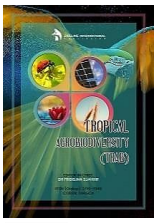
ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2716-7046 (Online)
CODEN: TARCGA

Tropical Agrobiodiversity (TRAB)

DOI: http://doi.org/10.26480/trab.02.2022.40.46



RESEARCH ARTICLE

EVALUATION OF CHERRY TOMATO (*SOLANUM LYCOPERSICUM* L. VAR. *CERASIFORME*) GENOTYPES FOR GROWTH AND YIELD ATTRIBUTES

Mohammad Zahir Ullah[a], M. Samsuzzaman[b], Md. Sarowar Alam[b], Joti Lal Barua[c], Elora Parvin[c]

[a] Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN), Noakhali
[b] Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Akbarpur, Moulvibazar-3210
[c] Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN), Head Office, Araihazar, Narayangonj
**Corresponding Author Email: asarowar04bau@gmail.com*

This is an open access article distributed under the Creative Commons Attribution License CC BY 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ARTICLE DETAILS

Article History:

Received 08 June 2022
Accepted 13 July 2022
Available online 18 July 2022

ABSTRACT

The research was conducted with 12 cherry tomato genotypes at Regional Research Station, Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN), Noakhali, Bangladesh during the year 2020-21 to select suitable cherry type tomato for processing purposes. Among the genotypes, highest number of fruits per cluster was observed in CT-11 (31.67), higher average fruit weight (69.53g) and the number of locules (5.67) per fruit was recorded in CT-14 but the highest fruit yielder was CT-15 (11.30 kg). Higher heritability, genetic advance, genotypic coefficient of variation for number of fruits and clusters per plant, fruits per cluster, fruit yield per plant were controlled by additive gene action, which indicates the scope for improvement of this characters. A significant positive correlation coefficient was observed with plant height, the number of clusters per pant, fruits per plant and pericarp thickness. Yield showed a significant linear regression coefficient with number of clusters per plant, fruits per cluster, fruits per plant, fruit length and fruit diameter. Principal component and cluster analyses revealed that four principal components accounted for 90.60% of the morphological variability of the genotypes evaluated. Among the genotypes, CT-5 produced the highest number of fruits per plant and CT-15 produced the highest fruit yield and can be selected for cultivation under Bangladesh conditions.

KEYWORDS

Phenotypic variability, Heritability, Principal component analysis, Tomato.

1. INTRODUCTION

Cherry tomato (*Solanum lycopersicum* var. *Cerasiforme*) is indeterminate type with smaller fruits and are consumed either fresh as a salad or after cooking as snacks and are very popular to the children like as grape (Prema, et al., 2011; Flores et al., 2017). Though cherry tomato became popular as a cash crop in some Asian countries and is still new in Bangladesh. It is widely cultivated in central America and distributed in Europe and major parts of Asia (Bauchet and Causse, 2012). Cherry tomato is a small type of tomato with a range of 10-40 g in weight with oblong, round and flattened shape as well as red and yellow in color. It is growing quickly, ripen early, and are good for homestead garden planting (Anon., 2009). Cherry tomatoes are utilized for preparing different processed foods such as ketchup, sauce, paste, soup, powder, chutney, pickles and curries (Flores et al., 2017; Kobryn and Hallmann, 2005).

Cherry tomato is popular horticultural crop due to its high soluble solid, unique aroma, taste, antioxidants, vitamins like ascorbic acid, beta-carotene, vitamin E, minerals like calcium and fiber, important for human nutrition and health (Prema et al., 2011; Beckles, 2012; Liu et al., 2018). It also contains other essential bio compounds, like flavonoids, phenolic acids, and carotenoids (George et al., 2004; Kuti and Konuru, 2005). Higher lycopene content in cherry tomato is widely known, which may be used to increase the lycopene content in tomato breeding program (Medina and Lobo, 2001; Acharya et al., 2018). Knowledge of genotypic and phenotypic coefficient of variations, heritability, genetic advance, traits association are helpful in selecting suitable plant type (Salim et al., 2013). Therefore, 12 cherry tomato lines were developed by BIRTAN, Noakhali. So, for the identification of suitable cherry tomato genotypes, present research was implemented to characterize growth and yield attributes, which would help the plant breeders in planning a successful breeding program for tomato improvement.

2. MATERIALS AND METHODS

The experiment was performed with twelve cherry tomato inbred lines at the Regional Research Station field of BIRTAN, Noakhali during the Rabi season of 2020-2021in RCB design with three replications. Seeds were sown on 20 November 2020 in plastic trays in the mixture (2:1) of coco peat and farmyard manure. Irrigation and plant protection measures were taken properly to raise the quality seedlings. Seedlings of 30 days old were transplanted in the main field. The land was well prepared and fertilized with cow-dung, Urea, TSP, and MoP at the rate of 15 ton, 340, 430 and 250 kg per ha, respectively. Full amount of cow-dung, TSP and MoP were applied as basal dose while urea was top dressed twice at 30 and 45 days after transplanting.

