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Growth and Yield of Boro Rice (BRRI Dhan 50) as Affected by Planting Geometry under System of Rice Intensification

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Abstract

Rice (Oryza sativa L.) is the staple crop in Bangladesh and different factors influence *its productivity. Among these factors, desired number of plant spacing per unit area is important for higher yield attainment*.Therefore, this *study were undertaken to define the optimum plant geometry for getting the maximum yield. The experiment was conducted at Agronomy field, Sher-e-Bangla Agricultural University during December*, *2011 to May*, *2012 to study the growth and yield of Boro rice (BRRI dhan 50) as affected by planting geometry under System of Rice Intensification (SRI). Experiment comprised 5 level of plant spacing, viz.* S_1*: 25 cm × 25 cm,* S_2*: 30 cm × 30 cm,* S_3*: 35 cm × 35 cm,* S_4*: 40 cm × 40 cm and* S_5*: 25 cm × 15 cm following Completely Randomized Block Design with three replication. Maximum dry matter (156.2 g/hill), number of tiller (44.0/hill), number of effective tiller (36.3/hill), number of filled grains (101.5/panicle), grain yield (6.9 t/ha), straw yield (5.9 t/ha), biological yield (12.7 t/ha) and harvest index (54.5%) was found from 40 x 40 cm plant spacing while minimum was observed from 25 x 25 cm of plant spacing in this study.*

Key words: *Oryza sativa, planting geometry, growth and yield*

I. Introduction

Rice (*Oryza sativa* L.) is the staple crop in Bangladesh and its production cannot fulfill the requirements due to the shortage of cultivable land. So, special attention should be given for increasing the yield per unit area. The crop depends largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. A thick population crop may have limitations in the maximum availability of these factors. Optimum plant spacing influences the availability of sunlight and nutrients for growth and development. Among the different factors of rice productivity, desired number of plant spacing per unit area is an important one for getting higher yield (Soratto, 2004). Improper spacing reduced yield up to 20-30% (IRRI, 1997) while optimum spacing ensures better plant growth through efficient utilization of solar radiation and nutrients (Khan *et al.*, 2005; Mohaddesi *et al.*, 2011). Plant spacing directly affects the normal physiological activities through intra-specific competition (Oad *et al.*, 2001). Wider space allows the individual plants to produce more tillers but it provides the smaller number of hills per unit area which results in low grain yield (Baloch *et al*., 2002; Vijayakumar *et al.*, 2004; Gozubenli, 2010; Kandil *et al.*, 2010). Maintenance of a critical level of rice plant population in field is necessary to maximize grain yields. The effect of plant density on kernel dimension was also identified during different panicle development stages

(Senanayake *et al*., 1991; Banik *et al*., 1997; Wang and Luo, 1998). Current study were undertaken to determine the optimum plant geometry for getting the maximum yield in BRRI Dhan 50.

II. Materials and Method

Experimental site and duration: This experiment was conducted in Agronomy farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh from December, 2011 to May, 2012.

Treatments and experimental design: Experiment consisted five different plant spacing viz. S_1: 25 cm × 25 cm, S_2: 30 cm × 30 cm, S_3: 35 cm × 35 cm, S_4: 40 cm × 40 cm and S_5: 25 cm × 15 cm following Completely Randomized Block Design with three replications.

Planting material: The seeds of BRRI Dhan 50 were collected from Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur.

Fertilization: The fertilizers N, P, K, S, Zn and B in the form of urea (150 kg ha^{-1}), TSP (100 kg ha^{-1}), MP ($kgha^{-1}$), gypsum (60 kg ha^{-1}), zinc sulphate (10 kg ha^{-1}) and borax (10 kg ha^{-1}) respectively were applied. Entire amount of TSP, MP, gypsum, zinc sulphate and borax were applied during final preparation of plot land. Mixture of cowdung and compost ($10tha^{-1}$) was applied during 15 days before transplantation. Urea was applied in three equal installments at after recovery, tillering and before panicle initiation (BRRI, 2012).

Data collection: Data were collected on plant height, number of tillers/hill, leaf area index, dry matter/hill, effective tillers/hill, ineffective tillers/hill, panicle length, filled grains/panicle, unfilled grains/panicle, weight of 1000-grains, grain yield, straw yield, biological yield, harvest index, weed population/m^2 and weed dry matter/m^2. Leaf area index measured manually and final data calculated multiplying by a correction factor 0.75 as per Yoshida (1981). Collected plants including roots (after uprooting), leaves, grain and straw were oven dried at 70^0C for 72 hours then transferred into desiccator and allowed to cool down at room temperature, final weight was taken and converted into dry matter content/hill.

