International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(2): 117-126

Received: 14-11-2021
Accepted: 23-12-2021

I Jagga Rao
Ph.D., Scholar, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, ANGRAU, Guntur, Andhra Pradesh, India

CH Sujani Rao
Professor, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, ANGRAU, Guntur, Andhra Pradesh, India

PRK Prasad
Professor and Head, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, ANGRAU, Guntur, Andhra Pradesh, India

CH Pulla Rao
Professor, Department of Agronomy (Retd.), Agricultural College, Bapatla, ANGRAU, Guntur, Andhra Pradesh, India

K Jayalalitha
Professor, Department of Crop Physiology, Agricultural College, Bapatla, ANGRAU, Guntur, Andhra Pradesh, India

Corresponding Author:
I Jagga Rao
Ph.D., Scholar, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla, ANGRAU, Guntur, Andhra Pradesh, India

Effect of organic manures and inorganic phosphorus on soil fertility status (N, P and K) in rice-blackgram cropping sequence

I Jagga Rao, CH Sujani Rao, PRK Prasad, CH Pulla Rao and K Jayalalitha

DOI: https://doi.org/10.22271/chemi.2021.v9.i2b.11710

Abstract
The present study attempts to relate the phosphorus dynamics in relation to nutrient management in rice-blackgram cropping sequence with respect to changes in soil fertility. Results of two years (2017-2019) experimentation revealed that 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}(M_3) and this was on par with RDNK+ Sunhemp @ 10t ha^{-1}(M_2), whereas lowest was recorded in RDNK (M_0) alone in all four 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 (P_1) to 120 kg P_2O_5 (P_5) ha^{-1}, irrespective of the nutrients imposed to rice crop. Significantly highest was recorded in P_5 (120 kg P_2O_5 ha^{-1}) and this was on par with P_4 (90 kg P_2O_5 ha^{-1}), whereas the lowest was recorded in treatment P_1 that received 0 kg P_2O_5 ha^{-1}. However, as like preceeding rice crop the similar trend was observed at flowering and harvest in succeeding blackgram.

Keywords: Organic manures, phosphorus fertilizer, Soil fertility status, rice-blackgram sequence

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. Krishna Agroclimatic Zone is the potential tract in the traditional rice based cropping systems cultivated area of Andhra Pradesh. 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 rice-blackgram cropping sequence to monitor soil fertility status.

Material and Methods

The present experiment in rice based cropping system *viz.*, rice - blackgram was started at Agricultural College Farm, Bapatla (15^0 54' N latitude, 80^0 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 sub tropical monsoon type. Rice and blackgram crops, one during *kharif* transplanting in August and harvest in December and the second during *rabi* sowing in December and harvest in March were 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) and for *rabi* blackgram (residual effect of preceeding rice crop), 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 (M_2 and M_3), 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} (M_1) in both 2017-18, 2018-19 on dry weight basis, respectively.) was incorporated as main plots and five phosphorus levels 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 for *kharif* rice. The *rabi* experiment was continued on the same site without disturbing the soil for succeeding blackgram crop to study residual effect of organic manures and P levels applied to preceeding rice crop. 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 (Subbiah and Asija, 1956).

Available phosphorus: Available phosphorus in the soil samples was extracted with 0.5 M $NaHCO_3$ buffered at pH 8.5 and the phosphorus in the extract was estimated by ascorbic acid method using spectrophotometer at 660 nm (Watanabe and Olsen, 1965) [26].

Available potassium: It was extracted with neutral normal ammonium acetate and estimated with the help of flame photometer (Jackson, 1973) [8].

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.

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} (M_3-229.05 and 237.87 kg ha^{-1}) which was on par with the application of RDNK+sunhemp 10 t ha^{-1} (M_2-226.68 and 235.18 kg ha^{-1}), while these two treatments were followed by RDNK+FYM (M_1-214.29 and 220.69 kg ha^{-1}) and found significantly superior over application of RDNK (M_0-198.97 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 (Alagappan and Venkitaswamy 2016) [1].

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*. (2017) [5].

