Original Research Article

Influence of planting time and variety on the growth, development, and yield of Tomato

Abstract: Tomato growth and reproductive properties, particularly fruit yield, are significantly influenced by planting time. In this study, eight open-pollinated tomato cultivars at two different planting periods (December 18, 2019 and January 18, 2020) were used to determine the most effective planting time for tomato cultivation. Different sowing dates and varieties have a substantial impact on tomato yield. The highest number of fruits per plant were recorded in BARI tomato-3 (46.87), followed by BARI tomato-14 (43.22), while the minimum in Marglobe (13.00) in December planting. Khattabegun variety had the highest number of fruits per plant (14.17), followed by BARI tomato-3 (14.02) and BARI tomato-14 (13.97) in January planting. BARI tomato-14 produced the highest yield (38.55 ton/ha), followed by BARI tomato-3 (38.16 ton/ha) in December planting, while the lowest yield was found in Riograndi (9.17 ton/ha). In January planting, the maximum yield was found in BARI tomato-15 (12.10 tons/ha), while the minimum yield was observed in Khattabegun (6.25 tons/ha). Considering the features that contribute to increase yield and disease tolerance, the combination of December planting with BARI Tomato-14 is lucrative.

Key words: Tomato (*Solanum lycopersicum* L.); planting time; variety; yield; diseases tolerance; pests tolerance

1. Introduction

Tomato (*Solanum lycopersicum* L.) is the World's second most significant and consumed vegetable crop, with a global production of 186,821,216 metric tons and cultivated on 5,051,983 hectares in 2020 (FAOSTAT, 2022). Because of its multiple uses, nutritional advantages, and the rapid changes in global food systems, the tomato is currently the most important marketable vegetable crop in the world (FAOSTAT, 2022; Vats et al., 2020). Annual tomato output has expanded by more than six-fold in the previous fifty years, while global traffic in tomatoes and tomato products has increased by about tenfold. Furthermore, from 1961 to 2018 per capita, tomato consumption increased dramatically from 8 kg to 21.17 kg per day (FAOSTAT, 2020). Tomatoes contribute significantly to human nutrition since they are a good source of vitamins, essential minerals, macronutrients, bioactive compounds, and antioxidants, all of which help to prevent cancer, cardiovascular disease, eye, nerve, and other diseases (Alam et al., 2019; Asiry et al. 2022; Hossain et al., 2019; Huda et al., 2022; Sommer and Vyas, 2012; Tomlinson et al., 2017; Vats et al., 2020; Young and Lowe, 2018).

Tomato quality is affected by climate, growing medium and plant nutrition (Jankauskieno, 2013). Planting periods are highly correlated with local climatic variability. Different sowing dates and types have a significant effect on tomato yield (Rahman et al., 2020). Plant maturity, harvesting time, yield, and crop quality can all be affected by planting time. At the pre-flowering and blooming stages, the high temperature (32^0C) significantly reduced photosynthetic rate, number of fruits, individual fruit weight, and fruit output per plant. Temperature impacts were more during blooming than pre-flowering (Islam, 2011).

Agronomic practices have long been recognized as critical to crop nutrition (Barrett et al., 2007; Souri and Dehnavard, 2018). The nutritional value of tomatoes is controlled by the tomato variety and harvest maturity (Erba et al., 2013). Delayed planting reduces tomato plant height, fruit set, fruit weight, and yield. Appropriate planting dates boost production while improving vegetable quality (Kleinhenz and Wszelaki, 2003). It is in high demand throughout the year, while most of the tomato production in Bangladesh takes place in winter (Biswas et al., 2017; Islam et al., 2017). The planting time also affects the fruit yield and quality (Tomar et al., 2018).

In the eastern side of Bangladesh, including the Chittagong Hill Tracts areas, farmers have been cultivating tomato between October to March without knowing the best time for planting tomatoes. Due to a lack of knowledge of planting time, the tomato growers had not got maximum production though they used modern varieties. Therefore, the experiment was conducted to investigate the impact of planting times and varieties on tomato performance in the eastern regions of Bangladesh.

