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Influence of Integrated nutrient management on growth, yield and nitrogen uptake and economics of rice-rice-greengram cropping system

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Abstract
A Field study was conducted at wetland farm, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore during *kharif- rabi* – summer seasons in 2014-15 and 2015-16 to study the integrated nutrient management options for sustainable growth and production in rice-rice-greengram cropping sequence. The experiment was laid out in split plot design with the three replications. The main plot treatment comprised of incorporation of green manures and residue addition of 30 % of paddy straw during both the *kharif* and *rabi* season in rice viz.,M_1- No application of green manure and No application of crop residue, M_2- Dhaincha@ 6.25t ha^{-1} and No. application of crop residue, M_3- No application of crop residue and residue addition of 30 % paddy straw and M_4- Dhaincha@ 6.25t $ha^{-1}$and residue addition of 30 % paddy straw and sub plot treatments consists of various fertilizer management approaches- S_1-Recommended dose of NPK, S_2- STCR approach, S_3- LCC based Napplication. The growth parameters, yield and yield attributes and N uptake were assessed during the course of study. Data on growth parameters, Nuptake, yield attributes and yield, economics were recorded and analysed during the entire tenure of experimentation. The results revealed that the treatment combination of M_4S_3 (M_4-*kharif*- Dhaincha@ 6.25t ha and residue addition of 30 % paddy straw; S_3- LCC based N application) found to be significantly superior over the other treatments with respect to DMP, N uptake, yield attributes, yield and economics.

Keywords: Nitrogen uptake, residue addition, STCR, LCC and yield

Introduction
Rice (*Oryza sativa* L.) is well known as' Wonder cereal' and is cultivated in a variety of ecological zones with wide variations in productivity. Stagnation in yield levels and increased food demand warrant an urgent need to increase the productivity of rice which is the staple food for more than half the world's population. In Asia alone, more than 2.0 billion people obtained 60 to 70 percent of their food energy from rice alone and its derived products (Kumar, 2005) [3]. In India, rice is cultivated in 44.1 million hectares with an annual production of approximately 105.5 million tons and Tamil Nadu alone contributed 3.9 percent to national rice production from an area of 2.0 million hectares with a production of 4.1 MT (*Indiastat*, 2018). Integrated nutrient management optimizes all aspects of the cycling of nutrients. It attempts to achieve nutrient cycling with synchrony between crop nutrient demand and soil nutrient release with minimizing losses through leaching, runoff, volatilization and immobilization. The aim of INM is to integrate the use of all natural and man-made sources of plant nutrients in order to increase the crop productivity in an efficient and sustainable manner without deteriorating soil health. Rice-based crop planting system are the main production systems contributing to food production and food security. Current crop production systems are characterized by inadequate and imbalanced use of fertilizers and blanket fertilizer recommendations over large areas with less regard to soil fertility and productivity variability. Future productivity gains and input efficiency require improved soil and crop management technologies tailored to the specific characteristics of individual farms or fields. Under these conditions, it is necessary to explore the possibilities of using the expanding native sources of plant nutrition to find out the optimal combination of fertilizers and organic manures with rice and their residual effect on greengram grown after rice. Considering the above, the present work was undertaken as INM for sustainable growth and production in rice-rice-greengram cropping system.

Materials and Methods

A Field experiment was conducted at Wetland farm, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore during 2014-16 to investigate the impact of "Integrated nutrient management for sustainable growth and production in Rice- Rice - Greengram cropping system" on clay loam soils in Western agro-climatic zone of Tamil Nadu.). The soil of the experimental site was was slightly alkaline (pH = 7.76) with low soluble salts (EC = 0.63 dSm^{-1}), medium in organic carbon content (0.68 %), low in available Nitrogen (241 kg ha^{-1}), medium in Phosphorus (35.0 kg ha^{-1}) and high in potassium (451 kg ha^{-1}). The experiment was laid out in a split plot design having four main treatments, three subplot treatments replicated thrice. The main treatment details of the experiment were as follows

The main treatment details of the experiment were as follows

	I Crop	II Crop
M_1	No application of green manure	No Application of crop residue
M_2	Daincha @6.25 t/ha	No Application of crop residue
M_3	No Application of crop residue	Paddy straw residue Addition @ 30%
M_4	Daincha @6.25 t/ha	Paddy straw residue Addition @ 30%

