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Effect of different sources of phosphorus with and without PSF on available nutrient content of soil and its influence on growth and yield of rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted at AHRS, Kathalagere, during *kharif* 2014, to study the effect of different sources of phosphorus with and without PSF on release of available phosphorus and its influence on growth and yield of rice. The effect of different sources and levels of phosphorus @ 40, 50 and 60 kg ha^{-1} P_2O_5 as rock phosphate applied in the form of nutriphos with or without PSF were tried along with single super phosphate in a randomized complete block design comprising eight treatments replicated thrice.
The highest value for nitrogen, phosphorus, calcium and magnesium was recorded (149.38,72.59kg ha^{-1},4.38, 3.58 cmol (p^+) kg^{-1}, respectively) in the treatment which received 50 kg ha^{-1} P_20_5 through rock phosphate applied in the form of nutriphos + PSF and lowest values of available nutrients were recorded where treatment (T_3) where 40 kg ha^{-1} P_2O_5 through rock phosphate in the form of nutriphos. Positive and significant correlation was observed between uptake of nitrogen, phosphorus and potassium and grain yield (r=0.933**, 0.876** and 0.854**respectively). Similar results were found by Ravindra and Ananthanarayana (1999) and Saavedra and Delgado (2005).

Keywords: phosphorus, PSF, nutrient, soil, growth, yield, *Oryza sativa* L.

Introduction

Phosphorus (P) is found in soil, plant and in microorganisms in a number of organic and inorganic compounds. It is second only to nitrogen as an inorganic nutrient required by plants and microorganisms, its major physiological role being in certain essential steps in the accumulation and release of energy during cellular metabolisms. Phosphorus is an essential constituent of adenosine triphosphate (ATP), adenosine diphosphate (ADP), nucleotides, nucleic acids and phospholipids. Phosphorus is involved in energy storage and transfer and membrane integrity. It promotes tillering, root development, early flowering and ripening (especially where the temperature is low). Phosphorus also increases straw strength and provide disease resistance. The Phosphorus is added to the soil in the form of chemical fertilizers, or by manures in the form of leaf litter, plant residues or animal remains. Thus Phosphorus occupies a critical position both in plant growth and in the biology of soil.

Crops cannot absorb insoluble forms of phosphorous and has to be converted into soluble forms by phosphatase enzyme such as acidic and alkaline phosphatase. Several soil microorganisms like fungus particularly those belonging to phosphate solubilizing fungus (*Aspergillus sp*), possess the ability to solubilize insoluble inorganic phosphate and make it available to plants, Hedley *et al.* (1982) [5]. Application of rock phosphate along with PSF has been found to increase the availability of P to rice under low land condition and Phosphorous solubilizing organisms have been used to increase the availability of P to crops in several countries.

Keeping these points in view, present investigation was carried out to study the "Effect of different sources of phosphorus with and without PSF on release of phosphorus and its influence on growth and yield of rice (*Oryza sativa* L.)" at AHRS, Kathalagere, Davanagere district during *kharif* 2014, with the following objectives. 1. To study the effect of different sources of phosphorus and PSF on soil properties under rice. 2. To study the effect of different sources of phosphorus and PSF on growth and yield of rice and 3. To study the effect of different sources of phosphorus and PSF on releasing pattern of phosphorus in rice.

Materials and Methods

A field experiment was conducted to study the effect of different sources of phosphorus and PSF on releasing pattern of phosphorus and its influence on growth and yield of rice during the *kharif* 2014 at Agricultural and Horticultural Research Station (AHRS) Kathalgere, which comes under University of Agricultural and Horticultural Sciences, Shivamogga and belongs to Southern Transitional Zone (zone-7) of Karnataka. It is situated at 12º 45' to 13º 57' north latitude and 76º 45' to 78º 24' east longitude with an altitude of 584.3 meters above mean sea level. A total rainfall of 605.8 mm was received in 82 rainy days during the year of investigation. As against the actual rainfall, the highest rainfall was recorded in the month of August 238.9 mm. The experiment with rice crop (*Oryza sativa*, L) var. JGL-1798 was laid out in Randomized Complete Block Design (RCBD) with three replications which includesT_1: RDF (P applied in the form of SSP),$T_{2:}$ P applied in the form of SSP + PSF (*Aspergillus awamori*), T_3: 40 kg ha^{-1} P_20_5 through rock phosphate, T_4: 50 kg ha^{-1} P_20_5 through rock phosphate, T_5: 60 kg ha^{-1} P_20_5 through rock phosphate, T_6: T_3 + PSF (*Aspergillus awamori*), T_7: T_4 + PSF (*Aspergillus awamori*) and T_8: T_5 +PSF (*Aspergillus awamori*) with recommended N, K and FYM are common to all the treatments. The growth parameters *viz.*, few plants were randomly selected to recorded the plant height and number of tillers $plant^{-1}$ were recorded on five randomly selected plants from each net plot at tillering, panicle initiation and at harvest stages of the crop.

