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EFFECT OF PLANTING DENSITY ON THE PERFORMANCE OF BORO RICE (BRRI dhan28)

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Abstract

A field experiment was conducted at the Agrotechnology Field Laboratory of Khulna University during the *boro* season to evaluate the effect of planting density on the performance of rice variety BRRI dhan28. The experiment received twelve treatments, which were divided into two distinct patterns - single row and paired row. The single row had four treatments and paired row had eight treatments. Planting densities were 40, 27, 20 and 16 hills m^{-2}. The experiment was arranged in a randomized complete block design (RCBD) with three replications. Standard management practices were followed in raising crops. Results revealed that closer spacing produced higher yields where 40 hills m^{-2} produced the most (4.81 t ha^{-1}), which was statistically similar with that of 27 hills m^{-2}. Paired row planting showed better performance than single row planting. Plant height, grains $panicle^{-1}$, sterile spikelets $panicle^{-1}$, 1000-grain weight, grain yield were found better in paired row planting. Paired row planting at a spacing of (35 cm + 15 cm) × 10 cm i.e row to row distance is 35 cm & 15 cm and hill to hill distance is 10 cm; found the highest grain yield (4.81 t ha^{-1}) and the lowest yield (2.97 t ha^{-1}) was found in single row using a spacing of 25 cm × 25 cm.

Introduction

Rice is the most important cereal crop in the world. It is the staple food for about 50 % of the world's population. Bangladesh is the fourth largest producer and consumer of rice in the world with an annual production ranging from 17 to 20 million tons. Rice occupies 70.66 % of total cropped area in which *boro* rice is cultivated in 47.60 lakh ha area in 2012-13. The average total production of rice in Bangladesh is 187.78 lakh m ton (AIS, 2014). Compared with mid-sixties, Bangladesh has almost doubled its production during the past three decades and the growth in production came mainly from reallocation of land from traditional to high yielding modern varieties (HYVs). Modern varieties at present cover 92.3 % of *boro*, 31.4 % of *aus* and 51% of transplanted *aman* rice area (Miah and Hamid, 1999) and Bangladesh has attained nearly self-sufficiency in food. A modest estimate (Zaman, 1996) suggests that to feed the growing population, the demand for rice in Bangladesh would have to be increased by over 80 % even in the next 20 years. To produce the required quantity of additional food, yield must be increased through increasing that per area.

To meet this challenge rice scientists have been working to develop new techniques Among them, desired number of plant population per unit area has profound influence on grain yield of rice (Islam, 1986). The plant density influences leaf area index, crop growth rate, net assimilation rate, specific leaf area, photosynthesis, respiration and ultimately yield. Optimum planting density enables the rice plant to grow properly both in its aerial and underground parts by utilizing maximum radiant energy, space and water which ultimately leads to boost crop production (Miah *et al.*, 1990). In densely populated rice fields the intra - specific competition between the plants is high which sometimes results in lower grain yield. On the contrary, sparsely populated fields with wide spacing lead to uneconomic utilization of space, profuse growth of weeds and pests and reduction of grain yield unit area^{-1}.

There had been several studies on the yield - density relationship (Willey and Heath, 1969) using a wide variety of crops, but the concept of optimum population density for maximum yield has not yet been figured out (Duncan, 1986). In contrast to the earlier proposition that closer spacing increases intra - specific competition and affects grain yield (BRRI, 1990) and quality (Karim *et al.*, 1992). Several studies revealed that closer spacing increases grain yield (Islam *et al.*, 1994). However, there is a third school of thought which advocated that grain yield is unaffected by plant density (Balsubramaniyan and Palaniappan, 1991). A number of reports (Counce *et al.*, 1989) also indicated a curvilinear relationship between plant population density and rice grain yield. Under transplanted condition, grain yield plateau has been found to reach with 25 to 200 plants m^{-2} (Akita, 1982). Works conducted at BRRI (Anonymous, 1992) suggested that within a range of 16 to 67 plant m^{-2}, grain yield increased with the increase of plant density irrespective of varieties.

