J Bangladesh Agril Univ 18(2): 260–265, 2020
https://doi.org/10.5455/JBAU.90309

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau

Yield performance of aromatic fine rice as influenced by integrated use of vermicompost and inorganic fertilizers

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ARTICLE INFO

Article history:
Received: 03 March 2020
Accepted: 27 April 2020
Published: 30 June 2020

Keywords:
Vermicompost,
Fertilizer,
Integrated nutrient management,
Aromatic rice,
Variety

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ABSTRACT

Yield performance of various aromatic rice varieties needed to be assessed by different nutrient management practices before promoting a suitable integrated nutrient management for aromatic rice production in Bangladesh. Therefore, an experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during July 2017 to December 2017 to study the combined effect of vermicompost with inorganic fertilizers on the yield and yield contributing characters of aromatic fine rice varieties. The experiment comprised three varieties *viz.* BRRI dhan34, Binadhan-13 and Kalizira and five nutrient managements *viz.* control (no application of manures and fertilizer), recommended dose of inorganic fertilizers (i.e. 150, 95, 70, 60, 12 kg ha^{-1} of Urea, TSP, MOP, Gypsum and Zinc Sulphate respectively), vermicompost @ 3 t ha^{-1}, 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1}, 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1}. The experiment was laid out in a randomized complete block design with three replications. Result showed that, yield and yield components of aromatic fine rice were significantly influenced by variety, nutrient management and interaction of variety and nutrient management. In case of variety, the highest and the lowest value of grain yield (3.89, 2.80 t ha^{-1}) and straw yield (5.29, 4.03 t ha^{-1}) were found in Binadhan-13 and Kalizira, respectively. In case of nutrient managements, the highest yield and yield component were obtained from 50% less than the recommended dose of inorganic fertilizers + vermicompost @ 3 t ha^{-1} treatment. The highest number of total tillers hill^{-1}, effective tillers hill^{-1}, number of grains panicle^{-1}, panicle length, grain yield (4.04 t ha^{-1}) and straw yield (6.20 t ha^{-1}) were obtained from the interaction of Binadhan-13 and 50% less than the recommended dose of inorganic fertilizers + vermicompost @ 3 t ha^{-1}. The lowest values related to yield were found in Kalizira with control condition. Binadhan-13 along with 50% less than the recommended dose of inorganic fertilizers + vermicompost @ 3 t ha^{-1} might be a promising practice for aromatic fine rice cultivation.

Introduction

Rice (*Oryza sativa* L.) is the large scale cultivated crop which provides half of the daily food for one of every three persons on the earth (Sangeetha *et al.* 2013). It is consumed as the staple food and has been given the highest priority in meeting the demand of the ever-increasing population in Bangladesh. It has been reported that the production of milled rice reached around 33.803 million tons in the FY 2016-17 (BBS, 2017). Among the total rice production, *amon* rice occupies 13.48 million tons in 2016-2017 (BBS, 2017) and aromatic rice constitutes 12.50 % of the total transplanted *aman* rice (Roy *et. al.* 2018) which has greater potential to attract rice consumer and boost up the economic condition of the rice grower in the developing countries.

Bangladesh has a bright prospect for exporting fine rice and thereby earning foreign exchange. But majority of the aromatic rice cultivars are low yielding and the national average aromatic rice yield is rather low which is 3.04 t ha^{-1} (Sinha *et al.* 2018). Besides the genetic constituents of aromatic rice varieties, lack of appropriate management practices could be responsible for low yield. Among these management practices, lack of improved variety and judicious use of fertilizers are the main reasons. In Bangladesh, nutrient mining, depletion of soil organic matter and reduction in soil aggregates have been identified as the reasons of yield stagnation or decline in the productivity of crops (Rahman and Yakupitiyage, 2006) and these are increasing day by day.