At tillering, Among the P levels, highest N content was recorded in P_5 (225.05 and 232.24, kg ha^{-1}) and this was on par with P_4 (222.50 and 229.61 kg ha^{-1}), P_3 (219.04 and 226.08 kg ha^{-1}) and P_2 (214.46 and 221.43 kg ha^{-1}) and significantly superior over P_1 (205.19 and 212.07 kg ha^{-1}) during 2017 and 2018, respectively.

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_2O_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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		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		

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}

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_2O_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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		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		

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}

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_2O_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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		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		

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}

However the lowest N content was observed in P_1 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.

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} (M_3-64.95, 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} (M_2-64.59, 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 and/or due to refixation of solubilized phosphorus (Chikkaraju, 2012) [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 CO_2 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 (2008) [12], 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.

Table 4: Effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P_2O_5 ha^{-1}) in soil at tillering stage of rice

P levels (kg P_2O_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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±	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			

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}

Table 5: Effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P_2O_5 ha^{-1}) in soil at panicle initiation stage of rice

P levels (kg P_2O_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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		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		

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}

Table 6: Effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P_2O_5 ha^{-1}) in soil at harvest of rice

P levels (kg P_2O_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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		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		

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}

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 (Bajpai *et al.*, 2006) [3]. Tolanur and Badanur (2003) [20] 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.*, 2002 [25]. 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 suchas phosphatases and phytases of carboxylates such as gluconates and oxalates (Jones and Oburger, 2011) [10]. Similar results were observed by Jemila *et al*. (2017) [9].

At all growth stages of rice, among the P levels, the significantly higher soil available P content was observed with the P_5 (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 P_2 and P_1. Significantly lower available phosphorus content was observed in P_1 (56.16, 53.09, 50.17, 63.03, 59.30 and 56.04 kg ha^{-1}). However the treatment P_5 was on par with P_4, while P_4 was on par with P_3 during both the years of study. Among the P fertilizer treatments, available phosphorous content in soil increased with increased P levels. Verma *et al.* (2012) [24] opined that the increase in available P with increase in levels of fertilizer might be due to the addition of P at higher rates.

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-**1**)

Table 7: Effect of organic manures and inorganic P fertilizer on available potassium status (kg K_2O ha^{-1}) in soil at tillering stage 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	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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		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		

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}

Table 8: Effect of organic manures and inorganic P fertilizer on available potassium status (kg K_2O ha^{-1}) in soil at panicle initiation stage 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	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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		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		

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}

Table 9: Effect of organic manures and inorganic P fertilizer on available potassium status(kg K_2O ha^{-1}) in soil at harvest 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	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	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		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		

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}

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 P_5 (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 P_4 and P_3, while significantly superior over P_1 (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 P_1 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.* (2011) [21].
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 (Singh *et al.*, 2002). Verma *et al.* (2002) [25] 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*. (2017) [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 Pratapkumarreddy (2017) [19]. This might be due to the continuous depletion of K by crop uptake and also due to potassium fixation in soils (Veeranagapapa *et al.*, 2011) [22].

Nitrogen

Data pertaining to available nitrogen as influenced by different organic manures and P levels were presented in tables 10 and 11. It was evident from the data presented in the above tables that available nitrogen was significantly influenced due to different treatments.

Table 10: Residual effect of organic manures and inorganic P fertilizer on available nitrogen content (kg ha^{-1}) of succeeding blackgram at flowering stage in rice based cropping sequence

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018 Organic manures				Mean	*Rabi* 2019 Organic manures				Mean
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	180.84	191.42	199.94	202.05	193.56	185.06	197.68	208.28	210.74	200.44
P_2– 30	187.39	199.31	207.21	210.05	200.99	191.75	205.63	215.62	218.84	207.96
P_3– 60	191.65	203.36	210.46	214.55	205.01	196.07	209.73	218.95	223.41	212.04
P_4– 90	194.16	206.35	214.01	217.78	208.08	198.69	212.81	222.59	226.66	215.19
P_5– 120	196.19	208.30	216.04	219.82	210.09	200.80	214.86	224.69	228.73	217.27
Mean	190.05	201.75	209.53	212.85		194.48	208.14	218.03	221.68	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		CD (p=0.05)		CV (%)
M	4.63		16.03		8.8	4.52		15.65		8.3
P	4.92		14.18		8.4	4.97		14.30		8.2
M at P	9.84		NS			9.93		NS		
P at M	9.95		NS			9.97		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}

