



Effect of Organic Manures and Phosphorus on Soil Nutrient Status in *Kharif* Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Field experiments were conducted at Agricultural College Farm, Bapatla during *Kharif* and *Rabi* seasons of 2017-2018 and 2018-2019 to study the Phosphorus dynamics in relation to nutrient management in rice- blackgram cropping sequence with respect to changes in soil nutrient status. Results of two years (2017-2019) experimentation revealed that at all growth stages of rice,

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significantly highest available nitrogen, phosphorus and potassium in soil were recorded with application of RDNK+*Dhaincha* @ 10t ha⁻¹ (M₃) and this was on par with RDNK+ Sunhemp @ 10t ha⁻¹ (M₂), whereas lowest was recorded in RDNK (M₀) alone in both seasons of study. Among the P levels the available nutrient status (N, P and K) were increased with the increasing level of P from 0 (P₁) to 120 kg P₂O₅ (P₅) ha⁻¹, irrespective of the nutrients imposed to rice crop. Significantly highest was recorded in P₅ (120 kg P₂O₅ ha⁻¹) and this was on par with P₄ (90 kg P₂O₅ ha⁻¹), whereas the lowest was recorded in treatment P₁ that received 0 kg P₂O₅ ha⁻¹.

Keywords: Organic manures; phosphorus fertilizer; soil nutrient status; kharif rice.

1. INTRODUCTION

Rice based cropping systems are the major production systems contributing to food production. Current crop production systems are characterized by inadequate and imbalanced uses of fertilizers e.g., blanket fertilizer recommendations over large domains with least regard to the variability in soil fertility and productivity. Future gains in productivity and input use efficiency require soil and crop management technologies that are tailored to specific characteristics of individual farms or fields. To meet the food requirement of the growing population, the rice and pulse production has to be enhanced with good management practices with shrinking availability of land and water resources condition. A large part of the problems that have not been sufficiently clarified yet can be solved only by using integrated nutrient management techniques. The supply of soils with soil organic matter and the elaboration of suitable methods to determine optimal humus contents and the factors of the humus balance. Since many decades, we have optimal values for all macro and micronutrients in the soil, we have also limit values for pollutants, however, we have no optimal values for the most important elements in soil, i.e., carbon and nitrogen. The effect of crop rotations on the crop yields, soil health and chemical, physical and biological soil characteristics. We owe predominantly to the results of the integrated nutrient management techniques for the contemporary knowledge regarding the sustainable land use. Integrated nutrient management experiments will also be indispensable in future, as they cannot be replaced by new analytical techniques or models; on the contrary, they are an indispensable basis for the calibration and validation of these techniques. Rice-blackgram is the most common cropping system existing in Krishna Agroclimatic Zone of Andhra Pradesh. Therefore it was decided to study the effect of different treatment combinations in *kharif* rice to monitor soil fertility status.

2. MATERIALS AND METHODS

The present experiment in rice based cropping system viz., rice-blackgram was started at Agricultural College Farm, Bapatla (15° 54' N latitude, 80° 25' E longitude, 5.49 meters above the mean sea level) during June, 2017-19. During normal years, the annual rainfall is 1200 mm of which around 70 % is received during September to October (South East monsoon). The climate of the experimental site is subtropical monsoon type. Rice crop transplanting in August and harvest in December was grown under irrigated conditions. The soil of the experimental site is clay loam texture. Here, we are discussing the results of two consecutive years. The initial analytical data of the available N (156.60 kg ha⁻¹), phosphorus (35.20 kg ha⁻¹) and potassium (385.23 kg ha⁻¹). The Experiment was laid out in a split block design with 20 treatments and three replications. Nitrogen was applied in three equal splits for *kharif* rice (transplanting, tillering and panicle initiation), while phosphorus was applied entirely as basal and potassium in two equal splits (as basal and at panicle initiation stage). The fertilizers used were urea, single super phosphate, muriate of potash. For treatments of organic manures (M₂ and M₃), sunhemp (2.43 % N, 0.48 % P and 1.96% K and 2.51 % N, 0.53 % P and 2.03% K), *dhaincha* (3.20 % N, 0.57 % P and 1.70 % K and 3.40 % N, 0.65 % P and 1.91 % K) was incorporated @ 10 t ha⁻¹ and FYM (0.70 % N, 0.27 % P and 0.56% K and 0.76 % N, 0.29 % P and 0.59% K) @ 5 t ha⁻¹ (M₁) in both 2017-18, 2018-19 on dry weight basis, respectively.) was incorporated as main plots and five phosphorus levels of 0 kg P₂O₅ ha⁻¹ (P₁), 30 kg P₂O₅ ha⁻¹ (P₂) and 60 kg P₂O₅ ha⁻¹ (P₃), 90 kg P₂O₅ ha⁻¹ (P₄) and 120 kg P₂O₅ ha⁻¹ (P₅) as sub-plot treatments for *kharif* rice. Need based plant protection measures were taken up against pest and diseases. The chemical properties of soil viz., available nitrogen, phosphorus and potassium was analysed by different chemical methods as described below.

