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RESEARCH ARTICLE :

Impact of different sources of organic manures in comparison with RDF and INM on important quality parameters of rice variety co(r)48 with yield and derived correlation and regression equations under site-specific organic farming condition

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SUMMARY : Field experiments were carried out at Tamil Nadu Agricultural University, Coimbatore, India during *Samba* 2012 (August-December) and *Samba* 2013 to study the impact of different sources of organic manures in comparison with RDF and INM on important quality parameters of rice variety CO(R)48 with yield and derived correlation and regression equations under site-specific organic farming condition. 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, the same layout was maintained for next year *Samba* rice season. The quality parameters such as milling percentage, hulling percentage, head rice percentage, co-efficient of shelling, volume expansion ratio, water absorption ratio, elongation ratio, amylose content and protein content under organic farming were recorded higher during both the years of experimentation. Similarly, the grain yield of rice was also recorded during both the years of experimentation. All the important milling characteristics of paddy and the important quality parameters of rice were subjected to correlation and regression analysis and the separate correlation and regression equations were derived for grain yield of rice for both the years of study under site-specific organic farming condition. The important milling characteristics of paddy and the important quality parameters of rice were recorded with 100 % RDN through green manure (Dhaincha) *Sesbania aculeata* applied treatment, followed by 25% RDN through each organic manures combination recorded better results than other organic, RDF and INM treatments in both the years of experimentation. The performance of INM imposed treatment followed by RDF recorded more rice grain yield than the organic treatments, whereas the quality parameters wise, the organic treatments such as 100% RDN through green manure followed by 25% RDN through each organic manures combination recorded better results under organic farming than RDF and INM imposed treatments during both the years of investigation.

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BACKGROUND AND OBJECTIVES

Organic farming can provide quality food without adversely affecting the soil health and environment. The number of organic farms are increasing in India day by day. The demand for organic products are increasing all over the world as increasing number of people are becoming health conscious. Food materials produced organically has got in place in food market in developed and developing countries (Urkurkar *et al.*, 2010). In this direction, organic production of rice may increase the profitability of the farmers by earning foreign exchange through exports (Mahajan *et al*., 2012). Organic sources of nutrients are the best alternative for improving physical and biological properties of soil and improving crop productivity of rice based high value crops (Yadav *et al*., 2013).

Research programmes undertaken to increase the production and productivity of rice is of great value in the service of mankind and the nation (Barwale, 1993). A knowledge of association between yield and morpho-physiological and quality traits will help to make simultaneous selection for more characters. Partitioning the correlation co-efficients into direct and indirect effects will help in estimating the actual contribution of an attribute and its influence through other characters. Awareness about crop quality and soil health increased the attention of people towards organic farming (Sharma *et al.*, 2008). Balanced use of nutrients through organic sources like farmyard manure, vermicompost, green manuring, neem cake and biofertilizers are prerequisites to sustain soil fertility, to produce maximum crop yield with optimum input level (Dahiphale *et al*., 2003). The organic manures leave behind sufficient residual effect for the sequence crops (Singh *et al*., 1996). The cropping sequence of rice-pulse is practically feasible, viable, economical, eco-friendly water saving technology for sustaining soil fertility and rice productivity (Srinivasa Reddy, 2002).

Good crop stand establishment is one of the key components for efficient use of resources and inputs, consequently for achieving desired level of productivity. Efficient utilization and recycling of on farm resources is highly possible in organic farming situations to produce more farm inputs and for enhancing the quality of the farm produces. The wider spacing adoption (25 x 25 cm) for transplanting of rice enhanced the number of tillers per hill, enhances the rice productivity and economic returns (Gujja and Thiyagarajan, 2009).Therefore, the field experiment was conducted to find out the impact of different sources of organic manures in comparison with RDF and INM on the dependant variable (yield) of rice variety CO(R)48 with different independent variables (different milling and quality parameters) of rice with derived correlation and regression equations under site-specific organic farming condition.

RESOURCES AND METHODS

Description of the study site :

Field experiments were carried out at Tamil Nadu Agricultural University, Coimbatore, India during *Samba* 2012 and 2013 (August-December) and the experimental plot was in 'O' block of the Wetland farm, situated at the Western agro-climatic zone of Tamil Nadu at 11^{o}N latitude and 77^{o}E longitude and at an altitude of 426.7 m above mean sea level. The soil of the experimental field was clay loam in texture belonging to *Typic Haplustalf* with low in available N (254.0 and 260.0 kg ha^{-1}), low in available P (16.7 and 17.8 kg ha^{-1}) and high in available K (402.0 and 418.0 kg ha^{-1}) during the first and second years, respectively.

Materials used for the experiment :

Planting materials :

The medium duration rice variety called CO(R)48 was used in *Samba* season as the test crop during 2012-2013.

Table A : 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

Treatments and experimental design :

Treatment details :

T_1 : Absolute control (No fertilizers / manures)

T_2 : 100% Recommended dose of nitrogen (RDN) through FYM

T_3 : 100% RDN through Vermicompost

T_4 : 100% RDN through Poultry manure

T_5 : 100% RDN through Green manure*

T_6 : 50% RDN through FYM + 50% RDN through Vermicompost

T_7 : 50% RDN through FYM + 50% RDN through Poultry manure

T_8 : 50% RDN through FYM + 50% RDN through Green manure*

T_9 : 50% RDN through Vermicompost + 50% RDN through Poultry manure

T_{10} : 50% RDN through Vermicompost + 50% RDN through Green manure*

T_{11} : 50% RDN through Poultry manure + 50% RDN through Green manure*

T_{12} : 25% RDN each through FYM + Vermicompost + Poultry manure + Green manure*

T_{13} : Recommended Dose of Fertilizers (RDF) through inorganic fertilizers (150:50:50) NPK kg ha^{-1}

T_{14} : Integrated Nutrient Management (INM) practice (RDF + GM @ 6.25 t ha^{-1}).

*Green manure : Dhaincha (*Sesbania aculeata*) incorporation as green leaf manure at the time of puddling (two weeks prior to transplanting). T_{13} and T_{14} involving inorganic fertilizer applied plots were established separately well away from organic treatmental plots.

Experimental design :

The experiments were laid out in a Randomized Block Design with three replications. The gross and net plot sizes were 5.0 x 4.0 m and 4.5 x 3.5 m, respectively.

Experimental procedure :

Organic manure application :

On N equivalent basis, required quantities of farmyard manure, decomposed poultry manure, vermicompost were applied in the soil one week before transplanting, whereas the dhaincha (*Sesbania aculeata*) green manure was applied two weeks prior to transplanting on wet weight basis. Different sources of organic manures nutrient content were furnished in (Table A), and the quantity applied as per treatment schedule were furnished in (Table B).

