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# EVALUATION OF THE PERFORMANCE OF SUMMER TOMATO LINES IN BANGLADESH CONDITIONS

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## Abstract

The experiment was carried out at the Olericulture division of the Bangladesh Agricultural Research Institute's experimental field in Joydebpur, Gazipur. The objective was to evaluate the performance of eleven potential inbreed lines (CLN-3849, CLN-3850, CLN-3859, CLN-3860, CLN-3862, CLN-3864, CLN-3906, CLN-3916, CLN-3735, CLN-3791, CLN-3792) along with BARI Hybrid Tomato-8. Data on different parameters such as, plant height (cm), days to 50% flowering, individual fruit weight, fruit length, fruit breadth, locules number per fruit, Total Soluble Solids (TSS), pericarp thickness (cm), number of fruits per plant and fruit yield per plant were measured. Significant differences were observed in terms of plant height, days to 50% flowering, single fruit weight, number of locules and pericarp thickness among the genotypes. The outcome showed that the 12 tomato genotypes varied in the quantity of fruits produced per plant. Number of fruits per plant of different tomato line ranged from 7.33 to 21.67. It was found that the genotype BARI Hybrid Tomato-8 had maximum number of fruits per plant (21.67) followed by CLN-3791 (18.33) whereas the inbred line CLN-3791 produced maximum quantity of fruits (1.616 kg/plant).

**Key words**: Flowering, fruit weight and length, plant height, yield.

## Introduction

The tomato (*Solanum lycopersicum* L.) has a chromosomal number of 2n = 24 and is a member of the Solanaceae family. It is one of the most popular, healthy and widely consumed vegetable crops in the world (Ahmad 2002). In terms of vegetable production, tomatoes come in third place behind potatoes and sweet potatoes (Rashid 1993). When compared to other tomato-producing countries, Bangladesh's overall tomato production in 2011 was quite low at roughly 415,494 tons from 61 thousand hectares of land with an average yield of 3.80 t/ha (BBS 2011). In India, tomato occupies an area of 5.213 lakh ha with an annual production of 90.64 lakh MT and productivity of 17.387 t/ha (Sekhar et al. 2010). The causes of low yield of tomato in Bangladesh are particularly due to several major factors *viz*., lack of good variety, limited availability of good quality seeds of improved varieties, inadequate number of hybrid variety, pest and disease infestation.

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Bangladesh grows tomatoes in the winter because the conditions are ideal for maximum growth and yield at that time. But demand of tomato is constant throughout the year mainly because of its flavor and vitamin content. It has a strong chance of growing in the summer as well since some cultivars have heat tolerant capacity. However, because of agro-ecological restrictions, fresh tomatoes are less readily available in the summer. The monsoon season's extreme rains, windstorms, etc. have an impact on the summer tomato crop. In order to improve summer yield and, consequently, the farm family's income flow, special effort is required.

Nowadays, the farmers of Bangladesh prefer to grow hybrid varieties of tomato in order to avoid disease problems, get an early harvest (short duration) of good quality fruits and high yield. Hybrid variety development requires the creation and maintenance of inbred lines. The physico-morphological characterization of the inbred lines is very important to maintain genetic integrity. For tomato growers all around the world, the tomato yellow leaf curl virus (TYLCV) has grown to be a serious issue. The Middle East, Southwest Europe, Tropical Africa, Southeast Asia, and the Caribbean Islands are among the countries where the TYLCV-transmitted by whiteflies can cause an up to 100% drop in tomato production (Czosnek and Laterrot 1997). Bangladesh is also badly impacted by the virus, which, depending on the types, stages of infection, and spread throughout the country, may be responsible for up to 100% of cases (Akanda and Rahman 1993, Gupta 2000). In order to avoid crop damage and quality degradation, TYLCV control is of utmost importance.

