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**Growth, yield and grain quality of traditional paddy varieties
as influenced by nutrient management practices**

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ABSTRACT

A field experiment was conducted during Kharif 2014 in red gravely loam soil at Agriculture and Horticultural Research Station, University of Agricultural and Horticultural Sciences, Honnavale to study the effect of different nutrient management practices on growth, yield and grain quality of traditional paddy varieties. The experiment was laid out in a randomized complete block design (factorial concept) with four varieties and four different nutrient management practices with three replications. The high yielding paddy variety JGL-1798 recorded significantly higher plant height (81.6 cm), number of effective tillers (29.0/hill), larger leaf area (361.6 cm²/hill), leaf area index (1.18), leaf area duration (104.8 days), total dry matter accumulation (91.5 g/hill), grain yield (4997 kg/ha) and straw yield (5488 kg/ha) compared to all traditional varieties. Among the different nutrient management practices, application of recommended FYM + 100 per cent recommended N equivalent through organics recorded significantly taller plants (74.8 cm), number of effective tillers (26.3/hill), leaf area (337.5 cm²/hill), leaf area index (1.69), leaf area duration (96.0 days), total dry matter accumulation (83.1 g/hill), grain yield (3580 kg/ha) and straw yield (4558 kg/ha). Higher hulling, milling per cent and lower cooking time were recorded with traditional paddy variety Chinnaponni along with the application of recommended FYM + 100 per cent recommended N equivalent through organics (73.2, 68.1% and 10.0 minutes, respectively). The variety Coimbatore Sanna along with application of recommended FYM + 100 per cent recommended N equivalent through organics recorded higher overall acceptability, amylose and starch content of cooked rice (8.0, 29.2% and 83.8% respectively). Higher water uptake ratio of cooked rice (1:6.7) was recorded in variety Mysore Mallige along with the application of recommended FYM + 100 per cent recommended NPK through inorganics. The volume expansion of cooked rice (14.8%) was recorded with variety Mysore Mallige along with application of recommended FYM + 50 per cent N equivalent through organics + 50 per cent NPK through inorganics compared to all other treatments.

Keywords: Amylase; cooking quality; grain yield; plant height; sensory evaluation

INTRODUCTION

Organic agriculture which supports sustainable forms of food production and

long-term security of our food supply at low cost is gradually regaining importance. The demand for organic food is steadily increasing both in developed and

developing countries. Rice produced by organic farming has higher grain quality, appearance, size and shape, behaviour upon cooking, taste, tenderness and flavour of cooked rice which are highly influenced by the nutrient management practices. In this context organically grown rice has the potential to produce high quality products with relevant improvements in terms of contents of anti-oxidants, phyto-nutrients and minerals with no pesticides residues (Hegde et al 2013). On-farm conservation of traditional seeds provides healthy environment, enhances biological wealth and retains germplasms within the farming communities which aims at community self-reliance towards seeds and food. Malnad tracts and coastal parts of Karnataka are still houses of several hundred of traditional varieties of rice which need to be collected, conserved and popularized among the farming community before the extinct. No doubt most of hybrids were high yielding but traditional varieties have valuable advantages such as better taste, adaptation to local climatic conditions, medicinal value, lesser fertilizer and water requirements, pest and diseases resistant etc.

MATERIAL and METHODS

A field experiment was conducted during the Kharif 2014 at the University of Agricultural and Horticultural sciences, Agriculture and Horticultural Research Station, Honnavile. The soil of the experimental site was red gravelly loam

(sand 81.1%, clay 11.5% and silt 7.4%) with acidic pH (5.6), electrical conductivity of 0.14 dS/m, bulk density of 1.25 mg/m³ and low organic carbon (0.42%). The available nitrogen was low (224.6 kg/ha), with medium phosphorus (26.7 kg/ha) and potassium (206.3 kg/ha). The experiment was laid out in a randomized complete block design (factorial concept) with four varieties and four nutrient management practices with three replications. The traditional cultivars viz Chinnaponni, Mysore Mallige, Coimbatore Sanna and high yielding variety JGL-1798 and different nutrient management practices viz recommended FYM + 100 per cent recommended NPK through organics, 100 per cent recommended NPK through inorganics (100:50:50 NPK kg/ha), recommended FYM + 50 per cent NPK through organics + 50 per cent NPK through inorganics and recommended FYM + 100 per cent recommended NPK through inorganics were used.

