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Impact of Transplant Age on the Yield and Yield Contributing Characteristics of Cherry Tomato Varieties (*Solanum lycopersicum* var. *cerasiforme*)

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Abstract: Cherry tomatoes are a high-value crop with growing demand. This research focused on identifying the ideal seedling age for transplanting and evaluating the most productive variety of cherry tomatoes in terms of yield during winter in Gazipur district, Bangladesh, with a specific emphasis on local environmental adaptation. The experiment, designed as a two-factor study focusing on seedling age and variety, was organized using a Randomized Complete Block Design (RCBD) with four replications. Seedlings of varying ages (21, 28, 35, and 42 days) along with two cherry tomato varieties (red and yellow) were used in the study. All experimental plots were transplanted based on the seedling age concurrently. Data analysis involved conducting a two-way ANOVA to assess the relationship between seedling age and variety using R statistical software. Mean separation was performed using Duncan's Multiple Range Test (DMRT) at a 5% significance level. The interaction between variety and seedling age had a significant impact ($P < 0.05$) on fruit yield and other traits of cherry tomatoes. The highest average yield per hectare (39.37 t/ha) was observed in the 28-day-old seedlings of the red cherry tomato. This result was attributed to a higher number of fruits per plant (141.25) and greater individual fruit weight (7.08g). Among the varieties, the red cherry tomato exhibited superior plant height, number of fruits per plant, fruit weight per plant, and yield per hectare. So, it may be concluded that transplanting of cherry tomato seedlings at approximately 28 days old is optimal for achieving higher yield during winter in Gazipur district of Bangladesh.

Keywords: Cherry tomato; Cultivars; Seedling age; Yield attributes; Fruit yield.

INTRODUCTION

The age of seedlings during transplantation has a considerable impact on the yield and quality of crops (Silva et al., 2021). The cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is a popular variety of tomato recognized for its economic significance and nutritional benefits (Lahoz et al., 2016). Its produce is frequently enjoyed more as fruits rather than vegetables (Islam et al., 2012; Ali et al., 2021). Cherry tomatoes are an excellent source of vitamin C and B vitamins, such as β-carotene, thiamine, niacin, riboflavin, along with various vital minerals (Prema et al., 2011; Kumari et al., 2017; Koh et al., 2012; Hanson, 2003). The weather conditions in Bangladesh are suitable for cultivating cherry tomatoes in winter (Haque et al., 1999). The success of any crop is influenced by seed quality, environmental factors, type of cultivar, and farming practices. Among these, the age of the seedlings is a significant factor affecting growth and yield, yet it is often neglected by farmers (Saxena and Singh, 2019). There exists a positive correlation between the quality of seedlings and the growth and yield outcomes of tomatoes (Nkurunziza et al., 2022). Seedlings represent a critical stage in the growth and development of tomatoes, particularly concerning the timing of production and the quantity of fruits per plant (Markovic et al., 1996). The state of the plant at the moment of transplanting significantly influences its establishment phase, the timing of harvest, fruit size, and overall yield (Weston and Zandstra, 1986). Variations in climatic conditions lead to different durations until the appropriate transplanting of well-developed seedlings (Jankauskieno et al., 2013). The age of the transplant guarantees consistent and uniform growth of the plants post-planting, thereby contributing to increased yields (Weston and Zandstra, 1986; Widders, 1989). Middle-aged transplants outperformed younger or older transplants in terms of fruit yield (Shukla et al., 2013). Healthy seedlings are vital for maximizing the growth potential of field-grown tomatoes and achieving favorable outcomes (Markovic et al., 1997). Seedlings that are too young (16 days) may struggle to take root after being transplanted, likely due to their delicate and tender roots. Conversely, plants that spend an extended period in the nursery bed may become excessively leggy or overly woody, as growth slows down, resulting in older seedlings (44 days) failing to establish quickly when moved to the main field (Thompson and Kelly, 1983). To boost cherry tomato yield in Bangladesh, it is important to encourage farmers to adopt superior varieties (Saha and Rashid, 2020). For the effective production of cherry tomatoes, the age of the seedlings is critical for achieving higher yields. Whereas, there is a lack of research regarding the best varieties and the influence of seedling age on cherry tomato crops in Bangladesh. Consequently, this study was carried out to determine the optimal transplant age of cherry tomato for enhancing fruit yield in the Gazipur district of Bangladesh, especially in relation to local environmental conditions. The research assessed the growth and yield performance of two cherry tomato varieties at different seedling ages.

