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Assessment of genetic variability, heritability, genetic advance and correlation analysis among fruit-yield components in tomato inter-varietal hybrids

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Abstract
Tomato is one of the most important vegetable crops grown in India. We aimed to investigate the genetic variability, heritability, genetic advance, and correlation analysis for eleven yield and quality attributes. High heritability coupled with genetic advance was found for pericarp thickness, plant height, number of fruits per cluster, fruit length and fruit yield per hectare. Correlation analyses have been successful tools in developing selection criteria. Since increased fruit yield is an important goal in our tomato hybrid breeding program, we used correlation and path-coefficient analyses on fruit yield data. Fruit length, fruit width, chlorophyll content, pericarp thickness and number of seeds per fruit had a significant positive association with fruit yield quintal per hectare at both phenotypic and genotypic levels. Thus, selection for these characters could be considered as important selection criteria in improving hybrid tomato for high fruit yield per hectare.

Keywords: Correlation, genotypic, path-coefficient, phenotypic, yield

Introduction
The cultivated tomato (*Solanum lycopersicum* var. *lycopersicum* L.; 2n = 2x= 24) holds the fifth rank in crop value after maize, soybean, wheat and cotton (FAOSTAT, 2008) [4] belonging to the family Solanaceae. In country like India, area and production of total tomatoes in last five years increased due to shifting of farmers to the cultivation of high valuable tomato vegetables. Despite that, the current level of productivity is falling short to meet the demand of rapidly growing population. To meet the progressive increase in the demand, hybrid vegetables are becoming very popular in urban and semi-urban areas of the country. Now a days, tomato has also been recognized as an industrial crop because diversified processed food products like paste, puree, syrup, juice, ketchup and whole canned tomato etc. can be developed.

Genetic amelioration of a crop relies on the existing genetic variability in the population generated by the plant breeder. Henceforth, the genotypic variance and phenotypic variance are useful parameters to reveal the variability in a population. Furthermore, the genetic component of an attribute is the only portion of variation inheriting to the subsequent generation. Heritability in broad sense is regarded as the ratio of genotypic variance to the phenotypic variance. Estimates of heritability alone could not give a reliable estimate for the response to selection. Thus, heritability estimates integrated with the genetic advance, would be more beneficial in speculating the genetic advance under selection (Johnson *et al*., 1955) [7, 8]. Fruit yield is a complex character as result of interrelationships among various yield components and also influenced by environmental factors (Grafius, 1960) [5]. Thus, information on genotypic and phenotypic correlation coefficients among various plant traits help to ascertain the degree to which these are associated with economic productivity. The association between two characters can directly be observed as phenotypic correlation while genotypic correlation expresses the extent to which two traits are genetically associated. Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding programme.

Additionally, breeder has to grapple with hundreds of crosses to get the desired line with better superior performance. So correlation studies between yield and yield components, is a pre-requisite to planning a meaningful breeding programme with purpose to select pureline or inbred lines of tomato with high yielding capability.

Several researchers aimed to estimate the association between the characters on which the selections for high yields can be made and they emphasized the utility of the estimates of genetic components in the response prediction of quantitative characters to selection as well as the correlated response of various traits to fruit yield. Accordingly, the present research was undertaken to study correlation of various yield-related traits was determined that would be a valuable support in selecting parents for developing superior cross combinations in tomato hybrids.

Materials and Methods

The 15 tomato varieties based on their *per se* performance for various traits used as parents in the present investigation. From these 15 genotypes (10 lines and 5 testers), 50 crosses were evolved in a Line x Tester (Kempthorne, 1957) [9] design with ten genotypes as female (lines) and five genotypes as male (testers) during 2017-18, 2018-19 and 2019-20. The characteristic features of the parents involved in this study are given in Table 1. All the crosses were produced by hand emasculation and pollination to avoid chances of contamination. A set of 65 experimental materials including 15 parents with their 50 F_1's were evaluated at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, B.H.U, Varanasi, Uttar Pradesh during *Rabi* season in Randomized Block Design with three replications. The average monthly temperature and rainfall recorded from a weather station at B.H.U in Varanasi during the growing period in 2017, 2018 and 2019 presented in figure 1. Eleven traits were measured namely, days to 50% flowering, plant height (cm), fruit length (cm), fruit width (cm), pericarp thickness (mm), number of seeds per fruit, number of fruits per cluster, total soluble solids (˚Brix), ascorbic acid (mg/100ml), chlorophyll (SPAD) and fruit yield quintal per hectare (q/ha). Each plot in a replication comprised of a five rows and each row of 3 m length spaced at 60 cm. Plant to plant distance of 60 cm was maintained by thinning. Recommended package of practice was followed equally for all the entries in order to raise a good crop. The mean values were used for statistical analysis. The phenotypic and genotypic correlation coefficient estimates were reckoned as per the procedure implied by Johnson *et al*. (1955) [7, 8]. Further, path analysis was worked out using the simple correlation coefficient to perceive the direct and indirect effects of the yield and component traits as proposed by Wright (1921) [22] and elucidated by Dewey and Lu (1959) [3].

