Indian Journal of Ecology (2024) 51(3): 552-558
DOI: https://doi.org/10.55362/IJE/2024/4272

Manuscript Number: 4272
NAAS Rating: 5.38

Yield and Quality of Aromatic Rice (*Oryza sativa* L.) Varieties under Nutrient Management in Organic Environment of Coastal Odisha

S.S. Mohapatra, Stuti D. Behera*, B. Behera, G. Sahu, J. Jena, K.S. Giri Swosti D. Behera[1], R.K. Sahoo, S. Mishra and M. Panda

Faculty of Agricultural Sciences, Siksha 'O' Anusandhan (Deemed to be) University, Bhubaneswar-751 029, India
[1]School of Agriculture, GIET University, Gunupur-765 022, India
E-mail: stuteedebapriya12@gmail.com

***Abstract*:** Organic aromatic rice can be raised with recommended dose of nitrogen (RDN) through farmyard manure (FYM), vermicompost (VC) and neem cake (NC). An experiment was conducted at Bhubaneswar, Odisha, India during *kharif* 2022 comprising four aromatic rice cultivars, 'Geetanjali', 'Poornabhoga', 'CR Dhan 910' and 'Nua Chinikamini' and four manuring sources, FYM (100% RDN), FYM (40% RDN)+ VC (30% RDN)+ NC (30% RDN), FYM (50% RDN)+ VC (25% RDN)+ NC (25% RDN) and FYM (60% RDN)+ VC (20% RDN)+ NC (20% RDN) in split plot design with three replications. The FYM, VC and NC had nitrogen content of 0.46, 3.0 and 4.4%, respectively. Among varieties, 'Poornabhoga' was the best for growth and yield attributes and produced grain yield of 2.95 t/ha. Among manuring sources, application of FYM (40% RDN)+ VC (30% RDN)+ NC (30% RDN) recorded the maximum growth , yield attributes and grain yield of 3.05 t/ha. Among treatment combinations, rice variety 'Poornabhoga' with application of 60kg N/ha as 24kg N/ha (FYM) + 18kg N/ha (VC)+ 18kg N/ha (NC) proved to be the best and produced the maximum yield of 3.59 t/ha. Among rice varieties, 'Geetanjali' had the maximum milling percent (71.67%), head rice recovery (63.75%), kernel length: breadth ratio (3.72), whereas 'Nua Chinikamini' had the maximum hulling % (77.50%), kernel elongation ratio (1.84) and volume expansion ratio (3.66). For higher yield and quality of aromatic rice, the rice cultivar 'Poornabhoga' should be grown with application of 24+18+18 kg N/ha as FYM+VC+NC, respectively.

***Keywords*:** Head rice recovery, Hulling, Milling, Neem oilcake, Vermicompost

There is an upward trend in demand for quality rice worldwide due to change in eating habits of people caused by hike in per capita income and improvement of economic condition (Rashid et al 2016). Aromatic rice has good taste, eating qualities and export potential. It fetches a much higher price than ordinary brand rice (Mannan et al 2012, Roy et al 2018). Basmati type of aromatic rice includes slender and long to very long grained type, while non-basmati group mainly constitutes of small, medium and long grained types. India has a rich genetic diversity of aromatic rice (*Oryza sativa* L.) cultivars whose cultivation is restricted to localized pockets in almost all the states. These varieties have unique aroma, cooking and eating qualities (Patnaik et al 2014). Due to lack of systematic efforts for the collection, evaluation and genetic improvement, such varieties are slowly disappearing. These cultivars differ greatly in phonological behavior, growth, yield attributes, yield, and quality.

