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Integrated use of organic and inorganic sources of nutrients on growth and yield of rice (*Oryza sativa* L.)

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Abstract
Field experiments were carried out at Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, to study the effect of different sources of organic manures in comparison with different level of recommended dose of fertilizer on growth and yield of rice during *rabi* season of 2015-16 and 2016-17. The experiments were laid out in split plot design and replicated thrice. Main plot treatments were assigned with five levels of organic manures namely, silt from fish pond fed with desi poultry dropping @ 5 t/ha + vermicompost @ 5 t/ha (M_1), silt from fish pond fed with duck dropping @ 5 t/ha + vermicompost @ 5 t/ha (M_2), silt from fish pond fed with turkey dropping @ 5 t/ha + vermicompost @ 5 t/ha (M_3), farm yard manure @ 12.5 t/ha (M_4) and no manure application (M_5) and 100% RDF (S_1), 75% RDF (S_2) and no fertilizer application (S_3) were assigned to sub plot treatments. Among the growth and yield contributing characters studied, plant height, productive tillers/m^2, panicle length and filled grains/panicle were varied significantly by the different treatments. Most of the growth and yield contributing characters influenced positively in treatment having organic manures over recommended dose of fertilizer. The highest grain yield (6783 and 7122 kg/ha) and straw yield (8177 and 8618 kg/ha) were recorded in application of farm yard manure 12.5 t/ha in combination with 100% recommended dose of fertilizer (M_4S_1) over rest of the treatments during both the years.

Keywords: Rice, Pond silt, Vermicompost, FYM, RDF, Grain and straw yield

Introduction
Rice (*Oryza sativa* L.) is the staple food crop of the world, cultivated in about 163.2 million ha with a grain production of 719.7 million tons. India is the second most populous nation and the largest producer of rice in the world after China. India produces about 152.6 million tons from 42.5 million ha with an average productivity of 3.57 tons/ha; while, China produces 204.3 million tons from 30.3 million ha with an average productivity of 6.73 tons/ha (FAOSTAT, 2014) [1].

Sustainable agricultural productivity might be achieved through wise use of integrated nutrient management. Hence, soil fertility maintenance is essential in achieving and maintaining high crop yields over a period of time. Unscrupulous use of inorganic fertilizers is to meet the demands of high yielding varieties rendering the soil organic matter depletion in tropical agriculture. As a result, low organic matter content of the soil, unbalanced use of chemical fertilizers, less use of organic manures and inadequate attention given for its improvement and maintenance have made the situation difficult. Integrated use of organic manure and chemical NPK fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status. Organic matter takes an important role in maintaining soil fertility and productivity (Ali *et al.*, 2009) [2].

The problem of nutrient deficiencies as well as nutrient mining caused by intensive cropping with high yielding variety of rice and nutrient imbalance can be minimized by judicious application of nutrients through organic manures. Losses of soil organic matter can only be replenished in the short term by application of organic matter such as manures. Energy crisis, higher fertilizer cost, sustainability in agri-production system and ecological stability are the important issues which renewed the interest of farmers and research workers to opt for non-chemical sources of plant nutrients like biofertilizers, azolla, farmyard manure, green manure, vermicompost, poultry manure, *etc.* Awareness about soil health and crop quality has increased the attention of people towards organic agriculture. Growing awareness of health and environmental issues associated with the intensive use of chemical inputs has led to the interest of alternate agriculture. Balanced use of nutrients through organic sources like farmyard manure, vermicompost, green manuring, neem cake and bio-fertilizers are prerequisites to sustain soil fertility, to produce maximum crop yield with optimum input level. The use of inorganic fertilizer to sustain cropping was found to increase yield only for some

few years but on long-term, it has not be effective and leads to soil degradation. On the other hand, continuous application of organic fertilizer alone on rice field resulting low yield and low N and K content at the mid-tillering stage of rice plant. This implies that the need of integrated nutrient management for rice production. Therefore the combined use of organic manures and inorganic fertilizers help in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients, enhancing efficiency of applied nutrients and providing favourable soil physical conditions (Gill and Walia, 2014) [3].

