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Effect of Transplanting Dates and Varieties on the Vegetative Growth, Yield, and Yield Components of Tomato (*Solanum lycopersicum* L.)

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Authors' contributions

This study was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was carried out in the Research field of the Regional Agricultural Research Station (RARS), Hathazari, Chattogram, Bangladesh from November 2019 to April 2020 to observe the effect of transplanting date and variety for tomato production. Eight open-pollinated tomato varieties viz. BARI tomato-2, BARI tomato-3, BARI tomato-14, BARI tomato-15, Marglobe, Roma

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VF, Riograndi, and Khattabegun were considered as the factor A and two transplanting dates viz. 18th December 2019 and 18th January 2020 were considered as factor B. The study was laid out in factorial Randomized Complete Block Design (RCBD) with three replications. Different transplanting dates and varieties showed significant effects on the vegetative growth and yield of tomato. In 18th December transplanting, the highest number of fruits per plant was recorded in BARI Tomato-3 (46.87), followed by BARI Tomato-14 (43.22), while the lowest number of fruits per plant was recorded in variety Marglobe (13.00). Khattabegun variety had the maximum number of fruits per plant (14.17), followed by BARI tomato-3 (14.02) and BARI tomato-14 (13.97) on transplanting date 18th January. In 18th December transplanting, the highest yield was obtained from BARI tomato-14 (38.55 ton ha^{-1}), followed by BARI tomato-3 (38.16 ton ha^{-1}), while the lowest yield was found in variety Riograndi (9.17 ton ha^{-1}). The highest yield was recorded in BARI tomato-15 (12.10 ton ha^{-1}), while the lowest yield was observed in local variety Khattabegun (6.25 ton ha^{-1}) on transplanting date 18th January. Therefore, it is concluded that BARI Tomato-14 and BARI Tomato-3 with a combination of transplanting date in 18th December was noted as the best combination to get the optimum yield of tomato.

Keywords: Tomato; transplanting date; variety; yield; disease infestation; pest infestation.

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 [1]. 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 [1,2]. Annual tomato production has been 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 [1]. 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 [3-9].

Tomato quality is affected by climate, growing medium and plant nutrition [10]. Transplanting periods have a significant relation with local climatic variability. Different transplanting dates and varieties have significant effect on the yield of tomato [11]. Plant maturity, harvesting date, yield, and crop quality can be affected by transplanting date. At the pre-flowering and blooming stages, the high temperature (32°C) significantly reduced photosynthetic rate, number of fruits, individual fruit weight, and fruit output per plant. Temperature impacts were more during blooming than pre-flowering [12]. Agronomic practices have long been recognized as critical to crop nutrition [13]. The nutritional value of tomato is controlled by the tomato variety and harvest maturity [14]. Delayed transplanting reduces the plant height, fruit set, fruit weight, and yield of tomato. Appropriate transplanting date boost production as well as improve the fruit quality [11,15]. It is in high demand throughout the year, while most of the tomato production in Bangladesh takes place in winter [16,17].

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

2. MATERIALS AND METHODS

The experiment was conducted from November 2019 to April 2020 in the research field of Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Hathazari, Chattogram, Bangladesh. During the experimental period, the data of different environmental factors i.e., maximum and minimum rainfall (mm), maximum and minimum temperature (°C), and relative humidity (%) were collected from the weather station of RARS research field, Hathazari (Fig. 1). A total of eight tomato varieties including four BARI varieties (BARI tomato-2, BARI tomato-3, BARI

