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GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS STUDIES IN TOMATO (SOLANUM LYCOPERSICUM L.) FOR GROWTH AND YIELD TRAITS

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ABSTRACT

The present investigation involving sixteen genotypes (S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, and S16) of tomato was carried out in Randomized Block Design (RBD) during 2022-2023 at Faculty of Agriculture Farm, Guru Kashi University, Talwandi Sabo. The observations were recorded for growth, quality and yield characters. The result revealed that maximum plant height was recorded in genotype S13 (215.33 cm). The maximum number of primary branches was recorded in S8 (16.00) which is followed by S13 (15.00), S7 (14.67), S5 (13.00). All varieties were having acidic pH except for S7 and S13 genotypes were basic in nature with 7.733 and 8.30, respectively. The minimum TSS (4.27) was recorded in S9. The maximum average fruit weight was recorded in S13 (63.73 g). The maximum yield was recorded in S5 (2.43 Kg/plant) followed by S1 (2.38 Kg/plant), S6 (2.22 Kg/plant), S15 (2.14 Kg/plant). The path analysis estimates indicated that plant height, Days of last fruit harvest, pH , TSS, Plant height, Pericarp thickness, Number of locules, Number of fruit per cluster, Average fruit weight, Number of fruit per has highest positive direct effect on total yield per plant. Therefore out of all sixteen varieties S5 is showing significantly highest yield, S12 is showing maximum number of fruit per plant, whereas S13 is showing maximum fruit weight. So, these are promising genotypes which can be used for further commercially exploited or can be used in breeding programme for more refined development.

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INTRODUCTION

Tomato (Solanum *lycopersicum* L., Family: Solanaceae) is one of the worlds commonly consumed vegetable used in the form of puree, paste, powder, ketchup, sauce, soup and canned whole fruit (Thamburaj and Singh, 2005; Kimura and Sinha 2008). India ranked second after China with 11.2 percent in tomato production and area worldwide (Gupta *et al*. 2021; Nimbrayan *et al*. 2022). Gujarat, Andhra Pradesh, Haryana, Utter Pradesh, West Bengal, Bihar, Madhya Pradesh, Maharashtra, Tamil Nadu and Chhattisgarh are the major tomato producing states (Gaikward *et al*. 2020). It is rich source of vitamins A, B-complex, C, E, K and 23 minerals (Abdullahi *et al*. 2016; Ahmed *et al*. 2020). It contains water, total sugar, carbohydrates, lipid, protein, fiber and antioxidant due to these it is also called as Protective food (Oboulbiga *et al*. 2017; Imran *et al*. 2020). It is having many medicinal values. It is having many medicinal values. It prevents cancer and neurodegenerative, constipation, detoxify the toxin, maintain proper bone structure (Saini *et al*. 2020; Vats *et al*. 2022). It prevents cardiovascular diseases, cognitive function, osteoporosis, obesity and diabetes (Cheng *et al*. 2019; Li *et al*. 2020; Zhu *et al*. 2020). The demand of tomato is increasing every year due to its high nutritive and medicinal value. But the production and productivity of this crop in India is far below compare to the global demand (Ara *et al*., 2009). The genetic variability knowledge of various characters is important for crop improvement programme to develop superior varieties (Tiwari et.al. 2019). The genotypic and phenotypic coefficients of variation are helpful in determining the amounts of variability present in the population (Sesay *et al* 2016). Genetic advance can be used to predict the efficiency of selection (Terfa and Gurmu 2020).Genetic improvement of plants for quantitative traits requires reliable estimates of heritability in order to plan an efficient breeding program (Akinwale *et al*. 2011). Heritability and genetic advance help in assessing the influence of environment in expression of characters and the extent of improvement possible after selection (Ogunniyan and Olakojo, 2014). Hence, there is need to develop superior varieties for different agro-ecological conditions. Therefore the present study on was conducted to identify good quality and high yielding variety of tomato.

