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Enriched Rock Phosphate as an Alternative P-Nutrition for Improving Wheat Productivity and Soil Health in Poplar + Wheat System

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ABSTRACT

A field experiment was conducted during r*abi* season of 2009-10 on an established plantation from 2006 at Agroforestry Research Centre, Haldi, G. B. Pant University of Agriculture and Technology, Pantnagar to evaluate the suitable sources of phosphorus nutrition on the yield of understorey wheat and soil physico-chemical properties under poplar–wheat system. Treatments *viz.*, single super phosphate (SSP) alone (@ 375 kg ha^{-1}), RP alone (@ 300 kg ha^{-1}), RP (@ 300 kg ha^{-1}) + FYM (@ 300 kg ha^{-1}), RP (@ 300 kg ha^{-1}) + FYM (@ 300 kg ha^{-1})+ PSB(@ 1 L ha^{-1}), RP (@ 300 kg ha^{-1})+ pressmud (PM) (@ 300 kg ha^{-1}) and RP(@ 300 kg ha^{-1}) + PM (@ 300 kg ha^{-1}) + PSB (@ 2 L ha^{-1}) and control (without tree or open condition and recommended phosphorus with SSP) were selected. Rock phosphate (RP) enriched with FYM + PSB had significantly highest wheat yield among all the treatments however, it was statistically at par with RP + PM + PSB. Rock phosphate (RP) enriched with FYM + PSB had recorded 16.49 % higher yield over SSP alone. Yield attributes like number of spikes, number grains per spike, 100 grain weight were found maximum with RP + FYM + PSB being statistically at par with all enriched treatments except RP alone and RP+ FYM. Among rock phosphate enriched treatments under poplar, the maximum cost of cultivation was recorded in RP + FYM + PSB and RP + PM+PSB whereas, the highest gross return, net return and benefit: cost ratio (1.53) were observed in RP + FYM + PSB. However, effects on tree growth and soil properties were non-significant. The overall results demonstrated that in Poplar-wheat system (5.0m×4.0m) enriched rock phosphate along with farm yard manure and phosphorus solubilizing bacteria can be used as alternate P-fertilizer for improving under storey wheat yield.

Keywords:

Phosphorous, poplar, wheat, yield

INTRODUCTION

Phosphorus deficiency is widespread in India with more than 50 percent of the farms severely deficient in P, with less than 5 ppm of available P when analysed by the Olsen's procedures. As a consequence, crop yields remain low. Under these conditions, P input is a must if

crop yields are to be improved. Although trees can add some P to the soil, this is mostly by recycling what is already there and not through new additions. The exception is biomass transfer. Even then, the amounts that can be added through the biomass of trees are often low. In addition, due to continuous use of chemical phosphatic fertilizers, the soil health as well as soil quality is going to deteriorate thus adversely affect the sustainability. Therefore, options for P inputs are chemical phosphatic fertilizers and natural rock phosphate (RP), depending on which is cost-effective and environmentally safe.

Rock phosphate is an alternate source of phosphorous for direct application because loosely consolidated aggregate of microcrystals with a relatively large specific surface area with greater proportion of isomorphic substitution (Zapata, 2003). It contains about 50% of its total P_2O_5 as tri-calcium phosphate, which is neither water soluble nor citrate soluble. But its solubility can be increased by adding acids or acid forming substances which increases phosphorous supplying power of rock phosphate in the presence of decaying organic matters. These organic matters while decomposing release CO_2, citric acid, malonic acid, fulvic acid and other organic acids which in turn attack insoluble tri-calcium phosphate in rock phosphate to convert them in to water and citric acid soluble form. Some microorganism like *Bacillus megatherium* var- *phosphaticum* and cellulose decomposing fungi *Phanerochaet chrysosporium* also enhances the phosphorous availability (Sekhar et al. 2002). Microbial solubilization of rock phosphates and use of acidulating materials like farmyard manure, crop residue and press mud are receiving greater attention these days.

Wheat (*Triticum aestivum* L.) is the most important food crop under agroforestry system in North India. In India it is widely intercropped cereal crop during rabi season (November-April) with poplar in Uttarakhand, Punjab, Haryana, U.P and Bihar, parts of M.P, Chhatisgarh and W.B. Therefore, enriched rock phosphate was tested in poplar-wheat system an alternative source of P - nutrition and to obtain the sustainability of phosphorus.