2. Materials and methods

The experiment was conducted during Robi season of 2019-2020 at the RARS research field, Hathazari, Chittagong, Bangladesh. During the experimental period, the data of different environmental factors i.e., maximum and minimum rainfall, maximum and minimum temperature, and relative humidity (RH) was obtained from weather station of RARS research field, Hathazari (Table 1). A total of eight tomato varieties, including four BARI varieties (BARI tomato 2, BARI tomato 3, BARI tomato 14, and BARI tomato 15) and four commercial varieties (Marglobe, Roma VF, Riograndi, and Khattabegun), were used in this study. December 18, 2019 and January 18, 2020 were the dates for the first and second plantings, respectively of 30-days old seedlings in the

main field. Planting period and varietal effect were used as variables in the experiment with a split-plot design. Plot dimensions were 4m × 3m with a spacing of 70cm × 45cm. Urea, TSP, MoP, and Gypsum were applied at 500kg, 200kg, 200kg, and 100kg per hectare of land, respectively, in addition to the 10 tons of cow manure. Half of the cow dung, all TSP, and all MoP were applied to the land during final land preparation. The remaining cow manure was utilized to prepare the pit. The total amount of urea was applied in three equal instalments at 21, 35, and 45 days. Intercultural operations were carried out when needed. Days to 50% flowering, plant height at first harvest, individual fruit weight, length and breadth, and fruits per plant were recorded. The CROP STAT application was used to analyse the collected data. Before analysis, disease and insect infestation data were square-root ([x + 0.5]) normalized and the original values were given in parenthesis.

3. Results

There were significant differences among the variables in Table 2, Table 3, and Table 4. Some crucial parameters showed significant differences in tomato varieties. Plant height at first harvest was found to be significantly affected by the relation between planting times and varieties. Local tomato variety Khattabegun was proven to have the highest plant height (118.40 cm and 108.84 cm) at both planting times, whereas BARI tomato-14 was shown to have the second-highest plant height (111.47 cm and 91.07 cm). The commercial variety Roma VF was found to have the lowest plant height at both planting times (46.15cm and 41.01cm). Days of 50% flowering significantly affected by both planting times and varieties. Roma VF took the maximum number of days (50.67 and 41.49) to reach 50% flowering, whereas BARI tomato 2 required the minimum number of days (50.67 and 41.49) to reach 50% flowering (Table 2).

The number of fruit clusters per plant showed a significant effect. Riograndi had the highest number of fruit clusters per plant (12.15), followed by BARI tomato 14, BARI tomato 15, and BARI tomato 3 (10.67, 10.47, and 10.27, respectively) in December planting. During the initial planting, Khattabegunes had the lowest number of fruit clusters per plant (6.24) (Table 2).

There was a significant correlation between planting time and the number of fruits per plant. In the initial planting, BARI tomato-3 had the highest number of fruits per plant (46.87), followed by BARI tomato-14 (43.22), while Marglobe had the fewest number of fruits per plant (13.00). During the second planting time, BARI tomato-3 and BARI tomato-14 were second and third with 14.02 and 13.97 fruits per plant, respectively.

Yield per plot showed significant differences in both planting times and varieties. In December planting, BARI tomato-14 had the highest yield per plot (48.26 kg), followed by BARI tomato-3 (46.33kg), while lowest yield per plots was recorded in Riograndi (10.77 kg). For second planting, BARI tomato-15 produced the highest yields per plot (14.30 kg), while Khattabegun production was the lowest (7.5kg) (Table 2).

Individual fruit weight was significantly affected by planting times and varieties. Individual fruit weights of 168.54gm and 97.29gm were recorded for Marglobe, while 70.49gm and 63.53gm were recorded for Khattabegunes in December and January, respectively (Table 3). For fruit length, there was a strong time-variety relation but planting time had no significant effect. The maximum fruit length was recorded in Marglobe 6.30 cm in December and 5.87 cm in January, whereas the minimum fruit length was observed in Khattabegun (3.94 cm and 3.91 cm), respectively (Table 3). For fruit breadth, there was a substantial time-variety interaction, but there was no

significant effect of planting time. BARI tomato-2 had the highest fruit breadth of 6.17 cm during December planting, whereas the lowest fruit breadth was 2.46 cm in Khattabegunes. When the BARI tomato-14 was planted in January, the maximum fruit breadth was 5.86 cm and the minimum was 2.88 cm.