The organic manures were applied and incorporated 15 days before transplanting of seedlings. Entire recommended P and K with 50 per cent recommended N were applied at transplanting while 25 per cent recommended N each was top-dressed 30 and 50 days after transplanting. The separate nursery beds were prepared near to the main field and seeds were sown in nursery and 25 days old seedlings were transplanted at a spacing of 20 x 10 cm using one seedling/hill in plot of 4.0 x 3.0 m. The crop

was transplanted and harvested during 2nd week of August and 4th week of November respectively. The growth and yield parameters were recorded at 30, 60 and 90 days after transplanting and at harvest by following standard procedures. Grain quality parameters were analyzed by following procedures:

Physical parameters (hulling and milling percentage): Hulling percentage is the ratio between weight of total brown rice and weight of total rough rice expressed in percentage. Milling percentage is the ratio between weight of total milled rice and weight of total rough rice expressed in percentage (Ganga Devi et al 2012).

Sensory evaluation of cooked rice: The samples were evaluated by a panel of semi-trained judges (n= 12). The products were evaluated for appearance, texture, aroma, taste and overall acceptability on a nine point hedonic scale (9: Like extremely, 8: Like very much, 7: Like moderately, 6: Like slightly, 5: Neither like nor dislike, 4: Dislike slightly, 3: Dislike moderately, 2: Dislike very much, 1: Dislike extremely).

Keeping quality of cooked rice: The samples were evaluated by a panel of semi-trained judges (n= 5) for appearance, texture and aroma on a three point hedonic scale (1: Poor, 2: Good and 3: Excellent). Keeping quality was judged for 12 hours at four time intervals viz freshly cooked,

four hours after cooking, eight hours after cooking and twelve hours after cooking.

Cooking quality of rice: The cooking time was determined by boiling 2.0 g of whole rice kernels from each treatment in 20 ml distilled water, removing a few kernels at different time intervals during cooking and pressing them between two glass plates until no white core was left. Optimum cooking time was taken as the established cooking time plus two (2) additional minutes.

Water uptake ratio: It was determined by cooking 2.0 g of whole rice kernels from each treatment in 20 ml distilled water for a minimum cooking time in a boiling water bath and draining the superficial water from the cooked rice. The cooked samples were then weighed accurately and the water uptake ratio was calculated as the ratio of final cooked weight to uncooked weight.

Volume expansion: It was determined by observing the difference between volume of raw rice and cooked rice expressed in percentage.

Amylose and starch: Estimation of starch was done by anthrone reagent and amylose by iodine binding method described by Sadasivam and Manickam (1972).

The data obtained were subjected to statistical analysis by adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984).

RESULTS and DISCUSSION

Growth attributes

The high yielding paddy variety JGL-1798 recorded significantly higher plant height (81.6 cm), number of effective tillers (29.0/hill), higher leaf area (361.6 cm²/hill), leaf area index (1.81), leaf area duration (104.8 days) and total dry matter accumulation (91.5 g/hill) compared to all traditional varieties. Among the traditional paddy varieties, Chinnaponni recorded higher plant height (76.1 cm), number of effective tillers (26.4/hill), leaf area (323.3 cm²/hill), leaf area index (1.66), leaf area duration (94.0 days) and total dry matter accumulation (82.9 g/hill) compared to Coimbatore Sanna and Mysore Mallige (Table 1). Significant increase in plant height might be due to greater availability and steady release of nutrients from organic sources (FYM) which perhaps enabled the recovery of plant height towards reproductive stage. Devaraju and Honnegowda (1998) opined that adequate and balanced supply of plant nutrients resulted in increased plant height, number of tillers and leaf area. Dry matter production of rice increased with increasing N levels which could be the result of taller plants and larger leaf area which increased the photosynthates production resulting in to enhanced dry matter accumulation (Zhao et al 2005). Among the different nutrient management practices recommended FYM + 100 per cent recommended N equivalent through organics recorded

significantly taller plants (74.8 cm), number of effective tillers (26.3/hill), leaf area (337.5 cm²/hill), leaf area index (1.69), leaf area duration (96.0 days) and total dry matter accumulation (83.1 g/hill). Application of FYM might have provided nutrients continuously as well as growth hormones that are linked to the increase in leaf area/plant as a consequence of more assimilatory surface area which promoted production of larger quantities of photosynthates finally resulting in better plant growth and development. More leaves/plant might be owing to the adequate availability and supply of nutrients in balanced proportion which ultimately resulted in triggering the production of plant growth hormones in combination with humic acid and other hormones in paddy. Lal et al (2002) found that increased rates of organic manure application resulted in better plant growth as indicated by increase in plant height and number of leaves/plant.

