International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(6): 319-322

Received: 16-09-2018
Accepted: 18-10-2018

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Phosphorus management influence on partial factor productivity and agronomic efficiency in rice

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Abstract
A field experiment was conducted in rice at Agricultural College Farm, Bapatla, ANGRAU, during 2016-17 and 2017-18 in order to investigate the effect of sources and variable levels of phosphorus on grain yield, agronomic efficiency and partial factor productivity of rice. Maximum partial factor productivity and agronomic efficiency was obtained with the combination of PSB @ 750 ml ha^{-1} + 30 kg P_2O_5 which was closely followed by green manuring + PSB along with 30 kg P_2O_5.

Keywords: Phosphorus, partial factor productivity, agronomic efficiency, green manuring, PSB and rice

Introduction
Rice is the most important and extensively grown staple food crop, accounting for 43% of the total food grain in the country. In Krishna zone of Andhra Pradesh majorly the cultivation of rice is under wetland conditions in which the phosphorus use efficiency and the recovery of phosphorus is low particularly in cereal crops like rice. Inappropriate phosphorus management practices are responsible for low partial factor productivity and agronomic efficiency. In addition to this the availability of native or applied phosphorus to crop plants is limited greatly by a natural phenomenon called phosphorus fixation. The fixation of phosphorus in soils by soil colloids has been considered as an important reason for the low recovery of applied phosphatic fertilizer. To increase the recovery of phosphorus this experiment was carried out by the incorporation of green manures and use of biofertilizers like Phosphorus Solubilizing Bacteria (PSB) which can improve the availability of soluble phosphates which inturn increase the grain yield.

Material and methods
This experiment was carried out in Agricultural College Farm, Bapatla, Guntur during *kharif* seasons of 2016-17 and 2017-18. The farm is situated at a latitude of 15^0 54' N and 80^0 25'E longitude, at an altitude of 5.49 m above the mean sea level and is 7 km away from the Bay of Bengal. The experimental soil is clay loam, (42, 40% sand, 20, 21% silt and 38, 39% clay) slightly alkaline in nature with a pH of 7.6, 7.4, low in available nitrogen (234, 251 kg ha^{-1}), medium in available phosphorus (19.0, 21.4 kg ha^{-1}) and high in available potash (554, 572 kg ha^{-1}) in both the years respectively. Rice cv. 'BPT-5204' was sown in July with a spacing of 20 x15 cm. The experiment was laid out in a split plot design with four main plot treatments (M_1: inorganic fertilizer phosphorus through SSP, M_2: green manuring *in-situ* with dhaincha @ 25 kg ha^{-1}, M_3: phosphorus solubilizing bacteria biofertilizer @ 750 ml ha^{-1} and M_4: green manuring *in-situ* with dhaincha @ 25 kg ha^{-1} + phosphorus solubilizing bacteria biofertilizer @ 750 ml ha^{-1}) and three sub plot treatments (S_1: 50%, S_2: 100% and S_3:150% RDP) with three replications. The experimental field was ploughed twice by a tractor drawn cultivator, followed by a rotovator to obtain a good tilth. The levelled field was then divided into the required number of main plots and sub plots as per the layout plans. Dhaincha was incorporated at 45 days after sowing with a tractor drawn rotopuddler during both the years of experimentation. The main plots were divided into sub plots after incorporation of green manure by making strong bunds and irrigation was given for better decomposition. Data obtained from different treatments were analyzed with statistical procedures. Treatmental differences were found significant based on results of F test, critical differences were calculated at 5% level of probability (Rangaswamy, 2013) [1]. Before the incorporation of the green manure (dhaincha), P_2O_5 content was estimated and results are furnished in Table1.

Table 1: Quantity of biomass and nutrient concentration of green manure (dhaincha) on dry weight basis

Year	Fresh biomass of dhaincha (t ha^{-1})	Drymatter (t ha^{-1})	Nutrient (P_2O_5) concentration (%)	Nutrient (P_2O_5) accumulation (kg ha^{-1})
2016-17	19.6	2.8	0.46	12.8
2017-18	21.4	3.0	0.50	15.0

Partial Factor Productivity (PFP) and Agronomic Efficiency (AE) were determined according to following formulas.