MATERIALS AND METHODS

The present study was conducted at Guru Kashi University, Talwandi Sabo, Punjab, India during 2022-2023. Seeds of 16 genotypes (S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, and S16) were sown in elevated nursery beds. To raise the healthy nursery, suggested cultural practices were adopted. A Randomized Block Design (RBD) and three replications of each genotype were used for experiment. The plants were raised at a row distance of 1.25 m by plant distance of 30 cm.

Table 1. Mean performance of tomato genotypes for different characters

Characters / Genotypes	Plant height (cm)	Number of primary branches	Days of first fruit harvest	Days of last fruit harvest	pH	TSS (Brix)	Polar diameter (cm)	Equatorial diameter (cm)	Pericarp thickness (cm)	Number of locules	Number of fruit per cluster	Average fruit weight (g)	Number of fruit per plant	Total yield per plant (kg)
S1	160	10.67	114.0	162.67	4.23	4.5	3.8	4.23	0.37	2.67	5.67	39.6	60.0	2.38
S2	198.67	8.33	111.0	165.33	5.1	4.37	5.57	4.9	0.63	2.0	5.33	23.0	84.67	2.04
S3	153.33	12.33	114.67	164.0	4.23	4.3	3.97	4.93	0.47	5.33	6.0	57.63	30.33	1.67
S4	145.33	9.67	112.33	164.33	5.77	5.07	3.87	3.23	0.53	2.0	5.33	40.43	40.67	1.62
S5	196.0	13.0	116.67	164.33	5.3	5.33	3.2	3.2	0.3	2.0	5.67	33.73	72.0	2.43
S6	159.0	11.33	116.0	166.33	4.73	4.73	4.83	4.6	0.6	2.33	5.0	28.57	78.33	2.22
S7	205.0	14.67	115.67	167.67	7.73	4.4	2.0	2.0	0.2	2.67	6.0	27.76	70.33	1.98
S8	214.0	16.0	116.67	168.0	4.27	5.77	2.9	3.1	0.3	2.0	6.33	15.9	133.33	2.11
S9	153.0	10.33	115.33	164.33	4.2	4.27	4.0	4.13	0.4	4.33	5.0	18.57	80.0	1.49
S10	157.67	11.33	116.0	164.67	5.4	5.23	4.1	3.73	0.47	3.33	4.67	28.67	64.67	1.89
S11	148.0	10.33	114.67	168.0	4.4	5.03	6.77	4.93	0.67	2.33	5.0	25.37	71.33	1.85
S12	166.0	8.67	117.67	165.67	4.2	4.7	4.1	3.93	0.43	2.0	6.33	11.6	172.0	2.04
S13	215.33	15.0	117.33	163.67	8.3	4.33	3.33	3.67	0.3	2.0	6.0	63.73	27.67	1.84
S14	157.67	11.0	115.0	163.67	3.73	4.4	5.27	3.93	0.47	2.33	8.33	36.13	52.0	1.66
S15	161.0	10.0	115.67	164.67	5.33	5.43	6.37	5.23	0.67	2.0	5.67	38.33	54.0	2.14
S16	153.33	11.33	113.33	165.67	4.1	4.57	3.9	3.7	0.43	3.33	6.33	40.67	48.67	1.86
Mean	171.46	11.5	115.13	165.19	5.07	4.78	4.25	3.97	0.45	2.67	5.79	33.11	71.25	1.95
CD(0.05)	5.05	1.02	0.56	4.32	1.05	1.32	0.27	0.42	0.25	0.36	0.80	1.05	1.03	3.04
Range	145.33-215.33	8.33-16.0	117.67-111.0	168.0-163.67	3.73- 8.3	4.27-5.43	2.0-6.77	2.0-5.23	0.2-0.67	2.0-4.33	4.67-8.33	11.6- 63.73	27.67-172.0	1.62-2.43