In international market, importance of organic produce is increasing day by day due to health consciousness of consumers. Organic crop cultivation involves use of natural processes or products for crop management. Nutrient need of crop can be satisfied through various sources like FYM, vermicompost (VC), oilcakes, green manure, bio fertilizer, *Jeevamrut, Beejamrut, Amrutpani* etc. Indigenous aromatic rice responds well to organic manuring. Farmyard manure is the major source of nutrient for organic production by farmers, but other sources like vermicompost and oilcakes have additional benefits that promote crop growth and development. Vermicompost is a native organic fertilizer rich in major and micronutrients, beneficial soil microbes as nitrogen fixing bacteria and mycorrhizal fungi. Besides, it contains many enzymes (amylase, lipase, cellulase and chitinase), that helps in breaking down organic matter in the soil. Neem oilcake (NC) has inhibitory effect on nitrification and hence, minimizes the rate of nitrate leaching (Murugan and Swarnam 2013). However, vermicompost and oil cakes are costlier than FYM. So, there is a need to find out a nutrient supply system comprising diverse organic sources for fulfillment of the nutrient requirement of crop and simultaneously cost effective for the farmers. Pandey and Chitale (2015) reported positive impact of application of 100% N from organic manures (1/3rd each from cow dung manure, neem cake and composted crop residue) on growth and yield attributes of Basmati rice.

Quality parameters of aromatic rice are influenced by variety and nutrient management. Bora et al (2014) reported better grain quality parameters of aromatic rice variety 'Ketakijoha' with organic manuring. Saquib et al (2017)

reported better yield and quality parameters of scented rice with superimposition of neemcake @3t/ha, FYM @12t/ha and vermicompost @6t/ha with recommended dose of fertilizer (RDF) than RDF alone. Ruan et al (2023) reported higher head rice recovery, 2-acetyl-1-pyrroline content and flavor profiles of aromatic rice with application of vermicomost @ 3t/ha compared to inorganic fertilizers. Under such circumstances, the present experiment was designed to assess the effect of cultivars and combination of organic manure sources on phenology, growth, yield, and quality of aromatic rice.

MATERIAL AND METHODS

The field experiment was conducted at Agricultural Research Station, SOADU, Binjhagiri, Chhatbar, Khordha, Odisha during *kharif* 2022. The experimental site is located at 20^0 23' N latitude and 85^0 83' E longitude, and 20 km away from the city of Bhubaneswar with an altitude of 45 meters above mean sea level. The Research Station comes under East Coast Plains and Hills Region of India. The treatments comprising four aromatic rice varieties viz., V_1-'Geetanjali' (mutant of Basmati 370), V_2-'Poornabhoga' (mutant of Pusa Basmati 1), V_3-'CR Dhan 910' (cross of Swarna and Geetanjali) and V_4-'Nua Chinikamini' (pureline selection from landrace) and four manuring sources viz., M_1- FYM (100% recommended dose of nitrogen or RDN), M_2- FYM (40% RDN)+ VC (30% RDN)+ NC (30% RDN), M_3- FYM (50% RDN)+ VC (25% RDN)+ NC (25% RDN) and M_4- FYM (60% RDN)+ VC (20% RDN)+ NC (20% RDN) were tried in split plot design with three replications. The experimental soil was sandy loam in texture with bulk density 1.66 g/cc, acidic in reaction (pH 5.4), medium in organic carbon (0.52%), medium in available nitrogen (256.5 kg/ha), low in available phosphorus (10.5 kg/ha) and medium in available potassium (210.8 kg/ha). Recommended dose of 60 kg nitrogen/ha was applied through organic manures as per treatment specifications. The seed was sown in the raised bed nursery on 30 June. After puddling of the experimental field, layout was done on 18 June, neem oilcake was applied a week before on 19 June and FYM and vermicompost were applied on 25 June. The seedlings were transplanted in the main field on 26 July 2022 with spacing of 20 cm × 15 cm.

Days to various phenophases (50% flowering and physiological maturity) was recorded based on 10 hills/plot. The crop growth rate values were computed by using the following formula.

$$\text{Crop growth rate (CGR)} = \frac{W_2\text{-}W_1}{t_2\text{-}t_1}\ g/m^2/day$$

Where, w_1 and w_2 were total dry weight per unit area at time t_1 and t_2, respectively.

After proper drying, plot-wise grain yields were recorded and expressed as t/ha. The length and breadth of grain and kernel were measured by using slide calipers. Quality parameters were studied as described below.

