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Yield, Quality Parameters and Economics of rice as influenced by Phosphorus Management in Rice-Groundnut sequence

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ABSTRACT

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A field experiment was conducted during *Kharif* 2016-17 and 2017-18 respectively on sandy loam soils of Agricultural College Farm Bapatla to study the yield, economics and quality parameters as influenced by phosphorus management in rice-groundnut sequence. The experiment was laid out in split plot design in *Kharif* rice and the treatments were replicated thrice. The treatments consisted of four main plots sources of phosphorus S1 : Inorganic fertilizer phosphorus through SSP, S2 : Green manuring in-situ with dhaincha @ 25 kg seed ha⁻¹, S3 : Biofertilizer (PSB) @ 750 ml ha⁻¹, S4 : Green manuring in-situ with dhaincha @ 25 kg seed ha⁻¹ + Biofertilizer (PSB) @ 750 ml ha⁻¹ and three subplots levels of phosphorus L1 : 50% Recommended dose of P, L2 : 100 % Recommended dose of P and L3 : 150% Recommended dose of P. Results of the experiment showed that application of in-situ green manuring + PSB along with inorganic phosphorus through SSP showed superior performance in terms of yield, quality parameters and economics over alone application of inorganic fertilizer phosphorus through SSP. Among the levels of phosphorus 150 % RDP showed higher yield, quality parameters and economics over 50 % RDP and however it was on par with 100 % RDP.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crop. In India, rice ranks first among all the crops occupying 43.95 m ha area and production of 106.54 mt with an average productivity of 2424 kg/ha (CMIE, 2017-18). Among the fertilizer elements, phosphorus is an essential nutrient and no

plant can produce good yield if it suffers from P deficiency. It is involved in the supply and transfer of energy for all biochemical processes in plants and hence, it is called as the "energy currency of living cells". It stimulates early root growth and development, encourages more active tillering, drymatter accumulation and promotes early flowering, maturity and good

grain development. Further, optimum response to added nitrogen could be obtained only when adequate amount of P is supplied. Therefore, P availability from soils to the plant is the key to sustain higher yields. Green manures represent a promising approach to maintain sustainable nutrient supply for crop growth. The P in green manure could potentially be delivered to the soil in a form which is readily available to plants and soil microorganisms. Plants utilize less amounts of phosphatic fertilizers that are applied and the remaining portion is rapidly converted in to insoluble complexes in the soil. Slow mobility of applied phosphorus and its marked fixation results in low crop recoveries in the order of 20-25%. Phosphate solubilizing bacteria (PSB) solubilize insoluble phosphorus and increase its availability phosphorus in the soil and return the overall phosphate use efficiency. Integrated use of chemical fertilisers with green manure crop and bio-fertilizer is important for sustainable rice production.

The increased prices of fertilizers also intensified the problem by increasing cost of inputs. so, trail was conducted with different doses of phosphorus levels in combinaion with *in-situ* green manur ing and psb then reduce the higher use of chemical fertilizers . The present study was, therefore, designed to find out the response of rice to sources and levels of phosphorus with regard to yield, quality and economics of rice.

Materials and Methods

The experiment was conducted at the Agricultural College Farm, Bapatla. Initial soil sample analysis revealed that the experimental soil was sandy loam in texture, slightly alkaline in reaction (pH7.6, 7.8), low in organic carbon (0.42, 0.43 %), low in available nitrogen (226, 230 kg ha⁻¹), low in available phosphorus (18, 20 kg ha⁻¹) and

