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Genetic Variation for Phosphorus Use in Wheat at Two Levels of Soil Applied Phosphorus

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Abstract: Wheat genotypes grown at control and adequate P levels differed markedly in their growth response. Growth response in terms of straw and grain yields was influenced by P application, genotype and their interaction. Relative reduction in grain yield ranged from none to 4%. Among all the genotypes Pervaz-94 showed response to P application. It was also observed that genotypes with high P concentration had low P uptake, low phosphorus use efficiency and hence low grain yield. Inqlab-91 and Chakwal-86 used phosphorus efficiently at both the P levels. Phosphorus efficient genotypes could be grown under low or little P fertilizer conditions.

Key Words: Wheat, cultivars, soil, phorsphorus, use efficiency

Introduction

Among cereals, wheat (*Triticum aestivum* L.) is the most abundantly grown crop for grain and dry fodder in Pakistan. It is staple food for majority of the country's population. No doubt, some achievement in wheat production has been achieved but still its yield per hectare in the country is lower than many other wheat growing countries of the world (Anonymous, 1998a).

Imbalanced use of nutrients is one of the various constraints to self-sufficiency in wheat production in Pakistan (Anonymous, 1998b). Phosphorus after nitrogen is the key element for plant growth. Its availability is seriously affected due to alkaline calcareous nature of soils of Pakistan which is very much clear from its recovery efficiency, i.e., 15-20 percent (Zia *et al.*, 1991). The remaining 80-85% phosphorus retains as fixed phosphorus in soil. On the other hand, P-use efficiency by wheat is only 11-20% (Zia *et al.*, 1991). Phosphorus is a costly input and there is a need to improve its use efficiency to cut down the cost of production. Low availability of P is one of the yield limiting factors (Ahmad *et al.*, 1992; Gourley *et al.*, 1993). Phosphorus fertilizers are applied to overcome the phosphorus deficiency. However, use of phosphatic fertilizer is not affordable by every farmer. This is the reason that most of the farmers applied this fertilizer at much less rates than the recommended level (Anonymous, 1998b). Agricultural scientists are focusing their attention to cutdown the cost of production and introducing low input technology. In this regard one of the supplementary approach is the identification/selection of P-efficient genotypes. It is well known that crop genotypes differ in P-use efficiency and in their ability to take up and utilize mineral elements (Clark and Duncan, 1991). Possibility of exploiting genotypic differences in absorption and utilization of P to obtain higher productivity on P-deficient soil has received considerable attention in recent years. The aim of this experiment is to screen out the P-efficient wheat cultivars under field conditions.

Materials and Methods

The experiment was carried out in P-deficient soil (8 mg kg^{-1}) to determine the genetic variation for phosphorus use efficiency in wheat at two levels of soil applied phosphorus in the research area of Department of Soil Science, University of Agriculture Faisalabad. The experiment was laid out in split plot with four replications. The phosphorus levels were applied in main plots while crop genotypes in sub-plots. The phosphorus levels were control (zero P application) and 120 kg P_2O_5 ha^{-1} as single superphosphate. Nitrogen at 120 kg ha^{-1} as urea and potassium at 60 kg K_2O ha^{-1} as KCl were applied according to recommended method. The crop was harvested on net plot size basis at maturity. Plants were separated into straw and grainand their weights were recorded. Ground plant material was digested and analyzed for phosphorus concentration and stress factor. For it 0.5 g of each sample was digested in 5 mL tri-acid mixture of nitric, sulphuric and perchloric acids (2:1:1) and phosphorus was determined by yellow colour method (Chapman and Pratt, 1961). Comparison among the cultivars was made following standard statistical procedures (Steel and Torrie, 1980).

