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Effect of organic and inorganic amendments on yield and phosphorus nutrition of rice under Red and Laterite Zone of West Bengal

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ABSTRACT

A pot culture experiment was carried out at the Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during Rabi season 2015 to evaluate the effect of organic and inorganic amendments on yield and phosphorus nutrition of rice cv. Shatabdi under Red and Laterite Zone of the State. There were six treatments with or without application of a consortium of phosphate solubilising bacteria (Pseudomonas spp.) Among different treatments, the application of silicon through calcium silicate with FYM (T5) recorded highest uptake of phosphorus in rice. P content in rice straw as well as grain was also increases significantly with the inoculation of PSB. Interaction between treatments and PSB inoculation exhibited a positive significant effect on phosphorus uptake and content in rice. The correlation between available phosphorus and plant parameters was positive and significant. Multiple regression analysis revealed that the positive influence of available P at tillering stage on grain yield and about 75 per cent of the variability in grain yield could be explained by given relationship.

***Keywords*: Available phosphorus, inoculation, phosphate solubilizing bacteria, silicon and uptake**

Phosphorus is one of the most important major nutrients required for growth and development of crop plants. While phosphorus is one of the most immobile, inaccessible, and unavailable nutrients in the soil, it plays a vital role in virtually every plant process like photosynthesis, energy storage and transfer, stimulating root development and growth, giving plant rapid and vigorous start leading to better tillering in rice and encouraging earlier maturity and seed formation. Deficiency of soil phosphorus is one of the important chemical factors restricting plant growth. Therefore, sufficient quantity of soluble form of phosphorus fertilizers is applied to achieve maximum plant productivity. However, the applied soluble forms of phosphatic fertilizers rapidly become unavailable to plants by conversion into inorganic P fractions that are fixed by chemical adsorption and precipitation.

Phosphorus solubilizing microorganisms (bacteria and fungi) enable P to become available for plant uptake after solubilization. Several soil bacteria, particularly those belonging to the genera *Bacillus* and *Pseudomonas*, and fungi belonging to the genera, *Aspergillus* and *Penicillium* possess the ability to convert insoluble phosphates in soil into soluble forms by secreting organic acids such as formic, acetic, propionic, lactic, glycolic, fumaric, and succinic acids. In a study carried out by Venkateswarlu *et al.* (1984) have reported that during solubilization of rock phosphate by fungi, the pH of the culture decreased from 7 to 3. Available literature also suggested significant increase in grain and straw yields of rice due to inoculations (Kundu and Gaur, 1984).

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The present investigation was thus carried out to evaluate the effect of organic and inorganic amendments on phosphorus uptake in rice crop grown in an *Alfisol* soil collected from Red and Laterite zone of West Bengal.

The pot culture experiment was conducted in the net house of the Department of Agricultural Chemistry and Soil Science, BCKV, Nadia, West Bengal during *Rabi* season in 2015 in an *Alfisol* soil. The soil was typical lateritic soil (*Typic Haplustalf)* growing rice with good drainage facilities and texturally classified as sandy loam. Six treatments *viz*., T_1= Control (without any amendments); T_2= Silicon @ 25mg kg^{-1} through calcium silicate]; T_3= Silicon @ 25mg ha^{-1} through rice straw]; T_4= Organic manure @ 3.75g kg^{-1} through FYM [7.5 t ha^{-1}]; T_5= Silicon @ 25mg kg^{-1} through calcium silicate [50kg ha^{-1}] + organic manure @ 3.75 g kg^{-1} through FYM [7.5 t ha^{-1}] ; T_6= Silicon @ 25mg ha^{-1} through rice straw [50kg ha^{-1}] + organic manure @ 3.75g kg^{-1} through FYM [7.5t ha^{-1}] were tested with or without application of a consortium of phosphate solubilising bacteria (*Pseudomonas* spp.). Thus, a total of 12 treatment combinations were replicated thrice and laid out in a Completely Randomised Design.

Fully decomposed organic manure (FYM) and silicon (through chopped rice straw) were incorporated into the pots at the time of soil filling. Common dose of Nitrogen (100kg ha^{-1}), Phosphorus (50 kg ha^{-1}) and Potassium (50 kg ha^{-1}) were applied to all pots through Urea, DAP and MOP, respectively. While one half of fertilizer N, full doses of P and K were applied as basal dose and the other one half of nitrogen was applied at 21 days after transplanting of seedlings.

Rice variety *Shatabdi* was grown to maturity following standard cultural practices. Soil and plant samples were collected from the pots at the time of maximum tillering (30 DAT), flowering (60 DAT) and at harvesting stages (90 DAT) by following standard technique.