Inorganic fertilizer application :

Recommended doses of 150:50:50 kg ha^{-1} of N, P and K in the form of urea, single super phosphate and muriate of potash were applied to the rice crop in respect of treatment T_{13}. The N was applied in four equal splits *viz.*, at basal, active tillering, panicle initiation and

Table B : Quantity of organic manures added on N equivalent basis and quantity of P_2O_5 and K_2O substituted (kg ha^{-1})

Treatments	Quantity added for 100 % N		P_2O_5 and K_2O		P_2O_5 and K_2O	
	2012	2013	Substituted during 2012		Substituted during 2013	
T_1 : Absolute control	-	-	-	-	-	-
T_2 : 100% RDN through FYM	25000	25862	105.00	160.00	103.00	176.00
T_3 : 100% RDN through VC	7853	7979	50.30	94.24	54.26	98.94
T_4 : 100% RDN through PM	6608	6667	93.83	81.94	96.67	81.34
T_5 : 100% RDN through GM	25281	25470	38.20	70.79	37.36	72.45
T_6 : 50% RDN each of FYM + VC	12500 + 3927	12931 + 3990	77.65	127.12	78.63	137.47
T_7 : 50% RDN each of FYM + PM	12500 + 3304	12931 + 3334	99.42	120.97	99.84	128.67
T_8 : 50% RDN each of FYM + GM	12500 + 12640	12931 + 12735	71.60	115.40	70.18	124.23
T_9 : 50% RDN each of VC + PM	3927 + 3304	3990 + 3334	72.07	88.09	75.47	90.14
T_{10} : 50% RDN each of VC + GM	3927 + 12640	3990 + 12735	44.25	82.52	45.81	85.70
T_{11} : 50% RDN each of PM + GM	3304 + 12640	3334 + 12735	66.02	76.37	67.02	76.90
T_{12} : 25% RDN each of FYM + VC + PM + GM	6250 + 1963 + 1653 + 6320	6466 + 1995 + 1666 + 6368	71.86	101.75	72.83	107.19
T_{13} : RDF : (150 : 50 : 50) NPK kg ha^{-1}	-	-	-	-	-	-
T_{14} : INM Practice (RDF + GM @ 6.25 t ha^{-1})	-	-	-	-	-	-

FYM : Farmyard manure, VC : Vermicompost, PM : Poultry manure and GM: Green manure Dhaincha (*Sesbania aculeata*)

INM : (150:50:50) NPK kg ha^{-1}, *Azospirillum* @ 2.5 kg ha^{-1}, *Phosphobacteria* @ 2.5 kg ha^{-1}, Zinc sulphate @ 50 kg ha^{-1} and Green manure 6.25 t ha^{-1}

flowering stages. The entire dose of P and K were applied basally before sowing. Only rice crop was fertilized while greengram was raised as a residual crop without any organic and fertilizer application.

Integrated Nutrient Management (INM) application:

In INM treatment T_{14}, 6.25 t ha^{-1} of green manure Dhaincha (*Sesbania aculeata*) was incorporated two weeks prior to transplanting along with the recommended doses of 150:50:50 kg ha^{-1} N, P and K in the form of urea, single super phosphate and muriate of potash were applied to the rice crop. In addition to this, application of 5 kg ha^{-1} of *Azospirillum*, 5 kg ha^{-1} of *Phosphobacteria* and 50 kg ha^{-1} of zinc sulphate were applied as basal prior to transplanting.

Water management :

The experimental plots were irrigated to 2 cm depth uniformly in all the treatments after the appearance of hair line cracks, upto panicle initiation stage. After panicle initiation, the crop was irrigated to 5 cm depth. Irrigation was stopped 15 days prior to harvesting of the crop.

Weed management :

One Cono weeding was given on 15 days after transplanting followed by two hand weeding on 30th and 45thday after transplanting to keep the field under weed free condition. No herbicide was applied for organic treatments whereas for inorganic and INM treatments Butachlor @ 2.5 lit ha^{-1}as pre emergence herbicide applied on 3 DAT.

Plant protection :

Neem seed kernel exract @ 3% and *Panchagavya* @ 3% were sprayed at 35 and 50 days after transplanting as a prophylactic measure against rice leaf folder and stem borer. *Panchagavya* @ 3% was again sprayed at 70 days after transplanting along with liquid formulation of *Pseudomonas fluorescens* @ 500 ml ha^{-1} against the neck blast, leaf spot diseases and grain discoloration. For the inorganic treatments (T_{13} and T_{14}), the chemical plant protection measures were taken as recommended in CPG (2012) on need basis.

Grain yield :

Harvesting was done manually using hand sickles and for the rice crop, border rows in the plots were harvested first and the net plots were then harvested and threshed, cleaned and dried to 14% moisture level and the grain yield from net plot was calculated and expressed in kg ha^{-1} (Hemalatha *et al*., 2000).

Milling characteristics of paddy :

Milling percentage :

The hulled brown rice was subjected to milling for 90 seconds *i.e.*, 5% milling (Chauhan *et al*., 1994) [9] in "Satake grain testing mill" and the weight was recorded. The milling percentage was calculated by using the following formula and presented in percentage.

$$\text{Milling percentage} = \frac{\text{Total weight of milled rice (g)}}{\text{Total weight of rough rice (g)}} \times 100$$

Head rice recovery :

Head rice percentage was estimated as below :

$$\text{Head rice percentage} = \frac{\text{Total head rice (g)}}{\text{total rough rice (g)}} \times 100$$

Broken rice percentage :

Broken rice percentage is defined as the percentage of broken rice to the weight of total quantity of rice obtained by shelling.

$$\text{Broken rice (\%)} = [\ W_2 / (W_1 + W_2)] \times 100$$

where,

W_1 -Weight of whole rice in the sample (g), and

W_2 -Weight of broken rice in the sample (g).

Co-efficient of shelling :

Co-efficient of shelling (C) was calculated with the following formula :

$$C = (W - W1) / W$$

where,

W - Total quantity of shelled paddy (g), and

W1 - Weight of unshelled paddy (g)

Effectiveness of shelling :

The effectiveness of shelling (ES) was calculated with the following formula :

$$ES = C \times H$$

where,

C - Co-efficient of shelling, and

H - Head rice percentage.

Physical parameters of rice grain :

The rice grains were cleaned manually to remove foreign matters such as stones, sand, clay particles, shrivelled, discoloured and infected grains. The following physical parameters were studied to evaluate the quality of rice.

Length :

The length was estimated by the method described by Khan and Ali (1985).Ten rice grains of uniform size were kept length-wise on a graph paper and the mean length was me measured and expressed in mm.