Table 2.1: Parent collected from/Pedigree and characteristics of the experimental material

S. No.	Parents	Collected from	Salient features
Lines (Female)			
1	Punjab Chhuhara	ICAR-IIVR, Varanasi	Medium-Size, pear-shaped fruit and a high-yielding variety.
2	Prestige	ICAR-IIVR, Varanasi	Semi-indeterminate variety that bears flat round fruits.
3	L-97/754	ICAR-IIVR, Varanasi	Determinate, round shape fruit and a high-yielding variety.
4	Pant T-5	ICAR-IIVR, Varanasi	Determinate and round shape fruit.
5	Roma	ICAR-IIVR, Varanasi	Determinate, fruit in cluster and High TSS.
6	Kashi Amrit	ICAR-IIVR, Varanasi	Determinate and Fruits spherical. Suitable for cultivation in TLCV infested period developed through back cross pedigree selection, high yielding.
7	Kashi Hemant	ICAR-IIVR, Varanasi	This has been developed through pedigree selection from a cross combination Sel-18 x Flora Dade. The plants are determinate, fruits attractive red and round, weight varies from 80 to 85 g; yield 400-420 q/ha.
8	ToLcv-28	ICAR-IIVR, Varanasi	Determinate, medium size and red color fruit.
9	VRT-01	ICAR-IIVR, Varanasi	Determinate, medium size fruit and high lycopene content
10	PBB-2	ICAR-IIVR, Varanasi	Semi determinate, high ascorbic acid content and average fruit weight 40-50 gram.
Testers (Male)			
1	H-86	ICAR-IIVR, Varanasi	Determinate, dark green, fruit red spherical, medium size
2	ToLcv-16	ICAR-IIVR, Varanasi	Determinate, fruit in cluster and yield 350-450 q/ha.
3	Selection-7	ICAR-IIVR, Varanasi	Determinate, extremely early maturing, dwarf erect, with cut leave and synchronized clustered flowering bearing 15-20 fruits. Fruits are round, red, medium developed through modified pedigree method from a cross Pusa Early Dwarf × K-1 at HAU, Hisar.
4	Punjab Barkha	ICAR-IIVR, Varanasi	Determinate, medium size fruit and fruit in cluster.
5	EC- 620446	ICAR-IIVR, Varanasi	Semi determinate, fruit are round in shape and thick stem.
Check			
1	Pant T-3	ICAR-IIVR, Varanasi	Plants are semi-determinate with thick round and hairy stem and dark green foliage. Fruit are round, smooth and uniformed.

Statistical analysis

The heritability and correlation analysis among various traits was performed using software package META-R Version 6.04. Path analysis was performed by using phenotypic correlation estimates in OPSTAT software.

Results and discussion

Genetic Variability

Analysis of variance revealed significant differences for 11 quantitative traits. The maximum coefficient of variation (CV) for hybrids was recorded in chlorophyll (8.09) followed by fruit width (7.29), fruit yield (6.75), pericarp thickness (6.03) respectively (Table 3.1). Hence, the coefficients of variation expressed at phenotypic and genotypic levels have been used to compare the variability observed among different characters for both parents and hybrids. High genotypic variance were observed for plant height (181.22) followed by number of seeds per fruit (74.54) and fruit length (44.53). In contrast low genotypic variance were observed in case of total soluble solids (0.23), fruit yield (0.41) and chlorophyll content (0.41) in tomato. This finding is in line with Singh (2005) [20], Mahapatra *et al*. (2012) [12], Kumar *et al*. (2015) [10] and Saravanan *et al*. (2019) [18].

