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Sowing date effects on phenology and yield of white maize genotypes during Kharif season under subtropical environment

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ABSTRACT

This study was aimed at evaluating the effect of planting dates on the phenology, morphology, and yield of white maize varieties under a subtropical environment. Four varieties, V_1: PSC 121, V_2: Yangnuo-7, V_3: Youngnau 30 and V_4: Changnuo-6 and three planting dates, S_1: 29 May 2017, S_2: 21 June 2017, and S_3: 6 July 2017 were the treatment variables. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. Data on various phenological, morphological, and yield and yield-related attributes were collected. May sowing took longer days to attain 6-collar leaf and 10-collar leaf stages. The 50% tasselling and 50% silking showed at least 4-5 days early for late sowing in July. Days to maturity were not remarkably affected by the sowing dates, but varietal differences existed. Yungnuo-30 took the longest days to maturity in May sowing. The highest plant height was measured in PSC-121 followed by Changnuo-6 sown in May. The genotype Yungnuo-30 showed a 28.7% reduction in plant height in July sowing. The sowing date had little effect on the number of leaves, but varietal differences in producing leaves were highly significant. It is remarkable that the genotype PSC-121 developed the maximum leaf area at 60 DAS for May planting but produced the least at 90 DAS for June planting. The total dry matter decreased to a great extent for June sowing irrespective of genotypes. The highest dry matter weight was observed from May sowing for the PSC-121 genotype followed by July sowing for the same genotype. Crop sown in May recorded the highest ear weight, the number of grains per cob, grain weight, and seed yield, which were statistically similar with July sowing but June sowing significantly reduced all those parameters. The June planting experienced moisture stress at the early stage of stand establishment. The genotype PSC-121 performed better for all those parameters for May and July sowing, followed by the genotype Yungnuo-30. The highest seed yield (7.35 t ha^{-1}) was obtained in PSC-121 followed by Yungnuo-30 for May sowing. The higher seed weight for May sowing was attributed to higher ear weight and the number of grains per ear. Therefore, sowing of white maize in Kharif season depends of the yield potential of the genotypes and weather conditions for achieving higher production.

INTRODUCTION

Maize is an annual determinate crop having a C_4 carbon fixation pathway (Hussain et al., 2016). It is known as the "Queen of Cereals' due to its high production potential and adaptability to a wide range of environments (Shima et al., 2017; Choudhari and Channappagouda, 2015). The crop contains about 72% starch, 10% protein, 4.0% fat, having higher energy of 365 Kcal/100 than rice and wheat, and is grown throughout the world (Nuss and Tanumihardjo, 2010). FAO reported that the production of maize has increased because of its high demand for feed, food manufactures, food, and bioethanol, corresponding to 54, 19, 13.8, and 14%, respectively. Generally, maize grains are white and yellow types. The white grain is particularly ideal for human feasting because of its delicious nature (Bastola et al., 2021). White maize produces fine-grained flour over yellow

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maize, and it is recognized as a principal food item of many countries in the world. The food items manufactured from white maize are similar to those produced from rice or wheat (Bithy et al., 2020). Most people in Africa generally consume white maize (Nuss et al., 2012). The white maize has an enormous contribution to the nutrition and food security of developing countries. Its consumption in Spain is so intense that some farmers do not use yellow maize as a food in their daily diet. The main source of income for those farmers is the selling of white maize flour in the market and shop (Souza et al., 2008). Market prices are usually slightly higher for white maize compared to the yellow type.

In Bangladesh, maize covers an area of about 0.99 million ha with a production of over 3.29 million tons per year, which is almost exclusively used as livestock feed (BBS, 2019). This estimate is much higher than two decades ago. The increasing area under maize is much rapid due to the expansion of the poultry industry and the development of hybrid maize (Mondal et al., 2014). It is predicted that a large amount of maize production will be required for the increased population in 2050 (UN, 2015; Mukherjee et al., 2011; Alkanda, 2010). Considering the maximum yield gap, 85% maize demand will be fulfilled in 2050 by increasing maize area, allowing an increase in area under maize through a reduction in boro rice areas (Timsina et al., 2018). This scenario will be more favorable if white maize is introduced as a source of the human diet. It is because maize has 2-3 folds yields compared to rice and wheat. Thus, the research organization took the initiative to popularize white maize for its enormous potentials to use as human food in Bangladesh.

Maize is grown both in Rabi and Kharif season (summer), and there is enough scope of bringing the fallow land for the Kharif maize (Ali et al., 2009). During the Kharif season, the temperature is the major factor regulating the phenological response of maize (Hatfield and Prueger, 2015). The phenology of a crop encompasses the relationship between the environmental factors and seasonal changes in respect of growth and development during the life cycle (Varma et al., 2014). It determines the ability of crops to mature and grain set within a growing season and the synchrony of important developmental stages with ambient environmental settings critical for productivity (Kumudini et al., 2014). Identifying suitable high-yielding varieties and planting at the optimum time are the vital factors for future farming with white maize (Liaqat et al., 2018; Ramankutty, 2002). The productivity of maize is highly affected by variety, row spacing, and time of sowing (Anderson et al., 2004). Despite huge potentials to increase the production of white maize in Bangladesh during the Kharif season, there is scanty research information on planting time and high-yielding cultivars of white maize. Therefore, the study was aimed atinvestigating the effect of planting dates on the phenology, yield-related traits, and yield of white maize varieties under a subtropical environment.