The inability to grow tomatoes in hot, humid, and wet climates and the scarcity of suitable types that are tolerant to the tomato yellow leaf curl virus are the two main issues with growing summer tomatoes. In some tomato growing countries, attempts have been made to develop heat-tolerant TYLCV tolerant varieties and in generating technology for summer production of tomato. Several summer tomato varieties have been introduced in this country. It is needed to evaluate the performance of TYLCV tolerant summer tomato inbred lines collected from AVRDC for Bangladesh conditions to overcome these problems and for a successful summer tomato production. The goal of the current study was to assess how well TYLCV-tolerant summer tomato inbred lines performed in Bangladesh conditions.

**Materials and Methods**

The experiment was carried out in the research field of Olericulture Division, Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh. The study site's subtropical environment is marked by high rainfall from June to October and little else. The soil at the test site had a sandy loam texture and had an acidic pH of roughly 5.8. It belongs to the “Shallow red-brown terrace” soil of Madhupur tract (FAO 1988, Haider et al. 1991). Along with BARI Hybrid Tomato-8, eleven potential tomato inbred lines collected from the olericulture department of the horticulture research center at BARI, Gazipur were evaluated in this experiment (Table 1).

**Table 1.** Table showing major traits and source of collection of tomato inbreed lines.

| Sl. No. | Tomato lines | Major trait | Source of collection |
|---|---|---|---|
| 1. | CLN-3849 | Semi-indeterminate | HRC, BARI, Gazipur |
| 2. | CLN-3850 | Do | Do |
| 3. | CLN-3859 | Do | Do |
| 4 | CLN-3860 | Do | Do |
| 5. | CLN-3862 | Do | Do |
| 6. | CLN-3864 | Do | Do |
| 7. | CLN-3906 | Do | Do |
| 8. | CLN-3916 | Do | Do |
| 9. | CLN-3735 | Do | Do |
| 10. | CLN-3731 | Do | Do |
| 11. | CLN-3792 | Do | Do |
| 11. | BARI Hybrid Tomato-8 | Determinate | Do |

Using a Randomized Complete Block Design (RCBD), the experiment was set up to have three replications. In this experiment, three seedbeds (3.0 m × 1.0 m) were used, with each seedbed serving as one replication. The field experiment had a unit plot size of 1.0 m × 4.8 m, a double row of plants per bed, 12 plants per row, and 24 plants per plot. Plants were separated by 60 cm between each plant and 40 cm between each row. Blocks and the unit plot were 50 cm and 75 cm apart.

At first seeds were sown in seedbed. Throughout the entire growing time, a polytunnel was placed over the crop to protect it from excessive rain. 25 days old seedlings were transplanted in the main field. Intercultural cultural operations were done as and when necessary. Data on different parameters such as, plant height (cm), days to 50% flowering, individual fruit weight, fruit length, fruit breadth, locules number per fruit, Total Soluble Solids (TSS), pericarp thickness (cm), number of fruits per plant and fruit yield per plant were measured. Collected data parameters were subjected to statistical tools for Agricultural Research (STAR) Program software for analysis of variance and mean separation. Correlation coefficient analysis was done by MSTAT program software. Box plots were prepared for some parameters which is a practical method for displaying groups of numerical data graphically through their quartiles (minimum, first quartile, median, third quartile and maximum).

## Results and Discussion

Significant differences were observed in terms of plant height, days to 50% flowering, single fruit weight, number of locules and pericarp thickness among the genotypes (Table 2).

### Plant height

The plant height increased with the advancement of growth period up to 90 days after transplanting (DAT) and then remained constant. All the studied genotypes of tomato were significantly different according to plant height (Table 2). In the boxplot (Fig. 1a**)** of plant height indicated that it ranged from 134.33 cm to 182.00 cm. The tallest plant height (182.00 cm) was recorded for the inbred line CLN-3792. Rectangle of boxplot indicated that 50% of the plant heights of inbred line ranged from 146 cm to 166.33cm. The bold black line inside the rectangle indicates the median value (153.16), which also indicated that plant height of 50% genotypes (6) was greater than this value. The lowest plant height was shown by the inbred line CLN-3906, which was considerably different from all the other lines (134.33 cm). Phookan et al. (1990) when studied with 29 tomato genotypes grown in summer under plastic house condition reported plant height range of 46.00 to 95.00. The plant height of the studied genotypes was higher than the reported results. These variations might have arisen from the genetic variability present in the cultivars, and environment condition employed in the current study.

