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GROWTH AND YIELD OF NEW AROMATIC RICE UNDER DIFFERENT LEVELS OF PLANT SPACING AND APPLIED FERTILIZER

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ABSTRACT

A field experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur to assess growth and yield of newly released aromatic rice variety (cv. BUdhan 2) under different levels of plant spacing and applied fertilizer. The variety was grown incorporating three fertilizer levels viz. recommended (57-10-8-7-0.9 kg N-P-K-S-Zn ha^{-1}), 50% higher (114-20-16-14-1.8 kg N-P-K-S-Zn ha^{-1}) and 50% lower (28.5-5-4-3.5-0.45 kg N-P-K-S-Zn ha^{-1}) than the recommended dose with three plant spacings (20 × 25 cm, 20 × 20 cm and 20 × 15 cm) representing wider, standard and closer plant densities. Results revealed that growth parameters like plant height, leaf area index, dry matter production and crop growth rate were better under the condition of higher fertilizer level with closer plant spacing. Consequently, the highest grain yield (5.18 t ha^{-1}) of the variety was achieved under higher dose of fertilizer at closer plant spacing.

Keywords: Aromatic rice, plant spacing, fertilizer level, crop growth

Introduction

Rice (*Oryzia sativa* L.) plays an important role as a staple food in different parts of the world including Bangladesh. The average yield of rice in Bangladesh is however, much lower (4.20 t ha^{-1}) than the yield (6.56 t ha^{-1}) of other Asian countries like China, Japan and Korea (FAO 2012). The population in the country is increasing by two million every year and may increase by another 30 million in next 20 years when it will require about 27.26 million tons of rice (BRRI 2011). To feed the increasing population, rice production must be increased per unit area as rice-growing area is decreasing day by day. Yield of rice per unit area may be increased by optimizing plant density through plant spacing. Optimum plant spacing causes plants to grow properly which depends upon plant characteristics, growth duration, planting time and methods, soil fertility and other agronomic management (Bozorgi 2011). Moradpour *et al.* (2013) observed that grain yield of rice increased with increasing in plant density. In general, higher yield in closer spacing is found because of higher number of panicles per unit area while in wider spacing, higher grain yield achieved through better grain filling due to lesser competition among the plants for growth resources.

The fashion of response of yield to plant spacing is however dependent on level of fertilizer rates and degree of plant density. Ottis and Talbert (2005) explained the yield and density relationship of rice in different ways where rice yields decreased in some varieties with the increase of plant spacing while yields of other varieties not affected even at a density three times higher than those varieties. This indicated that each rice genotype has own compensation mechanism in production of effective tiller to support better grain yield. Another way to increase rice yield per unit area is the application of chemical fertilizer. Maximum yield of rice is achieved when adequate and timely supply of plant nutrients is provided. In Bangladesh, average use of chemical fertilizer in rice is 70-11-5-2 kg NPKS ha^{-1}, which is much lower than removal from soil (Islam *et al.* 1994). This fertilizer rate indicates that nitrogen applications tend to be high in relation to the amount of potassium and phosphate used. This is partly the result of lower price of urea and partly the lack of knowledge among farmers relating balanced fertilizer

application. This is not only wasteful, but also causes nitrate pollution with excessive nitrogen. (Mohaddesi *et al.* 2011). Therefore, application of optimum level of plant nutrients is essential to preserve soil productivity through possible all sources of organic, inorganic and biological components in an integrated fashion.

Integration of most important nutrients, viz. nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and zinc (Zn) are important to enhance the rice yield. To supply the required amount of nutrients to rice in time at a cheaper rate is of paramount importance. It is also equally significant for economic utilization of fertilizer in rice production. Acquaintance with the most common visual deficiency symptoms of nutrients in rice crop is too indispensable for proper fertilizer management. The efficiency of certain variety to utilize nutrients depends on several processes associated with the acquisition and utilization of nutrients, soil fertility status and the agronomic practices required for the crop (Belanger *et al.* 2000). However, information on effect of spacing and nutrient rate on growth and yield of new aromatic rice variety (BUdhan 2) is not sufficiently available. Therefore, the aim of the experiment was to optimize plant spacing and fertilizer rates for better growth and productivity of newly developed aromatic rice variety.

