INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 23, No. 3, p. 147-157, 2023

RESEARCH PAPER OPEN ACCESS

Effect of planting time on the growth and yield of different aromatic rice varieties

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Key words: Scented rice, Transplanting time, Morphophysiology, Production

http://dx.doi.org/10.12692/ijb/23.3.147-157 Article published on September 09, 2023

Abstract

The experiment was conducted at the Research Field of Sher-e-Bangla Agricultural University (SAU), Dhaka during *Aman* season, 2020-2021 to effect of planting time on the growth and yield of different aromatic rice verities. The experiment consisted of two factors: A) Varieties-Badshabhog (V_1), Modhumala (V_2), Chiniatap (V_3), Kataribhog (V_4), Zirabhog (V_5), Kalizira (V_6), and B) Transplanting time - T_1 = (20 DAS), T_2 = (30 DAS), T_3 = (40 DAS). The two factor experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and the differences between means were separated by both Duncan's New Multiple Range Test (DMRT) and Least Significant Difference (LSD) test at 5% level of probability. In case varieties, highest Plant height, No. of tiller plant^{-1}, Booting of 50% plant, Emergence of (1st, 50, 100)% panicle, Starting of maturity, 100% maturity, Harvesting day (DAT), Life cycle (DAS) duration, Life cycle duration (DAT), No. of fertile tiller plant^{-1}, No. of sterile tiller plant^{-1}, Length of panicle, Seed weight plant^{-1}, Dry weight plant^{-1}, No. of filled grain panicle^{-1}, No. of unfilled grain panicle^{-1}, 1000grain weight, Grain weight plant^{-1}, Straw weight plant^{-1}, Biological yield (ton ha^{-1}), Grain yield (ton ha^{-1}), Straw yield (ton ha^{-1}), was V_5, V_2, V_4, V_4, V_4, V_4, V_5, V_5, V_5, V_5, V_5, V_2, V_6, V_5, V_4, V_6, V_6, V_5, V_4, V_4,V_1, V_1, V_4, V_6 respectively and lowest grain yield ha^{-1} was observed in V_5(3.5h) ton ha^{-1}. In case of transplanting time, most of the yield character and highest grain yield was observed in T_3 (40 days seedling age), and others no significant difference. In case interaction, highest Plant height, No. of tiller plant^{-1}, Booting of 50% plant, Emergence of (1st, 50, 100)% panicle, Starting of maturity, 100% maturity, Harvesting day (DAT), Life cycle (DAS) duration, Life cycle duration (DAT), No. of fertile tiller plant^{-1}, No. of sterile tiller plant^{-1}, Length of panicle, Seed weight plant^{-1}, Dry weight plant^{-1}, No. of filled grain panicle^{-1}, No. of unfilled grain panicle^{-1}, 1000grain weight, Grain weight plant^{-1}, Straw weight plant^{-1}, Biological yield (ton ha^{-1}), Grain yield (ton ha^{-1}), Straw yield (ton ha^{-1}), was V_5T_1, V_4T_1, V_4T_1, V_4T_1, V_4T_1, V_4T_1, V_5T_1, V_5T_1, V_5T_3, V_5T_1, V_5T_3, V_2T_2, V_3T_2, V_5T_1, V_4T_1, V_4T_1, V_6T_2, V_1T_1, V_5T_1, V_5T_2,V_4T_3, V_1T_1, V_1T_1, V_4T_3 and V_1T_1 respectively. The results of the numerous characters evaluated in the studies also revealed that there are certain beneficial characters in local aromatic rice cultivars that can be exploited through breeding.

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Introduction

Rice is the staple food source for over half the world's population. In Bangladesh, rice production occurs over an area of 11.4 million hectares (ha), generating 51.6 million tons of rice annually (BBS 2015), with 77% of the total cropped area being devoted to rice production, contributing more than 80% to the total food supply, and with rice providing 76% of the country's countries caloric intact as well as 66% of its total required daily protein intake (Majumder, 2013). At present, rice alone constitutes about 93% of the total food grains produced annually in Bangladesh (BER, 2013). Historically, thousands of local rice varieties have been cultivated across Bangladesh (Hamid *et al.*, 1982) and local landraces, including aromatic ones, which have often been cultivated in less than favorable ecosystems that cover 12.16% of the total rice growing areas1. Some of these local varieties have desirable characteristics around aroma, better taste, and higher cooking quality, all of which potentiate value-added parameters to the rice both socially and economically. These aromatic rice varieties constitute a small but important group of rice which familiar in many countries of the world for their aroma or super-fine grain quality or both (Singh *et al.*, 2000).

There are thousands of local land races in this country, many of which some good qualities i.e, fitness, taste, aroma and protein content (Kaul *et al.*, 1982). Consumer demand for the fine rice genotypes is higher due to its good nutrition quality, palatability, taste, cooking quality and fragrance (Kaul *et al.*, 1982). Most of the consumers prefer fine rice genotypes with good cooking quality that have aroma. Due to special flavor and taste, aromatic rice is highly favored. This quality of rice receives a premium price in the market and has export potential (Arumugachamy *et al.*, 1992).

