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RESEARCH ARTICLE :

Developing better organic nutrient management package for the rice variety Co(R)48 under site specific organic farming condition in comparison with RDF and INM practices

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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 to develop better organic nutrient management package for the rice variety CO(R)48 under site specific organic farming condition in comparison with RDF and INM. 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% RDN on equi-nutrient basis [farm yard manure, vermicompost, 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 (INM) practice (RDF + Dhaincha). The nutrient content(N, P and K) of the different organic manures used in the experiment was given. The important growth parameters like tillers per square meter, number of panicle per square meter, total grains per panicle, thousand grain weight and grain yield of rice were recorded. The root length, root dry weight, root volume, and N, P and K uptake of rice at harvest was recorded. The rice quality parameters like milling percentage, hulling percentage, head rice recovery, length breadth ratio, volume expansion ratio, amylose and protein content in percentage were recorded. The INM imposed treatment recorded better growth parameters and yield attributes of rice and N, P and K uptake of rice at harvest, whereas, among the organic treatments, 100% RDN through green manure followed, by 25% RDN through each organic manures combination recorded more growth and yield attributes and important quality parameters and N, P and K uptake of rice at harvest in both the years of experimentation.

KEY WORDS :
Growth parameters, Yield attributes, Grain yield, NPK uptake, Quality parameters ofrice

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BACKGROUND AND OBJECTIVES

Today organic agriculture is one of the fastest growing production systems in the Agriculture sector (Ramesh *et al*., 2005). Rice production was almost stagnated for last one decade by oscillating around 93 million tones in India. However, the projected demand by 2025 is 116.5 million tones to keep the present per capita rice availability of 215-g per day in future. Better crop management and nutrient management strategies can support the needed future yield increase. Rice is the major contributor of total food grain production of India (43%), is now witnessed the yield stagnation and declining productivity due to continuous use of high level of chemical fertilizers which had also led to soil degradation problems. Despite the past gains in rice production through chemical fertilizers, recent observations of stagnant or declining yields have raised concerns about the long term sustainability of the crop production (Khan *et al*., 2010). Continuous use of inorganic fertilizers leads to deterioration in soil chemical, physical and biological properties, and soil health (Mahajan *et al*., 2008).

The negative impacts of chemical fertilizers, coupled with escalating prices, have led to growing interests in the use of organic fertilizers as a source of nutrients (Mahajan *et al*., 2008 and Dejene and Lemlem, 2012). Organic materials such as FYM have traditionally been used by rice farmers (Satyanarayana *et al*., 2002). FYM supplies all major nutrients (N, P, K, Ca, Mg and S) necessary for plant growth, as well as micronutrients (Fe, Mn, Cu and Zn). Hence, it acts as a mixed fertilizer (Khan *et al*., 2010 and Dejene and Lemlem, 2012). FYM improves soil physical, chemical and biological properties (Khan *et al*., 2010). Improvement in the soil structure due to FYM application leads to a better environment for root development (Prasad and Sinha, 2000). FYM also improves soil water holding capacity (Dejene and Lemlem, 2012). The fact that the use of organic fertilizers improves soil structure, nutrient exchange, and maintains soil health has raised interests in organic farming. The use of FYM alone as a substitute to inorganic fertilizer is not be enough to maintain the present levels of crop productivity of high yielding varieties (Efthimiadou *et al*., 2010). Therefore, integrate nutrient management in which both organic manures and inorganic fertilizers are used simultaneously is the most effective method to maintain a healthy and sustainably productive soil (Dejene and Lemlem, 2012). Emerging evidence indicated that integrated soil fertility management involving the judicious use of combined organic and inorganic resources is a feasible approach to overcome soil fertility constrains (Efthimiadou *et al*., 2010).

Organic manures although, not useful as sole sources of nutrients, are however, good complementary sources with inorganic fertilizers (Chaudhary *et al*., 2004). Organic manures and phosphatic fertilizers have been carry-over effect on succeeding crops. About less than 30% of N and small fraction of P and K in organic manures may become available to immediate crop and rest to subsequent crops (Sharma and Vyas, 2001). Only half of the nitrogen and one-fifth of phosphorus may be available at slower rate to subsequent crops. Organic rice rose better nutritional quality (Saha *et al*., 2007) and fetches higher market price. Studies suggest that yield could be sustained without increasing the chemical nutrient inputs but by tightening the nutrient cycles (Stockdale *et al*., 2001) and diversifying the soil biota (Ramesh and Rao, 2009). Modern high yielding varieties producing around 5 t ha^{-1} of grain can remove from the soil about 110 kg N, 15 kg P, 129 kg K, 5 kg S, 2 kg Fe, 2 kg Mn, 200 g Zn, 150g B per hectare. 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, 2006). Site-specific nutrient management approach is one being focused in recent years to reverse the present declining trend in factor productivity (Shukla *et al*., 2004). Keeping the above points in view, the present study was undertaken to study the site-specific nutrient management on maximization of yield and quality of rice in organic rice cultivation. There were sporadic evidences for influence of different combination of organic sources nutrients and its performance towards growth, yield and quality parameters of rice. The purpose of this study is to evolve site-specific better organic nutrient management package for the rice variety CO(R)48 while comparing with RDF and INM on organic rice cultivation.

RESOURCES AND METHODS

Field experiments were carried out 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°N latitude and 77°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 per cent RDN on equi-nutrient basis [farm yard manure, vermicompost, poultry manure and (Dhaincha) green manure] another six treatments consisted of 50 per cent combination of each manure, one treatment with $1/4^{th}$ 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. Square planting with the spacing of 25 x 25 cm was adopted 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, *Pachagavyaa* and *Pseudomonas* were used as prophylactic plant protection measures. In the net plot area, five sample hills (plants) were selected randomly and tagged for recording biometric observations.

Root dry matter :

After measuring the root volume, the roots were dried in shade and then oven dried at 70^0C, till the attainment of constant weight and expressed in g $hill^{-1}$.

Number of productive tillers m^{-2} :

The ear bearing tillers were counted from the five tagged plants and the mean number of productive tillers m^{-2} was calculated.

Number of panicles m^{-2}:

Well matured ear bearing panicles were selected randomly and ten hills or plants m^{-2} were counted for number of panicles and the average was worked out and this average value obtained from the ten randomly selected and counted panicles were multiplied with the number of hills m^{-2} and expressed in numbers.

Thousand grain weight :

Thousand grains selected randomly was counted, taken from each plot and the test weight was expressed in g.

Number of filled grains $panicle^{-1}$:

The total number of spikelets from each of five primary panicles were separated and sorted into filled and ill-filled grains and the mean values of filled grains $panicle^{-1}$ was worked out and expressed in numbers.

Grain and straw yield of rice:

The harvested produce from each net plot was threshed, sun dried, winnowed separately and the grain yield was recorded at 14% moisture content and expressed in kg ha^{-1}.The straw yield was recorded from the net plot area, sun dried and expressed in kg ha^{-1} (Hemalatha *et al*., 2000).

Table A : Analytical methods employed for N, P and K uptake of rice (plant sample) at harvest

Parameters	Methods	Reference
Total N	MicroKjeldahl's method using di acid extract	Humphries (1956)
Total P	Vanadomolybdophosphoric yellow colour method using tri acid extract	Piper (1966)
Total K	Flame photometry using tri acid extract	Piper (1966)

Quality characteristics of rice :

Head rice recovery percentage :

Head rice recovery percentage was estimated as below.

$$\text{Head rice recovery percentage} = \frac{\text{Total head rice}}{\text{Total rough rice}} \times 100$$

Length breadth (L : B) ratio :

The data on measured length and breadth for individual sample used to calculate L:B ratio.

Thousand grain weight (g) :

One thousand kernels each of the milled rice was counted randomly in duplicate and weighed in a single pan balance in grams.

Chemical parameters :

Rice samples of each treatment were cleaned by removing stones and other foreign particles. Good grains were powdered and used for chemical analysis.

Moisture :

Five gram samples were placed in moisture weighing bottle and kept in hot air oven maintained at 105°C. After 16+1 or 16-1 hours of drying, they were cooled in a desiccators for 30 minutes. The weight of the seeds before and after drying was recorded and expressed in gram. The moisture content of the seed was calculated using the following formula (ISTA, 1999).

$$\text{Moisture content (\%)} = \frac{M_2 - M_3}{M_2 - M_1} \times 100$$

where,

M_1 - Weight of the weighing bottle alone,

M_2 - Weight of bottle + seed sample before drying, and

M_3 - Weight of bottle + seed sample after drying.

Fat content :

Fat was estimated as crude ether extract of the dry material. Fat content in per cent was calculated by the following formula (A.O.A.C.,1980).

$$\text{Fat content in percentage} = \frac{\text{Weight of ether extract}}{\text{Weight of the sample}}$$

Protein :

Protein content of rice sample was estimated as per the method suggested by Lowry *et al.* (1951). The estimation of protein was based on the development of blue colour by the hydroxyl groups present in the amino acids with the folin-ciocalteau phenol reagent. The protein content of sample was expressed as percentage.

Carbohydrate :

Carbohydrate content was estimated from the samples of each treatment by anthrone method as suggested by Hedge and Hofreiter (1962) and expressed as percentage.

Amylose content :

The method suggested by Sadasivam and Manickam (1996) was followed in determining amylose content.