Yield attributes

Yield attributes as well as grain and straw yields of rice were significantly influenced by cultivars and different nutrient management practices. Significantly higher number of panicles (29.7), panicle length (23.5 cm), panicle weight (4.81 g), 1000-grain weight (24.1 g), total number of grains (182.5), number of filled grains (174.8), higher grain yield (4997 kg/ha) and straw yield (5487 kg/ha) were recorded with variety JGL-1798 compared to all traditional varieties (Table 2). Increase in

Table 1. Growth parameters of paddy varieties as influenced by nutrient management practices

Treatment	Plant height (cm)	Effective tillers/hill	Leaf area (cm ² /hill)	Leaf area index	Leaf area duration (days)	Total dry matter accumulation (g/hill)
Variety (V)						
V ₁	76.1	26.4	323.3	1.66	94.0	82.9
V ₂	63.0	20.4	288.5	1.45	83.1	67.9
V ₃	68.2	23.8	318.9	1.60	87.9	75.6
V ₄	81.6	29.0	361.6	1.81	104.8	91.5
SEm±	1.0	0.6	7.0	0.03	1.32	1.19
CD _{0.05}	3.0	1.8	20.1	0.08	3.84	3.44
Nutrient level (N)						
N ₁	74.8	26.3	337.5	1.69	96.0	83.1
N ₂	68.4	22.3	305.7	1.53	87.0	74.1
N ₃	72.8	25.2	317.9	1.63	93.0	80.0
N ₄	72.9	25.8	331.2	1.66	93.9	80.8
SEm±	1.0	0.6	7.0	0.03	1.32	1.19
CD _{0.05}	3.0	1.8	20.1	0.08	3.84	3.44
Interaction (V x N)						
SEm±	2.1	1.2	13.9	0.05	2.65	2.37
CD _{0.05}	NS	NS	NS	NS	NS	NS

V₁ = Chinnaponni, V₂ = Mysore Mallige, V₃ = Coimbatore Sanna, V₄ = JGL-1798, N₁ = Recommended FYM + 100% recommended N equivalent through organics, N₂ = 100 % recommended NPK through inorganics (100:50:50 NPK kg/ha), N₃ = Recommended FYM + 50% N equivalent through organics + 50% NPK through inorganics, N₄ = Recommended FYM + 100 % recommended NPK through inorganics, NS = Non-significant

grain and straw yield may be due to the higher yield attributing parameters viz number of panicles/hill, number of grains/panicle, panicle length and higher filled grains/panicle. Application of higher levels of nutrients through FYM was found to enhance the process of tissue differentiation ie from somatic to reproductive phase leading thereby to increased floret number and grain setting. Similar findings were reported by Maiti et al (2006). The traditional paddy varieties produced less

number of panicles/hill, number of grains/panicle, panicle length and higher unfilled grains/panicle. Among the different nutrient management practices application of recommended FYM + 100 per cent recommended N equivalent through organics noticed significantly higher number of panicles (26.0), panicle length (20.8 cm), panicle weight (3.76 g) 1000-grain weight (22.2 g), total number of grains (161.5), number of filled grains (152.0), grain yield (3580 kg/ha) and straw yield (4558 kg/ha)

Table 2. Yield and yield parameters of paddy varieties as influenced by nutrient management practices

