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Screening of low P tolerant rice cultivars under flooded/irrigated conditions

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Abstract
The objective of experiment is to study the P uptake pattern of rice genotypes and an attempt has been made in this study to screen out low P tolerates rice cultivators. The field experiment was conducted in kharif season 2015 at the research farm of Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana. Initial soil analysis characterization carried out for which previous soil analysis showed near neutral soil pH (7.2 to 8.2) with low to high status in available phosphorus. This augmented well as a gradient was selected. Out of number of plots available, low P plots was used for selecting the genotypes tolerant to low P condition. However, to screen the genotypes for their P use efficiency and response to its application, the 30 genotypes were taken under different gradients so as to compare their performance under different regimes of P application. Therefore, low P plots were divided into 4 sub-plots with different gradients (i.e. absolute control, 20 kg P_2O_5/ha, 40kg P_2O_5/ha and 60kg P_2O_5/ha). Among genotypes in absolute control swarna uptake highest 2.98 kg/ha grain P followed by sugandhmati 2.52 kg/ha followed by akhayadhan 2.27 kg/ha. therefore this varieties should be most suitable for organic farming.Uptake of all genotypes increases with increasing phosphorus levels and maximum at 60kg P_2O_5/ha while PUE of all genotypes decreases with increasing phosphorus levels.

Keywords: Phosphorus, Low-P tolerant cultivars, Environmental pollution

Introduction

Phosphorus is one of the most limiting nutrients for plant growth in soil. Both acid and alkali soils are P deficient. P deficiency is perhaps one of the most important factors that limit crop yields on many soils. Its availability depends on soil characteristics and contents of labile P fraction. It is estimated that P availability to plant roots is limited in two thirds of the cultivated soil in the world (Batjes 1997) [2]. Phosphorus application is essential to minimize yield loss on the soil. However, most of the P applied to soil is converted into unavailable forms that cannot be easily utilized by plants. With an increase in the prices of P fertilizers and a growing concern about environmental pollution, screening, and cultivating low-P tolerant cultivars have become a hot research field. Development of efficient genotypes with a great ability to grow and yield in P-deficient soil is, therefore, an important goal in plant breeding (Hash *et al*. 2002; Wissuwa *et al*. 2002) [4, 7]. Release of P efficient genotypes in both high and low input farming systems would reduce the production costs associated with P fertilizer applications, minimize environmental pollution and contribute to the maintenance of P resources globally (Cakmak 2002; Vance *et al*. 2003) [3, 6]. Plant species and genotypes of a given species develop diverse adaptive responses to P deficiency. To improve growth under P-deficient conditions, P-efficient plants have evolved two major mechanisms: (i) increasing P acquisition (root morphology, root exudation and P uptake mechanisms), and (ii) enhancing P utilization (internal mechanisms associated with conservable use of absorbed P at the cellular level) (Raghothama 1999; Bates and Lynch 2001; Vance *et al*. 2003) [5, 6]. Rice, one of the most important cereal crops, is moderately sensitive to P deficiency. There are significant differences among rice genotypes for the tolerance to P deficiency. The application of P generally improves biomass production, tillering, P uptake, decreases root to shoot ratio, root length, surface area and P utilization efficiency. Genotypes vary in their P uptake patterns. The overwhelming majority of soils in the rice-producing areas are P-deficient with a high P-fixing capacity. In acidic soils, free iron and aluminium oxides bind native and applied P into the forms unavailable to plants, whereas in calcareous soils, the abundant calcium and magnesium compounds bind inorganic phosphates into forms highly unavailable to plants. The high P-fixing capacity in both types of soils results in very low P-availability and thus low rates of uptake by the plants. Thus, improving the uptake efficiency of the rice plant in P-fixing soils need to be a major research target. The development of rice cultivars capable of using a higher portion of the fixed P already present in soils may be an attractive and cost effective approach to increasing rice yields where P deficiency is the major constraint. A greater effort to enhance the efficiency of P use for crop production will reduce environmental impacts associated with fertilizers and P waste, increase the nutritional value of grains, and improve farm economies. Developmental and physiological aspects of PUE are being unraveled by genetics and molecular biology, which suggest that significant improvement in internal PUE is possible. The magnitude of PUE gains that may be obtained through different mechanisms and their variation associated with genetic and environmental factors should be quantified through targeted research. More efficient use of P within the plant adds to the gains that can be made by improving P-acquisition efficiency, but also reduces P fluxes on crop land and in the environment. The largest yield benefits of improved PUE are expected for crops growing in soils that have very low P content and where little or no P fertilizer is applied. The largest savings in P fertilizer are expected on productive land where conditions for crop growth are near optimal.

