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Original Research Article

Effect of Levels of Phosphorus and its Time of Application on Soil Nutrient Status and Yield of Rice Grown on P Accumulated Soil

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Keywords

Phosphorus, Time of Application, Rice, Nutrient Status, Yield

A B S T R A C T

A field experiment was conducted on a sandy loam soil during *kharif* 2015 with a view to study the effect of levels of phosphorus (100, 75 and 50 % farmers dose and 100, 75 and 50 % RDP) and its time of application (Farmer practice of split application and basal application) on soil nutrient status and yield of rice. As part of this investigation, a survey was carried out during May, 2015 from 50 rice growing farmers to identify the farmer's practice of dose and time of P application. The crop has given good response to application of 100 % farmers dose of P (85 kg P_2O_5 ha^{-1}) but at the same time which was found to be on par with the application of 100 % RDP (60 kg P_2O_5 ha^{-1}), 75 % farmers dose (64 kg P_2O_5 ha^{-1}) and 75 % RDP (45 kg P_2O_5 ha^{-1}). With respect to time of P application, P uptake by the grain was significantly higher in split application than the treatment receiving basal P, although this had no significant influence on the increase in grain yield of rice. The available P_2O_5 content in soil increased by 47 % from planting to 30 DAT, remained slightly decreased from 30 DAT to 90 DAT and decreased to its original content by post-harvest time. The application of P at the vegetative growth stage of the plants maintained a higher value of available P_2O_5 in soil up to 60 days after transplanting.

Introduction

Crop utilization of applied fertilizer phosphorus is generally low due to sorption and precipitation reactions in soils. Consequently, a large accumulation of phosphorus takes place over the years, particularly in the soils that receive regular and liberal rates of P applied to each crop in a cropping system. The long-term fertilization experiments conducted across the country have clearly demonstrated the accumulation of phosphorus in the soils of different types, in spite of using recommended fertilizer doses (Nambia, 1994). This is mainly because the applied P is usually fixed very quickly and is being retained in the top layers of the soil leading to slow and steady saturation of P-fixation sites on the soil. The residual P accumulated from previous additions can influence not only speciation and availability of P but also the availability of other nutrients. Under these circumstances, it is necessary to ascertain the requirement of P on such soil to crops not only to reduce the cost of chemical P fertilizer input from the current level of general recommendation but also to avoid any nutritional imbalances that might arise due to excess P availability (*e.g.*zinc).

The availability of P to rice grown on submerged soils depends on dose of fertilizers and time of fertilizer application. The rice growing farmers in many regions applying P fertilizer in split doses through complex fertilizers because they perceive that plants require P throughout the crop growth period like nitrogen. However, according to many researches, application of P at the time of transplanting is the recommended practice for paddy. Moreover, farmers do not pay much attention on time of phosphorus fertilizers application resulting in low phosphorus use efficiency. But more often, due to various reasons, it is not always possible to apply the entire P at the time of transplanting as required. Under such circumstances, it is appropriate to know whether split applications of P or delayed application is permissible without any loss in yield, P use efficiency and its economy in these P accumulated soils. Keeping in view, the significance of optimum level and time of application for improving the soil phosphorus availability and yield of rice, present experiment was planned to study the phosphorous requirement and its time of application to rice grown on P accumulated soil.

Materials and Methods

As part of this investigation, a survey was conducted on May, 2015 from 50 rice growing farmers from different villages of Nizamabad district, to identify the way of farmers applying fertilizers including farmer's practice of dose and time of P application. Based on the survey data, treatments were decided for conducting field experiment on rice in P accumulated soil. Soil samples were collected from rice growing soils of Nizamabad district. A total of 50 soil samples were collected at the same geo-reference sites for characterizing soil nutrient status.

A field experiment was conducted during *kharif* 2015 with rice (*Var*., BPT 5204) at Regional Sugarcane and Rice Research Station, Rudrur, Nizamabad District, Telangana. As per title of experiment we have selected phosphorus accumulated soil for conducting field experiment on rice. The experimental site was sandy clay loam in texture. The soil was slightly alkaline in reaction and non-saline in nature. It was low in organic carbon and available nitrogen and high in available phosphorus and potassium. The experiment was laid out in Randomized Block Design with factorial concept consisting of twelve treatment combinations with six levels of phosphorus viz., P_1 (100% Farmers dose of P), P_2 (75% of Farmers dose of P), P_3 (50% of Farmers dose of P), P_4 (100% RDP), P_5 (75% RDP) and P_6 (50% RDP) and its time of application viz., T_1 (No. of splits as per farmers practice) and T_2 (Basal Application). A common dose of N and K_2O was applied to all the treatments the details of the treatment combinations and amount of P fertilizers applied under different treatments are presented in Table 1.

