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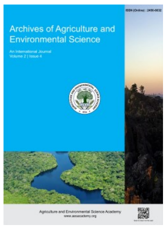

ORIGINAL RESEARCH ARTICLE

Assessing the influence of integrated nutrient management on growth performance of aromatic fine rice

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ABSTRACT

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 growth attributes 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. Growth characters of aromatic fine rice were significantly influenced by variety, nutrient management and interaction of variety and nutrient management. In case of variety, the highest number of total tillers hill^{-1} leaf area index, total dry matter production and chlrophyll content were obtained from Binadhan-13 at all sampling dates. While, Kalizira produced the lowest number of total tillers hill^{-1}, total dry matter, leaf area index and chlorophyll content except plant height at all sampling dates. In case of nutrient management, the tallest plant, the highest number of total tillers hill ,$^{1-}$total dry matter production, leaf area index and chlrophyll content were obtained from % 50 less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} at all sampling dates. But the shortest plant, the lowest number of total tillers hill^{-1}, leaf area index, total dry matter production, crop growth rate and chlorophyll content were found in control (no manures and fertilizers) at all sampling dates. In case of interaction of variety and nutrient management, the highest number of total tillers hill^{-1}, leaf area index, total dry matter production and chlorophyll content were found in Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} at all sampling dates. So, it can be concluded that Binadhan-13 along with 50% less than the recommended dose of inorganic fertilizers + vermicompost @ 3 t ha^{-1} combination might be a promising practice for aromatic fine rice cultivation.

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INTRODUCTION

Rice (*Oryza sativa* L.) is a widely farmed crop that provides half of the daily sustenance for one out of every three people on the planet (Sangeetha *et al.*, 2013). It is a staple food in Bangladesh, and it has been given top attention in satisfying the demands of the country's rapidly growing population. In the fiscal year 2019-20, milled rice production was estimated to be around 36.60 million tons (BBS, 2020). In 2017-2018, *Aman* rice accounted for 13.993 million tons of total rice output (BBS, 2018) and aromatic rice accounts for 12.50 percent of all transplanted *Aman* rice (Roy *et al.*, 2018), and it has a better potential to attract rice consumers and improve rice producer economic conditions in underdeveloped nations. Farmers in Bangladesh cultivate a variety of quality rice varietals. Some of them are particularly appealing due to their scent. Chinisagar, Badshabhog, Kataribhog, Kalizira, Tulsimla, Dulabhog, Basmati, Banglamoti (BRRI dhan50), BRRI dhan34, BRRI dhan37 and BRRI dhan38, Binadhan-13 are among of the most common varieties. The majority of fine rice varieties are native to Bangladesh, although the Bangladesh Rice Research Institute (BRRI) and the Bangladesh Institute of Nuclear Agriculture (BINA) have released some new fragrant fine rice types. The majority of aromatic rice cultivars are poor yielding, but their higher price and low cultivation costs result in a bigger profit margin than other kinds (Biswas *et al.*, 2016). Bangladesh has a good chance of exporting quality rice and earning foreign currency. However, the majority of aromatic rice varieties are poor yielding, with a national average aromatic rice yield of 3.04 t ha^{-1} (Sinha *et al.*, 2018). Low yield could be due to a lack of adequate management strategies. Among the management strategies, low use of organic fertilizer, lack of improved crop varieties and judicious use of fertilizers are the main. Organic inputs such as crop residues, manures, and compost offer a significant deal of potential to boost crop growth, development and production through improving soil characteristics and nutrient availability (Stone and Elioff, 1998). According to Sinha *et al.* (2009) vermicompost is high in NKP, minerals, beneficial soil bacteria, and plant developing hormones and enzymes. However, higher growth of rice plants depends on proper management of nutrients (Mahmud *et al.*, 2016; Paul *et al.*, 2021a; Anisuzzaman *et al.*, 2021). However, numerous researchers have found that (organic + inorganic fertilizers) have a considerable impact on rice growth and production in diverse soils in Bangladesh (Mahmud *et al.*, 2016; Hossain *et al.*, 2017; Uddin *et al.*, 2018). As a result, in a tropical country, judicious application of organic and inorganic fertilizers is critical for rice growth and output (Mahmud *et al.*, 2016; Esfahani *et al.*, 2019). A meta-analysis has been reported that, vermicompost increased shoot and root biomass of plants (Blouin *et al.*, 2019). Moreover, increased in plant height in response to recommended dose of fertilizer might be primarily due to the improved vegetative growth and supplementary contribution of nitrogen (Awan *et al.*, 2011). In contrast, it has been also reported that, application of higher amount of nitrogenous fertilizer increased plant height, tiller number, panicle length in wheat plant (Gismy *et al.*, 2020). However, Mahmud *et al.* (2016) reported that, combined use of vermicompost and NPKS fertilizer increased plant height, tiller number, flag leaf length and panicle length of rice plant. Plant height, tiller number, leaf area index, and dry matter production were all significantly higher in the chemical fertilizer and organic manure treatment (Sheikh *et al.*, 2013). Hasanuzzaman *et al.* (2010) also reported increased plant height, tiller number, panicle length, and straw yield with the application of vermicompost and NPK fertilizer. The application of chemical fertilizer with organic manure resulted in a considerable increased in effective tillers $hill^{-1}$, according to Nayak *et al.* (2007). In addition, Rahman *et al.* (2009) reported increased panicle length in rice with the combine use of organic and inorganic fertilizer. Many studies have proven that neither inorganic nor organic sources can produce optimal growth and long-term production on their own (Parihar *et al.*, 2015). The ideal solution for managing soil fertility is to use a combination of organic and inorganic fertilizers, with the inorganic fertilizer providing nutrients and the organic fertilizer primarily increasing soil organic matter and improving soil structure and buffering capacity. Furthermore, for improved plant growth, an appropriate mix of variety, vermicompost rate, and rate of inorganic fertilizer dose is required. Again, it has been reported that, growth attributes are directly related to increase the yield of rice plant (Takai *et al.*, 2006; Senthilvalavan and Ravichandran, 2019; Paul *et al.*, 2021b). Despite the fact that rice is one of the world's most important crops, there is a scarcity of information in the literature about fine rice cultivars and their responses to vermicompost and inorganic fertilizers. In this contrast, the present study focuses on the interaction between variety and integrated nutrient management on growth performance of aromatic fine rice.

