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Effect of transplanting geometry on the yield of scented fine rice varieties in *aman* season

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Abstract

Rice (*Oryza sativa* L.) is one of the major staple foods in the world. The present study was undertaken for the improvement of the yield of scented fine rice variety of aman season through the manipulation of transplanting geometry. The experiment was comprised of two factors; *viz.* Factors A: Five scented fine rice varieties (Chinigura, Kalijira, Kataribhog, BRRI dhan37 and BRRI dhan38) and Factor B: Three different spacing (20 cm × 20 cm, 25 cm × 15 cm and 20 cm × 10 cm). In case of varieties filled grains per panicle (101) were observed from Chinigura variety, while the maximum grain yield (3.3 t/ha) and straw yield (9.07 t/ha) were found from Kataribhog variety. In case of spacing filled grains per panicle (116.4), non-filled grains per panicle (33.4), the highest 1000 grain weight (17.11 g), grain yield (3.56 t ha^{-1}), straw yield (8.86 t ha^{-1}), harvest index (28.71%) were recorded from S_1(20 cm x 20 cm). In case of interaction the highest number of filled grains per panicle (131.0),the highest grain yield (4.3 t ha^{-1}) and straw yield (10.7 t ha^{-1}) were recorded from the treatment combination of V_5S_2 (BRRIdhan38+25cmx15cm) while the highest 1000 grain weight(19.07g) was recorded from the combined treatment of (V_5S_2) (Kalijira + 25 cm x 15 cm).Therefore, the treatment combination of V_5S_2(BRRI dhan38 + 25 cm x 15 cm) produced the best results for grain yield and straw yield.

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Introduction

Rice is the most important staple food of about half the world's population, of which more than 90% of the rice consumers inhabit in Asia (FAORAP and APSA, 2014). In Bangladesh it covers about 80% of the total cropped area and contributes about 90% of food grains (BBS, 2009). Therefore, rice plays an important role in ensuring food security, and contributing to poverty alleviation in Asia special in Bangladesh. As the population of Bangladesh continues to increase, there will be further increase of rice production to meet additional consumption.

Bangladesh is an agrarian country and it agro-ecological conditions arefavourable for rice cultivation. Among the top rice producing countries of the world, Bangladesh ranks sixth next to China, India, Indonesia, Vietnam and Thailand (FAOSTAT, 2016). Rice is the most extensively cultivated crop of Bangladesh that covers 75% of the total cultivable area of which around 27% is occupied by fine rice varieties. It plays a dominant role in Bangladesh agriculture and is the prime commodity in our domestic market. Bangladesh is in fourth position with annual rice consumption per head (160 kilograms) after Brunei Darussalam (245 kilograms), Vietnam (166 kilograms) and Laos (163 kilograms) (FAOSTAT, 2016). In 2014-2015, about 11.42 million hectares of land were used for rice cultivation, producing 34.86 million metric tons yield of which transplanted *Aman* rice covered 5.53 million ha with a yield of 2.38 t/ha which was lower than the national average (3.05 t/ha). This yield was also much below the potential yield level compared to other leading rice growing countries. The lower yield of transplanted *Aman* rice has been attributed to several reasons, improper population density being the leadingone.

Scented or aromatic rice constitutes a special group of rice genotypes well known in many countries across the world for their aroma and/or super fine grain quality. During recent years, Bangladeshi farmers are more interested in growing high yielding coarse grain varieties for achieving higher yield per unit area instead of fine rice. Yet, the aromatic fine quality rice varieties are the highly valued rice commodity in Bangladesh agricultural trade market due to having small grain, pleasant aroma and sof ttexture upon cooking (Dutta *et al.,* 1998). Consumer demand for the fine rice varieties both in internal and external markets is also high due to its good nutritional quality, palatability as well as special flavour and taste (Sood, 1978). Bangladesh produces several fine aromatic rice varieties with excellent eating qualities for regular consumption as steamed rice as well as for polau, biryani, jarda, khir, finny type preparations which are served on special occasions. Yet, Bangladeshi aromatic rice is virtually unknown due to insufficient production and lack of storage trade linkage.

Yield is the product of several components such as number of effective tillers per hill, number of grains per panicle and weight of individual grain. These components are influenced by variety, planting geometry and environment in which the crop grows. Planting geometry of a crop affects the interception of solar radiation, crop canopy coverage, dry matter accumulation and crop growth rate. Planting geometry can increase the yield and yield components of rice are greatly influenced by plant spacing (Khalil, 2001; Islam *et al.*, 2008). Spacing is the key factor that needs to be considered for transplanted *Aman*(T. *Aman*) rice. The growth and development of T. *Aman*rice are greatly influenced by plant spacing. However, closer planting geometry causes competition among plants for light, water, and nutrients which consequently slow down growth as well as the grain yield. Optimum planting geometry ensures the proper growth of aerial as well as underground plant parts by efficient utilization of solar radiation, nutrients and water (Miah *et al.,* 1990). Similarly, the tillering habit and formation of spikelets per panicle are also influenced by the planting geometry, which is responsible for the yield of rice per unit area. As the tiller production in aromatic rice is very low and most of them are low yielding, the maximum benefit can be derived from rice if the crop is properly spaced. So, the planting geometry and plant spacing should be optimized by keeping in mind different aspects of cropping management techniques. Therefore, it is essential to find out the suitable transplanting geometry for the scented fine rice varieties in *Aman*season to get better yield andquality. Selection of potential variety and optimum planting geometry can play an important role to increase yield. A large number of experiments have so far been carried out throughout the world to find out the optimum planting geometry in rice. However, sufficient research works have not yet been done on different plant density, especially with modern and local aromatic *Aman*rice varieties in Bangladesh. Such commonly grown fine rice cultivars as Chinigura, Kalijira, Kataribhog, BRRI dhan37 and BRRI dhan38 etc.require detailed study for their different agronomic traits, yield and yield contributing attributes for varietal improvement. Therefore, the present piece of research work was undertaken to select the potential scented fine rice varieties and to find out optimum transplanting geometry for obtaining maximum yield of aromatic rice in Bangladesh.