Unit plot size was 4.8 m × 1.0 m with spacing at 60 cm × 40 cm between row to row and plant to plant, respectively. Intercultural operations were done properly. Randomly ten plants were selected from each plot for data collection. The ANOVA for the traits was performed using MSTAT and OPSTAT software. The genotypic and phenotypic co-efficient of variation

Quick Response Code	Access this article online	
	Website: www.trab.org.my	**DOI:** 10.26480/trab.02.2022.40.46

Cite The Article: Mohammad Zahir Ullah, M. Samsuzzaman, Md. Sarowar Alam, Joti Lal Barua, Elora Parvin (2022). Evaluation of Cherry Tomato (*Solanum Lycopersicum* L. Var. Cerasiforme) Genotypes For Growth And Yield Attributes. *Tropical Agrobiodiversity, 3(2): 40-46.*

were calculated by following (Burton and Devane, 1953). The expected genetic advance for the studied traits was clculated following and mean percentage of genetic advance was estimated as per the procedure (Johnson et al., 1955; Comstock and Robinson, 1952). The correlation coefficient was measured as described (Panse and Sukhatme, 1967).

3. Results and Discussion

A wide range of variation was observed in respect to days to first flowering. It was also reported by for an experiment with six genotypes of cherry tomato (Prema et al., 2011). Genotype CT-11 required only 68.00 days to first flower while the highest days was required for CT-6 (83.00). Among the genotypes, CT-9 was the tallest in height (159.33 cm) and it was statistically dissimilar and followed by CT-17 (155.7 cm) and both genotypes CT-15 and CT-16 (155.3 cm). Genotype CT-5 had the highest number of clusters per plant (35.33) while CT-14 had the lowest number (7.33). The maximum number of fruits per cluster was recorded in CT-11 (31.67) and minimum was recorded in CT-14 (4.00). Singh and Gopalkrishnan also reported same trends for number of fruits per cluster (Gopalkrishnan, 2000). Again, other researchers also observed similar results. Individual fruit weight ranged from 10.33g (CT-16) to 69.53 g (CT-14) (Mohanty, 2003; Prashanth, 2003; Mehta and Asati, 2008; Prema et al., 2011).

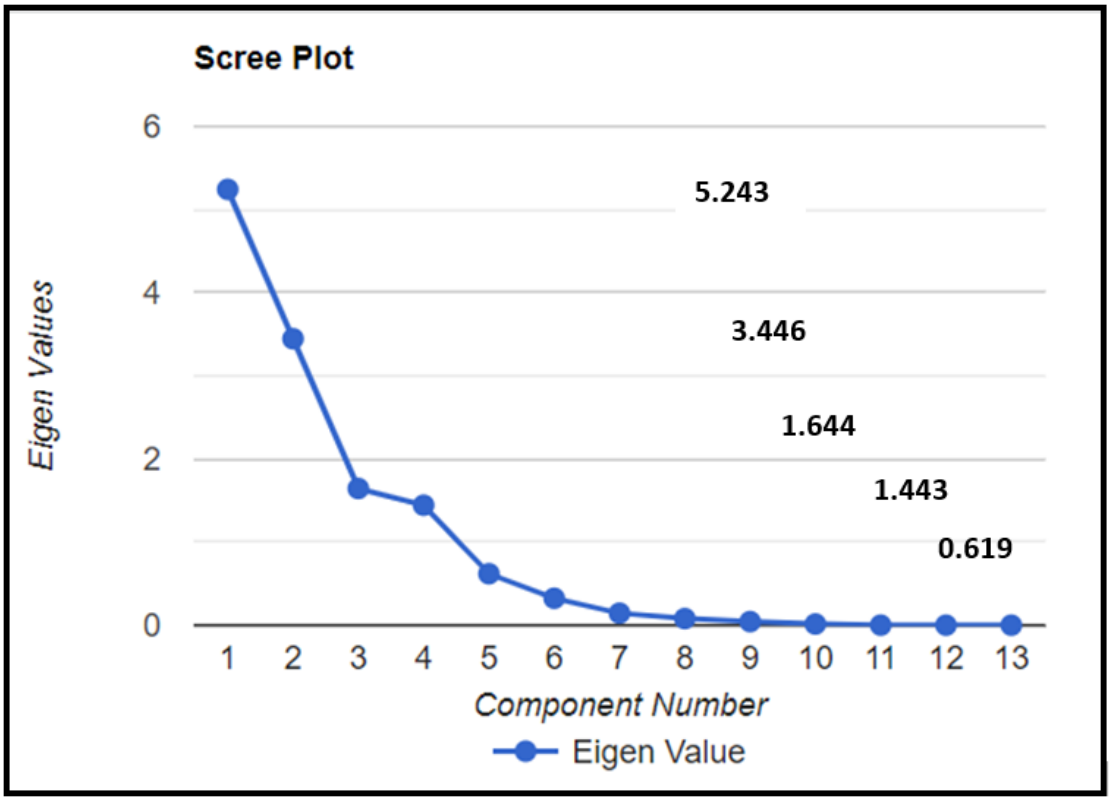


Figure 1: Percentage of variability explained by main principal components

The finding also confirmed similar result (Renuka et al., 2017). The fruit weight directly contributes towards the fruit yield per plant this was confirmed (Deepa and Thakur, 2008). The highest number of fruits per plant was recorded in CT-5 (738.0) and it was statistically similar with CT-11 (696.0). The lowest number of fruits per plant was recorded in CT-14 (29.33). Fruit size in respect of fruit length and fruit breadth, the genotype CT-14 had the biggest fruit (3.83 cm × 5.16 cm) while the genotype CT-16 had the smallest fruit (3.30 cm × 2.10 cm). Among all genotypes pericarp thickness varied between 2.97 mm (CT-16) and 6.50 mm (CT-15). Similar results were reported by in tomato (Joshi et al., 1998). Pericarp thickness and firmness are very important for post-harvest storage life of tomato. Present findings supported by the results obtained by in tomato (Shivanand, 2008). The maximum number of locules per fruit was observed in CT-14 (5.67) which was followed by CT- 4 (4.66) and CT- 9 (4.33).

