International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Growth Yield and Yield Attributes of Some White Maize Varieties As Influenced By Planting Configuration

Md. Mahirul Islam Biswas[1], Md. Jafar Ullah[2], Quazi Mostaque Mahmud[3], Shahrima Zahan Shormi[4]

[1,3]Assistant Professor, City University
[2]Professor, Sher-e-Bangla Agricultural University
[4]Lecturer, City University

Abstract
A field experiment was conducted at Agronomy field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during the period from November to April (winter season) 2015-2016. This study investigated the combined effects of four Chinese white maize varieties (V_1 = Changnau-1, V_2 = Q-Xiangnau-1, V_3 = Changnau-6, V_4 = Youngnau-7) and two planting configurations (S_1 =70 cm x 25 cm and S_2 = 60 cm x 25 cm) on their growth, yield, and yield attributes. The experiment was laid out in a factorial randomized complete block design (RCBD) with three replications. Significant variations were observed among the varieties for all measured parameters. Changnau-6 (V_3) produced the longest cob (17.54 cm), maximum grains cob-1 (418.36), highest grain yield (8.3670 t ha^{-1}), stover yield (9.6921 t ha^{-1}) and biological yield (18.059 t ha^{-1}) while Youngnau-7 (V_4) had the shortest cob (12.683 cm), maximum grains cob-1 (247.53), lowest grain yield (4.8469 t ha-1), stover yield (7.957 t ha^{-1}), biological yield (10.982 t ha-1) shortest maturation time. Planting at 70 cm x 25 cm (S1) spacing resulted in taller plants, more leaves, and longer cobs compared to 60 cm x 25 cm (S_2) spacing, but yielded less grain, stover, and biomass. The interaction between variety and planting configuration further influenced the traits. Changnau-1 (V_1) planted at 70 cm x 25 cm (S_1) had the highest plant height, number of leaves, and days to maturity, while Changnau-6 (V_3) planted at 60 cm x 25 cm (S_2) achieved the highest grain yield (8.7645 t ha^{-1}), stover yield (10.089 t ha^{-1}) biological yield (18.853 t ha^{-1}) and harvest index (46.487 %). Overall, the choice of variety and planting configuration significantly impacted the growth, yield, and yield attributes of white maize. Changnau-6 (V_3) variety with 60 cm x 25 cm (S_2) plant spacing was found to be the most promising combination for maximizing grain yield and harvest index under the conditions of this field trial.

Keywords: White maize, Variety, Planting configuration, Grain yield, Harvest index

Introduction

Maize (*Zea mays* L.) has garnered recognition as the third most crucial cereal crop globally, owing to its remarkable adaptability and high productivity (Mosisa *et al.*, 2002). Flourishing under diverse climatic conditions, maize attains optimal yields in moderate temperatures with adequate water supply (Aldrich *et al.*, 1978). Characterized by a superior carbohydrate production potential per unit land, maize underwent a pioneering technological transformation in cultivation, positioning itself as the first major cereal to undergo rapid and widespread advancements (Palwal, 2000). In developed countries, maize serves predominantly as animal feed and raw materials for industrial products like starch, glucose, dextrose, and biofuel, boasting a grain composition of 72% starch, 10% protein, and 4% fat, contributing to an energy density of 365 Kcal/100g (Nuss and Tanumihardjo, 2010).

Bangladesh sees maize as a vital crop alongside rice and wheat, with a current cultivation area encompassing approximately 963,000 acres (BBS, 2017). However, the bulk of maize production is dedicated to livestock or poultry feed, revealing untapped potential for human consumption. With the rising population and increasing income, the demand for food is escalating, while agricultural land is diminishing due to urbanization, industrialization, and infrastructure development (Dass *et al.*, 2012). Confronted with these challenges and considering the limitations in increasing rice yield and production (Chen *et al*., 2014), the introduction of white maize in Bangladesh emerges as a promising alternative for sustaining food security. White maize, known for its higher productivity compared to rice and wheat, could play a pivotal role in meeting the growing demand for food (Ray *et al.*, 2013).

Optimizing planting configurations becomes crucial for maximizing maize productivity. Previous research has indicated that greater yields are observed in irrigated corn planted at higher populations, emphasizing the significance of planting density in influencing yield potential. Maize planted in twin rows has demonstrated higher yields than those planted in single rows, suggesting an interplay between row spacing and plant density. The quest for the optimum distance between neighboring rows and plants aims to enhance biological productivity by reducing competition among plants for light, water, and nutrients through a more equidistant plant arrangement (Olson & Sander, 1988; Porter *et al.*, 1997). This not only promotes favorable growth conditions but also contributes to early canopy closure, improving sunlight interception, radiation use efficiency, and ultimately, grain yield (Bullock *et al.*, 1988; Westgate *et al.*, 1997; McLachlan *et al.*, 1993).

In this context, the present study conducted at Sher-e-Bangla Agricultural University (SAU) farm delves into the impact of planting configurations on the growth and yield of select Chinese white maize varieties. By assessing the response of white maize to different planting configurations, this research aims to contribute valuable insights into the agronomic practices necessary for enhancing the productivity of white maize in Bangladesh. The findings are expected to guide future recommendations for planting configurations tailored to the unique agro-climatic conditions of the region, thereby promoting sustainable and efficient white maize cultivation.

Materials and Methods

The experiment was conducted at Sher-e-Bangla Agricultural University farm in Dhaka, during winter (rabi) season of 2015-2016 to find out appropriate planting configuration for Chinese hybrid white maize varieties. The experiment comprised four Chinese white maize hybrids viz. (V_1 = Changnau-1, V_2 = Q-Xiangnau-1, V_3 = Changnau-6 and V_4 = Youngnau-7) and two planting configurations S_1= 70 cm × 25 cm (57,142 plants ha-1) and S2 = 60 cm × 25 cm (61,538 plants ha-1). The experiment was laid out in a Randomized Complete Block design with three replications. The experimental area was organized into three blocks, each block sub divided into eight plots. Each unit plot measured 4.8 m² (2.4 m × 2 m) with an 80 cm border between adjacent plots and 1 m gap between adjacent replications or blocks, resulting in a total of 24-unit plots. Seeds were sown on 30 November 2015 maintaining spacing as per treatments. Fertilizers were applied @ 250-55-110-40-5-1.5 kg ha-1 of N-P-K-S-Zn-B in the form of urea, TSP, MOP, gypsum, zinc sulphate and boric acid respectively. One third N along with full amount of other fertilizers was applied as basal dose during final land preparation. Remaining N was applied as top dress at 30 DAS after first irrigation and pre-tasseling stage, as recommended by BARI (2014). Weeding was done at 25 DAS while earthing-up was done at 45 DAS. Data were collected on plant height, leaf number and dry matter of plant parts at harvest. Days to first flowering, first tasseling, and first silking were recorded through visual observation, Days to maturity were recorded when the cob exhibited a straw color, considering the black layer of the grain within the shell or rachis. Cob characteristics were assessed by measuring the length, diameter, number of rows, and grains per row of ten randomly selected cobs from each plot. Average cob length (cm), cob diameter (cm), number of rows per cob, and number of grains per row were calculated. Total grains per cob were determined by randomly selecting ten cobs from each plot. Additionally, three samples of 100 grains were randomly taken from each plot's seed lot, weighed separately, and averaged to calculate grain weight per plant in grams. From each plot, ten plants were randomly harvested, and grains were separated from cobs, oven-dried at 70 ºC for 48 hours, and weighed to express grains' dry weight in grams per plant, later converted into tons per hectare. Stover weight was determined similarly, expressing it as grams per plant and converting it into tons per hectare. Biological yield, defined as the sum of grain yield and stover yield, was measured for each plant and expressed in tons per hectare. Harvest index (HI), computed as the ratio of grain yield to the total above-ground dry matter yield, was calculated using the formula HI = (Grain yield / Total biological yield) × 100 (%). Data for growth, phenology, yield, and contributing characters were compiled and tabulated using MS Excel and statistically analyzed with the MSTAT-C computer package. Mean differences among treatments were compared using the Least Significant Difference (LSD) technique at a 5% level of significance, following Gomez and Gomez (1984).

Results and Discussion

The research program was formulated aiming at investigating the combined effect of four Chinese white maize varieties and two planting spacings on their growth, yield and yield attributing characters. Relevant data have been presented in this chapter and statistically analyzed with the possible explanation. Almost all the growth parameters were significantly affected by maize varieties and plant densities.