MATERIALS AND METHODS

Characteristics of the experimental site

The field experiments were conducted at Sher-e-Bangla Agricultural University Farm, Dhaka, during the Kharif season 2017. It is located at 23º46'41 N"latitude and 90º22'33"E longitude with an elevation of 8.2 meters from the mean sea level. The experimental site lies at Madhupur Tract (Agro-ecological zone - 28) (FAO/UNDP, 1988). Topsoil was clay loam in texture, olive-gray with fine to medium distinct dark yellowish brown mottles having pH 6.5. The experimental area was flat prepared with available irrigation and drainage facilities. The trend of rainfall during the growing period of maize planted on different sowing dates is illustrated in Figure 1.

The maize plants sowing on 29 May and 6 July received a comparatively higher amount of rainfall corresponding to 1857 and 1812 mm, respectively, whereas June sowing received 1684 mm rainfall. From the Figure, the plants sowing in June experienced acute moisture stress because of low rainfall, and crop establishment was little affected. The variation of maximum and minimum temperature for the three growing periods was not remarkable. The average maximum and minimum temperatures were 32.8^{o}C and 26.1^{o}C, respectively.

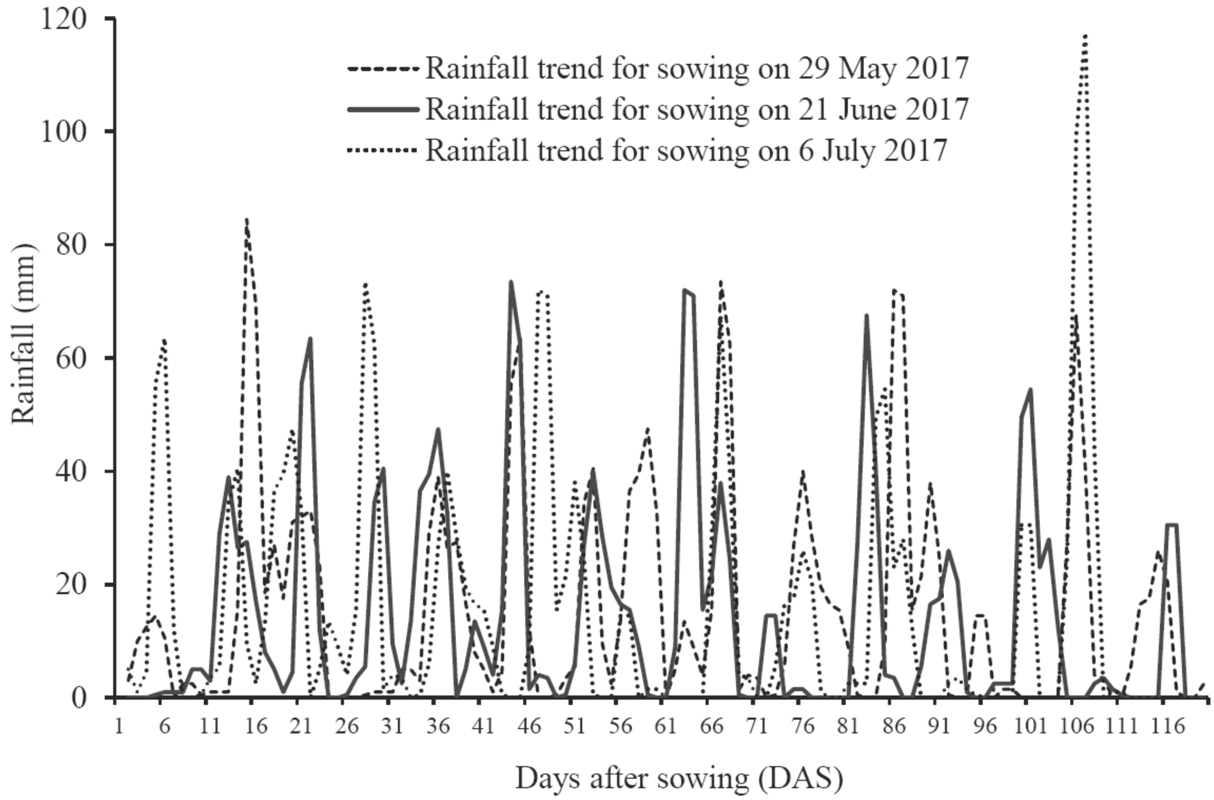

Figure 1: Trend of rainfall during the growing period of four varieties of white maize after their respective date of sowing

Treatments and experimental design

The experimental treatments were as follows: Four varieties (Factor-A) viz. V_1=PSC 121, V_2=Yangnuo-7, V_3=Youngnau 30 and V_4=Changnuo-6; Three planting dates (Factor-B) viz. S_1=29 May 2017, S_2=21 June 2017, and S_3=6 July 2017. The experiment was laid out following Randomized Complete Block Design (RCBD) with three replications. The size of each experimental unit was 2.4×3.5 m^2.