Hulling percentage: For determining hulling percentage, 100g of grain sample was weighed. The clean sample was shelled with the Satake Sheller. The samples were hulled, and weights of de-hulled grains were recorded. Hulling percentage was determined by formula (Hallick and Kelly 1959).

$$\text{Hulling percentage} = \frac{\text{Weight of brown rice (g)}}{\text{Weight of paddy (g)}} \times 100$$

Milling percentage: The hulled samples were milled, and weight of milled grains was recorded. Milling percentage was determined by

$$\text{Milling percentage} = \frac{\text{Weight of milled rice (g)}}{\text{Weight of paddy (g)}} \times 100$$

Head rice recovery percentage: After milling, the whole and broken grains were separated. The per cent of head rice or unbroken rice grain were determined based on the initial weight of the rough rice per cent of total rice or sum total of head rice and all classes of broken rice.

$$\text{Head rice recovery percentage} = \frac{\text{Weight of head polished rice (g)}}{\text{Weight of milled rice (g)}} \times 100$$

Elongation ratio: Elongation ratio of cooked kernels was determined by dividing the length of cooked kernel to length of uncooked kernel (Juliano and Betchel 1985).

$$\text{Elongation ratio} = \frac{\text{Length of cooked kernel (mm)}}{\text{Length of raw kernel (mm)}}$$

Volume expansion ratio: Volume expansion ratio was determined from the ratio of cooked volume rice to that of the uncooked rice (Sidhu et al 1975). Rice kernel of 5g weight was added to 15ml of water in a test tube and rise in volume (x ml) was noted. Rice grain sample was cooked for 20 mins in a thermostatically controlled heating mantle at 90 °C and 15ml of water was added to the cooked rice. Then rise in volume (y ml) was noted and volume expansion ratio was found out by the following formula.

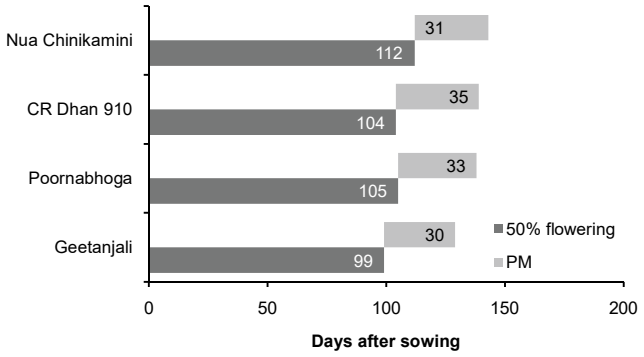
Volume Expansion Ratio = y/x

RESULTS AND DISCUSSION

Crop phenology: Among the varieties, 'Geetanjali' attained the 50% flowering stage at 99 days after sowing, whereas 'Nua Chinikamini' came to 50% flowering stage at 112 days

after sowing (Fig. 1). The variety 'Geetanjali' was the earliest to attain physiological maturity in 129 days, whereas 'Nua Chinikamini' took the longest time to attain physiological maturity stage. The varieties 'Poornabhoga' and 'CR Dhan 910' were similar for seed to seed duration and came to physiological maturity in 138-139 days. Various manuring sources failed to exert significant influence on days to 50% flowering and physiological maturity. Onset of developmental stages depends on genetical characters and climatic factors, mostly temperature. Patel et al (2014) reported variation (92-121 DAT) among aromatic rice varieties for days to attainment of 50% flowering.

Growth attributes: The aromatic rice varieties exerted significant influence on plant height and tillers/hill (Table 1). Plant height increased progressively from 30 days after transplanting (DAT) till harvest. At 30 DAT, 'Nua Chinikamini' had the minimum vertical growth and other three varieties recorded significantly higher plant height. At 60 DAT, 'Gitanjali' had the maximum vertical growth, placing 'Poornabhoga' at par. The varieties 'CR Dhan 910' and 'Nua Chinikamini' recorded significantly less plant height. A differential trend was noted at physiological maturity. At physiological maturity 'Nua Chinikamini' had the tallest, whereas 'CR Dhan 910' had the shortest plant. The longest duration variety 'Nua Chinikamini' had the maximum rate of vertical growth during 60 DAT to physiological maturity. The plant height of these non-basmati aromatic rice varieties was predominantly a genetical feature. 'Nua Chinikamini' is a tall variety, whereas 'CR Dhan 910' is a semi-dwarf variety. Patnaik et al (2014) reported plant height of 'Nua Chinikamini' as 140 cm. In general, the lower plant height of the variety in the present study was due to delayed sowing, photosensitivity (short day) nature and organic mode of cultivation. Sources of manuring failed to influence plant height of aromatic rice varieties significantly at 30 and 60 DAT. At physiological maturity, the three combinations of manuring sources i.e. M_2, M_3 and M_4 recorded significantly higher plant height than M_1. Pandey and Chitale (2015) reported positive impact of manuring combinations on growth and yield attributes of basmati rice.



