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Study of Character Association and Path Coefficient Analysis in Tomato Genotype to Improve the Yield and its Components

Gaurav Mishra, Nandan Kumar, Raj Kumar, Pratyksh Pandey, Niranjan Singh

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ABSTRACT

An experiment was conducted using thirty-seven germplasms of tomato in three replication using Randomized Block Design during the *rabi* (October-April) 2020–21 season to find out the association of character with weight of fruit/plant and yield contributing characters. The mean values of the different characters showed that genotypes 7053, 8105, 8202, 8623 and 8730 were higher for the fruit weight plant^{-1} (kg). At the genotypic level the relative weight of the fruit per plant showed a positive and significant correlation with the width of the fruit and the number of fruits per plant. At the phenotypic level of fruit size, the number of fruits per plant showed positive and significant correlation with the weight of the fruit per plant. In the case of direct effect two characters the width of the fruit and the number of fruits plant^{-1} showed a direct and positive correlation with the weight of the fruit plant^{-1} at the phenotypic level. The study provided an opportunity to identify the suitable genotypes and a detailed study of character association with path coefficient analysis found that some characters are directly associated with character yield (weight of fruit plant^{-1}) improvement like number of fruit plant^{-1} followed by width of the fruit, plant height, number of branches, fruit width. So, all these traits can be use in further breeding program for tomato yield improvement.

Keywords Genotype, Path coefficient, Correlation coefficient, Breeding program.

Gaurav Mishra[1]*, Nandan Kumar[2], Raj Kumar[3], Pratyksh Pandey[4], Niranjan Singh[5]

[5]Assistant Professor
[1,4,5]Department of Vegetable Science, CSAUA&T, Kanpur 208002, India
[2]Department of Horticulture, SHUATS, Prayagraj, India
[3]Department of Genetics & Plant Breeding, SVPUA&T, Meerut, India

Email: mishragaurav2002@gmail.com
*Corresponding author

INTRODUCTION

Tomatoes are a green fruit vegetable and belong to the family Solanaceae, which includes about 100 genera and 2500 species, including a few other important agronomic plants namely, potatoes, eggplant, peppers, and tobacco (Olmstead *et al*. 2008). It consists of a diploid chromosome number (2n = 2X = 24) with 950 Mbp genome size, and it has several notable genes in the Solanaceae (Arumuganathan and Earle 1991).

It is the South American native most popular temperate vegetable with special economic value in the horticulture industry, and it belongs to the Solanum variety, the similarity between the leaves and flowers of potatoes and tomato plants seems to confirm this taxonomic group (He *et al.* 2003, Shidfar *et al.* 2011). Tomato is a climacteric fruit, meaning it undergoes a surge in respiration and ethylene production at the onset of ripening (Li *et al.* 2019). Originally, tomatoes were little berries like the size of peas, but domestication and genetic modification through plant breeding eventually resulted in larger fruits (Soyk *et al*. 2017).

These varieties are classified into two subgroups based on the color of the fruit, namely Eriopersicon (green with anthocyanin coloring) and Eulycopersicon (red-type fruit behavior and year of growth). Both the domesticated (*L. esculentum*) and wild (*L. pimpinellifolium*) tomato varieties are members of the *Eulycopersicon* genus, which is further classified into five species. There are 16 wild tomato species, including *S. habrochaites, S.pennellii, S.pimpinellifolium, S.cheesmaniae, S.galapagense, S.peruvianum, S.corneliomulleri, S.chilense, S.chmielewskii, S.arcanum, S.neorickii, S.huaylasense, S.lycopersicoides, S.ochranthum, S. jugandifolium*, and *S. sitiens* (Knapp *et al.* 2008). One of these varieties, namely, *L. esculentum* var. *Cerasiformae* (cherry tomato) is regarded as the forerunner of contemporary planted tomatoes (Kalloo 1986). According to the theory, these species in the tomato genus are considered to have developed primarily by genetic mutations rather than chromosomal regeneration on a large scale (Anderson *et al.* 2010).

