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

S. Ahmad, M. Yaseen and A. Saboor[1]
Department of Soil Science, [1]Department of Agricultural Economics,
University of Agriculture, Faisalabad-38040, Pakistan

Abstract: Rice genotypes differed significantly in their growth response. Growth response in terms of paddy yield was influenced by P application, genotype and their interaction. Relative reduction in paddy yield ranged from none to 13%. The genotypes K. Basmati, NIAB-6, IRRI-6, Kernal, Basmati-370 and KSK-282 showed positive response to P application. Mostly genotypes with high P concentration had low P uptake, low phosphorus use efficiency and hence low paddy yield. NIAB-6 had used phosphorus efficiently at control P level. Rice genotypes NIAB-6, IRRI-6 and K. BASMATI were P responsive and productive and hence could be regarded as P-efficient rice genotypes. Phosphorus efficient genotypes could be grown under native or little P fertilizer application conditions.

Key words: Rice, cultivars, phosphorus, soil, use efficiency

Introduction

Rice is grown on 2317.3 thousands hectares with a production of 4333 thousands tones which is very low than the other rice producing countries. Rice is important staple food of Pakistan population. Rice is grown in summer and need non-aerated soil growth conditions. Imbalanced use of nutrients is one of the various constraints to self-sufficiency in crop production in Pakistan (NFDC, 1998). 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% (Zia *et al.*, 1991). The remaining 80-85% phosphorus retains as fixed phosphorus in soil. For rice, P-availability is not a problem due to high water contents (Zia *et al.*, 1998). However, still there is a need to improve the P-use efficiency by this crop. 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 a much less rates than the recommended level (NFDC, 1998). 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 rice cultivars under field conditions.

Materials and Methods

The experiment was carried out in P-deficient soil (8 mg/kg) to determine the genetic variation for phosphorus use efficiency in rice at two levels of soil applied phosphorus. The experiment was laid out in split plot with four replications in the research area of Department of Soil Science University of Agriculture Table Faisalabad. 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 paddy, and 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 paddy yields of seven rice genotypes were influenced by P level and genotype, however two way interaction of P level x genotype influenced the yield non-significantly. All the genotypes showed increase in straw to a varying extent with the increase in P supply (Table 1). There was about 26% increase in rice straw by increasing the P supply from nil to 120 Kg P_2O_5 ha^{-1}. Maximum straw was yielded by DM-25 at both the P levels. Genotype NIAB-6 showed the highest response to P application for straw production. Differential yielding potential of rice genotypes showed existence of genetic variation among rice genotypes. Data regarding the effect of phosphorus levels on paddy yield is presented in Table 2. Maximum paddy yield was obtained at adequate P level. The difference in paddy yield among

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

	Phosphorus level		
Genotypes	Control-P	Adequate-P	Mean
NIAB-6	8341.0^{NS}	12845.0^{NS}	10593.0C
DM-25	12817.0	14873.0	13845.0C
Basmati-370	12691.0	14203.0	13447.0AB
KSK-282	10242.0	10964.0	10603.0 C
IRRI-6	9944.0	11812.0	10878.0C
K. Basmati	10335.0	13146.0	11740.0C
Kernal	10348.0	13729.0	12045.0BC
Mean	10674.0 B	13082.0 A	

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

genotypes was statistically highly significant. Contrary to general trend of increase in paddy yield with P-application, paddy yield of DM-25 was higher at deficient P than at adequate P supply. This genotype might has inverse response to P supply. Fageria and Barabosa-Filho (1982) reported existence of varietal differences for tolerance to P deficiency. Iqbal (1995) also reported similar results where most of these genotypes behaved similarly. Average paddy yield of rice genotypes differed significantly. The genotypes K-Basmati and IRRI-6 produced statistically similar and maximum paddy yield. This might be due to its better ability to 1: obtain P from the soil. Such differences in rice genotypes were also reported by Iqbal (1995). Genotype × P level interaction found significant. At deficient P level, Table K. BASMATI produced maximum paddy yield whereas BAS-370 and Kernal produced statistically similar and minimum paddy yield than all the other genotypes. At adequate P levels, K. BASMATI and DM-25 produced maximum and minimum paddy yield, respectively. Among the rice genotypes, DM-25 showed decrease in its paddy yield with P supply. Data elucidate that Kernal and Basmati-370 were highly P responsive rice genotype as their paddy yields were increased more with P supply among all the genotypes. At adequate P levels, the rice genotypes can be ranked according to paddy yield potential as K. Basmati > IRRI-6 > NIAB-6 > BAS-370 > KSK-282 > Kernal > DM-25. Similar results were obtained by Rajkhowa and Baroova (1992) in rice. Relative reduction in paddy yield is given in Table 3. Gourley *et al*. (1993) had the opinion that screening of cultivars for harvestable produce in low-P conditions may provide the best estimate of productivity in low-P soils. Statistical analysis shows significant differences among rice genotypes. Rice genotypes having stress factor values with positive sign indicate dependence upon P supply whereas genotypes with values close to unity have either low P requirement or efficient user of soil P. Phosphorus stress factor (PSF) for all genotypes varied from 0.4 to 12.70%. Maximum stress factor was observed in Kernal.