Partial factor productivity (PFP)

The partial factor productivity (PFP) from applied nutrients is a useful measure of nutrient use efficiency because it provides integrative index that quantifies total economic output related to utilization of all nutrient resources added to the system (Cassmen *et al.,* 1996) [2]. It is the ratio of yield in kg ha^{-1} to applied nutrient in kg ha^{-1} and expressed as,

$$\text{Partial factor productivity (PFP)} = \frac{Y}{Nr}$$

Where, Y is the yield in kg ha^{-1} and
Nr is the amount of fertilizer nutrients applied in kg ha^{-1}

Agronomic Efficiency (AE)

Agronomic Efficiency (AE) (kg grain/kg P_2O_5 applied) =

$$\frac{\text{Grain yield in fertilized plot (kg ha}^{-1}\text{)} - \text{Grain yield in control plot (kg ha}^{-1}\text{)}}{\text{Fertilizer } P_2O_5 \text{ applied}}$$

Results and discussion

Agronomic Efficiency of rice was influenced by both source and levels of phosphorus. (Table. 2, Fig. 1). Maximum agronomic efficiency was observed with the incorporation of green manure *i.e.,* dhaincha @ 25 kg ha^{-1} + soil application of PSB along with 50% RDP *i.e.,* (30 kg P_2O_5 ha^{-1}) followed by 100% RDP (60 kg P_2O_5 ha^{-1}). Agronomic efficiency decreased with increased dose of phosphorus regard less of phosphorus sources. In case of phosphorus sources agronomic efficiency was increased with increased availability of soluble phosphates. It might be due to phosphorus utilization patterns of higher magnitude and exhibited greater competition for nutrient absorption at the lowest dose of phosphorus application. Selvi *et al.* (2003) [3] observed greater P use efficiency in rice at lower dose of P level along with green manures. Meelu and Moris (1984) [4] also reported that a healthy population of soil green manuring improves the physical and microbial conditions of soil and enhances fertilizer use efficiency when applied in conjunction with mineral fertilizer. These results clearly indicate that inoculation of rice with PSB and green manure incorporation along with limited doses of P fertilizers enhances the phosphorus use efficiency.

The application of essential plant nutrients in optimum quantity and in right proportion, through correct method and time of application, is the key to increase and sustained crop production (Cisse and Amar, 2000) [5]. Since higher fertilizer use efficiency is always associated with low fertilizer rate, cultural practices meant for promoting integrated nutrient management through various organic sources like green manuring and PSB etc., (Karim and Ramasamy, 2000)[6]. Efficient use of phosphorus for rice production is important for increasing grain yield, maximizing economic return and minimizing fixation of phosphorus.Similar results were reported in maize crop by Amanullah and Almas (2009)[7]. Phosphorus use efficiency was higher due to PSB application (44 to 67 kg grain per kg P applied) as compared to without PSB application (30 kg grain per kg P_2O_5 applied). (Mahendra Kumar *et al*. (2008) [8]. Janaki and Chitra (2000) [9] studied the relative performance of different sources of phosphorus with green manure and reported that the application of SSP along with green manure produced higher grain yield and phosphorus use efficiency in rice.

Data presented in table 2 and Fig. 2 revealed that partial factor productivity declined steadily with successive increase in level of phosphorus. This was obvious as the grain yield could not increase in tune with rate of fertilizer application following the law of diminishing return and low phosphorus utilization efficiency which resulted in lower partial factor productivity (Panda, 2002) [10].

Averagedly inorganic phosphorus through SSP performed very poorly as compared to biological sources of phosphorus (M_2, M_3 and M_4). The decline of partial factor productivity for phosphorus might be due to the lack of luxury consumption of phosphorus on one hand and higher fixation of phosphorus on the other hand (Ogoke *et al.,* 2006)[11]. In contrary to phosphorus levels, biological sources of phosphorus (M_2, M_3, M_4) had a positive effect on partial factor productivity. Among these PSB (M_3) showed higher partial factor productivity followed by green manure + PSB (M_4) and green manure (M_2) alone. Application of PSB increased conversion of unavailable form to available form through the production of organic acids which enhanced the availability and resulted in higher uptake of added phosphorus and finally increased the grain yield (Mahanta, 2008) [12]. Per unit utilization of phosphorus through PSB contributed greater towards grain yield of rice as compared to that of other sources, hence resulted in increased partial factor productivity. Decline in partial factor productivity and agronomic efficiency at higher level of phosphorus may be attributed to nutrient imbalance and decline in indigenous soil P supply. Similar results were shown by Amanullah and Almas (2009) [7].