Sakor, Sagardana Chini, Sagar, Meny, Tilkapur, Binnaphul, Kalobhog, Jabsiri, Kalgochi, Chinisakkor, Chiniatob, Noyonmoni, Saubail, Chinniguri, Kalomala, Begunmala, Gopalbhog, Tulsimoni, Jirabuti, Khirshabuti, Rajbut, Soru kamina, Kamini soru, Doiarguru, Premful, Begun bichi, Elai, Gua masuri, Luina, Lal Soru, Chini Kanai, Kalijira, Rajbhog, Philippines, Baoibhog, Baoijhaki, Jirabhog (Bolder), Chinigura, Tulsimala, Bashmati, Uknimodhu, Ranisalut, Jira dhan, Gandhakusturi, Sakkorkhora, Badshabhog,Jirakatari, Desikatari, Thakurbhog, Tulsimaloty, Raduni pagal, Sugandhi dhan, Kalijira (long grain), Jesso balam, Dakshahi, Hatisail, Khasa, Buchi, Awned, Black, Straw, Dubsail, Duksail, Khaskani, Khazar, Basmati, BR5, BRRI dhan34, BRRI dhan37, BRRI dhan38, BRRI dhan50, Khasa Mukpura, Uknimodhu, Bawaibhog-2, Chiniatob-2, Tilokkachari, Begunbichi-2, Chinairri, Bhatir chikon, Gordoi, Dolagocha, Kalonunia, Dhan chikon, Badshabhog-2, Thakurbhog-2, Khuti chikon, Sunduri samba, Basmati, Basnatu sufaid, Tulsimala-2, Chinisail, Malshira, Sadagura, Modhumadab, Parbatjira, Chinikanai-2, Meedhan, Gobindhabhog, Kataribhog, Fulkari, BU dhan2R, Padmabhog, Dudsail, Sakkorkhana, Maloti, Bashful, Kalijira, Oval, Kalobakri etc. are the different varieties local and modern aromatic rice in Bangladesh (Islam *et al.,* 2016).

So we need to improve the yield of aromatic rice for worldwide purpose. Different cultivation method in our country applied for rice production such as transplantation, drilling, broadcast, Japanese and SRI. Among them transplantation is very popular in our country. But our most of the farmer illiterate, they don't know the exact transplanting time of rice in different season. As a result most of the time yield is lower. Considering the above facts this study has been undertaken to investigate the improvement of yield of aromatic rice by different cultivation method such different transplanting time.

Detailed project objective(s)

The objectives of this research proposal are as follows –

1. To find out the exact transplanting time for the aromatic rice in aman season.
2. To study the improvement of yield of aromatic rice by using different transplanting time.

Materials and methodology

The experiment was conducted in the experimental field of Department of Agricultural Botany, SAU during *aman season*, and July, 2020 to March, 2021.

a) Plant material

Six traditional aromatic rice cultivars *viz.* Kataribhog, Kalizira, Chiniatap, Zirabhog, Modhumala, Badshabhog, were used in these study.

Plan of action

Seeds of afore-mentioned cultivars/varieties were collected from Rice Research Institute (BRRI) and SAU Germplasm, respectively. The field experiment was carried out during July, 2020 to March, 2021.

Experimental design, layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 18 (6x3) treatment combinations. The total numbers of unit plots were 54. The size of unit plot is 2m x 1.5m= 3m^2. The distances between plant to plant 15 cm and row to row 20cm.

Treatments

There were two factors in this experiment as follows-

Factor a) Variety

V_1 = Badshabhog	V_4 = Kataribhog
V_2 = Modhumala	V_5 = Zirabhog
V_3 = Chiniatap	V_6 = Kalijira

Factor b) Treatments: Transplanting time

i. T_1 = 20 DAS (30th July 2020)

ii. T_2 = 30 DAS (9th August 2020)

iii. T_3= 40 DAS (19th August 2020)

Transplanting and fertilization

Twenty, Thirty and Fourty days-old seedlings were transplanted according to treatments in the experimental field in 30th July, 9th August and 19th August respectively. Fertilizers were applied @ 88.92-51.87-59.28-44.46-0 kg N, P_2O_5, K_2O, S and Zn ha^{-1} (BRRI, 2013). All fertilizers except urea were applied as basal during final land preparation. Urea was top-dressed in three equal splits at early tillering, mid tillering and at 4-5 days before panicle imitation stages.

Other cultural operations

Proper intercultural operations were done to ensure the normal growth of the crops. Seedlings in some hills, if die off, then these were replaced by new one within one week of transplanting with seedlings from the respective source. Weeding was done as and when necessary. Plant protection measures *viz.* insecticide and fungicide were sprayed as require to keep the crop free from insect and pathogen attack.

Data collection

Data were collected on the following parameters: Ten plants were sampled from each plot.

1. *Plant height:* Plant heights were recorded at 60DAS, 80DAS and 100DAS. The height of 10 randomly selected plants in each plot was collected from ground level to top portion of the plant and the mean value of plant height was recorded in cm.
2. *No. of tiller/plant:* Number of tillers plant^{-1} were recorded at 60DAS, 80DAS and 100DAS. 10 randomly selected plants in each plot were collected and the mean value was recorded.
3. *Booting of 50% plant:* Time required for booting (Days After Sowing, DAS) was recorded from each plot
4. *Emergence of (1st, 50, 100)% panicle:* Time required for panicle emergence (Days After Sowing, DAS) was recorded from each plot.
5. *Starting of maturity:* Time required for maturity (Days after Sowing, DAS) was recorded from each plot.
6. *100% maturity:* Time required for maturity (Days after Sowing, DAS) was recorded from each plot.
7. *Harvesting day (DAT):* Time required for harvesting (Days after Transplanting, DAT) was recorded from each plot.
8. *Life cycle (DAS) duration:* Time required for life cycle duration (Days after Sowing, DAS) was recorded from each plot.
9. *Life cycle duration (DAT):* Time required for life cycle duration (Days after Transplanting, DAT) was recorded from each plot.
10. *No. of effective or fertile tiller/plant:* The number of effective tillers plant-1 was recorded at harvesting stage by counting average of same 10 plants selected from each treatment of each plot.

