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RESEARCH ARTICLE :

Impact of different sources of organic manures in comparison with RDF and INM on growth, yield, system productivity, nutrient status and economics in rice- greengram cropping system

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SUMMARY : Field experiments were carried out at Tamil Nadu Agricultural University, Coimbatore, India during *Samba* (August-December) season of 2012 and 2013, and summer 2013 and 2014 with rice fallow green gram to study the effect of different sources of organic manures in comparison with RDF and INM on growth, yield, economics and nutrient status in rice-green gram cropping system. The experiment consisted of fourteen treatments which were laid out in Randomized Block Design, replicated thrice and square planting with 25 x 25 cm spacing was adopted during both the years experimentation. The gross return per hectare during 2012-2013, extended from Rs. 62,971 to Rs. 1,14,730 for the rice-greengram cropping system. The growth parameters such as productive tillers m^{-2} and the yield attributes like dry matter production, grain and straw yield of rice was recorded during both the years of the cropping system. The system productivity was worked out for the entire period of the cropping system. The nutrient balance status (N, P and K) was worked out at the end of the entire cropping system. The N and P balance at the end of the cropping system was positive in all the treatments except the absolute control, whereas the negative K balance was worked out in the entire cropping system. Higher gross return (Rs. 1,14,730) and net return (Rs. 68,245) were associated with the INM treatment (T_{14}) with the grain yield of 6235 kg ha^{-1} and it was corresponded to that observed with T_5*viz.*, 100% RDN through green manure (T_5) with the grain yield of 5084 kg ha^{-1} for gross return (Rs. 1,12,979) and net return (Rs. 66,978). During 2013-2014, the gross return and net return of the rice-greengram cropping sequence varied from Rs. 63,817 to Rs. 1,17,175 and from Rs. 32,385 to Rs. 70,690, respectively. The INM treatment (T_{14}) recorded with the grain yield of 6270 kg ha^{-1} and the higher gross return (Rs. 1,17,175) and net return (Rs. 70,690) and which was comparable with 100% RDN through green manure (T_5) with the grain yield of 5140 kg ha^{-1} and the gross return of Rs. 1,15,380 and the net return of Rs. 69,340, respectively. The lowest gross return was registered with the absolute control (T_1) (Rs. 63,817) and net return (Rs. 32,385) with the grain yield of 3602 and 3646 kg ha^{-1} during the cropping sequence 2013-2014.

KEY WORDS :
Growth parameters, Yield parameters, System productivity, Nutrient balance status, Economics, Rice-green gram cropping system

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BACKGROUND AND OBJECTIVES

Rice production was almost stagnated for last one decade by oscillating around 95 million tones in India. However, the projected demand by 2025 is 116.5 million tones to keep the present per capita rice availability of 215g/day in future. Better nutrient management strategies can support the needed future yield increase. Emergence of widespread multi nutrient deficiencies, depletion of native nutrient reserves, imbalanced fertilization are matter of serious concern, causing serious stagnation and declining productivity of various rice ecosystems (Rai, 2007). Site-specific nutrient management approach is being focused in recent years to reverse the present declining trend in factor productivity (Shukla *et al*., 2004). Green gram (*Vigna radiata* L. Wilczek) is an important pulse crop popularly grown in rotation with rice. The present experiment was conducted to study the impact of different sources of organic manures in comparison with RDF and INM on growth, yield, economics and nutrient status in rice-green gram cropping system. Suitable rice based cropping has to be evaluated, to assess the stability in production, inclusion of pulses or vegetable in the cropping system is more beneficial than cereal after cereal (Kumpawat, 2001). The response of component crops in cropping system is influenced by the preceding crops and the input applied to them. Use of organic manures alone, as a substitute to chemical inorganic fertilizer is not profitable and will not be enough to maintain the present levels of crop productivity of high yielding varieties. Use of organic manures along with inorganic fertilizers lead to increase in productivity of the system and also sustain the soil health for a longer period (Gawai and Pawar, 2006).