Materials and Methods

The experiment was conducted at the experimental field of Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, during Boro season of 2014-2015. The Aromatic rice variety BUdhan 2 was used as the test crop of the experiment. The experiment having two factors (plant spacing and fertilizer levels) was set up in a randomized complete block design with four replications. Three levels of spacing and three levels of fertilizer constituted the treatment variables. The spacing were wider (20 × 25 cm), standard (20 × 20 cm) and closer (20 × 15 cm). While fertilizer levels were higher (114-20-16-14-1.8 kg N-P-K-S-Zn ha^{-1}), recommended (57-10-8-7-0.9 kg N-P-K-S-Zn ha^{-1}) and lower (28.5-5-4-3.5-0.45 kg N-P-K-S-Zn ha^{-1}). Each plot size was 4 m long and 3 m wide. Distance between plot to plot and block to block was maintained as 1.0 m and 1.5 m respectively, for weeding and other intercultural operations. The field was irrigated during the whole growing period of the crop. Weeding was done manually and diazinon 60 EC was sprayed to control rice stem borer. Data on plant height, leaf area index, dry matter accumulation, crop growth rate, yield contributing characters (panicles number, grain per panicle, thousand grain weight) and grain yield were recorded. All the data of different parameters were analyzed by analysis of variance. Microsoft Excel and STAT 10 software program were used whenever appropriate to perform statistical analysis. Duncan's Multiple Range Test was used to compare means at 0.05 level of significance.

Results and Discussion

In general, height of the rice plant increased with the advancement of time, although it was influenced by applied fertilizer and plant spacing (Figure 1). When the crop was fertilized with higher dose of fertilizer at closer spacing, it showed the tallest plant (98.47 cm) at the time of maturity. Increase in plant height under higher fertilizer dose and closer spacing also reported in other cereal (Tajul *et al.* 2013).

$F_1 S_1$: Higher fertilizer with wider spacing; $F_1 S_2$: Higher fertilizer with standard spacing; $F_1 S_3$: Higher fertilizer with closer spacing; $F_2 S_1$: Recommended fertilizer with wider spacing; $F_2 S_2$: Recommended fertilizer with standard spacing; $F_2 S_3$: Recommended fertilizer with closer spacing; $F_3 S_1$: Lower fertilizer with wider spacing; $F_3 S_2$: Lower fertilizer with standard spacing; $F_3 S_3$: Lower fertilizer with closer spacing.

The highest leaf area index (3.18) was observed at higher dose of applied fertilizer and wider plant spacing at panicle initiation stage of the variety (Figure 2). While, the lowest leaf area index (1.47) was recorded from lower applied fertilizer and closer plant spacing at same growing stage of the crop. In higher fertilizer level, there was positive effect of nutrients on leaf and tiller development and increased in leaves photosynthetic activity durability (Fageria 2008). Higher amount of nitrogen at higher fertilizer dose enhanced gibberellin production, which increased growth of young leaves and leaf area index of the variety (Azarpour *et al.* 2014).

$F_1 S_1$: Higher fertilizer with wider spacing; $F_1 S_2$: Higher fertilizer with standard spacing; $F_1 S_3$: Higher fertilizer with closer spacing; $F_2 S_1$: Recommended fertilizer