11. *No. of ineffective or sterile tiller/plant:* The number of ineffective tillers plant^{-1} was recorded at harvesting stage by counting average of same 10 plants selected from each treatment of each plot.
12. *Length of panicle:* The length of the panicle was measured with a meter scale from 10 selected panicles and the average value was recorded.
13. *Seed weight/plant:* Weight of number of filled grain/panicle multiplied by panicle/plant
14. *Weight of panicle/plant:* The weight of the panicle was measured with a digital balance from 10 selected panicles and the average value was recorded.
15. *Dry weight/plant:* For data recording at first 10 plants were selected from each plot after harvesting with root enough. Then these plants were cut into small pieces and packed in paper bags for oven dry. These samples were kept in oven at 700C for 72 hours. Then dry weight were taken from these samples where each bag contain 10 plant parts sample. Then dry weight (gm per plant) was calculated from of different parts and lastly total dry matter in gm was calculated. For TDM calculation need seed wt. per plant was also included.
16. *No. of fertile or filled spikelets/panicle:* Average number of filled grains panicle^{-1} was calculated by counting the number of filled grain of 10 panicles plant^{-1}
17. *No. of sterile or unfilled spikelets /panicle:* Number of unfilled grains panicle^{-1} was also counted.
18. *Total no. of spikelets/panicle:* Total number of grains panicle^{-1} was calculated by counting the number of filled grain of 10 panicles plant^{-1}
19. *1000grain weight:* One thousand grains were counted randomly from the total cleaned harvested grains of each individual plot and then weighed in grams and recorded.
20. *Grain weight/plant:* The weight of the grain was measured with a digital balance from 10 selected plant and the average value was recorded
21. *Straw weight/plant:* The weight of the straw was measured with a digital balance from 10 selected plant and the average value was recorded
22. *Biological yield:* Biological yield was determined using the following formula Biological yield = Grain yield + Straw yield
23. *Grain yield ton/ha:* Grain from each plot area was thoroughly sun dried till constant weight was attained. Then yield per hectare was determined based on net plot area.
24. *Straw yield ton/ha:* After separation of grains from plants of each plot the straw was sun dried till a constant weight is obtained and expressed as tonha^{-1}.

Statistical analysis of data

The data obtained for different parameters will be statistically analyzed following computer based software Statistix 10 and mean separation will be done by LSD at 5% level of significance. (Gomez and Gomez, 1984)

Results and discussion

Plant Height (cm)

Significant variation was observed of plant height among the test rice varieties at 60, 80,and 100 DAS. In case of varieties, at 60 DAS highest plant height was observed in V_3 (Chiniatap) and lowest in V_4 (Kataribhog). At 80 DAS highest plant height was observed in V_6 (Kalizira) and lowest in V_4 (Kataribhog). At 100 DAS highest plant height was observed in V_5 (Zirabhog) and lowest in V_1 (Badshabhog) (Fig. 1).

In case of transplanting time, at 60 DAS highest plant height was observed in T_1 (20 DAS) and lowest in T_3 (30 DAS). At 80 DAS highest plant height was observed in T_1 (20 DAS) and lowest in T_3 (30 DAS). At 100 DAS highest plant height was observed in T_1 (20 DAS) and lowest in T_3 (30 DAS) (Fig. 2).

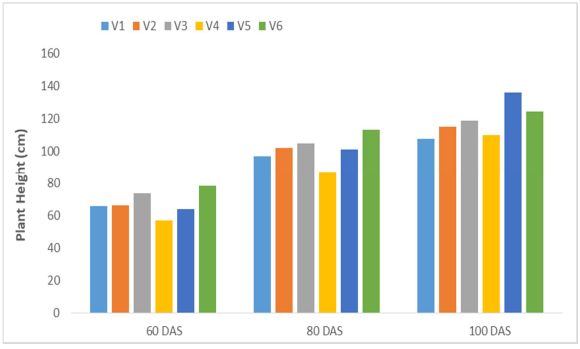

Fig. 1. Effect of varieties on plant height at different DAS of aromatic rice.

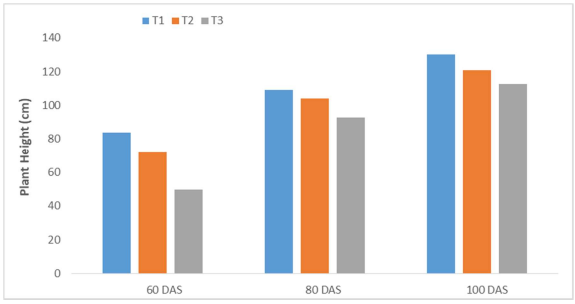

Fig. 2. Effect of transplanting time on plant height at different DAS of aromatic rice.

In case of interaction, at 60 DAS highest plant height was observed in V_6T_1 (Kalizira+ 20 DAS). At 80 DAS highest plant height was observed in V_6T_2 (Kalizira+ 30 DAS). At 100 DAS highest plant height was observed in V_5T_1 (Zirabhog+ 20 DAS) (Fig. 3).

