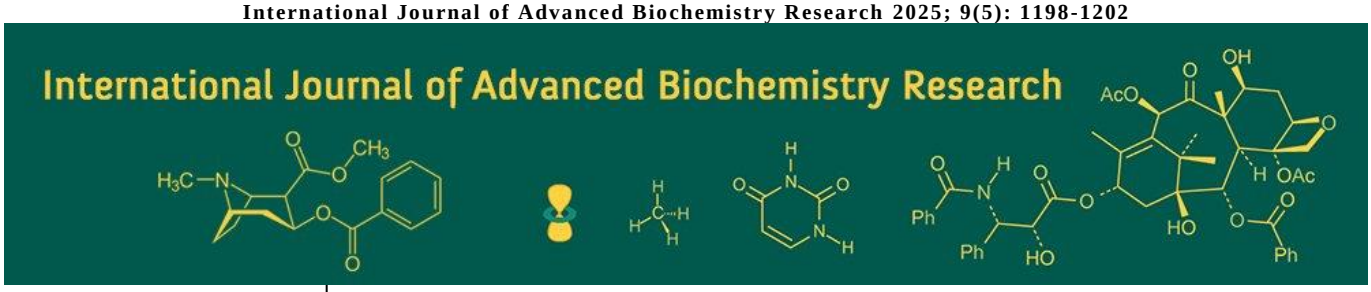

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Pavithra YN
College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India

Akkamahadevi D Agasimani
College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India

MS Biradar
College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India

SA Biradar
College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India

Prasanna Kumar BH
College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India

Corresponding Author:
Akkamahadevi D Agasimani
College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka, India

Genetic variability, correlation and path coefficient studies in cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) grown under protected condition

Pavithra YN, Akkamahadevi D Agasimani, MS Biradar, SA Biradar and Prasanna Kumar BH

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Abstract
An experiment was conducted to evaluate the cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) genotypes grown under protected condition at, ICAR-Krishi Vigyan Kendra, Saidapur farm, University of Agricultural Sciences, Dharwad during 2022-23. The present experiment was taken out in Randomized Block Design (RBD) with fifteen treatments and three replications. The fifteen genotypes are namely, Punjab Red Cherry, SJCT-01, BRCT-1, Dharwad Local, Pusa Golden Cherry Tomato-2, Phule Jayshree, Red Cherry Tomato, CT-IET, Swarna Ratna, Namdhari-096, Zircconyta, Kaziranga Red Cherry Tomato, Black Cherry Tomato, Swarna Ratan and Pusa Cherry Tomato-1. These genotypes of cherry tomato were assessed to determine the nature and magnitude of variability and correlation between growth, yield and quality contributing characters. High genotypic coefficient of variability (GCV) and phenotypic coefficient of variability (PCV), heritability estimates, coupled with high genetic mean, were observed for number of flowers per cluster, ascorbic acid, fruit yield per plant, number of fruits per cluster, fruit yield per plot, fruit yield per hectare, individual fruit weight, number of flower clusters per plant, pericarp thickness, shelf life, number of fruits per plant and fruit set. Correlation coefficient genotypic and phenotypic level indicated that fruit yield per plant was significantly and positively associated with pericarp thickness, fruit length, fruit diameter, individual fruit weight and shelf life at genotypic and phenotypic level.

Keywords: Cherry tomato, correlation, gcv, pcv, yield

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 (Flores *et al.*, 2017) [3]. Cherry tomato is a small variety of tomato that weighs between 10 to 30 g, has an oblong, round and flattened shape, and it is available in red, black, orange, pink, and yellow colours. After been discovered for the first time in Tropical and Subtropical America, the wild cherry tomato later moved to the Tropics of Asia and Africa. Cherry tomatoes, according to Renuka *et al.* (2014) [13], are produced in huge quantities all over Central America and exported to California, Korea, Mexico and Florida. Yellow cherry tomatoes were the first type of tomato to be produced in Europe. Cherry tomato plants are still observed growing unnamed in the coastal mountains of Peru, Ecuador and Northern Chile. The primary growing areas for cherry tomatoes in India are Kashmir, Hyderabad, Gujarat, Andhra Pradesh, Rajasthan, Karnataka, Bihar, etc. They are becoming more popular in retail chains and are advertised at a higher price than a typical tomato. They are among the most intriguing new products to hit the developing tiny veggie market.