Cooking quality

Water absorption ratio :

The milled rice was put into a test tube containing distilled water @ 50 m lit. per two gm of milled rice. It was allowed to soak for 30 minutes and then boiled for 45 minutes at 77^0 C to 80^0C. The test tubes were taken out and placed in a beaker containing cold water for cooling. The cooked rice was blotted for free of water without the loss of solids and weighed to find out water absorption. The water absorption ratio was calculated by the formula and expressed in m lit. / 100 g by multiplying the value with 100. The water absorption ratio was estimated by the method described by Khan and Ali (1985). It is the ratio between the weight of the cooked rice to the uncooked.

$$\text{Water absorption (ml/100g)} = \frac{\text{Weight of cooked rice (g)} - \text{Weight of milled rice (g)}}{\text{Weight of milled rice (g)}}$$

Volume expansion ratio :

The volume of the initial milled rice was measured by water displacement method in a graduated measuring cylinder. Then the milled rice was put into a test tube and cooked in boiling water bath for 20 minutes. then the cooked rice was decanted on a filter paper to remove the excess water. Then the cooked rice volume was measured again, by water displacement method. The volume expansion is calculate by using following formula. The volume expansion ratio was estimated by the method described by Khan and Ali (1985). It is the ratio between the cooked volume to the uncooked.

$$\text{Volume expansion} = \frac{\text{Volume of cooked rice (g)}}{\text{Volume of milled rice (g)}}$$

Kernel length and breadth after cooking :

Ten normal milled grains are pre soaked to 10 to 30 minutes and placed directly into boiling water either by direct dropping or in a wire cage or basket until its optimum cooking time. The length and breadth of cooked rice are measured and the average is worked out.

$$\text{Linear elongation ratio (LER)} = \frac{\text{Length of cooked rice (mm)}}{\text{Length of raw rice (mm)}}$$

$$\text{Breadth wise expansion ratio (BER)} = \frac{\text{Breadth of cooked rice (mm)}}{\text{Breadth of raw rice (mm)}}$$

Length breadth (L : B) ratio :

The data on measured length (mm) and breadth

Table B : Nutrient content of organic manures used in the field experiment on dry weight basis

Organic manures	*Samba* 2012 Nutrient content (%)						*Samba* 2013 Nutrient content (%)					
	N	P	K	Ca	Mg	C : N ratio	N	P	K	Ca	Mg	C : N ratio
Farm yard manure	0.60	0.42	0.64	0.21	0.18	20:96	0.58	0.40	0.68	0.18	0.17	23:00
Vermicompost	1.91	0.64	1.20	0.31	0.27	18:98	1.88	0.68	1.24	0.33	0.28	18:82
Poultry manure	2.27	1.42	1.24	4.22	0.65	17:36	2.25	1.45	1.22	4.01	0.62	17:41
Green manure (Dhaincha) *Sesbania aculeata*	2.67	0.68	1.26	1.17	0.75	18:91	2.65	0.66	1.28	1.07	0.77	18:64

(mm) for individual sample used to calculate L:B ratio.

Statistical analysis :

The important growth parameters like tillers per square meter, number of panicle per square meter, total grains per panicle, thousand grain weight and grain yield of rice were recorded. The root length, root dry weight, root volume, and N, P and K uptake of rice at harvest was recorded. The rice quality parameters like milling percentage, hulling percentage, head rice recovery, length breadth ratio, volume expansion ratio, amylose and protein content in percentage were recorded. Data on various characters were subjected to statistical analysis (Gomez and Gomez, 2010).

OBSERVATIONS AND ANALYSIS

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

Root dry weight :

The root dry weight was influenced at all growth stages of the crop and it was increased upto flowering and thereafter declined at harvest in both the years of investigation (Table 1). The INM practice (T_{14}) enhanced (5.38 and 5.48 g hill^{-1} during 2012 and 2013) root dry weight at flowering and at harvest (5.16 and 5.24 during 2012 and 2013) and it was comparable with recommended

Table 1 : Effect of organic nutrient supply packages in comparison with RDF and INM on root dry weight, root volume at flowering and harvest anduptake of NPK at harvest of rice

Treatments	*Samba* 2012							*Samba* 2013						
	Root dry weight in (g hill^{-1})		Root volume in (cc hill^{-1})		Uptake at harvest (kg ha^{-1})			Root dry weight in (g hill^{-1})		Root volume in (cc hill^{-1})		Uptake at harvest (kg ha^{-1})		
	F	H	F	H	N	P	K	F	H	F	H	N	P	K
T_1 : Absolute control	1.98	1.94	11.9	11.8	61.1	14.0	85.1	2.06	1.98	12.0	11.9	63.0	14.7	88.1
T_2 : 100% RDN through FYM	2.85	2.78	22.1	22.2	80.4	19.5	104.2	2.68	2.67	22.0	21.1	82.0	21.8	108.1
T_3 : 100% RDN through VC	3.11	3.04	22.9	23.0	84.2	19.6	110.2	2.98	2.99	22.8	21.9	86.0	22.2	116.2
T_4 : 100% RDN through PM	3.17	3.13	23.3	21.5	88.6	19.6	118.1	3.00	2.99	24.0	22.5	91.4	23.0	126.1
T_5 : 100% RDN through GM	4.89	4.68	27.8	26.0	96.4	22.4	131.3	5.08	4.89	27.4	26.2	99.8	24.5	138.4
T_6 : 50% RDN each of through FYM + VC	2.78	2.69	21.1	21.2	76.3	19.4	100.1	2.68	2.57	21.0	20.3	77.5	21.0	106.3
T_7 : 50% RDN each of through FYM + PM	3.17	3.10	23.5	21.9	90.4	19.6	124.2	2.94	2.99	24.2	22.8	93.2	23.4	132.2
T_8 : 50% RDN each of through FYM + GM	2.97	2.94	22.5	22.6	82.4	19.5	107.3	2.82	3.13	22.4	21.5	84.0	22.0	112.0
T_9 : 50% RDN each of through VC + PM	3.22	3.16	23.6	22.0	93.1	20.4	128.0	3.16	3.13	24.4	23.0	95.0	23.8	135.2
T_{10} : 50% RDN each of through VC + GM	2.83	2.74	21.7	22.0	78.4	19.4	102.1	2.62	2.61	21.7	20.7	79.4	21.4	106.1
T_{11} : 50% RDN each of through PM + GM	3.14	3.09	23.0	23.2	86.5	19.6	114.2	2.98	2.97	23.2	22.0	90.0	22.4	121.3
T_{12} : 25% RDN each of through FYM + VC + PM + GM	4.79	4.56	26.8	25.9	95.0	22.2	130.1	4.92	4.78	27.0	26.0	97.2	24.2	137.2
T_{13} : RDF : (150 : 50 : 50) NPK kg ha^{-1}	4.98	4.76	28.0	26.2	99.1	22.8	133.2	5.20	5.02	27.6	26.4	102.0	24.6	139.1
T_{14} : INM Practices (RDF + GM @ 6.25 t ha^{-1})	5.38	5.16	30.6	28.8	104.0	25.9	137.3	5.48	5.24	31.4	29.4	106.0	28.4	145.3
S.E.±	0.33	0.32	2.1	2.0	8.0	1.8	10.2	0.32	0.32	2.2	2.1	8.2	2.1	11.2
C.D. (P=0.05)	0.67	0.66	4.4	4.2	16.8	3.8	21.5	0.67	0.66	4.5	4.3	17.2	4.4	23.5

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.
F: Flowering, H: Harvest

NPK fertilizers (T_{13}). Similar trend was noticed during 2013 also. Among the organic treatments, 100% RDN through green manure (T_5) recorded higher root dry weight (4.89 and 4.68 during 2012) at flowering and harvest stages, respectively and it was on par with 25% RDN through each organic manures. Similar trend was repeated in 2013 also. Lower root dry weight (1.98 and 1.94 during 2012; 2.06 and 1.98 during 2013) was recorded at flowering and harvest stages of crop growth in absolute control (T_1).

Root volume :

The root volume had the influence on all growth stages of the crop and it was increasing from active tillering to flowering and there after declined at harvest in both the years of investigation (Table 1). The highest root volume (30.6 and 28.8 hill^{-1} during 2012) was observed in INM practice (T_{14}) at flowering and harvest stages, respectively and it was followed by recommended NPK fertilizers (T_{13}). Similar results were observed during 2013 also. Among the organic treatments, 100% RDN through green manure (T_5) observed with higher root volume (27.8 and 26.0) and (27.4 and 26.2) at flowering and harvest stages during 2012 and 2013, respectively and it was followed by 25% RDN through each organic manure (T_{12}), same nature of trends were repeated during 2013 also. The lowest root volume (11.9 and 11.8 during 2012) was registered in absolute control (T_1) at flowering and harvest stages of crop growth. Similar trend was noticed in 2013 also.