high in available potassium (483, 521 kg ha⁻¹) during 2016-17 and 2017-18 respectively. The experiment was laid out in a split plot design in *Kharif* rice and the treatments were replicated thrice. The treatments consisted of four main plots sources of phosphorus S₁: Inorganic fertilizer phosphorus through SSP, S₂: Green manuring *in-situ* with dhaincha @ 25 kg seed ha⁻¹, S₃: Biofertilizer (PSB) @ 750 ml ha⁻¹, S₄: Green manuring *in-situ* with dhaincha @ 25 kg seed ha⁻¹ + Biofertilizer (PSB) @ 750 ml ha⁻¹ and three subplots levels of phosphorus L₁: 50% Recommended dose of P, L₂: 100% Recommended dose of P and L₃: 150% Recommended dose of P. A very popular variety, BPT 5204 (Samba Mahsuri) was used for the study. The experimental field was ploughed twice by a tractor drawn cultivator, followed by a rotovator to obtain required tilth. The levelled field was then divided into the required number of main plots as per the layout plans. Dhaincha seed was broadcasted in the main plots namely S₂ (Green manuring @ 25 kg ha⁻¹) and S₄ (Green manuring *in situ* + biofertilizer (PSB) @ 750 ml ha⁻¹) in all the three replications as per the layout plans and the seeds were covered by dragging a spike toothed harrow. These main plots (Green manure plots) were divided into sub plots after incorporation of green manure by making strong bunds and irrigation was given for better decomposition before transplanting of rice crop during both the years of experimentation.

A common dose of nitrogen at 120 kg ha⁻¹ was applied in the form of urea in three splits, half at basal, one fourth at active tillering and remaining at panicle initiation stage. Phosphorus in the form of single super phosphate was applied basal as per the treatments. A common dose of 40 kg K₂O ha⁻¹ was applied as basal just before transplanting through muriate of potash by taking the plot size into consideration.

Quality parameters

Protein Content

Grain nitrogen content (%) estimated by microkjeldhal method (Jackson, 1973) was multiplied by the factor 6.25 and expressed as protein content (%) of the grain.

$$\text{Protein content (\%)} = \text{Total N content (\%)} \times 6.25$$

Amylose Content

Grain amylose content was estimated as per the procedure as described by Sadasivam and Manickam (1992) and expressed as percentage.

Procedure

Weigh 0.1 g of the rice powdered sample, and add 1 ml of distilled ethanol. Then add 10 ml of 1 N NaOH and leave it overnight. Make up the volume to 100 ml. Take 2.5 ml extract, add about 20 ml distilled water and then three drops of phenolphthalein. Add 0.1 N HCl drop by drop until the pink colour just disappears. Add 1 ml of iodine reagent and make up the volume to 50 ml and read the colour at 590 nm. Take 0.2, 0.4, 0.6, 0.8 and 1 ml of the standard amylose solution and develop the colour as in the case of sample. Calculate the amount of amylose present in the sample using the standard graph. Dilute 1 ml of iodine reagent to 50 ml with distilled water for a blank.

Volume Expansion Ratio

Volume expansion ratio was determined as suggested by Verghese (1950) and modified by Murthy (1965) by using the following formula

$$\text{Volume Expansion} = \frac{\text{Increase in volume after cooking (X-50)}}{\text{Increase in volume before cooking (Y-15)}}$$

Five grams of rice sample was soaked in 15ml of water for 5 minutes in a 50 ml graduated centrifuge tube. The volume of water was recorded after adding rice samples (Y-15). Rice cooked for 20 minutes in water bath was dipped in 100ml measuring cylinder (X) containing 50ml water. The volume raised was recorded (X-50) and was computed by using the above formula.

The gross returns from each treatment were worked out with the prevailing market prices. The net returns from each treatment were arrived at by deducting the cost of cultivation with the existing prices of inputs and wages of labour. Returns per rupee investment for all the treatments was worked out on the basis of net returns in terms of rupees after deducting the cost of treatments from gross returns.

$$\text{Gross returns} = \text{Value of the product (Grain + Straw)}$$

$$\text{Net returns} = \text{Gross returns} - \text{Total cost of cultivation}$$

$$\text{Returns per rupee investment} = \frac{\text{Net returns}}{\text{Cost of cultivation}}$$

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Results and Discussion

Grain Yield (kg ha⁻¹)

Grain yield was significantly influenced by sources and levels of phosphorus and their interaction too during both years of study and pooled data of study. The data pertaining to the grain yield of rice are presented in Table 1. The grain yield of various treatments was higher during the second year (2017-18) of study than that of the first year (2016-17). However the influence of different treatments was almost consistent in the both years of study and pooled data as well.