Materials and Methods

Field experiments were carried out at wetland farm, Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore during *rabi* season of 2015-16 and 2016-17. The soil of the experimental field was clay loam in texture belonging to *Typic Haplustalf* with organic carbon (0.64 and 0.69 %), low in available N (259.4 and 264.1 kg/ha), high in available P (22.3 and 23.7 kg/ha) and high in available K (487.8 and 491.6 kg/ha) during the first and second years respectively. The integrated nutrient management experiments were laid out in split plot design and replicated thrice. Main plot treatments were assigned with five levels of organic manures viz., silt from fish pond fed with desi poultry dropping @ 5 t/ha + vermicompost @ 5 t/ha (M_1), silt from fish pond fed with duck dropping @ 5 t/ha + vermicompost @ 5 t/ha (M_2), silt from fish pond fed with turkey dropping @ 5 t/ha + vermicompost @ 5 t/ha (M_3), farm yard manure @ 12.5 t/ha (M_4) and no manure application (M_5) and three levels of inorganic fertilizer viz., 100% RDF (S_1), 75% RDF (S_2) and no fertilizer application (S_3) were assigned to sub plot treatments. The rice variety CO (R) 50 with duration of 135 days was used in the experiment. Method of planting was SRI with the spacing of 25 x 25 cm was adopted and transplanted with 14 days old seedlings. All other package of practices was carried out as per recommendation of TNAU CPG (2012) [4] except treatments. Five sample hills (plants) were selected randomly and tagged for recording biometric observations. In the tagged plant, the productive tillers were counted and expressed as numbers/m^2. Grains from each net plot was cleaned, sun dried, weighed and adjusted to 14 per cent moisture content and the grain yield was expressed in kg/ha. Data on various characters were subjected to statistical analysis (Gomez and Gomez, 2010) [5].

Results and Discussion

Effect of INM on plant growth and yield contributing characters of rice

Plant height

Plant height was significantly influenced by the INM treatments. Plant height was increased significantly due to different treatments compared to control treatment. In harvesting stage the highest plant height was registered in application of farm yard manure @ 12.5 t/ha in combination with 100% RDF (M_4S_1) followed by fish pond silt from desi poultry dropping @ 5 t/ha + vermicompost @ 5 t/ha combined with 100% RDF (M_1S_1). The highest plant height (123.5 and 130.2 cm) was attained in treatment (M_4S_1) followed by (120.1 and 127.7 cm) treatment (M_1S_1) in harvesting stage during both years respectively (Table 1). The lowest plant height (81.7 and 84.2 cm) was observed in absolute control treatment M_5S_3 (no manure and no fertilizer application) in harvesting stage during both years respectively, which was significantly lower from all other treatments. Farm yard manure, vermicompost and recycled poultry droppings as pond silt together with chemical fertilizers showed better performance in increasing the plant height compared to their single application. The enhancement in growth with increase in fertility was owing to rapid conversion of synthesized photosynthates into protein to form more protoplasm, thus increasing the number and size of cell, which might have increased the plant height. Channabasavanna and Birandar (2001) [6] noticed that poultry manure induced taller plants as compared to FYM. The dose of both the organic manures had positive effects on plant height.

Productive tillers/m^2

The number of productive tillers/m^2 was significantly influenced by the different treatments. Number of productive tillers/m^2 was ranged from (409 to 211) and (422 to 219) during both years respectively (Table. 1). The highest number of productive tillers/m^2 (409 and 422) was obtained in the treatment M_4S_1 (farm yard manure @ 12.5 t/ha in combination with 100% RDF) during both years respectively, which was followed by M_1S_1 (fish pond silt from desi poultry dropping @ 5 t/ha + vermicompost @ 5 t/ha with 100% RDF). The lowest number of productive tillers/m^2 (211 and 219) was recorded in treatment M_5S_3 (no manure and no fertilizer). The results clearly indicated that the application of organic manures with 100% RDF increased productive tillers/m^2 which was comparable to the organic manures with 75% RDF treatments. Rahman *et al.* (2009) [7] observed that the effect of FYM on productive tillers/m^2 were more prominent than poultry manure, it was more so when chemical fertilizers were used in combination.