Use of fertilizer is an essential component of modern farming (Prodhan, 1992) but extensive and improper use of chemical fertilizers in the soil causes soil degradation in an alarming level. To overcome the situation, soil organic matter has long been suggested as the single most important indicator of soil fertility (Haynes, 2005). But, many research findings have shown that neither inorganic nor organic source can alone result in sustainable productivity (Parihar *et al.* 2015). So, the best remedy for soil fertility management is a combination of both organic and inorganic fertilizers where inorganic fertilizer provides nutrients and the organic fertilizers increases soil organic matter and

Cite this article

Laila, N., Sarkar, M.A.R., Paul, S.K. and Rahman, A. 2020. Yield performance of aromatic fine rice as influenced by integrated use of vermicompost and inorganic fertilizers. *Journal of Bangladesh Agricultural University*, 18(2): 260–265. https://doi.org/10.5455/JBAU.90309

improve soil structure as well as ameliorate the buffering capacity of soil. In this concern, vermicomposting with earthworms has been recognized as a composting technique that transforms complex organic substances into stabilized humus like product (Benitez *et al.* 2000) and helps to convert them in to valuable soil amendment and source of plant nutrients.

To get the maximum benefit from *aman* rice, it is essential to develop appropriate package of practices for successful cultivation and yield maximization. Among the various cultural practices, suitable combination of variety along with appropriate vermicompost and inorganic fertilizer rate is necessary for yield maximization. In this study, attempts have been made to test the possibility of optimizing and improving the yield of aromatic fine rice by exploring different integrated nutrient management practices and different aromatic rice cultivars.

Materials and Methods

The research work was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh. The experimental field belongs to the non-calcareous dark grey floodplain soil under the Agro-ecological Zone of the Old Brahmaputra Floodplain (AEZ-9) (UNDP and FAO, 1988) located at 24.75° N latitude and 90.50°E longitude at an elevation of 18 m above the sea level. The field was a medium high land with flat and well drained condition with the pH value, organic matter, total nitrogen, available phosphorus (P_2O_5) and potassium of the soil ranged from 5.9-6.5, 0.93%, 0.13%, 16.3 ppm and 0.28%, respectively (Rahman, 2018). The experiment consists of two factors; Factor A: rice cultivars *viz.* BRRI dhan34, BINAdhan13 and Kalizira; Factor B: nutrient management *viz.* Control (no application of manures and fertilizers), recommended dose of inorganic fertilizer (i.e. 150, 95, 70, 60, 12 kg ha^{-1} of Urea, TSP, MoP, Gypsum, Zinc Sulphate, respectively) (FRG, 2012), vermicompost (i.e. Organic carbon 11.4-13.5%, Nitrogen 0.84-1.58%, Phosphorous 0.56-1.51%, potassium 0.80-0.90%, Sulfur 0.52-0.55%, Zinc 0.01% , Calcium 0.68-0.72%) @ 3 t ha^{-1}, 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1}, 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} (Table 1). The experiment was laid out in randomized complete block design with three replications. The size of the unit plot was 10 m^2 (4 m × 2.5 m). The sprouted seeds were sown in the nursery bed on 10 July 2017. The main field was prepared by power tiller with three times ploughing and cross ploughing followed by laddering. The land was fertilized as per treatment specifications. The whole amount of manures and triple superphosphate, muriate of potash, gypsum and zinc sulphate were applied at final land preparation as per treatment. Urea was applied in three equal splits at 15, 30 and 45 days after transplanting (DAT). The seedlings were uprooted and immediately transferred to the main field on 10 August, 2017. Seedlings were transplanted at the rate of three seedlings hill^{-1}, maintaining a spacing of 25 cm× 15 cm. Intercultural operations were done as and when necessary. When 80-90% of the panicles turned into golden yellow color, the crop was assessed to attain maturity. Five hills (excluding border hills and central 2.0 m × 2.5 m harvest area) were selected randomly from each unit plot for recording data. An area of central 2.0 m × 2.5 m was selected from each plot to record the yield of grain and straw. The three varieties were harvested at different dates. Harvesting of BRRI dhan34, Binadhan-13 and Kalizira were done on 10 December, 23 December and 31 December 2017, respectively. Grains were then sun dried at 14% moisture level and cleaned. The straw was also sun dried properly. Finally, the yield of grain and straw plot^{-1} were recorded and converted to t ha^{-1}. Data were collected on plant height (cm), number of total tillers plant^{-1}, number of effective tillers plant^{-1}, panicle length (cm), number of grains panicle^{-1}, number of sterile spikelets panicle^{-1}, 1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), harvest index (%). The collected data were compiled and tabulated in proper from and subjected to statistical analysis. Data were analyzed using the analysis of variance technique with the help of computer package program MSTAT-C and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Table 1. Total amount of nutrient applied in different treatments

