The Andhra Agric. J 66 (2): 260-265, 2019

Performance of Rice Crop as Influenced by Green Manures and Phosphorus Levels

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ABSTRACT

A field experiments was conducted during *kharif* 2015 and 2016 to study the effect of green manures and phosphorus levels in rice crop at Agricultural College Farm, Bapatla. The experiment was conducted in split plot design on sandy clay loam soil with three main treatments and three sub-treatments. The treatments consisted of *dhaincha* green manure crop, sunnhemp green manure crop and without green manure as main plot treatments and three phosphorus levels to rice crop @ 45 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and 75 kg P_2O_5 ha^{-1} as sub- plot treatments during *kharif* season. Green manure incorporation significantly influenced the growth parameters, yield attributes and yield of rice. Significantly the highest grain yield of rice was recorded with *dhaincha* green manure incorporated treatment (5592 and 5587 kg ha^{-1}) when compared to control (5049 and 5003 kg ha^{-1}). Among the phosphorus levels applied to rice crop the highest grain yield (5545 and 5567 kg ha^{-1}) was recorded with 75 kg P_2O_5 ha^{-1} and it was on a par with 60 kg P_2O_5 ha^{-1} during both the years of study.

Rice (*Oryza sativa* L.) is the principal food crop for billions of people throughout the world. India has the largest area (44.2 m ha) among rice growing countries and stands second in production (108.9 m t) with a productivity of 2391 kg ha^{-1}. In Andhra Pradesh, rice is grown in an area of 2.4 million hectare with a production of 7.24 million tonnes and productivity of 3022 kg ha^{-1} (Ministry of Agriculture, Government of India, 2016-17). Now a day, chemical fertilizers are expensive due to the energy crisis and are unavailable to many farmers, particularly in developing countries like India. Green manures improving the organic matter content, soil fertility, water holding capacity, aeration, colloidal complex and hence its ability to retain nutrients (Buresh and De Datta, 1991 and Becker *et al*., 1995).

Phosphorus is the second essential plant nutrient required by plant in large quantity next to nitrogen to rice crop is more compared to other crops. So it is necessary to know the optimum dose of phosphorus fertilizer for maximum yield. Hence, the present investigation was carried out with a view to evaluate the effect of phosphorus levels and green manures effect on growth and yield of wetland rice.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* season of 2015 and 2016 at Agricultural College Farm, Bapatla on sandy clay loam soil. The initial soil having low in organic carbon (0.45%), low in available nitrogen (251 kg ha^{-1}), medium in available phosphorus (23 kg ha^{-1}) and high in available potassium (541 kg ha^{-1}). The experiment was conducted in split plot design with three main treatments and three sub-treatments replicated thrice. The treatments consisted of *dhaincha* green manure crop, sunnhemp green manure crop and without green manure as main plot treatments and three phosphorus levels to rice crop 45 kg P_2O_5 ha^{-1}, 60 kg P_2O_5 ha^{-1} and 75 kg P_2O_5 ha^{-1} as sub- plot treatments. Nitrogen, phosphorus and potassium (120:60:40 kg ha^{-1}) were applied throug urea, single super phosphate and murate of potash, respectively. Recommended agronomic management practices and plant protection measures were followed during crop growth period. BPT 2231 (Akshavya) rice variety was used for this experiment. The data recorded were analyzed following standard statistical analysis of variance procedure.

RESULTS AND DISCUSSION

Plant height (cm)

At maturity significantly the highest plant height (114.8 and 118.9 cm) was registered in *dhaincha* green manuring treatment and the lowest height (104.8 and 109.8 cm) was recorded in the control treatment during both the years of experimentation. Organic manure especially green manure treated plots increase the organic matter and available N and other nutrients. Nitrogen enhances the tiller number as it increases the cytokynin content within tiller nodes and further enhances the germination of the tiller primordia (Anitha and Jose Mathew, 2010).

