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Research Communication

Effect of organic and inorganic nutrient sources on growth, yield and economics of aromatic rice (*Oryza sativa*) in *Gangetic* delta of West Bengal

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ABSTRACT

A field experiment was conducted at the Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal, during rainy season (*kharif*) 2019, to study the effect of different nutrient sources on growth, yield and economics of scented rice (*Oryza sativa* L.). Among 9 treatments, integrated nutrient management (FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha) led to the maximum tiller production (345.4 /m^2) at 56 days after transplanting (DAT), the highest leaf-area index (LAI) (2.90) and dry-matter production (596.2 g/m^2) at 84 DAT. Chemical fertilizer-based nutrition ($N_{40}P_{20}K_{20}$ kg/ha) resulted in the maximum plant height (125.0 cm) at harvesting and grain yield (2.57 t/ha), being at par with FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha (2.53 t/ha). Plants in LCC-based N-fertilized plots had moderate grain yield (2.18 t/ha) and least lodging tendency (score 2.3). Chemical fertilizer-based nutrition could record the maximum yield (2.57 t/ha), net income (₹42,126/ha) and benefit: cost ratio (2.02); but integrated nutrient management (FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha) might be an alternative option for sustainable cultivation (2.53 t/ha, ₹38,069.50/ha and 1.86) in lower Gangetic plains of West Bengal.

***Key words*:** Aromatic rice, Economics, Growth, Nutrient management, Yield

'Harinakhuri' is a non-basmati type aromatic rice (*Oryza sativa* L.) cultivar, which is traditionally cultivated in lower *Gangetic* plains of West Bengal for a long period. The nutrition of 'Harinakhuri' rice is traditionally provided by locally-available organic manures or chemical fertilizers in recent times. Such untested nutrition schedule needs refinement for desired production and quality of 'Harinakhuri' rice. Literatures indicates that, combination of organic and inorganic sources of nutrients improved the yield, nutrient-use efficiency, and soil health. Besides, the use of leaf-colour chart (LCC) is a new technique for need-based N top-dressing through chemical fertilizers in rice field. In the context, a few attempts have been made to standardize the nutrient management of folk scented rice varieties like 'Radhunipagal' (Pal, 2016) and 'Gobindabhog' (Mahata *et al*., 2018), excluding this 'Harinakhuri' rice till date. Keeping in view, the present study was undertaken to find out the appropriate nutrient management for large-scale cultivation of the variety in the native region of the state.

A field experiment was conducted to study the effect of organic and inorganic nutrient sources on growth, yield and economics of scented rice cv. 'Harinakhuri' during the rainy (*kharif*) season of 2019 at the Instructional Farm (22°93' N, 88°53' E, and 9.75 m above mean sea-level) of the Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Nadia, West Bengal. The soil of lowland field was clay loam (Order Entisols), neutral in reaction (*p*H 7.1), medium in organic C (0.62%), low in available N (210.2 kg/ha), high in P (40.5 kg/ha) and medium in K (155.5 kg/ha). The experiment was laid out in a randomized block design (RBD) replicated thrice, which consisted of 9 treatments, viz. control, $N_{40}P_{20}K_{20}$ kg/ha as recommended dose of fertilizer (RDF), farmyard manure (FYM) @ 8 t/ha, vermicompost (VC) @ 4 t/ha, FYM @ 4 t/ha + $N_{20}P_{10}K_{10}$ kg/ha, VC @ 2 t + $N_{20}P_{10}K_{10}$ kg/ha, FYM @ 4 t + mustard cake (MC) @ 0.4 t/ha, VC @ 2 t + MC @ 0.4 t/ha, and leaf colour chart (LCC) based N @ 15 kg/ha. Urea, single superphosphate and muriate of potash were used to supply N, P_2O_5 and K_2O respectively. Seeds of 'Harinakhuri' paddy collected from RKVY Project on 'Bengal Aromatic Rice', BCKV, Nadia, were sown in wet nursery (6 m × 1 m). Thirty-two days old seedlings of 'Harinakhuri' rice were transplanted @ 2–3/hill at a spacing of 20 cm × 15 cm in plots of puddled field. The recommended dose of fertilizer and other crop management practices were adopted as per

