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Research Communication

Influence of sources and rates of phosphorus on plant growth, productivity and economics of aerobic rice (*Oryza sativa*)

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ABSTRACT

A field experiment was conducted at New Delhi in rainy (*kharif*) season of 2013 to study the effect of 2 sources of phosphorus, viz. rock phosphate (RP) and di-ammonium phosphate (DAP), 2 levels of phosphorus viz. 15 and 30 kgP/ha and 2 microbial inoculants viz. phosphate-solubilizing bacteria (PSB) and arbuscular mycorrhizal fungi (AMF) in different combination along with control on growth, productivity and economics of aerobic rice (*Oryza sativa* L.). Seed was inoculated with liquid formulation of PSB @ 250 ml/ha before sowing and AMF was applied @ 12 kg/ha in the furrows at the time of sowing. Recommended doses of N (120 kg/ha) and K (40 kg/ha) were applied in all the treatments. Results revealed that plant height, tillers/plant, dry-matter/plant, panicle/plant and yield (5.62 t/ha) of aerobic rice increased significantly due to application of 30 kg P/ha through RP + PSB + AMF. There was significant increase in plant height, tillers, dry-matter, number of panicles and grain yield of aerobic rice with increase in P application rate from 15 kg P/ha to 30 kg P/ha applied either through DAP or RP. The application of 30 kg P/ha through RP + PSB + AMF resulted in highest net return (139.0 × 10^3 ₹/ha) of aerobic rice.

Key words : Aerobic rice, Arbuscular mycorrhizal fungi, Phosphorus solubilizing bacteria, Rock phosphate

Phosphorus (P) deficiency has been recognized as one of the main limiting factors in upland rice production in many parts of the world (Sahrawat *et al.,* 1995). P deficiency can be rectified with supplying phosphate to the soils but a large portion of soluble inorganic phosphate applied to the soil as chemical fertilizer is immobilized rapidly and becomes unavailable to plants (Goldstein, 1986). Rock phosphate (RP) is cheapest P containing fertilizer but completely insoluble in soil hence, there is growing interest in manipulating RP by biological methods in order to enhance its solubilization and agronomic effectiveness (Whitelaw, 2000). Micro-organisms especially phosphate-solubilizing bacteria (PSB) and arbuscular mycorrhizal fungi (AMF) have the ability to solubilize P in soil and reduce burden of chemical fertilizers (Arpana and Bagyaraj, 2007). With this background, the present study was undertaken to investigate the effect of microbial inoculants with RP in supplying the P and find out the optimum application rate for higher plant growth and yield of aerobic rice.

A field experiment was conducted during rainy (*Kharif*) season (June-November) of 2013 at the research field of ICAR-Indian Agricultural Research Institute, New Delhi. The soils of experimental field had 142.3 kg/ha alkaline permanganate oxidizable N, 13.46 kg/ha available P, 252.2 kg/ha 1N ammonium acetate exchangeable K and 7.7 pH. The experiment was laid out in randomized block design with fifteen treatments including P control, phosphate-solubilizing bacteria (PSB), arbuscular mycorrhizal fungi (AMF), PSB + AMF, 15 kg P/ha through rock phosphate (RP), 30 kg P/ha through RP, 15 kg P/ha through di-ammonium phosphate (DAP), 30 kg P/ha through DAP, 15 kg P/ha through RP + PSB, 15 kg P/ha through RP + AMF, 15 kg P/ha through RP + PSB + AMF, 30 kg P/ha through RP + PSB, 30 kg P/ha through RP + AMF, 30 kg P/ha through RP + PSB + AMF and P on soil test basis. The rice variety 'Pusa Basmati 1509' was sown at 20 cm row to row spacing on 26 June, 2013. Seed rate of 40 kg/ha was used. Liquid formulation of PSB was inoculated with seed at 250 ml/ha before sowing and AMF was applied in the furrows at the time of sowing at 12 kg/ha. N (120 kg/ha) and K (40 kg/ha) were applied in all treatments

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and P was applied as per the treatments. Observations on plant growth, yield attributes, yield and economics were recorded as per standard procedures.

Results showed that plant growth parameters, viz. plant height, dry matter and leaf area index were lowest with control treatment and increased significantly with increasing rates of P up to 30 kg P/ha (Table 1). Yield attributes like effective tillers, number of grains/panicle, weight of panicle etc. were significantly higher with 30 kg P/ha through RP + PSB + AMF over the other treatments while there was no significant difference in test weight with application of 30 kg P/ha through RP + PSB + AMF over 30 kg P/ha through DAP. Inoculation of microbial inoculants like PSB showed the beneficial effect on P release from RP and significantly enhanced plant growth and yield attributes of aerobic rice as compared to non-inoculated treatments. Qurban *et al.* (2011) also reported similar results. Enhanced amount of soluble P in the soil solution and increased in plant biomass proved that application of microbial inoculants along with rock phosphate had a

Table 1. Effect of rate and sources of phosphorus on growth and yield attributes at maturity of aerobic rice

