Determination of ideal spacing for the growth and development of BRRI Dhan27

ABSTRACT

A study was carried out in the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, Bangladesh to investigate the impact of spacing on the growth and yield of Boro rice cv. BRRI dhan47. The experiment consisted of four spacings viz. 25 cm × 10 cm, 25 cm × 15 cm, 25 cm × 20 cm and 25 cm × 25 cm as treatment. The experiment was laid out in a randomized complete block design with three replications. Spacing significantly influenced most of the parameters except plant height, panicle length and weight of 1000 grain. The highest number of total tillers hill-1, non-effective tillers hill-1, sterile spikelets panicle-1, total spikelets panicle-1 (146.07) and straw yieldwere obtained from 25 cm × 25 cm spacing. But, the maximum number of effective tillers hill-1, grains panicle-1 (125.40), grain yield (5.05 t ha-1), biological yield (11.22 t ha-1) and harvest index (44.86%) were recorded from 25 cm × 15 cm spacing. The lowest value of the above-mentioned characters was obtained from 25 cm × 10 cm spacing in most of the cases except minimum non-effective tillers hill-1 and number of sterile spikelets panicle were obtained from 25 cm × 15 cm spacing and the lowest harvest index (41.14%) was recorded from 25 cm × 25 cm spacing. Based on the findings of the study, it can be suggested that the use of 25 cm × 15 cm spacing would be a promising practice to improve growth and maximize the grain yield of BRRI dhan47.

Keywords: Spacing, Growth, Yield, BRRI Dhan47

UNDER PEER REVIEW

INTRODUCTION

The increasing global population, especially in Asia and Africa, has made food security a critical concern. There is an urgent need to increase food production utilizing efficient and sustainable agricultural systems in order to feed the rapidly growing population [1]. Bangladesh's natural resources face substantial strain due to the country's dense population [2]. Rice, scientifically known as Oryza sativa, holds significant importance as a key dietary staple globally. According to [3] it is the second most extensively used commodity globally, following wheat. Agriculture is a crucial component of Bangladesh's economy, with a predominant focus on rice agriculture, which occupies over 75% of the arable area. The main agricultural activity centers around the cultivation of Boro and T. Aman rice. It constitutes 91.12% of the whole cereal production. The reported acreage for Aus, Aman, and Boro production is 1.16 million hectares, 5.72 million hectares, and 4.81 million hectares, respectively. The respective yields for these crops are 3 metric tons per hectare, 1.46 metric tons per hectare, and 2.02 metric tons per hectare [4]. Bangladesh's agriculture industry must address the escalating need for food resulting from population growth. [5]. In order to increase rice production, it is crucial to prioritize the development of high yielding varieties (HYV) that have a higher number of productive tillers per unit area. This can be accomplished through strategic spacing, prudent application of nutrients, effective water management, and appropriate plant protection measures.

Spacing is a crucial factor in increasing the output of rice crop, among other better agricultural practices. Proper plant spacing is a crucial aspect to consider while transplanting rice. Plant spacing has a significant impact on the production and yield components of rice. Farmers are employing variable plant spacing for Boro rice growth in field conditions. Some individuals employ a narrower spacing between plants, while others opt for a larger gap. Tighter spacing impedes intercultural operations. Ensuring smooth cross-cultural collaboration and effective herbicide application for weed management are important aspects of maintaining optimal spacing in crop production [6]. Proper planting geometry is crucial for achieving maximum light interception, average light consumption efficiency, and optimal light dispersion within the crop canopy. The yield of crops is indirectly influenced by these characteristics [7]. The planting density, as indicated by the distances between rows and individual plants, directly impacts the rice production. Moreover, grain yield may decrease in narrow spacing as compared to optimal spacing due to heightened competition for nutrients and moisture [8]. However, the effectiveness of crop production relies on the utilization of suitable and location-specific varieties. Furthermore, the implementation of enhanced cultural methods should also be considered. Planting spacing and variety are crucial factors [9], although not all genotypes thrive equally in the same planting space. The ideal distance for planting varies significantly depending on climatic circumstances, geographical places, soil types, and plant kinds [10]. Hence, it is imperative to ascertain the

UNDER PEER REVIEW

optimal spacing necessary for a particular variety. This study intended to determine the ideal spacing for the BRRIdhand 47 variety in order to enhance growth and maximum grain output, based on the information provided.