Table 11: Residual effect of organic manures and inorganic P fertilizer on available nitrogen content (kg ha^{-1}) of succeeding blackgram at harvest in rice based cropping sequence

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	172.16	181.86	189.39	195.29	184.68	175.71	187.45	197.07	203.31	190.89
P_2– 30	178.16	187.86	196.22	202.09	191.08	181.86	193.51	203.96	210.21	197.38
P_3– 60	182.25	192.47	200.39	206.08	195.30	186.00	198.18	208.21	214.27	201.67
P_4– 90	185.83	195.21	203.43	209.93	198.60	189.69	201.01	211.34	218.14	205.05
P_5– 120	187.79	197.30	205.42	211.87	200.60	191.73	203.20	213.40	220.12	207.11
Mean	181.24	190.94	198.97	205.05		185.00	196.67	206.80	213.21	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		CD (p=0.05)		CV (%)
M	4.00		13.83		8.0	3.87		13.41		7.5
P	4.50		12.97		8.0	4.54		13.09		7.9
M at P	9.00		NS			9.09		NS		
P at M	8.99		NS			9.00		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}

At flowering and harvest, among the different sources of organic manures, the significantly highest soil available nitrogen was observed with the RDNK+ *Dhaincha* 10 t ha^{-1} (M_3-212.85, 205.05, 221.68 and 213.21 kg ha^{-1}) which was on par with the application of RDNK+sunhemp 10 t ha^{-1} (M_2-209.53, 198.97, 218.03 and 206.80 kg ha^{-1}) and found significantly superior over application of RDNK (M_0-190.05, 181.24, 194.48, and 185.00 kg ha^{-1}) during 2018 and 2019 at flowering and harvest, respectively). However the treatment M_2 was on par with M_1, while M_1 was remain on par with M_0 in both the years of study, respectively. The per cent increase was ranged from 11.9 to 13.1% during 2018 and 13.9 to 15.2% during 2019 was achieved in M_3 over M_0 treatment. This might be due to fixation of atmospheric nitrogen by legumes in their nodules by *rhizobium* through symbiotic N- fixation process. Ali *et al*., (2012) [2] reported that legumes were potentially important to diversify cereal based mono cropping into cereal-legume sequences which had nutrient cycling advantages. Bhargavi *et al.* (2007) [4] also concluded soil available nitrogen was more with greenmanure/greengram haulms incorporated in rice-rice system than other systems.

Among the P levels, the treatment P_5 (210.09, 200.60 in 2018 and 217.27, 207.11 kg ha^{-1} in 2019) recorded significantly highest available nitrogen and it was on par with P_4 (208.08, 198.60 in 2018 and 215.19, 205.05 kg ha^{-1} in 2019), P_3 (205.01, 195.30 in 2018 and 212.04, 201.67 kg ha^{-1} in 2019) and P_2 (200.99, 191.08 in 2018 and 207.96, 197.38 kg ha^{-1} in 2019), while significantly superior over P_1 (193.56, 184.68 in 2018 and 200.44, 190.89 kg ha^{-1} in 2019) at flowering and harvest, respectively. However, the significantly lowest available nitrogen was recorded in P_1. Interaction between organic manures and P levels was not significant. Even though, it was not significant, the highest nitrogen content in M_3P_5 and lowest was registered in M_0P_0 during both the years of study. Phosphorus application might have encouraged the buildup of available nitrogen due to enhanced activity of microbes and increased the formation of root nodules and thereby fixing atmospheric nitrogen in root nodules (Singaram and Kothandaraman, 1992) [16].