Results and Discussion

Straw and grain yields of seven wheat genotypes were influenced by P level, genotype and two way interaction of P level and genotype. Except Blue silver, all the genotypes showed increase in straw to a varying extent with the increase in P supply. There was about 11% increase in wheat straw by increasing the P supply from nil to 120 Kg P_2O_5 ha^{-1}. Maximum straw was yielded by Chakwal-86 at both the P levels (Table 1, 2). This genotype also showed the highest response to P application for straw production. Differential yielding potential of wheat genotypes showed existence of genetic variation among wheat genotypes. Maximum grain yield was produced at deficient P level. The difference in grain yield among genotypes was statistically significant. The grain yield of only Parvaz-94 increased with increase in P supply. Grain yields of Pb-96, Inqlab-91, Pb-85, Blue Silver, Fsd-83 and Chakwal-86 were higher at deficient P than at adequate P. These genotypes might have inverse response to P supply. Fageria and Barabosa-Filho (1982) reported existence of varietal differences for tolerance of P deficiency. Yaseen *et al.* (1998) also reported similar results where most of these genotypes behaved similarly.

Average grain yield of wheat genotypes differed significantly. The genotype Chakwal-86 produced maximum grain yield. This might be due to its later ability to obtain P from the soil. Such differences in wheat genotypes were also reported by El Bassam (1998).

Genotype x P level interaction was significant. At control P Chakwal-86 produced maximum while Parvaz-94 produced minimum grain yield among all the genotypes. At adequate P levels, Parvaz-94 appeared as P responsive genotype and produced maximum grain yield while minimum by Pb-85, Inqlab-91, Chakwal-86, Fsd-83, Blue Silver, Pb-96. These genotypes might be tolerant to P deficient conditions, have low P requirements or capable of using soil P efficiently. Data showed that Parvaz-94 was highly P responsive as its yield was increased with P supply. Dhillon and Deve (1993) reported increase in wheat grain yield and P uptake with increasing P supply.

Gourley *et al.* (1993) had the opinion that screening of cultivars for have stable produce in low P conditions may provide the best

Table 1: Straw yield (kg ha^{-1}) of seven wheat genotypes at control and adequate P levels

Genotypes	Phosphorus level		Mean
	Control-P	Adequate-P	
Inqlab-91	2707 e	2811 d	2759 D
Parvaz-94	3087 d	4003 b	3545 C
Chakwal-86	4437 a	6024 a	5231 A
Fsd-83	3436 c	3873 bc	3654 C
Blue Silver	3781 bc	3604 c	3692 C
Pb-96	4005 b	4110 b	4058 B
Pb-85	3650 bc	3750 bc	3700 C
Mean	3586 B	4025 A	

Means sharing different letter(s) differ significantly at 5% level of probability

Table 2: Grain yield (kg ha^{-1}) of seven wheat at control and adequate P levels

Genotypes	Phosphorus level		Mean
	Control-P	Adequate-P	
Inqlab-91	2778 b	2585 b	2681 C
Parvaz-94	2630 b	3163 a	2897 B
Chakwal-86	3156 a	3036 a	3096 A
Fsd-83	2775 b	2678 b	2727 BC
Blue Silver	2861 b	2686 b	2734 BC
Pb-96	2873 b	2544 b	2709 BC
Pb-85	2655 b	2482 b	2571 C
Mean	2818 A	2739 B	

Means sharing different letter(s) differ significantly at 5% level of probability

Table 3: Phosphorus stress factor (%) for grain of seven wheat genotypes

Genotypes	Mean
Inqlab-91	-4.6 AB
Parvaz-94	4.4 A
Chakwal-86	-31.9 C
Fsd-83	-6.8 B
Blue Silver	-4.5 AB
Pb-96	-6.4 B
Pb-85	-6.7 B

Means sharing different letter(s) differ significantly at 5% level of probability

Table 4: Phosphorus concentration (mg g^{-1}) in grain of seven wheat genotypes at control and adequate P levels

