

Yield and Nutrient Uptake of Rice Crop as Influenced by Green Manures and Phosphorus Levels

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ABSTRACT

A field experiment was conducted during kharif 2015 and 2016 to study the effect of green manures and phosphorus levels to 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 during kharif season and three phosphorus levels to rice crop @ 45 kg P₂O₅ ha⁻¹, 60 kg P₂O₅ ha⁻¹, and 75 kg P₂O₅ ha⁻¹ as sub-plot treatments. Significantly the highest grain yield (5592 and 5587 kg ha⁻¹) and nutrient uptake both in grain and straw of rice was recorded with dhaincha green manure incorporated treatment when compared to control. Among the phosphorus levels applied to rice crop the highest grain yield (5545 and 5567 kg ha⁻¹) and nutrient uptake was also recorded with 75 kg P₂O₅ ha⁻¹ and it was on a par with 60 kg P₂O₅ ha⁻¹ during both the years of study.

Keywords: Dhaincha, Sunnhemp and phosphorus.

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food for more than half of the world population and it provides 21% and 15% per capita of dietary energy and protein, respectively (Maclean et al., 2002). Rice is one of the most important cereal food crops of India in terms of area, production and consumer preference. In India, rice accounts for more than 40% of food-grain production, providing direct employment to 70% people in rural areas. Our national food security hinges on the growth and stability of

rice production. Now days, chemical fertilizers are expensive due to the energy crisis and are unavailable to many farmers, particularly in developing countries like India. Green manuring is the process of growing leguminous crops and ploughing the same *in situ* in to soil. On decomposition, it results in increased soil fertility. At the same time, Green manures improve the organic matter, soil fertility, water holding capacity, aeration, colloidal complex and hence its ability to retain nutrients (Becker et al., 1995).

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Green manures increased the availability of P through the mechanism of reduction, chelation and favourable changes in soil pH. Better utilization of P and K to an extent of 10 to 12 per cent was observed due to green manure incorporation (Lekha Sreekantan & Palaniappan, 1990). Phosphorus was thought to be one of the most immobile, inaccessible and unavailable nutrient present in the soil and the phosphatic fertilisers added to the soil to meet the crop demand also will soon be converted to immobile forms. It is involved in a wide range of plant processes starting from permitting cell division to the development of a good root system, ensuring timely and uniform ripening of the crop. Phosphorus is needed mostly by young, fast growing tissues and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrates. It is a constituent of ADP and ATP, two of the most important substances in life processes. But the main problem concerning phosphatic fertilizers is its fixation with soil complex with in a short period of application rendering more than two thirds unavailable. So, it is necessary to know the optimum dose of phosphorus fertilizer for maximum yield. Phosphorus fertilization is required to sustain optimum crop yields (Pypers et al., 2005; & Nachimuthu et al., 2009).

The chemical composition of plants is a translation of the conditions under which they complete their life cycle fully or a part of it. The chemical composition is a net summary of all the changes either positive or negative, which are faced by the plants. The nutrient uptake is directly or indirectly affected by many factors like total concentration as well as available quantity of different nutrients, root development, aeration, water potential, climatic conditions and other related soil parameters. Beside all these, the presence of a nutrient in available form and in appropriate concentrations for the plant plays the deciding role. Some fraction of it may be permanently fixed but when organic materials are applied, the overall fertility status of the soil builds up and the total reserve of nutrients is increased

and a stage for enhanced availability is set up. Singh et al. (2008) reported that uptake of nutrients was improved by the application of integrated use of organic manures and inorganic fertilizers. Hence, the present investigation carried out with a view to evaluate the effect of phosphorus levels and green manures effect on growth, yield and nutrient uptake of wetland rice.

MATERIALS 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 experiment was conducted in split plot design 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 during *kharif* season and three phosphorus levels to rice crop 45 kg P₂O₅ ha⁻¹, 60 kg P₂O₅ ha⁻¹ and 75 kg P₂O₅ ha⁻¹ as sub- plot treatments. Nitrogen, phosphorus and potassium were applied through urea, single super phosphate and murate of potash, respectively. Nitrogen was applied in 3 different splits 1/3 of nitrogen at transplanting stage, 1/3 of nitrogen at maximum tillering stage and 1/3 of nitrogen at panicle initiation stage. Total recommended phosphorus was applied as basal and potash was applied in two splits in that 1/2 potash was applied as basal and 1/2 potash was applied in panicle initiation stage. Recommended agronomic management practices and plant protection measures were followed during crop growth. The data recorded were analyzed following standard statistical analysis of variance procedure.