Plant height (cm)

Plant height is an important component which helps in the determination of growth attained during the growing period. Various treatments such as variety, plant spacing and their combination were used to observe their effects on plant height of white maize and the result was represented in figure 1, 2, and 3. It was revealed from the results that plant height was significantly influenced by four examined white maize hybrid varieties. Among the varieties, V_1 (Changnuo -1) showed significantly the tallest plant (234.17 cm) and V_4 (Yangnuo -7) produced significantly the shortest (181.17 cm) plants. Likewise, V_3 had significantly longer plants (230.83 cm) than that of V_2 (220.67 cm) (Figure 1). Among the plant spacing treatments, S_1 (had the tallest plants (219.50 cm) while S_2 showed the shortest (213.9 cm) plants (Figure 2). For their various combination among the above stated treatments, V_1S_1 produced significantly the tallest plants (236.67 cm) which was statistically similar to V_3S_1 (233.6 cm) whileV_4S_2 showed significantly the shortest (179.00 cm) plants. Likewise, V_1 S_2 had significantly longer plants (231.6 cm) than that of V_3 S_2 and V_2 S_1 (228.0 cm and 224.0 cm respectively) (Figure 3) These results are in the line with Gozubenli *et al.* (2001) and Konuskan (2000) who found that there was a considerable varietal variation for the plant height. Dawadi and Sah (2012) also observed that plant height was significantly influenced by the densities and varieties.

Here, V_1 = Changnuo-1, V_2 = Q- Xiangnuo-1, V_3 = Changnuo-6, V_4 = Yangnuo-7

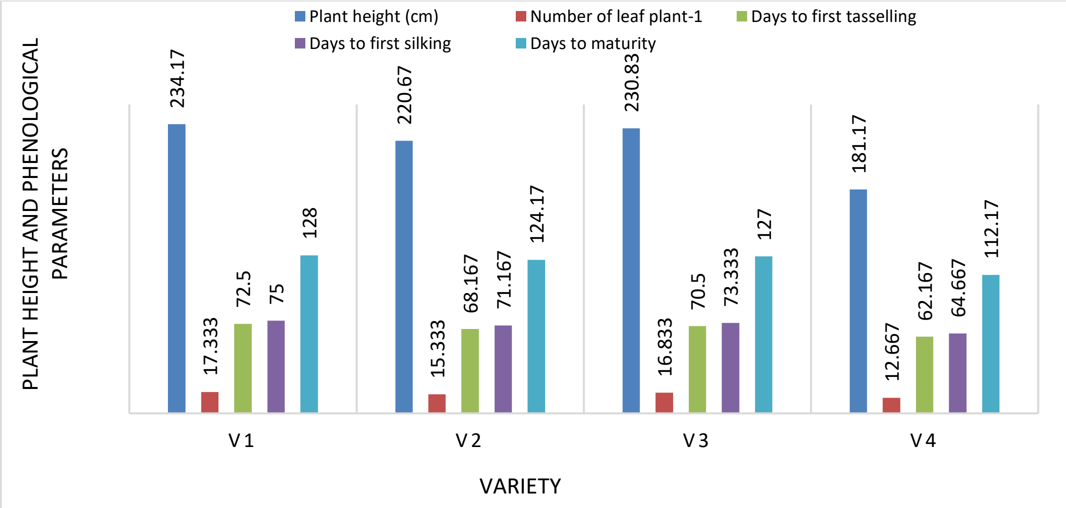


Fig. 1. Effect of variety on plant height, number of leaves per plant, days to first tasseling, days to first silking and days to maturity of white maize

Leaf number per plant

Total number of leaves plant^{-1} was significantly influenced by varieties, plant spacing and their combinations (Figure 1, 2, and 3). Significantly the maximum number of leaves plant^{-1} (17.333) was produced by the variety V_1 followed by V_3 (16.833) variety while V_4 variety was significantly the lowest leaves producer (12.667). Likewise, V_2 produced medium number of leaves plant^{-1} (15.333) Figure 1). Among the various plant spacing treatments, S_1 produced significantly highest number of leaves plant^{-1} (16.083) whereas S_2 produced significantly the least number of leaves plant^{-1} (15.000) (Figure 2). Their combinations revealed that, V_1S_1 (18.000) showed significantly the highest number of leaves plant^{-1} (18.000) followed by V_3S_1 (17.330) while V_4 S_2 showed significantly lowest number of leaves plant^{-1} (12.333) which was statistically at par with V_4S_1 (13.000). Likewise, V_1S_2 had significantly medium number of leaves plant^{-1}(16.667) than that of V_3 S_2, V_2 S_1 and V_2 S_2 (16.333,16.000 and 14.667 respectively) (Figure 3). Leaf number was greater at the low population density than at high population density. This decrease number of leaves resulted from greater inter competetion at higher plant densities (Fakorede MAB, Mock JJ, 1978), Similar result was also reported by (Bahadur *et. al*, 1999) and (Shafshak *et. al*, 1984).

Days to tasseling

Varieties and plant spacing treatments separately and their combinations were used to observe their effects on days to tasseling (Figure 1, 2, and 3). It was found that days to tasseling was significantly influenced by varieties. Among the treatments, V_1 variety significantly took the maximum days to first tasselling (72.500 days) followed by V_2 and V_3 (68.167 days and 70.500 days), while V_4 significantly took minimum days to tasselling (62.1670 days) (Figure 1). Plant spacing treatments were non-significant effect on days to first tasseling (Figure 2). Although having non-significant effect, S_1 took to reach maximum days to first tassel (68.500 days) while S_2 took to reach minimum days to first tassel (68.167 days) (Figure 2). On the other hand, for the combination of varieties and plant spacing treatment it was found that, V_1S_1 combination significantly took more days to first tassel (72.667 days) followed by V_1S_2 (72.333 days) whereas V_4S_1 took the lowest days to first tassel (62.333 days) which was statistically at par with V_4S_2 (62.000 days) (Figure 3). Significantly earlier tasseling and silking and shorter physiological maturity was observed in the variety Yangnuo-7. Early tasseling, silking and short physiological maturity of Yangnuo-7 might be due to its genetic characteristics. Late maturing varieties took more days to tassel and hence had a better chance to utilize more nutrients and more photosynthetic activity, which ultimately resulted in late maturity. The earliest tasselling observed in the highest plant density of 66,666 plants ha^{-1} was due intra-specific competition for soil nutrients, water and sunlight among the plants which ultimately triggers the plants to early reproductive phase while lower plant density utilized soil nutrients, water and solar radiation efficiently thereby prolonged the tasselling dates. Park *et al*., (1987) reported that plant density did not affect days to tasseling and silking. Dawadi and Sah, (2012) also reported that tasseling, silking and physiological maturity were not significantly influenced by plant density. However, there was a lower number of days to silking, tasseling and physiological maturity with increases in plant density. Azam *et al*., (2007) reported different tasseling days for different maize varieties.

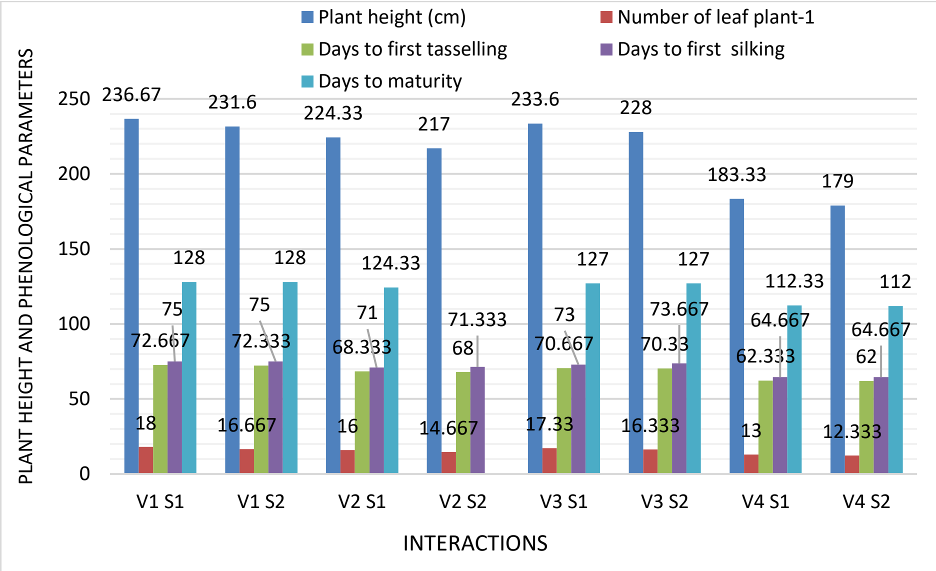
Here, S_1 = 70 cm x 25 cm, S_2 = 60 cm x 25 cm

Fig. 2. Effect of planting geometry on plant height, number of leaves per plant; days to first tasseling, days to first silking and days to maturity of white maize

Days to silking

White maize varieties and plant spacing treatment separately and their combinations were used to observe their effects on days to silking of white maize (Figure 1, 2, and 3). It was found that days to silking was significantly influenced by varieties. Among the varieties, V_1 variety took significantly maximum number of days for silking (75.000 days) followed by V_4 (64.667 days) which was significantly took minimum number of days for silking (64.667 days) (Figure 1). It could be due to differences in genetic makeup of these varieties. Plant spacing treatments were non- significant effect on days to first silking of white maize. Although having non-significant effect, S_1 took the highest number of days to first silking (71.167 days) while S_2 took the lowest number of days to first silking (70.917 days) (Figure 2).