Materials and Methods

The field experiment was conducted at the research farm (plot D-5) of the Indian Institute of Rice Research (IIRR), Rajendranagar, Hyderabad, Telangana state. The farm is geographically located at 17º19' N latitude and 78º23' E longitude at an altitude is 1719 ft.The climate of the place is subtropical. It receives rainfall mainly from South West monsoon (June-October). The experiment was laid out in a factorial randomized block design with three replications. The plot size was 35m × 10m (350 m^2). The experimental area was provided with a fallow strip of 1.4 m on all the sides as experimental border. Physico-chemical properties of experimental field are suitable for rice crop. The soil was deep black (Vertisols) sandy clay loam in texture with alkaline pH (8.01). It was non-saline (EC 0.27 dS m^{-1}) and low in organic carbon content (0.44%). The soil was low in available nitrogen (253 kg ha^{-1}), low in available phosphorus (5.95 kg P_2O_5 ha^{-1}) and high in available potassium (370 kg K_2O ha^{-1}). Available Ca and Mg both are high (24meq/100g) each. Available S was low (6 ppm). Available zinc content (4 ppm) was above the critical level (0.6 mg kg^{-1}). Available Fe, Cu and Mn was high (5.58 ppm, 16ppm and 7.24ppm). Plant samples collected at harvest stage of rice were oven dried and powdered into fine powder and used for chemical analysis. Straw and grain samples collected were first shade dried and then oven dried at 65ºC. The dried straw and grain samples were powdered through grinding machine properly and the finely grind material was used for chemical analysis by yellow colour development. Read the intensity of the colour at 420 nm in a spectrophotometer.

Results and Discussion

The significant yield benefits of improved PUE are expected for crops growing in soils that have very low P content or no P fertilizer is applied. The largest savings in P fertilizer are expected on productive land where conditions for crop growth are near optimal.Results on grain uptake is presented in table 1 revealed that overall mean of grain uptake in 60kg P_2O_5/ha is 5.28kg/ha followed by 4.44 kg/ha in 40kg P_2O_5/ha followed by 3.81 kg/ha in20kg P_2O_5/ha and 1.93 kg/ha in control.

It ranged from 1.23 kg/ha to 2.98 kg/ha in absolute control, 3.23 to 5.42 kg/ha in 20kg P_2O_5/ha group, 3.51 to 5.62 kg/ha in 40 kg P_2O_5/ha and 4.21 to 6.67 kg/ ha under 60kg P_2O_5/ha group. Among genotypes in absolute control swarna uptake highest 2.98 kg/ha grain P followed by sugandhmati 2.52 kg/ha followed by akhayadhan 2.27 kg/ha, in 20 kg P_2O_5/ha highest grain P uptake obtained in swarna (5.42 kg/ha) followed by vikas (4.99 kg/ha) followed by IR 64 (4.24 kg/ha), in 40kg P_2O_5/ha highest grain uptake done by swarna (5.62kg/ha) followed by kasalatha (5.16kg/ha) followed by akshayadhan (5.14kg/ha) and in 60kg P_2O_5/ha swarna uptake highest grain P (6.67kg/ha) followed by vandana (6.17 kg/ha) followed by BPT5204 (5.57 kg/ha).Interaction studies (varieties x levels of P) revealed that the grain P uptake is highly significant.

Table 1: P uptake by rice grain (kg/ha) recorded for different cultivars of rice at varying doses of Phosphorus

