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Evaluating the impact of planting dates on seed cotton production across diverse cultivars under variable temperature conditions

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ABSTRACT

Cotton yield in Bangladesh is often constrained by suboptimal planting times under subtropical conditions. The present study aimed to evaluate the impact of planting dates on seed cotton yield across four cultivars to identify the optimal timing for profitable production. A three-replicated field trial was conducted at the Cotton Research Farm in Gazipur using a split-plot design during the cotton growing season of 2022-23. Four cotton cultivars: DM-3, Rupali-1, Suvra, and CB-12 were planted on five dates at 15-day intervals from June to August (viz: 5 June, 20 June, 5 July, 20 July, and 5 August). Results showed that planting on 20 July significantly increased seed cotton yield by 2.580 t ha^{-1} compared to 5 June, while the 5 August planting produced the lowest yield and ginning outturn (8.9%) ($P < 0.01$). Among cultivars, CB-12 achieved the highest yield (2.14 t ha^{-1}), followed by Rupali-1 (1.93 t ha^{-1}) and DM-3 (1.56 t ha^{-1}). Although no significant interaction was observed between planting date and cultivar, CB-12 consistently performed best on 20 July, with similar trends for the other cultivars. The study emphasizes the significance of choosing the most suitable planting dates and cultivars. Adoption of 20 July as the ideal planting date may enhance productivity, offering valuable guidance for cotton growers, researchers, and policymakers.

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1. INTRODUCTION

Cotton (*Gossypium* spp.), a major textile fiber, is crucial for economic and social welfare in Asian countries (Tokel et al., 2022). It provides food, fuel, and fiber sustaining millions of people in various industries, making it the lifeblood of many Asian economies. Bangladesh's history of cotton production, particularly 'Muslin', is renowned due to the country's favorable weather and soil conditions for the production of high-quality fabrics (Mortuza, 2020). Cotton is the main raw material utilized in the textile industry and the second-most significant cash crop in Bangladesh. Bangladesh produced approximately 0.20 million cotton bales in 2021-2022, resulting in 6.35 bales per hectare, equivalent to 218 Kg per bale (Dristy et al., 2024; Tabib, 2023). The Bangladesh Textile Mills Association (BTMA) states that the total demand for cotton in Bangladesh is about 7.0 -8.0 million bales in 2022-2023, with the domestic production only meeting 3 – 4 % of this national demand (CDB, 2023). The textile industries, therefore, are predominantly dependent upon cotton imports. Despite Bangladesh's strong demand for cotton, there is not sufficient supply or production (Fibre2Fashion, 2022). Bangladesh aims to increase cotton production to five times higher by 2030 by introducing new cultivars and increasing cultivation areas (The Business Standard, 2022).

The climate and terrain in Bangladesh make it the ideal place to cultivate cotton trees (Asaduzzaman, 2022). A Baseline Survey Report found that cotton is grown on over 45,000 hectares, producing about 201,272 bales a year in different districts of Bangladesh (Dristy et al., 2024). Compared to the global average of 556 kg lint, Bangladesh's cotton yield is substantially lower, at only 450 kg lint ha^{-1}. This low level productivity of cotton is believed to be mainly due to the delay of planting (Arshad et al., 2021; Bilal et al., 2019;

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M. A. Shah et al., 2017; Singh et al., 2020; Wumbei, 2014) declining soil organic matter, reduced soil fertility, nutrient imbalance, and inappropriate fertilizer uses (Mitu et al., 2025; Ripoche et al., 2015). Cotton crop yield/production depends on the locality, cultivars, agro-ecological-based information, genetic factors, planting times, appropriate fertilizer, and other cultivation and management measures (Rizzo et al., 2022). Among the many factors, regional climate and cotton cultivars are important for increasing cotton production and quality.

Climate variables like temperature, precipitation, humidity, and soil moisture significantly influence cotton quality and productivity. The most effective management systems can be created by optimizing the interplay between plants, the environment, and management techniques. Warm soil is ideal for cotton planting, but planting too soon or too early can lead to poor establishment and increased insect susceptibility. Although early sowing enhances cotton yields and fiber quality, but also increases the risk of disease and insect attacks (Singh et al., 2017). On the other hand, late sowing might lessen these hazards but might produce poorer yields (Najib et al., 2022). Variations in temperature have an impact on fiber quality; late sowing reduces the yield of micronaire and lint but has no effect on the length, strength, or elongation of the fiber. On the other hand, Pettigrew (2002) observed that early planting boosted yields by 22%, and (Khan et al., 2017) reported 26 % higher lint yield, indicating that the sowing/planting date selection depends on the cotton fiber quality and production (Mudassir et al., 2022). Climate patterns and regional insights are crucial for determining the optimal sowing window for cotton production, and adjusting sowing dates can help adapt crops to changing climate patterns (Sankaranarayanan et al., 2020; Wu et al., 2023).