Variety (V)	Nutrient level									
	N ₁	N ₂	N ₃	N ₄	Mean	N ₁	N ₂	N ₃	N ₄	Mean
	Panicle length (cm)									
V ₁	27	24	26	26	25.7	22.0	20.0	21.5	21.7	21.3
V ₂	21	18	21	21	20.2	17.3	15.4	16.5	16.7	16.5
V ₃	25	22	24	25	24.0	19.7	17.5	18.6	19.0	18.7
V ₄	31	28	30	30	29.7	24.2	22.1	23.7	23.9	23.5
Mean	26.0	23.0	25.2	25.5	24.9	20.8	18.7	20.1	20.3	20.0
	SEm±		CD _{0.05}			SEm±		CD _{0.05}		
Variety	0.4		1.2			0.3		0.9		
Nutrient level	0.4		1.2			0.3		0.9		
V x N	0.9		NS			0.6		NS		
	Panicle weight (g)									
V ₁	4.3	3.7	4.1	4.2	4.10	22.6	20.7	22.1	22.7	22.0
V ₂	2.7	2.2	2.7	2.7	2.61	18.7	18.3	18.4	19.4	18.7
V ₃	2.9	2.7	3.2	3.2	3.00	23.3	17.8	19.1	20.8	20.3
V ₄	5.1	4.4	4.8	4.9	4.81	24.5	23.0	23.8	24.9	24.1
Mean	3.76	3.20	3.70	3.72	3.62	22.2	19.9	20.8	21.9	21.3
	SEm±		CD _{0.05}			SEm±		CD _{0.05}		
Variety	0.1		0.3			0.3		1.0		
Nutrient level	0.1		0.3			0.3		1.0		
V x N	0.2		NS			0.7		NS		
	1000-grain weight									

Traditional paddy as influenced by nutrient management

	# filled grains/panicle				Total # grains/panicle					
V ₁	156.0	143.0	152.0	154.0	151.3	165.0	153.0	161.0	162.0	160.3
V ₂	128.0	114.0	123.0	125.0	122.5	140.0	128.0	136.0	138.0	135.5
V ₃	142.0	128.0	136.0	139.0	136.3	152.0	140.0	147.0	149.0	147.0
V ₄	182.0	168.0	173.0	176.0	174.8	189.0	177.0	181.0	183.0	182.5
Mean	152.0	138.2	146.0	148.5	146.2	161.5	149.5	156.2	158.0	156.3
	SEm±		CD _{0.05}			SEm±		CD _{0.05}		
Variety	2.2		6.2			2.1		6.1		
Nutrient level	2.2		6.2			2.1		6.1		
V x N	4.3		NS			4.2		NS		
	Grain yield (kg/ha)				Straw yield (kg/ha)					
V ₁	3908	3277	3562	3696	3610	5125	4618	4875	4951	4892
V ₂	1997	1505	1686	1880	1767	2813	2052	2386	2579	2458
V ₃	3132	2638	2785	2970	2881	4488	3874	4015	4043	4105
V ₄	5284	4730	4946	5029	4997	5809	5147	5389	5606	5487
Mean	3580	3037	3244	3393	3314	4558	3916	4166	4294	4436
	SEm±		CD _{0.05}			SEm±		CD _{0.05}		
Variety	62		177			73		211.1		
Nutrient level	62		177			73		211.1		
V x N	124		NS			146		NS		

V₁ = Chinnaponni, V₂ = Mysore Mallige, V₃ = Coimbatore Sanna, V₄ = JGL-1798, N₁ = Recommended FYM + 100% recommended N equivalent through organics, N₂ = 100 % recommended NPK through inorganics (100:50:50 NPK kg/ha), N₃ = Recommended FYM + 50% N equivalent through organics + 50% NPK through inorganics, N₄ = Recommended FYM + 100 % recommended NPK through inorganics, NS= Non-significant

followed by recommended FYM + 100 per cent recommended NPK through inorganics and recommended FYM + 50 per cent N equivalent through organics + 50 per cent NPK through inorganics. This significant increase in grain yield may be due to the continuous supply of nutrients in balanced quantity throughout the growth stages that enabled the plant to assimilate sufficient photosynthetic products and thus increased dry matter accumulation and better nutrient supply for chlorophyll synthesis and healthy root growth for translocation of photosynthates. Therefore plants at higher level of nutrients produced more panicles and grains/panicle with increased test weight resulting into higher grain yield. The findings are supported by the results of Sudhakar et al (2006).

Grain quality parameters

Physical parameters: Higher hulling and milling per cent was recorded with traditional paddy variety Chinnaponni with the application of recommended FYM + 100 per cent recommended N equivalent through organics (73.2 and 68.1% respectively) followed by variety Chinnaponni with recommended FYM + 100 per cent recommended NPK through inorganics (73.1 and 68.0% respectively) (Table 3). Lakshmi et al (2014) also recorded higher values of milling and head rice recovery percentage with the application of organic sources when compared to no organic manuring which

might be due to balanced fertilization of N and K through organics. Similar findings were reported by Kesarwani et al (2009).