Phosphorus

Data pertaining to available phosphorus was presented in tables 12 and 13 and revealed among the different sources of organic manures to preceeding rice crop,

Table 12: Residual effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P_2O_5 ha^{-1}) of succeeding blackgram at flowering stage in rice based cropping sequence

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	36.33	44.63	49.71	51.77	45.61	40.65	50.98	58.15	60.56	52.58
P_2– 30	37.50	46.23	52.59	53.62	47.48	41.96	52.64	61.10	62.51	54.55
P_3– 60	39.78	48.75	54.41	56.48	49.85	44.29	55.22	62.99	65.43	56.98
P_4– 90	42.99	48.95	56.11	57.68	51.43	47.62	55.51	64.79	66.65	58.64
P_5– 120	43.72	50.97	57.03	58.18	52.47	48.43	57.63	65.78	67.19	59.76
Mean	40.06	47.90	53.97	55.54		44.59	54.40	62.56	64.47	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		CD (p=0.05)		CV (%)
M	0.71		2.45		8.6	0.69		2.40		7.7
P	0.90		2.59		9.3	0.93		2.67		8.1
M at P	1.80		NS			1.85		NS		
P at M	1.76		NS			1.80		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}

Table 13: Residual effect of organic manures and inorganic P fertilizer on available phosphorus content (kg P_2O_5 ha^{-1}) of succeeding blackgram at harvest in rice based cropping sequence

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	29.38	40.31	47.17	48.12	41.25	33.13	46.10	55.05	56.35	47.66
P_2– 30	30.72	41.54	49.47	50.27	43.00	34.62	47.39	57.42	58.60	49.51
P_3– 60	32.21	45.79	50.82	53.32	45.54	36.16	51.70	58.84	61.71	52.10
P_4– 90	35.69	47.00	53.07	54.47	47.56	39.76	53.00	61.19	62.88	54.21
P_5– 120	37.59	49.24	54.67	55.77	49.32	41.73	55.34	62.86	64.22	56.04
Mean	33.12	44.78	51.04	52.39		37.08	50.71	59.07	60.75	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		CD (p=0.05)		CV (%)
M	0.82		2.84		7.0	0.79		2.73		5.9
P	0.94		2.71		7.2	0.96		2.75		6.4
M at P	1.88		NS			1.91		NS		
P at M	1.87		NS			1.88		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}

the highest soil available P was registered with the RDNK+ *Dhaincha* 10 t ha^{-1} (M_3-55.54, 52.39, 64.47 and 60.75 kg P_2O_5 ha^{-1}) which was on par with the application of RDNK+sunhemp 10 t ha^{-1} (M_2-53.97, 51.04, 62.56 and 59.07 kg P_2O_5 ha^{-1}), found significantly superior over application of RDNK+FYM (M_1-47.90, 44.78, 54.40 and 50.71 kg P_2O_5 ha^{-1}) and RDNK (M_0-40.06, 33.12, 44.59 and 37.08 kg P_2O_5 ha^{-1}) alone at flowering and harvest during 2018 and 2019, respectively. The significantly lowest available phosphorus was recorded in M_0. However, the soil available phosphorus was decreased with advancement of crop stage during both the years and in all the treatments. This decrease in phosphorus might be attributed to absorption of P by the growing plants and/or due to refixation of solubilized phosphorus (Veeranagappa *et al*., 2011; Chikkaraju, 2012) [22, 6].

Bhargavi *et al*. (2007) [4] reported that the highest available phosphorus was recorded with sunhemp-rice-rice and build up of available phosphorus in soil was due to release of organic acids during microbial decomposition of greenmanure which helped in the solubility of native phosphorus in soil. As the phosphorus requirement of rice was meagre, organic and inorganic additions increased the soil phosphorus content. Dudhat *et al.* (1997) [7] reported that the application of FYM alone or in combination with chemical fertilizer significantly increased the residual status of available phosphorus in soil. During decomposition of organic manures, various organic acids would be produced which solubilized phosphatase and other phosphate bearing minerals and thereby lowered the phosphate fixation and increased its availability (Meghadubey *et al*., 2015) [14]. Manna *et al*. (2006) [13] reported that available phosphorus content was increased due to addition of farmyard manure over control. Mahala *et al.* (2006) [11] also noticed the positive residual significant effect of farmyard manure on succeeding mustard crop in terms of the available phosphorus in soil.