MATERIALS AND METHODS

Study area

The field experiment took place at the Agricultural Field Research Center of Bangladesh Open University, located in Gazipur Sadar, Bangladesh, during the winter months from October 2023 to March 2024. The coordinates for the experimental site are latitude 23.9443°N and longitude 90.3819°E (Figure 1).

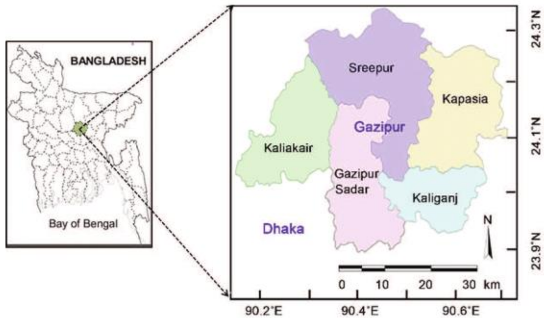

Figure 1. Location map of Gazipur District, Bangladesh (Rony et al., 2021)

This experimental area is part of the Madhupur Tract Agroecological Zone (AEZ-28) (UNDP and FAO, 1988). Table 1 presents the monthly average maximum and minimum air temperatures, mean temperatures, rainfall, humidity, and sunshine hours recorded at the experimental site throughout the study period. The soil in the experimental field is classified as sandy loam, featuring a pH of 6.95 and an organic matter content of 1.21%. The initial levels of other key soil elements were found to be 0.054% nitrogen, 26.541% phosphorus, 0.132% potassium, 10.718% sulfur, 0.891% zinc, and 0.244% boron (BRAC-Lab, 2022).

Table 1. Monthly average air maximum temperature, minimum temperature, mean temperature, rainfall, humidity, and sunshine hours of the experimental site during the study period (November 2023 to March 2024)

Month	Air temperature (°C)			Rainfall (mm)	Humidity (%)	Sunshine (h)
	Maximum	Minimum	Mean			
Nov, 2023	31.09	20.03	25.56	28	85.93	7.55
Dec, 2023	26.67	16.24	21.46	45	86.20	4.56
Jan, 2024	22.72	12.73	17.72	00	84.42	3.70
Feb, 2024	27.84	15.73	21.78	18	73.59	6.15
Mar, 2024	31.72	18.87	25.29	58	75.47	7.15

Source: Weather Station, Gazipur

Experimental design and treatments

A two-factor experiment was conducted using a Randomized Complete Block Design (RCBD), consisting of four replications. It included four different seedling ages: 21, 28, 35, and 42 days, as well as two varieties: red cherry tomato (cv. BARI Tomato-11) and yellow cherry tomato (Philippines variety). The 32 plots received a total of 8 treatment combinations. There were sixteen plants in each plot, spaced 50 by 50 cm apart. In October 2023, the Bangladesh Rural Advancement Committee (BRAC) Nursery in Gazipur provided the seeds for the red and yellow cherry tomatoes.

Land preparation, transplanting and intercultural operations

The main field and nursery bed were leveled using a ladder after being ploughed four times with a power tiller. The field's residual stubble and emerging weeds were thoroughly incorporated into the soil. Nursery sowing began on October 7, 2023, and continued at 7-day intervals until October 28, 2023, in two distinct seedbeds to produce seedlings of red (V1) and yellow (V2) cherry tomatoes. On November 15, 2023, the primary experimental field was prepared. The unit plot was 2 m by 2 m. Cow dung (@10 t/ha), urea (@300 kg/ha), TSP (@200 kg/ha), and MP (@250 kg/ha) were used to fertilize each plot. Twenty-one days prior to the transplanting of seedlings, cow dung, an organic manure, was spread to various unit plots and gently mixed into the soil. At the last stage of land preparation, a third of N and the entire dosage of P and K fertilizers with urea, TSP, and MP, respectively, were applied. Two equal portions of