Over the last decade, Consumers have grown more conscious of the fact that food can provide health advantages, play a part in preventing a number of chronic diseases and dysfunctions, and contains substances that are good for health (Martí *et al.* 2016). Although a wide variety of functional foods have been developed to meet these needs, it is crucial to remember that eating "conventional foods" such as fruits and vegetables is more productive for this goal (Viuda-Martos *et al.* 2014). Tomato fruit is widely used in salads and in various processed forms namely, pastes, sauces, pulps, juices, sauces and flavoring ingredients in dishes, meat or fish dishes (Gosselin and Trudel 1984).

The tomato fruit is frequently used as a salad ingredient and in a variety of processed forms, including pastes, sauces, pulps, juices, and flavorings for meat and fish meals. The fruit contains large amounts of lycopene pigment, beta-carotene, magnesium, iron, phosphorus, potassium, riboflavin, niacin, sodium and thiamine along with vitamin-A, Vitamin-C value and sugar. It has antioxidant properties and potentially beneficial health effects (Zhang *et al.* 2009). Due to their high protein content, tomato seeds have been used as a supplement in animal feeding and as a replacement in bakery products (Gebeyew *et al.* 2015). An extensive body of research has supported the use of tomato seed waste as a beneficial food element (Kumar *et al.* 2021). Improving flavor is currently a crucial challenge to satisfy consumers' requests and to further consolidate tomato consumption on a global scale, going far beyond a merely hedonistic target. Thus, improving tomato flavor means better understanding these interactions such as environmental conditions, crop management practices, postharvest technologies, and processing in order to propose targeted breeding strategies, pre and postharvest management, or processing methods that significantly impact consumers' preferences (Distefano *et al.* 2022).

MATERIALS AND METHODS

The research has been conducted at Vegetable Research Farm, Kalyanpur, Department of Vegetable Science, C. S. Azad University of Agriculture and Technology, Kanpur during the *rabi* season 2020–21. Geographically, it is located at latitude 25.26 to 26.28º N and longitude of 79.30 to 84.34º E. It has subtropical climate having a temperature range of 23ºC to 45ºC and 6ºC to 31ºC in summer and winter season, respectively. Thirty-seven genotype was taken from Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. Date of nursery sowing is on 10 October 2020 and transplanting of the nursey in the main field is on 05 November, 2020. The experiments are laid out in three replications in Random Block Design and the size of the building is kept at 75 × 60 cm^2 for plant to plant and 2×2 m^2 distance for rows to row.

The morphological characters were recorded in five randomly selected plants for each replication and treatment. The observation of the various characteristics was reported such as plant length,

Table 1. Promising genotype identified on the basis of mean value for all character.

Sl. No.	Characters	Genotype
1	Days to flowering	8730, 9424, 9425, 9429, 1903
2	Days to maturity	8761, 9424, 9425
3	Plant height	8730, 8731, 8202, 8203, 7053, 7206, 8708,
4	No. of branch	8731, 6512, 7053, 8203, 8506, 8623
5	No. of fruit per cluster	8752
6	Fruit length	1904,9432, 1901, 1902, 1903, 8767, 1905,1906
7	Fruit width	1904, 9432, 1901, 1903, 1905, 1906, 8506, 9429, 1902,
8	No. of locule	9432,1906,1903,9429, 8761
9	No. of fruit per plant	8730, 7202
10	Weight of fruit per plant (kg)	7053, 8105, 8202, 8623, 8730

number of branches, days to flowering, ripening dates^{-1}, fruit number cluster^{-1}, fruit length fruit^{-1}, fruit length, number of locules fruit^{-1}, fruit number plant^{-1}, fruit weight, fruit weight plant^{-1}. The correlations at genotypic, phenotypic and environmental levels were estimated from the analysis of variance and covariance as suggested by Searle (1961). The analysis of path coefficient was conducted following the procedure Proposed by Wright (1921). The yield contributing characters were considered in path coefficient analysis to estimate their direct and indirect effect on seed yield.