Materialsand Methods

The study was carried out at the Agronomy Field Laboratory of Bangladesh Agriculture University, Mymensingh. The objective was to investigate the impact of spacing on the production of Boro rice cv. BRRI dhan47. The experimental location is located inside the agro-ecological zone known as the old Brahmaputra Floodplain (AEZ 9), which is characterized by dark gray soil [11]. The experimental region exhibits a sub-tropical climate with substantial precipitation occurring from June to September and limited rainfall for the remainder of the year. The experiment included four different spacings, namely 25 cm × 10 cm, 25 cm × 15 cm, 25 cm × 20 cm, and 25 cm × 25 cm, which were used as treatment conditions. The BRRI dhan47 variety was utilized for this investigation. The cross between IR 51511-B-34-B and TCCP 266-2-49-BB-3 resulted in the development of this variety, which was done by the Bangladesh Rice Research Institute. BRRI Dhan47, a variety of Boro rice, was introduced in 2007. This particular cultivar has the ability to withstand salt levels of 12–14 ds/m during the seedling stage and 6 ds/m for the remainder of its lifespan. The BRRI dhan47 cultivar reaches maturity 150 days after being transplanted. The plant reaches a height of around 105 cm. The BRRI dhan47 variety had an average yield of 6.1 metric tons per hectare. The experiment was conducted using a randomized, complete block design with three replications. Each replication served as a distinct block in the experiment. The blocks were partitioned into plots of four units each, with the treatment combinations assigned randomly. In total, there were 12 plots consisting of 12 units each in the experiment. The dimensions of a unit plot were 2.0 meters by 2.5 meters, resulting in a total area of 5 square meters. The replications were spaced 1 meter apart, while the plots were spaced 0.75 meters apart. The crop in each treatment was cultivated using identical management procedures. A suitable plot of elevated terrain was chosen at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, for the purpose of cultivating rice seedlings. Subsequently, the germinated seeds were planted in the nursery beds. Undesirable plants were eliminated, and watering was provided in the seedling nursery as needed. The experimental plot was laid out immediately after completing the

UNDER PEER REVIEW

final land preparation, in accordance with the experimental specifications. The weeds and stubbles were removed from each individual plot, and then the plots were levelled so well using a wooden board that there was no water left in the puddled field. The experiment involved the application of full doses of chemical fertilizer, specifically triple superphosphate at a rate of 125 kg per hectare, muriate of potash at a rate of 100 kg per hectare, and gypsum at a rate of 55 kg per hectare. These fertilizers were applied at the final land preparation of each individual plot. Urea was treated at 120 kg N ha-1 in equal amounts at 15 and 45 days after transplanting as a top dressing. The seedlings were removed from the ground without causing any physical damage to the roots. Subsequently, the displaced young plants were relocated to the primary cultivation area. The various intercultural activities and plant protection measures were carried out as required. Prior to harvesting, a random selection of five hills was made from each plot. The harvest of each experimental plot was conducted individually when the crops reached full maturity. The crop plants were picked from the central 1 m2 region of each plot to collect data on grain and straw yields. The measurements include the height of the plant (in centimeters), the total number of tillers per hill, the number of effective tillers per hill, the number of non-effective tillers per hill, the length of the panicle (in centimeters), the total number of grains per panicle, and the number of sterile spikelets per panicle. Measurements were conducted as required for the weight of 1000 grains, grain yield, greatest straw yield, and biological yield (in metric tons per hectare). The combination of grain yield and straw yield was together referred to as biological yields. The biological yield was determined using the formula: Biological yield (t ha-1) = grain yield (t ha-1) + straw yield (t ha-1). It is the ratio of grain yield to biological yield and was calculated with the following formula:

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

The collected data were analyzed using the analysis of variance (ANOVA) technique. Mean differences were determined using Duncan's Multiple Range Test (DMRT) [12] (Gomez and Gomez, 1984) with the assistance of the STAR (Statistical Tool for Agricultural Research) data analysis program developed by the International Rice Research Institute (IRRI) in Los Baños, Philippines.