The sub plot treatments were as follows

Sub plot		
S_1	:	Recommended dose of NPK
S_2	:	STCR approach
S_3	:	LCC based N application

Inorganic fertilizer was applied based on the treatment schedules. Initially recommended dose of fertilizer (150:50:50) N, P_2O_5 and K_2O kg ha^{-1}were applied in the form of Urea, SSP and MOP (S_1). Prior to sowing, soil sample were collected from the experimental plot for the detection of N, P_2O_5 and K_2O content based on STCR approach. In LCC approach that followed, P_2O_5 and K_2O were applied in full dose as basal, Nitrogen was applied in four equal splits viz., at 50% at basal and remaining N at three equal split viz., active tillering, panicle initiation and flowering stages. Dhaincha (*Sesbania aculeata*) was incorporated @ 6.25 t ha^{-1}on dry weight basis two weeks prior to transplanting along with the recommended dose of 150:50:50 NPK kg ha^{-1}, where N, P and K were applied in the form of urea, single super phosphate and muriate of potash to the rice crop (*Kharif* season). As per the treatment schedule to the second crop of rice (*Rabi* season), 30% of paddy straw residue was incorporated two weeks prior to transplanting. However no fertilizers were applied to the summer raised greengram which utilizes only the residual nutrients and soil moisture for its growth and development. The seed rate used for study was 60 kg ha^{-1} of rice with a spacing of 20 x 10 cm and seed rate of 20-25 kg ha^{-1} with a spacing of 30 x 10 cm.

Results and Discussion

Dry Matter Production

Higher dry matter production of transplanted rice were significantly influenced by integrated nutrient management treatments during *kharif* and *rabi* seasons of 2014 and 2015 respectively. Higher dry matter production were recorded in M_4S_3 (M_4-Dhaincha@ 6.25 t ha^{-1}, S_3-LCC based N application) (M_4-2202kg ha^{-1},S_3-1965 kg ha^{-1}–*kharif* season; M_4-1850 kg ha^{-1},S_3-1592 kg ha^{-1} in *rabi* season at active tillering stage), (M_4-8843 kg ha^{-1}, S_3-7921 kg ha^{-1}– *kharif* season; M_4-9579 kg ha^{-1},S3-8027 kg ha^{-1} – Rabi season at flowering) (M_4-16827 kg ha^{-1},S_3-14417 kg ha^{-1} *kharif* season; M_4-15651 kg ha^{-1}, S_3-13488 kg ha^{-1} in *rabi* season at harvest). M_1S_1 (M_1-No application of Green manure and crop residue, S_1- Recommended dose of NPK) recorded lower DMP in all three stages viz., active tillering, flowering and at harvest showed significant value recorded in *kharif* and *rabi* seasons during 2014 treatment (M_1-1621 kg ha^{-1}, S_1-1398 kg ha^{-1} *kharif*, M_1-1341 kg ha^{-1}, S_1-1257 kg ha^{-1} *rabi* at active tilering), (M_1- 6563 kg ha^{-1}, S_1-5884 kg ha^{-1} *kharif*, M_1-5978, S_1-5374 kg ha^{-1} *rabi* at flowering) and (M_1-11940 kg ha^{-1}, S_1-9861 kg ha^{-1}-*kharif*, M_1-10368 kg ha^{-1}, S_1-8495 kg ha^{-1}-*rabi* at harvest). The same trend was noticed in the year 2015 also.

The total dry matter production was mainly influenced by assimilatory surface area and its photosynthetic ability. Photosynthetic ability of crop plants can also be traced based on leaf area development and dry matter accumulation in leaf at different stages of growth. Dry matter production increased steadily with advancing growth stages and reached maximum at harvest. This might be due to the reason that 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 have lead to higher biomass production thereby, good accumulation of dry matter. Similar results were obtained by Amanullah *et al*. (2006) [1].

The supply of nitrogen might have increased the process of photosynthesis, higher the photosynthesizing area which ultimately led to the higher dry matter production in rice crop receiving nitrogen based on LCC. This result is in conformity with the findings of Kumar and Singh (2008) [4].