Treatments	Total Nutrient applied (Kg ha^{-1})						
	N	P	K	Ca	Zn	S	Mg
1. Control	0	0	0	0	0	0	0
2. Recommended dose of inorganic fertilizer	69	20	35	19.8	4.32	12.96	0
3. Vermicompost @ 3 t ha^{-1}	47.4	45.3	27	21.6	0.3	16.5	15.6
4. 25% less than recommended dose of inorganic fertilizer + vermicompost @1.5 t ha^{-1}	75.45	37.65	39.75	25.65	3.39	17.97	7.8
5. 50% less than recommended dose of inorganic fertilizer + vermicompost @3 t ha^{-1}	81.9	55.3	44.5	31.5	2.46	22.98	15.6

Results and Discussion

Varietal differences on yield contributing characters and yield

Different yield and yield contributing characters of aromatic rice differed significantly due to varietal differences except panicle length (Table 2). The tallest plant (149.81 cm) was found in Kalizira while the shortest plant (138.98 cm) was found in BRRI dhan34. The highest number of total and effective tillers hill^{-1} (7.97 and 6.84, respectively) was observed in Binadhan-13 and the lowest (6.89 and 5.62, respectively) was observed in Kalizira. Effect of variety on total and effective tillers hill^{-1} was also reported by Meshenji *et al.* (2018) and Ali *et al.* (2018) who observed that number of total and effective tillers hill^{-1} differed among the varieties. It might be due to varietal character or heredity. The highest number of grains panicle^{-1} (141.69) was produced by Binadhan-13 variety while the lowest number of grains panicle^{-1} (98.33) was produced by Kalizira variety. The highest number of sterile spikelets panicle^{-1} (26.80) was recorded in Kalizira variety and the lowest (14.98) was observed in Binadhan-13 variety. The highest weight of 1000-grain (13.74 g) was recorded in Binadhan-13 variety and the lowest (11.33 g) was found in Kalizira variety. It might be because of 1000-grain weight is a varietal character and it varies from variety to variety. Sarkar *et al.* (2014) found the similar highest and lowest 1000-grain weight in terms of Binadhan-13 and Kalizira rice. The highest grain and straw yield (3.89 t ha^{-1} and 5.29 t ha^{-1}, respectively) was produced by Binadhan-13 while the lowest grain and straw yield (2.80 t ha^{-1} and 4.03 t ha^{-1}, respectively) was produced by Kalizira. This might be due to the fact that Binadhan-13 produced the highest number of grains panicle^{-1} and heaviest 1000-grain which ultimately contributed to the highest grain yield in Binadhan-13. Adhikari *et al.* (2018) as well as Uppu and Shiv (2019) reported that grain yield of aromatic fine rice was significantly affected by variety. The highest harvest index (42.32%) was observed in Binadhan-13 variety and the lowest (40.93%) was observed in Kalizira variety.