According to Flores *et al.* (2017) [3], cherry tomatoes are used to make a variety of processed culinary products, including sauce, paste, ketchup, powder, chutney, soup, pickles and curries. Due to its high total soluble solids, distinct aroma, flavour, ascorbic acid, vitamin E, betacarotene, calcium and fibre, which are all essential for human nutrition and health, so it is a widely used horticulture crop (Liu *et al.*, 2018) [8]. Additionally, it includes other vital biochemicals such carotenoids, phenolic acids and flavonoids. It is well known that cherry tomatoes contain more lycopene than other types of tomatoes, which could be exploited to

improve the lycopene content of tomato breeding programmes (Acharya *et al.*, 2018) [1]. In order to choose the best plant type or variety, it is helpful to be aware of the genotypic and phenotypic coefficients of variation, heritability, genetic advance and studies on correlation. (Salim *et al.*, 2013) [15]. So the present research was studied to characterize growth, yield and quality attributes, which would help the plant breeders in planning a successful breeding program for cherry tomato improvement.

Materials and Methods

The experiment was conducted during 2022-23 at ICAR-Krishi Vigyan Kendra, Saidapur Farm, University of Agricultural Sciences, Dharwad, Karnataka. Fifteen genotypes were collected from various institutes and companies. The experiment was taken out in a Randomized Block Design and was replicated thrice. Using sterilised and enriched coco-peat as growing media, the seeds were sown in the portrays. The main field was prepared to a fine tilth and FYM at 25 t ha^{-1} was applied at the time of ploughing. The cherry tomato seedlings were planted on beds in a paired row system under shade net house condition. All the other cultural practices as recommended were followed as in tomato. Growth, yield and quality characters were recorded from five plants in each replicated entry selected randomly and were tagged. The ANOVA for the traits was performed using R STUDIO and OPSTAT software. The genotypic and phenotypic co-efficient of variation (GCV and PCV) were calculated by following the procedure of Burton and Devane, 1953 [2]. The expected genetic advance for the studied traits was calculated following and mean percentage of genetic advance was estimated as per the procedure of Johnson *et al.*, 1955 [4]. The correlation coefficient was measured as described by Panse and Sukhatme, 1967 [11].

Results and Discussion

Mean performance of genotypes

The genetic variability estimates including mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance as a percent of mean are presented in Table 1.

Wide range of variability was observed for most of the traits under study. A range of 20.40 to 41.00 with mean value of 30.63 was observed for number of branches. Days taken for first flowering exhibited a range of 25.00 to 44.60 with mean value of 30.18. Days taken from flowering to fruit harvest exhibited a range of 26.30 to 50.20 with mean value of 36.37. Number of flowers per cluster exhibited a range of 7.00 to 49.00 with a mean value of 16.36. Number of flower clusters per plant exhibited a range of 8.36 to 36.35 with an average of 25.31. Percent fruit set ranged from 31.20 to 95.36 with a mean value of 70.03. Number of fruits per cluster and number of fruits per plant exhibited a range of 4.85 to 18.72 and 150.36 to 398.54 respectively and mean values of 10.33 and 252.54, respectively. Truss length exhibited a range of 5.00 to 29.00 with an average of 16.69. Fruit length and fruit diameter showed mean value of 2.40 and 2.38 with a range of 1.32 to 3.62 and 1.23 to 3.50, respectively. Individual fruit weight recorded mean value of 9.37 with a range of 1.20 to 14.32. pH and total soluble solids demonstrated mean values of 3.87 and 7.49 with a range of 3.10 to 4.41 and 4.51 to 10.25, respectively. The mean values of 91.92, 13.08 and 38.22 were recorded for moisture content, shelf life and ascorbic acid with a range 83.88 to 99.32, 6.00 to 20.50 and 15.60 to 115.26 respectively. Fruit yield per plant, fruit yield per plot and fruit yield per hectare exhibited a range of 0.63 to 3.85, 8.36 to 48.30 and 15.64 to 75.53, respectively and mean values of 2.20, 26.85 and 44.52, respectively.

Genotypic and Phenotypic coefficient of variation

High GCV was observed in case of number of flowers per cluster (65.01%), ascorbic acid (61.93%), fruit yield per plant (43.42%), number of fruits per cluster (40.31%), fruit yield per plot (39.74%), fruit yield per hectare (39.06%), individual fruit weight (37.91%), number of flower clusters per plant (29.81%), pericarp thickness (27.21%), shelf life (26.25%), number of fruits per plant (24.12%), fruit set (23.38%) and truss length (17.88%).