Each variety has certain tiller producing capacity and adequate number of effective tillers per unit area that exerts a role in producing panicles and spikelets and ultimately grain yield (Miller *et al.*, 1991). Optimum number of tillers per unit area is a prerequisite for obtaining maximum yield that increases with increased number of panicles per unit area (BRRI, 1995). Higher yield potential of hybrid rice is primarily attributed to profused tillering, large number of panicles and higher spikelet density. It is assumed that BRRIdhan28 may also yield higher if higher number of panicles per unit area with more or equivalent of 100 filled spikelets per panicles are ensured.

Under the above circumstances, it was felt necessary to examine the effect of planting density on the performance of BRRI dhan28 with the objectives of observing the growth and yield performance of BRRI dhan-28 rice at a range of different population densities, and finding out the optimum population density and planting configuration of rice variety BRRI dhan-28 for better growth and higher yield.

Materials and Methods

A field experiment was conducted at the Agrotechnology Field Laboratory of Khulna University, Khulna during the *boro* season of 2005. The soil was characterized by silty loam texture having p^{H} value of 5.6. The experiment was comprised of twelve treatments which were divided into two distinct pattern – single row and paired row. The single row had four treatments : 25 cm × 10 cm (40 hills m^{-2}), 25 cm × 15 cm (27 hills m^{-2}), 25 cm × 20 cm (20 hills m^{-2}) & 25 cm × 25 cm (16 hills m^{-2}) and Paired row had eight treatments: (35 cm + 15 cm) × 10 cm (40 hills m^{-2}), (35 cm + 15 cm) × 15 cm (27 hills m^{-2}), (35 cm + 15 cm) × 20 cm (20 hills m^{-2}), (35 cm + 15 cm) × 25 cm (16 hills m^{-2}), (30 cm + 20 cm) × 10 cm (40 hills m^{-2}), (30 cm + 20 cm) × 15 cm (27 hills m^{-2}), (30 cm + 20 cm) × 20 cm (20 hills m^{-2}) & (30 cm + 20 cm) × 25 cm (16 hills m^{-2}). The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. The unit plot size was 4.0 m × 2.5 m. Plot to plot distance was 0.75 m and block to block distance was 1 m. The seedlings of rice variety BRRIdhan28 were hand transplanted at the age of 40 days, transplanting two seedlings in each hill. Row to row and hill to hill distance were maintained according to the treatment. The experimental plots were fertilized with 80, 50, 40, 10 and 5 kg ha^{-1} of N, P, K, S and Zn, respectively. One third dose of urea and full dose of other fertilizers were applied as basal at the time of final land preparation and thoroughly incorporated into the soil. The remaining two third of urea was top dressed in two equal installments, at panicle initiation stage and another at active tillering stage. Growth parameters of the experiment was studied considering plant height, number of tillers, dry matter accumulation & crop growth rate and yield & yield contributing characters were studied considering plant height, number of tillers & panicles, length of panicle, grain number per panicle, 1000-grain weight, grain yield, straw yield, biological yield and harvest index. The crops were harvested at full maturity when 90% of the seeds turned golden yellow in color. The grain and straw yield were adjusted to 14% moisture level. Quantitative data were subjected to Analysis of Variance (ANOVA) and means of the treatments were compared using Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Plant height increased progressively reaching maximum or peak (Fig.1). Plant height increased almost exponentially up to 53 DAT (flowering) irrespective of treatments, thereafter it nearly reached a plateau. Variation in plant height was observed among the treatments. It was observed that wider spacing increased plant height which was obvious (Shah *et al.*, 1991; Zadeh and Mirlohi, 1998). It was also seen that paired row planting performed well than single row planting. Planting pattern (35 cm + 15 cm) × 25 cm having 16 hills m^{-2} showed higher height than that of 25 cm × 20 cm (20 hills m^{-2}).

