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Effect of Organic Manures and Inorganic Phosphorus on Growth and Yield of Rice

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ABSTRACT

A field experiment was conducted on Phosphorus dynamics in relation to nutrient management in rice- blackgram cropping sequence at Agricultural College Farm, Bapatla. The results revealed that drymatter production, grain yield and straw yield of rice were significantly higher with the application of 100% RDNK in combination with *Dhaincha* @10t ha^{-1} and it was on par with that of application of RDNK along with sunhemp @10t ha^{-1}. However the lowest grain and straw yields were recorded in RDNK alone during both the years of the study. Among the P levels, the treatment P_5 (120 kg P_2O_5 ha^{-1}) recorded significantly higher dry matter, grain and straw yield and it was on par with P_4 (90 kg P_2O_5 ha^{-1}) and P_3 (60 kg P_2O_5 ha^{-1}) while the lowest was recorded in P_1 (0 kg P_2O_5 ha^{-1}).

keywords: *Growth and yield*, *Organic manures, Phosphorus fertilizer.*

Rice (*Oryza sativa* L.) is the staple food crop not only in India but also for entire South Asia. Of the total rice production in the world, more than 90 % is in Asia and it is increasing annually at the rate of 2.7% (IRRI, 1986). In India, it is grown in an area of 43.9 m.ha with a production of 99.24 m t with a productivity of 2494 kg ha^{-1}. In Andhra Pradesh, it is grown in an area of 2.15 m.ha with a production of 8.05 m.t with productivity of 3741 kg ha^{-1} (Ministry of Agriculture, Govt of India, 2018-19). During the last two decades, due to crop intensification and increased availability of chemical fertilizers, use of organic manures were declined substantially. In recent years, however, with increasing pressure to produce high yields from a single crop and higher total yields under intensive cropping systems, concern for sustainable soil productivity has emerged out as an issue of vital importance. It has clearly resulted in a tremendous renewal of interest on the part of researchers, farmers and planners in the old practice of organic manuring. It is increasingly appealing as a means to reduce losses of soil organic matter, compaction, soil erosion and still maintain economic returns. Organic manures may also favourably alter the availability of several plant nutrients including micronutrients through its impact on chemical and biological properties of soil.

Phosphorus is an essential, irreplaceable element in all living cells and without it, there would be no living thing on the earth. It has structural function in macromolecules, metabolic pathways and degradation and 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. But the main problem concerning phosphatic fertilizers is its fixation with soil complex within a short period of application rendering more than two thirds unavailable. Moreover phosphorus fertilization is required to sustain optimum crop yields (Nachimuthu *et al*., 2009). So, it is necessary to know the optimum dose of phosphorus fertilizer for maximum yield. Hence present investigation was planned and carried out.

MATERIAL AND METHODS

A field experiment entitled was conducted for two consecutive years (2017-2018 and 2018-2019) at Agricultural College Farm, Bapatla. The experimental soil was clay loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium. The micronutrients suchas Fe, Mn, Zn and Cu were above their critical levels. The experiment was laid out in a split plot design and replicated thrice. The treatments consisted of RDNK (M_0), RDNK+FYM @ 5t ha^{-1} (M_1), RDNK+sunhemp @ 10t ha^{-1} (M_2) and RDNK+*Dhaincha* @ 10t ha^{-1}(M_3) as main plots and five phosphorus levels to rice crop comprising of 0 kg P_2O_5 ha^{-1} (P_1), 30 kg P_2O_5 ha^{-1} (P_2) and 60 kg P_2O_5 ha^{-1} (P_3), 90 kg P_2O_5 ha^{-1} (P_4) and 120 kg P_2O_5 ha^{-1} (P_5) as sub- plot treatments. These treatments were imposed to rice crop during *kharif* season. Five successive hills were sampled at tillering, panicle initiation and at harvest. The samples were dried in shade first and then dried in hot-air oven at 65°C till to attain constant weight. Sample dry weights were summed up to arrive at mean dry matter per hill in individual treatment. The mean dry weight was multiplied by number of hills m^{-2} and expressed in t ha^{-1}. The crop harvested from each net plot was bundled up separately and allowed for drying in sun and threshed individual plot wise by using pedal operated paddy thresher. Cleaning of the grain was done after threshing and then dried in sun to a constant weight to record the final yield. Grain yields from the labeled hills were added to the corresponding plot yields before expressing the final grain yield in t ha^{-1} during both the years of study.

