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Influence of Organic Nitrogen Sources on Aromatic Rice (*Oryza sativa* L.) Cultivation in the Eastern Plateau and Hill Region of India

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ABSTRACT

The field experiment was conducted at farm of Divyayan Krishi Vigyan Kendra, Ramakrishna Mission Ashrama, Ranchi, Jharkhand, India during *kharif* season of 2021 following the three times replicated randomized Block Design with 7 organic N sources (control, 100% FYM, 100% vermicompost (VC), 100% Karanj cake (KC), 50% FYM +50% VC, 50% VC +50% KC, 50% FYM +50% KC) to study the response of transplanted aromatic rice to various organic N sources. The results expressed that N applied through manures ensured higher plant response over control and specifically, that through 50% VC +50% KC recorded the maximum plant height, tillers/m^2 and leaves/plant. Further, this combined application of VC and KC also recorded maximum productive tillers/m^2 (199.3), panicle length (24.1 cm), filled grains/panicle (172.8), test weight (22.9 g), grain yield (7.37 t/ha), straw yield (9.08 t/ha) and harvest index (44.8%) resulting in higher gross return (₹4,83,590/ha), net return (₹3,37,079/ha) and B:C (3.30). 100% N applied through KC remained as the second-best alternative in ensuring high growth, yield and profitability in aromatic rice.

Keywords Aromatic rice, Farm yard manure, Karanj cake, Organic N, Vermicompost, Yield.

INTRODUCTION

Rice (*Oryza sativa* L.) serves as a major staple food for more than 60% world's people. India is the top rice producing country in the world with 112.91 mt production from 43.79 mha area and 2.58 t/ha productivity (GOI 2018). It is mostly grown for grains as staple food. Besides, various value-added food products are also produced from it. Rice oil, straw as mulching, livestock feed, manuring, roof thatching material, fuel are some diverse uses of rice. In Eastern plateau and hill region of India, aromatic rice has a high demand and its market price is relatively higher than the non-aromatic rice. Aromatic rice is well cherished for its unique aroma which enhance the quality and taste of various food dishes as well as desserts. However, its production is relatively less than the non-aromatic rice. Currently, under climate change scenario, rice cultivation in India is

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experiencing a setback due to lack of agricultural land, labor unavailability, urbanization and facing trouble to meet the food demand of ever-increasing population (Nayak *et al.* 2020). It is forecasted that the demand will rise up to 160 mt by 2030 (Mishra *et al.* 2013). Therefore, rice production needs a boon to revamp its productivity.

Green revolution has made the rice growers to rely completely on chemical based intensive farming, which in short-run is effective, but in long run is not recommended due to its detrimental impacts on soil health, consumer's health and overall, health of environment (Biswas *et al.* 2019). The toxic footprint left by the chemical fertilizers reduces soil's productive potential causing serious damage to micro-organisms' survivals and activities. Therefore, considering the urge of high qualitative and quantitative production, rice cultivation needs a paradigm shift from chemical based intensive farming to eco-friendly, sustainable organic farming. Nutrient management plays a key role in enhancing crop growth, quality and yield and therefore, suitable organic nutrient management can be the win-win option not only for uplifting crop growth and productivity but also in achieving environment protection from excessive use of chemical fertilizers (Verhulst *et al.* 2013). Specifically, use of organic source of nutrients like nitrogen can be an effective option for boosting up the aromatic rice productivity. Nitrogen, as an essential element for plant, plays a major role in chlorophyll synthesis, resulting in upliftment of photosynthesis efficiency which finally gets reflected on dry matter production and its partitioning to reproductive organs (Reddy *et al.* 2022). In cereal crops like rice, requirement of nitrogen is relatively high and desired outcome to a great extent relies on timely and adequate supply of nitrogen.

In rained areas of Eastern plateau and hill region of India, most of the rice growers are resource poor and therefore, they are unable to apply costly chemical fertilizers. Awareness regarding use of organic sources of nitrogen can help them to realize higher and economically profitable crop production. Among different low cost, eco-friendly organic sources of nutrients, farm yard manure, vermicompost and karanj cake can be the good options for elevating rice growth and yield as these manures are rich in beneficial micro-organisms, various macro and micro-nutrients, growth regulating hormones, vitamins and be prepared from locally available resources (Biswas *et al.* 2020a). Sole or combined use of these manures with chemical fertilizers has already proved their efficacies on various crops (Saha *et al.* 2007, Biswas *et al.* 2020b). However, researches regarding use of different manures in combinations on crops like rice is relatively less and therefore, the present study was planned to study the influence of different organic sources of N as sole or in combination on growth, yield and profitability of aromatic rice in Eastern plateau and hill region of India.

