Indian J. Hort. 70(2), June 2013: 243-247

Genetics of yield and yield contributing traits in tomato under low temperature grown climatic regime

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ABSTRACT

The generation mean analysis studied in six generations of tomato involving four parents, *viz*., Pusa Sheetal, Pusa Sadabahar, Booster and Pusa Rohini showed importance of dominance x dominance followed by additive gene effect, additive x dominance and dominance with a small proportion of additive x additive gene effect. Breeding methods, *i.e.*, pedigree followed by selection can simultaneously be exploited both for additive and non-additive gene effects. Appreciable heterosis was observed for all the characters studied over their respective better parents. The range of heterosis for yield/ plant varied from 16.01 to 29.04 per cent over the respective better parents. Hybrid Pusa Sadabahar x Pusa Rohini was found to be best performing for yield which exhibited superior performance for the characters like number of flowers per truss, number of primary branches per plant, internodal length, fruit diameter, days to first harvest and yield per plant. The next best cross was Pusa Sheetal x Booster as it showed superior performance for characters like days to 50% flowering, number of fruit-set per truss and number of fruits per plant. These hybrids can be commercialized to get an early yield in tomato.

Key words: *Solanum lycopersicum*, low temperature, generation mean analysis, gene action, yield traits.

INTRODUCTION

Tomato is considered a warm season vegetable crop and lack of fruit setting under low temperature climatic regimes is a major problem especially during December-January months under North Indian plains condition. Some wild species, *viz.*, *Lycopersicon hirsutum* and *L. peruvianum*, have shown better adaptability for growing under low temperature for extending the availability of tomato fruit. It will also be beneficial in the areas where growing period is preceded by high temperature to have an early crop during spring to keep the continuity of tomato fruits in local market by growing them in open field conditions. Although many sources of cold tolerance have been reported and even used in breeding but not much is known about the genetic factors controlling this trait, except that the inheritance is complex (Kalloo and Banerjee, 5; Lewis, 7). The study of genetics of fruit setting under low temperature can be helpful in the development of early maturing varieties/hybrids for the areas where normal growing period is preceded by low temperature regime. Therefore, the generation mean analysis was done to know the gene effects as well as for the presence or absence of epistasis. Considering the above facts, the present research work was carried out to study the heterosis as well as genetic inheritance pattern of fruit yield and other yield attributes under low temperature regimes.

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MATERIALS AND METHODS

An experiment was conducted at the Research Farm, Division of Vegetable Science, IARI, New Delhi, during third week of November, by involving four parents and their F_1s, F_2s, B_1 and B_2 generations developed from pure lines of two cold set varieties, *i.e.*, Pusa Sheetal and Pusa Sadabahar and two normal set varieties, i.e., Pusa Rohini and Booster of tomato. The experiment was conducted in randomized complete block design with three replications. The seedlings were transplanted at a spacing of 45 cm x 45 cm. Farm yard manure @20 t/ha was applied at the time of land preparation along with N:P:K@100:60:50 kg/ha. All other recommended cultural practices for successful growing of tomato were also followed. Data were recorded on randomly selected 10 plants in parents and F_1, B_1 and B_2 and 20 plants in F_2 populations from each replication for 12 traits namely, days to 50% flowering, number of flower per truss, number of fruit set per truss, number of primary branches per plant, internodal length (cm), plant height (cm), number of fruits/plant, fruit length (cm), fruit diameter (cm), fruit weight (g), days to first harvest and yield per plant (kg). The pooled data of three replications was subjected for generation mean analysis as suggested by Hayman (4). Monthly mean minimum & maximum temperatures and relative humidity (%) during growing period is given in Table 5.

RESULTS AND DISCUSSION

The per cent heterosis for various characters has been presented in Table 1. Heterosis was calculated for better parent and mid parent for all the 12 traits under study. The cross Pusa Sheetal x Booster showed highly significant heterosis over better parent for days to 50% flowering (-15.67), number of fruit set/ truss (0.66) , number of fruits per plant (17.00), fruit length (0.99) and yield per plant (17.96). The same cross has also showed highly significant heterosis over mid-parental value for days to 50% flowering (-6.50), number of fruits per plant (12.62), fruit diameter (-0.75) and yield per plant (26.23). The important trait contributing to earliness, *i.e.*, days to 50% flowering has been observed in the cross Pusa Sheetal x Booster only, showing negative heterosis.