RESULTS AND DISCUSSION

Grain Yield (kg/ha)

Grain yield of rice was significantly affected by green manures and phosphorus levels but not due to their interaction during the both the years of experimentation. The highest grain yield (5592, 5587 and 5590 kg ha⁻¹) was recorded with *dhaincha* green manure incorporation and was found statistically on a par with sunnhemp green manure

incorporation during the first and second years of study and pooled data, but both of these treatments differed significantly with control treatment respectively. The lowest grain yield (5049, 5003 and 5026 kg ha⁻¹) was registered with control. Dhaincha green manure incorporation treatment gave 10.8, 11.7 and 11.2 per cent higher yield over control treatment during both the years of study and in pooled data too.

Incorporation of green manure might have provided biological nitrogen fixed in the soil leading to continuous supply of nutrients in phased manner in to the soil solution ultimately increasing nutrient supply to the rice crop (Muntasir et al., 2001). These results are in confirmation with the findings of Sai Saravan et al. (2016) and Winarni et al. (2016).

Among different levels of phosphorus, significantly the highest grain yield of 5545, 5567 and 5556 kg ha⁻¹ was registered by the application of the 75 kg P₂O₅ ha⁻¹ during first and second year of study and pooled data, respectively. Applying 75 kg P₂O₅ ha⁻¹ and 60 kg P₂O₅ ha⁻¹ were statistically comparable with each other. Applying 60 kg P₂O₅ ha⁻¹ recorded 5505, 5457 and 5481 kg ha⁻¹ of grain yield which was statistically comparable with 45 kg P₂O₅ ha⁻¹ during first and second year of experimentation and pooled data. The lowest grain yield of 5124, 5081 and 5103 kg ha⁻¹ was obtained with application of 45 kg P₂O₅ ha⁻¹ in 2015, 2016 and pooled data, respectively. The beneficial role of phosphorus in enhancing the yield components and in-turn the yield was very well established by different workers such as Srujana et al. (2011), Ashiana Javeed et al. (2017) and Sampath et al. (2017).

Straw yield (kg/ha)

Perusal of the data (Table-1) on straw yield revealed that the straw yield also followed almost similar trend as that of grain yield during both the years of study. Straw yield of rice was significantly influenced by green manures and phosphorus levels but their interaction could not have any significant impact on straw yields in both the years of study as well as in pooled data. Among the

main treatments, dhaincha green manure incorporation recorded significantly the highest straw yield (7079, 7138 and 7109 kg ha⁻¹) and was statistically on a par with sunnhemp incorporation only. The lowest straw yield (6561, 6600 and 6565 kg ha⁻¹) was recorded with control during first and second years of experimentation. Increased growth and drymatter accumulation by green manure incorporation might have resulted in the more straw yield. The data on growth and drymatter accumulation indicated lower growth and yield attributes in control. This reduced growth and drymatter accumulation could be the possible reason for the lower straw yield in control treatment. Dhaincha green manure incorporation treatment gave 7.9, 8.2 and 8.3 per cent higher straw yield over control treatment. These results are in confirmation with the findings of Vijay Pooniya et al. (2012), Manjappa (2014) and Prathibha Sree et al. (2016).

Applying 75 kg P₂O₅ ha⁻¹ registered significantly the highest straw yield (7063, 7171 and 7110 kg ha⁻¹) during first and second years of study and in pooled data) which was statistically on a par with treatment received 60 kg P₂O₅ ha⁻¹. Overall, the increase in straw yield with these treatments might be due to better growth reflected in these treatments in terms of plant height, drymatter accumulation and tillering. These findings are in tune with the findings of Lungmuana et al. (2013), Prakash et al. (2013). The lowest straw yield of rice (6690, 6610 and 6650 kg ha⁻¹) was recorded with the treatment that received 45 kg P₂O₅ ha⁻¹ and was comparable with 60 kg P₂O₅ ha⁻¹. Lower rates of growth and drymatter accumulation might have caused the lower straw yields at low phosphorus levels.

Nitrogen uptake by rice grain

Significantly the highest nitrogen uptake of rice grain was recorded with *dhaincha* green manure incorporation (72.8, 72.1 and 72.4 kg/ha) which was statistically on a par with sunnhemp green manure incorporation during both the years of study and pooled data. This might be due to the higher availability of nitrogen at higher dose of nutrients to the rice

crop. However, sunnhemp green manuring treatment and control were significantly differed during both the years of experimentation and pooled analysis also (Table-2). Green manure incorporation increases the immobilization and mineralization of N in the soil and could regulate the addition of organic matter to improve the N uptake by rice (Tiwari et al., 1980).

