The Pharma Innovation Journal 2023; 12(8): 2325-2329

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(8): 2325-2329
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www.thepharmajournal.com
Received: 28-06-2023
Accepted: 30-07-2023

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Genetic variability, correlation and path coefficient analysis in tomato (*Solanum lycopersicum* L.)

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Abstract
The present investigation was conducted at Experimental Field, Doon PG College of Agriculture and Allied Sciences, Dehradun. Seven genotypes of tomato were evaluated to study variation, correlation and path coefficient analysis and yield traits, during winter season 2022-2023. The experiment was carried out in Randomized Block Design with three replications. Analysis of variance (ANOVA) revealed highly significant difference among genotypes for all characters indicating high degree of variability. The estimates of phenotypic variation (PCV) were higher than the genotypic variation (GCV) for all traits. High PCV and GCV recorded for number of fruit per plant followed by fruit yield per plant and number of fruit per cluster. Correlation indicated Fruit yield per plant had highly significant and positive correlation with average fruit weight followed by number of cluster per plant, number of primary branches per plant. Path analysis revealed direct positive effect exerted by number of fruits per plant, average fruit weight, number of primary branches per plant, number of clusters per plant and plant height; and negative direct effect exerted by diameter of fruit per plant and number of fruits per cluster."

Keywords: Tomato, genotype, correlation, path analysis

Introduction
Tomato (*Solanum lycopersicum* L.) belongs to the Solanaceae family (the night shade family). "It is a self-pollinated diploid species with 12 pairs of Chromosome (2 n = 24). Tomato is a herbaceous sprawling plant growing to 1-3m in height with weak woody stem. The flowers are yellow in colour. Botanically tomato is berry type fruit. Scientific information's indicate that cultivated tomato was originated in South America, most probably in the Peru-Ecuador region (Kalloo *et al*., 2001) [13]. The Nahuat word tomat gave rise to the Spanish word tomate, from which the English word tomato derived. It is the important warm season vegetable grown throughout the world. Tomato is a day neutral plant with certain percentage of cross pollination. It is reasonably resistant to heat and drought and grows under wide range of soils and climatic conditions. Tomato fruit contain 93.1 g water, protein 19 g, fat 0.1 g, carbohydrate 3.6 g, mineral 0.6g, calcium 20 mg, phosphorus 36 mg, iron 0.8 mg, carotene 320 IU, thiamine 0.4 mg, riboflavin 0.01 mg and ascorbic acid 3.1 mg per 100 g of pulp of fruit, also contain folic acid, penthothenic acid, biotin, vitamin K (acc. to Aykroyed, 1963) [14]."

"Phenotypic and genotypic coefficients of variation are useful in detecting amounts of variability present in genotypes. The success of crop improvement programme depends on extreme of genetic variability existing in the population or germplasm with which plant breeder is working."

"Correlation studies between fruit weight and its components and their relative contribution to yield are of value in planning breeding program. Correlation and path coefficient analysis give an insight into the genetic variability present in populations. Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be based for improvement of yield."

"Path analysis splits the correlation coefficients into direct and indirect effect of a set of dependent variables on the independent variable thereby aids in selection of elite genotype. Path analysis facilitates the portioning of the correlation coefficient into direct and indirect effects on yield and any other attributes (Islam *et al*., 2010) [15]. The analysis of path coefficient can also be utilized to determine the best breeding strategy for improving elite genotypes through selection in advanced generations (Gopinath and Irene Vethamoni, 2017) [12]."

Methods and Material

"The experimental material in the study consists of seven genotypes of tomato collected from different sources. The experiment was laid out in Randomized Block Design with seven treatment replicated thrice at Experimental field during winter season 2022-2023. The experiment was carried out at Experimental field, Department of Horticulture, Geographically located between the Latitude of $23^{0}26$"17.7" North and Longitude of $85^{0}18$"58.8" East and an Altitude of 651m above MSL having Sub-tropical climate. Genotypes evaluated were *viz*. Heemsona, S-22, Namdhari, Cherry tomato, US-2853, SW-1104 and Dehradun desi. Seedlings were grown on the ridges of height 10 cm, with spacing of 60 × 40 cm, each plot contains two ridges and each ridge contains three plants thus each plot accommodate 6 plants. Farm yard manure (FYM) 300 kg, Neem cake 10 kg applied in roots of plant during the time of transplanting, mustard cake 10 kg and NPK 252gm in two split doses were applied respectively."

