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INFLUENCE OF PHOSPHORUS APPLICATION IN DIFFERENT PROPORTIONS WITH NITROGEN AND POTASSIUM ON WHEAT YIELD UNDER IRRIGATED CONDITIONS

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A field investigation was carried out on a sandy clay loam in Lyallpur soil series under irrigated conditions during rabi seasons 1984-85 and 1985-86 on wheat cultivar LU-26S. The application of phosphorus in increasing proportions with nitrogen upto an amount of 100 kg N + 50 kg P_2O_5 /ha significantly improved grain yield and its components. The highest grain yield of 4525 kg/ha and the highest net income of Rs. 5,966/ha with a BCR of 2.22 was obtained with this application.

Multiple regression of yield on its contributing components shows that an increase of one fertile tiller/m^2, spike length by one centimetre, a grain per spike and 1000-grain weight by one g. would result in an increase in grain yield by 0.1942, 0.1160, 0.1947 and 0.0064 quntal per hectare respectively.

Key words: *Triticum aestivum*, Phosphorus response, Sandy clay loam.

INTRODUCTION

Wheat (*Triticum aestivum* L.) has a key position in Pakistan's agricultural economy. During the seasons 1981-85, on an average it was grown on 7.3 million hectares with a total production of 11.6 million tonnes corresponding to 1584 kg/ha [1]. Although our country has made remarkable progress in wheat production, yet the average yield is still far below the potential yield of the existing recommended varieties. A major constraint for low yield is the imbalanced use of fertilizers [2]. The application of phosphorus in appropriate amount along with nitrogen [3] is essential as most of our soils have developed a nutritional imbalance because of intensive cultivation and use of high yielding varieties [4].

Application of appropriate amount of phosphatic fertilizer in combination with nitrogenous fertilizers is a key factor in enhancing grain yield. Shafi [5] and Stibbe and Kafkafi [6] reported that the number of tillers per unit area, spike length, the number of grains per spike, 1000-grain weight, grain and straw yield were increased substantially when nitrogen and phosphorus were applied in 2:1 ratio. The application of phosphorus in combination with nitrogen significantly increased grain and dry matter yield [8-11]. Chaudhry and Memon [11], Shafi [5], and Kaishtha and Marwaha [12] observed that in wheat straw and grain ratio improved considerably with adequate application of phosphorus. Kaishtha and Marwaha [12] reported that the addition of nitrogen and phosphorus in appropriate amounts significantly improved the harvest index owing to increased physiological efficiency of the crop to utilize dry matter for yield formation.

Guseinkov and Grozdenkov [13] reported that grain flintiness and protein contents increased with the application of 60 kg N, 20-60 kg P_2O_5 and 20 kg K_2O per ha.

The present investigations were carried out to study the effect on wheat of phosphorus application in different proportions with nitrogen in irrigated conditions at Faisalabad.

MATERIALS AND METHODS

The field experiments were conducted on sandy clay loam soil in Lyallpur soil series (Typic camborthids) at the University of Agriculture, Faisalabad during rabi seasons of 1984-85 and 1985-86. The composite soil samples were collected before seed bed preparation during each season to determine the nutrient status at planting. The particle size and free lime in soil were determined by methods of Moodie, *et al.* [15]. The available soil phosphorus was determined by method described by S.R. Olsen, *et al.* [16] and other soil analyses were undertaken according to methods given by Black [17]. The physico-chemical characteristics of the investigated site are presented in Table 1.

The crops were sown on November 15, 1984 and November 22, 1985 on a well prepared seed bed with single row hand drill in rows 23 cm apart [18]. Wheat cultivar LU-26S was sown using a seed rate of 100 kg per ha. The

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different amounts of nitrogenous, phosphatic and potassic fertilizers (Table-2) were top dressed at the time of first irrigation (at days 20 after planting) in the form of urea, single superphosphate and sulphate of potash, which is a common source of potassium in Pakistan [19] respectively. The fertilizer treatments were arranged in a randomized complete block design having four repeates with a net plot size of 50 m^2 (5m x 10m). The crop was irrigated 5 times including heavy pre-plant irrigation through tubewell and canal supply with total quantity of 406 mm and the area received 176 mm rainfall during the growing period. The total consumptive use of water was 532 mm during the whole growth period. Standard crop husbandry practices were adopted. Data on the number of tillers were recorded from 1 m^2 area and observations on spike length and the number of grains per spike were based on 50 tillers taken at random from each treatment..