Almost similar result was observed and found in line COHBT-208 (4.00) (Najibullah et al., 2020). Presence of limited number of locules in cherry tomato (2-3) is preferred than fruit having more locules as a cherry tomato is generally preferred as table fruit vegetable. The results were in consonance with the finding of (Renuka et al., 2014). The lowest locules were observed in CT-5, CT-6, CT-11 and CT-16 (2.00), respectively. The highest yield per plant was observed in CT-15 (11.30 kg) and it was statistically similar with CT-13 (10.2 kg), CT-17 (10.01 kg) and CT-9 (9.68 kg). Though genotype CT-15 produced medium individual fruit (39.78 g) but its fruit yield per plant was the highest (11.3 kg) due to higher number of fruits per plant. The lowest yield per plant was recorded in genotype CT-14 (1.76 kg). A wide range of yield per plant (1.57 to 4.25 kg) was also reported in six cherry tomato genotypes (Prema et al., 2011).

Variability, in regarding of GCV, PCV along with heritability, genetic advance is presented in Table 2. In general, phenotypic coefficient of variation (PCV) was higher than GCV in all the traits. GCV and PCV were high (>20%) for number of clusters per plant (29.91 and 33.33), fruits per cluster (36.84 and 42.55), fruit weight (44.60 and 45.86), fruits per plant (50.20 and 61.43), fruit length (20.43 and 23.80), fruit diameter (24.37 and 24.86), pericarp thickness (22.35 and 26.07), locule number per fruit (33.78 and 37.92) and fruit yield per plant (28.17 and 35.16), respectively. The results for high estimates of phenotypic and genotypic coefficient of variation for different characters are in agreement with the results reported in tomato (Anjum et al., 2009; Prema et al., 2011). Lower GCV and PCV were obtained for days to first flowering (6.01 and 6.08), days to 50% flowering (6.17 and 6.25), days to maturity (7.19 and 7.38).

Maximum traits were found high heritability (>60%). High heritability of traits was indicated that these characteristics are less influenced by the environment. Genetic advance (GA) in percent of mean was very high for fruit weight (89.34) followed by fruits per plant (84.51), fruits per cluster (65.70), locule number (62.00), number of cluster per plant (55.30), fruit diameter (49.19), fruit yield per plant (46.49), pericarp thickness (39.46) and fruit length (36.13), whereas this estimate was the lowest for days to first flowering (12.24) followed by days to 50% flowering (12.54) and days to maturity (14.42). Heritability, genetic advance and GCV together could be more fruitful to know the amount of advance from selection (Johnson et al., 1955). Higher GA, heritability and GCV revealed that the studied traits were controlled by additive gene action and the phenotypic selection would be effective for these parameters. High heritability and moderate GA and GCV for fruit diameter indicated the effectiveness for this trait. Lower heritability and lower genetic advance can be improved by breeding (Liang and Walter, 1968; Anjum et al., 2009).

Table 1: Mean performance of twelve cherry tomato genotypes

Code	DFF	D50F	DM	PH (cm)	NCP	FPC	FW (g)	FPP	FL (cm)	FD (cm)	PT (mm)	LN	FYP (kg)
CT-4	79.00 c	89.00b	139.3a	149.7c	21.00b	13.33c	27.33cde	279.0b	3.00 h	3.80cd	4.00defg	4.66ab	7.54bcd
CT-5	76.00f	82.00cd	118.3e	151.0c	35.33a	21.00b	12.00f	738.0a	2.50i	2.50e	3.56efg	2.00d	8.79abc
CT-6	83.00a	93.00a	121.0c	120.0f	15.00cd	14.67c	23.00def	220.0bc	4.43a	3.50d	5.20bc	2.00d	5.04de
CT-7	80.00b	90.00b	126.0b	129.7e	15.00cd	22.00b	21.33ef	330.7b	3.50efg	3.30d	4.13cdef	2.10d	7.09cd
CT-9	72.00h	80.00e	114.0i	159.3a	19.67bc	13.00c	38.03bcd	254.7b	3.70de	4.13bc	4.66bcde	4.33abc	9.68abc
CT-11	68.00i	76.00f	108.0j	130.7e	21.33b	31.67a	11.00f	696.0a	3.33fgh	2.10e	3.10fg	2.00d	7.50bcd
CT-12	72.00h	80.00e	114.7h	155.0b	21.00b	11.67c	33.23bcde	245.7b	3.66def	3.80cd	5.33b	3.00bcd	8.25bc
CT-13	72.67g	81.00de	116.0g	154.3b	19.00bc	11.67c	46.40b	223.0bc	4.33ab	4.43b	5.00bcd	2.66cd	10.2ab
CT-15	71.67h	80.00e	115.0h	155.3b	23.00b	12.33c	39.78bc	283.7b	4.06bc	4.26bc	6.50a	2.33d	11.30a
CT-17	73.00g	82.00cd	117.0f	155.7b	21.33b	12.67c	37.13bcd	269.7b	3.96cd	3.90bcd	4.33bcde	2.67cd	10.01ab
CT-14	77.00e	83.00c	119.0d	139.3d	7.333e	4.000d	69.53a	29.33c	3.83cde	5.16a	5.00bcd	5.66a	1.76f
CT-16	78.00d	83.00c	118.0e	155.3b	10.33de	24.33b	10.33f	251.0b	3.30gh	2.10e	2.96g	2.00d	2.59ef
Min	68.00	76.00	108.00	120.00	7.33	4.00	10.33	29.33	2.40	2.10	2.97	2.00	1.76
Max	83.00	93.00	139.33	159.33	35.33	31.67	69.53	738.00	4.43	5.17	6.50	5.67	11.30
Mean	75.19	83.25	118.86	146.27	19.11	16.02	30.75	318.38	3.63	3.58	4.48	2.95	7.48
F-test	**	**	NS	NS	NS	**	**	**	**	**	**	**	**
CV (%)	1.30	2.98	2.23	1.91	11.95	12.71	9.34	8.57	5.92	10.26	14.53	15.30	12.67