"The analysis of variance was completed according to the method suggested by Panse and Sukhatme (1967) [16]. The genotypic and phenotypic coefficient of variation were calculated using the procedure suggested by Burton and De Vane (1953) [25]. Genotypic and phenotypic correlations calculated as procedure suggested by Panse and Sukhatme (1967) [16]. In path coefficient analysis direct and indirect effect calculated using formula given by Dewey and Lu (1959) [17]."

Result and Discussion

Analysis of variance

"In the analysis of variance mean sum of squares due to treatments/genotypes was highly significant for all the characters studied indicating and the mean sum of squares due to replication was significant for diameter of fruit per plant (cm) (Table-1). Similar result reported by Chabbi *et al*. (2018) [1], Namita *et al*. (2021) [2], Pooja *et al*. (2022) [3]."

Table 1: Analysis of variance for ten characters in Tomato

S. No.	Traits	Source of variation		
		Replication	Treatment	Error
	DF	2	6	12
1.	Plant height (cm)	241.33	10175.87***	163.1
2.	No. of primary branches / plant	0.15	7.35**	0.94
3.	Days to 50% flowering	8.04	242.53***	3.49
4.	No. of clusters / plant	0.21	82.84***	0.32
5.	No. of fruits / cluster	0.09	39.42***	0.11
6.	No. of flowers / cluster	0.12	29.61***	0.17
7.	Diameter of fruit / plant (cm)	0.18*	5.60***	0.03
8.	No. of fruits / plant	2.60	9803.76***	11.17
9.	Average fruit weight (gm)	6.47	2094.73***	9.38
10.	Fruit yield / plant (kg)	0.20	17.91***	0.11

Coefficient of variation

"The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all traits indicating that environment played important role on traits expression. High magnitude of phenotypic as well as genotypic coefficient of variation were observed in number of fruit per plant followed by fruit yield per plant (kg) and number of fruit per cluster. Similar, result reported by Basavraj *et al*. (2015) [5], Singh *et al*. (2015) [18], Ligade *et al*. (2017) [10], Patel *et al*. (2017) [11], Nevani *et al*. (2022) [8], Pooja *et al*. (2022) [3], Himanshu *et al*. (2022), Anuradha *et al*. (2020) [4], Chabbi *et al*. (2018) [1] Kumari *et al*. (2020) [19], Prakash *et al*. (2019) [20], Panchbhaiya *et al*. (2018) [7], Priyanka *et al*. (2018) [6]. Moderate PCV and GCV were recorded for number of primary branches per plant followed by number of cluster per plant, number of flower per cluster, diameter of fruit per plant (cm) and average fruit weight. Lower PCV and GCV were recorded for plant height (cm) and days to 50% flowering. (Table- 2)."

Correlation coefficient

"Correlation coefficient revealed genotypic correlation were comparatively higher than the corresponding value of phenotypic correlation coefficient, therefore suggesting, a strong inherent relationship in different pair of characters. Similar result reported by Rakesh *et al*. (2014) [21]. Fruit yield per plant (kg) exhibited highly significant positive genotypic and phenotypic correlation with average fruit weight followed by number of cluster per plant and number of primary branches per plant, similar result reported by Rakesh *et al*. (2014) [21] Sridevi *et al*. (2021) [22] Nevani *et al*. (2022) [8]. Significant positive genotypic and phenotypic correlation with diameter of fruit per plant and days to 50% flowering, similar result reported by Reddy *et al*. (2013) [23], Gopinath *et al*. (2017) [12] Singh *et al*. (2018) [24]. Non-significant positive genotypic and phenotypic correlation with plant height and number of fruits per plant. Non-significant negative genotypic and phenotypic correlation with number of fruits per cluster and number of flowers per cluster. (Table-3 and Table-4)."