Materials and methods

Experimental Site and soil of the experimental field

The experiment was carried out on the farm of Sher-e-Bangla Agricultural University, Dhaka. The location of the site is 23°74/N latitude and 90°35/E longitude with an elevation of 8.2 meter from sea level.

The experimental site belongs to the ago-ecological zone of Modhupur Tract (AEZ-28). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 5.6 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land.

Planting materials, varieties and treatments of the experiment

In this research, five scented fine rice varieties namely Chinigura, Kalijira, Kataribhog, BRRI dhan37 and BRRI dhan38 were used as planting material. The seeds were collected from the Bangladesh Rice Research Institution (BRRI), Joydeppur, Gajipur.

The experiment were conducted to justify the effect of transplanting geometry on scented fine rice varieties in *Aman*season. It consisted of two factors as mentioned below: (1) Rice Variety: Chinigura (V_1), Kalijira(V_2), Kataribhog(V_3), BRRI dhan37(V_4), BRRI dhan38(V_5). (2) Spacing: 20 cm x 20 cm (S_1), 25 cm x 15 cm (S_2), 20 cm x 10 cm (S_3).

Layout and land preparation of the experiment

The experimental design was laid out in a Randomized Complete Block Design (RCBD) with two factors and three replicates for each treatment. The experiment was arranged in a Randomized Complete Block Design (RBCD) having spacing in the main plots and varieties in the sub-plot. The total numbers of unit plots were 45. The size of unit plot was 3.0 m x 3.0 m. There were 15 treatment combinations.

The distances between plot to plot and replication to replication were 0.5 m and 1m respectively.

Fertilizer application

Cow-dung was used as decomposed organic matter @ 10 ton /hectare before final land preparation. The recommended doses of chemical fertilizer were applied as Urea, TSP, MOP, Gypsum, and Zinc at the rate of 120, 100, 70, 60, 10 kg ha^{-1}. The whole amount of all the fertilizers except urea were applied at the time of final land preparation as basal dose and thoroughly incorporated with soil with the help of a spade. Urea was top-dressed into three equal splits each at 15, 30 and 45 days after transplanting (DAT).

Seed treatment and sowing

Healthy seeds were kept in water bucket for 24 hours and then it was kept tightly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours. As per BRRI recommendation seedbed was prepared with 1 m wide adding nutrients as per the requirements of soil. Seeds were sown in the seed bed on 20 july, 2017 in order to transplant the seedlings in the main field.

The plot selected for the experiment was opened in the 2nd week of August, 2017 with a power tiller and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross ploughed several times followed by laddering to obtain a good tilt. Weeds and stubble were removed, and finally obtained a desirable tilt of soil for trans- planting of seedlings. The nursery bed was made wet by application of water one day before uprooting the seedlings. The seedlings were uprooted on 15 August, 2017 without causing much mechanical injury to the roots. Thirty (30) days old seedlings were transplanted in the experimental plots using three seedlings per hill on 15 August, 2017.

Intercultural operations

Some intercultural operations are irrigation and drainage, gap filling, weeding, top dressing, spraying of insecticides and fungicides, protection of crops from other pests.

Harvesting

Five hills were randomly selected at maturity (when 80% of the grains became golden yellow) and uprooted from each unit plot prior to harvest for recording data. The harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. The grains were threshed, cleaned and sun dried (adjusted to 12% moisture content) to record grain yield plot^{-1}. Straws were also sun-dried to record its yield plot^{-1} and both grain and straw yields plot^{-1} were then converted to t ha^{-1}.

Data collection

The following data were collected during the study period: Filled grains panicle^{-1}, 1000 grain weight, Grain yield, Straw yield, Harvest index.

Statistical analysis

All the data collected on different parameters wear statistically analysed following the analysis of variance (ANOVA) technique using MSTAT-C computer package program and the mean difference were adjudged by least significant difference (LSD) test at 5% level of significance.

Results and discussion

Yield and yield contributing characters

Number of filled grains panicle^{-1}

Number of filled grains panicle^{-1} was highly significant due to the effect of variety (Fig. 1).

Table 1. Interaction effect of different varieties and different spacing on yield contributing characters and yield of aromatic rice.

