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Effect of Planting Time on the Yield and Quality of Cherry Tomato (*Solanum lycopersicum* var. *Cerasiforme*)

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ABSTRACT

Planting date is an important factor which directly related to crop production in a specific area. Different planting time may affect crop yield and quality due to varying climatic conditions at different stages of crop growth and development. The present experiment was laid out to investigate the effect of planting date at an interval of 15 days during winter season of 2019-20 on the yield and quality of cherry tomato. The potentiality of fruiting in the winter season was evaluated by planting on November 15, November 30, December 15, December 30 and January 14. Data on yield and quality attributes of cherry tomato like plant height, number of fruits per plant, fruit yield per plant (g), yield (t ha^{-1}), TSS (%), pH and vitamin C contents (mg 100 g^{-1}) were recorded. Results revealed that planting time had significant effects on the yield and quality parameters of cherry tomato. Cherry tomato performed better on 30 November planting date in respect of yield and vitamin C content due to favorable climatic conditions at different growing stages as per requirements that may lead to higher yield and quality of fruits.

Introduction

Tomato (*Solanum lycopersicon* L.) is one of the most economically important vegetable crops that are produced in many countries under field as well as greenhouse conditions (Lahoz et al., 2016; Souri and Dehnavard, 2018). Its fruit contains about 94% water, 2.5% total sugars, 2% total fiber, 1% proteins and other nutritional compounds like acids, lipids, amino acids and carotenoids (Koh et al., 2012). Tomato is a nutritious and delicious vegetable used in salad, soups and processed into stable products like ketchup, sauce, pickles paste, chutney and juice (Islam et al., 2017). This fruit is a reservoir of potentially healthy molecules, such as ascorbic acid, vitamin E and phenolic compounds, particularly flavonoids (Beecher 1998; Raffo et al., 2002) and regular consumption of tomatoes has been associated with decreased risk of chronic degenerative diseases due to the presence of different antioxidant (Frusciante et al., 2007). Tomato flavonoids, due to their high antioxidant power and significant biological activities, can have a substantial role in the health benefits (Bourne and Rice-Evans, 1998;

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Bhowmik et al., 2012). Cherry tomato [*Solanum lycopersicum* L. var. *cerasiforme* (Dunal) A. Gray] is a newly cultivated variety of tomato in Bangladesh. It has become more popular all over the world because of a good source of vitamins A and C, solids content, good taste and fruit set even at high temperature (Prema et al., 2011). Cherry tomato contain more vitamin C (George et al., 2004) and lycopene than others (Kuti and Konuru, 2005). The quality of tomato depends on climate, growing media, plant nutrition and other factors (Jankauskieno, 2013). Planting date is an important factor in crop production and directly related to climatic factors in a specific area. The yield of tomato is significantly influenced by different sowing dates and varieties (Rahman et al., 2020). Planting time can affect plant maturity, harvesting time, yield and quality of crops. Photosynthetic rate, number of fruits, individual fruit weight and fruit yield per plant significantly decreased with the high temperature (32 °C) at pre-flowering and flowering stages. Effects of temperature were more pronounced at flowering stage compared to pre-flowering stage (Islam, 2011). Agronomic practices have been recognized as a critical factor in determining the nutritional quality of crops (Barrett et al., 2007; Souri and Dehnavard, 2018). Tomato variety and maturity of the fruits at harvest are the main factors affecting nutritional value of tomato (Erba et al., 2013). Delayed planting gradually decreased the plant height, fruit set, fruit number, fruit weight and yield of tomato. Appropriate planting dates may not only lead to greater yield, but also may contribute to better vegetable quality (Kleinhenz and Wszelaki, 2003). It has great demand throughout the year and its production is mainly concentrated during the winter season in Bangladesh (Biswas et al., 2017; Islam et al., 2017). Ambient temperature in winter of Bangladesh generally remains optimum for tomato production (Islam 2011). The variation in planting time also affects the yield and quality of fruits (Tomar et al., 2018). The information is limited on response of cherry tomato to date of planting particularly in respect of yield and quality. Therefore, the present investigation was aimed to study the effect of planting dates in relation to climatic factors on the yield and quality of cherry tomato.