Available nitrogen: Available nitrogen was estimated by alkaline permanganate method by using macro Kjeldahl distillation unit [1].

Available phosphorus: Available phosphorus in the soil samples was extracted with 0.5 M NaHCO₃ buffered at pH 8.5 and the phosphorus in the extract was estimated by ascorbic acid method using spectrophotometer at 660 nm [2].

Available potassium: It was extracted with neutral normal ammonium acetate and estimated with the help of flame photometer [3].

3. RESULTS AND DISCUSSION

Available NPK status of soil was significantly influenced by different organic manures along with inorganic fertilizers and also by inorganic phosphorus fertilizer levels during both the years of the study. However, the interaction effect was not significant.

3.1 Nitrogen

Data pertaining to the soil available nitrogen at all stages of rice was presented in the Tables 1, 2 and 3 which revealed that available N in the soil did differ significantly due to organic manure treatments and levels of phosphorus, but not by their interaction during both the years of study. At tillering, among the different sources of organic manures, the higher soil available nitrogen was recorded with the RDNK+ *Dhaincha* 10 t ha⁻¹ (M₃-229.05 and 237.87 kg ha⁻¹) which was on par with the application of RDNK+sunhemp 10 t ha⁻¹ (M₂-226.68 and 235.18 kg ha⁻¹), while these two treatments were followed by RDNK+FYM (M₁-214.29 and 220.69 kg ha⁻¹) and found significantly superior over application of RDNK (M₀-198.97 and 203.40 kg ha⁻¹) alone during 2017 and 2018, respectively. Similar trend was observed at panicle initiation and harvest of rice also.

The results of the present study revealed that combined application of organics and inorganics recorded the highest available nitrogen content. This might be due to positive response of green manuring with inorganic fertilizers on soil N status and may be attributed to N mineralization from organic sources or by retaining N in labile microbial pool with the changing microbial flush. The most soil conditions might have helped the mineralization of soil N and greater multiplication of soil microbes, which could convert organically

bound nitrogen into readily available form leading to building up of higher available N. The inclusion of green manure (*Sesbania aculeate*) in rice based cropping sequence reduced the loss of native nitrate N accumulated during aerobic cycle of the rice based cropping sequence and also conserved nitrate nitrogen, which would be lost upon flooding [4].

Incorporation of organic manures in rice-maize system increased the nutrient pool and reduced the losses of nutrients. Green manuring, which are comparatively more succulent with narrow C: N ratio release nitrogen on decomposition steadily into the soil pool to meet the crop requirement. Significantly lower available N in soil was observed with application of 100% NPK. Urea which contains highest content of N when applied to rice is subjected to leaching, volatilization losses in addition to crop uptake resulted in lower availability after *kharif* rice. Similar results were observed in the findings of Chettri et al. [5].

At tillering, Among the P levels, highest N content was recorded in P₅ (225.05 and 232.24, kg ha⁻¹) and this was on par with P₄ (222.50 and 229.61 kg ha⁻¹), P₃ (219.04 and 226.08 kg ha⁻¹) and P₂ (214.46 and 221.43 kg ha⁻¹) and significantly superior over P₁ (205.19 and 212.07 kg ha⁻¹) during 2017 and 2018, respectively.

However, the lowest N content was observed in P₁ during both the years of study at all the growth stages of rice. Similar trend was observed at panicle initiation and harvest of rice also.

3.2 Phosphorus

Data pertaining to the soil available phosphorus (P) at all growth stages of rice are presented in the Tables 4, 5 and 6 and the data revealed that available P in the soil differed significantly due to organic manure treatments and levels of phosphorus, but not by their interaction during both the years of study.

