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RESEARCH PAPER

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

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Abstract : Field experiments were carried out at Tamil Nadu Agricultural University, Coimbatore, India during *samba* (August-December) season of 2012 and 2013 to study the effect of different sources of organic manures in comparison with INM and RDF on nutrient uptake and soil properties in rice (*Oryza sativa* L.). The experiment consisted of fourteen treatments which were laid out in Randomized Block Design, replicated thrice and SRI method of planting was adopted during both the years. Among fourteen treatments, four treatments with different organic manures at 100 per cent RDN on equi nutrient basis (farm yard manure, vermi-compost, poultry manure and (Dhaincha) green manure) another six treatments consisted of 50 per cent combination of each manure, one treatment with 1/4th combination of all the manures and one absolute control (without organic or inorganic). These treatments were compared with the recommended dose of fertilizer (RDF) and integrated nutrient management practice (RDF + Dhaincha). Higher N, P and K uptake was observed with INM practice followed by RDF. Among the organic treatments, 100 per cent RDN through green manure resulted with higher nutrient uptake followed by 25 per cent RDN through each organic manures. Lower nutrient uptake was observed with absolute control where no fertilizers / manures received during both the years of study. The soil available N and P balance was positive with the INM treatment (85.0 and 5.10 kg ha^{-1}) at the end of two year of cropping sequence. Among the organic treatments, 100 per cent RDN through green manure recorded the highest N balance (46.0 kg ha^{-1}) followed by 25 per cent RDN through each organic manures (42.0 kg ha^{-1}) at the end of the cropping system (2012 -14). Similarly, the highest P balance was recorded with 25 per cent RDN through each organic manures (3.1 kg ha^{-1}) and which was followed by 100 per cent RDN through green manure (3.0 kg ha^{-1}) at end of the two years of cropping sequence. The least N and P balance was noticed with absolute control (-4.0 and -2.5 kg ha^{-1}) at the end of cropping sequence. Invariably, all the treatments recorded net negative K balance in both the years of cropping sequence.

Key Words : Rice- greengram cropping sequence, Organic manures, RDF, INM, Nutrient uptake, Nutrient balance, Soil properties

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INTRODUCTION

The productivity of rice-rice/rice-pulse cropping system is declining day by day due to continuous use of inorganic fertilizers resulting in deteriorating the soil physical, chemical and biological properties besides, application of inorganic fertilizer in large quantities over a long period created imbalance in soil supply of nutrients. On the other hand, escalation of price of inorganic fertilizers is beyond to the reach of the farmers. There is increasing dearth of farm yard manure (FYM) in most agricultural farms because of two main reasons *viz.*, the cattle population is dwindling as more and more farmers are switching over to machinery to carry out various farm operations and the cattle dung is increasingly diverted to make fuel cakes as availability of fire wood is becoming scarce. This is why these days' farmers either do not apply FYM or apply only limited quantities only limited quantities. Long lasting improvements in soil physical and chemical characteristics are possible only by the additions of sufficient amounts of organic manures. Tejada and Gonzalez (2009) reported that vermi-compost has been considered as a soil additive to reduce the use of mineral fertilizers.

The organic manures like farm yard manure (FYM), green manures, green leaf manures, vermicompost, poultry manure and other organic manures are possessing considerable quantities of macro and micro nutrients and can be used to improve the soil physical, chemical and biological properties of the soil. Application of different sources of organic manures or its different combinations helps to improve the productivity of rice-rice / rice-pulse cropping sequence as well as soil properties. Efficient collection and application of these organic resources will go a long way in reducing our dependence on inorganic fertilizers (Palaniappan, 2002). Kumar *et al*. (2013) reported that the use of green manure such as Sesbania, sunnhemp, dhaincha and pillipesara enhances the rice yield, conserves soil organic matter and nutrients especially nitrogen. Hence, an attempt was made to study the performance of different sources of organic manures and its various combinations in comparison with RDF and INM on nutrient uptake and soil properties in rice.

