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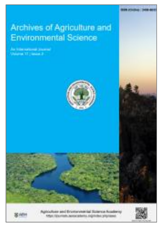

Original Research Article

Evaluation of two white maize varieties under varying planting spacing in Teesta River Basin, Rangpur, Bangladesh

Md. Mahirul Islam Biswas[1,*], Md. Jafar Ullah[2], Sahida Easmin[3], Hasina Begum[1] and Lutfunnaher Laila[1]

[1] Department of Agriculture, Faculty of Agriculture, City University, Savar, Dhaka-1340, Bangladesh
[2] Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh
[3] School of Agriculture, National Institute of Youth Development, Savar, Dhaka, Bangladesh
[*] Corresponding author's E-mail: mahirul71@gmail.com

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ABSTRACT

This study investigated the effects of plantation spacing on maize growth, yield and yield attributes of two white maize varieties *viz.*, V_1(PSC-121) and V_2 (KS- 510) and three planting spacing *viz.*, 50 cm × 25 cm, 60 cm × 25 cm and 70 cm × 25 cm. The taller plant (230 cm), longer cob (16.75 cm), maximum number of rows cob^{-1}(12.90), number of grains row^{-1} (28.47), number of total grains cob^{-1}(369.96), 100-grains weight (26.20 g), grain yield (6.66 t ha^{-1}), stover weight (9.15 t ha^{-1}), biological yield (15.81 t ha^{-1}) and harvest index (42.20 %) were recorded in variety PSC-121 compared to variety KS-510. The longest cob (16.68 cm), highest number of grains cob^{-1}(379.20) and highest 100-grain weight (27.05 g) ware observed in the planting spacing of 70 cm × 25 cm but showed the lowest grain yield (5.81 t ha^{-1}), stover yield (7.88 t ha^{-1}) and biological yield (13.69 t ha^{-1}). In contrasts, planting spacing 50 cm × 25 cm resulted the highest grain yield (7.07 t ha^{-1}), stover yield (10.21 t ha^{-1}) and biological yield (17.28 t ha^{-1}). In regard to interaction effect of variety and spacing, highest grain yield (7.37 t ha^{-1}), maximum stover yield (10.40 t ha^{-1}) and biological yield (17.77 t ha^{-1}) were found at the planting spacing 50 cm × 25 cm with variety PSC-121. The lowest values of these parameters were recorded in the widest planting spacing (70 cm × 25 cm) with variety KS-510. Therefore, the optimal planting spacing 50 cm × 25 cm and variety PSC-121 produced highest grain yield 7.37 t ha^{-1} in sandy soil.

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INTRODUCTION

Maize (*Zea mays* L.) has become the third most important cereal crop in the world because of its high adaptability and productivity (Mosisa *et al.*, 2002). Globally maize is grown under diverse climatic conditions but yields best under moderate temperatures with sufficient water (Aldrich *et al.*, 1978). Maize has a higher carbohydrate production potential per unit land than other cereals and was the first major cereal to undergo rapid and widespread technological transformation in its cultivation (Palwal, 2000). In developed countries, maize is grown mainly for animal feed and as raw materials for industrial products, such as starch, glucose, and dextrose and bio fuel. Its grain contains 72% starch, 10% protein, and 4% fat, supplying an energy density of 365 Kcal/100g (Nuss & Tanumihardjo, 2010). Therefore, maize occupies an important position next to rice and wheat in Bangladesh. At present its area under cultivation accounts near about 963000 acres (BBS, 2017) with a projected production of 3.025 million metric tons a year almost the sole of which is used as livestock or poultry feed (BBS, 2017). Bangladesh produces food grains of nearly 38.332 million tons annually from rice and wheat which is enough for its 160 millions of people (BBS, 2015). However, due to the increased population of Bangladesh it is speculated that the current yield productivity of rice and wheat once upon a time may not be able to cope with the increased food demand leaving an uncertainty in sustaining food security. Being C_3 in genetic nature these two crops have lower yield productivity compared to maize which is a C_4 crop having two to three fold more compared to rice and wheat. With the growing population and rising income, demand of food is on the increase in one hand, and shrinking of agricultural land due to urbanization, industrialization and infrastructure development on the other hand. Therefore, growing food keeping pace with the demand faces unprecedented challenges (Dass *et al*., 2012) while raising the yield and production of rice remains questionable (Chen *et al*., 2014). It is against this backdrop, introduction of white maize in Bangladesh as human food can be a viable alternative for sustaining food security given the productivity of maize much higher than rice and wheat (Ray *et al*., 2014).