Table 2. Genotypic and Phenotypic Correlation of different characters of tomato

Characters		Plant height (cm)	Number of primary branches	Days of first fruit harvest	Days of last fruit harvest	pH	TSS (Brix)	Polar diameter (cm)	Equatorial diameter (cm)	Pericarp thickness (cm)	Number of locules	Number of fruit per cluster	Average fruit weight (g)	Number of fruit per plant	Total yield per plant (kg)
Plant height (cm)	G		0.676**	0.600**	0.446**	0.582**	0.099	-0.567**	-0.634**	-0.680**	-0.553**	0.185	-0.016	0.211	0.400**
	P		0.623**	0.180	0.170	0.577**	0.092	-0.407**	-0.334*	-0.457**	-0.295*	0.101	-0.018	0.215	0.346*
Number of primary branches	G			1.131**	0.464**	0.476**	0.215	-0.795**	-0.844**	-0.879**	-0.015	0.296*	0.284	-0.124	0.099
	P			0.235	0.177	0.441**	0.123	-0.482**	-0.364*	-0.562**	0.050	0.106	0.248	-0.106	0.175
Days of first fruit harvest	G				0.723**	0.382**	0.578**	-0.404**	-0.358*	-0.585**	-0.144	0.236	-0.135	0.706**	0.659**
	P				-0.008	0.131	0.128	-0.292*	-0.225	-0.423**	-0.085	0.094	-0.071	0.226	0.036
Days of last fruit harvest	G					0.061	0.656**	-0.052	-0.498**	-0.064	-0.122	-0.316*	-1.032**	0.874**	0.258
	P					0.023	0.214	0.030	-0.124	0.083	-0.265	-0.075	-0.356*	0.312*	0.022
pH	G						-0.097	-0.455**	-0.614**	-0.449**	-0.369**	-0.207	0.386**	-0.320*	0.031
	P						-0.100	-0.336*	-0.337*	-0.300*	-0.201	-0.155	0.379**	-0.317*	0.030
TSS (Brix)	G							0.103	-0.111	0.129	-0.560**	-0.247	-0.306*	0.293*	0.468**
	P							0.050	-0.098	0.104	-0.328*	-0.149	-0.283	0.281	0.311*
diameter (cm)	G								0.884**	1.067**	-0.377**	-0.155	-0.072	-0.095	-0.102
	P								0.817**	0.782**	0.041	-0.067	-0.108	-0.066	-0.053
Equatorial diameter (cm)	G									1.048**	0.142	-0.512**	0.208	-0.167	-0.048
	P									0.645**	0.216	-0.015	0.016	-0.089	-0.004
Pericarp thickness (cm)	G										-0.200	-0.342*	-0.085	-0.105	-0.025
	P										-0.008	-0.250	-0.083	-0.085	-0.195
No. of locules	G											-0.233	0.344*	-0.422**	-0.738**
	P											-0.056	0.161	-0.226	-0.315*
No. of fruits per cluster	G												0.215	0.043	-0.154
	P												0.088	0.023	-0.113
Average fruit weight (g)	G													-0.845**	-0.194
	P													-0.828**	-0.124
No. of fruits per /plant	G														0.323*
	P														0.274

Table 3. Path analysis: Direct and indirect effects at genotypic and phenotypic levels in tomato