Sensory evaluation of rice: Sensory evaluation of cooked rice (appearance, texture, aroma, taste and overall acceptability) differed due to varieties and different nutrient management practices (Table 4). The variety Coimbatore Sanna along with application of recommended FYM + 100 per cent recommended N equivalent through organics recorded higher appearance (8.1), texture (7.6), aroma (7.6), taste (8.0) and overall acceptability of cooked rice (8.0) followed by variety JGL-1798 with recommended FYM + 100 per cent recommended NPK through inorganics (Table 4). This might be due to the reason that application of organic source of nutrients improved eating quality of rice than conventional farming and improved organoleptic properties were observed in organically produced food (Kumaran and Vadivel 2001). Similarly Sangeetha et al (2013) reported that application of enriched poultry manure compost registered higher colour, texture, taste and overall acceptability score as compared to recommended NPK fertilizer.

Keeping quality of rice: Keeping qualities viz appearance, texture and aroma differed due to varieties and different nutrient management practices (Table 5). Appearance of cooked rice was higher (2.45) with traditional variety Coimbatore

Table 3. Physical quality parameters of paddy varieties as influenced by nutrient management practices

Treatment	Hulling (%)	Milling (%)
V ₁ N ₁	73.17	68.13
V ₁ N ₂	72.17	67.57
V ₁ N ₃	73.00	67.93
V ₁ N ₄	73.13	68.00
V ₂ N ₁	72.03	67.27
V ₂ N ₂	70.97	66.53
V ₂ N ₃	71.70	66.90
V ₂ N ₄	72.00	67.07
V ₃ N ₁	70.93	66.47
V ₃ N ₂	70.00	65.70
V ₃ N ₃	70.87	66.33
V ₃ N ₄	70.67	66.40
V ₄ N ₁	69.43	65.47
V ₄ N ₂	68.53	64.83
V ₄ N ₃	69.33	65.17
V ₄ N ₄	69.30	65.33
Mean	71.08	66.57
SE	0.37	0.26

V₁ = Chinnaponni, V₂ = Mysore Mallige, V₃ = Coimbatore Sanna, V₄ = JGL-1798, N₁ = Recommended FYM + 100% recommended N equivalent through organics, N₂ = 100 % recommended NPK through inorganics (100:50:50 NPK kg/ha), N₃ = Recommended FYM + 50% N equivalent through organics + 50% NPK through inorganics, N₄ = Recommended FYM + 100 % recommended NPK through inorganics

Sanna along with the application of recommended FYM + 100 per cent recommended N equivalent through organics followed by variety JGL-1798 with recommended FYM + 100 per cent recommended NPK through inorganics (2.10). Higher texture of cooked rice (2.25) was recorded with traditional variety Coimbatore Sanna with the application of recommended FYM + 100 per cent recommended N equivalent through organics followed by variety JGL-1798 along with the recommended FYM + 100 per cent recommended NPK through

inorganics (2.20). The traditional variety Coimbatore Sanna with the application of recommended FYM + 100 per cent recommended N equivalent through organics recorded higher aroma of cooked rice (2.00) followed by variety JGL-1798 with application of recommended FYM + 100 per cent recommended NPK through inorganics (1.85) (Table 5). Keeping and cooking quality parameters are varietal characters and cannot be altered by agronomic practices (Champange et al 2007). Sangeetha et al (2013) also reported higher values of keeping quality parameters

Table 4. Sensory evaluation (nine point hedonic scale 1-9) of paddy varieties as influenced by nutrient management practices

Treatment	Appearance	Texture	Aroma	Taste	Overall acceptability
V ₁ N ₁	6.3	6.1	6.4	6.2	6.4
V ₁ N ₂	5.8	6.3	6.4	6.3	6.1
V ₁ N ₃	6.3	6.4	5.6	6	6.3
V ₁ N ₄	5.8	6.6	6.5	6.6	6.7
V ₂ N ₁	6.5	6.4	6.5	6.1	6.5
V ₂ N ₂	5.2	5.1	5.5	5.4	5.3
V ₂ N ₃	5.8	5.8	6.2	6.1	6.4
V ₂ N ₄	5.8	6.3	6.3	6.0	6.4
V ₃ N ₁	8.1	7.6	7.6	8.0	8.0
V ₃ N ₂	6.7	7.0	7.4	7.3	7.0
V ₃ N ₃	6.8	6.1	7.5	6.8	6.7
V ₃ N ₄	7.1	6.8	7.1	6.3	6.9
V ₄ N ₁	7.2	7.3	6.2	6.8	7.0
V ₄ N ₂	8	8.3	7.1	7.1	7.6
V ₄ N ₃	7.8	7.9	7.1	7.5	7.5
V ₄ N ₄	7.6	7.9	7.0	7.3	7.7
Mean	6.68	6.74	6.65	6.61	6.78
SE	0.22	0.22	0.16	0.17	0.17