The relation between time and variety was significant for total yield. Total yield of 38.55 tons per hectare was recorded in December planting for BARI tomato-14, followed by BARI tomato-3 with 38.16 tons per hectare. The lowest yield was in Riograndi (9.17 ton/ha) in December planting. In January planting, the highest total yield was recorded in BARI tomato-15 (12.10 tons/ha), while the lowest total yield was observed in Khattabegun (6.25 tons per hectare) (Table 3).

There was no statistically significant interaction between time and variety for bacterial wilt disease. Bacterial wilt disease infected by 6.9% and 5.48% in Riograndi variety plots, whereas the Khattabegun variety plots infected by 1.34% and 1.12% in December and January planting, respectively (Table 4). Early-blight infestations were significantly influenced by the time-variety correlation. During December planting, Roma VF had the highest infestation rate of 2.41%, while BARI tomato-3, BARI tomato-15, Marglobe, and the local variety had no significant differences. There was no infestation in BARI tomato-3, BARI tomato-15, and Khattabegun, while 4.13% plots were infested during January planting of Riograndi (Table 4). There were no significant differences in number of fruits infected by fruit borer. The number of infected fruits per plot were highest in BARI tomato-2 (2.15%), followed by BARI tomato-3 (2.23%) in December and January planting, respectively. In both cases, there was no infestation observed in the Khattabegun variety. In case of virus infestation, the interaction was found non-significant between planting time and variety. The highest

virus-infested plant was found in Marglobe (3.27%) and the lowest in BARI tomato-14 and BARI tomato-15 (1.12%) at December planting but in January planting, the maximum infestation was recorded in Khattabegun (2.90%) while no viral infestation was observed in BARI tomato-3 and BARI tomato-14 (Table 4).

4. Discussion

The planting time and variety significantly impact on the growth as well as yield and yield components of tomatoes. Planting times influenced plant height (cm), fruit yield (g), total yield (ton/ha), diseases, and pest infestation (Afreen et al., 2017). Light, temperature, CO2, humidity, soil moisture, fertilizer, farming system, and plant genetic materials influenced crop performance in the field (Souri and Sooraki, 2019; Weston, 1988; Ciardi et al., 1998; Vavrina, 1998; Damato and Trotta, 2000; Paul and Metzger, 2005). According to Jong et al. (2009) environmental factors affect the commencement of fruit setting and growth. Gent (1992) found that delayed planting of heat-tolerant early tomato varieties delayed fruit maturity by two weeks. With enough time for growing, the highest plant height was observed after first transplanting on December 18. The impact of transplanting time on environmental temperature is mostly shown in height of the plant (Islam et al., 2017). Srivastava and Srivastava (2007) found that seedling transplanting time affects tomato plant height. Tomato plant height decreased after late planting owing to environmental conditions. The environment controls the fruit yield per plant (Islam et al., 2017). On the other hand, Drost and Price (1991) found that early transplanting increases fruit yield planted on December 18 which gave the most exquisite fruits, maybe it's because of the long growing season and the ideal day-night temperature for fruit development. Plant cultivated on January 18 produced the lowest number of fruit and yield per plant. In this case, the highest yield was

achieved by planting tomatoes in December, which is corroborated by earlier studies (Ahammad et al., 2009; Rogers and Wszelaki, 2012; Sharma and Tiwari, 1996). Late planting on January 18 had the lowest yield. Late planting had significant effect on tomato growth, yield, and yield components. Islam et al. (2017) observed early planting increased tomato production. The 18 December transplant improved all yield-related characters compared to the 18 January transplants. Sanjoy (1999) reported a decline in fruit yield and other yield-related traits in recent plantings.