The selection of the appropriate cultivar and other agronomic practices significantly influences the growth and production of the crop. It is essential to utilize the cotton germplasm resources for better quality fiber and yield production (Fatima et al., 2025). Cultivars have a significant effect on yield and its components (T. Shah et al., 2017). Ali et al. (2015) study discovered that seed cotton yield variation in cultivars (Ali Akbar-703 and MNH-886) occurred with different planting dates. The early-planted cotton varieties yielded the maximum seed cotton compared to the late-planted varieties. Seed cotton yield in many countries is below global standards due to low plant population and potential varieties, requiring optimal plant population and morphological characteristics for maximum yield (T. Shah et al., 2017). Ullah et al. (2016) discovered that uncontrollable environmental variables affect cotton growth and development, with CIM-599 yielding the highest, and delayed planting decreasing yield. Akhteruzzaman and Islam (2014) found that cultivars DM-3 and CB-12 yielded the most seed cotton planted on 5 June, while Rupali-1 yielded the most on 20 June, with CB-12 and Suvra being most suitable for the climatic situation of the Hill Tracts region in Bangladesh. Therefore, the optimization of planting dates based on varietal characteristics is crucial for enhancing yield and fiber quality.

Cotton is grown in Bangladesh during the rainy season, with optimal seed planting from July 15th to August 15th, and harvesting between December and March. The crop faces competition from transplant *aman* rice (a major food crop) and other *Rabi* crops in terms of land use under an intensive cultivation system. However, in the growing stage, abundant water encourages vegetative growth and pest infestation. Frequent cloudy days decrease photosynthesis, resulting in poor boll formation. Lack of rain in the later part of the growing stage (October-November) also reduces the yield significantly. Thus, there is a significant discrepancy between potential and average national yield. Farmers are expected to achieve higher yields by picking cotton bolls earlier to grow another crop on the same land. The planting timing, however, is contrasted with early or delayed planting in the changing climate conditions, leading to a question of developing an ideal or optimum planting time for cotton cultivars to get a higher yield without disturbing another important crop. Research is needed to identify optimal sowing dates and suitable cultivars that align with changing temperature and precipitation patterns for optimal cotton production and economic return. This study aimed to optimize cotton cultivation practices by evaluating the effects of early, normal, and late planting times on yield and agronomic traits across different cotton cultivars to enhance yield potential.

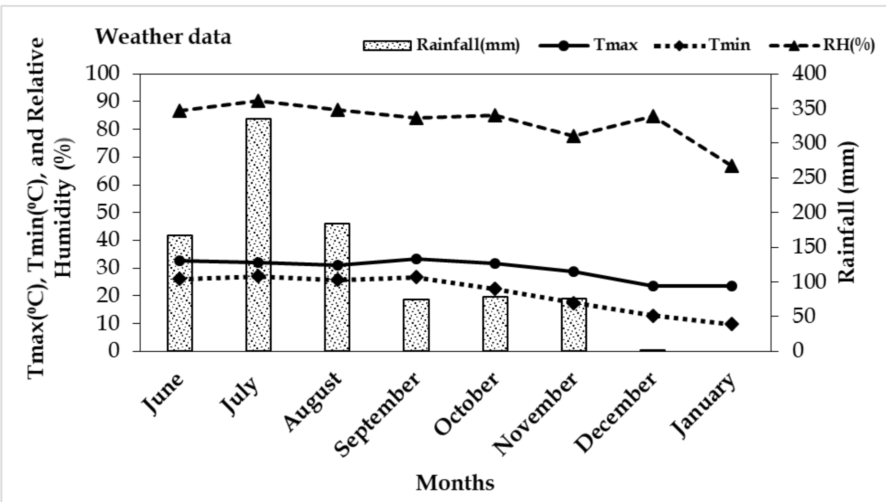

Figure 1. Weather data of relative humidity, rainfall, and air temperatures during the field trial.

2. MATERIALS AND METHODS

2.1. Study location

This experiment was carried out at the Cotton Research Farm at Sreepur, Gazipur, which is situated in the center of the Madhupur Tract of the agro-ecological zone AEZ-28 (between 24.09° N latitude and 90.26° E longitude, an elevated of 8.4 m from sea level). The soil is categorized as Shallow Red-Brown Terrace type under the Salna series within the Inceptisols group (FAO, 1988; Islam et al., 2017). The climatic condition is subtropical, with abundant rainfall between June and September and scant during the winter months. February marks the beginning of the temperature increase, which lasts until September before progressively decreasing in October. Weather data gathered from the experimental site during the field trial, including monthly rainfall, temperature, and humidity, are displayed in Figure 1.

