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Estimation of heritability and correlation for fruit yield and yield related traits in f_4 population of the cross EC15127×EC362941 in tomato under protected condition

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Abstract
Study on genetic parameters in F_4 population of the cross EC15127×EC362941 during Summer 2024 for fruit yield and its attributing traits was conducted in augmented block design. Results obtained Analysis of variance indicates the presence of significant variability for most of the characters among F_4 segregants which indicates the presence of sufficient variability. Hence the population was used for estimation of variability parameters and correlation. Wider range has been observed for all the characters among the F_4 segregants which imply the presence of higher phenotypic variability. Further high PCV and GCV were found for number of fruits per cluster, number of fruits per plant, fruit yield per plant and number of locules per fruit indicating less environmental influence on expression of characters therefore individual plant selection can be followed for improvement of these characters. High heritability coupled with high genetic advance as a per cent over mean was observed for plant height, days to first harvest, number of fruits per plant, average fruit weight, fruit yield per plant, pericarp thickness, and number of locules per fruit indicating the involvement of additive gene action for expression of these traits in crosses studied. Characters like fruits per plant, average fruit weight, fruit volume, pericarp thickness and number of locules per fruit shown the presence of positive significant association with fruit yield among F_4 segregants which implies that fruit yield per plant could be improved up on improving some of the traits like number of fruits per plant, average fruit weight, fruit volume, fruit length, days to first flowering and days to first harvest.

Keywords: Heritability, correlation, fruit yield, yield-related traits

Introduction
Tomato (*Solanum lycopersicum* L.), belonging to family solanaceae is one of the most important vegetable crops in the world pertaining to nutrition, health and is an important source of sugars, vitamins, minerals and antioxidant compounds.

Tomato is predominantly self-pollinated, but a certain percentage of cross pollination may also occur. It grows as a series of branching stems and most of the tomato plants have compound leaves, both the stem and leaves are covered with dense glandular hair and the flowers are borne in a cymose inflorescence. Botanically, tomato fruit is known as a berry that contains hollow spaces filled with seeds and moisture called locular cavities (Okey *et al*., 2016) [7].

The success of any crop improvement programme largely depends upon the nature and extent of genetic variability that exists in the breeding material with which the plant breeder is working (Prabu *et al*., 2009) [8]. The phenotypic expression of plant character is mainly controlled by the plant's genetic makeup, the environment in which it is grown, and the interaction between the genotype and environment. The genetic variance of any quantitative trait is composed of additive variance (heritable) and non-additive variance (non-heritable), which includes dominance and epistasis (non-allelic interaction). Therefore, it becomes necessary to partition the observed phenotypic variability into its genotypic (partly-heritable) and environmental (non-heritable) components with suitable parameters such as phenotypic and genotypic coefficient of variation and heritability in broad sense.

The estimates of heritability help the plant breeder in selection of elite genotypes from diverse genetic population. Heritability indicates only the effectiveness with which selection of a genotype can be based on phenotypic performance, but it fails to indicate the expected genetic progress in one cycle of selection. Heritable variation can be effectively used with greater degree of accuracy when heritability is studied in conjunction with genetic advance (Johnson *et al*., 1955) [6].

Improvement made in crop varieties is concentrated on increasing yield and yield attributing characters. A study of correlation between different quantitative characters provides an idea of association. It could be effectively exploited to formulate selection strategies for improving yield and quality.

Materials and Methods

Firstly, evaluated parental lines were tested for specific and general combining ability and the present cross EC15127×EC362941 of tomato which are used for study was found best. Further it was evaluated for F_2 generation later eleven lines from the cross were selected which are carried for F_3 generation.

During Summer 2023 season, five generations (P_1, P_2, F_1, F_2 and F_3) of the crosse of tomato namely, EC15127 × EC362941 were studied for generation mean analysis and selected and collected seeds from eleven lines from the crosse of F_3 population to carry the generation for F_4. During Summer 2024 season, F_4 plants along with four check varieties were raised. The experiment comprised of 20 plants with four check varieties in each block, and 200 plants each of the F_4 populations were sown at a spacing of 60 cm × 45 cm in an augmented design.

All recommended agronomic practices and plant protection measures were followed during the crop growth period to ensure proper growth and good yield. The observations were recorded for all the plants.

Observations for individual plants was recorded for yield and yield related traits that includes plant height (cm), primary branches per plant, days to first flowering, days to first harvest, number of fruits per plant, fruit volume (cc), average fruit weight (g), pericarp thickness (mm), number of locules per fruit and fruit yield per plant (kg).

The genotypic and phenotypic co-efficient of variations was computed as suggested by AlJibouri *et al.*, (1958) [2]. Heritability and genetic advance were worked out as per the method outlined by Johnson *et al*. (1955) [6].