V₁ = Chinnaponni, V₂ = Mysore Mallige, V₃ = Coimbatore Sanna, V₄ = JGL-1798, N₁ = Recommended FYM + 100% recommended N equivalent through organics, N₂ = 100 % recommended NPK through inorganics (100:50:50 NPK kg/ha), N₃ = Recommended FYM + 50% N equivalent through organics + 50% NPK through inorganics, N₄ = Recommended FYM + 100 % recommended NPK through inorganics, Nine point hedonic scale (9: Like extremely, 8: Like very much, 7: Like moderately, 6: Like slightly, 5: Neither like nor dislike, 4: Dislike slightly, 3: Dislike moderately, 2: Dislike very much, 1: Dislike extremely)

through the application of enriched poultry manure compost that registered higher appearance, texture, taste and aroma as compared to recommended NPK fertilizer which might be due to the reason that higher levels of N application through organics improved organoleptic properties of cooked rice.

Cooking quality of rice: The traditional paddy variety Chinnaponni with the application of recommended FYM + 100 per cent recommended N equivalent

through organics registered lower cooking time (10.0 minutes) followed by Chinnaponni and Coimbatore Sanna with application of 100 per cent recommended NPK through inorganics (100:50:50 NPK kg/ha) (12.3 minutes). Higher cooking time (18.7 minutes) was recorded with variety JGL-1798 with the application of 100 per cent recommended NPK through inorganics (100:50:50 NPK kg/ha). Higher water uptake ratio of cooked rice (1:6.7) was recorded with variety Mysore Mallige with the application of recommended FYM +

Table 5. Keeping quality of paddy varieties (three point hedonic scale 1-3) as influenced by nutrient management practices

Treatment	Appearance					Texture					Aroma				
	Hours after cooking					Hours after cooking					Hours after cooking				
	F	4	8	12	Mean	F	4	8	12	Mean	F	4	8	12	Mean
V ₁ N ₁	1.20	1.20	1.20	1.20	1.20	1.80	1.40	1.80	1.00	1.50	2.00	2.00	1.60	1.00	1.65
V ₁ N ₂	1.00	1.40	1.20	1.20	1.20	1.00	1.40	1.60	1.00	1.25	1.80	1.80	1.40	1.00	1.50
V ₁ N ₃	1.20	1.20	1.00	1.20	1.15	1.20	2.00	1.40	1.20	1.45	1.40	1.60	1.20	1.40	1.40
V ₁ N ₄	1.80	1.60	1.40	1.40	1.55	2.00	1.40	1.40	1.60	1.60	1.80	1.20	1.60	1.40	1.50
V ₂ N ₁	2.20	1.80	1.40	1.20	1.65	1.80	1.60	1.60	1.20	1.55	1.80	1.80	1.40	1.80	1.70
V ₂ N ₂	1.60	1.40	1.00	1.00	1.25	1.80	1.20	1.40	1.60	1.50	1.20	1.80	1.00	1.20	1.30
V ₂ N ₃	2.20	1.80	1.40	1.00	1.60	1.80	2.00	1.80	1.60	1.80	2.00	1.80	1.40	1.40	1.65
V ₂ N ₄	1.80	1.40	1.00	1.00	1.30	1.80	1.60	1.20	1.20	1.45	2.00	1.40	1.40	1.40	1.55
V ₃ N ₁	2.60	2.60	2.60	2.00	2.45	2.20	2.80	2.20	1.80	2.25	2.60	2.20	1.80	1.40	2.00
V ₃ N ₂	1.80	1.80	1.00	1.00	1.40	2.40	2.40	1.40	1.20	1.85	2.20	2.00	1.60	1.20	1.75
V ₃ N ₃	1.40	1.40	1.20	1.20	1.30	1.40	1.60	1.00	1.00	1.25	2.00	2.40	1.40	1.00	1.70
V ₃ N ₄	1.60	1.40	1.00	1.20	1.30	2.20	1.80	1.40	1.00	1.60	2.40	1.60	1.60	1.60	1.80
V ₄ N ₁	1.40	1.60	1.40	1.40	1.45	1.40	2.40	1.60	1.00	1.60	1.80	1.60	1.20	1.00	1.40
V ₄ N ₂	2.40	2.20	2.00	1.80	2.10	2.60	2.60	2.40	1.60	2.10	2.40	1.80	1.40	1.20	1.70
V ₄ N ₃	2.40	1.80	1.60	1.20	1.75	2.60	2.00	1.80	1.40	1.95	2.00	2.20	1.60	1.00	1.70
V ₄ N ₄	2.60	2.20	2.00	1.40	2.05	2.60	2.40	2.20	1.60	2.20	2.60	2.20	1.60	1.00	1.85