Breadth :

The breadth was estimated by the method described by Khan and Ali (1985). Ten rice grains of uniform size were kept breadth-wise on a graph paper and the mean breadth was measured and expressed in mm.

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 of rice grain :

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).

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

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.

Fibre :

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

Total ash :

Ash content per cent was calculated by using the following formula (A.O.A.C., 1980) :

$$\text{Ash content per cent} = \frac{\text{Weight of the ash}}{\text{Weight of the sample taken}} \times 100$$

Cooking qualities rice :

Optimum cooking time :

The time taken for cooking was estimated by the method described by Jayachandran (1997). Five gram of sample was taken in a boiling test tube. To this, 35 ml of water was added and placed in a boiling water bath. A few rice grains were periodically withdrawn and pressed between two slides and the cooking time was adjusted to be complete when white chalky spots had

disappeared.

Water absorption ratio :

The milled rice was put into a test tube containing distilled water @ 50 mL 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 mL / 100 gm 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.

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

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.

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

Elongation ratio :

The length of 20 milled grains were recorded and they were pre soaked for 30 minutes and placed directly into a test tube containing boiling water and cooked for 20 minutes. Then the length was measured with the help of a thread. The kernel length after cooking was calculated by using the following formula :

$$\text{Elongation ratio} = \frac{\text{Kernel length after cooking (mm)}}{\text{Kernel length before cooking (mm)}}$$

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 :

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

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

$$\text{Length breadth ratio after cooking (LBAC)} = \frac{\text{Kernel length after cooking}}{\text{Kernel breadth after cooking}}$$

Correlation and regression :

The data on important growth, yield parameters and nutrient uptake were correlated with the rice grain yield and their significant relationship was tested using 't' test and these levels of significance was noted as * for (0.05) and ** for (0.01). The significant parameters were further regressed using stepwise regression analysis and regression equations were derived. Correlation studies were made between grain yield and yield parameters. The values of correlation co-efficient (r) was calculated and tested for their significance at five per cent as per the procedure outlined by Snedekar and Cocoharan (1967). Simple regression analysis was also made and test of significance was done at five per cent as outlined by Snedekar and Cocoharan (1967).

Statistical analysis :

The data on various characters studied during the course of investigation were statistically analysed as suggested by Gomez and Gomez (2010). Wherever, the treatment differences were found significant by the ' F ' test, critical differences were worked out at five per cent probability level and the values furnished. Treatment differences that were non-significant were denoted by ' NS '. The correlation analysis was made between yield components and yield.

OBSERVATIONS AND ANALYSIS

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

Rice grain yield :

The treatments imposed had direct influence on rice grain yield in both the years of experimentation (Table 3). 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 per cent and 11.4 per cent 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 per cent and 22.0 per cent 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 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.

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 Vijay 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 which ultimately leads to higher total biomass production of rice. Padmaja Rao (1998) 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

Table 1 : Effect of organic manures, fertilizers and INM on milling quality of raw paddy (*samba* 2012)

Treatments	Milling recovery (%)	Whole rice (g)	Unshelled paddy (g)	Head rice recovery (%)	Broken rice (%)	Co-efficient of shelling	Effectiveness of shelling (%)
T_1 : Absolute control	61.9	34.6	12.50	58.6	41.4	0.74	44.0
T_2 : 100% RDN through FYM	65.2	40.6	9.80	61.4	38.6	0.80	51.0
T_3 : 100% RDN through VC	65.7	41.0	9.20	62.4	37.8	0.81	52.3
T_4 : 100% RDN through PM	66.4	41.4	8.40	63.2	36.8	0.82	53.0
T_5 : 100% RDN through GM	69.1	46.8	5.90	68.4	31.2	0.89	58.7
T_6 : 50% RDN each of through FYM + VC	64.4	40.0	9.20	60.2	39.2	0.78	48.3
T_7 : 50% RDN each of through FYM + PM	66.6	41.8	8.20	63.7	36.4	0.83	53.3
T_8 : 50% RDN each of through FYM + GM	65.6	40.8	8.60	61.8	38.2	0.81	51.4
T_9 : 50% RDN each of through VC + PM	66.8	42.0	7.90	64.0	36.2	0.79	53.7
T_{10} : 50% RDN each of through VC + GM	64.9	40.4	8.90	61.0	38.8	0.82	50.0
T_{11} : 50% RDN each of through PM + GM	65.8	41.2	8.80	62.8	37.4	0.74	52.7
T_{12} : 25% RDN each of through FYM+VC + PM + GM	67.2	42.1	7.70	64.2	35.9	0.84	54.2
T_{13} : (150 : 50 : 50) NPK kg ha^{-1}	62.4	39.6	10.40	59.4	39.8	0.76	46.2
T_{14} : INM Practice	67.4	42.3	7.60	64.3	35.8	0.84	54.8
S.E. ±	6.3	3.9	0.89	5.9	3.6	0.08	4.9
C.D. (P=0.05)	NS	7.9	1.84	NS	7.4	NS	10.1

NS=Non-significant

increase in yield contributing characters due to addition of mineral N along with organics like *Sesbania aculeata*, Gheethalakshmi (1996), Veerabadran and Solaiappan (1996) and Basnet (1999), FYM, Parida *et al*. (1995) and Geethalakshmi (1996), poultry manure, Dixit and Gupta (2000), Hemalatha *et al*. (1999) and Mohandas *et al*. (2008). Generally, the tiller formation in rice is highly influenced by solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately enhanced the growth and development and yield of rice reported by Yoshida (1976).

Table 2 : Effect of organic manures, fertilizers and INM on milling quality of raw paddy (*samba* 2013)

Treatments	Milling recovery (%)	Whole rice (g)	Unshelled paddy (g)	Head rice recovery (%)	Broken rice (%)	Co-efficient of shelling	Effectiveness of shelling (%)
T_1 : Absolute control	61.7	34.2	12.3	58.4	41.2	0.75	43.9
T_2 : 100% RDN through FYM	65.0	39.6	9.6	61.2	38.4	0.79	51.2
T_3 : 100% RDN through VC	65.5	39.0	9.0	62.2	37.6	0.80	52.3
T_4 : 100% RDN through PM	66.2	41.1	8.2	63.0	36.6	0.81	53.1
T_5 : 100% RDN through GM	69.2	46.4	5.8	69.2	31.0	0.88	58.8
T_6 : 50% RDN each of through FYM + VC	64.2	39.8	10.0	60.0	39.0	0.79	48.4
T_7 : 50% RDN each of through FYM + PM	66.4	41.4	8.0	63.5	36.2	0.82	53.2
T_8 : 50% RDN each of through FYM + GM	65.4	40.6	9.4	61.6	38.0	0.80	51.2
T_9 : 50% RDN each of through VC + PM	66.6	41.8	7.7	64.0	36.0	0.82	53.2
T_{10} : 50% RDN each of through VC + GM	64.7	40.2	9.8	60.8	38.6	0.80	50.3
T_{11} : 50% RDN each of through PM + GM	65.5	41.0	8.7	62.6	37.2	0.81	52.3
T_{12} : 25% RDN each of through FYM+VC+PM+GM	67.0	42.0	7.5	64.0	35.7	0.83	54.0
T_{13} : (150 : 50 : 50) NPK kg ha^{-1}	63.4	38.2	10.2	59.2	37.2	0.78	47.2
T_{14} : INM Practice	67.2	42.0	7.4	64.1	35.5	0.83	54.6
S.E. ±	6.2	3.8	0.9	5.9	3.5	0.08	4.9
C.D. (P=0.05)	NS	7.8	1.8	NS	7.3	NS	10.1