Characters		Plant height (cm)	Number of primary branches	Days of first fruit harvest	Days of last fruit harvest	pH	TSS (Brix)	Polar diameter (cm)	Equatorial diameter (cm)	Pericarp thickness (cm)	Number of locules	Number of fruit per cluster	Average fruit weight (g)	Number of fruit per plant
Plant height (cm)	G	1.162	-0.877	-0.263	0.242	0.237	0.125	-0.044	0.177	-0.172	-0.519	0.082	-0.027	0.276
	P	0.271	0.004	-0.036	-0.016	-0.121	0.022	-0.077	-0.104	0.279	0.092	-0.032	-0.005	0.068
Number of primary branches	G	0.786	-1.298	-0.495	0.252	0.194	0.272	-0.062	0.236	-0.222	-0.015	0.131	0.483	-0.163
	P	0.169	0.007	-0.047	-0.017	-0.093	0.029	-0.091	-0.113	0.343	-0.016	-0.033	0.070	-0.034
Days of first fruit harvest	G	0.697	-1.468	-0.438	0.393	0.155	0.733	-0.032	0.100	-0.148	-0.135	0.104	-0.230	0.926
	P	0.049	0.002	-0.199	0.001	-0.028	0.030	-0.055	-0.070	0.258	0.027	-0.029	-0.020	0.071
Days of last fruit harvest	G	0.519	-0.602	-0.317	0.543	0.025	0.833	-0.004	0.139	-0.016	-0.114	-0.140	-1.754	1.146
	P	0.046	0.001	0.002	-0.093	-0.005	0.051	0.006	-0.039	-0.051	0.083	0.023	-0.101	0.099
pH	G	0.676	-0.618	-0.167	0.033	0.407	-0.124	-0.036	0.171	-0.113	-0.346	-0.092	0.657	-0.419
	P	0.156	0.003	-0.026	-0.002	-0.211	-0.024	-0.063	-0.105	0.183	0.063	0.048	0.107	-0.100
TSS (Brix)	G	0.115	-0.278	-0.253	0.356	-0.040	1.269	0.008	0.031	0.033	-0.526	-0.109	-0.521	0.384
	P	0.025	0.001	-0.025	-0.020	0.021	0.237	0.009	-0.031	-0.064	0.103	0.046	-0.080	0.089
Polar diameter (cm)	G	-0.659	1.032	0.177	-0.028	-0.185	0.131	0.078	-0.247	0.269	-0.354	-0.069	-0.123	-0.124
	P	-0.110	-0.003	0.058	-0.003	0.071	0.012	0.189	0.254	-0.477	-0.013	0.021	-0.031	-0.021
Equatorial diameter (cm)	G	-0.737	1.096	0.157	-0.270	-0.250	-0.141	0.069	-0.279	0.265	0.134	-0.226	0.354	-0.218
	P	-0.091	-0.002	0.045	0.012	0.071	-0.023	0.154	0.311	-0.394	-0.067	0.005	0.004	-0.028
Pericarp thickness (cm)	G	-0.791	1.141	0.256	-0.035	-0.183	0.164	0.083	-0.293	0.253	-0.188	-0.151	-0.145	-0.138
	P	-0.124	-0.004	0.084	-0.008	0.063	0.025	0.148	0.201	-0.610	0.003	0.078	-0.023	-0.027
No. of locules	G	-0.642	0.020	0.063	-0.066	-0.150	-0.710	-0.030	-0.040	-0.051	0.940	-0.103	0.584	-0.553
	P	-0.080	0.000	0.017	0.025	0.042	-0.078	0.008	0.067	0.005	-0.313	0.017	0.046	-0.071
No. of fruits per cluster	G	0.215	-0.384	-0.103	-0.171	-0.084	-0.314	-0.012	0.143	-0.086	-0.219	0.442	0.365	0.056
	P	0.028	0.001	-0.019	0.007	0.033	-0.035	-0.013	-0.005	0.153	0.017	-0.312	0.025	0.007
Average fruit weight (g)	G	-0.018	-0.368	0.059	-0.560	0.157	-0.389	-0.006	-0.058	-0.022	0.323	0.095	1.699	-1.107
	P	-0.005	0.002	0.014	0.033	-0.080	-0.067	-0.020	0.005	0.051	-0.050	-0.027	0.283	-0.262
No. of fruits per /plant	G	0.245	0.161	-0.309	0.475	-0.130	0.372	-0.007	0.047	-0.027	-0.397	0.019	-1.436	1.311
	P	0.058	-0.001	-0.045	-0.029	0.067	0.066	-0.013	-0.028	0.052	0.071	-0.007	-0.235	0.317

The regular watering, weeding, application of pesticide and fungicides has been carried out. The observations on the selected parameters i.e. Plant height (cm), Number of primary branches, Days to first fruit harvest, Days to last fruit harvest, Polar Diameters (cm), Equatorial diameters (cm), Pericarp thickness (cm), Number of locules, Number of fruit per cluster, Average fruit weight (g), Number of fruit per plant, Total yield per plant (Kg/plant), pH, and TSS were recorded from five randomly selected plants from each plot. The collected raw data during experiment trial was transfer on the Excel sheet in Microsoft Excel 2016 and OPSTAT software to analysis genetic correlation, path analysis.