During both the years significantly higher yields were recorded with the treatment that received in combination with inorganic fertilizer through SSP and *in-situ* green manuring + biofertilizer (PSB) *i.e.* 5656 kg ha⁻¹, 5896 kg ha⁻¹ and 5776 kg ha⁻¹ during 1st, 2nd years and pooled data respectively, which was statistically on a par with *in-situ* green manuring treatment (5520, 5730 and 5625 kg ha⁻¹) during 1st and 2nd years and pooled data respectively but proved significantly superior to alone inorganic fertilizer through SSP (4620, 4649, 4635 kg ha⁻¹) and biofertilizer (PSB) alone treatment (5179, 5329 and 5254 kg ha⁻¹) under test.

Total drymatter accumulation might have reflected on the economic yield in view of the fact that vegetative part of the plant serves as the source, where as the spikelets are serve as sink. Accumulation of drymatter during the

vegetative growth stage and its distribution to yield attributes during reproductive stage through a process of translocation from source to sink and finally determines the economic yield of the crop.

Present study results showed that *in-situ* green manuring + biofertilizer (PSB) with inorganic fertilizer through SSP significantly influenced the grain yield of rice. Application of *in-situ* green manuring + biofertilizer (PSB) along with fertilizer was found to be superior in realizing maximum grain yield. It might be due to the fact that green manure biomass is a potential source of major nutrients for lowland rice and showed significant improvement in growth, yield, net returns, soil moisture retention, organic carbon and nutrient status of soil and reduction in bulk density of plough layer (Jyothi and Nallaiah (2015) and Siva Jyothi *et al.*, 2013). The yield increase may be due to increase in growth attributes like drymatter production and yield attributes like panicle length, total number of grains, more number of filled grains per panicle. Similar findings were also reported by Arivukkarasu and Kathiresan (2007) and Deshpande and Devasenapathy (2010). Green manure + Biofertilizer (PSB) promotes improvement in leaf photosynthetic rate, biomass production and sink formation, which increased the grain yield of rice. Besides P solubilisation activity, PSB liberates growth hormone (IAA) that might have influenced on root growth and yield. The extensive root system might have increased nutrient uptake from the surroundings which boosted plant biomass and subsequently more grain yield of rice. These results were alike with the findings of Panhwar *et al.*, (2010).

However, the lowest grain yield was recorded with inorganic fertilizer through SSP (4620 kg ha⁻¹, 4649 kg ha⁻¹ and 4635 kg ha⁻¹ during 1st, 2nd year and pooled data of study). This might be due to phosphorus fixation in soil

and lowest growth parameter like drymatter production and yield attributes like panicle length, total number of grains, more number of filled grains per panicle with SSP treatment.

Among the levels of phosphorus, 150 % RDP recorded highest grain yield (5425, 5583 and 5504 kg ha⁻¹) over 50 % RDP (5024, 5164 and 5094 kg ha⁻¹) it was remained on a par with 100 % RDP (5283, 5456 and 5369 kg ha⁻¹) during first, second and pooled data of study. This might be due to adequate supply of P in soil might have favoured efficient use of P in turn brought higher grain yield. These results are in close conformity with the findings obtained by Dutta and Gogoi (2009) and Ramesh Babu *et al.*, (2013).

Quality Parameters

Cooking quality parameters (Amylose and Volume expansion ratio)

Data pertaining to cooking quality are presented in (Table 2 and Table 3) indicated that significant differences were observed in respect of amylose content and volume expansion ratio, among the various phosphorus sources and levels under study during both the years and pooled data of experimentation.

Significantly higher amylose content and volume expansion ratio were recorded with the treatment *in-situ* green manuring + biofertilizer (PSB) which was statistically on a par with *in-situ* green manuring. This might be due to higher total carbohydrates with the combination of *in-situ* green manuring + biofertilizer (PSB) of which may lead to higher alpha amylase activity. Starch is the major source of carbohydrate in rice which consists of amylose and amylopectin. Starch is biosynthesized from adenine disphosphate glucose of which N and P are constituents. Hence, amylose content increased due to

application of nutrients was quite natural. Similar findings were reported by Dixit and Gupta (2000) and Vijayan and Krishnasamy (2014).