Table 2: Coefficient of variation for ten characters in tomato

S.No.	Characters	Range		Mean	Variance		PCV%	GCV%
		Min.	Max.		Phenotypic	Genotypic		
1	Days to 50% flowering	228	399.33	290.19	3500.69	3337.58	20.38	19.9
2	Plant height (cm)	3.26	7.8	5.53	3.08	2.13	31.73	26.41
3	No. of primary branches / plant	59.33	84	72.8	83.17	79.68	12.52	12.26
4	No. of clusters / plant	5	18.53	11.81	27.83	27.5	44.63	44.37
5	No. of fruits / cluster	2.73	13.53	5.67	13.21	13.1	64.05	63.77
6	No. of flowers / cluster	5.46	14.93	8.18	9.99	9.81	38.63	38.28
7	Diameter of fruit / plant (cm)	2.07	5.91	5.05	1.89	1.85	27.19	26.97
8	No. of fruits / plant	11	179.13	67.53	3275.37	3264.19	84.74	84.6
9	Average fruit weight (gm)	6.3	85.42	61.53	704.49	695.11	43.13	42.84
10	Fruit yield / plant (kg)	0.52	6.92	2.99	6.05	5.93	82.11	81.33

Table 3: Genotypic correlation coefficient

Traits	Days to 50% Flowering	Plant Height (cm)	No. of primary branches / plant	No. of clusters / plant	No. of flowers / cluster	No. of fruits / cluster	Diameter of fruit / plant (cm)	No. of fruits / plant	Average fruit weight (gm)	Fruit yield / plant (kg)
Days to 50% flowering	1.000	-0.559**	-0.242	0.153	-0.618**	-0.641**	0.779**	-0.475*	0.778**	0.470*
Plant height (cm)		1.000	0.560**	0.498*	0.936**	0.954**	-0.725**	0.936**	-0.599**	0.070
No. of primary branches / plant			1.000	0.888**	0.409	0.382	-0.006	0.571**	0.164	0.820**
No. of clusters / plant				1.000	0.454*	0.413	0.004	0.643**	0.151	0.836**
No. of flowers / cluster					1.000	1.000**	-0.874**	0.969**	-0.785**	-0.082
No. of fruits / cluster						1.000	-0.882**	0.960**	-0.796**	-0.111
Diameter of fruit / plant (cm)							1.000	-0.746**	0.985**	0.511*
No. of fruits / plant								1.000	-0.628**	0.157
Average fruit weight (gm)									1.000	0.647**

Table 4: Phenotypic correlation coefficient

Traits	Days to 50% Flowering	Plant Height (cm)	No. of primary branches / plant	No. of clusters / plant	No. of flowers / cluster	No. of fruits / cluster	Diameter of fruit / plant (cm)	No. of fruits / plant	Average fruit weight (gm)	Fruit yield / plant (kg)
Days to 50% flowering	1.000	-0.524*	-0.142	0.139	-0.608**	-0.620**	0.756**	-0.468*	0.757**	0.450*
Plant height (cm)		1.000	0.460*	0.485*	0.902**	0.925**	-0.694**	0.908**	-0.574**	0.075
No. of primary branches / plant			1.000	0.730**	0.346	0.344	0.008	0.486*	0.136	0.684**
No. of clusters / plant				1.000	0.451*	0.404	0.007	0.639**	0.148	0.818**
No. of flowers / cluster					1.000	0.983**	-0.851**	0.960**	-0.780**	-0.082
No. of fruits / cluster						1.000	-0.871**	0.958**	-0.782**	-0.102
Diameter of fruit / plant (cm)							1.000	-0.738**	0.972**	0.504*
No. of fruits / plant								1.000	-0.621**	0.161
Average fruit weight (gm)									1.000	0.641**

Table 5: Direct and indirect effect of ten characters on fruit yield per plant at phenotypic level

