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HETEROSIS AND QUALITATIVE ATTRIBUTES IN WINTER TOMATO (*Solanum lycopersicum* L.) HYBRIDS

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Abstract

An investigation was carried out at the Research Farm of Olericulture Division of Horticulture Research Centre of Bangladesh Agricultural Research Institute (BARI) to evaluate the heterotic performance in F_1 generation of tomato. The hybrids showed significant variation in heterosis. The highest heterobeltiotic effects were observed in the cross P_3 x P_8 (-18.46%) for earliness, P_1 x P_6 (8.57 %) for flowers per cluster, P_2 x P_6 (21.73%) for fruits per cluster, P_6 x P_7 (75.54%) for plant height, P_5 x P_6 (67.44%) for fruits per plant, P_9 x P_{10} (54.82 %) for yield per plant, P_2 x P_8 (21.21 %) for individual fruit weight, P_7 x P_8 (3.09 %) for fruit length, P_3 x P_8 (14.11 %) for fruit diameter and P_1 x P_6 (13.11 %) for brix content. In respect of fruit external characters like shape, pedicel area, shape of pistil scar, blossom end shape genotypes were found diverse. Internal qualitative character like firmness, fleshiness and less seeded and locule numbers were highly variable among the genotypes. Considering all the characters the crosses P_1 x P_8, P_2 x P_6, P_2 x P_7, P_2 x P_8, P_3 x P_8 and P_5 x P_6 were found suitable for further studies to variety selection.

Keywords: Heterosis, qualitative attributes, winter tomato.

Introduction

Tomato (*Solanum lycopersicum* L.), one of the most popular and an important vegetable of Bangladesh, is widely grown in many parts of the world because of its taste, high nutritional value, multipurpose uses and commercial importance. Bangladesh produces 137 thousand tons of tomato per year from 15.39 thousand hectares of land with an average yield of 8.90 t/ha (BBS, 2007). The yield is very low compared to that of other tomato growing countries. For this reason, this crop has received high attention to the researchers for its improvement.

Estimation of heterosis is an important way to assess the performances of the hybrids compared to their parents and is essential to develop high yielding varieties of different crop plants. The development of hybrid varieties with desired characters has proven to be an effective strategy to increase tomato production in the world. In tomato, heterosis has been exploited in F_1 hybrids to a great extent for more than 50 years in many developed countries like USA, Europe, and Japan. In India, heterosis in tomato resulted in an increased yield of

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20-50% (Choudhury and Khanna, 1972). Apart from high total yield F_1 hybrids have specific advantages on early yield, number of fruits, size of fruit, improved quality, uniformity, adaptation to adverse climatic condition, resistance to diseases and pests (Tesi *et al*., 1970).

Keeping this view in consideration, the present study has been undertaken with the following objectives:

1. to determine the heterosis or hybrid vigor of the crossed materials;
2. to select winter hybrid varieties having desired qualities.

Materials and Method

The experiment was conducted in the research farm of Olericulture Division, Horticulture Research Centre (HRC) of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur during the winter season (October to March) of 2007-2008. The location of the site was 24.00^0N Latitude and 90.25^0 E Longitude at an elevation of 8.4 meters from the sea level (Anon., 1995). The climate of the experimental site is suited in the sub-tropical climate zone and characterized by heavy rainfall during the months of May to August and medium to low during the rest of the year. The monthly average minimum and maximum temperatures during the crop period were 17.56^0C and 28.18^0C, respectively. The monthly average relative humidity was 54.88 %, rainfall was 10.59mm. The soil of the experimental field was clay loam in texture having a pH around 6.0. Seeds of the selected 19 cross combinations from a half diallel cross without reciprocals and their 14 parental lines were used for the study. Recommended dose of fertilizer (550, 450, and 250 kg/ha of urea, TSP, MP, and 10 t/ha of cowdung) were applied (Razzaque *et al*., 2000).

A tri-replicated experiment was laid out in the Randomized Complete Block Design. The unit plot size was 4.8 m. x 1m accommodating 20 plants in a plot having row to row and plant to plant spacing of 60 and 40 cm, respectively. The unit plots and blocks were separated by 50 cm and 1 m space, respectively. Treatments were randomly allotted in each block. Thirty days old seedlings were transplanted in the experimental field on 10 November 2007. Harvesting was started from 77 days after transplanting (27 January 2008) and continued for 35 days. Five plants were randomly selected from each unit plot for recording data.

For estimation of heterosis in each character, the mean values of 19 F_1s were compared with better parent (BP) for heterobeltiosis. MSTAT-C program was used for statistical analysis of the data. The recorded data for different characters were subjected to variance analysis. Genotypes means were compared by Tukey’s Honestly Significant Difference Test and Coefficient (CV %) were also estimated as suggested by Gomez and Gomez (1984).

Results and Discussion

A. Heterosis

Days to 50 % flowering

All 19 combinations showed negative heterobeltiosis of which 18 are highly significant for this trait (Table 1). The highest negative heterosis was observed in the combination P_3 x P_8 (-18.46 %) and the lowest was in P_2 x P_6 (-3.76 %). Ahmad (2002) reported negative heterosis for days to 50 % flowering.