PM- Physiological maturity

Fig. 1. Effect of variety on days to attainment of phenophases

The varieties of rice influenced tillers/hill both at 30 and 60 days after transplanting. At 30 DAT the variety 'Poornabhoga' was the most profuse tillering with 5.6 tillers/hill, placing 'Nua Chinikamini, and 'Geetanjali' at par. The variety 'CR Dhan 910' had the minimum tillers/hill and proved significantly inferior to other cultivars. At 60 DAT, 'Nua Chinikamini' recorded the maximum tillers/hill (9.3), being at par with 'Poornabhoga' and both proved significantly superior to

Table 1. Effect of variety and manuring sources on plant height and tillers/hill of organic aromatic rice

Treatment	Plant height (cm)			Tillers/hill	
	30 DAT	60 DAT	PM	30 DAT	60 DAT
Variety					
V_1- Geetanjali	61.9	85.8	88.5	5.4	6.6
V_2- Poornabhoga	62.5	83.7	92.1	5.6	8.8
V_3- CR Dhan 910	63.4	72.4	74.9	4.8	6.3
V_4- Nua Chinikamini	52.8	70.0	104.0	5.4	9.3
CD (p=0.05)	5.0	10.6	4.2	0.5	0.9
Sources of manuring (% of RDN)					
M_1-FYM (100%)	58.5	76.7	84.8	5.1	7.4
M_2-FYM (40%)+ VC (30%)+ NC (30%)	61.0	78.8	94.2	5.6	8.1
M_3-FYM (50%)+ VC (25%)+ NC (25%)	60.9	77.5	90.3	5.3	7.7
M_4-FYM (60%)+ VC (20%)+ NC (20%)	60.3	78.9	90.1	5.2	7.7
CD (p=0.05)	NS	NS	5.8	0.3	0.5

RDN- Recommended dose of nitrogen (60kg/ha), FYM- Farm yard manure, VC- Vermicompost, NC- Neem oilcake, DAT- days after transplanting, PM- Physiological maturity, CD- Critical difference

'Geetanjali' and 'CR Dhan 910'. Mia and Shamsuddin (2011) reported higher tillers/hill with aromatic rice varieties compared to modern rice varieties. Among manuring sources, M_2 recorded the maximum tillers/hill at both 30 and 60 DAT, being at par with M_3 and M_4 at 60 DAT and M_3 at 30 DAT. This reflects superiority of combination of manuring sources compared to 100% recommended dose of nitrogen as FYM.

Both varieties and sources of manuring influenced dry matter accumulation and leaf area index significantly (Table 2). Dry matter accumulation increased progressively from 30 DAT till physiological maturity (PM). Among varieties, 'Poornabhoga' accumulated the maximum dry matter at all the three stages. The variety 'Geetanjali' ranked the second with respect to dry matter accumulation. The higher dry matter accumulation by 'Poornabhoga' was due to higher LAI and profuse tillering. At physiological maturity, 'Poornabhoga' recorded dry matter accumulation of 880 g/m^2, reflecting 22, 27 and 28% increase over 'Geetanjali', 'Nua Chinikamini' and 'CR Dhan 910', respectively. Similar dry matter accumulation by aromatic rice was reported by Yadav and Meena (2014) and Rathiya et al (2017). Among organic nutrient management practices, the manuring combinations viz. M_4 and M_2 at 30 DAT, M_3 and M_2 at 60 DAT and M_2 at 90 DAT recorded higher dry matter accumulation than M_1. Pandey and Chitale (2015) reported better efficacy of combined application of manuring sources (FYM, VC and NC) on dry matter accumulation in rice.