Table 1. Physico-chemical characteristics of the investigated site
(2 years average)

pH_s (Black, 1965)	= 8.2
BC_e x 10^3 (Black, 1965)	= 2.2
Organic matter (%) (Black, 1965)	= 0.53
$CaCO_3$ (%) (Moodie *et al*, 1959)	= 8.7
Total nitrogen (%) (Black, 1965)	= 0.024
Available P (ppm) (Olsen *et al*, 1954)	= 7.5
Available K (ppm) (Black, 1965)	= 264
Textural class (Moodie *et al*, 1959)	= Sandy clay loam (Sand = 56%, Salt = 22%, Clay = 20%)

The crop was harvested on 26th April, 1985 and 2nd May, 1986. The total biomass was determined before threshing by weighing sun dried tied bundles from each plot. Grain yield from each plot was recorded and straw yield was calculated by substracting the grain weight from the total biomass and calculated on per ha basis. The harvest index was calculated by the formula, economic yield/ total biological yield x 100 [20]. Water use efficiency was determined by the formula, biological yield (kg/ha)/crop evapotranspiration (mm) [21]. The percentage yield was calculated according to Cate-Nelson Graphical Method [22]

Total nitrogen in the grain was determined by method described by the official methods of analysis [23]. Protein content was calculated by total nitrogen multiplied by 5.7 [23,24]. The data were subjected to Fisher's analysis of variance technique using Duncan's new Multiple Range Test at 5% level of probability to compare the significance of treatment means [25].

RESULTS AND DISCUSSION

The data given in Table 2 indicate large significant differences among various fertilizer treatments in grain yield and its components, i.e. the total number of tillers and number of fertile tiller per unit area, spike length, number of grains per spike and 1000-grain weight. Accordingly, the application of phosphorus and nitrogen alone or in combination significantly increased the grain yield and

Table 2. The grain yield and its components as affected by phosphorus application in different proportions with N and K.
(2 years average)

Treatments N	P_2O_5 (kg/ha)	K_2O per m^2	Total No. of tillers per m^2	Number of fertile tillers per m^2	Spike length (cm)	Number of grain per spike	1000-grain weight (g)	Grain yield (Kg/ha)	Straw yield (Kg/ha)
0	0	0	259 e	242 e	8.7 c	30 b	46.5 d	2463 f	4330 d
100	0	0	287 cd	283 cd	9.2 bc	35 c	50.3 c	3563 d	5975 b
0	100	0	269 de	262 de	8.9 c	33 c	50.5 c	2875 e	4865 c
100	25	0	309 bc	302 bc	9.5 ab	38 b	51.7 b	3925 c	6450 ab
100	50	0	352 a	339 a	10.1 a	46 a	54.9 a	4525 a	7175 a
100	75	0	320 b	315 ab	9.6 ab	44 a	54.4 a	4175 bc	6936 a
100	100	0	319 b	311 b	9.7 ab	45 a	54.8 a	4225 abc	7075 a
100	100	50	324 ab	320 ab	9.9 ab	45 a	54.6 a	4375 abc	7188 a

Any two means not sharing a letter in common differ significantly at 5% probability level.

its components. Phosphorus substantially contributed towards grain development, particularly when applied along with nitrogen. The maximum grain yield 4525 kg/ha resulted from an application of 100 kg N and 50 kg P_2O_5/ha. Grain yields with an application of larger amounts of phosphorus with or without potassium ($N_{100}P_{100}K_0$ + $N_{100}P_{100}K_{50}$) were less, i.e. 4225 and 4375 kg/ha, though not significantly different. These studies demonstrate that N applied in an amount of 100 kg N in the ratio of 2:1 (100 : 50 kg/ha) was more appropriate and productive than the ratio of either 1:1, 4:3 or 2:2:1 on a sandy clay loam having about 8 ppm P and 265 ppm K nutrient status at the time of planting. The high status of potassium in the soil perhaps accounting for the apparent lack of adequate response to this nutrient. The experimental treatments proceded a more thorough examination of this aspect. These findings are supported by the results reported by earlier workers [5-10].

