Original Research Article

Effect of Rock Phosphate, Single Super Phosphate and Phosphorus Solubilizing Bacteria on phosphorus concentration and dry matter yield of paddy

ABSTRACT

A pot experiment was conducted in Department of Soil Science and Agricultural Chemistry of College of Agriculture, Central Agricultural University, Imphal (Manipur) during kharif season of 2021 to study the effect of rock phosphate (RP), single super phosphate (SSP) and phosphorus solubilizing bacteria (PSB) on phosphorus concentration and dry matter yield of paddy. A total of 198 plastic pots were procured and each pot was filled with 5 kg of air-dried soil. To each experimental pot, recommended dose (RD) of 60 kilograms of N ha^{-1} in the form of urea and 30 kg K_2O ha^{-1} in the form of muriate of potash were applied as basal and thoroughly mixed with the soil. Rock phosphate and SSP were administered to the pots as phosphorus sources according to different sets of treatment based on the recommended amount of 40 kg P_2O_5 ha^{-1} for paddy. Seeds were treated with PSB (*Bacillus megatherium*). Result revealed that the changes in soil phosphorus concentration and dry matter yield of paddy were significantly affected by RP applied either singly or in combination with SSP and PSB. All the parameters showed different trend of changes during the whole crop growth stages till harvest. Among the treatments higher values were recorded in soil treated with T_{10} (50% RD of P_2O_5 from SSP + 50% RD of P_2O_5 from RP + PSB). Addition of PSB enhances release of less soluble and fixed forms into easily available form as well as reduces P fixation. Efficiency of rock phosphate as P source for crop production is improved by the solubility effect of PSB.

Keywords: Rock Phosphate, Single super phosphate, Phosphorus Solubilizing Bacteria, Paddy, Total phosphorus, Dry matter

1. INTRODUCTION

Rice is the most important human food crop in the world, directly feeding more people than any other crop. Rice production in India is an important part of the national economy. India is the world's 2nd largest producer with approximately 43 mha planted area, accounting for 22% of the world's rice production. Rice is a basic food crop and being a tropical plant, it flourishes in hot and humid climate. It can be grown under diverse soil and climatic conditions. Developing resourceful fertilizers and fertilization methods are imperative considerations for sustainable rice production (Slaton, 2011).

Phosphorus is one of 17 nutrients essential for plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next. Phosphorus occurs in soil in a wide range of organic and inorganic compounds. Both organic as well as inorganic forms of phosphorus are found as compounds with aluminium (Al), iron (Fe), and calcium (Ca).

These compounds affect the availability of phosphorus to plants. Acidic soils commonly have large reserves of ‘fixed’ P that could support long term crop requirements if it could be mobilized through appropriate soil management involving organic matter additions and/or use of P solubilizing microbes. Options for P inputs are organic materials, mineral P fertilizers or phosphate rocks (PR). P availability in soil is often a limiting factor for plant growth, even though the total amount of soil P may be great. Its availability is governed by solubility and how readily phosphorus becomes fixed in soils (Manimaran, 2014). The high cost of soluble phosphate fertilizer such as single or triple super phosphate has generated considerable interest in the utilization of rock phosphate. Rock phosphate is considered as slow releasing P source and commonly cannot supply P in the rate as per crop requirement (Bhattacharyya and Singh, 1990). Several groups of micro-organisms (fungi, bacteria, actinomycetes) are known to help dissolve fixed P. In association with phosphate solubilizing microorganisms and organic manure, RP could be used as a P source in many crops (Wahid *et al*., 2015). Phosphobacterins in general have been found effective in solubilizing inorganic P in the soils. Proper soil management through integrated use of efficient phosphatic biofertilizers along with inorganic sources of P fertilizers may increase the production of rice crop in the country. Integrated use of chemical fertilizers and phosphatic biofertilizer may be a good option to increase the use efficiency of chemical P fertilizer by rice crops. But information is scanty on use of efficient PSB strain as phosphatic biofertilizer for rice cultivation.

Keeping the above points in view, the investigation was undertaken to study the effect of rock phosphate, single super phosphate and phosphorus solubilizing bacteria on total phosphorus concentration and dry matter yield of paddy (variety CAU-R1) grown in soil of Manipur, India.

2. MATERIALS AND METHODS

A pot experiment was conducted during the *Kharif* season of 2021 to investigate the effect of applied rock phosphate, single super phosphate and phosphorus solubilizing bacteria on phosphorus concentration and dry matter yield of paddy (variety CAU-R1). Composite soil samples (0–15 cm depth) were collected from the Research farm, College of Agriculture, Central Agricultural University, Imphal, Manipur, India following the standard process as described by Jackson (1973). The general characteristics of the experimental soil were: sand (28.20%), silt (22.50%), clay (49.30%), soil texture (clayey), pH (5.20), EC (0.31 dSm^{-1}), CEC [14.92 cmol(p+) kg^{-1}], organic carbon (1.65%), available N (263.42 kg ha^{-1}), available P_2O_5 (22.76 kg ha^{-1}) and available K_2O (211.73 kg ha^{-1}) (Table 1).