Results and Discussion

Analysis of variance in F_4 segregating population of the cross EC15127×EC362941 revealed significant differences (Table 1.) among the lines for most of the characters. Further, segregating progenies and checks also recorded presence of high variability for all the characters, which indicating the presence of enormous genetic variability and the choice of the material for the investigation is appropriate.

Genetic variability parameters

Data presented in the table 2 indicates the presence of wide range of the characters studied which implies availability of a higher magnitude of variability among the segregating population which is further confirmed by the presence of higher PCV and GCV for the traits, number of fruits per cluster, number of fruits per plant, fruit yield per plant and number of locules per fruit, therefore influence of environment on the expression of these characters is low. Similar results were recorded by Sunilkumar *et al*. (2016) [11] and Al-ballat and Al-araby (2020) [1] for fruit yield per plant, Rathod *et al*. (2016) [9] and Sunilkumar *et al*. (2016) [11] for locules per fruit and Aralikatti *et al*. (2018) [3] for number of fruits per plant.

High heritability coupled with high GAM was noticed for the characters *viz*., plant height, days to first harvest, number of fruits per plant, average fruit weight, fruit yield per plant, pericarp thickness and number of locules per fruit which implies that involvement of additive gene action on the expression of fruit yield and its attributes. Therefore, individual plant selection for these traits could be practiced for selection of superior segregants from the F_4 generation. These results are in agreement with the report of Eppakayala *et al*. (2021) [4] for plant height, number of fruits per plant, days to first harvest and fruit yield per plant.

Correlation of fruit yield per plant with yield and yield related traits at phenotypic level

Phenotypic correlation coefficients studies revealed that (Table 3) fruit yield per plant exhibited strong positive correlation with fruits per plant, average fruit weight, fruit volume, pericarp thickness and number of locules per fruit were indicating that improvement of above, mentioned traits indirectly leads to improvement in fruit yield coupled.

Significant negative association of fruit yield per plant with days to first harvest was observed indicating that negative relationship of fruit yield per plant with days to first harvest. Therefore, selection of plants which produce fruits in minimum number of days which leads to higher fruit yield would thus, leads to development of superior segregants for high yielding in a single selection programme.

These results are in agreement with the reports of Al-ballat and Al araby (2020) [1], Vidya (2019) [13], Vijaylaxmi *et al*. (2021) [14] for average fruit weight, Souza *et al*. (2012) [10], Gill (2021) [5] for pericarp thickness and Vidya (2019) [13] for number of fruits per plant.

Correlation of fruit yield per plant with yield and yield related traits at genotypic level

Genotypic correlation coefficients studies revealed that (Table 4) fruit yield per plant exhibited strong positive correlation with fruits per plant, average fruit weight, days to first flowering, days to first harvest, pericarp thickness and number of locules per fruit were indicating that improvement of above, mentioned traits indirectly leads to improvement in fruit yield coupled.

Significant negative association of fruit yield per plant with average fruit weight, plant height and primary branches per plant was observed indicating that negative relationship of fruit yield per plant. Therefore, selection of plants which produce fruits in minimum number of days which leads to higher fruit yield would thus, leads to development of superior segregants for high yielding in a single selection programme. These results are in line with the findings of Sushma *et al*. (2020) [12] for days to first harvest, Kumar (2015) for fruit volume, Gill (2021) [5] for pericarp thickness.

Table 1: Analysis of variance for growth, flowering and yield parameters in F_4 segregating population of tomato cross EC15127×EC362941

Source/ Character	Block	Entries	Checks	Varieties	Varieties vs. checks	Error
DF	9	203	3	199	1	27
Plant height (cm)	3302.843 **	1800.289 **	3185.367 **	1678.078 **	21964.960 **	431.717
Number of primary branches per plant	6.222 **	2.312 **	2.025	1.827 *	99.763 **	0.951
Days to first flowering	34.693 **	19.697 *	48.025 **	19.163 *	41.070 *	9.247
Days to first harvest	47.032 **	71.520 **	1.167	69.556 **	673.501 **	6.758
Number of fruits per plant	25.863 *	19.044 **	1.825	13.686**	1136.853 **	8.307
Average fruit weight (g)	128.881	296.912 *	93.994	214.391	17327.240 **	164.892
Fruit volume (cc)	557.591 *	320.848	106.425*	279.089*	9274.080 **	198.593
Fruit yield per plant (g)	0.126 **	0.250 **	0.059 *	0.139 **	22.878 **	0.013
Pericarp thickness (mm)	0.763 **	0.726 **	0.779 **	0.648 **	16.194 **	0.036
Number of locules per fruit	1.272 **	1.564 **	0.395 **	1.578 **	2.129 **	0.011