V₁ = Chinnaponni, V₂ = Mysore Mallige, V₃ = Coimbatore Sanna, V₄ = JGL-1798, N₁ = Recommended FYM + 100% recommended N equivalent through organics, N₂ = 100 % recommended NPK through inorganics (100:50:50 NPK kg/ha), N₃ = Recommended FYM + 50% N equivalent through organics + 50% NPK through inorganics, N₄ = Recommended FYM + 100 % recommended NPK through inorganics, F= Fresh cooked, Three point hedonic scale (1: Poor, 2: Good and 3: Excellent)

Table 6. Cooking quality of different paddy varieties as influenced by various nutrient management practices

Treatment	Cooking time (minutes)	Water uptake ratio	Volume expansion (%)	Amylose (%)	Starch (%)
V ₁ N ₁	10.0	1: 5.7	11.4	21.0	83.2
V ₁ N ₂	12.3	1: 3.9	9.4	26.2	82.2
V ₁ N ₃	15.3	1: 4.2	12.4	23.0	83.2
V ₁ N ₄	17.0	1: 5.2	13.0	22.0	79.4
V ₂ N ₁	15.0	1: 3.3	10.0	23.4	82.2
V ₂ N ₂	17.0	1: 4.3	12.6	27.5	78.3
V ₂ N ₃	15.0	1: 4.7	14.8	28.4	80.9
V ₂ N ₄	13.0	1: 6.7	14.1	27.0	82.6
V ₃ N ₁	13.0	1: 5.1	9.7	29.2	83.8
V ₃ N ₂	12.3	1: 4.5	11.0	28.4	83.4
V ₃ N ₃	15.3	1: 4.4	9.1	27.9	82.1
V ₃ N ₄	13.7	1: 4.7	10.5	23.4	80.8
V ₄ N ₁	15.7	1: 5.2	13.9	21.7	79.5
V ₄ N ₂	18.7	1: 5.3	13.5	22.1	80.5
V ₄ N ₃	15.3	1: 4.9	10.7	23.0	82.1
V ₄ N ₄	14.7	1: 5.7	12.5	26.0	79.5
Mean	14.6	4.86	11.7	25.0	81.5
SE	0.54	0.20	0.45	0.70	0.42

V₁= Chinnaponni, V₂= Mysore Mallige, V₃= Coimbatore Sanna, V₄= JGL-1798, N₁= Recommended FYM + 100% recommended N equivalent through organics, N₂= 100 % recommended NPK through inorganics (100:50:50 NPK kg/ha), N₃= Recommended FYM + 50% N equivalent through organics + 50% NPK through inorganics, N₄= Recommended FYM + 100 % recommended NPK through inorganics

100 per cent recommended NPK through inorganics followed by variety Chinnaponni with application of recommended FYM + 100 per cent recommended N equivalent through organics and JGL-1798 with the application of recommended FYM + 100 per cent recommended NPK through inorganics (1:5.7). Higher volume expansion of cooked rice (14.8%) was recorded with variety Mysore Mallige with the application of recommended FYM + 50 per cent N equivalent through organics + 50 per cent NPK through inorganics followed by variety

Mysore Mallige with the application of recommended FYM + 100 per cent recommended NPK through inorganics (14.1 %). The traditional paddy variety Coimbatore Sanna with the application of recommended FYM + 100 per cent recommended N equivalent through organics recorded higher amylose content (29.2%) in cooked rice followed by Mysore Mallige with application of recommended FYM + 50 per cent N equivalent through organics + 50 per cent NPK through inorganics and Coimbatore

Sanna with application of 100 per cent recommended NPK through inorganics (100:50:50 NPK kg/ha) (28.4%). Starch content of cooked rice was higher with variety Coimbatore Sanna (83.8%) along with the application of recommended FYM + 100 per cent recommended N equivalent through organics followed by Chinnaponni with application of recommended FYM + 100 per cent recommended N equivalent through organics and Chinnaponni with application of recommended FYM + 50 per cent N equivalent through organics + 50 per cent NPK through inorganics (83.2%) (Table 6).