MATERIALS AND METHODS

The field experiment was executed at the farm of Divyayan Krishi Vigyan Kendra, Ramakrishna Mission Ashrama, Morabadi, Ranchi during *kharif* (monsoon) season of 2021 with the aim to evaluate the response of transplanted aromatic rice (cv Rajendra Kasturi) to various organic nitrogen sources. The experimental soil was clay loam in texture, red and lateritic in nature with 6.97 of pH, 0.91% organic carbon, 393.1 kg/ha of available N, 102.1 kg/ha of available P_2O_5 and 170.0 kg/ha of available K_2O. The experiment was placed in three times replicated Randomized Block Design comprising 7 treatments (Control or no manure use, 100% N through farm yard manure (FYM), 100% N through vermicompost (VC), 100% N through Karanj cake (KC), 50% N through FYM + 50% N through VC, 50% N through VC + 50% N through KC, 50% N through FYM + 50% N through KC). The recommended dose of nutrients for rice was 80: 40: 20 kg N: P_2O_5: K_2O /ha. The one-month-old rice seedlings were transplanted to 6 m× 4 m sized plot on 24th July, 2021 at a spacing of 25 cm × 25 cm and harvested on 22nd November 2021. All the manures were applied during land preparation. The details of different organic nitrogen sources were shown in Table 1. Other agronomic and plant protection measures were done according to standard organic farming practices.

Observations were taken on plant height (cm), tillers/m^2, leaves/plant at 25, 45, 65, 85 days after transplanting (DAT) and at maturity. It further in-

Table 1. Nutrient status and quantity used of different organic nitrogen sources.

Organic N sources	N: P_2O_5: K_2O (%)	Quantity used (t/ha)		Additional P_2O_5 supply (kg/ha)		Additional K_2O supply (kg/ha)	
		100% N	50% N	100% N	50% N	100% N	50% N
Farm yard manure	0.5:0.3:0.4	16.0	8.0	48.0	24.0	64.0	32.0
Vermicompost	1.2:1.5:1.7	6.67	3.34	100.1	50.0	113.3	56.6
Karanj cake	4:0.9:1.3	2.0	1.0	18.0	9.0	26.0	13.0

cluded productive tillers/m^2, panicle length (cm), number of filled and chaffed grains/panicle, 1000 grain weight (g), grain yield (t/ha), straw yield (t/ha), biological yield (t/ha) and harvest index (%) of rice at maturity. In order to estimate residual soil status, soil pH, available N, P_2O_5 and K_2O were analyzed from soil the soil collected from each plot after harvest of rice using the methods prescribed by Jackson (1967), Jackson (1973), Olsen *et al.* (1954) and Jackson (1973), respectively at laboratory of Ramakrishna Mission Vivekananda Educational and Research Institute, Ranchi. Finally, production economics was worked out using the following formulas:

Cost of cultivation (₹/ha) = Cost involved in input purchase and all the practices
Gross return (₹/ha) = Tuber yield × market price
Net return (₹/ha) = Gross return- cost of cultivation
Benefit: cost (B:C) = Gross return/ cost of cultivation

Data obtained from field as well as from laboratory were statistically analyzed through analysis of variance (ANOVA) method as suggested by Panse and Sukhatme (1985) and treatment means were compared according to the critical difference (CD) values at 5% significance level.

RESULTS AND DISCUSSION

Growth attributes

It has been revealed from Table 2 that growth attributes of aromatic rice viz., plant height, tillers/m^2 and leaves/plant showed significant variations ($p \leq 0.05$) among different organic nitrogen sources at various observation intervals. Plant height gradually increased with the crop progress towards maturity with increase occurred at higher pace up to 85 DAT. Similar response was also noticed in case of tillers/m^2 with higher generation of tillers occurred between 45-65 DAT period. It was possibly due to active vegetative growth occurred during that phase resulting in cell division and multiplication for generation of higher number of tillers. Numbers of leaves/plant gradually increased up to 85 DAT, followed by a decrease at harvest. It might be due to leaf senescence and fall of dry leaves after their maturation. Maximum

Table 2. Growth attributes of aromatic rice as influenced by various organic nitrogen sources.