MATERIALS AND METHODS

Description of the experimental site

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh during July 2017 to December 2017 to study the combined effect of vermicompost with inorganic fertilizers on the growth of aromatic fine rice in *Aman* season. The experimental site is located at 24.75° N latitude and 90.50°E longitude at an elevation of 18 m above the sea level. The site 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). The experimental field was a medium high flat land with well drained condition and the site is under subtropical monsoon type of climate. Again, the soil of the experimental field was characterized by non-calcareous dark grey floodplain soils with the organic matter, pH, total nitrogen, available phosphorus (P_2O_5) and potassium of the soil ranged from 0.93%, 5.9-6.5, 0.13%, 16.3 ppm and 0.28%, respectively (Rahman, 2018).

Experimental treatment, design and layout

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. Each of the replication represented a block in the experiment. Each block was divided into 15-unit plots where 15 treatment combinations were randomly allocated. There were 45-unit plots in the experiment. The size of unit plot was 4.0 m × 2.5 m. The distances between blocks and plots were 1 m and 75 cm, respectively.

Crop husbandry

Three modern scented varieties BRRI dhan34, Binadhan-13 and fine grained popular local scented rice Kalizira were used in the experiment. Seeds of these rice varieties were collected from Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. A piece of land was selected at Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh for raising seedlings. The sprouted seeds were sown in the nursery bed on 10 July 2017. The field was prepared by power tiller with three times ploughing and cross ploughing followed by laddering. The layout of the field was made on August 9 2017 according to the experimental specification immediately after final land preparation. Weeds and stubble were removed and cleaned from individual plots. The land was fertilized as per treatment specifications. At the time of final land preparation, respective unit plots were fertilized with different levels of fertilizers according to treatments. The manure was thoroughly mixed with the soil. The amount of nitrogen, phosphorus, potassium, sulphur and zinc required for each unit plot was calculated on ha^{-1} basis and applied. 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 on 9 August 2017 without causing mechanical injury to the roots and transplanted in the well-prepared field on 10 August, 2017 at the rate of three seedlings $hill^{-1}$, maintaining row and hill distance of 25 cm and 15 cm, respectively. Intercultural operations like gap filling, weeding, bund repairing was done as and when necessary for ensuring and maintaining normal growth of the crop.

Data collection

Plant height, number of tillers $hill^{-1}$, dry matter $hill^{-1}$ and chlorophyll content were recorded at 30, 50, 70 and 90 days after transplanting (DAT), respectively. Five hills were randomly selected soon after transplanting and marked with bamboo sticks in each plot excluding border rows for determining growth parameters (plant height, number of total tillers $hill^{-1}$) at 30, 50, 70 and 90 DAT, respectively. Plant height (selected five plants) was measured in cm from the ground level to the tip of the longest panicle. Tillers which had at least one leaf visible were counted. It included both effective and non-effective tillers. For determining growth parameters like leaf area index, total dry matter production was done by uprooting 1 hill from each plot excluding border rows at 30, 50, 70 and 90 DAT, respectively. Leaf area index was measured at the above growth stages of sampling by using automatic leaf area meter. Plants were cut at the soil surface, and then kept in polythene bags. Collected samples were brought to the Professor Mohammad Hossain Central Laboratory, Bangladesh Agricultural University, Mymensingh. Leaf blades were separated from stems and leaf area was measured immediately. Then leaf area index was calculated. Leaf area index (LAI) is the ratio of total surface area of leaves and its ground area (Hunt, 1978).

$$LAI = LA/P$$

Where,
LAI = Leaf area index, LA = Total leaf area of the leaves of all the sampled plants (cm^2), P = Area of the ground surface covered by the plant (cm^2).