Table 2: Paddy yield (kg ha^{-1}) of seven rice genotypes at control and adequate p levels

	Phosphors level		
Genotypes	Control-P	Adequate-P	Mean
NIAB-6	2640 abc	2801 b	2720.0BC
DM-25	2570 bc	2382 c	247.06D
Basmati-370	2486 c	2799 b	2643C
KSK-282	2552 bc	2720 b	2636C
IRRI-6	2755 ab	2930 ab	2842AB
K. Basmati	2820 a	3057 a	2939 A
Keneral	2456 c	2772 b	2614CD
Mean	2661 B	2780 A	

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

Table 3: Phosphorus stress factor (%) for paddy

Genotypes	Mean
NIAB-6	7.9 C
DM-25	0.4 BC
Basmati-370	8.5 AB
KSK-282	2.0 ABC
IRRI-6	7.7 AB
K. Basmati	1.7 ABC
Kernal	12.7 A

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

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

	Phosphorus level		
Genotypes	Control-P	Adequate-P	Mean
NIAB-6	1.05^{NS}	1.87^{NS}	1.46 C
DM-25	1.10	2.00	1.55 BC
BasmatI-370	1.15	1.97	1.56 ABC
KSK-282	1.3	2.20	1.75 A
IRRI-6	1.00	2.1	1.55 BC
K. Basmati	1.12	1.82	1.47
Kernal	1.12	2.3	1.71
Mean	1.12 B	2.03 A	

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

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

	Phosphorus level		
Genotypes	Control-P	Adequate-P	Mean
NIAB-6	2873.93 a	1352.77 c	2113.35
DM-25	1969.45 c	1980.40 ab	1974.92 AB
Basmati-370	1913.80 c	2016.24 a	1965.02 AB
KSK-282	2218.61 b	1869.95 b	2014.28 AB
IRRI-6	1800.26 c	1360.77 c	1580.51 C
K. Basmati	1936.14 c	1794.09 b	1865.12 B
Kernal	1416.89 d	903.65 d	1160.27 D
Mean	2018.44 A	1602.55 B	

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

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

	Phosphorus level		
Genotypes	Control-P	Adequate-P	Mean
NIAB-6	2873.93 a	1352.77 c	2113.35 A
DM-25	1969.45 c	1980.40 ab	1974.92 AB
Basmati-370	1913.80 c	2016.24 a	1965.02 AB
KSK-282	2218.61 b	1869.95 b	2014.28 AB
IRRI-6	1800.26 c	1360.77 c	1580.51 C
K. Basmati	1936.14 c	1794.09 b	1865.12 B
Kernal	1416.89 d	903.65 d	1160.27 D
Mean	2018.44 A	1602. B	

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

This means that Kernal is a P responsive rice genotype and depends on P supply for paddy yield. The genotype DM-25 showed least response to P supply for paddy yield. This genotype might be termed as non-responsive P efficient in terms of its relative paddy yield under P deficient soil conditions. On the basis of PSF, rice genotypes can be ranked in the order of their dependence on substrate P as Kernal > BAS-370 >NIAB-6 > IRRI-6 > KSK-282 > DM-25. Genotypic differences for relative reduction in paddy yield at different P supply levels have also been reported by Iqbal (1995) in rice and Siddique (1998) in wheat cultivars. Phosphorus concentration and uptake increased with increasing P concentration in soil (Table 4). Phosphorus concentration is considered a good criterion to identify genetic specificity of plant mineral nutrition among cultivars (Saric, 1981). Genotypes having higher P concentration showed lower uptake and vice versa. Higher uptake depicted generally higher paddy yield and lower P uptake may be due to the dilution effect of higher growth (Table 5). Phosphorus uptake ranged from 1.58 to 3.17 kg ha^{-1} and 3.36 to

6.30 kg ha^{-1} at control and adequate P levels, respectively. Basmati-370 absorbed maximum P at control while IRRI-6 absorbed minimum P among all the genotypes. High P uptake indicated high paddy yield. Phosphorus use efficiency provides information about paddy yield per unit P absorbed. It was influenced significantly by P level, genotype and their interaction. It was observed that rice genotypes having higher P absorption in paddy under P deficient conditions had use phosphorus efficiently (Table 6). Rice genotypes NIAB-6 and KSK-282 had produced the highest paddy per unit P absorbed. Results clearly showed that P efficient genotypes (NIAB-6, KSK-282 and IRRI-6) could be successfully grown on soils with low available P or where soil is replenished with little or no phosphorus.

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