Optimum planting spacing should be maintained to exploit natural resources, such as nutrients, sunlight and soil water fully to ensure satisfactory yields. Many studies were conducted with the aim of determining the optimum plant density for maize. There is no single recommendation for all conditions, because the optimum plant density varies depending on environmental factors such as soil fertility, water supply, crop management and genotype (Gonzalo *et al*., 2006). Hence, cultural practices such as row spacing and plant density, collectively known as spatial variation could influence water use efficiency. For each production system, there is a plant density that optimizes the use of available resources, allowing the expression of maximum attainable grain yield in that environment. Generally, irrigation farmers use a 0.915 m row spacing with plant densities that varies from 75, 000 to 95, 000 plant per hectare. As the planting configuration interacts with nutrient and water supply (FAO, 2015) this aspect is also needed to evaluate. Cox (1997); Widdicombe & Thelen (2002); Stranger & Lauer (2006) indicated that there is a need to regularly monitor the response of maize grain yield to plant density for new hybrids to maintain accurate recommendations for growth. Therefore, row spacing and plant density guidelines to maximize attainable potential yield of an ultra-fast maize hybrid have to be developed for specific conditions. This study was carried out for the evaluation of two white maize varieties under varying planting spacing in Teesta River Basin, Rangpur, Bangladesh.

MATERIALS AND METHODS

Description of study area

The experimental site was situated in Rangpur, Bangladesh. The study was conducted in the rabi season or winter season. In Bangladesh, the winter season's (rabi) temperature is generally low and there is a plenty of sunshine. The temperature tends to increase from February as the season proceeds towards summer season. Rainfall seldom occurs during winter in the period from November to January and scanty in February to March (Figure 1). The rainfall of Rangpur was 12, 0, 152, 20, 313, 451 and 707 millimeters respectively in the months of January, February, March, April, May, June and July of 2016.

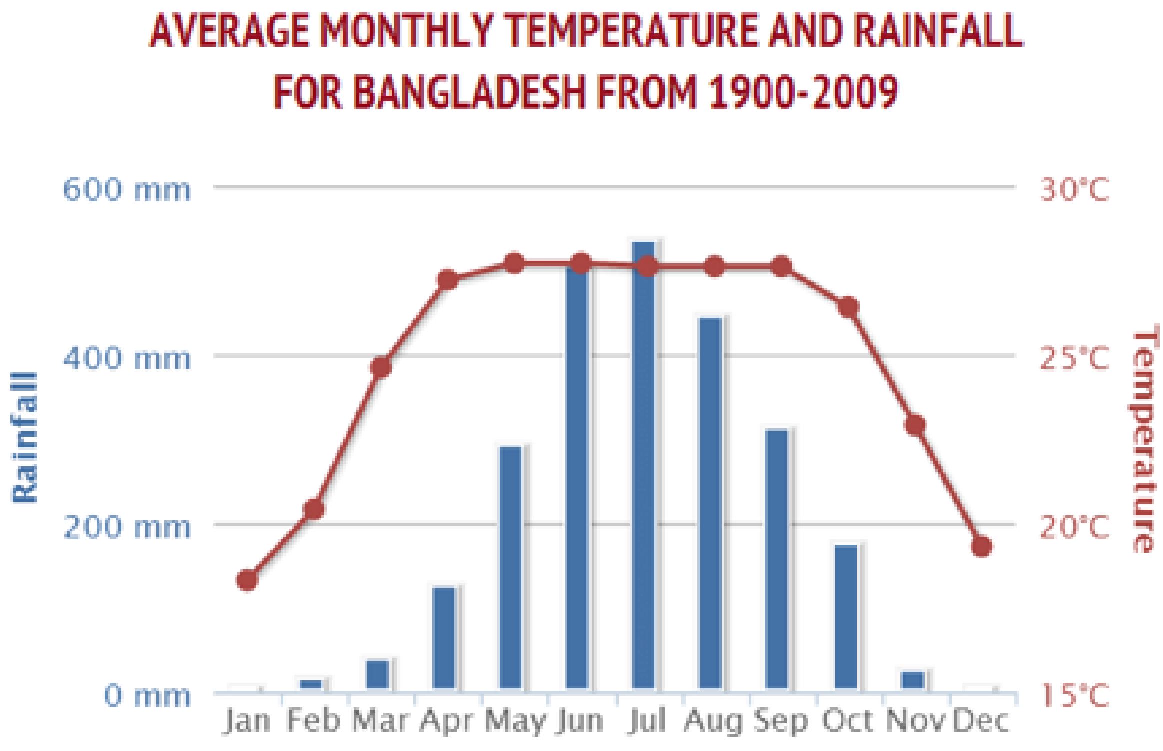

Figure 1. *Average monthly temperature and rainfall for Bangladesh from 1900-2009.*

Experimental details

The seeds were collected from Indian seed company. Two white maize varieties were used as planting materials viz. PSC-121and KS-510. The experiment incorporated two varieties, namely V1 (PSC-121) and V2 (KS-510), and three planting spacing labeled as S1 (50 cm × 25 cm), S2 (60 cm × 25 cm), and S3 (70 cm × 25 cm), treated as experimental factors to explore their interactions. Employing a factorial Randomized Complete Block Design (RCBD) with three replications, the experimental area was divided into three blocks, each subdivided into six plots. Each unit plot, measuring 6.0 m^2 (3 m × 2 m), had an 80 cm border between adjacent plots and a 1 m gap between adjacent replications or blocks, resulting in a total of 18 unit plots. Fertilizer management adhered to the BARI guideline of 2014.

