	32.58c	2.31a	2.24a	39.56c	39.55c	1.28c	1.32c
90 kg N/fad	33.81b	35.28b	2.06b	2.08b	40.97b	41.58b	1.43b	1.44b
120 kg N/fad	34.54a	36.08a	2.03c	2.05c	41.52a	42.07a	1.49a	1.50a
F. test	*	**	*	*	**	**	**	**
Phosphorus level effect: (P)								
Check	31.21b	31.99b	2.34a	2.29a	38.66b	39.32b	1.23b	1.29b
23 kg P_2O_5/fad	35.68a	37.30a	2.02b	2.01b	42.70a	42.82a	1.56a	1.55a
F. test	**	*	*	*	**	**	**	**
Interaction effects:								
C X N	*	N.S	*	*	N.S	N.S	*	N.S
C X P	*	*	*	*	*	N.S	*	N.S
N X P	*	*	*	*	*	N.S	*	*

*, ** and N.S indicate significant at 0.05, 0.01 and insignificant, respectively.

could have been more partitioned to internode elongation and hence were less available for grain set / spikelet. Several workers reported significant varietal differences in yield attributes (Essa, 1990 ; El-Karamity, 1998 and Mowafy, 1999).

2- b. Nitrogen level effect:

In both seasons, each increase of N level was followed by a significant increase in the number and weight of grains / spike as well as the 1000 – grain weight. On the other hand the number of grains / spikelet was significantly decreased.

The increase of grain weight / spike due to the increase of N level could be attributed to the increase of both grain number / spike and 1000 – grain weight. Similar results were reported by Abo-Warda (1993), El-Bana and Aly (1993) and Aly and El- Bana (1994) when they increased N level to wheat up to 120 , 100 and 80 kg N/fad under sandy soil conditions. However the decrease of grain number / spikelet due to the increase of N level could be attributed to a more inter and intra – spikelet competitions caused by the significant increase of spikelet number / spike (Table 1).

2- C. Phosphorus level effect :

In both seasons, addition of P increased each of grain number and weight / spike, 1000 – grain weight but decreased the number of grains / spikelet (Table 2). Similar effect was observed due to addition of N and the same discussion could be served to account for the trend observed herein due to addition of P. Under sandy soil conditions, Aly (1998) and El-Bana (2000) got similar results due to additions of P up to higher levels of 46.0 and 45.0 kg P_2O_5/ fad, respectively.

2-d. Interaction effect:

Significant cultivar response was observed to the increase of N level and to the addition of P regarding the number of grains / spike and per spikelet as well as 1000 – grain weight and grain weight/ spike, but no particular trend could be detected in any of these characters in the two seasons. However, the NXP interaction affected these characters with clear trends in the two seasons. This interaction indicated that with the addition of P, lower N levels were needed to maximize either the grain number or weight / spike and the 1000 – grain weight (Table 2-a). Also when P was added all these responses were quadratic whereas it was linear in some cases when P was not added. Similar results were observed in plant height, spike length, number of spikelets/spike and number of spikes / m^2. It is interesting to note down here, Table (2-a) : Number of grains/spike, grain weight/spike and thousand grain weight as affected by N x P interaction, as well as, response equations and predicted maximum (Y_{max}) and N level (X_{max}) in the two seasons.

Phosphorus levels (kg P_2O_5/fad)	N levels (kg N/fad) 60	90	120	$Y^{\wedge} = a + bx - cx^2$	Y_{max}	X_{max} (kg N/fad)
			Number of grains/spike			
			First season			
0	C 30.34(b)	B 31.18(b)	A 32.13(b)	$30.34+0.90x$	-	-
23	C 33.66(a)	B 36.43(a)	A 36.95(a)	$33.66+3.91x-1.13x^2$	37.03	111.9
			Second season			
0	C 30.15(b)	B 32.28(b)	A 33.53(b)	$30.15+2.57x-0.44x^2$	35.73	147.6
23	C 35.01(a)	B 38.27(a)	A 38.63(a)	$35.01+4.71x-1.45x^2$	38.83	108.7
			Grain weight/spike (gm)			
			First season			
0	C 1.14(b)	B 1.24(b)	A 1.32(b)	$1.14+0.11x-0.01x^2$	1.44	225.0
23	C 1.43(a)	B 1.62(a)	A 1.65(a)	$1.42+0.27x-0.08x^2$	1.65	110.6
			Second season			
0	C 1.18(b)	B 1.29(b)	A 1.38(b)	$1.18+0.10x$	-	-
23	C 1.46(a)	B 1.58(a)	A 1.62(a)	$1.46+0.16x-0.04x^2$	1.62	120.4
			Thousand grain weight (gm)			
			First season			
0	C 37.90(b)	B 38.85(b)	A 39.24(b)	$37.09+0.67x$	-	-
23	C 41.22(a)	B 43.08(a)	A 43.81(a)	$41.22+2.44x-0.57x^2$	43.83	124.2

that the rate of decrease in the number of grains / spikelet due to the increase of N level to the P fertilized plants was much higher than that observed in the P unfertilized ones. This could be attributed to the higher rates of increase observed in spike length and the number of spikelet / spike due to the increase of N level in the formers than in the latters (Table 1-c).