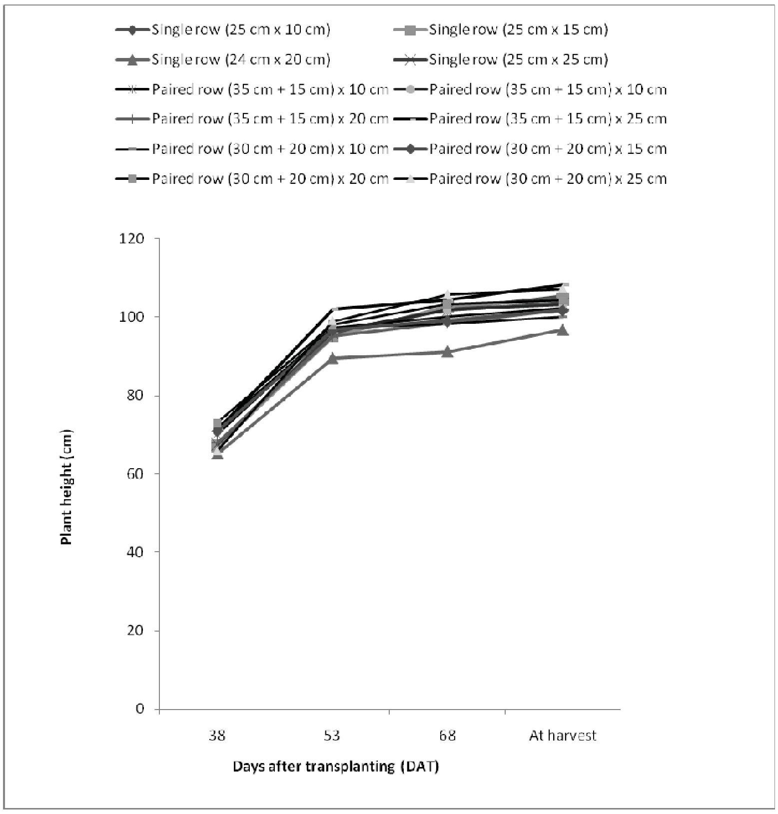

Fig. 1. Plant height over time as affected by planting density

The highest plant height (108.1 cm) at maturity was found in a paired row planting with a spacing of (35 cm +15 cm) × 25 cm having 16 hills m^{-2} and the lowest plant height was found in single row planting of 25 cm × 10 cm spacing (40 hills m^{-2}).

Tiller production was affected markedly by planting density. Tiller number in all the treatments increased almost exponentially up to 53 DAT (Fig. 2) i.e. flowering time. It was shown that higher planting density produced higher number of tillers m^{-2}. From 53 DAT onwards, a sharp decline in tiller number was noticed which again reached a plateau from 68 DAT and onwards. Number of tillers m^{-2} was found to be higher in single row than paired row. In single row pattern 25 cm × 10 cm spacing showed higher tillers than that in paired row.