RESULTS AND DISCUSSION

Drymatter production

The results pertaining to dry matter production at different growth stages were presented in the tables 1, 2 and 3. Among the organic sources, RDNK + *Dhaincha* @ 10 t ha^{-1} (M_3- 2675, 4996, 12869, 2836, 5492 and 13640 kg ha^{-1}) was significantly recorded the highest dry matter production and it was on par with RDNK + sunhemp @ 10 t ha^{-1} (M_2- 2576, 4895, 12927, 2731, 5385 and 13702 kg ha^{-1}) at tillering, panicle initiation and harvest in 2017 and 2018, respectively). These two treatments were significantly superior over 5t FYM ha^{-1} + 100% RDNK (M_1- 2277, 4577, 11501, 2414, 5045, and 12191 kg ha^{-1}) and RDNK alone (M_0- 1908, 4176, 10252, 2023, 4615 and 10867 kg ha^{-1}) during 2017 and 2018 at all growth stages of rice. However the lowest drymatter production was recorded in M_0 (RDNK alone).

The drymatter production was significantly increased by the addition of organic manures. This might be due to increased radiation interception as well as better nutrition of crop plants due to green manure and FYM application, which inturn increased the photosynthesis rate and reflected in significant increase in the dry matter accumulation at all the stages of growth over inorganics alone. Combined application of organics and RDNK recorded significantly higher dry matter accumulation over RDNK alone (M_1). The beneficial effect of organic manures like green manuring and FYM on dry matter yield was reported earlier by Premalatha (2017).

Among the P levels, the treatment P_5 (120 kg P_2O_5 ha^{-1}) (2586, 4986, 12869, 2741, 5482 and 13640 kg ha^{-1}) recorded significantly higher drymatter production and it was on par with P_4 (90 kg P_2O_5 ha^{-1}) (2515, 4919, 12675, 2666, 5411 and 13434 kg ha^{-1}) and P_3 (60 kg P_2O_5 ha^{-1}) (2403, 4814, 12514, 2548, 5298 and 13265 kg ha^{-1}) at tillering, panicle initiation and harvest during 2017 and 2018, respectively.

These three treatments were significantly superior over P_1 (0 kg P_2O_5 ha^{-1}) (2064, 4107, 10345, 2188, 4542 and 10965 kg ha^{-1}) and P_2 (30 kg P_2O_5 ha^{-1}) (2227, 4478, 11382, 2361, 4939, and 12063 kg ha^{-1}). However, the significantly lower drymatter production was recorded in P_1 (0 kg P_2O_5 ha^{-1}) during both the years of study. The significant improvement in drymatter accumulation of rice with increasing phosphorus nutrition was due to better growth and development of the plant. The higher soil available nutrients might have helped in enhancing leaf area, which thereby resulted in higher photo-assimilation and more drymatter accumulation. Significant increase in growth characters (tiller number per unit area and plant height) due to phosphorus application might have resulted in increased photosynthesis and production of photosynthates which finally transformed into higher source and photosynthates and thereby higher accumulation of drymatter (Watanabe *et al*., 2007). Similar findings were reported by Ashiana *et al.* (2017).

Grain yield

Critical examination of the data indicated that the grain yield of rice during both the years were significantly increased due to application of organics along with RDNK over RDNK alone. Application of *Dhaincha* @10t ha^{-1} + RDNK (M_3) recorded the highest grain yield (5524 and 5801 kg ha^{-1}) and it was on par with sunhemp 10t ha^{-1} + RDNK (M_2- 5382 and 5651 kg ha^{-1}) and these two treatments were significantly superior over FYM along with RDNK (M_1-4684 and 4949 kg ha^{-1}) and RDNK alone (M_0-3943 and 4140 kg ha^{-1}) during 2017 and 2018, respectively. Incorporation of green manure might have provided biological nitrogen fixed in the soil leading to continuous supply of nutrients in phased manner into the soil solution ultimately increasing nutrient supply to the rice crop. The increased grain yield due to green manure incorporation might be due to the cumulative effect of substantial improvement in growth characters like plant height, drymatter accumulation, higher yield attributes *viz*., panicle length, number of filled grains and test weight. The improved growth and yield attributes contributed towards the increase in yield of rice in green manure plots. Addition of different green manures enhanced the organic carbon percentage of the soil which is a key factor determining soil fertility and productivity. This increase in organic matter content in the soil improved the physical properties (bulk density, water holding capacity and infiltration rate) of the soil thereby increase in growth parameters, yield attributes and yield (Ram *et al*., 2011).