Same letter(s) in a column did not differ significantly at $p \leq 0.05$ by DMRT; * and ** = Significant at 5 and 1% level of probability, respectively; NS = Not significant, CV (%) = coefficient of variation.

DFF: days to 1st flowering, D50F: days to 50% flowering, DM: days to maturity, PH: plant height (cm), NCP: number of cluster per plant, FPC: fruits per cluster, FW: fruit weight (g), FPP: fruits per plant, FL: fruit length (cm), FD: fruit diameter (cm), PT: pericarp thickness (mm), LN: locule number per fruit and FYP: fruit yield per plant (kg).

Table 2: Estimation of genetic parameters for thirteen traits in twelve cherry tomato genotypes

Parameters	PCV	GCV	ECV	Heritability	GA (5%)	GAM
Days to 1st flowering	6.08	6.01	0.93	97.69	9.16	12.24
Days to 50% flowering	6.25	6.17	1.01	97.38	10.44	12.54
Days to maturity	7.38	7.19	1.68	94.83	17.04	14.42
Plant height (cm)	9.17	9.12	0.94	96.95	27.47	18.70
Number of cluster per plant	33.33	29.91	14.71	80.53	11.16	55.30
Fruits per cluster	42.55	36.84	21.29	74.95	11.25	65.70
Fruit weight (g)	45.86	44.60	10.69	94.57	23.98	89.34
Fruits per plant	61.43	50.20	35.41	66.78	291.27	84.51
Fruit length (cm)	23.80	20.43	12.22	73.67	1.30	36.13
Fruit diameter (cm)	24.86	24.37	4.96	96.03	1.69	49.19
Pericarp thickness (mm)	26.07	22.35	13.43	73.47	1.75	39.46
Locule number per fruit	37.92	33.78	17.23	79.37	1.68	62.00
Fruit yield per plant (kg)	35.16	28.17	21.04	64.18	3.67	46.49

PCV: Phenotypic coefficient of variation GA (5%): Genetic advance

GCV: Genotypic coefficient of variation GAM: Genetic advance (% of mean)

ECV: Environmental coefficient of variation

Genotypic and phenotypic correlation coefficients for all pairs of twelve traits are presented (Table 3). Days to first flowering was observed highly significant and positive correlation with days to 50% flowering in both phenotypic and genotypic level (r_g=0.949** and r_p=0.933**), days to maturity (r_g=0.700** and r_p=0.699**) and significant negative correlation with plant height (r_g=-0.463** and r_p=-0.459**), number of cluster per plant (r_g=-0.367* and r_p=-0.338*) and fruit yield per plant (r_g=-0.586** and r_p=-0.509**). Significant positive correlation was found of days to 50% flowering with days to maturity (r_g=0.760** and r_p=0.748**) and negative significant correlation with plant height (r_g=-0.531** and r_p=-0.526**) and fruit yield per plant (r_g=-0.356* and r_p=-0.341*). Plant height was observed significant positive correlation with fruit yield per plant (r_g=0.451** and r_p=0.423*). Fruits per cluster were found significant positive correlation with fruits per plant (r_g=0.753** and r_p=0.786**) and significant negative correlation with fruit weight (r_g=-0.959** and r_p=-0.760**), fruit length (r_g=-0.496** and r_p=-0.460**), fruit diameter (r_g=-0.996** and r_p=-0.839**), pericarp thickness (r_g=-0.812** and r_p=-0.614**) and locule number per fruit (r_g=-0.807** and r_p=-0.515**).

Table 3: Genotypic (G) and phenotypic (P) correlations among different traits of cherry tomato genotypes

		DFF	D50F	DM	PH	NCP	FPC	FW	FPP	FL	FD	PT	LN
D50F	G	0.949**											
	P	0.933**											
DM	G	0.700**	0.760**										
	P	0.699**	0.748**										
PH	G	-0.463**	-0.531**	-0.111									
	P	-0.459**	-0.526**	-0.110									
NCP	G	-0.367*	-0.299	-0.095	0.305								
	P	-0.338*	-0.280	-0.089	0.303								
FPC	G	-0.130	-0.135	-0.218	-0.310	0.227							
	P	-0.117	-0.158	-0.189	-0.271	0.222							
FW	G	-0.123	-0.113	-0.030	0.211	-0.385*	-0.959**						
	P	-0.106	-0.101	-0.030	0.190	-0.371*	-0.760**						
FPP	G	-0.339*	-0.322	-0.259	-0.130	0.764**	0.753**	-0.791**					
	P	-0.289	-0.313	-0.214	-0.089	0.713**	0.786**	-0.609**					
FL	G	-0.020	0.109	-0.273	-0.157	-0.492**	-0.496**	0.569**	-0.681**				
	P	-0.017	0.099	-0.257	-0.148	-0.440**	-0.460**	0.491**	-0.595**				
FD	G	-0.009	0.072	0.143	0.200	-0.272	-0.996**	0.954**	-0.798**	0.598**			
	P	-0.008	0.065	0.130	0.186	-0.296	-0.839**	0.943**	-0.657**	0.554**			
PT	G	-0.082	0.047	-0.092	0.120	-0.022	-0.812**	0.673**	-0.597**	0.726**	0.793**		
	P	-0.054	0.039	-0.077	0.099	-0.093	-0.614**	0.607**	-0.450**	0.611**	0.732**		
LN	G	0.047	0.010	0.386*	0.227	-0.369*	-0.807**	0.712**	-0.659**	0.032	0.702**	0.197	
	P	0.027	0.016	0.276	0.169	-0.303	-0.515**	0.732**	-0.406*	-0.026	0.668**	0.202	
FYP	G	-0.586**	-0.356*	-0.187	0.451**	0.721**	-0.092	-0.044	0.397*	0.094	0.139	0.378*	-0.324
	P	-0.509**	-0.341*	-0.164	0.423**	0.714**	0.051	0.008	0.393*	0.075	0.126	0.385*	-0.155