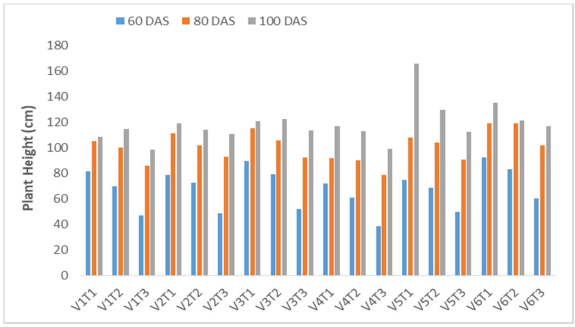

Fig. 3. Interaction effect of varieties and transplanting time on plant height at different DAS of aromatic rice.

No. of Tiller plant^{-1}

Significant variation was observed in no. of tiller plant^{-1} among the test rice varieties at 60, 80 and 100 DAS. In case of varieties, at 60 DAS, 80 DAS and 100 DAS the highest plant height was observed in V_2 (Modhumala) (Fig. 4).

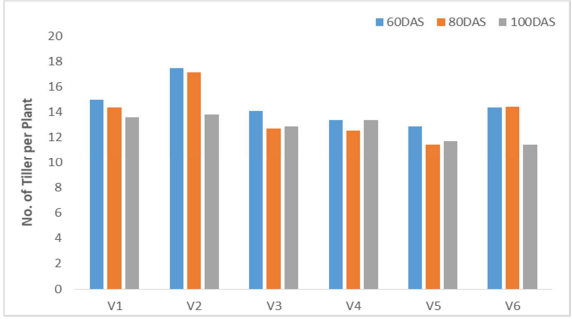

Fig. 4. Effect of varieties on No. of Tiller plant^{-1} at different DAS of aromatic rice.

In case of transplanting time, at 100 DAS highest in T_2 (30 DAS) and others are statistically similar (Fig. 5).

In case of interaction, at 60 DAS highest in V_2T_2 (Modhumala + 30 DAS) others are statistically similar. At 80 DAS highest in V_2T_1 (Modhumala + 20 DAS). At 100 DAS highest in V_4T_1 (Kataribhog + 20 DAS) (Fig. 6).

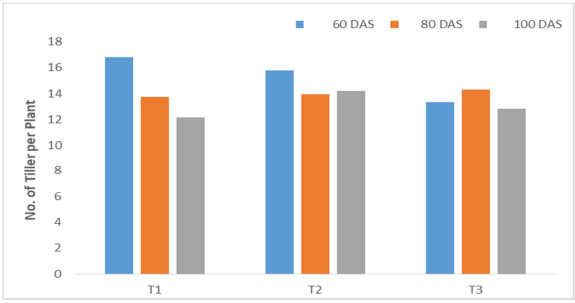

Fig. 5. Effect of transplanting time on No. of Tiller plant^{-1} at different DAS of aromatic rice.

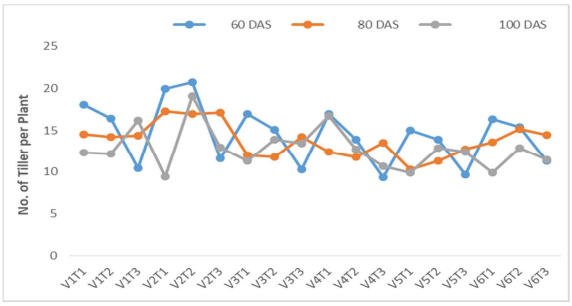

Fig. 6. Interaction effect of varieties and transplanting time on No. of Tiller plant^{-1} at different DAS of aromatic rice.

50% Booting of plant

Significant variation was observed of 50% booting of plant among the test rice varieties. In case of varieties, early booting was observed in V_4 (Kataribhog) (Table 1).

In case of transplanting time, early booting was observed in T_1 (20 DAS) (Table 1).

In case of interaction, early booting was observed in V_4T_1 (Kataribhog + 20 DAS) (Table 2).

Emergence of panicle

Significant variation was observed in panicle emergence of plant among the test rice varieties.

In case of variety early was observed in V_4 (Kataribhog) (Table 1).

In case of transplanting time early was observed in T_1 (20 DAS) (Table 1).

In case of interaction early was observed in V_4T_1 (Kataribhog + 20 DAS) (Table 2).

Table 1. Effect of varieties and transplanting time on Booting and Emergence of panicle at different DAS of aromatic rice.

Variety	50% Booting of plant(DAS)	Emergence of panicle(DAS)		
		1st	50%	100%
V_1	99.5	106.5	113.5	120.5
V_2	97.5	104.5	111.5	118.5
V_3	95.83	102.83	109.83	116.83
V_4	88.83	95.83	102.83	109.83
V_5	97.5	104.5	111.5d	118.5
V_6	101.17	108.17	115.17	122.17
LSD	1.6813	1.6813	2.5347	1.6813
CV%	1.47	1.37	1.94	1.21
Transplanting time				
T_1	96.781	103.78	111.09	117.78
T_2	98.938	105.94	112.63	119.94
T_3	99.5	106.5	113.72	120.5
LSD	0.7280	0.7280	1.0976	0.7280
CV%	1.47	1.37	1.94	1.21

Table 2. Interaction effect of varieties and transplanting time on Booting and Emergence of panicle at different DAS of aromatic rice.