RESULTS AND DISCUSSION

The present study results revealed that the maximum plant height was recorded in genotype S 13(215.33 cm) which is followed by S8 (214.00cm), S7 (205.00 cm), S2 (198.67 cm), S5(196.00 cm), S12(166.00 cm), S1 (160.00 cm), S15(161.00 cm), and S6(159.00 cm). The maximum number of primary branches was recorded in S8 (16.00) which is followed by S13 (15.00), S7 (14.67), S5 (13.00), S3 (12.33). The minimum number of primary branches (8.333) was recorded from genotype S2. There is no significant variation was recorded with days to first fruit harvest. The genotypes S8 and S11 took 168.00 days to last fruit harvest followed by S7 (167.66 days), S6 (166.33 days), and S2 (165.33 days). The result also revealed that the genotype S14 (3.733) was most acidic in nature followed by S16 (4.100), S9 and S12 (4.20 each), S1 and S3 (4.23 each), S8 (4.27), S11 (4.40), S6 (4.73), S2 (5.10), S5 (5.30), S15 (5.33), S10 (5.40), and S4 (5.77). Genotypes S7 and S13 was basic in nature with 7.733 and 8.300 pH, respectively. The maximum TSS recorded in S8 (5.77). Maximum equatorial diameters (cm) was recorded in S15 (5.23 cm) and minimum (2.00 cm) in S7. The maximum pericarp thickness was recorded in S4 (2.03 cm) and minimum (0.20 cm) in S7. The maximum number of locules was recorded in S3 (5.33) followed by S9 (4.33). The maximum number of fruit per cluster was recorded in S14 (8.00) followed S16 and S8 (6.33). The maximum average fruit weight was recorded in genotype S13 (63.73 g) followed by S3 (57.63 g) and minimum 11.60 g fruit weight was recorded in S12. The maximum number of fruit per plant was recorded in S12 (172.00) followed by S8 (133.33). The significant difference in total yield per plant in all selected sixteen genotypes of tomato was recorded. The maximum yield was recorded in S5 (2.43 Kg/plant) followed by S1 (2.38 Kg/plant), S6 (2.22 Kg/plant) and minimum yield per plant (1.49 kg/plant) was recorded in S9 (Table 1).

Genotypic Correlation Coefficients: The genotypic correlation coefficients among 14 characters showed that Plant height was positively correlated to number of primary branches (0.676), Days of first fruit harvest (0.600), Days of last fruit harvest (0.446), pH (0.582), and Total yield per plant (0.400).

Number of primary branches was positively correlated to Days of first fruit harvest (1.131), Days of last fruit harvest (0.464), pH(0.464), and Number of fruit per cluster (0.296). Days of first fruit harvest was positively correlated to Days of last fruit harvest (0.723), pH (0.382), TSS (0.578), Number of fruit per plant (0.706), and Total yield per plant (0.659). pH was positively correlated to Average fruit weight (0.386). TSS was positively correlated to Number of fruit per plant (0.293) and Total yield per plant (0.468). Polar diameter was positively related to Equatorial diameter (0.884), and Pericarp thickness (1.067), while negatively correlated to Number of locules (-0.377). Equatorial diameter was positively correlated to Pericarp thickness (1.048) and negatively to Number of fruit per cluster (-0.512). Number of fruit per plant was showing positive correlation with total yield per plant (0.323) (Table 2).

Phenotypic correlation coefficients: The phenotypic correlation revealed that the Plant height was positively correlated to number of primary branches (0.623), pH (0.577), and Total yield per plant (0.346). Number of primary branches was positively correlated to Days of first fruit harvest (1.131), Days of last fruit harvest (0.464), pH(0.464), and Number of fruit per cluster (0.296). Days of first fruit harvest was positively correlated to pH (0.441). pH was positively correlated to Average fruit weight (0.379), whereas negatively correlated to Polar diameter (-0.336), Equatorial diameter (-0.337), Pericarp thickness (-0.300), and Number of fruit per plant (-0.317). TSS was positively correlated to Total yield per plant (0.311) and negatively correlated to Number of locules (-0.328). Polar diameter was positively related to Equatorial diameter (0.817), and Pericarp thickness (0.782). Average fruit weight negatively correlated to Number of fruit per plant (-0.828)(Table2).