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the leftover nitrogen fertilizer were applied 15 and 30 days after transplanting. From the two distinct nursery beds, healthy seedlings of 21, 28, 35, and 42 days old were chosen. On November 19, 2023, seedlings were transplanted into each treatment plot on the same day. Weeding was done two times to keep the plots free from weeds, and irrigated regularly during the growing season to keep the field moist for better growth and development of plants.

Data collection and statistical analysis

The experimental location and the Bangladesh Open University Agricultural Laboratory were used to measure the morphological characteristics of cherry tomato cultivars. Data collection began during flowering and continued until the last fruit harvest. Out of the 16 plants in each plot under each treatment, five were chosen at random to provide all the data. A meter scale was used to measure the height of the plants, and the result was stated in centimeters (cm). To determine the total number of fruits per plant and the total fruit weight per plant, the number of fruits per sample plant was counted and weighed following each harvest. Individual fruit weights were then determined. Digital slide calipers were used to measure the fruit's diameter and length, respectively, as the vertical and horizontal distances. Plant yield and individual fruit weights were measured in grams (g). To determine the total fruit weight per plant, the weight of the fruits from each harvest was recorded using an electronic balance. The total number of plants (per hectare) was multiplied to calculate the yield per hectare per treatment, which was then expressed in tons per hectare (t/ha). The gathered information was put together, properly collated, and then statistically examined. The statistical software program R was used to assess all the growth and yield attribute data that had been recorded. At the 5% level of probability, mean separation was carried out using Duncan's Multiple Range Test and analysis of variance (ANOVA) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The growth and yield characteristics of cherry tomatoes in the study were influenced by the age of the seedlings, the variety, and their interaction, as shown in Tables 3, 4 and 5 explained in the relevant section.

Effect of Seedling Age

Table 3 illustrates how seedling age affects the growth and yield-contributing traits of cherry tomatoes. Cherry tomato plant height was considerably ($P<0.05$) impacted by the seedling age treatment. With 28-day-old seedlings, the plant height peaked at 198.89 cm, and with 42-day-old seedlings, it decreased to 172.11 cm. Similarly, 28-day-old seedlings produced the most fruit per plant, averaging 132.13 fruits, while 42-day-old seedlings produced 96.38 fruits. Additionally, there were notable differences in fruit dimensions throughout seedling ages. While 42-day-old seedlings produced smaller fruits, averaging 1.90 cm in length and 1.51 cm in width, 28-day-old seedlings produced the longest fruit length (2.34 cm) and breadth (1.79 cm). Furthermore, the 28-day-old seedlings had the maximum individual fruit weight (7.03 g), while the 42-day-old seedlings had the lowest weight (6.51 g). 28-day-old transplants produced the most fruit per plant (922.13 g), 28-day-old seedlings produced the highest average yield per hectare (36.88 t), while 42-day-old seedlings produced 25.12 t, presumably as a result of larger fruit weights and quantities. These findings are similar to several researchers (Orzolek et al., 1991; Weston and Zandstra, 1989; Utomo et al., 2023; Setyorini. 2005). They reported that transplanting of tomato plants 28 days after seeding increased plant growth and yields more than 21 days age of transplants. Older seedlings of both cultivars were harvested early after transplantation. When compared to younger seedlings, cherry tomatoes transplanted with older seedlings began to flower the quickest (Table 2). This observation was similar to Jankauskieno et al. (2013). According to their findings, older transplants blossom more quickly than younger ones.

Table 2. Effect of seedling age on the start of flowering time of cherry tomato

Cherry tomato Variety	Required average days to start flowering (>50%) *			
	Seedling age			
	21 days (A1)	**28 days (A2)**	**35 days (A2)**	**42 days (A3)**
Red (V1)	61	58	54	51
Yellow (V2)	67	62	57	54

* Average data of each treatment was calculated from four replicated plots.