MATERIAL AND METHODS

Field experiments were carried out at Wetland Farms of "O" block at Tamil Nadu Agricultural University, Coimbatore, India during *Samba* (August-December) season of 2012 and 2013. Coimbatore is situated in the Western agro-climatic zone of Tamil Nadu at 11^{o}N latitude and 77^{o}E longitude and at an altitude of 426.7 m above mean sea level. The soil of the experimental field was clay loam in texture belonging to *Typic Haplustalf* with the initial analysis of the soil of the experimental site revealed that the soil was slightly alkaline (pH= 8.0 and 8.1) with low soluble salts (EC= 0.43 and 0.42dSm^{-1}), medium in organic carbon content (0.42 and 0.41%), low in available N (214.0 and 228.0 kg ha^{-1}), low in available P (16.7 and 17.8 kg ha^{-1}) and high in available K (536.0 and 438.0 kg ha^{-1}) during the first and second years respectively.

Field experiment :

The field experiment consisted of fourteen treatments which were laid out in Randomized Block Design, replicated thrice and square planting (25 x 25 cm) was adopted during both the years. Among fourteen treatments, four treatments with different organic manures at 100 per cent RDN on equi nutrient basis (farm yard manure, vermi-compost, poultry manure and (Dhaincha) green manure) another six treatments consisted of 50 per cent combination of each organic manure, one treatment with 1/4th combination of all the manures and one absolute control (without organic or inorganic). These treatments were compared with the recommended dose of fertilizer (RDF) and integrated nutrient management practice (RDF + Dhaincha). The rice variety CO (R) 48 with field duration of 135 days was used in the trial. Separate nurseries were raised for conventional (INM and RDF) treatments and organic nursery for organic treatments. For organic and inorganic treatments separate experimental plots were maintained in both the years of study. Method of planting adopted was square planting and transplanted with 14 days old seedlings. All other package of practices were carried out as per recommendation of CPG (2012) for INM and RDF treatments. For organic treatments no herbicide was used, neem seed kernel extract, *Pnchagavyaa* and *Pseudomonos* were used as prophylactic plant protection measures. Irrigation and plant protection measures were followed uniformly in all the plots as per the requirements during both the years of experimentation.

On N equivalent basis, required quantities of farmyard manure, decomposed poultry manure, vermi-compost and Dhaincha (*Sesbania aculeata*) green manure were applied in the soil one week before

transplanting, whereas the dhaincha (*Sesbania aculeata*) green manure was applied two weeks prior to transplanting. Different sources of organic manures were applied as per treatment schedule. Recommended doses of 150:50:50 kg ha^{-1} of N, P and K in the form of urea, single super phosphate and muriate of potash were applied to the rice crop in respect of treatment T_{13} (RDF Treatment). In INM treatment (T_{14}), 6.25 t ha^{-1} of green manure Dhaincha (*Sesbania aculeata*) was incorporated two weeks prior to transplanting along with the recommended doses of 150:50:50 kg ha^{-1} N, P and K in the form of urea, single super phosphate and muriate of potash were applied to the rice crop. In addition to this, application of 5 kg ha^{-1} of *Azospirillum*, 5 kg ha^{-1} of *Phosphobacteria* and 50 kg ha^{-1} of zinc sulphate were applied as basal prior to transplanting. The uptake of N, P and K by rice crop and rice fallow greengram and their status in soil after harvest was studied using standard laboratory methods.

Nutrient balance in the cropping sequence :

Soil available nutrient (N, P_2O_5 and K_2O) balance in the cropping system was computed for the treatments as per the specific nutrient added to the rice crop and the nutrient added by the residual crop was put together computed as the total quantity of the nutrient added and the same manner the total quantity of nutrient removal was also computed. The specific nutrient's computed balance was derived from total quantity of the specific nutrient added was subtracted from the total quantity of the specific nutrient removed. The specific nutrient balance was computed from the soil specific nutrient status at harvest was subtracted from the specific nutrient status at initial as per the procedure suggested by Sadanandan and Mahapatra (1973). Finally the N, P and K actual balance at the end of the cropping sequence was worked out.

Biometric and yield observations :

Five plants in each plot were selected at random and tagged. These plants were used for recording biometric observation at different stages of crop growth. The harvested produce from each net plot was threshed, sun dried, winnowed separately and the grain yield was recorded at 14 per cent moisture content and expressed in kg·ha^{-1} (Hemalatha *et al*., 2000).