Again, for determine total dry matter, plants were collected from field at the above growth stages and they were kept separately in brown paper packets and then placed in electric oven at 72°C for 48 hours. Oven dried samples were weighed separately by using an electric balance to have total dry matter in gram. Crop growth rate is the rate of total dry matter production per unit of ground area per unit of time. It was measured by using the following formula as described by Watson (1956).

$$CGR = \frac{1}{A} \times \frac{W_2 - W_1}{T_2 - T_1} \text{ g m}^{-2}\text{day}^{-1}$$

Where, W_1 and W_2 are the total dry matter at the time T_1 and T_2, respectively and A is the ground area (cm^2). Chlorophyll meter values (SPAD) were recorded using a portable SPAD meter (Model SPAD-502, Minolta crop, Ramsey, NJ) at 30, 50, 70 and 90 DATs, respectively. For recording the SPAD values, five new fully expanded leaves were selected which was adjacent to a similar about to emerge leaf and the mean data was recorded in the morning between 9:00 and 10.00 am from the middle point of the five leaves $plant^{-1}$ (Bithy *et al.*, 2020; Paul *et al.*, 2021b).

Statistical analysis

Data were compiled and tabulated in proper form for statistical analysis. The recorded data were statistically analyzed to find out the significance of variation resulting from the experimental treatments. All the collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) using a computer operated program namely, MSTAT-C.

RESULTS AND DISCUSSION

Plant height

Variety exerted significant effect on plant height at 30, 50, 70 and 90days after transplanting (DAT) (Figure 1A). The tallest plants of 77.59 cm, 106.1 cm, 127.8 cm and 138.4 cm were obtained from Kalizira at 30, 70 ,50 and 90DAT, respectively. While, the shortest plants of 70.64 cm, 98.81 cm, 108.6 cm and 113.7 cm were recorded from BRRI dhan 34 at all samping dates respectively (Figure 1A) .Regarding plant height, Sarkar *et al.* (2014) also showed that variety had significant effect on plant height of aromatic fine rice variety. Plant height was significantly affected by nutrient management at all sampling dates (Figure 1B). The tallest plants of 80.10 cm, 112.1 cm, 128.9 cm and 137.7 cm were obtained from 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} at 30, 50, 70 and 90 DAT, respectively. While, the shortest plants of 66.37 cm, 94.93 cm, 113.9 cm and 120.1 cm were recorded from control at all samping dates respectively which was at par with vermicompost @ 3 t ha^{-1} (Figure 1B). Arindam *et al.* (2016) also showed similar result in case of combined application of nitrogen and vermicompost. Plant height was not significantly affected by the interaction of nutrient management and variety at all sampling dates except 90 DAT (Table 1). At 90 DAT, the tallest plant (150.7cm) was found in Kalizira along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{1} and the shortest plant (107.3 cm) was observed in BRRI dhan34 along with control which was statistically identical to BRRI dhan34 along with vermicompost) 3 @ t ha^{-1} (Table 1).

Number of total tillers hill^{-1}

Number of total tillers hill^{-1}was significantly influenced by variety during the period of 30, 50, 70 and 90 days after transplanting (DAT)) Figure 1C). At 30 and 50 DAT, the highest number of total tillers hill^{-1}(7.98 and (12.34 was obtained from Binadhan-13 which was satistically identical to BRRI dhan34 and the lowest number of total tillers hill^{-1}was recorded from Kalizira. At 70 and 90 DAT, the highest number of total tillers hill-1 (13.64 and 13.06) was obtained from Binadhan-13 and the lowest number of total tillers hill^{-1}(12.96 and 11.80) was recorded from Kalizira (Figure 1C). Adhikari *et al.* (2018) and Islam *et al.* (2013) reported that number of total tillers hill^{-1} was significantly influenced by variety. Nutrient management had significant effect on total tillers hill^{-1}at all sampling dates) Figure 1D). At 70 ,50 ,30 and 90DAT, the highest number of total tillers hill^{-1}(8.50, 13.83, 14.91 and 14.22, respectively) was obtained from 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} followed by 25 % less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1} and the lowest total numbers of tillers hill^{-1}(6.53, 10.59, 11.60 and 10.81, respectively) was recorded from Control (Figure 1D). Number of total tillers hill^{-1}was significantly influenced by combined application of organic and inorganic fertilizers (Adhikari *et al.*, 2018 and Saha *et al.*, 2014). Numbers of total tillers hill^{-1}was not significantly influenced by the interaction of nutrient management and variety (Table 2). Numerically, the highest number of total tillers hill^{-1} (15.63) was found in Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} at 70 DAT and the lowest one (6.78) was observed in BRRI dhan34 along with control at 30 DAT, respectively (Table 2).