Among varieties, 'Poornabhoga' recorded the maximum LAI of 1.37 and 4.13 at 30 and 60 DAT, respectively. The variety 'Geetanjali' at 30 DAT and 'Geetanjali' and 'Nua chinikamini' at 60 DAT recorded statistically similar LAI. Higher LAI up to the optimum leads to higher photosynthesis and dry matter accumulation. The higher dry matter production in case of 'Poornabhoga' and 'Geetanjali' was due to higher LAI that increased photosynthesis. Among combination of manuring sources, M_2 recorded the maximum LAI at 30 and 60 DAT. Manuring combinations with higher proportion of vermicompost and neem cake could ensure sustained supply of nitrogen to the crop. Inhibitory effect of neem cake on nitrogen facilitated slow release of N and minimization of nitrate leaching. Sustained N availability promoted leaf expansion leading to higher LAI.

Crop growth rate: Crop growth rate values during 30-60 DAT intervals were higher than that during 60 DAT-physiological maturity (Table 3). Among varieties, 'Poornabhoga' had the maximum crop growth rates of 11.1 g/m^2/day and 8.3 g/m^2/day during 30-60 DAT and 60 DAT-physiological maturity, respectively, keeping 'Geetanjali' at par. Higher growth rate in these two varieties is reflection of genetical features of the varieties. Among combination of manuring sources, M_2 recorded the minimum CGR of 10.1 and 8.1 g/m^2/day during 30-60 DAT and 60 DAT-physiological maturity, respectively, and M_3 recorded statistically similar CGR values. Application of higher proportion of N through vermicompost and neem oil cake recorded higher CGR. Sustained supply of N matching to the crop growth under these two combinations led to higher crop growth rates.

Yield attributes: Both varieties and manuring sources influenced yield attributes of aromatic rice significantly (Table 3). Among varieties, 'Poornabhoga' recorded the maximum of 221 panicles/m^2 and 'Nua Chinikamini' with 210 panicles/m^2 remained at par. Both these varieties recorded significantly higher tillers/hill than other varieties. Among

Table 2. Effect of variety and manuring sources on dry matter accumulation and LAI of organic aromatic rice

Treatment	Dry matter accumulation (g/m^2)			Leaf area index	
	30 DAT	60 DAT	PM	30 DAT	60 DAT
Variety					
V_1	123	432	722	1.31	3.96
V_2	146	478	880	1.37	4.13
V_3	94	379	688	1.17	2.72
V_4	87	339	692	1.22	3.75
CD (p=0.05)	11	25	57	0.06	0.40
Sources of manuring (% of RDN)					
M_1	102	385	694	1.13	3.45
M_2	119	422	797	1.39	3.91
M_3	108	425	764	1.29	3.55
M_4	122	395	727	1.25	3.65
CD (p=0.05)	10	24	27	0.08	0.26

varieties, 'Nua Chinikamini' recorded the maximum of 133 filled grains/panicle and proved superior to all other varieties. Among varieties, 'Geetanjali' had the heaviest grain and 'Nua Chinikamini' had the lightest grain with test weight of 13.37g/1000 grains. The 1000 grain weight is predominantly decided by the genetic make-up of the varieties and to some extent by climatic, edaphic and management factors. Rashid et al (2017) reported similar variable trend of aromatic rice varieties for yield attributes. They reported 255.6 filled grain/panicle in 'Kataribhoga' as against the minimum values of 130.7/panicles in 'Badshabhoga'. The variety 'Badshabhoga' had the heaviest grain with 1000 grain weight of 18.3g and the variety 'Kataribhoga' had the minimum 1000-grain weight of 11.4g.

Among manuring sources, application of M_2 recorded the maximum values of panicles/m^2 and filled grains/panicle, being at par with M_3. Application of 100% N as FYM recorded the minimum values of panicles/m^2 and filled grains/ panicle. The trend of manuring sources for yield attributes established the superiority of combination of manuring sources over application of recommended N from single organic source.

Grain yield: Among varieties, 'Poornabhoga' recorded the maximum grain yield of 2.95 t/ha, being at par with 'Geetanjali' with grain yield of 2.83 t/ha (Table 4). The variety 'Poornabhoga' produced 16 and 32% higher grain yield over 'CR Dhan 910' and 'Nua Chinikamini', whereas 'Geetanjali' produced 11 and 27% higher grain yield over 'CR Dhan 910' and 'Nua Chinikamini', respectively. The superiority of 'Poornabhoga' for grain yield was due to higher values of panicles/m^2, LAI, dry matter accumulation and tillers/hill, whereas the superiority of 'Geetanjali' for yield over two other varieties was due to higher tillers/hill, LAI and 1000-grain weight. The variety 'Nua Chinikamini' had the maximum plant height at physiological maturity, tillers/hill and panicle/m^2, but it exhibited the minimum grain yield due to the minimum test weight of grains. Grain yield can be expressed as a function of panicles/m^2, filled grains/panicle and test weight of 1000 grains. The yield levels are similar to those reported by

