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Research Communication

Effect of organic manure and LCC-based N top dressing on growth, yield, quality and economics of aromatic rice in *Gangetic* alluvial soil

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ABSTRACT

A field experiment was conducted at Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal during rainy (*kharif*) season of 2023 to find out the effect of 3 organic manures (cow dung manure, vermicompost and poultry manure) @ 20 kg N/ha as basal in main plots, and four LCC-based N top dressing (no top dressing, neem-coated urea @ 15 kg N/ha, nano urea @ 4 ml/litre and mustard cake @ 15 kg N/ha) in sub-plots. Basal application of vermicompost @ 20 kg N/ha to aromatic 'Gobindabhog' rice resulted in tallest plant at maturity (143.7 cm), maximum dry matter accumulation (492.2 g/m^2) at 84 DAT and maximum grain yield (2.67 t/ha), but it led to least net income (₹48,549/ha) due to higher cost of cultivation. However, basal application of poultry manure @ 20 kg N/ha resulted in moderate grain yield (2.54 t/ha), better lodging resistance (score 2.0), higher protein content (7.39%) and much-better net income (₹57,778/ha). Among LCC-based (score <3) top dressing, mustard cake @ 15 kg N/ha twice recorded better growth attributes, chlorophyll content in leaf (2.52 mg/g) at 84 DAT and maximum grain yield (2.79 t/ha); while the crop nourished with neem-coated urea recorded moderate yield (2.61 t/ha), better lodging resistance (score 2.0), highest protein content (7.47%) and maximum net income (₹58,434/ha) in the study.

Key words: Aromatic rice, Economics, Growth, Leaf colour chart, Organic manure, Quality, Yield

'Gobindabhog' is the most popular non-Basmati type indigenous aromatic rice cultivated in lower *gangetic* plains and *rahr* region of West Bengal. It is a tall-*indica* type, long duration rice (140-145 days) having small, white kernel and medium-strong aroma. It is used for preparation of *bhog* (*khichuri*), *payesh* (dessert), *polao*, *pitha* (home-made cake), *chira* (flattened rice), etc. during social functions and religious festivals. With comprehensive effort of 'Bengal Aromatic Rice' Project of BCKV, it has been registered as a farmer's variety (No. 233 of 2014) under PPV&FRA, geographical indication product (GI No. 531 of 2017) of South Bengal (BCKV, 2020) and included in AGMARK system of the country (Government of India, 2024).

Farmers in native districts grow 'Gobindabhog' rice following traditional practices, which indicates the need of refined nutrient management for desired yield, improved grain quality and sustained soil health. The application of organic matter in the form of cow dung manure, FYM, vermicompost, green manure, etc. improves the biological properties of soil (Rahman *et al*., 2018), and also plays crucial role in quality enhancement of scented rice (Davari and Sharma, 2010). In the context, poultry manure and mustard cake are uncommon nutrient-rich organic inputs; while neem-coated urea increases nitrogen use efficiency and liquid nano urea even in minute quantity is claimed equally effective to granular urea in rice cultivation in the country. Besides, the use of leaf colour chart (LCC) is a new technique for need-based N top dressing through chemical fertilizers in rice field. Keeping in view, the present study was undertaken to find out the response of GI-tagged Gobindabhog rice to organic manure and LCC-based N top dressing by various N sources in *gangetic* alluvial soil.

A field experiment was conducted to study the effect of organic manures and inorganic N sources on growth, yield, grain quality and economics of scented rice (*cv.* 'Gobindabhog') during the rainy (*kharif*) season of 2023 at the Instructional Farm (22°93' N, 88°53' E and 9.75 m above mean sea level) of Bidhan Chandra Krishi Viswavidyalaya (BCKV), Jaguli, Nadia, West Bengal. The soil of lowland field was clay-loam (order Inceptisol),