Rice nutrient uptake :

Nitrogen uptake :

The N uptake was influenced by the INM practice, recommended NPK fertilizers and organic manures at all stages of crop growth during both the years of study (Table 1), (Fig. 5 and 6). The N uptake was progressively increased with advancement in the growth stages and reached maximum at harvest stage.The uptake of N varies from 61.1to 104.0 and 63.0 to 106.0 kg ha^{-1}during 2012 and during 2013, respectively at harvest stage of the rice crop. The increased N uptake was observed in the INM practice (T_{14}) (104.0 and 106.0 during 2012 and 2013, respectively) at harvest of rice, during both the years of study, and it was comparable with recommended NPK fertilizers (T_{13}), 100% RDN through

Table 2 : Effect of organic nutrient supply packages in comparison with RDF and INM on yield attributes, grain and straw yield of rice

Treatments	*Samba* 2012						*Samba* 2013					
	Tillers sqm^{-1}	Panicles sqm^{-1}	Filled grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Tillers sqm^{-1}	Panicles sqm^{-1}	Filled grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1 : Absolute control	300	228	70	16.2	3602	4907	303	236	74	16.2	3646	4939
T_2 : 100% RDN through FYM	409	270	103	17.8	4164	5424	413	272	106	17.8	4190	5425
T_3 : 100% RDN through VC	419	278	116	17.8	4296	5549	423	280	109	17.9	4380	5618
T_4 : 100% RDN through PM	429	288	111	17.9	4377	5608	432	292	114	17.9	4550	5760
T_5 : 100% RDN through GM	508	310	132	17.9	5084	6445	510	308	138	17.9	5140	6467
T_6 : 50% RDN each of through FYM + VC	416	259	102	17.6	3910	5120	419	260	104	17.6	3980	5175
T_7 : 50% RDN each of through FYM + PM	432	299	113	17.9	4721	6024	436	300	118	17.9	4833	6155
T_8 : 50% RDN each of through FYM + GM	412	274	105	17.8	4236	5494	416	276	108	17.8	4316	5568
T_9 : 50% RDN each of through VC + PM	436	301	115	17.9	4923	6255	440	304	117	17.9	4986	6304
T_{10} : 50% RDN each of through VC + GM	404	264	103	17.7	4079	5321	407	268	105	17.7	4140	5385
T_{11} : 50% RDN each of through PM + GM	422	282	109	17.9	4322	5578	425	284	111	17.9	4430	5655
T_{12} : 25% RDN each of through FYM+VC+PM + GM	452	306	131	17.9	5004	6376	455	308	128	17.9	5120	6455
T_{13} : RDF : (150 : 50 : 50) NPK kg ha^{-1}	502	312	134	17.9	5603	7103	507	316	139	17.9	5680	7128
T_{14} : INM practices (RDF+GM @ 6.25 t ha^{-1})	584	328	159	18.2	6235	7470	588	330	164	18.3	6270	7490
S.E.±	41	26	11	1.6	425	546	41	26	11	1.7	432	552
C.D. (P=0.05)	83	54	22	NS	874	1123	83	55	22	NS	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 NS=Non-significant

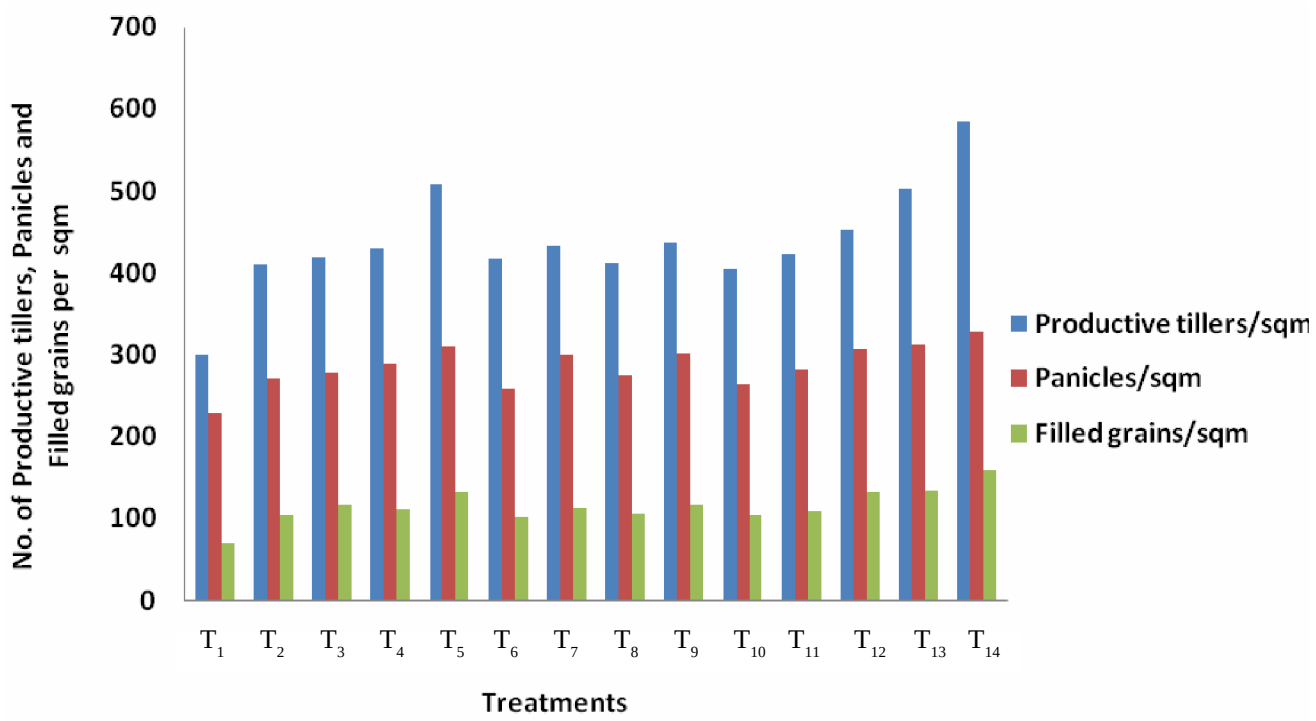

Fig. 1 : Effect of organic nutrient supply packages in comparison with RDF and INM on yield attributes (Samba, 2012)

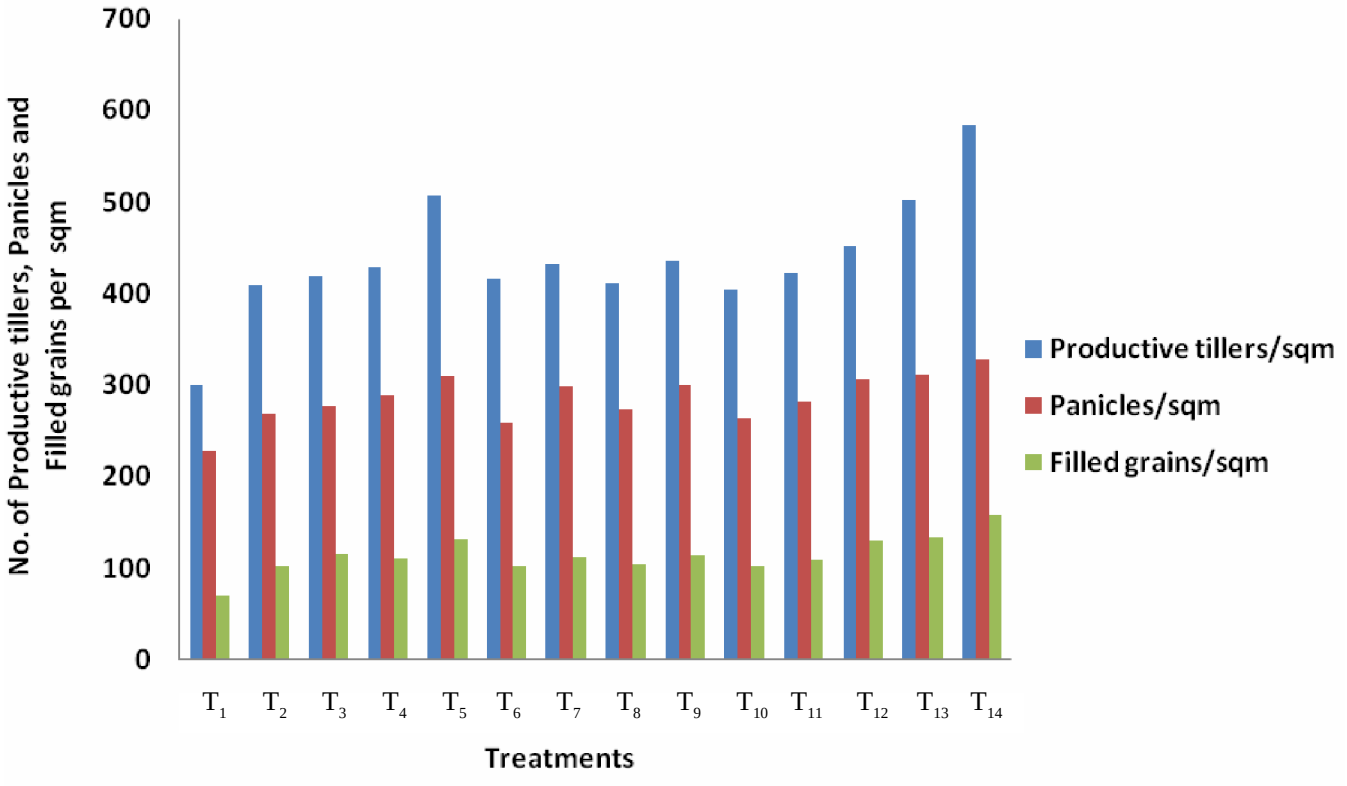

Fig. 2 : Effect of organic nutrient supply packages in comparison with RDF and INM on yield attributes (Samba 2013)

green manure (T_5) and 25% RDN through each organic manures (T_{12}).The N uptake was lower in absolute control (T_1) (61.1 and 63.0during 2012 and 2013, respectively) at harvest stage of the rice in both the years of study.