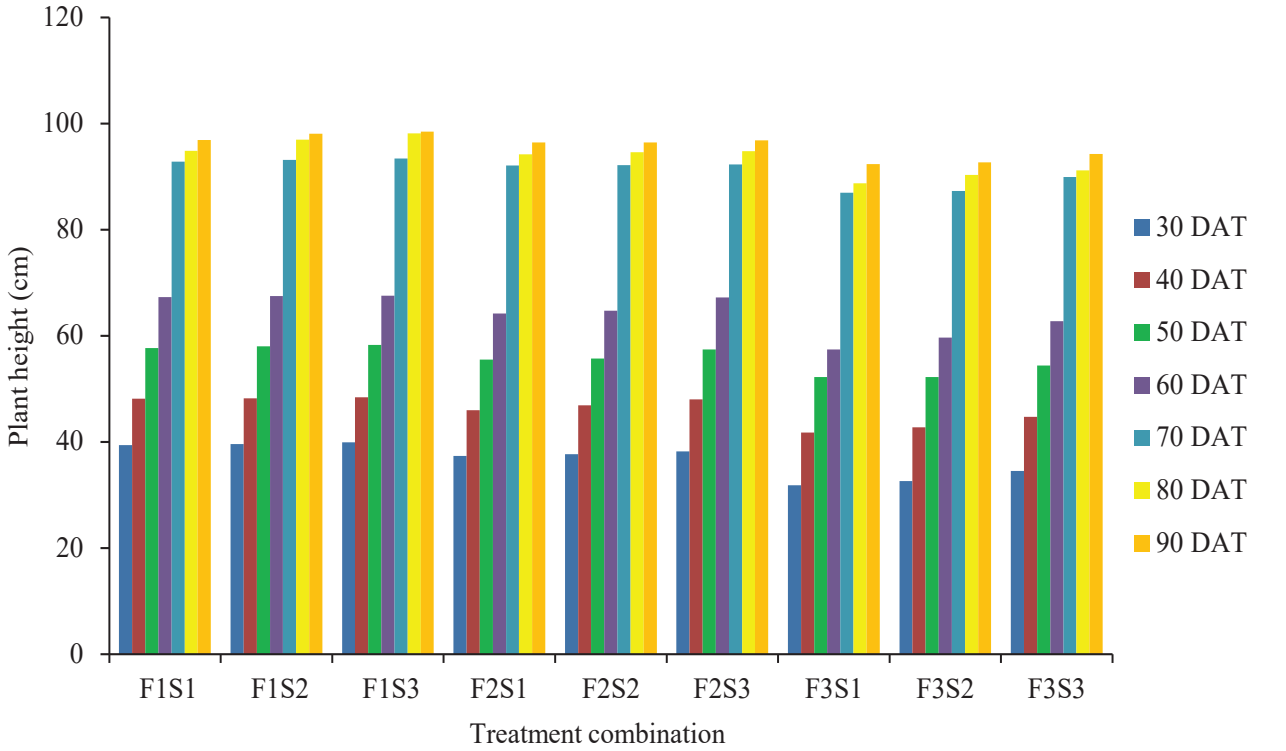


Figure 1. Interaction effect of the fertilizer level and plant spacing on plant height of new aromatic rice variety.