Table 2: Grain yield (kg ha^{-1}), Partial factor productivity (grain yield kg ha^{-1} $P_2O_5^{-1}$ applied in kg ha^{-1}) and Agronomic efficiency (kg grain yield kg $P_2O_5^{-1}$) of rice as influenced by phosphorus management during *kharif* 2016-17 and 2017-18

Treatments	2016-17			2017-18		
	Grain yield	Agronomic Efficiency	Partial factor productivity	Grain yield	Agronomic Efficiency	Partial factor productivity
M_1S_1	3661	29.5	122.0	4019	23.6	134
M_1S_2	4826	19.4	80.4	4880	14.4	81.3
M_1S_3	5082	15.8	56.5	5289	14.1	58.8
M_2S_1	5910	52.5	138.1	6151	47.4	136.7
M_2S_2	5912	30.9	81.2	6164	28.6	82.2
M_2S_3	5937	22.1	57.8	6170	20.5	58.8
M_3S_1	5470	60.3	182.3	5764	58.2	192.1

M_3S_2	5470	30.2	91.2	5766	29.1	96.1
M_3S_3	5491	20.3	61.0	5771	19.5	64.1
M_4S_1	6052	55.9	141.4	6286	50.4	139.7
M_4S_2	6062	33.0	83.3	6358	31.2	84.8
M_4S_3	6063	23.4	59.0	6412	22.8	61.1

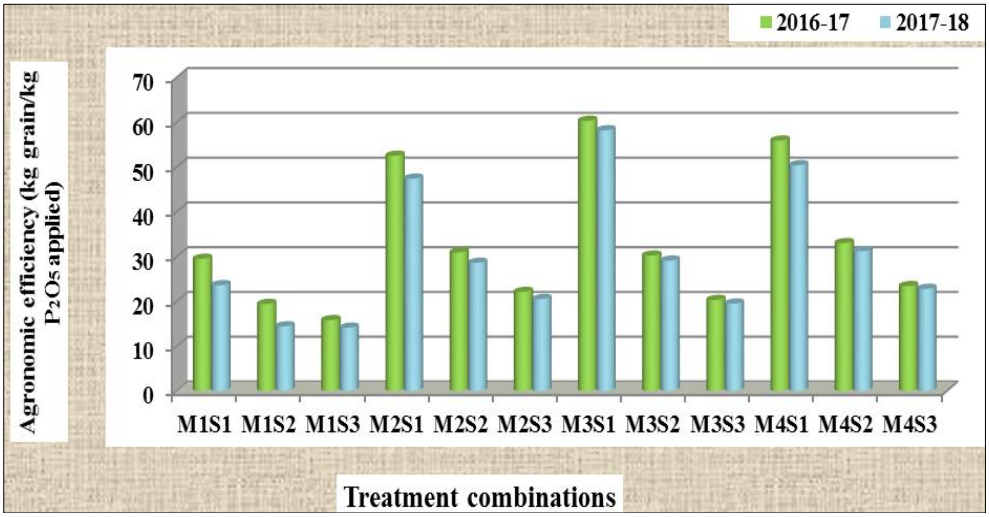

Fig 1: Agronomic Efficiency (kg grain yield kg $P_2O_5^{-1}$ applied) of rice as influenced by phosphorus management during *kharif* 2016-17, 2017-18