Nitrogen uptake

Nitrogen uptake was significantly influenced by the nutrient management practices throughout the respective growth stages of rice during *kharif* and *rabi* seasons of 2014.The same trend was noticed in 2015 irrespective of both the seasons. Among the main plot treatments, incorporation of Daincha @ 6.25t ha^{-1} during first season with the addition of 30 % crop residue in the second season recorded higher nitrogen uptake in rice during active tillering (43.07 and 34.55 kg ha^{-1}) flowering (93.93 and 86.76 kg ha^{-1}) and at harvest stages in rice (115.90 and 106.71 kg ha^{-1}) during the years 2014 and 2015 respectively irrespective of the seasons. With regards to fertilizer recommendation, fertilizer applied as per the LCC based N application (S_3) registered higher nitrogen uptake irrespective of the seasons and years of study during all the crop growth stages and also at harvest. The fertilizer application as per LCC based N application (S_3) recorded higher nitrogen uptake in rice during active tillering (38.57 and 30.54 kg ha^{-1}) flowering (83.27 and 77.69 kg ha^{-1}) and at harvest stages (103.65 and 94.32 kg ha^{-1}) during *kharif* and *rabi* 2014 respectively. Similiar trend was noticed during 2015 in both the seasons.

Interaction effect was significant during all the stages of growth and development in the respective seasons and years of study. Incorporation of Daincha at 6.25t ha^{-1} in the first crop of rice and residue addition of 30 % of paddy straw along with LCC based N application (M_4S_3) produced plants with higher nitrogen uptake in both the seasons of 2014 and 2015 which recorded plants with significantly higher nitrogen uptake at active tillering (45.02 and 36.12), flowering (93.18 and 90.69) at harvest stages (122.8 and 111.54) during *kharif* and *rabi* 2014 respectively. The same treatment combination recorded higher nitrogen uptake of rice irrespective of the seasons of both 2014 and 2015.

Nitrogen is an integral constituent of protein, nucleic acids, chlorophyll, co-enzymes, phytohormones and secondary metabolites. Imposed treatments enhanced nitrogen uptake from vegetative stage to maturity. Results indicated that higher uptake was associated in M_4S_3. The primary value of green manure as a source of N is realized when the green manure decomposes and its organic N is transformed into available form. Hence, the efficiency of dhaincha was much more in fixing N_2 that would have caused vigorous plant growth and thus higher N uptake recorded by rice in the study is in concurrence, supported by the findings of Javaid *et al.* (1999) [2].

Yield attributes and yield

Yield attributes viz., No. of panicles m^{-2}, No. of productive tillers m^{-2} and No. of filled grains per panicle showed significant values in *kharif* and *rabi* seasons 2014. M_4S_3 recorded higher yield (M_4 - 279, S_3 - 218 No. of panicle m^{-2} in *kharif*, M_4 -264, S_3 -215 No. of panicle m^{-2} in *rabi* seasons), (M_4 - 403, S_3 -353 No. of productive tillers m^{-2} *kharif*, M_4-375, S_3-337 No. of productive tillers m^{-2} in *rabi* seasons) and (M_4 - 271, S_3 -244 No. of filled grains per panicle in *kharif*, M_4-208, S_3-213 No. of filled grains per panicle in *rabi* seasons). Meanwhile M_1S_1 recorded low No. of panicles m^{-2}, No. of productive tillers m^{-2} and No. of filled grains per panicle showed significant values (M_1 -184, S_1 -153 No. of panicles m^{-2} in *kharif*, M_1 - 176, S_1 -148 No. of panicle m^{-2} in *rabi* seasons), (M_1 -301, S_1 - 282 No. of productive tillers m^{-2} in *kharif*, M_1 -280, S_1 -268, No. of productive tillers m^{-2} in *rabi* seasons) and (M_1 - 203, S_1 -226 No. of filled grains per panicle in *kharif*, M_1 -188, S_1 -188 No. of filled grains per panicle m^{-2} in *rabi* seasons). Similar trend was observed also in the year 2015.

Grain yield in rice depends upon the yield attributes like number of grains panicle^{-} m^{-2} and. No. of filled grains per panicle m^{-2}. In the present study, the yield components obtained in rice revealed that the yield attributes and yield were significantly influenced by both the green manure as well as inorganic fertilizers. Green manure application resulted more influence over yield components and yield than control (without green manure and crop residue addition). This might be due to sufficient nitrogen available and its increased efficiency with dhaincha incorporation, releasing N slowly, that made available throughout the growth stages of the rice. The manure N as organic in the green manure had an effect, similar to basal nitrogen application, which increased plant growth and tillering in rice, while the supplemental nitrogen application lead to increased grain size and grain weight, the major yield attributes in rice. Green manure incorporation lead to recycling of nutrients into the soil with increased availability of nutrients and thus improved the yield attributes and yield of rice. The result of the present study is in conformity with the finding of Singh and Shivay (2014) [7].