Table 3. Effect of variety and manuring sources on crop growth rate and yield attributes of organic aromatic rice

Treatment	Crop growth rate (g/m^2/day)		Panicles/m^2	Filled grains/ panicle	1000- grain weight (g)
	30-60 DAT	60 DAT-PM			
Variety					
V_1	10.3	7.6	204	72	23.85
V_2	11.1	8.3	221	94	20.51
V_3	9.5	6.3	199	91	22.07
V_4	8.4	6.7	210	133	13.37
CD (p=0.05)	0.8	1.0	13.6	9	0.75
Sources of manuring (% of RDN)					
M_1	9.4	6.5	189	88	19.98
M_2	10.1	8.1	231	104	20.13
M_3	10.6	7.3	218	101	19.88
M_4	9.1	6.9	196	97	19.80
CD (p=0.05)	0.9	0.9	13.4	6	NS

Table 4. Effect of variety and manuring sources on grain yield of organic aromatic rice

Treatment	M_1	M_2	M_3	M_4	Mean
Variety					
V_1	2.19	3.28	3.20	2.66	2.83
V_2	2.89	3.59	3.13	2.19	2.95
V_3	2.19	3.13	2.73	2.11	2.54
V_4	2.19	2.19	1.96	2.58	2.23
Mean	2.36	3.05	2.76	2.38	2.64
CD (p=0.05)	Variety (V)	Manuring (M)	V x M	M x V	
	0.22	0.15	0.34	0.29	

V x M- Variety in same or different levels of M, M x V- Manuring sources in same level of variety

Chowdhury et al (2016) for aromatic rice. They achieved grain yield of 2.11 t/ha with 'Kalazira' to the maximum of 3.33 t/ha with variety 'Binadhan-13' in Bangladesh condition. Rathiya et al (2017) reported the maximum tillers/m^2 and 1000-grain weight in variety 'Pusa Basmati-1', but the variety 'Jeerafool' recorded the maximum grain and straw yield due to higher plant height, panicle length and grains/panicle. Among nutrient management, the manure combination with higher proportion of vermicompost and neem oil cake i.e. FYM (40% RDN)+ VC (30% RDN)+ NC (30% RDN) recorded the maximum grain yield of 3.05 t/ha and proved superior to all other combination of organic manuring sources. This was due to higher values of growth and yield attributes. Increase in grain yield of rice with combination of manuring sources over single source has been earlier reported by Davari and Sharma (2010), Singh et al (2011) and Pandey and Chitale (2015). Interaction effect of variety and manuring sources were found significant for grain yield. The variety 'Poornabhoga' with application of FYM (40% RDN)+ VC (30% RDN)+ NC (30% RDN) gave the maximum grain yield of 3.59 t/ha and proved better than other combinations.

Grain quality: The aromatic rice varieties differed widely for grain quality (Table 5). The variety 'Geetanjali' had the longest grain with grain length of 10.89 mm, whereas 'Nua Chinikamini' had the shortest grain with grain length of 4.95 mm. The variety 'Geetanjali' (2.43 mm) had the maximum grain length, while 'Poornabhoga' (2.07 mm) and 'CR Dhan 910' (2.05 mm) had the minimum grain breadth. Among varieties, 'Poornabhoga' had the maximum grain length: breadth ratio, while 'Nua Chinikamini' had the minimum grain L/ B ratio. The variety 'Nua Chinikamini' had the maximum hulling % and the variety 'CR Dhan 910' had the minimum hulling %. The variety 'Geetanjali' (71.67%) had the maximum milling %, while 'Poornabhoga' had the minimum milling %. The variety 'Geetanjali' had the maximum head rice recovery percentage, whereas the variety 'Poornabhoga' had the minimum HRR percentage. Manuring sources could not cause much variation in grain quality.