3- Grain, Straw and total yields / fad and harvest index.

3-a. Cultivar differences:

Regarding grain yield/fad, Giza 164 outyielded all the tested cultivars except Sakha 8 in the first season whereas Sids 7 outyielded Sids 1 in the second season but both had at par averages in the first one (Table 3).

Table (3) : Grain yield, straw yield and total yield per fad. and harvest index of the four wheat cultivars as affected by N and P levels and their interactions in the two seasons.

Main effects and interactions	Grain yield (ardab/fad)		Straw yield (ton/fad)		Total yield (ton/fad)		Harvest index (%)	
	First season	Second season	First season	Second season	First season	Second season	First season	Second season
Cultivar effect: (C)								
Sakha 8	11.23ab	13.91b	3.41a	2.96b	5.10a	5.05b	32.92	41.09
Sids 1	10.73b	12.40d	3.10b	2.77c	4.71c	4.65d	34.10	40.13
Sids 7	10.92b	13.13c	3.20b	2.79c	4.84b	4.81c	33.76	40.76
Giza 164	11.81a	14.31a	3.35a	3.09a	5.13a	5.23a	34.63	40.77
F. test	**	**	*	*	*	*	N.S	N.S
Nitrogen level effect: (N)								
60 kg N/fad	10.29c	12.58c	3.07b	2.76b	4.61c	4.66c	33.47b	40.22b
90 kg N/fad	11.35b	13.58b	3.36a	2.94a	5.07b	5.01b	33.62b	40.44b
120 kg N/fad	11.95a	14.22a	3.37a	3.00a	5.16a	5.13a	34.46a	41.39a
F. test	**	**	*	*	*	*	*	*
Phosphorus level effect: (P)								
Check	10.00b	11.48b	3.05b	2.89b	4.55b	4.63b	33.03b	37.13b
23 kg P_2O_5/fad	12.39a	15.44a	3.48a	2.91a	5.34a	5.24a	34.67a	44.24a
F. test	**	**	*	*	*	*	*	*
Interaction effects:								
C X N	N.S	N.S	*	N.S	*	*	N.S	N.S
C X P	N.S	N.S	*	N.S	*	*	N.S	N.S
N X P	*	*	N.S	**	*	*	N.S	*

*, ** and N.S indicate significant at 0.05, 0.01 and insignificant, respectively.

Regarding straw yield/fad, Giza 164 produced the highest average followed by Sakha 8 without a significant difference in the first season whereas the two Sids cvs produced at par the lowest yields in the two seasons. Therefore, Giza 164 and Sakha 8 produced at par higher total yields / fad, than Sids 7 or Sids 1 which produced the lowest average. However, no significant differences could be detected among the four wheat cultivars regarding harvest index in both seasons. The superiority of Giza 164 cv in grain and straw yields/fad could be attributed to its superiority in all yield attributes (Tables 1 and 2). In the literature, several authors reported significant differences among wheat cvs in grain yield / fad, (El-Sayed *et al.*, 1992 ; Hassanien *et al.*, 1997 and Mahfouz and Ghabour, 1998), Straw yield/fad (El-Douby, 1997 ; Hassanien *et al.*, 1997 and AbdulGalil *et al.*, 2000) and hence the total yield/fad. Whereas these data disagreed with those reported by Makhloof (1996) as they reported significant cultivar differences in harvest index.

3-b. Nitrogen level effect:

In the two seasons, each N increment up to 120 kg N/fad secured a significant increase in each of grain and total yields / fad. However, the second N increment , failed to yield a further significant increase in straw yield / fad. Therefore, harvest index was significantly increased when the level of N was increased from 90 to 120 kg N/fad.