* and ** = Significant at 5 and 1% level of probability, respectively.

DFF: days to 1st flowering, D50F: days to 50% flowering, DM: days to maturity, PH: plant height (cm), NCP: number of cluster per plant, FPC: fruits per cluster, FW: fruit weight (g), FPP: fruits per plant, FL: fruit length (cm), FD: fruit diameter (cm), PT: pericarp thickness (mm), LN: locule number per fruit and FYP: fruit yield per plant (kg).

Positive significant correlation of fruit weight was observed with fruit length (r_g=0.569** and r_p=0.491**), fruit diameter (r_g=0.954** and r_p=0.943**), pericarp thickness (r_g=0.673** and r_p=0.607**), locule number per fruit (r_g=0.712** and r_p=0.732**) and negative significant correlation with fruits per plant (r_g=-0.791** and r_p=-0.609**). Fruits per plant were found positive significant correlation with fruit yield per plant (0.397* and 0.393*) at both levels. On the contrary, It was negatively and significantly correlated with fruit length (r_g=-0.681** and r_p=-0.595**), fruit diameter (r_g=-0.798** and r_p=-0.657**), pericarp thickness (r_g=-0.597** and r_p=-0.450**) and locule number per fruit (r_g=-0.659** and r_p=-0.406*). The significant positive correlation of fruit length was recorded with fruit diameter (r_g=0.598** and r_p=0.554**) and pericarp thickness (r_g=0.726** and r_p=0.611**).

A highly significant positive correlation coefficient was observed for fruit diameter with pericarp thickness (r_g=0.793** and r_p=0.732**) and locule number per fruit (r_g=0.702** and r_p=0.668**). Pericarp thickness was found positively significant correlation with fruit yield per plant (r_g=0.378* and r_p=0.385*). The present results show similarities with the results reported by other researchers in tomato (Alam et al., 2019; Mohanthy, 2003). Again, in another study with potatoes, strong and significant correlations were observed for yield and tuber grade by weight, tuber weight per plant (Samsuzzaman et al., 2022).

Linear regression analysis of fruit yield and yield related traits is given in Table 4. A significant linear regression coefficient between yield and number clusters per plant (b=0.560***), fruits per cluster (b=0.556***), fruits per plant (b=0.012*), fruit length (b=1.499*) and fruit diameter (b=2.945**). Linear regression analysis revealed that the selection of best regression equation done through backward elimination procedure revealed that fruit diameter, fruit length, fruits per cluster, fruits per plant and clusters per plant were the most effective variables contributing to the yield. Similar findings were also confirmed by other researchers in tomato and other crops (Alam et al., 2019; Salim et al., 2013; Samsuzzaman et al., 2022).

Table 4: Linear regression coefficients of vegetative and reproductive attributes on yield of cherry tomato genotypes

Attributes	Linear Regression Coefficients (b)	t-Value	Significance
Days to 1st flowering	-0.242	-1.506	0.141
Days to 50% flowering	0.176	0.927	0.360
Days to maturity	0.025	0.539	0.593
Plant height (cm)	0.054	1.811	0.079
Number of cluster per plant	0.560	5.081***	0.000
Fruits per cluster	0.556	4.750***	0.000
Fruit weight (g)	0.007	0.166	0.869
Fruits per plant	0.012	2.218*	0.033
Fruit length (cm)	1.499	2.332*	0.026
Fruit diameter (cm)	2.945	3.026**	0.005
Pericarp thickness (mm)	-0.004	-0.017	0.986
Locule number	-0.153	-0.680	0.501

*= significant at 5%, **= significant at 1%, ***= significant at 0.1%

3.1 Principal Component Analysis

Principal components (PCs) in relation to the respective eigenvalues were presented in Figure 1. The PCA (Table 5) showed that four principal

components with eigenvalues greater than 1, accounted for 90.60 % of studied variations. Chahal and Gosal reported that, plant characters having higher absolute values within the first PC largely accounted for clustering of individuals (Chahal and Gosal, 2002). In our present study, PC_1 and PC_2 explained the traits variations of 40.30 and 26.50%, respectively. Agong employed PCA for detecting variation in 35 tomato germplasm in which the first three PCs were adequate in determining more than 70% of total variation (Agong, 2001). Again, some researchers conducted principal component analysis and observed that first five axes accounted for 91.71% of the total variations for the traits under that study (Alam et al., 2020). A group researcher also found same results in PCA (Ghosh et al., 2009). Lobo and Medina assessed the phenotypic variation of tomato cultivars and found 66% of the trait variability of the studied cultivars (Lobo and Medina, 1994).