Results and Discussion

Current Status of Fertilizer Use by Rice Growing Farmers

The fertilizer use trends in the surveyed region indicated that, the total (N, P_2O_5 and

K_2O) fertilizer use by farmers was highest in all the villages, with an average of 131, 85 and 76 kg N, P_2O_5 and K_2O kg ha^{-1}. The recommended NPK fertilizer application rate for rice is 120-60-40 kg N, P_2O_5 and K_2O ha^{-1}, respectively. Thus, application of NPK fertilizers is higher than crop demand. These results also indicated that application of phosphorus fertilizer by farmers was almost two times higher than the crop requirement. The difference in phosphorus application between farmers practice and recommended dose of phosphorus is about 25 kg P_2O_5 ha^{-1}, which is equal to 42 %. These results are in conformity with the findings of Swamy and Rao (1995) who have reported that more than half of the farmers surveyed indicated that they were using increased rates of fertilizers inspite of higher costs of these materials.

This survey also revealed that, farmers applying are P fertilizer in split doses through complex fertilizers because they perceive that P is required throughout the crop growth period like nitrogen. However, according to many researches, application of P at the time of transplanting is the recommended practice for paddy. The survey indicated, majority of the rice growing farmers (44 %) in this area applying p fertilizers at basal and top dressing at early tillering stage. Whereas 26, 10, 10, 6, and 4 % of the farmers applying P fertilizers at basal, basal + mid tillerig, basal+mid tillering + panicle initiation, basal + early tillering + panicle initiation and basal + panicle initiation stages, respectively.

The average of 50 farmer's phosphorus fertilizer application dose *i.e.* 85 kg P_2O_5 ha^{-1} was described as 100 % farmer's dose of P fertilizer application for conducting field experiment on rice in P accumulated soil. With respect to time of P fertilizer application, majority of the farmer's practice two equal splits at basal and at top dressing at early tillering stage (14 to 20 DAT) was decided as per the objective laid out in the experiment.

Available Phosphorus (kg P_2O_5 ha^{-1})

The available P_2O_5 content in soil increased by 47 % from planting to 30 DAT, remained slightly decreased from 30 DAT to 90 DAT and decreased to its original content by post-harvest time (Table 2). The available phosphorous content in soil increased with increase in P level from 50 to 100 % in both the cases, registering highest values with application of 100 % farmers dose (P_0). Among the phosphorus levels, P_1 (100 % farmers dose) has recorded highest available phosphorus at 30 DAT (105.2 kg ha^{-1}), 60 DAT (92.25 kg ha^{-1}), 90 DAT (83.50 kg ha^{-1}) and after harvest (76.80 kg ha^{-1}) while the lowest was recorded in P_6.

The buildup of available P_2O_5 status was 44.5, 26.7, 14.7 and 5.5 per cent at 30, 60, 90 DAT and after harvest, respectively due to application of 100 % farmer's dose when compared to the initial nutrient status of 72.8 kg P_2O_5 ha^{-1}. In P accumulated soil, P fixation sites are already saturated with native soil P, hence the external applied P directly absorbed by the plants. Lesser fixation of applied P might be the cause of higher buildup of applied P in soil having higher initial available P. The contribution of P from reserved soil pool to the crop was also higher with the increase in initial soil available P status. Both the extent of initial available P in soil and the levels of P applied to this soil resulted in increase in soil P fertility for crop growth.

With respect to time of P application, farmers practice of split application recorded significantly highest available soil phosphorus status (95.44 kg ha^{-1}) when compared to basal P application. However, it was not significant at 60, 90 DAT and at harvest. The application of P at the vegetative growth stage of the plants maintained a higher value of available P_2O_5 in soil up to 60 days after transplanting. Beneficial effect of P application at this stage of growth of plant might be attributed to the greater content of available P in soil during this period. The results are in conformity with the findings of Nandi and Madal (1979). At early stage (30 DAT), the available P_2O_5 content was maximum when all the P was applied in two equal splits as basal and top dressing, however at later stages it was not significant. Similar results reported by Basak and Battacharya (1962). However, in certain studies, full dose of P as basal resulted highest available P content in soil (Chandrasekaran and Raj, 1970 and Verma *et al.*, 2002).