Table 1: Overall statistics of genetic parameters of studied traits

Statistics	DTF	FL	FW	PT	PH	TSS	AA	NSPF	NFPC	SPAD	FYPH
Heritability	0.77	0.93	0.83	0.98	0.96	0.90	0.87	0.85	0.94	0.04	0.91
Genotype Variance	2.51	44.53	41.93	2.34	181.22	0.23	2.99	74.54	0.49	0.41	0.41
Residual Variance	1.51	7.08	16.71	0.12	15.54	0.05	0.88	26.31	0.06	22.06	926.80
GA (5%)	8.48	28.24	21.51	53.25	35.29	17.48	14.49	17.15	26.17	1.06	43.93
Grand Mean	30.18	47.74	56.07	5.72	76.33	5.27	22.46	88.63	5.35	58.05	451.30
LSD	1.58	3.81	5.51	0.51	5.75	0.32	1.29	6.99	0.37	1.26	44.24
CV	4.06	5.57	7.29	6.03	5.16	4.35	4.17	5.79	4.75	8.09	6.75

DTF: Days to 50% flowering, FL: fruit length, FW: fruit width, PT: Pericarp thickness, PH: Plant height, Total soluble solids: TSS%, AA: ascorbic acid, NSPF: number of seeds per fruit, NFPC: Number of fruits per cluster, SPAD: Chlorophyll content and FYPH: Fruit yield quintal per hectare.

Table 2: Phenotypic (P) and genotypic (G) correlation coefficients for yield and its components in tomato hybrids along with their parents

Traits		DTF	FL	FW	PT	PH	TSS	AA	NSPF	NFPC	SPAD
FL	G	0.08									
	P	0.04									
FW	G	0.14	0.95**								
	P	0.08	0.91**								
PT	G	0.22	0.19	0.09							
	P	0.22	0.19	0.08							
PH	G	0.14	0.95**	-0.32*	0.11						
	P	0.11	-0.19	-0.30*	0.10						
TSS	G	0.17	-0.03	0.00	0.48**	-0.15					
	P	0.11	-0.04	0.01	0.47**	-0.13					
AA	G	-0.14	-0.20	-0.17	0.34**	0.18	0.27*				
	P	-0.12	-0.18	-0.15	0.33*	0.16	0.25*				
NSPF	G	0.10	0.43**	0.48**	0.02	-0.35**	-0.13	-0.35**			
	P	0.03	0.37**	0.40**	0.02	-0.32*	-0.13	-0.30*			
NFPC	G	-0.12	-0.06	-0.08	0.11	0.15	0.26*	0.24	0.10		
	P	-0.13	-0.06	-0.09	0.11	0.14	0.21	0.21	0.11		
SPAD	G	-0.86**	0.51**	0.38**	0.49**	-0.11	0.81**	0.16	0.66**	0.35**	
	P	-0.18	0.14	0.09	0.18	-0.05	0.25*	0.06	0.10	0.11	
FYPH	G	0.05	0.77**	0.77**	0.31*	-0.09	0.21	0.06	0.26*	0.14	0.54**
	P	0.05	0.74**	0.72**	0.30*	-0.08	0.19	0.04	0.23*	0.14	0.19

DTF: Days to 50% flowering, FL: fruit length, FW: fruit width, PT: Pericarp thickness, PH: Plant height, Total soluble solids: TSS%, AA: ascorbic acid, NSPF: number of seeds per fruit, NFPC: Number of fruits per cluster, SPAD: Chlorophyll content and FYPH: Fruit yield quintal per hectare.

Heritability and Genetic Advance

Heritability estimates revealed the heritable portion of variability present in different characters (Table 1). The knowledge of heritability enables the plant breeder to decide the course of selection procedure to be followed under a given situation. Moderate to high heritability was observed for all the traits except chlorophyll content of leaves (SPAD). Very high heritability (>90%) coupled with very high genetic advance as per cent over mean (> 40%) was recorded for the characters *viz*., fruit yield quintal per hectare and pericarp thickness. This finding indicating the predominance of additive gene effects for such traits. Thus selection for such traits would be more reliable and useful in formulating selection procedure. Similar finding was reported by Rai *et al*. (2016) [16] and Sajjan *et al*. (2016) [17].