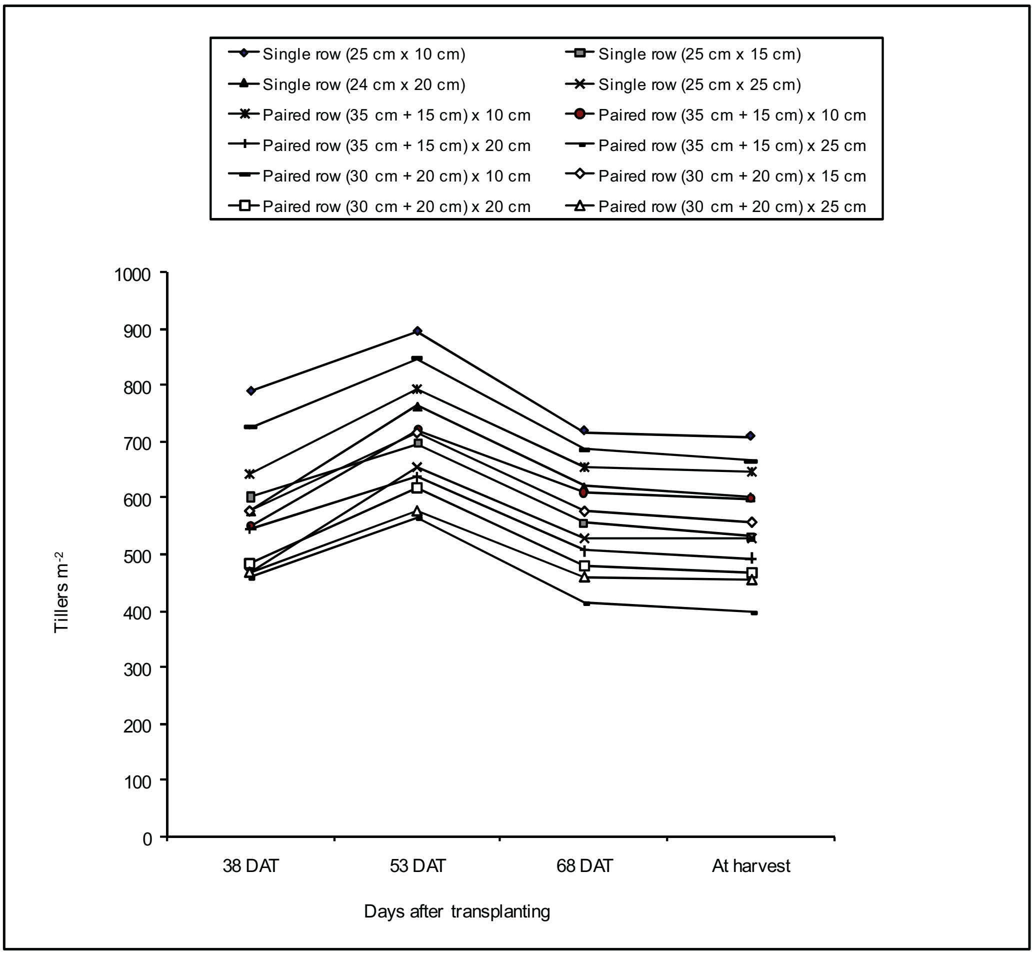

Fig. 2. Tiller dynamics over time as affected by planting density

The result agreed well with Hassan (1991). Miller *et al.* (1991) reported that the number of active tillers declined until reaching a constant tiller density by heading which was also apparent in the present study.

In the present study it was observed that the single row performed well than paired row. Planting pattern that includes 40 hills m^{-2} also performed well than 16 hills m^{-2} at maturity. The highest tillers m^{-2} was found in a single row planting with a spacing of 25 cm × 10 cm having 40 hills m^{-2} and the lowest tillers m^{-2} was found in paired row spacing of (35 cm +15 cm) × 25 cm having 16 hills m^{-2}.

Dry matter (DM) accumulation was recorded at 15 days interval starting at 38 DAT (Fig. 3). It increased with increasing plant density and this phenomena was previously demonstrated by many workers (Talukder, 1998; Jahan, 1988; Roshid, 1998; Rahman, 1997). In paired row planting pattern, (30 cm + 20 cm) × 10 cm showed higher values of dry matter till harvest.