Phosphorus uptake :

The P uptake was also influenced by the INM practice, recommended NPK fertilizers and by various sources of organic manures application (Table 3), (Fig. 5 and 6) .During 2012 and 2013 the INM treatment (T_{14}) recorded higher P uptake (25.9 and 28.4 kg ha^{-1}) at harvest stage, and it was at par with recommended NPK fertilizers (T_{13}), 100% RDN through green manure (T_5) and 25% RDN through each organic manure (T_{12}). The lower P uptake was observed in absolute control (T_1) (14.0 and 14.7 kg ha^{-1}) at harvest stage of rice during 2012 and 2013.

Potassium uptake :

During 2012 and 2013, the positive influence of treatments on K uptake by rice was evidenced (Table 1), (Fig. 5 and 6). The highest K uptake was associated with the INM treatment (T_{14}) (137.3 kg ha^{-1} in 2012; 145.3 kg ha^{-1} in 2013) at harvest of rice and it was comparable with recommended NPK fertilizers (T_{13}).Among the organic treatment, the higher K uptake was recorded with 100% RDN through green manure (T_5) (131.3 and 138.4 kg ha^{-1} during 2012 and 2013, respectively) at harvest of rice and it was followed by 25% RDN through each organic manures (T_{12}). The lower K uptake was observed in absolute control (T_1) (85 and 88 kg ha^{-1}, respectively) at harvest stage of rice during 2012 and 2013.

Yield attributes :

The foremost important yield attributes *viz.*, number of productive tillers m^{-2}, (Table. 2), (Fig. 3 and 4) number of panicles per square meter, number of filled grains per panicle, thousand grain weight (g), rice grain and straw yield were recorded and the results are presented in Table 2. Appreciable improvement was observed with organic manures and recommended NPK fertilizers application on all the yield attributes except the thousand grain weight.

Number of tillers m^{-2} :

Treatments under study had significant influence on

Table 3 : Effect of organic nutrient supply packages in comparison with RDF and INM on important quality parameters of rice (2012)

Treatments	Cooking characteristics of rice					Chemical composition of rice				
	Water absorption ratio	Volume expansion ratio	Linear elongation ratio	Breadth elongation ratio	L/B ratio	Moisture (%)	Fat (%)	Protein content (%)	Carbohy-drate content (%)	Amylose content (%)
T_1 : Absolute control	4.11	2.48	1.70	1.19	2.69	12.4	0.51	5.82	74.50	19.00
T_2 : 100% RDN through FYM	4.15	2.56	1.74	1.21	2.73	12.2	0.53	7.01	76.60	24.47
T_3 : 100% RDN through VC	4.20	2.68	1.74	1.21	2.76	12.2	0.54	6.82	77.00	24.50
T_4 : 100% RDN through PM	4.27	2.92	1.75	1.22	2.78	12.2	0.54	7.05	77.40	24.52
T_5 : 100% RDN through GM	4.68	3.24	1.88	1.20	2.80	12.4	0.58	7.14	78.28	26.82
T_6 : 50% RDN each of through FYM+VC	4.13	2.54	1.73	1.20	2.70	12.1	0.52	6.44	75.40	20.43
T_7 : 50% RDN each of through FYM+PM	4.28	2.96	1.75	1.22	2.79	12.2	0.55	7.06	77.50	24.53
T_8 : 50% RDN each of through FYM+GM	4.16	2.58	1.74	1.21	2.74	12.2	0.53	6.96	76.80	24.48
T_9 : 50% RDN each of through VC+PM	4.29	2.97	1.77	1.22	2.80	12.3	0.55	7.08	77.53	24.53
T_{10} : 50% RDN each of through VC+GM	4.14	2.55	1.74	1.2	2.72	12.1	0.53	6.64	76.20	24.45
T_{11} : 50% RDN each of through PM+GM	4.24	2.86	1.76	1.21	2.77	12.2	0.54	7.03	77.20	24.51
T_{12} : 25% RDN each of through FYM+VC+PM + GM	4.30	2.98	1.76	1.22	2.80	12.2	0.56	7.09	77.56	24.54
T_{13} : (150 : 50 : 50) NPK kg ha^{-1}	4.12	2.52	1.77	1.24	2.70	12.2	0.51	7.00	76.00	24.24
T_{14} : INM Practice	4.33	3.00	1.76	1.22	2.80	12.2	0.56	7.10	77.55	24.55
S.E.±	0.40	0.26	0.17	0.12	0.26	1.2	0.05	0.65	7.31	2.28
CD (P=0.05)	NS	0.54	NS	NS	NS	NS	NS	1.33	NS	4.68

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 NS= Non-Significant

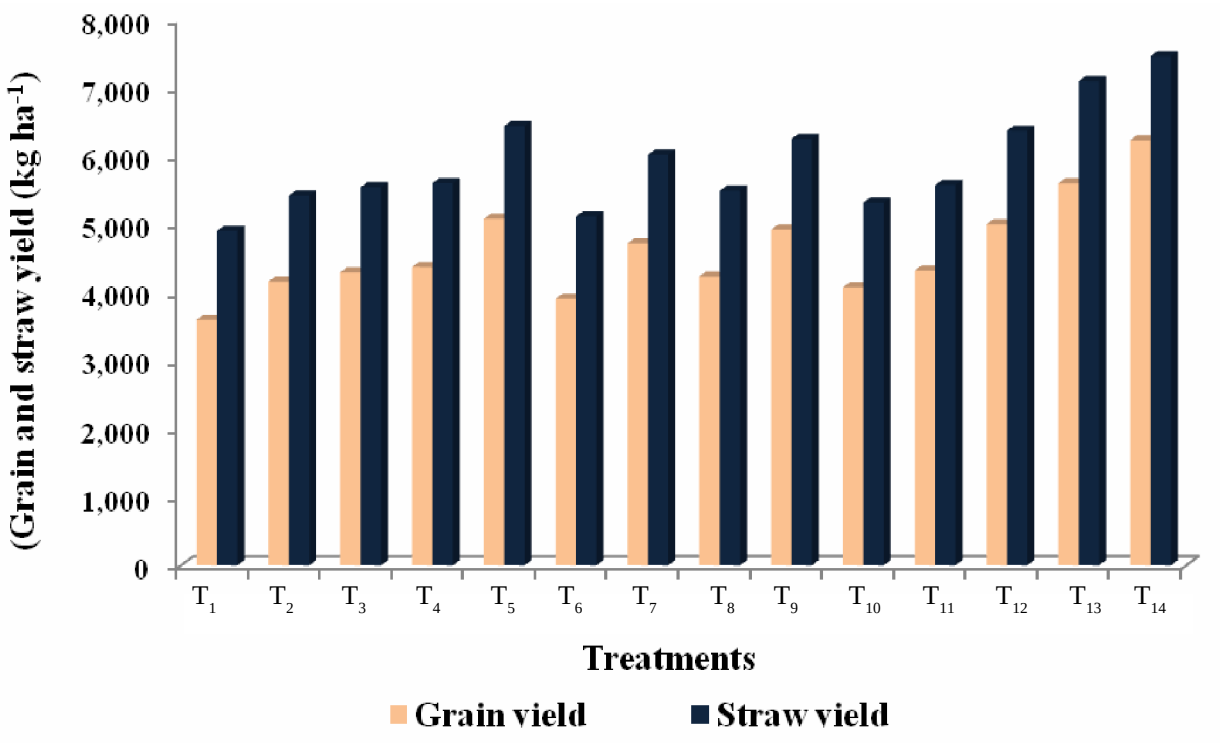

Fig. 3 : Effect of organic nutrient supply packages in comparison with RDF and INM on grain and strawyield of rice (kg ha^{-1}) (Samba, 2012)

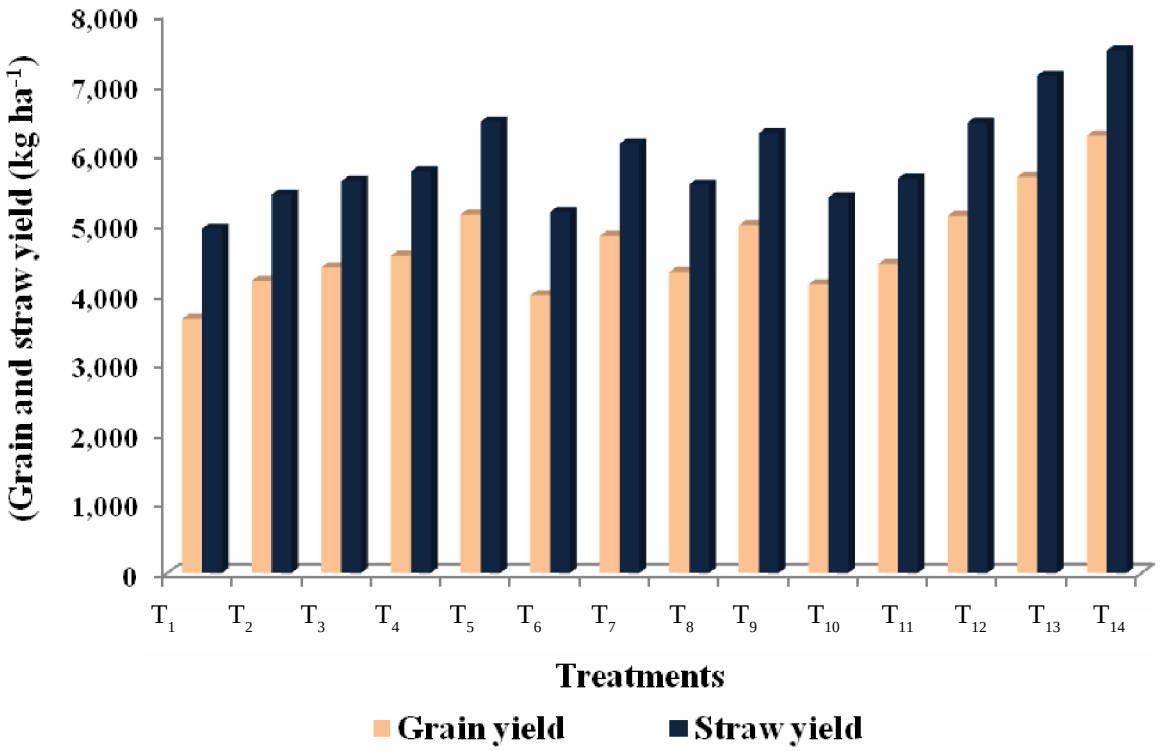

Fig. 4: Effect of organic nutrient supply packages in comparison with RDF and INM on grain and straw yield of rice (kg ha^{-1}) (Samba, 2013)