Interaction	50% Booting of plant(DAS)	Emergence of panicle(DAS)		
		1st	50%	100%
V_1T_1	99.5	106.5	113.5	120.5
V_1T_2	99.5	106.5	113.5	120.5
V_1T_3	99.5	106.5	113.5	120.5
V_2T_1	99.5	106.5	113.5	120.5
V_2T_2	93.5	100.5	107.5	114.5
V_2T_3	99.5	106.5	113.5	120.5
V_3T_1	102.5	109.5	116.5	123.5
V_3T_2	85.5	92.5	99.5	106.5
V_3T_3	99.5	106.5	113.5	120.5
V_4T_1	83.5	90.5	97.5	104.5
V_4T_2	95.5	102.5	109.5	116.5
V_4T_3	87.5	94.5	101.5	108.5
V_5T_1	88.5	95.5	102.5	109.5
V_5T_2	99.5	106.5	113.5	120.5
V_5T_3	104.5	111.5	118.5	125.5
V_6T_1	99.5	106.5	113.5	120.5
V_6T_2	101.5	108.5	115.5	122.5
V_6T_3	102.5	109.5	116.5	123.5
LSD	2.9122	2.9122	4.3902	4.3902
CV%	1.47	1.37	1.94	1.21

Maturity, harvesting day (DAT), Life cycle (DAS) and Life cycle (DAT)

Significant variation was observed in maturity, harvesting day (DAT), life cycle (DAS) and life cycle (DAT). In case of variety early was observed in V_5 (Zirabhog) (Table 3). In case of transplanting time early was observed in T_1 (20 DAS) (Table 3). In case of interaction early was observed in V_5T_1 (Zirabhog + 20 DAS) but in case of harvesting day (DAT) and life cycle (DAT) early was observed in V_5T_3 (Zirabhog + 40 DAS) (Table 4).

Table 3. Effect of varieties and transplanting time on Maturity, Harvesting day and Life cycle at different DAS of aromatic rice.

Variety	Maturity		Harvesting day (DAT)	Life cycle (DAS)	Life cycle (DAT)
	1st	100%			
V_1	131.17	161.17	132.17	162.17	132.17
V_2	129.67	159.67	130.67	160.67	130.67
V_3	133.17	163.17	134.17	164.17	134.17
V_4	131.17	161.17	132.17	162.17	132.17
V_5	103.5	133.5	104.5	134.5	104.5
V_6	133.17	163.17	134.17	164.17	134.17
LSD	0.3556	0.3556	0.3556	0.3556	0.3556
CV%	0.24	0.19	0.24	0.19	0.24
Transplanting time					
T_1	127.06	157.06	138.06	158.06	138.06
T_2	129.38	159.38	130.38	160.38	130.38
T_3	130.59	160.59	121.59	161.59	121.59
LSD	0.1540	0.1540	0.1540	0.154	0.1540
CV%	0.24	0.19	0.24	0.19	0.24

Table 4. Interaction effect of varieties and transplanting time on Maturity, Harvesting day and Life cycle at different DAS of aromatic rice.

Interaction	Maturity		Harvesting day (DAT)	Life cycle (DAS)	Life cycle (DAT)
	1st	100%			
V_1T_1	126.5	156.5	137.5	157.50	137.5
V_1T_2	133.5	163.5	134.5	164.50	134.5
V_1T_3	133.5	163.5	124.5	164.50	124.5
V_2T_1	127.5	157.5	138.5	158.5	138.5
V_2T_2	129.5	159.5	130.5	160.5	130.5
V_2T_3	132	162	123	163h	123
V_3T_1	130.5	160.5	141.5	161.5	141.5
V_3T_2	134.5	164.5	135.5	165.5	135.5
V_3T_3	134.5	164.5	125.5	165.5	125.5
V_4T_1	115.5	145.5	126.5	146.5	126.5
V_4T_2	146.5	176.5	147.5	177.5	147.5
V_4T_3	131.5	161.5	122.5	162.5	122.5
V_5T_1	100.5	130.5	111.5	131.5	111.5
V_5T_2	102.5	132.5	103.5	133.5	103.5
V_5T_3	107.5	137.5	98.5	138.5	98.5
V_6T_1	134.5	164.5	145.5	165.5	145.5
V_6T_2	132.5	162.5	133.5	163.5	133.5
V_6T_3	132.5	162.5	123.5	163.5	123.5
LSD	0.6160	0.6160	0.6160	0.6160	0.616
CV%	0.24	0.19	0.24	0.19	0.24

No. of effective or fertile tiller plant^{-1}

Significant variation was observed in no. of effective tiller plant^{-1} of plant among the test rice varieties. In case of varieties, highest was observed in V_2 (Modhumala) (Table 5).

In case of transplanting time, highest was observed in T_3 (40 DAS) (Table 5). In case of interaction, highest was observed in V_2T_2 (Modhumala+ 30 DAS) (Table 6).

No. of ineffective or sterile tiller plant^{-1}

Significant variation was observed in no. of ineffective tiller plant^{-1} of plant among the test rice varieties. In case of varieties, highest was observed in V_6 (Kalizira) (Table 5). In case of transplanting time, highest was observed in T_2 (30 DAS) (Table 5). In case of interaction, highest was observed in V_3T_2 (Chiniatap + 30 DAS) (Table 6).

Panicle length (cm)

Significant variation was observed in panicle length (cm) of plant among the test rice varieties. In case of varieties, highest was observed in V_5 (Zirabhog) (Table 5). In case of transplanting time, highest was observed in T_1 (20 DAS) (Table 5). In case of interaction, highest was observed in V_5T_1 (Zirabhog + 20 DAS) (Table 6).

Table 5. Effect of varieties and transplanting time on No. of effective or fertile tiller plant^{-1}, No. of ineffective or sterile tiller plant^{-1} and Panicle length (cm) at different DAS of aromatic rice.