Among the P levels, application of 120 kg P_2O_5 ha^{-1} (P_5 - 52.47, 49.32, 59.76 and 56.04 kg P_2O_5 ha^{-1}) recorded significantly higher available phosphorus and this was on par with 90 kg P_2O_5 ha^{-1} (P_4-51.43, 47.56, 58.64 and 54.21 kg P_2O_5 ha^{-1}), while P_4 was on par with 60 kg P_2O_5 ha^{-1} (P_3-49.85, 45.54, 56.98 and 52.10 kg P_2O_5 ha^{-1}) at flowering and harvest in 2018 and 2019, respectively. However, these three treatments were significantly superior over 0 kg P_2O_5 ha^{-1} (P_1-45.61, 41.25, 52.58 and 47.66 kg P_2O_5 ha^{-1}) during both the years of study. Significantly lowest nitrogen was recorded in P_1 during both the years of study. Whereas, the per cent increase in P_2O_5 content at flowering and harvest in both the years over control was 15.04, 19.56, 13.65 and 17.58%, respectively. However, interaction between organic manures and P levels were not significant. Even though, the highest available phosphorus was obtained in M_3P_5, followed by M_3P_4 and superior over M_3P_3, M_3P_2 and lowest was obtained in M_3P_1. Application of phosphorus in any form at any level could build up a higher level of residual phosphorus and higher doses of phosphorus application could account for higher residual values (Singaram and Kothandaraman, 1992) [16].

Potassium

Data pertaining to soil available potassium (k_2O) at flowering and harvest of blackgram was presented in the tables 14 and 15 and revealed that available K in the soil did differ significantly due to organic manure treatments and levels of phosphorus to preceeding rice crop, but not by their interaction during both the years of study. Among the different sources of organic manures, significantly higher soil available K was recorded with the RDNK+ *Dhaincha* @ 10 t ha^{-1} (M_3-498.53, 485.02, 510.02 and 495.85 kg k_2O ha^{-1}), which was at par with the application of RDNK+sunhemp 10 t ha^{-1} (M_2-495.94, 481.80, 506.90 and 492.30 kg k_2O ha^{-1}) and found significantly superior to application of RDNK+FYM (M_1-454.23, 443.06, 463.29 and 451.45 kg k_2O ha^{-1}) and RDNK (M_0-437.68, 431.34, 442.78 and 435.77 kg k_2O ha^{-1}) alone at flowering and harvest in 2018 and 2019, respectively. Whereas the treatment M_1 was on par with M_0. However, the significantly lowest available potassium was recorded in M_0 which received RDNK alone.

Among the P levels, the treatment P_5 (492.58, 481.34, 501.93 and 490.02 kg k_2O ha^{-1}) significantly recorded highest available potassium and lowest was recorded in P_1 (441.99, 430.94, 451.04 and 439.32 kg k_2O ha^{-1}) at flowering and harvest in 2018 and 2019, respectively. However the treatment P_5 was on par with P_4 (484.82, 474.06, 494.10 and 482.67 kg k_2O ha^{-1}) and P_3 (475.17, 463.38, 484.37 and 471.91kg k_2O ha^{-1}), while P_3 was on par with P_2, P_2 with P_1 during both the years of study. However, the interaction effect between organic manures and P levels were not significant. Dudhat *et al.* (1997) [7] reported that application of FYM alone or in combination with chemical fertilizer significantly increased the residual status of available K in soil. When manure was applied to the soil, it had a longer lasting effect as indicated by positive response of the cowpea to previous season applied FYM (Rutunga and Neel, 2006) [15].

Table 14: Residual effect of organic manures and inorganic P fertilizer on available potassium status (kg K_2O ha^{-1}) of succeeding blackgram at flowering stage in rice based cropping sequence

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	409.66	425.54	465.46	467.31	441.99	414.55	434.46	476.47	478.67	451.04
P_2– 30	429.91	446.39	486.81	489.56	463.17	434.94	455.37	497.89	501.02	472.30
P_3– 60	440.84	457.40	498.94	503.49	475.17	445.92	466.44	510.09	515.01	484.37
P_4– 90	450.66	467.46	509.86	511.31	484.82	455.86	476.59	521.11	522.85	494.10
P_5– 120	457.34	474.36	517.64	520.99	492.58	462.62	483.59	528.96	532.57	501.93
Mean	437.68	454.23	495.94	498.53		442.78	463.29	506.90	510.02	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		CD (p=0.05)		CV (%)
M	6.16		21.33		8.1	5.73		19.84		6.6
P	8.11		23.37		7.0	8.18		23.57		7.9
M at P	16.22		NS			16.36		NS		
P at M	15.77		NS			15.72		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}