Kernel quality: Among varieties, rice variety 'Geetanjali' (8.59 mm) had the maximum kernel length, while 'Nua Chinikamini' (3.32 mm) had the minimum kernel length (Table 6). 'Geetanjali' (2.31 mm) had the maximum kernel

Table 5. Effect of variety and manuring sources on grain quality parameters of organic aromatic rice

Treatment	Grain length (mm)	Grain breadth (mm)	Grain L/B ratio	Hulling (%)	Milling (%)	HRR (%)
Variety						
V_1	10.89	2.43	4.48	76.33	71.67	63.75
V_2	9.65	2.07	4.66	72.50	56.50	35.50
V_3	8.60	2.05	4.21	70.32	64.76	56.76
V_4	4.95	2.24	2.21	77.50	70.40	51.50
Sources of manuring (% of RDN)						
M_1	8.52	2.23	3.82	74.16	65.83	51.88
M_2	8.66	2.21	3.94	74.26	65.58	52.13
M_3	8.47	2.17	3.93	74.09	65.96	51.63
M_4	8.43	2.19	3.86	74.14	65.96	51.88

Table 6. Effect of variety and manuring sources on kernel quality parameters of organic aromatic rice

Treatment	Kernel length (mm)	Kernel breadth (mm)	Kernel L/B ratio	Elongation ratio	VER
Variety					
V_1	8.59	2.31	3.72	1.22	3.57
V_2	5.79	1.66	3.50	1.61	3.64
V_3	5.85	1.90	3.07	1.42	3.32
V_4	3.32	2.02	1.65	1.84	3.66
Sources of manuring (% of RDN)					
M_1	5.90	2.00	2.94	1.55	3.55
M_2	6.00	1.98	3.03	1.53	3.54
M_3	5.84	1.94	3.02	1.52	3.54
M_4	5.81	1.96	2.96	1.50	3.56

VER- Volume Expansion Ratio

breadth and 'Poornabhoga' (1.66 mm) had the minimum breadth. The kernel L/B ratio value was the maximum for 'Geetanjali' (3.72) and the minimum for 'Nua chinikamini' (1.65). Lakra (2012) reported L/B ratio on Badshabhoga (3.3), Pusa Basmati (4.0), Safri (3.5), Chandrabasini (3.5) and Rajeshwari (2.7) belonging to group traditional aromatic-non basmati type, improved aromatic varieties, traditional non-aromatic basmati type, improved non-aromatic non-basmati type and improved non-aromatic, respectively. Elongation ratio refers to ratio of length of cooked kernel (mm) to length of raw kernel (mm). The elongation ratio was the maximum for 'Nua Chinikamini' (1.84) and the minimum for 'Geetanjali' (1.22). Volume expansion ratio (VER) is the ratio of cooked rice volume to raw rice volume. Among varieties, 'Nua Chinikamini' (3.66) had the maximum volume expansion ratio closely followed by 'Poornabhoga' (3.64). The maximum yielding variety 'Poornabhoga' had the kernel length: breadth ratio of 3.50 (next to Geetanjali) and the volume expansion ratio of 3.64 (next to Nua Chinikamini). The manuring sources did not differ much in volume expansion ratio.

CONCLUSIONS

The experiment comprising four varieties and four manure sources was conducted to find out the best treatment combination for better yield and quality of aromatic rice under organic environment of Coastal Odisha. It is concluded that variety 'Poornabhoga' with 60 kg nitrogen/ha through farmyard manure, vermicompost and neem cake contributing 40, 30 and 30%, respectively, excelled other combinations. Organic rice farmers should combine these three manures instead of using farmyard manure alone to fulfil the nitrogen demand of the crop and achieve desired yield and quality.

AUTHORS CONTRIBUTION

Stuti DB, SSM, BB and GS conceptualized and designed the experiment. SSM, GS, JJ and KSG conducted the field experiment and laboratory analysis work and collected data. SSM, RKS, SM, Stuti DB, Swosti DB and MP analysed the data, prepared the figures and wrote the original manuscript. BB revised the manuscript.

REFERENCES

Bora D, Goswami J, Saud RK and Begum M 2014. Effect of organic inputs on production and quality of scented rice (*Oryza sativa*) variety *Ketekijoha* in Assam and its economic aspect. *Agricultural Science Digest* **34**(2): 115-118.