NS=Non-significant

Table 3 : Effect of organic manures, RDF and INM on physical characteristics of raw rice grain

Treatments	*samba* 2012				*samba* 2013			
	Grain yield (kg ha^{-1})	Grain length (mm)	Grain breadth (mm)	L/B ratio	Grain yield (kg ha^{-1})	Grain length (mm)	Grain breadth (mm)	L/B ratio
T_1 : Absolute control	3602	5.20	1.80	2.69	3646	5.22	1.81	2.70
T_2 : 100% RDN through FYM	4164	5.25	1.85	2.73	4190	5.24	1.84	2.72
T_3 : 100% RDN through VC	4296	5.28	1.88	2.76	4380	5.26	1.89	2.77
T_4 : 100% RDN through PM	4377	5.30	1.90	2.78	4550	5.31	1.91	2.78
T_5 : 100% RDN through GM	5084	5.35	1.93	2.80	5140	5.37	1.94	2.82
T_6 : 50% RDN each of through FYM + VC	3910	5.24	1.84	2.70	3980	5.25	1.85	2.73
T_7 : 50% RDN each of through FYM + PM	4721	5.31	1.91	2.79	4833	5.30	1.90	2.79
T_8 : 50% RDN each of through FYM + GM	4236	5.26	1.86	2.74	4316	5.25	1.92	2.78
T_9 : 50% RDN each of through VC + PM	4923	5.32	1.92	2.80	4986	5.31	1.91	2.78
T_{10} : 50% RDN each of through VC + GM	4079	5.24	1.84	2.72	4140	5.26	1.86	2.74
T_{11} : 50% RDN each of through PM + GM	4322	5.29	1.89	2.77	4430	5.28	1.88	2.76
T_{12} : 25% RDN each of through FYM + VC + PM + GM	5004	5.33	1.92	2.80	5120	5.32	1.92	2.79
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	5603	5.22	1.83	2.70	5680	5.23	1.83	2.71
T_{14} : INM Practice (RDF + GM @ 6.25 t ha^{-1})	6235	5.32	1.92	2.80	6270	5.31	1.91	2.79
S.E. ±	425	0.50	0.18	0.26	432	0.50	0.18	0.26
C.D. (P=0.05)	874	NS	NS	NS	889	NS	NS	NS

NS=Non-significant

Rice quality parameters :

Milling characteristics of paddy :

The INM practice, addition of organic manures and recommended NPK fertilizers in the first and second crop of rice had marked influence on the quality parameters in both the year of investigation (Table 1 and Table 2).

Milling recovery :

The treatments imposed did not significantly influenced the milling recovery percentage in both the years of experimentation. However, the milling recovery was higher in all the treatments except absolute control. Similar trend was also observed by Dixit and Gupta (2000) and Sreenivasa Reddy (2002).

Hulling percentage :

The treatments imposed did not significantly influenced the hulling recovery percentage in both the years of experimentation (Table 2). However, the hulling recovery was higher in all the treatments. Similar trend was also observed by Dixit and Gupta (2000) and Sreenivasa Reddy (2002).

Whole rice :

The treatments imposed had marked influence on weight of whole rice in both the years of experimentation. Application of 100 per cent RDN through green manure (T_5) registered with more weight of whole rice (46.8 g during 2012 and 46.4 g during 2013) and it was comparable with INM practice (T_{14}) (42.3 and 42.0) during 2012 and 2013. Lower weight of whole rice was registered in absolute control (T_1) (34.6 and 34.2, respectively) during both the years of study. The recommended dose of NPK fertilizers (T_{13}) recorded with lower weight of whole rice (39.6 and 38.2) during 2012 and 2013, respectively. Invariably all the organic treatments resulted with higher weight of whole rice and it was comparable with INM practice (T_{14}) during both the years of study.

Unshelled Paddy :

The treatments imposed had marked influence on weight of unshelled paddy in both the years of experimentation. The highest unshelled paddy was observed in absolute control (T_1) (12.5 g during 2012 and 12.3 g during 2013) followed by recommended NPK fertilizers (T_{13}) (10.4 and 10.2) during both the years of experimentation. Application of 100 per cent RDN through green manure (T_5) registered with lower weight of unshelled paddy (5.9 g during 2012 and 5.8 g during 2013) and it was comparable with INM practice (T_{14}) (7.6 and 7.4) during 2012 and 2013. Invariably all the organic treatments resulted with lesser weight of unshelled paddy when compared with recommended dose

Table 4 : Effect of organic manures, RDF and INM on chemical composition of rice (*samba* 2012)

Treatments	Moisture (%)	Protein (%)	Carbohydrate (%)	Amylose (%)	Fat (%)	Fibre (%)	Total ash (%)
T_1 : Absolute control	12.4	5.82	74.50	19.00	0.51	0.182	0.830
T_2 : 100% RDN through FYM	12.2	7.01	76.60	24.47	0.53	0.194	0.872
T_3 : 100% RDN through VC	12.2	6.82	77.00	24.50	0.54	0.196	0.874
T_4 : 100% RDN through PM	12.2	7.05	77.40	24.52	0.54	0.199	0.876
T_5 : 100% RDN through GM	12.4	7.14	78.28	26.82	0.58	0.229	0.882
T_6 : 50% RDN each of through FYM + VC	12.1	6.44	75.40	20.43	0.52	0.192	0.840
T_7 : 50% RDN each of through FYM + PM	12.2	7.06	77.50	24.53	0.55	0.200	0.877
T_8 : 50% RDN each of through FYM + GM	12.2	6.96	76.80	24.48	0.53	0.195	0.873
T_9 : 50% RDN each of through VC + PM	12.3	7.08	77.53	24.53	0.55	0.200	0.877
T_{10} : 50% RDN each of through VC + GM	12.1	6.64	76.20	24.45	0.53	0.193	0.870
T_{11} : 50% RDN each of through PM + GM	12.2	7.03	77.20	24.51	0.54	0.198	0.875
T_{12} : 25% RDN each of through FYM + VC + PM + GM	12.2	7.09	77.56	24.54	0.56	0.202	0.878
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	12.2	7.00	76.00	24.24	0.51	0.188	0.862
T_{14} : INM Practice (RDF + GM @ 6.25 t ha^{-1})	12.2	7.10	77.55	24.55	0.56	0.203	0.879
S.E. ±	1.2	0.65	7.31	2.28	0.05	0.018	0.083
C.D. (P=0.05)	NS	1.33	NS	4.68	NS	0.038	NS

NS=Non-significant

of fertilizer treatment and absolute control during both the years of study.