Treatments	No. of filled grain panicle^{-1}	1000 grain weight (gm)	Grain yield (ton ha^{-1})	Straw yield (ton ha^{-1})	Harvest Index(HI)
Chinigura×					
S_1	118.0b	14.5d	4.0b	10.3b	27.97cd
S_2	53.0m	10.17k	3.2d	9.9c	24.42g
S_3	64.0k	11.70h	2.8e	7.5g	27.18e
Kalijira×					
S_1	101.0d	9.5m	2.7e	5.8i	31.76a
S_2	96.0e	19.07a	3.5c	8.5e	28.97b
S_3	76.0j	11.20i	2.8e	6.1i	31.45a
Kataribhog×					
S_1	84.0hi	10.3k	2.7e	8.6e	23.88g
S_2	89.0fg	12.90g	3.9b	10.2bc	27.66de
S_3	127.0a	18.83b	3.0d	7.5g	28.8b
BRRI dhan37×					
S_1	110.0c	14.2e	3.0d	7.3gh	29.12b
S_2	80.0ij	10.0l	2.5f	8.5e	22.73h
S_3	85.0gh	15.0c	3.2d	7.9f	28.8b
BRRI dhan 38×					
S_1	93.0ef	13.8f	3.2d	9.0d	26.22b
S_2	131.0a	18.97ab	4.3a	10.7a	28.67bc
S_3	58.0l	10.7j	3.2d	7.0h	31.37a
$LSD_{(0.05)}$	4.44	0.15	0.18	0.32	0.07
CV (%)	2.92	0.72	3.39	2.30	1.51

Values in column having different letter(s) are significantly different and same letter are not significantly different at 0.05 level of probability. S_1= 20 cm x 20 cm, S_2= 25 cm x 15 cm, S_3= 20 cm x 10 cm.

The variety Chinigura (V_1) produced the highest number of filled grains panicle^{-1} (101) but the lowest number (85.33) of filled grains panicle^{-1} was found in the variety Kalijira (V_2). Hossain *et al.* (1991) also observed varietal variation in number of filled grains panicle^{-1}.

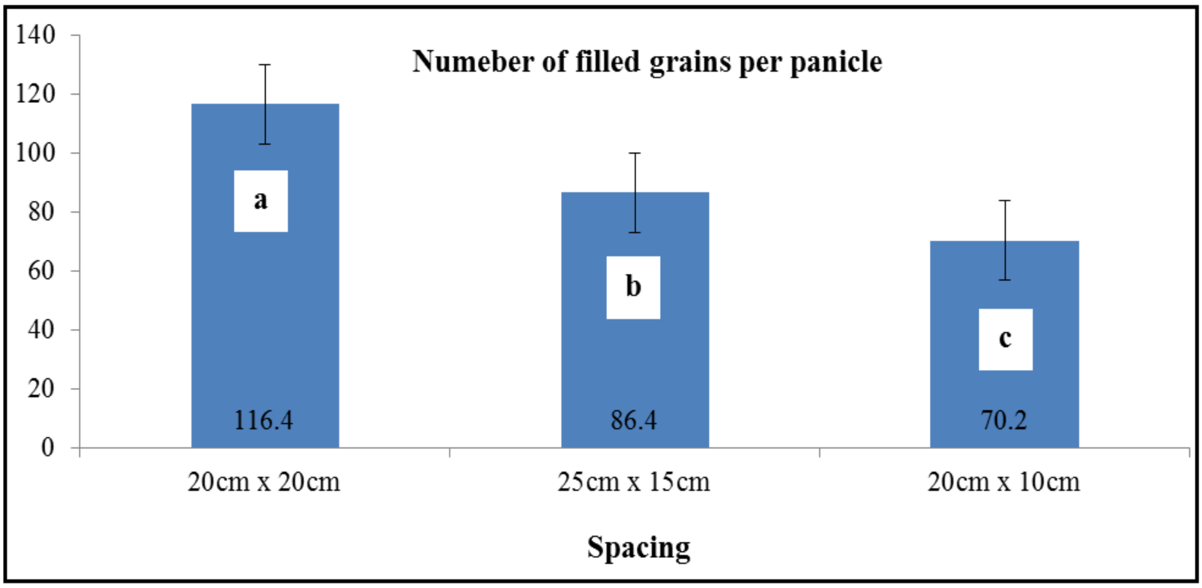

Fig. 1. Effect of variety on the number of filled grains per panicle of scented rice.