Treatments	Plant height (cm)					Tillers/m^2					Leaves/plant				
	25 DAT	45 DAT	65 DAT	85 DAT	At harbest	25 DAT	45 DAT	65 DAT	85 DAT	At harbest	25 DAT	45 DAT	65 DAT	85 DAT	At harbest
Control	25.1	41.6	63.4	79.6	96.4	81.0	107.3	179.3	246.0	269.3	3.2	6.0	10.2	14.3	13.1
FYM $_{100\% N}$	30.2	48.2	69.5	82.7	96.7	89.4	121.3	256.0	315.3	332.4	4.1	7.2	12.8	15.9	14.8
VC $_{100\% N}$	33.4	53.2	72.7	89.4	98.9	93.7	127.7	267.0	327.3	337.6	4.7	7.5	13.6	16.3	15.0
KC$_{100\%N}$	36.5	53.8	74.3	94.1	101.5	96.7	133.3	283.3	336.5	352.7	5.3	8.4	14.4	18.4	17.2
FYM$_{50\%N +KC50\%N}$	32.9	50.1	72.6	86.1	97.2	91.5	123.7	264.6	322.6	334.6	4.5	7.4	12.9	16.1	15.0
VC$_{50\% +KC50\%N}$	37.7	59.6	79.8	96.4	102.7	100.1	141.0	292.6	348.0	362.0	5.6	8.8	15.6	20.3	19.4
VC$_{50\%N +FYM50\%N}$	35.5	54.7	74.5	92.2	99.7	94.3	129.3	274.6	331.6	346.4	4.7	7.7	14.1	19.7	18.4
SEm±	0.08	0.22	0.29	0.37	0.18	1.27	2.43	2.64	3.41	3.27	0.08	0.10	0.31	0.37	0.43
CD (p=0.05)	0.2	0.7	0.9	1.1	0.5	3.8	7.3	7.9	10.2	9.8	0.2	0.3	0.9	1.1	1.3

generation of leaves occurred between 45-65 DAT. It was due to greater generation of tillers during that period leading to more formation of leaves.

Among the different organic nitrogen sources, nitrogen (N) equally supplied from vermicompost (VC) and Karanj cake (KC) together ensured maximum plant height (37.7, 59.6, 79.8, 96.4 and 102.7 cm), tillers/m^2 (100.1, 141.0, 292.6, 348.0 and 362.0) and leaves/plant (5.6, 8.8, 15.6, 20.3 and 19.4), closely followed by 100% N through KC (plant height: 36.5, 53.8, 74.3, 94.1 and 101.5 cm; tillers/m^2: 96.7, 133.3, 283.3, 336.5 and 352.7; leaves/plant: 5.3, 8.4, 14.4, 18.4 and 17.2), 50% N each from VC and FYM (plant height: 35.5, 54.7, 74.5, 92.2 and 99.7 cm; tillers/m^2: 94.3, 129.3, 274.6, 331.6 and 346.4; leaves/plant: 4.7, 7.7, 14.1, 19.7 and 18.4) at 25, 45, 65, 85 DAT and at harvest, respectively. As indicated in Table 1, vermicompost, apart from nitrogen, also supplied adequate amounts of other two primary nutrients. Further, it perhaps released various micro-nutrients which also promoted the growth of rice. Karanj cake was the source of concentrated organic manure, which probably released nutrients specially nitrogen quickly soon after application with vermicompost in combination. Besides, karanj cake is known for bio-pesticidal activities against nematodes and different rice pests and in this study, this might be another reason behind such result (Paramasiva *et al.* 2020). Adequate supply of nitrogen possibly helped in cell division and multiplication, resulting in generation of higher tillers, leaves as well as increment of plant height. Control (no manure use) resulted in poorest growth attributes of aromatic rice. It was possibly due to non-receipt of any nutrition specially nitrogen from external source of organic manures.