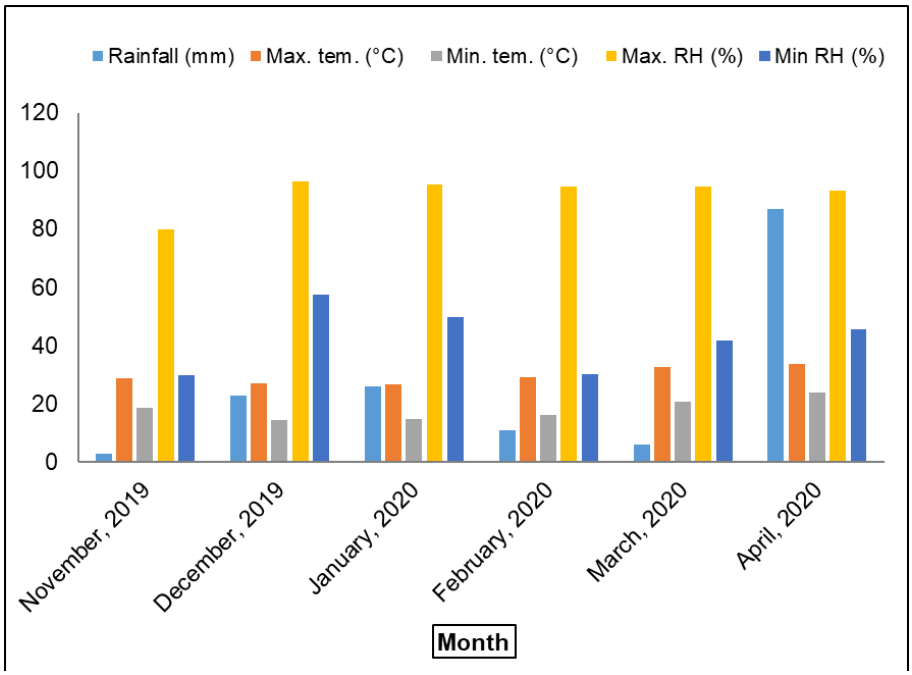

Fig. 1. Monthly weather data during tomato growing period

tomato-14, and BARI tomato-15), three commercial varieties (Marglobe, Roma VF, and Riograndi), and one local variety Khattabegun were used in this study. Seedling of the all varieties were grown in the nursery and 30-days old seedlings were transplanted in the main field in two different dates; 18th December 2019 and 18th January 2020. The study was laid out in factorial Randomized Complete Block Design (RCBD) with three replications. Plot dimensions were 4m × 3m with plant spacing of 70cm × 45cm. Urea, TSP, MoP, and Gypsum were applied @ 500, 200, 200, and 100 kg ha^{-1}, respectively in addition to the 10 ton ha^{-1} of cowdung manure [18]. Half of the cowdung manure with all TSP and MoP were applied to the land during final land preparation. The remaining cowdung manure was utilized to prepare the pit. The total amount of urea was applied in three equal instalments at 21, 35, and 45 days after transplanting. All necessary intercultural operations were carried out through the whole growing period. Plant height at first harvest, days to 50% flowering, no. of fruit clusters per plant, no. of fruits per plant, fruit yield per plot (kg), individual fruit weight (g), fruit length (cm), fruit girth (cm), and total yield (ton ha^{-1}) were recorded. However, fruit length (cm) and fruit girth (cm) were measured by slide calipers. Moreover, the disease i.e., bacterial wilt, early blight, and tomato leaf curl virus infested plants were counted from each plot in fifteen days interval from vegetative stage to final harvest, while the number of tomato fruits were counted infested by fruit borer during harvest and converted into percent. The statistical analysis was performed using the CropStat 7.2 Software [19].

3. RESULTS

3.1 Effect of Transplanting Dates and Varieties on the Vegetative Growth, Yield and Yield Components of Tomato

There were significant differences among the variables showed in Table 1, Table 2, and Table 3. Some crucial parameters showed significant differences in tomato varieties ($p \leq 0.05$). Plant height at first harvest was found to be significantly affected by transplanting dates and varieties, whereas the tallest plant was recorded in local tomato variety Khattabegun (118.40 cm and 108.84 cm), followed by BARI tomato-14 (111.47 cm and 91.07 cm) at transplanting dates 18th December and 18th January, respectively. The commercial variety Roma VF had the lowest plant height (46.15cm and 41.01cm) at transplanting dates 18th December and 18th January, respectively. Days to 50% flowering were significantly affected by transplanting dates and varieties. Roma VF was reached days to

50% flowering within long period of time (50.67 and 41.49 days after transplanting), whereas BARI tomato-2 required short period of time (34.33 and 25.00 days after transplanting) at transplanting dates 18th December and 18th January, respectively (Table 1).

The number of fruit clusters per plant significantly affected by transplanting dates and varieties. The variety Riograndi had the highest number of fruit clusters per plant (12.15), followed by BARI tomato-14 (10.67), BARI tomato-15 (10.47), and BARI tomato-3 (10.27) at the transplanting date 18th December. In 18th December transplanting, local variety Khattabegune had the lowest number of fruit clusters per plant (6.24) (Table 1).

BARI tomato-3 had the highest number of fruits per plant (46.87), followed by BARI tomato-14 (43.22), while the variety Marglobe had the lowest number of fruits per plant (13.00) at the transplanting date 18th December. In 18th January transplanting, BARI tomato-3 and BARI tomato-14 were second and third with 14.02 and 13.97 fruits per plant, respectively.