Yield of rice

Grain yield recorded during both *kharif* and *rabi* seasons were significantly influenced by the integrated nutrient management practices. Among the main plot treatments, incorporation of Dhaincha@ 6.25t ha^{-1} during first season with the addition of 30 % crop residue in the second season recorded higher grain yield (6481 and 5396 kg ha^{-1}) and straw yield (10396 and 9994 kg ha^{-1}) during *kharif* and *rabi* seasons respectively irrespective of the seasons and year of study.

The fertilizer applied as per the LCC based N application (S_3) registered higher grain yield during both the years irrespective of the seasons. The fertilizer application as per LCC based N application (S_3) recorded higher grain yield (5487and 4983 kg ha^{-1}) and straw yield (8831and 8444 kg ha^{-1}) during *kharif* and *rabi* 2014 respectively. Similiar trend was obtained during 2015 in both the seasons.

Interaction effect was significant in the treatment combination where Daincha was incorporated at 6.25t ha^{-1} in the first crop of rice and residue addition of 30 % of paddy straw along with LCC based N application (M_4S_3) produced higher grain yield in both the seasons of 2014 and 2015 which recorded significantly higher grain yield (6777 and 5998 kg ha^{-1}) during *kharif* and *rabi* during 2014. The same treatment combination recorded higher grain yield in rice irrespective of the seasons of both 2014 and 2015. In both the seasons of study the lowest grain yield was found in M_1S_1. (No application of green manure and recommended dose of NPK) which recorded (3835 and 3765 kg ha^{-1}) during *kharif* and *rabi*. Similar trend was recorded irrespective of the seasons during 2015 also.

Increase in yield of rice with nitrogen application might be due to higher N uptake, resulting in higher biomass production and photosynthates translocation to reproductive parts. Improvement in the nutrient use efficiency of the applied inorganic nitrogen in transplanted rice after green manure incorporation; also may be the reason for higher yield. This result was supported by Yadvinder-Singh *et al*. (1991) [9].

Residual effect on succeeding greengram

Significant impact was noticed by incorporation of Daincha @ 6.25 t ha^{-1} and residue addition of 30% paddy straw residue in rice crops with regard to grain yield of green gram. Incorporation of Dhaincha in the first crop of rice and residue addition of 30 % paddy straw in the second crop of rice (M_4) registered higher grain yield (604 and 579 kg ha^{-1}) and haulm yield (1243 and 1210 kg ha^{-1}) during summer 2015 and 2016 respectively. This was next followed by treatment M_2 during the summer season of both the years. The lower grain yield was recorded in the treatment M_1 (449 and 424 kg ha^{-1}) during the same respective stages. Among the subplot treatment, the fertilizer recommendation as per LCC based N application method (S_3) recorded higher grain yield of green gram (552 and 521 kg ha^{-1}) during summer 2015 and 2016 respectively when compared to other fertilizer application methods.

Interaction effect have showed significant effect over the grain yield of green gram by the addition of Daincha @ 6.25 t ha^{-1} and 30 % of paddy straw residue with LCC based N application (M_4S_3) produced higher grain yield (625 and 634 kg ha^{-1}) during summer 2015 and similar trend was noticed during 2016 respectively. The lower grain yield was recorded in the treatment combination M_1S_1 (401 and 387 kg ha^{-1}) simultaneously during both the years of study irrespective of the season.

The treatment combination have significant effect over the grain and haulm yield of succeeding crop green gram. These results are in conformity with Pramanick *et al.* (2007) [5].

Economics

The economic analysis of integrated nutrient management revealed that higher economic benefits were realized under M_4S_3 (M_4-*kharif*- Dhaincha@ 6.25t ha^{-1}; *rabi*- Residue addition of 30 % paddy straw; S_3- LCC based N application) (192493ha^{-1} and 195073 ha^{-1}) followed by M_2S_2 (M_2- *kharif*-Dhaincha@ 6.25t ha^{-1}; *rabi*-No. application of crop residue,