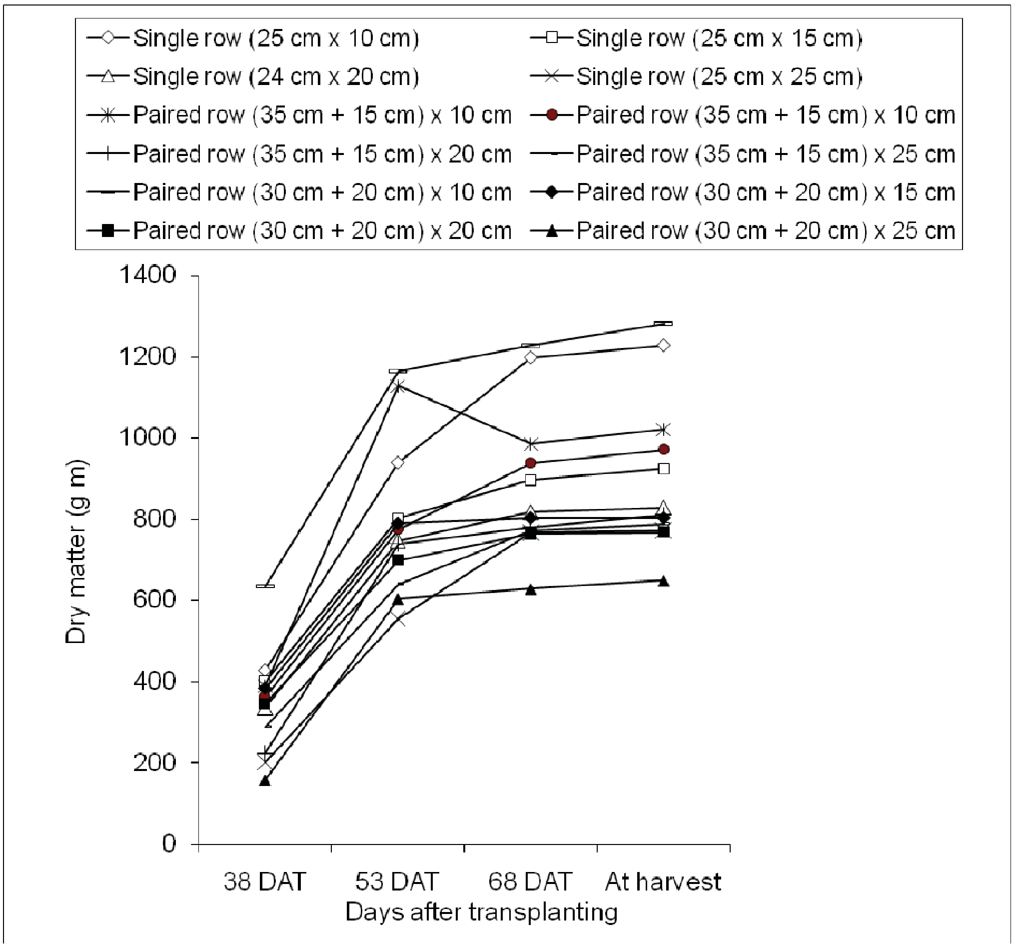

Fig. 3. Total dry matter production as affected by planting density

Increased plant density increased crop growth rate (CGR) during early stage which then gradually decreased and this result agree well with that of Miah and Hamid (1999).

The lowest panicles m^{-2} was found in paired row having 16 hills m^{-2} which increased up to planting density of 40 hills m^{-2} in single row. The highest (522.7) panicles m^{-2} was found in single row spacing 25 cm × 25 cm, and also found highest with (35 cm + 15 cm) × 10 cm, (30 cm + 20 cm) × 10 cm spacing, respectively. The lowest (233.6) panicles m^{-2} was found in paired row spacing of × (30 cm + 20 cm) × 25 cm (Table 1).

