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GENETIC VARIABILITY AND CORRELATION ANALYSIS FOR YIELD, YIELD ATTRIBUTES AND QUALITY TRAITS IN TOMATO (*SOLANUM LYCOPERSICUM L.*)

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ABSTRACT

Tomato (*Solanum lycopersicum L.*) is an important vegetable crop belonging to the family *Solanaceae*, widely cultivated across tropical and subtropical regions for its nutritional and economic value. The experiment took place during the *Kharif* 2024 season at the Agriculture Research Farm, SGVU, Jaipur. It aimed to examine genetic differences, heritability, genetic progress and the relationship between different tomato traits. Ten tomato genotypes (Pusa ruby, Arka vikas, Rajshree, Rajlaxmi, Arka Meghali, Pant T-3, NS-4266, Punjab Chuhara, Abhinav and Hisar Lalit) were tested using a randomized block design with three replications. Data were collected on growth, yield and quality, such as days to 50% flowering, plant height, number of branches, number of fruits, fruit length, fruit diameter, fruit weight, fruit yield, total soluble solids (TSS), acidity and vitamin C content. The results showed significant differences among the tomato types, indicating a lot of genetic variation. The number of fruits and vitamin C content showed high variability, suggesting potential for improvement. Moderate variation was seen in the number of branches, while other traits like fruit size and plant height showed less variability. High heritability was found for fruit yield, fruit size, number of fruits, plant height, acidity and average fruit weight, meaning selection based on these traits would be effective. Moderate heritability was noted for days to 50% flowering and low heritability for the number of branches. Genetic progress was moderate for several traits, indicating both additive and non-additive gene effects. The study found that fruit yield was positively linked with fruit size and acidity and the number of fruits and TSS were positively linked with yield. These traits are key for improving tomato yield. The study provides valuable information for developing high-yielding, quality tomatoes suitable for Rajasthan's climate.

Keywords : Genetic variability, Heritability, Genetic advance, Correlation, Ascorbic acid, TSS etc.

Introduction

Nature has bestowed varied agro-climatic conditions to our country enabling to grow large number of vegetables from temperate to humid tropics and from sea level to snow line. Emphasis is now shifting from supply of basic food (calorie and protein) towards supply of balanced diet (calories, proteins, vitamins, micronutrients, fiber and antioxidants). Thus, the demands for vegetables are increasing at fast rate. India is the second largest producer of vegetables in the world next to China. The annual growth rate of vegetable production in India is 2.6%, still the consumption of vegetables is only 210 g/day/caput

against the minimum requirement of 285 g/day/caput for a balanced diet (Singh *et al.*, 2001). More than 70 vegetable crops are grown in our country but the maximum emphasis has been given on important vegetables like tomato, brinjal, chillies, potato, cabbage, cauliflower, pea and few important cucurbits. Among these, tomato is one of the most popular and widely grown important solanaceous, tender fruit vegetable crop in the world ranking second in importance to potato including India (Lakshmikanth and Mani, 2004). Tomato (*Solanum lycopersicum L.*) thrives well under a wide range of climatic conditions but performs best in warm, moderately dry climates. It

is a day-neutral crop, adaptable to both tropical and subtropical regions, as well as mild temperate zones. The ideal temperature range for tomato growth is 18–27°C, while 20–25°C is most favorable for fruit set and development. Hence, a moderately warm and dry climate with bright sunshine is most suitable for obtaining high yield and good quality fruits. Tomato can be grown on a wide variety of soils, but well-drained, fertile loamy soils rich in organic matter are most desirable for optimum growth and yield. The soil should have good aeration and water-holding capacity to support healthy root development. The ideal soil pH ranges from 6.0 to 7.0, which favors proper nutrient availability and root activity.

Tomato (*Solanum lycopersicum* L.) which belongs to the family Solanaceae also called Night shade family includes more than 3000 species. Its chromosome number are $2n=2x=24$. Tomato is grown worldwide in all types of climates viz., temperate, subtropical and tropical. It is also known as “poor man’s orange” in India and “Love of apple” in England. It originated in wild form in the Peru-Ecuador-Bolivia region of Andes (South America) and is grown in almost every corner of the World (Robertson and Labate, 2007). It is a typical day neutral plant and is mainly self-pollinated, but a certain percentage of cross pollination also occurs (Depra *et al.*, 2014).