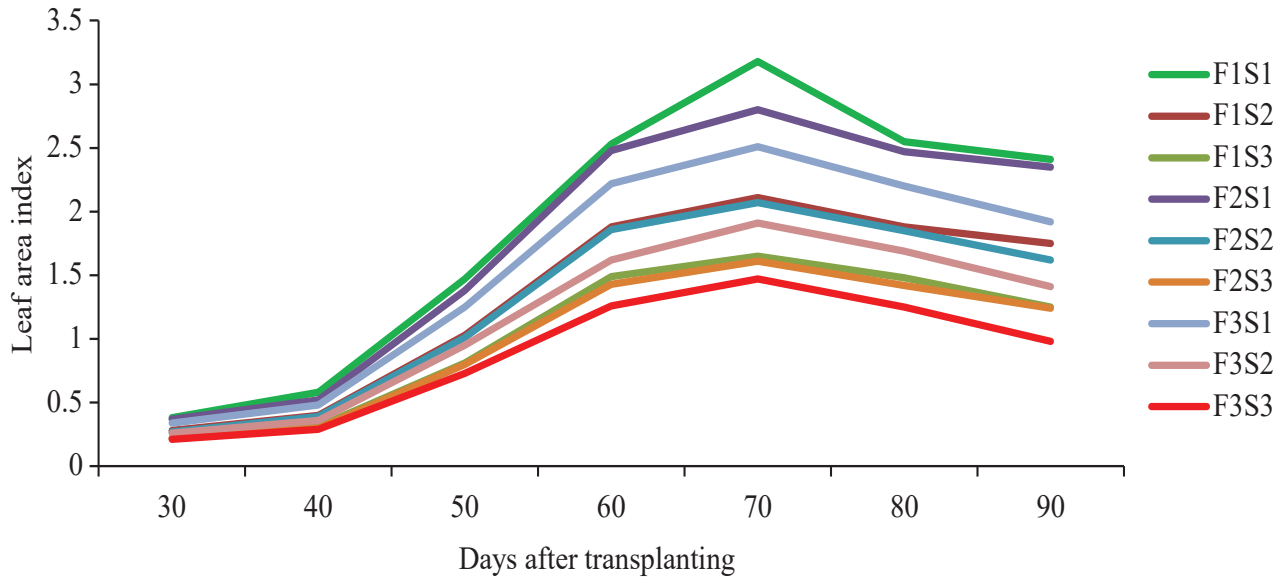


Figure 2. Leaf area index of new aromatic rice BU Dhan2 variety under variable fertilizer dose and plant spacing.

with wider spacing; $F_2 S_2$: Recommended fertilizer with standard spacing; $F_2 S_3$: Recommended fertilizer with closer spacing; $F_3 S_1$: Lower fertilizer with wider spacing; $F_3 S_2$: Lower fertilizer with standard spacing; $F_3 S_3$: Lower fertilizer with closer spacing.

The highest dry matter (1384.57 g m^{-2}) was produced from higher dose of fertilizer with closer spacing of the variety at maturity stage (Figure 3). Fertilizer induced maximum growth with higher rates of fertilizer and was supported the findings of Zang *et al.* (2009). The lowest dry matter (638.13 g m^{-2}) was observed from lower dose of fertilizer at wider spacing at same stage of the crop. Closer spacing and higher fertilizer rates increased dry matter because of the increasing number of tillers per unit area of land. Increase in dry matter at higher fertilizer levels and closer spacing emphasizes that higher amount of fertilizer is necessary for the variety for higher dry matter production. It sounds that higher level of fertilizer under closer spacing causes more increment in total dry matter accumulation in rice (Wenxue *et al.* 2014).

$F_1 S_1$: Higher fertilizer with wider spacing; $F_1 S_2$: Higher fertilizer with standard spacing; $F_1 S_3$: Higher fertilizer with closer spacing; $F_2 S_1$: Recommended fertilizer with wider spacing; $F_2 S_2$: Recommended fertilizer with standard spacing; $F_2 S_3$: Recommended fertilizer with closer spacing; $F_3 S_1$: Lower fertilizer with wider spacing; $F_3 S_2$: Lower fertilizer with standard spacing; $F_3 S_3$: Lower fertilizer with closer spacing.

Considering crop growth rate, it was observed that increase in leaf area index over time, crop growth rate was also raised until flowering stage and then declined (Figure 4). Islam and Bhuiya (2007) explained that sharp declined of leaf area with leaf senescence might be the cause of declining of crop growth rate in post flowering stage of the variety. At panicle initiation stage, the highest (31.32 g $m^{-2}d^{-1}$) crop growth rate was observed, when the crop was fertilized with higher dose at closer spacing. Contrary, the lowest (23.55 g $m^{-2}d^{-1}$) crop growth rate was recorded when the crop was fertilized with lower dose at wider spacing.

$F_1 S_1$: Higher fertilizer with wider spacing; $F_1 S_2$: Higher fertilizer with standard spacing; $F_1 S_3$: Higher fertilizer with closer spacing; $F_2 S_1$: Recommended fertilizer with wider spacing; $F_2 S_2$: Recommended fertilizer with standard spacing; $F_2 S_3$: Recommended fertilizer with closer spacing; $F_3 S_1$: Lower fertilizer with wider spacing; $F_3 S_2$: Lower fertilizer with standard spacing; $F_3 S_3$: Lower fertilizer with closer spacing.