Preparation of land, seed sowing and raising crops

The land was prepared with power tiller ploughed for 3 times until it got the desirable tilth condition. Then the plots were prepared according to the design of the treatments. The plots were fertilized with Urea, TSP (Triple super phosphate), MOP (Muriate of potash), Gypsum, Zinc sulphate (ZnSO4) and Boric acid at the rate of 550 kg/ha, 250 kg/ha, 220, 220, 12.5 and 6 kg/ha respectively. The total amount of TSP, MoP, Gypsum, ZnSO4, Boric acid and 1/3rd of urea were broadcasted and incorporated in a plot at final land preparation. The rest of the urea were top dressed in 2 installments: at 8-10 leaf stage (30-35 DAS) and pre tasselling stage (60-70 DAS) (BARI, 2014). Cow dung was also applied @ 5 ton/ha at the time of final land preparation. Seeds were sown on 24 November, 2016 maintaining spacing as per treatments. One seed was sown in each hill. Weeding was done at 25 DAS while earthing-up was done at 40- 45 DAS. The crop was irrigated four times at 30, 50, 70 and 90 DAS.

Data collection

In the study, data for growth and growth-indicating parameter was collected by measuring plant height at harvest using a measuring tape from the soil surface to the highest tip of the tassel. Phenological parameters, including days to 50% tasseling, days to 50% silking, and days to maturity, were recorded through visual observation. Yield and yield-contributing parameters involved measuring cob length without husk and cob diameter at the middle of each cob from ten randomly selected plants, determining the number of rows per cob and the number of grains per row on ten cobs, calculating total grains per cob, and assessing the 100-grains weight from three samples. Grain yield was determined by harvesting ten plants, Biological yield, defined as the sum of grain yield and stover yield was measured for each plant and expressed in tons per hectare. Randomly, removing cobs, separating kernels, oven-drying, and expressing the weight as grams per plant, later converted to tons per hectare. Stover yield was determined similarly, and biological yield, the sum of grain yield and stover yield, was expressed in tons per hectare. The harvest index was computed as the ratio of grain yield to the total above-ground dry matter yield, presented as a percentage.

Statistical analysis of data

Information pertaining to growth, phenology, yield, and related characteristics was compiled and organized in Microsoft Excel. The gathered data underwent statistical analysis through the MSTAT-C computer package. To assess mean differences among the treatments, the Least Significant Difference (LSD) technique, as outlined by Gomez & Gomez (1984) was applied at a 5% significance level.

RESULTS AND DISCUSSION

Plant height

Plant height was significantly influenced by the varieties. V_1 (230.94 cm) showed the longest plants followed by V_2 (196.88 cm), which was also the shortest (Table 1). Considering spacing, plant height was also significantly influenced by the plant spacing. Among the two spacing treatments, S_3 revealed the tallest plant (221.46 cm) followed by S_2 (212.96 cm), whereas S_1 produced the shortest plant (206.25cm) (Table 2). Their combination was significant effect on plant height. Among the observed treatments, V_1S_3 showed the tallest plant (236.92 cm) which was statistically similar to V_1S_2 (230.92 cm). However, V_2S_1 (187.50 cm) revealed the smallest plants which was statistically similar to V_2S_2 (194.50 cm). Likewise, V_1S_1 had longer plant (225.00 cm) than that of V_2S_3 (205.75 cm) (Table 3). Similar result was also reported by Chayanont *et al.* (2021) where they noticed that higher plant height was recorded in higher spacing and lower plant height was found in lower plant spacing in maize.

Table 1. Effect of variety on crop characters and yield contributing characters of white maize.

Treatments	Plant height (cm)	Days to 50 % tasselling	Days to 50 % Silking	Days to maturity	Cob length (cm)	Rows cob^{-1} (no)	Grains row^{-1} (no)	Grains cob^{-1} (no)	100-grain weight (g)
V_1	230.94 a	79.78 b	82.11 b	138.78 b	16.75 a	12.901 a	28.48 a	369.96 a	26.20 a
V_2	196.08 b	87.78 a	89.78 a	145.56 a	15.81 b	12.687 b	26.33 b	349.64 b	24.26 b
LSD (0.05)	5.04	0.85	0.46	0.64	0.44	1.56	2.11	3.31	1.77
CV (%)	7.77	4.31	3.2	5.44	1.12	0.77	5.20	11.41	2.20

In a column figures with same letters do not differ significantly whereas figures with dissimilar letters differ significantly (as per DMRT).