Statistical analysis :

The data on various characters studied during the course of investigation were statistically analysed (Gomez and Gomez, 2010) for Randomized Block Design. Wherever treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. Treatment differences that were not significant were denoted as "NS".

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under following heads :

Rice nutrient uptake :

Nitrogen uptake :

The N uptake was influenced by the INM practice, recommended NPK fertilizers and organic manures at harvest of crop during both the years of study (Table 1). The uptake of N varies from 61.12 to 104.02 kg ha^{-1} during 2012; 63.02 to 106.03 kg ha^{-1} during 2013, respectively at harvest of the crop. The increased N uptake was observed in the INM practice (T_{14}) 104.02 kg ha^{-1} in 2012 and 106.03 kg ha^{-1} in 2013, respectively at harvest of the rice and it was comparable with recommended NPK fertilizers (T_{13}), 100 per cent RDN through green manure (T_5) and 25 per cent RDN through each organic manures (T_{12}). The N uptake was lower in absolute control (T_1) (61.12) in 2012 and (63.02) in 2013, respectively at harvest of the rice.

Phosphorus uptake :

The P uptake was also influenced by the INM practice, recommended NPK fertilizers and organic manures application (Table 1). During 2012 and 2013 the INM treatment (T_{14}) recorded higher P uptake was 25.93 and 28.44 kg ha^{-1} at harvest of rice, and it was on par with recommended NPK fertilizers (T_{13}), 100 per cent RDN through green manure (T_5) and 25 per cent RDN through each organic manures (T_{12}). Lower P uptake was observed in absolute control (T_1) (14.04 and 14.72 kg ha^{-1}) at harvest of rice during 2012 and 2013, respectively.

Potassium uptake :

During 2012 and 2013, the positive influence of treatments imposed on K uptake by rice was evidenced and presented in Table 1. The highest K uptake was associated with the INM treatment (T_{14}) (137.01 and

145.02 kg ha^{-1} during 2012 and 2013, respectively) and it was comparable with recommended NPK fertilizers (T_{13}) at harvest of rice . Among the organic treatments, higher K uptake was recorded with 100 per cent RDN through green manure (T_5) (131.05 and 138.01 kg ha^{-1} during 2012 and 2013, respectively) and it was followed by 25 per cent RDN through each organic manures (T_{12}). Lower K uptake was observed in absolute control (T_1) (85.02 and 88.04 kg ha^{-1}, respectively) at harvest of rice during 2012 and 2013.

Table 1 : Effect of organic manures, RDF and INM on total nutrient uptake of rice at harvest

Treatments	Samba 2012			Samba 2013		
	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1 : Absolute control	61.12	14.04	85.02	63.02	14.72	88.04
T_2 : 100% RDN through FYM	80.41	19.52	104.04	82.01	21.81	108.05
T_3 : 100% RDN through VC	84.22	19.64	110.05	86.03	22.23	116.06
T_4 : 100% RDN through PM	88.62	19.62	118.03	91.42	23.04	126.09
T_5 : 100% RDN through GM	96.44	22.45	131.05	99.81	24.52	138.01
T_6 : 50% RDN each of through FYM + VC	76.34	19.42	100.04	77.53	21.02	106.05
T_7 : 50% RDN each of through FYM + PM	90.42	19.61	124.05	93.24	23.43	132.02
T_8 : 50% RDN each of through FYM + GM	82.45	19.54	107.06	84.03	22.05	112.03
T_9 : 50% RDN each of through VC + PM	93.16	20.42	128.06	95.05	23.81	135.05
T_{10} : 50% RDN each of through VC + GM	78.42	19.44	102.04	79.42	21.42	106.01
T_{11} : 50% RDN each of through PM + GM	86.55	19.62	114.02	90.04	22.43	121.03
T_{12} : 25% RDN each of through FYM + VC + PM + GM	95.04	22.25	130.04	97.22	24.22	137.03
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	99.14	22.82	133.08	102.05	24.64	139.04
T_{14} : INM practice (RDF + GM @ 6.25 t ha^{-1})	104.02	25.93	137.01	106.03	28.44	145.02
S.E. ±	8.01	1.82	10.02	8.22	2.12	11.04
C.D. (P=0.05)	16.82	3.84	21.05	17.25	4.45	23.09