Sangeetha et al (2013) opined that higher volume expansion and water absorption ratio was observed in bold rice grain along with application of poultry manures. The increased length breadth ratio after cooking was observed in enriched farmyard manure compost and composted poultry manure, vermicompost and farmyard manure + neem cake. This character is considered as desirable trait in high quality rice.

The field experiments conducted at Annamalai University with rice indicated a positive approach towards organic farming in attaining premium quality produce with higher grain yield. Quality characters viz milling recovery, head rice percentage and protein percentage were significantly higher with organic sources (Anon 2001).

REFERENCES

- Anonymous 2001. Organic farming for sustainable agriculture. www.indiaagronet.com.
- Champange ET, Bett-Garber KL, Grimm CC and McClung AM 2007. Effects of organic fertility management on physicochemical properties and sensory quality of diverse rice cultivars. *Cereal Chemistry* **84(4)**: 320-327.
- Devaraju KM and Honnegowda 1998. Agronomic investigations on hybrid rice cultivation and seed production. Manual, Hybrid rice seed production theory and practice, ZARS, VC Farm, Mandya, Karnataka, India, pp 56-63.
- Ganga Devi M, Tirumala Reddy S, Sumati V, Pratima T and John K 2012. Nitrogen management to improve the nutrient uptake, yield and quality parameters of scented rice under aerobic culture. *International Journal of Applied Biology and Pharmaceutical Technology* **3(1)**: 340-344.
- Gomez KA and Gomez AA 1984. Data that violate some assumptions of the analysis of variance. In: *Statistical procedures for agricultural research* (KA Gomez and AA Gomez eds), 2nd edn, John Wiley and Sons, Inc, Third Avenue, New York, pp 294-315.
- Hegde S, Yenagi N, Itagi S, Babalad HB and Prashanthi SK 2013. Evaluation of red rice varieties for nutritional and cooking quality cultivated under organic and conventional farming systems. *Karnataka Journal of Agricultural Sciences* **26(2)**: 288-294.
- Kesarwani A, Chen SS and Lee JF 2009. Influence of nutrient management on the grain quality, cooking and eating quality of rice in Taiwan. *Research and Development Annual Report, Taiwan*, pp 1-4.
- Kumaran PS and Vadivel V 2001. Organic farming for sustainable agriculture. *Spice India*, pp 2-4.
- Lakshmi CS, Reddy APK and Jayasree G 2014. Effect of organic sources and fertilizer levels on quality and grain yield of hybrid rice. *Annals of Plant and Soil Research* **16(2)**: 93-97.

- Lal S, Yadav AC, Mangal JL, Singh A and Batra VK 2002. Effects of FYM and irrigation levels on growth and yield of onion cv Hisar-2. Haryana Journal of Horticultural Sciences **31(3-4)**: 256-258.
- Maiti S, Saha M, Banerjee H and Pal S 2006. Integrated nutrient management under hybrid rice (*Oryza sativa*)- hybrid rice cropping sequence. Indian Journal of Agronomy **51(3)**: 157-159.
- Sadasivam and Manickam 1972. Estimation of starch by anthrone reagent and amylose by iodine binding method. Pharmaceutical Research Library **8**: 52-56.
- Sangeetha SP, Balakrishnan A and Devasenapathy P 2013. Influence of organic manures on yield and quality of rice (*Oryza sativa* L) and blackgram (*Vigna mungo* L) in rice-blackgram cropping sequence. American Journal of Plant Science **4**: 1151-1157.
- Sudhakar PC, Singh JP, Singh Y and Singh R 2006. Effect of graded fertility level and silicon sources on crop yield, uptake and nutrient-use efficiency in rice (*Oryza sativa*). Indian Journal of Agronomy **51(3)**: 186-188.
- Zhao D, Reddy KR, Kakani VG and Reddy VR 2005. Nitrogen deficiency effects on plant growth, leaf photosynthesis and hyperspectral reflectance properties of sorghum. European Journal Agronomy **22(4)**: 391-403.

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