### Plant type

Plant type also differed significantly among the studied genotypes (Table 1). Two types i.e., semi-indeterminate and determinate plant structures were observed among the studied inbred line. Among them except for BARI Hybrid Tomato-8 all other tomato lines were semi- indeterminate type structured and only the BARI Hybrid Tomato-8 was determinate type plant structure.

### Days to 50% plant flowering

Significant differences between the genotypes were seen in the days to 50% plant flowering (Table 2). The range was from 15.00 to 27.00 days after transplanting. The inbred line CLN-3860 (15.00 days) had the earliest flowering, and it was statistically pretty close to the inbred lines CLN-3849 (15.33 days), CLN-3850 (16.00 days), and CLN-3906 (15.00 days) (16.00 days). The maximum or late flowering was observed in the inbred line CLN-3859 (27.00 days). According to research conducted with 8 tomato hybrid lines for the summer season by Alam et al. (2010), the time required to reach 50% flowering ranges from 45 to 48 days. The cultivars and growth conditions employed in the current study could be the cause of these differences. In the boxplot (Fig. 1b), rectangle indicated that most of the (about 50%) days to 50% plant flowering of inbred line ranged from 16.00 days to 18.00 days. The inbred lines are CLN-3792 (17.67 days); CLN-3850 (16.00 days); CLN-3862 (17.00 days); CLN-3864 (17.00 days); CLN-3906 (16.00 days); CLN-3916 (17.00 days) and BARI Hybrid Tomato-8 (17.00 days). The bold black line inside the rectangle indicates the median value (17.83).

**Single fruit weight**

The weight of a single fruit varied greatly between tomato genotypes (Table 2). The weight of a single tomato fruit from several tomato lines varies from 48.67 g to 83.33 g. The highest single fruit weight was recorded in the inbred line CLN-3791 (83.33 g). The line CLN-3860 produced the lowest single fruit weight of 48.67 g, which was statistically equivalent to the lines CLN-3862, CLN3864, and CLN-3906 (52.33, 53.33 and 54.33, respectively). According to Ahmad (2002), the weight of each fruit ranged from 29 to 83 g. The weight of each fruit ranged from 32.87 g to 46.35 g, according to Roy (2009). In the present study fruit weight was found to be higher than the earlier report. It could be because the genetic makeup of the lines employed in the current experiment changes.

From the rectangle of boxplot (Fig. 1c), it indicated that 50% of the single fruit weights of inbred lines ranged from 54.00 gm to 70.00 gm. The tomato lines are CLN-3859 (56.33); BARI Hybrid Tomato-8 (56.33); CLN-3849 (64.33); CLN-3792 (68.33); CLN-3916 (67.67) and CLN-3906 (54.33). The bold black line inside the rectangle indicates the median value (60.16), which was very much close to the mean value (62.25) of the inbred lines.

**Fruit length**

There was a small difference in fruit length among the tomato genotypes (Table 2). The fruit lengths of various tomato lines varied from 5.03 to 6.33 cm. From this observation it was found that the inbred lines CLN-3735, CLN-3849 and CLN-3859 had the maximum length of fruit (6.33 cm). The inbred line CLN-3792 gives the shortest fruit (5.00 cm). According to Patwary (2009), during the winter, tomato fruit lengths ranged from 3.24 cm to 6.09 cm. Ahmad (2002) got similar results in an experiment with 49 genotypes of tomato in summer season, which ranged from 1.94 cm to 5.46 cm. Findings from the present study, is different from reported results regarding the fruit length of tomato. This might be due to the difference in the inbred line as well as in the growing environment used in the present study.