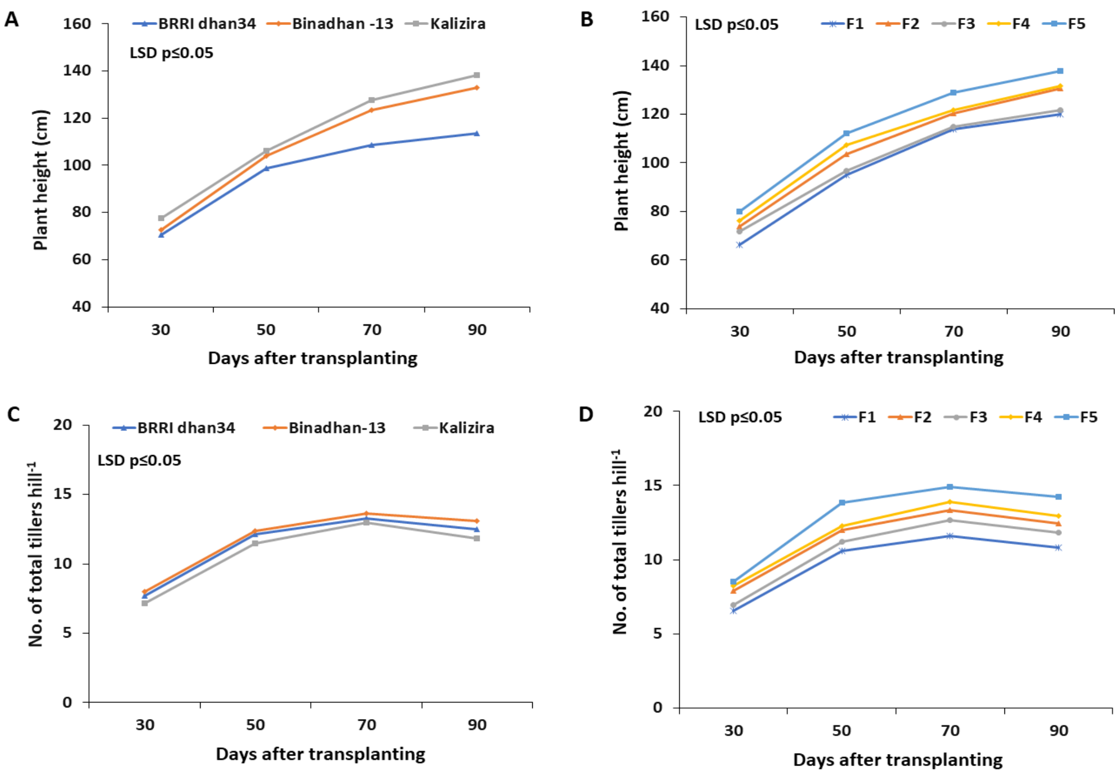

Figure 1. *Effect of variety on plant height and number of total tillers hill^{-1} at different days after transplanting of fine aromatic rice (A-D).*

Table 1. Interaction effects of variety and nutrient management on plant height at different days after transplanting of aromatic fine rice.

Interaction (variety × nutrient management)	Plant height (cm) Days after transplanting (DAT)			
	30	50	70	90
$V_1×F_1$	60.63	90.13	104.83	107.3h
$V_1×F_2$	72.33	100.6	108.87	115.5g
$V_1×F_3$	70.00	93.80	105.23	107.9h
$V_1×T_4$	73.92	101.9	110.07	117.3fg
$V_1×F_5$	76.30	107.7	113.83	120.3f
$V_2×F_1$	65.90	96.10	114.07	124.4e
$V_2×F_2$	73.03	105.0	125.63	134.9c
$V_2×F_3$	71.13	99.48	115.90	127.8d
$V_2×F_4$	74.30	106.6	127.27	135.6c
$V_2×F_5$	78.60	113.1	134.57	142.1b
$V_3×F_1$	72.57	98.55	122.90	128.6d
$V_3×F_2$	76.20	105.6	126.72	141.6b
$V_3×F_3$	73.93	97.17	123.73	129.4d
$V_3×F_4$	79.83	113.8	127.66	141.9b
$V_3×F_5$	85.40	115.4	138.16	150.7a
$S\bar{x}$	1.86	2.62	3.23	1.13
Level of significance	NS	NS	NS	**
CV (%)	4.38	4.40	4.67	1.53

In a column, mean values with same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% 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, 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}.

Table 2. Interaction effects of variety and nutrient management on number of total tillers hill^{-1} at different days after transplanting of aromatic fine rice.

Interaction (variety × nutrient mangement)	Total tillers hill^{-1} (no.) Days after transplanting (DAT)			
	30	50	70	90
$V_1×F_1$	6.78	11.07	11.83	11.00
$V_1×F_2$	8.05	12.20	13.39	12.47
$V_1×F_3$	7.00	11.20	12.66	11.70
$V_1×F_4$	8.27	12.40	13.70	13.33
$V_1×F_5$	8.30	13.73	14.61	13.94
$V_2×F_1$	7.02	11.16	11.90	11.22
$V_2×F_2$	8.15	12.46	13.53	13.07
V_2xF_3	7.33	11.27	12.83	12.30
$V_2×F_4$	8.38	12.70	14.31	13.48
$V_2×F_5$	9.10	14.13	15.63	15.23
$V_3×F_1$	5.80	9.53	11.07	10.22
$V_3×F_2$	7.47	11.39	13.08	11.78
$V_3×F_3$	6.45	11.17	12.50	11.42
$V_3×F_4$	8.06	11.67	13.67	12.10
$V_3×F_5$	8.11	13.61	14.48	13.49
$S\bar{x}$	0.319	0.271	0.407	0.461
Level of significance	NS	NS	NS	NS
CV (%)	7.26	3.92	5.31	6.42

In a column, mean values with same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT); 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, 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}.