High PCV exhibited for number of flowers per cluster (67.31%), ascorbic acid (62.58%), fruit yield per plant (44.25%), truss length (42.43%), number of fruits per cluster (41.15%), fruit yield per plot (40.89%), fruit yield per hectare (39.97%), individual fruit weight (39.26%), number of flower clusters per plant (31.91%), pericarp thickness (28.57%), shelf life (28.05%), number of fruits per plant (24.83%), fruit set (24.47%) and fruit length (20.77%).

High GCV and PCV indicate the presence of a wide range of genetic variability for these characters and chances for improvement of these characters though selection to be high. Most of the traits under study depicted a very good scope for improvement through selection. The observed PCV values were higher than their corresponding GCV values for all the traits studied, which indicated that the apparent variation is not only due to the genotypes and also due to the influence of the environmental condition. In this study, the estimates of phenotypic coefficients of variation were more than genotypic coefficients of variability for all the studied characters which might be due to the interaction of genotype with environment. Similar results were also observed by Singh and Singh (2019) [16], Khuntia *et al.* (2019) [6] and Kherwa *et al.* (2018) [5].

Moderate genotypic and phenotypic coefficient of variation were recorded for fruit diameter, total soluble solids and days taken for first flowering. This is in line with the results reported by Saleem *et al.* (2013) [14]. Moderate GCV with the high PCV were observed for fruit diameter, low GCV with the moderate PCV were reported for number of branches per plant and days taken from flowering to harvest. Low GCV and PCV were noted for pH and moisture content, similar findings were noticed by Panchbhaiya *et al.* (2018) [10].

Heritability and genetic advance mean

The characters that recorded high heritability were ascorbic acid (97.93%), truss length (97.84%), fruit yield per plant (96.30%), fruit yield per hectare (95.45%), fruit yield per plot (94.42%), number of fruits per plant (94.39%), number of fruits per cluster (93.30%), number of flowers per cluster (93.30%), individual fruit weight (93.20%), fruit set percentage (91.27%), pericarp thickness (90.68%), shelf life (87.59%), number of flower clusters per plant (87.29%), days taken for first flowering (82.06%), fruit length (74.11%), fruit diameter (67.59%) and total solid (61.62%). Moderate heritability was observed for character days taken from flowering to harvest (44.1%) and moisture content

(42.48%). Low heritability was observed for pH (27.70%) and number of branches per plant (12.06%).

High genetic advance as percent over mean (GAM) was observed for the number of flowers per cluster (89.36%) followed by number of fruits per cluster (89.29%), fruit yield per plant (87.79%), truss length (85.52%), number of fruits per cluster (81.33%), fruit yield per plot (79.54%), fruit yield per hectare (78.60%), individual fruit weight (75.38%) and ascorbic acid (75.24%), number of flower clusters per plant (57.38%), pericarp thickness (53.38%), shelf life (50.61%), number 0f fruits per plant (48.28%), fruit set (46.01%), fruit length (31.71%), fruit diameter (26.81%), total soluble solids (23.78%) and days taken for first flowering (24.25%). pH (3.83%) recorded low genetic advance.

High heritability coupled with a high expected genetic advance mean indicated the involvement of additive genetic variance, therefore selection may be effective. Similar observations were noticed by several researchers (Kumar *et al.*, 2018; Khuntia *et al.*, 2019 and Singh and Singh, 2019) [7, 6, 16]. Low heritability and low genetic advance mean recorded for pH and number of branches per plant. Suggesting that which indicates the presence of non-additive gene action for these characters and therefore, these traits could not be improved through simple selection. These results are similar with Panchbhaiya *et al.* (2018) [10].

Genotypic and phenotypic correlation coefficient analysis

An essential strategy in a breeding programme is association analysis. It identifies the component characters on which selection can be employed for genetic improvement in fruit production and provides an overview of how the relationships between the various characters relate to one another. The strength of the relationship also influences how well the selecting process works. The genotypic and phenotypic correlation coefficient for fruit yield, quality and its component character in cherry tomato are presented in Table 2 and only significant correlations are discussed here.