RESOURCES AND METHODS

Field experiments were carried out at Tamil Nadu Agricultural University, Coimbatore, India during *Samba* (August-December) season of 2012 - 2013 for rice and summer season of 2013 and 2014 for residual green gram. 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 low in available N (254.0 and 260.0 kg ha^{-1}), low in available P (16.7 and 17.8 kg ha^{-1}) and high in available K (402.0 and 418.0 kg ha^{-1}) during the first and second years, respectively. The experiment consisted of fourteen treatments which were laid out in Randomized Block Design, replicated thrice and square planting was adopted during both the years. Among fourteen treatments, four treatments with different organic manures at 100% RDN on equi nutrient basis [farm yard manure, vermi-compost, poultry manure and (Dhaincha) green manure] another six treatments consisted of 50% 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 @ 6.25 t ha^{-1}). The rice variety CO (R) 48 with field duration of 135 days was used in the trial followed by summer green gram (Co 6) as residual succeeding crop without addition of any manures and fertilizers in both the years of experiment. 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. The rice crop was 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, *Panchagavyaa* and *Pseudomonas* were used as prophylactic plant protection measures. The experiments were received uniform plant protection and cultural management practices throughout the period of crop growth. The yield and economics of the entire cropping system was worked out for both the years of experimentation.

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 analyzed (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".

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads:

Productive tillers m^{-2}:

The number of productive tillers m^{-2} ranged from 300 to 584 and from 303 to 588 during 2012 and 2013, respectively (Table 1). The INM practice (T_{14}) recorded more number of productive tillers m^{-2} (584 in 2012 and 588 in 2013, respectively) and which was on par with recommended NPK fertilizers (T_{13}). In rice, taller plants, more productive tillers $hill^{-1}$, increased panicle length, higher number of filled grains $panicle^{-1}$, better test weight and grain yield was obtained integrated use of Dhaincha at 6.25 t ha^{-1} and 100 kg N ha^{-1} applied at equal splits at basal, 21 DAP, panicle initiation and flowering stages (Geethalakshmi, 1996) also confirmed the superiority of *Sesbania aculeata* in promoting the growth attributes in rice which was recorded higher mineralization than other organic sources of nutrients in rice. Similar results were supported by Kenchaiah (1997). Among the organic treatments, 100% RDN through green manure (T_5) recorded higher number of productive tillers m^{-2} (508 and 510 during 2012 and 2013, respectively) and it was on par with 25% RDN through each organic manures (T_{12}). The least number of productive tillers m^{-2} (300 in 2012) was associated with the treatment of absolute control (T_1). Similar trend was observed in the conformity trial during 2013 also. Increase in rice grain yield owing to green manure incorporation might be attributed to the release of nutrients to soil slowly for longer duration after decomposition, resulting in better plant growth and yield contributing characters as reported by Patra *et al*. (2001). The enhanced and continuous supply of nutrients by the organics lead to better tiller production and filled grain of rice was reported by Mohandas *et al.* (2008).

Dry matter production :

Dry matter accumulation is considered to be the reliable index of crop growth. The effects of variables on the total dry matter production (DMP) (kg ha^{-1}) of rice are furnished in (Table 1). In both the years of study, the DMP was increased steadily with the advancement of the crop growth. The DMP was favourably increased

Table 1 : Effect of organic manures, RDF and INM on effective tillers m^{-2}, dry matter production, grain and straw yield of rice (kg ha^{-1})