**Fruit breadth**

There was a small difference in fruit breath among the tomato genotypes (Table 2). Different tomato lines produced fruits with lengths ranging from 4.67 cm to 6.00 cm. According to this observation, the inbred line CLN-3906 had the largest fruit breadth (6.00 cm), which was identical to the inbred line CLN-3916 (6.00 cm). The inbred line CLN-3735 produced the shortest fruit (4.67 cm), which was identical to the inbred lines CLN-3792 (4.67 cm) and CLN-3862 (4.67 cm). According to Patwary (2009), during the summer, tomato fruit ranged in width from 4.08 cm to 4.14 cm. These variations can be a result of the various cultivars used in the current study.

**Locules number per fruit**

The genotypes of tomato showed variation in case of locules per fruit (Table 2). The range of tomato lines' locule counts was 2.0 to 5.33. The genotype BARI Hybrid Tomato 8 produced the maximum (5.33) locules per fruit followed by inbred line CLN-3791 (4.67). The inbred line CLN-3859 produced the lowest (2.00)

locules per fruit. The present result is not similar to other results previously reported. It might be due to the divergence of genetic makeup of lines used in the present study.

**Total soluble solids (TSS)**

The genotypes of tomato showed variation in case of total soluble solids (Table 2). The range of TSS% between tomato lines was 3.67% to 5.33%. The highest TSS% (5.33%) was recorded in CLN-3859. The inbred line CLN-3735 produced the lowest TSS% which was (3.67%). According to Patwary (2009), the TSS% ranged from 3.39% to 4.77% in the summer and from 4.37% to 5.67% in the winter. The present result is different than the reported results. The variation of TSS% is due to the difference of tomato inbred lines used in the present study.

**Pericarp thickness**

Pericarp thickness significantly differed between genotypes (Table 2). The highest pericarp thickness of 0.5667 cm was recorded in the inbred line CLN-3735. The lowest pericarp thickness was 0.4200 cm recorded in the inbred line CLN-3849. According to Ahmad et al. (2011), tomato pericarp thickness varied from 0.44 cm to 0.63 cm. It might be due to the difference of genetic make-up of lines used in the present study.

**Number of fruits per plant**

The outcome showed that the 12 tomato genotypes varied in the quantity of fruits produced per plant (Table 2). Number of fruits per plant of different tomato line ranged from 7.33 to 21.67. It was found that the genotype BARI Hybrid Tomato-8 had maximum number of fruits per plant (21.67) followed by CLN-3791 (18.33). The inbred lines CLN-3859 and CLN-3906 produced the fewest fruits per plant, equally (7.33). Phookan et al. (1990) investigated 29 tomato genotypes in relation to eight different growth and yield-attributing factors in a plastic house during the course of the summer and found that the fruit number varied from 2.67 to 70.00. According to Ahmad (2002), tomato plants could produce anywhere between 17.80 and 179.59 fruits per plant. The range of tomato fruits per plant, according to Roy (2009), is 35 to 76.39. Regarding the tomato plant's fruits per plant, a significant difference was found between the previously reported and current results. This difference might be due to the difference in the genotypes and genetic make-up as well as in the growing environment used in the present study. From the rectangle of boxplot (Fig. 1d), it indicated that, about 50% of the number of fruits per plant of inbred lines ranged from 10.0 to 17.5 (Fig. 4). The inbred lines are CLN-3735 (17.33), CLN-3849 (11.33), CLN-3850 (12.67), CLN-3860 (15.33), CLN-3864 (15.33), and CLN-3916 (11.67). The bold black line inside the rectangle indicates the median value (14.00), which was very much close to the mean value (13.78) of the tomato lines.