Here, V_1 = Changnuo-1, V_2 = Q-Xiangnuo-1, V_3 = Changnuo-6, V_4 = Yangnuo -7



S_1 = 70 cm x 25 cm, S_2 = 60 cm x 25 cm

Fig. 3. Interaction effects of variety and planting configuration on plant height, number of leaves per plant, days to first tasseling, days to first silking and days to maturity of white maize

On the other hand, for the combination of variety and plant spacing treatment it was found that V_1S_1 significantly took more days for silking (75.000 days), which were statistically similar to V_1S_2 (75.000 days). V_4S_1 took the lowest days to silking (64.667 days), which were statistically similar to V_4S_2 (64.667 days) (Figure 4.1.3). Hassan (1987) revealed that maize cultivars had significant differences in days to 50% silking.

Days to maturity

Varieties, plant spacing and their combinations showed significant positive effect on days to maturity for the two tested cultivars (Figure 1, 2 and 3). There were significant variations reported in plant maturity with the varieties. V_1 variety significantly took maximum days to be matured (128.00 days) followed by V_2 and V_3 (124.17 days, 127.00 days respectively) while V_4 variety significantly took very minimum days (112.17 days) to be matured (Figure 1). Plant spacing treatments showed the non-significant effects on days to be matured of white maize (Figure 2). S_1 took the highest number of days to be matured (122.92 days) and S_2 took the lowest number of days to be matured (122.75 days) (Figure 2). On the other hand, for the combination of variety and plant spacing it was found that V_1S_1 significantly took the highest days to be matured (128.00 days), which was statistically similar to V_1S_2, V_3S_1 and V_3S_2 treatments (128.00 days, 127 days and 127 days respectively) whereasV_4S_2 significantly took the lowest days to be matured (112.00 days) which was statistically similar to V_4S_1 (112.33 days) (Figure 3). Dawadi and Sah, (2012) also reported that tasseling, silking and physiological maturity were not significantly influenced by plant density. This might be due to the reason that different crop cultivars take their normal time to develop different vegetative and reproductive structure and attain maturity. These results were akin to that of Otegui *et al*., (1995).

Here, V_1 = Changnuo-1, V_2 = Q - Xiangnuo-1, V_3 = Changnuo-6, V_4 = Yangnuo-7

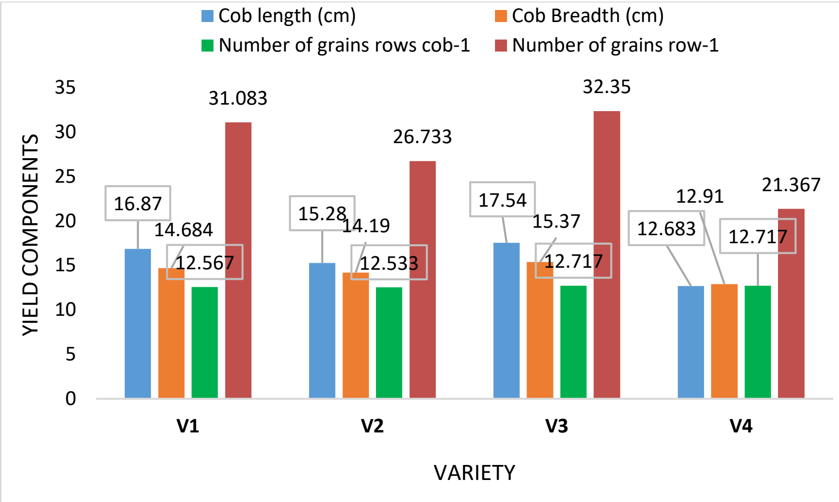


Fig. 4. Effect of variety on cob length; cob breadth, number of grains rows per cob; number of grains per row of white maize

Cob length (cm)

Population density, white maize hybrids and the interactive effect of plant population density and hybrids had significant effects on cob length. Maximum cob length (17.54 cm) was significantly achieved with V_3 variety followed by V_1 (16.87 cm) and V_2 variety (15.28 cm) while the minimum cob length was achieved with V_4 variety (12.683 cm) (Figure 4). Cob length was increased with increasing plant spacing. Among the plant spacing treatments, S_1 spacing significantly produced the tallest cobs (16.097 cm) while S_2 significantly produced the shortest cobs (15.092 cm). (Figure 5). Moreover, for the combinations of varieties and plant spacing, it was observed that V_3S_1 significantly showed the highest cob length (18.077 cm) which was statistically similar to V_3S_2 and V_1S_1 (17.07 and 17.300 cm). Among the other treatments, V_4S_2 significantly showed the lowest cob length (12.00 cm) (Figure 6). These results are in line with the findings of Karim *et al*. (1983), Kamel *et al.* (1983) and Akcin *et al*. (1993) who 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, probably due to variable plant competition. Konuskan (2000) and Gozubenli *et al.* (2001) reported that variations in ear characteristics of maize depend upon genotype and environmental conditions. Similar results were also reported by Chakor & Awasthi (1983); Esechie (1992) and Hassan (2000). They observed that ear length decreased with increase in plant population. This may be due to the fact that available nutrients, moisture, space and light become limited in high plant population due to high competition of soil resources between plants. Ultimately plants produced relatively small ears.

Cob breadth (cm)

Cob breadth was significantly affected by planting density, varieties and their combinations. Among the varieties significant difference was found on the production of cob breadth. Maximum cob breadth (15.370 cm) was significantly achieved with V_3 variety and the minimum (12.910 cm) was significantly achieved with V_4 variety (Figure 4). Cob breadth was increased with increasing plant spacing. Among the plant spacing, S_1 produced the highest cob breadth (14.601 cm) and S_2 produced the lowest cob breadth (13.976 cm) (Figure 5). Moreover, for the combination of varieties and plant spacing, it was observed that V_3S_1 treatment showed maximum cob breadth (15.607 cm), which was statistically similar to V_3S_2 (15.133 cm).

Here, S_1 = 70 cm x 25 cm, S_2 = 60 cm x 25 cm

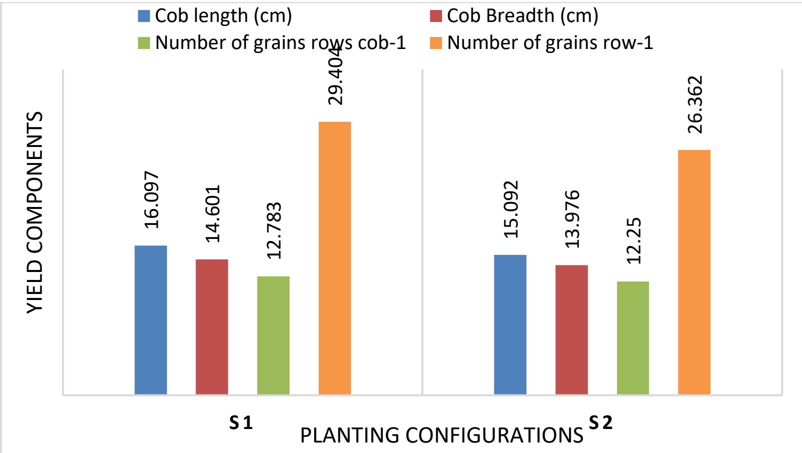


Fig. 5. Effect of planting configurations on cob length; cob breadth, number of grains rows per cob; number of grains per rows of white maize