Treatments	*Samba* 2012				*Samba* 2013			
	Effective tillers m^{-2}	Dry matter production (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Effective tillers m^{-2}	Dry matter production (kg ha^{-1})	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 : Absolute control	300	9525	3602	4907	303	10065	3646	4939
T_2 : 100% RDN through FYM	409	9890	4164	5424	413	10433	4190	5425
T_3 : 100% RDN through VC	419	10208	4296	5549	423	10744	4380	5618
T_4 : 100% RDN through PM	429	10411	4377	5608	432	10950	4550	5760
T_5 : 100% RDN through GM	508	13628	5084	6445	510	13998	5140	6467
T_6 : 50% RDN each of through FYM + VC	416	9827	3910	5120	419	10363	3980	5175
T_7 : 50% RDN each of through FYM + PM	432	11231	4721	6024	436	11767	4833	6155
T_8 : 50% RDN each of through FYM + GM	412	10063	4236	5494	416	10599	4316	5568
T_9 : 50% RDN each of through VC + PM	436	11720	4923	6255	440	12256	4986	6304
T_{10} : 50% RDN each of through VC + GM	404	9845	4079	5321	407	10381	4140	5385
T_{11} : 50% RDN each of through PM + GM	422	10266	4322	5578	425	10802	4430	5655
T_{12} : 25% RDN each of through FYM+VC+PM+GM	452	12058	5004	6376	455	12525	5120	6455
T_{13} : RDF : (150 : 50 : 50) NPK kg ha^{-1}	502	13506	5603	7103	507	13973	5680	7128
T_{14} : INM Practices (RDF + GM @ 6.25 t ha^{-1})	584	15038	6235	7470	588	15505	6270	7490
S.E.±	40	1036	425	546	40	1083	432	552
C.D. (P=0.05)	83	2130	874	1123	83	2227	889	1136

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

in all stages due to INM practice, organic manures and recommended NPK fertilizer application. During the course of investigation, the INM practice (T_{14}) recorded significantly higher DMP (15038 and 15505 kg ha^{-1} during 2012 and 2013, respectively) at harvest stage, which was however, comparable with 100% RDN through green manure (T_5) and recommended NPK fertilizers (T_{13}Among the organic treatments, 100% RDN through green manure (T_5) recorded more DMP (13628 and 13998) at harvest stage during 2012 and 2013, respectively and was followed by 25% RDN through each organic manures (T_{12}), the same results were repeated in both the years. The lowest dry matter production at harvest of crop growth period was associated in absolute control (T_1) (9525 and 10065 during 2012 and 2013, respectively). This was significantly inferior to the dry matter produced by all the organic, inorganic and INM treatment during both the years of investigation. The probable reason might be attributed to the continuous slow release of nutrients which might have enabled the leaf area duration to extend, thereby providing an opportunity for plants to increase the photosynthetic rate which could have led to higher accumulation of dry matter. Similar results were obtained by Sangeetha (2013).

Rice grain yield :

The effect of treatment variables on grain yield (kg ha^{-1}) of rice are furnished in (Table 1). The treatments imposed had direct influence on rice grain yield in both the years of experimentation. The grain yield of rice extended from 3602 to 6235 kg ha^{-1} during 2012 and from 3646 to 6270 kg ha^{-1} during 2013. The INM practice (T_{14}) recorded higher grain yield (6235 and 6270 kg ha^{-1} in 2012 and 2013, respectively) and was found to be at par with recommended NPK fertilizers (T_{13}), which were at par with each other during both the years. Among the organic treatments, 100% RDN though green manure (T_5) recorded higher grain yield (5084 and 5140 in 2012 and 2013, respectively) and was followed by 25% RDN through each organic manures (T_{12}) (5004 and 5120 in 2012 and 2013, respectively). The lower grain yield (3602 in 2012) obtained with absolute control (T_1), which did not receive organic manures and recommended NPK fertilizers. This was significantly inferior to the grain yield obtained with 100% RDN through farm yard manure

Table 2 : Effect of organic manures, RDF and INM on system productivity, economics and nutrient balance status of rice-greengram cropping system (2012-2014)