Table 15: Residual effect of organic manures and inorganic P fertilizer on available potassium status (kg K_2O ha^{-1}) of succeeding blackgram at harvest in rice based cropping sequence

P levels (kg P_2O_5 ha^{-1})	*Rabi* 2018				Mean	*Rabi* 2019				Mean
	Organic manures					Organic manures				
	M_0	M_1	M_2	M_3		M_0	M_1	M_2	M_3	
P_1– 0	402.72	414.45	451.78	454.80	430.94	406.94	422.71	462.12	465.49	439.32
P_2– 30	423.07	435.03	473.03	476.15	451.82	427.43	443.35	483.44	486.94	460.29
P_3– 60	434.10	446.26	484.96	488.18	463.38	438.52	454.64	495.45	499.03	471.91
P_4– 90	445.02	456.33	495.78	499.10	474.06	449.55	464.80	506.36	509.98	482.67
P_5– 120	451.80	463.21	503.46	506.88	481.34	456.41	471.77	514.11	517.79	490.02
Mean	431.34	443.06	481.80	485.02		435.77	451.45	492.30	495.85	
	S.Em ±		CD (p=0.05)		CV (%)	S.Em ±		CD (p=0.05)		CV (%)
M	8.02		27.77		6.8	7.59		26.28		6.3
P	9.34		26.90		7.0	9.37		27.00		6.9
M at P	18.67		NS			18.75		NS		
P at M	18.53		NS			18.41		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}

Conclusion

Overall it can be concluded that, Soil fertility status in terms of available N, P and K at different growth stages of rice crop was higher in the treatment that received organics along with 100% RDNK than 100% RDNK alone. The fertility status was increased with the increasing level of P from 0 (P_1) to 120 kg P_2O_5 (P_5) ha^{-1} irrespective of the nutrients imposed to rice crop. However, the similar trend was observed in succeeding blackgram at both flowering and harvest.

References

1. Alagappan S, Venkitaswamy S. Performance of different sources of organic manures in comparison with RDF and INM on nutrient uptake, nutrient balance and soil properties in rice-greengram cropping sequence. International Journal of Agricultural Science 2016;12(2):326-334.
2. Ali RI, Awan TH, Ahmad M, Saleem MU, Akthar. Diversification of rice based cropping systems to improve soil fertility, sustainable productivity and economics. The Journal of Animal, plant Sciences 2012;22(1):108-112.
3. Bajpai RK, Chitale S, Upadhyay SK, Urkurkar JS. Long-term studies on soil physico-chemcal properties and productivity of rice-wheat system as influenced by integrated nutrient management in *Inceptisol* of Chhattisgarh. Journal of Indian Society of Soil Science. 2006;54:24-29.
4. Bhargavi K, Raghavareddy C, Yellamandareddy T, Srinivasula Reddy D. The productivity and residual soil fertility status under different rice based cropping systems in scarce rainfall zone of Andhra Pradesh. International Journal of Agricultural Sciences. 2007;3(2):26-31.
5. Chettri P, Maiti D, Rizal B. Studies on soil properties as affected by integrated nutrient management practice in different cultivars of local scented rice. *Journal of Crop and Weed*. 2017;13(2):25-29.
6. Chikkaraju SN. Studies on impact of nitrogen management practices on soil properties, growth and yield of rice. M.Sc (Ag) thesis, University of Agricultural Sciences, Bangaluru 2012.
7. Dudhat MS, Malavir DD, Mathukia RK, Khanpara VP. Effect of nutrient management through organic &