*Significance at 5% and ** Significance at 1%

Table 2: Estimates of genetic parameters for growth, flowering and yield attributes in F_4 population of tomato cross EC15127×EC362941

Sl.no	Genetic Parameters	GV	PV	GCV (%)	PCV (%)	h^2 bs (%)	GA	GAM (%)
1.	Plant height (cm)	1078.37	1510.09	15.01	17.76	71.41	57.17	26.12
2.	Number of primary branches per plant	0.76	1.71	19.03	28.55	44.44	1.20	26.14
3.	Days to first flowering	8.58	17.83	9.19	13.24	48.12	4.19	13.13
4.	Days to first harvest	54.33	61.09	10.46	11.09	88.93	14.32	20.32
5.	Number of fruits per plant	7.03	7.97	20.09	21.39	88.21	5.13	38.86
6.	Average fruit weight (g)	46.87	51.19	10.18	10.64	91.56	13.49	20.07
7.	Fruit volume (cc)	51.49	55.37	9.64	9.99	92.99	14.25	19.14
8.	Fruit yield per plant (kg)	0.11	0.12	36.85	38.49	91.67	0.65	72.68
9.	Pericarp thickness (mm)	0.53	0.57	17.71	18.37	92.98	1.45	35.19
10.	Number of locules per fruit	1.36	1.37	32.04	32.16	99.27	2.39	65.76

GV: Genotypic variance, PV: Phenotypic variance, GCV: Genotypic coefficient of variation, PCV: Phenotypic coefficient of variation, h^2 bs: Heritability (broad sense), GA: Genetic advance, GAM: Genetic advance as per cent of mean.

Table 3: Estimates of phenotypic correlation coefficient of F_4 population of tomato cross EC15127 × EC362941

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	1.000	0.047	-0.077	-0.097	-0.061	-0.026	0.005	-0.021	0.004
X_2		1.000	0.007	-0.060	-0.065	0.054	0.095	0.065	0.072
X_3			1.000	0.056	0.047	-0.019	-0.011	-0.059	-0.036
X_4				1.000	-0.093	-0.079	-0.104	-0.023	-0.179*
X_5					1.000	0.152*	0.270**	0.182*	0.760**
X_6						1.000	0.156*	-0.024	0.675**
X_7							1.000	0.292**	0.359**
X_8								1.000	0.155*
X_9									1.000

Critical r_g value at 5% = 0.1374, *Significant at p = 0.05, Critical r_g value at 1% = 0.2287, **Significant at p = 0.01

X_1 = Plant height (cm) X_2 = Number of primary branches per plant
X_3 = Days to first flowering X_4 = Days to first harvest
X_5 = Number of fruits per plant X_6 = Average fruit weight (g)
X_7 = Fruit volume (cc) X_8 = Pericarp thickness (mm)
X_9 = Fruit yield per plant (kg)

Table 4: Estimates of genotypic correlation coefficient of F_4 population of tomato cross EC15127 × EC362941

Traits	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	1.000	0.834**	0.879**	0.737**	-0.763**	-0.689**	-0.425**	-0.597**	-0.502**
X_2		1.000	-0.032	-0.132	-0.430**	-0.558**	0.249**	0.337**	-0.423**
X_3			1.000	-0.059	0.361**	0.116	0.745**	0.673**	0.443**
X_4				1.000	0.133	0.723**	-0.245**	-0.611**	0.411**
X_5					1.000	-0.314**	0.286**	0.612**	0.857**
X_6						1.000	-0.304**	0.760**	-0.466**
X_7							1.000	0.548**	0.472**
X_8								1.000	0.512**
X_9									1.000

Critical r_g value at 5% = 0.1374, *Significant at p = 0.05, Critical r_g value at 1% = 0.2287, **Significant at p = 0.01

X_1 = Plant height (cm) X_2 = Number of primary branches per plant
X_3 = Days to first flowering X_4 = Days to first harvest
X_5 = Number of fruits per plant X_6 = Average fruit weight (g)
X_7 = Fruit volume (cc) X_8 = Pericarp thickness (mm)
X_9 = Fruit yield per plant (kg)

Conclusion

In conclusion, the study of the cross EC15127 × EC362941 of tomato revealed significant genetic variability and heritable traits among the F4 generation. High phenotypic and genotypic coefficients of variation indicated a strong potential for selection in improving yield-related characteristics. Positive correlations between fruit yield and traits such as number of fruits per plant and average fruit weight suggest that focusing on these factors can enhance overall yield. The findings underscore the importance of genetic analysis in crop improvement programs, providing valuable insights for selecting superior genotypes aimed at maximizing tomato production.

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