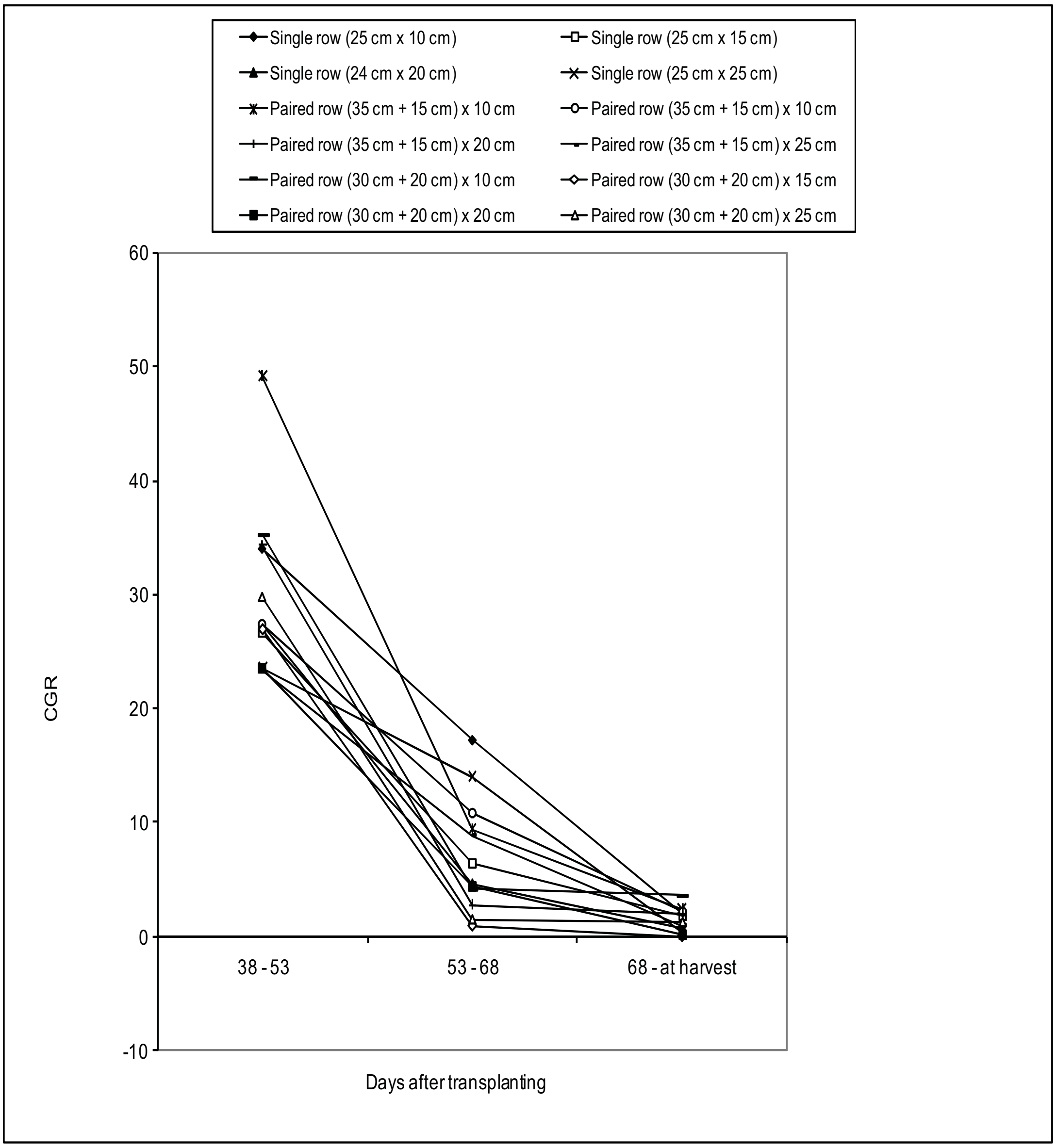

Fig. 4. Crop growth rate (CGR) as affected by planting density.

Single row planting showed longer panicle than double row and this was obvious as the single row planting had more population (Liou, 1987). 16 hills m^{-2} also showed longer panicles than 40 hills m^{-2}. That is, higher panicle length (24.33 cm) was found in single row planting at a spacing of 25 cm × 25 cm and the lowest panicle length (21.80 cm) founded in paired row planting at a spacing of (35 cm + 15 cm) × 10 cm.

Table 1. Planting density effects on plant characters, yield and yield attributes of rice variety BRRI dhan28

Treatments	Panicles m^{-2}	Panicle length (cm)	Grain number $panicle^{-1}$	Sterile spikelets $panicle^{-1}$	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
T_1	522.7a	22.13bc	225.1j	88.0e	19.84c	4.24ab	7.29a	36.86
T_2	416a-d	22.33bc	255.9h	91.67e	20.74bc	4.03abc	5.47bc	42.62
T_3	402.7a-d	22.40bc	270.9f	109.6d	21.64abc	3.023c	5.41bc	35.83
T_4	293.4cd	24.33a	293.0c	109.9d	21.73abc	2.977c	4.960c	37.30
T_5	493.3ab	21.80c	262.8g	67.07g	19.07c	4.81a	6.86ab	41.33
T_6	421.2abc	22.20bc	280.8e	73.47f	19.88c	4.39ab	5.46bc	44.23
T_7	333.3bcd	22.73abc	287.9d	116.9c	21.0bc	3.75abc	5.37bc	41.12
T_8	252.8cd	23abc	297.1b	182.2a	23.95a	3.27bc	4.86c	40.45
T_9	496ab	21.87bc	251.7i	74.13f	20.52bc	4.27ab	6.37abc	40.18
T_{10}	375.2a-d	22.60abc	257.6h	76.60f	20.86bc	3.69abc	6.35abc	36.67
T_{11}	320bcd	23.67ab	298.4b	111.7d	21.12bc	3.24bc	5.66bc	36.36
T_{12}	233.6d	22.87abc	332.8a	164.4b	22.64ab	2.98c	4.99c	37.11
Level of significance	0.05	0.01	0.01	0.01	0.01	0.05	0.05	NS
CV (%)	24.99	3.05	0.40	1.84	4.91	16.75	14.17	12.96

Figures bearing letter(s) in common do not differ significantly, whereas figures with dissimilar letter(s) differ significantly.