Table 2. Effect of planting spacing on crop characters and yield contributing characters of white maize

Treatments	Plant height (cm)	Days to 50 % tasselling	Days to 50 % Silking	Days to maturity	Cob length (cm)	Rows cob^{-1} (no)	Grains row^{-1} (no)	Grains cob^{-1} (no)	100-grain weight (g)
S_1	206.25 c	83.33b	85. 88b	145.33 b	15.78 b	12.57 b	25.78 c	340.69 b	23.44 b
S_2	212.96 b	83.33ab	85.89ab	145.33ab	16.38 a	12.85 a	27.21 ab	359.50 a	25.20 a
S_3	221.46 a	84.50 a	86.17 a	146.00 a	16.68 a	12.97 a	29.20 a	379.20 a	27.06 a
LSD (0.05)	1.57	0.93	0.80	0.70	0.88	0.47	0.56	2.33	1.17
CV (%)	2.22	3.17	4.69	5.23	2.14	1.67	3.22	6.56	2.34
Level of significance		NS	NS	NS					

In a column figures with same letters do not differ significantly whereas figures with dissimilar letters differ significantly (as per DMRT), NS= Non-significance

Days to 50% tasseling

Days to tasseling significantly influenced by the varieties, and their combinations but did not influence by the plant spacing treatments and the result was represented in Tables 1, 2, 3. For individual treatments V_2 (87.67 days) took significantly the maximum days to tasseling. On the other hand, V_1 (79.67 days) showed significantly the lowest days to tasseling. For various plant spacing treatments, S_3 showed the highest days to tasseling. (84.00 days), whereas S_1 (83.67 days) and S_2 (83.67 days) took the minimum days to tasseling. Simachew (2020) reported that the effect of inter and intra-row spacing did not significantly effect on tasseling period of maize.

Days to 50% silking

Days to silking also significantly influenced by the varieties, and their combinations but did not influence by the plant spacing treatments and the result was represented in Tables 1, 2, 3. For individual treatments V_2 (89.778 days) took significantly the maximum days to silking. On the other hand, V_1 (82.11 days) showed the lowest days to silking. For various plant spacing treatments, S_3 showed the highest days to silking. (86.17 days), which was statistically alike to whereas S_1 (85.89 days) and S_2 (85.88 days) took the minimum days to silking. Among the combination treatments, V_2S_3 (90.00 days) showed the significantly highest days to silking which was statistically similar with V_2S_2 (89.67 days) and V_2S_1 (89.67 days). Whereas V_1S_1 performed the lowest (82.00). Simachew (2020) also reported that the effect of inter and intra-row spacing did not significantly effect on silking period of maize.

Days to maturity

Days to maturity was significantly influenced by the varieties, and their combinations but plant spacing treatments did not influence and the result has been represented in Tables 1, 2, 3. For individual treatments, V_2 took significantly the maximum days to be matured (145.56 days. On the other hand, V_1 showed significantly the lowest days (138.788 days) to be matured. For various plant spacing treatments, S_3 showed the highest days to be matured (146.00 days), whereas S_1 and S_2 took the minimum days (145.33 days each) to be matured. Among the combination treatments, V_2S_3 (146.00 days) showed the significantly highest days to be matured. Whereas V_1S_1 (134.33 days) perform the lowest which was statistically similar to V_1S_3 (138.67 days). This result are in line with the findings of Ullah *et al.* (2016) and Simachew (2020), where they reported that days to maturity is a non-significant matter in respect of

Cob length

Statistically significant differences were found among the varieties, plant spacing and their combinations on the production of cob length of white maize (Tables 1, 2, 3). Maximum cob length (16.75 cm) was achieved with V_1 and the minimum was achieved V_2 (15.81 cm). Among plant spacing treatments, S_3 produced significantly the tallest cobs (16.68 cm) which was statistically similar to S_2 (16.38 cm) and the shortest cobs was found from S_1 (15.783 cm). Moreover, for the combinations of variety and plant spacing, it was observed that V_1S_3 (17.14 cm) treatments showed the highest cob length, which was statistically similar to V_1S_2 (16.89 cm), V_1S_1 (16.23 cm), V_2S_3 (16.23 cm) and V_2S_2 (15.87 cm) while V_2S_1 (15.34 cm) showed the shortest cob length. The data showed that the cob length decreased as the plant population increased. Zamir *et al.* (2011) concluded that the cob length decreased linearly with increase in plant population. These results indicate that there is a positive relationship between plant spacing and cob length of maize.