Pusa Sheetal x Pusa Sadabahar showed highly significant heterosis positive for days to 50% flowering,, number of fruits per plant, fruit weight and yield per plant, however negative heterosis was recorded for number of flowers per truss over both better parent and mid-parent. Similarly, in Pusa Sadabahar x Pusa Rohini highly significant and positive heterosis over both better parent and mid-parent was recorded for days to 50% flowering (5.0 and 8.5), number of fruits/plant (12.33 and 8.92) and yield per plant (29.04 and 30.92 respectively) except days to first harvest (-14.67 and -6.17, respectively). Baishya *et al.* (1) recorded heterosis for days to 50% flowering, number of fruits per plant in tomato. Heterosis for yield per plant was also reported by Wang *et al.* (10), Chaudhary and Malhotra (2), and Dudi and Sanwal (3).

During December the minimum and maximum temperature range was recorded 5.6 to 24.1°C. Under these conditions, earliest fruit set was observed in Pusa Sadabahar (56.33 days) followed by Pusa Sheetal (58.67 days). Whereas, in Pusa Rohini and Booster after 63.33 and 77 days respectively. First picking started in month of March, 2007, in parent Pusa Sadabahar (105 days) followed by Pusa Sheetal (126 days), whereas in the normal set parents, the first picking was delayed, *i.e.*, 142 and 150 days in Booster and Pusa Rohini, respectively.

Estimates of gene effects presented in Table 2 represents Pusa Sheetal x Booster. Additive gene effects were positively significant for number of fruits per plant, however, it was significant in negative direction for number of flowers per truss, number of primary branches per plant, internodal length, plant height and fruit length. Dominance gene effects were significant in desirable negative direction for days to 50% flowering, intermodal length and day to first harvest. Additive x additive components of gene effects were significant in negative direction for days to 50% flowering, internodal length and days to fruit harvest. Significant values of additive x dominance gene effects were observed in desirable direction for number of fruits/plant and intermodal length and it was negatively significant for number of flowers/ truss. Though dominance x dominance gene effects were significant for days to 50% flowering, internodal length, days to first fruit harvest, but in positive

Table 1. Heterosis (%) for different characters over better parent (BP) and mid-parent (MP) in tomato three crosses.

Trait	Pusa Sheetal × Booster		Pusa Sheetal × Pusa Sadabahar		Pusa Sadabahar × Pusa Rohini	
	BP	MP	BP	MP	BP	MP
Days to 50% flowering	-15.67**	-6.50**	8.33**	9.50**	5.00**	8.50**
No. of flowers/ truss	0.45	0.05	-0.82**	-0.82**	1.00**	0.34
No. of fruit-set/ truss	0.66*	0.58*	-0.10	-0.19	0.77**	0.25
No. of primary branches/ plant	0.32	0.24	0.64	0.57	1.32**	0.82*
Internodal length (cm)	0.83	-1.00*	0.50	0.30	1.67**	0.75
Plant height (cm)	-19.07	-13.32	12.33	-2.17	25.73*	17.90
No. of fruits/ plant	17.00**	12.62**	16.33**	10.83**	12.33**	8.92**
Fruit length (cm)	0.93**	0.35	0.30	0.25	0.20	0.20
Fruit diameter (cm)	-0.17	-0.75**	0.90*	0.55	0.90*	0.82*
Fruit weight (g)	3.00	-1.83	5.67*	5.17*	3.83	2.25
Days to first harvest	0.67	4.00	-0.33	1.00	-14.67**	-6.17*
Yield/ plant (kg)	17.96**	26.23*	16.01**	16.58**	29.04**	30.92**

*, **Significant at 5 and 1%, respectively.

Table 2. Gene effects for different parameters in cross Pusa Sheetal × Booster.