Leaf Area Index (LAI)

Leaf area index (LAI) was significantly influenced by variety at different days after transplanting (DAT) (Figure 2A). At 30 DAT, the highest LAI (1.97) was obtained from Binadhan-13 and the lowest LAI (1.51) was recorded from Kalizira. Also, at 50, 70 and 90 DAT, the highest LAI (2.75, 3.14, and 3.02, respectively) was obtained from Binadhan-13 and the lowest LAI (2.21, 2.67, and 2.50, respectively) was recorded from Kalizira (Figure 2A). From the result it was observed that LAI increased gradually up to 70 DAT and then declined at 90 DAT in all varieties due to the fact

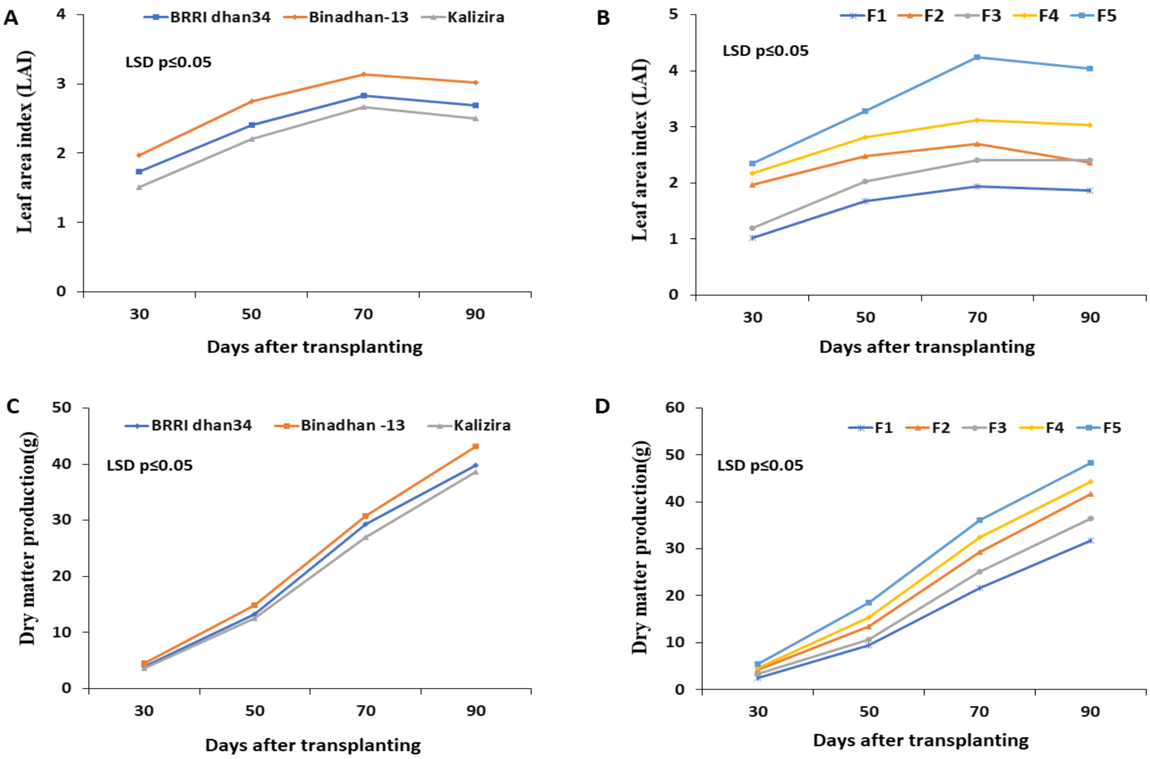

Figure 2. Effect of variety on leaf area index (LAI) and dry matter production at different days after transplanting of aromatic fine rice (A-D).

Table 3. Interaction effects of variety and nutrient management on leaf area index (LAI) at different days after transplanting of fine aromatic rice.

Interaction (variety × nutrient mangement)	Leaf area index (LAI)			
	Days after transplanting (DAT)			
	30	50	70	90
$V_1×F_1$	1.04ef	1.67h	1.89g	1.79g
$V_1×F_2$	2.04c	2.38de	2.72e	2.35e
$V_1×F_3$	1.11e	1.95g	2.45f	2.44e
$V_1×F_4$	2.09c	2.67c	2.92d	2.87c
$V_1×F_5$	2.40b	3.38a	4.17b	4.03a
$V_2×F_1$	1.07ef	1.88g	2.04g	2.11f
$V_2×F_2$	2.32b	2.81bc	2.93d	2.76cd
$V_2×F_3$	1.47d	2.18f	2.72e	2.66d
$V_2×F_4$	2.44ab	3.35a	3.62c	3.47b
$V_2×F_5$	2.56a	3.51a	4.42a	4.13a
$V_3×F_1$	0.95f	1.49h	1.89g	1.71g
$V_3×F_2$	1.54d	2.23ef	2.43f	1.98f
$V_3×F_3$	1.00ef	1.94g	2.05g	2.10f
$V_3×F_4$	1.98c	2.45d	2.82de	2.77cd
$V_3×F_5$	2.06c	2.93b	4.14b	3.94a
$S\bar{x}$	0.045	0.061	0.052	0.061
Level of significance	**	**	**	**
CV (%)	4.59	4.33	3.02	3.85

In a column, mean values with same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% level of probability; 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}.