Days taken for first flowering was observed significant negative correlation with number of branches per plant in both genotypic and phenotypic level (-1.3371 and-0.3133).Significant positive correlation was found for number of flower clusters per plant with number of branches per plant (1.284 and 0.3565) and negative significant correlation with days taken for first flowering (-0.6025 and-0.5143) in both genotypic and phenotypic level. Whereas, for number of flowers per cluster with days taken from flowering to harvest (-0.6043 and-0.43) and number of flower clusters per plant (-0.5377 and-0.5102) expressed significant negative correlation at genotypic and phenotypic levels, negative genotypic level for number of branches per plant (-0.6206). Fruit set was showed negative significant correlation with number of flowers per cluster (-0.7019 and-0.613) in both genotypic and phenotypic level. Significant positive correlation was found for number of fruits per plant with number of flowers per cluster (0.5994 and 0.5617) and negative correlation with days taken from flowering to harvest (-0.7471 and-0.4659) in both genotypic and phenotypic level. Number of fruits per cluster expressed significant positive correlation with number of flowers per cluster (0.8403 and 0.799) and number of fruits per plant (0.5802 and 0.5683) at genotypic and phenotypic level and days taken for first flowering (0.362) at phenotypic level only, negative correlation was found for days taken from flowering to harvest (-0.7556 and-0.4854) and number of flower clusters per plant (-0.7954 and-0.722) at genotypic and phenotypic level, number of branches per plant (-0.824) at genotypic level only. Pericarp thickness expressed significant positive correlation with number of fruits per plant (0.6221 and 0.5653) and number of fruits per cluster (0.6668 and 0.6327) in both genotypic and phenotypic level, only positive phenotypic level for number of flowers per cluster (0.3324), negative genotypic level for number of branches (-0.5353) and phenotypic level number of clusters per plant (-0.4082). Fruit length had significant positive correlation with number of flowers per clusters (0.5458 and 0.4448) and pericarp thickness (0.8354 and 0.6415) at genotypic and phenotypic level, whereas fruit set (0.3593) expressed significant positive correlation at phenotypic level only, negative genotypic and phenotypic level for number of flower clusters per plant (-0.6286 and-0.5449), negative genotypic level for number of branches (-1.0585). Significant positive correlation was found for fruit diameter with pericarp thickness (0.6698 and 0.5266) at genotypic and phenotypic level, only phenotypic level for fruit length, significant negative correlation was found for number of branches (-0.9491 and-0.3049) at genotypic and phenotypic level. Individual fruit weight had significant positive correlation with pericarp thickness (0.5792 and 0.5481), fruit length (0.7478 and 0.5946) and fruit diameter (0.9094 and 0.6841) at genotypic and phenotypic level, negative correlation with number of branches (-1.1014 and-0.3757).Significant positive correlation was found for pH with fruit set (0.7636 and 0.4014) in both genotypic and phenotypic level, only genotypic level for pericarp thickness (0.5475), whereas significant negative genotypic level for number of branches (-0.5528). Significant positive correlation for genotypic level was found for total soluble solids with fruit length (0.3315) and individual fruit weight (0.3545), negative genotypic level for days taken from flowering to harvest (-0.6303). Significant positive correlation was found for phenotypic level for moisture content with number of fruits per plant (0.3234), whereas days taken for flowering to harvest (-0.294) and fruit set (0.3143) expressed negative correlation at phenotypic level only. Significant positive correlation was found for shelf life with pericarp thickness (0.8451 and 0.7463), fruit length (0.6887 and 0.5782), fruit diameter (0.6065 and 0.4716), fruit weight (0.541 and 0.5182 and pH (0.9462 and 0.381) at genotypic and phenotypic level, only positive phenotypic level for fruit set (0.3669), number of fruits per plant (0.4223) and number of fruits per cluster (0.4055). Ascorbic acid had significant negative correlation with moisture content (-0.3327) only for phenotypic level. Significant positive correlation was found for fruit yield per plant with pericarp thickness (0.7661 and 0.716), fruit length (0.6738 and 0.5646, fruit diameter (0.8238 and 0.6487), individual fruit weight (0.8858 and 0.8304) and shelf life (0.683 and 0.6248) atgenotypic and phenotypic level, only phenotypic level for number of fruits per plant (0.4225), number of fruits per cluster (0.3411) and total soluble solids (0.3631), number of branches (-0.7829) expressed significant negative correlation at genotypic level only. The present findings are in conformity with the result of Nwosu *et al.* (2014) [9] and Ullaha *et al.* (2022) [17]. Moreover, a significant negative correlation was reported by Rani *et al.* (2010) [12] under different environmental conditions.