Head rice recovery :

The treatments imposed did not significantly influenced the head rice recovery percentage in both the years of experimentation. However, the head rice recovery was higher in all the treatments except absolute control.

Broken rice :

The treatments imposed had marked influence on

Table 5 : Effect of organic manures, RDF and INM on chemical composition of rice (*samba* 2013)

Treatments	Moisture (%)	Protein (%)	Carbohydrate (%)	Amylose (%)	Fat (%)	Fibre (%)	Total ash (%)
T_1 : Absolute control	12.4	5.84	74.62	19.03	0.51	0.184	0.835
T_2 : 100% RDN through FYM	12.2	7.02	76.80	24.50	0.54	0.196	0.874
T_3 : 100% RDN through VC	12.2	6.83	77.20	24.53	0.55	0.198	0.876
T_4 : 100% RDN through PM	12.2	7.06	77.60	24.55	0.55	0.201	0.878
T_5 : 100% RDN through GM	12.5	7.17	78.50	26.86	0.59	0.231	0.884
T_6 : 50% RDN each of through FYM + VC	12.2	6.46	75.60	20.47	0.53	0.194	0.842
T_7 : 50% RDN each of through FYM + PM	12.2	7.07	77.70	24.56	0.56	0.202	0.879
T_8 : 50% RDN each of through FYM + GM	12.2	6.98	77.00	24.51	0.54	0.197	0.875
T_9 : 50% RDN each of through VC + PM	12.3	7.10	77.73	24.57	0.56	0.202	0.879
T_{10} : 50% RDN each of through VC + GM	12.2	6.66	76.40	24.48	0.54	0.195	0.872
T_{11} : 50% RDN each of through PM + GM	12.2	7.05	77.40	24.54	0.55	0.199	0.877
T_{12} : 25% RDN each of through FYM + VC + PM + GM	12.2	7.09	77.76	24.57	0.57	0.204	0.879
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	12.2	7.01	76.20	24.38	0.52	0.191	0.868
T_{14} : INM Practice (RDF + GM @ 6.25 t ha^{-1})	12.2	7.12	77.68	24.58	0.57	0.205	0.881
S.E. ±	1.2	0.65	7.33	2.28	0.52	0.019	0.083
C.D. (P=0.05)	NS	1.33	NS	4.68	NS	0.039	NS

NS=Non-significant

Table 6 : Effect of organic manures, RDF and INM on cooking time, volume expansion ratio and water absorption ratio of milled rice

Treatments	*samba*2012			*samba*2013		
	Cooking time (minutes)	Volume expansion ratio	Water absorption ratio	Cooking time (minutes)	Volume expansion ratio	Water absorption ratio
T_1 : Absolute control	18.16	2.48	4.11	18.48	2.40	4.10
T_2 : 100% RDN through FYM	18.16	2.56	4.15	18.16	2.62	4.18
T_3 : 100% RDN through VC	18.17	2.68	4.20	18.17	2.70	4.22
T_4 : 100% RDN through PM	18.17	2.92	4.27	18.17	2.90	4.26
T_5 : 100% RDN through GM	18.46	3.24	4.68	18.50	3.26	4.70
T_6 : 50% RDN each of through FYM + VC	18.15	2.54	4.13	18.18	2.55	4.15
T_7 : 50% RDN each of through FYM + PM	18.18	2.96	4.28	18.19	2.97	4.25
T_8 : 50% RDN each of through FYM + GM	18.17	2.58	4.16	18.18	2.66	4.20
T_9 : 50% RDN each of through VC + PM	18.19	2.97	4.29	18.20	2.98	4.26
T_{10} : 50% RDN each of through VC + GM	18.16	2.55	4.14	18.15	2.60	4.16
T_{11} : 50% RDN each of through PM + GM	18.17	2.86	4.24	18.18	2.87	4.25
T_{12} : 25% RDN each of through FYM + VC + PM + GM	18.20	2.98	4.30	18.22	2.99	4.27
T_{13} : RDF (150 : 50 : 50) NPK kg ha^{-1}	18.22	2.52	4.12	18.27	2.50	4.11
T_{14} : INM Practice (RDF + GM @ 6.25 t ha^{-1})	18.23	3.00	4.33	18.26	3.10	4.28
S.E. ±	1.73	0.26	0.40	1.74	0.26	0.40
C.D. (P=0.05)	NS	0.54	NS	NS	0.54	NS

NS=Non-significant

broken rice percentage in both the years of study. The absolute control (T_1) had shown higher broken rice percentage of 41.4 and 41.2 during 2012 and 2013, respectively. Lower broken rice percentage was recorded with 100 per cent RDF through green manure (T_5) (31.2 and 31.0) and it was comparable with all the other organic treatments and INM practice (T_{14}) (35.8 and 35.5) during both the years of study. Among the organic treatments, the highest broken rice percentage was noticed with 50 per cent RDN through FYM and vermicompost (T_6) (39.2 and 39.0) followed by 50 per cent RDN through vermicompost and green manure (T_{10}) (38.8 and 38.6) in both the years of experiments. The recommended NPK fertilizers resulted with higher broken rice percentage (39.8 and 37.2) and it was inferior to absolute control during both the years of study.

Co-efficient of shelling :

The treatments imposed did not significantly influenced the Co-efficient of shelling in both the years of experimentation. However, the Co-efficient of shelling was higher in all the treatments except absolute control.

Effectiveness of shelling :

The treatments imposed had marked influence on effectiveness of shelling percentage in both the years of study. Higher effectiveness of shelling percentage was registered with 100 per cent RDN through green manure (T_5) (58.7 and58.8) and it was comparable with INM practice (T_{14}) (54.8 and 54.6) during 2012 and 2013. Lower effectiveness of shelling percentage was registered in absolute control (T_1) (44.0 and 43.9) during both the years of study. The recommended dose of NPK fertilizers (T_{13}) recorded with lower effectiveness of shelling percentage of 46.2 and 47.2 during 2012 and 2013, respectively. Invariably all the organic treatments resulted with higher effectiveness of shelling percentage and it was comparable with INM practice (T_{14}) during both the years of study.