2.2. Experimental design management

The experiment was set up in split-plot design and three replications. The unit plot size measured (5.6 m × 2.7 m) with a row-to-row distance of 90 cm and plant-to-plant 45 cm. The spacing between the plots was 1.0 m. Variety was accommodated in the main plot and planting date was in the subplot. The experimental blocks were separated by 2.0 m. Four cotton cultivars, Viz. DM-3, Rupali-1, Suvra, and CB-12 were established and grown in 5 different planting dates: 5 and 20 June, 5 and 20 July, and 5 August for the evaluation.

2.3. Agronomic and crop management practices

The experimental land was prepared through deep ploughing, harrowing, and laddering to achieve a good tilth. Acidic land was limed 25 days before planting using dolochun. The experiment was laid out in a north-south row orientation, and weeds were removed. Fertilizers were applied according to the Cotton Development Board's recommendation including 95 kg N, 38 kg P, 110 kg K, 12.6 kg S, 3.5 kg Zn, 7.2 kg Mg, and 1.5 kg B ha^{-1}. Management practices were followed during the crop growing period, including gap filling, final thinning, weeding, earthing up, and insecticides. Seed cotton was harvested at full maturity, sun-dried, and weighed. Ginning out turn has been calculated as follows (Eq. 1).

$$\text{Ginning out turn (GOT)} = \frac{weight\ of\ lint}{weight\ of\ seed\ cotton} \times 100 \ldots\ldots[1]$$

(M. A. Shah et al., 2017)

2.4. Statistical analysis

The collected data were arranged in an excel sheet and analyzed (ANOVA) for F variance test was done to check the variability among different treatments. The data was analyzed using a statistical computer program (SPSS, version 16.0). If differences between the means were considered significant at P ≤.05. The study used Duncan's Multiple Range Test (DMRT) to separate means if significant differences were detected at P ≤.05.

3. RESULTS

3.1. Growth attributes

Analysis revealed significant differences for plant height, branches and first flowering across planting dates but first boll bursting was not significantly differed (Table 1). Crops planted on 20 July produced the tallest plant (105.2 cm) and the shortest (83.7 cm) in 5 July, followed by crops planted on 20 June (85.6 cm), 5 August (85.77 cm), and 5 June (87.69 cm). The maximum number of monopodial branches $plant^{-1}$ (1.21) was noted in the crop planted on 20 July, whereas the minimum monopodial branches per plant was noted in the crop planted on 20 June (0.69), which was statistically identical with 5 July (0.73) planted crop. The highest sympodial branches (15.67) per plant noted in the 20 July crop, which was statistically identical with the first planting date (5 June). The time needed for the first blooming of the tested cotton cultivars was greatly impacted by the planting dates, with the longest duration (57.65 days) recorded in the 5 June crop and the shortest mean duration (55.42 days) in the 20 July crop. The varieties also differed significantly in their plant height, monopodial & sympodial branches and first boll bursting in different planting dates but first flowering was not significantly different (Table 1).

Table 1. Impact of variety and planting date on the growth characteristics of cotton

Treatment		Plant height (cm)	Monopodial branches $plant^{-1}$	Sympodial branches $plant^{-1}$	Duration of 1st flowering (days)	Duration of 1st boll bursting (days)
Date of planting	5-June	87.69 b	0.8225 b	14.48 ab	56.83 ab	114.3
	20-June	85.60 b	0.6900 c	13.53 bc	56.92 ab	115.0
	5-July	83.70 b	0.7333 c	13.26 bc	57.65 a	115.1
	20-July	105.2 a	1.217 a	15.67 a	55.42 b	115.3
	5-August	85.77 b	0.8467 b	12.41 c	56.83 ab	115.3
	Level of significance	**	**	**	*	NS
	CV (%)	7.09	12.07	10.70	3.01	3.32
Variety	DM-3	94.06 a	0.7807 b	15.69 a	56.87	114.9 ab
	Rupali-1	98.37 a	0.7200 c	9.314 b	57.13	113.4 b
	Suvra	66.36 b	0.8153 b	14.68 a	57.67	113.2 b
	CB-12	99.58 a	1.132 a	15.81 a	55.25	118.5 a
	Level of significance	**	**	**	NS	*
	CV (%)	7.09	12.07	10.70	3.01	3.32

Variety CB-12 showed the maximum plant height (99.58 cm) followed by variety Rupali-1 (98.37 cm) and DM-3 (94.06 cm) which were statistically identical. The shortest plant was recorded in the variety Suvra (66.36 cm). The CB-12 variety had the highest number of monopodial branches (1.13 plant^{-1}), while the Rupali-1 variety had the lowest (0.72). Variety CB-12 showed the highest sympodial branches plant^{-1} (15.81) followed by DM-3 (15.69) and Suvra (14.68) which were statistically identical. The Rupali-1 variety was found to have the minimum sympodial branches plant^{-1} at 9.31. Among the cotton varieties, boll bursting duration of CB-12 was the longest (118.5 days) followed by DM-3 (114.9 days). The shortest duration was recorded in var. Suvra (113.2 days) which was similar to var. Rupali-1 (113.4 days). First flowering of cotton varieties did not differ significantly. Among the evaluated cotton varieties, CB-12 showed the shortest (55.25 days) mean duration of first flowering. The CB-12 cotton variety demonstrated the shortest mean duration of first flowering among the evaluated varieties, lasting 55.25 days.

