The Pharma Innovation Journal 2017; 6(12): 430-432

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating 2017: 5.03
TPI 2017; 6(12): 430-432

www.thepharmajournal.com
Received: 04-10-2017
Accepted: 05-11-2017

Satish Yadav
Department of Vegetable Science, Department of Horticulture, NDUA&T Kumarganj Faizabad, Uttar Pradesh, India

GC Yadav
Department of Vegetable Science, Department of Horticulture, NDUA&T Kumarganj Faizabad, Uttar Pradesh, India

Vimlesh Kumar
Department of Vegetable Science, Department of Horticulture, NDUA&T Kumarganj Faizabad, Uttar Pradesh, India

Dheeraj Yadav
Department of Vegetable Science, Department of Horticulture, NDUA&T Kumarganj Faizabad, Uttar Pradesh, India

Correspondence
Satish Yadav
Department of Vegetable Science, Department of Horticulture, NDUA&T Kumarganj Faizabad, Uttar Pradesh, India

Gene action studies in tomato (*Solanum lycopersicon* (Mill.) Wettsd.) For growth, yield and quality traits

Satish Yadav, GC Yadav, Vimlesh Kumar and Dheeraj Yadav

Abstract
The present investigation was conducted using 36 cross combination obtained by crossing 9 lines with 4 tester in Line × Tester mating design to know the gene effects with to respect to its nature and magnitude for growth, yield and quality characters. The study revealed estimates of sca variance were higher than gca variances for all most of the traits. The value of sca variances were found significant and positive for all the characters. Likewise, positive and significant gca variances were also exhibited by almost all the characters. The value of degree of dominance was more than unity (1) for all the traits except for plant height (0.76), pericarp thickness (0.74), number of fruits per plant (0.83) and ascorbic acid (0.90) and revealed over dominance in 2012 -2013. The value of degree of dominance was more than unity (1) for all the traits except for plant height (0.68) and ascorbic acid (0.83) and revealed over dominance in 2013-2014. Plant height, pericarp thickness and ascorbic acid in fruit exhibited average degree of dominance less than unity (1) indicating partial dominance. These results clearly indicates that in the majority growth, yield quality non-additive gene action were in preponderance practice of exploration of hybrid vigor in tomato.

Keywords: Gene action, average degree of dominance, tomato, combining ability, line × tester

Introduction
Tomato (*Solanum lycopersicon* (Mill.) Wettsd.), 2n=24) of nightshade or Solanaceae family with primary center of origin in Mexico-Peru-Equador region was once considered inedible but has evolved into globally leading popular vegetable. It is highly worked crop by the horticulturists and breeders. It has wide range of variation in terms of growth habit, morphological traits and uses making it a repository of glowing traits in its armory. It is used as fresh as well as processed vegetable. The total area of tomato in India is 9205 hectare which is 9.6 per cent of vegetables area. While, the total production is 18226.6 mt which is 11.2 per cent of total vegetables production(20.7 mt/ha). The leading tomato producing states are U.P. (12.1%), West Bengal (15.7%), Bihar (10.16%), Gujrat (6.2%) and Punjab (4.3%) (Annonymous, 2014) [2] It is also very important for processing industry as it ranks first as processing vegetable crops in the world.Ripe tomato is widely used for the preparation of several processed items like paste, syrup, juice, soup, ketchup, drinks, whole peeled tomato and canned tomato etc, in the processing industry on large scale. Being very good appetizer, tomato is rich source of minerals, vitamins and organic acids. Its nutritional importance is enlarged with antioxidant properties of lycopene and its anticancerous properties. Growing consumption of tomato in processed or fresh form is driven by its versatile, palatable, culinary and attractive properties apart from its health benefits. It was introduced in India in 17th century by Europeans and today it has become part and parcel of Indian food besides becoming one of the leading vegetable with lot of research work and outcomes seen in it. Globally, India is the third largest producer of tomato after China and USA. Hence the present study to understand the ene effects governing various growth, yield and quality traits.

Materials and methods
The present investigation was carried out at the Main Vegetable Research Station, Division of Vegetable Science, and in the laboratory of the College of Horticulture and Forestry, Narendra Deva University of Agriculture and Technology Narendra Nagar (Kumarganj), Faizabad, India, during 2012- 13 and 2013-14. The farm is situated at 26.56^{0} N latitude and 82.12^{0} E longitudes at an altitude of 113 m above the mean sea level. The soil type of experimental site was sandy loam. This area falls in sub-tropical zone of Eastern India and experimental designs adapted, statistical procedures followed and methodology adopted is described here under.

Forty nine genotypes consisting of thirteen parents and 36 F_1 hybrids which were made from the parents in line ×tester design of mating. The experiments were conducted in Randomized Complete Block Design (RBD) with three replications to assess the performance of 36 F_1 hybrids and 13 parents (9 lines and 4 testers). The treatments were planted in rows spaced at 0.6 meters apart with a plant to plant spacing of 0.5 meter. The experiments were sown on 17th November, 2012 and 15th October, 2013. All the recommended agronomic package of practices and protection measures were followed to raise good crops.

The data were recorded on the characters *viz.,* days to 50% flowering, plant height (cm), number of primary branches per plant, number of fruits per cluster, number of fruit per plant, average fruit weight (gm), fruit length (cm), fruit girth (cm), number of locules per fruit, pericarp thickness (mm), total soluble solids (TSS), ascorbic acid (mg/100 g fresh fruit), marketable fruit yield per plant (kg) and total fruit yield per plant (kg).

Results and Discussion

The estimates of gca and sca variances, predictability ratio and average degree of dominance had given in table-1.