FYM: Farm yard manure, VC: Vermicompost, PM: Poultry manure, GM: Green manure (Dhaincha) *Sesbania aculeata*
RDN: Recommended dose of nitrogen, RDF: Recommended dose of fertilizers, INM: Integrated nutrient management

Table 2 : Residual effect of organic manures, RDF and INM on total nutrient uptake of greengram at harvest

Treatments	Summer 2013			Summer 2014		
	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
T_1 : Absolute control	31.72	8.60	32.92	33.64	8.90	34.05
T_2 : 100% RDN through FYM	38.12	10.25	39.61	40.22	10.15	38.54
T_3 : 100% RDN through VC	38.13	10.35	40.23	40.46	10.32	38.92
T_4 : 100% RDN through PM	38.21	10.52	40.42	40.85	10.61	39.91
T_5 : 100% RDN through GM	39.34	12.55	42.21	42.44	12.64	39.26
T_6 : 50% RDN each of through FYM + VC	38.05	10.41	39.81	40.43	10.46	38.22
T_7 : 50% RDN each of through FYM + PM	38.32	10.51	40.32	40.81	10.75	38.44
T_8 : 50% RDN each of through FYM + GM	38.41	10.62	40.43	41.35	10.91	38.62
T_9 : 50% RDN each of through VC + PM	38.53	10.72	40.54	41.53	11.26	38.83
T_{10} : 50% RDN each of through VC + GM	38.64	10.83	40.62	41.62	11.52	38.96
T_{11} : 50% RDN each of through PM + GM	38.72	10.92	40.75	41.81	11.72	39.02
T_{12} : 25% RDN each of through FYM + VC + PM + GM	38.83	11.25	41.22	42.25	12.24	39.14
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	35.25	10.14	36.84	38.26	9.91	36.82
T_{14} : INM practice (RDF + GM @ 6.25 t ha^{-1})	39.52	12.82	42.82	42.66	13.06	41.82
S.E. ±	3.52	1.02	0.43	3.83	1.02	3.63
C.D. (P=0.05)	7.45	2.15	0.86	7.96	2.14	7.56

FYM: Farm yard manure, VC: Vermicompost, PM: Poultry manure, GM: Green manure (Dhaincha) *Sesbania aculeata*
RDN: Recommended dose of nitrogen, RDF: Recommended dose of fertilizers, INM: Integrated nutrient management

Rice fallow residual greengram nutrient uptake :

Nitrogen uptake :

The N uptake was influenced by the INM practice, recommended NPK fertilizers and organic manures at harvest of crop during both the years of study (Table 2).The uptake of N varies from 31.72 to 39.52 kg ha^{-1} during 2012; 33.64 to 42.66 kg ha^{-1} during 2013, respectively at harvest of the residual greengram. The increased N uptake was observed in the INM practice (T_{14}) 39.52 kg ha^{-1} in 2012 and 42.66 kg ha^{-1} in 2013, respectively) at harvest of the residual greengram and it was comparable with recommended NPK fertilizers (T_{13}), 100% RDN through green manure (T_5) (39.34 and 42.44) and 25% RDN through each organic manures (T_{12}). The N uptake was lower in absolute control (T_1) (31.72) in 2012 and (33.64) in 2013, respectively at

Table 3 : Effect of organic manures, RDF and INM on haulm dry weight and addition of nutrients (kg ha^{-1}) through haulms of residual greengram