During blossom and ripening stages of late-cultured plants, they were affected by harsh conditions such as high temperatures and humidity. A study by Preedy and Watson (2008) demonstrated that tomatoes thrive in high altitudes with little humidity and high light intensity. Fruit set percentage and fruit weight per plant declined when the daily mean temperature was 29°C, compared to 25 °C (Harel, 2014). The decline in production is mainly due to the decrease in pollen viability and poor pollen development (Sato et al., 2006). According to the findings, planting in December results in more blossoms and fruit than planting in January. This result is consistent with the previous studies.

Planting time manipulation affects the diversity and abundance of different insect pests; therefore, it is considered as one of the crucial factors for reducing the infestation by insect pests to get optimum yield in tomato (Afreen et al., 2017). In the present study it was observed the infestation by Bacterial wilt, Early blight, fruit borer, and virus were more in December 18 planting than January 18 planting in BARI tomato-2, BARI tomato-14, and BARI tomato-15. The higher infestation was observed by Bacterial wilt, Early blight, and fruit borer in January 18 planting compared to December 18 planting virus in BARI tomato-3 and Roma VF except virus infection;

virus infection was higher in December 18 planting than January 18 planting in BARI tomato-3, while Roma VF was not infected by virus. Marglobe variety was highly infested by Early blight, fruit borer, and virus in December 18 planting compared to January 18 planting, while, bacterial wilt infestation was opposite trend. The infestation by early blight, fruit borer, and virus was high late planting compared to early planting in Variety Riograndi but bacterial wilt infestation was high in early planting than late planting. Moreover, Khattabegun variety showed high infestation by bacterial wilt in December 18 planting compared to January 18 planting and virus infestation showed opposite trend but no infestation was observed by early blight and fruit borer in this variety. However, most of the varieties highly infected by Bacterial wilt, early blight, fruit borer, and virus in December 18 planting compared to January 18 planting. A study was conducted by Afreen et al. (2017), they observed that planting of tomato in 10 December is effective for insect pests' reduction with better yield. Aphids and whitefly showed higher infestation in December 4 planting while leaf miner and tomato fruit borer showed higher infestation in December 19 planting in Tomato (Waluniba and Ao, 2014).

5. Conclusion

The growth and yield of tomato was significantly affected by different planting dates and varieties. Tomato planting on December 18 with BARI tomato-14 followed by BARI tomato-3 varieties is suitable for optimum yield with less disease and pest infestations. However, Khattabegunes (local variety) showed high tolerant capacity against bacterial wilt, early blight, and virus which may be used as breeding materials for biotic stress tolerance tomato variety.

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Table 1. Monthly weather data of tomato growing period.

Month	Rainfall	Max. tem.	Min. tem.	Max. RH (%)	Min RH (%)
November, 2020	3	28.9	18.5	80	30
December, 2020	23	27.06	14.53	96.33	57.66
January, 2021	26	26.82	14.94	95.4	50
February, 2021	11	29.13	16.36	94.66	30.33
March, 2021	6	32.62	20.67	94.75	41.75
April, 2021	87	33.77	24.07	93.25	45.75

Table 2. Effect of planting time and variety on tomato production and yield components.

Varieties	Plant height at 1st harvest		Days to 50% flowering		No. of fruit clusters per plant		No. of fruits/plant		Fruit yield/plot (kg)	
	1st Time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)
BARI tomato 2	64.67	52.03	34.33	25.00	9.84	3.12	33.53	12.28	39.75	10.53
BARI tomato 3	70.37	48.27	37.00	25.33	10.27	2.68	46.87	14.02	46.33	11.70
BARI tomato 14	111.47	91.07	38.67	26.33	10.47	2.68	43.22	13.97	48.26	8.80
BARI tomato 15	74.27	63.80	34.33	27.00	10.67	2.67	36.23	11.46	41.11	14.30
Marglobe	73.77	56.90	43.33	37.80	7.00	4.27	13.00	7.26	15.16	11.20
Roma VF	46.15	41.01	50.67	41.94	7.40	5.93	19.00	10.44	16.40	10.98
Riograndi	51.84	42.90	35.00	34.39	12.15	6.00	30.33	10.77	10.77	9.50
Khattabegun	118.40	108.84	48.33	43.69	6.24	6.30	27.33	14.17	13.28	7.50
LSD ($p \leq 0.05$)	V=3.86 SD=5.10 V x SD=5.46		V=2.98 SD=3.95 V x SD=4.21		V=0.76 SD=0.95 V x SD=1.07		V=2.73 SD=1.47 V x SD=3.86		V=2.65 SD=3.98 V x SD=3.75	