The study found that the combination of variety and planting date significantly impacted plant height, monopodial and sympodial branches, but not first flowering and first boll bursting. The highest plant height was achieved by var. CB-12 on 20 July planting, while the minimum was found in var. Suvra on 5 June. The highest monopodial branches plant^{-1} was achieved by var. Rupali-1 on 5 August. The maximum sympodial branches plant^{-1} was achieved by var. CB-12 on 20 July, and was similar to var. DM-3 on the same date.

3.2. Yield contributing characters

Bolls plant^{-1} is crucial component for managing seed cotton yield variations, making selection for a larger number essential for cotton improvement. The statistical analysis revealed that planting dates significantly impacted the number of bolls plant^{-1}, boll weight, and 100-seed weight (Table 2). The crop with the highest bolls plant^{-1} (30.30), boll weight (5.38 g), and highest seed weight was planted on 20 July, while the minimum bolls plant^{-1} (20.57) and lowest seed weight (4.53 g) were planted on 5 July and 5 August (Table 2).

The cultivars showed significant differences in the number of bolls per plant and the weight of single bolls. CB-12 had the highest number of bolls and boll weight (5.09 g), while DM-3 had the lowest (16.63 and 4.25 g) bolls. Significant differences in 100-seed weight were not found due to cotton varieties. The seed weight of var. Suvra was the highest at 11.0 g, while the lowest was recorded in DM-3 at 10.42 g (Table 2).

The study reveals that the variety and planting date significantly impact the number of bolls plant^{-1}, boll weight, and 100-seed weight (Table 3). The highest number of bolls (34.0 plant^{-1}) was found in var. CB-12 planted on 5 June, while the minimum number (4.03) was in var. DM-3 on the first planting date. The highest boll weight was obtained by var. CB-12 planted on 20 July, similar to var. Rupali-1. The highest seed weight (12.0 g) was obtained by var. CB-12 planted on 20 July, which was statistically identical with var. Rupali-1 and var. Suvra on the same date of planting (Table 3).

3.3. Seed cotton yield

The seed cotton yield is greatly influenced by planting date and variety. The highest yield was observed on 20 July due to increased bolls and boll weight, resulting from favorable environmental conditions. The lowest yield was observed on 5 August. The average rainfall in June was lower than in July, but during the first week of July, the rainfall was higher, reducing the number of plant population and bolls, ultimately reducing seed cotton yield. However, after mid-July, the rainfall gradually decreased, allowing for better plant establishment and higher seed cotton yield (Fig. 3). The study revealed significant variations in seed cotton yield among different cotton varieties (Fig. 2). CB-12 had the highest yield (2.14 t ha^{-1}), at the same time DM-3 had the lowest (1.56 t ha^{-1}). Rupali-1 had the second-highest yield (1.93 t ha^{-1}). On the other hand, planting date and variety interactions did not substantially affect the yield of seed cotton. CB-12 yielded the highest (2.74 t ha^{-1}) on 20 July, and with earlier or later planting, the yield decreased significantly. Similar trends were observed for Rupali-1, Suvra, and DM-3 on 20 July (Fig. 2).

Table 2. Impact of planting date and variety on cotton yield and its contributing characteristics

Treatment		Bolls number plant^{-1}	Weight of single boll (g)	100 seed weight (g)	GOT (%)
Date of Planting	5 June	23.51 b	4.62 b	10.27 c	44.58 a
	20 June	22.25 bc	4.60 b	10.50 c	42.95 a
	5 July	20.57 d	4.53 b	11.00 b	44.17 a
	20 July	30.30 a	5.38 a	11.75 a	43.10 a
	5 August	20.78 cd	4.79 b	10.25 c	34.05 b
	Level of significance	**	**	**	**
	CV (%)	7.96	6.94	4.84	4.96
Variety	DM-3	16.63 d	4.26 c	10.42	41.62 b
	Rupali-1	25.41 b	4.76 b	10.80	44.34 a
	Suvra	23.89 c	5.03 a	11.00	39.10 c
	CB-12	27.99 a	5.09 a	10.80	42.02 b
	Level of significance	**	**	NS	**
	CV (%)	7.96	6.94	4.84	4.96