The highest fruit yield per plot was noted in BARI tomato-14 (48.26 kg) and the lowest was in variety Riograndi (10.77 kg) in 18th December transplanting, while the maximum fruit yield per plot was observed in BARI tomato-15 (14.30 kg) and minimum was in local variety Khattabegune (7.50 kg) on transplanting date 18th January (Table 1).

Individual fruit weight was significantly affected by transplanting dates and varieties. Individual fruit weight 168.54 g and 97.29 g were recorded for variety Marglobe, while 70.49 g and 63.53 g were recorded for Khattabegun in 18th December and in 18th January transplanting, respectively (Table 2). The maximum fruit length was recorded in the variety Marglobe (6.30cm and 5.87cm), whereas the minimum fruit length was observed in the local variety Khattabegun (3.94 cm and 3.91 cm) in 18th December and 18th January transplanting, respectively (Table 2).

There was no significant effect of transplanting date on fruit girth. BARI tomato-2 had the highest fruit girth of 6.17 cm, whereas the lowest fruit girth was 2.46 cm in variety Khattabegun in 18th December transplanting. When the BARI tomato-14 was transplanted in 18th January, the maximum fruit girth was 5.86 cm and the minimum was 2.88 cm.

The total yield (ton ha^{-1}) of tomato has significantly affected by transplanting date and variety. The highest yield was recorded in BARI tomato-14 (38.55 ton ha^{-1}), followed by BARI tomato-3 (38.16 ton ha^{-1}), while the lowest yield was observed in variety Riograndi (9.17 ton ha^{-1}) at transplanting date 18th December. In 18th January transplanting, the highest yield was recorded in BARI tomato-15 (12.10 ton ha^{-1}), while the lowest total yield was observed in local variety Khattabegun (6.25 ton ha^{-1}) (Table 2).

Table 1. Effect of transplanting date and variety on plant height at 1st harvest, days to 50% flowering, no. of fruit clusters per plant, no. of fruits per plant, and fruit yield per plot

Varieties	Plant height at 1st harvest		Days to 50% flowering		No. of fruit clusters per plant		No. of fruits/plant		Fruit yield/plot (kg) unit (kg)	
	18thDec.	18thJan.	18thDec.	18thJan.	18th Dec.	18th Jan.	18th Dec.	18th Jan.	18thDec.	18th 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		V=2.98		V=0.76		V=2.73		V=2.65	
	SD=5.10		SD=3.95		SD=0.95		SD=1.47		SD=3.98	
	V x SD=5.46		V x SD=4.21		V x SD=1.07		V x SD=3.86		V x SD=3.75	

Table 2. Effect of transplanting date and variety on individual fruit weight, fruit length, fruit girth, and total yield

Varieties	Individual fruit wt. (gm)		Fruit length (cm)		Fruit girth (cm)		Total yield (ton ha^{-1})	
	18th Dec.	18th Jan.	18th Dec.	18th Jan.	18th Dec.	18th Jan.	18th Dec.	18th 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 tomato-14	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	65.53	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	

3.2 Effect of Transplanting Dates and Varieties on Diseases and Pest Infestation

Levels of infections due to bacterial wilt disease did not significantly vary with transplanting date and variety. Level of bacterial wilt disease infection was 6.9% and 5.48% in Riograndi variety, whereas the Khattabegun variety was infected by 1.34% and 1.12% in 18th December and 18th January transplanting, respectively (Table 3). Early blight infestations were significantly influenced by transplanting date and variety. In 18th December transplanting, Roma VF had the highest infestation (2.41%) by early blight and the lowest infestation was observed in BARI tomato-3, BARI tomato-15, Marglobe, and Khattabegun with the value of (0.71%). Riograndi had the maximum infestation by early blight (4.13%), while the minimum infestation was reported in BARI tomato-3, BARI tomato-15, and Khattabegun (0.71%) in 18th January transplanting (Table 3).

There were no significant differences in number of fruits infected by fruit borer and tomato leaf curl virus between transplanting date and variety (Table 3). The percent of infected fruits by fruit borer was the highest in BARI tomato-2 (2.15%) and the lowest in Khattabegun (0.71%) in 18th December transplanting. In 18th January transplanting, the highest percentage of fruits damaged by fruit borer observed in BARI tomato-3 (2.23%), the lowest was in Khattabegun (0.71%). The highest tomato leaf curl virus infested plant was recorded in variety Marglobe (3.27%), while the lowest in BARI tomato-14 and BARI tomato-15 (1.12%) in 18th December transplanting but in 18th January transplanting, the maximum infestation was recorded in Khattabegun (2.90%), whereas the minimum infestation was observed in BARI tomato-3 and BARI tomato-14 (0.71) (Table 3).