The bulk surface soil (0-15 cm) was collected from rice growing low land from Jhargram in the Red and Laterite Zone of West Bengal. Six kg air dried soil was filled in plastic pots (capacity 10 kg) and saturated with water for 21 days. After decomposing organic manure and straw (as source of silicon), yes because chopped rice straw decompose easily four healthy 21day old rice seedlings were transplanted in each pot and thinned to two plants per pot after panicle initiation stage. Pots were irrigated with water as and when required. Biological parameter *i.e.* plant height, number of tillers and number of panicles were recorded during harvesting stage of the crop. Grain yield and straw yield were recorded at harvesting stage after proper drying. Phosphorus uptake in grain and rice straw during harvesting stage were calculated.

The collected soil samples from pots were air dried, ground, passed through a 2 mm sieve and stored temporarily in polyethylene bags. The experimental soil was a sandy loam having sand – 68.16%, silt-12.00% and clay-19.84% (Bouyoucous, 1962) with acidic reaction (pH- 5.23) (Jackson, 1973); low organic carbon content (0.42 %) (Walkley and Black, 1934); medium available nitrogen (290 kg ha^{-1}) (Subbiah and Asija, 1956); low available potassium (ammonium acetate extractable) (100 kg ha^{-1}) (Jackson, 1973) and high available P (34.24 kg ha^{-1}) (Olsen *et al.*, 1954). The data generated were analyzed following standard statistical methods meant for completely randomized design.

The effect of organic and inorganic amendments on P content and uptake of grain and straw of rice crop are presented in the table-1. Total phosphorus concentration in rice straw and rice grain at harvest stage ranged from 0.08 to 0.13 and 0.10 to 0.15 per cent respectively. Application of silicon (through rice straw) in combination with organic manure (T_6) recorded highest content of Total P in grain as well as straw. At harvest stage, the phosphorus uptake (mg pot^{-1}) in rice grain and straw significantly increased with the application of silicon (through calcium silicate) along with organic manure (T_5) because the preference of silicon for positive site is greater than phosphate so iron and aluminium ions get adsorbed with silicon and release phosphate to the soil solution. The recorded total uptake of phosphorus was also highest in the T_5. Application PSB along with different treatments promoted microbial environment in rhizosphere, increased the solubility of insoluble phosphates resulting significant increase in P uptake in rice straw as well as grain.

Better supply of nutrients through incorporation of organic manures (FYM) could be ascribed to conducive physical environment leading to better root activity and higher nutrient absorption. This could have resulted in higher nutrient uptake of rice observed in this experiment. Similar results were reported by Laxminarayan and Patiram (2006).

Inoculation of phosphate solubilizing bacteria had a significant effect on different yield attributing parameters of rice. In agreement with the results reported by Lal (2002), phosphate solubilizing bacteria could have synthesized growth promoting substances and produced vitamins, that augmented proper root growth and nutrient solubility, resulting in better nutrient uptake and in turn, improved yield attributes and grain and straw yield.

Interaction among treatments and PSB significantly influenced the content and uptake of phosphorus by rice crop (Table 2). Total phosphorus content of rice straw and grain during harvest stage ranged from 0.08 to 0.14 and 0.09 to 0.17 per cent, respectively.

Table 1: Effect of different treatments on content and uptake of phosphorus in rice crop

Treatments	Grain yield (g pot^{-1})	Straw yield (g pot^{-1})	Straw P (%)	Grain P (%)	P uptake in straw (mg pot^{-1})	P uptake in grain (mg pot^{-1})	Total P uptake (mg pot^{-1})
T_1	7.80	5.71	0.09	0.11	5.20	8.36	13.55
T_2	8.70	6.19	0.08	0.10	5.15	8.52	13.67
T_3	8.47	4.85	0.08	0.10	4.08	8.31	12.39
T_4	12.74	5.55	0.12	0.14	6.70	18.15	24.85
T_5	13.74	7.17	0.11	0.13	8.18	18.66	26.84
T_6	12.02	5.59	0.13	0.15	7.27	18.41	25.69
Mean	**10.58**	**5.84**	**0.10**	**0.12**	**6.10**	**13.40**	**19.50**
SEm (±)	**0.33**	**0.61**	**0.01**	**0.02**	**0.85**	**2.01**	**2.62**
LSD (0.05)	**0.98**	**1.77**	**0.04**	**0.05**	**2.49**	**5.87**	**7.64**
			PSB				
Without	10.10	5.27	0.10	0.11	4.67	11.49	16.25
With	11.05	6.41	0.11	0.13	7.43	15.32	22.75
Mean	**10.58**	**5.84**	**0.10**	**0.12**	**6.10**	**13.40**	**19.50**
SEm (±)	**0.19**	**0.35**	**0.01**	**0.01**	**0.49**	**1.16**	**1.51**
LSD (0.05)	**0.56**	**1.02**	**0.02**	**0.03**	**1.44**	**3.39**	**4.41**