Table 5: Eigenvalues of Correlation Matrix

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13
Eigenvalues	5.243	3.446	1.644	1.443	0.619	0.324	0.144	0.079	0.043	0.014	0.000	0.000	0.000
Proportion	0.403	0.265	0.126	0.111	0.048	0.025	0.011	0.006	0.003	0.001	0.000	0.000	0.000
Cumulative Proportion	0.403	0.668	0.795	0.906	0.953	0.978	0.989	0.996	0.999	1.000	1.000	1.000	1.000

3.2 Cluster Analysis

The hierarchical cluster analysis grouped the 12 cherry tomato genotypes into four clusters (Figure 1). Cluster IV was the largest cluster (66.67%) containing eight genotypes together following by Cluster I (16.67%) containing two genotypes. Clusters II and III both are containing one genotype each. A group researchers employed Mahalanobis distance (D^2) to classify 27 tomato genotypes in to nine clusters (Nalla et al., 2014). Some researchers found similar cluster pattern with 40 segregating hybrids of tomato (Ghosh et al., 2009). In a study with seventy genotypes, similar clustering was reported (Ullah et al., 2019). In a previous study, 23 tomato genotypes were grouped into five distinct clusters considering fourteen yield and yield related traits (Alam et al., 2020).

Table 6: Eigen values of the principal components of the correlation matrix for 12 cherry tomato genotypes

Principal Component	Eigenvalue	Difference Between Eigenvalue	% Variation Explained	Cumulated Value
1	5.243	1.797	0.403	0.403
2	3.446	1.802	0.265	0.668
3	1.644	0.202	0.126	0.795
4	1.443	0.824	0.111	0.906
5	0.619	0.295	0.048	0.953

3.3 Cluster Mean

The traits mean values in each cluster is presented in Table 4. Cluster I consisted of two genotypes having the traits of early flowering (72 days) and maturity (113.15 days) than the remaining clusters. It had medium plant height (140.85 cm) and highest value of number of clusters per plant (28.33), fruits per cluster (26.34), fruits per plant (717.00) and finally fruit yield per plant (8.15 kg). On the other hand, genotypes of cluster II had the maximum fruit weight, fruit length, fruit diameter, pericarp thickness and locule number. Cluster III had the highest days to flowering, days to maturity and lowest in plant height. Genotypes of cluster IV showed the highest plant height and moderate days to flowering and maturity, fruit weight and fruit yield per plant.

Table 7: Loadings (Eigenvectors) of Correlation Matrix

	PC1	PC2	PC3	PC4	PC5
Days to 1st flowering	0.089	0.487	0.131	0.179	-0.119
Days to 50% flowering	0.104	0.458	0.146	0.348	-0.034
Days to maturity	0.093	0.345	0.521	0.088	-0.078
Plant height (cm)	0.040	-0.342	0.342	-0.213	-0.720
Number of cluster per plant	-0.238	-0.257	0.407	0.299	0.228
Fruits per cluster	-0.403	0.091	-0.196	-0.038	-0.022
Fruit weight (g)	0.394	-0.156	-0.005	-0.140	0.243
Fruits per plant	-0.399	-0.093	0.099	0.068	0.409
Fruit length (cm)	0.285	-0.074	-0.454	0.323	-0.153
Fruit diameter (cm)	0.410	-0.132	0.105	0.060	0.192
Pericarp thickness (mm)	0.310	-0.192	-0.047	0.418	0.080
Locule number per fruit	0.297	0.002	0.289	-0.444	0.335
Fruit yield per plant (kg)	-0.062	-0.387	0.236	0.446	-0.051

Table 8: Distribution of 12 genotypes in different clusters

Cluster	No. of Genotypes	Name of Genotypes	Varietal Code
Cluster I	2	G2, G6	CT-5, CT-11
Cluster II	1	G11	CT-14
Cluster III	1	G4	CT-7
Cluster IV	8	G1, G3, G5, G7, G8, G9, G10, G12	CT-4, CT-6, CT-9, CT-12, CT-13, CT-15, CT-17, CT-16
Total	12		