Land preparation and fertilization

The land was prepared with a power tiller plowed several times until it got the desirable tilth condition. After removing stubble and weeds, the land was divided into experimental units as per experimental design. The experimental plots were fertilized with urea, TSP, MoP, gypsum, zinc sulfate, and boric acid as per recommendation (BARI, 2016). One-third of urea and all other fertilizers were applied two days before seeding. The rest of the urea fertilizer was top-dressed in two equal splits of which one-third was top-dressed at the 5-leaf stage and the rest at pre tasselling stage. Besides, cow dung was applied at 5 ton ha^{-1} at the time of final land preparation.

Planting and intercultural operation

Seeds of four varieties were sown on three different planting dates maintaining planting spacing of 60×20 cm. Seeds were treated with Sevin (Bayer Company) at 3.0g/kg before planting. The seedlings were thinned out at 15 DAS by keeping one healthy seedling $hill^{-1}$. The first weeding was done at 25 DAS and the second one at 55 DAS. Earthing up was carried out at 35 and 55 DAS. Irrigation was applied as per crop water need.

Collection of experimental data

The data on the growth, phenology, yield, and yield contributing characteristics were collected.

The number of days to emergence, 6-collar leaf, 10-collar leaf, 50% tasselling, 50% silking, and maturity were recorded. Plant height was measured at harvest from the soil surface to the highest tip of the tassel. The total number of leaves of each plant was counted at harvest. Yield and yield attributes included plant dry weight, ear dry weight, grains/ear, 100-grain weight, and grain yield. Harvest index was calculated as the ratio of grain yield and biological yield.

Statistical analysis

The collected data were analyzed statistically by using the Statistix 10 software package. The Least Significant Difference (LSD) technique at a 5% level of significance was used to compare the mean differences among the treatments.

RESULTS AND DISCUSSION

Phenology of white maize

The highest days to emergence were observed for May sowing, and delay in sowing decreased the days to emergence. The varietal differences in days to emergence were not remarkable.

However, the days to emergence were the highest in May sowing of Yungnuo-30 followed by PSC-121 and a statistically similar result was also found in Changnuo-6. The sowing in July showed a comparatively shorter duration of time to the emergence in almost all the genotypes. According to Banotra et al. (2017), a significant effect of planting times was noticed on days to the emergence ofsweet corn. Almost similar results

Table1: Days to physiological maturity of white maize as influenced by varying sowing dates in Kharif season and varieties

Treatments	Days to emergence	Days to 6-collar stage	Days to 10-collar stage	Days to 50% tasseling	Days to 50% silking	Days to maturity
Sowing dates						
S_1	5.9	21.4	35.6	60.9	69.5	110.3
S_2	5.7	18.9	33.7	57.6	67.0	109.8
S_3	5.6	17.1	32.0	55.5	65.5	110.3
$LSD_{0.05}$	0.09	1.66	2.71	3.90	3.60	8.71
Genotypes						
V_1	5.8	21.6	36.2	60.7	72.3	115.3
V_2	5.6	17.1	29.6	51.9	62.3	95.6
V_3	5.8	18.6	35.9	60.9	68.3	116.2
V_4	5.7	19.2	33.1	58.5	66.3	113.2
$LSD_{0.05}$	0.10	1.91	3.13	4.51	4.16	10.06
Sowing dates × genotypes						
$S_1 \times V_1$	5.9	25.0	38.0	63.3	75.0	115.7
$S_1 \times V_2$	5.7	18.7	31.7	54.9	65.0	95.3
$S_1 \times V_3$	6.0	20.7	37.6	63.9	70.0	116.7
$S_1 \times V_4$	5.8	21.1	34.9	61.5	68.0	113.3
$S_2 \times V_1$	5.8	20.9	36.3	60.6	72.0	115.0
$S_2 \times V_2$	5.6	17.1	29.4	51.3	62.0	95.7
$S_2 \times V_3$	5.7	18.5	35.7	60.3	68.0	116.0
$S_2 \times V_4$	5.7	19.1	33.2	58.3	66.0	112.3
$S_3 \times V_1$	5.7	18.9	34.4	58.2	70.0	115.3
$S_3 \times V_2$	5.5	15.4	27.7	49.5	60.0	95.7
$S_3 \times V_3$	5.7	16.6	34.4	58.5	67.0	116.0
$S_3 \times V_4$	5.6	17.5	31.3	55.8	65.0	114.0
$LSD_{0.05}$	0.19	3.3	5.4	7.8	7.2	17.4

Note: S_1= sown on 29/05/2017, S_2= sown on 21/06/2017, S_3= sown on 06/07/2017; V_1=PSC-121, V_2=Yangnuo-7, V_3= Yungnuo-30, V_4= Changnuo-6.