Panicle length

Panicle length of rice was significantly influenced by different INM treatments (Table 2). All the treatments produced higher panicle length over control treatment. Panicle length was varied from (25.4 to 16.7 cm) and (26.6 to 17.7 cm) during both the years respectively. The highest panicle length (25.4 and 26.6 cm) was registered in the treatment M_4S_1 which was higher than rest of the treatments during both the years respectively, which was statistically identical to the treatment M_1S_1. The lowest panicle length (16.7 and 17.7 cm) was recorded in the absolute control treatment M_5S_3 (no manure and no fertilizer). The result further showed that panicle length increase was directly influenced by the organic manure in combination with 100% recommended chemical fertilizers. Kumar and Singh (2006) [8] reported that the combined application of organic manure and chemical fertilizers increased panicle length of rice.

Filled grains/panicle

The number of filled grains/panicle was significantly influenced due to application of farm yard manure, recycled poultry dropping as pond silt, vermicompost and RDF. The number of filled grains/panicle ranged from (286 to 184) and (299 to 193) during both the years respectively (Table 3). The significantly highest number of filled grains/panicle (286 and 299) was recorded in the application of farm yard manure @ 12.5 t/ha in combination with 100% RDF (M_4S_1) during both the years respectively. On the other hand, the lowest number of filled grains/panicle (184 and 193) was recorded in treatment M_5S_3 (no manure and no fertilizer).

1000 grain weight

The 1000 grain weight of CO(R) 50 was influenced by the different INM treatments. 1000 grain weight ranged from

(20.96 to 20.22g) and (20.89 to 20.31) during both the years respectively (Table 3). The highest 1000 grain weight (20.96 and 20.89 g) was observed in the farm yard manure @ 12.5 t/ha in combination with 100% RDF (M_4S_1) during both the years respectively, which was statistically identical to other treatments. The lowest 1000 grain weight (20.22 and 20.31g) was observed in treatment M_5S_3 (no manure and no fertilizer).

Effect of INM on grain and straw yield of rice

Grain yield

The grain yield of CO(R) 50 rice responded significantly to integrated use of farm yard manure, recycled poultry dropping as pond silt (desi poultry, duck and turkey dropping) and vermicompost with chemical fertilizers and results have been presented in the Table 4. The grain yields of rice ranged from (6783 to 3116 kg/ha) and (7122 to 3302 kg/ha) due to different INM treatments during both the years respectively. All the treatments produced significantly higher grain yield over control. The highest grain yield of 6783 and 7122 kg/ha showing 117.7% and 115.7% increase over control was obtained in the application of farm yard manure @ 12.5 t/ha combined with 100% RDF (M_4S_1) followed by recycled desi poultry dropping as pond silt @ 5 t/ha + vermicompost @ 5 t/ha with 100% RDF (M_1S_1) during both the years respectively, but they were statistically identical. The lowest grain yield of 3116 and 3302 kg/ha was observed in M_5S_3 (no manure and no fertilizer). The NPK supplied from farm yard manure, recycled poultry dropping as pond silt and vermicompost with 75% RDF was found more effective in producing grain yield of rice as compared to 100% RDF alone. The results clearly indicated that organic sources of nutrients combined with 100 and 75% RDF gave significantly higher grain yield over 100% RDF alone. This might be due to improvement in nutrient supply with more organics, which improve soil physico-chemical and biological properties by providing essential food to microbes (Sutaliya and Singh, 2005) [9]. Relatively higher yield with sufficient quantity of organics might be due to its nature of providing balanced supply of all the essential nutrients, which synchronize with crop needs, uptake and thus result in significantly higher grain yield over inorganic fertilizers (Ghosh, 2007) [10].