S_2- STCR approach (163239 ha^{-1} and 161607 ha^{-1}) cropping system as a whole during 2014-15 and 2015-16. Higher benefit-cost ratio was also associated with M_4S_3 (M_4-*kharif*- Dhaincha@ 6.25t ha^{-1}; *rabi*- Residue addition of 30 % paddy straw; S_3- LCC based N application) (3.99 and 4.08). It may be concluded that M_4S_3 (M_4-*kharif*- Dhaincha@ 6.25t ha^{-1}; *rabi*- Residue addition of 30 % paddy straw; S_3- LCC based N application) can be a suitable and economical integrated nutrient management for transplanted rice and higher productivity. The cost of cultivation was higher in all the treatments compared to control, which might be due to additional inputs. The highest gross returns, net returns and returns per rupee investment were recorded with M_4S_3. This might be due to higher yields of rice - rice-greengram sequence that resulted in higher net returns and benefit cost ratio. These results are in conformity with Mathew (1994) [6].

Table 1: Dry matter production (kg ha^{-1}) as influenced by INM practices at various growth stages and at harvest in rice during *kharif* 2014

Treatment	Active Tillering				Flowering				Harvest			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	1398	1657	1807	1621	5884	6851	6954	6563	9861	13659	12300	11940
M_2	1850	1801	1838	1830	6164	6868	8315	7116	12701	14715	15208	14208
M_3	1429	1915	1917	1754	7530	7558	6745	7278	11558	15497	13338	13464
M_4	2045	2263	2297	2202	8994	7863	9671	8843	14059	19598	16824	16827
Mean	1681	1909	1965		7143	7285	7921		12045	15867	14417	

	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
Sed	88	50	120	100	324	154	411	309	604	437	935	873
CD(P=0.05)	215	106	275	212	794	328	955	655	1479	925	2109	1851

Table 1a: Dry matter production (kg ha^{-1}) as influenced by INM practices at various growth stages and at harvest in rice during *rabi* 2014

Treatment	Active Tillering				Flowering				Harvest			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	1257	1559	1207	1341	5374	5840	6718	5978	8495	11508	11102	10368
M_2	1499	1663	1640	1601	6594	7794	8122	7503	13452	13040	13693	13395
M_3	1556	1737	1543	1612	7769	7330	7688	7596	12658	13112	12883	12884
M_4	1734	1837	1977	1850	9374	9784	9580	9579	15662	15018	16272	15651
Mean	1512	1699	1592		7278	7687	8027		12567	13170	13488	

	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
Sed	69	46	101	91	366	225	519	450	573	335	792	669
CD(P=0.05)	168	97	230	194	895	477	1184	955	1402	709	1814	1419

	Main plot			Sub plot
‘	I Crop	II Crop		
M_1	No application of green manure	No Application of crop residue	S_1	Recommended dose of NPK
M_2	Dhaincha @6.25 t/ha	No Application of crop residue	S_2	STCR approach
M_3	No Application of crop residue	Residue Addition of 30% paddy straw	S_3	LCC based N application
M_4	Dhaincha @6.25 t/ha	Residue Addition of 30% paddy straw		

Table 2: Dry matter production (kg ha^{-1}) as influenced by INM practices at various growth stages and at harvest in rice during *kharif* 2015

Treatment	Active tillering				Flowering				Harvest			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	1484	1737	1560	1594	5018	7225	5872	6038	11648	13181	13188	12673
M_2	1929	1993	2068	1997	7968	7710	9470	8383	13965	16234	15015	15071
M_3	1546	1829	2070	1815	8040	6935	9328	8101	12898	15067	14648	14204
M_4	2413	2414	2499	2442	9239	9312	9866	9472	16211	15218	17784	16404
Mean	1843	1993	2049		7566	7795	8634		13681	14925	15158	

	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
SEd	85	42	110	85	368	247	546	493	626	346	844	693
CD(P=0.05)	209	90	254	179	902	523	1239	1046	1532	734	1941	1469

Table 2a: Dry matter production (kg ha^{-1}) as influenced by INM practices at various growth stages and at harvest in rice during *rabi* 2015

Treatment	Active tillering				Flowering				Harvest			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	1309	1288	1574	1390	5519	5622	6781	5974	9786	11628	11730	11048
M_2	1435	1587	1487	1503	6064	7169	8578	7271	11670	13189	11171	12010
M_3	1620	1755	1740	1705	6278	8142	8729	7716	12772	11989	14463	13075
M_4	1833	2146	2087	2022	9049	9730	9514	9431	14975	15220	15628	15274
Mean	1550	1694	1722		6727	7666	8401		12301	13007	13248	