**Fruit yield per plant (kg)**

Several genotypes showed significant variance in terms of fruit yields per plant. The fruit production of various tomato lines per plant ranged from 0.436 kg to 1.616 kg (Fig. 1e). From the present observation it

was found that the inbred line CLN-3791 produced maximum quantity of fruits (1.616 kg/plant) which was statistically identical to CLN-3735 (1.496 kg/plant) and CLN-3792 (1.496 kg/plant). The least amount of fruit was produced (0.436 kg/plant) by the inbred line CLN-3859. In research with 29 types of genotypes of tomato conducted in a plastic house during the summer. The output per plant ranged from 0.21 to 1.60 kg, according to Phookan et al. (1990). The finding of the present experiment was very similar to the results of the previous reports. Significant differences were observed in terms of plant height, days to 50% flowering, single fruit weight, number of locules and pericarp thickness among the genotypes (Table 2).

**Table 2.** Table showing plant, floral and fruit characteristics of TYLCV tolerant summer tomato genotypes.

| Genotype | Plant Height (cm) | Days to 50% plant flowering | Single fruits weight (gm) | Fruit length (cm) | Fruit breadth (cm) | No. of locule | TSS% | Pericarp thickness (cm) | Number of fruits per plant |
|---|---|---|---|---|---|---|---|---|---|
| CLN-3735 | 165.33$^{b}$ | 19.33$^{b}$ | 72.33$^{b}$ | 6.33 | 4.67 | 3.00$^{bc}$ | 3.67 | 0.5667$^{a}$ | 17.3$^{ab}$ |
| CLN-3791 | 166.33$^{b}$ | 19.67$^{b}$ | 83.33$^{a}$ | 5.33 | 5.33 | 4.67$^{ab}$ | 4.67 | 0.5000$^{abc}$ | 18.33 $^{ab}$ |
| CLN-3792 | 182.00$^{a}$ | 17.67$^{b}$ | 68.33$^{b}$ | 5.00 | 4.67 | 4.67$^{ab}$ | 4.33 | 0.5200$^{abc}$ | 17.33 $^{ab}$ |
| CLN-3849 | 151.33$^{cd}$ | 15.33$^{b}$ | 64.33$^{bc}$ | 6.33 | 5.00 | 3.33$^{abc}$ | 4.33 | 0.4200$^{c}$ | 11.33$^{bcd}$ |
| CLN-3850 | 156.00$^{c}$ | 16.00$^{b}$ | 69.67$^{b}$ | 5.33 | 5.33 | 4.00$^{abc}$ | 4.67 | 0.4400$^{bc}$ | 12.67 $^{bcd}$ |
| CLN-3859 | 169.33$^{b}$ | 27.00$^{a}$ | 56.33$^{cd}$ | 6.33 | 5.33 | 2.00$^{c}$ | 5.33 | 0.5433$^{ab}$ | 7.33$^{d}$ |
| CLN-3860 | 155.33$^{c}$ | 15.00$^{b}$ | 48.67$^{d}$ | 5.67 | 5.00 | 3.00$^{bc}$ | 4.33 | 0.5233 $^{abc}$ | 15.33 $^{abc}$ |
| CLN-3862 | 151.00$^{cd}$ | 17.00$^{b}$ | 52.33$^{d}$ | 5.33 | 4.67 | 4.00$^{abc}$ | 4.67 | 0.4567$^{bc}$ | 9.67$^{cd}$ |
| CLN-3864 | 146.33$^{de}$ | 17.00$^{b}$ | 53.33$^{d}$ | 5.33 | 5.33 | 3.00$^{bc}$ | 4.00 | 0.5167 $^{abc}$ | 15.33 $^{abc}$ |
| CLN-3906 | 134.33$^{f}$ | 16.00$^{b}$ | 54.33$^{d}$ | 6.00 | 6.00 | 4.00$^{abc}$ | 4.00 | 0.4633 $^{abc}$ | 7.33$^{d}$ |
| CLN-3916 | 146.00$^{de}$ | 17.00$^{b}$ | 67.67$^{b}$ | 5.67 | 6.00 | 4.00$^{abc}$ | 4.00 | 0.5033 $^{abc}$ | 11.67 $^{bcd}$ |
| BARI Hybrid | 141.33$^{e}$ | 17.00$^{b}$ | 56.33$^{cd}$ | 5.67 | 5.67 | 5.33$^{a}$ | 4.33 | 0.4867 $^{abc}$ | 21.67$^{a}$ |
| F-test | ** | ** | ** | NS | NS | ** | NS | ** | ** |
| CV(%) | 1.32 | 10.42 | 5.23 | 18.70 | 25.95 | 20.10 | 16.66 | 7.22 | 17.73 |