Under sandy soil conditions, several authors reported significant increase in grain yield of wheat due to the increase of N level up to 90 kg N/ fad (Moselhy, 1995 and Abdel – Messeih and Abdel-Nour, 1999). However, others got similar response when they added 100 kg N/ fad (El-Bana and Aly, 1993 and Hassan and Gaballah, 2000) whereas, Abo – Warda (1993) reported that grain yield responded to N additions of 120 kg N/fad. Moreover Fayed (1992), Bassiouny *et al.*, (1993) and Soliman (2000) found that straw yield / fad responded to addition of 120, 150 and 180 kg N/fad respectively. Furthermore, Attia and Aly (1998) reported that the increase of N level was followed by as significant increase in harvest index.

3- c. Phosphorus level effect:

In both seasons , addition of phosphorus produced a significant increase in each of grain yield / fad, straw yield / fad , total yield and harvest index.

. Similar effect was observed in all grain yield components (Tables 1 and 2). Under sandy soil conditions, Attia and Aly (1998) , Aly (1998) and El-Bana (2000) reported significant increase in grain and straw yields of wheat due to addition of 31.0 kg P_2O_5/ fad.

3-d. Interaction effect:

No significant cultivar response to the increase of N level could be detected regarding grain yield / fad, indicating that the four wheat cvs were in an almost similar need for the increase of N level up to 120 kg N /fad. However, a significant cultivar response to the increase of N level could be

detected in the total yield / fad. It is evident from table (3-a) that the response was almost quadratic but of different magnitudes where Giza 164 was in need for more N (121.4 and 120.0 kg N/fad in the two seasons, respectively) to maximize its total yield than the rest of the tested cultivars.

Table (3-a) : Total yield (ton/fad) as affected by C x N interaction, as well as, response equations and predicted maximum total yield (Y_{max}) and N level (X_{max}) in the two seasons.

Cultivars	N levels (kg N/fad) 60	90	120	$Y^{\wedge} = a + bx - cx^2$	Y_{max} (ton/fad)	X_{max} (kg N/fad)
			First season			
Sakha 8	C 4.81(a)	B 5.20(a)	A 5.29(a)	$4.81+0.54x-0.15x^2$	5.30	114.0
Sids 1	C 4.28(c)	B 4.89(c)	A 4.97(c)	$4.28+0.89x-0.27x^2$	5.01	109.4
Sids 7	C 4.48(b)	B 4.98(b)	A 5.06(b)	$4.48+0.71x-0.21x^2$	5.08	110.7
Giza 164	C 4.87(a)	B 5.20(a)	A 5.32(a)	$4.87+0.45x-0.11x^2$	5.33	121.4
			Second season			
Sakha 8	B 4.75(b)	A 5.17(a)	A 5.23(b)	$4.75+0.60x-0.18x^2$	5.25	110.0
Sids 1	B 4.33(d)	A 4.75(b)	A 4.86(d)	$4.33+0.59x-0.16x^2$	4.86	115.3
Sids 7	C 4.57(c)	B 4.82(b)	A 5.03(c)	$4.57+0.23x$	-	-
Giza 164	B 5.00(a)	A 5.30(a)	A 5.40(a)	$5.00+0.40x-0.10x^2$	5.40	120.0

Also, the CxP interaction affected total yield / fad in the two seasons (Table 3-b) , where Sids 1 was more responsive to added P than the other cvs. Regarding the effect of NxP interaction on grain yield/fad, the response was different between the two seasons and between the two p levels. In the first season, the response was quadratic at the two P level, but a higher N level of 180 kg N/fad was needed to maximize yield to 11.06 ardab / fad for the P unfertilized plants compared with 134.1 needed to maximize yield to 13.36 ardab/fad by the P fertilized ones. In the second season, the response of grain yield was linear when P was not added but quadratic when P was added. It is clear from Table (3-c) that 112.5 kg N/fad were quite enough to maximize grain yield to 15.8 ardab / fad for the P fertilized plants. Also, a higher optimum grain yield of 15.51 could be obtained due to addition of 82.5 kg N/fad for the P fertilized plants in the second season compared with an optimum yield of 13.1 ardab / fad due to addition of 107.6 kg N/fad in the first one. Therefore, a higher profit (1385.9 LE) was obtained in the second than in the first season (1094.3 LE).

Table (3-b) : Total yield (ton/fad) as affected by C x P interaction in the two seasons.