Trait	m	d	h	i	j	l	Epistasis
Days to 50% flowering	72.00**	-4.33	-41.83**	-35.33**	4.83	40.99**	D
No. of flowers/ truss	5.50**	-0.70*	3.25*	3.12*	-1.10*	-4.09*	D
No. of fruit-set/ truss	3.69**	-0.45	0.91	0.33	-0.53	2.75	
No. of primary branches/ plant	6.48**	-0.29*	0.35	3.26**	-0.37	-3.08	D
Internodal length (cm)	9.00**	-3.50**	-11.33**	-10.33**	-1.67**	12.67**	D
Plant height (cm)	45.20**	-22.66**	6.28	19.60	-16.91	3.03	C
No. of fruits/ plant	45.33**	12.33**	22.61*	10.00	7.94**	56.09**	C
Fruit length (cm)	4.26**	-0.43*	-0.11	-0.46	-1.01**	-0.43	C
Fruit diameter (cm)	5.00**	-0.66	-1.42	-0.66	-1.25	-1.83	C
Fruit weight (g)	39.00**	1.33	4.83	6.66	-3.50	-28.33	D
Days to first harvest	167.00**	1.66	-20.66**	-24.66**	5.00*	25.33*	D
Yield/ plant (kg)	1.76	0.37	0.37	0.36	0.23	0.94	

*, **Significant at 5 and 1%, respectively.

direction, which is undesirable. It was significant in desirable direction for number of fruits per plant only. Duplicate type of epistasis was observed for days to 50% flowering, number of flowers per truss, number of primary branches per plant, internodal length, average fruit weight and days to first harvest. Complementary epitasis was observed for plant height, number of fruits per plant, fruit length and fruit diameter.

In Pusa Sheetal x Pusa Sadabahar, additive gene effects were significant in positive direction for days to 50% flowering, number of fruits set per truss, number of primary branches per plant, internodal length and yield per plant (Table 3). Additive gene effects were in negative direction for number of flowers per truss, plant height and fruit diameter. Dominance gene effect was significant in desirable direction for number of primary branches per plant, fruit length and average fruit weight. Additive x additive gene effects were significant in desirable direction for days to 50% flowering, number of primary branches and fruit length. Additive x dominance gene effects were significant in positive direction for days to 50% flowering, number of fruit set/truss, number of primary branches per plant, internodal length and yield per plant. Similarly, dominance x dominance gene effects were significant in positive direction for days to 50% flowering, number of fruits per plant and fruit diameter. Duplicate type of epistasis was observed for days to 50% flowering,

Table 3. Gene effects for different parameters in cross Pusa Sheetal × Pusa Sadabahar.

Trait	m	d	h	i	j	l	Epistasis
Days to 50% flowering	65.33**	6.00*	-6.50	-16.00**	4.83**	19.66**	D
No. of flowers/ truss	5.76**	-8.33**	0.55	1.36*	-8.33**	-1.63	D
No. of fruit-set/ truss	3.50	0.69**	0.56	0.75	0.60**	1.13	C
No. of primary branches/ plant	6.15	0.83**	2.97**	2.40**	0.72**	0.65	C
Internodal length (cm)	6.00**	0.90**	-2.16	-2.46	0.70**	5.39	D
Plant height (cm)	60.13**	-5.16**	-46.09**	-43.93**	-19.66**	11.67	D
No. of fruits/ plant	52.00**	7.33	2.83	-8.00	1.83	77.00**	C
Fruit length (cm)	3.63**	-0.50	3.38**	3.13**	-0.45	-2.76	D
Fruit diameter (cm)	4.43	-0.83**	-2.18**	-2.73**	-1.18**	8.10**	D
Fruit weight (g)	35.33**	0.33	15.16**	10.00	0.83	14.49	C
Days to first harvest	157.67**	-1.66	10.99	9.99	-3.00	7.33	C
Yield/ plant (kg)	1.72**	0.45*	0.67	0.33	0.44**	1.32	C

*, **Significant at 5 and 1%, respectively.

number of flowers per truss, internodal length, plant height, fruit length and fruit diameter indicating that heterosis method of breeding may be effective for improvement of these traits.

The epistasis was complementary type for number of fruit set per truss, number of primary branches, number of fruits per plant, average fruit weight, days to first harvest and yield per plant indicating the selection method may be predominant for improvement. Megha *et al.* (8) also reported non-additive gene action for days to 50% flowering and additive gene effect for plant height and number of fruits per plant.