were found in days to attain 6-collar leaf and 10-collar leaf stages. It reveals that May sowing took longer days to reach the 6-collar leaf and 10-collar leaf stages for almost all the genotypes, and that of July planting took less time to attain those stages. As expected, June plating showed an intermediate period to attain those stages. It indicates that the delay in sowing shortened the vegetative growth of white maize genotypes. Sulochana et al. (2015) observed a longer phenological period in Kharif maize sown on June 15 compared to late-sown crops. The genotypic variation was also noticeable in delaying the period. Days to 50% tasselling and days to 50% silking showed almost similar trends. Irrespective of genotypes, sowing dates affected the number of days to reach 50% tasselling and 50% silking and showed at least 4-5 days early for late plating. Grain fill is the last set of stages of the maize growth cycle. However, the days to maturity were not remarkable for sowing dates, whereas varietal differences were highly noticeable. The longest days to physiological maturity were observed in May sown Yungnuo-30 genotype, followed by PSC-121. The genotype Yungnuo-7 was identified as a short-duration genotype that showed similar growth duration for variable sowing dates. It is well documented that the days to attain various phenological events delayed with late sowing (Shrestha et al., 2016).

Plant height

The effects of sowing dates and white maize genotypes showed significant differences in plant height (Figure 2). In general, plant height decreased with the delay in sowing from May to July. The plant height of maize was reported to increase significantly (13%) when the sowing date shifted from March to May (Maresma et al., 2019). Warm weather during the month of May has stimulatory effects on vegetative growth as observed by Cirilo and Andrade (1994). The genotypes showed differences in plant height, and PSC-121 had the higher plant height for sowing in May and June, followed by Changnuo-6 sown in May. While the lowest plant height was obtained from July sowing Yungnuo-7 genotype. The genotype Yungnuo-30 showed the maximum reduction (28.7%) in plant height, followed by Changnuo-6 for July sowing compared to May sowing. Research results showed that plant height significantly differs with sowing dates and varieties (Buriro et al., 2015) and the early sown maize plants were tallest than late sown plants (Liaqat et al., 2018; Ogbomo and Remison, 2009). The varietal difference in plant heightis a fact that it is genetically controlled.

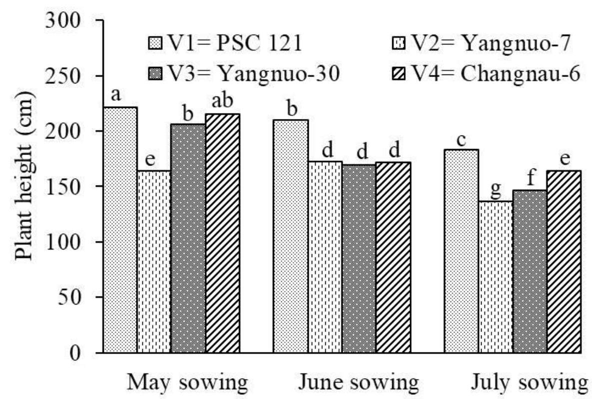

Figure 2: The plant height of white maize as influenced by varying sowing dates in Kharif season and varieties. The different letters indicate statistically significant differences among the mean values at P<0.05 using LSD test

Number of leaves

The sowing date had little effect on the number of leaves, but the varietal effect was highly significant. The interaction effects of sowing dates and the genotypes on the number of leaves were significant (Figure 3). However, Tsimba et al. (2013) reported that delay planting produces fewer leaves, but the reverse was a case reported by Shete et al. (2020). The highest number ofthe leaf was observed in May sowing for Changnuo-6 genotype, followed June sowing genotypes PSC-121 and Changnuo-6. While the lowest number of leaves was obtained from May sowing Yungnuo-7 genotype, followed by June sowing by the same.

Leaf area per plant

The trend of leaf area development of white maize genotypes is illustrated in Figure 4. At the initial growth stage, the genotypes showed slower leaf expansion. After 45 DAS, there exhibited an exponential growth of leaf area that continued up to 90 DAS. Then, the leaf area growth declined till the harvesting period. The Figure also showed the interaction effects of the sowing dates and the genotypes on the leaf area development. From Figure, the leaf area was not significantly affected by the sowing dates and the genotypes at 30 and 45 DAS. Then, it shows a significant variation among the treatments. At 90 DAS, the genotype PSC-121 showed the lowest leaf area irrespective of sowing dates. However, the genotype PSC-121 developed the maximum leaf area at 60 DAS for May planting but produced the least at 90 DAS for June planting. Irrespective of sowing dates, the other genotypes showed almost identical leaf area development at 90 DAS. Tian et al. (2020) observed that the leaf area in maize reached the highest level at the silking stage. They also observed that the mean leaf area was lower in the variety ZND4 before the 12-leaf collar stage but superseded at silking stage compared to the variety ZD958. At the maturity, there existed a wider variation in leaf area development, especially due to the genotype PSC-121. The genotypic variation in leaf area due to planting dates was also reported in maize hybrids grown in different locations of Khyber Pakhtunkhwa Province of Pakistan (Muhammad et al., 2019).

