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RESEARCH ARTICLE :

Effect of dose and time of application of phosphorus on changes in phosphorus uptake pattern and yield of rice grown on P accumulated soil

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SUMMARY : 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.Based on the survey data, the average of 50 farmers P fertilizer dose (85 kg P_2O_5 ha^{-1}) was fixed as 100 % farmer's dose and majority of the farmers practice *i.e.* two equal splits at basal and at top dressing at early tillering stage (14 to 20 DAT) was decided as farmer practice of splitsfor conducting field experiment on rice in P accumulated soil. The field experiment was consisting of twelve treatment combinations with six 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). As part of this investigation,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}). This can be inferred as saving of P fertilizer to rice from current recommended dose and farmer's dose in soils having higher initial available P. 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.

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BACKGROUND AND OBJECTIVES

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 (Nambiar, 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.

RESOURCES 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.

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Survey experiment :

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. The details of the treatment combinations and amount of P fertilizers applied under different treatments are presented in Table 1.

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

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 2 and 3).

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. 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 favouring 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,

Table 2: Effect of levels of phosphorus 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.E.±		C.D. (P=0.05)
P	0.08		0.17
T	0.05		NS
P x T	0.11		NS

Note: Farmer No. of splits **:** 50 % basal + 50 % at early tillering stage NS= Non-significant

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 (1979) 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 Balasubramaniyan *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.

Changes in phosphorus uptake pattern of rice:

The P uptake of rice plant increased upto 90 DAT and then decreased at harvest. P uptake increased with increasing levels of phosphorus and its time of application at all the stages of crop growth except in straw at harvest, where in P uptake was not significantly influenced by time of P application.Application of 100 % farmers dose (P_1) recorded highest P uptake by rice plant at 30 (4.90 kg ha^{-1}), 60 (17.60 kg ha^{-1}), 90 DAT (22.57 kg ha^{-1}), grain (14.55 kg ha^{-1}) and straw (15.57 kg ha^{-1}) at harvest, respectively while the lowest was recorded in P_6 (Table

Table 3: Effect of levels of phosphorus 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.E.±	C.D. (P=0.05)	
P	0.06	0.13	
T	0.03	NS	
P x T	0.08	NS	

NS= Non-significant

Table 4 : Effect of levels of phosphorus 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			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.E.±		C.D. (P=0.05)	S.E.±		C.D. (P=0.05)	S.E.±		C.D. (P=0.05)	S.E.±		C.D. (P=0.05)	S.E.±		C.D. (P=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
P x T	0.29		NS	1.27		NS	2.01		NS	1.69		NS	2.03		NS

NS= Non-significant

4). The favourable effect of higher availability of phosphorus in soil and different levels of P applied on dry matter production and content ultimately reflected in significant increase in P uptake by rice. Similar increase in P uptake by rice plant due to application of P was reported by Agarwal (1980); Babu *et al.* (2005) and Subbian *et al.* (1989).

With respect to time of P application, farmers practice of split application recorded highest P uptake at 30 (4.38 kg ha^{-1}), 60 (15.22 kg ha^{-1}), 90 DAT (20.58 kg ha^{-1}) and grain (13.11 kg ha^{-1}) at harvest and were significantly superior over basal application of P. The per cent increase being 19.6, 11.7, 16.87 and 14.80 at 30, 60, 90 DAT and grain at harvest, respectively over their corresponding basal application. The results also indicated that, 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 straw uptake at harvest. P absorbed during the early tillering stage through top dressing is directly translocated to the grain and was adequate to improve the P uptake.

These observations along with yield data of rice in high P soil indicated that top dressing at early stages maintaining higher level of available P in soil helps in realization of maximum P uptake. Tandon (1987) opined that the modern high yielding varieties continue to absorb P till maturity and almost 70-80 % of the absorbed P ends up in the panicles and ear heads. The positive effect of split application at basal and maximum tillering stage on P uptake was reported by Ramaiah (1979). Sometimes delayed or split application of P is reflected in better P uptake rather than in higher yields, which was evident in the present study and is in agreement with the findings of Srujana *et al.* (2013); Goswami and Kamath (1984) and Raju *et al.* (1983).

Conclusion:

The results on grain yield and uptake of rice 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.

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