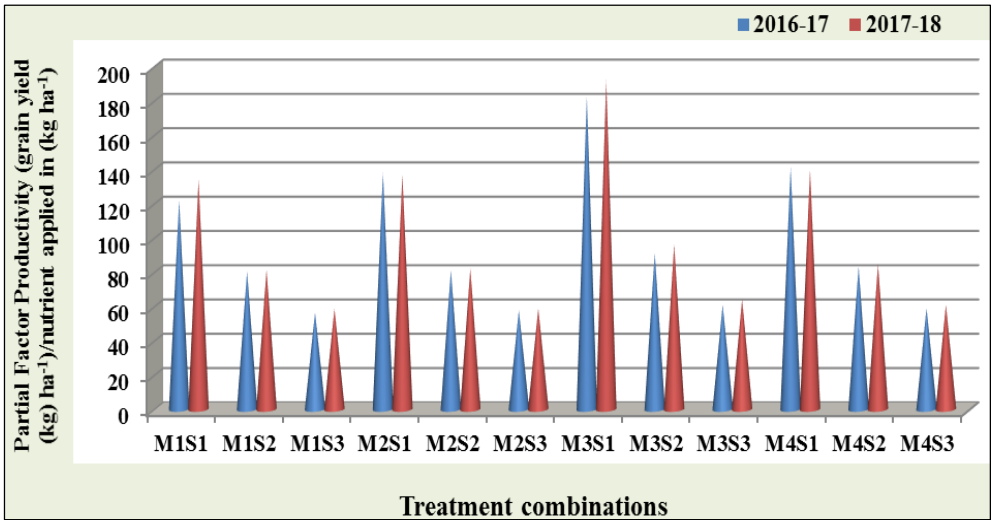

Fig 2: Partial factor productivity (grain yield kg ha^{-1} $P_2O_5^{-1}$ applied in kg ha^{-1}) of rice as influenced by phosphorus management during *kharif* 2016-17, 2017-18

Conclusion

Soil application of PSB @ 750 ml ha^{-1} along with 50% RDP (30 kg P_2O_5) recorded the higher partial factor productivity and agronomic efficiency for phosphorus in rice. This was closely followed by incorporation of green manuring with dhaincha @ 25 kg ha^{-1} + PSB @ 750 ml ha^{-1} along with 50% RDP than inorganic source of phosphorus through SSP as alone.

References

1. Rangaswamy R. A Text book of Agricultural Statistics. New age international publishers, New Delhi, 2013. www.newage publishers.com 2nd edition.
2. Cassmen KU, Gines GC, Dizon MA, Samson MI, Alcantace M. Nitrogen use efficiency in tropical low land rice system- contribution from indigenous and applied nitrogen. Field Crop Research. 1996; 47:1-12.
3. Selvi D, Mahima Raja S, Santhy P, Rajkannan B. Influence of integrated nutrient management on crop yield, P uptake and available P status of soil in a rice based cropping system. Oryza. 2003; 40(3-4):65-69.
4. Meelu OP, Morris RA. Integrated management of plant nutrients in rice and rice based cropping systems. Fertilizer News. 1984; 29(2):65-76.
5. Cisse L, Amar B. The importance of Phosphatic fertilizer for increased crop production in developing countries. In: Proceedings of the AFA 6th International Annual conference held on 31 January – 2 February, 2000, Cairo, Egypt, 2000.
6. Karim AA, Ramasamy C. Expanding frontiers of agriculture: contemporary issues. Kalyani Publishers, Ludhiana, India, 2000.
7. Amanullah, Almas LK. Partial factor productivity, agronomic efficiency and economic analysis of maize in wheat- maize cropping system in Pakistan. Selected paper prepared for presentation at the Sothern Agricultural Economic Association Annual Meetings, Atlanta, Georgia, 2009.

8. Mahendra Kumar R, Murthy AGK, Latha PC, Surekha K, Singh SP, Prasad JS, *et al*. Enhancement of phosphorus use efficiency (PUE) under rice in vertisols soil. Journal of Farming Systems Research and Development. 2008; 14(1):111-113.
9. Janaki P, Chitra L. Direct and residual supply of available phosphorus and balance sheet in rice-rice cropping sequence. Oryza. 2000; 37(2):17-19
10. Panda BB. Influence of phosphate solubilizing and mobilizing micro-organisms on phosphorus use efficiency in wheat using ^{32}P as a tracer. Ph.D. Thesis, IARI, New Delhi, 2002.
11. Ogoke IJ, Togun AO, Dashiell KE. Soybean phosphorus use efficiency in the moist Savana of West Africa. Journal of Sustainable Agriculture. 2006; 28(1):5-18.
12. Mahanta D. Relative performance of single super phosphate and rock phosphate in cognizance with biofertilizers on rhizosphere augmentation and productivity of soybean-wheat cropping system. Ph. D (Ag.) Thesis, Agronomy thesis, submitted to the Post-Graduate School, Indian Agricultural Research Institute, New Delhi, 2008.