Treatments	Summer 2013				Summer 2014			
	Haulm (dry weight)	N	P	K	Haulm (dry weight)	N	P	K
T_1 : Absolute control	1142	30.2	7.5	30.1	1174	31.6	8.0	30.2
T_2 : 100% RDN through FYM	1477	32.9	10.1	36.0	1754	32.8	10.4	37.2
T_3 : 100% RDN through VC	1524	33.7	10.5	37.2	1809	34.3	10.7	38.1
T_4 : 100% RDN through PM	1585	34.9	10.7	38.4	1845	35.5	10.9	38.8
T_5 : 100% RDN through GM	1864	36.2	11.1	40.1	2164	38.8	11.6	39.4
T_6 : 50% RDN each of through FYM + VC	1386	31.6	9.5	34.2	1682	32.1	9.7	36.4
T_7 : 50% RDN each of through FYM + PM	1672	35.1	10.8	39.2	1964	36.2	11.0	38.9
T_8 : 50% RDN each of through FYM + GM	1504	33.1	10.3	36.9	1790	33.9	10.6	37.8
T_9 : 50% RDN each of through VC + PM	1745	35.7	10.9	39.5	2036	37.1	11.3	39.0
T_{10} : 50% RDN each of through VC + GM	1445	32.2	9.9	35.7	1736	32.6	10.0	36.9
T_{11} : 50% RDN each of through PM + GM	1536	34.3	10.6	37.9	1822	34.9	10.8	38.7
T_{12} : 25% RDN each of through FYM + VC + PM + GM	1772	36.0	11.0	39.7	2054	37.9	11.6	39.1
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	1986	36.8	11.2	38.2	2282	39.6	11.6	38.9
T_{14} : INM Practice (RDF + GM @ 6.25 t ha^{-1})	2918	39.7	14.2	41.4	3172	42.7	15.8	42.9
S.E. ±	155	3.3	1.0	3.6	179	3.4	1.0	3.6
C.D. (P=0.05)	318	6.8	2.1	7.5	369	6.9	2.1	7.5

FYM: Farm yard manure, VC: Vermicompost, PM: Poultry manure, GM: Green manure (Dhaincha) *Sesbania aculeata*
RDN: Recommended dose of nitrogen, RDF: Recommended dose of fertilizers, INM: Integrated nutrient management

Table 4 : Effect of organic manures, RDF and INM on soil available N balance (kg ha^{-1}) during the cropping sequence 2012-14

Treatments	Initial soil N	N applied	Residual N added	Total N added	Total N removal	Expected balance	Actual balance	Net gain or loss
T_1 : Absolute control	214	-	80.9	80.9	189.4	-108.5	210	-4.0
T_2 : 100% RDN through FYM	214	300	89.2	389.2	240.7	148.5	234	20.0
T_3 : 100% RDN through VC	214	300	93.1	393.1	248.7	144.4	242	28.0
T_4 : 100% RDN through PM	214	300	96.7	396.7	259.0	137.7	248	34.0
T_5 : 100% RDN through GM	214	300	105.9	405.9	277.1	128.8	260	46.0
T_6 : 50% RDN each of through FYM + VC	214	300	87.1	387.1	231.8	155.3	227	13.0
T_7 : 50% RDN each of through FYM + PM	214	300	97.2	397.2	262.9	134.3	250	36.0
T_8 : 50% RDN each of through FYM + GM	214	300	92.0	392.0	245.1	146.9	238	24.0
T_9 : 50% RDN each of through VC + PM	214	300	99.4	399.4	267.8	131.6	254	40.0
T_{10} : 50% RDN each of through VC + GM	214	300	88.8	388.8	236.5	152.3	231	17.0
T_{11} : 50% RDN each of through PM + GM	214	300	95.6	395.6	255.8	139.8	244	30.0
T_{12} : 25% RDN each of through FYM + VC + PM + GM	214	300	104.3	404.3	272.1	132.2	256	42.0
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	214	300	108.0	408.0	278.5	129.5	224	10.0
T_{14} : INM practice (RDF + GM @ 6.25 t ha^{-1})	214	300	119.3	419.3	294.3	125.0	299	85.0

FYM: Farm yard manure, VC: Vermicompost, PM: Poultry manure, GM: Green manure (Dhaincha) *Sesbania aculeata*
RDN: Recommended dose of nitrogen, RDF: Recommended dose of fertilizers, INM: Integrated nutrient management

harvest of the residual greengram.

Phosphorus uptake :

The P uptake was also influenced by the INM practice, recommended NPK fertilizers and organic manures application (Table 2). During 2012 and 2013 the INM treatment (T_{14}) recorded higher P uptake was 12.82 and 13.06 kg ha^{-1} at harvest of residual greengram and it was at par with recommended NPK fertilizers (T_{13}), 100 per cent RDN through green manure (T_5) (12.55 and 12.64) and 25 per cent RDN through each organic manures (T_{12}). Lower P uptake was observed in absolute control (T_1) (8.60 and 8.90 kg ha^{-1}) at harvest of residual greengram during 2012 and 2013, respectively.