Among the phosphorus levels, the significantly higher grain yield was recorded in P_5 (120 kg P_2O_5 ha^{-1}) (5333 and 5600 kg ha^{-1}) and it was on par with P_4 (90 kg P_2O_5 ha^{-1}) (5228 and 5489kg ha^{-1}) and P_3 (60 kg P_2O_5 ha^{-1}) (5144 and 5401kg ha^{-1}) treatments and these three treatments were significantly superior over 30 kg P_2O_5 (P_2-4628 and 4859 kg ha^{-1}), 0 kg P_2O_5 (P_1- 4085 and 4290 kg ha^{-1}) during 2017 and 2018, respectively. However the

Table 1. Effect of organic manures and inorganic P fertilizer on drymatter production (kg ha^{-1}) of rice at tillering stage

P levels (kg P_2O_5 ha^{-1})	*Kharif* 2017 Organic manures				Mean	*Kharif* 2018 Organic manures				Mean
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	1641	1967	2278	2372	2064	1739	2084	2414	2514	2188
P_2– 30	1813	2136	2439	2520	2227	1922	2264	2586	2671	2361
P_3– 60	1991	2291	2596	2736	2403	2110	2428	2752	2900	2548
P_4– 90	2014	2449	2756	2843	2515	2135	2596	2922	3013	2666
P_5– 120	2082	2544	2811	2907	2586	2207	2697	2980	3082	2741
Mean	1908	2277	2576	2675		2023	2414	2731	2836	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	99.26		333		11.8	97.83		339		12.1
P	51.6		149		7.6	55.92		161		9.1
M at P	119.13		NS			130.96		NS		
P at M	143.6		NS			152.61		NS		

Table 2. Effect of organic manures and inorganic P fertilizer on drymatter production (kg ha^{-1}) of rice at panicle initiation stage

P levels (kg P_2O_5 ha^{-1})	*Kharif* 2017 Organic manures				Mean	*Kharif* 2018 Organic manures				Mean
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	3674	4013	4324	4418	4107	4078	4441	4774	4874	4542
P_2– 30	4014	4361	4719	4820	4478	4442	4813	5196	5304	4939
P_3– 60	4330	4725	5050	5149	4814	4780	5203	5550	5656	5298
P_4– 90	4401	4862	5158	5256	4919	4857	5349	5666	5771	5411
P_5– 120	4460	4925	5224	5336	4986	4920	5417	5736	5856	5482
Mean	4176	4577	4895	4996		4615	5045	5385	5492	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	81.55		282		7.6	87.88		304		7
P	102.9		297		8	114.31		329		10
M at P	215.18		NS					NS		
P at M	209.03		NS					NS		

M_0- No Organic manure;
M_1- RDNK+FYM 5 t ha^{-1};
M_2- RDNK+Sunhemp 10 t ha^{-1};
M_3- RDNK+Dhaincha 10 t ha^{-1}

significantly lower grain yield was recorded in P_1 which received 0 kg P_2O_5 during both the years of study. The improvement in grain yield of rice with increase in the level of phosphorus might be due to the manifestation of elevated level of phosphorus on growth and yield parameters resulting in the superior performance of rice over the lower levels. 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 in yield attributes, which might have enabled the plants to absorb more nutrients in order to prepare more photosynthates. Further, their translocation to sink finally might have reflected in higher yield. The beneficial role of phosphorus in enhancing the yield components and in-turn the yield was very well established by different research workers such as Ashiana *et al*. (2017) and Sampath *et al*. (2017).

Straw yield

The results pertaining to straw yield was presented in the table 5. Straw yield also followed the

Table 3. Effect of organic manures and inorganic P fertilizer on drymatter production (kg ha^{-1}) of rice at harvest

P levels (kg P_2O_5 ha^{-1})	*Kharif* 2017 Organic manures				Mean	*Kharif* 2018 Organic manures				Mean
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	8742	9847	11375	11415	10345	9082	10199	11740	11780	10700
P_2– 30	9764	10910	12392	12462	11382	10104	11262	12757	12827	11738
P_3– 60	10782	12049	13483	13742	12514	11122	12401	13848	14107	12869
P_4– 90	10953	12182	13599	13966	12675	11293	12534	13964	14331	13030
P_5– 120	11017	12516	13784	14158	12869	11357	12868	14149	14523	13224
Mean	10252	11501	12927	13148		10592	11853	13292	13513	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	309.11		1070		10.1	322.69		1117		9.9
P	254.54		733		7.4	271.07		781		7.4
M at P	508.97		NS			541.94		NS		
P at M	550.26		NS			582.31		NS		

Table 4. Effect of organic manures and inorganic P fertilizer on grain yield (kg ha^{-1}) of rice.

P levels (kg P_2O_5 ha^{-1})	*Kharif* 2017 Organic manures				Mean	*Kharif* 2018 Organic manures				Mean
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	3231	3872	4615	4622	4085	3393	4066	4846	4855	4290
P_2– 30	3693	4372	5113	5333	4628	3878	4591	5369	5599	4859
P_3– 60	4159	4942	5673	5800	5144	4367	5189	5957	6090	5401
P_4– 90	4302	5006	5716	5887	5228	4517	5256	6002	6181	5489
P_5– 120	4329	5230	5794	5980	5333	4546	5491	6083	6279	5600
Mean	3943	4684	5382	5524		4140	4949	5651	5801	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD		CV (%)
M	127.85		442		10.1	124.45		431		9.4
P	159.44		459		11.3	164.95		475		11.1
M at P	318.88		NS			329.9		NS		
P at M	312.56		NS			320.24		NS		