Material and Methods

A field experiment was conducted at Agricultural Field Research Center of Bangladesh Open University, Gazipur, Bangladesh during winter season of 2019-20 to evaluate the effects of planting time on yield and quality aspects of cherry tomato. The experimental site belongs to Madhupur Tract (AEZ-28). The experimental area is characterized by relatively scanty rainfall, low humidity, low temperature, short day and long clear sunshine period during October to March (Table 2). The land was ploughed with power tiller for four times and leveled by ladder. The weeds and stubbles were cleaned properly. The final land preparation was done on 10 November, 2019. The unit plot size was 3m x 2m. Each plot was fertilized by cow-dung at 10 t ha^{-1}, urea at 300 kg ha^{-1}, TSP at 200 kg ha^{-1} and MP at 250 kg ha^{-1}. Cow-dung, one third of N fertilizer and PK fertilizer with urea, TSP and MP respectively were applied at the final land preparation. Remaining nitrogen fertilizer was applied in two equal splits at 20 and 40 days after transplanting. Cultural practices were done when necessary. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. Five transplanting were done at an interval of 15 days. Five planting dates were November 15, November 30, December 15, December 30 and January 14. In this experiment, indeterminate yellow cherry tomato cv. Houngli was used as a test crop. Primarily, seeds were collected from China in 2017 and multiplied subsequent year at Bangladesh Open University agricultural field research center. Seeds were sown on October 15, October 30, November 14, November 29 and December 14, 2019 in the seedbed, respectively. Healthy and uniform sized 30 dayold seedlings were taken separately from the seedbed and were transplanted on November 15, November 30, December 15, December 30, 2019 and January 14, 2020 in the experimental field maintaining spacing of 60 cm and 50 cm between plants inter rows and plants, respectively. The treatments were applied per raised bed. In each plot, 20 plants were grown. The tomato seedlings were irrigated uniformly with one day interval to ensure good stand establishment. Stalking is done by bamboo stick, both the sides of plants like as 'A' shape to overcome plants lodging on ground due to weak stem. Stacking facilitate management operations such as irrigation; inter tillage, pest control and harvesting. Plant height and yield were measured at laboratory of school of agriculture and rural development of Bangladesh Open University. Ten plants from each plot were selected for data collection of plant height, number of fruits per plant and fruits yield per plant (g). Fruit yield from different harvests was recorded on the whole plot basis. The plant height was measured from the soil level to the tip of the shoot and expressed in cm. Fruit yield per plant expressed in gram (g) and yield expressed as ton per hectare (t ha^{-1}). Ripen fruit sample (200 g) of each treatment was sent to the laboratory after harvesting for quality test. All biochemical parameters associated with this study (TSS%, pH, Vitamin C) were analyzed at the Post-Harvest Technology Department of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh following standard procedure.

Statistical analysis

Data recorded on yield and quality characters were subjected to statistical analysis through analysis of variance. The mean differences among the treatments were compared using Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results

The planting dates had significant influence on the plant height (cm), fruits number per plant, fruit yield per plant (g), fruit yield (t ha^{-1}), pH and vitamin C content (mg 100 g^{-1}) of cherry tomato. However, TSS (%) of tomato fruits was not significantly influenced by the planting dates. The results are presented in Table 1.

Results showed that significant differences of plant height of cherry tomato was due to planting date. The plant height slowly increased up to 30 d, increased quickly up to 75 d after transplanting and then unchanged. The plant height ranged from 143.7 to 173.0 cm at 90 day after transplanting (DAT) under different treatments. The highest plant height (173.0 cm) was observed on 15 November planting and the lowest (143.7 cm) was observed on 14 January planting date.