The taller plants with 113.7 and 119.0 cm during 2015 and 2016 years of study respectively were found with the treatment received 75 kg P_2O_5 ha^{-1} which was statistically comparable with 60 kg P_2O_5 ha^{-1}. Control treatment registered the dwarf plants 106.9 and 111.1 cm during first and second years of

Table 1. Growth of *kharif* rice as influenced by green manure and phosphorus treatments

Treatments	Plant height (cm)		Number of effective tillers m^{-2}		Drymatter accumulation (kg ha^{-1})	
	2015	2016	2015	2016	2015	2016
Green manures (M)						
Dhaincha	114.8	118.9	439.0	439.0	13949.0	13883.0
Sunnhemp	113.9	118.4	422.0	433.0	13739.0	13789.0
Without green manure	104.8	109.8	391.0	401.0	12598.0	12630.0
SEm±	2.0	1.9	7.4	7.6	241.0	255.6
CD (p=0.05)	7.9	7.6	29.0	30.0	646.0	1004.0
CV (%)	5.4	5.0	5.3	5.4	5.4	5.7
P Levels (L)						
45 kg P_2O_5 ha^{-1}	106.9	111.1	393.0	409.0	12770.0	12808.0
60 kg P_2O_5 ha^{-1}	113.0	117.0	424.0	426.0	13632.0	13556.0
75 kg P_2O_5 ha^{-1}	113.7	119.0	435.0	438.0	13885.0	13939.0
SEm±	2.1	2.1	10.3	8.1	307.5	243.8
CD (p=0.05)	6.6	6.5	32.0	25.0	947.0	751.0
CV (%)	5.7	5.5	7.4	5.7	6.9	5.4
Interaction						
L at same level of M						
SEm±	3.7	3.7	17.8	14.0	532.6	422.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS
M at same or different levels of L						
SEm±	3.6	3.6	16.3	13.7	497.2	429.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS

study respectively. Increased root growth by phosphorus application enabled the crop to extract more water and nutrients and increased the photosynthetic activity of plant and translocation of photosynthates to the sink and improved stature of the plant and might have contributed to production of more number of tillers per hill (Alam and Azmi, 1989). Interaction between the green manuring and phosphorus levels was found to be non-significant.

Productive tillers/m^2

Among the green manures, significantly the highest number of tillers (439 and 439) were recorded with *dhaincha* green manure incorporation (Table-1) over control but remained on a par with sunnhemp green manuring treatment (422 and 433) during first and second years of study respectively. Increased number of tillers in green manures incorporated plots might be attributed to the high NH_4- N and redox potential in the soil as stated by Annadurai and Palaniappan (1998).

Among the different levels of phosphorus, the highest numbers of tillers (435 and 438) were recorded significantly during first and second year of study, respectively by the application of 75 kg P_2O_5 ha^{-1} which was on a par with 60 kg P_2O_5 ha^{-1}. The lowest number of tillers 393 and 409 m^{-2} were registered with 45 kg P_2O_5 ha^{-1} in both the years of study. Phosphorus application might have promoted more extensive root system through accelerating various metabolic processes such as cell division, cell development and cell enlargement in roots, which, in turn, improved the stature of the plant and have contributed to production of more number of tillers per hill (Srujana *et al*., 2011).

Drymatter Accumulation (kg ha^{-1})

At maturity, significantly the highest drymatter accumulation (13949 and 13883 kg ha^{-1}) was recorded with *dhaincha* green manure incorporation and was statistically comparable with sunnhemp green manuring only (13739 and 13789 kg ha^{-1} during the first and second year of experimentation). The lowest drymatter (12598 and 12630 kg ha^{-1}) was recorded with the control. Green manure incorporation increased the organic matter, available N and other nutrients (Table 1). Adequate nitrogen supply always increases the amount of protoplasm and chlorophyll which are the

Table 2. Yield attributes of *kharif* rice as influenced by green manure and phosphorus treatments

Treatments	Panicle length (cm)		Total number of grains panicle^{-1}		Filled grains panicle^{-1}	
	2015	2016	2015	2016	2015	2016
Green manures (M)						
Dhaincha	27.5	26.2	173.0	173.0	171.0	171.0
Sunnhemp	27.2	26.1	171.0	171.0	169.0	170.0
Without green manure	25.0	24.2	160.0	159.0	157.0	155.0
SEm±	0.5	0.4	2.8	2.8	2.8	2.7
CD (p=0.05)	2.0	1.7	11.0	11.0	11.0	11.0
CV (%)	5.7	5.2	5.0	5.0	5.1	5.0
P Levels (L)						
45 kg P_2O_5ha^{-1}	24.5	24.4	160.0	160.0	158.0	157.0
60 kg P_2O_5ha^{-1}	27.2	25.8	172.0	171.0	168.0	168.0
75 kg P_2O_5ha^{-1}	28.0	26.3	173.0	172.0	171.0	171.0
SEm±	0.9	0.5	3.3	3.8	3.1	4.8
CD (p=0.05)	2.7	1.6	10.0	12.0	10.0	15.0
CV (%)	10.0	6.0	6.0	6.8	5.7	8.7
Interaction						
L at same level of M						
SEm±	1.53	0.94	5.8	6.6	5.4	8.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS
M at same or different levels of L						
SEm±	1.35	0.83	5.5	6.1	5.3	7.3
CD (p=0.05)	NS	NS	NS	NS	NS	NS

key factors for increasing photosynthetic leaf area, which in turn might have enhanced drymatter production of rice (Hemalatha *et al.*, 2000).