The biological yield was calculated using the following formula:

Biological yield = Grain yield + Straw yield

Harvest Index (HI) was calculated by following formula:

HI (%) = {Economic yield (grain weight) ÷ Biological yield (Total dry weight)} × 100

Statistical analysis: Collected data were statistically analyzed using IRRISTAT software to observe the significant difference among the treatments. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

III. Results and Discussion

Plant height and Leaf Area Index (LAI)

Plant height was not varied significantly among different plant spacing at different DAT (days after transplanting). However, tallest plant was found from S_3 (76.9 cm) while shortest from S_1 (75.2 cm) at 120 DAT (Figure 1a). Wider spacing of 40 × 40 cm found to have significant influence on growth parameters (Krishna *et al.*,2008). Plant height was found significant difference among sixteen varieties in SRI system (Tohiduzzaman, 2011).The closest spacing produced the shortest plant; it might be due to more competition for nutrient, moisture, space and light among the plants in closest spacing.

LAI of rice varied significantly among the different plant spacing as different DAT. Maximum LAI was found from S_5 (4.5) while minimum from S_4 (2.5) at 120 DAT (Fig. 1b). Significant difference among sixteen varieties in leaf area index was found in SRI system (Tohiduzzaman, 2011). The seedling density affects the plant growth due to its direct relation with plant population. The higher plant population increases competition among plants for nutrients, light and space, while lower population density causes inefficient use of natural resources and inputs (Lone *et al.*, 2010). The total dry weight of leaves, leaf area index (LAI) was decreased with increasing plant densities (Rad *et al.*, 1999).

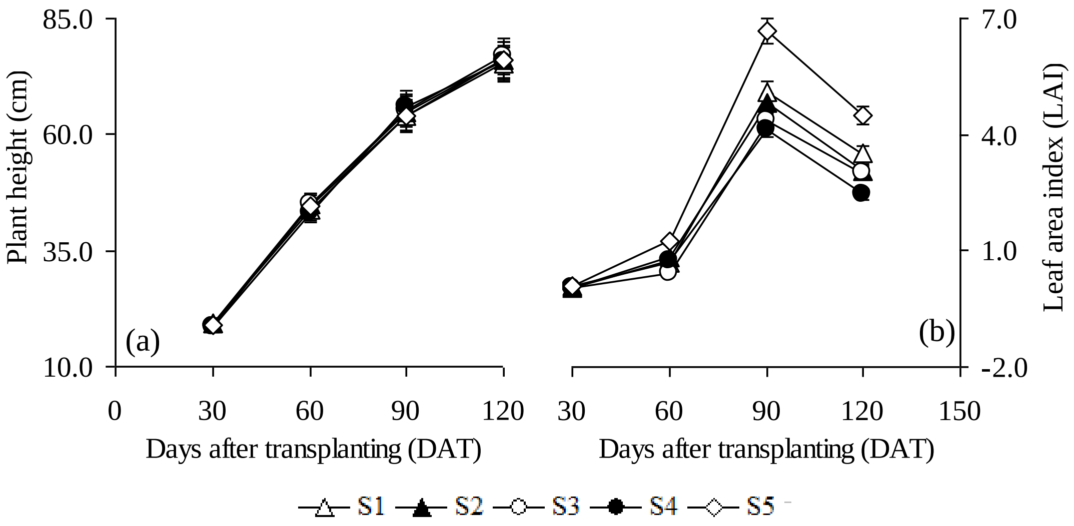

Figure 1. (a) Plant height and (b) Leaf Area Index of BRRI Dhan 50

Dry matter/hill and number of tillers/hill

Plant spacing showed a significant variation for dry matter/hill in rice. Maximum dry matter was found from S_4 (156.2 g/hill) while minimum from S_5 (44.6 g/hill) which was statistically identical with S_1 (50.8 g/hill) (Figure 2a). Significant difference among sixteen varieties was found for dry matter/hill in SRI system (Tohiduzzaman, 2011). Significantly higher dry matter accumulation was recorded in BI-43 with 30 cm × 30 cm spacing under direct seeding (Sridhara *et al.*, 2011). Process of dry matter accumulation in all planting densities has been presented in figure 4. With density increasing, plant number per area, leaf area and photosynthetic organs would be increased that causes improve in dry matter material. These findings are similar to Shekari (2001) results on millet.

Number of tiller/hill was varied significantly among the different plant spacing of rice. However, maximum number of tillers was found from S_4 (44.0/hill) followed by S_3 (40.7/hill) while minimum from S_5 (19.5/hill) (Figure 2b). Number of tillers and panicles per unit area were higher in closer spacing (Karmakar *et al.*, 2004). Significant difference was found for number of tillers among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011). Higher tiller numbers/plant was found to greater space (Balasubramaniyan and Palaniappan, 1991) due to increased levels of soil fertility, less competition among the plants also larger row spacing will promote production of healthier and more panicle bearing tillers. In contrast, with limited soil fertility, crowded plant population will produce lest panicle fertile tillers.