Straw yield

Straw yield of rice responded significantly to the application of farm yard manure, recycled poultry droppings as pond silt (desi poultry, duck and turkey dropping) and vermicompost in combination with different levels of recommended dose of fertilizer. The straw yield varied from (4721 to 8177 kg/ha) and (5004 to 8618 kg/ha) (Table 4) during both the years respectively. The highest straw yield (8177 and 8618 kg/ha) was recorded in the application of farm yard manure @ 12.5 t/ha combined with 100% RDF (M_4S_1) followed by recycled desi poultry dropping as pond silt @ 5 t/ha + vermicompost @ 5 t/ha with 100% RDF (M_1S_1), which was 73.2% and 72.2% increased over M_5S_3 (no manure and no fertilizer) during both the years respectively. The lowest straw yield (4721 and 5004 kg/ha) was recorded in M_5S_3 (no manure and no fertilizer) during both the years respectively. The results showed that the application of organic manures with 100% and 75% RDF registered higher straw yield of rice than 100% RDF alone. Reddy *et al.* (2004) [11] found that significant effects of combined application of manures and fertilizers on straw yield.

Table 1: Effect of INM practices on Plant height (cm) at harvesting stage and Productive Tillers/m^2 of rice during *rabi* season of 2015-16 and 2016-17.

Treatments	Plant height (cm)								Productive tillers/m^2							
	Rabi 2015-16				*Rabi* 2016-17				*Rabi* 2015-16				*Rabi* 2016-17			
	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	120.1	110.2	99.2	109.8	127.7	116.5	103.7	115.9	409	364	295	356	422	369	313	368
M_2	114.8	104.5	94.2	104.5	121.1	110.4	98.2	109.9	387	332	278	332	392	344	295	344
M_3	117.0	107.6	96.9	107.2	124.5	113.6	101.0	113.0	394	348	285	342	409	361	303	358
M_4	123.5	112.7	101.7	112.6	130.2	118.9	105.8	118.3	421	372	309	367	434	384	321	380
M_5	97.8	90.0	81.7	89.9	104.3	95.0	84.2	94.5	325	264	211	267	337	273	219	276
Mean	114.6	105.0	94.8		121.6	110.9	98.6		387	336	276		399	346	290	
	M	S	M x S		M	S	M x S		M	S	M x S		M	S	M x S	
SEd	3.9	2.5	6.0		3.4	3.2	6.8		9.1	6.6	15.1		12.8	6.3	17.3	
CD (P=0.05)	9.0	5.2	NS		8.0	6.6	NS		21.0	13.8	NS		29.5	13.3	NS	

Main plot:

M_1 - Fish pond silt fed with desi poultry dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_2 - Fish pond silt fed with duck dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_3 - Fish pond silt fed with turkey dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_4 - FYM @ 12.5 t/ha
M_5 – No manure application

Sub plot:

S_1 - 100% RDF
S_2 - 75% RDF
S_3 - No fertilizer

Table 2: Effect of INM practices on panicle length (cm) of rice during *rabi* season of 2015-16 and 2016-17.

Treatments	Panicle length (cm)							
	Rabi 2015-16				*Rabi* 2016-17			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
M_1	24.8	22.9	20.2	22.6	26.1	23.9	21.2	23.7
M_2	23.4	21.4	19.4	21.4	24.7	22.7	20.3	22.6
M_3	24.1	22.2	19.9	22.1	25.4	23.4	20.9	23.2
M_4	25.4	23.1	20.3	22.9	26.6	24.3	21.8	24.2
M_5	20.6	18.5	16.7	18.6	22.3	19.4	17.7	19.8
Mean	23.7	21.6	19.3		25.0	22.7	20.4	
	M	S	M x S		M	S	M x S	
SEd	1.07	0.50	1.42		0.90	0.34	1.10	
CD (P=0.05)	2.48	1.05	NS		2.08	0.71	NS	

Main plot:
M_1 - Fish pond silt fed with desi poultry dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_2 - Fish pond silt fed with duck dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_3 - Fish pond silt fed with turkey dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_4 - FYM @ 12.5 t/ha
M_5 – No manure application

Sub plot:
S_1 - 100% RDF
S_2 - 75% RDF
S_3 - No fertilizer

Table 3: Effect of INM practices on filled grains/panicle and 1000 grain weight (g) of rice during *rabi* season of 2015-16 and 2016-17.