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Table 3. Effect of seedling age on the growth and yield contributing characteristics of cherry tomato

Seedling age	Plant height (cm)	Fruits plant^{-1} (no.)	Fruit yield plant^{-1} (g)	Individual fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Fruit Length: breadth	Yield (t/ha)
21 days old (A1)	194.08^{ab}	118.63^{b}	811.97^{b}	6.85^{b}	2.20^{b}	1.69^{b}	1.36^{ab}	32.50^{b}
28 days old (A2)	198.89^{a}	132.13^{a}	922.13^{a}	7.03^{a}	2.34^{a}	1.79^{a}	1.39^{a}	36.88^{a}
35 days old (A3)	187.05^{b}	112.50^{b}	776.58^{b}	6.88^{b}	2.10^{c}	1.59^{c}	1.34^{ab}	31.06^{b}
42 days old (A4)	172.11^{c}	96.38^{c}	627.83^{c}	6.51^{c}	1.90^{d}	1.51^{c}	1.26^{b}	25.12^{c}
Level of significance	1%	1%	1%	1%	1%	1%	5%	1%
CV (%)	5.63	6.80	7.03	1.88	4.20	5.53	7.89	6.97

Note: A column with a similar letter (s) is statistically similar and those with a dissimilar letter(s) differ significantly as per DMRT.

Effect of Variety

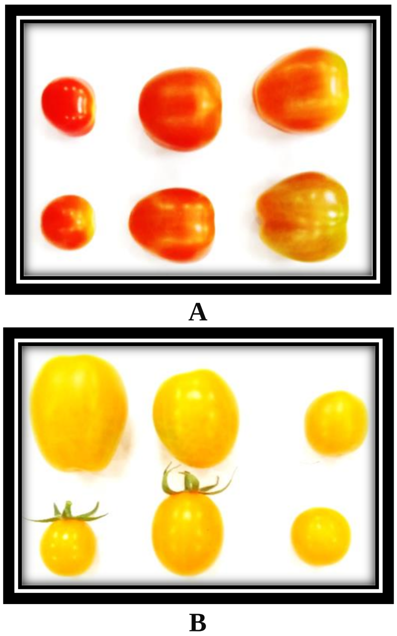
Irrespective of seedling age, a number of growth characteristics showed statistically significant differences ($P<0.05$) between the cherry tomato varieties, excluding the fruit weight and fruit length-to-breadth ratio (Table 4).

Table 4. Effect of variety on the growth and yield contributing characteristics of cherry tomato

Variety	Plant height (cm)	Fruits plant^{-1} (no.)	Fruit yield plant^{-1} (g)	Individual fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Fruit Length: breadth	Yield (t/ha)
Red cherry tomato (V1)	199.48^{a}	119.88^{a}	822.51^{a}	6.86	2.18^{a}	1.69^{a}	1.36	32.91^{a}
Yellow cherry tomato (V2)	176.59^{b}	109.94^{b}	746.75^{b}	6.77	2.09^{b}	1.60^{b}	1.31	29.86^{b}
Level of significance	1%	1%	1%	NS	1%	5%	NS	1%
CV (%)	5.63	6.80	7.03	1.88	4.20	5.53	7.89	6.97

Note A column with a similar letter(s) are statistically similar and those with a dissimilar letter(s) differ significantly as per DMRT.

Both types have small, variable-sized fruits and do not all mature simultaneously (Figure 2 & 3). Plant height (199.48 cm), number of fruits per plant (119.88), fruit yield per plant (822.51g), fruit length (2.18 cm), fruit breadth (1.69 cm), and yield per hectare (32.91 t/ha) were all maximum for the red cherry tomato variety (V1). Plant height (176.59 cm), number of fruits per plant (109.94), fruit length (2.09 cm), fruit breadth (1.60 cm), and yield per hectare (29.86 t/ha) were all lower for the yellow cherry tomato variety (V2). The cultivars did not significantly differ in terms of individual fruit weights or the ratio of fruit length to breadth.



A

B

Figure 2. Red (A) and yellow (B) variety fruits of cherry tomato.