Significant difference in nitrogen uptake among different levels of phosphorus applied to rice crop, more nitrogen uptake by rice grain was observed by the application of the 75 kg P₂O₅ ha⁻¹ (71.6, 72.2 and 72.4 kg/ha) during first and second year of study and pooled data. While lower nitrogen uptake of rice grain was registered by applying 45 kg P₂O₅ ha⁻¹ in 2015, 2016 and pooled analysis. Significant increase in nutrient uptake could be due to irrespective increase in nutrient concentration of grain and straw as well as increase in total drymatter production (Masthana Reddy et al., 2005).

Nitrogen uptake in rice straw

During both the years of study and pooled analysis, it was observed that significantly higher nitrogen uptake by rice straw was observed with *dhaincha* green manuring (63.6, 61.4 and 62.3 kg/ha), which was statistically on a par with sunnhemp green manure but proved significantly superior to the control during first, second year of study and pooled data, respectively. The uptake being the product of nutrient content and drymatter accumulation, the increase in N uptake by the crop might be due to increased availability of nitrogen and higher grain and straw yields reported by Vijay Pooniya and Yashbir Sing Shivay (2012).

Among different levels of phosphorus, higher nitrogen uptake by rice straw was observed by the application of 75 kg P₂O₅ ha⁻¹ (62.9, 60.6 and 61.7 kg/ha) during first and second year of study and in pooled data, respectively and found significantly superior to 45 kg P₂O₅ ha⁻¹ only. The lower nitrogen uptake of rice straw was registered by applying 45 kg P₂O₅ ha⁻¹ in 2015-16, 2016-17 and pooled data, respectively.

Phosphorus uptake by rice grain

Among the different green manures, the highest P uptake of rice grain was registered with *dhaincha* green manuring (20.4, 21.1 and 20.8 kg/ha) during the first and the second years of study and pooled data, while it was significantly superior to control and remained on a par with the sunnhemp incorporation. The lowest P uptake of rice grain was registered by control (17.2, 18.1 and 17.6 kg/ha). However, sunnhemp green manuring and control were significantly differed with each other during both the years of experimentation and pooled analysis also. Available P in soil significantly enhanced due to application of organic manures. The increased availability of P resulted in more uptake of P by the plant. The pH of the soil also indicated a positive change i.e. a shift towards neutrality. This positive change enhanced the solubility of different nutrients especially phosphorus in the soil (Upadhyay et al., 2011).

Significantly the highest P uptake in rice grain was recorded by 75 kg P₂O₅ ha⁻¹ (20.6, 21.2 and 20.9 kg/ha). Application of 75 kg P₂O₅ ha⁻¹ and 60 kg P₂O₅ ha⁻¹ were statistically comparable with each other. Application of 60 kg P₂O₅ ha⁻¹ and 45 kg P₂O₅ ha⁻¹ were also remained statistically identified during first and second years of experimentation and pooled data. The increase in available phosphorus due to phosphorus fertilization may be due to narrowing down C: P ratio (<20:1) which resulted in higher availability. It might be due to the fact that all the phosphorus applied to the soil is not fixed and all the available phosphorus is not absorbed by the crop (Singaram & Kothandaraman, 1993).

Phosphorus uptake in rice straw

Irrespective of the green manures significantly increased the P content and p uptake (Table-3) over the no green manure treatment. The maximum (8.67, 9.01 and 8.84 kg ha⁻¹) phosphorus uptake of straw in rice was significantly increased with the application of *dhaincha* green manure incorporation during

1st & 2nd years and pooled respectively and was on par with sunnhemp incorporation. The lowest P uptake of rice straw (6.97, 7.35 and 7.16 kg ha⁻¹) was recorded with no green manure treatment noticed during both the years of the study and in pooled data, respectively.

Significantly the phosphorus uptake of rice straw was highest (8.69, 9.30 and 9.00 kg ha⁻¹) with 75 kg P₂O₅ ha⁻¹ and was on a par with 60 kg P₂O₅ ha⁻¹. Significantly the lowest phosphorus uptake of 7.09, 7.31 and 7.20 kg ha⁻¹ was recorded in 45 kg P₂O₅ ha⁻¹ treatment during both the years and pooled respectively.