RESULTS AND DISCUSSION

A distinctive feature of the current study is discussed below: Correlation studies, path oefficient analysis.

Superior genotypes

The superior genotype of each character has been categorized to select the desirable germplasm for further hybridization program. Among thirty-seven genotypes for weight of fruit per plant (kg), five germplasms have been observed as superior, like 7053, 8105, 8202, 8623, and 8730. A detailed study of superior germplasm for each character has been given in (Table 1).

Correlation coefficient analysis

The effectiveness and power of any system of selective breeding depends on the nature and relationship between yield and other components of the character. The correlation of all the characters is given in (Table 2).

Weight of fruits plant^{-1}

At the genotypic level the weight of the fruit plant^{-1} shows a positive correlation with the number of fruits per plant (0.489) followed by the width of the fruit (0.313), plant height (0.186), number of locule fruit^{-1}

Table 2. Estimates of correlation coefficient at phenotypic (upper diagonal) and genotypic (lower diagonal) levels between different traits in tomato.

	Days to flowering	Days to maturity	Plant height	No. of branch	No. of fruit/cluster	Fruit length	Fruit width	No. of locule	No. of fruit/plant	Weight of fruit/plant (kg)
Days to flowering		0.687*	0.372*	0.323	0.149	0.464*	0.336*	0.043	- 0.295	- 0.261
Days to maturity	0.698*		0.301	0.063	0.131	0.531*	0.382*	0.149	- 0.504*	- 0.243
Plant height	0.375*	0.294		0.510*	0.205	0.183	0.234	-0.123	0.207	0.189
Number of branches per plant	0.315*	0.027	0.523*		0.152	-0.068	-0.124	-0.261	0.307*	0.079
Number of fruits per cluster	0.140	0.128	0.211	0.058		0.140	0.201	-0.161	-0.075	0.010
Fruit length	0.458*	0.530*	0.170	-0.139	0.107		0.787	0.292	-0.415	0.072
Fruit width	0.326*	0.379*	0.226	-0.209	0.153	0.799*		0.527*	-0.318*	0.337*
Number of locules per fruit	0.009	0.127	-0.151	-0.371*	-0.301	0.245	0.507*		-0.363*	0.143
Number of fruits per plant	-0.314*	-0.529*	0.203	0.312*	-0.128	-0.460*	-0.359*	-0.422		0.487*
Weight of fruits per plant	-0.294	-0.273	0.186	0.037	-0.051	0.041	0.313	0.108	0.489*	

*Significant at 5%.

Table 3. Estimates of direct and indirect effects of different characters on weight of fruit per plant in tomato at phenotypic levels.

	Days to flowering	Days to maturity	Plant height	No. of branch	No. of fruit/cluster	Fruit length	Fruit width	No. of locule	No. of fruit/plant	Weight of fruit/plant (kg)
Days to flowering	**-0.360**	0.057	-0.004	0.037	-0.006	-0.054	0.237	0.002	-0.170	-0.261*
Days to maturity	-0.247	**0.083**	-0.003	0.007	-0.005	-0.062	0.269	0.006	-0.291	-0.243
Plant height	-0.134	0.025	**-0.010**	0.058	-0.008	-0.021	0.164	-0.005	0.120	0.189
Number of branches per plant	-0.116	0.005	-0.005	**0.114**	-0.006	0.008	-0.087	-0.011	0.178	0.079
Number of fruits per cluster	-0.054	0.011	-0.002	0.017	**-0.038**	-0.016	0.141	-0.007	-0.043	0.010
Fruit length	-0.167	0.044	-0.002	-0.008	-0.005	**-0.116**	0.554	0.012	-0.240	0.072
Fruit width	-0.121	0.032	-0.002	-0.014	-0.008	-0.092	**0.703**	0.022	-0.184	0.337*
Number of Locules per fruit	-0.015	0.012	0.001	-0.030	0.006	-0.034	0.371	**0.042**	-0.210	0.143
Number of fruits per plant	0.106	-0.042	-0.002	0.035	0.003	0.048	-0.224	-0.015	**0.578**	0.487*

*Significant at 5%. Bold values showed direct effects.