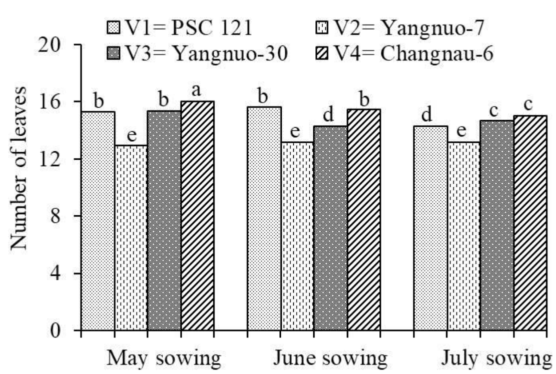

Figure 3: The number of leaves per plant of white maize as influenced by varying sowing dates in Kharif season. The different letters indicate statistically significant differences among the mean values at P<0.05 using LSD test

Dry matter production per plant

The effects of sowing dates and white maize genotypes showed significant differences in total dry matter production at harvest (Figure 5). The total dry matter decreased to a great extent forJune sowing irrespective of genotypes. The highest dry matter weight was observed from May sowing for the PSC-121 genotype followed by July sowing for the same genotype. The statistically similar results were also found from the May and July sowing of the Yungnuo-30 genotype. While the lowest dry weight was obtained from the June sowing for Yungnuo-7. The genotype Yangnuo-7 showed the maximum reduction (21.3%) in dry matter production, followed by PSC-121 (17.1%) for June sowing compared to May sowing.

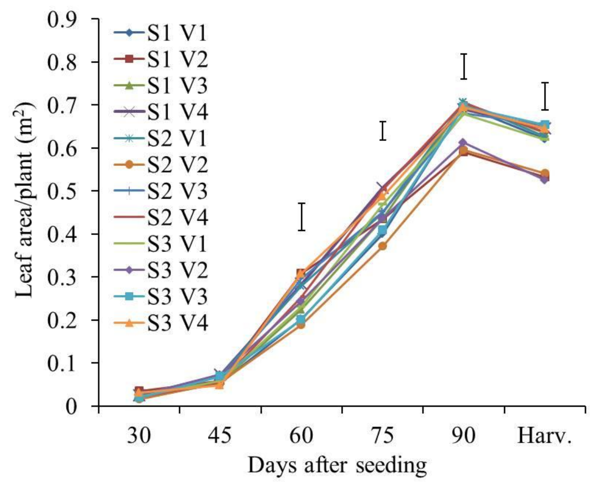

Table 4: Leaf area per plant of white maize as influenced by varying sowing dates in Kharif season and varieties. Notes: S_1= sown on 29/05/2017, S_2= sown on 21/06/2017, S_3= sown on 06/07/2017; V_1=PSC-121, V_2=Yangnuo-7, V_3= Yungnuo-30, V_4= Changnuo-6. Bar indicates LSD 0.05.

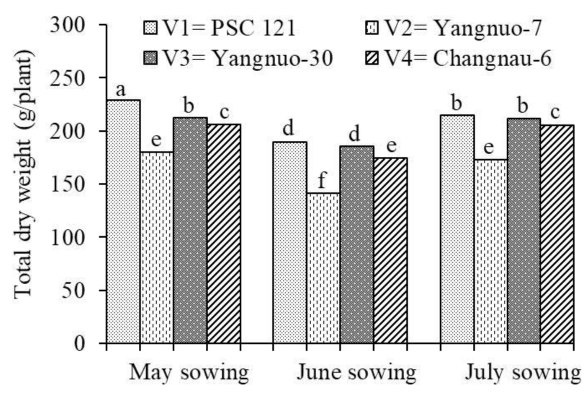

Figure 5: Total dry weight of white maize as influenced by varying sowing dates in Kharif season. Thedifferent letters indicate statistically significant differences among the mean values at P<0.05 using LSD test

Sowing dates and cultivars influenced the dry matter production in maize, and late sowing was found to decrease dry matter production (Opsi et al., 2012). In this study, the cause of the decrease in dry matter production in June is due to comparatively poor stand establishment associated with low rainfall, for which plants experienced moisture stress at the early stage of crop growth.

Yield and yield contributing traits

Ear weight

The genotypes and planting dates, and their interactions had a significant effect onear weight per plant (Table 2). Crop sown in May recorded the highest ear weight, which was statistically similar with July sowing, but June sowing significantly reduced ear weight. Statistically, significant variation was observed for different white maize genotypes in terms ofear weight. The highest ear weight was found in PSC-121, which was statistically similar to that produced in Yungnuo-30. The lowest ear weight was found in Yungnuo-7. The interaction effect of white maize genotypes and planting dates showed significant differences in ear weight. Results showed a significant difference in sowing time and sweet maize on cob dry weight contributing to grain yield (Rah Khosravani et al., 2017). The highest ear weight was observed for May sowing in the PSC-121 genotype, followed by the same sowing date in Yungnuo-30. A statistically similar result was also found for the May sowing of Changnuo-6 genotype. While the lowest weight was obtained for June sowing in Yungnuo-7 followed the Yungnuo-30 genotype.