Number of rows cob^{-1}

Number of rows cob^{-1}was significantly influenced by varieties, plant spacing and their combinations (Tables 1, 2, 3). The maximum number of rows cob^{-1} was reported from the treatments having V_1 variety (12.90) and V_2 (12.69) was significantly the lowest performer (Table 1). However, in white maize plant spacing treatments showed the significant effects on number of rows cob^{-1}. Among the various treatments, S_3 (12.97) produced highest number of rows cob^{-1} which was statistically similar to S_2 (12.84) and S_1 (12.57) produced the lowest number of rows cob^{-1} (Table 2). Moreover, their combinations revealed that V_1S_3 showed the highest number of rows cob^{-1} (13.07) which was statistically similar to others excepting V_1S_1 (12.68) while V_2S_1 (12.46) showed significantly the minimum number of rows cob^{-1} (Table 3). Hashemi *et al.* (2005) reported a linear decline in number of kernel rows/ear with increasing plant density.

Table 3. Combined effect of variety and planting spacing on crop characters and yield contributing characters of white maize

Treatments	Plant height (cm)	Days to 50% tasselling	Days to 50% silking	Days to maturity	Cob length (cm)	Rows cob^{-1} (no)	Grains row^{-1} (no)	Grains cob^{-1} (no)	100-grain weight (g)
V_1S_1	225.0 b	79.67 c	82.00 b	134.33 d	16.23a	12.68a	26.72b	348.73b	23.44b
V_1S_2	230.92 a	80.67 c	82.00 b	135.66 cd	16.89a	12.95a	28.07a	370.92a	26.16 a
V_1S_3	236.92 a	80.33 c	82.33 b	134.67 c	17.13a	13. 07a	30.63a	419.75a	28.00 a
V_2S_1	187.50 d	87.00 b	89.67 a	140.67 b	15.33b	12.46b	24.85b	322.65c	22.67 c
V_2S_2	194.50 c	88.33 a	89.67 a	142.33 b	15.87a	12.74b	26.35b	348.08b	24.00b
V_2S_3	205.75 c	87.33 ab	90.00 a	146.33 a	16.23a	12.86a	27.77b	368.18b	26.11a
LSD (0.05)	2.30	1.31	1.44	1.01	0.67	0.45	1.11	2.45	0.78
CV (%)	2.38	0.86	0.66	3.47	1.56	1.21	2.23	6.77	1.34
Level of significance		NS	NS						

In a column figures with same letters do not differ significantly whereas figures with dissimilar letters differ significantly (as per DMRT), NS= Non-significance

Number of grains row^{-1}

Number of grains row^{-1} was significantly influenced by varieties, plant spacing and their combinations (Tables 1, 2, 3). The maximum number of grains row^{-1} (28.47) was reported from the treatments having V_1 variety and V_2 was the lowest performer (26.23) (Table 1). However, in white maize plant spacing treatments showed significant differences on number of grains row^{-1}. Among the treatments, S_3 (29.20) produced highest number of grains row^{-1} which was statistically similar to

S_2 (27.21) whereas S_3 produced significantly the lowest (25.78) number of grains row^{-1}(Table 2). Moreover, their combination revealed that, V_1S_3 showed the highest number of grains row^{-1} (30.63 which was statistically similar with V_1S_2 (28.07) and V_2S_3 (27.73). Again, the treatment, V_2S_1 showed the lowest number of grains row^{-1}(24.85) which was statistically similar to V_2S_1 (27.517) and V_1S_1 (26.72) (Table 3). Mia *et al.* (2020) who reported that variety and spacing was found significant in respect of grains row^{-1}

Total number of grains cob^{-1}

Total number of grains cob^{-1} was significantly influenced by varieties, plant spacing and their combinations (Tables 1, 2, 3). The maximum number of grains cob^{-1} was reported from the treatments having V_1 (369.96) and V_2 (349.64) was significantly the lowest performer (Table 1). However, plant spacing treatments showed the significant effects on number of grains cob^{-1}. Among the various treatments, S_3 produced highest number of grains cob^{-1} (379.20) and followed by S_2 (359.50) and S_1 produced the lowest number of grains cob^{-1} (340.69) (Table 2). Moreover, their combination revealed that V_1S_3 showed significantly the highest number of grains cob^{-1} (419.75) which was statistically similar to V_1S_2 (370.92) and V_2S_3 (368.92). Among the other treatments V_2S_1 showed the lowest number of grains cob^{-1} (322.65), which was statistically similar to V_2S_2 (348.08) and V_1S_1 (348.78) (Table 3). Biswas *et al.* (2024) and reported that wider spacing (17.50 cm) produced higher number of kernels per ear (717.00) while narrower spacing (10 cm) gave lower number of grains (540.30) per cob in maize hybrids. Xu *et al.* (2017) also reported that, 1000-kernel weight and kernel number per ear decreased as plant density increased in maize.