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neutral in reaction (pH 7.3), medium in organic C (0.59%), medium in available N (282.2 kg/ha), P (24.4 kg/ha) and K (190.0 kg/ha). The experiment was laid out in split-plot design with 3 replications, which consisted of three organic manures (cowdung manure, vermicompost and poultry manure) @ 20 kg N/ha as basal in main plots, and four LCC-based N top dressing (no top dressing, neem-coated urea @ 15 kg N/ha, nano urea @ 4 ml/litre and mustard cake @ 15 kg N/ha) in sub plots. Based on variation in N content among three organic manures, the quantity was estimated as: cow dung manure (0.4% N) @ 5 t/ha; vermicompost (1.0% N) @ 2 t/ha and poultry manure (1.5% N) @ 1.3 t/ha. Entire dose of recommended P_2O_5 and K_2O @ 25:25 kg/ha were applied as basal in the form of single super phosphate and muriate of potash, respectively in all experimental units. Twenty-nine days old seedlings of 'Gobindabhog' rice were transplanted @ 2-3/hill at a spacing of 20 cm × 15 cm in plots of puddled field. Top dressing of N was done based on score <3 of Customized Leaf Colour Chart [CLCC developed by NRRI, Cuttack, India] through different N sources including IFFCO-Neem-coated urea @ 15 kg N/ha, IFFCO-Nano urea (liquid) @ 4 ml/litre (312 litres ha^{-1}) and mustard cake @ 0.29 t/ha (5.1% N) to supply 15 kg N/ha each time. Based on LCC value <3, neem-coated urea and mustard cake were given twice at 28 and 42 DAT, while nano urea was sprayed thrice at 28, 42 and 56 DAT. Two hand weeding were done at 3 and 6 weeks after transplanting in all the plots. The crop was raised with south-west monsoon rainfall with need-based irrigations.

The growth attributes of scented rice like plant height, leaf area index (Watson, 1958), tillering habit, dry matter (DM) production at different stages were noted; while yield components and grain yield were determined at maturity. The chlorophyll content of leaf (Arnon, 1949) was determined at 84 DAT, while lodging intensity (IRRI, 1996) was noted at maturity. The grain quality parameters like amylose content (Juliano, 1971), protein content (total N × 5.95) and aroma (Nagaraju *et al*., 1991) were estimated at Aromatic Rice Laboratory of BCKV. Total N uptake (grain + straw) and available N in soil were determined by modified Kjeldhal method (Jackson, 1973), while total bacterial population in soil was estimated following serial dilution and pour plate method (Pepper *et al*., 2004). The economics of production *viz*. total cost of cultivation, gross return, net income and benefit: cost ratio were calculated considering the market price of inputs, outputs and labour wages. The data obtained in the study were analyzed using on-line OPSTAT software following standard statistical procedures.

The growth parameters like plant height and DM accumulation of 'Gobindabhog' rice was gradually increased at varied rate toward maturity, while tillering habit and leaf area were increased upto a certain growth stage and thereafter declined. 'Gobindabhog' rice nourished with vermicompost as basal @ 20 kg N/ha produced tallest plant at maturity (143.7 cm) and showed lodging susceptibility (score 3.4) at hard dough stage, while the crop received poultry manure as basal had less lodging tendency (score 2.0) (Table 1). Top dressing with mustard cake @ 15 kg N/ha twice based on LCC value <3 resulted in greater plant height at maturity (148.0 cm) and higher lodging tendency (score 2.9) among sub-plot treatments. 'Gobindabhog' rice nourished with basally applied vermicompost produced maximum number of tillers/m^2 (347) at 63 DAT (maximum tillering stage), LAI (4.90) at 84 DAT (pre-heading stage) and CGR (11.5 g/m^2/day) at 63-84 DAT. On the other hand, the crop received poultry manure as basal had maximum total chlorophyll content in leaf (2.37 mg/g) at 84 DAT. Top dressing with mustard cake @ 15 kg N/ha twice resulted in better growth attributes like tiller production (366/m^2), LAI (5.37) and leaf chlorophyll content (2.52 mg/g) at 63 and 84 DAT, which indicated slower release of nutrients from mustard cake compared to chemical N sources used (neem-coated urea and nano urea) in the study. Biswas *et al*. (2023) also found that the combination of vermicompost and mustard cake significantly increased the LAI of indigenous aromatic rice (*cv*. Harinakhuri) of coastal West Bengal.