the number of tillers m^{-2} in rice during both the years of study (Table 2) (Fig. 1 and 2). The number of tillers m^{-2} ranged from 300 to 584 and from 303 to 588 during 2012 and 2013, respectively. The INM practice (T_{14}) recorded more number of productive tillers m^{-2} (584 in 2012 and 588 in 2013, respectively) and which was at par with recommended NPK fertilizers (T_{13}).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 manure (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. Single seedling planted on 14 days after sowing (DOS) registered significantly more number of productive tillers m^{-2} during both the years. Transplanting of younger seedlings *i.e.*, less than 15 day old seedlings in SRI method had higher tillering capacity both in conventional and organic farming systems. This result is in conformity with the findings of Thiyagarajan (2003).

Number of paniclesm^{-2}:

Treatments under study had significant influence on the number of panicles m^{-2} in rice during both the years of study (Table 2) (Fig. 1 and 2). The number of panicles m^{-2} ranged from 228 to 328 and from 236 to 330 during 2012 and 2013, respectively. The INM practice (T_{14}) recorded more number of panicles m^{-2} (328 in 2012 and 330 in 2013, respectively) and which was on par with recommended NPK fertilizers (T_{13}). Among the organic treatments, 100% RDN through green manure (T_5) recorded higher number of panicles m^{-2} (310 and 308 during 2012 and 2013, respectively) and it was on par with 25% RDN through each organic manure (T_{12}). The least number of panicles m^{-2} were recorded as 228 and 236 in 2012 and 2013 which was associated with the treatment of absolute control (T_1). Similar trend was observed in the conformity trial during 2013 also.

Thousand grain weight :

Thousand grain weight did not vary due to the application of organic manures and recommended NPK fertilizers during 2012 and 2013 (Table 4). However, the thousand grain weight ranged from 16.2 to 18.2 g during 2012 and from 16.2 to 18.3 g during 2013.

Table 4 : Effect of organic nutrient supply packages in comparison with RDF and INM on important quality parameters of rice (2013)

Treatments	Cooking characteristics of rice					Chemical composition of rice				
	Water absorption ratio	Volume expansion ratio	Linear elongation ratio	Breadth elongation ratio	L/B ratio	Moisture (%)	Fat (%)	Protein content (%)	Carbohydrate content (%)	Amylose content (%)
T_1 : Absolute control	4.10	2.40	1.71	1.20	2.70	12.4	0.51	5.84	74.62	19.03
T_2 : 100% RDN through FYM	4.18	2.62	1.75	1.23	2.72	12.2	0.54	7.02	76.80	24.50
T_3 : 100% RDN through VC	4.22	2.70	1.75	1.24	2.77	12.2	0.55	6.83	77.20	24.53
T_4 : 100% RDN through PM	4.26	2.90	1.76	1.24	2.78	12.2	0.55	7.06	77.60	24.55
T_5 : 100% RDN through GM	4.70	3.26	1.90	1.22	2.82	12.5	0.59	7.17	78.50	26.86
T_6 : 50% RDN each of through FYM + VC	4.15	2.55	1.73	1.23	2.73	12.2	0.53	6.46	75.60	20.47
T_7 : 50% RDN each of through FYM + PM	4.25	2.97	1.75	1.24	2.79	12.2	0.56	7.07	77.70	24.56
T_8 : 50% RDN each of through FYM + GM	4.20	2.66	1.74	1.24	2.78	12.2	0.54	6.98	77.00	24.51
T_9 : 50% RDN each of through VC + PM	4.26	2.98	1.77	1.25	2.78	12.3	0.56	7.10	77.73	24.57
T_{10} : 50% RDN each of through VC + GM	4.16	2.60	1.74	1.23	2.74	12.2	0.54	6.66	76.40	24.48
T_{11} : 50% RDN each of through PM + GM	4.25	2.87	1.76	1.24	2.76	12.2	0.55	7.05	77.40	24.54
T_{12} : 25% RDN each of through FYM + VC + PM + GM	4.27	2.99	1.77	1.25	2.79	12.2	0.57	7.09	77.76	24.57
T_{13} : (150 : 50 : 50) NPK kg ha^{-1}	4.11	2.50	1.78	1.26	2.71	12.2	0.52	7.01	76.20	24.38
T_{14} : INM Practice	4.28	3.10	1.78	1.25	2.79	12.2	0.57	7.12	77.68	24.58
S.E.±	0.40	0.26	0.17	0.12	0.26	1.2	0.52	0.65	7.33	2.28
C.D. (P=0.05)	NS	0.54	NS	NS	NS	NS	NS	1.33	NS	4.68

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 NS=Non-significant

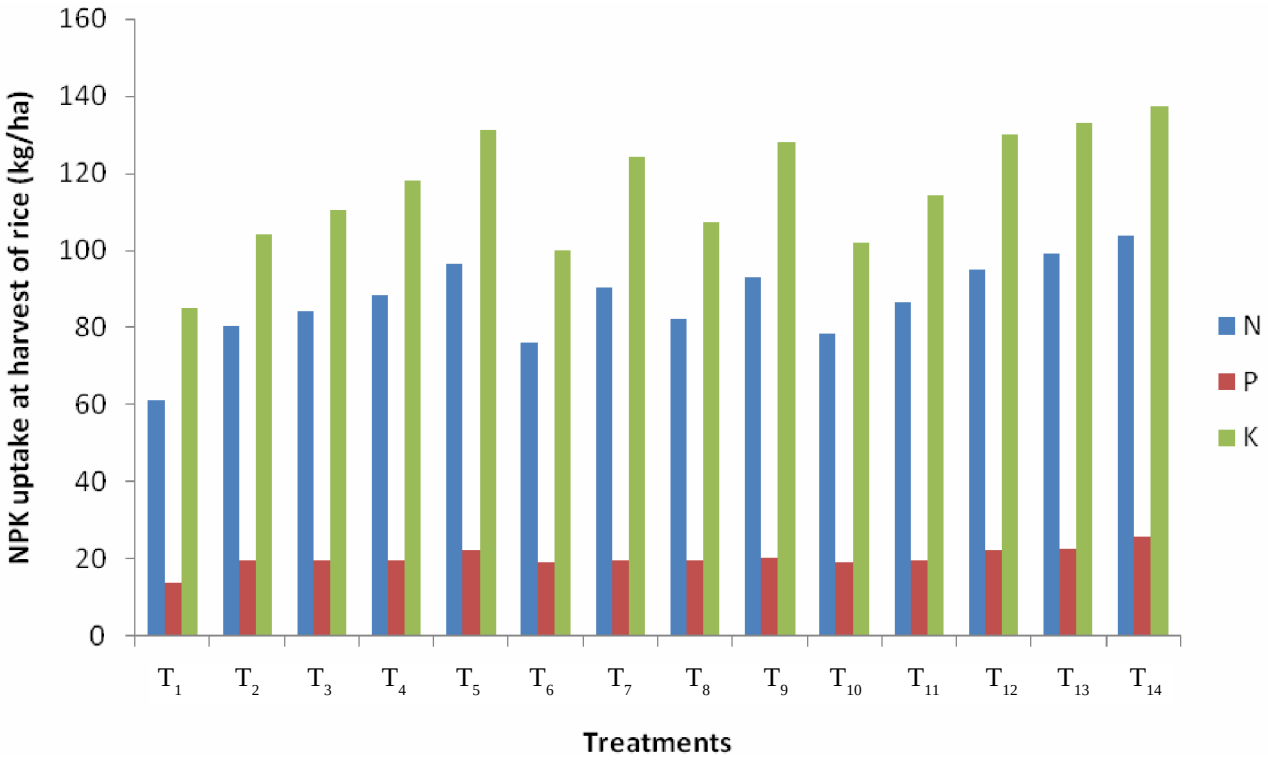

Fig. 5 : Effect of organic nutrient supply packages in comparison with RDF and INM on NPKuptake (kg ha^{-1}) at harvest stage of rice (Samba, 2012)