Grain and Straw Yield (t ha^{-1})

The results revealed that there was significant increase in rice grain and straw yield with application of different levels of phosphorus. However, time of application of phosphorus and their interaction effects were found to be non-significant. The mean grain yield of the crop was highest (6.41 t ha^{-1}) when 100 % farmers dose of P was supplied to the crop but at the same time it was found to be on par with the application of 100 % RDP (6.38 t ha^{-1}), 75 % farmers dose (6.37 t ha^{-1}) and 75 % RDP (6.34 t ha^{-1}). Lower grain yield was recorded in 50 % RDP (5.83 t ha^{-1}) which was significantly lower than the rest of the treatments (Table 3&4).

The data also indicate that, the yield level that could be achievable with 100 % farmers dose of P (85 kg P_2O_5 ha^{-1}) to P accumulated soil can be obtained with a lower dose of 75 % RDP (45 kg P_2O_5 ha^{-1}) supplied to the same crop and thus saving 40 kg of cost of P input in P accumulated soil. These observations point out that, there is a possibility of reducing the farmer's dose and recommended dose of P by 40 kg (48 % of farmer's dose) and 15 kg (25 % of RDP) P_2O_5 ha^{-1}, respectively without sacrificing the yield of rice crop grown on P accumulated soils.

Table.1 Phosphorus nutrient use under different treatments

Treatments	Total P_2O_5 applied (kg ha^{-1})		
	Basal	**Topdressing**	**Total**
P_1 T_1	42.50	42.50	85.00
P_1 T_2	85.00	-	85.00
P_2 T_1	32.00	32.00	64.00
P_2 T_2	64.00	-	64.00
P_3 T_1	21.25	21.25	42.50
P_3 T_2	42.50	-	42.50
P_4 T_1	30.00	30.00	60.00
P_4 T_2	60.00	-	60.00
P_5 T_1	22.50	22.50	45.00
P_5 T_2	45.00	-	45.00
P_6 T_1	15.00	15.00	30.00
P_6 T_2	30.00	-	30.00

Table.2 Effect of levels of phosphorous and its time of application on P uptake (kg ha^{-1}) by rice at different growth stages of rice

P Levels	30 DAT			60 DAT			90 DAT			At Harvest					
										Grain			Straw		
	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean	T_1	T_2	Mean
P_1	5.43	4.36	**4.90**	17.83	17.36	**17.60**	24.80	20.33	**22.57**	15.12	13.58	**14.55**	15.96	15.58	**15.77**
P_2	4.79	4.25	**4.52**	17.34	14.83	**16.09**	22.28	19.81	**21.04**	15.68	12.95	**14.32**	13.66	13.49	**13.58**
P_3	3.23	2.78	**3.01**	12.30	11.00	**11.65**	15.65	13.87	**14.76**	10.08	8.60	**9.34**	10.56	10.32	**10.44**
P_4	5.07	4.16	**4.62**	16.28	14.59	**15.43**	22.19	19.49	**20.84**	14.60	13.04	**13.82**	16.79	14.35	**15.57**
P_5	4.68	3.79	**4.23**	15.17	13.38	**14.28**	21.87	18.33	**20.10**	13.22	11.23	**12.23**	16.18	14.83	**15.50**
P_6	3.09	2.63	**2.86**	12.40	10.58	**11.49**	16.70	13.82	**15.26**	9.57	9.13	**9.35**	10.99	11.20	**11.09**
Mean	4.38	3.66		15.22	13.62		20.58	17.61		13.11	11.42		14.02	13.29	

	S.Ed±	CD (0.05)	S.Ed±	CD (0.05)	S.Ed±	CD (0.05)	S.Ed±	CD (0.05)	S.Ed±	CD (0.05)
P	0.20	0.43	0.90	1.86	1.42	2.94	1.19	2.48	1.44	3.00
T	0.12	0.24	0.52	1.07	0.82	1.70	0.69	1.43	0.83	NS
PXT	0.29	NS	1.27	NS	2.01	NS	1.69	NS	2.03	NS

Table.3 Effect of levels of phosphorous and its time of application on grain yield (t ha^{-1}) of rice