Days to last harvest

Six cross combinations out of 19 showed significant negative heterobeltiosis for this trait. Seventeen showed negative, one showed positive and another one showed no heterosis (Table 1). Heterosis for this trait ranged from – 13.95 to 4.9 percent. The highest negative heterosis was observed in the combination P_6 x P_9 (-13.95 %). The highest positive heterotic effect was observed in the combination P_4 x P_6 (4.9 %).

Plant height (cm)

In the case of plant height, 17 cross combinations out of 19 showed positive heterosis over better parent, but only 10 were significantly different. The heterotic effects ranged from –7.51 to 75.54 percent (Table 1). The highest significant positive heterosis was observed in P_6 x P_7 (75.54 %) followed by P_2 x P_7 (40.26 %). The highest significant negative heterosis for plant height at last harvest was observed in P_7 x P_9. Ahmad (2002) recorded appreciable heterosis for plant height.

Flowers per cluster

Four cross combinations out of 19 showed significant positive better parent heterosis for flowers per cluster (Table 1). The heterosis over better parent ranged from –13.22 to 8.57 percent. The highest positive heterosis was observed in P_1 x P_6 (8.57 %) followed by P_6 x P_9 (6.93%). The highest significant negative heterosis was observed in P_7 x P_9 (– 13.57 %). These results also support the findings of Ahmad (2002).

Fruits per cluster

Eleven cross combinations out of 19 showed significant positive better parent heterosis for fruits per cluster (Table 1). The heterosis over better parent ranged from –27.93 to 21.73 percent. The highest positive heterosis was observed in P_3 x P_6 (21.73%) followed by P_7 x P_8 (17.94 %). The highest significant negative heterosis was observed in P_{11} x P_{12} (–27.93%). Resende *et al.* (2000) also found appreciable heterosis for fruits per cluster in tomato.

Fruits per plant

Eleven cross combinations out of 19 showed significant positive heterosis for fruits per plant (Table 2). Range of better parent heterosis was –43.30 to 67.44 percent. The highest significant positive heterosis was observed in P_5 x P_6 (67.44%) followed by P_1 x P_8 (49.02%). The highest significant negative better parent heterosis was observed in P_7 x P_9 (– 43.30 %). Heterosis for fruits per plant in tomato was also reported by Ahmad (2002).

Table 1. Percent heterosis over better parent in 19 tomato hybrids for morphological characters.

Crosses	Days to 50% flowering	Days to last harvest	Plant height (cm)	No. of flowers/cluster	No. of fruits/cluster
P_1 X P_6	-9.14 **	-11.36 **	12.46	8.57 **	10.01 **
P_1 X P_7	-9.84 **	-3.81	16.74	-7.43 **	2.51 **
P_1 X P_8	-7.69 **	-7.79	17.90 *	-1.76 **	15.00 **
P_2 X P_6	-3.76 *	-6.20	29.24 **	-0.957 *	-5.56 **
P_2 X P_7	-9.84 **	-3.81	40.26 **	-6.186 **	-10.25 **
P_2 X P_8	-15.72 **	-7.79	28.15 **	-11.49 **	8.10 **
P_3 X P_6	-12.36 **	-11.36 **	15.38	-1.79 **	21.73 **
P_3 X P_8	-18.46 **	-10.48 **	21.57 *	-0.49	8.11 **
P_4 X P_6	-7.53 **	4.90	36.84 **	5.94 **	15.93 **
P_5 X P_6	-10.21**	-8.78 *	6.76	2.85 **	15.93 **
P_6 X P_7	-11.92 **	-4.90	75.54 **	-12.39 **	-10.25 **
P_6 X P_8	-6.66 **	-6.20	8.68	-0.87 *	10.82 **
P_6 X P_9	-10.75 **	-13.95 **	-6.50	6.93 **	10.15 **
P_7 X P_8	-8.72 **	-2.41	12.19	-9.91 **	17.94 **
P_7 X P_9	-17.62 **	-9.26 *	-7.51	-13.22 **	-11.53 **
P_9 X P_{10}	-13.23 **	-7.59	33.11 **	-4.306 **	-7.78 **
P_{11} X P_{12}	-5.69 **	-1.30	9.13	-8.41 **	-27.93 **
P_{11} X P_{13}	-5.82 **	0.00	34.55 **	-5.17 **	-18.63 **
P_{11} X P_{14}	-16.4 **	-7.59	18.21 *	-0.42	-10.46 **
LSD (0.01)	4.90	10.40	22.89	1.11	1.14
LSD (0.05)	3.69	7.84	17.25	0.83	0.86

* Significant at 5 % level of probability

** Significant at 1 % level of probability

Fruit weight (g)

Six F_1s out of 19 showed significant negative better parent heterosis and four F_1s showed significant positive heterosis for fruit weight (Table 2). The heterosis ranged from – 42.84 to 21.21 percent. The highest positive better parent heterosis was observed in P_2 x P_8 (21.21 %) followed by P_2 x P_6 (18.51). It was clear that higher individual fruit weight in a particular F_1 did not show high heterosis because of higher performance by the parental line. The significant negative heterosis was observed in P_{11} x P_{14} (– 42.84 %). Ahmad (2002) also reported heterosis for this trait.