(0.108), fruit length (0.041), number of branches (0.037) and negative genotypic correlation for weight of fruit plant^{-1} were associated with days to flowering (-0.294), days to maturity (-0.273) and number of fruit cluster^{-1} (-0.051).

At the phenotypic level the weight of the fruit per plant shows a positive correlation with the number of fruit plant^{-1} (0.487) followed by width of the fruit (0.337), plant height (0.189), number of locule fruit^{-1} (0.143), number of branches (0.079), fruit length (0.072), fruit cluster^{-1} (0.010) and negative genotypic correlation for weight of fruit plant^{-1} were associated with days to flowering (-0.261), days to maturity (-0.243).

Number of fruits plant^{-1}

At the genotypic level the number of fruits per plant shows positive character association with number of branches (0.312) and plant height (0.203) and negative genotypic correlation for number of fruits plant^{-1} were observed with days to maturity (-0.529) followed by fruit length (-0.460), number of locule fruit^{-1} (-0.422), days to flowering (-0.314), number of fruit cluster^{-1} plant^{-1} (-0.128).

At the genotypic level the number of fruits plant^{-1} shows positive character association with number of branches (0.307) and plant height (0.207) and negative genotypic correlation for number of fruits plant^{-1} were observed with days to maturity (-0.504) followed by fruit length (-0.415), number of locule fruit^{-1} (-0.363), days to flowering (-0.295), number of fruit cluster^{-1} plant^{-1} (-0.075).

Correlation is an effective selection parameter to improve yield through particular hybridization program. The similar finding has been reported by Randhawa *et al*. (1988) for fruit plant^{-1}, fruit width (Kumar *et al*. 1990) for fruit plant^{-1}, fruit width, Nainar *et al.* (1990) for fruit plant^{-1}, fruit width (Ahmed *et al.* 2013) for fruit plant^{-1}, fruit width, and Sushma *et al.* (2020) for fruit plant^{-1}, fruit width, plant height, fruit length and number of primary branches.

Phenotypic path coefficient analysis

In order to determine the direct or indirect contribution of different factors regarding fruit weight plant^{-1}, an analysis of the coefficient of method was performed and presented in (Table 3). In the case of direct positive and significant effect on fruit weight plant^{-1} were observed exerted by fruit width (0.703), number of fruits plant^{-1} (0.578) and positive non-significant were exerted by number of branches plant^{-1} (0.114), days to maturity (0.083), number of locule fruit^{-1} (0.042). The negative phenotypic direct effect on fruit weight plant^{-1}were observed for days to flowering (-0.360) followed by fruit length (-0.116), number of fruits cluster^{-1} (-0.038) and plant height (-0.010).

Path coefficient analysis provide the second most important selection parameter to improve the yield in any crop and the similar result has been reported by Ahmed *et al.* (2013) for fruit width, number of fruits plant^{-1}, plant height, Singh *et al*. (2018) for number of fruits plant^{-1}, number of locule fruit^{-1}, days to 50 % flowering, Sushma *et al.* (2020) for number of fruits plant^{-1}, number of branches, days to maturity and for days to 50% flowering.

CONCLUSION

On the basis of the mean performance of yield, the superior genotype is 7053, 8105, 8202, 8623, and 8730 as compared to the best checks 8716 and 9426. After a detailed study of character association with path coefficient analysis found that yield (weight of fruit per plant) are directly associated with number of fruit per plant followed by width of the fruit, plant height, number of branches, fruit width. So, all these traits can be use in further breeding program.

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