Among different levels of phosphorus, significantly the highest drymatter accumulation (13885 and 13939 kg ha^{-1} was recorded during first and second year of study, respectively) due to the application of 75 kg P_2O_5 ha^{-1} and was on a par with 60 kg P_2O_5 ha^{-1}. The lowest drymatter 12770 and 12808 kg ha^{-1} was registered by applying 45 kg P_2O_5 ha^{-1} in 2015 and 2016. The higher soil available nutrient status might have helped in enhancing leaf area, which thereby resulted in higher photo-assimilation and more drymatter accumulation (Rama Rao *et al*., 1991).

Length of the panicle (cm)

Dhaincha green manure incorporation registered significantly the highest panicle length (27.5 and 26.2 cm) over control (25.0 and 24.2 cm) which recorded the lowest panicle length during the first and second years of experimentation. Taller plants with more number of tillers and drymatter accumulation in green manure plots could be the possible reason for the increased panicle length (Table 2.)

Significantly the highest panicle length was observed by application of phosphorus @ 75 kg P_2O_5 ha^{-1} (28.0 and 26.3 cm) where as the lowest was found with (24.5 and 24.4 cm) 45 kg P_2O_5 ha^{-1} and which was on a par with 60 kg P_2O_5 ha^{-1} during both the years of study.

Total number of grains panicle^{-1}

The higher number of grains panicle^{-1} (173) was recorded with *dhaincha* green manure incorporation during 2015 and 2016. Dhaincha and sunnhemp green manure incorporations were statistically on a par with each other during the first and second years of study, but control recorded significantly the lowest number of grains panicle^{-1} (160, and 160 in the first and second year of study). It might be attributed to increasing the availability of macro and micro nutrients due to the incorporation of green manure which is the source of all essential plant nutrients as described by Raju and Reddy (2000).

Significantly the highest number of grains (173 and 172) was recorded with the application 75 kg P_2O_5 ha^{-1} during first and second years of experimentation. However, 75 kg P_2O_5 ha^{-1} was

Table 3. Grain yield (kg ha^{-1}) straw yield (kg ha^{-1}) and harvest index of *kharif* rice as influenced by green manure and phosphorus treatments

Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Harvest index (%)	
	2015	2016	2015	2016	2015	2016
Dhaincha	5592.0	5587.0	7079.0	7138.0	44.4	43.8
Sunnhemp	5533.0	5515.0	7064.0	7078.0	44.2	43.3
Without green manure	5049.0	5003.0	6561.0	6600.0	41.2	39.8
SEm±	108.7	107.4	115.2	120.0	0.7	0.8
CD (p=0.05)	427.0	421.0	452.0	471.0	2.8	3.1
CV (%)	6.0	6.0	5.0	5.2	5.0	5.6
P levels (L)						
45 kg P_2O_5ha^{-1}	5124.0	5081.0	6690.0	6610.0	42.3	41.8
60 kg P_2O_5ha^{-1}	5505.0	5457.0	6952.0	7036.0	43.3	42.2
75 kg P_2O_5ha^{-1}	5545.0	5567.0	7063.0	7171.0	44.3	42.9
SEm±	126.8	127.3	118.8	140.1	1.0	1.2
CD (p=0.05)	391.0	392.0	366.0	432.0	NS	NS
CV (%)	7.1	7.1	5.2	6.1	7.1	8.4
Interaction						
L at same level of M						
SEm±	219.7	220.5	205.7	242.7	1.8	2.0
CD (p=0.05)	NS	NS	NS	NS	NS	NS
M at same or different levels of L						
SEm±	209.7	209.6	203.7	231.7	1.6	1.8
CD (p=0.05)	NS	NS	NS	NS	NS	NS

statistically comparable with 60 kg P_2O_5 ha^{-1}. During both the years of study, significantly the lowest number of grains panicle^{-1} (160 and 160) was obtained with 45 kg P_2O_5 ha^{-1}(Table 2). Higher rate of cell division, enlargement and cell differentiations could have encouraged toproduce more number of grains panicle^{-1} at higher phosphorus levels. Similar findings were also reported by Getahun Dereje *et al*. (2017).