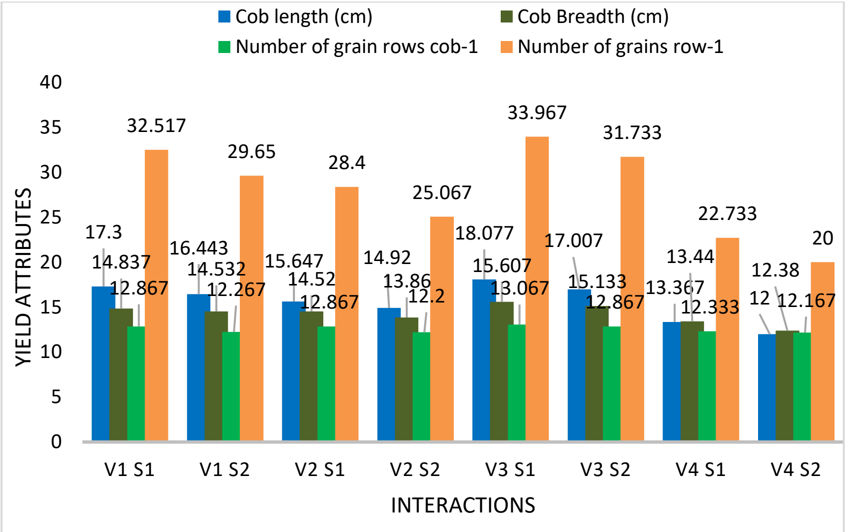
Among the other treatments V_4S_2 showed minimum cob breadth (12.380 cm) (Figure 6). Number of rows cob^{-1} was significantly influenced by varieties, plant spacing and their combinations (Figure 4, 5 and 6).

Number of rows cob^{-1}

Among the varieties, the maximum number of rows cob^{-1} was found in V_3 (12.717) which was statistically similar to V_1 and V_2 (12.567 and 12.533) whereas V_4 was the lowest performer (12.250) (Figure 4). However, plant spacing treatments showed the significant effects on number of rows cob^{-1}. Among the various treatments, S_1 produced significantly the highest number of rows cob^{-1} (12.783) while the lowest (12.250) was produced from S_2 (Figure 5). Moreover, their combination revealed that, V_3S_1 showed the highest number of rows cob^{-1} (13.067), which was statistically similar to V_3S_2, V_1S_1 and V_2S_1 respectively (12.867, 12.867 and 12.867 respectively). Again, the treatment V_4S_2 showed the minimum number of rows cob^{-1} (12.167), which was statistically similar to V_2S_2 (12.200) (Figure 6). Hashemi *et al*. (2005) reported a linear decline in number of kernel rows/ear with increasing plant density.

Number of grains row^{-1}

Number of grains row^{-1} was significantly influenced by varieties, plant spacing and their combinations (Figure 4, 5 and 6). The maximum number of grains row^{-1} (32.350) was significantly reported from the treatments having V_3 variety which were statistically similar to V_1 (31.083) followed by V_2 (26.733) whereasV_4 had the lowest performer (21.367) (Figure 4). However, plant spacing treatments showed the significant effects on number of grains row^{-1}. Among the various treatments, S_1 produced the highest number of grains row^{-1} (29.404) and the lowest (26.362) was produced from S_2 (Figure 5). Moreover, their combination revealed that V_3S_1 showed significantly the highest number of grains row^{-1} (33.967) than the other combinations, which were statistically similar to V_1S_1 (32.517) and V_2S_2 (31.733) where V_4S_2 produced significantly the minimum number of grains row^{-1} (20.000) (Figure 6). Observed results were alike with the following results where it was stated that increased competition due to dense population may also lead to abortion of ovary and eventually producing lesser number of kernels increasing barrenness (Gozubenli *et al.*, 2004). Comparing the response of old and modern maize varieties (Jacobs and Pearson, 1991), however, Sangoi and Salvador (1998) reported that high plant population decreased number of grains per ear of dwarf lines and did not affect this variable for modern varieties (Akbar *et al.*, 2016).



Here, V_1 = Changnuo-1, V_2 = Q- Xiangnuo-1, V_3 = Changnuo-6, V_4 = Yangnuo-7
S_1=70 cm x 25 cm, S_2= 60 cm x 25 cm

Fig. 6. Interaction effects of variety and planting configurations on cob length, cob breadth, number of rows cob,$^{-1}$ number of grains row^{-1} of white maize

Total number of grains cob^{-1}

Total number of grains ear-^{1} contributes to the economic yield as well as represent the productive efficiency of any cereal crop or crop variety. Total number of grains cob^{-1} was significantly influenced by varieties, their combinations but not plant spacing (Figure 7, 8 and 9). The maximum number of grains cob^{-1} (418.36) was reported from the treatments having V_3 followed by V_1 (387.85) and V_2 (348.09) and V_4 was the lowest performer among others (247.53) (Figure 7). However, in white maize plant spacing treatments showed the non-significant effects on number of grains cob^{-1}. Among the various treatments, S_1 produced highest number of grains cob^{-1} (367.64), which was statistically similar to S_2 (351.31) and it was the lowest (366.50) grain producer (Figure 8). Moreover, their combination revealed that V_3S_1 showed the highest number of grains cob^{-1} (431.7) than the other combinations, which were statistically similar to V_3S_2, V_1S_1 and V_1S_2 (412.35, 405.49 and 380.66). Among the treatments V_4S_2 showed the very minimum number of grains cob^{-1} (275.28), which was statistically similar to V_4S_1 (277.12) (Figure 9). These results are in line with Esechie (1992) and Zada (1998) who found that the number of grains ear-^{1} decreased with increasing plant density. It may be due to source sink relationship and competition among maize plants for nutrients. The lowest number of kernels/ear at high plant density may be due to high competition for the resources such as light, moisture and fertilizer. The high barrenness (%) at high densities was due to the absence of the usual sink for the assimilate supply and limiting optimum conversion of light energy to grain in maize grown at high plant densities which inhibited the plants to produce viable ears. density. Tetio-kagho and Gardner (1987) and Andrade *et al*. (1999) also reported that kernel number per plant declines sharply when the plant density increases which support our research finding.

Here, V_1 = Changnuo-1, V_2 = Q-Xiangnuo-1, V_3 = Changnuo-6 and V_4 = Yangnuo-7

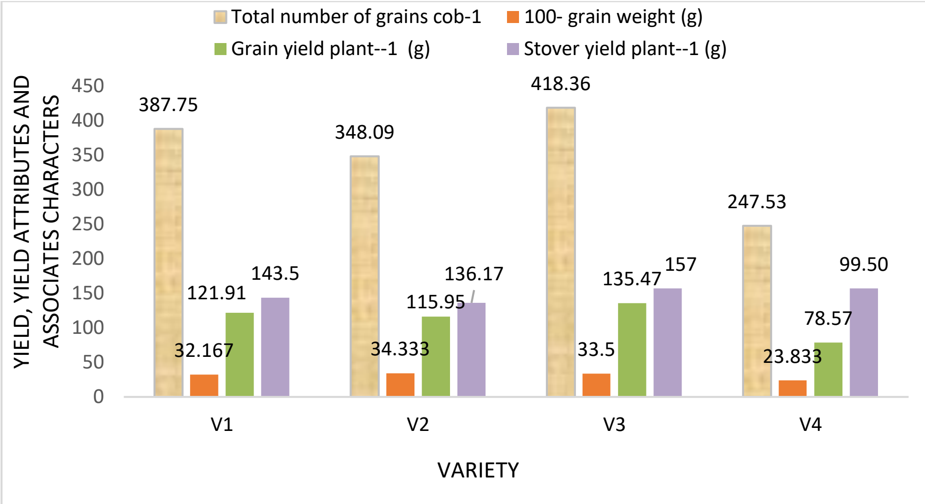
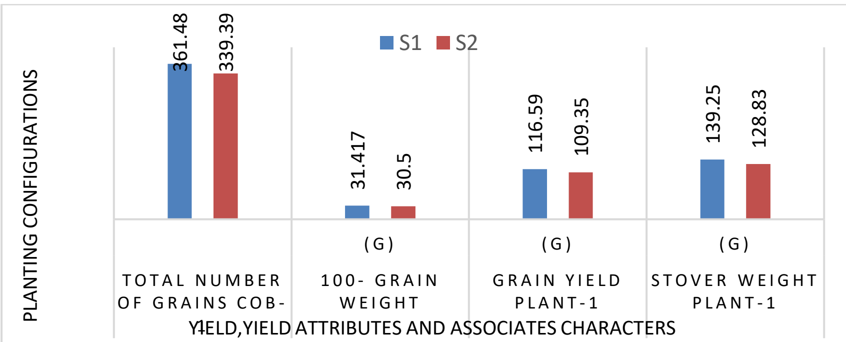