Yield attributes

Different yield attributes also showed similar trend of growth attributes (Table 3). Application of N 50% each from VC and KC recorded maximum numbers of productive tiller/m^2 (199.3) and panicle length (24.1 cm), followed by 100% N from KC (productive tillers/m^2: 192.7, panicle length: 23.4 cm) and 50% N each from VC and FYM (productive tillers/m^2: 186.3; panicle length: 22.7 cm). 50% N each from VC and KC and 100% N from KC remained statistically at par with each other in terms of panicle length. Similarly, filled grains were maximum from application of N 50% each from VC and KC (172.8), followed by 100% N through KC (164.2) and 50% N each from VC and FYM (157.7). The number of chaffed grains also showed similar trend where it was least when N was applied equally from VC and KC together (21.0), followed by 100% N from KC (21.3) and 50% N each from VC and FYM (22.7) and all those three treatments remained statistically indifferent. Although 1000 grain weight did not vary significantly among the nitrogen sources, it was maximum from application of N 50% each from VC and KC (22.9 g), next followed by 100% N through KC (22.6 g). Control exhibited lowest yield attributes cited above and maximum numbers of chaffed grain/panicle. Combination of bulky vermicompost and concentrated karanj cake outperformed others as they were possibly improved soil microbial activity resulting higher decomposition and release of nutrients (Cavender *et*

Table 3. Yield attributes and yield of aromatic rice as influenced by various organic nitrogen sources.

Treatments	Productive tillers (/m^2)	Panicle length (cm)	Grains/panicle		1000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
			Filled	Chaffed					
Control	147.3	18.5	129.4	35.7	20.5	3.34	4.79	8.13	41.1
$FYM_{100\%N}$	167.3	21.2	141.5	27.8	21.7	4.78	6.11	10.89	43.9
$VC_{100\%N}$	178.0	22.0	150.8	23.8	22.0	5.31	6.68	11.99	44.3
$KC_{100\%N}$	192.7	23.4	164.2	21.3	22.6	6.86	8.56	15.42	44.5
$FYM_{50\%N+KC50\%N}$	174.7	21.1	153.8	21.0	21.8	5.45	6.88	12.33	44.2
$VC_{50\%+KC50\%N}$	199.3	24.1	172.8	18.3	22.9	7.37	9.08	16.45	44.8
$VC_{50\%N+FYM50\%N}$	186.3	22.7	157.7	22.7	21.8	6.07	7.63	13.70	44.3
SEm±	2.17	0.32	2.27	0.87	1.07	0.15	0.12	0.29	0.08
CD (p=0.05)	6.5	1.0	6.8	2.6	NS	0.43	0.36	0.85	0.2

al. 2003). Further, they might improve soil physical health as well as enhance soil fertility status through supplying different essential nutrients, plant growth promoting hormones. Greater root growth as well as uptake of nutrients specially nitrogen might improve chlorophyll content for higher photosynthetic efficiency resulting in high dry matter production and translocation of dry matter from vegetative (source) to reproductive parts (sink) (Biswas *et al.* 2020b).

Yield and harvest index

Grain yield (GY) of aromatic rice expressed identical trend of yield attributes (Table 3). Maximum GY (7.37 t/ha) was recorded when N was applied equally from VC and KC together, followed by 100% N from KC (6.86 t/ha), N 50% each from VC and FYM (6.07 t/ha). Straw yield (SY) and biological yield (BY) also showed similar trend of grain yield, in which application of N 50% each from VC and KC recorded maximum SY (9.08 t/ha) and BY (16.45 t/ha), followed by 100% N through KC (SY: 8.56 t/ha. BY: 15.42 t/ha) and 50% N each from VC and FYM (SY: 7.63 t/ha. BY: 13.70 t/ha). Further, application of N 50% each from VC and KC recorded highest harvest index (44.8%), next followed by 100% N through KC (44.5%). Control was the worst one record GY (3.34 t/ha), SY (4.79 t/ha), BY (8.13 t/ha) and harvest index (41.1%) (Table 3). Higher photosynthetic efficiency followed by translocation of dry matter for development of reproductive organs might improve the yield of aromatic rice under organic manure application, specifically, when vermicompost and karanj cake were applied together (Biswas *et al.* 2020b). Higher straw yield was the result from greater vegetative growth (Sarangi *et al.* 2016).