Cultivars	First season P levels ($kg\ P_2O_5$/fad) 0	23	Percentage increase (%)	Second season P levels ($kg\ P_2O_5$/fad) 0	23	Percentage increase (%)
Sakha 8	B 4.70(b)	A 5.50(a)	17.0	B 4.71(b)	A 5.38(b)	14.2
Sids 1	B 4.29(d)	A 5.13(c)	19.6	B 4.30(d)	A 4.99(c)	16.0
Sids 7	B 4.42(c)	A 5.25(b)	18.8	B 4.54(c)	A 5.07(c)	11.7
Giza 164	B 4.80(a)	A 5.48(a)	14.2	B 4.96(a)	A 5.51(a)	11.1

Table (3-c) : Grain yield (ardab/fad) as affected by N x P interaction, as well as, response equations and predicted maximum and optimum yields and N levels and the expected profit in the two seasons.

Phosphorus levels ($kg\ P_2O_5$/fad)	N levels (kg N/fad) 60	90	120	$\hat{Y} = a + bx - cx^2$	Y_{max} (Ardab/fad)	X_{max} (kg N/fad)	Y_{optim} (Ardab/fad)	X_{optim} (kg N/fad)	Total profit (L.E.)
	First season								
0	C 9.30(b)	B 10.07(b)	A 10.62(b)	$9.30+0.88x-0.11x^2$	11.06	180.0	10.24	98.2	827.7
23	C 11.28(a)	B 12.62(a)	A 13.27(a)	$11.29+1.68x-0.34x^2$	13.36	134.1	13.10	107.6	1094.3
	Second season								
0	C 10.27(b)	B 11.52(b)	A 12.65(b)	$10.27+1.19x$	-	-	-	-	-
23	B 14.89(a)	A 15.64(a)	A 15.78(a)	$14.89+1.05x-0.30x^2$	15.80	112.5	15.51	82.5	1385.9

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تأثير إضافة الفوسفور على استجابة أربع أصناف من القمح لمستوى التسميد النيتروجينى تحت ظروف الأراضى الرملية

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قسم المحاصيل - كلية الزراعة - جامعة الزقازيق - الزقازيق

الملخص العربى

أجريت تجربتان حقليتان بمزرعة كلية الزراعة - جامعة الزقازيق بمنطقة الخطارة - محافظة الشرقية خلال موسمين زراعيين (١٩٩٩/٩٨ ، ٢٠٠٠/٩٩) بهدف دراسة استجابة أربع أصناف من القمح (سخا ٨ ، سدس ١ ، سدس ٧ ، جيزة ١٦٤) لثلاث مستويات من التسميد النيتروجينى (٦٠ ، ٩٠ ، ١٢٠ كجم ن / فدان) عند عدم إضافة أو إضافة التسميد الفوسفاتى بمعدل ٢٣ كجم فو٢أ٥ / فدان تحت ظروف الأراضى الرملية ويمكن تلخيص أهم النتائج كما يلى :

- تفوق الصنف جيزة ١٦٤ وتلاه الصنف سخا ٨ فى معدل امتلاء الحبوب فى حين تميز الصنف سدس ٧ ، جيزة ١٦٤ من حيث الفترة الفعالة لامتلاء الحبوب وقد لوحظ ذلك أيضا فى موسمى الدراسة من حيث تفوق الصنف جيزة ١٦٤ فى كلا من محصول الحبوب والقش والمحصول الكلى بالفدان وذلك لتفوقه فى مكونات المحصول وهى عدد سنابل / م٢ وعدد وزن حبوب السنبلة .
- أدت كل زيادة فى معدل التسميد النيتروجينى أو إضافة الفوسفور إلى زيادة معدل امتلاء الحبوب فى حين لم يكن لأى منهما تأثير معنوى على فترة الامتلاء وعموما كان لكل زيادة فى معدل التسميد النيتروجينى أو إضافة الفوسفور وتداخل الفعل بينهما تأثير معنوى موجب على محصول الحبوب فى الفدان وجميع مكوناته .
- أدت إضافة السماد الفوسفاتى الى زيادة كفاءة التسميد النيتروجينى من حيث تأثيرهما على محصول الحبوب وجميع مكوناته حيث مكنت معظمة المحصول باستخدام مستوى نيتروجينى أقل عند إضافة الفوسفور إذ أمكن معظمة محصول الحبوب إلى ١٣,٤ ، ١٥,٨ إردب / فدان بإضافة ١٣٤ ، ١١٣ كجم ن / فدان فى الموسمين على التوالى ، كما أمكن ترشيد استخدام السماد النيتروجينى والحصول على أعلى محصول اقتصادى يعادل ١٣,١ ، ١٥,٥ إردب / فدان بإضافة معدل تسميد ١٠٨ ، ٨٣ كجم ن / فدان فى موسمى الدراسة وذلك يحقق عائد كلى ١٠٩٤ ، ١٣٨٦ جنيه مصرى للفدان فى الموسمين على التوالى .