Table 1. Effect of planting time on yield and quality of cherry tomato

Planting date	Plant height (cm)	Fruit $plant^{-1}$	Yield $plant^{-1}$(g)	Yield (tha^{-1})	TSS (%)	pH	Vitamin C (mg 100 g^{-1})
P_1	173.0a*	142.7a	799.7b	31.99b	6.3	4.7a	15.23ab
P_2	170.1a	147.0a	851.0a	33.85a	6.5	4.7a	15.33a
P_3	161.4b	131.3ab	793.3b	31.73b	6.1	4.6ab	14.93bc
P_4	150.4c	125.0ab	680.0c	27.20c	6.3	4.5ab	14.70c
P_5	143.7d	115.7b	638.0d	25.52d	6.1	4.4b	13.80d
CV (%)	1.80	8.80	2.89	2.92	3.05	2.78	1.16
Level of significance	0.01	0.05	0.01	0.01	NS	0.05	0.01

*In the column figures having common letter(s) do not differ significantly as per DMRT. NS = Not significant, 0.01 = Significant at 1% level of probability, 0.05 = Significant at 5% level of probability. [P_1-Planting on 15 November), P_2-Planting on 30 November), P_3-Planting on 15 December), P_4-Planting on 30 December), P_5-Planting on 14 January)].

Cherry tomatoes transplanted on 30 November, plants were started flowering 5-25 February (65-85 DAT) and harvested from 1st March to 20 March (90-110 DAT). Whereas, late transplanted (14 January) plants were flowered during 1 to 15 March and ripened 30 March to 10 April. The highest number of fruit per plant (147.0) was recorded in plants cultured on 30 November that was statistically similar to those cultured on 15 November. The lowest number of fruits per plant (115.7) was observed on 14 January planting. The yield per plant was significantly different under all 5 planting dates. The highest fruit yield per plant (851.0 g) was obtained when plants cultured on 30 November followed by those cultured on 15 November, 15 December, 30 December and 14 January. The highest yield (33.85 t ha^{-1}) was obtained from plants cultured on 30 November and the lowest yield (25.52 t ha^{-1}) was observed by late planting on 14 January. The higher yield was found on 30 November planting date due to higher number of fruit setting per plant and individual fruit weight. TSS (%) did not differ significantly due to planting date. The pH of ripen fruits juice was slightly varied due to planting date and late planting showed lower pH than the earlier ones. Among the treatments, maximum amount of vitamin C content (15.33 mg 100 g^{-1}) was recorded in plants cultured on 30 November and it was statistically similar to those planted on 15 November. Minimum vitamin C content (13.82 mg 100 g^{-1}) was found in late planting on 14 January (Table 1). Monthly average temperature of experimental site gradually decreased from October to December and then it was stable (15 °C) up to February. Minimum monthly rainfall and maximum sunshine hour with sunny days was observed during December to February. Monthly average relative humidity gradually decreased from October to March (Table 2).

Table 2. Monthly average temperature (maximum, minimum and average ^{0}C), rainfall (mm), rainy days, relative humidity (%), sunshine hours and sunny days of experimental site (2019-2020)

Metrological parameters	Months (2019-2020)					
	October, 19	November, 19	December, 19	January, 20	February, 20	March, 20
Temperature (Max.)	31	30	27	26	29	34
Temperature (Min.)	28	26	22	22	24	29
Temperature (Aver.)	23	20	15	15	15	20
Rainfall (mm)	240.7	34.7	1.3	18.8	10.7	33.2
Rainy days	27	08	04	07	20	07
Relative humidity (%)	85	80	69	65	50	47
Sunshine (hr.)	184.5.	259	298	281.5	274.5	279
Sunny days	04	22	27	24	27	24

[**Source:**https://www.worldweatheronline.com/gazipur-weather-averages/bd.aspx]