Table 4. Residual soil status after cultivation of aromatic rice using nitrogen various organic sources.

Treatments	Soil pH	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Control	6.90	361.3	100.4	371.3
$FYM_{100\%N}$	6.54	457.7	136.8	353.9
$VC_{100\%N}$	6.58	461.7	118.1	301.0
$KC_{100\%N}$	6.47	411.5	128.2	308.8
$FYM_{50\%N+KC50\%N}$	6.53	401.4	160.6	372.5
$VC_{50\%+KC50\%N}$	6.51	371.3	121.0	294.9
$VC5_{0\%N+FYM50\%N}$	6.56	441.4	133.4	326.5
SEm±	0.31	11.2	4.1	9.9
CD (p=0.05)	NS	32.4	11.3	29.7

Residual soil status

Residual soil status was presented in Table 4. It was found that soil pH did not vary among the treatments. However, it showed decline in value in manure applied plot as compared to control. Maximum content of available N (461.7 kg/ha) was obtained from 100% VC, while maximum available P_2O_5 (160.6 kg/ha) and K_2O (372.5 kg/ha) were obtained from 50% N each from VC and FYM. It could be speculated that in that treatment, both vermicompost and FYM released nutrients slowly and therefore, higher amounts of nutrients were left in the soil even after uptake of nutrients. Relatively less N, P_2O_5 and K_2O were recorded from N equally applied from VC and KC together and through 100% KC. It might be due to greater uptake of nutrients by the crop for ensuring high growth and productivity. Control recorded lowest available N and P_2O_5, but relatively higher K_2O.

Production Economics

Production economics (Table 5) revealed that control fetched lowest cost of cultivation (₹96,340/ha), while application of manures increased production cost of aromatic rice. Maximum cost of cultivation was incurred by combined application of 50% N from VC and 50% N from KC (₹1,63,468/ha), followed by 100% N through KC (₹1,58,997/ha). Application of N through VC and KC (50% from each) recorded maximum gross return (GR) (₹4,83,590/ha), net return (NR)(3,20,122/ha) and B:C (2.96). It was closely followed by 100% N through KC (GR: ₹4,50,180/ha, NR: ₹2,91,183/ha, B:C of 2.83). Control generated lowest GR (₹2,19,495/ha), NR (₹1,23,155/ha) and B:C (2.28). Higher growth and production of yield due to beneficial influence of vermicompost and karanj cake together helped in fetching higher gross return, net return and economic profitability. The present finding differed from Kumari *et al.* (2014) who obtained less economic return from vermicompost and karanj cake due to their high cost. Control was unable to attain high growth and yield as it was devoid of any nutrient application, resulting in lowest

Table 5. Production economics of aromatic rice as influenced by various organic nitrogen sources.

Treatments	Cost of cultivation (₹/ha)	Gross return (₹/ha)*	Net return (₹/ha)	Benefit: cost ratio (B:C)
Control	96,340	2,19,495	1,23,155	2.28
$FYM_{100\%N}$	1,34,026	3,13,755	1,79,729	2.34
$VC_{100\%N}$	1,47,940	3,48,490	2,00,550	2.36
$KC_{100\%N}$	1,58,997	4,50,180	2,91,183	2.83
$FYM_{50\%N + KC50\%N}$	1,50,983	3,57,690	2,06,707	2.37
$VC_{50\% + KC50\%N}$	1,63,468	4,83,590	3,20,122	2.96
$VC_{50\%N + FYM50\%N}$	1,46,511	3,98,365	2,51,854	2.72
SEm±	-------	1904.4	2212	0.04
CD (p=0.05)	-------	5713	6633	0.12

*Price of grain and straw: ₹65/- and ₹0.5 per kg.

gross return, net return and B:C.

CONCLUSION

The study well established the need of nutrient management for flourishing the growth and productivity of aromatic rice. Specifically, under the context of intensive chemical farming drawn environmental pollution and health issues as well as climate change scenario, replacement of chemical fertilizers with organic nitrogen sources proved to be good alternative and eco-friendly options in rice cultivation. Overall, based on the above findings, application of nitrogen 50% each through vermicompost and karanj cake together can be recommended for achieving maximum growth, yield attributes, yield and economic profitability of transplanted aromatic rice during *kharif* season in Eastern plateau and hill region of India.

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