Table 2. Effect of variety on crop characters, yield components and yield of aromatic fine rice

Variety	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. sterile spikelets panicle^{-1}	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
BRRI dhan34	138.98c	7.54b	6.34b	23.13	116.35b	18.31b	13.29b	3.35b	4.64b	41.83ab
Binadhan-13	144.14b	7.97a	6.83a	22.44	141.69a	14.98c	13.74a	3.89a	5.29a	42.32a
Kalizira	149.81a	6.89c	5.61c	22.23	98.33c	26.80a	11.33c	2.80c	4.03b	40.93b
$S\bar{x}$	1.70	0.068	0.054	0.442	1.68	0.544	0.111	0.037	0.082	0.339
Sig. level	**	**	**	NS	**	**	**	**	**	*
CV (%)	4.55	3.53	3.36	7.58	5.47	10.52	3.36	4.18	3.91	3.14

Effect of nutrient management on yield contributing characters and yield

The plant height varied significantly due to different nutrient managements (Table 3). The tallest plant (150.80 cm) was found in 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} which was statically similar to 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1}. Variation in the number of total and effective tillers hill^{-1} might be due to the different nutrient management. The highest number of total and effective tillers hill^{-1} (8.40 and 7.35, respectively) was observed in 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} treatment and the lowest one (6.18 and 4.84, respectively) was observed in control. It is due to the enhanced and continuous supply of nutrients by the combination of vermicompost and inorganic fertilizer which led to better tiller production. Sarkar *et al.* (2016) and Islam *et al.* (2013) found similar result that integrated nutrient management had significant effect on total and effective tillers hill^{-1}. The longest panicle (24.81) was observed in 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} treatment which was statistically identical to recommended dose of inorganic fertilizer (i.e. 150, 95, 70, 60 and 12 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively) and 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1} treatment. The shortest panicle (19.17 cm) was found in control which shows statistically similar result with vermicompost @ 3 t ha^{-1} treatment. The highest number of grains panicle^{-1} (134.50) was observed in 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} treatment and the lowest number of grains panicle^{-1} (104.50) was found in control which was statistically identical to vermicompost @ 3 t ha^{-1} treatment. Combined application of organic and inorganic fertilizers influences number of grains panicle^{-1} which was reported by Jahan *et al.* (2017). The highest number of sterile spikelets panicle^{-1} (22.59) was observed in control which was statistically similar to vermicompost @ 3 t ha^{-1} and recommended dose of inorganic fertilizer (i.e. 150, 95, 70, 60 and 12 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively) treatment. The lowest one (16.60) was found in 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} treatment which was statistically similar to 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1} treatment. Different nutrient managements had significant effect on grain and straw yield. The highest grain and straw yield (4.04 t ha^{-1} and 5.42 t ha^{-1}, respectively) was obtained in 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} treatment and the lowest grain and straw yield (2.66 t ha^{-1} and 3.83 t ha^{-1}, respectively) was obtained in control. During the growth period control treated plots suffered from inadequate nutrient so it produced lower grain and straw. The increased yield in 50% less than recommended dose of inorganic fertilizers + vermicompost @ 3 t ha^{-1} treatment might be due to the supremacy of the combination of vermicompost and inorganic fertilizer which lies in the fact that it can supply the nutrients in soluble form for a quite longer period by not allowing the entire nutrient into solution which minimize fixation and precipitation. So, integrated nutrient management might allowed the plant roots to compete with loss mechanisms and absorb more nutrients leading to better yield by producing highest effective tillers hill^{-1} and grains panicle^{-1}. Similar variation due to nutrient management was reported by Saha *et al.* (2014). Straw yield of fine rice was influenced by combined application of organic and inorganic fertilizers (Jahan *et al.,* 2017). The highest harvest index (42.65%) was found in 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} treatment. The lowest harvest index (41.05 %) was found in control treatment which was statistically identical to recommended dose of inorganic fertilizer (i.e. 150, 95, 70, 60 and 12 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc Sulphate, respectively), vermicompost @ 3 t ha^{-1} and 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1} treatment.