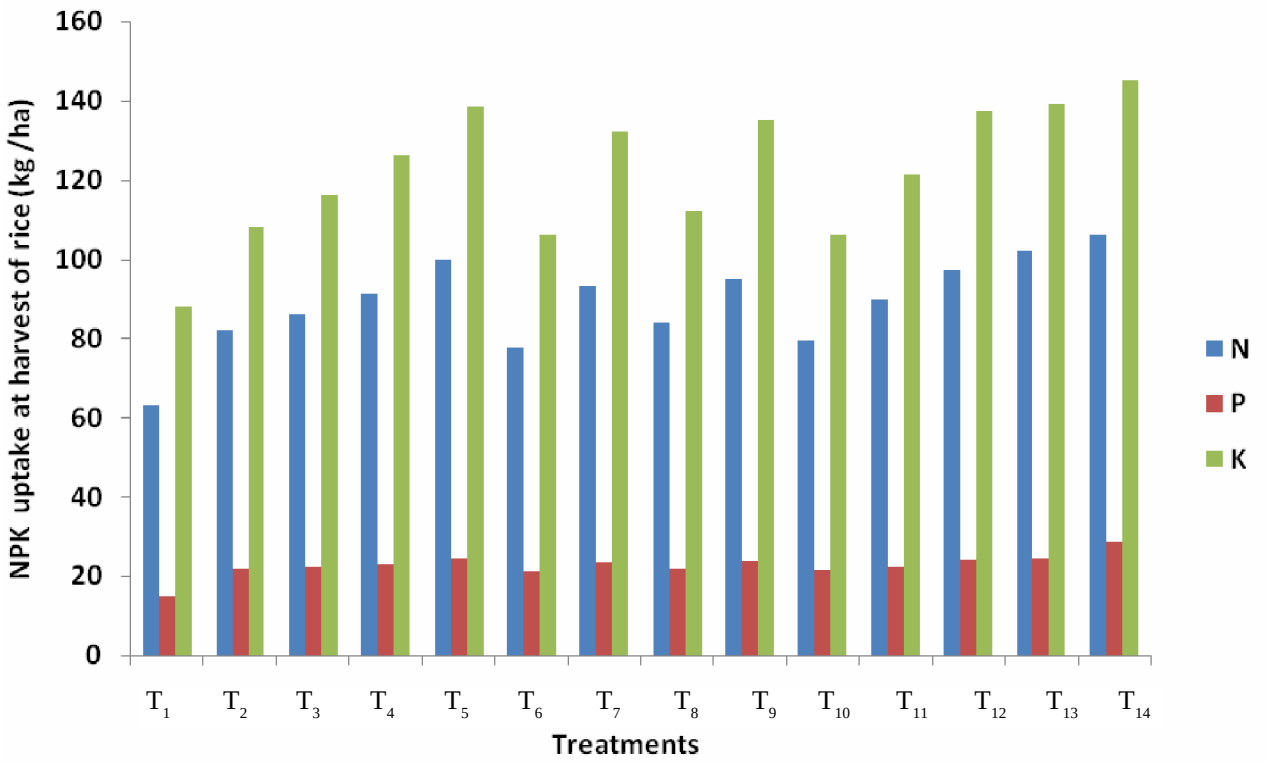

Fig. 6 : Effect of organic nutrient supply packages in comparison with RDF and INM on NPK uptake (kg ha^{-1}) at harvest stage of rice (*Samba* 2013)

Filled grains panicle $^{-1}$:

The number of filled grains per panicle had influenced by the imposed treatments in both the years of experimentation (Table 2) (Fig. 1 and 2). The number of filled grains panicle^{-1} ranged from 70 to 159 in 2012 and from 74 to 164 in 2013. The INM practice (T_{14}) enhanced filled grains panicle^{-1} (159, 164 in 2012 and 2013, respectively) and was comparable with recommended NPK fertilizers (T_{13}).Among the organic treatments, 100% RDN through green manure (T_5) recorded more number of filled grains panicle^{-1} (132 during 2012), and was followed by 25% RDN through each organic manure (T_{12}) (131 during 2012). Same nature of results were observed during 2013 also. The absolute control (T_1) recorded lesser filled grains panicle^{-1} (70 during 2012 and 74 during 2013)

Grain yield :

The treatments imposed had direct influence on rice grain yield in both the years of experimentation (Table 2) (Fig. 3 and 4) 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). The percentage yield increased under INM ranged from 73.1 in 2012 to 72.0 in 2013 over absolute control. The grain yield under INM practices was comparable with recommended RDF (5603 and 5680 in 2012 and 2013, respectively) and resulted in yield reduction of 11.3% and 11.4% over INM in both the years of study. Among the organic treatments, 100% RDN though green manure (T_5) recorded higher grain yield (5084 and 5140 in 2012 and 2013, respectively) resulted in yield reduction of 22.6% and 22.0% over INM and the percentage yield increase over absolute control ranged from 41.1 in 2012 to 41.0 in 2013, respectively.

Next to 100% RDN through green manure, higher grain yield was recorded with 25% RDN through each organic manure (T_{12}) (5004 and 5120 in 2012 and 2013, respectively) resulted in percentage yield increase over absolute control was 38.9 in 2012 and 40.9 in 2013. While comparing all the organic treatments, the percentage yield increase ranged from 8.5 to 41.1 in 2012 and 9.2 to 41.0 in 2013, respectively over absolute control.The RDF treatment recorded higher grain yield (5603 and 5680 in 2012 and 2013, respectively) resulted in percentage yield reduction of 11.3 and 11.4 over INM and percentage yield increase of 9.9 and 10.5 over 100 per cent RDN

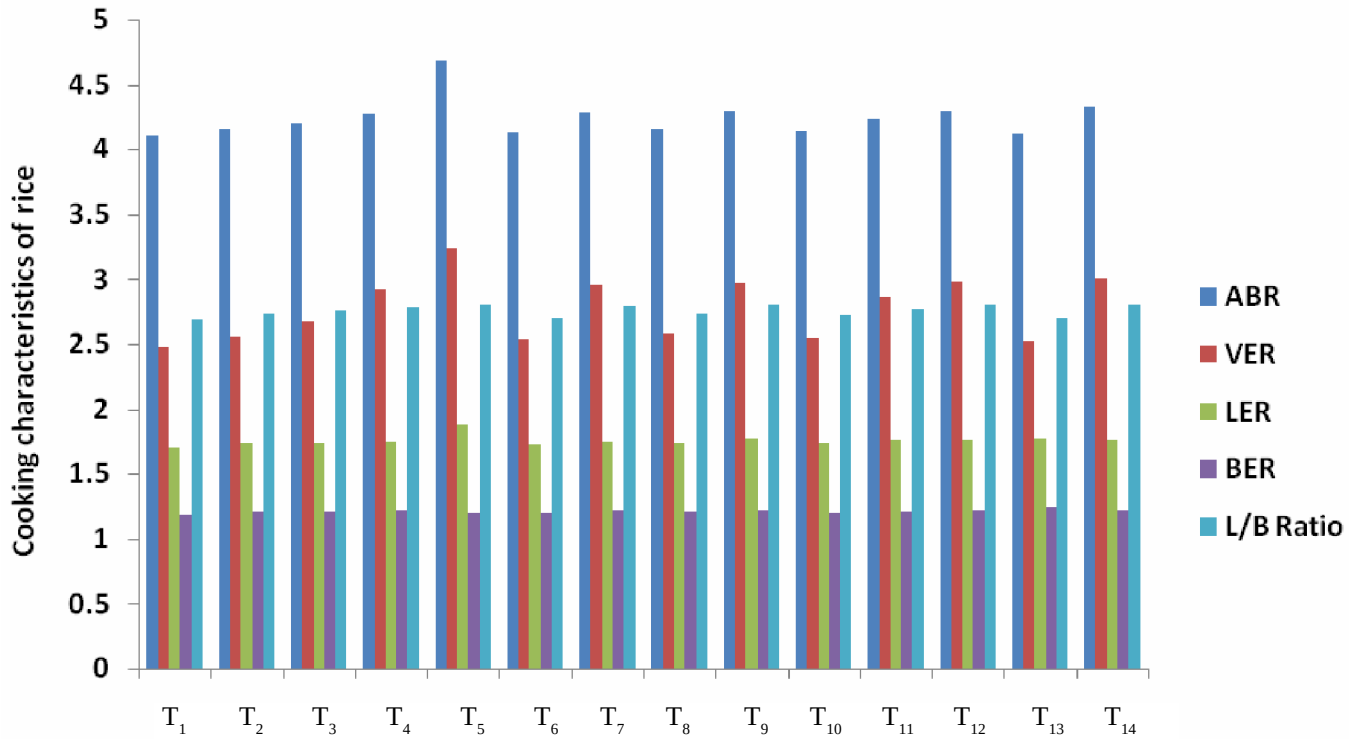

Fig. 7 : Effect of organic nutrient supply packages in comparison with RDF and INM on cooking characteristics of rice (*Samba* 2012)