UNDER PEER REVIEW

Results and Discussion

The result of the study showed both the significant and insignificant variation among the studied characters (Table 1). The tallest plant (94.05), highest number of effective tillers hill^{-1} (8.85), topmost number of grains panicle^{-1} (125.40), maximum grain yield (5.05 t ha^{-1}), highest biological yield (11.22 t ha^{-1}), greater harvest index (44.86%) and highest harvest index recorded in 25 cm × 15 cm spacing. In opposite, the minimum number of non-effective tillers hill^{-1} (2.35), the lowest most (12.69) number of sterile spikelets panicle-1 was recorded from 25 cm × 15 cm spacing which is highly desirable. Moderately close spacing allows for more plants per unit area, resulting in higher yields per hectare. With more plants closely packed together, the available space is maximized, and more grains can be produced. The dense canopy formed by closely spaced rice plants shades the soil, suppressing weed growth. This reduces competition for nutrients, water, and sunlight, thereby enhancing the productivity of the rice crop. Lodging, or the bending or breaking of rice plants due to wind or rain, can significantly reduce yields. Close spacing promotes stronger stems and root systems, reducing the likelihood of lodging and ensuring better standability of the crop. In close spacing, rice plants compete more intensely for water and nutrients, leading to more efficient use of these resources. This can result in better water and nutrient management, ultimately improving crop health and productivity. Close spacing facilitates rapid canopy closure, where the rice plants' foliage forms a continuous canopy over the field. This canopy helps conserve soil moisture, suppress weeds, and create a microclimate conducive to optimal growth. close spacing in rice cultivation is important for maximizing yield, minimizing weed competition, reducing lodging, optimizing resource use, and promoting healthy crop growth.

On the other hand, he maximum number of non-effective tillers hill^{-1} (3.34), uppermost number of sterile spikelets panicle^{-1} (20.19), 1000-grain weight (26.13 g) and highest straw yield (6.40 t ha^{-1}) was obtained at 25 cm × 25 cm spacing. With wider spacing, there's more space between rice plants for weeds to grow. Weeds compete with rice plants for nutrients, water, and sunlight, reducing overall yield and quality. Rice plants grown with wider spacing might produce fewer grains per plant compared to those grown with optimal spacing. This can lead to lower overall yield per hectare. Sparse planting can make rice plants more susceptible to pest infestations and diseases. When plants are spaced too far apart, pests can easily move between them, and diseases can spread more rapidly. Wider spacing means fewer plants per unit area, resulting in underutilization of land. Additionally, more water may be required to irrigate the same area compared to denser planting, potentially leading to water wastage. Rice plants spaced too far apart may not efficiently utilize nutrients in the soil. This can lead to nutrient loss through leaching or runoff, reducing the fertility of the soil over time.

Besides, Insignificant variation was observed for panicle length, where the highest panicle length (24.04) was found at 25 cm × 20 cm spacing and the shortest panicle length (22.42) was from 25 cm × 10 cm spacing. In most of the cases the lowest value of the studied characters was recorded from 25 cm × 10 cm spacing (Table 1). Very close spacing can limits the access of individual plants to sunlight, water, and nutrients, leading to competition among them. This competition results in stunted growth and reduced tillering, ultimately lowering the overall yield of the crop. Additionally, inadequate spacing increases the risk of disease and pest infestation due to the lack of air circulation and increased humidity among closely packed plants.

[13, 14] reported that the highest grain yield, straw yield, biological yield and harvest index were obtained from the planting spacing of25 cm × 15 cm. Closer spacing covers maximum number of hills per unit area consequently produces maximum tillers [15, 16]. closer row spacing provided highest grain yield and straw yield which resulted in the highest biological yield [15, 17].

The study's findings suggest that using 25 cm× 15 cm plant spacing could be a promising practice to maximize the grain yield of BRRI dhan47.

UNDER PEER REVIEW

Table 1. Effect of different spacings on plant characters and yields of *Boro* rice cv. BRRI dhan47

Spacing	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	Total spikelets panicle^{-1} (no.)	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
S_1	90.61	9.77c	6.85b	2.92b	22.42	113.39c	15.41c	129.64b	25.99	4.38c	6.04b	10.43c	41.81c
S_2	94.05	11.20b	8.85a	2.35c	22.61	125.40a	12.69d	133.61b	26.13	5.05a	6.17b	11.22a	44.86a
S_3	93.45	11.71ab	8.78a	2.93b	24.04	122.74ab	17.97b	141.54a	26.04	4.67b	6.11b	10.78b	43.12b
S_4	93.39	12.09a	8.75a	3.34a	23.11	118.99b	20.19a	146.07a	26.27	4.54b	6.40a	10.94ab	41.14c
Level of significance	NS	**	**	**	NS	**	**	**	NS	**	*	**	**
$S\bar{x}$	0.93	0.20	0.17	0.08	0.59	1.52	0.28	1.62	0.17	0.05	0.07	0.12	0.29
CV (%)	6.47	6.26	7.10	9.94	8.86	5.38	5.90	4.08	2.26	6.07	6.20	5.77	3.38

In a column, the figures with similar letter (s) do not differ significantly whereas the figures with dissimilar letter (s) differ significantly (as per DMRT).