At all growth stages of rice, among the different sources of organic manures, the highest soil available P was recorded in RDNK+ *Dhaincha* 10 t ha⁻¹ (M₃-64.95, 62.35, 61.30, 73.77, 69.56, and 69.12 kg ha⁻¹) which was on par with the application of RDNK+sunhemp 10 t ha⁻¹ (M₂-64.59, 69.56, 60.03, 73.09, 61.73 and 67.52 kg ha⁻¹) and these two treatments were significantly

superior over RDNK+FYM (M_1 -59.99, 55.66, 53.55, 66.38, 61.39 and 58.94 kg ha⁻¹) and RDNK alone (M_0) during 2017 and 18 at tillering, panicle initiation and harvest, respectively. The significantly lower available phosphorus content was recorded in RDNK (M_0 -48.79, 47.82, 42.23, 53.22, 51.58 and 45.65 kg ha⁻¹) alone. However, the soil available phosphorus was decreased with advancement of crop stage during both the years with the application of organic manures. This decrease in phosphorus might be attributed to absorption of P by the growing plants or due to refixation of solubilized phosphorus [6].

Increase in available P with FYM application and green manuring might be due to additional application of P and mobilization of P of the soil. This increase in P might also be attributed to the decomposition of organic manures accompanied by release of appreciable quantity of CO₂ and organic acids. Available P content of the soil increased with the incorporation of green manures and organic manures as compared to its initial status. These results were in conformity with the findings of Mallareddy and Devenderreddy [7], who reported that the buildup of available P in soil was due to release of organic acids during microbial decomposition of green manures which, might have helped in the solubility of native P.

The buildup in available P may be due to the influence of organic manures in increasing the labile P in soil though complexing of cations like Ca⁺² and Mg⁺² which are mainly responsible for fixation of P [8]. Tolanur and Badanur [9] also reported that organic manures like FYM and green manuring with inorganic fertilizers had the beneficial effect on increasing the phosphate availability. These results are in general agreement with the findings of Verma et al. [10]. The maximum available P recorded in treatments with green leaf manuring may be due to the mobilization of soil P by the acidification of soil and the release of enzymes phosphatases and phytases of carboxylates such as gluconates and oxalates [11]. Similar results were observed by Jemila et al. [12].

At all growth stages of rice, among the P levels, the significantly higher soil available P content was observed with the P₅ (62.22, 60.07, 57.98, 69.40, 66.59 and 64.15 kg ha⁻¹) in 2017 and 2018, respectively and this treatment was significantly superior over P₂ and P₁. Significantly lower available phosphorus content was

observed in P₁ (56.16, 53.09, 50.17, 63.03, 59.30 and 56.04 kg ha⁻¹). However the treatment P₅ was on par with P₄, while P₄ was on par with P₃ during both the years of study. Among the P fertilizer treatments, available phosphorous content in soil increased with increased P levels. Verma et al. [13] opined that the increase in available P with increase in levels of fertilizer might be due to the addition of P at higher rates.

3.3 Potassium

The data on soil available potassium (K) as influenced by different organic manures and P levels were presented in Tables 7, 8 and 9. During both the years of study, significant differences in available potassium content were noticed due to different organic manures and P levels. However the interaction effect was not significant. At all growth stages of rice, among the different sources of organic manures, the highest soil available K was observed with RDNK+ *Dhaincha* @ 10 t ha⁻¹ (M_3 -529.20, 510.41, 487.91, 540.69, 521.23 and 498.40 kg ha⁻¹) which was at par with the application of RDNK+sunhemp 10 t ha⁻¹ (M_2 -522.72, 505.71, 483.21, 533.89, 516.21 and 493.37 kg ha⁻¹) in 2017 and 18 at tillering, panicle initiation and harvest, respectively. These two treatments were significantly superior over RDNK+FYM (M_1 -478.59, 457.80, 487.65, 439.96, 466.20 and 448.02 kg ha⁻¹) and RDNK (M_0 -434.53, 417.73, 403.23, 439.62, 422.16 and 407.32 kg ha⁻¹) alone during both the years of study.