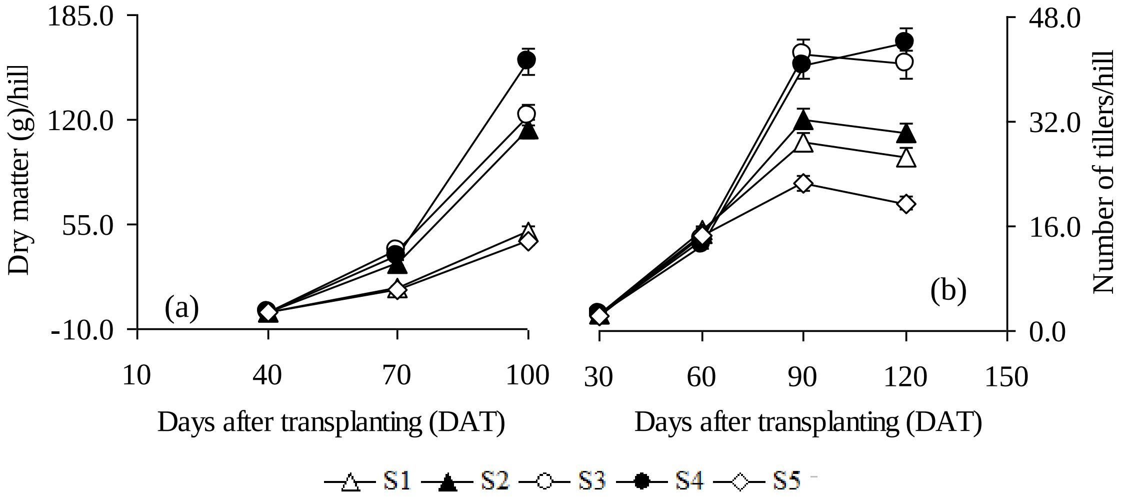

Figure 2. (a) Dry matter/hill and (b) Number of tiller/hill of BRRI Dhan 50

Number of effective tillers

Maximum number of effective tillers was found from S_4 (36.3/hill) while minimum from S_5 (18.3/hill) (Table 1). Significant difference was found for number of effective tillers among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011). In wider spacing plants absorbed more nutrient, moisture and light which resulted on more number of effective tillers hill-1. This result was agreement with that view of Miah *et al.* (1990).

Number of ineffective tillers

Minimum number of ineffective tillers was found from S_5 (1.7/hill) while maximum from S_4 (3.3/hill) (Table 1). Significant difference was found for number of ineffective tillers among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011).

Panicle length

Longest panicle was found from S_2 (23.4 cm) which was statistically identical with S_3 (23.1 cm) while minimum from S_5 (22.1 cm) (Table 1). Significant difference was found for panicle length among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011).

Number of filled grains

Maximum number of filled grain was found from S_4 (101.5/panicle) while minimum from S_1 (94.0/panicle) which was statistically identical with S_2 (94.7/panicle) (Table 1). Significant difference was found for filled grains numbers among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011). Veeramani (2011) reported significant higher number of filled grains/panicle at wider row spacing of 30 cm x 25 cm compared with closer pacing of 25 cm x 25 cm. Number of grains/panicle of rice varied significantly among different plant spacing (Awan *et al.*, 2006 and 2007)

Number of unfilled grains

Maximum number of unfilled grains was found from S_4 (26.5/panicle) which was statistically identical with S_3 (26.3/panicle) and S_1 (26.1/panicle) while minimum from S_2 and S_5 (24.8/panicle) (Table 1).

Significant difference was found for number of unfilled grains among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011).

1000-grain weight

Maximum 1000-grain weight was found from S_2 (19.0 g) which was statistically identical with S_4 (18.9 g) while minimum from S_1 (17.9 g) (Table 1). Significant difference was found for 1000-grain weight due to the variation of plant spacing (Tohiduzzaman, 2011; Awan*et al.*, 2011). When there are more spacing there will be more air, light and inputs availability and that may responsible for maximum 1000 grain weight. Increase in grain weight at higher nitrogen rates might be primarily due to increase in chlorophyll content of leaves which led to higher photosynthetic rate and ultimately plenty of photosynthates available during grain.