Table 1: Initial soil properties of experimental site

Soil properties	Values
Texture	Sandy clay loam
Sand	72.54
Silt	9.25
Clay	18.21
pH (1:2.5)	5.6
EC (dS m^{-1})	0.05
Organic Carbon (g kg^{-1})	3.3
Av. N (Kg ha^{-1})	191.6
Av. P_2O_5 (Kg ha^{-1})	43.64
Av. K_2O (Kg ha^{-1})	180.46
Exchangeable Ca (cmol (p^+) kg^{-1})	4.5
Exchangeable Mg (cmol (p^+) kg^{-1})	3.8
Av. S (mg kg^{-1})	10.75

The soil samples were collected after the harvest of crops and analyzed for pH, EC, OC, available N, P, K, Ca, Mg and S. The soil pH was determined in 1:2.5 soil: water suspension by potentiometric method using glass electrode (Jackson, 1973). Electrical conductivity (1:2.5 soil-water extract) was determined using Conductivity Bridge and expressed as dSm^{-1} (Jackson, 1973) [6]. The soil organic carbon of a soil finely ground and sieved through 0.2mm was determined by Walkely and Black wet-oxidation method as described by Jackson (1973) [6], available nitrogen was determined by modified alkaline permanganate method as described by Subbaiah and Asija (1956) [17]. Available phosphorus using a spectrophotometer (Jackson, 1973) [6], available potassium was determined by flame photometer as described by Page *et al*., (1982) [10]. Available sulphur was determined by turbido metric method using $CaCl_2$ as an extractant as outlined by Jackson (1973) [6], All analysis was carried out on the three replicates. The data were analyzed statistically by the analysis of variance (ANOVA) procedure. The treatment effects were declared as significant at 5% probability levels

Results and Discussion

Effect of different sources P with and without PSF on yields of rice: Among the different sources tried, the higher grain and straw yield was noticed in (T_7) with the application of 50 kg ha^{-1} P_2O_5 through rock phosphate applied in the form of nutriphos + PSF, as compared to conventional sources like SSP. It may be due to partial fixation of P from the water soluble sources consequent to the prevailing acid soil pH (lower soil pH). The lower grain and straw yield was noticed in treatment which received 40 kg ha^{-1} P_2O_5 through rock phosphate in the form of nutriphos (T_3). It may be due to the presence of higher amount of citrate soluble phosphorus in rock phosphate. The results of the present investigation are in agreement with Jagadesh *et al.* (1986) and Khalil *et al.* (2002). The increase in yield could be attributed to the supply of calcium and other micronutrients from rock phosphate. The higher grain and straw yield in PSF treated plots in comparison with untreated plots could be due to chelation of iron and Aluminum ions with Organic anions produced during microbial decomposition Organic manure might have increased P availability rendering low fixation. The results are in agreement with the findings of Didiek *et al.* (2000) [4] and Kucey *et al.* (1988) [8].

Available nitrogen: Data pertaining to the available nitrogen content in soil after harvest of rice are presented in Table 4. Available nitrogen status in soil was found to be non-significant among the different treatments. The nitrogen content of soil ranged from 149.38 to 133.73 kg ha^{-1}. The highest available nitrogen content (149.38 kg ha^{-1}) was recorded in the treatment which received 50 kg ha^{-1} P_2O_5 through rock phosphate in the form of nutriphos + PSF and the lowest available nitrogen content (130.33 kg ha^{-1}) was recorded in the treatment (T_3) where 40 kg ha^{-1} P_2O_5 through rock phosphate in the form of nutriphos. The highest available nitrogen after harvest it might be due to the phosphorus fertilization which helps in promoting root growth and efficient function of PSF which in turn increases microbial activity and thus increases nitrogen availability in the soil. Similar results were also found by Singaram and Kothandaraman (1992) [14] and Sheela (2006) [13].