Chowdhury A, Paul SK and Sarkar MAR 2016. Yield performance of fine aromatic rice in response to variety and level of nitrogen. *Journal of Environmental Science and Natural Resources* **9**(1): 41-45.

Davari MR and Sharma SN 2010. Effect of different combinations of organic materials and biofertilizer on productivity, grain quality and economics of basmati rice in organic farming of basmati rice. *Indian Journal of Agronomy* **55**(4): 290-294.

Halick JV and Kelly VJ 1959. Gelatinization and pasting characteristic of rice varieties as related to cooking behaviour. *Cereal Chemistry* **36**: 91-98.

Juliano BO and Betchel DB 1985. The rice grain and its gross composition, pp. 17-57. In: *Rice chemistry and technology* (eds). American Association of Cereal Chemists, Minnesota.

Lakra A 2012. *Identification and characterization of rice varieties suitable for organic farming*. M.Sc. Dissertation, IGKV, Raipur.

Mannan MA, Bhuiya MSU, Akand MM and Rana MM 2012. Influence of date of planting on the growth and yield of locally popular traditional aromatic rice varieties in Boro season. *Journal of Science Foundation* **10**(1): 20-28.

Mia MB and Shamsuddin ZH 2010. Rhizobium as a crop enhancer and biofertilizer for increased cereal production. *African Journal of Biotechnology* **9**(37): 6001-6009.

Murugan Vel A and Swarnam TP 2013. Nitrogen release pattern from organic manures applied to an acid soil. *Journal of Agricultural Science* **5**(6): 174-184.

Pandey D and Chitale S 2015. Response of basmati rice to organic, inorganic and integrated nutrient management practices. *Current Advances in Agricultural Sciences* **7**(1): 68-69.

Patel NB, Shrivastava R, Kumar V and Dhirhi N 2015. Genetic diversity among some traditional aromatic Rice (*Oryza sativa* L.) land races of Chhattisgarh. *Electronic Journal of Plant Breeding* **6**(1): 204-209.

Patnaik A, Roy PS, Rao GJN, Patnaik SSC, Jena M, Das KM and Singh ON 2014. Nua Kalajeera, Nua Dhusara and Nua Chinikamini**.** *Indian Journal of Genetics and Plant breeding* **74**(4): 537-538.

Rashid MM, Ghosh AK, Roni MN, Islam MR and Alam MM 2017. Yield performance of seven aromatic rice varieties of Bangladesh. *International Journal of Agriculture and Environmental Research* **3**(2): 2637-2642.

Rathiya PS, Singh VK and Kumar R 2017. Growth and yield performance of aromatic rice (*Oryza sativa* L.) varieties as affected by various nutrient management practices. *Journal of Pharmacognogy and Phytochemistry* **SP1**: 866-868.

Roy A, Sarkar MAR and Paul SK 2018. Effect of age of seedlings at staggered transplanting and nutrient management on yield performance of aromatic fine rice (cv. BRRI dhan38). *SAARC Journal of Agriculture* **16**(1): 49-59.

Ruan S, Qi J, Wu F, Lai R and Tang X 2023. Response of yield, grain quality, and volatile organic compounds of aromatic rice to vermicompost application. *Journal of Cereal Science* **109**: 103620.

Saquib M, Singh R, Kumar H, Yadav MP and Khan N 2017. Superimposition of organic sources of manures to enhance yield and quality parameters of scented rice (*Oryza sativa* L.) in indo-gangetic plain zone. *Plant Archives* **17**(2): 1765-1768.

Sidhu JS, Gill MS and Bains GS 1975. Milling of paddy in relation to yield and quality of rice of different Indian varieties. *Journal of Agricultural and Food Chemistry* **23**(6): 1183-1185.

Singh YV, Dhar DW and Agrawal B 2011. Influence of organic nutrient management on basmati rice (*Oryza sativa*)- wheat (*Triticum aestivum*)- green gram (*Vigna radiata*) cropping system. *Indian Journal of Agronomy* **56**(3): 169-175.

Yadav L and Meena RN 2014. Performance of aromatic rice genotypes as influenced by integrated nitrogen management. *Indian Journal of Agronomy* **59**(2): 251-255.

Received 27 December, 2023; Accepted 21 May, 2024