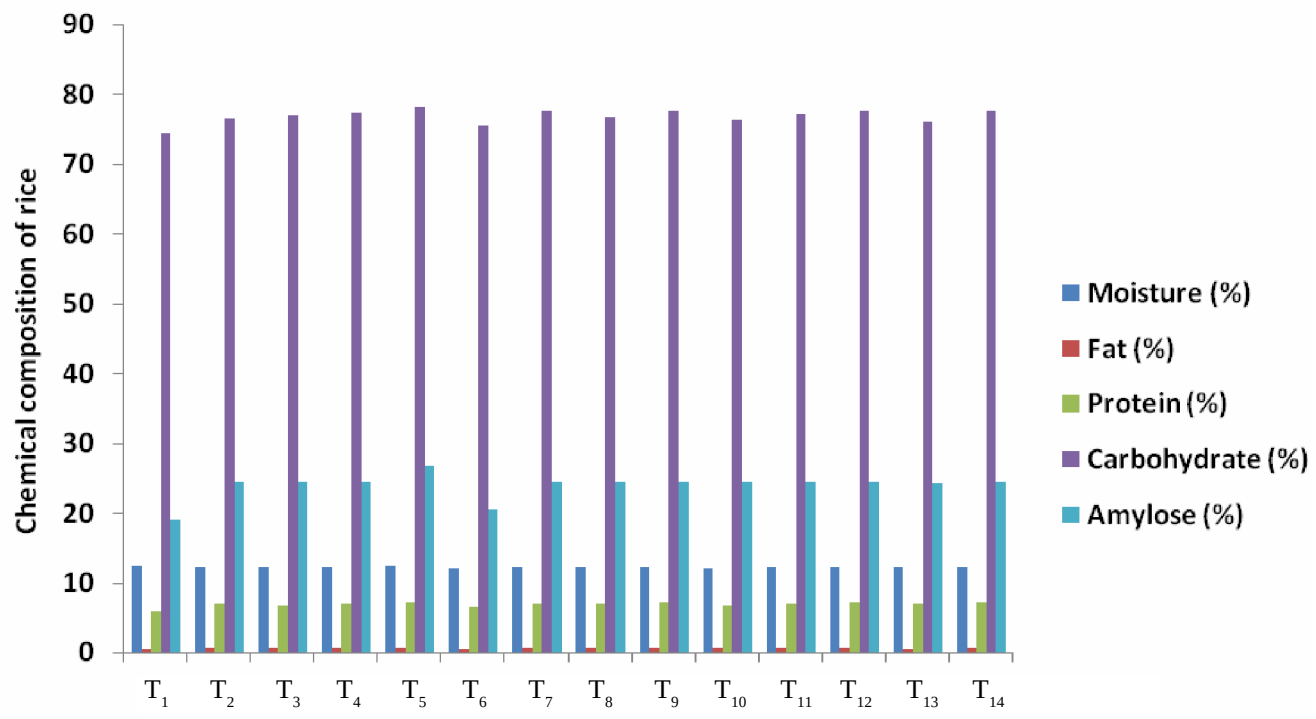

Fig. 8 : Effect of organic nutrient supply packages in comparison with RDF and INM on chemical composition of rice (Samba 2013)

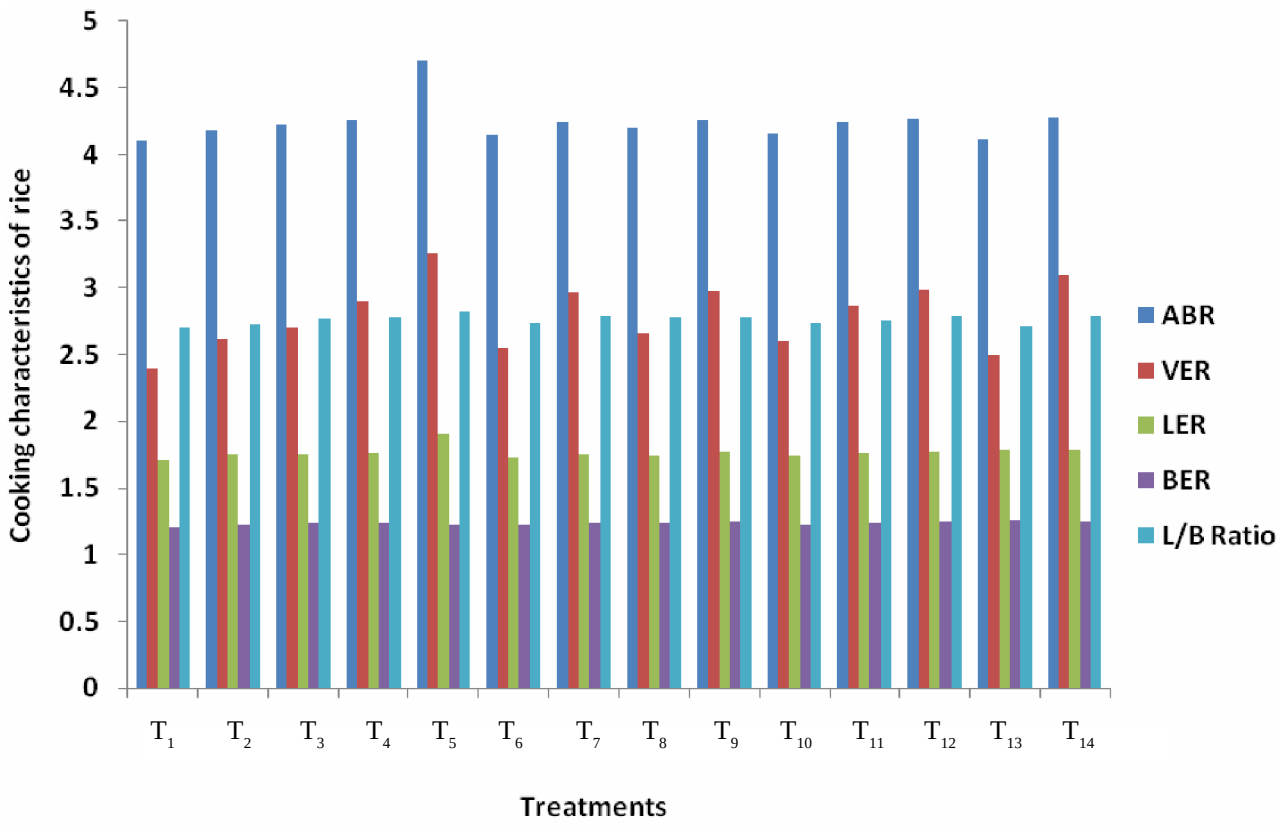

Fig. 9 : Effect of organic nutrient supply packages in comparison with RDF and INM on cooking characteristics of rice (*Samba* 2013)

through green manure treatment.The lower grain yield (3602 in 2012 and 3646 in 2013) was obtained with absolute control (T_1), which did not receive organic manures and recommended NPK fertilizers. The treatments like INM, RDF, 100% RDN through green manure and 25% RDN through each organic manures resulted in percentage yield increase (73.1 and 72.0, 55.6 and 55.8, 41.1 and 41.0, and 38.9 and 40.9, respectively) over absolute control in both the years of study. This was significantly inferior to the grain yield obtained with 100% RDN through farm yard manure (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.

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, 1996 and Basnet 1999), FYM (Shine and Ghosh, 1971 and Kenchaiah, 1977) poultry manure (Budhar *et al*., 1991) Datta and Laskar (1992) and Presmud (Sinha and Sakal, 1993 and Jain and Tiwari, 1995). 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

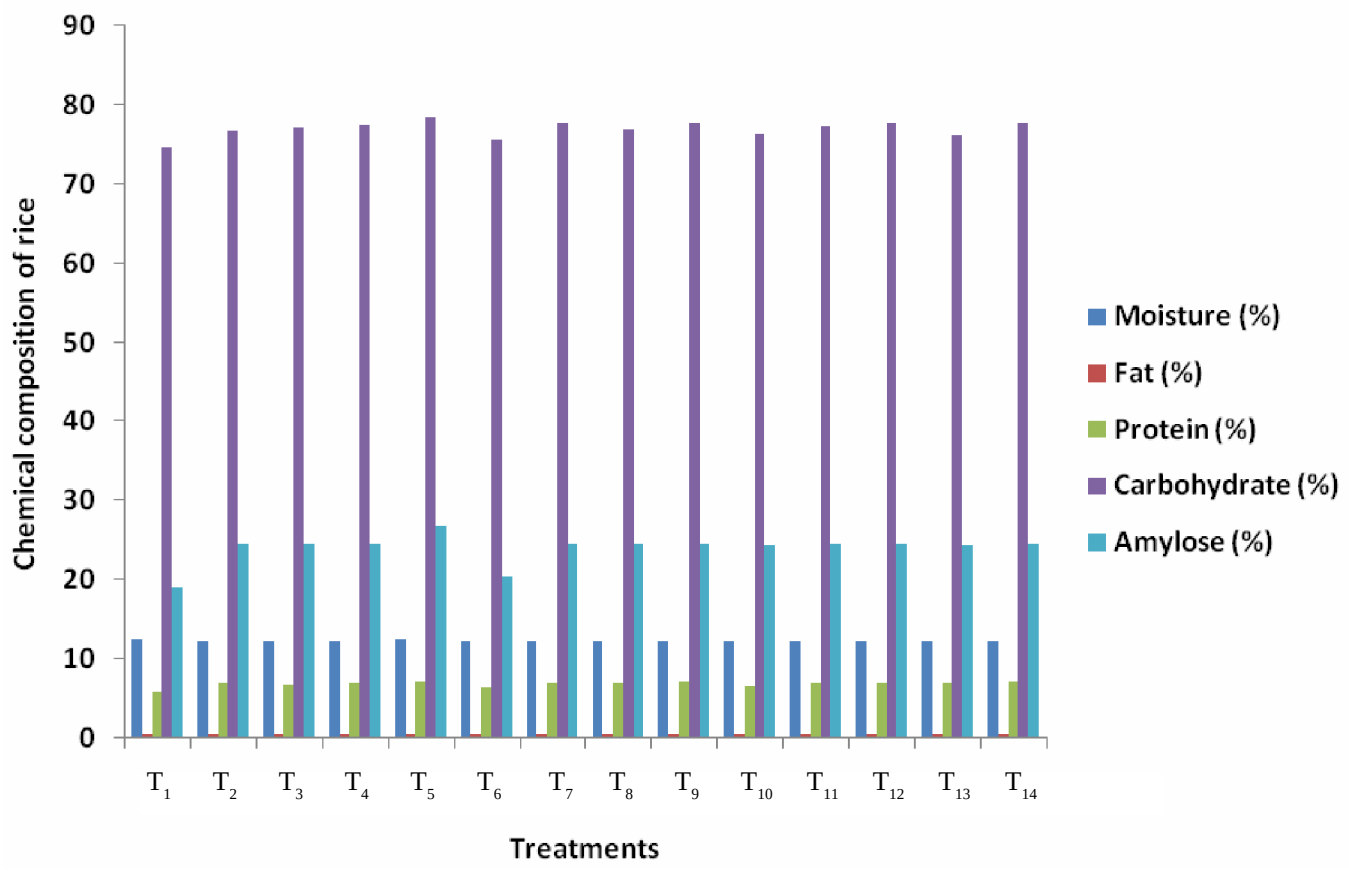

Fig. 10 : Effect of organic nutrient supply packages in comparison with RDF and INM on chemical composition of rice (*Samba* 2013)

development and yield of rice (Yoshida, 1972).