	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
SEd	70	52	110	103	380	261	572	522	585	354	822	707
CD(P=0.05)	172	109	247	218	931	554	1294	1108	1432	750	1879	1500

	Main plot			Sub plot
	I Crop	II Crop		
M_1	No application of green manure	No Application of crop residue	S_1	Recommended dose of NPK
M_2	Dhaincha @6.25 t/ha	No Application of crop residue	S_2	STCR approach
M_3	No Application of crop residue	Residue Addition of 30% paddy straw	S_3	LCC based N application
M_4	Dhaincha @6.25 t/ha	Residue Addition of 30% paddy straw		

Table 3: N uptake (kg ha^{-1}) in rice at the active tillering and flowering stage as influenced by INM practices during *kharif* and *rabi* 2014

Treatment	Active tillering –*kharif*				Active tillering –*Rabi*				Flowering –*kharif*				Flowering –*Rabi*			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	27.62	32.50	32.83	30.98	22.16	26.07	26.34	24.86	60.24	70.87	71.59	67.57	55.65	65.47	66.13	62.41
M_2	35.78	36.28	39.65	37.24	25.24	28.45	29.31	27.67	78.02	79.13	81.93	79.69	63.66	74.95	76.09	71.57
M_3	33.09	37.21	36.77	35.69	28.70	29.11	30.40	29.41	72.17	77.14	81.38	76.90	69.07	75.09	77.83	73.99
M_4	41.06	43.13	45.02	43.07	32.94	34.60	36.12	34.55	89.54	94.06	98.18	93.93	82.71	86.88	90.69	86.76
Mean	34.39	37.28	38.57		27.26	29.56	30.54		74.99	80.30	83.27		67.77	75.60	77.69	

	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
Sed	1.65	1.01	2.34	2.02	1.40	0.98	2.13	1.97	4.25	1.34	4.78	2.68	3.28	2.30	4.98	4.59
CD(P=0.05)	4.05	2.14	5.33	4.28	3.44	2.09	4.83	4.18	10.41	2.84	11.38	5.67	8.02	4.87	11.26	9.74

Table 3a: Nuptake (kg ha^{-1}) in rice at the harvest stage as influenced by INM practices during *kharif* 2014

Treatment	Harvest -*Kharif*				Harvest –*Rabi*			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	74.12	87.2	88.08	83.13	68.44	80.52	81.33	76.76
M_2	95.99	98.84	105.36	100.06	81.94	89.89	90.80	87.55
M_3	88.79	95.36	98.34	94.16	88.60	92.18	93.59	91.46
M_4	110.17	114.73	122.8	115.90	101.73	106.86	111.54	106.71
Mean	92.27	99.03	103.65		85.18	92.36	94.32	

	M	S	M at S	S at M	M	S	M at S	S at M
SEd	4.28	2.65	6.09	5.30	4.01	2.53	5.76	5.07
CD(P=0.05)	10.48	5.62	13.90	11.23	9.81	5.37	13.13	10.74

	Main plot			Sub plot
	I Crop	II Crop		
M_1	No application of green manure	No Application of crop residue	S_1	Recommended dose of NPK
M_2	Dhaincha @6.25 t/ha	No Application of crop residue	S_2	STCR approach
M_3	No Application of crop residue	Residue Addition of 30% paddy straw	S_3	LCC based N application
M_4	Dhaincha @6.25 t/ha	Residue Addition of 30% paddy straw		

Table 4: No. of panicles m^{-2}, No. of productive tillers m^{-2} and No. of filled grains per panicle as influenced by INM practices in rice during *kharif* 2014

Treatment	No. of panicle m^{-2}				No.of productive tiller m^{-2}				No. of filled grains per panicle			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	153	215	183	184	282	316	305	301	189	211	209	203
M_2	204	232	185	207	363	353	328	348	252	257	253	254
M_3	223	229	225	226	313	384	362	353	194	246	265	235
M_4	267	290	281	279	390	401	417	403	271	294	248	271
Mean	212	241	218		337	364	353		226	252	244	

	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
Sed	12	7	17	14	16	8	20	15	10	7	15	13
CD(P=0.05)	30	15	38	29	39	16	48	33	26	14	34	28

Table 4a: No. of panicles m^{-2}, No. of productive tillers m^{-2} and No. of filled grains per panicle as influenced by INM practices in riceduring *rabi 2014*