Potassium uptake :

During 2012 and 2013, the positive influence of treatments imposed on K uptake by residual greengram was evidenced and presented in Table 2. The highest K uptake was associated with the INM treatment (T_{14}) (42.82 and 41.82 kg ha^{-1} during 2012 and 2013, respectively) and it was comparable with recommended NPK fertilizers (T_{13}) at harvest of residual greengram . Among the organic treatments, higher K uptake was recorded with 100 per cent RDN through green manure (T_5) (42.21 and 39.26 kg ha^{-1} during 2012 and 2013, respectively) and it was followed by 25 per cent RDN through each organic manures (T_{12}). Lower K uptake was observed in absolute control (T_1) (32.92 and 34.05 kg ha^{-1}, respectively) at harvest of residual greengram during 2012 and 2013.

Residual greengram haulm dry weight and addition of nutrients :

Similar trend was noticed in greengram's haulm dry weight and addition of nutrients (N, P and K) after the harvest of residual greengram and the incorporation of the haulms (on dry weight basis) in the same experimental plots were expressed in kg ha^{-1} and presented in Table 3. The addition of nutrients contributed by greengram haulms were taken into account for the computation of nutrient balance in the entire cropping system during both the years of study.

Total soil available N balance at the end of two years cropping sequence (2012-14) :

The INM practice (T_{14}) positively influenced post harvest available N and its balance (Table 4). Net N loss was high (-4.0 kg ha^{-1}) in absolute control (T_1), *viz*., without INM, organic manures and recommended fertilizer N, whereas, net N gain was maximum recorded with the INM treatment (T_{14}) (85.0 kg ha^{-1}). The 100 per cent RDN through green manure (T_5) (46.0 kg ha^{-1}), 25 per cent RDN through each organic manure (T_{12}) (42.0 kg ha^{-1}), 50 per cent RDN through vermicompost and poultry manure (T_9) (40.0 kg ha^{-1})

Table 5 : Effect of organic manures, RDF and INM on soil available P balance (kg ha^{-1}) during the cropping sequence 2012-14

Treatments	Initial soil P	P applied	Residual P added	Total P added	Total P removal	Expected balance	Actual balance	Net gain or loss
T_1 : Absolute control	16.7	-	18.7	18.7	46.2	-27.5	14.2	-2.5
T_2 : 100% RDN through FYM	16.7	208.0	24.5	232.5	62.0	170.5	18.6	1.9
T_3 : 100% RDN through VC	16.7	104.6	25.8	130.4	62.8	67.6	19.0	2.3
T_4 : 100% RDN through PM	16.7	190.5	26.5	217.0	64.1	152.9	19.4	2.7
T_5 : 100% RDN through GM	16.7	75.6	28.7	104.3	68.1	36.2	19.7	3.0
T_6 : 50% RDN each of through FYM + VC	16.7	156.2	23.2	179.4	60.7	118.7	17.7	1.0
T_7 : 50% RDN each of through FYM + PM	16.7	199.2	26.4	225.6	64.7	160.9	19.3	2.6
T_8 : 50% RDN each of through FYM + GM	16.7	141.7	25.4	167.1	62.3	104.8	19.0	3.0
T_9 : 50% RDN each of through VC + PM	16.7	147.6	27.2	174.8	66.0	108.8	19.6	2.9
T_{10} : 50% RDN each of through VC + GM	16.7	90.0	24.5	114.5	61.4	53.1	18.9	2.2
T_{11} : 50% RDN each of through PM + GM	16.7	133.0	26.9	159.9	63.2	96.7	19.4	2.7
T_{12} : 25% RDN each of through FYM + VC + PM + GM	16.7	144.6	28.2	172.8	67.2	95.3	19.8	3.1
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	16.7	100.0	29.1	129.1	69.7	59.4	19.5	2.8
T_{14} : INM practice (RDF + GM @ 6.25 t ha^{-1})	16.7	100.0	31.9	131.9	84.1	47.8	21.8	5.1