Variety	No. of effective or fertile tiller plant^{-1}	No. of ineffective or sterile tiller plant^{-1}	Panicle length (cm)
V_1	18.3	1.467	23.6
V_2	25.167	2.233	25.767
V_3	16.733	1.8	25.45
V_4	16.067	0.5	24.883
V_5	13.3	1.467	26.933
V_6	17.9	2.267	26.35
LSD	3.5127	3.9385	2.0906
CV%	16.6	112.17	6.93
Transplanting time			
T_1	16.275	2.7625	26.559
T_2	18.963	3.325	26.053
T_3	19.419	2.9813	25.28
LSD	1.521	1.7054	0.9053
CV%	16.6	112.17	6.93

Seed wt. plant^{-1}

Significant variation was observed in seed wt. plant^{-1} of plant among the test rice varieties. In case of varieties, highest was observed in V_4 (Kataribhog) (Table 7). In case of transplanting time, there is no significant difference (Table 7). In case of interaction, highest was observed in V_4T_1 (Kataribhog + 20 DAS) (Table 8).

Table 6. Interaction effect of varieties and transplanting time on No. of effective or fertile tiller plant^{-1}, No. of ineffective or sterile tiller plant^{-1} and Panicle length (cm) at different DAS of aromatic rice.

Interaction	No. of effective or fertile tiller plant^{-1}	No. of ineffective or sterile tiller plant^{-1}	Panicle length (cm)
V_1T_1	14.7	3	22.25
V_1T_2	17.9	0.4	24.5
V_1T_3	22.3	1	24.05
V_2T_1	20.9	3.7	26
V_2T_2	29.7	1.5	25.3
V_2T_3	24.9	1.5	26
V_3T_1	16.7	0.7	25.15
V_3T_2	16.6	4.5	25.95
V_3T_3	16.9	0.2	25.25
V_4T_1	16.9	0.7	25.65
V_4T_2	14.9	0.1	26.35
V_4T_3	16.4	0.7	22.65
V_5T_1	10.6	2.3	29.9
V_5T_2	15.3	1	27
V_5T_3	14l	1.1	23.9
V_6T_1	15.6	2.3	26.75
V_6T_2	21.6	2.8	26.45
V_6T_3	16.5	1.7	25.85
LSD	6.0842	6.8217	3.6211
CV%	16.6	112.17	6.93

Table 7. Effect of varieties and transplanting time on Seed wt. plant^{-1}, Panicle wt. plant^{-1} and Dry wt. plant^{-1}at different DAS of aromatic rice.

Variety	Seed wt. plant^{-1}	Panicle wt. plant^{-1}	Dry wt. plant^{-1}
V_1	27.767	36.467	53.568
V_2	26.63	37.3	45.791
V_3	29.067	36.1	49.212
V_4	38.6	53.26	50.174
V_5	24.867	34.2	53.729
V_6	25.967	31.43	57.832
LSD	6.6653	18.39	9.2173
CV%	20.18	40.29	15.10
Transplanting time			
T_1	27.719	36.44	54.311
T_2	28.569	42.79	56.09
T_3	29.044	38.66	47.26
LSD	2.8861	7.9632	3.9912
CV%	20.18	40.29	15.10

Panicle wt. plant^{-1}

Significant variation was observed in panicle wt. plant^{-1} of plant among the test rice varieties. In case of varieties, highest was observed in V_4 (Kataribhog) (Table 7). In case of transplanting time, there is no significant difference (Table 7). In case of interaction, highest was observed in V_4T_1 (Kataribhog+ 20 DAS) (Table 8).

Dry wt. plant^{-1}

Significant variation was observed in dry wt. plant^{-1} of plant among the test rice varieties. In case of varieties, highest was observed in V_6 (Kalizira) (Table 7). In case of transplanting time, there is no significant difference (Table 7). In case of interaction, highest was observed in V_6T_2 (Kalizira+ 30 DAS) (Table 8).

Table 8. Interaction effect of varieties and transplanting time on Seed wt. plant^{-1}, Panicle wt. plant^{-1} and Dry wt. plant^{-1} at different DAS of aromatic rice.

Interaction	Seed wt. plant^{-1}	Panicle wt. plant^{-1}	Dry wt. plant^{-1}
V_1T_1	25.1	34.4	56.82
V_1T_2	25.5	33.4	52.67
V_1T_3	32.7	41.6	51.21
V_2T_1	27.5	37.2	43.607
V_2T_2	26.6	38.3	53.049
V_2T_3	25.8	36.4	40.716
V_3T_1	33.1	40.7	58.306
V_3T_2	30.7	38b	52.07
V_3T_3	23.4	29.8	37.256
V_4T_1	45.9	61.9	61.676
V_4T_2	30.7	48.5	44.86
V_4T_3	39.2	49.4	43.986
V_5T_1	16.4	29.8d	51.344
V_5T_2	24.1	34.5	64.82
V_5T_3	34.1	38.3	45.02
V_6T_1	22.1	27.3	58.006
V_6T_2	34.4	40.1	68.768
V_6T_3	21.4	26.9	46.72
LSD	11.545	31.853	15.965
CV%	20.18	40.29	15.10

No. of fertile spikelets/ filled grain panicle^{-1}

Significant variation was observed in no. of filled grain panicle^{-1} of plant among the test rice varieties. In case of varieties, highest was observed in V_6 (Kalizira) (Table 9). In case of transplanting time, highest was observed in T_3 (40 DAS) (Table 9). In case of interaction, highest was observed in V_6T_3 (Kalizira + 40 DAS) (Table 10).