Path analysis: The path analysis results indicated at genotypic level plant height (1.162), Days of last fruit harvest (0.543), pH (0.407), TSS (1.269), Polar diameter (0.078), Number of fruit per cluster (0.442) , Number of fruit per plant (1.311), and Average fruit weight (1.699) had positive direct effect on total yield per plant. The primary branches (-0.495), and Days of first fruit harvest (-0.438), had negative direct effect on total yield per plant. The path analysis at phenotypic level reported that the plant height (0.271), number of primary branches (0.007), TSS (0.237), Polar diameter (0.189), and Average fruit weight (0.283) had positive direct effect on total yield per plant. Days of first fruit harvest (-0.199), Days of last fruit harvest (-0.093), pH (-0.211), and Number of fruit per cluster (-0.312) had negative direct effect on total yield per plant (Table 3). Many researchers worked on tomato genotypes. Prema et al. (2011) conducted similar type of studies on six cherry tomatoes. Jilani et al. (2013) conducted experiment to evaluate the 11 tomato cultivars under the agro-climatic conditions. Lekshmi and Celine (2015) conducted investigation at Department of Olericulture, College of Agriculture, Vellayani, Kerala on twelve tomato hybrids obtained from public and private sectors and grown under polyhouse conditions. Prajapati et al. (2015) evaluated 39 genotypes of tomato reported that number of fruits per plant showed the highest genotypic and phenotypic variance (1282.0 and 1287.6) whereas test weight showed the lowest (0.03 and 0.08). Doddamani et al. (2017) also recorded the genetic variability, heritability and genetic advance in 36 genotypes of cherry tomato. The result revealed that phenotypic coefficient of variation was higher than genotypic coefficient of variation for all the characters studied. Similarly, Maurya et al. (2020) carried out an experiment on sixteen genotypes of tomato to study Correlation and path analysis. The result revealed that genotypic correlations were comparatively higher than the phenotypic correlations for most of the traits.

CONCLUSION

The present investigation was conducted to identify the variety of tomato having high yield at Guru Kashi University, Talwandi Sabo**,** Punjab, India during 2022-2023 revealed that the maximum plant height was recorded in S13 (215.33 cm) which is followed by S8 (214.00cm), S7 (205.00 cm) whereas S11was showing 148.00 cm plant height. All varieties were having acidic pH except for S7: and S13 selection was basic in nature with 7.733 and 8.300 pH, respectively. The minimum TSS (4.27) was recorded in S9. The maximum average fruit weight was recorded in S13 (63.73 g). The maximum number of fruit per plant was recorded in S12 (172.00). Interestingly the significant difference in total yield per plant in all selected sixteen varieties of tomato. The maximum yield was recorded in S5 (2.43 Kg/plant) followed by S1 (2.38 Kg/plant), S6 (2.22 Kg/plant), S15 (2.14 Kg/plant). The path analysis estimates indicated that plant height, Days of last fruit harvest, pH , TSS, Plant height, Pericarp thickness, Number of locules, Number of fruit per cluster, Average fruit weight, Number of fruit per has highest positive direct effect on total yield per plant. The path analysis estimates indicated that plant height, Days of last fruit harvest, pH , TSS, Plant height, Pericarp thickness, Number of locules, Number of fruit per cluster, Average fruit weight, Number of fruit per has highest positive direct effect on total yield per plant. Therefore out of all sixteen varieties S5 is showing significantly highest yield, S12 is showing maximum number of fruit per plant, whereas S13 is showing maximum fruit weight. So, these are promising genotypes which can be used for further commercially exploited or can be used in breeding programme for more refined development.

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