Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(6): 1859-1861
Received: 12-09-2017
Accepted: 14-10-2017

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Gene action studies for yield and its attributing traits in tomato (*Solanum lycopersicum* L.) under Kashmir conditions

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Abstract
Nature of gene action for ten important characters of tomato viz., days to first fruit set, days to first picking, plant height (cm), number of primary branches per plant, fruit size (cm^2), flesh thickness (mm), number of fruits per plant, average fruit weight (g), fruit yield per plant (kg) and number of locules were determined by analyzing 10x 10 diallel population. The nature of gene action determined from two biometrical methods matched well and it appeared that the characters were under the control of both fixable and non-fixable gene effects, with the non-fixable gene effects with gene interactions being more important. Diallel analysis revealed low to moderate narrow sense heritability estimates suggested non-additive gene action. Non-significant value of t^2 along with non-significant deviation of regression coefficient from unity in all environment as well as in pooled data revealed the absence of epistasis in all traits.

Keywords: Gene action, diallel, tomato.

Introduction
Tomato (*Lycopersicon esculentum* Mill) or love apple is one of the important commercially growing vegetable belongs to the nightshade family Solanaceae which is believed to consist of 96 genera and over 2800 species distributed in three subfamilies, Solanoideae (to which Solanum belongs), Cestroideae and Solanineae (Knapp *et al*., 2004) [9]. The cultivated tomato is widely grown around the world and constitutes a major agricultural industry and it is the second most consumed vegetable after potato. Genetic determinants of nutritional quality have long been studied. However, it is only recently that these studies have largely focused on single, or at most, a handful of metabolites, such as carotenoid content in tomato (Liu *et al*., 2003) [8]. Hence, there has been much renewed interest in the possibility of breeding not only higher yielding but also better quality crops. The information on genetics of different traits of paramount importance is required for devising any breeding methodology for the improvement of various traits. The selection of the breeding method for taking genetic problems is an equally important consideration in all genetically and breeding studies as the performance of the parents and their F1S. The efficiency of breeding of crops could be increased if the value of crosses of selection could be increased.

Materials and Methods
The material for the present invertigation comprised ten genotypes of tomato (*Lycopersicon esculentum* Mill) namely, Arka Vikas, KS-227, VLT-32, DARL-63, DVRT-I, Local, Marglobe, Shalimar-II, Roma and Shalimar-I. These comprised of commercial varieties and indigenous collections from different parents of India. All the homozygous parents were sown at Vegetable Experimental Farm of Division of Vegetable Science, SKUAST (K), Shalimar during the season of Kharif 2010. All the possible 45 F1 crosses (excluding reciprocals) were made among these ten parents. All the 45 F1S were sown during the Kharif season of 2011. All these F1S were selfed for producing the F2 seeds. All the 45 F1S and F2S along with ten parents were sown in a randomized block design with three replications at three locations i.e. Vegetable Experimental Farm, SKUAST-K, Shalimar; KVK, Malangpora and RRS & FOA Wadura during the season of Kharif 2011. The row to row and plant to plant spacing was maintained at 60 x 45 cm. The observations were recorded on randomly selected five plants for days to first fruit set, days to first picking, plant height (cm), number of primary branches per plant, fruit size (cm^2), flesh thickness (mm), number of fruits per plant, average fruit weight (g), fruit yield per plant (kg) and number of locules. The analysis of diallel cross was made according to Hayman (1954) [1].

Results and Discussion

The analysis of variance for combining ability (Table 1) revealed that GCA and SCA variance were highly significant for all the characters indicating the importance of both additive as well as non-additive genetic variance in the expression of these characters. The magnitude of GCA variance was mostly greater than SCA variance for all the characters except fruit size and fruit yield/plant. The estimates of GCA effect of 10 parents for all ten attributes are presented in Table 2. The GCA estimates showed that the best general combining ability inbreds for days to first fruit set were Arka Vikas followed by DVRT-I, Local, Marglobe, Shalimar-II and Roma. Out of ten parents, all the ten parents exhibited significant GCA effect for days to maturity in F1. For plant height nine parents out of 10 shows significant GCA effect in F1 generation being five negative and five in positive directions. Among the parents studied Arka Vikas, VLT-32, DVRT-I, Local, Marglobe, Shalimar-II and Roma were found to have significant and positive GCA effect for number of primary branches/plant and Arka Vikas, Marglobe, Shalimar-II and Roma for fruit size. VLT-32, DARL-63, DVRT-I, Shalimar-II, Roma and Shalimar-I were highly significant for flesh thickness.