Table 3. Effect of nutrient management on crop characters, yield components and yield of aromatic fine rice

Nutrient management	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. of sterile spikelet panicle^{-1}	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
F_1	137.80c	6.18e	4.84e	19.17b	104.50c	22.59a	12.49	2.66e	3.83e	41.05b
F_2	145.60ab	7.81c	6.60c	24.22a	122.30b	21.19a	12.81	3.29c	4.67c	41.30b
F_3	139.70bc	6.83d	5.58d	20.36b	107.10c	22.13a	12.73	3.00d	4.28d	41.18b
F_4	147.60a	8.11b	6.94b	24.44a	125.70b	17.65b	12.92	3.72b	5.05b	42.37ab
F_5	150.80a	8.40a	7.35a	24.81a	134.50a	16.60b	12.99	4.04a	5.42a	42.65a
$S\bar{x}$	2.19	0.088	0.070	0.571	2.17	0.702	0.143	0.047	0.061	0.437
Sig. level	**	**	**	**	**	**	NS	**	**	*
CV (%)	4.55	3.53	3.36	7.58	5.47	10.52	3.36	4.18	3.91	3.14

In a column figures having common letter(s) do not differ significantly as per DMRT.
** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Not significant. F_1 = Control (no manures and fertilizers), F_2 =Recommended dose of inorganic fertilizer (i.e. 150, 95, 70, 60 and 12 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc Sulphate, respectively), F_3 = Vermicompost @ 3t ha^{-1}, F_4 = 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1}, F_5 = 50% less than recommended dose of inorganic fertilizer + vermicompost@ 3 t ha^{-1}.

Table 4. Interaction effects of variety and nutrient management on yield contributing characters and yield of aromatic fine rice

Interaction (Variety× nutrient)	Plant height (cm)	No. of total tillers hill^{-1}	No.of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	No. of sterile spikelets panicle^{-1}	1000- grain weight (g)	Straw yield (t ha^{-1})	Harvest index (%)
V_1F_1	133.23	6.34h	5.00h	19.63	103.2de	19.85	12.92	3.80g	41.25
V_1F_2	140.80	8.06cd	6.86de	24.78	122.4c	19.25	13.28	4.84e	41.53
V_1F_3	134.67	6.93g	5.70g	21.20	104.3d	19.66	13.25	4.28f	41.34
V_1F_4	142.60	8.16cd	7.00cde	25.00	123.0c	17.41	13.51	4.96de	42.51
V_1F_5	143.60	8.20cd	7.16cd	25.05	128.8c	15.39	13.52	5.31c	42.67
V_2F_1	138.17	6.35h	5.06h	19.50	118.4c	17.32	13.48	4.25f	41.65
V_2F_2	146.90	8.43bc	7.28bc	23.45	144.2b	15.90	13.77	5.23cde	41.94
V_2F_3	138.27	7.20fg	6.00fg	20.19	123.7c	16.32	13.64	4.95de	41.81
V_2F_4	148.53	8.66b	7.56b	23.56	152.3b	12.84	13.84	5.80b	43.05
V_2F_5	148.82	9.22a	8.26a	25.49	169.8a	12.49	13.97	6.20a	43.22
V_3F_1	142.13	5.86i	4.46 i	18.37	91.85e	30.59	11.08	3.43h	40.25
V_3F_2	149.13	6.93g	5.65g	24.44	100.2de	28.42	11.38	3.93g	40.43
V_3F_3	146.07	6.36h	5.06h	19.68	93.24de	30.39	11.30	3.62gh	40.40
V_3F_4	151.73	7.50ef	6.26f	24.77	101.6de	22.69	11.40	4.39f	41.56
V_3F_5	159.97	7.80de	6.63e	23.90	104.7d	21.91	11.48	4.75e	42.05
$S\bar{x}$	3.80	0.153	0.121	0.990	3.75	1.22	0.248	0.105	0.757
Level of sig.	NS	**	**	NS	**	NS	NS	*	NS
CV (%)	4.55	3.53	3.36	7.58	5.47	10.52	3.36	3.91	3.14

In a column figures having common letter(s) do not differ significantly as per DMRT.
** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Not significant. V_1 = BRRI dhan34, V_2 = Binadhan-13, V_3 = Kalizira., F_1 = Control (no manures and fertilizers), F_2 =Recommended dose of inorganic fertilizer (i.e. 150, 95, 70, 60 and 12 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc Sulphate, respectively), F_3 = Vermicompost @ 3t ha^{-1}, F_4 = 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1}, F_5 = 50% less than recommended dose of inorganic fertilizer + vermicompost@ 3 t ha^{-1}.