The number of grains per cob

The sowing date significantly affected the number of grains percob of white maize. Crop sown in May recorded the highest number of grain per cob, which was statistically identical to that produced from July sowing. The lowest number of grains was observed in June sowing. The genotypes showed significant variation in the number of grain percob. The highest grains were found in PSC-121, which was statistically similar to that produced in Yungnuo-30. Both the genotypes were found disease resistant and having yield potential.

The interaction effect of white maize genotypes and planting dates showed significant differences in the number of grain per cob. Buriro et al. (2015) also reported that grains per cob of maize varieties were significantly influenced by the sowing dates. The highest number of grain per cob was observed from the May sowing of the PSC-121 genotype, followed by its July sowing. The lowest number of the grain of cob was obtained in Yungnuo-7 sown in July, followed by June sowing. The higher number of grain per cob under May sowing was attributed to the cob characteristics.

100-seed weight

The planting dates had no significant effects on the 100-seed weight. However, a statistically significant variation was observed for different white maize genotypes interms of 100-seed weight. The highest seed weight was found for PSC-121, which was statistically similar to Changnuo-6, whereas the lowest seed weight was found in Yungnuo-7. The interaction effect of white maize genotypes and planting dates showed significant differences on 100-seed weight. The highest seed weight was recorded from May sowing in PSC-121 followed by PSC-121 sown in July. A statistically similar result was found from the June sowing of the PSC-121 genotype. While the lowest weight was obtained from the treatment combination of June sowing and genotype Yungnuo-7, followed by July sowing genotype.

Seed yield

Planting date had a significant effect on seed yield of white maize genotypes. Cropsown in May noted the highest seed weight (6.34 t ha^{-1}), which was statistically similar (6.16 tha^{-1}) to that of July sowing, but June sowing showed significantly lower (5.70 t ha^{-1}) seed yield. The highest seed weight was found in PSC-121, which was statistically similar to that obtained in Yungnuo-30, whereas the lowest weight was found in Yangnuo-7. The interaction effect of white maize genotypes and planting dates showed significant differences in seed yield. A significant interaction effect of planting dates and varieties on grain yield of maize was also observed by Bk et al. (2018). The highest seed yield (7.35 t ha^{-1}) was observed for May sowing of PSC-121 followed by

Table 2: Yield and yield contributing traits of white maize as influenced by varying sowing dates and genotypes in Kharif season

Treatments	Ear dry wt. (g/plant)	No. of grain /cob	100-grain weight (g)	Grain yield (t/ha)	Harvest index (HI)
Sowing dates					
S_1	102.5	249.3	20.4	6.34	46.4
S_2	73.9	223.8	20.2	5.70	45.5
S_3	98.7	238.5	20.9	6.17	45.0
$LSD_{0.05}$	12.99	22.62	NS	0.52	0.21
Genotypes					
V_1	98.0	311.6	22.3	6.59	45.6
V_2	79.5	172.0	17.7	5.35	45.7
V_3	95.4	234.5	20.8	6.38	45.7
V_4	94.0	230.7	21.1	5.96	45.4
$LSD_{0.05}$	15.00	60.77	2.15	0.60	NS
Sowing dates × Genotypes					
$S_1 \times V_1$	108.4	332.6	22.8	7.35	46.4
$S_1 \times V_2$	89.6	174.7	18.5	5.68	46.4
$S_1 \times V_3$	106.6	214.3	21.0	6.73	46.4
$S_1 \times V_4$	105.6	248.5	21.0	5.60	46.1
$S_2 \times V_1$	81.2	289.2	21.8	5.92	45.4
$S_2 \times V_2$	61.1	172.8	16.9	5.06	45.6
$S_2 \times V_3$	77.3	225.4	21.0	5.98	45.8
$S_2 \times V_4$	75.9	207.8	20.9	5.86	45.2
$S_3 \times V_1$	104.4	312.9	22.2	6.50	45.0
$S_3 \times V_2$	87.9	168.5	17.8	5.31	45.0
$S_3 \times V_3$	102.3	236.8	20.5	6.44	45.0
$S_3 \times V_4$	100.4	235.8	21.2	6.42	45.0
$LSD_{0.05}$	12.53	105.3	3.73	1.04	0.43

Note: S_1= sown on 29/05/2017, S_2= sown on 21/06/2017, S_3= sown on 06/07/2017; V_1=PSC-121, V_2=Yangnuo-7, V_3= Yungnuo-30, V_4= Changnuo-6.

Yungnuo-30 sown in May and a statistically similar result was also obtained for July sowing of PSC-121 genotype. The lowest seed yield was noted for June sowing in Yungnuo-7 followed by July sowing of Yungnuo-7 genotype. The higher seed weight for May sowing was attributed to higher ear weight.