Number of filled grains panicle^{-1}

The highest number of filled grains was recorded with *dhaincha* green manuring (171 and 171) and it was remained on a par with sunnhemp incorporation treatment. The lowest number of filled grains panicle^{-1} was recorded with control (157 and 155), which differed significantly from green manured plots in both the years. Continued availability of nutrients to crop during later stages in green manure applied plots might have supported photosynthesis during later stages of crop and better translocation of photosynthates to grain for better grain filling (Sunitha and Raju, 2004).

The number of filled grains panicle^{-1} was also increased with increase in phosphorus level up to 75 kg ha^{-1} (171 and 171) during first and second year of the study. Applying 75 and 60 kg P_2O_5 ha^{-1} were statistically comparable with each other. Significantly the lowest number of filled grains panicle^{-1} 158, 157 and 155 were registered with the treatment that received 45 kg P_2O_5 ha^{-1} during both the years of experimentation.

Grain Yield (kg ha^{-1})

The highest grain yield (5592 and 5587 kg ha^{-1}) was recorded with *dhaincha* green manure incorporation and was found statistically on a par with sunnhemp green manure incorporation only during the first and second years of study. Significantly the lowest grain yield (5049 and 5003 kg ha^{-1}) was registered in control. Dhaincha green manure incorporation treatment gave 10.8 and 11.7 per cent higher yield over control treatment during both the years of study. The yield increase was basically due to higher number of panicles per unit area and number of grains per panicle. Rice is relatively leafy in its early stages and adequate supply of nutrients improve it's photosynthetic rate and better nutrient uptake and ultimately the grain yield (Zahir Shah *et al*., 2011).

Among different levels of phosphorus, significantly the highest grain yield of 5545 and 5567 kg ha^{-1} was registered by the application of the 75 kg P_2O_5 ha^1 during first and second year of study (Table 3). The lowest grain yield of 5124 and 5081 kg ha^{-1} was obtained with application of 45 kg P_2O_5 ha^{-1} in 2015 and 2016.

The positive response of rice at higher levels of phosphorus application could be attributed to the overall improvement in crop growth by accumulating more drymatter increase in yield attributes which might have enabled the plants to absorb more nutrients in order to prepare more photosynthates. Further their translocation to sink which finally might have reflected in the higher yield. The beneficial role of phosphorus in enhancing the yield components and in-turn the yield was very well established by different workers such as Ashiana Javeed *et al*. (2017) and Sampath *et al*. (2017).

Straw yield (kg ha^{-1})

Among the main treatments, *dhaincha* green manure incorporation recorded significantly the highest straw yield (7079 and 7138 kg ha^{-1}) and was statistically on a par with sunnhemp incorporation only over control. The lowest straw yield (6561 and 6600 kg ha^{-1}) was recorded in control during 2015 and 2016. This might be due to stimulated vegetative growth as evidenced through higher plant height, more number of tillers and drymatter accumulation on account of adequate and prolonged supply of greater availability of P in soil, improved soil environment and higher root penetration leading to better absorption of moisture and nutrients (Harish *et al*., 2010).

Applying 75 kg P_2O_5 ha^{-1} registered significantly the highest straw yield (7063 and 7171 kg ha^{-1} during first and second years of study) which was statistically on a par with treatment received 60 kg P_2O_5 ha^{-1}. The lowest straw yield of rice (6690 and 6610 kg ha^{-1}) was recorded in the treatment that received 45 kg P_2O_5 ha^{-1} and was comparable with 60 kg P_2O_5 ha^{-1}. More growth and drymatter accumulation associated with higher levels of phosphorus could be the reason for the higher straw yield. Similar results were reported by Dwivedi *et al*. (2006).

Harvest Index (%)

Among the different green manure incorporation treatments, significantly the highest harvest index (44.4 and 43.8 % during the first and second years of study, respectively) was registered by *dhaincha* green manure incorporation treatment followed by sunnhemp green manure. The lower, harvest index values 41.2 and 39.8 % were recorded by the control during both the years of study. There was no significant difference existing among different levels of phosphorus and their interaction in case of harvest index during both the years of study.

CONCLUSION

From this study, it can be concluded that incorporation of green manure crops with 75kg P_2O_5 ha^{-1} application, closely followed by green manure crops with 60 kg P_2O_5 ha^{-1} recorded higher grain yield of *kharif* rice in both the years of study. Hence, the present study indicated that 15 kg P can be reduced by the green manure crops incorporation instead of going for higher dose of phosphorus application.

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Received on 27.04.2018 and revised on 14.08.2019