Traits	Days to 50% Flowering	Plant Height (cm)	No. of primary branches / plant	No. of clusters / plant	No. of flowers / cluster	No. of fruits / cluster	Diameter of fruit / plant (cm)	No. of fruits / plant	Average fruit weight (gm)	Fruit yield / plant (kg)
Days to 50% flowering	-0.087	-0.039	-0.022	0.017	0.250	0.768	-0.096	-0.841	0.500	0.450*
Plant height (cm)	0.046	0.075	0.072	0.059	-0.370	-1.145	0.088	1.631	-0.379	0.075
No. of primary branches / plant	0.012	0.034	0.156	0.089	-0.142	-0.426	-0.001	0.872	0.090	0.684**
No. of clusters / plant	-0.012	0.036	0.114	0.122	-0.185	-0.501	-0.001	1.148	0.098	0.818**
No. of flowers / cluster	0.053	0.067	0.054	0.055	-0.411	-1.217	0.108	1.724	-0.516	-0.082
No. of fruits / cluster	0.054	0.069	0.054	0.049	-0.404	-1.238	0.110	1.720	-0.517	-0.102
Diameter of fruit / plant (cm)	-0.066	-0.052	0.001	0.001	0.350	1.078	-0.127	-1.325	0.642	0.504*
No. of fruits / plant	0.041	0.068	0.076	0.078	-0.394	-1.186	0.093	1.796	-0.410	0.161
Average fruit weight (gm)	-0.066	-0.043	0.021	0.018	0.321	0.968	-0.123	-1.116	0.661	0.641**

Table 6: Direct and indirect effect of ten characters on fruit yield per plant at genotypic level

Traits	Days to 50% Flowering	Plant Height (cm)	No. of primary branches / plant	No. of clusters / plant	No. of flowers / cluster	No. of fruits / cluster	Diameter of fruit / plant (cm)	No. of fruits / plant	Average fruit weight (gm)	Fruit yield / plant (kg)
Days to 50% flowering	0.178	-0.155	-0.070	0.073	-0.260	1.152	-1.725	-0.162	1.439	0.470*
Plant height (cm)	-0.099	0.277	0.162	0.237	0.393	-1.716	1.604	0.319	-1.107	0.070
No. of primary branches / plant	-0.043	0.155	0.290	0.423	0.172	-0.688	0.013	0.195	0.303	0.820**
No. of clusters / plant	0.027	0.138	0.257	0.477	0.191	-0.742	-0.010	0.219	0.279	0.836**
No. of flowers / cluster	-0.110	0.259	0.118	0.217	0.420	-1.799	1.934	0.330	-1.452	-0.082
No. of fruits / cluster	-0.114	0.264	0.111	0.197	0.420	-1.798	1.954	0.327	-1.472	-0.111
Diameter of fruit / plant (cm)	0.138	-0.201	-0.002	0.002	-0.367	1.586	-2.214	-0.254	1.822	0.511*
No. of fruits / plant	-0.084	0.259	0.165	0.307	0.407	-1.726	1.651	0.341	-1.162	0.157
Average fruit weight (gm)	0.138	-0.166	0.048	0.072	-0.330	1.431	-2.182	-0.214	1.850	0.647**

Path coefficient analysis

"Path coefficient analysis indicated highly positive direct effect on fruit yield per plant exerted via number of fruits per plant, average fruit weight, number of primary branches pr plant, number of clusters per plant, plant height, similar result reported by Chabbi *et al*. (2018) [1], Sharma *et al*. (2021) [22], Sridevi *et al*. (2021) [22], Anuradha *et al*. (2018) [4], Reddy *et al*. (2013) [23], Badge *et al*. (2021) [9]. And negative direct effect on fruit yield per plant exerted via diameter of fruit per plant (cm) and number of fruits per cluster (Table-5 and Table-6)."

Conclusion

The study revealed that the Fruit yield per plant exhibited highly significant and positive correlation with average fruit weight, number of cluster per plant and number of primary branches per plant. Hence, these characters can be recognized as the key characters contributing towards yield directly and indirectly and thus the selection might be valuable in developing high yielding tomato varieties.

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