Table 3. Effect of planting time and variety on tomato production and yield components**.**

Varieties	Individual fruit wt. (gm)		Fruit length (cm)		Fruit breadth (cm)		Total yield (t/ha)	
	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)
BARI tomato 2	120.85	67.87	5.81	4.72	6.17	4.44	31.01	8.44
BARI tomato 3	92.80	63.87	5.60	4.23	5.18	4.47	38.16	9.75
BARI tomato14	94.65	63.00	6.10	5.26	4.99	5.86	38.55	8.89
BARI tomato 15	85.53	67.83	5.82	4.06	5.10	4.64	33.42	12.10
Marglobe	168.54	97.29	6.30	5.87	5.59	4.74	16.24	9.33
Roma VF	84.96	66.37	5.97	5.48	5.01	4.64	13.94	9.31
Riograndi	80.25	77.48	5.67	5.44	4.49	5.40	9.97	7.36
Khattabegun	70.49	63.53	3.94	3.91	2.46	2.88	10.23	6.25
LSD ($p \leq 0.05$)	V=8.61 SD=3.71 V x SD=12.17		V=0.55 SD=NS V x SD=0.78		V=0.48 SD=NS V x SD=0.67		V=2.81 SD=3.07 V x SD=3.98	

Table 4. Diseases and insect infestation as influenced planting time and varieties.

Varieties	Bacterial wilt/plot (%)		Early blight		Fruit borer		Virus	
	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)	1st time (Dec)	2nd time (Jan)
BARI tomato 2	4.20 (19.8)	1.76 (3.3)	1.53 (2.2)	1.12 (1.1)	2.15 (5.3)	1.39 (1.7)	2.71 (7.3)	1.12 (1.1)
BARI tomato 3	1.6 (4.2)	1.68 (4.3)	0.71 (0.0)	0.71 (0.0)	1.86 (3.0)	2.23 (4.8)	1.75 (3.2)	0.71 (0.0)
BARI tomato14	2.51 (7.5)	2.00 (4.3)	1.35 (2.2)	1.35 (2.2)	1.94 (4.0)	1.86 (3.7)	1.12 (1.1)	0.71 (0.0)
BARI tomato 15	3.71 (13.5)	2.00 (4.3)	0.71 (0.0)	0.71 (0.0)	1.39 (1.7)	1.18 (1.3)	1.12 (1.1)	1.53 (2.2)
Marglobe	5.44 (31.1)	4.80 (23.9)	0.71 (0.0)	2.30 (6.3)	1.48 (2.0)	1.10 (1.0)	3.27 (10.4)	2.64 (8.3)

Roma VF	4.83 (22.9)	5.47 (31.2)	2.41 (5.4)	3.61 (12.5)	1.25 (1.7)	1.48 (2.0)	1.34 (6.3)	1.67 (6.3)
Riograndi	6.9 (47.8)	5.48 (31.3)	1.53 (2.6)	4.13 (16.7)	1.71 (3.0)	1.93 (3.3)	1.97 (6.3)	2.89 (15.5)
Khattabegun	1.34 (2.1)	1.12 (1.08)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	1.51 (3.1)	2.90 (10.4)
LSD ($p \leq 0.05$)	V=1.62 SD=0.85 V x SD=NS		V=0.68 SD=NS V x SD=0.96		V=NS SD=NS V x SD=NS		V=1.30 SD=NS V x SD=NS	