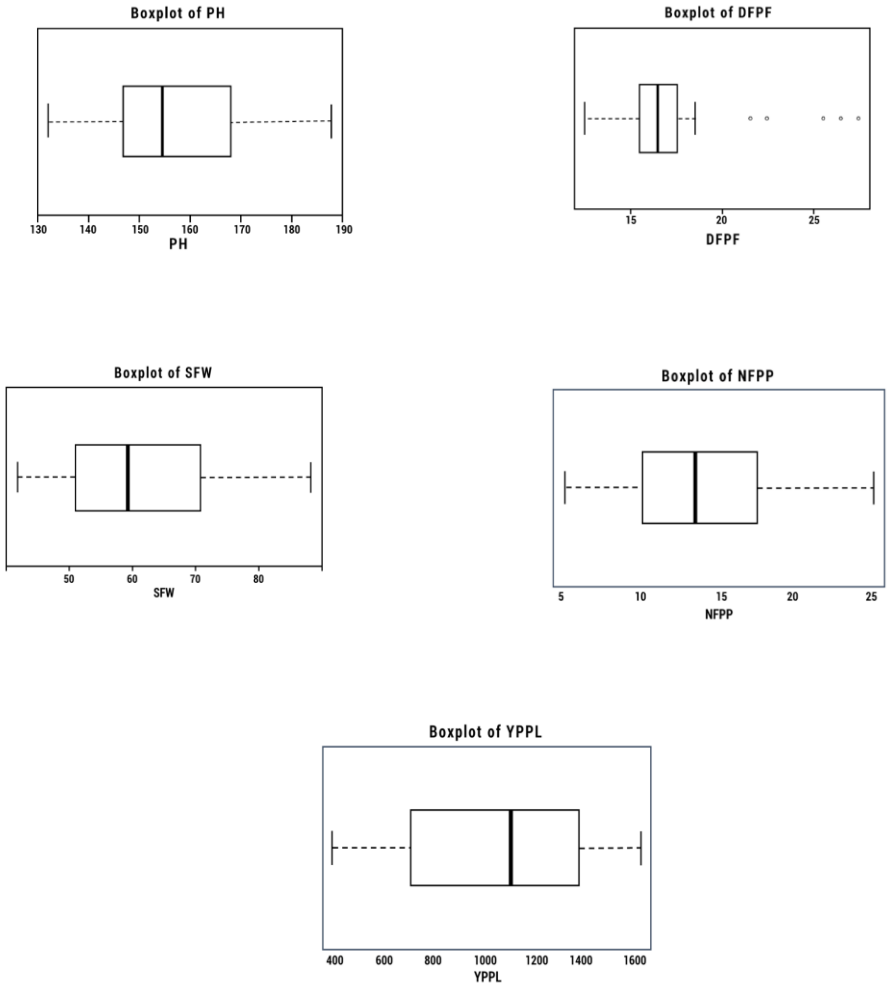


**Fig. 1(a-e):** Boxplot representing various yield characters. a) plant height of tomato lines, b) the number of days required for 50% flowering, c) single fruit weight of tomato lines, d) the number of tomato fruits per line, e) fruit yield per plant of tomato lines.