MATERIALS AND METHODS

The experiment was conducted during *rabi* season of 2009-10 at Agroforestry Research Centre (AFRC) of G.B.P.U.A. & T., Pantnagar, U.S. Nagar, Uttarakhand. Experimental soil was silty loam in texture with neutral in reaction (pH 7.5) having high organic carbon (0.88 %) and low in available nitrogen (225.27 kg ha^{-1}) and medium in available phosphorous (20.6 kg ha^{-1}) and potassium (184.57 kg ha^{-1}). The experiment was laid out in Randomized Block Design with 3 replications. Treatments *viz.*, single super phosphate (SSP) alone (@ 375 kg ha^{-1}), RP alone (@ 300 kg ha^{-1}), RP (@ 300 kg ha^{-1}) + FYM (@ 300 kg ha^{-1}), RP (@ 300 kg ha^{-1}) + FYM (@ 300 kg ha^{-1})+ PSB(@ 1 L ha^{-1}), RP (@ 300 kg ha^{-1})+ pressmud (PM) (@ 300 kg ha^{-1}) and RP(@ 300 kg ha^{-1}) + PM (@ 300 kg ha^{-1}) + PSB (@ 2 L ha^{-1}) and control (without tree or open condition and recommended phosphorus with SSP) were selected. Wheat variety PBW-502 was sown in the month of November at the row spacing of 22.5 cm following the seed rate of 100 kg ha^{-1} under poplar clone-G48 planted at 5.0m x 4.0 m spacing. Recommended rate of NPK (150 kg N/ 60 kg P_2O_5 and 40 kg K_2O ha^{-1}) was applied in wheat. Half of the nitrogen (75 kg ha^{-1}) through urea, entire quantity of phosphorus (60 kg ha^{-1}) and potassium (40 kg ha^{-1}) was applied at the time of sowing as basal dose. The remaining half quantity of nitrogen (75 kg ha^{-1}) was applied at the time of first irrigation. The field was flood irrigated three times during its growing season. Rock phosphate and their acidulating materials were mixed manually just before application and applied as per treatment. The growth and yield observations were recorded in net plot ($6m^2$) leaving one tree row on the sides of border. Grain, straw and biological yields (kg ha^{-1}) were determined on the net plot area basis. The soil samples were collected from the net plots after harvesting of the wheat crop for study the nutrient status and physic-chemical properties. Organic carbon was determined by the procedure of Walkley and Black (1934). Available N was determined by an alkaline permanganate method (Subbiah and Asija 1956). Available P was extracted using the Olsen reagent (Olsen *et al.* 1954) and determined with the help of a Spectronic 20-D at 660 nm wave length. Available K was

extracted with neutral ammonium acetate (Merwin and Peech 1951) and was determined by Flame-emission Spectrophotometry.

RESULTS AND DISCUSSION

In agroforestry system, wheat crop grown under poplar recorded lower yield than in control (without trees). Under open condition, growth characters, yield and yield attributes of wheat crop were higher in comparison to wheat grown under poplar trees. Per cent decrease in of 13.7-48.05 % was recorded in understorey wheat than open control.

Different enriched rock phosphate treatments significantly affected the plant height and number of tillers per m^2 of wheat crop at 90 DAS under poplar trees. Highest plant height was recorded with rock phosphate (RP) + FYM + PSB which was statistically *at par* with SSP alone and all the enrichment treatments except RP alone. However, number of tillers per m^2 were found maximum in RP + FYM + PSB being statistically at par with rock phosphate (RP) + press mud and rock phosphate (RP) + press mud + PSB (Table 1).

Effect of different rock phosphate enrichment treatments on wheat yield as well as yield attributes *viz*., number of fertile and sterile spikelets and test weight was significant (Table 1). Number of spikes per m^2 was found maximum with RP + FYM + PSB which was statistically at par with all enriched treatments except RP alone while number grains per spike and grain yield were found maximum with RP + FYM + PSB which was statistically at par with all enriched treatments except RP alone and RP+ FYM (Table 1). Rock phosphate (RP) enriched with FYM + PSB had significantly highest yield among all the treatments however, it was statistically at par with RP + PM + PSB. Rock phosphate (RP) enriched with FYM + PSB had recorded 16.49 % higher yield over SSP alone. It is because of acidulating materials, which reduces the phosphorous fixation capacity of soil and make them available to plants (Mclean and Ssali 1977).