Physical characteristics of raw rice grain :

Grain length :

The treatments imposed did not significantly influenced the grain length in both the years of experimentation. However, the grain length was higher in all the treatments except absolute control (Table 3).

Grain breadth :

The treatments imposed did not significantly influenced the grain breadth in both the years of experimentation. However, the grain breadth was higher in all the treatments except absolute control.

Table 7 : Effect of organic manures, fertilizers and INM on cooking characteristics of milled rice

Treatments	*samba* 2012					*samba* 2013				
	KLAC (mm)	KBAC (mm)	LER	BER	LBAC (mm)	KLAC (mm)	KBAC (mm)	LER	BER	LBAC (mm)
T_1 : Absolute control	9.42	2.30	1.70	1.19	3.99	9.55	2.31	1.71	1.20	4.01
T_2 : 100% RDN through FYM	9.72	2.32	1.74	1.21	4.04	9.82	2.43	1.75	1.23	4.08
T_3 : 100% RDN through VC	9.78	2.36	1.74	1.21	4.03	9.92	2.44	1.75	1.24	4.08
T_4 : 100% RDN through PM	9.86	2.42	1.75	1.22	4.02	9.98	2.46	1.76	1.24	4.07
T_5 : 100% RDN through GM	11.02	2.56	1.88	1.20	4.12	11.04	2.58	1.90	1.22	4.14
T_6 : 50% RDN each of through FYM + VC	9.65	2.30	1.73	1.20	4.04	9.77	2.40	1.73	1.23	4.09
T_7 : 50% RDN each of through FYM + PM	10.0	2.45	1.75	1.22	4.02	10.00	2.48	1.75	1.24	4.07
T_8 : 50% RDN each of through FYM + GM	9.76	2.34	1.74	1.21	4.03	9.86	2.43	1.74	1.24	4.08
T_9 : 50% RDN each of through VC + PM	10.01	2.46	1.77	1.22	4.02	10.02	2.49	1.77	1.25	4.07
T_{10} : 50% RDN each of through VC + GM	9.70	2.31	1.74	1.20	4.04	9.80	2.42	1.74	1.23	4.09
T_{11} : 50% RDN each of through PM + GM	9.80	2.39	1.76	1.21	4.03	9.96	2.45	1.76	1.24	4.08
T_{12} : 25% RDN each of through FYM+VC+PM+GM	10.02	2.47	1.76	1.22	4.02	10.03	2.50	1.77	1.25	4.07
T_{13} : (150 : 50 : 50) NPK kg ha^{-1}	10.04	2.49	1.77	1.24	4.03	10.04	2.52	1.78	1.26	4.08
T_{14} : INM Practice	10.03	2.48	1.76	1.22	4.02	10.02	2.51	1.78	1.25	4.07
S.E. ±	0.94	0.23	0.17	0.12	0.38	0.95	0.23	0.17	0.12	0.39
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

KLAC : Kernel length after cooking
KBAC : Kernel breadth after cooking
BER : Breadth wise expansion ratio
NS=Non-significant
LER : Linear elongation ratio
LBAC : Length breadth ratio after cooking

L/B ratio :

The treatments imposed did not significantly influenced the L/B ratio in both the years of experimentation. However, the L/B ratio was higher in all the treatments except absolute control.

Chemical composition of rice :

Moisture :

The treatments imposed did not significantly influenced the moisture percentage of rice in both the years of experimentation (Table 4 and 5).

Protein :

The treatments imposed had direct influence on protein content of rice in both the years of study (Table 4 and 5). 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% 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. Similar trend was also observed by Parida *et al*., 1995,, Hemalatha *et al*. (2000) and Hemalatha *et al*. (1999).

Carbohydrate :

The treatments imposed did not significantly influenced the carbohydrate content of rice in both the years of experimentation. However, the carbohydrate content of rice was higher in all the treatments except absolute control.

Amylose :

The treatments imposed had direct influence on amylose content of rice in both the years of study. 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

Table 8 : Correlation between grain yield of rice with different quality parameters (*samba* 2012)

	YLD 2012	MIL REC	HEAD REC	BRO KEN	GRN LEN	GRN BRDT	LB RATIO	G1000 WT	M CONT	PRO TEIN	CARBO HYD	AMY LOSE	FAT	FIBRE	TOT ASH	VOL EXP	WAT EXP	KLAC	KBAC	LER	BER	LBAC
YLD2012	1																					
MILREC	0.739**	1																				
HEADREC	0.796**	0.991**	1																			
BROKEN	0.108	0.730**	0.662**	1																		
GRNLEN	0.614**	0.983**	0.964**	0.836**	1																	
GRNBRDT	0.662**	0.989**	0.978**	0.782**	0.993**	1																
LBRATIO	0.643**	0.988**	0.973**	0.811**	0.998**	0.998**	1															
G1000WT	0.656**	0.983**	0.967**	0.756**	0.975**	0.983**	0.978**	1														
MCONT	0.595**	0.972**	0.952**	0.853**	0.996**	0.981**	0.991**	0.955**	1													
PROTEIN	0.756**	0.964**	0.961**	0.621**	0.921**	0.948**	0.937**	0.971**	0.891**	1												
CARBOHYD	0.648**	0.991**	0.974**	0.812**	0.998**	0.994**	0.998**	0.982**	0.992**	0.941**	1											
AMYLOSE	0.798**	0.901**	0.917**	0.471**	0.834**	0.868**	0.854**	0.911**	0.802**	0.958**	0.862**	1										
FAT	0.771**	0.995**	0.997**	0.691**	0.973**	0.986**	0.982**	0.971**	0.961**	0.958**	0.981**	0.906**	1									
FIBRE	0.834**	0.969**	0.987**	0.579**	0.926**	0.943**	0.935**	0.939**	0.915**	0.935**	0.938**	0.916**	0.978**	1								
TOTASH	0.648**	0.990**	0.973**	0.805**	0.994**	0.992**	0.996**	0.986**	0.985**	0.951**	0.998**	0.882**	0.980**	0.935**	1							
VOLEXP	0.907**	0.897**	0.933**	0.400**	0.824**	0.870**	0.851**	0.842**	0.802**	0.900**	0.845**	0.877**	0.922**	0.933**	0.842**	1						
WATEXP	0.772**	0.988**	0.994**	0.688**	0.969**	0.975**	0.974**	0.954**	0.965**	0.931**	0.975**	0.881**	0.992**	0.986**	0.969**	0.915**	1					
KLAC	0.813**	0.986**	0.994**	0.652**	0.955**	0.962**	0.961**	0.948**	0.949**	0.937**	0.964**	0.894**	0.990**	0.988**	0.960**	0.924**	0.994**	1				
KBAC	0.777**	0.990**	0.993**	0.692**	0.969**	0.980**	0.979**	0.951**	0.962**	0.943**	0.977**	0.877**	0.994**	0.968**	0.972**	0.932**	0.991**	0.988**	1			
LER	0.690**	0.984**	0.978**	0.774**	0.987**	0.979**	0.985**	0.956**	0.989**	0.909**	0.987**	0.843**	0.980**	0.960**	0.980**	0.857**	0.991**	0.980**	0.979**	1		
BER	0.565**	0.962**	0.937**	0.875**	0.992**	0.976**	0.988**	0.945**	0.996**	0.886**	0.988**	0.782**	0.949**	0.887**	0.982**	0.788**	0.947**	0.930**	0.954**	0.975**	1	
LBAC	0.518**	0.963**	0.934**	0.885**	0.994**	0.975**	0.987**	0.955**	0.997**	0.885**	0.989**	0.786**	0.946**	0.889**	0.984**	0.768**	0.945**	0.928**	0.945**	0.976**	0.997**	1