of leaf abscission and tiller drying. Similar trend of LAI was reported by Paul *et al.* (2016). Nutrient management exerted significant effect on LAI at all sampling dates (Figure 2B). The highest LAI (2.34, 3.27, 4.24, 4.03, respectively) at 30, 50, 70 and 90 DAT was obtained from 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} and the lowest LAI (1.02, 1.68, 1.94 and 1.87, respectively) was recorded from control at 30, 50, 70 and 90 DAT, respectively (Figure 2B). The LAI increased with the increasing days up to 70 DAT and then declined thereafter may be due to leaf senescence at higher ages. Integrated nutrient management has significant effect on LAI was also reported by Ali *et al.* (2017). LAI was significantly

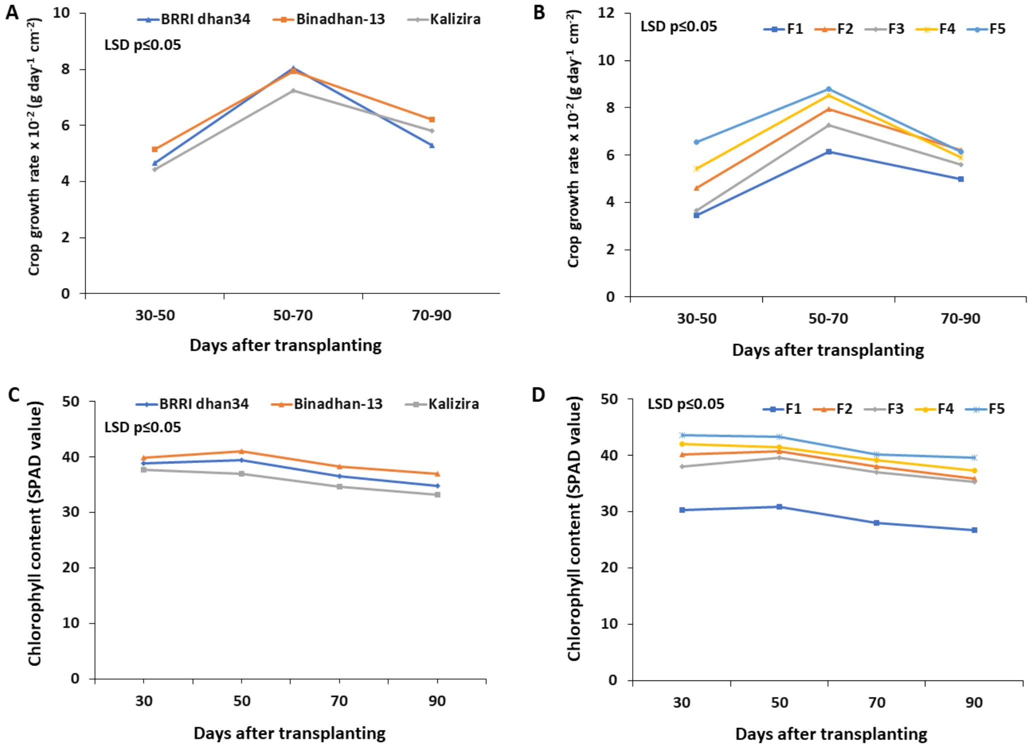

Figure 3. *Effect of variety on crop growth rate (CGR) and chlorophyll content at different days after transplanting of aromatic fine rice (A-D).*

Table 4. Interaction effects of variety and nutrient management on dry matter content at different days after transplanting of fine aromatic rice.

Interaction (Variety× nutrient mangement)	Dry matter content (g 10 m^{-2} plot)			
	Days after transplanting (DAT)			
	30	50	70	90
$V_1 \times F_1$	2.57fg	9.67h	23.70gh	32.17h
$V_1 \times F_2$	4.17cd	13.60ef	30.00cde	41.73de
$V_1 \times F_3$	3.27e	10.03h	25.73fg	35.40g
$V_1 \times F_4$	4.33cd	15.00d	30.97c	43.60cd
$V_1 \times F_5$	5.17b	17.70b	36.10b	46.37b
$V_2 \times F_1$	2.60fg	9.77h	18.37i	33.17gh
$V_2 \times F_2$	4.23cd	13.70ef	30.27cde	43.60cd
$V_2 \times F_3$	4.07d	12.43g	28.07def	39.10f
$V_2 \times F_4$	5.10b	17.27bc	36.10b	46.40b
$V_2 \times F_5$	6.53a	20.90a	40.60a	53.20a
$V_3 \times F_1$	2.33g	8.83i	23.13h	29.83i
$V_3 \times F_2$	4.10d	12.93fg	27.67ef	39.90ef
$V_3 \times F_3$	2.73f	9.533hi	21.83h	34.70g
$V_3 \times F_4$	4.27cd	14.10e	30.50cd	42.97d
$V_3 \times F_5$	4.50c	16.90c	31.60c	45.50bc
$S\bar{x}$	0.110	0.255	0.833	0.785
Level of significance	**	**	**	*
CV (%)	4.77	3.28	4.98	3.36

In a column, mean values with same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% level of probability, * =Significant at 5% level of probability; 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}.

affected by the interaction of nutrient management and variety at 30, 50, 70 and 90 days after transplanting (Table 3). At 30 DAT, the highest LAI (2.56) was found in Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} and the lowest LAI (0.95) was observed in Kalizira along with control. At second sampling date, the highest LAI (3.51) was found in Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} which was at par with BRRI dhan34 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} and Binadhan-13 along with 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1}. While, at 50 DAT, the lowest LAI (1.49) was observed in Kalizira along with control which was statistically identical to BRRI dhan34 along with control. Again, at 70 DAT, the highest LAI (4.42) was found in Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} and the lowest LAI (1.89) was observed in BRRI dhan34 along with control. In addition, at 90 DAT, the highest LAI (4.13) was found in Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} which was at par with Kalizira along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} and the lowest LAI (1.71) was observed in Kalizira along with control which was statistically identical to BRRI dhan34 along with control (Table 3).