Phenotypic and Genotypic correlation coefficients

The phenotypic and genotypic correlation coefficients among 11 quantitative traits are presented in table 2. In majority, the genotypic correlation estimates were higher than the phenotypic correlation, revealing strong inherent association among the studied attributes. Correlation studies among yield components indicated that fruit width was significantly correlated with fruit length (0.95 and 0.91) at genotypic and phenotypic level, respectively. Plant height was positively inter-related with fruit width (0.95) at genotypic level only. Similarly, total soluble solids was significantly and positively associated with pericarp thickness (0.48 and 0.47) at genotypic and phenotypic level, respectively. Ascorbic acid was significantly and positively associated with pericarp thickness (0.34 and 0.33) and total soluble solids (0.27 and 0.25) at genotypic and phenotypic level, respectively. Number of seeds per fruit was significantly and positively associated with fruit length (0.43 and 0.37) and fruit width (0.48 and 0.40) at genotypic and phenotypic level, respectively. At genotypic level, chlorophyll content (SPAD) was significantly and positively associated with fruit length (0.51), fruit width (0.38), pericarp thickness (0.49), total soluble solids (0.81), number of seeds per fruit (0.66) and number of fruits per cluster (035).

Accordingly, the total fruit yield (FYPH) was positively and significantly associated with fruit length (0.77 and 0.72), fruit width (0.77 and 0.72), pericarp thickness (0.31 and 0.30) and number of seeds per plant (0.26 and 0.23) at 1% significance level at genotypic and phenotypic level, respectively. While, total fruit yield (FYPH) was positively and significantly associated with leaf chlorophyll content (0.54) at only 5% significance level at only genotypic level. A clustering dendrogram and PCA biplot graphs are built for fruit yield quintal per hectare presented in figure 2. It can be inferred that fruit yield per hectare showed a higher correlation with fruit length, fruit width and number of seeds per fruit. Days to 50% flowering, plant height, ascorbic acid and number of fruits per cluster generate own group while, pericarp thickness, TSS and chlorophyll form another group. Fruit yield quintal per hectare (FYPH) showed highly significant positive correlation with fruit length (Singh *et al*., 2007) [21]; (Islam *et al*., 2010) [6], fruit width (Prashanth *et al*., 2008; Kumar *et al*., 2013; Maurya *et al*. (2020) [15, 11, 13], chlorophyll, pericarp thickness (Shankar *et al*., 2013) [19] and number of seeds per fruit (Maurya *et al*., 2020) [13]. A negative association was observed between fruit yield quintal per hectare and its component traits such as plant height.