Treatments	System productivity (kg ha^{-1}) (2012-13) and (2013-14)		Economics (2012-13)			Economics (2013-14)			Nutrient balance status (kg ha^{-1})		
			Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B : C ratio	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B : C ratio	N	P	K
T_1 : Absolute control	3853	3904	62971	31589	2.00	63817	32385	2.03	-4.0	-2.5	-118.0
T_2 : 100% RDN through FYM	4489	4576	92381	19413	1.27	94972	20895	1.28	20.0	1.9	-78.0
T_3 : 100% RDN through VC	4631	4778	95228	12968	1.16	99006	16078	1.19	28.0	2.3	-72.0
T_4 : 100% RDN through PM	4718	4956	96989	47747	1.97	102475	53156	2.08	34.0	2.7	-62.0
T_5 : 100% RDN through GM	5494	5616	112979	66978	2.46	115380	69340	2.51	46.0	3.0	-46.0
T_6 : 50% RDN each of through FYM + VC	4215	4350	86780	9165	1.12	90362	11859	1.15	13.0	1.0	-85.0
T_7 : 50% RDN each of through FYM + PM	5089	5265	104533	43428	1.35	108930	47232	1.77	36.0	2.6	-58.0
T_8 : 50% RDN each of through FYM + GM	4567	4710	94428	34944	1.59	97672	37613	1.63	24.0	3.0	-40.0
T_9 : 50% RDN each of through VC + PM	5307	5434	108975	43223	1.66	112391	46267	1.70	40.0	2.9	-54.0
T_{10} : 50% RDN each of through VC + GM	4397	4522	90494	26363	1.41	93897	29413	1.46	17.0	2.2	-82.0
T_{11} : 50% RDN each of through PM + GM	4660	4831	95832	48210	2.01	100042	52363	2.10	30.0	2.7	-66.0
T_{12} : 25% RDN each of through FYM + VC + PM + GM	5394	5572	110784	48166	1.77	115102	52011	1.82	42.0	3.1	-50.0
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	6040	6182	98788	57586	2.40	102102	60900	2.48	10.0	2.8	-44.0
T_{14} : INM Practice (RDF + GM @ 6.25 t ha^{-1})	6877	6968	114730	68245	2.47	117175	70690	2.52	85.0	5.1	-16.0
S.E. $\pm$	459	472	8992	3674	-	9299	3949	-	NS	NS	NS
C.D. (P=0.05)	944	970	18883	7715	-	19528	8293	-	NS	NS	NS

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

(T_2). During the conformity trial also similar nature of results were noticed. Physiologically proper partitioning might have occurred from source to sink, as a result improved the yield attributes. The results are similar to the findings of Kumar and Singh (2006). Mohandas *et al*. (2008) observed that the enhanced and continuous supply of nutrients by the enriched organics leading to better tiller production enhanced panicle length and filled grain of rice. Generally, the tiller formation in rice is highly influenced by solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately enhanced the growth and development and yield of rice (Yoshida, 1972).

Rice straw yield :

The mean data pertaining to straw yield (kg ha^{-1}) of rice are furnished in (Table 1). The straw yield was significantly influenced by the treatments imposed in both the years of study. The straw yield of rice during 2012 and 2013 was also influenced by the INM practice, organic manures and recommended NPK fertilizers. The straw yield ranged from 4907 to 7470 kg ha^{-1} and from 4939 to 7490 kg ha^{-1} during 2012 and 2013, respectively. The INM practice (T_{14}) enhanced straw yield (7470 and 7490 kg ha^{-1} in 2012 and 2013, respectively) which was on par with recommended NPK fertilizers (T_{13}). Among the organic treatments, 100% RDN through green manure (T_5) recorded higher straw yield (6445 and 6467 during 2012 and 2013, respectively) and was followed by 25% RDN through each organic manures (T_{12}) with 6376 kg ha^{-1} and 6455 kg ha^{-1} of straw yield during 2012 and 2013. In both the years of study, lower straw yield (4907 and 4939 during 2012 and 2013) was recorded in T_1 *viz*., absolute control. Padmaja Rao (1988) indicated that further filling of grains with photosynthates is likely to occur. Steady and continuous supply of N throughout the entire crop growth period due to gradual transformation and mineralization of organics, solubilization of water insoluble P compounds by organic acids released during decomposition of organics resulting in greater P availability to crop coupled with higher native K availability might have played a key role in ensuring superior yield attributes by organics in combination with inorganic N like in INM practice. This was in agreement with the findings of several workers who reported all increase in yield contributing characters due to addition of mineral N along with organics like *Sesbania aculeata* (Geethalakshmi, 1996; Veerabadran and Solaiappan, 1996 and Basnet 1999), FYM (Shine and Ghosh, 1971 and Kenchaiah, 1997) poultry manure (Budhar*et al*., 1991) Datta *et al*., 1992 and Presmud (Sinha and Sakai and 1993 and Jain and Tiwari, 1995) which ultimately increases grain and straw yield of rice.