Discussion

The planting dates had significant influence on plant height (cm), fruits number per plant, fruit yield (g), total yield (t ha^{-1}), pH and vitamin C content (mg 100 g^{-1}) of studied cherry tomato. The seedlings quality in the field and associated growth performance were significantly affected by factors such as light, temperature, CO_2, air humidity, water supply, fertilization, growing media, cultivation practices, crop varieties (Souri and Sooraki, 2019; Weston 1988, Ciardi et al. 1998, Vavrina 1998, Damato and Trotta 2000, Paul and Metzger 2005). Jong et al. (2009) reported that the initiation of tomato fruit growth and fruit setting is very sensitive to environmental conditions. Gent (1992) reported that two week delay in planting of heat tolerant early tomato variety resulted in delayed fruit maturity by two weeks. The highest plant height was observed by first transplanting on 15 November and it may be due to sufficient time for growth. It has been reported that the effect of transplanting time in relation to change in the temperature of environment will be reflected primarily by the plant height (Islam et al., 2017). Srivastava and Srivastava (2007) reported that transplanting time had influence on the regulation of plant morphology as well as plant height of tomato. Plant height of tomato decreased with the late planting from optimum time due to environmental situations (Islam et al., 2017). Maximum number of fruits and fruit weight were observed at 30 November planting. It may be due to getting long growing period and availability of optimum day-night temperature at the time of fruit setting and development. The lowest fruit number and yield per plant was obtained when plant cultured on 14 January. Drost and Price (1991) reported that late transplanting reduces fruits number and early transplanting causes increasing trend. Maximum number of fruits per plant occurred by early and the minimum from late transplanting due to high temperature at required stages (BARI, 1989). Sharma and Tiwari (1996) stated that transplanting on 13 February resulted in greater fruit set and number of fruit per plant than transplanting on 5 or 25 March. Environmental condition regulates the number fruits per plant (Islam et al., 2017). Kaur and Kanwar (2006) evaluated yield and components of tomato under four planting dates including 20th November, 5th December, 20th December and 5th January at Punjab Agricultural University, Ludhiana and they found maximum number of fruits and yield when planted on 20th November. In this experiment, the highest yield was obtained from early planting on 30 November. This finding agreed with the previous studies (Ahammad et al. 2009; Rogers and Wszelaki 2012; Sharma and Tiwari 1996). Rogers and Wszelaki (2012) reported that tomato planted earlier in high tunnels yielded more marketable fruit during the production season than plants established on later planting dates. The lowest yield was obtained from late planting on 14 January. The planting time in the late season had remarkable influence on the growth as well as yield and yield components of tomato. Delayed planting gradually decreased the plant height, fruit set, fruit number per plant, individual fruit weight and yield of tomato. Different planting dates showed significant influence on growth and reproductive characters of tomato including fruit yield. Islam et al. (2017) indicated that earlier transplanting produced higher fruit yield of tomato. The transplanting on 10 December resulted in improvement of all the components compared to transplanting on 20 December and 30 December. Sanjoy (1999) showed a declining trend in fruit yield and other yield attributing characters when planted lately. Kadam et al. (1991) stated that sowing on 15th November was found to be suitable growing tomato as it gave higher fruit yield. TSS (%) did not differ significantly due to planting date. The late plantings showed lower pH of fruit juice than earlier ones. A higher content of Vitamin C was detected in early plantings due to favorable climatic conditions in the growing stages. The vitamin C content of tomatoes generally varies with season, environmental conditions, fertilization and other management practices (Davies and Hobson, 1981; Dehnavard et al., 2017). Variations in the light intensity prior to harvesting considerably affected the ascorbic acid content of the fruit (Dumas et al., 2003). The ascorbic acid content of the ripe fruit was increased by 66% when plants were transferred from shade to sunshine at the mature green stage (Hamner et al., 1945). Fast ripening tomatoes contained significantly more Vitamin C when ripe than the slow ripening ones (Clutter and Miller, 1961). Vitamin C in tomato decreases with increase in temperature (Ghamande et al., 2018). Liptay et al. (1986) reported that tomatoes grown at low temperature had lower