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The red cherry tomato (V1) has more fruits per plant, which is probably because of its innate genetic potential. Regardless of seedling age, this cultivar also produces the most fruit per hectare (32.91 t) and has a higher fruit output per plant (822.51 g). However, the yield per hectare (29.86 t) of the yellow cherry tomato (V2) was lower. In the red cherry tomato variety (V1), fruit harvesting began 72 days after transplanting on January 31, 2024, and lasted until March 5, 2024.

A **B**

Figure 3 Red (A) and yellow (B) variety cherry tomato plant at ripening stage

On the other hand, harvesting of the yellow cherry tomato variety (V2) began 79 days after transplanting on February 7, 2024, and lasted until March 12, 2024. Ripe fruits are often plucked seven to ten times, separated by three to four days. Compared to the yellow type, the red cherry tomatoes ripened earlier and were harvested a week ago . The red cherry tomato variety (V1) showed promise for increased productivity by performing better in the majority of growth and yield parameters. Because the red variety did better than the yellow variety under the conditions, the study emphasizes how crucial it is to choose the right variety in order to optimize yield. In comparison to the yellow cherry tomato variety (V2), the red cherry tomato (V1) had the tallest plants due genetic and environmental differences. This observation agreed with earlier findings (Utomo et al., 2023; Kallo et al., 1998; Manoj and Ragav, 1998; Olaniyi et al., 2010; Fayaz et al., 2007). Additionally, the maximum number of fruits per plant, fruit length, fruit breadth, and individual fruit weight were recorded for the red variety (V1). This could be explained by the red cherry tomatoes innate genetic potential. Numerous genes regulate characteristics such as fruit length, breadth, and average individual weight (Venkadeswaran et al., 2018; Ramya et al., 2016; Renuka et al., 2014; Najeema et al., 2018; Saidu et al., 2012; Mohanty, 2002). According to Richardson (2013) and Olaniyi et al. (2010), the variance in fruit production is caused by the variations in the traits of the varieties under study and their capacity to respond to the site conditions that were chosen. Genetic variants under the same environmental conditions might also affect the differences in yield between various kinds (Olaniyi and Fagbayide, 1999; Aguirre and Cabrera, 2012; Islam et al., 2012; Renuka et al., 2014). Zahedi and Ansari (2012) found significant heterogeneity in tomato yield between genotypes. According to the study, the red cherry tomato variety (BARI Tomato-11) outperforms the yellow type in terms of yield and is well adapted to the local environment.

Interaction Effect of Seedling Age and Variety

The interaction effect of seedling age and cherry tomato types resulted in significant changes ($P<0.05$) in plant height, number of fruits per plant, individual fruit weight, fruit length, fruit breadth, and fruit yield per plant (Table 5). The 28-day-old red cherry tomato variety (A2V1) had the highest values for plant height (212.38 cm), number of fruits per plant (141.25), individual fruit weight (7.08 g), fruit length (2.38 cm), fruit breadth (1.85 cm), fruit yield per plant (984.35 g), and yield per hectare (39.37 t).

Table 5. Interaction effect of seedling age and varieties on the growth and yield of cherry tomato

Seedling age × Variety	Plant height (cm)	Fruits plant^{-1} (no.)	Fruit yield plant^{-1} (g)	Individual fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Fruit Length: breadth	Yield (t/ha)
21 days old X Red (A1V1)	205.28^{a}	123.75^{b}	859.92^{b}	6.92^{ab}	2.30a	1.80^{a}	1.38^{ab}	34.25^{b}
21 days old yellow (A1V2)	182.88^{c}	113.50^{bc}	768.93^{c}	6.77^{b}	2.10^{b}	1.58^{c}	1.33^{ab}	30.36^{c}
28 days old X Red (A2V1)	212.38^{a}	141.25^{a}	984.35^{a}	7.08^{a}	2.38^{a}	1.85^{a}	1.43^{a}	39.37^{a}
28 days old X Yellow (A2V2)	185.40b^{c}	115.75^{bc}	800.63^{bc}	6.99^{a}	2.30^{a}	1.73^{ab}	1.36^{ab}	34.39^{b}
35 days old X Red (A3V1)	199.93^{ab}	123.00^{b}	855.01^{b}	6.88^{ab}	2.13^{b}	1.60^{bc}	1.356^{ab}	32.02^{bc}