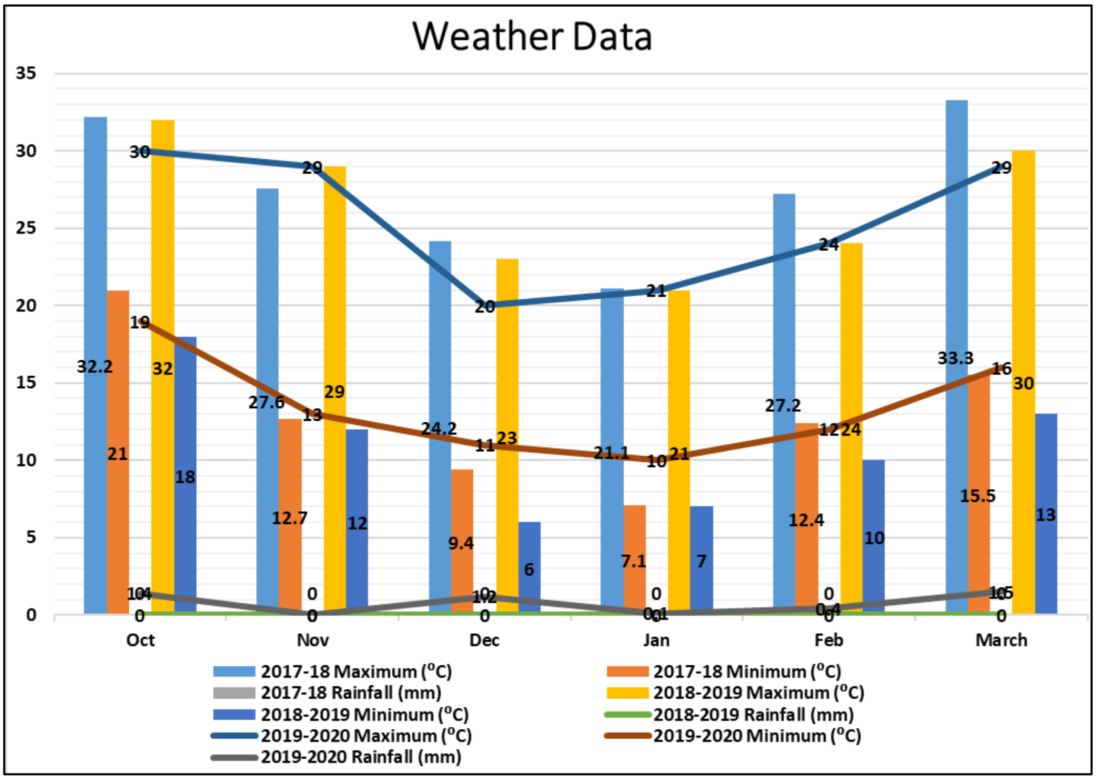
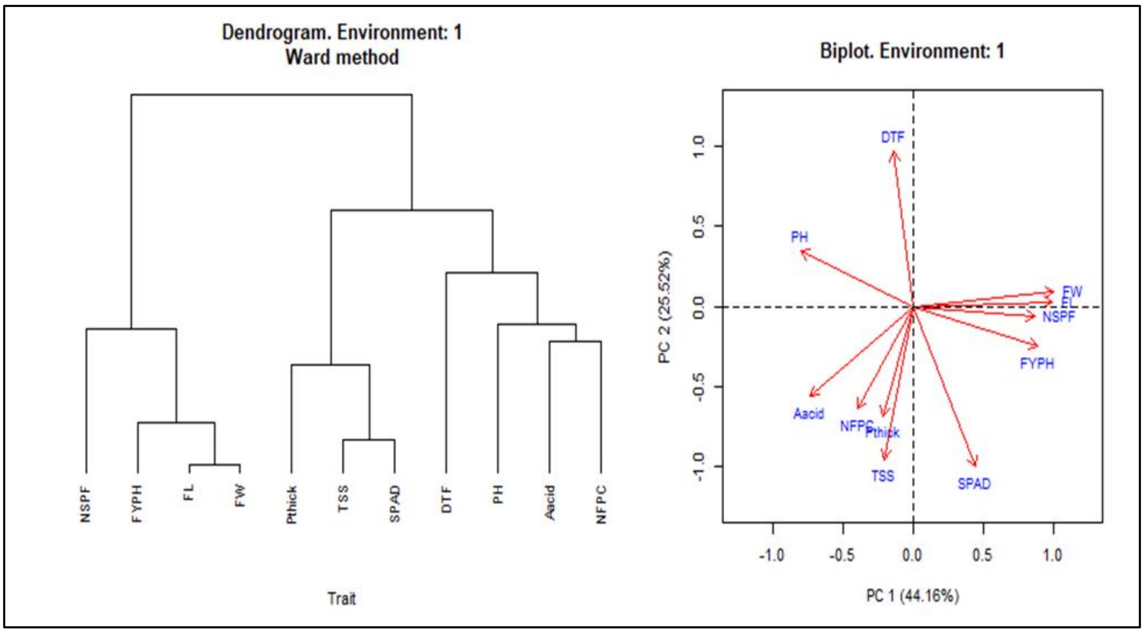


Fig 1: Average monthly temperature and rainfall recorded from a weather station at BHU in Varanasi during the growing period in 2017, 2018 and 2019



DTF: Days to 50% flowering, FL: fruit length, FW: fruit width, PT: Pericarp thickness, PH: Plant height, Total soluble solids: TSS%, AA: ascorbic acid, NSPF: number of seeds per fruit, NFPC: Number of fruits per cluster, SPAD: Chlorophyll content and FYPH: Fruit yield per hectare

Fig 2: A clustering dendrogram and PCA biplot graphs showing different clusters of traits based on their interrelationships

Conclusion

It may be concluded that fruit length, fruit width, chlorophyll content, pericarp thickness and number of seeds per fruit had a significant positive association with fruit yield per hectare at both phenotypic and genotypic levels. Thus, selection for these characters could be considered as important selection criteria in improving hybrid tomato for high fruit yield quintal per hectare.