System productivity :

The mean data on system productivity in rice-greengram cropping system was worked out and expressed in (kg ha^{-1}). Higher system productivity was recorded with INM practice (T_{14}) (6877 and 6968) followed by 100% RDN treatment (T_{13}) (6040 and 6182) during 2012-13 and 2013-14, respectively (Table 2). Among the organic treatments, 100% RDN through green manure (T_5) (5494 and 5616) recorded higher system productivity followed by 25% RDN through each organic manure (T_{12}) (5394 and 5572) during both the years of the cropping system. The least system productivity was recorded with absolute control (T_1) (3853 and 3904) during both the years of the experimentation.

Economics of rice – greengram cropping system :

The data on yield and economics of rice- greengram cropping sequence influenced by the imposed treatments in both the years of study were computed and presented in Table 2. Gross return per hectare during 2012-2013, extended from Rs. 62,971 to Rs. 1,14,730 for the rice-greengram cropping sequence. Higher gross return (Rs. 1,14,730) and net return (Rs. 68,245) were associated with the INM treatment (T_{14}) with the grain yield of 6235 kg ha^{-1} and it was corresponded to that observed with T_5*viz*., 100% RDN through green manure (T_5) with the grain yield of 5084 kg ha^{-1} resulted with the gross return (Rs. 1,12,979) and net return (Rs. 66,978). These were followed by the application of recommended NPK fertilizers (T_{13}) with the grain yield of 5603 kg ha^{-1} resulted with the gross return (Rs. 98,788) and net return of Rs. 57,586) and 50% RDN through poultry manure and green manure (T_{11}) with the grain yield of 4322 kg ha^{-1} resulted with (Rs. 95,832 and Rs. 48,210 as gross return and net return, respectively). The least gross return was recorded with 100% RDN through FYM (T_2) with the grain yield of 4164 kg ha^{-1} resulted with the gross return (Rs. 92,381) and net return (Rs. 19,413) which

was superior of the absolute control (T_1) with the grain yield of 3602 kg ha^{-1}, resulted with (Rs. 62,971) as gross return and (Rs. 31,589) as net return during the cropping sequence 2012-2013. The pure crop of rice without organic manures or dhaincha during the previous season resulted in the least net return and B:C ratio was reported by Patra *et al.* (2001). Higher B:C ratio (2.47) was registered with the INM treatment (T_{14}) and which was followed by 100% RDN through green manure (T_5) (2.46) the recommended NPK fertilizer (T_{13}) (2.40) and 50% RDN through poultry manure and green manure (T_{11}) (2.01) during the cropping sequence 2012-2013.