Potassium uptake by rice grain

Potassium uptake by the rice grain was significantly affected by green manures and P levels during both the years of experimentation, but not their interaction was found significant. Potassium uptake followed the similar trend as that was noticed in respect of N & P uptakes during both the years of study and in pooled analysis. The highest K uptake of rice grain was recorded with dhaincha green manuring treatment (18.65, 21.26 and 19.96 kg/ha), which was on a par with that of sunnhemp green manure incorporation, but it was significantly superior to control. The lowest K uptake of rice grain was recorded with control during both years of the study and pooled analysis, respectively. Dekhamedhi et al. (1996) observed that application of green manuring increased the K uptake in rice grain. The increase in uptake of potassium in organic treated plots due to the release of K from organic manures during decomposition and solubilisation and release of native and fixed forms of potassium, charging the soil solution with K⁺ ions (Hemalatha et al., 2000). Incorporation of green manures have improved the soil environment, which encouraged proliferous root system resulting in better absorption of nutrients from lower layers and thus resulting

in higher yield and nutrient uptake (Vinay Singh, 2006).

The higher uptake of potassium by rice grain was recorded with the treatment which received 75 kg P₂O₅ ha⁻¹ 19.05, 21.44 and 20.36 kg/ha). Application of 60 kg P₂O₅ ha⁻¹ was identified as the next best treatment. The lower values of K content were recorded in 45 kg P₂O₅ ha⁻¹ in both the years of experimentation and in pooled analysis. Higher K uptake recorded might be due to better soil condition reduced K fixation (Dushyant Panday et al., 2015).

K uptake in rice straw

The maximum K uptake of rice straw 87.15, 92.49 and 89.83 kg ha⁻¹ was recorded with dhaincha green manuring, which was on a par with that of the application of sunnhemp incorporation and it was proved significantly superior no green manure during both the years of the study and pooled data also. The minimum K uptake of rice straw (78.64, 80.06 and 79.35 kg ha⁻¹) was recorded with the no green manure treatment during both years of the study and pooled data, respectively. Application of green manures might have improved the soil environment, which encouraged proliferous root system resulting in better absorption of water and nutrients from lower layers and thus resulting in higher yield and nutrient uptake (Upadhyay et al., 2011).

The higher (86.76, 92.54 and 89.66 kg ha⁻¹) uptake of potassium in rice straw was found with 75 kg P₂O₅ ha⁻¹ while, the lower K uptake of rice straw (80.24, 82.62 and 81.43 kg ha⁻¹) was recorded by 45 kg P₂O₅ ha⁻¹ treatment. Critical observations of the data (Table-4) revealed that potassium uptake by the crop was increased with increase in level of phosphorus due to the enhanced number of small root hairs which in turn facilitated the absorbing ability per unit dry weight (Dushyant Panday et al., 2015).

Table 1: Grain yield (kg ha⁻¹) and straw yield (kg ha⁻¹) of *kharif* rice as influenced by green manures and phosphorus levels during 2015 and 2016 and pooled

Green manures (M)	Grain Yield (kg/ha)			Straw yield (kg/ha)		
	2015	2016	Pooled	2015	2016	Pooled
Dhaincha	5592	5587	5590	7079	7138	7109
Sunnhemp	5533	5515	5524	7064	7078	7072
Without green manure	5049	5003	5026	6561	6600	6565
SEm±	108.7	107.4	90.0	115.2	120.0	122.7
CD (P=0.05)	427	421	353	452	471	482
CV (%)	6.0	6.0	5.0	5.0	5.2	5.3
P levels (L)						
45 kg P ₂ O ₅ ha ⁻¹	5124	5081	5103	6690	6610	6650
60 kg P ₂ O ₅ ha ⁻¹	5505	5457	5481	6952	7036	6986
75 kg P ₂ O ₅ ha ⁻¹	5545	5567	5556	7063	7171	7110
SEm±	126.8	127.3	77.6	118.8	140.1	131.1
CD (P=0.05)	391	392	239	366	432	404
CV (%)	7.1	7.1	4.3	5.2	6.1	5.7
Interaction						
L at same level of M						
SEm±	219.7	220.5	134.5	205.7	242.7	227.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS
M at same or different levels of L						
SEm±	209.7	209.6	142.0	203.7	231.7	222.3
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 2: Nitrogen uptake in *kharif* rice grain and straw as influenced by green manures and phosphorus levels during 2015, 2016 and pooled