Treatment	Height (cm)	Tillers/ m^2	Dry matter (g/m^2)	LAI	No. of panicles/ m^2	Weight/ panicle (g)	Panicle length (cm)	Total grains/ panicle	Filled grains/ panicle	Test weight (g)
P_0	84.7	280	782	4.08	240	2.45	24.3	86	78	21
PSB @ 250 ml/ha	93.6	312	985	4.18	272	2.58	25.7	90	80	22
AMF @ 12 kg/ha	88.9	286	972	4.15	246	2.46	25.2	89	79	22
PSB@ 250 ml/ha + AMF @ 12 kg/ha	94.1	353	988	4.25	313	2.70	25.8	90	82	22
15 kg P/ha through RP	94.6	360	992	4.75	320	2.72	26.0	92	83	23
30 kg P/ha through RP	102.0	383	1105	5.14	347	2.89	27.5	98	88	24
15 kg P/ha through DAP	96.5	376	1042	5.09	336	2.75	26.3	93	83	23
30 kg P/ha through DAP	102.4	383	1120	5.63	347	2.91	29.0	99	90	24
15 kg P/ha through RP + PSB	95.8	363	997	5.09	323	2.73	26.3	92	83	23
15 kg P/ha through RP + AMF	97.1	382	1044	5.10	343	2.75	26.5	94	84	23
15 kg P/ha through RP + PSB + AMF	101.2	383	1096	5.13	347	2.88	27.0	95	86	24
30 kg P/ha through RP + PSB	103.8	390	1142	6.12	354	3.10	30.0	106	97	25
30 kg P/ha through RP + AMF	103.6	387	1141	6.02	352	3.10	29.3	103	92	25
30 kg P/ha through RP + PSB + AMF	105.7	399	1145	6.13	364	3.13	30.0	111	100	25
P on soil test basis	103.0	385	1132	5.66	349	3.03	29.0	102	91	25
SEm±	0.22	4.11	5.97	0.04	4.11	0.04	0.20	0.86	1.38	0.34
CD (P=0.05)	0.63	11.89	17.29	0.11	11.89	0.12	0.58	2.48	4.0	0.98

Table 2. Effect of rate and sources of phosphorus on grain and straw yield and economics of aerobic rice

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Cost of cultivation ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
P_0	3.83	6.63	36.2	38.7	86.2	2.23
PSB @ 250 ml/ha	3.95	6.94	36.3	38.8	90.1	2.32
AMF @ 12 kg/ha	3.89	6.84	36.3	39.3	87.6	2.23
PSB@ 250 ml/ha + AMF@ 12 kg/ha	3.97	6.98	36.6	39.4	90.1	2.29
15 kg P/ha through RP	4.44	6.98	38.6	39.4	104.2	2.64
30 kg P/ha through RP	4.93	7.25	40.9	40.1	118.6	2.95
15 kg P/ha through DAP	4.56	7.08	39.1	40.2	107.2	2.67
30 kg P/ha through DAP	5.24	7.27	41.0	41.9	126.1	3.01
15 kg P/ha through RP + PSB	4.53	7.08	38.9	39.5	106.9	2.71
15 kg P/ha through RP + AMF	4.65	7.10	39.4	40.0	110.1	2.75
15 kg P/ha through RP + PSB + AMF	4.75	7.15	40.1	40.2	113.0	2.81
30 kg P/ha through RP + PSB	5.57	7.50	43.2	40.3	138.0	3.43
30 kg P/ha through RP + AMF	5.45	7.39	42.9	40.8	133.8	3.28
30 kg P/ha through RP + PSB + AMF	5.62	7.57	43.4	40.9	139.0	3.40
P on soil test basis	5.45	7.27	42.1	40.0	134.3	3.36
SEm±	0.03	0.05	0.27	-	-	-
CD (P=0.05)	0.09	0.14	0.77	-	-	-

positive effect on plant growth parameters and yield attributes.

Grain and straw yields of aerobic rice increased significantly due to the inoculation of PSB and AMF with 30 kg P/ha through RP over P control (Table 2). The highest grain and straw yields and harvest index (HI) were obtained with the 30 kg P/ha through RP + PSB + AMF treatment and these were statistically higher than application of 30 kg P through DAP. The increase in yield might be due to the improvement in leaf photosynthetic rate, biomass production and sink formation, which promoted the grain and straw yields of aerobic rice. Besides P solubilization activity, PSB liberates phytohormone (IAA) that might have an influence on root growth and yield. The extensive root system increased nutrient uptake from the surroundings which boosted plant biomass and subsequently the yield of aerobic rice. These results were alike with the findings of Panhwar *et al.* (2010). The highest net return was obtained with 30 kg P/ha through RP + PSB + AMF and 30 kg P/ha through DAP gave 9.2% less return. The highest benefit: cost ratio was obtained with the 30 kg P/ha through RP + PSB treatment but it was close to 30 kg P/ha through RP + PSB + AMF. Meena *et al.* (2014) also reported similar results.

It was concluded that integrated application of 30 kg P/ha through RP + PSB + AMF is not only effective in supplying P from low cost RP for better growth and yield of aerobic rice crop but economical also as compared to others treatments. Liquid PSB was efficient microbial inoculants in solubilization of insoluble P from RP in aerobic rice soil.

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