For number of fruits/plant the lines Arka Vikas, KS-227, Local, Marglobe, Shalimar-II and Roma were found to be good combiners. For average fruit weight GCA effect out of 10 parental lines were significant, parents Arka Vikas, KS-227, DARL-63, DVRT-I, Local, Marglobe and Shalimar-II were good general combiners. Parents Arka Vikas, KS-227, Local Marglobe and Shalimar-II were significant and positive while as DVRT-I, DARL-63, VLT-32 and Shalimar-I has negative GCA in fruit yield/plant. KS-227, VLT-32, DARL-63, Local, Marglobe and Shalimar-II were significant and positive for locule number/fruit. For yield components six parental lines in diallel had significant and positive GCA effects. Analysis of variance for combining ability revealed highly significant variances for all the characters. Estimated variance indicated higher contribution to non-additive gene effect for all the characters. Such results had been reported by Makesh *et al.* (2002) [11], Bhatt *et al.* (2001) [7], Patil and Bojappa (1988), for fruit yield and its components traits. However the best combiner across two diallel was KS- 29 for six characters *viz.*, fruit length, fruit width, primary branches, fruit per plant, biological yield and fruit yield followed by Azad Type-2 and Kalyanpur Type-1 for three characters.

Rai *et al.* (1997) [4] reported preponderance of non-additive effects than additive. The greater role played by non-additive genetic components suggest that heterosis breeding would be desirable to improve the quality of tomato fruits. Thakur *et al.* (2005) [6] indicated that additive gene effects exhibited greater role in the inheritance of traits like number of locules fruit^{-1}, fruit firmness and shelf life. Kumar *et al.* (1997) [3, 4] reported significant gca variance for plant height, locule number depicting the role of non-additive gene action. However, significant sca variance for fruit yield plant^{-1}, number of fruits plant^{-1}.

Hannan *et al.* (2007) [2] reported that both gca and sca were found to be highly significant but the sca variance is more for fruits plant^{-1}, flowers cluster^{-1} and fruit weight plant^{-1}. It indicated the importance of both additive and non-additive gene action in controlling the inheritance of yield and yield component characters, with a major effect of the sca.

Rao *et al.* (2008) [5] reported both additive and dominance components were highly significant and positively contributing towards greater plant height. However, sca variance was of higher magnitude than additive component depicting the predominance of non-additive gene action. The ratio of additive variance to total genotypic variance revealed the predominance of non-additive gene action.

The estimates of components due to $\hat{\sigma}^2 g$ and $\hat{\sigma}^2 s$ revealed that under present situation, the magnitude of $\hat{\sigma}^2 s$ was greater than that of corresponding $\hat{\sigma}^2 g$ for all the traits indicating the greater role of non-additive gene effects. The magnitude of dominance variance was found to be higher than the corresponding additive variance for all the traits again indicating the importance of non-additive gene action.

None of the parents revealed significant and desirable gca effects for all the traits simultaneously. The parents A. Vikas, KS-227, Roma, DVRT-1 and DARL-63 were found to exhibit desirable and significant gca effect for most of the traits indicating the preponderance of additive gene action. Significant advancement could be achieved in the segregating generations involving these or either of the parents using simple selection procedures.

Table 1: Analysis of variance for combining ability for maturity and yield attributing traits in Tomato (*Solanum lycopersicum* L.)

Variance due to	df	Mean square									
		Days to 1st fruit set	Days to 1st picking	Plant height	No. of primary branches/plant	Fruit size	Flesh thickness	No. of fruits/plant	Av. Fruit Weight	Fruit yield/plant	Locule no.
GCA	9	14.10**	7.41**	151.68**	1.08**	19.61**	0.64**	18.28**	49.18**	0.07**	0.52**
SCA	45	11.79**	4.49**	130.70**	0.72**	21.78**	0.46**	16.10**	31.06**	0.19**	0.24**
Error	154	0.02	0.15	0.21	0.01	0.03	0.01	0.04	0.03	0.002	0.01

Table 2: Estimation of GCA effects for yield attributing traits in 10 varieties of tomato (*Solanum lycopersicum* L.)

Parent	Days to 1st fruit set	Days to 1st picking	Plant height	No. of primary branches/plant	Fruit size	Flesh thickness	No. of fruits/plant	Av. Fruit Weight	Fruit yield/plant	Locule no.
Arka Vikas	-1.253**	1.644**	-5.708**	0.441**	2.355**	-0.278**	0.548**	1.621**	0.045**	-0.247**
KS-227	0.313**	-0.239*	-4.986**	-0.337**	-0.225**	-0.084**	0.648**	1.449**	0.018	0.142**
VLT-32	0.086*	0.339**	-1.697**	0.052**	-1.588**	0.077*	-0.129*	-2.106**	-0.044**	0.203**
DARL-63	2.019**	0.583**	-0.269*	-0.426**	-1.115**	0.211**	-0.641**	1.160**	-0.067**	0.175**

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