Table 3. Interaction of planting date and variety with yield and yield-contributing characters

Interaction (V×D)	Monopod plant^{-1}	Sympod plant^{-1}	Duration of 1st flower	Duration of 1st boll bursting	Number of bolls plant^{-1}	Single boll weight (g)	100-seed weight (g)	GOT (%)
$V_{1x}D_1$	0.770fgh	16.20 abc	56.00	114.3	4.03 k	4.26 de	10.10 b	43.70 abc
$V_{1x}D_2$	0.500 j	15.33 abcd	56.67	111.7	16.00 ij	4.133 e	10.00 b	41.40 bcd
$V_{1x}D_3$	0.566 ij	14.47 bcd	58.00	116.0	14.00 j	4.13 e	11.00 b	43.30 abc
$V_{1x}D_4$	1.30 ab	17.40 a	56.33	115.7	32.00 ab	4.63 cde	11.00 ab	43.60 abc
$V_{1x}D_5$	0.767 fgh	15.03 abcd	57.33	116.7	17.13 hij	4.13 e	10.00 b	36.10 e
$V_{2x}D_1$	0.870 efg	11.63 ef	58.33	109.7	28.00 cd	4.43 cde	10.00 b	46.40 a
$V_{2x}D_2$	0.730 ghi	7.87 gh	58.00	115.7	23.00 fg	4.87bcd	11.00 b	46.00 a
$V_{2x}D_3$	0.670 hij	10.17 fg	57.67	116.3	22.83 fg	4.43cde	11.00 b	45.90 a
$V_{2x}D_4$	1.03 cde	11.33 ef	55.33	115.0	29.20 bc	5.60a	12.00 a	45.20 ab
$V_{2x}D_5$	0.300 k	5.57 h	56.33	110.3	24.00 ef	4.46cde	10.00 b	38.20 de
$V_{3x}D_1$	0.550 ij	13.57 cde	57.33	115.3	28.00 cd	5.36 ab	11.00 b	45.80 a
$V_{3x}D_2$	0.600 hij	14.90 abcd	56.67	114.0	25.00 def	4.46 cde	10.00 b	43.60 abc
$V_{3x}D_3$	0.567 ij	13.23 de	60.00	109.7	18.43 hi	4.60 cde	11.00 ab	43.90 abc
$V_{3x}D_4$	1.33 a	16.53 ab	56.00	111.7	28.00 cd	5.46 ab	12.00 a	43.00 abc
$V_{3x}D_5$	1.03 cde	15.17 abcd	58.33	115.3	20.00 gh	5.27 ab	11.00 b	19.20 f
$V_{4x}D_1$	1.10 cd	16.53 ab	55.67	117.7	34.00 a	4.43 cde	10.00 b	42.40 abc
$V_{4x}D_2$	0.930 def	16.03 abcd	56.33	118.7	25.00 def	4.93 bc	11.00 ab	40.80 cd
$V_{4x}D_3$	1.13 bc	15.17 abcd	54.93	118.5	27.00 cde	4.96 bc	11.00 ab	43.60 abc
$V_{4x}D_4$	1.21 abc	17.43 a	54.00	119.0	32.00 ab	5.83 a	12.00 a	40.60 cd
$V_{4x}D_5$	1.29 ab	13.87 bcde	55.33	118.7	21.97 fg	5.30 ab	10.00 b	42.70 abc
Level of significance	**	*	NS	NS	**	**	*	**
CV (%)	12.07	10.70	3.01	3.32	7.96	6.94	4.84	4.96

Remarks: the DMRT indicates that figures with similar letters do not differ significantly, while figures with dissimilar letters do, with a 1% level of probability (**) and a 5% level of probability (*). NS= Not significant. Planting date: D_1= 5 June, D_2= 20 June, D_3= 5 July, D_4= 20 July and D_5= 5 August, Varieties: V_1= DM-3, V_2= Rupali-1, V_3= Suvra and V_4= CB-12.