India is one of the largest producers of tomato globally. According to Horticultural Statistics at a Glance (2023), the area under tomato cultivation is approximately 865 thousand hectares, with a total production of 22.6 million tonnes and average productivity of 26.1 tonnes per hectare. Major tomato-producing states include Andhra Pradesh, Madhya Pradesh, Karnataka, Maharashtra, Odisha and Gujarat. Despite this, productivity and quality vary widely due to differences in genotype, management and environment.

Tomato genetic analysis is critical for improving the genetic potential for yield and maximising the use of desirable characters in the synthesis of any ideal genotypes (Kumar *et al.*, 2003). Plant breeding for crop improvement begins with genetic variability, which can be obtained easily from germplasm. The existence of genetic variability and understanding of genotypic as well as the phenotypic correlation of yield, yield ascribing components are required for the development of an effective improvement programme. Genetic variability measures how different genotypes in a population are from one another. Genetic factors, environmental factors like edaphic and climatic factors, bioactive compounds which are caused by physiological factors and other factors influence

variability. Heritability refers to the degree to which a quantitative character's variability is passed down to the progeny. It is a useful biometrical concept that has been considered as a selection efficiency index because it helps divide total variation into environmental effects as well as heritable effects.

The correlation coefficient determines the reciprocal relationship between two or more variables and provides insight into the different relationships that exist between yield and yield components. The correlation coefficient between two characters can be high or low, positive or negative. To understand the direction of selection and maximize yield in the shortest amount of time, the correlation coefficient between the yield & quality contributing variables must be estimated. The genetic correlation shows the relative significance of a single character or more than one character on which choice for yield & quality improvement should be prioritized.

Materials and Methods

The experiment was conducted during *Kharif* 2024 at the Agriculture Research Farm, SGVU, Jaipur. The experimental material for the present investigation consisted of ten tomato (*Solanum lycopersicum* L.) genotypes (Pusa ruby, Arkavikas, Raj shree, Raj laxmi, ArkaMeghali, Pant T-3, NS-4266, Punjab Chhuhara, Abhinav and Hisar Lalit) collected from different sources (IARI, IIHR, SKNAU, PAU, G.B. Pant University, Namdhari Seeds Pvt. Ltd., and private sector). The genotypes were sown in six rows of 3 m length, with 60 cm spacing between rows, following a Randomized Block Design (RBD) with three replications. Sowing was carried out in the first week of July 2024, and standard agronomic practices were adopted for proper plant growth.

Observations were recorded on five randomly selected plants from each genotype in each replication. A total of 11 traits were measured, including days to 50% flowering, plant height (cm), number of branches per plant, fruit length (cm), fruit diameter (cm), number of fruits per plant, fruit weight (g), fruit yield per plant (kg), total soluble solids (°Brix) by Refractometer, titrable acidity (%) was determined following the procedure of Ranganna (1986) and ascorbic acid content (mg/100 g) was estimated by 2, 6-dichlorophenol-indophenol visual titration method (AOAC, 1984). The analysis of variance (ANOVA) was carried out following the Panse and Sukhatme (1995) procedure.

Results and Discussion

The analysis of variance (ANOVA) for the mean data of all 11 Characters was statistically tested at 5%

level of significance in Table 1. It revealed that there were highly significant differences among the genotypes for all 11 Characters under investigation, showing extensive range of variation in 10 genotypes of tomato. Consequently, it can be assumed that systematic crossing between chosen genotypes will result in increased genetic diversity in subsequent generations. This approach will enhance the effectiveness of selection for desirable traits, leading to improved plant varieties with higher yield and better adaptability.

Genetic variability parameters

Among all the characters studied, the maximum genotypic coefficient of variation was observed for number of fruits per plant followed by acetic acid content and maximum phenotypic coefficient of variation was observed for number of branches per plant followed by number of fruits per plant, which indicated the presence of wide variation for these characters under study to allow selection for individual traits. Moderate phenotypic coefficient of variation was observed for number of branches per plant and number of fruits per plant was also reported earlier by Ara *et al.* (2009), while Mann and Paul (2012), Ligade *et al.* (2017), Verma *et al.* (2020) and Yadav *et al.* (2021) observed for the days to 50 % flowering.