Results of yield components of the variety showed that the highest number of panicles (244.65 m^{-2}) was observed from higher dose of fertilizer with closely plant spacing. It is expected that densely populated plants produced higher number of panicles per hill because of drawing higher amount of nutrition and absorbed more solar radiation for better photosynthetic process (Mohaddesi *et al.* 2011). The highest number of grains per panicle (126.9) was

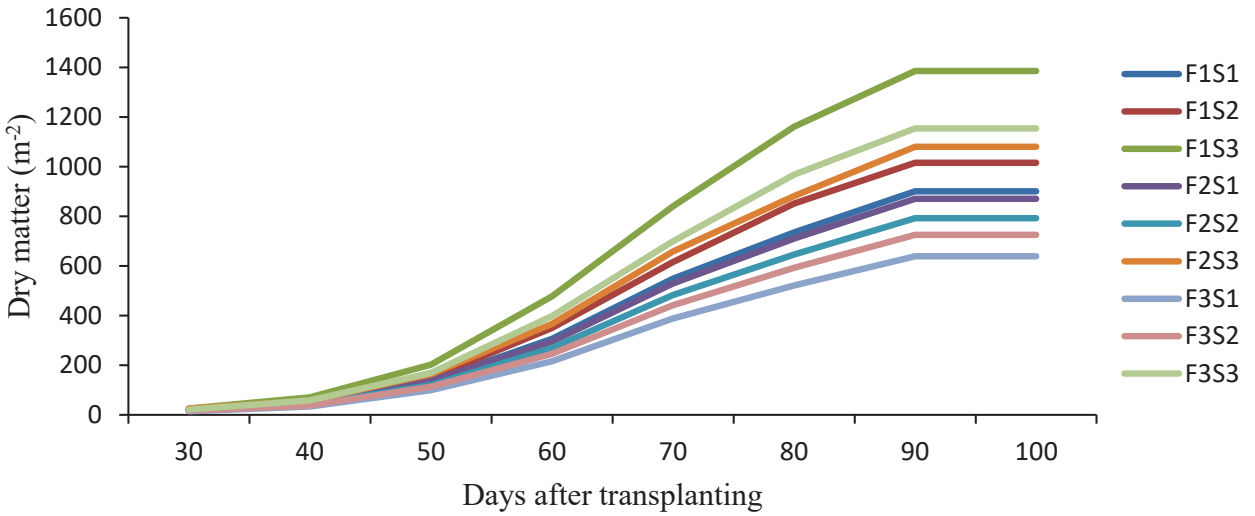


Figure 3. Interaction effects of fertilizer level and plant spacing on dry matter accumulation of new aromatic rice variety, BU Dhan2.