Single row:
T_1 = 25 cm × 10 cm (40 hills m^{-2})
T_2 = 25 cm × 15 cm (27 hills
T_3 = 25 cm × 20 cm (20 hills m^{-2})
T_4 = 25 cm × 25 cm (16 hills m^{-2})

Paired row:
T_5 = (35 cm + 15 cm) × 10 cm (40 hills m^{-2})
T_6 = (35 cm + 15 cm) × 15 cm (27 hills m^{-2})
T_7 = (35 cm + 15 cm) × 20 cm (20 hills m^{-2})
T_8 = (35 cm + 15 cm) × 25 cm (16 hills m^{-2})
T_9 = (30 cm + 20 cm) × 10 cm (40 hills m^{-2})
T_{10} = (30 cm + 20 cm) × 15 cm (27 hills m^{-2})
T_{11} = (30 cm + 20 cm) × 20 cm (20 hills m^{-2})
T_{12} = (30 cm + 20 cm) × 25 cm (16 hills m^{-2})

Paired row had more grain on panicle than single row. 16 hills m^{-2} had more grains than 40 hills m^{-2} which may be attributed to the negative relationship between grain number and population density. The highest grain number $panicle^{-1}$ (332.8) was found in paired row at a spacing of (30 cm + 20 cm)   25 cm and the lowest (225.1) was found in single row planting at a spacing of 25 cm × 10 cm (Table 1). The reasons might be due to that competition for growth resources was more in closer spacing, at the same time assimilate production as well as translocation was also poor in over crowded stands (Zadeh and Mirlohi, 1998).
Sterile spikelets $panicle^{-1}$ was higher in less planting density treatments. Best result was found in paired row planting and 16 hills m^{-2} had significantly more sterile spikelets than 40 hills m^{-2}. Higher (182.2) sterile spikelets $panicle^{-1}$ was found in paired row planting at a spacing of (35 cm + 15 cm) × 25 cm and the lowest (67.07) was found in also paired row planting at a spacing of (35 cm + 15 cm) × 10 cm.

Thousand grain weight decreased with decreasing spacing which may be attributed to the greater competition due to higher population density as the consequence of decreased spacing (Shah *et al.,* 1996, Ang *et al.,* 2002, Wang *et al.,* 2002). The highest grain weight (23.95 g) was found in paired row planting at a spacing of (35 cm + 15 cm) × 25 cm and the lowest grain weight (19.07) was also found in paired row at a spacing of (35 cm + 15 cm) × 10 cm.

Paired row performed better than single row showing higher seed yields and 40 hills m^{-2} also performed better than 16 hills m^{-2}. The highest grain yield (4.81 t ha^{-1}) was recorded (Table 1) in paired row at a spacing of (35 cm + 15 cm) × 10 cm and lowest grain yield (2.97) was in single row planting at a spacing of 25 cm × 25 cm. The lowest yield of this treatment might be attributed to its lower number of tillers m^{-2}, panicles m^{-2} (Table 1). Assimilate translocation towards grains was probably poorest in this treatment as compared to others. It was also evident from earlier reports (BRRI, 1992) that closer spacing gives more yield than wider spacing (Gupta and Sharma,1990; Mannan *et al.,* 1991).

Straw yield increased with increasing planting density which is obvious as increased planting density increases straw (Islam *et al.,*1994). The highest straw yield (7.29 t ha^{-1}) was recorded in single row at a spacing of 25 cm × 10 cm and also found highest in spacing (35 cm + 15 cm) × 10 cm, (30 cm + 20 cm) × 10 cm, (30 cm + 20 cm) × 15 cm, respectively. The lowest was recorded in paired row at a spacing of (35 cm + 15 cm) × 25 cm.

Harvest index did not follow any regular trend and no significant difference was not obtained due to variation in planting densities. But roughly it could be assumed that increasing population density decreased harvest index. The highest harvest index (44.23) was found in paired row at a spacing of (35 cm + 15 cm) × 15 cm having 27 hills m^{-2} and the lowest harvest index (35.83) was found in single at a spacing of 25 cm × 20 cm having 20 hills m^{-2}.

From the findings of the present study it might be concluded that paired row planting of (35 cm + 15 cm) × 10 cm spacing (40 hills m^{-2}) found the best planting pattern of rice variety BRRI dhan28 rice in terms of producing the highest grain yield (4.81 t ha^{-1}).

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