Total Dry Matter (TDM)

Total dry matter) TDM) production was significantly influenced by variety at different days after transplanting (DAT) (Figure 2C). At 30, 50, 70 and 90 DAT, the highest TDM (4.51 g, 14.81 g, 30.68 g, 43.09 g, respectively) was obtained from Binadhan-13 and the lowest TDM (3.59 g, 12.46 g, 26.95 g, 38.58 g, respectively) was recorded from Kalizira (Figure 2C). Due to genetic constituents and also for the available fertilizers TDM increased at all sampling dates. Islam *et al.* (2013) revealed that dry matter accumulation over time varied considerably due to variety. Nutrient management had significant effect on TDM production at different growth stages (Figure 2D). The highest TDM (5.40 g, 18.50 g, 36.10 g and 48.36g, respectively) was obtained from 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} and the lowest TDM (2.50 g, 9.42 g, 21.73 g and 31.72 g, respectively) was recorded from control at all samping dates respectively) Figure 2D). TDM production increased progressively with the advancement of time due to application of inorganic fertilizer and vermicompost at all sampling dates. Suresh *et al.* (2013) reported that TDM of rice was significantly influenced by integrated nutrient management. TDM was significantly influenced by the interaction of nutrient management and variety at 30, 50, 70 and 90 days after transplanting (Table 4). The highest TDM production (6.53 g, 20.90 g, 40.60 g, and 53.20 g, respectively) was found in Binadhan-13 along with 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} at 30, 50, 70 and 90 DAT. While, at 30 and 50 DATs, the lowest TDM (2.33 g, 8.83 g) was observed in Kalizira along with control. Again, at 70 DAT, the lowest TDM (18.37 g) was found in Binadhan-13 along with control combination and at 90 DAT, the lowest TDM (29.83 g) was observed in Kalizira along with control combination (Table 4).

Crop Growth Rate (CGR) (g day^{-1} cm^{-2})

Crop Growth Rate (CGR) was significantly influenced due to variety at 30-50 and 70-90 days after transplanting (DAT) except 50-70 DAT (Figure 3A). From first to second sampling date, the highest CGR (5.15) was obtained from Binadhan-13 and the lowest CGR (4.43) was recorded from Kalizira. Again, at 70-90 DAT, the highest CGR (6.21) was obtained from Binadhan-13 which was statistically identical to Kalizira and the lowest CGR (5.28) was recorded from BRRI dhan34 (Figure 3A). Alam *et al.* (2009) also observed the similar kind of result in respect of CGR with rice varieties. CGR was significantly influenced due to nutrient management at 30-50 and 50-70 DAT, but not significantly influenced due to nutrient management at 70-90 DAT (Figure 3B). At 30-50 DAT, the highest CGR (6.55) was obtained from 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1}. Again, at 50-70 DAT, the highest CGR (8.80) was recorded from 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} which was at par with 25% less than recommended dose of inorganic fertilizer + vermicompost @ 1.5 t ha^{-1} and recommended dose of inorganic fertilizers (i.e. 150, 95, 70, 12 kg ha^{-1} of Urea, TSP, MoP, Gypsum and Zinc sulphate, respectively). While, at 30-50 and 50-70 DAT, the lowest CGR (3.45, 6.15) was recorded from control (no manures and fertilizers) (Figure 3B). The CGR increased with the advancement of time and reached to a peak at 50-70 DAT and then declined at 70-90 DAT. Similar pattern of CGR was also observed by Sarkar *et al.* (2016) who stated that CGR significantly influenced by integrated nutrient management. Interaction of nutrient management and variety had significant effect on CGR at 50-70 and 70-90 DAT except at 30-50 DAT (Table 5). At 50-70 DAT, the highest CGR (9.85) was found in Binadhan-13 along with 50% less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} and the lowest crop growth rate (4.30) was observed in Binadhan-13 along with control. Again, at 70-90 DAT, the highest (7.40) and lowest (3.35) value of CGR were found in Binadhan-13 along with control and Kalizira along with control (Table 5).