Among the P levels, the treatment P₅ (513.01, 494.55, 475.28, 522.37, 503.23 and 483.62 kg ha⁻¹) recorded significantly highest available potassium and this was on par with P₄ and P₃, while significantly superior over P₁ (462.84, 444.50, 425.32, 471.89, 452.88 and 433.36 kg ha⁻¹) at tillering, panicle initiation and harvest in 2017 and 2018, respectively. The lowest was recorded in P₁ during both the years of study at all growth stages of rice. However, the available potassium status of the soil increased with increasing rates of phosphorus application might be due to release of potassium from decaying roots and the continuous replenishment of the potassium containing minerals in the soil. The green manures registered significantly higher K availability in soil due to its easy decomposition of mineral constituents and their effect on dislodging the exchangeable K into the soil solution. These results were in conformity with the Upadhyay et al. [14].

Table 1. Effect of organic manures and inorganic P fertilizer on available nitrogen content (kg ha⁻¹) in soil at tillering stage of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃		M ₀	M ₁	M ₂	M ₃	
P ₁ - 0	186.79	201.57	214.83	217.57	205.19	191.01	207.83	223.17	226.26	212.07
P ₂ - 30	196.01	211.89	223.79	226.15	214.46	200.37	218.21	232.20	234.94	221.43
P ₃ - 60	200.69	216.28	228.54	230.66	219.04	205.11	222.66	237.03	239.51	226.08
P ₄ - 90	204.30	219.77	231.83	234.08	222.50	208.83	226.24	240.41	242.96	229.61
P ₅ - 120	207.06	221.94	234.41	236.79	225.05	211.67	228.50	243.06	245.70	232.24
Mean	198.97	214.29	226.68	229.05		203.40	220.69	235.18	237.87	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	3.34		12.23		7.7	3.61		14.27		8.0
P	3.25		12.25		6.8	3.18		12.05		6.5
M at P	7.51		NS			3.37		NS		
P at M	7.76		NS			3.79		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

Table 2. Effect of organic manures and inorganic P fertilizer on available nitrogen content (kg ha⁻¹) in soil at panicle initiation stage of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃		M ₀	M ₁	M ₂	M ₃	
P ₁ - 0	163.54	175.98	188.64	194.76	180.73	167.09	181.57	196.32	202.78	186.94
P ₂ - 30	175.61	186.10	198.31	204.35	191.09	179.30	191.75	206.06	212.47	197.40
P ₃ - 60	180.52	195.11	207.98	210.96	198.64	184.27	200.82	215.80	217.48	204.59
P ₄ - 90	184.30	198.57	211.55	215.91	202.58	188.16	204.37	219.47	225.79	209.45
P ₅ - 120	187.23	200.99	214.60	217.16	204.99	191.17	206.89	222.58	225.41	211.51
Mean	178.24	191.35	204.22	208.63		182.00	197.08	212.04	216.79	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	3.41		11.81		6.8	3.63		12.57		7.0
P	3.46		9.97		6.1	3.82		11.01		6.6
M at P	6.92		NS			7.64		NS		
P at M	7.07		NS			7.74		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

Table 3. Effect of organic manures and inorganic P fertilizer on available nitrogen content (kg ha⁻¹) in soil at harvest of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃	M ₀	M ₁	M ₂	M ₃		
P ₁ - 0	153.67	172.07	183.34	187.58	174.17	156.89	177.32	190.68	195.27	180.04
P ₂ - 30	163.09	181.83	192.51	196.69	183.53	166.44	187.14	199.91	204.47	189.49
P ₃ - 60	167.46	185.86	197.26	201.10	187.92	170.87	191.23	204.74	208.95	193.95
P ₄ - 90	171.29	189.31	200.82	204.63	191.51	174.80	194.76	208.40	212.51	197.62
P ₅ - 120	174.26	192.03	203.65	207.47	194.35	177.86	197.58	211.30	215.37	200.53
Mean	165.95	184.22	195.52	199.49		169.37	189.61	203.01	207.32	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	3.02		11.18		10.4	4.42		13.24		10.9
P	3.19		14.96		9.7	4.01		14.44		9.0
M at P	9.39		NS			9.02		NS		
P at M	9.56		NS			9.48		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