100-grain weight (g)

The varieties, plant spacing and their combination also influenced the weight of 100-grain in white maize (Tables 1, 2, 3). The highest 100- grain weight was significantly produced with V_1 (26.20 g) and the lowest with V_2 (24.26 g) (Table 1). Plant spacing treatments showed the statistically significant effects on 100- grain weight, Among them, the maximum 100-grain- weight (27.06 g) was significantly found from S_3 and followed by the S_2 (25.2 g) while the minimum weight of 100-grain (23.44 g) was produced by the S_1 treatment (Table 2). Treatment combinations revealed that V_1S_3 showed significantly the highest 100- grain weight (28.00 g) than the other combinations, which was statistically similar to V_1S_2 (26.16 g), and V_2S_3 (26.11 g) whereasV_2S_1 showed significantly the minimum weight (22.667 g) which was statistically similar to V_2S_2(24.00g) (Table 3). Sibonginkosi *et al.* (2019) who reported that plant density increased, 1000 grain weight was decreased linearly in maize hybrid. Xu *et al.* (2017) also reported that, 1000-kernel weight and kernel number per ear decreased as plant density increased in maize.

Grain yield

The varieties, plant spacing and their combination remarkably significantly influenced the grain yield in white maize (Figures 2, 3, 4). Maximum grain yield (6.66 t ha^{-1}) was significantly achieved with the treatment V1. The minimum grain yield (6.12 t ha^{-1}) was significantly obtained from the treatment V2 (Figure 2). For plant spacing treatments, the highest grain yield (7.07 t ha^{-1}) was significantly found from the treatment S1 and followed by S2 (6.29 t ha^{-1}) while the minimum grain yielder (5.81 t ha^{-1}) was S3 (Figure 3). For their combination, maximum grain yield (7.38 t ha^{-1}) counted from treatment V1S1 followed by V2S1 (6.77 t ha^{-1}) and V1S2 (6.54 t ha^{-1}) whereas the minimum grain yield was observed from V2S2 treatment (5.57 t ha^{-1}) (Figure 4). Ahamed (2020) reported that the grain yield was increased by 65.16% on 88,888 plants ha^{-1} with 161 kg N ha^{-1} as compared to 44,444 plants ha^{-1}.

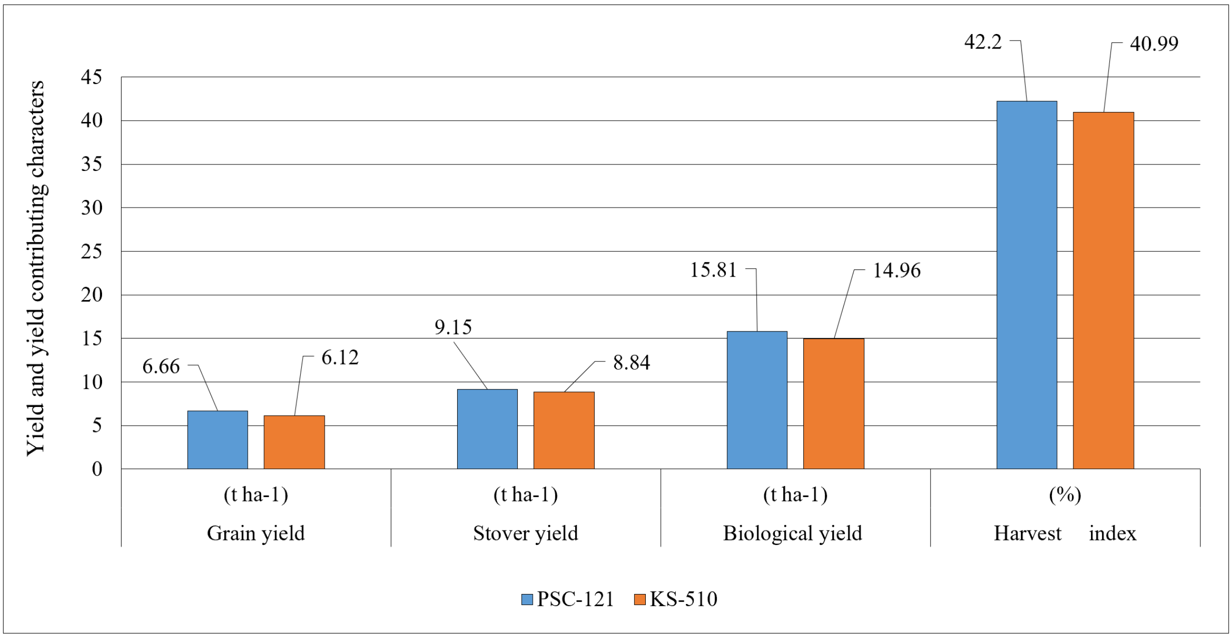

Figure 2. *Effect of variety (PSC-121 and KS-510) on grain yield; stover yield; biological yield and harvest index of white maize.*