Fig. 7. Effect of variety on grain yield per plant, stover yield per plant, 100-grains weight and total number of grains per cob of white maize

100-grains weight (g)

100-grain weight is an important yield contributing factor, which plays an important role in showing the potential of a variety. The varieties, plant spacing and their combination also influenced the weight of 100-grain in white maize (Figure 7, 8 and 9). The highest 100-grain weight was produced with V_2 (34.333 g) followed by V_3 (33.500 g) and V_1 (32.16 g) while the lowest 100-grain weight was recorded fromV_4 (23.833 g) (Figure 7). Plant spacing treatments showed the significant effects on 100- grain weight, where the maximum 100- grain weight (31.167g) was significantly found from S_1 and the minimum weight of 100-grain (30.750 g) was observed from S_2 treatment (Figure 8). For their combination, the highest 100- grain weight (34.667 g) was produced with V_2S_2, which was statistically similar to V_2S_1, V_3S_1 and V_3S_2 (34.000, 34.00 and 33.667 g). The minimum weight of 100-grain (24.33 g) was produced by the V_4S_2 treatments,



Here, S_1 = 70 cm x 25 cm, S_2 = 60 cm x 25 cm

Fig. 8. Effect of planting configurations on grain yield per plant (g), stover weight per plant (g), 100-grains weight (g) and total number of grains per cob of white maize

which was statistically similar to V_4S_2 (23.33 g) (Figure 9). White maize varieties showed significant effect on 100 grain weight (Ullah *et al*., 2016). Abuzar *et al.* (2011) reported increasing population density adversely affected the number of grains per ear and individual grain weight. Akcin *et al*. (1993) also reported that 100-grain weight increased with decreasing plant population density in maize. These results are in conformity with the findings of Rogers and Lomman (1988), Konuskan (2000) and Gozubenli *et al.* (2001) who stated that there were varietal differences in 100-grain weight, which increased with increasing plant spacing.

Grain weight plant^{-1} (g)

The varieties, plant spacing and their combinations remarkably influenced the grain yield plant^{-1} (g) in white maize (Figure 7, 8 and 9). Maximum grain yield plant^{-1} (135.47 g) was significantly achieved with the treatment V_3 and the minimum grain yield plant^{-1} (78.57 g) was significantly recorded from the treatment V_4. Likewise, V_2 (121.91 g) had more grain producer than that of V_2 (115.95 g) For plant spacing treatments, the maximum grain yield plant^{-1} (116.59 g) was significantly obtained with the treatment S_1 and the minimum per plant grain yielder was S_2 (109.35 g). For their combinations, maximum grain yield plant^{-1} (139.46 g) was recorded from treatment V_3S_1. From others treatments applications the minimum grain yield plant^{-1} was significantly observed from V_4S_2 (75.07 g) and it was statistically similar to V_4S_1 (82.06 g). Likewise, V_3S_2 (131.47 g) had significantly more grain achiever than that of V_3S_2 (125.92 g). These results are in agreement with Sharma and Adamu (1984) who reported that grain weight ear-^{1} was highest at lowest plant population. It may be due to source sink relationship and competition among maize plants for nutrients.

Stover weight plant^{-1} (g)

The varieties, plant spacing and their combinations remarkably influenced the Stover weight Plant^{-1} (g) in white maize (Figure 7, 8 and 9). The maximum stover weight plant^{-1} (157.0 g) was significantly achieved with the treatment V_3 and the minimum stover weight plant^{-1} (99.50 g) was significantly found the treatment V_4. Likewise, V_2 (143.50 g) had significantly more stover producer than that of V_2 (136.17 g) For plant spacing treatments, the maximum stover weight plant^{-1} (139.25 g) was observed from the treatment S_1 and the minimum per plant stover yielder was S_2 (128.83 g). For their combinations, maximum stover weight plant^{-1} (162.67 g) was recorded from treatment V_3S_1 followed by V_3S_2 (151.33 g) and V_1S_1 (149.67 g) which were statistically similar to each other. From others treatments, the minimum stover weight plant^{-1} was significantly found from V_4S_2 (94.33 g). Likewise, V_2S_1 (140.00 g) had significantly more stover producer than that of V_2S_2 (132.33 g). These results are in agreement with Sharma and Adamu (1984) who reported that grain weight ear-^{1} was highest at lowest plant population. It may be due to source sink relationship and competition among maize plants for nutrients.

Here, V_1 = Changnuo -1, V_2 = Q- Xiangnuo -1, V_3 = Changnuo - 6, V_4 = Yangnuo -7
S_1 =70 cm x 25 cm, S_2 = 60 cm x 25 cm

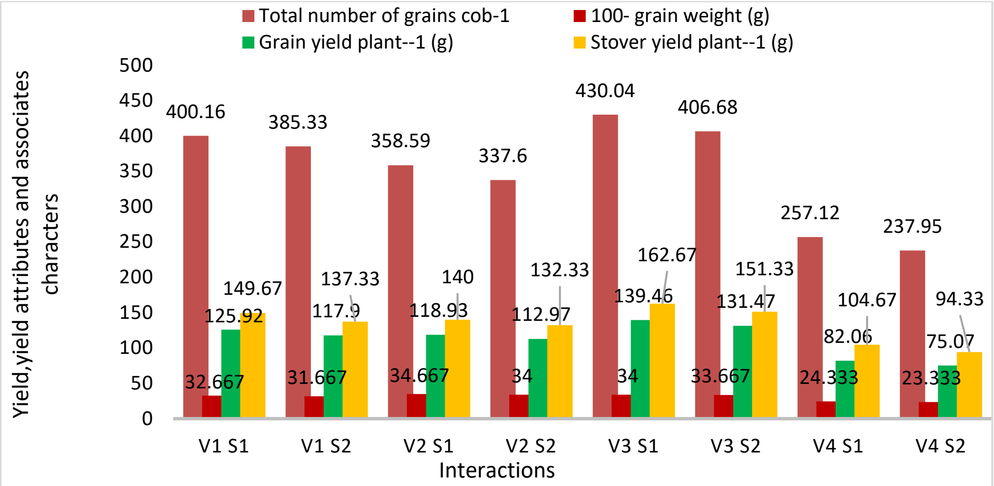
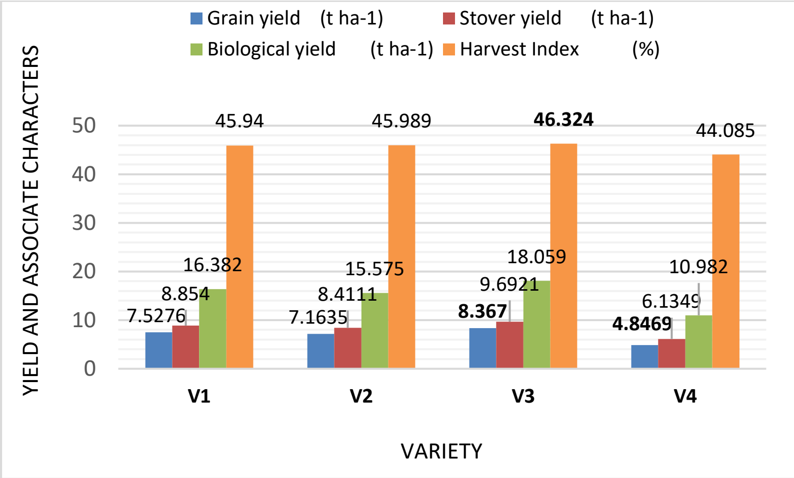


Fig. 9. Interaction effect of variety and planting configurations on grain yield per plant, stover weight per plant, 100-grain weight and total number of grains per cob of white maize

Grain yield (t/ha)