References

1. Al-Aysh F, Al-Serhan M, Al-Shareef A, Al-Nasser M, Kutma H. Study of genetic parameters and character interrelationship of yield and some yield components in tomato (*Solanum lycopersicum* L.). International Journal of Genetics 2012;2(2):29-33.
2. Alvarado Gregorio, Lopez Marco, Vargas Mateo, Pacheco Angela, Rodriguez Francisco, Burgueno Juan. "META-R (Multi Environment Trail Analysis with R for Windows) Version 6.04", https://hdl.handle.net/11529/10201, CIMMYT Research Data & Software Repository Network 2015, V23.
3. Dewey DR, Lu K. A correlation and path-coefficient analysis of components of crested wheat grass seed production. Agronomy Journal 1959;51(9):515-518.
4. FAOSTAT. Production – Crops – Area harvested/ Production quantity – Tomatoes, FAO Statistics online database, Food and Agriculture Organization, Rome 2008. www.fao.org/faostat/en.
5. Grafius JE. Does overdominance exist for yield In corn. Agronomy Journal 1960;52(6):361-370.
6. Islam BMR, Ivy NA, Rasul MG, Zakaria M. Character association and path analysis of exotic tomato (*Solanum lycopersicum* L.) genotypes. Bangladesh Journal of Plant Breeding and Genetics 2010;23(1):13-18.
7. Johnson HW, Robinson HF, Comstock RE. Estimates of genetic and environmental variability in soybeans. Agronomy Journal 1955;47(7):314-318.
8. Johnson HW, Bobinson HW, Comstock RE. Estimates of genetic and environmental variability in soybeans. Agronomy Journal 1955;47(7):314-318.
9. Kempthorne O. An introduction to genetics statistic, John Wiley and Sons, Inc. New York 1957, pp. 468-471.
10. Kumar R, Singh SK, Srivastava K, Singh RK. Genetic Variability and Character Association for Yield and Quality Traits in Tomato (*Lycopersicon Esculentum* Mill). *Agriways* 2015;3(1):31-36.
11. Kumar V, Nandan R, Srivastava K, Sharma SK, Kumar R, Kumar A, *et al*. Genetic parameters and correlation study for yield and quality traits in tomato (*Solanum lycopersicum* L.). Plant Archives 2013;13(1), 463-467.
12. Mahapatra AS, Singh AK, Vani VM, Mishra R, Singh BK. Genetic Variability, Heritability and Genetic Advance in Tomato. Journal of Plant Development Sciences 2012;4(4):525-527.
13. Maurya RK, Singh AK, Sai A. Correlation and path analysis in tomato (*Solanum lycopersicum* L.) for yield and yield contributing traits. Journal of Pharmacognosy and phytochemistry 2020;9(3):1684-1687.
14. Namdev SK, Dongre R. Correlation and path analysis in tomato. Research Journal of Agricultural Sciences 2018;9(3):588-590.
15. Prashanth SJ, Jaiprakashnarayan RP, Ravindra M, Madalageri MB. Correlation and path analysis in tomato (*Lycopersicon esculentum* Mill.). Asian Journal of Horticulture 2008;3(2):403-408.
16. Rai AK, Vikram A, Pandav A. Genetic variability studies in tomato (*Solanum lycopersicum* L.) for yield and quality traits. International Journal of Agriculture, Environment and Biotechnology 2016;9(5):739-744.
17. Sajjan AM, Lingaiah HB, Fakrudin B. Studies on genetic variability, heritability and genetic advance for yield and quality traits in tomato (*Solanum lycopersicum* L.). International Journal of Horticulture 2016;6(18):1-15.
18. Saravanan KR, Vishnupriya V, Prakash M, Anandan R. Variability, heritability and genetic advance in tomato genotypes. Indian Journal of Agricultural Research 2019;53(1):224-236.
19. Shankar A, Reddy RVSK, Sujatha M, Pratap M. Genetic association analysis for yield and quality traits in tomato (*Solanum lycopersicum* L.). International Journal of Innovative Horticulture 2013;2(1):70-77.
20. Singh AK. Genetic variability, correlation and path coefficient studies in tomato (*Lycopersicon esculentum* Mill.) under cold arid region of Ladakh. Progressive Horticulture 2005;37(2):437-443.
21. Singh AK, Sharma JP, Kumar S. Variability, correlation and path studies on harvest index and yield components in tomato (*Lycopersicon esculentum* Mill.). The Horticulture Journal 2007;20(1):25-29.
22. Wright S. Correlation and causation. Journal of agriculture Research 1921;20(1):557-580.