Table 1. Responses of different plant spacing on yield related attributes of BRRI Dhan 50[X]

Plant spacing	Number of effective tillers/hill	Number of ineffective tillers/hill	Panicle length (cm)	Number of filled grains/panicle	Number of unfilled grains/panicle	1000-grain weight (g)	Grain yield (t/ha)
S_1	21.1 cd	2.3 bc	22.7 b	94.0 d	26.1 a	17.9 c	4.8 b
S_2	24.8 c	2.7 ab	23.4 a	94.7 d	24.8 b	19.0 a	3.4 d
S_3	31.9 b	3.0 ab	23.1 a	96.1 c	26.3 a	18.3 b	4.1 c
S_4	36.3 a	3.3 a	22.9 b	101.5 a	26.5 a	18.9 a	6.9 a
S_5	18.3 d	1.7 c	22.1 c	98.9 b	24.8 b	18.1 c	5.2 b
LSD(0.05)	4.1	0.7	0.4	0.8	1.7	0.5	0.6
CV(%)	4.1	5.8	6.6	1.6	5.3	2.4	8.9

[X]In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

Grain yield

Maximum grain yield was from S_4 (6.9 t/ha) while minimum from S_3 (4.1 t/ha) (Table 1). Significant difference was found for grain yield among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011). SRI recommended wider spacing (25 cm × 25 cm to 30 cm × 30 cm) for higher yields (Batuwitage, 2000). Singh *et al.* (1983) studied the effect of row spacing in combination with nutrient supply on grain yield of semi-dwarf upland rice variety Narendra 1 (IET 2232) and found more grain yield with 20 cm spacing as compared to the others. The plant density at spacing of 20 x 20 cm^2 was more effective and gave significantly higher grain yield than 25 x 25 cm^2 and 15 x 15 cm^2 (Bari *et al.*, 1984).

Straw yield

Maximum straw yield was found from S_4 (5.9 t/ha) which was statistically identical with S_5 (5.5 t/ha) while minimum from S_2 (3.2 t/ha) (Table 2). Significant difference was found for straw yield among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011). Bozorgi*et al.* (2011) also found significant variation in straw yield of rice on different plant spacing of rice.

Biological yield

Maximum biological yield was found from S_4 (12.7 t/ha) followed by S5 (10.7 t/ha) while minimum from S_3 (8.3 t/ha) and S_1 (9.2 t/ha) (Table 2). Significant difference was found for biological yield among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011). Biological yield varied due to the variation of planting density (Bozorgi *et al.*, 2011).

Harvest index (HI)

Harvest index showed a non-significant variation among the different plant spacing. However, maximum HI was found from S_4 (54.5%) while minimum from S_5 (50.3%) (Table 2). Significant difference was found for harvest index among sixteen varieties due to the variation of plant height in SRI system (Tohiduzzaman, 2011). Bozorgi *et al.* (2011) also found significant variation in harvest index of rice on different plant spacing of rice.

Number of weed population

Maximum number of weed population was found from S_2 (61.3/m^2) which was statistically identical with S_5 (55.9/m^2) while minimum from S_4 (38.0/m^2) at 30 DAT (Table 2). On the other hand, maximum number of weed population was found from S_3 (84.3/m^2) while minimum from S_1 (65.8/m^2) (Table 2).

Weed dry matter

Weed dry matter showed a non-significant variation among the different plant spacing at 30 DAT and 60 DAT. Maximum weed dry matter was found from S_2 (2.8 g/m^2) while minimum from S_3 and S_4 (2.2 g/m^2) at 30 DAT. On the other hand, maximum weed dry matter was found from S_3 (3.6 g/m^2) while minimum from S_1 (3.0 g/m^2) (Table 2).

Table 2. Effect of plant spacing on different attributes of BRRI Dhan 50[X]

Plant spacing	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Number weed population m^{-2} at		Weed dry matter (g m^{-2}) at	
				30 DAT	60 DAT	30 DAT	60 DAT
S_1	4.4 bc	9.2 c	52.0 a	49.2 b	65.8 d	2.3 a	3.0 a
S_2	3.2 d	6.6 d	52.0 a	61.3 a	74.9 c	2.8 a	3.3 a
S_3	4.1 cd	8.3 c	51.2 a	48.6 b	84.3 a	2.2 a	3.6 a
S_4	5.9 a	12.7 a	54.5 a	38.0 c	78.0 b	2.2 a	3.2 a
S_5	5.5 ab	10.7 b	50.3 a	55.9 ab	74.6 c	2.5 a	3.1 a
LSD(0.05)	1.1	1.4	5.9	9.1	2.9	0.9	0.7
CV(%)	3.6	6.2	6.5	7.2	8.9	6.9	5.6

[X]In a column, means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability

IV. Conclusion

It can be concluded that 40 cm × 40 cm plant spacing is optimum for growth and maximum yield of rice under System of Rice Intensification (SRI). Growth and yield contributing characters such as maximum dry matter (156.2 g/hill), number of tiller (44.0/hill), number of effective tiller (36.3/hill), number of filled grains (101.5/panicle), grain yield (6.9 t/ha), straw yield (5.9 t/ha), biological yield (12.7 t/ha) and harvest index (54.5%) was found best from 40 x 40 cm plant spacing while minimum was observed from 25 x 25 cm of plant spacing.

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