The significantly higher volume expansion ratio was noticed in *in-situ* green manuring + biofertilizer (PSB) which was on par with treatment *in-situ* green manuring. This may be due to application of organic manure gave a higher L/B ratio of rice after cooking than with inorganic fertilizer. Treatment with green manure + PSB has showed highest score by sensory evaluation in terms of overall acceptability with respect to colour, texture and taste of cooked rice. Similar findings were reported by Priyadarsini (2001) and Nguyen *et al.*, (2002).

With regard to increasing levels of phosphorus increased amylose content and volume expansion ratio due to increased availability of nutrients. These findings are in close accordance with those of Yajie *et al.*, (2012).

Protein content

A perusal of the data pertaining protein content (Table 4) showed significant differences due to various sources of phosphorus but not levels of phosphorus and their interaction during both the years and pooled data of study

During both the years and pooled data of study, it was observed that significantly higher protein content in grain was recorded with treatment that received *in-situ* green manuring + biofertilizer (PSB) (8.4, 8.6 and 8.5 %), and was statistically remained on a par with *in-situ* green manuring (7.9, 8.1 and 8.0 %) but proved significantly superior to inorganic fertilizer through SSP alone (6.4, 6.5 and 6.4 %) and biofertilizer (PSB) alone treatments (7.2, 7.3 and 7.2 %).

Table.1 Grain yield (kg ha⁻¹) of *Kharif* rice as influenced by phosphorus management practices

Treatments	2016-17	2017-18	Pooled data
Source of phosphorus			
S ₁ - Inorganic phosphorus	4620	4649	4635
S ₂ - Green manuring	5520	5730	5625
S ₃ - Soil application of PSB	5179	5329	5254
S ₄ - Green manuring + PSB	5656	5896	5776
S.Em±	73.14	79.45	75.81
CD (p = 0.05)	253.1	274.9	262.3
CV (%)	4.2	4.4	4.3
Levels of phosphorus			
L ₁ - 50% RDP	5024	5164	5094
L ₂ - 100% RDP	5283	5456	5369
L ₃ - 150% RDP	5425	5583	5504
S.Em±	55.92	70.28	57.21
CD (p = 0.05)	167.7	210.7	171.5
CV (%)	3.7	4.5	3.7
Interaction	s	S	S

Table.2 Amylose content (%) ratio of *Kharif* rice as influenced by phosphorus management practices

Treatments	2016-17	2017-18	Pooled data
Source of phosphorus			
S ₁ - Inorganic phosphorus	19.4	20.1	20
S ₂ - Green manuring	22.9	25.0	24
S ₃ - Soil application of PSB	20.3	21.6	21
S ₄ - Green manuring + PSB	23.9	26.0	25
S.Em±	0.70	1.03	0.80
CD (p = 0.05)	2.1	3.0	2.4
CV (%)	9.7	13.3	10.7
Levels of phosphorus			
L ₁ - 50% RDP	20.3	21.8	21
L ₂ - 100% RDP	21.8	23.4	23
L ₃ - 150% RDP	22.8	24.4	24
S.Em±	0.55	0.52	0.53
CD (p = 0.05)	1.6	1.5	1.5
CV (%)	8.9	7.8	8.2
Interaction	NS	NS	NS

Table.3 Volume expansion ratio of *Kharif* rice as influenced by phosphorus management practices

Treatments	2016-17	2017-18	Pooled data
Source of phosphorus			
S ₁ - Inorganic phosphorus	3.1	3.3	3.2
S ₂ - Green manuring	3.6	4.3	3.9
S ₃ - Soil application of PSB	3.2	3.6	3.4
S ₄ - Green manuring + PSB	4.1	4.9	4.5
S.Em±	0.18	0.16	0.18
CD (p = 0.05)	0.5	0.4	0.5
CV (%)	15.0	12.2	14.0
Levels of phosphorus			
L ₁ - 50% RDP	3.0	3.5	3.3
L ₂ - 100% RDP	3.4	3.4	3.7
L ₃ - 150% RDP	4.1	4.6	4.3
S.Em±	0.15	0.15	0.15
CD (p = 0.05)	0.5	0.5	0.5
CV (%)	15.0	12.8	14.0
Interaction	NS	NS	NS