Table 2: Effect of treatments and PSB interaction on content and uptake of phosphorus in rice crop

Treatment × PSB	Straw P (%)	Grain P (%)	P uptake in straw (mg pot^{-1})	P uptake in grain (mg pot^{-1})	Total P uptake (mg pot^{-1})
T_1× PSB_0	0.09	0.10	3.87	7.08	10.96
T_1×PSB_1	0.10	0.12	6.52	9.63	16.15
T_2×PSB_0	0.09	0.10	6.14	8.07	14.21
T_2×PSB_1	0.08	0.09	4.16	8.97	13.12
T_3×PSB_0	0.09	0.11	4.09	8.81	12.90
T_3×PSB_1	0.08	0.09	4.08	7.81	11.89
T_4×PSB_0	0.10	0.12	4.20	14.99	19.18
T_4×PSB_1	0.14	0.17	9.20	21.32	30.52
T_5×PSB_0	0.09	0.10	5.23	13.83	19.06
T_5×PSB_1	0.14	0.16	11.13	23.49	34.62
T_6×PSB_0	0.12	0.14	5.07	16.13	21.19
T_6×PSB_1	0.14	0.17	9.48	20.70	30.18
Mean	**0.10**	**0.12**	**6.10**	**13.40**	**19.50**
SEm (±)	**0.02**	**0.02**	**1.20**	**2.84**	**3.70**
LSD (0.05)	**0.06**	**0.07**	**3.52**	**8.30**	**10.81**

*Note: *PSB-Phosphorus Solubilising Bacteria*

Table 3: Correlation coefficient (r) between available P at different growth stages and growth parameters of rice crop

Parameters	Av. P_Till	GY	SY	Straw P (%)	Grain P (%)	P uptake_ straw	P uptake_ grain	Total P uptake
Av. P_till	1.00							
Av. P_flow	0.86**							
GY	0.85**	1.00						
SY	NS	NS	1.00					
Straw P (%)	0.45**	0.43**	NS	1.00				
Grain P (%)	0.45**	0.42**	NS	0.99**	1.00			
P uptake_straw	0.44**	0.46**	0.64**	0.75**	0.75**	1.00		
P uptake_grain	0.69**	0.75**	NS	0.91**	0.91**	0.76**	1.00	
Total P uptake	0.65**	0.70**	NS	0.91**	0.91**	0.88**	0.98**	1.00

Note: **Till-tillering stage, Flow-flowering stage, Har-harvesting stage, GY-grain yield, SY- straw yield*

Table 4: Regression analysis between available P and plant parameters

Variables	Dependent variable	Beta value	Constant	Ad. R2
Available P at tillering	Grain yield	0.559	3.095	0.717
Available P at flowering	Total P uptake	0.759	2.623	0.488

The mean data of treatments revealed significant influence of amendments on phosphorus content of plants during harvest stage. Application of calcium silicate and organic manure (T5) along with PSB recorded the highest total P content in rice straw as well as grain. Interactive effect of T_5 and PSB also significantly increased P uptake in rice grain and straw at harvest stage. The total uptake of phosphorus at harvest stage ranged from 10.96 mg pot^{-1} (T_1) without PSB to 34.62mg pot^{-1} (T_5) with the application of PSB.

Correlation coefficient among available P in soil, grain yield, straw yield, P content in grain and straw and total P uptake by rice are presented in the table 3. Available phosphorus in soil at harvest had positive and significant correlation with available P at tillering stage (r = 0.816**) and at flowering (r=0.874**) stage; grain yield (r = 0.776**), P concentration in straw (r = 0.370*), P concentration in grain (r=0.367*), P uptake in straw (r=0.450**), P uptake in grain (r=0.596**) and total P uptake (r=0.583**). Positive relationship between available P in soil and uptake of P by rice crop could be the reason for the enhanced P content in rice (grain + straw) as well as yield.

Multiple regression analysis between available phosphorus in soil and growth parameters are presented in table 4. Regression analysis revealed positive influence of available phosphorus in soil at tillering stage on grain yield and about 75per cent of the variability in grain yield could be explained by this relationship. Significant influence of available P in soil at flowering stage on P uptake in grain and total P uptake at harvest of rice was also observed and about 58 and 53 per cent of the variability in grain yield could be explained by these relationships, respectively.

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