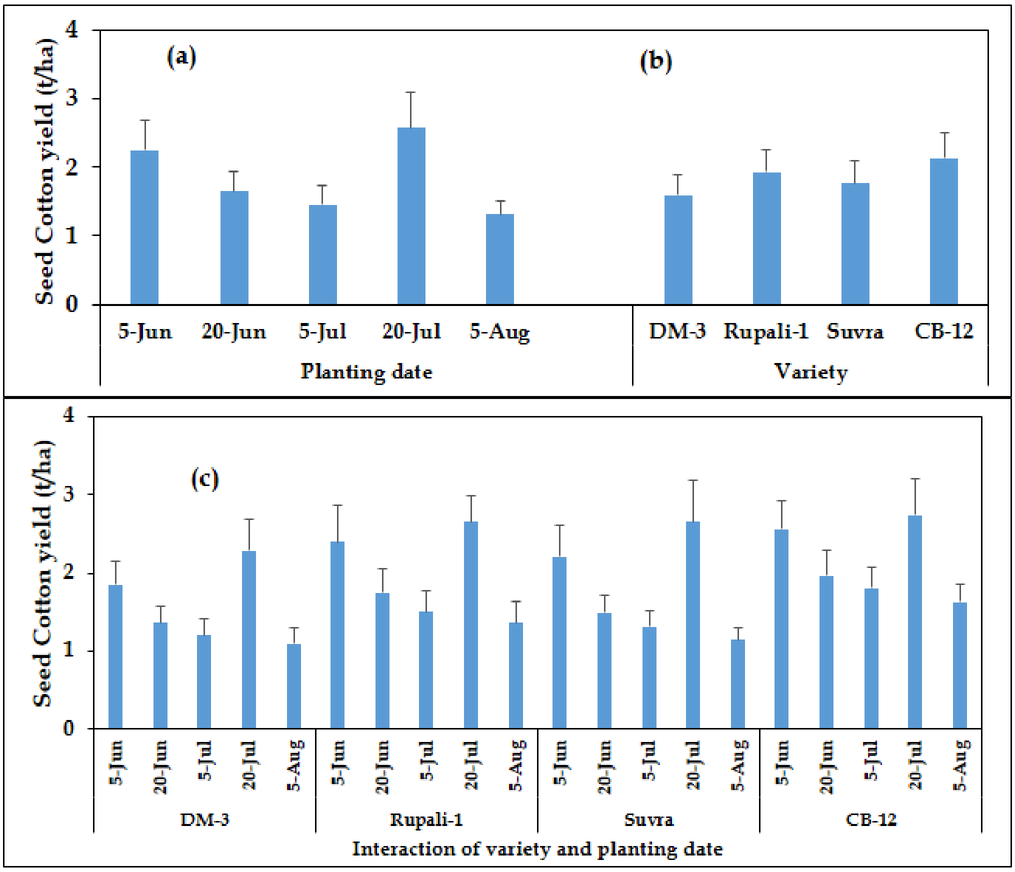

Figure 2. Impact of planting date (a), variety (b), and their combination (c) on the yield of seed cotton

3.4. Ginning out turn (GOT)

The GOT is a key consideration in cotton production. The data analysis revealed significant variations in GOT based on the planting date of cotton (Table 2). The lowest GOT (34.05%) was recorded on 5 August i.e. last planting date and the highest GOT (44.58%) was found on 5 June, which was statistically identical to the rest of the planting dates. The variety also differed significantly regarding GOT. Variety Rupali-1 showed the highest GOT (44.34%) and the minimum GOT was recorded in the variety Suvra (39.10%). The combination of planting time and cultivar had a substantial impact on GOT (Table 3). Var. Rupali-1 achieved the highest GOT on all planting dates except for August 5.

4. DISCUSSION

Cotton, a perennial plant, is highly sensitive to environmental factors (Noreen et al., 2020; Rehman & Farooq, 2019; Saeed et al., 2021) and requires a long growing season. Cotton growth, production, and quality are influenced by a number of factors, including variety, environment, and agronomic practices. Planting time, a predictable and human-controlled variable, significantly affects seed cotton yield (Abbas et al., 2019; Ali et al., 2015; Zhou et al., 2024). Early planting can cause adverse conditions to negative germination along with seedling growth, while warm soil conditions are essential for high yield and high-quality fiber (Reddy et al., 2017; Ul-Allah et al., 2021). Climatic variations in the cotton growing season significantly influence yield and fiber quality. Early planting can increase cotton yield by reducing moisture stress and crop improvement, while late planting can decline yield to a significant level through disrupting vegetative growth reduced lint quality in cotton. Regional climatic variations influence the crop growth, yield and productivity through variable planting time and different cultivars (Akhteruzzaman & Islam, 2014; Istipliler et al., 2024). The knowledge about the optimal planting time for new cultivars in a given area is crucial for understanding crop output and adapting to climate change conditions. However, an investigation is necessary to explore the optimal planting time for cotton cultivars in diverse climatic conditions for best crop production management. Therefore, the planting time with cotton cultivars were selected to find the best combination.

Planting cotton when soil temperatures are warm is recommended to avoid poor stands. Planting time also impacts plant height, fruiting branches, individual boll weight, and seed cotton yield (Akhteruzzaman & Islam, 2014). Cotton crops respond to their growing environment through an indeterminate growth habit, changing their canopy structure based on factor like planting density and sowing time (Chen et al., 2014; Yang et al., 2014). It is essential to sow at the right time to accommodate the growing season and cultivar maturity length to maximize yield (Andarzian et al., 2015). Planting date, either early or late, impacts seed cotton yield by the incidence variation of cotton and pink boll worms and some predators (Attia et al., 2021). Therefore, optimum planting time determination and suitable variety selection for specific growing regions are crucial for high yield and high-quality cotton production. Variety plays a significant role in seed cotton yield $plant^{-1}$.