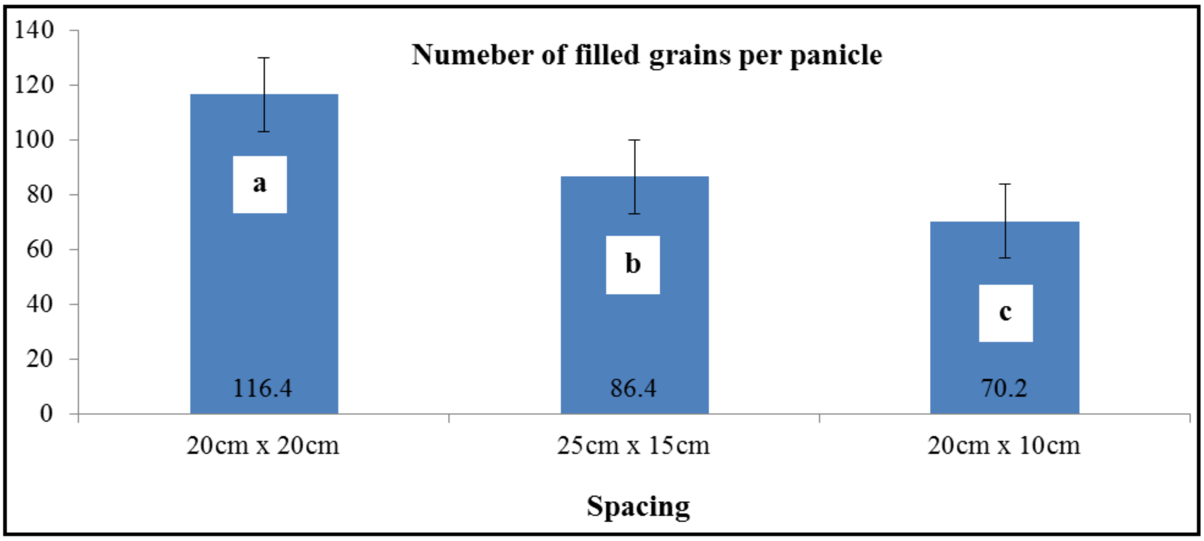

Fig. 2. Effect of different spacing on the number of filled grains per panicle of scented rice.

Spacing had highly significant effect on number of filled grains panicle^{-1} (Fig. 2). The spacing 20 cm × 20 cm (S_1) produced the highest number of filled grains panicle^{-1} (116.4) but it was the lowest (70.2) in the closest spacing of 20 cm × 10 cm (S_3).

This result was in compliance with those of Quddus and Huda (1975) and Rao *et al.* (1990) who found that wider spacing produced higher number of filled grains panicle^{-1}. Significantly the highest number of filled grains per panicle (131.0) was recorded from the treatment combination of BRRI dhan38 (V_5) + 25 cm × 15 cm (S_2) and the lowest number of filled grains per panicle was (53.0) from the combined treatment of Chinigura (V_1) + 25 cm x 15 cm (S_2) (Table 1).

1000 grain weight

It was observed that 1000-grain weight was highly significant due to variety (Fig. 3).

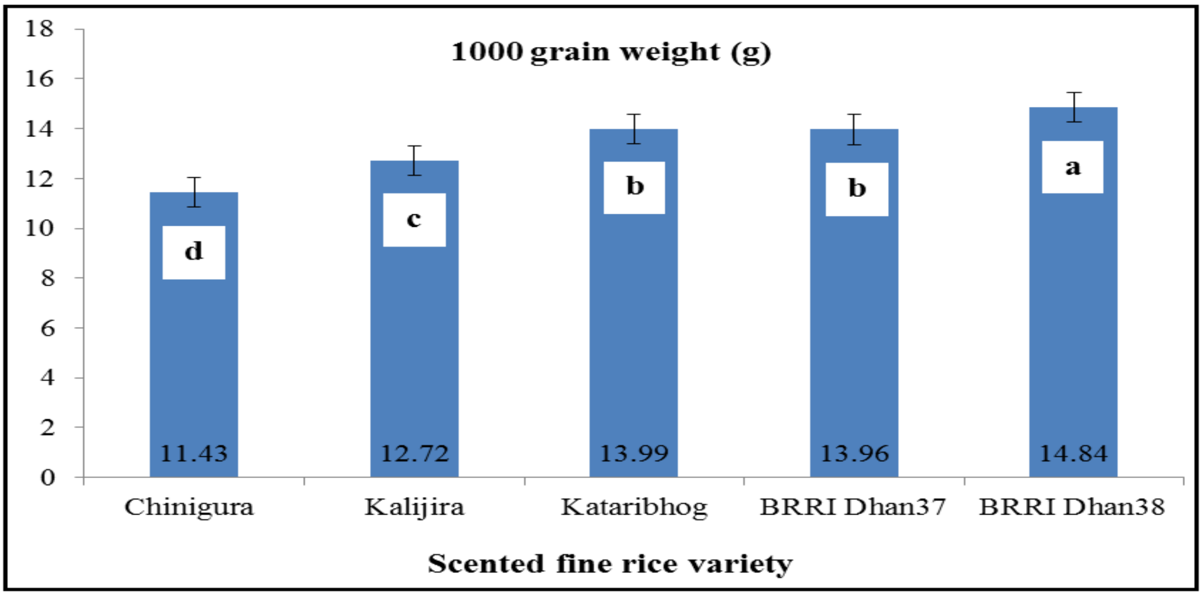

Fig. 3. Effect of variety on 1000- grain weight (g) of scented rice.

The variety BRRI dhan38 (V_5) produced the highest 1000-grain weight (14.84 g) whereas the lowest was produced in Chinigura(11.43 g). It might be due to varietal variation, which is primarily influenced byheredity. A significant effect of spacing was observed in 1000 grain weight (Fig. 4). A gradual increase in 1000 grain weight was observed as the spacing become wider between the lines and hills.