M_0- No Organic manure;
M_1- RDNK+FYM 5 t ha^{-1};
M_2- RDNK+Sunhemp 10 t ha^{-1};
M_3- RDNK+Dhaincha 10 t ha^{-1}

similar trend as that of grain yield during both the years of the study and ranged from 6095 to 6460 and 7551 to 8004 kg ha^{-1} during 2017 and 2018, respectively. Among the P levels also the same trend was followed. The straw yield ranged from 6081 to 6445 and 7319 to 7758 kg ha^{-1} due to different P levels during two years of study. As was noticed with grain yield, straw yield was also the highest with *Dhaincha* 10t ha^{-1} + RDNK (M_3) with 7551 and 8004 kg ha^{-1} and it was on par with sunhemp 10t ha^{-1} + RDNK (M_2) with 7328 and 7767 kg ha^{-1}, while these two treatments were significantly superior over FYM @ 5 t ha^{-1} along with RDNK (M_1) with 6607 and 7004 kg ha^{-1} and RDNK (M_0) with 6095 and 6460 kg ha^{-1} during 2017 and 2018, respectively. However, significantly lower haulm yield was recorded in M_0 (RDNK alone). Mahajan *et al.* (2008), who reported increased straw yields in rice with the combined application of FYM and inorganic fertilizers. This implies that by combining inorganic fertilizers with green manures and/or FYM, farmers could reduce the need for inorganic fertilizers and still increasing their productivity. The significant increase

Table 5. Effect of organic manures and inorganic P fertilizer on straw yield (kg ha^{-1}) of rice

P levels (kg P_2O_5 ha^{-1})	*Kharif* 2017 Organic manures				Mean	*Kharif* 2018 Organic manures				Mean
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	5308	5795	6544	6676	6081	5626	6143	6936	7076	6445
P_2– 30	5855	6321	7062	7346	6646	6206	6701	7486	7786	7045
P_3– 60	6406	6890	7593	7865	7188	6790	7303	8048	8337	7620
P_4– 90	6435	6960	7666	7909	7243	6821	7377	8126	8384	7677
P_5– 120	6471	7070	7773	7961	7319	6859	7494	8240	8438	7758
Mean	6095	6607	7328	7551		6460	7004	7767	8004	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	93.45		323		10.7	145.67		504		7.7
P	165.73		477		8.3	160.62		463		8.1
M at P	264.83		NS			343.71		NS		
P at M	254.64		NS			340.19		NS		

in straw yield in response to the combined application of organic and inorganic fertilizers could be attributed to increased nutrient availability and thus increased uptake of nutrients by plant. This might be attributed to the nutrient supplying capacity of the organics as well as their propensity to improve the soil physico-chemical properties. Neither organics nor chemical fertilizers alone could be sufficient to increase yield sustainability under cropping system where nutrient turnover in soil plant system has been much higher. However, in an integrated nutrient management, organics can maintain plant nutrients in the available forms for longer periods due to improved soil organic matter (SOM), soil physico-chemical and biological characteristics. These results were in conformity with the findings of Amit *et al*. (2018), who reported that combined application of green manures, FYM and chemical fertilizers increased straw yield in rice crop.

Among the P levels, the treatment P_5 (120 kg P_2O_5 ha^{-1}) (7319 and 7758 kg ha^{-1}) recorded significantly higher straw yield and it was on par with P_4 (90 kg P_2O_5 ha^{-1}) (7243 and 7677 kg ha^{-1}) and P_3 (60 kg P_2O_5 ha^{-1}) (7188 and 7620 kg ha^{-1}). However, these three treatments were significantly superior over P_2 (30 kg P_2O_5 ha^{-1}) (6646 and 7045 kg ha^{-1}) and P_1 (0 kg P_2O_5 ha^{-1}) (6081 and 6445 kg ha^{-1}). The lowest straw yield was recorded in P_1 during 2017 and 2018, respectively. However, the interaction was not significant. The straw yield was significantly increased due to different levels of P. This might be due to more growth and drymatter accumulation associated with higher levels of phosphorus could be the reason for the higher straw yield. Lower rates of growth and drymatter accumulation might have caused the lower straw yields at low phosphorus levels. 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 were in tune with the findings of Bekele and Getahun (2016).

CONCLUSION

Significantly higher drymatter production and yields (grain and straw yield) of rice were recorded due to the application of 100% RDNK in combination with *Dhaincha* @10t ha^{-1} and the lowest was recorded in RDNK alone. Among the P levels, the treatment P_5 (120 kg P_2O_5 ha^{-1}) recorded significantly higher dry matter production and grain and straw yield and the lowest was recorded in P_1 (0 kg P_2O_5 ha^{-1}) during both the years of study.

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