In Pusa Sadabahar x Pusa Rohini (Table 4), additive gene effects were significant and in desirable negative direction for days to 50% flowering and in positive direction for number of fruit set/ truss, number of primary branches per plant, which is desirable. However, for internodal length and number of fruits per plant, it was significant in undesirable direction (positive). The dominance gene effects were significant in negative direction for days to 50% flowering, plant height, number of fruits per plant, days to first harvest and yield per plant. The dominant gene effects were positively significant only for number of flowers per truss. Additive x additive gene effects were significant and in desirable direction (negative direction) for both days to 50% flowering and days to first harvest, indicating that selection between families and lines may be useful for improvement of these traits. Additive x dominance gene effects were significant in desirable direction for number of fruit set per truss and number of primary branches. Dominance x dominance gene effects was significant in desirable direction for number of fruit set per truss, internodal length and number of primary branches per plant, plant height, number of fruits per plant, fruit diameter, average fruit weight and yield per plant, however, it showed significance in undesirable direction for days to 50% flowering and days to first harvest both in positive direction. Complementary type of epistasis was recorded in case of number of flowers per truss and fruit diameter. However, for rest of the traits studied, epistasis was of duplicate type. Singh *et al.* (9) also reported importance of additive

Table 4. Gene effects for different parameters in cross Pusa Sadabahar × Pusa Rohini.

Trait	m	d	h	i	j	l	Epistasis
Days to 50% flowering	74.00**	-4.99**	-26.83**	-35.33**	-1.49	31.00**	D
No. of flowers/ truss	5.65**	-0.10	7.50*	-0.27	-0.76*	0.45	C
No. of fruit-set/ truss	4.16	0.62**	-0.79	1.24*	0.93**	4.66**	D
No. of primary branches/ plant	6.76**	0.59*	-0.38	-1.20	9.99**	3.57*	D
Internodal length (cm)	5.50**	1.17*	1.75	1.00	0.24	-4.83*	D
Plant height (cm)	51.27**	-3.63	-33.23*	-51.13**	4.20	74.99**	D
No. of fruits/ plant	57.00**	-10.67**	-25.75*	-34.67**	-14.08**	55.50**	D
Fruit length (cm)	4.33**	-0.50	0.53	0.33	-0.50	-0.27	D
Fruit diameter (cm)	4.17*8	-0.43	0.35	-0.47	-0.35	3.30*	C
Fruit weight (g)	40.33**	2.33	-10.41	-12.67	3.91	46.17**	D
Days to first harvest	162.33**	-1.00	-38.83**	-32.67**	7.50**	49.67**	D
Yield/ plant (kg)	2.29	-0.27	-1.39**	-2.03**	-0.25	4.43**	D

*, **Significant at 5 and 1%, respectively.

Table 5. Monthly mean minimum & maximum temperature and relative humidity (%) range during growing period.

Month	Mean Temperature range (°C)		Humidity range (%)	
	Minimum	Maximum	Morning	Evening
November, 2006	7.0-14.2	24.4-30.2	77-90	27-38
December, 2006	5.6-11.0	20.1-24.1	77-92	39-52
January, 2007	2.2-9.6	17.4-25.9	83-94	33-91
February, 2007	9.2-11.9	20.1-24.6	86-95	57-77
March, 2007	11.5-15.8	23.8-33.1	81-83	41-67

genetic systems present in good general combining parents and epistatic effects in the hybrids in the same direction. Katoch and Vidyasagar (6) also reported additive and epistasis gene action for days to first harvest and yield/ plant.

It may be concluded that in tomato generation mean analysis has shown the importance of dominance x dominance effects followed by additive gene effect for number of fruit set per truss, internodal length and number of primary branches per plant, plant height, number of fruits per plant, fruit diameter, average fruit weight and yield per plant, therefore, heterosis as well as pedigree selection method can be exploited for genetic improvement respectively. The hybridization programme should be planned by involving one of the parents with the ability to set fruits under low temperature climatic regimes. In this study cross Pusa Sheetal x Booster exhibited the desired traits and further selection is in progress.

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Received: January, 2012; Revised: April, 2013;
Accepted: May, 2013