Effect of interaction between variety and nutrient management on yield contributing characters and yield

Interaction of variety and nutrient management had no significant effect on plant height, panicle length, sterile spikelets panicle^{-1}, 1000-grain weight and harvest index (Table 4). There was significant variation in total tillers hill^{-1}, number of effective tillers hill^{-1}, number of grains panicle^{-1}, grain yield and straw yield due to interaction between variety and nutrient management. The highest number of total and effective tillers hill^{-1} (9.22 and 8.26, respectively) was produced in Binadhan-13 with 50% less than recommended dose of inorganic fertilizers + vermicompost @ 3 t ha^{-1} treatment, while the lowest number of total and effective tillers hill^{-1} (5.86 and 4.46, respectively) was produced in Kalizira × control treatment. The highest number of grains panicle^{-1} (169.8) was produced by Binadhan-13 with 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} treatment, while the lowest number of grains panicle^{-1} (91.85) was produced by Kalizira × control treatment. The highest grain yield (4.71 t ha^{-1}) was produced in Binadhan-13 × 50 % less than recommended dose of inorganic fertilizer + Vermicompost @ 3 t ha^{-1} treatment, while the lowest grain (2.31 t ha^{-1}) was produced in Kalizira with Control treatment (Fig. 1). Higher rice yield might be due to the beneficial effect of combination of organic and inorganic fertilizer which offers a steady nutrient release compared to only inorganic fertilizer. This phenomenon allows plants to higher nutrient uptake which resulted in the greater source accumulation and efficient translocation of photosynthates into the sink as indicated by higher yield attributes. The highest straw yield (6.20 t ha^{-1}) was produced in Binadhan-13 × 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} treatment, while the lowest straw yield (3.43 t ha^{-1}) was produced in Kalizira with Control treatment.

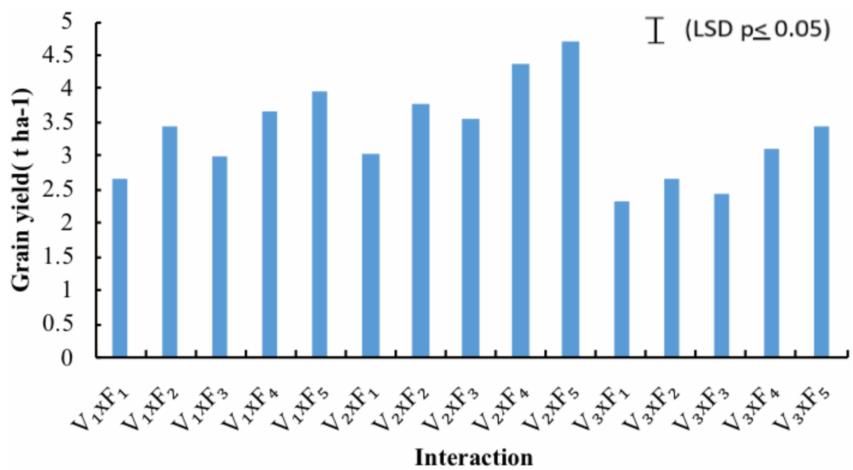

Fig. 1 Interaction effect of variety and nutrient management on grain yield of aromatic fine rice. V_1 = BRRI dhan34, V_2 = Binadhan-13, V_3 = Kalizira; F_1 = Control (no manures and fertilizers), F_2 = Recommended dose of inorganic fertilizer (i.e. 150, 95, 70, 60 and 12 kg ha^{-1} of Urea, TSP, MoP, Gypsum, Zinc sulphate respectively), F_3 = Vermicompost @ 3 t ha^{-1}, F_4 = 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1}, F_5 = 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1}.

Conclusion

Therefore, in order to meet the increasing demand of aromatic rice, Binadhan-13 with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} can be feasible in increasing higher productivity of aromatic fine rice.

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