Treatment	No. of panicle m^{-2}				No. of productive tiller m^{-2}				No. of filled grains per panicle			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	148	177	204	176	268	260	311	280	183	184	196	188
M_2	182	242	195	206	267	338	340	315	208	221	205	211
M_3	209	216	189	205	297	330	325	317	185	233	232	217
M_4	254	268	271	264	371	381	373	375	178	228	217	208
Mean	198	226	215		301	327	337		188	216	213	

	M	S	M at S	S at M	M	S	M at S	S at M	M	S	M at S	S at M
Sed	9.93	5.38	13.25	10.75	14.36	7.11	18.46	14.22	9	5	13	11
CD(P=0.05)	24.29	11.40	30.53	22.80	35.13	15.07	42.79	30.14	22	11	29	22

	Main plot			Sub plot
	I Crop	II Crop		
M_1	No application of green manure	No Application of crop residue	S_1	Recommended dose of NPK
M_2	Dhaincha @6.25 t/ha	No Application of crop residue	S_2	STCR approach
M_3	No Application of crop residue	Residue Addition of 30% paddy straw	S_3	LCC based N application
M_4	Dhaincha @6.25 t/ha	Residue Addition of 30% paddy straw		

Table 5: Grain yield and straw yield (kg ha^{-1}) as influenced by INM practices in rice during *kharif* and *rabi* 2014

Treatment	Grain yield -*kharif* (kgha^{-1})				Grain yield - *Rabi*(kg ha^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	3835	4206	4748	4263	3765	3911	4577	4084
M_2	4885	5967	5481	5444	4761	5440	4475	4892
M_3	4245	5887	4940	5024	5063	5593	4882	5179
M_4	5905	6760	6777	6481	5276	4915	5998	5396
Mean	4718	5705	5487		4716	4965	4983	

	M	S	M at S	S at M	M	S	M at S	S at M
SEd	247	170	371	339	223	131	309	263
CD(P=0.05)	605	359	841	719	546	278	708	557

Table 5a: Straw yield (kg ha^{-1}) as influenced by INM practices in rice during *kharif and rabi* 2014

Treatment	Straw yield – *Kharif* (kg ha^{-1})				Straw yield - *Rabi* (kg ha^{-1})			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	5562	6566	7936	6688	5704	7617	6533	6618
M_2	8977	10549	9134	9553	7231	8017	8185	7811
M_3	7041	8418	7380	7613	8242	8420	8082	8248
M_4	9575	10743	10871	10396	9124	9879	10978	9994
Mean	7789	9069	8831		7575	8483	8444	

	M	S	M at S	S at M	M	S	M at S	S at M
SEd	370	141	436	283	425	234	572	468
CD(P=0.05)	905	300	1027	599	1041	497	1316	993

	Main plot			Sub plot
	I Crop	II Crop		
M_1	No application of green manure	No Application of crop residue	S_1	Recommended dose of NPK
M_2	Dhaincha @6.25 t/ha	No Application of crop residue	S_2	STCR approach
M_3	No Application of crop residue	Residue Addition of 30% paddy straw	S_3	LCC based N application
M_4	Dhaincha @6.25 t/ha	Residue Addition of 30% paddy straw		

Table 6: Grain yield (kg/ha) as influenced by INM practices in rice during *kharif* and *rabi 2015*

Treatment	Grain yield - *Kharif* (kg/ha)				Grain yield - *Rabi* (kg/ha)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	4340	4941	4809	4697	4138	5042	4859	4680
M_2	5425	5696	5295	5472	4687	5780	5265	5244
M_3	5188	4680	5430	5099	5549	4595	5365	5170
M_4	6370	6745	6920	6679	5498	6053	6093	5881
Mean	5331	5516	5614		4968	5368	5396	

	M	S	M at S	S at M	M	S	M at S	S at M
SEd	232	151	339	303	265	166	379	333
CD(P=0.05)	569	321	772	642	648	352	864	705

Table 6a: Grain yield and straw yield (kg/ha) as influenced by INM practices in rice during *kharif* and *rabi 2015*

Treatment	Straw yield - *Kharif* (kg/ha)				Straw yield - *Rabi* (kg/ha)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	6979	8066	9173	8073	5404	7103	7959	6822
M_2	9292	7825	8025	8381	7807	7291	9473	8190
M_3	7804	8247	8994	8349	6538	7317	8615	7490
M_4	9109	10891	10791	10263	10155	9773	10018	9982
Mean	8296	8757	9246		7476	7871	9016	