For optimizing yield, sowing at an appropriate time is crucial (Ali et al., 2018; McCutcheon et al., 2001). Maize plants are sensitive to sowing dates, especially the delaying sowing date influenced anthesis silking interval, physiological maturity, and dry matter production resulting in a decrease in maize grain yields (Shrestha et al., 2018; Dekhane et al., 2017). Early sowing maize took more days to attain different phenological stages and produced higher grains ear-1 and grain yield (Ahmed et al., 2011). Similarly, heat use efficiency (HUE) was found higher in the early sowing date (Shrestha et al., 2016). The genotypic responses also varied depending on planting dates. Varieties of maize differed in phenology viz. 50% silking and 50% tasselling and morphology viz. plant height, leaf area, cobs weigh, grains per cob for which biomass and grain yields varied. The results are in confirmation with Liaqat et al. (2018).

Harvest Index

Crop planted in May recorded the highest harvest index (HI), which was statistically superior to June sowing. The varietal differences in HI were not significant. The interaction effect of white maize genotypes and planting dates showed significant differences on HI. Significantly higher harvest indices were observed in May sowing for all the genotypes, followed by June sowing. The lowest HI was obtained for July sowing for all the genotypes. However, Khan et al. (2011) recorded a maximum harvest index of the Azam variety that was planted on 21 June and 26 July.

CONCLUSION

This study reveals that late sowing narrowed down the days to reproductive stages but had no such observation for days to maturity. Sowing at the end of May improves crop productivity through improving yield and yield contributing characters. Conversely, crop sown in June accumulated less amount of dry matter for experiencing moisture stress at early-stage crop establishment, and thereby seed yield declined. However, yield and yield contributing characters improved a lot for July sowing and gave better yield results. It implies that appropriate sowing dates have a significant influence on the yield of white maize. The sowing dates effect on the genotypes were significant, and the genotype PSC-121 performed the best among the four genotypes giving the highest seed yield (7.35 t ha-1) for May sowing. This information may be useful for the farmers in choosing the genotypes and appropriate planting time for white maize cultivation in the subtropical environment.

REFERENCES

Ahmed A, Munsif F, Arif M, Inamullah and Nuaman M (2011). Yield, and yield components ofmaize as affected by sowing dates and sowing methods. FUUAST Journal of Biology, 1: 75-80.

Ali MY, Waddington SR, Timsina J, Hodson D and Dixon J (2009). Maize-rice cropping systems in Bangladesh: Status and research needs. Journal of Agricultural Science and Technology, 3(6): 35-53.

Alkanda AI (2010). Rethinking crop diversification under changing climate, hydrology and food habit in Bangladesh. Journal of Agriculture and Environment for International Development, 104: 3–23.

Anderson WK, Sharma DL, Shackley BJ and D'Antuono MF (2004). Rainfall, sowing time, soiltype and cultivar influence on optimum plant density for wheat in Western Australia. Australian Agriculture Research Journal, 55: 921-930.

BARI (Bangladesh Agricultural Research Institute) (2016). Krishi Projukti Hatboi, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh.

Bastola A, Soti, A, Pandey U, Rana M, Kandel M and Shrestha J (2021).Evaluation of white grainmaize varieties for growth, yield and yield components. Journal of Agriculture and NaturalResources, 4(1): 265-272.

BBS (Bangladesh Bureau of Statistics) (2019). Statistical Yearbook of Bangladesh 2018. 38thed. Statistics and Information Division, Ministry of Planning, Dhaka, Bangladesh.

Bithy PA, Ahamed KU, Shamsuzzaman AMM and Haque MM (2020). Natural mulches effect onthe yield of white maize. International Journal of Plant and Soil Science, 32(19): 1-10.

Bk A, Shrestha J and Subedi R (2018). Grain yield and yield attributing traits of maize genotypesunder different planting dates. Malaysian Journal of Sustainable Agriculture (MJSA), 2(2):6-8.

Buriro M, Bhutto TA, Gandahi AW, Kumbhar IA and Shar MU (2015). Effect of sowing dates ongrowth, yield and grain quality of hybrid maize. Journal of Basic and Applied Sciences, 11:553-558.

Choudhari VV and Channappagouda BB (2015). Effect of organics on morpho-physiological traitsand grain yield of maize (*Zea mays* L.). The Bioscan, 10(1): 339-341.

Cirilo AG and Andrade F (1994). Sowing date and maize productivity: I. Crop growth and drymatter partitioning. Crop Science, 34: 1039-1043.

Hatfield J and Prueger JH (2015). Temperature extremes: Effect on plant growth anddevelopment. Weather and Climate Extremes, 10: 4–10.

Hussain I, Naveed S, Shah S, Rahman AU, Zada H, Ullah I, Khan AA, Din S, Imran C and Growth SU (2016). Growth and yield of Maize varieties as affected by different planting dates in Swat Pakistan. Pure and Applied Biology (PAB), 5(1): 114-120.

Khan JH, Khalil SK, Farhatullah, Khan MY, Israr M and Basir A (2011). Selecting optimum planting date for sweet corn in Peshawar, Pakistan. Sarhad Journal of Agriculture, 27(3): 341-347.