During 2013-2014, the gross return and net return of the rice-greengram cropping sequence varied from Rs. 63,817 to Rs. 1,17,175 and from Rs. 32,385 to Rs. 70,690, respectively. The INM treatment (T_{14}) recorded with the grain yield of 6270 kg ha^{-1} resulted with higher gross return (Rs. 1,17,175) and net return (Rs. 70,690) and which was comparable with 100% RDN through green manure (T_5) with the grain yield of 5140 kg ha^{-1}, resulted with the gross return of Rs. 1,15,380 and the net return of Rs. 69,340, respectively. This was followed by 25% RDN through each organic manures (T_{12}) with the grain yield of 5120 kg ha^{-1}, resulted with the gross return of Rs. 1,15,102 and the net return of Rs. 52,011 during the sequence 2013-2014 and which were comparable with the gross return and net return received from (T_9) (Rs. 1,12,391 and Rs. 46,267), (T_7) (Rs. 1,08,930 and Rs. 47,232), (T_4) (Rs. 1,02,475 and Rs. 53,156) and (T_{13}) (Rs. 1,02,102 and Rs. 60,900) during the cropping sequence 2013-2014. The lowest gross return was registered with the absolute control (T_1) (Rs. 63,817) and act return (Rs. 32,385) resulted with the grain yield of 3646 kg ha^{-1}during the cropping sequence 2013-2014.

Higher B:C ratio was (2.52) was observed with the INM treatment (T_{14}) and which was followed by 100% RDN through green manure (T_5) (2.51), the recommended NPK fertilizers (T_{13}) (2.48), 50% RDN through poultry manure and green manure (T_{11}) (2.10) and 100% RDN through poultry manure (T_4) (2.08) during the cropping sequence 2013-2014. The reason for the higher net return in the INM and 100% RDN through green manure than the recommended NPK fertilizers was due to higher product price of organic rice than inorganically produced rice as well as the yield obtained in these treatments was more than inorganic fertilizers treatments, similar observations was obtained earlier by Yadav and Lourduraj (2006).

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 2). 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% RDN through green manure (T_5) (46.0 kg ha^{-1}), 25% RDN through each organic manure (T_{12}) (42.0 kg ha^{-1}), 50% RDN through vermicompost and poultry manure (T_9) (40.0 kg ha^{-1}) 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 2). 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% RDN through each organic manures (T_{12}) (3.1 kg ha^{-1}), 100% RDN through green manure (T_5) (3.0 kg ha^{-1}) 50% RDN through FYM and green manure (T_8) (3.0 kg ha^{-1}) and 50% 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 phosphorous 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 phosphorous 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 2. 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 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%RDN with FYM and vermi-compost (T_6) (-85.0 kg ha^{-1}), 50% RDN through vermi-compost and green manure (T_{10}) (-82.0 kg ha^{-1}), 50% RDN through poultry manure and green manure (T_{11}) (-66.0 kg ha^{-1}), 25% RDN through each organic manures (T_{12}) (-50.0 kg ha^{-1}), 100% 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.

Conclusion :

From this study, it was concluded that, more number of productive tillers m^{-2}, dry matter production, grain and straw yield of rice was recorded with the INM practice followed by recommended dose of fertilizers (RDF) treatment. Among the organic treatments, more number of productive tillers m^{-2}, dry matter production, grain and straw yield of rice was recorded with 100% RDN through green manure followed by 25% RDN through each organic manures in both the years of study (Alagappan and Venkitasamy, 2015). The system productivity also recorded the similar trend during both the years of the cropping system. Higher B:C ratio was registered with the INM treatment and which was followed by 100% RDN through green manure in rice-greengram cropping system during both the years of experimentation. The different sources of organic manures particularly the composted poultry manure at the rate of 5 t/ha application had increased the rice yield as well as the rice fallow pulse (blackgram) yield in the rice-blackgram cropping sequence (Sangeetha *et al.*, 2013).

Further, it was concluded that the application of 100% RDN through green manure recorded more number of productive tillers m^{-2}, dry matter production, grain and straw yield with higher B:C ratio among the organic treatments in both the years of experiments (Alagappan and Venkitasamy, 2015). For organic rice production, application of 100% RDN through green manure for realizing better yield and economic returns followed by 25% RDN through each organic manures for rice-greengram cropping system (Alagappan and Venkitasamy, 2015).

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% RDN through green manure recorded the highest N balance (46.0 kg ha^{-1}) followed by 25% 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% 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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