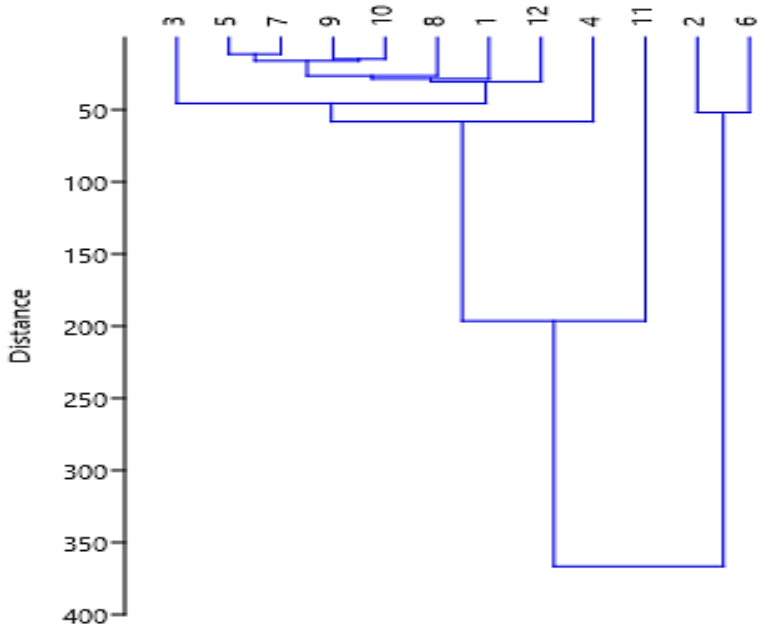


Figure 2: Hierarchical clustering of 12 genotypes of cherry tomato

Table 9: Cluster mean value of 12 genotypes

Cluster	DFF	D50F	DM	PH (cm)	NCP	FPC	FW (g)	FPP	FL (cm)	FD (cm)	PT (mm)	LN	FYP (kg)
Cluster 1	72.00*	79.00*	113.15*	140.85	28.33**	26.34**	11.50*	717.00**	2.50*	2.30*	3.33*	2.00*	8.15**
Cluster II	77.00	83.00	119.00	139.30	7.33*	4.00*	69.53**	29.33*	3.83**	5.16**	5.00**	5.66**	1.76*
Cluster III	80**	90**	126**	129.7*	15	22	21.33	330.7	3.5	3.3	4.13	2.1	7.09
Cluster IV	75.17	83.86	119.38	150.58**	18.79	14.21	31.90	253.35	3.81	3.74	4.75	2.96	8.08

*, ** indicate the lowest and highest mean value of the characters.

DFF: days to 1st flowering, D50F: days to 50% flowering, DM: days to maturity, PH: plant height (cm), NCP: number of cluster per plant, FPC: fruits per cluster, FW: fruit weight (g), FPP: fruits per plant, FL: fruit length (cm), FD: fruit diameter (cm), PT: pericarp thickness (mm), LN: locule number per fruit and FYP: fruit yield per plant (kg).

4. Conclusion

Cherry tomatoes are of greater importance for its nutritional and commercial values and there is a higher scope of their genetic improvement. Genetic study in respect of phenotypic and genotypic coefficient of variation, traits association, PCA and clustering could be effective for the identification of genotypes and traits of breeding interests. We found the number of locules, pericarp thickness and fruit number per cluster were responsible for higher variability and these traits could be selected for a stable phenotypic and genotypic response. Regression analysis also revealed that number of clusters per plant, fruits per plant and diameter of fruit were of greater importance for cherry tomatoes. We found in PCA that four PCs had higher values than 1 and accounted of 90.60 % of variations. From the cluster analysis, we found that the studied genotypes were grouped into four clusters and maximum heterosis could be obtained from crosses between the genotypes of cluster I and III. Finally, considering different traits and genetic analysis the CT-9, CT-15, and CT-13 were better and could be selected for further breeding research in cherry tomato

Acknowledgement

The authors are highly thankful to the Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN), Araihazar, Narayangonj for providing technical and financial assistance during the research.

References

Acharya, B., Dutta, S., Dutta, S., Chattopadhyay, A., 2018. Breeding tomato for simultaneous improvement of processing quality, fruit yield, and dual disease tolerance. Int. J. Veg. Sci., 24 (5), Pp. 407–423.

Agong, S.G., 2001. Genetic variation of Kenyan tomato (Lycopersicon esculentus L.) germplam. Journal of Food Technology Africa, 6 (1), Pp. 13-17.

Alam, M.S., Hossain, S., Ali, M.A., Hossain, M.G., Islam, M.F., 2020. Assessment of Genetic Divergence in Tomato (Solanum lycopersicum L.) through Clustering and Principal Component Analysis. Assessment. J. Agric. Sci. Eng. Innov., 1 (1), Pp. 10–14. doi: 10.5281/zenodo.3965945.

Alam, M.S., Huda, M.N., Rahman, M.S., Azad, A.K.M., Rahman, M.M. and Molla, M.M., 2019. Character association and path analysis of tomato (Solanum lycopersicum L.). Journal of Bioscience and Agriculture Research, 22 (01), Pp. 1815-1822. https://doi.org/10.18801/jbar.220119.223.

Anjum, A., Raj, N., Nazeer, A., and Khan, S.H., 2009. Genetic variability and selection parameters for yield and quality attributes in tomato. Indian Journal of Horticulture, 66 (1), Pp. 73-78.

Anonymous., 2009. Cherry tomato nutritional information; USDA National Nutritional Database for Standard Reference. (Www. Lose-weightwithus.com/cherry tomato- nutrition. Html).

Bauchet, G., Causse, M., 2012. Genetic diversity in tomato (Solanum lycopersicum) and its wild relatives. In: Çaliskan M (ed) Genetic diversity in plants, Pp. 133–162.

Beckles, D.M., 2012. Factors affecting the postharvest soluble solids and sugar content of tomato (Solanum lycopersicum L.) fruit. Postharvest Biol. Technol., 63, Pp. 129–140.

Burton, G.W., and Devane, E.H., 1953. Estimating heritability in tall fescue (Festuca arundiaceae) from replicated colonial material. Agronomy Journal, 45, Pp. 478-481.

Chahal, G.S., and Gosal, S.S., 2002. Principles and procedures of plant breeding: Biotechnology and conventional Approaches, Narosa Publishing House, New Delhi, Pp. 604.

Comstock, R.E., and Robinson, H.F., 1952. Genetic parameters, their

estimation and significance. Proc. 6th Intern. Grassland Cong., 1, Pp. 248-291.

Deepa, S., and Thakur, M.C., 2008. Evaluation of diallele progenies for yield and its contributing traits in tomato under midhill conditions. Indian Journal of Horticulture, 65 (3), Pp. 297-301.