The basal application of vermicompost to 'Gobindabhog' rice resulted in maximum grain yield (2.67 t/ha) due to significant improvement in number of panicles/m^2 (264.1) and number of filled grains/panicle (201.6), but that yield was at par with poultry manure (2.54 t/ha). Panotra *et al*. (2022) reported similar positive effect of vermicompost in increasing grain yield due to longer panicle and greater 1000 grain weight of Basmati 370 as compared to other organic management practices in Jammu. Karki *et al*. (2023) also found the favourable effect of vermicompost on grain yield of scented rice landraces of North Bengal. 'Gobindabhog' rice top dressed with mustard cake twice yielded highest (2.79 t/ha), which was 6.5%, 9.7% and 17.2% greater over neem-coated urea, nano urea and no N top dressing, respectively. It could be noted that foliar spray of nano urea (4% N) @ 1.25 litre/ha thrice was not found sufficient to provide the desired yield of 'Gobindabhog' rice. In support, LCC-based top dressing of urea resulted in maximum effective tillers (260.2 m^{-2}) and longest panicle (28.1 cm) leading to higher grain yield than other top dressing methods in Terai region of Nepal (Bhatt *et al*., 2024).

Mean amylose content in 'Gobindabhog' rice grain based on different organic manures and LCC-based N top dressing was 18.4%, which indicated that the variety belonged to low amylose group. The basal application of

Table 1. Effect of organic manures and N sources for LCC-based top dressing on growth and yield of aromatic 'Gobindabhog' rice during rainy season

Treatment	Plant height (cm) at harvest	Lodging (score)	Tillers/m^2 at 63 DAT	LAI at 84 DAT	Total chlorophyll (mg/g) at 84 DAT	Dry matter accumulation (g/m^2) at 84 DAT	CGR (g/m^2/day) at 63-84 DAT	Panicles/ m^2	Filled grains/ panicle	Grain yield (t/ha)
Organic manure										
Cow dung manure @ 20 kg N/ha	138.7	2.3	331	4.76	2.32	449.7	11.4	225.5	191.3	2.47
Vermicompost @ 20 kg N/ha	143.7	3.4	347	4.90	2.24	492.2	11.5	264.1	201.6	2.67
Poultry manure @ 20 kg N/ha	140.3	2.0	341	4.74	2.37	457.7	11.1	236.4	190.4	2.54
SEm±	0.66	0.08	2.97	0.01	0.01	0.86	0.04	0.85	0.35	0.03
CD (P=0.05)	2.68	0.30	11.99	0.05	0.02	3.46	0.15	3.42	1.40	0.13
N Top dressing at LCC <3										
No top dressing	133.2	2.6	302	4.14	2.11	400.8	9.2	204.4	180.7	2.31
Neem-coated urea @ 15 kg N/ha	144.1	2.0	366	4.88	2.37	469.9	11.0	255.9	191.6	2.61
Nano urea @ 4 ml/litre	138.2	2.8	324	4.82	2.24	468.9	12.0	241.8	197.3	2.52
Mustard cake @ 15 kg N/ha	148.0	2.9	366	5.37	2.52	526.6	13.3	265.9	208.2	2.79
SEm±	0.52	0.14	2.43	0.02	0.01	0.96	0.06	0.96	0.63	0.02
CD (P=0.05)	1.55	0.41	7.28	0.04	0.03	2.88	0.19	2.87	1.88	0.06

LCC, Leaf colour chart; DAT, Days after transplanting

Table 2. Effect of organic manures and N sources for LCC-based top dressing on quality, N status and economics of aromatic 'Gobindabhog' rice during rainy season