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35 days old X Yellow (A3V2)	174.18^{cd}	98.75d^{e}	650.04^{d}	6.89^{ab}	2.08^{b}	1.58^{c}	1.32^{ab}	30.10^{c}
42 days old X Red (A4V1)	180.33^{c}	109.25^{cd}	752.52^{c}	6.58^{c}	1.93^{c}	1.50^{c}	1.29^{ab}	26.02^{d}
42 days old X Yellow (A4V2)	163.90^{d}	94.00^{e}	605.62^{d}	6.44^{c}	1.88^{c}	1.53^{c}	1.24^{b}	24.22^{d}
Level of significance	hp	5%	5%	5%	5%	5%	5%	5%
CV (%)	5.63	6.80	7.03	1.88	4.20	5.53	7.89	6.97

Note: A column with a similar letter(s) are statistically similar and those with a dissimilar letter(s) differ significantly as per DMRT.

The A4V2 treatment had the lowest fruit weight (6.44 g) and the lowest fruit numbers per plant (94.00), while the A2V1 treatment had the highest fruit numbers per plant (141.25) and individual fruit weight (7.08 g). This suggests that the combined effects of seedling age and variety result in a considerable variance in the weights of the individual fruits. Furthermore, the A4V2 treatment had the lowest average fruit yield per plant (605.62 g) and yield per hectare (24.22 t). The production of more fruits per plant and heavier individual fruits is probably the cause of these results. Higher fruit production per unit area is the final result of improving plant development and yield characteristics. These findings demonstrate that, in comparison to typical middle-aged seedlings, seedlings that were either too young or too old considerably decreased plant growth. Several researchers have observed similar findings (Jaiswal et al., 2017 and Shukla et al., 2013). According to Shukla et al. (2013), 28-day-old seedlings benefit from superior above-ground and below-ground development when they are exposed to good weather and an enhanced environment. Osman and George (1984) also observed that increased yields were caused by plants of middle-aged seedlings producing more mature fruits. The physiological potential of transplants during the vegetative stage is improved by using seedlings that are biologically younger. According to Salik et al. (2000), middle-aged seedlings showed promising vegetative development since older shoots had reached maturity, which limited vegetative expansion, while younger seedlings had less stored food for vegetative spread. For the best production, young tomato transplants (3-4 weeks) need a longer growing period (Jankauskieno et al., 2013). Younger transplants of tomato have more chlorophyll in their leaves. The specific leaf area values and relative growth rate may have a more efficient photosynthetic system than older transplants (Leskovar et al.,1991). Ware and McCollum (1975) state that the plant's age, variety, and amount of stored food, particularly carbohydrates, all affect how quickly a plant recovers from transplantation. They pointed out that transplants that are about 28 days old probably have adequate nourishment saved for a full recovery. Transplants that were middle-aged produced the most fruits per plant. They developed well in the vegetative and reproductive stages. Middle-aged transplants produced healthier fruits, which ultimately led to a larger yield. Consequently, it can be said that in terms of yield, red cherry tomato variety (BARI Tomato-11) seedlings that are 28 days old perform better than those that are 21, 35, and 42 days old. This finding is supported by several earlier works (McCollum, 1975; Osman and George, 1984; Shukla et al. 2013; Utomo et al., 2023).

CONCLUSION

This finding showed how crucial it is to select the appropriate seedling type and age in order to maximize yield, especially when taking local environmental adaptability into consideration. The red cherry tomato cultivar is particularly adapted to the local climate of the Gazipur district of Bangladesh, and it produces a higher yield than the yellow cultivar. Thus, it is recommended that growers use 28-day-old cherry tomato seedlings for better yield. But more location-based research would be needed to determine the ideal transplant age for cherry tomato varieties under different climate conditions.

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