4. DISCUSSION

Transplanting date and variety had significantly impact on the vegetative growth, yield and yield components of tomato. Transplanting dates influenced plant height, fruit yield, total yield, diseases, and pest infestation [20,21]. Tomato growth and yield were influenced by environmental conditions (humidity, soil moisture) and plant genetic materials as reported by [22]. Hilborn et al. [23] reported that heat stress significantly affects the yield and fruit quality of tomato. The plant height of tomato affected by seedling transplanting dates and genotypes [11,21]. The maximum plant height was observed after first transplanting that was done in 18th December in all studied varieties. The impact of transplanting date on environmental temperature is mostly shown in plant height [17]. The plant height of tomato decreased after late transplanting owing to environmental conditions. The environment controls the fruit yield per plant [17]. Tomato transplanted on 18th January had the lowest number of fruits and yield per plant, while the highest yield was achieved by transplanting tomato in 18th December which is lined with earlier studies result [17,24]. The early transplantation (18th December) shows positive effect for all yield-related characters compared to the late transplantation (18th January) which is agreed with the findings of [21,25].

Table 3. Effect of transplanting date and variety on the infestation of bacterial wilt, early blight, fruit borer, and tomato leaf curl virus

Varieties	Bacterial wilt (%)		Early blight (%)		Fruit borer (%)		Tomato leaf curl virus (%)	
	18th Dec.	18th Jan.	18th Dec.	18th Jan.	18th Dec.	18th Jan.	18th Dec.	18th 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 tomato-14	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	

The fruit set, fruit size, and ripening of tomato affected by temperature [26]. Fruit set percentage and fruit weight per plant declined when the daily mean temperature was 29°C, compared to 25°C [27]. The decline in production is mainly due to the decrease in pollen viability and poor pollen development [28]. According to the present study findings, transplanting in 18th December led to more blossoms and fruit compared to 18th January transplanting. This result is consistent with the findings of Ahammad et al. [29].

Transplanting date 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 [20,30].

In the present study it was observed that infestation caused by bacterial wilt, early blight, fruit borer, and tomato leaf curl virus were reported higher on tomato transplanted in 18th December than those transplanted in 18th January particularly in BARI tomato-2, BARI tomato-14, and BARI tomato-15. The highest infestations caused by bacterial wilt, early blight, and fruit borer were observed in tomato transplanted in 18th January compared to those transplanted in 18th December. Tomato leaf curl virus infection was higher in BARI tomato-3 at transplanting date 18th December compared to transplanting date 18th January, while Roma VF was not infected by tomato leaf curl virus. In 18th December transplanting, variety Marglobe showed more susceptibility to early blight, fruit borer, and tomato leaf curl virus compared to 18th January transplanting, while, bacterial wilt infestation showed opposite trend. The infestation by early blight, fruit borer, and tomato leaf curl virus was high at transplanting date 18th January compared to transplanting in 18th December in Variety Riogrande but bacterial wilt infestation was high in 18th December transplanting than 18th January transplanting. Moreover, Khattabegun variety showed high infestation by bacterial wilt transplanted in 18th December compared to 18th January transplanting and tomato leaf curl virus infestation showed opposite trend. However, most of the varieties were more susceptible to bacterial wilt, early blight, fruit borer, and tomato leaf curl virus when transplanted in 18th December compared to 18th January. A study conducted by Afreen et al. [20], they observed that transplanting tomato in 10th December was effective in controlling insect pest' infestation and increasing fruit yield. Waluniba and Ao [31] also reported that tomato transplanted in 4th December was highly infested by aphids and whiteflies, while those transplanted in 19th December were more prone to leaf miner and tomato fruit borer attacks.

5. CONCLUSION

The vegetative growth, yield, and yield components of tomato was significantly affected by transplanting dates and varieties. Transplanting tomato in 18th December using BARI tomato-14 and BARI tomato-3 varieties lead to optimum fruit yield with less disease and pest infestations. Moreover, BARI tomato-2 could be cultivated in January to get earlier yield as it requires short period of date for flowering (25 days after transplanting). However, Khattabegune (local variety) showed high tolerance to bacterial wilt, early blight, and tomato leaf curl virus which may be used as breeding materials for the development of biotic stress tolerance variety of tomato.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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