**Correlation analysis**

**Table 3.** Correlation between yield per plant and other yield attributes.

| Traits | NFP | SFW | FL | FB | NL | TSS | PT | YDP |
|---|---|---|---|---|---|---|---|---|
| PH | 0.222 | 0.482 | -0.164 | -0.647* | -0.144 | 0.356 | 0.479 | 0.316 |
| NFP | - | 0.346 | -0.365 | -0.201 | 0.519 | -0.309 | 0.304 | 0.825** |
| SFW | - | - | -0.112 | -0.075 | 0.317 | -0.050 | 0.056 | 0.825** |
| FL | - | - | - | 0.107 | -0.577* | -0.058 | 0.115 | -0.375 |
| FB | - | - | - | - | 0.204 | -0.089 | -0.185 | -0.172 |
| NL | - | - | - | - | - | -0.156 | -0.361 | 0.535 |
| TSS | - | - | - | - | - | - | -0.137 | -0.417 |
| PT | - | - | - | - | - | - | - | 0.179 |

*= Significant at 5% level, **= Significant at 1% level, PH = Plant height, NFP = Number of fruits per plant, SFW = Single fruit weight, FL = Fruit length, FB = Fruit breadth, NL = Number of locules, TSS = Total soluble solids, PT = Pericarp thickness, YDP = Yield per plant.

The correlations between yields per plant with other yield attributes are shown in Table 3. Plant height correlated positively but not significantly with the number of fruits per plant, the weight of a single fruit, the total amount of soluble solids, the thickness of the pericarp, and the yield per plant and negative non-significant correlation between fruit length and the locules number. It had negative but significant correlation with fruit breadth. Despite both positive and negative associations with other characteristics, the number of fruits per plant demonstrated a positive and highly significant correlation with yield per plant. Single fruit weight also had positive and highly significance association with yield per plant and both negative and positive non-significant association with other characters. The finding shows that selection should be focused on more fruit that is greater in size and weight in order to increase yield (Hayder et al. 2007). According to Singh et al. (1997), fruit yield at Keonjhar during 1991–1992 under irrigated conditions exhibited a substantial positive association with the quantity of fruits per plant. For a correlation analysis experiment, Mohanty (2002) used 18 local and exotic tomato genotypes. He also stated that there was a large and significant correlation between fruit yield and the quantity of fruits per plant. Fruit length, fruit breadth, number of locules, total soluble solid and pericarp thickness had both negative and positive non-significant correlation with yield per plant and other yield attributes.

**Conclusion**

Extensive ranges of morphological variation, fruit and yield component characteristics were recorded among the genotypes. The performance of summer tomato inbred line was satisfactory as they did not exhibit any Tomato yellow leaf curl virus (TYLCV) infection in Bangladesh field condition. The inbred lines CLN-3791, CLN-3735 and CLN-3792 had the highest fruit yield potentiality and produced 1.616 kg, 1.496 kg and 1.496

kg fruit per plant respectively. Besides, the inbred lines CLN-3791 and CLN-3735 also produced the highest number of fruits per plant 18.33 and 17.33 respectively with bigger fruit size. The inbred lines showed a considerably high shelf life in normal condition. The best promising inbred line CLN-3791 can be subjected to multi-location trial with a view to releasing as one or more as Tomato yellow leaf curl virus (TYLCV) tolerant variety of tomato for summer season cultivation. The inbred lines CLN-3791, CLN-3735 and CLN-3792 need to be maintained properly for future breeding program since they produce appreciable fruit yield per plant and number of fruits per plant. Further evaluation of promising inbred lines CLN-3791, CLN-3735 and CLN-3792 can be made for selection of suitable hybrid(s) for summer season cultivation.

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**Author contributions**

Conceptualization: Saurav Brata Das, Dr. M. Nazim Uddin; Methodology, Investigation: Bani Krishna Goswami, Md. Abdul Baki; Supervision: Dr. M. Nazim Uddin; Formal analysis: Saurav Brata Das and Bani Krishna Goswami; Writing - Original draft preparation, review and editing: Saurav Brata Das, Dr. M. Nazim Uddin, Bani Krishna Goswami and Md. Abdul Baki. All authors have read and agreed to the published version of the manuscript.

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