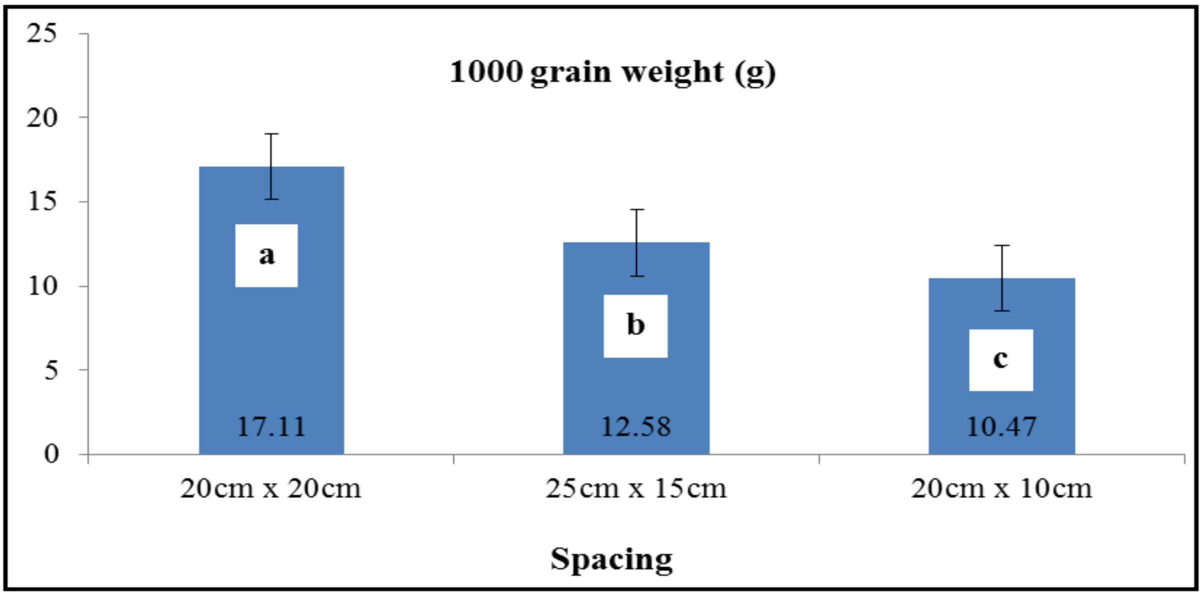

Fig. 4. Effect of different spacing on the number of filled grains per panicle of scented rice.

The widest spacing 20 cm x 20 cm (S_1) produced the highest 1000 grain weight (17.11 g) and the lowest (10.47 g) was observed in the closest spacing i.e. 20cmx 10 cm (S_3). Different varieties and spacing expressed significant differences due to their interaction effect on 1000 grain weight of scented rice (Table 1). Significantly the highest 1000 grain weight (19.07 g) was recorded from the treatment combination of Kalijira(V_2) + 25 cm x 15 cm (S_2) and lowest (9.5 g) was obtained from the combined treatment of Kalijira(V_2) + 20 cm x 20 cm (S_1).

Grain yield

Grain yield mainly depends on the yield contributing characters like number of effective tiller per unit area, number of spikelets panicle-1, filled grains panicle-1 and weight of individual grains. Interestingly, the results revealed that varieties did not influence statistically on the grain yield (Fig. 5). The highest grain yield (3.3tha-1) was recorded at the variety BRRI dhan37 and the lowest (3.13 t ha-1) was obtained from the variety Kalijira and Chinigura (Fig. 5).

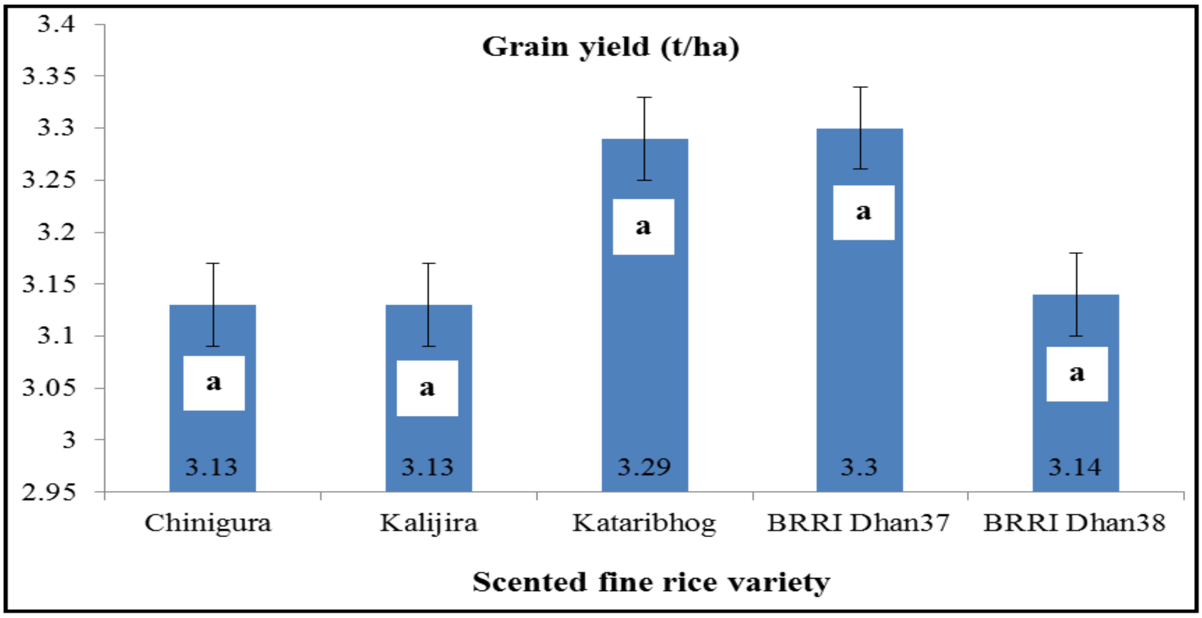

Fig. 5. Effect of variety on grain yield (t/ha) of scented.