In the year Y_1, estimates of sca variance were higher than gca variances for all most of the traits.The value of sca variances were found significant and positive for all the characters. Likewise, positive and significant gca variances were also exhibited by almost all the characters. The value of degree of dominance was more than unity (1) for all the traits except for plant hieght (0.76), pericarp thickness (0.74), number of fruits per plant (0.83) and ascorbic acid (0.90) and revealed over dominance. The magnitude of over dominance was the highest for number of locules per fruit (3.32) followed by total solule solids (3.01), days to 50% flowering (2.97), fruit girth (2.30), number of primary branches per plant (1.97), average fruit weight (1.68), marketable fruit field per plant (1.52), number of fruits per cluster (1.45), fruit length (1.34) and total fruit yield per plant (1.32). Plant height, pericarp thickness and ascorbic acid in fruit exhibited average degree of dominance less than unity (1) indicating partial dominance. The general predictability ratio was less than one for all the characters.

In Y_2, estimates of sca variance were higher than gca variances for all the traits except plant height and ascorbic acid. The value of sca variances were found significant and positive for all the characters. However, positive and significant gca variances were also exhibited by almost all the characters except number of primary branches per plant. The value of degree of dominance was more than unity (1) for all the traits except for plant height (0.68) and ascorbic acid (0.83) and revealed over dominance. The magnitude of dominance action was the highest for number of primary branches per plant (4.06) followed by number of locules per fruit (2.28), fruit girth (2.04), days to 50% flowering (1.96), marketable fruit yield per plant (1.81), total fruit yield per plant (1.79), average fruit weight (1.78), total soluble solids (1.56), number of fruits per plant and number of fruits per cluster (1.26), fruit length (1.16) and pericarp thickness (1.15). Plant hieght and ascorbic acid in fruit exhibited average degree of dominance less than unity (1) indicating partial dominance. The general predictability ratio was less than one for all the characters. The higher magnitude of sca variances indicates the preponderance of non additive gene action The values of dominance genetic variances (σ^2D) were larger than additive genetic variance (σ^2A) and average degree of dominance were more than unity (>1) for all the characters under study except for plant height and ascorbic acid in both the years and pericarp thickness and number of fruits per plant in Y_1 which indicated existence of over dominance and controlled by a preponderance of non-additive gene effects suggesting thereby scope of development of F_1's as well as the recombinants within the segregating populations. Plant height, ascorbic acid, pericarp thickness and number of fruits per plant which had less than one value of average degree of dominance suggested existence of partial dominance.

The results are in conformity with the earlier researchers findings viz, Amaral *et al.* (1996) [1]; Chadha *et al* (1997) [5]; Sharma (1998) [8]; Bhutani and Kalloo (1998) [4]; Bhatt *et al.* (2001) [3]; Sharma (2003) [9] and Dhaliwal *et al* (2004) [6].

Table 1: Components of genetic variance, average degree of dominance and predictability ratio for 14 characters in tomato.

S. No.	Characters	gca variance (σ^2g)		sca variance (σ^2s)		Average degree of dominance $\sqrt{\sigma^2s/2\sigma^2g}$		Predictability ratio $2\sigma^2g/2\sigma^2g+\sigma^2s)$		σ^2A		σ^2D	
		Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
1.	Days to 50 % flowering	0.16	0.33*	1.44**	1.26**	2.97	1.96	0.18	0.34	0.33	0.65	1.44	1.26
2.	Plant height (cm)	420.45**	451.59**	241.95**	211.76**	0.76	0.68	0.78	0.81	840.90	903.17	241.95	211.76
3.	Number of primary branches per plant	0.02*	0.01	0.06**	0.08**	1.97	4.06	0.34	0.11	0.03	0.01	0.06	0.08
4.	Fruit length (cm)	0.04**	0.32**	0.07*	0.88**	1.34	1.16	0.53	0.42	0.08	0.06	0.07	0.08
5.	Fruit girth (cm)	0.03	0.06*	0.31*	0.26**	2.30	2.04	0.18	0.32	0.07	0.12	0.31	0.26
6.	Average fruit weight (gm)	13.00**	9.19**	36.55**	29.33**	1.68	1.78	0.42	0.38	26.01	18.38	36.55	29.33
7.	Pericarp thickness (cm)	0.02**	0.06**	0.01	0.13**	0.74	1.15	0.78	0.49	0.04	0.12	0.01	0.13
8.	Number of locules per fruit	0.02	0.03*	0.24**	0.14**	3.32	2.28	0.16	0.28	0.04	0.05	0.23	0.13
9.	Total soluble solids	0.01	0.04**	0.12**	0.09**	3.01	1.56	0.18	0.45	0.03	0.07	0.12	0.09
10.	Ascorbic acid (mg/100g)	43.44**	39.21**	35.14**	26.93**	0.90	0.83	0.71	0.74	86.88	78.42	35.14	26.93
11.	Number of fruits	0.03**	0.07**	0.07	0.11*	1.45	1.26	0.48	0.56	0.07	0.14	0.07	0.11

	per cluster												
12.	Number of fruits per plant	9.04**	9.84**	6.24**	15.74**	0.83	1.26	0.74	0.55	18.08	19.68	6.24	15.74
13.	Marketable fruit yield per plant (kg)	0.03**	0.02**	0.06**	0.08**	1.52	1.81	0.46	0.38	0.05	0.05	0.06	0.08
14.	Total fruit yield per plant (kg)	0.03**	0.02**	0.06**	0.08**	1.32	1.79	0.53	0.38	0.07	0.05	0.06	0.08

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