Stover yield

It was observed that stover yield statistically significant effects at varieties, plant spacing and their combinations (Figures 2, 3, 4). The highest stover yield was observed in V_1 (9.15 t ha^{-1}) followed by V_2 (8.84 t ha^{-1}) which was lowest producer (Figure 2). In the plant spacing treatments, S_1 (10.21 t ha^{-1}) treatment was the highest stover yielder, followed by S_2 (8.889 t ha^{-1}) while S_3 treatment was the lowest yielder (7.88 t ha^{-1}) (Figure 3). However, for the combination of varieties and plant spacing it was observed that the maximum stover yield was produced by V_1S_1 (10.40 t ha^{-1}), which was statistically similar to V_2S_1 (10.03 t ha^{-1}) followed by V_1S_2 (9.00 t ha^{-1}) and V_2S_2 (8.78 t ha^{-1}) while V_2S_3 was the lowest yielder (8.36 t ha^{-1}) which was statistically similar to V_1S_3 (8.04 t ha^{-1}) (Figure 4). Simachew (2020) reported that above ground dry biomass yield increase at narrowest plant spacing.

Biological yield

Biological yield also increased significantly with the different varieties, plant spacing both separately and in combinations (Figures 2, 3, 4). Data revealed that, varieties V_1 produced significantly the highest biological yield (15.81 t ha^{-1}) and V_2 produced the minimum biological yields (14.96 t ha^{-1}) (Figure 2). In the plant spacing treatments, S_1 (17.29 t ha^{-1}) treatment was significantly the highest biological yielder, followed by S_2 (15.18 t ha^{-1}) while S_3 treatment was the lowest yielder (13.69 t ha^{-1}) (Figure 3). From their combinations, V_1S_1 showed the maximum biological yield (17.78 t ha^{-1}), which was statistically identical to V_1S_1 (16.80 t ha^{-1}) in this study. Treatment, V_2S_3 produced the minimum (13.28 t ha^{-1}) biological yield (Figure4). Similar result was found by Tajul *et al.* (2013) who stated that Biological yield was increased progressively with the progressive increase in planting densities. This might be due to higher number of plants per unit area.

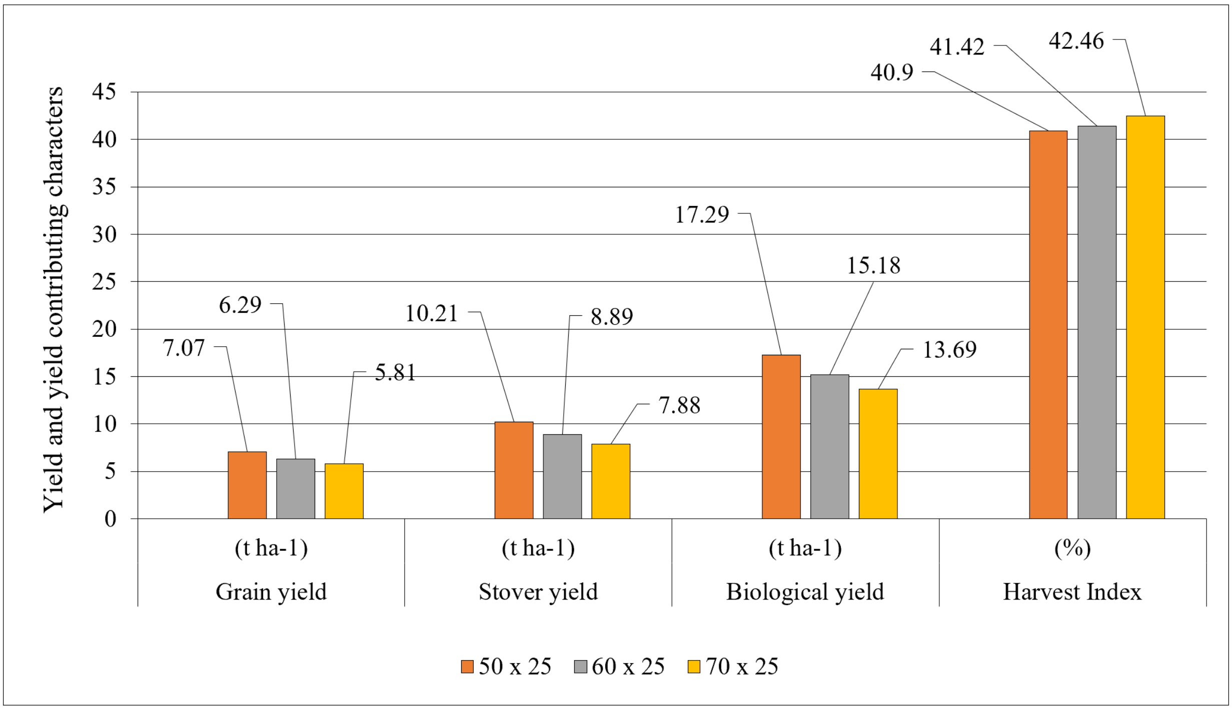

Figure 3. *Effect of planting spacing (50 × 25 cm, 60 × 25 cm and 70 × 25 cm) on grain yield; stover yield; biological yield and harvest index of white maize.*