	M	S	M at S	S at M	M	S	M at S	S at M
SEd	345	207	483	414	321	227	490	454
CD(P=0.05)	844	439	1105	879	785	481	1108	962

	Main plot			Sub plot
	I Crop	II Crop		
M_1	No application of green manure	No Application of crop residue	S_1	Recommended dose of NPK
M_2	Dhaincha @6.25 t/ha	No Application of crop residue	S_2	STCR approach
M_3	No Application of crop residue	Residue Addition of 30% paddy straw	S_3	LCC based N application
M_4	Dhaincha @6.25 t/ha	Residue Addition of 30% paddy straw		

Table 7: Grain yield and haulm yield kg/ha by INM of greengram during summer 2015-16

Treatment	Grain yield - kg/ha (2015)				Grain yield kg/ha (2016)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	401	472	474	449	387	462	424	424
M_2	484	477	584	515	458	533	518	503
M_3	450	513	527	497	501	436	506	481
M_4	573	614	625	604	580	522	634	579
Mean	477	519	552		482	488	521	

	M	S	M at S	S at M	M	S	M at S	S at M
SEd	23	11	29	22	21	12	29	25
CD(P=0.05)	57	23	68	47	52	26	67	53

Table 7a: Grain yield and haulm yield kg/ha by INM of greengram during summer 2015-16

Treatment	Haulm yield kg/ha (2015)				Haulm yield kg/ha (2016)			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	879	1017	1026	974	796	933	942	890
M_2	1150	1034	1166	1117	940	1045	1061	1015
M_3	1109	1124	1134	1122	1005	1020	1030	1018
M_4	1188	1237	1304	1243	1154	1212	1265	1210
Mean	1082	1103	1158		974	1053	1075	1034

	M	S	M at S	S at M	M	S	M at S	S at M
SEd	47	29	67	59	46	32	69	64
CD(P=0.05)	115	62	153	124	112	68	157	136

	Main plot			Sub plot
	I Crop	II Crop		
M_1	No application of green manure	No Application of crop residue	S_1	Recommended dose of NPK
M_2	Dhaincha @6.25 t/ha	No Application of crop residue	S_2	STCR approach
M_3	No Application of residue	Residue Addition of 30% paddy straw	S_3	LCC based N application
M_4	Dhaincha @6.25 t/ha	Residue Addition of 30% paddy straw		

Table 5: Economic of rice – rice- greengram cropping system 2014-16

Treatment	2014-15				2015-16			
	Cost of Cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	BCR	Cost of Cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	BCR
M1S1	56873	151198	94325	2.66	56343	164374	108031	2.92
M1S2	55543	168626	113083	3.04	54846	195139	140293	3.56
M1S3	56357	185636	129279	3.29	55731	192343	136612	3.45
M2S1	60223	194098	133875	3.22	59603	200481	140878	3.36
M2S2	58893	222132	163239	3.77	58196	219803	161607	3.78
M2S3	59707	207005	147298	3.47	59081	211227	152146	3.58
M3S1	61223	185475	124252	3.03	60603	206199	145596	3.40
M3S2	60547	222002	161455	3.67	59196	184681	125485	3.12
M3S3	60289	197776	137487	3.28	60081	213841	153760	3.56
M4S1	64573	225587	161014	3.49	63953	236446	172493	3.70
M4S2	63661	238767	175106	3.75	62546	248032	185486	3.97
M4S3	64293	256786	192493	3.99	63431	258504	195073	4.08

Data not satistically analysed

Conclusion

From the above results, it can be concluded that higher dry matter accumulation, grain yield, straw yield and nitrogen uptake was obtained with M_4S_3 (M_4-*kharif*- Dhaincha @ 6.25t ha^{-1}; *rabi*- Residue addition of 30 % paddy straw; S_3- LCC based N application), however it was on par with M_2S_2 (M_2-*kharif*- Dhaincha@ 6.25t ha^{-1}; *rabi*-No. application of crop residue, S_2- STCR approach). Over all, it can be concluded that from the present investigation, M_4S_3 (M_4-*kharif*-Dhaincha@ 6.25t ha^{-1}; *rabi*- Residue addition of 30 % paddy straw; S_3- LCC based N application) can be recommended for effective integrated nutrient management and higher productivity of transplanted rice.

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