No. of sterile or unfilled spikelets/grain panicle $^{-1}$

Significant variation was observed in no. of unfilled grain panicle^{-1} of plant among the test rice varieties. In case of varieties, highest was observed in V_5 (Zirabhog) (Table 9). In case of transplanting time, highest was observed in T_1 (20 DAS) (Table 9). In case of interaction, highest was observed in V_5T_1 (Zirabhog + 20 DAS) (Table 10).

Total no. of spikelets/grain panicle^{-1}

Significant variation was observed in no. of filled grain panicle^{-1} of plant among the test rice varieties. In case of varieties, highest was observed in V_6 (Kalizira) (Table 9). In case of transplanting time, highest was observed in T_3 (40 DAS) (Table 9). In case of interaction, highest was observed in V_6T_3 (Kalizira + 40 DAS) (Table 10).

Table 9. Effect of varieties and transplanting time on No. of filled grain panicle^{-1}, No. of unfilled grain panicle^{-1} and Total no. of grain panicle^{-1} at different DAS of aromatic rice.

Variety	No. of filled grain panicle^{-1}	No. of unfilled grain panicle^{-1}	Total no. of grain panicle^{-1}
V_1	143.19	16.31	159.50
V_2	136.15	16.422	152.57
V_3	144.75	17.345	162.1cd
V_4	134.92	20.668	155.58
V_5	71.74	51.619	123.36
V_6	731.84	13.413	745.25
LSD	26.175	3.5892	29.462
CV%	12.81	15.66	12.96
Transplanting time			
T_1	147.75	23.435	171.19
T_2	141.9	20.272	162.17
T_3	238.14	15.48	253.62
LSD	11.334	1.5542	12.757
CV%	12.81	15.66	12.96

1000 grain weight

Significant variation was observed in 1000 grain wt. of plant among the test rice varieties. In case of varieties, highest was observed in V_4 (Kataribhog) (Table 11). In case of transplanting time, there is no significant difference (Table 11). In case of interaction, highest was observed in V_5T_2 (Zirabhog+ 30 DAS) (Table 12).

Grain wt. plant^{-1}

Significant variation was observed in grain wt. plant^{-1} of among the test rice varieties. In case of varieties, highest was observed in V_4 (Kataribhog) (Table 11). In case of transplanting time, there is no significant difference (Table 11). In case of interaction, highest was observed in V_4T_3 (Kataribhog + 40 DAS) (Table 12).

Table 10. Interaction effect of varieties and transplanting time on No. of filled grain panicle^{-1}, No. of unfilled grain panicle^{-1} and Total no. of grain panicle^{-1} at different DAS of aromatic rice.

Interaction	No. of filled grain panicle^{-1}	No. of unfilled grain panicle^{-1}	Total no. of grain panicle^{-1}
V_1T_1	158.7	19.229	177.9
V_1T_2	158.3	19.922	178.2
V_1T_3	112.6	9.791	122.4
V_2T_1	141.2	18.378	159.5
V_2T_2	130.2	12.95	143.2
V_2T_3	137.1	17.937	155
V_3T_1	203.6	18.585	222.1
V_3T_2	124.1	15.576	139.6
V_3T_3	106.6	17.874	124.5
V_4T_1	120	31.391	151.4
V_4T_2	171.8	19.761	191.5
V_4T_3	113	10.851	123.9
V_5T_1	72	90.577	162.6
V_5T_2	54.3	55.418	109.7
V_5T_3	89	8.863	97.8
V_6T_1	154.4	14.754	169.1
V_6T_2	155.6	13.493	169.1
V_6T_3	1885.5	11.992	1897.5
LSD	45.336	6.2167	51.029
CV%	12.81	15.66	12.96

Straw wt. plant^{-1}

Significant variation was observed in straw wt. plant^{-1} of among the test rice varieties. In case of varieties, highest was observed in V_1 (Dholabhog) (Table 11). In case of transplanting time, highest was observed in T_1 (20 DAS) (Table 11). In case of interaction, highest was observed in V_1T_1 (Badshabhog + 20 DAS) (Table 12).

Table 11. Effect of varieties and transplanting time on 1000 grain wt., Grain wt. plant^{-1} and Straw wt. plant^{-1} at different DAS of aromatic rice.

Variety	1000 gran wt.	Grain wt. plant^{-1}	Straw wt. plant^{-1}
V_1	10.983	12.833	37.625
V_2	7.963	10.083	28.188
V_3	12.558	11.667	33.438
V_4	18.722	17.333	28.646
V_5	26.149	8.75	30.133
V_6	6.709	10.492	34.396
LSD	3.1649	2.0496	9.6508
CV%	22.12	14.83	26.06
Transplanting time			
T_1	12.517	11.555	37.892
T_2	12.367	11.461	30.387
T_3	12.075	12.694	27.363
LSD	1.3704	0.8875	4.1789
CV%	22.12	14.83	26.06

Table 12. Interaction effect of varieties and transplanting time on 1000 grain wt., Grain wt. plant^{-1} and Straw wt. plant^{-1} at different DAS of aromatic rice.