FYM: Farm yard manure, VC: Vermicompost, PM: Poultry manure, GM: Green manure (Dhaincha) *Sesbania aculeata*
RDN: Recommended dose of nitrogen, RDF: Recommended dose of fertilizers, INM: Integrated nutrient management

and 50% RDN through FYM and poultry manure (T_7) (36.0 kg ha^{-1}) at the end of the experiment. The recommended NPK fertilizers (T_{13}) recorded the soil available N balance of 10.0 kg ha^{-1} during the cropping sequence 2012-14. The increased N balance might be due to the slow decomposition of organic manures led to steady N release to meet the requirement of crops of initial stages. Even after completion of growing period, mineralization of N could be continued to the soil pool (Bouldin *et al.*, 1988). This might have helped in maintaining the soil available N in spite of depletion by the crops. Similar observations have been earlier made by Amanullah *et al.* (2006). The net loss of soil available N was observed when N was not applied through either organic manures or inorganic fertilizers (absolute control) end of two years. This might be due to susceptibility of inorganic fertilizers to various losses during after mineralization in addition to uptake by crops. Similar result was reported by Kenchaiah (1997). This may be due to the release of nutrients to soil and for the timely nutrient availability and uptake by plants. These results were in conformity with the findings of Kumar *et al*. (2007).

Total soil available P balance at the end of two years cropping sequence (2012-14) :

The INM practice, addition of organic manures and recommended NPK fertilizers in the first and second cropping system of rice-greengram altered the balance of soil available phosphorus (Table 5). Organic manuring positively influenced post harvest available P and its balance and P loss was high in (-2.5) absolute control (T_1) *viz*., without INM, organic manures and recommended fertilizer P, whereas net P gain was maximum recorded with the INM practice (T_{14}) (5.1 kg ha^{-1}), followed by 25 per cent RDN through each organic manures (T_{12}) (3.1 kg ha^{-1}), 100 per cent RDN through green manure (T_5) (3.0 kg ha^{-1}) 50 per cent RDN through FYM and green manure (T_8) (3.0 kg ha^{-1}) and 50 per cent RDN through vermicompost and poultry manure (T_9) (2.9 kg ha^{-1}). The available soil P balance was observed with the recommended NPK fertilizer (T_{13}) (2.8 kg ha^{-1}) at the end of the experiment. This might be due to the slow decomposition of organic manures and more mobilization of native P and uptake by the crop. There was a great reduction in the phosphorus balance where ever the organic manures are received in the entire cropping system due to the release of organic acids released during the decomposition of organic manures which in turn increases the phosphorus availability in the soil solution. This was inconformity with results observed by Pazhanivelan *et al.* (2006). The lowest net negative balance was observed with the absolute control this was attributed to luxurious consumption of K by crops (Barik *et al*., 2008).

Total soil available K balance at the end of two years cropping sequence (2012-14) :

The total soil available K balance at the end of two year cropping sequence was computed and presented in Table 6. The INM practice, addition of organic manures

Table 6 : Effect of organic manures, RDF and INM on soil available K balance (kg ha^{-1}) during the cropping sequence 2012-14

Treatments	Initial soil K	K applied	Residual K added	Total K added	Total K removal	Expected balance	Actual balance	Net gain or loss
T_1 : Absolute control	536	-	103.1	103.1	239.9	-136.8	418	-118.0
T_2 : 100% RDN through FYM	536	336.1	124.1	460.2	290.1	170.1	458	-78.0
T_3 : 100% RDN through VC	536	193.1	128.8	321.9	305.1	16.8	464	-72.0
T_4 : 100% RDN through PM	536	163.2	133.6	296.8	323.5	-26.7	474	-62.0
T_5 : 100% RDN through GM	536	143.2	144.5	287.7	349.4	-61.7	490	-46.0
T_6 : 50% RDN each of through FYM + VC	536	264.6	119.9	384.5	281.6	102.9	451	-85.0
T_7 : 50% RDN each of through FYM + PM	536	249.6	133.8	383.4	335.7	47.7	478	-58.0
T_8 : 50% RDN each of through FYM + GM	536	239.6	127.7	367.3	297.8	69.5	496	-40.0
T_9 : 50% RDN each of through VC + PM	536	178.2	135.2	313.4	342.9	-29.5	482	-54.0
T_{10} : 50% RDN each of through VC + GM	536	168.2	124.1	292.3	285.9	6.4	454	-82.0
T_{11} : 50% RDN each of through PM + GM	536	153.3	132.2	285.5	314.3	-28.8	470	-66.0
T_{12} : 25% RDN each of through FYM + VC + PM + GM	536	208.9	142.7	351.6	347.1	4.5	486	-50.0
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	536	100.0	143.2	243.2	352.5	-109.3	492	-44.0
T_{14} : INM practice (RDF + GM @ 6.25 t ha^{-1})	536	227.7	162.1	389.8	371.2	18.6	520	-16.0