Harvest index

White maize varieties showed statistically significant effect on harvest index. V1 (42.20 %) showed the highest HI, whereas V2 (40.99 %) was the lowest (Figure 2). The plant spacing treatments also showed significant differences on harvest index. Among them, S_3 (43.51 %) showed the highest harvest index which was statistically similar to S_2 (42.46 %) while S_1 (40.89 %) had the lowest (Figure 3). Moreover, harvest index varied significantly due to combination of varieties and plant spacing treatments. It was observed that, V_1S_1 treatment showed the highest harvest index (43.00 %), which was statistically similar to others V_1S_2 (42.10 %), V_2S_2 (41.92 %) and V_1S_1 (41.49 %) excepting V_2S_2 (40.75 %) whereas V_2S_1 (40.30 %) had the lowest harvest indexer (Figure 4). Eskandarnejada *et al.* (2013) showed that intermediate inter-row spacing gave significantly higher harvest index of maize than both lower and higher inter-row spacing. Similarly, Yousaf *et al.* (2007) reported that harvest index initially increased with increasing plant and row spacing but declined when plant density increased further.

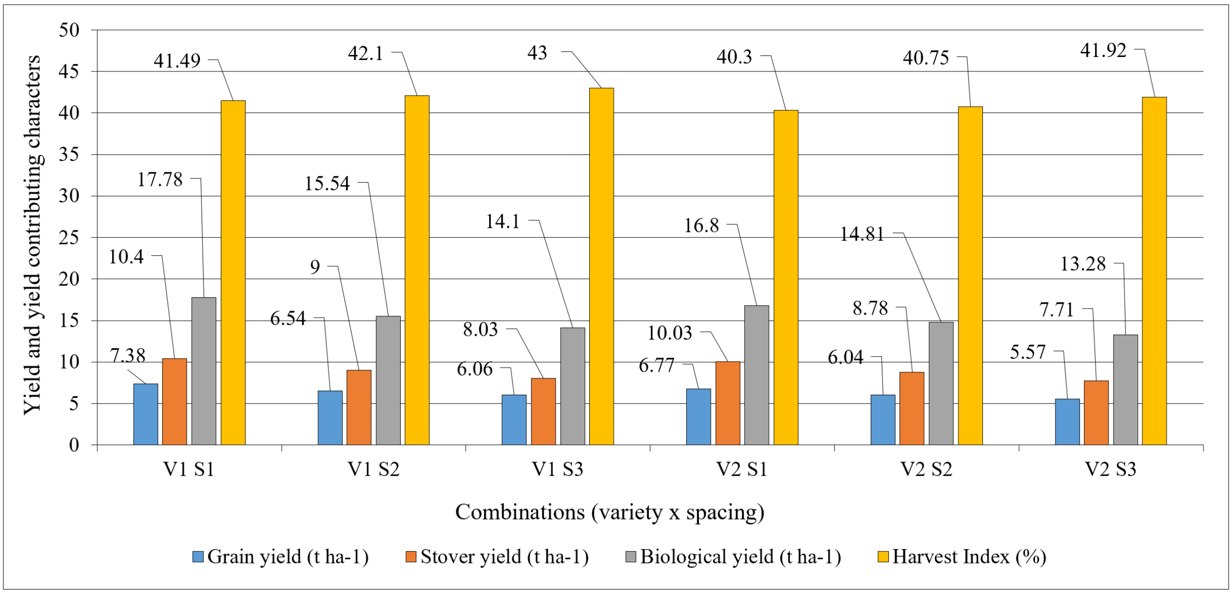

Figure 4. *Combined effect of variety and spacing on grain yield; stover yield; biological yield and harvest index of white maize. Variety: V_1 = PSC -121, V_2 = KS -510; Planting spacing: S_1 = 50 cm × 25 cm; S_2 = 60 cm × 25 cm; S_3 = 70 cm x 25 cm.*

Conclusion

Based on the findings of this study, growth, yield contributing characters and grain yield were significantly affected by white maize varieties and planting spacing. The varieties, plant spacing and their combination remarkably significantly influenced the grain yield in white maize. The study indicated that moderately increasing planting density increased yields. Stover yield shown statistically significant effects at varieties, plant spacing and their combinations. The varieties, plant spacing and their combination also influenced the weight of 100-grain in white maize. Biological yield also increased significantly with the different varieties, plant spacing both separately and in combinations. White maize varieties showed statistically significant effect on harvest index. The optimal planting spacing (50 cm × 25 cm) and variety (PSC-121) provided yield up to 7.38 t ha^{-1} of maize in Teesta River Basin, Rangpur, Bangladesh.

DECLARATIONS

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