A total of 198 plastic pots were procured and each pot was filled with 5 kg of air-dried soil. To each experimental pot, recommended dose (RD) of 60 kilograms of N ha^{-1} in the form of urea and 30 kg K_2O ha^{-1} in the form of muriate of potash were applied as basal and thoroughly mixed with the soil. Rock phosphate and SSP were administered to the pots as phosphorus sources according to different sets of treatment based on the recommended amount of 40 kg P_2O_5 ha^{-1} for paddy. Seeds were treated with PSB (*Bacillus megatherium*) collected from the department of Plant Pathology, College of Agriculture, CAU, Imphal, Manipur, India). The inoculated seeds were dried under shade and four seeds per pot were sown immediately. After germination, a single healthy seedling was retained

Table 1: General characteristics of the soil used in the experiment

Soil property	Results	Remarks
Soil Texture:		
Sand (%)	28.20	
Silt (%)	22.50	Clayey Soil
Clay (%)	49.30	
pH (1:2.5 soil: water ratio)	5.20	Acidic
EC (1:2.5 soil: water ratio, dSm^{-1})	0.31	No deleterious effect on crops
CEC (cmol(p+) kg-1)	14.92	
Organic carbon (%)	1.65	High

Available nitrogen (kg ha^{-1})	263.42	Medium
Available phosphorus (kg ha^{-1})	22.76	Medium
Available potassium (kg ha^{-1})	211.37	Medium

throughout the experiment. The soils of each treatment were kept at submergence during the entire experiment. The experiment was conducted in a completely randomized block design replicated thrice. The treatments were: T_1= Control, T_2= 100% RD of P_2O_5 from SSP, T_3= 100% RD of P_2O_5 from RP, T_4= 75% RD of P_2O_5 from SSP + 25% RD of P_2O_5 from RP, T_5= 50% RD of P_2O_5 from SSP + 50% RD of P_2O_5 from RP, T_6= 25% RD of P_2O_5 from SSP + 75% RD of P_2O_5 from RP, T_7=100% RD of P_2O_5 from SSP + PSB, T_8=100% RD of P_2O_5 from RP + PSB, T_9=75% RD of P_2O_5 from SSP + 25% RD of P_2O_5 from RP + PSB, T_{10}=50% RD of P_2O_5 from SSP + 50% RD of P_2O_5 from RP + PSB, T_{11}=25% RD of P_2O_5 from SSP + 75% RD of P_2O_5 from RP + PSB.

The soil samples were collected on 25^{th}, 50^{th}, 75^{th} and 100^{th} days after sowing seeds (DAS) and at harvest from the rhizosphere region by destructive sampling to estimate available phosphorus. Different soil parameters like soil texture (hydrometer method), pH (1:2.5 soil: water suspension using glass electrode systronic pH meter), EC (1:2.5 soil: water suspension using systronic direct reading conductivity meter), organic carbon (Walkley and Black`s rapid titration method, 1934), cation exchange capacity (leaching with 1N NH_4OAc), available N (alkaline potassium permanganate), P (Bray and Kurtz No.1, 1945) and K (flame photometrically by using extractant 1N NH_4OAc) were estimated as described by Jackson (1973).

Plant fresh weight, dry weight and dry matter yield were also recorded on 25^{th}, 50^{th}, 75^{th} and 100^{th} days after sowing seeds (DAS) and at harvest. Plant samples were digested in di-acid mixture of nitric acid and perchloric acid in 4:1 ratio and was analyzed in the digested plant materials by Vanadomolybdo phosphoric yellow colour method as described by Jackson (1973).

The experiment was carried out under completely randomized design (CRBD).Data obtained from the experiment were statistically analyzed through analysis of variance technique for comparing the effects of the treatments. The significance of various effects was tested at 5% level of probability (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

3.1. TOTAL PHOSPHORUS IN PLANT

Data on changes in P concentration in paddy grown in soil treated with SSP, RP and PSB are presented in Table 2. Results revealed that irrespective of different treatments, there was an increasing trend up to 50^{th} day with decline up to 100^{th} day followed by a slight increase at harvest. Exhibition of P decline with crop age was also reported earlier by Delin and Zhu (1996). All phosphorus applied treatments shows significantly higher total-P accumulation over control. Similar reports on higher P concentration in rice plants receiving P sources was also presented by White *et al*. (1999) and Banerjee and Pramanik (2009) and Vandamme *et al*. (2016). Molla *et al.* (1984); Gaur (1990) and Adhikari *et al.* (2014) recorded that introduction of P solubilizing microorganisms in the rizhosphere of crop and soil increases the availability of P from insoluble sources of phosphates, desorptions of fixed phosphates and also increases the efficiency of phosphorus fertilizers. Application of PSB significantly enhanced plant plant total P concentration comparing with the corresponding treatment without PSB at different stages of crop growth. Supportive reports were also given earlier by Costa *et al.* (2015). Soil fertilized with T10 (50%SSP + 50%RP + PSB) shows comparatively higher accumulation of total P at all the growth stages starting from 50^{th} day up to harvest. At 50^{th} day, among the PSB untreated soils T4 (75% SSP + 25% RP) show greater concentration which was at par with T5 (50% SSP + 50% RP).