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standard recommendations (Ghosh, 2019). The full dose of phosphate and potash, full dose of FYM and vermicompost were applied basal per treatment schedule in the assigned plots; while nitrogen was given in 3 splits: one-fourth basal, half at 3 weeks after transplanting (WAT) and rest at 6 WAT. Mustard-cake was top-dressed in 2 equal halves at 3 WAT and 6 WAT. The LCC-based plots received full phosphate and potash as basal, while nitrogen was top-dressed @ 15 kg/ha based on LCC readings (scale > 3.0), actually at 45 DAT in the experiment.

Growth attributes like plant height, tillers/m^2, leaf-area index (Watson, 1958) and dry-matter (DM) production, crop-growth rate (CGR), net assimilation rate (NAR) were recorded, and yield-attributing characters and grain yield were determined at maturity. The rating of lodging of plants was done at hard dough stage (IRRI, 1996). The economics of production, viz. total cost of cultivation, gross returns, total income, and benefit: cost ratio were calculated considering the prevailing market price of the inputs, outputs and labour wages. The data collected were statistically analysed by the analysis of variance method suitable for RBD in the investigation (Gomez and Gomez, 1984).

Plants supplied with 100% inorganic fertilizers ($N_{40}P_{20}K_{20}$ kg/ha) showed the maximum height (125.0 cm) at harvesting, being at par with integrated nutrient management (FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha) (Table 1). The tillering pattern indicated that, the application of chemical fertilizers ($N_{40}P_{20}K_{20}$ kg/ha) triggered the tiller production (260.6/m^2) at early and mid-vegetative stages (28 DAT), while sustained supply of nutrients from integrated nutrient management (FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha) resulted in the maximum number of tillers in 1 m^2 area at 56 DAT (345.4). The plants nourished with VC 2 t + MC @ 0.4 t/ha showed the highest LAI at 56 DAT (2.72) and 84 DAT (2.90) respectively. The leaf colour-based N-fertilization recorded low LAI (0.89) at 28 DAT, which was improved to 2.50 at 56 DAT owing to receiving top-dressed urea @ 15 kg/ha at 45 DAT. Similarly, the plots receiving only FYM @ 8 t/ha and VC @ 4 t/ha also showed improvement in leaf growth at mid-and late vegetative stage (56–28 DAT) because of slow release of nutrients from organic manures in the field. Integrated nutrition (FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha) led to produce the highest DM (596.2 g/m^2) at 84 DAT and the maximum crop-growth rate (14.38 g/day/m^2) during 56–84 DAT, being closely followed by the use of chemical fertilizers ($N_{40}P_{20}K_{20}$ kg/ha); while FYM 8 t/ha resulted in the highest NAR (5.82 g/m^2/day) at 56–84 DAT.

Nutrient management caused significant variation in yield components and grain yield of 'Harinakhuri' rice during the rainy season; but panicle length and test weight being genetical characters remained unaffected in study (Table 2). Integrated nutrient management (FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha) led to the production of maximum number of panicles in unit area (258.5/m^2), being at par with 100% inorganic fertilizers (257.4/m^2), VC 2 t + $N_{20}P_{10}K_{10}$ kg/ha (244.2/m^2) and FYM 8 t/ha (238.7/m^2). Application of FYM 8 t/ha resulted in highest number of filled grains/panicle (94.5), which was closely followed by integrated nutrient management (VC 2 t + $N_{20}P_{10}K_{10}$ kg/ha). The mean test weight of 'Harinakhuri' rice was 17.90 g, and that remained unaffected due to nutrient-based treatments in the experiment. Plants supplied with 100% inorganic fertilizers gave highest grain yield (2.57 t/ha), being at par with FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha (2.53 t/ha) and VC 2 t + MC 0.4 t/ha (2.50 t/ha). Saha *et al*., (2022) also reported that, application of 100% recommended dose ($N_{50}P_{25}K_{25}$ kg/ha) through chemical fertilizers to aromatic 'Lal Badshabhog' rice resulted in higher grain yield (2.64 t/ha) at Kalyani,