Available phosphorus: Data pertaining to the available phosphorus content in soil after harvest of rice crop as influenced by various treatments in rice are presented in Table 4. The highest available phosphorus content in soil (72.59 kg ha^{-1}) was recorded in the treatment which received 50 kg $ha^{-1}$$P_2O_5$ through rock phosphate in the form of nutriphos+ PSF and it was on par with the treatment where60 kg ha^{-1} P_2O_5 through rock phosphate in the form of nutriphos + PSF which recorded (70.23 kg ha^{-1}). Lowest available phosphorus content (54.19 kg ha^{-1}) was recorded in treatment which received P applied in the form of SSP and it was on par with the treatment where 40 kg ha^{-1} P_2O_5 through rock phosphate applied in the form of nutriphos (55.37 kg ha^{-1}).The highest available phosphorus status might be due to the increased availability of P in soil due to higher application of P and enhanced phosphorus availability by the mineralization of organic phosphorus in soil and solubilization of precipitated phosphate (Chen *et al.*, 2006) [3]. The lower P availability is due to the high fixation phosphorus due to water soluble SSP sources in acid soils.

Available potassium: Data on available potassium content in soil after harvest of crop are presented in Table 4. Available potassium status in soil was found to be non-significant among the different treatments. The phosphorus content of soil ranged from 139.93 to 125.98 kg ha^{-1}. The highest available potassium content (139.93 kg ha^{-1}) was recorded in the treatment where P applied in the form of SSP + PSF and the lowest (125.98 kg ha^{-1}) was recorded in the treatment where 40 kg ha^{-1} P_2O_5 through rock phosphate in the form of nutriphos + PSF applied plot. The highest available K might be due to the high microbial activity. The low K availability might be due to low P application without PSF and more uptake. Similar results have also been reported by Singh *et al.* (2004) [15] and Bhunia *et al.* (2006) [1].

Exchangeable Calcium: The data pertaining to the exchangeable calcium content in soil after harvest of rice crop as influenced by various treatments are presented in Table 5. Highest exchangeable calcium content (4.38 cmol (p^+) kg^{-1}) was recorded in the treatment where 60 kg ha^{-1} P_2O_5 through rock phosphate in the form of nutriphos and it was on par with 50 kg ha^{-1} P_2O_5 through rock phosphate in the form of nutriphos which recorded (4.35 cmol (p^+) kg^{-1}). The lowest (3.69 cmol (p^+) kg^{-1}) was recorded in treatment where P applied in the form of SSP, and it was on par with the treatment whereP applied in the form of SSP + PSF (3.71cmol (p^+) kg^{-1}).The highest exchangeable calcium might be due to the rock phosphate fertilizers contains higher amount of calcium in it. In comparison to conventional phosphorus sources like SSP. Similar results have also been reported by (Sperber, 1957 and Taha *et al.*, 1969) [16].

Exchangeable Magnesium: The data pertaining to the exchangeable magnesium content in soil after harvest of rice crop as influenced by various treatments is presented in Table-5. Highest exchangeable magnesium content (3.58 cmol (p^+) kg^{-1}) was recorded in the treatment where60 kg ha^{-1} P_2O_5 through rock phosphate applied in the form of nutriphos and it was on par with 50 kg ha^{-1} through rock phosphate in the form of nutriphos which recorded (3.55 cmol (p^+) kg^{-1}). The lowest (2.89 cmol (p^+) kg^{-1}) was recorded in treatment where P applied in the form of SSP and it was on par with the treatmentP applied in the form of SSP + PSF (2.91cmol (p^+) kg^{-1}).The highest exchangeable calcium might be due to the rock phosphate fertilizers contains higher amount of calcium in the nutriphos as compared to the SSP, Similar results have also been reported by (Sperber, 1957 and Taha *et al.*, 1969) [16].

Available sulphur: The data pertaining to the available sulphur content in soil after harvest of rice crop as influenced by various treatments is presented in Table-5. Highest available sulphur (13.23 mg kg^{-1}) was recorded in the treatment where P applied in the form of SSP + PSF. The lowest available sulphur was recorded in the treatment where 40 kg ha^{-1} P_2O_5 through rock phosphate applied in the form of nutriphos (9.86 mg kg^{-1}).The highest available sulphur might be due to phosphorus fertilization helps in promoting root growth which leads to increased sulphur content, and presences of high amount sulphur in SSP. Similar results have also been reported by (Sperber, 1957 and Taha *et al.*, 1969) [16].

Relationship between grain yield and available nutrients: Simple correlation coefficient (r) observed between grain yield and available nutrients are presented in Table 6. Grain yield had positively correlated with the available Nitrogen (r = 0.465), available potassium (r= 0.167), available Sulphur (r = 0.309), available Calcium (r = 0.208) and available Magnesium (r = 0.208), while it was positively and significantly correlated with available phosphorus (r = 0.719**). Similar results were found by Lopez Pineiro and Garcia Navarro (2001) [9].