Different plant spacing had significant effect on the grain yield of the aromatic rice varieties. A gradual increase of grain yield was observed with the increase of spacing (Fig. 6). The spacing 20 cm x 20 cm (S_1) produced the highest grain yield (3.56 t/ha) due to optimum and more number of effective tillers m^{-2} area, whereas 20 cm x 10 cm (S_3) produced the lowest grain yield (2.88 t/ha) due to less hill m^{-2} area.

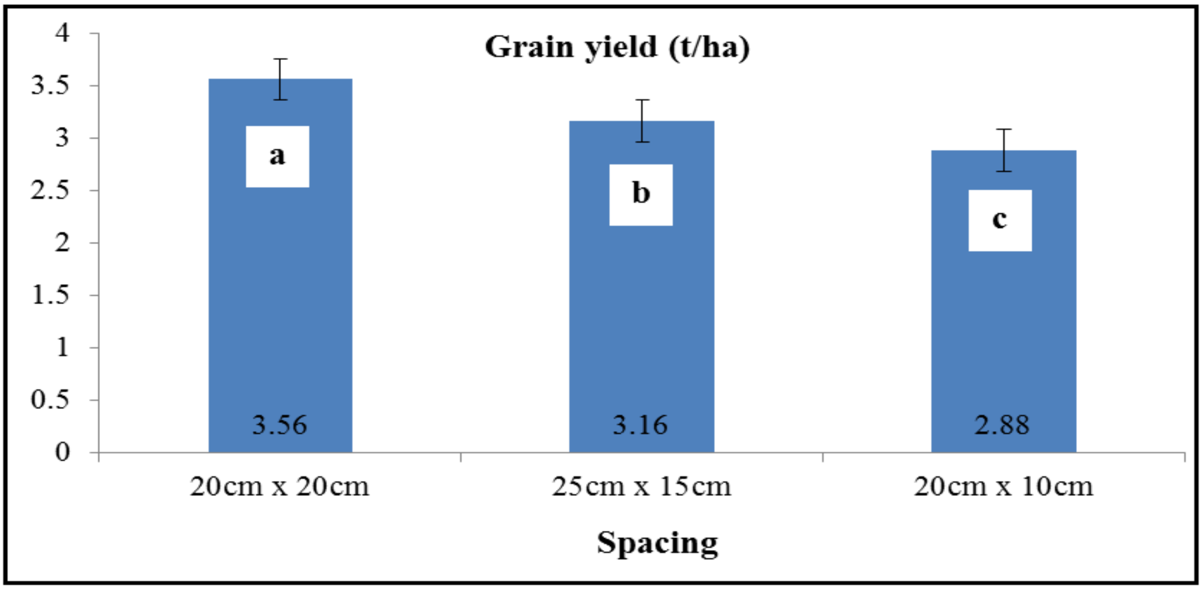

Fig. 6. Effect of different spacing on the grain yield (t/ha) of scented rice.

Significantly the highest grain yield (4.3 t/ha) was recorded from the treatment combination of BRRI dhan38 (V_5) + 25 cm x 15 cm (S_2) and The lowest grain yield (2.5 t/ha) was obtained from the combined treatment of BRRI dhan37 (V_4) + 25 cm x 15 cm (S_2) (Table 1).

Straw yield

It was observed that straw yield was highly significant due to variety (Fig. 7). The variety Kataribhog(V3) produced the highest straw yield (9.07 t/ha) whereas the lowest straw yield (7.47 t/ha) was produced in BRRI dhan38. It might be due to varietal variation, which is primarily influenced by heredity.

The spacing 20 cm x 20 cm (S_1) produced the highest straw yield (8.86 t/ha), whereas 20cm x 10 cm (S_3) produced the lowest straw yield (8.02 t/ha) (Fig. 8).