* and ** indicate significance of values at P=0.05 and 0.01, respectively

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. Similar trend was also observed by Parida *et al*. (1995), Hemalatha *et al*. (1999 and 2000) and Sreenivasa Reddy, (2002).

Fat :

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

Fibre :

The treatments imposed had very less influence on fibre content of rice in both the years of study. The more fibre content was recorded with 100 per cent RDN through green manure (T_5) (0.229 and 0.231%) and it was comparable with INM practice (T_{14}) (0.203 and 0.205 during 2012 and 2013 The recommended dose of NPK fertilizers (T_{13}) recorded with the fibre content of 0.188 and 0.191 per cent during 2012 and 2013, respectively. Lower fibre content was recorded for absolute control (T_1) (0.182 and 0.184 during 2012 and 2013, respectively). Invariably all the organic treatments resulted with more fibre content and it was comparable with INM practice (T_{14}) during both the years of study.

Total ash :

The treatments imposed did not significantly influenced the total ash content of rice in both the years of experimentation. However, the total ash content of rice was higher in all the treatments except absolute control.

Cooking quality of milled rice :

The cooking qualities like, cooking time, volume expansion ratio and water absorption ratio were recorded for both the years of study and furnished in Table 6.

Cooking time :

The different treatments imposed did not influence the cooking time (minutes) during both the years of experimentation (Table 6).

Volume expansion ratio :

The treatments imposed directly influenced on

Table 9 : Correlation between grain yield of rice with different quality parameters (*samba* 2013)

	YLD 2012	MIL REC	HEAD REC	BRO KEN	GRN LEN	GRN BRDT	LB RATIO	G1000 WT	M CONT	PRO TEIN	CARBO HYD	AMY LOSE	FAT	FIBRE	TOT ASH	VOL EXP	WAT EXP	KLAC	KBAC	LER	BER	LBAC
YLD2012	1																					
MILREC	0.748**	1																				
HEADREC	0.803**	0.994**	1																			
BROKEN	0.106	0.721**	0.653**	1																		
GRNLEN	0.627**	0.983**	0.964**	0.830**	1																	
GRNBRDT	0.666**	0.989**	0.976**	0.785**	0.993**	1																
LBRATIO	0.645**	0.987**	0.970**	0.813**	0.998**	0.998**	1															
G1000WT	0.674**	0.988**	0.972**	0.752**	0.977**	0.985**	0.982**	1														
MCONT	0.598**	0.970**	0.950**	0.851**	0.997**	0.985**	0.993**	0.961**	1													
PROTEIN	0.769**	0.965**	0.963**	0.610**	0.918**	0.941**	0.929**	0.970**	0.890**	1												
CARBOHYD	0.656**	0.991**	0.974**	0.805**	0.998**	0.995**	0.998**	0.987**	0.991**	0.942**	1											
AMYLOSE	0.807**	0.902**	0.917**	0.459**	0.830**	0.866**	0.846**	0.909**	0.800**	0.959**	0.862**	1										
FAT	0.776**	0.995**	0.997**	0.687**	0.974**	0.983**	0.979**	0.976**	0.961**	0.958**	0.982**	0.905**	1									
FIBRE	0.837**	0.970**	0.987**	0.574**	0.929**	0.945**	0.936**	0.945**	0.916**	0.937**	0.933**	0.916**	0.978**	1								
TOTASH	0.656**	0.990**	0.973**	0.798**	0.993**	0.993**	0.995**	0.990**	0.985**	0.951**	0.995**	0.882**	0.980**	0.936**	1							
VOLEXP	0.935**	0.900**	0.933**	0.381*	0.819**	0.848**	0.833**	0.849**	0.791**	0.913**	0.842**	0.893**	0.919**	0.930**	0.842**	1						
WATEXP	0.758**	0.985**	0.989**	0.696**	0.973**	0.976**	0.974**	0.962**	0.968**	0.925**	0.975**	0.877**	0.987**	0.985**	0.965**	0.889**	1					
KLAC	0.762**	0.987**	0.991**	0.657**	0.971**	0.976**	0.973**	0.967**	0.964**	0.933**	0.975**	0.889**	0.988**	0.989**	0.970**	0.891**	0.999**	1				
KBAC	0.715**	0.993**	0.985**	0.734**	0.992**	0.990**	0.993**	0.973**	0.987**	0.934**	0.994**	0.860**	0.991**	0.953**	0.989**	0.877**	0.988**	0.986**	1			
LER	0.699**	0.977**	0.973**	0.752**	0.984**	0.977**	0.982**	0.95**	0.986**	0.895**	0.983**	0.829**	0.976**	0.959**	0.972**	0.848**	0.993**	0.988**	0.992**	1		
BER	0.590**	0.971**	0.944**	0.851**	0.995**	0.984**	0.993**	0.965**	0.993**	0.904**	0.992**	0.801**	0.957**	0.895**	0.988**	0.794**	0.950**	0.947**	0.983**	0.969**	1	
LBAC	0.607**	0.977**	0.951**	0.849**	0.996**	0.984**	0.993**	0.973**	0.995**	0.910**	0.994**	0.815**	0.962**	0.911**	0.990**	0.798**	0.961**	0.959**	0.986**	0.976**	0.997**	1

* and ** indicate significance of values at P=0.05 and 0.01, respectively

volume expansion ratio of rice in both the years of study (Table 6). The higher volume expansion ratio was observed with 100 per cent 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 per cent 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. Similar trend was also observed by Shanmugasundaram 91987), Parida *et al*. (1995) and Singh *et al*. (2000).