Treatment	Amylose (%)	Protein (%)	Aroma (score) (kg/ha)	N uptake (kg/ha)	Residual N in soil	Bacterial population (cfu × 10^5/g soil)	Cost of cultivation (× 10^3 ₹/ha)	Gross return (× 10^3 ₹/ha)	Net income (×10^3 ₹/ha)	Benefit: cost ratio
Organic manure										
Cow dung manure @ 20 kg N/ha	18.96	7.02	1.97	54.6	283.9	97.7	60.37	111.55	51.18	1.86
Vermicompost @ 20 kg N/ha	18.51	7.08	2.00	62.2	289.6	89.4	72.87	121.41	48.55	1.67
Poultry manure @ 20 kg N/ha	17.71	7.39	1.85	55.5	280.1	101.8	58.07	115.84	57.78	2.01
SEm±	0.06	0.02	0.18	0.58	1.65	2.23		1.30	1.30	0.02
CD (P=0.05)	0.25	0.08	NS	2.34	6.64	8.98		5.24	5.24	0.09
N Top dressing at LCC <3										
No top dressing	18.40	6.98	1.85	52.6	279.6	98.0	57.78	104.97	47.19	1.84
Neem-coated urea @ 15 kg N/ha	17.93	7.47	1.91	59.0	292.0	94.1	59.76	118.19	58.43	2.00
Nano urea @ 4 ml/litre	18.71	6.97	2.04	55.1	280.1	94.0	61.84	115.17	53.33	1.87
Mustard cake @ 15 kg N/ha	18.53	7.23	1.96	62.9	286.4	99.0	75.71	126.75	51.05	1.68
SEm±	0.05	0.01	0.19	0.56	1.79	3.11		0.94	0.94	0.01
CD (P=0.05)	0.16	0.02	NS	1.68	5.36	NS		2.82	2.83	0.04

LCC, Leaf colour chart
Price of grain: ₹39/kg; Price of straw: ₹3/kg

poultry manure resulted in higher protein content (7.39%), while 'Gobindabhog' rice top dressed with neem-coated urea had more protein content (7.47%) in grain (Table 2). The aroma scores assigned in the study indicated that 'Gobindabhog' rice generally had medium aroma (score ±1.94), but the intensity of aroma in milled rice was not influenced due to different nutrition-based treatments in the study.

N uptake was recorded maximum (62.2 kg/ha) when the crop was nourished with vermicompost as basal, while mustard cake led to greater uptake (62.9 kg/ha) of total N (grain + straw). On the other hand, the crop grown without N top dressing recorded least total uptake of N, which indicated that less supply of nutrients led to less production of biological yield. A positive balance of available N (+2.6%) over initial status (282.2 kg/ha) was noted with vermicompost in the study. The soil biological study showed maximum bacterial population (101.8 cfu 10^5/g soil) in the plots which received poultry manure, and that was at par with cow dung manure (97.7 cfu 10^5/g soil) in new alluvial soil. Meena *et al.* (2012) found similar observation, where application of poultry manure @ 150% RDN led to increase in bacterial population over similar dose of FYM and vermicompost after harvesting of scented rice (*cv*. Pusa Sugandh 3) at Varanasi, Uttar Pradesh.

The common expenditure incurred for aromatic rice cultivation irrespective of organic nutrient management and LCC-based N top dressing was calculated as ₹46,884/ha in Nadia district of West Bengal. Due to variability in cost of organic manure, total cost of cultivation was varied as: ₹60,371/ha for cow dung manure, ₹72,871/ha for vermicompost and ₹58,071/ha for poultry manure. Similarly, differences in cost incurred for top dressing through different N sources resulted in variation in total cultivation cost between ₹57,784/ha for no N top dressing and ₹75,706/ha for top dressing with mustard cake for tall-*indica* rice (*cv*. 'Gobindabhog') during *kharif* season. But Paul *et al*. (2021) reported less cultivation cost for black-husked 'Kalonunia' rice under integrated nutrient management in Terai Zone of West Bengal. The crop nourished with vermicompost recorded maximum gross return (₹1,26,752/ha) because of highest grain and straw yield compared to FYM and poultry manure in the study. Poultry manure recorded maximum net income (₹57,778/ha), which was 16.0% greater over vermicompost and 11.4% over cow dung manure. As a result, poultry manure had >2.0 B:C ratio, while cow dung manure and vermicompost recorded lesser B:C ratio of 1.86 and 1.67, respectively. Although maximum yield was obtained with the use of mustard cake, but its higher cost led to lesser net income (₹51,046/ha) as compared to neem-coated urea (₹58,434/ha) and nano urea (₹53,332/ha) in the experiment. The application of neem-coated urea could result in B:C ratio of 2.0, but other three LCC-based N top dressing including control recorded <2.0 B:C ratio.

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