Varieties	P 0 (Kg/ha)	P 20 (Kg/ha)	P40 (Kg/ha)	P60 (Kg/ha)	Mean Varieties (Kg/ha)
Akshayadhan	2.27	3.96	5.14	5.18	4.14
Vasumathi	2.15	4.69	4.56	5.38	4.20
Sugandhamati	2.52	3.36	4.27	4.57	3.68
T.Hamsa	2.09	3.73	3.68	4.36	3.47
Vardhan	1.49	3.72	4.14	4.79	3.54
Vikas	1.95	4.99	4.07	4.24	3.81
Tulasi	1.79	4.14	3.60	5.07	3.65
Mahsuri	1.98	3.95	3.82	4.55	3.58
Mtu1010	1.55	3.56	4.61	5.89	3.90
Rpbio226	2.05	3.56	4.18	4.55	3.59
Ir64	1.46	4.24	3.57	4.45	3.43
Vandana	1.93	3.76	4.94	6.17	4.20
Rasi	1.85	3.23	4.28	4.84	3.55
Kasalatha	2.06	4.24	5.16	5.60	4.27
Swarna	2.98	5.42	5.62	6.67	5.17
Bpt5204	1.88	3.47	4.73	5.57	3.91
Krh2	1.72	3.68	3.75	4.41	3.39
Iet24036	2.05	3.87	4.88	5.08	3.97
Ravi	1.23	3.74	4.86	4.61	3.61
Iet24003	2.05	3.89	4.77	4.32	3.76
Triguna	1.77	3.48	4.83	4.80	3.72
Sampadha	1.72	3.94	4.14	5.09	3.72
Drrh3	1.42	4.73	4.05	5.20	3.85
Aditha	1.71	3.58	4.70	5.14	3.78
Pa6444	1.82	3.31	3.82	4.43	3.35
Pr133	1.84	3.54	4.26	4.89	3.63
Rnr15048	1.72	3.37	3.97	5.34	3.60
Inh10001	1.58	3.36	3.51	4.80	3.31
Inh10002	1.83	3.50	4.09	4.21	3.41
Inh12013	1.67	3.87	4.31	4.25	3.53
Mean (Levels of P)	1.93	3.81	4.44	5.28	

Factors	C.D.	SE(d)	SE(m)	CV (%)
Varieties	0.410	0.208	0.147	15
Levels of P	0.150	0.076	0.054	
Interaction (Varieties X Levels of P)	0.819	0.416	0.294	

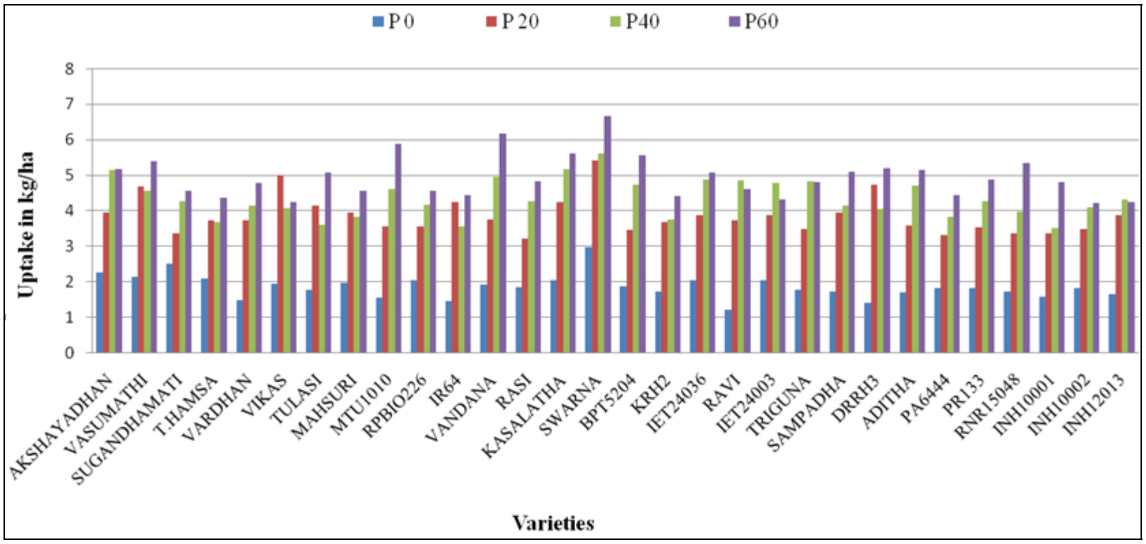

Fig 4.8: grain p uptake of all varieties in kg/ha

Conclusion

On the basis of observation and results of the experiment, following conclusion could be drawn, which may be considered for recommendation for the cultivation of different genotypes of rice in different levels of phosphorus under sandy clay loam soils. Among genotypes in absolute control swarna uptake highest 2.98 kg/ha grain P followed by sugandhmati 2.52 kg/ha followed by akhayadhan 2.27 kg/ha. therefore this varieties should be most suitable for organic farming. Uptake of all genotypes increases with increasing phosphorus levels and maximum at 60kg P_2O_5/ha while PUE of all genotypes decreases with increasing phosphorus levels.

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