Table 1: Estimates of mean, range and different genetic parameters for growth, yield and quality characters of cherry tomato genotypes grown under shade house condition

Sl. No.	Characters	Mean	Range		GCV (%)	PCV (%)	$h^2_{(BS)}$	GAM%
			min	max				
1	Number of branches per plant	30.63	20.40	41.00	6.30	18.14	12.06	4.51
2	Days taken for first flowering	30.18	25.00	44.60	12.99	14.34	82.06	24.25
3	Days taken from flowering to harvest	36.37	26.30	50.20	9.10	13.70	44.10	12.45
4	Number of flowers per cluster	16.36	7.00	49.00	65.01	67.31	93.30	89.36
5	Number of flower clusters per plant	25.31	8.36	36.35	29.81	31.91	87.29	57.38
6	Percent fruit set (%)	70.03	31.20	95.36	23.38	24.47	91.27	46.01
7	Number of fruits per cluster	10.33	4.85	18.72	40.31	41.15	95.94	81.33
8	Number of fruits per plant	252.54	150.36	398.54	24.12	24.83	94.39	48.28
9	Truss length (cm)	16.69	5.00	29.00	41.97	42.43	97.84	85.52
10	Fruit yield per plant (kg)	2.20	0.63	3.85	43.43	44.25	96.30	87.79
11	Fruit yield per plot (kg)	26.85	8.36	48.30	39.74	40.89	94.42	79.54
12	Fruit yield per hectare (t/ha)	44.52	15.64	75.53	39.06	39.98	95.45	78.60
13	Pericarp thickness (mm)	2.77	1.23	4.40	27.21	28.57	90.68	53.38
14	Fruit length (cm)	2.40	1.32	3.62	17.88	20.77	74.11	31.72
15	Fruit diameter (cm)	2.38	1.23	3.50	15.83	19.26	67.59	26.81
16	Individual fruit weight (g)	9.37	1.20	14.32	37.91	39.26	93.20	75.39
17	pH	3.87	3.10	4.41	3.54	6.72	27.70	3.83
18	Total soluble solids (˚Brix)	7.49	4.51	10.25	14.71	18.74	61.62	23.78
19	Moisture content (%)	91.92	83.88	99.32	2.07	3.17	42.48	2.78
20	Shelf life	13.08	6.00	20.50	26.25	28.05	87.59	50.61
21	Ascorbic acid (mg/100g)	38.22	15.60	115.26	61.93	62.58	97.93	75.24

Table 2: Genotypic and phenotypic correlation coefficient between growth, yield and its quality components in cherry tomato