Table 2: Effect of different sources of phosphorus with and without PSF on soil properties after harvest of the rice crop

Treatments	pH	EC (dS m^{-1})	OC (g kg^{-1})
T_1: RDF (P applied in the form of SSP)	5.44	0.05	3.20
T_2: P applied in the form of SSP + PSF (*Aspergillus awamori*)	5.57	0.05	3.29
T_3: 40 kg ha^{-1} P_2O_5 through rock phosphate	5.44	0.04	3.48
T_4: 50 kg ha^{-1} P_2O_5 through rock phosphate	5.40	0.04	3.52
T_5: 60 kg ha^{-1} P_2O_5 through rock phosphate	5.38	0.04	3.59
T_6: T_3 + PSF (*Aspergillus awamori*)	5.46	0.05	3.65
T_7: T_4 + PSF (*Aspergillus awamori*)	5.43	0.05	3.83
T_8: T_5 + PSF (*Aspergillus awamori*)	5.38	0.05	3.87
SEm±	0.05	0.002	0.02
CD @ 5%	NS	NS	0.05

NS = Non significant

Table 3: Effect of different sources of phosphorus with and without PSF on yield attributes of grain and straw (q ha^{-1}) yield of rice

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1: RDF (P applied in the form of SSP)	54.49	65.37
T_2: P applied in the form of SSP + PSF (*Aspergillus awamori)*	59.55	73.42
T_3: 40 kg ha^{-1} P_2O_5 through rock phosphate	50.54	61.49
T_4: 50 kg ha^{-1} P_2O_5 through rock phosphate	53.71	65.07
T_5: 60 kg ha^{-1} P_2O_5through rock phosphate	53.47	67.22
T_6: T_3 + PSF (*Aspergillus awamori*)	53.71	72.46
T_7: T_4 + PSF (*Aspergillus awamori*)	61.27	76.86
T_8: T_5 + PSF (*Aspergillus awamori*)	60.45	75.60
SEm±	1.53	1.49
CD @ 5%	4.67	4.53

Table 4: Effect of different sources of phosphorus with and without PSF on availability of primary nutrients status in soil after harvest of the paddy crop

Treatment	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})
T_1: RDF (P applied in the form of SSP)	133.73	54.19	138.63
T_2: P applied in the form of SSP + PSF (*Aspergillus awamori*)	140.93	59.48	139.93
T_3: 40 kg ha^{-1} P_2O_5through rock phosphate	130.33	55.37	139.39
T_4: 50 kg ha^{-1} P_2O_5 through rock phosphate	135.82	59.67	138.36
T_5: 60 kg ha^{-1} P_2O_5 through rock phosphate	138.26	60.90	136.01
T_6: T_3 + PSF (*Aspergillus awamori*)	139.52	65.42	125.98
T_7: T_4 + PSF (*Aspergillus awamori*)	149.38	72.59	134.41
T_8: T_5 + PSF (*Aspergillus awamori*)	145.11	70.23	130.93
SEm±	5.80	1.10	12.66
CD @ 5%	NS	2.37	NS

NS = Non significant

Table 5: Effect of different sources of phosphorus with and without PSF on availability of secondary nutrients status after Harvest of the paddy crop

Treatments	Exch. Ca	Exch. Mg	Available S (mg kg^{-1})
	[cmol (p$^+$) kg^{-1}]		
T_1: RDF (P applied in the form of SSP)	3.69	2.89	13.13
T_2: P applied in the form of SSP + PSF (*Aspergillus awamori)*	3.71	2.91	13.23
T_3: 40 kg ha^{-1} P_2O_5 through rock phosphate	4.21	3.41	9.86
T_4: 50 kg ha^{-1} P_2O_5 through rock phosphate	4.35	3.55	10.32
T_5: 60 kg ha^{-1} P_2O_5 through rock phosphate	4.38	3.58	10.59
T_6: T_3 + PSF (*Aspergillus awamori*)	4.17	3.37	10.22
T_7: T_4 + PSF (*Aspergillus awamori*)	4.26	3.46	10.49
T_8: T_5 + PSF (*Aspergillus awamori*)	4.19	3.39	10.70
SEm±	0.018	0.018	0.028
CD@ 5%	0.054	0.054	0.087

Table-6: Correlation coefficient (r) between grain yield and available nutrients after harvest of rice

Available nutrients	r value
Nitrogen	0.465
Phosphorus	0.719*
Potassium	0.167
Calcium	0.208
Magnesium	0.208
Sulphur	0.309

Note: *-significant @ 5 percent: **-significant @ 1 percent

Conclusion

Application of different sources of phosphorus with and without PSF on available nutrient content of soil and its influence on growth and yield of rice (*Oryza sativa* L.) concluded that higher values of available N, P, K, Ca and Mg content were obatained where treatment received50 and 60 kg ha^{-1} P_20_5 through rock phosphate was applied along with PSF respectively.

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