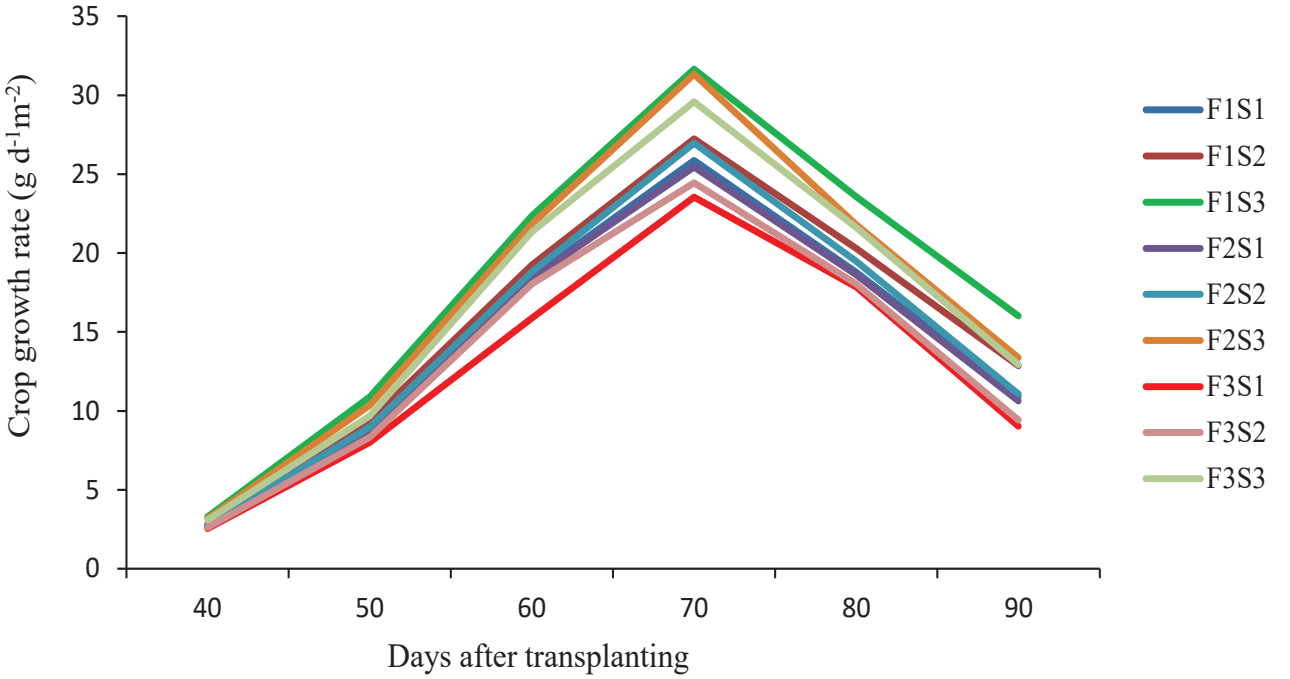


Figure 4. Crop growth rate of new aromatic rice variety, BU Dhan2 under the interaction effect of fertilizer dose and plant spacing.

Table 1. Interaction effect of fertilizer and plant spacing on yield components of new aromatic rice variety BU Dhan2

Fertilizer level (N-P-K-S-Zn kg ha^{-1})	Spacing (cm)	Panicle per sq. m	Grain per panicle	Filled grain per panicle	1000 grain wt (g)
Higher dose (114-20-16-14-1.8)	Wider (20 × 25)	170.59 de	126.9 a	91.89 a	25.95 a
	Standard (20 × 20)	196.68 cd	115.88 ab	88.86 a	25.87 ab
	Closer (20 × 15)	244.65 a	108.53 abc	82.16 a	25.78 b
Recommended dose (57-10-8-7-0.9)	Wider (20 × 25)	162.6 e	101.42 abc	85.8 a	25.62 c
	Standard (20 × 20)	180.11de	98.73 bc	82.93 a	25.55 cd
	Closer (20 × 15)	231.97 ab	94.56 bc	80.06 a	25.46 d
Lower dose (28.5-5-4-3.5-0.45)	Wider (20 × 25)	155.29 e	93.09 bc	84.4 a	25.29 e
	Standard (20 × 20)	172.8 de	84.52 c	81.4 a	25.15 f
	Closer (20 × 15)	215.27 bc	81.09 c	79.2 a	25.05 f

Means in a column followed by same letter (s) did not differ significantly by DMRT at 0.05 level.