Table 1: Growth, yield attributes and yields of wheat as influenced by different P-fertilizers under poplar –wheat system

Treatments	90 DAS		No. of spikes m^{-2}	Fertile spike lets $spike^{-1}$	grains $spike^{-1}$	1000 grain weight (g)	Grain yield (q ha^{-1})	Per cent decrease in yield over control
	Plant height (cm)	Tillers count m^{-2}						
Control (Open)	106.4	515	438	17	37	52.3	38.5	-
Under Poplar								
SSP alone	98.0	429	378	14	28	49.0	28.5	25.97
RP alone	96.5	390	309	13	27	46.6	20.0	48.05
RP+FYM	97.0	425	346	14	27	47.8	26.0	32.47
RP+FYM+PSB	102.5	495	388	15	34	50.8	33.2	13.77
RP+Press Mud	97.0	465	360	15	31	50.2	28.8	25.19
RP+Press Mud+PSB	101.0	469	391	14	30	50.1	31.6	17.92
SEm ±	1.2	15	14	1.1	2.0	2.3	1.9	-
C.D. (5%)	2.1	46	43	NS	7.0	NS	6.1	-

Table 2: Crop economics and soil properties as influenced by different P-fertilizers under poplar-wheat system

Treatments	Economics		pH	EC (ds m^{-1})	OC (%)	Avail N (kg ha^{-1})	Avail P (kg ha^{-1})	Avail K (kg ha^{-1})
	Gross Return (GR) (Rs. ha^{-1})	B:C ratio						
Initial	-	-	7.5	0.39	0.88	205.27	20.89	200.57
Control (Open)	56525.0	1.90	7.5	0.37	0.86	194.23	18.64	189.95
Under Poplar								
SSP alone	44425.0	1.28	7.5	0.37	0.87	197.57	19.12	192.64
RP alone	34375.0	0.77	7.5	0.38	0.88	198.26	19.59	194.35
RP+FYM	41525.0	1.12	7.5	0.37	0.86	198.03	19.82	196.91
RP+FYM+ PSB	50070.0	1.53	7.4	0.39	0.89	204.27	19.94	193.25
RP+Press Mud	44880.0	1.29	7.4	0.39	0.87	199.06	20.30	196.54
RP+Press Mud+PSB	48135.0	1.43	7.4	0.38	0.87	203.32	19.82	196.05
SEm ±			0.13	0.01	0.01	1.4	0.5	1.7
C.D. (5%)			NS	NS	NS	NS	NS	NS

Similar result was reported by Marwaha (1981) and Verma et al. (1987). Application of phosphorous solubilizing bacteria alone and along with FYM and press mud recorded 0.7, 5.5 and 5.5 % higher grain yield over rock phosphate alone. This is mainly attributed to the microorganism, caused excretion of organic acid like glutanic acid, succinic acid, lactic acid, oxalic acid, glyoxalic acid, maleic acid, fumaric acid, tartaric acid, -ketobutyric acid, propionic acid and formic acid. These acids solubilize the phosphorous and make them available to the plant. Since this reaction take place in the rhizosphere and because of microorganism render more phosphorous in to soil solution than is require for their own growth and metabolism. This surplus amount of phosphorous becomes available to plant (Singh and Kapoor 1999). This could be probably due to more growth and development of plants that had become possible due to more phosphorous availability.

Gross return and benefit: cost ratio was found higher in control in comparison to rock phosphate enrichments. Among rock phosphate

Table 3. Mean tree diameter (cm), height (m) of poplar under varying treatments.

Treatments	Diameter (cm/tree)	Height (m)
SSP alone	13.2	14.2
RP alone	12.8	13.7
RP+FYM	13.4	14.1
RP+FYM+PSB	13.1	15.6
RP+Press Mud	12.4	15.4
RP+Press Mud+PSB	13.0	14.8
SEm ±	0.43	1.1
C.D. (5%)	NS	NS

enriched treatments, the maximum cost of cultivation (Rs. 17323.70) was recorded in RP + FYM + PSB and RP + PM+PSB whereas, the highest gross return (Rs. 50070.00) and benefit: cost ratio (1.53) were observed in RP + FYM + PSB (Table 2).

Different rock phosphate enriched treatments had non-significant effect on soil properties after cop harvesting, however, Organic carbon, Available N, P and K were found to be higher under tree as compared to control (Table 2). The tree mean diameter (cm tree^{-1}) at standard (1.37m) breast height was maximum under RP+FYM followed by SSP alone. However, Height was highest in RP+FYM+PSB followed by RP+Pressmud (Table 3).

From this experiment it may be concluded that rock phosphate enriched with FYM + PSB is better source for P-nutrition for obtaining higher wheat yield and B: C ratio under poplar-wheat system.

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