In present investigation, high heritability was observed for the characters acidity, plant height, number of fruits per plant, fruit yield per plant, fruit diameter, average fruit weight. This indicates that good correspondence between genotypic and phenotypic values and there by low environmental effect on the expression of characters. High heritability for the characters are controlled by polygenes which might be useful for the plant breeders for making effective selection. High heritability for fruit length, yield per plant and plant height was reported by Ahmed *et al.* (2006), Kumar and Thakur (2003), Asati *et al.* (2008), Kumar *et al.* (2013), Nwosu *et al.* (2014) and Kaushal *et al.* (2017), while for average fruit weight, number of fruits per plant, fruit yield per plant was reported by Mohanty (2003), Dhankhar and Dhankhar (2006), Haydar *et al.* (2007), Ghosh *et al.* (2010), Khapte and Jansirani (2014), Ullah *et al.* (2015), Hasan *et al.* (2016), Bhandari *et al.* (2017), Dutta *et al.* (2018). High heritability for total soluble solids and acidity was reported by Mehta and Asati (2008), Kerketta and Bahadur (2019), Rasheed *et al.* (2023), who observed high heritability and genetic advance for fruit yield per plant and average fruit weight and Zannat *et al.* (2023) also highlighted considerable genotypic variability in tomato for fruit size and yield-contributing traits. In the present investigation, genetic advance as per cent of

mean was moderate for number of fruits per plant, fruit diameter, total soluble solids, plant height, acidity, acetic acid content, average fruit weight and fruit yield per plant. Similar conclusions were also made by Kumar *et al.* (2013) and Reddy *et al.* (2013), Moderate genetic advance for average fruit weight was observed by Meitei *et al.* (2014) and Ullah *et al.* (2015) and for plant height by Meitei *et al.* (2014), Sharma *et al.* (2016), Verma *et al.* (2020) and Fadhilah *et al.* (2022). Low genetic gain as per cent of mean was reported for fruit length, number of branches per plant and fruit diameter. Similar findings were reported by Asati *et al.* (2008), Al- aysh *et al.* (2012), Patel *et al.* (2013) and Kerketta and Bahadur (2019) It may be inferred that these traits were regulated by non-additive gene action and presence of high genotype \times environment interaction. Additionally, traits with high genetic advance and high heritability can be effectively because characters governed by additive gene action which is used for selection in further studies.

Estimation of Character association

Understanding the association between yield and its components is of paramount importance for making the best use of these relationships in selection. Yield is a complex trait and is dependent on other determinant traits which are mostly inherited quantitatively. The characters which have high and positive correlation with yield can be used in the indirect selection for yield and as an alternate mode of selection for yield improvement. Knowledge of genetic association between selection indices, yield and morpho-physiological yield determinants can be useful to improve the efficiency of breeding programs. The current study identified significant positive correlations between grain yield per plant and various important agronomic traits in Tomato (*Solanum lycopersicum* L.), highlighting the intricate and multifaceted nature of grain yield determination. Most breeding programs focus on increasing productivity per unit area per unit time as their major goal. Direct selection for seed yield may not be at a sufficient level since it has complex, highly variable characteristics that come from the cumulative influence of its component characteristics. These component characters are not dependent in their action but are interlinked and in this interlinked complex genetic system selection practiced for one individual character might eventually bring about a simultaneous change in the other. As a result, choosing traits with high heritability and a strong correlation to yield may aid in indirect selection for yield. 11 characters were evaluated for correlation in the current study in all feasible combinations at both the phenotypic and genotypic levels.

In present study, fruit yield was found to be significantly and positively correlated at both genotypic and phenotypic levels with fruit length, fruit diameter and acidity and at only genotypic level with number of fruits per plant and total soluble solids. This indicated that these attributes were more influencing the fruit yield in tomato and therefore, were important for bringing improvement in fruit yield. This relationship between fruit yield and number of fruits per plant, fruit length, fruit diameter and acidity was noted by Mohanty (2003), Kumar *et al.* (2013), Khapte and Jansirani (2014), Meena and Bahadur (2015), Ullah *et al.* (2015), Jogi *et al.* (2018) and Reddy *et al.* (2019). Similar associations were observed by Muntaha *et al.* (2023), who reported positive and significant correlations of fruit yield with fruit size traits. Likewise, Fadhilah *et al.* (2022) and Bhandari *et al.* (2023) also demonstrated positive correlations of fruit yield with fruit weight and size attributes.

Conclusion

The findings of this study reveal significant variability among tomato genotypes, which can be effectively harnessed for enhancing yield and quality. The high heritability, combined with moderate genetic advance for yield-related traits such as fruit yield per plant, number of fruits per plant, plant height, fruit diameter, average fruit weight, acidity, and total soluble solids (TSS), indicates the predominance of additive gene action. Consequently, simple selection would be effective for improving these traits. Conversely, traits such as the number of branches per plant and fruit length, which exhibit low heritability and genetic advance, appear to be strongly influenced by environmental factors, rendering direct selection for these traits less effective. Overall, selection based on fruit length, fruit diameter, number of fruits per plant, fruit yield per plant, acidity, and TSS will be most beneficial for developing high-yielding and quality-rich tomato genotypes.