Grain yield or economic yield is an important characteristic and ultimate objective for which most of crops are grown. The varieties, plant spacing and their combinations significantly influenced the grain yield in white maize (Figure 10, 11 and 12). Maximum grain yield (8.3670 t ha^{-1}) was observed with the treatment V_3 and the minimum grain yield (4.8469 t ha^{-1}) was achieved with the treatment V_4. Likewise, V_2 (7.5276 t ha^{-1}) had significantly more grain producer than that of V_2 (7.1635 t ha^{-1}). For plant spacing treatments maximum grain yield (7.2901 t ha^{-1}) was achieved with the treatment S_2 and the minimum grain yielder (6.6624 t ha^{-1}) was S_1. For their combinations, maximum grain yield (8.7645 t ha^{-1}) was counted from treatment V_3S_1. From others treatments combinations, the minimum grain yield was observed for V_4S_2 (4.6893 t ha^{-1}), which was statistically similar to V_4S_1 (5.0045 t ha^{-1}) cm) with lowest plant population (50000 plants ha-1) (4.38 t ha-1). The higher grain yield in high plant density plots might be due to higher number of effective plants per hectare (66,666) compared to 53,333 effective plants per hectare. The superior performance of Changnuo-6 could be attributed to its inherent yield potential and its better response to the environmental stress created by the increased plant density. It could be argued that Changnuo-6 which is a medium maturing variety was less affected by seasonal fluctuations. Availability of improved varieties with shorter plants, lower leaf number, upright leaves, smaller tassels and reduced anthesis silking interval has enhanced the ability of maize to withstand high plant populations without showing excessive barrenness (Sangoi, 2001). The highest grain yield obtained with plant density of 66,666 ha^{-1} might be due to large number of plants per m^2 which compensated the effects of decrease in other yield components. These components though decreased per seed, yet yield actually increased per unit area. Plants grown with wider spacing consume more nutrients and absorb more solar radiation for efficient photosynthesis and hence perform better at individual basis. The reason for deviation of this linearity in case of grain yield per unit area is that the yield does not solely depend on the performance of individual plant but rather depend on total number of grains per cob and other yield contributing characters. This study revealed that a density of 66,666 plants ha^{-1} would be the optimum for maximum grain production for the varieties tested. This is in agreement with Akbar *et al*. (1996) who reported that optimum plant density produced greater yield due to efficient utilization of available soil nutrients coupled with other growth factors. The lowest grain yield with highest density was due to smaller ear size, less number of ears plant-1due to more competition for growth factors.



Here, V_1 = Changnuo-1, V_2 = Q-Xiangnuo-1, V_3 = Changnuo-6 and V_4 = Yangnuo-7

Fig. 10. Effect of variety on grain yield; stover yield; biological yield and harvest index of white maize

Porter *et al*. (1997) suggested that plant distribution was a yield limiting factors when other limiting factors such as nutrient deficiencies were eliminated. Grain yield depends upon various factors such as soil status, environmental factor, plant population and plant characteristics. Grain yield is a function of integrated effects of genetic makeup of cultivars and growing conditions on the yield components of a crop. Grain yield is the end result of many complex morphological and physiological processes occurring during the growth. The growing conditions are changed by different plant spacing. As hybrids are regarded, the hybrids differed significantly for grain yield. These differences in the grain yield of hybrids are due to the differences in their potential yields. The present results are in good agreement with the findings of Konuskan (2000), Gozubenli *et al*. (2001) and Farnham (2001). Interaction effect of the variety with the planting configuration showed that the varieties when transplanted at higher population densities showed significantly higher yield. At the closer spacing the number of plants in a given area is higher than at the sparse spacing. In general, the closer spacing enhances the seed yield through increasing the potentials of yield attributes provided the population density at that level does not become competitive. (Ullah *et al*., 2016). Tollenaar *et al.* (1997) also reported that maize grain yield declines when plant density is increased beyond an optimum. Similar trend was also reported Dawadi and Sah (2012). They found that plant density of 66,666 plants/ha produced the higher grain yield (11.19 t/ha) compared to that of 55,555 plants/ha (9.52 t/ha). The reason of increased grain yield may be due to net crop assimilation rate and more number of ears unit-^{1} areas.

Stover yield (t/ha)

Stover yield was significantly affected by plant population, varieties and their interactions. (Figure 10, 11 and 12). The highest stover yield (9.6921 t ha^{-1}) was significantly observed in V_3 and the minimum by V_4 (6.1349 t ha^{-1}) which were also statistically dissimilar to each other. Likewise, V_2 (8.8540 t ha^{-1}) had significantly more stover producer than that of V_2 (8.4111 t ha^{-1}). In the plant spacing treatments, S_2 treatment was significantly the highest stover yielder (8.5889 t ha^{-1}), while S_1 treatment was significantly the lowest stover yielder (7.9571t ha^{-1}). However, for the combination of variety and plant spacing it was observed that, the maximum stover yield (10.089 t ha^{-1}) was significantly produced by V_3S_2 and the minimum was revealed with V_4S_1 treatment (5.981 t ha^{-1}), which was statistically similar to V_4S_2 (6.289 t ha^{-1}). It is clear from the data that the straw yield was progressively decreased with each decrease in plant population. The variability in straw yield per hectare is the result of variation in the crop stand per unit area. These results are in line with the findings of Knapp and Reid (1981), Anjum (1987) and Tetio-Kagho and Gardner (1988 b). These results are in agreement with Rezuvaev (1981) and Roy and Biswas (1992) who reported that fodder yield increased with increasing plant density. Park *et al.*, (1989) reported that increasing plant density linearly increased stover yield. Scarsbrook and Doss (1973) reported that stover yields of hybrid maize usually increased with each increment of plant population up to 80,000 plants/ha. Biological yield is a major contributor to total output of any crop and dependent upon crop management, type of variety and various other factors.

Biological yield also varied significantly by the different varieties, plant spacing and their combination (Figure 10, 11 and 12). Among the varieties V_3 significantly produced highest biological yield (18.059 t ha^{-1}). V_4 produced significantly the minimum biological yields (10.982 t ha^{-1}) (Figure 10). Likewise, V_2 (16.382 t ha^{-1}) had significantly more biological yield producer than that of V_2

Here, S_1 = 70 cm x 25 cm, S_2 = 60 cm x 25 cm

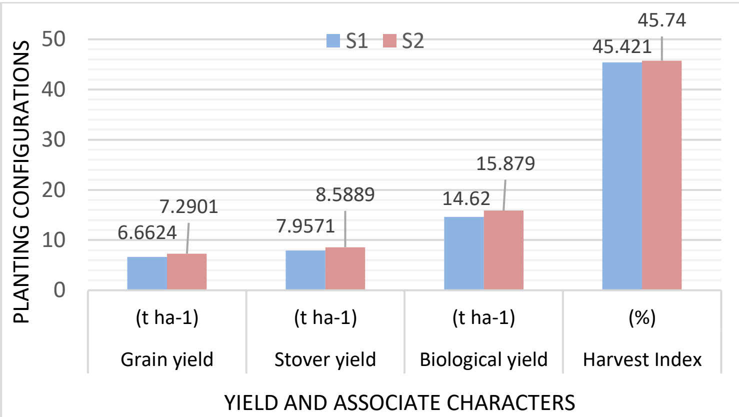
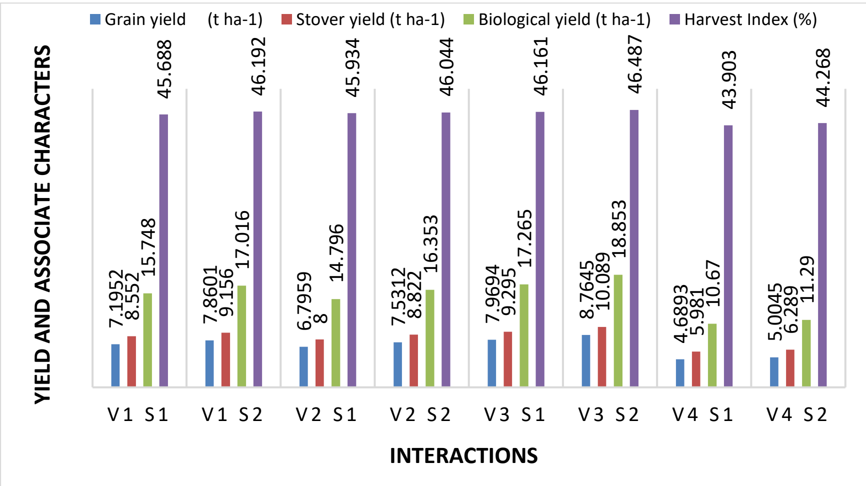


Fig. 11. Effect of planting configurations on grain yield; stover yield; biological yield and harvest index of white maize

(15.575 t ha^{-1}). Between two spacing treatments, S_2 showed significantly the maximum biological yield (15.879 t ha^{-1}) and S_1 was significantly the lowest biological yield (14.620 t ha^{-1}) producer (Figure 11). However, for the combination of varieties and plant spacing, it was observed that the maximum biological yield (18.853 t ha^{-1}) was significantly produced by V_3S_2 and the minimum was revealed with V_4S_1 treatment (10.670 t ha^{-1}) which was statistically similar to V_4S_2 (11.29 t ha^{-1}) (Figure 12). Abuzar *et al.*, (2011) observed that optimum planting space acquired optimum number of plants (60000 plants ha^{-1}), which produced the maximum biomass yield, grain yield and ultimately increased biological yield. Akbar *et al.*, (2002) reported that biological yield was significantly increased at 180000 plants ha-^{1}. These results are consistent with the findings of Plensicar & Kustori (2005) who reported that maximum biological yield was found at higher planting density.