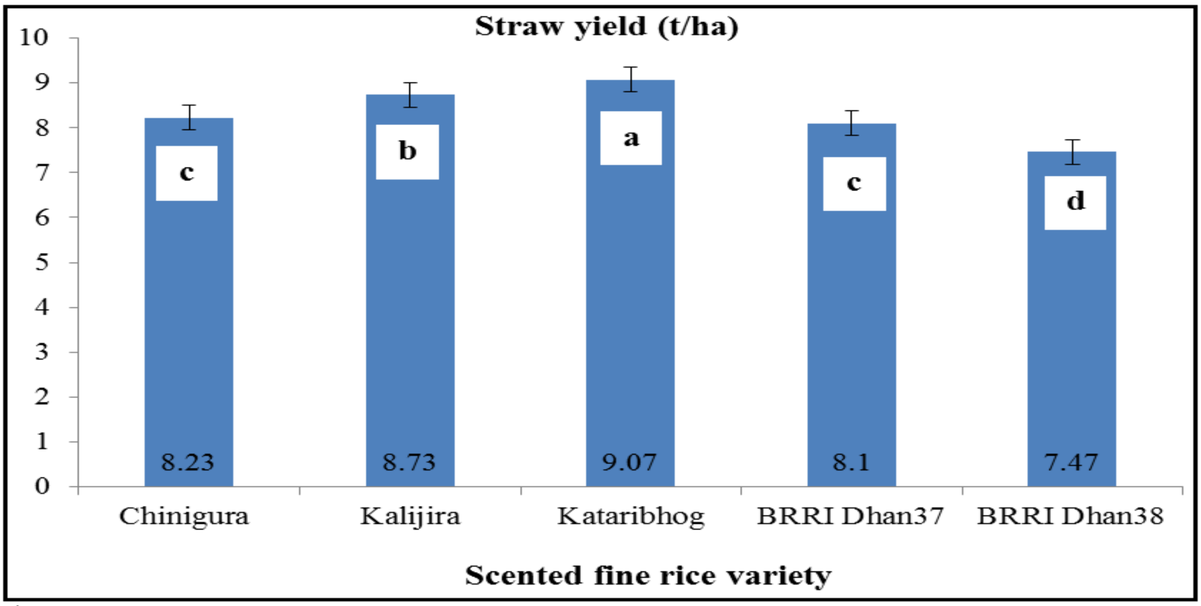

Fig. 7. Effect of variety on straw yield (t/ha) of scented rice.

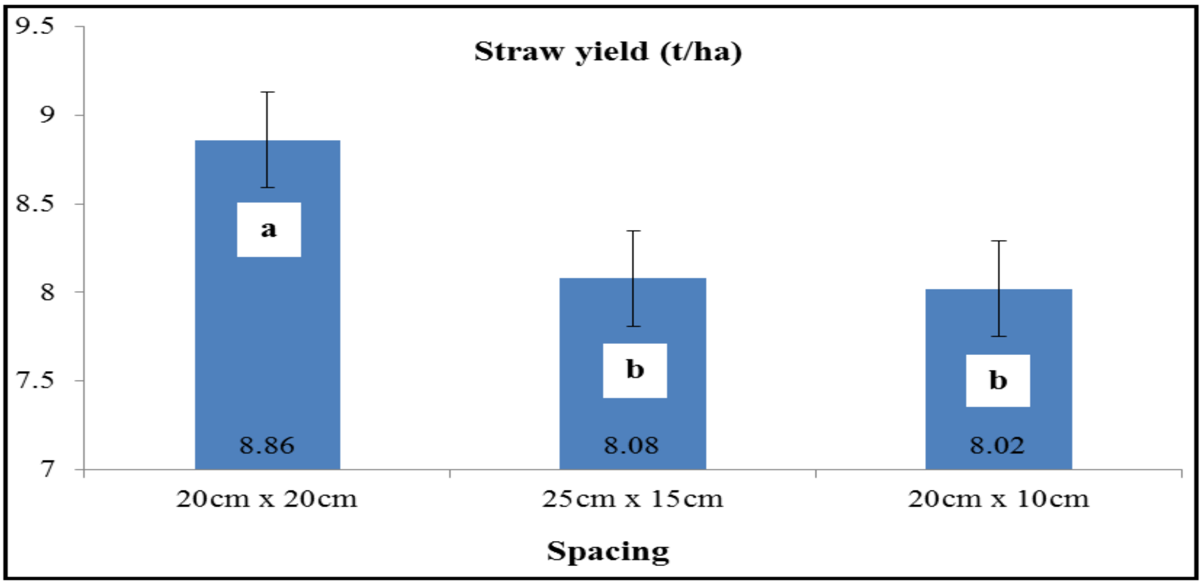

Fig. 8. Effect of different spacing on the straw yield (t/ha) of scented rice.

Significantly the highest straw yield (10.7 t/ha) was recorded from the treatment combination of BRRI dhan38 (V_5) + 25 cm x 15 cm (S_2) (Table 1). The lowest straw yield (5.8 t/ha) was obtained from the combined treatment of Kalijira(V_2) + 20 cm x 20 cm (S_1).Different varieties and spacing expressed significant differences due to their interaction effect on straw yield (t/ha) of scented rice. Interaction effect of different varieties and spacing differ each other. It is revealed that the number of days required for scented rice to reach to flowering stage vary from variety to variety and the location. So, some variety gives highest straw yield and some gives lowest straw yield.