Table 1 : Estimates of variability, heritability and genetic advance as per cent of mean for eleven characters in 10 genotypes of tomato.

Response Variable	Mean	Range		h ²	Genotypic Variance	Phenotypic Variance	GCV	PCV	Gen-Advance	Gen-Adv % Means
		Min	Max							
Ypp	2.47	2.15	2.76	99.93	0.04	0.04	7.73	7.73	0.39	15.93
Df	43.80	37.34	50.34	47.007	11.63	24.75	7.78	11.35	4.82	11.00
Ph	89.99	76.19	100.00	85.062	57.74	67.88	8.44	9.154	14.44	16.04
Bp	5.69	4.87	6.45	28.782	0.15	0.52	6.76	12.60	0.43	7.47
Fl	5.98	5.52	6.31	99.948	0.06	0.06	4.01	4.01	0.49	8.27
Fd	5.23	5.04	5.38	99.81	0.01	0.01	2.08	2.08	0.22	4.29
Fpp	30.28	23.80	35.00	69.378	9.04	13.03	9.92	11.92	5.15	17.04
Fw	74.93	64.00	83.67	82.992	37.85	45.60	8.21	9.01	11.54	15.41
Tss	4.24	3.83	5.00	87.045	0.13	0.15	8.61	9.23	0.70	16.56
Aci%	0.33	0.29	0.38	91.886	0.01	0.01	8.09	8.44	0.05	15.98
Aa	28.58	24.10	31.22	96.042	6.41	6.68	8.86	9.04	5.11	17.89

Ypp: Yield per Plant **Df:**Daysto50%flowering, **Ph** :Plant height, **Bp:** No. of branches/plant, **Fl:** Fruit length, **Fd:** Fruit diameter, **Fpp:** Fruit yield/plant, **Fw:** Fruit weight, **Tss:** TSS, **Aci:** Titrable acidity, **Aa:** Ascorbicacid.

Table 2 : Phenotypic (P) and genotypic (G) correlation coefficients among yield and yield attributes in 10 genotypes of tomato

		Ypp	Df	Ph	Bp	Fl	Fd	Fpp	Fw	Tss	Aci%	Aa
Ypp	P	1.000	-0.152	0.084	0.096	0.713**	0.965**	0.181	0.123	0.345	0.526**	-0.619**
	G	1.000	-0.232	0.094	0.182	0.714**	0.966**	0.892**	0.137	0.372*	0.549**	-0.631**
Df	P		1.000	-0.398*	-0.071	0.134	-0.103	-0.185	-0.383*	-0.099	0.035	-0.219
	G		1.000	-0.512**	-0.079	0.198	-0.163	-0.138	-0.606**	-0.349	0.127	-0.232
Ph	P			1.000	0.279	0.086	0.057	-0.376*	0.248	0.141	-0.106	-0.114
	G			1.000	0.381*	0.095	0.057	-0.526**	0.283	0.161	-0.13	-0.134
Bp	P				1.000	0.227	0.063	-0.146	0.352	0.145	0.156	0.192
	G				1.000	0.430*	0.138	0.072	0.820**	0.191	0.397*	0.474**
Fl	P					1.000	0.739**	0.158	-0.013	-0.253	0.654**	-0.601**
	G					1.000	0.740**	0.185	-0.016	-0.271	0.680**	-0.614**
Fd	P						1.000	0.09	0.165	0.248	0.513**	-0.599**
	G						1.000	0.102	0.173	0.266	0.537**	-0.612**

Fpp	P							1.000	0.079	-0.197	0.273	-0.132
	G							1.000	-0.032	-0.142	0.321	-0.176
Fw	P								1.000	0.097	0.036	0.301
	G								1.000	0.162	0.066	0.369*
Tss	P									1.000	-0.136	0.024
	G									1.000	-0.137	0.044
Aci%	P										1.000	-0.337
	G										1.000	0.237
Aa	P											1.000
	G											1.000

** = Significant at 1 % and * = Significant at 5 % level of significant.

Ypp: Yield per Plant **Df**:Daysto50%flowering, **Ph**:Plant height, **Bp**: No. of branches/plant, **Fl**: Fruit length, **Fd**: Fruit diameter, **Fpp**: Fruit yield/plant, **Fw**: Fruit weight, **Tss**: TSS, **Aci**: Titrable acidity, **Aa**: Ascorbic acid.

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