Straw yield :

The straw yield was significantly influenced by the treatments imposed in both the years of study (Table 2), (Fig. 3 and 4). 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 the straw yield (7470 and 7490 kg ha^{-1} in 2012 and 2013, respectively) which was on par with recommended NPK fertilizers (T_{13}),In 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 manure (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. In case of straw yield, the INM practice enhanced the straw yield and which was at par with recommended NPK fertilizers, 100% RDN through green manure and 25% RDN each through organic manure. All the treatments were superior over absolute control during both the years. This might be due to the fact that adequate biomass production and better nutrient uptake which might have resulted in higher straw yield in these treatments. This is in accordance with the results obtained by Yadav and Lourduraj (2006). The role of fertilizer N in improving the N availability which was responsible for higher DMP production in turn increased straw yield (Bridgit *et al.*, 1996). The straw yield increase in rice due to the combined use of organics and chemical fertilizers have been made earlier at several locations in India (Meelu and Morris, 1987; Singh *et al*., 1990; Siddeswaran, 1992 and Sudhakar, 2000).

Chemical composition of rice :

Moisture :

The treatments imposed did not significantly influenced the moisture percentage of rice in both the years of experimentation (Table 3 and 4) and (Fig. 8 for 2012 ; Fig. 10 for 2013).

Protein :

The treatments imposed had direct influence on protein content of rice in both the years of study (Table 3 and 4) and (Fig. 8 and 10). Higher protein content was recorded with100% RDN through green manure (T_5) (7.14 and 7.17%) and it was comparable with INM practice (T_{14}) (7.10 and 7.12) during 2012 and 2013 The recommended dose of NPK fertilizers (T_{13}) recorded with the protein content of 7.00 and 7.01 per cent during 2012 and 2013, respectively. Lower protein content was recorded for absolute control (T_1) (5.82 and 5.84 during 2012 and 2013, respectively). Invariably all the organic treatments resulted with more protein content and it was comparable with INM practice (T_{14}) during both the years of study.

Carbohydrate :

The treatments imposed did not significantly influenced the carbohydrate content of rice in both the years of experimentation (Fig. 8 and 10). However, the carbohydrate content of rice was higher in all the organic treatments which was higher than RDF and absolute control except INM.

Amylose :

The treatments imposed had direct influence on amylose content of rice in both the years of study (Fig. 8 and 10). The higher amylose content was registered with with100% RDN through green manure (T_5) (26.82 and 26.86%) and it was comparable with INM practice (T_{14}) (24.55 and 24.58) during 2012 and 2013. The recommended dose of NPK fertilizers (T_{13}) recorded with the amylose content of 24.24 and 24.38% during 2012 and 2013, respectively. Lower amylose content was recorded for absolute control (T_1) (19.00 and 19.03 during 2012 and 2013, respectively). Invariably all the organic treatments resulted with more amylose content and it was comparable with INM practice (T_{14}) during both the years of study.

Fat :

The treatments imposed did not significantly influenced the fat content of rice in both the years of experimentation (Fig. 8 and 10). However, the fat content of rice was higher in all the treatments except absolute control.

The INM practice registered with higher values of protein carbohydrates, amylose content and fat which was comparable with 100% RDN through green manure and all the other organic treatments than recommended dose of NPK fertilizer application in both the years of study. All these characters were lower in absolute control

during both the years of investigation. Nitrogen being an important element and constituent of the amino acids and protein probably, the increased uptake of N might have resulted in the increment of the crude protein. This might have lead to accumulation of higher quantities of seed components like calcium carbonate and increased the lipid metabolism which helps in increasing the protein content in seed. These results are in accordance with findings of Roy and Singh (2006). Higherand proper nutrition through the organic matter resulted with ensured supply of nutrients might have lead to increase in total amylase content and crude protein (Omar Hattab *et al.*, 1998; Radha, 1996 and Natarajan, 2003). Lampkin (1990) also stated that organic farming have higher protein content in the cereals.

Cooking quality of milled rice :

The cooking qualities like, volume expansion ratio and water absorption ratio, linear elongation ratio, breadth wise elongation ratio and length breadth ratio (L/B ratio) were recorded for both the years of study and furnished in (Table 3 for 2012; Table 4 for 2013) and (Fig. 8 for 2012 ; Fig. 10 for 2013). .

Volume expansion ratio :

The treatments imposed directly influenced on volume expansion ratio of rice in both the years of study (Table 3 and 4) and (Fig. 8 and 10). The higher volume expansion ratio was observed with 100% RDN through green manure (T_5) (3.24 and 3.26%) and it was comparable with INM practice (T_{14}) (3.00 and 3.10% during 2012 and 2013. The recommended dose of NPK fertilizers (T_{13}) recorded with the volume expansion ratio of 2.52 and 2.50% during 2012 and 2013, respectively. Lower volume expansion ratio was recorded for absolute control (T_1) (2.48 and 2.40 during 2012 and 2013, respectively). Invariably all the organic treatments resulted with more volume expansion ratio and it was comparable with INM practice (T_{14}) during both the years of study.

Water absorption ratio :

The treatments imposed did not significantly influenced the water absorption ratio in both the years of experimentation (Table 3 and 4) and (Fig. 8 and 10). However, the water absorption ratio was higher in all the treatments except absolute control.

Linear elongation ratio :

The treatments imposed did not significantly influenced the linear elongation ratio (LER) in both the years of experimentation (Table 3 and 4) and (Fig. 8 and 10). However, the linear elongation ratio was higher in 100% RDN through green manure applied treatment than all the other treatments whereas, lower linear elongation ratio was recorded in absolute control.

Breadth wise expansion ratio :

The treatments imposed did not significantly influenced the breadth wise elongation ratio in both the years of experimentation (Table 3 and 4) and (Fig. 8 and 10). However, the breadth wise elongation ratio was higher in 100% RDN through green manure applied treatment than all other treatments whereas, lower linear elongation ratio was recorded in absolute control.

The volume expansion ratio and water absorption ratio was higher with the INM practice followed by 100% RDN through green manure and all the other organic treatments than recommended dose of NPK fertilizer application in both the years of study. All the organic treatments registered higher volume expansion ratio and water absorption ratio and which was comparable with recommended NPK fertilizers and the lowest values were registered with absolute control in both the years of study. Bold rice grain was observed in the INM and all the organic treatments which may be due to higher volume expansion and water absorption ratio. This statement is also supported by Yadav and Lourduraj (2006). The cooking time was not significantly influenced by the different treatments, indicating no relationship of cooking time with the sources of nutrients.

Generally the grain length and breadth after cooking of rice were markedly influenced by INM practice followed by 100 per cent RDN through green manure and all the other organic treatments than recommended dose of NPK fertilizer application in both the years of study. Kernel length breadth after cooking (KBAC), linear elongation ratio (LER) were expressed similar trend in both the years of study. The increased length / breadth ratio after cooking was observed with the INM treatment followed by 100% RDN through green manure and 25% RDN through each organicmanure. This character is considered as desirable trait in high quality rice. Nguyen *et al.* (2002) reported that the application of organic manures gave a higher L:B ratio of rice after

cooking than with inorganic fertilizers.

Conclusion :

From this study, it was concluded that, the growth parameters and yield attributes like more number of tillers m^{-2}, more number of panicles m^{-2}, more number of filled grains per panicle, higher grain and straw yield of rice was recorded with the INM practice followed by recommended dose of fertilizers (RDF) treatment. Similar trend was noticed in root dry weight, root volume and NPK uptake at harvest of rice. Among the organic treatments, more number of tillers m^{-2}, more number of panicles m^{-2}, more number of filled grains per panicle, higher 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 experimentation.

Further from this study, it was found that the application of 100% RDN through green manure recorded higher grain and straw yield and the important quality parameters like water absorption ratio (WAR), volume expansion ratio (VER), linear elongation ratio (LER), breadth wise expansion ratio (BER) and L/B ratio was higher than the other organic treatments imposed in both the years of experimentation, which found to be the better organic nutrient management practice for enhancing organic rice production and for promoting organic rice farming in site-specific Western agro-climatic zone of Coimbatore in Tamil Nadu. With respect to the used quality parameters in the experiments are concerned, all other organic treatments were performed better than the RDF and INM treatments imposed in both the years of investigations.

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