S_1 = 25 cm × 10 cm
S_2 =25 cm × 15 cm
S_3 = 25 cm × 20 cm
S_4 = 25 cm × 25 cm

* Significant at 5% level of probability

** Significant at 1% level of probability

NS = Not significant

UNDER PEER REVIEW

UNDER PEER REVIEW

REFERENCES

1. Islam SM, Gaihre YK, Islam MR, Ahmed MN, Akter M, Singh U, Sander BO. Mitigating greenhouse gas emissions from irrigated rice cultivation through improved fertilizer and water management. Journal of Environmental Management. 2022 Apr 1;307:114520.
2. Bari A, Promi RJ, Shumsun N, Hasan K, Hosen M, Demir C, Barutçular C, Islam MS. Response of Sulphur and Boron on Growth, Yield Traits and Yield of Boro Rice (BRRI dhan28) at High Ganges River Floodplain of Bangladesh. ISPEC Journal of Agricultural Sciences. 2023 Mar 26;7(1):158-72.
3. Rajamoorthy Y, Munusamy S. Rice industry in Malaysia: Challenges, policies and implications. Procedia Economics and Finance. 2015 Jan 1;31:861-7.
4. BBS (Bangladesh Bureau of Statistics) 2022: Yearbook of Agricultural Statistics of Bangladesh, Government of Bangladesh, Dhaka.
5. Rahman MT, Sarker UK, Kabiraj MS, Jha S, Rashid MH, Paul SK. Response of Boro Rice (cv. BRRI dhan89) Yield to Foliar Application of Micronutrients. Journal of Agroforestry and Environment. 2023;16(2):153-9.
6. Koireng RJ, Devi NM, Devi KP, Gogoi M, Anal PR. Effect of variety and spacing on the productivity of direct seeded rice (Oryza sativa L.) under Manipur condition. Indian Journal of Pure & Applied Biosciences. 2019;7(5):335-41.
7. Hussain I, Khan MA, Ahmad K. Effect of row spacing on the grain yield and the yield components of wheat (Triticum aestivum L.). Pakistan Journal of Agronomy (Pakistan). 2003;2(3).
8. Das TK, Yaduraju NT. Effects of missing-row sowing supplemented with row spacing and nitrogen on weed competition and growth and yield of wheat. Crop and Pasture Science. 2011 Jan 12;62(1):48-57.
9. Eissa AM, Shehab TM, Dawood AM. Row-spacing and seeding-rate effects on yield and yield components of spring wheat in Al-Qassim region, Saudi Arabia.
10. Darwinkel A, Ten Hag BA, Kuizenga J. Effect of sowing date and seed rate on crop development and grain production of winter wheat. Netherlands Journal of Agricultural Science. 1977 May 1;25(2):83-94.
11. FAO U. Land Resources Appraisal of Bangladesh for Agricultural Development Report No. 2. Agro-ecological Regions of Bangladesh. United Nations Development Programme and Food and Agricultural Organization., Rome., Italy. 1988:212-21.
12. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John wiley& sons; 1984 Feb 17.
13. Hasan MK, Hossain MD, Uddin MR, Kobir MS, Kabir MH. EFFECT OF PLANT× ROW SPACING ON TWO VARIETIES OF BORO RICE. SAARC Journal of Agriculture. 2021 Jul 1;19(2).

14. Sultana MR, Rahman MM, Rahman MH. Effect of row and hill spacing on the yield performance of boro rice (cv. BRRI dhan45) under aerobic system of cultivation. Journal of the Bangladesh Agricultural University. 2012;10(1):39-42.
15. Paul SK, Roy B, Hasan AK, Sarkar MA. Yield and yield components of short duration transplant Aus rice (cv. Parija) as influenced by plant spacing and nitrogen level. Fundamental and Applied Agriculture. 2017 May 1;2(2):233-6.
16. Verma AK, Pandey N, Tripathi S. Effect of transplanting spacing and number of seedlings on productive tillers, spikelet sterility, grain yield, and harvest index of hybrid rice.
17. Halder J, Rokon GM, Islam MA, Salahin N, Alam MK. Effect of planting density on yield and yield attributes of local aromatic rice varieties.2018. 489-497.

UNDER PEER REVIEW