Flores, P., Sánchez, E., Fenoli, J., Heltin, P., 2017. Genotypic variability of carotenoids in traditional tomato cultivars. Food Res. Int., 100 (3), Pp. 510–516.

Ghosh, K.P., Islam, A.K.M.A., Mian, M.A.K., and Hossain, M.M., 2009. Genetic diversity in F_2 segregating population of different commercial hybrids of tomato (Solanum lycopersicum L.). Bangladesh Journal of Plant Breeding and Genetics, 22 (1), Pp. 43- 48.

George, B., Kaur, C., Khurdiya, D.S., Kapoor, H.C., 2004. Antioxidants in tomato (lycopersium esculentum) as a function of genotype. Food Chem., 84 (1), Pp. 45-51.

Johnson, H.W., Robinson, H.E., and Comstock, R.E., 1955. Estimates of genetic and environmental variability in soybeans. Agronomy Journal, 47, Pp. 314-318.

Joshi, A.K., Kumar, A., and Sharma, B.K., 1998. Evaluation tomato genotypes for horticultural traits. Punjab vegetable grower., 33, Pp. 21-22.

Kobryn, J., and Hallmann, E., 2005. The effect of nitrogen fertilization on the quality of three tomato types cultivated on Rockwool. Acta Horticult., 691, Pp. 341 - 348.

Kuti, J., and Konuru, H., 2005. Effects of genotype and cultivation environment on lycopene content in red-ripe tomatoes. Journal of the Science of Food and Agriculture, 85, Pp. 2021–2026.

Liang, G.H.L., and Walter, T.L., 1968. Heritability estimates and gene effect for agronomic traits in grain sorghum. Crop Science, 8, Pp. 77-80.

Liu, H.R., Meng, F.L., Miao, H.Y., Chen, S.S., Yin, T.T., Hu, S.S., Shao, Z.Y., Liu, Y.Y., Gao, L.X., Zhu, C.Q., Zhang, B., Wang, Q.M., 2018. Effects of postharvest methyl jasmonate treatment on main health-promoting components and volatile organic compounds in cherry tomato fruits. Food Chem., 263, Pp. 194–200.

Lobo, M., and Medina, C.I., 1994. Phenotypic evaluation of Latin American tomato cultivars. Tomato Genetics Cooperative Report, 44, Pp. 26.

Medina, C.I., and Lobo, M., 2001. Variabilidadmorfológica en el tomatepajarito (Lycopersicon esculentum var. cerasiforme), precursor deltomatecultivado. Revista Corpoica, 3 (2), Pp. 39–50.

Mehta, N., and Asati, B.S., 2008. Genetic divergence for fruit characters in tomato (Lycopersicon esculentum Mill.). Agricultural Science Digest, 28 (2), Pp. 141-142.

Mohanty, B.K., 2003. Genetic variability, correlation, and path coefficient studies in tomato. Indian Journal of Agricultural Research., 37 (1), Pp. 68-71.

Najibullah, A., Jyothi, K., Anjanappa, M., Sood, M., Reddy, B.A., and Kumar, M.S., 2020. Evaluation of Cherry Tomato (Solanum lycopersicum L. var. Cerasiforme) Genotypes for Yield and Quality Parameters. International Journal of Current Microbiology and Applied Science, 9 (3), xx-xx. doi: https://doi.org/10.20546/ijcmas.2020.903.xx

Panse, V.G., and Sukhatm, P.V., 1967. Statistical method for Agricultural workers. 2nd Ed. Indian Council of Agricultural Research, New Delhi, Pp. 381.

Prashanth, S.J., 2003. Genetic variability and divergence study in tomato (Lycopersicon esculentum Mill). M. Sc. (Agri.) Thesis, Uni. Agric. Sci., Dharwad (India).

Prema, G., Indiresh, K.K., and Santosha, H.M., 2011. Evaluation of cherry tomato (Solanum lycopersicum var. cerasiforme) genotypes for growth, yield, and quality traits. Asian Journal of Horticulture, 6 (1), Pp. 181-184.

Renuka, D.M., Sadashiva, A.T., Kavita, B.T., Vijendrakumar, R.C., and Hanumanthiah, M.R., 2014. Evaluation of cherry tomato lines (Solanum lycopersicum var. cerasiforme) for growth, yield, and quality traits. Plant Archives, 14 (1), Pp. 151- 154.

Salim, M., Hossain, S., Alam, S., Rashid, J.A., and Islam, S., 2013. Variability, correlation and path analysis in lablab bean (Lablab purpureus L.). Bangladesh J. Agri. Res., 38 (4), Pp. 705-118. http://www.banglajol.info/index.php/BJAR/article/view

Samsuzzaman, M., Habib, M.A., Miah, M.A.M., Alam, M.S., Ullah, M.Z., 2022. Genetic variability and correlation studies of BARI released Potato varieties in Sylhet Region. Int. J. Biosci., 20 (4), Pp. 137-143.

Singh, P.K., and Gopalkrishnan, T.R., 2000. Variability and heritability estimates in brinjal (Solanum melongena L.). South Indian Horticulture, 47 (1-6), Pp. 174-178.

Sivanand, V.H., 2008. Evaluation of tomato (Lycopersicon esculentum M.) hybrids under eastern dry zone of Karnataka. M.Sc. (Hort.) Thesis, UAS, GKVK, Bangalore. tomato and status of the problem. Abstr.

Ullah, M.Z., Hassan, L., Samsuzzaman, M., and Main, M.A., 2019. Phenotypic divergence in tomato germplasm. SAARC Journal of Agriculture, 17 (2), Pp. 185-195.