Table 4. Effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P₂O₅ ha⁻¹) in soil at tillering stage of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃	M ₀	M ₁	M ₂	M ₃		
P ₁ - 0	45.40	56.94	60.71	61.57	56.16	49.62	63.20	69.06	70.26	63.03
P ₂ - 30	47.04	58.16	63.35	63.64	58.05	51.40	64.48	71.77	72.43	65.02
P ₃ - 60	48.36	60.88	65.53	65.31	60.02	52.78	67.26	74.02	74.16	67.05
P ₄ - 90	51.19	61.44	66.39	66.78	61.45	55.72	67.91	74.97	75.66	68.56
P ₅ - 120	51.95	62.52	66.96	67.43	62.22	56.56	69.09	75.62	76.34	69.40
Mean	48.79	59.99	64.59	64.95		53.22	66.38	73.09	73.77	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	0.63		2.18		10.1	0.70		2.42		10.1
P	0.52		1.51		9.0	0.61		1.77		9.2
M at P	1.05		NS			1.23		NS		
P at M	1.13		NS			1.30		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

Table 5. Effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P₂O₅ ha⁻¹) in soil at panicle initiation stage of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃		M ₀	M ₁	M ₂	M ₃	
P ₁ - 0	44.09	52.38	57.49	58.41	53.09	47.64	57.97	65.17	66.43	59.30
P ₂ - 30	45.26	53.98	60.34	60.37	54.99	48.95	59.63	68.09	68.49	61.29
P ₃ - 60	47.53	56.50	62.16	63.23	57.36	51.28	62.21	69.98	71.42	63.72
P ₄ - 90	50.74	56.70	63.86	64.43	58.93	54.61	62.50	71.78	72.64	65.38
P ₅ - 120	51.47	58.73	64.79	65.30	60.07	55.42	64.62	72.78	73.55	66.59
Mean	47.82	55.66	61.73	62.35		51.58	61.39	69.56	70.51	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	0.72		2.51		8.9	0.93		3.22		9.7
P	0.65		1.86		7.9	0.69		1.98		7.8
M at P	1.29		NS			1.37		NS		
P at M	1.36		NS			1.54		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

Table 6. Effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P₂O₅ ha⁻¹) in soil at harvest of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃		M ₀	M ₁	M ₂	M ₃	
P ₁ - 0	38.29	49.22	56.14	57.03	50.17	41.51	54.47	63.48	64.72	56.04
P ₂ - 30	39.63	50.45	58.38	59.18	51.91	42.98	55.76	65.79	66.97	57.87
P ₃ - 60	42.46	54.70	60.07	62.23	54.86	45.87	60.07	67.54	70.09	60.89
P ₄ - 90	44.60	55.91	61.98	63.38	56.47	48.12	61.36	69.56	71.26	62.57
P ₅ - 120	46.16	57.48	63.58	64.68	57.98	49.76	63.03	71.24	72.58	64.15
Mean	42.23	53.55	60.03	61.30		45.65	58.94	67.52	69.12	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	0.96		3.33		8.9	0.98		3.40		8.3
P	0.57		1.65		6.7	0.59		1.70		6.4
M at P	1.15		NS			1.18		NS		
P at M	1.41		NS			1.44		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

Table 7. Effect of organic manures and inorganic P fertilizer on available potassium status (kg K₂O ha⁻¹) in soil at tillering stage of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃		M ₀	M ₁	M ₂	M ₃	
P ₁ - 0	405.23	448.68	495.70	501.76	462.84	410.12	457.60	506.71	513.12	471.89
P ₂ - 30	426.26	470.67	514.69	520.74	483.09	431.29	479.65	525.77	532.20	492.23
P ₃ - 60	437.42	481.75	525.46	531.43	494.02	442.50	490.79	536.61	542.95	503.22
P ₄ - 90	447.55	490.58	534.07	541.14	503.34	452.75	499.71	545.32	552.68	512.62
P ₅ - 120	456.17	501.26	543.70	550.93	513.01	461.45	510.49	555.02	562.51	522.37
Mean	434.53	478.59	522.72	529.20		439.62	487.65	533.89	540.69	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	8.42		29.13		8.6	8.66		29.96		8.7
P	7.91		22.80		7.6	7.89		22.72		7.4
M at P	15.83		NS			15.77		NS		
P at M	16.47		NS			16.55		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