Water absorption ratio :

The treatments imposed did not significantly influenced the water absorption ratio in both the years of experimentation. 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. 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. The increased length / breadth ratio after cooking was observed with 100% RDN through green manure followed by INM practices. 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.

Cooking characteristics of milled rice :

The cooking characteristics of milled rice like kernel length after cooking, kernel breadth after cooking, linear elongation ratio, breadth wise expansion ratio and length breadth ratio after cooking were recorded for both the years of experimentation (Table 7).

Table 10 : Regression analysis between grain yield of rice with different quality parameters (*samba* 2012 and 2013)

Sr. No.	Parameters	Regression Equation	R^2 values
1.	Milling qualities of raw paddy (2012)	Y = 5.295 + 693.407 (MILREC) -205.207 (WHOLE) + 400.297 (UNSHELL) -266.570 (HEADREC) - 526.272 (BROKEN)	0.979
2.	Milling qualities of raw paddy (2013)	Y = 29.766 + 447.003 (MILREC) -139.883 (WHOLE) + 265.816 (UNSHELL) -111.758 (HEADREC) - 389.483 (BROKEN)	0.972
3.	Physical characteristics of raw rice (2012)	Y = -32.079 -11143.809 (GRNLEN) - 3231.180 (GRNBRDT) + 23895.769 (L/B RATIO) + 203.324 (G1000WT)	0.575
4	Physical characteristics of raw rice (2013)	Y = -122.541 - 3625.869 (GRNLEN) + 10420.553 (GRNBRDT) + 18.267 (L/B RATIO) + 238.384 (G1000WT)	0.535
5.	Chemical composition of rice (2012)	Y = 16.755 - 208.272 (PROTEIN) + 683.943 (CARBOHYD) + 393.639 (AMYLOSE) + 37713.915 (FAT) - 27408.913 (FIBRE) - 81632.119 (TOTASH)	0.932
6.	Chemical composition of rice (2013)	Y = 6.256 + 7.368 (PROTEIN) + 564.353 (CARBOHYD) + 330.231 (AMYLOSE) + 36394.278 (FAT) -21483.042 (FIBRE) -71795.792 (TOTASH)	0.937
7.	Cooking qualities of milled rice (2012)	Y = - 9.114 - 702.190 (COOKTIM) + 1001.790 (VOLEXP) + 3426.415 (WATEXP)	0.921
8.	Cooking qualities of milled rice (2013)	Y = - 24.346 - 491.394 (COOKTIM) + 1933.743 (VOLEXP) + 1922.466 (WATEXP)	0.957
9.	Cooking characteristics of milled rice-open cooked (2012)	Y = - 12.973 + 1787.636 (KLAC) + 1093.589 (KBAC) - 4045.142 (LER) + 4401.250 (BER) - 3446.212 (LBAC)	0.986
10.	Cooking characteristics of milled rice-open cooked (2013)	Y = -56.540 - 592.173 (KLAC) + 22862.207 (KBAC) - 7725.936 (LER) - 31140.226 (BER) + 1614.128 (LBAC)	0.954

Kernel length after cooking :

The treatments imposed did not significantly influenced the kernel length after cooking (KLAC) in both the years of experimentation. However, the kernel length after cooking was higher in 100 per cent RDN through green manure applied treatment than all the other treatments whereas, lower kernel length after cooking was recorded in absolute control.

Kernel breadth after cooking :

The treatments imposed did not significantly influenced the kernel breadth after cooking (KBAC) in both the years of experimentation. However, the kernel breadth after cooking was higher in 100 per cent RDN through green manure applied treatment than all the other treatments whereas, lower kernel breadth after cooking 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. However, the breadth wise elongation ratio was higher in 100 per cent RDN through green manure applied treatment than all other treatments whereas, lower linear elongation ratio was recorded in absolute control.

Length breadth ratio after cooking :

The treatments imposed did not significantly influenced the length breadth ratio after cooking (LBAC) in both the years of experimentation. However, the length breadth ratio after cooking was higher in 100 per cent RDN through green manure applied treatment than all the other treatments whereas, lower the length breadth ratio after cooking was recorded in absolute control.

Correlation between grain yield with milling qualities of paddy, physical and chemical composition and cooking qualities of rice :

The correlation between grain yield with milling qualities of paddy *viz.*, (milling recovery, head rice recovery and broken rice recovery), physical characteristics of rice *viz.*, (grain length, grain breadth, L/B ratio and thousand grain weight), chemical composition of rice *viz.*, (moisture content, protein content, carbohydrate content, amylose content, fat content, fibre content and total ash content), cooking qualities of rice *viz.*, (volume expansion ratio and water expansion ratio) and cooking qualities of rice (open-cooked) *viz.*, (kernel length after cooking, kernel breadth after cooking, length elongation ratio, breadth elongation ratio and length breadth after cooking) were positively correlated at one per cent level during 2012 and 2013 (Table 8 and 9).

Regression between grain yield with milling qualities of paddy, physical and chemical composition and cooking qualities of rice :

To see the stepwise regression analysis, the independent variables which had a significant relationship with a dependent variable from the correlation study were selected and used. The equations presented in Table 10, represents the regression between grain yield with milling qualities of paddy *viz.*, (milling recovery, head rice recovery and broken rice recovery) with the R^2 values of (0. 979 and 0.972), physical characteristics of rice *viz.*, (grain length, grain breadth, L/B ratio and thousand grain weight) with the R^2 values of (0.575 and 0.535), chemical composition of rice *viz.*, (moisture content, protein content, carbohydrate content, amylose content, fat content, fibre content and total ash content) with the R^2 values of (0.932 and 0.937), cooking qualities of rice *viz.*, (volume expansion ratio and water expansion ratio) with the R^2 values of (0.921 and 0.957) and cooking qualities of rice (open-cooked) *viz.*, (kernel length after cooking, kernel breadth after cooking, length elongation ratio, breadth elongation ratio and length breadth after cooking) with the R^2 values of (0.986 and 0.954) were regressed during both the years of experimentation.

Conclusion :

The grain yield of rice, was higher recorded with INM practice followed by RDF treatment, whereas among the organic treatments, 100% RDN through green manure followed, by 25% RDN through each organic manures combination recorded more grain yield rice during both the years of experimentation. This study mainly focused on the correlation and regression analysis. The correlation between the grain yield of rice with important milling characteristics of paddy and cooking qualities of rice were positive during 2012 and 2013. The regression analysis was performed to assess the reliability of the most contributing independent variable (important milling characteristics of paddy and cooking qualities of

rice) on dependent variable (rice grain yield) over seasons. To see the stepwise regression analysis, the independent variables which had a significant relationship with a dependent variable. Separate regression equations were derived and furnished in Table 10.

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