Harvest index

Harvest index is the partitioning of dry matter by plant among biological and economic yield. Plant spacing did not affect significantly but varieties and their interactions had a significant effect on harvest index (Figure 10, 11 and 12). Harvest index was varied significantly due to varieties, V_3 showed the highest harvest index (46.324 %), which was statistically similar to V_1 and V_2 (45.940 % and 45.989 %) while V_4 variety was the lowest (44.085 %) harvest indexer (Figure 10). Plant spacing did not affect significantly on harvest index. Although having non–significant effect, S_2 had the highest harvest indexer (45.748 %), and S_1 showed the lowest harvest indexer (45.421 %) (Figure 11). For the combinations of variety and plant spacing, it was observed that V_3S_2 treatment showed the highest harvest index (46.487 %), which was statistically similar to V_1S_2, V_2S_1, V_2S_2 and V_3S_1 (46.192 %, 45.934 %, 46.044% and 46.161 % respectively). The minimum harvest index was revealed with V_4S_1 treatment (43.903%), which was statistically similar to V_4S_2 (44.268 %) (Figure 12). Ahmad & Khan (2002) reported that increase in plant density significantly increased harvest index. The reasons for such results could be better utilization of available nutrients by maize plants in highest plant population as compared to lowest plant population. In lowest plant population, weeds also compete with crop for nutrients. Similarly, grain become a dominant sink at their maturity stage and the entire photo assimilate deposited in the grains as compared to other parts of the plant. Highest plant population produced more grain and thus resulted in maximum harvest index.



Here, V_1 = Changnuo-1, V_2 = Q- Xiangnuo-1, V_3 = Changnuo-6, V_4 = Yangnuo-7
S_1 = 70 cm x 25 cm and S_2 = 60 cm x 25 cm

Fig. 12. Interaction effects of variety and planting configurations on grain yield, stover yield; biological yield and harvest index of white maize

Conclusion

Four Chinese white maize varieties viz. V_1 = Changnuo-1, V_2 = Q-Xiangnuo-1, V_3 = Changnuo-6 and V_4 = Yangnuo-7) were tested under two planting configurations viz. S_1 = 70 cm x 25 cm and S_2 = 60 cm x 25 cm. The result of present study showed that variety and planting configurations had significant influences on most of the phenological parameters, yield and yield components of white maize. The highest grain yield (8.765 t ha^{-1}) was achieved from V_3 (Changnuo-6) variety when sown at 60 cm x 25 cm planting configuration. The lowest grain yield (4.689 t ha^{-1}) was recorded from V_4 (Yangnuo-7) variety using planting configuration of (70 cm x 25 cm). Variety, Changnuo-6 (V_3) with planting configuration (60 cm x 25 cm) also produced the maximum stover yield (10.089 t ha^{-1}), biological yield (18.853 t ha^{-1}) and harvest index (46.487 %). From the above result, variety, Changnuo-6 was the most suitable of the four white maize varieties tested, and 60 cm x 25 cm planting configuration was better to achieve optimum yield.

Acknowledgment:
The authors would like to acknowledge the Department of Agronomy, Sher-e-Bangla Agricultural University Farm authority, Sher-e-Bangla Nagar, Dhaka-1207, Bangladesh for facilitating and Krishi Gobeshona Foundation (KGF) for financing this research work.

References

1. Abuzar M. R., Sadozai, G. U., Baloch, M. S. Baloch, A. A., Shah, I. H., Javaid and, T and Hussain, N. (2011). Effect of plant population densities on yield of maize. *J. Anim. Plant Sci.* **21**(4) 692-695
2. Ahmad, Z. and Khan, A. Z. (2002). Effect of zinc and plant population on yield and yield components of maize. M.Sc. (Hons) Thesis, Dept. of Agron. KPK Agric. Univ. Peshawar.
3. Akbar, H. P. Shah, A.Z. Khan, Saeed, H. and Munir, M. (1996). Biomass, grain yield and harvest Index as criteria for comparing corn types at different nitrogen levels and planting densities. *Sarhad J. of Agric.* **12**:117-121.
4. Akbar, H., Maftihullah, M., Jan, T. A., Jan and Hsanullah, I. (2002). Yield potential of sweet corn as influenced by different levels of nitrogen and plant population. *Asian J. Pl. Sci.*, **1**(6): 631-633.
5. Akbar, M. A., M. A. Siddique, M. S. Marma, M. M. Rahman, M. R. I. Molla, M. M. Rahman, M. J. Ullah, M. A. Hossain and A. Hamid. (2016). Planting arrangement, population density and fertilizer application rate for white maize (*Zea mays* L.) production in Bandarban valley. *J. Agric., Forest. and Fish.*., **5**(6): 215-224
6. Akcin A., B. Sade, A. Tamkoc, A. Topal, (1993). Effect of different plant densities and nitrogen fertilization rates on the grain yield, yield components and some morphological traits of hybrid TTM813 grown at Kenya. Doga, Turk Turmve orrmanculik Dergisi. **17**(1): 181-294. *Field Crop Absts*.,**47**(6):3339;1994]
7. Aldrich, S.R., Scott, W.O. & Leng, E.R., (1978). Modern corn production. 2nd edition. A & L Publications, Illinois.
8. Andrade, F. H., Vega, C., Uhart, S., Cirilo, A., Cantreno, M. and Valentinuz, O. (1999). Kernel determination in maize. *Crop Sci.*, **39**: 453-459.
9. Anjum J.I., (1987). Studies on the effect of plant population and fertilizer application on the growth and grain yield of summer maize. M.Sc. (Hons.) Agri. Thesis, Deptt. Agron. Univ. Agri., Faisalabad.
10. Azam, S., Ali, M. Amin., S. Bibi. and Arif. M. (2007). Effect of plant population on maize hybrids. *J. Agron. Bio. Sci***.** **2**, 13-16.
11. Bahadar, M. M, Zaman MA, Chowdry MF, Shaidullah SM (1999). Growth and yield component responses of maize as affected by plant population. *Pak. J. of Bio. Sci*, **2**: 1092-1095.
12. BARI (Bangladesh Agricultural Research Institute) (2014). Krishi Projukti Hatboi (Handbook on Agro Technology), Gazipur-1707, Bangladesh, 6th edition, pp-54.
13. BBS **(**Bangladesh Bureau of Statistics) (2017). Yearbook of Agricultural Statistics. Statistics and Information Division (SID), Ministry of Planning. Govt. of the People's Republic of Bangladesh, April, 2018.
14. Bullock, D., Nielsen, R.L. & Nyquist, W.E., (1988). A growth analysis comparison of corn grown in conventional and equidistant plant spacing. *Crop Sci*. **28**: 254-258
15. Chakor, I.S. and P.O. Awasthi (1983) Effect of plant stand, geometry and plant types on growth and