Kumudini S, Andrade FH, Boote KJ and Brown GA (2014). Predicting maize phenology: intercomparison of functions for developmental response to temperature. Agronomy Journal, 106(6): 2087-2097.

Liaqat W, Akmal M and Ali J (2018). Sowing date effect on production of high yielding maize varieties. Sarhad Journal of Agriculture, 34(1): 102-113.

Maresma A, Ballesta A, Santiveri F and Lloveras J (2019). Sowing date affects maize development and yield in irrigated Mediterranean environments. Agriculture, 9: 67.

Mondal MAA, Ahmed S, Amiruzzaman M and Talukdar MZA (2014). Maize in Bangladesh: Trends, Prospects, and Constraints. In: Prasanna BM, Vivek BS, Sadananda AR, Jeffers D, Zaidi PH, Boeber C, Erenstein O, Babu R, Nair SK, Gerard B, Jat ML, Palacios N, Pixley K (eds.). Book of Extended Summaries, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed, Nutrition and Environmental Security. Bangkok, Thailand, October 30-November 1, 2014. CIMMYT, Mexico D.F. and APAARI, Bangkok.

Muhammad A, Basıt A and Misbahullah (2019). Effect of climatic zones and sowing dates on maize emergence and leaf parameters. Acta Ecologica Sinica, 39: 461-466.

Mukherjee N, Choudhury GA, Khan MFA and Islam, AKMS (2011). Implication of changing consumption pattern on food security and water resources in Bangladesh. 3rd Int. Conf. on Water & Flood Management (ICWFM-2011), January 2011, Dhaka, Bangladesh.

Nuss ET, Arscott SA, Bresnahan K, Pixley KV, Rocheford Hotz C, Siamusantu W, Chileshe J and Tanumihardjo SA (2012). Comparative intake of white- versus orange-colored maize by Zambian children in the context of promotion of biofortified maize. Food and Nutrition Bulletin, 33(1): 63-71.

Nuss ET and Tanumihardjo SA (2010). Maize: a paramount staple crop in the context of global nutrition. Comprehensive Reviews in Food Science and Food Safety, 9(4): 417-436.

Ogbomo KE and Remison SU (2009). Growth and yield of maize as influenced by sowing date and poultry manure application. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 37 (1): 199-203.

Rah Khosravani AT, Mansourifar C, Modarres Sanavy, SAM, Asilan KS and Keshavarz H (2017). Effects of sowing date on physiological characteristics, yield and yield components for different maize (*Zea mays* L.) Hybrids. Notulae Scientia Biologicae, 9(1): 143-147.

Ramankutty N, Foley JA, Norman J and Mc Sweeney K (2002). The global distribution of cultivable lands: Current patterns and sensitivity to possible climate change. Global Ecology and Biogeography, 11: 377-392.

Shete PP, Kasal YG and Kakkar L (2020). Effects of sowing dates on the growth and yield of maize crop. European Journal of Molecular and Clinical Medicine, 7(7): 2714-2720.

Shima D, Lee KJ and Lee BW (2017). Response of phenology- and yield-related traits of maize to elevated temperature in a temperate region. The Crop Journal, 5: 305-316.

Shrestha J, Kandel M and Chaudhary A (2018). Effects of planting time on growth, development and productivity of maize (*Zea mays* L.). Journal of Agriculture and Natural Resources, 1(1), 43-50.

Shrestha U, Amgain LP, Karki TB, Dahal KR and Shrestha J (2016). Effect of sowing dates and maize cultivars in growth and yield of maize along with their agro-climatic indices in Nawalparasi, Nepal. Journal of Agricultural Research, 3(1): 57-62.

Souza ARR, Miranda GV, Pereira MG, Vagno de Souza L and Ferreira PL (2008). Agronomic performance of white maize landrace in different environmental conditions. Revista Ceres, 55: 497-503.

Sulochana, Solanki NS, Dhewa JS and Bajia R (2015). Effect of sowing dates on growth, phenology and agro meteorological indices for maize varieties. The Bioscan, 10(3): 1339-1343.

Tian B, Zhu J, Liu X, Huang S and Wang P (2020). Interacting leaf dynamics and environment to optimize maize sowing date in North China Plain. Journal of Integrative Agriculture, 19:1227-1240.

Timsina J, Wolf J, Guilpart N, van Bussel LGJ, Grassini P, Wart J, Hossain A, Rashid H, Islam S and Ittersum MK (2018). Can Bangladesh produce enough cereals to meet future demand? Agricultural Systems, 163: 36-44.

Tsimba R, Edmeades GO, Millner JM and Kemp PD (2013). The effect of planting date on maize grain yields and yield components. Field Crops Research, 150: 135-144.

UN (2015). World Population Prospects 2017. DESA/Population Division, United Nations.https://esa.un.org/unpd/wpp.

Varma VS, Durga KK and Neelima P (2014). Effect of planting date on maize grain yield andquality: a review. Review of Plant Studi.1 (2): 26-38.