However the sole application of nitrogen or phosphorus decreased the straw yield markedly compared to combined application of NPK fertilizers (Table 2). The maximum straw yield was obtained from a balanced fertilizer

Table 3. Response of wheat to fertilizer application

Treatments N	P_2O_5 (kg/ha)	K_2O	Biological yield (Kg/ha) Straw yield	Grain yield	Increase in grain yield over control kg/ha	%	Kg wheat grain/ Kg nutrient	Kg wheat grain/ Kg of N, P_2O_5 and K_2O	Water use* efficiency Kg/ha/mm (1)	(2)
0	0	0	4330	2463	–	–	–	–	12.8	4.6
100	0	0	5975	3563	1100	45	11.0	11.0 (N)	17.9	6.7
0	100	0	4865	2875	412	17	4.1	–	14.5	5.4
100	25	0	6450	3925	1462	59	11.7	14.5 (P_2O_5)	19.5	7.4
100	50	0	7175	4525	2062	84	13.8	19.2 (P_2O_5)	22.0	8.5
100	75	0	6938	4175	1712	70	9.8	8.2 (P_2O_5)	20.9	7.8
100	100	0	7075	4225	1762	72	8.8	6.6 (P_2O_5)	21.2	7.9
100	100	50	7188	4375	1912	78	7.7	3.0 (K_2O)	21.7	8.2

WUE (1) and WUE (2) are of total biological yield and grain yield respectively.
* = Based on ET as 532 mm.

Table 4. Protein content in grain as affected by phosphorus application in different proportions with N and K (2 year average)

Treatment N	P_2O_5 (kg/ha)	K_2O	Protein content (%)
0	0	0	8.83 e
100	0	0	10.09 d
0	100	0	8.72 e
100	25	0	10.57 d
100	50	0	11.18 c
100	75	0	11.91 b
100	100	0	12.23 b
100	100	50	13.2 a

Any two means not sharing a letter in common differ significantly at 5% probability level.

($N_{100}P_{100}K_{50}$) treatment. Many researchers [11,12] have reported similar results.

The results presented in Table 3 indicate that wheat yield of cv. LU-26S can be increased by 84%, from 2463 kg/ha to 4525 kg/ha with 100 kg N and 50 kg P_2O_5/ha fertilizer application. The data further show that the increase in yield per unit of the nutrient, water use efficiency and kg wheat grain/kg of P_2O_5 the maximum in 2:1:0 treatment. This is further illustrated by the data in Table 3 that fertilizers addition have caused led to large increase in WUE of biological yield. These results with those of Saleem [26].

The protein content difference was corroborate statistically significant due to various fertilizer treatments (Table 4). The highest protein content of 13.3 % was obtained in grain receiving $N_{100}P_{100}K_{50}$ kg/ha followed by 12.23 and 8.83% in $N_{100}P_{100}K_0$ and $N_0P_0K_0$ respectivley. However, the application of phosphorus alone significantly reduced the protein content. These results corroborate the earlier

Table 5. Harvest index as affected by phosphorus application in different proportions with N and K (2 year average)

Treatment N	P_2O_5 (Kg/ha)	K_2O	Harvest index
0	0	0	36.30 e
100	0	0	37.37 c
0	100	0	37.02 bc
100	25	0	37.81 a
100	50	0	38.74 a
100	75	0	37.59 bc
100	100	0	37.42 d
100	100	100	37.88 b

Any two means not sharing a letter in common differ significantly at 5% probability level.