Interaction	1000 grain wt.	Grain wt. plant^{-1}	Straw wt. plant^{-1}
V_1T_1	10.767	14.750	45.75
V_1T_2	9.201	11.5	35.063
V_1T_3	12.981	12.25	32.063
V_2T_1	9.36	11.25	40.875
V_2T_2	6.96	10.5	22.313
V_2T_3	7.564	8.5	21.37
V_3T_1	9.761	11.25	39
V_3T_2	14.918	12.25	35.813
V_3T_3	12.995	11.5	25.5
V_4T_1	22.776	14.625	26.5
V_4T_2	12.226	16.25	27.563
V_4T_3	21.162	21.125	31.875
V_5T_1	21.643	6.25	31.15
V_5T_2	29.111	5.75	32.438
V_5T_3	27.692	14.25	26.813
V_6T_1	9.173	10.25	37.75
V_6T_2	10.267	11.25	33.563
V_6T_3	0.688	9.975	31.875
LSD	5.4817	3.55	16.716
CV%	22.12	14.83	26.06

Biological yield (ton ha^{-1})

Significant variation was observed in biological yield (ton ha^{-1}) of among the test rice varieties. In case of varieties, highest was observed in V_1 (Badshabhog) (Table 13). In case of transplanting time, highest was observed in T_1 (20 DAS) (Table 13). In case of interaction, highest was observed in V_1T_1 (Badshabhog + 20 DAS) (Table 14).

Grain yield (ton ha^{-1})

Significant variation was observed in grain yield (ton ha^{-1}) of among the test rice varieties. In case of varieties, highest was observed in V_4 (Kataribhog) (Table 13). In case of transplanting time, highest was observed in T_3 (40 DAS) (Table 13). In case of interaction, highest was observed in V_4T_3 (Kataribhog + 40 DAS) (Table 14).

Straw yield (ton ha^{-1})

Significant variation was observed in straw yield (ton ha^{-1}) of among the test rice varieties. In case of varieties, highest was observed in V_6 (Kalizira) (Table 13). In case of transplanting time, highest was observed in T_1 (20 DAS) (Table 13). In case of interaction, highest was observed in V_1T_1 (Badshabhog+ 20 DAS) (Table 14).

Table 13. Effect of varieties and transplanting time on Biological yield, Grain yield and Straw yield at different DAS of aromatic rice.

Variety	Biological yield (ton ha^{-1})	Grain yield (ton ha^{-1})	Straw yield (ton ha^{-1})
V_1	20.183	5.13	15.05
V_2	15.308	4.03	11.275
V_3	18.042	4.667	13.375
V_4	18.392	6.93	11.458
V_5	15.553	3.5	12.053
V_6	17.955	4.2	13.758
LSD	3.8824	0.8198	3.8603
CV%	19.09	14.83	26.06
Transplanting time			
T_1	19.779	4.6219	15.157
T_2	16.739	4.5844	12.155
T_3	16.023	5.0775	10.945
LSD	1.6811	0.355	1.6716
CV%	19.09	14.83	26.06

Table 14. Interaction effect of varieties and transplanting time on Biological yield, Grain yield and Straw yield at different DAS of aromatic rice.

Interaction	Biological yield (ton ha^{-1})	Grain yield (ton ha^{-1})	Straw yield (ton ha^{-1})
V_1T_1	24.2	5.9	18.3
V_1T_2	18.625	4.6	14.025
V_1T_3	17.725	4.9	12.825
V_2T_1	20.85	4.5	16.35
V_2T_2	13.125	4.2	8.925
V_2T_3	11.95	3.4	8.55
V_3T_1	20.1	4.5	15.6
V_3T_2	19.225	4.9	14.325
V_3T_3	14.8	4.6	10.2
V_4T_1	16.45	5.85	10.6
V_4T_2	17.525	6.5	11.025
V_4T_3	21.2	8.45	12.75
V_5T_1	14.96	2.5	12.46
V_5T_2	15.275	2.3	12.975
V_5T_3	16.425	5.7	10.725
V_6T_1	19.2	4.1	15.1
V_6T_2	17.925	4.5	13.425
V_6T_3	16.74	3.99	12.75
LSD	6.7245	1.42	6.6863
CV%	19.09	14.83	26.06

Conclusion

Transplanting time is the one of the important method of cultivation. Highest Plant height, No. of tiller plant^{-1}, Booting of 50% plant, Emergence of (1st, 50, 100)% panicle, Starting of maturity, 100% maturity, Harvesting day (DAT), Life cycle (DAS) duration, Life cycle duration (DAT), No. of fertile tiller plant^{-1}, No. of sterile tiller plant^{-1}, Length of panicle, Seed weight plant^{-1}, Dry weight plant^{-1}, No. of filled grain panicle^{-1}, No. of unfilled grain panicle^{-1}, 1000grain weight, Grain weight plant^{-1}, Straw weight plant^{-1}, Biological yield (ton ha^{-1}), Grain yield (ton ha^{-1}), Straw yield (ton ha^{-1}),, was V_5T_1, V_4T_1, V_4T_1, V_4T_1, V_4T_1, V_4T_1, V_5T_1, V_5T_1, V_5T_3, V_5T_1, V_5T_3, V_2T_2, V_3T_2, V_5T_1, V_4T_1, V_4T_1, V_6T_2, V_1T_1, V_5T_1, V_5T_2,V_4T_3, V_1T_1, V_1T_1, V_4T_3 and V_1T_1 respectively and lowest grain yield was observed in V_4T_3.These results of various characters studied in the experiments also suggested that some good characters exist in local aromatic rice cultivars which can be exploited through breeding.

Recommendation

For aromatic rice breeding program, emphasis should be given on high dry matter accumulation trait and its remobilization to the grains.

Acknowledgement

I am feeling proud of expressing my sincere appreciation and gratitude to the Ministry of Science and Technology, the People's Republic of Bangladesh for selecting me as a Research and development (R and D) project researcher under National Science and Technology (2020-2021) to conduct this research.

Competing interests

There are no competing interests in this research article.

Authors' contributions

This work was carried out by PAB. Author PAB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript, managed the literature searches, read and approved the final manuscript.

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