Table 1. Effect of organic and inorganic nutrients on growth attributes of aromatic 'Harinakhuri' rice during the rainy season

Treatment	Plant height (cm) at harvesting	Tillers /m^2		LAI		Dry-matter accumulation (g/m^2) at 84 DAT	CGR (g/day/m^2) at 56–84 DAT	NAR (g/m^2/day) at 56–84 DAT
		28 DAT	56 DAT	56 DAT	84 DAT			
Control	114.0	212.0	254.8	2.04	2.23	463.8	10.64	5.02
$N_{40}P_{20}K_{20}$ kg/ha	125.0	260.6	319.0	2.46	2.82	580.3	13.91	5.28
FYM @ 8 t/ha	117.3	235.6	279.4	2.24	2.48	536.6	12.97	5.82
VC @ 4 t/ha	118.3	222.4	286.0	2.46	2.73	574.4	13.53	5.21
FYM @ 4 t + $N_{20}P_{10}K_{10}$ kg/ha	121.6	237.6	345.4	2.55	2.90	596.2	14.38	5.28
VC @ 2 t + $N_{20}P_{10}K_{10}$ kg/ha	117.7	224.4	310.0	2.53	2.71	510.1	11.69	4.46
FYM @ 4 t + MC @ 0.4 t/ha	118.8	232.2	292.6	2.61	2.54	490.8	10.86	4.23
VC @ 2 t + MC @ 0.4 t/ha	120.7	226.8	292.8	2.72	2.89	546.3	12.38	4.44
LCC-based N @ 15 kg/ha	120.8	228.8	281.6	2.50	2.56	509.4	11.59	4.59
SEm±	1.37	7.43	11.20	0.13	0.13	19.23	0.75	0.31
CD (P=0.05)	4.10	22.28	33.59	0.40	0.39	57.64	2.26	0.94

FYM, Farmyard manure; VC, vermicompost; MC, mustard-cake; LCC, leaf-colour chart; DAT, days after transplanting

Table 2. Effect of organic and inorganic nutrients on yield and economics of aromatic 'Harinakhuri' rice during the rainy season

Treatment	Panicles /m^2	Filled grains /panicle	1,000-grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Lodging (score)	Cost of cultivation (×10^3 ₹/ha)	Gross returns (×10^3 ₹/ha)	Net income (×10^3 ₹/ha)	Benefit: cost ratio
Control	204.5	80.6	17.28	2.00	5.32	2.3	38.82	65.32	26.50	1.68
$N_{40}P_{20}K_{20}$ kg/ha	257.4	90.1	18.05	2.57	6.30	5.0	41.17	83.30	42.13	2.02
FYM @ 8 t/ha	238.7	94.5	17.81	2.12	5.60	3.7	46.82	69.10	22.28	1.47
VC @ 4 t/ha	226.5	88.8	18.21	2.30	5.80	3.7	54.82	74.80	19.98	1.36
FYM @ 4 t + $N_{20}P_{10}K_{10}$ kg/ha	258.5	90.4	18.14	2.53	6.07	4.3	44.00	82.07	38.07	1.86
VC @ 2 t + $N_{20}P_{10}K_{10}$ kg/ha	244.2	93.8	17.55	2.35	5.90	3.7	48.00	76.40	28.40	1.59
FYM @ 4 t + MC @ 0.4 t/ha	223.8	90.4	17.98	2.35	6.25	3.0	52.02	76.75	24.73	1.48
VC @ 2 t + MC @ 0.4 t/ha	237.7	91.9	18.0	2.50	6.15	2.7	56.02	81.15	25.13	1.45
LCC-based N @ 15 kg/ha	221.1	88.7	18.15	2.18	5.85	2.3	40.74	71.35	30.61	1.75
SEm±	6.77	2.32	0.89	0.08	0.19	0.45		2.64		
CD (P=0.05)	20.30	6.94	NS	0.26	0.58	1.35		7.92		