findings [13]. The harvest index was significantly influnced by fertilizer application (Table 5). The highest harvest index of 38.7% was observed in treatments $N_{100}P_{100}K_0$ kg/ha compared with 36.30% of unfertilized plots. Evidently the phsiological efficiency of wheat crop to utilize dry matter for yield formation was significantly enhanced by fertilization. Almost similar results have been reported by Kaishta and Marwaha [12]. The economic dats given in Table 6 indicate that in general, fertilizer application gave s substantially higher net income per hectare over check. Among the fertilizer treatments, the highest net income of Rs. 5966/- per ha was obtained with an application of 100-50-0 kg/ha followed by treatments of 100-100-50 kg/ha and 100-100-0 kg/ha, yielding a net income of Rs. 5401 and 5211 per ha. However, it was most profitable to apply NP in the ratio of 2:1:0.

Co-efficients of correlation and simple and multiple regression equations of wheat grain yeild on various yeild components are presented in Tables 7 and 8. The co-effi-

Table 6. Economics of phosphorus application in different proportions with N and K (2 year average).

Treatment N	P_2O_5 (Kg/ha)	K_2O	Grain yield (Kg/ha)	Straw yield (kg/ha)	Income (Rs./ha) Grain	Straw	Gross income (Rs/ha)	Expenditure (Rs/ha)	Net income (Rs/ha)	Benefit cost ratio	Percentage increase of net income over control
0	0	0	2463	4330	4926	1083	6009	3600	2409	1.67	–
100	0	0	3563	5975	7126	1494	8620	4432	4188	1.94	74
0	100	0	2875	4865	5750	1216	6966	4115	2851	1.69	18
100	25	0	3925	6450	7850	1613	9462	4625	4837	2.05	101
100	50	0	4525	7175	9050	1794	10844	4878	5966	2.22	148
100	75	0	4175	6938	8350	1735	10085	4893	5192	2.06	116
100	100	0	4225	7075	8450	1769	10219	5008	5211	2.04	116
100	100	50	4375	7188	8750	1797	10547	5146	5401	2.05	124

Based on Rs. 200/ 100 kg gram; Rs. 138/50 kg urea; Rs. 37/50 kg SSP; and Rs. 50/50 kg SOP

Table 7. Simple regression equation and correlation co-efficient of wheat grain on various yield components

Yield components	Regression equations	Correlation co-efficient	Co-efficient of determination	S.E. of estimate
No. of fertile tillers/m^2 Y x X_1	$Y = -30.1910 + 0.2286\ X_1$	0.988**	0.976	0.274
Spike length (cm) Y x X_2	$Y = -104.9271 + 15.1032\ X_2$	0.983**	0.966	0.005

(Continued.....)

(Table 7, continued)

Number of grains/spike Y x X_3	Y =	– 7.9574 + 1.551 X_3	0.957**	0.916	0.098
1000-grain weight (g) Y x X_4	Y =	– 86.2942 + 2.3774 X_4	0.946**	0.865	0.053

** = Highly significant.

Table 8. Multiple regression equation of wheat grain yield on various yield components

Yield in Kg/ha on fertile tillers/m^2, Spike length (cm), No. of grain per spike and 1000-grain weight (g)

(Y on X_1, X_2, X_3, and X_4)

$$Y = -26.89893 + 0.19416\ (X_1) + 0.11601\ (X_2) + 0.19477\ (X_3) + 0.0064\ (X_4).$$

$R = 0.989^{**}$ $R^2 = 0.978$

cient of multiple correlation (Table 7) indicates a positive and highly significnat correlation between grain yield and its components. The co-efficient of correlation 0.989 was highly significant. The co-efficient of determination indicates that 97.8% (100 R^2-97.8) variation in yield was due to four component factors. The remaining 2.2% variation may be due to chance or other external factors like irrigation and weed.

Table 8 further reveal that an increase in one fertile tiller per unit area (m^{-2}) would result in no increase in grain yield by 0.1942 quintal/ha, while increase in spike by 1 cm would result in an increase in grain yield by 0.116 quintals/ha. Similarly, an increase in one grain/spike and 1000-grain weight of one grain will contribute to grain yield by 0.1947 and 0.0064 quintal/ha, respectively.

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