Table.4 Protein content (%) of *Kharif* rice as influenced by phosphorus management practices

Treatments	2016-17	2017-18	Pooled data
Source of phosphorus			
S ₁ - Inorganic phosphorus	6.4	6.5	6.4
S ₂ - Green manuring	7.9	8.1	8.0
S ₃ - Soil application of PSB	7.2	7.3	7.2
S ₄ - Green manuring + PSB	8.4	8.6	8.5
S.Em±	0.16	0.16	0.16
CD (p = 0.05)	0.5	0.5	0.5
CV (%)	6.3	6.1	6.2
Levels of phosphorus			
L ₁ - 50% RDP	7.2	7.3	7.3
L ₂ - 100% RDP	7.4	7.6	7.5
L ₃ - 150% RDP	7.8	8.0	7.9
S.Em±	0.25	0.25	0.25
CD (p = 0.05)	NS	NS	NS
CV (%)	11.7	11.5	11.5
Interaction	NS	NS	NS

Table.5 Cost of cultivation (Rs.), Gross returns (Rs.), Net returns (Rs.) and Returns per rupee investment of *Kharif* rice as influenced by phosphorus management practices

Treatments	2016-17				2017-18				Pooled data			
	Cost of cultivation	Gross returns	Net returns	Returns per rupee investment	Cost of cultivation	Gross returns	Net returns	Returns per rupee investment	Cost of cultivation	Gross returns	Net returns	Returns per rupee investment
Source of phosphorus												
S₁ - Inorganic phosphorus	36750	73250	36500	0.99	35516	76000	40484	1.16	36133	74625	38492	1.08
S₂- Green manuring	40570	89984	49414	1.25	40349	93346	52997	1.34	40460	91665	51206	1.30
S₃ - Soil application of PSB	39720	84373	44652	1.16	39472	86822	47350	1.23	39596	85598	46001	1.20
S₄- Green manuring + PSB	40545	92060	51515	1.29	40328	95935	55607	1.40	40437	93998	53561	1.35
S.Em±	—	1211.5	1212	0.03	—	1330.0	1330.0	0.03	—	1261.1	1261	0.03
CD (p = 0.05)	—	4192	4193	0.10	—	4603	4603	0.12	—	4364	4364	0.11
CV (%)	—	4.3	7.8	7.1	—	4.5	8.1	7.8	—	4.4	8	7.4
Levels of phosphorus												
L₁ - 50% RDP	38530	77350	38820	1.02	37950	77950	40000	1.05	38240	77650	39410	1.04
L₂ - 100% RDP	41080	87530	46450	1.13	41200	88840	47640	1.15	41140	88185	47045	1.14
L₃ - 150% RDP	42550	89500	46950	1.10	43178	91150	47972	1.11	42864	90325	47461	1.11
S.Em±	—	879.0	879.1	0.02	-----	1130.3	1130.3	0.03	—	977.2	977.2	0.02
CD (p = 0.05)	—	2635	2636	0.06	—	3389	3389	0.09	—	2930	2930	0.07
CV (%)	—	3.6	6.6	6.1	—	4.4	8.0	7.8	—	3.9	7.1	6.7
Interaction												
S X L	-	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS
L X S	-	NS	NS	NS	-	NS	NS	NS	-	NS	NS	NS

Among the levels of phosphorus, 150 % RDP (7.8, 8.0 and 7.9 %) recorded higher protein content followed by 100 % RDP (7.4, 7.6 and 7.5 %) and 50 % RDP (7.2, 7.3 and 7.3 %) during both the years and pooled data of study. This might be due to accumulation of higher quantities of seed components like calcium carbonate and increased lipid metabolism which helps in increasing the protein content in seed which in turn increased nitrogen content in grain and also increased phosphorus levels with inoculation of PSB strains. Similar findings were also reported by Roy and Singh (2006) and Aslam *et al.*, (2010).