Genotypes	Phosphorus level		Mean
	Control-P	Adequate-P	
Inqlab-91	1.23 d	2.02 d	1.62 D
Parvaz-94	1.55 ab	2.75 a	2.15 A
Chakwal-86	1.20 d	2.17 cd	1.68 D
Fsd-83	1.47 ab	2.55 b	2.01 B
Blue Silver	1.30 cd	2.32 c	1.81 C
Pb-96	1.40 bc	2.75 a	2.07 AB
Pb-85	1.60 a	2.55 b	2.07 AB
Mean	1.39 B	2.44 A	

Means sharing different letter(s) differ significantly at 5% level of probability

estimate of productivity in low P soil. Statistical analysis shows significant differences among wheat genotypes. Wheat genotypes having stress factor values with positive sign indicate dependence upon P supply where as genotypes values with negative sign having either low P requirement or efficient user of soil P. Stress factor for all the genotypes varied from -31.85 to 4.36% (Table 3). Maximum stress factor was found in Parvaz-94. This means that Parvaz-94 is a P responsive wheat genotype and is highly dependent on P supply compared to other wheat genotypes. The genotypes Fsd-83, Pb-85, Pb-96, Blue Silver and Inqlab-91 showed negative response to P supply for grain yield. These genotypes may be termed as P-efficient in terms of their relative grain yield under P deficient soil conditions. Minimum stress factor was observed in Chakwal-86. Therefore, Chakwal-86 may be termed as the most P efficient genotypes among all the genotypes tested in this study. Genotypic differences for relative reduction in grain yield at different P supply levels have also been reported by Siddique (1998) in wheat (Table 4).

Table 5: Phosphorus uptake (kg ha^{-1}) by grain of seven wheat genotypes at control and adequate P levels

Genotypes	Phosphorus level		Mean
	Control-P	Adequate-P	
Inqlab-91	4.20 bc	4.63 c	4.41 C
Parvaz-94	3.54 cd	7.11 a	4.32 AB
Chakwal-86	5.10 a	6.13 ab	5.61 A
Fsd-83	4.03 bcd	6.16 ab	5.09 AB
Blue Silver	3.26 d	4.11 c	3.68 D
Pb-96	4.74 ab	5.13 b	4.93 BC
Pb-85	3.62 cd	5.10 b	4.86 BC
Mean	4.07 B	5.62 A	

Means sharing different letter(s) differ significantly at 5% level of probability

Table 6: Phosphorus use efficiency in grain of seven wheat genotypes at control and adequate P levels

Genotypes	Phosphorus level		Mean
	Control-P	Adequate-P	
Inqlab-91	2292.61 a	1189.08 bc	1740.08 B
Parvaz-94	1665.58 c	1027.91 c	1346.74 C
Chakwal-86	2163.05 a	1781.98 a	1972.51 A
Fsd-83	1895.69 bc	986.50 c	1441.09 C
Blue Silver	2236.24 a	745.26 d	1490.75 C
Pb-96	2065.94 ab	1313.48 b	1689.71 B
Pb-85	1696.64 c	1064.89 c	1380.77 C
Mean	2002.25 A	1158.40 B	

Means sharing different letter(s) differ significantly at 5% level of probability

Genotypes having higher P concentration showed lower uptake and vice versa. Higher uptake generally depicted higher grain yield and lower P uptake was due to dilution effect of higher growth (Table 5). Phosphorus uptake ranged from 3.26 to 5.10 kg ha^{-1} and 4.11 to 7.11 kg ha^{-1} at control and adequate P levels, respectively. Chakwal-86 absorbed statistically maximum P at control while Blue Silver absorbed minimum P among all the genotypes. High P uptake indicated high grain yield. Therefore genotypes with good absorption of P enhanced grain production. It was influenced significantly by P level, genotype and their interaction. It was observed that wheat genotypes (except Blue silver) having higher P absorption in grain under P-deficient conditions had used phosphorus efficiently. Wheat genotypes Inqlab-91 and Chakwal-86 had produced the highest grain per unit P absorbed (Table 6).

The finding of the experiment showed that P efficient genotypes (Inq-91, Pb-96 and Pb-85) could be successfully grown on soils with low available P or where soil is replenished with little or no phosphorus.

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