Leaf chlorophyll content (SPAD Value)

Variety exerted significant effect on leaf chlorophyll content at different days after transplanting (DAT) (Figure 3C). At 30 ,50, 70 and 90 DAT, the highest chlorophyll content (39.89, 41.08, 38.36 and 36.96 respectively) was obtained from Binadhan-13 and the lowest values (37.74, 37.01, 34.59 and 33.15, respectively) were recorded from Kalizira (Figure 3C). The highest chlorophyll content was attributed due to differences in the genetic makeup of the varieties. Similarly, varieties had a significant effect on total chlorophyll content was also reported by Sikuku *et al.* (2016). Nutrient management had significant effect on leaf chlorophyll content at all sampling dates (Figure 3D). The highest leaf chlorophyll content (43.60, 43.39, 40.22, 39.56, respectively) was obtained from % 50 less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} and the lowest leaf chlorophyll content (30.28, 30.83, 28.04, 26.69 respectively) was recorded from control at all sampling dates, respectively (Figure 3D). This may due to increased chlorophyll content of the varieties from inorganic fertilizers and vermicompost. Mukherjee and Sen (2005) reported that nutrient management had significant effect on leaf chlorophyll content of rice. Leaf chlorophyll content was significantly influenced by the interaction of nutrient management and variety at all sampling dates except at first one (Table 6). At 50, 70 and 90 DAT, the highest chlorophyll content (44.17, 41.95 and 40.55,

Table 5. Interacting effects of variety and nutrient management on crop growth rate (CGR) at different days after transplanting of aromatic fine rice.

Interaction (Variety x nutrient mangement)	Crop growth rate × 10^{-2} (g day^{-1} cm^{-2}) Days after transplanting (DAT)		
	30-50	50-70	70-90
$V_1 \times F_1$	3.55	7.01de	4.23de
$V_1 \times F_2$	4.71	8.20abcd	5.87abcd
$V_1 \times F_3$	3.38	7.85bcde	4.84cde
$V_1 \times F_4$	5.33	7.98abcde	6.32abc
$V_1 \times F_5$	6.26	9.20abc	5.14bcd
$V_2 \times F_1$	3.58	4.30f	7.40a
$V_2 \times F_2$	4.73	8.28abcd	6.67abc
$V_2 \times F_3$	4.18	7.81bcde	5.51bcd
$V_2 \times F_4$	6.08	9.42ab	5.15bcd
$V_2 \times F_5$	7.18	9.85a	6.30abc
$V_3 \times F_1$	3.25	7.15de	3.35e
$V_3 \times F_2$	4.41	7.36cde	6.11abc
$V_3 \times F_3$	3.40	6.15e	6.43abc
$V_3 \times F_4$	4.91	8.20abcd	6.23abc
$V_3 \times F_5$	6.20	7.35cde	6.95ab
$S\bar{x}$	0.357	0.594	0.541
Level of significance	NS	**	**
CV (%)	13.03	13.30	16.25

In a column, mean values with same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter differ significantly (as per DMRT); ** =Significant at 1% 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, 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}.

Table 6. Interacting effects of variety and nutrient management on chlorophyll content at different days after transplanting of aromatic fine rice.

Interaction (Variety× nutrient mangement)	Chlorophyll content (SPAD value) Days after transplanting			
	30	50	70	90
$V_1 \times F_1$	29.87	29.36g	27.15g	25.90f
$V_1 \times F_2$	40.27	41.33abcde	38.89bcd	35.11d
$V_1 \times F_3$	38.57	40.07bcde	37.29de	35.03d
$V_1 \times F_4$	41.83	42.57ab	39.76bc	37.58bc
$V_1 \times F_5$	43.70	42.09ab	39.87bc	40.20a
$V_2 \times F_1$	31.19	36.19f	31.65f	30.79e
$V_2 \times F_2$	41.57	42.10abc	39.28bc	37.98bc
$V_2 \times F_3$	39.00	40.35bcde	38.40cd	36.52cd
$V_2 \times F_4$	43.18	42.59ab	40.54ab	38.98ab
$V_2 \times F_5$	44.50	44.17a	41.95a	40.55a
$V_3 \times F_1$	29.79	26.95g	25.32h	23.39g
$V_3 \times F_2$	38.73	38.63def	36.00e	34.60d
$V_3 \times F_3$	36.55	38.47ef	35.60e	34.53d
$V_3 \times F_4$	41.03	39.10cdef	37.18de	35.33d
$V_3 \times F_5$	42.60	41.90abcd	38.83bcd	37.92bc
$S\bar{x}$	0.800	1.03	0.619	0.663
Level of significance	NS	*	*	**
CV (%)	3.57	4.56	2.95	3.29

In a column, mean values with same letter (s) or without letter do not differ significantly whereas mean values with dissimilar letter 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 = Binadhan13, 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}.

respectively) was found in Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1}. While at 50 DAT, the lowest chlorophyll content (29.36) was observed in BRRI dhan34 along with control which was at par with Kalizira along with control and at 70 and 90 DAT, the lowest chlorophyll content (25.32 and 23.39, respectively) was found in Kalizira along with control nutrient management (Table 6).

Conclusion

From the above discussion it can be concluded that Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} influenced the growth attributes of aromatic fine rice. The highest number of total tillers hill^{-1}, leaf area index, total dry matter production, chlorophyll content and crop growth rate were recorded from Binadhan-13 along with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1}. So, in order to get the better growth attributes which ultimately influenced the grain yield of aromatic fine rice, Binadhan-13 fertilized with 50 % less than recommended dose of inorganic fertilizer + vermicompost @ 3 t ha^{-1} may be recommended for cultivation in *Aman* season.

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