FYM: Farm yard manure, VC: Vermicompost, PM: Poultry manure, GM: Green manure (Dhaincha) *Sesbania aculeata*
RDN: Recommended dose of nitrogen, RDF: Recommended dose of fertilizers, INM: Integrated nutrient management

and recommended NPK fertilizers in the first and second cropping system of rice-greengram altered the balance of soil available potassium. The INM practice and the addition of organic manures increased available soil K balance. The INM practice, addition of organic manures and recommended NPK fertilizers resulted net negative K balance. The net K loss was higher in absolute control (T_1) (-118.0 kg ha^{-1}) followed by 50 per cent RDN with FYM and vermicompost (T_6) (-85.0 kg ha^{-1}), 50 per cent RDN through vermicompost and green manure (T_{10}) (-82.0 kg ha^{-1}), 50 per cent RDN through poultry manure and green manure (T_{11}) (-66.0 kg ha^{-1}), 25 per cent RDN through each organic manures (T_{12}) (-50.0 kg ha^{-1}), 100 per cent RDN through green manure (T_5) (-46.0 kg ha^{-1}), the recommended NPK fertilizers (T_{13}) (-44.0 kg ha^{-1}) and the INM treatment (T_{14}) resulted with the net loss of K (-16.0 kg ha^{-1}) at the end of two years cropping period 2012-14. Similar work related to the present investigation also carried out by Rao *et al*. (2013); Bhatt *et al*. (2013); Bairwa *et al*. (2013) and Varia and Sadhu (2012).

Conclusion :

The soil available N and P balance was positive with the INM treatment (85.0 and 5.10 kg ha^{-1}) at the end of two year of cropping system. Among the organic treatments, 100 per cent RDN through green manure recorded the highest N balance (46.0 kg ha^{-1}) followed by 25 per cent RDN through each organic manures (42.0 kg ha^{-1}) at the end of the cropping system (2012 -14). Similarly, the highest P balance was recorded with 25% RDN through each organic manures (3.1 kg ha^{-1}) and which was followed by 100 per cent RDN through green manure (3.0 kg ha^{-1}) at end of the two years of cropping system. The least N and P balance was noticed with absolute control (-4.0 and -2.5 kg ha^{-1}) at the end of cropping sequence. This may be due to the faster uptake of soil available nutrients by the plants which did not received the fertilizers or manures in the entire cropping period. Invariably, all the treatments recorded net negative K balance in both the years of cropping system.

In general, during the period of field experimentation the pre-season green manuring and application of organic manures and the implementation of the INM practice showed favourable response towards improvement in soil fertility status and soil health when compared with their initial values except absolute control. The inclusion of green manure (*Sesbania aculeata*) 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 it, which would be lost upon flooding. Further, the biological N fixation (BNF) also improved the soil fertility status. The addition of organic manure of rice crop can build up the soil fertility over a period of time and the nutrient supply was increased at slower rate. The incorporation of greengram haulms as the source of organic manure also improved the soil fertility and soil health over a period of time. Similar results were supported by (Sangeetha *et al*., 2013) in rice -blackgram cropping sequence. Green manures have a good potential to maintain soil fertility, supplement nutrient supply to rice crop and could contribute to greater food security (Palaniappan, 2000), which found to be optimum for enhancing rice production for promoting organic rice farming in Western agro-climatic zone of Coimbatore.

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