yield of maize under mid-hill conditions of Himachal Pradesh. Bull. Faculty *Agric. Res*., l9: 57-60.
16. Chen**,** X., Cui, Z., Fan, M., Vitousek, P., Zhao, M., Ma, W., Wang, Z., Zhang, W., Yan, X., Yang, J., Deng, X., Gao, Q., Zhang, Q., Guo, S., Ren, J., Li, S., Ye, Y., Wang, Z., Huang, J., Tang, Q., Sun, Y., Peng, X., Zhang, J., He, M., Zhu, Y., Xue, J., Wang, G., WU, L., An, N., Wu, L., MA, L., Zhang, W., Zhang, F. (2014). Producing more grain without environmental costs. *Nature* **514**, 486, October 13.
17. Dass, S., Kumar, A., Jat, S. L., Parihar, C. M., Singh, A. K., Chikkappa, G. K. Jat, M. L. (2012). Maize holds potential for diversification and livelihood security. *Indian J. Agron*. (Special Issue) **57**: 86-91,
18. Dawadi, D. R. and Sah, S. K. (2012). Growth and yield of hybrid maize (*Zea mays* L.) in relation to planting density and nitrogen levels during winter season in Nepal. *Tropical Agril. Res.,* **23** (3): 218-227.
19. Esechie, H.A. (1992). Effect of planting density on growth and yield of irrigated maize in the Batinah coast region of Oman. *J. Agri. Sci.*, **119**: 165-169
20. Fakorede, MAB, Mock, J.J. (1978). Changes in morphological and physiological traits associated with recurrent selection for grain yield in maize. *Euphytica*.; **27:** 397-409.
21. Farnham, D.E., (2001). Effects of row spacing, plant density and variety on maize grain yield. *J. of Agron.*, **93**: 1049-1053.
22. Gomez, K**.** A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research. 2nd Ed. John Willey & Sons, Inc. New York. 641.
23. Gözübenli, H, Ö Konuskan (2001) Nitrogen dose and plant density effects on popcorn grain yield. *African J. of Biotechn.y* **9**: 3828-3832. Link: https://tinyurl.com/yd8pdxgg
24. Gozubenli, H., A.C. Ulger, O. Sener, (2001). The effect of different nitrogen doses on grain yield and yield-related characters of some maize genotypes grown as second crop. *J. Agric*. Fac. C.U., **16**: 39-48
25. Gozubenli, H., Klinic M., Sener O., Konuskan O. (2004): Effects of single and twin row planting on yield and yield components in maize. *Asian J. Plant Sci*., **3** (2): 203-206.
26. Hashemi, A.M., Herbert, S.J. and Putnam, D.H. (2005). Yield response of corn to crowding stress. *Agron. J*. **97**,839-846.
27. Hassan, A., A. (2000). Effect of plant population density on yield and yield components of 8 Egyptian maize hybrids. Bull. Faculty Agric. Uni. Cairo., **51**: 1-16.
28. Hassan, A.E. (1987). Performance of three corn cultivars (Zea mays L.) as affected by plant density in Riyadh region. *J. Agric. Bio. Sci*., **5**: 199-203.
29. Jacobs, B.J. & Pearson, C.J., (1991). Potential yield of maize determined by rates of growth and development of ears. *Field Crops Res*. **27**: 281-298.
30. Kamel, M.S., A. Raouf, M. S. Mahmood, E.A., S. Amer, (1983). The effect of plant population on local "Roumi" maize grain yield when grown under irrigation. *Ann. Agri. Sci.*, **19** (1): 79- 93. *Field Crop Absts*.,**37**(4): 963; 1984)
31. Karim, M.A., Bakhash, P. Shah, (1983). Effect of plant population on yield and yield components of synthetic 66(maize). *J. Agron. Res. Rab,* **21**(2): (*Maize Absts*., **1**(5): 2370; 1985)
32. Knapp, W.R., W. S. Reid, (1981). Interactions of hybrid maturity class, planting date, plant population and nitrogen fertilization on corn performance in New York. (*Field Crop Absts.,* **36** (3): 2235; 1983)

33. Konuskan O., (2000). Effects of plant density on yield and yield related characters of some maize hybrids grown in hatay conditions as second crop. M.Sc. Thesis, Science Institute. M.K.U., pp: 71.
34. Mclachlan, S.M., Tollenaar, M., Swanton, C.J. & Weise, S.F., (1993). Effect of corn induced shading on dry matter accumulation, distribution and architecture of redroot pigweed. *Weed Sci*. **41**: 569-573.
35. Mock, J. J. and Pearce, R. B. (1975). An ideotype of maize. *Euphytica*, **24:** 613-623.
36. Mosisa, W., Hadji, T., Mandefro, N. & Abera, D., (2002). Maize production trends and research in Ethiopia. In: N. Manderfo, D. Tanner & S. Afriyie (eds.). Proceeding of the second National Maize Workshop of Ethiopia. 12-16 November 2001, Addis Ababa, Ethiopia.
37. Nuss, E. T., Tanumihardjo, S. A. (2010). Maize: a paramount staple crop in the context of global nutrition. Compr. Rev. *Food Sci*. *Food Saf*. **9**: 417–436.
38. Olson, R. A., Sanders, D. H. Maize Production. In: Sprague, G. F. Dudley, J. W. (1988). Corn and corn improvement. American Society of Agronomy, Madison. pp. 639-686.
39. Otegui, M. E. (1995). Prolificacy and grain yield components in modern Argentineans maize hybrids. *Maydica*, **60**: 371-376.
40. Palwal, R.L., (2000). Introduction to maize and its importance: Tropical maize: Improvement and production. Pp 1-3. In: Plant production and protection series No. 28. FAO, Rome.
41. Park, S.U., K.Y. Park., Y.K. Kang., H.J. Moon and S.K. Jong. (1987). Effect of plant density on growth and yield of Sweet corn hybrid. Korean J. Crop Sci., 32: 92-96.
42. Plensicar, M. and R. Kustori. (2005). Corn yield and water use as influenced by irrigation level, N-rate and planting populations. *Trans. Kansan Acad. Sci*., **53** (4): 121-127.
43. Porter, P. D. Hicks, W. Lueschen, J. Ford, D. Warnes, T. Hoverstad, (1997). Corn response to row width and plant population in the northern Corn Belt. *J. Prod. Agric*., **10** (2): 293-300
44. Ray, D. K., Mueller, N. D., West, P. C., Foley, J. A. (2014).Yield trends are insufficient to double global crop production by 2050. PLoS ONE 8, e66428, 2013.
45. Rezuvaev A. I., (1981). Effect of fertilizers on maize productivity in relation to stand density in the voromezh region. Khimiya Selskom Khozyaistve. **19**(7): 7-10. Abstracted in *Field Crop Abst*.**35:** 9648. 1982
46. Rogers I.S., G.J. Lomman, (1988). Effects of plant spacing on yield, size and kernel fill of sweet corn. *Aust. J. Exp. Agron*., **28**: 787-792.
47. Roy, S.K., P.K. Biswas, (1992). Effect of plant density and detopping following silking on cob growth, fodder and grain yield of maize (Zea mays L.) J. Agricultural Science. Abstracted in *Field Crop Abst*., **46**: 1498. 1993.
48. Sangoi, L. and Salvador, R. J. (1998). Influence of plant height and of leaf number on maize production at high plant densities. *Pesqui. Agro. Brasilaria*, **33:** 297–306, 1998.
49. Sangoi, L., Gracietti, M., Rampazzo, C. and Biznchetti, P. (2002). Response of Brazilian maize hybrids from different eras to changes in plant density. *Field Crops Res*.,**79**: 39-51.
50. Scarsbrook, C.E. and Doss, B. D. (1973). Leaf area index and radiation as related to corn yield. *Agron. J*. **65**(3), 459-461.
51. Shafshak, S.E, Salem, M.S, El-Sayed KE, Seif, S.A, Galilah, GY. (1984). Effect of time and intensity of replanting on growth, yield and yield components of maize (Zea mays L.). *Annl. of Agricl., Sci*..;**21**: 209-228.
52. Sharma, T. R. and I. M. Adamu. (1984). The effects of plant population on the yield and yield

attributing characters in maize (Zea mays L.). Zeitschrift fur Acker-und pflanzenbau. 153(4): 315-318. *Field Crops Abst*., **38**: 3437.

53. Tetio-Kagho, F, and Gardner, F. P. (1987). Responses of maize to plant population density: II Reproductive development, yield and yield adjustments. *Agron. J*., **80**: 935-940.
54. Tetio-Kagho, F. and Gardner, F. P., (1988b). Response of maize to plant population density .II. Reproductive development, yield and yield adjustments. *Agron. J*., **80**: 935- 940.
55. Tollenaar, A., Aguilera, A. and Nissanka, S P. (1997). Grain yield is reduced more by weed interference in an old than in a new maize hybrid. *Agron. J.* **89**, 239-246.
56. Ullah, M. J., Islam, M. M., Fatima, K., Mahmud, M. S., Akter, S., Rahman, J. and Quamruzzaman, M. (2016). Comparing modern varieties of white maize with landraces in bangladesh: phenotypic traits and plant characters. *J. Expt. Biosci.* **8** (1):27-40.
57. Westgate, M. E., Forcella, F., Reicosky, D. C. and Somsen, J. (1997). Rapid canopy closure for maize production in the Northern US Corn Belt: Radiation use efficiency and grain. *Field Crops Res*., **49**: 249-258.
58. Zada, I. (1998). The effect of nitrogen on the yield of sweet corn grown under various plant densities. M.Sc (Hons) Thesis, Dept. of Agron. KPK Agric. Univ. Peshawar.