Table 2: Changes in total phosphorus in paddy plant (mg kg^{-1})

Treatment	Sampling Days				
	25DAS	50DAS	75DAS	100DAS	HARVEST

T_1	514.30	675.60	537.00	201.67	259.33
T_2	566.47	709.53	641.60	256.50	283.40
T_3	555.83	728.63	667.53	252.63	315.57
T_4	540.57	742.70	655.23	244.03	327.40
T_5	575.07	737.33	666.70	264.50	349.63
T_6	613.77	741.10	675.60	252.97	332.72
T_7	532.80	723.93	667.37	253.57	357.62
T_8	636.70	732.53	682.80	275.53	354.33
T_9	640.13	764.13	678.17	283.47	415.40
T_{10}	641.81	777.77	685.47	311.47	440.07
T_{11}	630.63	752.23	680.60	284.83	430.92
S.E.d(±)	3.41	3.69	3.62	2.67	4.42
$CD_{0.05}$	7.07	7.65	7.50	5.55	9.16

3.2. DRY MATTER YIELD

Data on dry matter yield of paddy grown in soil treated with SSP and RP in presence or absence of PSB are presented in Table 3. Results revealed that irrespective of different treatments, there was an increasing trend of dry matter of paddy up to harvest. The rise of rice dry matter with crop growth was also reported by Liu and Zhu (1996). Comparing with the untreated control all phosphorus treated soil gave significantly higher dry matter yield of paddy at different stages of crop growth. This is at par with the findings of Muraoka *et al*. (2002); Poleshi *et al*. (2008) and Banerjee and Pramanik (2009). Among the different treatments, significantly higher dry matter of paddy was recorded in soil applied with T9 (75% SSP + 25% RP + PSB) on 50th day followed by T10 (50%SSP + 50%RP + PSB). Also, further analysis of the data revealed more dry matter accumulation in paddy grown in T10 (50%SSP + 50%RP + PSB) treated soil on 100th day and at harvest which is at par with T9 (75% SSP + 25% RP + PSB) and T11 (25% SSP + 75% RP + PSB), respectively. Results further revealed that significantly higher dry matter yield of paddy was recorded in paddy grown in T2 (100% SSP) treated soil than that in T3 (100% RP). Enhanced agronomic effectiveness of rock phosphate was reflected in increased dry matter yield (Ikerre *et al.,* 1994). It was further observed that application of PSB increased significantly dry matter yield of paddy comparing with the corresponding phosphorus treated soil without PSB from 50th day onward till harvest. The increased in yield under rock phosphate and PSB application could be due to the continued availability of P that helped in the proliferation of root development and hence better nutrient acquirement and biomass accumulation (Egamberdiyeva *et al.* 2004; Saleem *et al*., 2013; Yu *et al*., 2014 and Costa *et al*., 2015).

Table 3: Changes in dry matter yield (g plant^{-1}) content in paddy plant

TREATMENTS	SAMPLING DAYS				
	DAYS AFTER SOWING				
	25	**50**	**75**	**100**	**HARVEST**
T1	2.44	4.37	8.63	21.68	27.68
T2	2.58	5.64	10.59	23.51	31.79
T3	3.44	5.47	10.37	22.53	32.95
T4	3.34	6.67	11.28	23.75	34.12
T5	3.46	5.69	11.27	24.60	34.86
T6	3.47	6.63	11.50	24.62	36.58
T7	3.52	6.55	11.92	24.75	40.80

T8	3.66	7.54	12.16	25.09	42.32
T9	3.52	7.66	12.30	25.56	41.54
T10	3.87	7.56	12.72	26.65	43.33
T11	3.54	7.46	12.46	25.56	42.70
S.E.d(±)	0.13	0.12	0.25	0.14	0.22
CD(p=0.05)	0.25	0.25	0.51	0.29	0.46

4. CONCLUSION

With the observation of above revealed results it is opined that application of single superphosphate, rock phosphate and phosphorus solubilizing bacteria significantly influenced phosphorus concentration and dry matter yield of paddy variety CAU-R1 and higher values are recorded in soil treated with T_{10} (50% RD of P_2O_5 from SSP + 50% RD of P_2O_5 from RP + PSB). Agronomic efficiency of rock phosphate is enhanced by the combined application with single superphosphate and phosphorus solubilizing bacteria. There is significant increase in total P concentration and dry matter yield in rock phosphate and SSP fertilized soil in presence or absence of PSB over the control at different growth stages of the plant.

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