Characters		NB	D1F	D1H	NFC/P	NFl/C	FS%	NFr/P	NFr/Cl	PT	FL	FD	IFW	pH	TSS	MC	SL	AA	FY/P
NB	G	**1 ****	-1.3371 **	0.28	1.284 **	-0.6206 *	0.02	0.25	-0.8724 **	-0.5353 *	-1.0585 **	-0.9491 **	-1.1014 **	-0.5528 *	-0.36	0.00	-0.39	-0.22	-0.7829 **
	P	**1 ****	-0.3133 *	-0.15	0.3565 *	-0.20	-0.01	0.06	-0.27	-0.17	-0.25	-0.3049 *	-0.3757 *	-0.05	-0.29	-0.04	-0.15	-0.09	-0.256
D1F	G		**1 ****	-0.09	-0.6025 *	0.32	-0.03	-0.18	0.39	-0.17	0.14	0.10	-0.05	-0.18	-0.08	-0.34	-0.07	0.06	-0.266
	P		**1 ****	-0.05	-0.5143 **	0.27	0.01	-0.18	0.362 *	-0.12	0.09	0.03	-0.01	0.09	-0.11	-0.294 *	-0.11	0.07	-0.246
D1H	G			**1 ****	0.33	-0.6043 *	-0.03	-0.7471 **	-0.7556 **	-0.45	-0.45	-0.06	0.01	-0.31	-0.6303 *	-0.27	-0.49	0.09	-0.271
	P			**1 ****	0.29	-0.43 **	0.01	-0.4659 **	-0.4854 **	-0.28	-0.17	0.00	0.00	-0.02	-0.23	-0.05	-0.24	0.06	-0.197
NFC/P	G				**1 ****	-0.5377 *	-0.01	0.01	-0.7954 **	-0.46	-0.6286 *	-0.36	-0.36	0.06	-0.08	0.01	-0.33	0.23	-0.203
	P				**1 ****	-0.5102 **	-0.01	0.06	-0.722 **	-0.4082 **	-0.5449 **	-0.26	-0.29	0.02	0.02	0.09	-0.25	0.21	-0.183
NFl/C	G					**1 ****	-0.7019 **	0.5994 *	0.8403 **	0.37	0.20	0.17	0.06	-0.45	0.29	0.42	0.14	-0.24	0.270
	P					**1 ****	-0.613 **	0.5617 **	0.799 **	0.3324 *	0.17	0.15	0.00	-0.28	0.21	0.24	0.11	-0.22	0.267
FS%	G						**1 ****	-0.26	-0.20	0.19	0.41	0.12	0.22	0.7636 **	-0.20	-0.42	0.42	0.29	0.051
	P						**1 ****	-0.24	-0.18	0.19	0.3593 *	0.10	0.17	0.4014 **	-0.13	-0.3143 *	0.3669 *	0.29	0.052
NFr/P	G							**1 ****	0.5802 *	0.6221 *	0.17	0.24	-0.01	0.26	0.12	0.44	0.46	-0.04	0.441
	P							**1 ****	0.5683 **	0.5653 **	0.12	0.21	0.00	0.12	0.13	0.3234 *	0.4223 **	-0.05	0.4225 **
NFr/Cl	G								**1 ****	0.6668 **	0.5458 *	0.35	0.18	0.00	0.14	0.18	0.46	-0.14	0.347
	P								**1 ****	0.6327 **	0.4448 **	0.28	0.16	0.02	0.10	0.09	0.4055 **	-0.14	0.3411 *
PT	G									**1 ****	0.8354 **	0.6698 **	0.5792 *	0.5475 *	0.14	0.32	0.8451 **	-0.07	0.7661 **
	P									**1 ****	0.6415 **	0.5266 **	0.5481 **	0.28	0.13	0.16	0.7463 **	-0.07	0.716 **
FL	G										**1 ****	0.45	0.7478 **	0.45	0.46	0.11	0.6887 **	-0.06	0.6738 **
	P										**1 ****	0.4247 **	0.5946 **	0.27	0.3315 *	0.10	0.5782 **	-0.04	0.5646 **
FD	G											**1 ****	0.9094 **	0.44	0.01	0.13	0.6065 *	0.15	0.8238 **
	P											**1 ****	0.6841 **	0.09	0.01	0.20	0.4716 **	0.14	0.6487 **
IFW	G												**1 ****	0.37	0.42	0.26	0.541 *	0.07	0.8858 **
	P												**1 ****	0.25	0.3545 *	0.17	0.5182 **	0.06	0.8304 **
pH	G													**1 ****	0.05	-0.35	0.9462 **	0.51	0.439
	P													**1 ****	0.09	-0.28	0.381 **	0.25	0.221
TSS	G														**1 ****	0.37	0.07	-0.09	0.510
	P														**1 ****	0.28	0.15	-0.09	0.3631 *
MC	G															**1 ****	-0.29	-0.51	0.505
	P															**1 ****	-0.13	-0.3327 *	0.288
SL	G																**1 ****	0.20	0.683 **
	P																**1 ****	0.18	0.6248 **
AA	G																	**1 ****	0.063
	P																	**1 ****	0.059
FY/P	G																		**1 ****
	P																		**1 ****

NB: Number of branches, D1F: Days taken for first flowering, D1H: Days taken from flowering to harvest, NFC/P: Number of flower clusters per plant, NFl/C: Number of flowers per cluster, FS%: Fruit set, NFr/P: Number of fruits per plant, NFr/Cl: Number of fruits per cluster, PT: Pericarp thickness, FL: Fruit length, FD: Fruit diameter, IFW-Individual fruit weight, TSS: Total soluble solids, MC: Moisture content, SL: Shelf life, AA: Ascorbic acid and FY/P: Fruit yield per plant

Conclusion

From the present investigation the characters like number of flowers per cluster, ascorbic acid, fruit yield per plant, number of fruits per cluster, fruit yield per plot, fruit yield per hectare, individual fruit weight, number of flower clusters per plant, pericarp thickness, shelf life, number of fruits per plant and fruit set at 120 DAT appeared to major yield components therefore phenotypic selection on these traits will result development better high yielding cherry tomato.

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