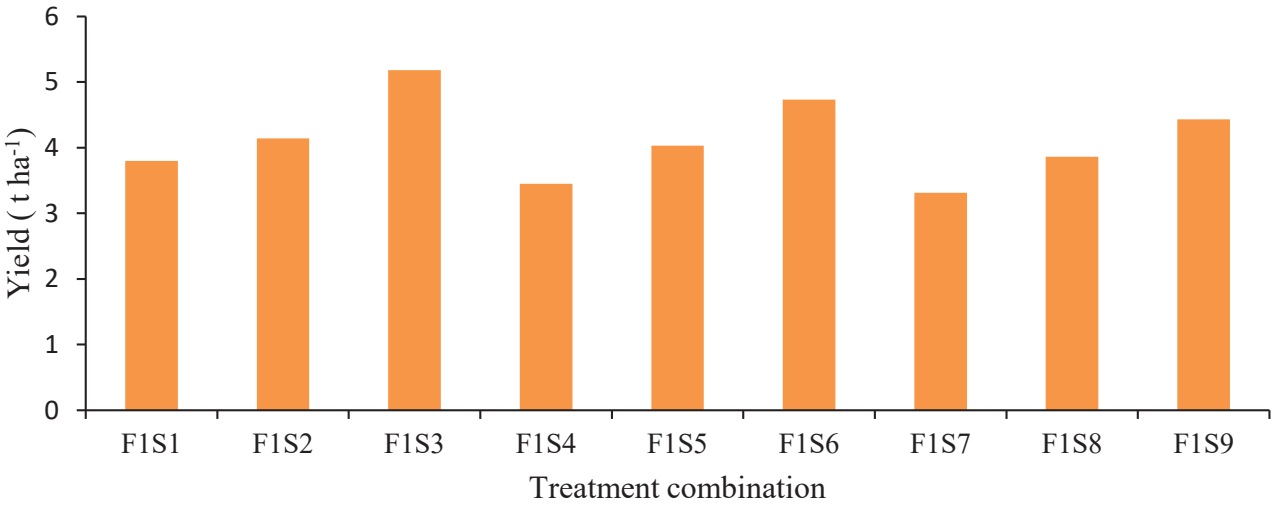


Figure 5. Grain yield of new aromatic rice variety, BU Dhan2 as influenced by variable fertilizer dose and plant spacing.

observed when the crop was fertilized with higher dose and wider spacing and the lowest number of grains per panicle (81.09) was recorded at lower fertilizer dose and closer plant spacing. This result was in accord with the findings of Fukushima (2010) who found higher number of grains per panicle under higher fertilizer dose and closer spacing. Maximum thousand grain weight (25.95 g) of the variety was recorded from the higher dose of fertilizer with wider spacing and minimum thousand grain weight (25.05 g) was found under lower dose of fertilizer with closer spacing.

The highest grain yield (5.18 t ha^{-1}) of the variety was observed from higher dose of fertilizer at closer spacing and the lowest grain yield (3.31 t ha^{-1}) was found under lower dose of fertilizer at wider spacing (Figure 5). The variation of yield of this new aromatic rice variety BUdhan 2 was found mostly due to variation in panicle per unit area. In this regard, Uddin, *et al.* (2013) also observed maximum grain yield of rice at higher fertilizer dose and closer plant spacing of rice. Similarly, (Lampayan *et al.* (2010) reported that with the increasing of fertilizer level grain yield of rice increased considerably to a certain extent. While, Bari *et al.* (1984) observed that grain yield is depended evidently on the performance of individual plants, panicle density as well as total number of plants grown on that area which is determined mostly by plant spacing and fertilizer level.

$F_1 S_1$: Higher fertilizer with wider spacing; $F_1 S_2$: Higher fertilizer with standard spacing; $F_1 S_3$: Higher fertilizer with closer spacing; $F_2 S_1$: Recommended fertilizer with wider spacing; $F_2 S_2$: Recommended fertilizer with standard spacing; $F_2 S_3$: Recommended fertilizer with closer spacing; $F_3 S_1$: Lower fertilizer with wider spacing; $F_3 S_2$: Lower fertilizer with standard spacing; $F_3 S_3$: Lower fertilizer with closer spacing.

Conclusion

It may be concluded from the results of this study that growth and grain yield of new aromatic rice variety (BUdhan 2) was significantly influenced by applied fertilizer and plant spacing. The new variety grown with higher dose of fertilizer (114-20-16-14-1.8 kg N P K S Zn ha^{-1}) at closer spacing (20 cm × 15 cm) produced the highest dry matter, panicle number per unit area and number of grains per panicle, which eventually contributed to produce the highest grain yield of the variety.

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