Fertilizer Phosphorus Levels (t ha^{-1})	Time of P Application		Mean
	T_1: Farmer No. of splits	T_2: Basal Application	
P_1: 100 %Farmer dose (85 kg P_2O_5 ha^{-1})	6.43	6.39	6.41
P_2: 75 % of Farmers dose (63 kg P_2O_5 ha^{-1})	6.42	6.32	6.37
P_3: 50% of Farmers dose (42 kg P_2O_5 ha^{-1})	6.11	6.06	6.08
P_4: 100% RDP (60 kg P_2O_5 ha^{-1})	6.41	6.35	6.38
P_5: 75% RDP (45 kg P_2O_5 ha^{-1})	6.37	6.31	6.34
P_6: 50% RDP (30 kg P_2O_5 ha^{-1})	5.85	5.81	5.83
Mean	6.27	6.21	
	S.Ed±	**CD (0.05)**	
P	0.08	0.17	
T	0.05	N.S.	
PXT	0.11	N.S.	

Note: Farmer No. of Splits: 50 % Basal + 50 % at Early Tillering Stage

Table.4 Effect of levels of phosphorous and its time of application on straw yield (t ha^{-1}) of rice

Fertilizer Phosphorus Levels (t ha^{-1})	Time of P Application		Mean
	T_1: Farmer No. of splits	T_2: Basal Application	
P_1: 100 %Farmer dose (85 kg P_2O_5 ha^{-1})	7.70	7.65	7.67
P_2: 75 % of Farmers dose (63 kg P_2O_5 ha^{-1})	7.69	7.59	7.64
P_3: 50% of Farmers dose (42 kg P_2O_5 ha^{-1})	7.33	7.33	7.33
P_4: 100% RDP (60 kg P_2O_5 ha^{-1})	7.68	7.62	7.65
P_5: 75% RDP (45 kg P_2O_5 ha^{-1})	7.61	7.59	7.60
P_6: 50% RDP (30 kg P_2O_5 ha^{-1})	7.30	7.27	7.28
Mean	7.55	7.51	
	S.Ed±	**CD (0.05)**	
P	0.06	0.13	
T	0.03	N.S.	
PXT	0.08	N.S.	

The results of this finding also corroborate earlier finding of Babu *et al.,* (2004), Kumar *et al.,* (2015) and Meena *et al.,* (2014). Higher yields associated with higher levels of P are obviously due to better root growth and increased uptake of nutrients favoring better of the crop.

With respect to time of P application, farmers practice of P *i.e.,* two equal splits at basal and top dressing at early tillering stage (14 to 20 DAT) along with first top dressing of N after the first weeding recorded highest grain and straw yield (6.27 and 7.55, t ha^{-1}, respectively) which was on par with complete P as basal application (6.21 and

7.51 t ha^{-1}, respectively). Based on the results, it can be inferred that, P is more absorbed in first 20 DAT for root growth and penetration. The P absorbed during the early tillering stage of long duration rice var. BPT 5204 was more efficiently utilized for grain production. The results revealed that, soil having high P supplying capacity top dressing may be done without decrease in yield. This positive relationship of two splits of P was reported by Rao *et al.,* (1973) at basal and 21 DAT, Ramaiah (1979a) at basal and top dressing at 30 DAT and Budhar (1992) at basal and tillering stage. Similar positive results in three splits of P were reported by Singh *et al.,* (1988) and Yadav *et al.,* (2004) and four splits of P were reported by Thakur (1993). Non-significant differences in grain yield due to split application were also reported by Balasubramanian *et al.,* (1982), Sahu and Sahoo (1969) and Reddy *et al.,* (1984). The interaction of levels of P with its time of application found to be non-significant.

The results on grain yield concluded that, there is a possibility of saving of P fertilizers from current recommended dose and farmer's dose without sacrificing the yield of rice crop grown on P accumulated soils. Hence the application of 75 % RDP may be recommended for rice grown in P accumulated soil under Nizamabad condition. With respect to time of P application, the split application also be followed successfully in rice crop without any adverse effect on grain yield of rice grown in P accumulated soil.

Further Research

From the present study, the following may be the thrust areas for future line of research.

A lot of information on the effect of levels of P on performance of rice in P deficient soil and less or no recommendations were developed on P accumulated soil.

Dry matter yield and P uptake by the grain was significantly higher in split application than the treatment receiving basal P although this had no significant influence on the increase in grain yield of rice.

To prove this statement more investigations on this topic are needed.

The present study has not taken into account the high P effect on eutrophication of water bodies due to loss of P from top soil to into water. Hence, a continuous monitoring and surveillance programme is highly warranted for determining the human health risk by considering P exposure due to various sources.

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