Table 8. Effect of organic manures and inorganic P fertilizer on available potassium status (kg K₂O ha⁻¹) in soil at panicle initiation stage of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃		M ₀	M ₁	M ₂	M ₃	
P ₁ - 0	387.90	428.63	479.43	482.04	444.50	392.12	436.89	489.77	492.73	452.88
P ₂ - 30	409.88	449.65	497.45	502.01	464.75	414.24	457.97	507.86	512.80	473.22
P ₃ - 60	421.11	460.46	507.91	513.05	475.63	425.53	468.84	518.40	523.91	484.17
P ₄ - 90	430.07	470.35	517.36	522.81	485.15	434.60	478.82	527.94	533.69	493.76
P ₅ - 120	439.71	479.93	526.42	532.13	494.55	444.32	488.49	537.07	543.04	503.23
Mean	417.73	457.80	505.71	510.41		422.16	466.20	516.21	521.23	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	7.58		26.22		6.2	9.06		31.35		7.3
P	8.57		24.68		6.3	8.61		24.81		6.2
M at P	17.13		NS			17.23		NS		
P at M	17.09		NS			17.88		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

Table 9. Effect of organic manures and inorganic P fertilizer on available potassium status (kg K₂O ha⁻¹) in soil at harvest of rice

P levels (kg P ₂ O ₅ ha ⁻¹)	Kharif 2017				Mean	Kharif 2018				Mean
	Organic manures					Organic manures				
	M ₀	M ₁	M ₂	M ₃	M ₀	M ₁	M ₂	M ₃		
P ₁ - 0	374.34	410.07	457.25	459.61	425.32	378.22	417.99	467.25	469.97	433.36
P ₂ - 30	395.37	432.05	475.27	479.62	445.58	399.38	440.02	485.34	490.07	453.70
P ₃ - 60	405.56	443.14	485.33	490.24	456.07	409.64	451.18	495.47	500.76	464.26
P ₄ - 90	415.67	452.08	494.57	500.31	465.66	419.85	460.20	504.81	510.85	473.93
P ₅ - 120	425.23	462.47	503.65	509.76	475.28	429.50	470.69	513.97	520.33	483.62
Mean	403.23	439.96	483.21	487.91		407.32	448.02	493.37	498.40	
	SEm ±		CD (p=0.05)		CV (%)	SEm ±		CD (p=0.05)		CV (%)
M	6.99		24.19		7.0	7.55		26.11		7.3
P	7.57		21.79		6.8	7.23		20.83		6.4
M at P	15.13		NS			14.46		NS		
P at M	15.23		NS			14.97		NS		

M₀- No Organic manure; M₁- RDNK+FYM 5 t ha⁻¹; M₂- RDNK+Sunhemp 10 t ha⁻¹; M₃- RDNK+Dhaincha 10 t ha⁻¹

When acid forming compounds are added in the form of compost to the soil, these acids affect potassium availability. The effect is positive resulting in more availability of K to the plants. The hydrogen ions released from organic materials are exchanged with K on exchange site or set free from the fixed site of the clay micelle. Thus, the overall status of soil regarding availability of potassium content was improved [15]. Verma et al. [10] also reported that continuous use of FYM and green manures enhanced the potassium status in the soil. The beneficial effect of green leaf manuring and FYM on available potassium might be due to reduction of potassium fixation, solubilisation and release due to the interaction of organic matter with clay besides the direct potassium addition to the potassium pool of soil. Similar results were also observed by Chettri et al. [5]. On the other hand, the available potassium content was gradually decreased with advancement of crop stage i.e from tillering to harvest stage in both the years. These results were coincide with Subhalakshmi and Pratap kumar reddy [16]. This might be due to the continuous depletion of K by crop uptake and also due to potassium fixation in soils [17].

4. CONCLUSION

At all growth stages of rice, significantly highest available nitrogen, phosphorus and potassium in soil were recorded with application of RDNK+*Dhaincha* @ 10t ha⁻¹ (M₃) and this was on par with RDNK+Sunhemp @ 10t ha⁻¹ (M₂), whereas lowest was recorded in RDNK (M₀) alone in both seasons of study. Among the P levels the available nutrient status (N, P and K) were increased with the increasing level of P from 0 (P₁) to 120 kg P₂O₅ (P₅) ha⁻¹, irrespective of the nutrients imposed to rice crop. Significantly highest was recorded in P₅ (120 kg P₂O₅ ha⁻¹) and this was on par with P₄ (90 kg P₂O₅ ha⁻¹), whereas the lowest was recorded in treatment P₁ that received 0 kg P₂O₅ ha⁻¹.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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