The study revealed that the quantity of bolls in cotton, the weight of individual bolls, and the seed cotton yield significantly influence the yield. The highest yield was recorded in variety CB-12, with 2.14 t ha^{-1}. The highest yield was recorded on July 20th at 2.58 t ha^{-1}, at the same time the lowest yield was recorded on August 5th at 1.31 t ha^{-1}. According to earlier studies (Guo et al., 2024; Jamro et al., 2017; Najib et al., 2022), the yield of seed cotton drastically decreased when planting was postponed. Iqbal et al. (2023) and Kassambara et al. (2024) also reported similar findings. Our study found that Variety CB-12 outperformed other varieties at all planting dates (Table 3), aligning with previous research by Kakar et al. (2012); Huang (2016); Salih (2019); and Iqbal et al. (2024). Cotton production is influenced by planting dates, boll weight, and boll formation, making it crucial to select the right planting time for optimal growth due to delicate nature.

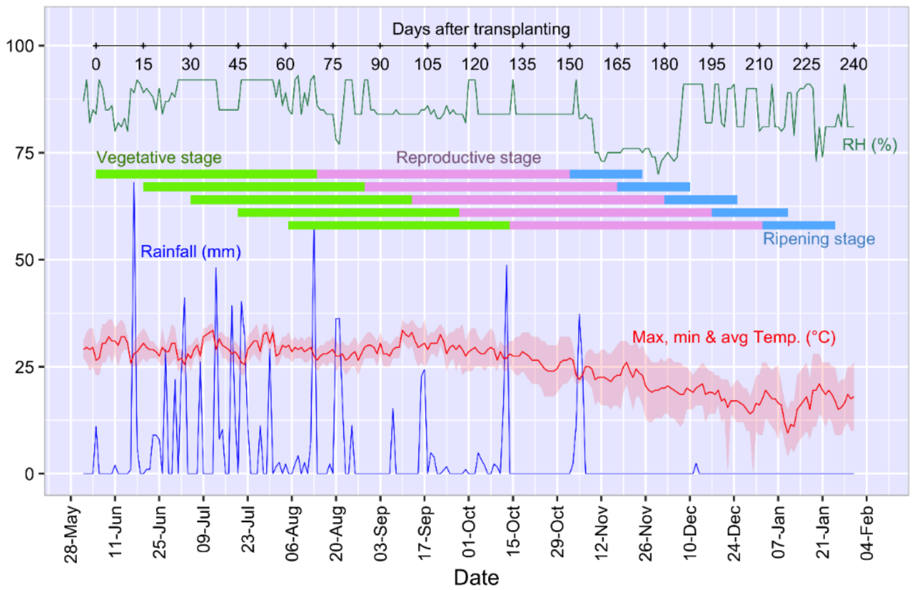

Figure 3. Effect of weather on the different physiological stages of cotton at varying planting date.

A study revealed that increasing the planting date by 15 days from early to optimal yield significantly increased cotton yield by 93.58 kg ha^{-1} (Ullah et al., 2016). However, delay in planting also resulted in lower yield. Early planting is crucial to reduce fruit loss and abortion during hot, humid monsoon weather, resulting in lower yield potential (Dietz et al., 2021; Godara et al., 2023). Cotton yield and its quality decreased with later planting dates, possibly due to insect vulnerability and bad weather (Godara et al., 2023). Sowing date significantly impacts cotton growth and development, particularly during flower initiation and development, leading to delayed crop maturity (Hu et al., 2017). The effect of climatic conditions like rainfall, temperature and humidity on the physiological stages of the studied cotton cultivars are illustrated in Figure 3. Late planting, such as 5 August in our study extends vegetative growth and ball formation in cooler weather leading yield reduction. Late planting can delay onset of flower and prolong boll setting time in crops compared to regular/optimum planting (Hu et al., 2017; Muharam et al., 2014). Cotton, a crop with a long growing season, often faces adverse conditions during the early stages of seedling development and germination due to early planting dates (Fig. 3). Cotton seeds need warm soil to provide a good yield and high-quality fiber. Planting cotton should start when the soil is sufficient warm to support a crop of healthy seedlings establishment, as over sowing can lead to poor stands. Both early and delayed cotton planting can reduce yields due to suboptimal heat unit accumulation during critical growth stages. Early planting crops exposes to cooler weather, while delayed planting reduces the time available for boll development, leading to lower yields (Fan et al., 2024). Delaying sowing exposes cotton plants to high temperatures during critical stages, reducing yield and quality (Iqbal et al., 2021). Therefore, selecting an optimal planting date is essential for maximum cotton yield and its quality.