inorganic sources on growth, yield, quality and nutrient uptake by wheat. Indian Journal of Agronomy 1997;42(3):455- 458.
8. Jackson ML. *Soil Chemical Analysis*. Prentice Hall of India Private Limited, New Delhi. 1973, 41.
9. Jemila C, Bakiyathusaliha B, Udayakumar S. Evaluating the effect of phosphatic fertilizer on soil and plant P availability and maximizing rice crop yield. *Oryza*. 2017;54(3):305-313.
10. Jones DL, Oburger E. Solubilization of phosphorus by soil micro organisms In: EK Beunemann, A. Oberson, E. Froard, eds. Phosphorus in action. Springer, Newyork. 2011, 169-198.
11. Mahala HL, Shakawat MS, Shivram RK. Direct and residual effect of organic sources and levels of P & N in maize mustard cropping sequence. Indian Journal of Agronomy 2006;51(1):10-13.
12. Mallareddy M, Devenderreddy M. Integrated nutrient management for higher productivity and better soil health under rice (*Oriza sativa*) - based cropping systems. The Andhra Agricultural Journal 2008;55(3):267-272.
13. Mann KK, Brar BS, Dhillon NS. Influence of long-term use of farm yard manure and inorganic fertilizers on nutrient availability in a Typic Ustochrept. Indian Journal of Agricultural Science 2006;76(8):477-480.
14. Meghadubey KK, Agarwal, Aruna Devi, Ahirwar, Ahirwar SK. Rice-berseem cropping system influenced a remarkable effect on growth of different soil microorganisms in different rice based cropping systems. Plant Archives. 2015;15(1):115-118.
15. Rutunga V, Neel H. Yield trends in the long-term crop rotation with organic and inorganic fertilizers on Alfisols in Mata. Biotechnology Agronomic Society Environment. 2006;10(3):217-228.
16. Singaram P, Kothandaraman GV. Effect of residual phosphorus on availability of nutrients by different sources and levels of phosphorus in a cropping system. Madras Agricultural Journal 1992;79(10):579-582.
17. Singh RN, Kumar B, Prasad, Janardan, Singh, Surendra. Integrated nutrient management practices and their effect on rice crop in farmer field. Journal of Research 2002;14(1):65-67.
18. Subbiah BV, Asija CL. A rapid procedure for the estimation of available nitrogen in soils. Current Science 1956;25:259-260.
19. Subhalakshmi C, Pratap kumar reddy A. Soil available nutrient status as influenced by organic sources and fertilizer levels in hybrid rice. International Journal of Science and Nature 2017;8(1):40-43.
20. Tolanur SI, Badanur VP. Effect of integrated use of organic manure, green manure and fertilizer nitrogen on sustaining productivity of *rabi* sorghum-chickpea system and fertility of Vertisol. Journal of Indian Society Soil Science 2003;51(1):41-44.
21. Upadhyay VB, Vikas Jain, Vishwakarma SK, Kumar AK. Production potential, soil health, water productivity and economics of rice (*Oryza sativa*) – based cropping systems under different nutrient sources. Indian Journal of Agronomy 2011;56(4):311-316.
22. Veeranagappa P, Prakasha HC, Ashoka KR, Venkatesha MM, Mahendra Kumar. Effect of zinc enriched compost on soil chemical properties and nutrients availability. An Asian Journal of Soil Science 2011;6(2):189-194.
23. Verma BC, Datta SP, Rattan RK, Singh AK. Long term effect of tillage, water and nutrient management practices on mineral nutrient, available phosphorus and sulphur content under rice-wheat cropping system. Journal of the Indian Society of Soil Science 2016;64(1):71-77.
24. Verma G, Mathure AK, Verma A. Effect of continuous use of organics and inorganics on nutrient status of soil and yield under maize – wheat intensive cropping system in an Inceptisol. Journal of Soils and Crops. 2012;22(2):280-286.
25. Verma TS, Suri VK, Paul J. Prescription Based Fertilizer Recommendations for Rice, Maize and Wheat in Different Agro-Climatic Zones of Himachal Pradesh. Journal of the Indian Society of Soil Science. 2002;50(3):272-277.
26. Watanabe FS, Olsen SR. Test of ascorbic acid method fordetermining phosphorous in water and sodium bicarbonate extracts of soil. Soil Science Society of American Journal. 1965;29:677-78.