ascorbic acid content when compared to its content at higher temperatures. Soluble sugars, organic acids and volatile compounds determine the taste of tomato. There is an increase in TSS and a decrease of titratable acidity (TA) during ripening of tomato. The main components of TSS in domesticated tomatoes are fructose and glucose. Citric acid is considered as the main organic acid, which is responsible for acidity of tomatoes and it decreases from green to red ripening stage (Carrari and Fernie, 2006). Optimum temperature of seed germination, growth and fruit setting is 16-29 °C, 21-24°C and 20-24 °C respectively, while pollen viability and release are adversely affected by high temperatures and causes poor fruit set of tomato (Naika et al., 2005). When seedlings transplanted on 30 November, plants were started flowering on 5-25 February (65-85 DAT) after sufficient plant growth and harvested from 1st March to 20 March (90-110 DAT). Monthly average temperature, rainfall, relative humidity, sunshine hour at that time were favorable for flowering, pollination, fruit setting, yield and quality of cherry tomato. Whereas, late transplanted (14 January) plants were flowered at comparatively high temperature and rainfall situation during 1 to 15 March and ripened on 30 March to 10 April (Table 2). Late cultured plants were flowered before sufficient growth and faced adverse conditions due to high temperature and humidity at flowering and ripening stages. As a result, fruit setting, yield and quality of cherry tomato were lower than their values in earlier planted seedlings. Preedy and Watson (2008) reported that most suitable environmental conditions for production of tomatoes are high altitudes with low humidity and high light intensity. Daily mean temperatures of 29 °C decreases fruit number and fruit set percentage and fruit weight per plant in comparison with those at 25 °C (Harel, 2014). This reduction in yield is mainly due to impaired pollen and anther development and reduced pollen viability (Sato et al., 2002, Sato et al., 2006). Temperature also affect the level of endogenous hormones. Abdul and Harris (1978) found that low temperature reduced the level of different gibberellins in young leaves and this was associated with an increase in the number of flowers. Another climatic factor that might influence pollen viability is relative humidity of the air. Pollen grains of different species exhibit diverse reactions to changes in relative humidity. Relative humidity between the ranges of 50-70% is generally considered to be the optimal relative humidity for tomato pollination (Peet et al., 2002). Temperature and light intensity play vital roles in tomato plants growth and fruit setting. There is a need to ascertain appropriate planting time of tomato plants to achieve higher quantitative and better qualitative yield (More and Bhanderi, 2014). Yahia et al. (1999) reported that ascorbic acid in tomato fruit increases slowly and reaches a maximum level after about 75 days from fruit set and then declined slowly. Temperatures below 12 °C strongly inhibit lycopene biosynthesis and temperatures above 32 °C stop this process altogether (Dumas et al., 2003). It has been reported that vitamin C content significantly decreases at 32 °C compared with its content at 24°C during the advanced stages of fruit development (Hernandez et al., 2018). Viet Trang (2015) stated that harvesting stages affect physicochemical properties of cherry tomato. Half ripe yellow cherry tomatoes consisted with cryopreservation can maintain better quality after postharvest. Seedlings transplanted on 30th November received most suitable temperature and relative humidity at growing and flowering stages, which increased photosynthetic activity and proper translocation of photosynthates in plants required for growth, yield and quality.

Conclusion

In the present study, cherry tomato was planted on different dates from 15 of November to 14 of January with 15 day intervals. It was found that the planting date had significant effect on plant height, number of fruits per plant, fruit yield per plant, yield (t ha^{-1}), pH and vitamin C contents of cherry tomato. Due to favorable temperature, relative humidity and sunshine hour at different growth stages as requirements of flowering, pollination, fruit setting, yield and quality, higher yield and vitamin C content was found in cherry tomato plants cultured on 30 November. On the other hand, later plantations resulted in early flowering before sufficient growth and faced adverse conditions due to high temperature and humidity at flowering and ripening stages. Therefore, it can be concluded that planting of cherry tomato around 30 of November is the best time of plantaton in respect of yield and quality under Gazipur district conditions of Bangladesh.

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