Treatments	Filled grains/panicle								1000 grain weight (g)							
	Rabi 2015-16				*Rabi* 2016-17				*Rabi* 2015-16				*Rabi* 2016-17			
	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	274	251	226	250	291	264	229	261	20.82	20.64	20.42	20.63	20.84	20.68	20.49	20.67
M_2	258	240	211	236	277	251	217	248	20.71	20.56	20.35	20.54	20.72	20.57	20.37	20.55
M_3	269	244	220	244	284	258	224	255	20.74	20.59	20.36	20.56	20.76	20.59	20.36	20.57
M_4	286	260	229	258	299	270	236	268	20.96	20.69	20.47	20.71	20.89	20.76	20.51	20.72
M_5	237	203	184	208	244	209	193	215	20.52	20.28	20.22	20.34	20.56	20.44	20.31	20.44
Mean	265	240	214		279	250	220		20.75	20.55	20.36		20.75	20.61	20.41	
	M	S	M x S		M	S	M x S		M	S	M x S		M	S	M x S	
SEd	6.7	5.1	11.5		6.2	3.9	9.5		0.76	0.56	1.28		0.40	0.57	1.12	
CD (P=0.05)	15.5	10.6	NS		14.4	8.1	NS		NS	NS	NS		NS	NS	NS	

Main plot:
M_1 - Fish pond silt fed with desi poultry dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_2 - Fish pond silt fed with duck dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_3 - Fish pond silt fed with turkey dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_4 - FYM @ 12.5 t/ha
M_5 – No manure application

Sub plot:
S_1 - 100% RDF
S_2 - 75% RDF
S_3 - No fertilizer

Table 4: Effect of INM practices on grain and straw yield of rice during *rabi* season of 2015-16 and 2016-17.

Treatments	Grain yield (kg/ha)								Straw yield (kg/ha)							
	Rabi 2015-16				*Rabi* 2016-17				*Rabi* 2015-16				*Rabi* 2016-17			
	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	6634	5621	4478	5577	6965	5930	4628	5841	7991	7113	5909	7004	8389	7508	6259	7385
M_2	5999	5191	4121	5104	6299	5368	4348	5338	7498	6734	5617	6616	7912	7104	5941	6986
M_3	6382	5401	4366	5383	6701	5698	4442	5614	7794	6931	5720	6815	8154	7316	6063	7178
M_4	6783	5759	4619	5720	7122	6076	4746	5981	8177	7281	6084	7181	8618	7637	6458	7571
M_5	5038	3944	3116	4032	5165	4180	3302	4216	6515	5353	4721	5530	6817	5687	5004	5836
Mean	6167	5183	4140		6450	5450	4293		7595	6682	5610		7978	7050	5945	
	M	S	M x S		M	S	M x S		M	S	M x S		M	S	M x S	
SEd	162.3	102.7	248.0		225.7	163.4	374.2		243.1	170.2	394.6		260.7	173.4	410.2	
CD (P=0.05)	374.3	214.2	NS		520.5	340.8	NS		560.8	354.9	NS		601.2	361.6	NS	

Main plot:
M_1 - Fish pond silt fed with desi poultry dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_2 - Fish pond silt fed with duck dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_3 - Fish pond silt fed with turkey dropping @ 5 t/ha and vermicompost @ 5 t/ha
M_4 - FYM @ 12.5 t/ha
M_5 – No manure application

Sub plot:
S_1 - 100% RDF
S_2 - 75% RDF
S_3 - No fertilizer

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