Economics

The results of the trial showed that sources and levels of phosphorus but not their interaction had a significant influence on economics *Kharif* rice crop (Table 5). Gross returns, net returns and return per rupee invested were higher with *in-situ* green manuring + biofertilizer (PSB) which was closely followed by the treatment that received *in-situ* green manuring. This is due to lower cost of cultivation and higher grain and straw yields obtained with these treatments. Similar views were also expressed by Mondal *et al.*, (2004).

The lower gross returns and net returns were obtained with inorganic fertilizer through SSP alone and biofertilizer (PSB) alone treatments. This is due to higher cost of cultivation and low grain and straw yield obtained with these treatments. These results are in conformity with the findings of Yogesh *et al.*, (2013), Sharma *et al.*, (2015) and Nanda *et al.*, (2016).

Gross Return (Rs.ha⁻¹)

Gross returns from rice cultivation were influenced by sources and levels of

phosphorus in both the years and pooled data of study (Table 5).

The highest gross return (Rs.92060 and Rs. 95935 ha⁻¹ during 2016-17 and 2017-18, respectively) were realized with the combined application of *in-situ* green manuring + biofertilizer (PSB) which was superior over inorganic fertilizer through SSP and Biofertilizer (PSB) alone. The lowest gross return (Rs.73250 and Rs. 76000 ha⁻¹ during 2016-17 and 2017-18, respectively) were obtained with inorganic fertilizer through SSP. Among the levels of phosphorus 150 % RDP recorded significantly higher gross return which was closely followed with 100 % RDP and was superior over 50 % RDP.

Gross return from rice in response to sources and levels of phosphorus a distinctly descending order of *in-situ* green manuring + biofertilizer (PSB), *in-situ* green manuring, Biofertilizer (PSB), inorganic fertilizer through SSP during both the years of study. Similar findings were reported by Mehla and Panwar (2000).

Net Return (Rs.ha⁻¹)

Among the sources and levels of phosphorus to rice crop exhibited significant influence on net returns from rice crop during both the years of study (Table 5)

Net returns were the highest (Rs.51515 and Rs. 55607 ha⁻¹ during 2016-17 and 2017-18, respectively) with *in-situ* green manuring + biofertilizer (PSB), which was superior to inorganic fertilizer through SSP. The lowest net return (Rs.36500 and Rs.40484 ha⁻¹ during 2016-17 and 2017-18, respectively) were recorded with the application of inorganic fertilizer through SSP. The trend of net returns was similar during both the years and pooled of investigation. Among the levels of phosphorus 150 % RDP recorded

significantly higher net return over 50 % RDP which was closely followed with 100 % RDP. Similar results were also reported by Kavitha and Subramanian (2007) and Moola Ram *et al.*, (2011).

Returns per rupee investment

Returns per rupee investment was altered by sources and levels of phosphorus in both the years and pooled data of study (Table 5).

Combined use of green manure *in-situ* and PSB resulted in realizing the highest returns per rupee investment (1.29), which was superior to all other treatments. Supply of inorganic fertilizer through SSP was inferior to all other P sources, which resulted in the lowest BCR in both the years and pooled of study.

Among the sources of phosphorus, application of green manure *in-situ* + PSB attained significantly higher economic returns (Gross returns, Net returns and returns per rupee investment) during both the years owing to higher grain yield and in turn higher gross and net returns in this treatment. The beneficial effect of green manure and PSB in improving the net returns and returns per rupee investment was also reported by Prasad Rao and Bhupal Raj (2001) and Talathi *et al.*, (2009).

Among the levels of phosphorus 150 % RDP recorded significantly higher returns per rupee investment (1.10) over 50 % RDP (1.02) which was closely followed with 100 % RDP (1.13). Similar findings were also reported by Kumari *et al.*, (2013) and Shahbaz *et al.*, (2015).

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