Early cotton planting optimizes soil and agro-environmental resources, leading to improved yields. It capitalizes on available resources before high temperatures, enhances photosynthetic efficiency, reduces pest and disease pressure, and extends the growing season, allowing more bolls to develop and mature, ultimately increasing seed cotton yield (Hussain et al., 2022; Iqbal et al., 2021). Research shows that planting cotton early increases both seed cotton and lint yields (Kassambara et al., 2024; Tlatlaa et al., 2024), while late planting leads to reduced yield due to low temperature and inadequate light interception (Guo et al., 2024; Khan et al., 2017; Liu et al., 2015; Monpara & Vaghasia, 2016).

This study found a significant cultivar effect and interaction between cultivars and planting date effect (Table 3). Seed cotton yield is influenced by planting date and variety, with the highest yield on 20 July due to favorable environmental conditions. The lowest yield was on 5 August. During the first week of July, higher rainfall reduced plant population and bolls, but decreased after mid-July. The first flowering and first boll bursting were non-significant to cultivars and planting time interaction (Table 3) while 1000-seed weight was significant ($P<0.01$). Crop planting dates significantly impact growth and development by altering light, temperature, and water environments during various growth periods (Li et al., 2021; Zimmermann et al., 2017). Different cotton varieties yielded different amounts of cotton, with CB-12 having the highest yield. Seed cotton production is significantly impacted by reproductive and vegetative stages, with planting time significantly affecting growth (Fig. 3). Late planting leads to decreased yield, insect vulnerability, and fewer stands which are caused by cold weather (Iqbal et al., 2023). In our study, we have seen that in case of early planting, cotton matures at comparatively higher temperature that the cases in late planting stage (Fig. 3). Later the planting dates lower the temperature during maturity stages during flowering and ball development leading to yield loss (Guo et al., 2023; Sui et al., 2018; Wu et al., 2022). Similar results also observed by Sankaranarayanan et al. (2020) who reported yield variation of cotton cultivars in different sowing date.

GOT, a crucial quality parameter in cotton crops, is affected by sowing time and variety selection. Statistical results show significant differences in ginning out-turn based on varieties ($P<0.05$) (Table 2), while sowing dates and interaction between varieties have significant effects ($P>0.05$) (Table 3). The GOT (Ginning out-turn) cotton production significantly impacts the planting date, with the highest GOT (44.58%) observed in June. Varieties Rupali-1 and Suvra showed significant differences in GOT, with Var. Rupali-1 achieving the highest GOT on all dates excluding August 5. The variation of GOT in cotton cultivars also observed with the interaction of variety and planting time in different combination (Jamro et al., 2017). This differences in Ginning out-turn indicates that, it is closely linked to crop genetic diversity, with management practices and input quantities being less significant.

Climate change poses significant threats to agriculture, particularly cotton production, due to various environmental factors like temperature, rainfall, etc. Planting at the right time can improve water use and reduce climate change impact (Srivastava et al., 2022). Cotton crop planting date is crucial due to temperature variability and ecological regions, with optimum planting time being the most manageable factor for new cultivars. The present planting date practices by producers in Gazipur cotton producing region are from mid-June to mid –July, with a slight variation due to climatic influences and cultivars (CDB, 2025). Planting between ends of July to the early May is a strategy to address water scarcity and climate change, but later dates could no align with optimal production (Akhteruzzaman & Islam, 2014). From this experiment, the results found that yield varies based on cultivar. Our findings support the consideration of appropriate planting date and selection of suitable cultivars for better agronomic practices and higher cotton yield.

5. CONCLUSION

The study aimed to assess the influence of planting time and cultivars on cotton production in the subtropical climatic conditions of Cotton Research Farm, Gazipur, Bangladesh. The study concluded that cotton variety CB-12 exhibited superior performance in terms of plant height, number of sympodial branches, and seed cotton yield. The 20 July planting date resulted in the highest number of sympodial and monopodial branches, as well as the highest seed cotton yield and ginning outturn (GOT), with CB-12 consistently outperforming other varieties. These findings suggest that adopting CB-12 and aligning planting schedules with the 20 July window can significantly enhance cotton productivity. Therefore, for maximizing seed cotton yield, CB-12 combined with a 20 July planting date is recommended as the optimal variety and planting strategy under similar agro-climatic conditions. The study's findings could help cotton farmers, agricultural researchers, and stakeholders in improving extension services, reducing import dependency, and lowering manufacturing costs for economic growth and sustainable agricultural development. Furthermore, the continuous research and monitoring are crucial for continuously refining and adapting recommendations based on changing agricultural, climatic and market conditions.

Declaration of Competing Interest

The authors declare that no competing financial or personal interests may appear to influence the work reported in this paper.

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