Green manures (M)	Grain Nitrogen uptake (kg/ha)			Straw Nitrogen uptake (kg/ha)		
	2015	2016	Pooled	2015	2016	Pooled
Dhaincha	72.8	72.1	72.4	63.6	61.4	62.3
Sunnhemp	71.8	71.1	71.9	62.4	59.9	61.2
Without green manure	63.4	63.9	64.5	56.0	51.3	54.6
SEm±	1.84	1.83	1.42	1.34	1.33	1.23
CD (P=0.05)	7.2	7.1	5.6	5.1	5.1	4.6
CV (%)	7.9	7.7	6.1	6.4	6.6	5.9
P levels (L)						
45 kg P ₂ O ₅ ha ⁻¹	66.3	65.1	65.7	57.9	53.9	56.1
60 kg P ₂ O ₅ ha ⁻¹	70.2	69.8	70.7	61.3	57.9	60.3
75 kg P ₂ O ₅ ha ⁻¹	71.6	72.2	72.4	62.9	60.6	61.7
SEm±	1.64	1.75	1.65	1.53	2.14	1.54
CD (P=0.05)	4.9	5.41	5.1	4.8	6.3	4.5
CV (%)	6.9	7.62	7.1	7.6	10.7	7.5
Interaction						
L at same level of M						
SEm±	2.74	3.04	2.83	2.74	3.65	2.64
CD (P=0.05)	NS	NS	NS	NS	NS	NS
M at same or different levels of L						
SEm±	2.93	3.05	2.74	2.52	3.23	2.44
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 3: Phosphorus uptake in *kharif* rice grain and straw as influenced by green manures and phosphorus levels during 2015, 2016 and pooled

Green manures (M)	Grain Phosphorus uptake (kg/ha)			Straw Phosphorus uptake (kg/ha)		
	2015	2016	Pooled	2015	2016	Pooled
Dhaincha	20.36	21.1	20.76	8.67	9.01	8.84
Sunnhemp	19.91	20.6	20.25	8.24	8.69	8.47
Without green manure	17.20	18.1	17.63	6.97	7.35	7.16
SEm±	0.374	0.65	0.405	0.364	0.153	0.152
CD (P=0.05)	1.46	2.3	1.59	1.41	0.58	0.59
CV (%)	5.84	8.9	6.20	13.55	5.35	5.53
P levels (L)						
45 kg P ₂ O ₅ ha ⁻¹	16.55	18.2	17.39	7.09	7.31	7.20
60 kg P ₂ O ₅ ha ⁻¹	20.32	20.3	20.33	8.11	8.44	8.28
75 kg P ₂ O ₅ ha ⁻¹	20.60	21.2	20.91	8.69	9.30	9.00
SEm±	0.734	0.6	0.423	0.212	0.373	0.204
CD (P=0.05)	2.25	1.9	1.29	0.66	1.14	0.63
CV (%)	11.45	9.1	6.40	8.09	13.25	7.49
Interaction						
L at same level of M						
SEm±	1.274	1.1	0.722	0.374	0.643	0.352
CD (P=0.05)	NS	NS	NS	NS	NS	NS
M at same or different levels of L						
SEm±	1.104	1.0	0.713	0.472	0.544	0.334
CD (P=0.05)	NS	NS	NS	NS	NS	NS

Table 4: Potassium uptake in *kharif* rice grain and straw as influenced by green manures and phosphorus levels during 2015, 2016 and pooled

Green manures (M)	Grain Potassium uptake (kg/ha)			Straw Potassium uptake (kg/ha)		
	2015	2016	Pooled	2015	2016	Pooled
Dhaincha	18.65	21.26	19.96	87.15	92.49	89.83
Sunnhemp	18.47	20.44	19.46	86.26	90.97	88.62
Without green manure	16.44	17.02	16.96	78.64	80.06	79.35
SEm±	0.404	0.352	0.383	1.712	2.153	1.654
CD (P=0.05)	1.58	1.38	1.50	6.70	8.44	6.46
CV (%)	6.78	5.39	6.11	6.09	7.34	5.75
P levels (L)						
45 kg P ₂ O ₅ ha ⁻¹	16.46	17.39	16.93	80.24	82.62	81.43
60 kg P ₂ O ₅ ha ⁻¹	18.05	19.89	19.09	85.05	88.37	86.71
75 kg P ₂ O ₅ ha ⁻¹	19.05	21.44	20.36	86.76	92.54	89.66
SEm±	0.494	0.953	0.641	2.162	2.534	2.178
CD (P=0.05)	1.50	2.91	1.96	NS	7.79	6.70
CV (%)	8.18	14.48	10.16	7.72	8.63	7.59
Interaction						
L at same level of M						
SEm±	0.842	1.643	1.101	3.744	4.382	3.773
CD (P=0.05)	NS	NS	NS	NS	NS	NS
M at same or different levels of L						
SEm±	0.804	1.383	0.982	3.502	4.173	3.491
CD (P=0.05)	NS	NS	NS	NS	NS	NS

CONCLUSION

From this study, it can be concluded that incorporation of green manure crops with 75kg P₂O₅ ha⁻¹ application, closely followed by green manure crops with 60 kg P₂O₅ 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 level consumption of inorganic fertilizers.

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