FYM, Farmyard manure; VC, vermicompost; MC, mustard cake; LCC, leaf-colour chart
Price of grain: ₹30/kg; Price of straw: ₹1/kg

West Bengal; and scented rice ('Birsamati') grown with recommended inorganic fertilizer gave higher grain yield than the best organic source combination of green manuring @ 5 t/ha + FYM @ 10 t/ha at Ranchi, Jharkhand (Kumari *et al*., 2010). Perusal of data in Table 2 revealed that, sole application of FYM @ 8 t/ha or vermicompost @ 4 t/ha or LCC-based N topdressing @ 15 kg/ha were not found sufficient to provide the desired yield of 'Harinakhuri' rice. The LCC-based N fertilization resulted in less grain yield (2.18 t/ha) than chemical fertilizer-based nutrition or different combinations of nutrient management in the experiment, which was in contradiction with the findings of Kumar *et al.,* (2018) and Subedi *et al*., (2018). Plants raised with LCC-based N nutrition showed slightly lodging tendency (score 2.3), followed by combined use of vermicompost 2 t + mustard cake 0.4 t/ha (score 2.7), but most (>50%) of the plants nourished with $N_{40}P_{20}K_{20}$ kg/ha lodged completely (score 5.0) at hard dough stage. However, it was observed (data not shown) that the overall lodging resistance was found better in 'Harinakhuri' rice than the surrounding fields of traditional rice ('Kerala Sundari' and 'Gobindabhog') at the experimental site within the extended area of a very severe cyclonic storm *'Bulbul'* on 10 November 2019.

The common cost of cultivation was same (₹38,820/ha) for all the treatments adopted in the experiment, but the cost related to nutrient management varied due to different doses and costs of inorganic and organic nutrient sources used in the field. Except in unnourished control, the minimum cost of cultivation (₹40,739/ha) was recorded for LCC-based fertilization, followed by chemical fertilizer-based nutrient management (₹41,174/ha). The higher cost of vermicompost and mustard-cake led to greater cultivation expenditure (>₹50,000/ha) in plots receiving either or both of them. The highest gross return (₹83,300/ha) was obtained with chemical fertilizer-based nutrition ($N_{40}P_{20}K_{20}$ kg/ha), which was ₹17,983/ha higher over the unnourished control. The net income from 'Harinakhuri' rice cultivation varied between ₹19,980/ha (vermicompost @ 4 t/ha) and ₹42,126/ha ($N_{40}P_{20}K_{20}$ kg/ha). Integrated nutrient management (FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha) could record higher net return (₹38,070/ha), while LCC-based N @ 15 kg/ha resulted in moderate net income (₹30,611/ha). However, Kumar *et al*., (2018) reported that real-time N management (100% RDN) using LCC to rice cv. 'SHIATS Dhan 1' led to maximum net returns (₹47,034/ha) compared to conventional N-management practices (70, 80, 90 and 100% RDN) at Allahabad, Uttar Pradesh. Due to higher cost of manures and oil cakes compared to chemical fertilizers, organic nutrient management registered lower net income (₹19,980–25,130 /ha). Like net income, chemical fertilizer-based nutrition led to the highest benefit: cost ratio (2.02), which was closely followed by FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha (1.86) and LCC-based N application (1.75). The least remunerative nutrient management (benefit: cost ratio 1.36) was found with sole application of vermicompost @ 4 t/ha in the investigation.

Thus, it could be concluded that chemical fertilizer-based nutrition ($N_{40}P_{20}K_{20}$ kg/ha) resulted in the maximum grain yield (2.57 t/ha) of 'Harinakhuri' rice, but integrated nutrition (FYM 4 t + $N_{20}P_{10}K_{10}$ kg/ha) might be an alternative option for sustainable cultivation (2.53 t/ha) in *Gangetic* delta region of West Bengal.

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