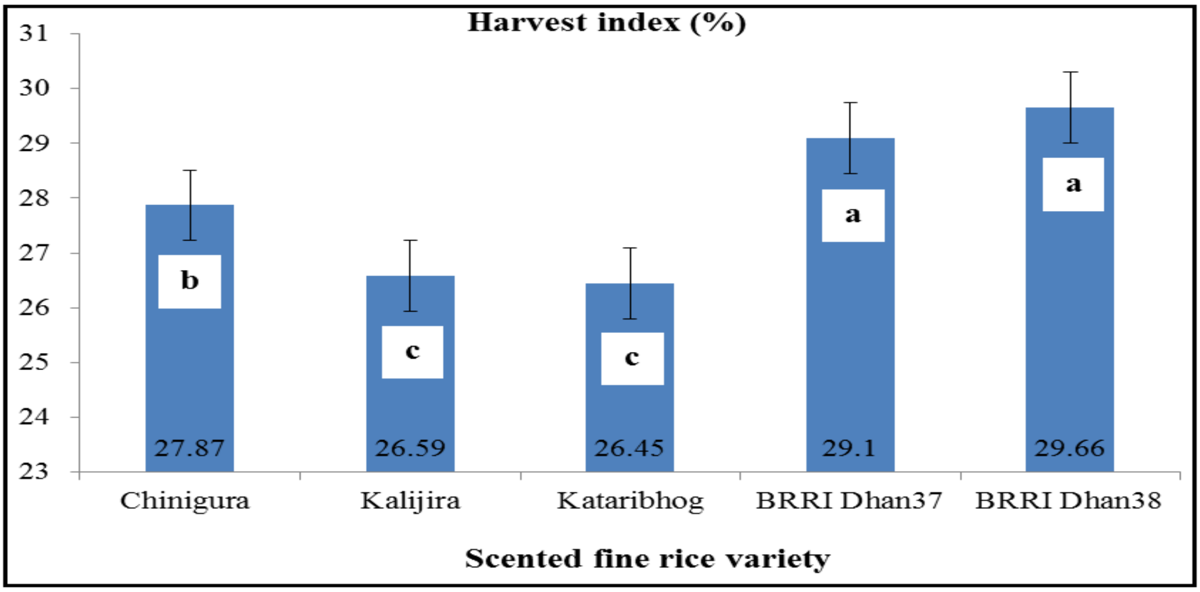

Fig. 9. Effect of variety on harvest index (%) of scented rice.

Harvest index (%)

It was observed that harvest index was highly significant due to variety (Fig. 9). The variety BRRI dhan38 (V_5) produced the highest harvest index (29.66%) and the lowest was produced in Kataribhog (26.45%).

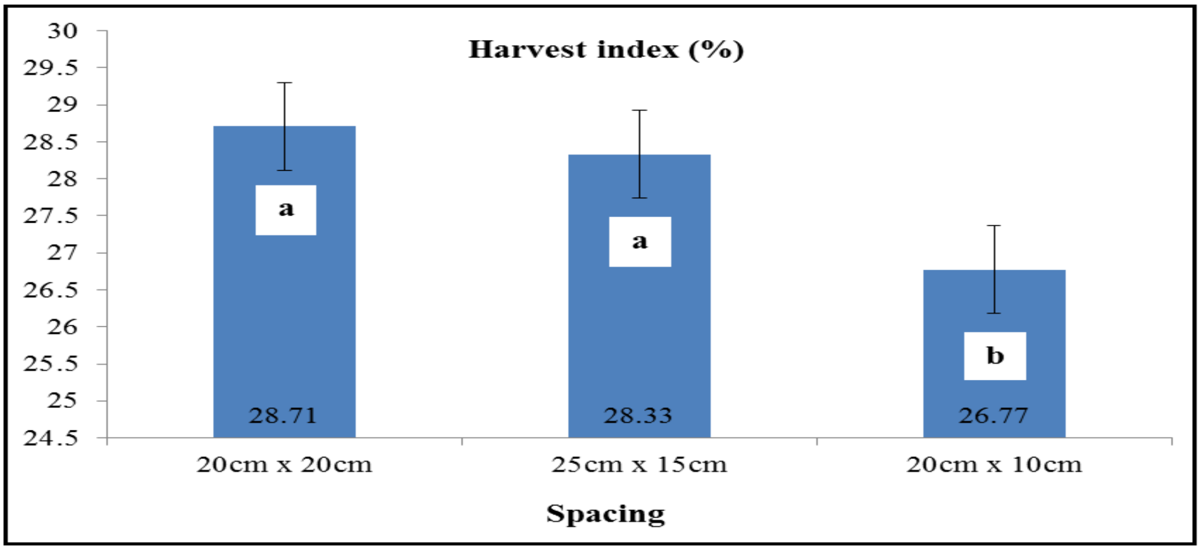

Fig. 10. Effect of different spacing on the straw yield (t/ha) of scented rice.

The spacing 20 cm x 20 cm (S_1) produced the highest harvest index (28.71%) and the spacing 20 cm x 10 cm (S_3) produced the lowest harvest index (26.77%). A gradual increase of harvest index was observed with the increase of spacing (Fig. 10). Significantly the highest harvest index (31.76%) was recorded from the treatment combination of Kalijira(V_2) + 20 cm x 20 cm (S_1) and the lowest harvest index (22.73%) was obtained from the combined treatment of BRRI dhan37 (V_4) + 25 cm x 15 cm (S_2) (Table 1).

Conclusion

On the basis of present research, it can be concluded that the combination of BRRI dhan38 and S_2 (25 cm × 15 cm) provided highest grain yield attributed by no. of filled grain panicle^{-1}, grain yield, and straw yield and statistically similar with 1000grain weight. Kataribhog provided the highest grain yield and straw yield among the test cultivars.

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