Yield per plant (kg)

Sixteen cross combinations out of 19 showed significant positive heterosis for yield per plant (Table 2). Better parent heterosis ranged from –21.74 to 54.82 percent. The cross combination P_9 x P_{10} (54.82 %) showed maximum heterosis followed by P_3 x P_6 (45.99 %), P_1 x P_8 (43.11 %), P_6 x P_8 (38.86 %) and P_2 x P_6 (36.48 %). The cross P_{11} x P_{12} exhibited highest significant negative better parent heterosis (–21.74 %). Makesh *et al*. (2002) also reported heterobeltiosis for this trait.

Fruit length (cm)

For fruit length, only two cross combinations out of 19 showed significant positive better parent heterosis (Table 2). Heterosis ranged from –17.87 to 3.09 percent. The highest positive heterosis for this trait was observed in P_7 x P_8 (3.09%) followed by P_9 x P_{10} (1.62%). The highest value of significant negative heterosis was observed in P_3 x P_8 (–17.87 %). Singh *et al.* (1995) and Ahmad (2002) also reported heterosis for fruit length.

Fruit diameter (cm)

In the case of fruit diameter, eight crosses exhibited significant positive better parent heterosis, one combination exhibited no heterosis, but the rest of the crosses showed significant negative heterosis (Table 2). Heterosis for this trait ranged from –16.37 to 14.11 percent. The highest value of positive heterotic effect was exhibited by the cross P_3 x P_8 (14.11 %). The highest significant negative better parent heterosis was observed in P_7 x P_9 (–16.37 %). Heterosis for fruit breadth in tomato was also reported by Ahmad (2002) and Chaudhury and Khanna (1972).

Brix percent

Significant positive heterosis over better parent was observed for brix % in six crosses, one exhibited zero heterosis and others showed negative heterosis. Percent heterosis ranged from–29.12 to 13.11(Table 2). Highest positive heterosis was observed in P_1 x P_6 (13.11 %) and highest significant negative heterosis was obtained in P_{11} x P_{12} (– 29.12 %). Ahmad (2002) and Kurian *et al.* (2001) also reported heterosis for this trait in tomato.

Table 2. Percent heterosis over better parent in 19 tomato hybrids for yield component characters.

Crosses	Fruits/ plant	Fruit wt (g)	Yield/ plant (kg)	Fruit length (cm)	Fruit diameter (cm)	Brix %
P_1 X P_6	16.76 **	-10.00	5.21 **	-14.26 **	-5.15 **	13.11 **
P_1 X P_7	0.17	-7.80	28.76 **	-0.32	0.00	-13.63 **
P_1 X P_8	49.02 **	-10.00	43.11 **	-6.81 **	-8.45 **	2.07 **
P_2 X P_6	18.73 **	18.51 **	36.48 **	-6.97 **	9.22 **	4.46 **
P_2 X P_7	16.90 **	18.18 **	35.42 **	0.24	6.17 **	-9.08 **
P_2 X P_8	12.64 **	21.21**	25.64 **	-3.02 **	1.11 **	11.78 **
P_3 X P_6	30.71 **	-14.31 *	45.99 **	-16.57 **	8.06 **	1.14 *
P_3 X P_8	10.69 *	-1.55	26.70 **	-17.87 **	14.11 **	-7.57 **
P_4 X P_6	28.25 **	-24.31**	16.58 **	-10.36 **	-9.87 **	4.00 **
P_5 X P_6	67.44 **	-4.97	20.22 **	-11.91 **	-4.43 **	0.69
P_6 X P_7	-8.09	-2.91	-7.83 **	-17.44 **	-3.65 **	-6.48 **
P_6 X P_8	22.3 **	-15.74**	38.86 **	-3.94 **	-9.33 **	-9.73 **
P_6 X P_9	-8.61	-1.25	18.44 **	-13.98 **	-9.06 **	0.69
P_7 X P_8	8.62	-4.81	11.14 **	3.09 **	3.27 **	0.00
P_7 X P_9	-43.3 **	-19.48**	-20.83**	-9.13 **	-16.37 **	-20.76 **
P_9 X P_{10}	4.08	11.86 *	54.82 **	1.62 **	4.40 **	-23.60 **
P_{11} X P_{12}	-29.66**	-4.04	-21.74**	-6.03 **	-4.18 **	-29.12 **
P_{11} X P_{13}	23.56 **	-15.3 **	25.15 **	-3.54 **	1.82 **	-10.9 **
P_{11} X P_{14}	-5.15	-42.84**	1.53 **	-14.57 **	-10.05 **	-6.67 **
LSD(0.01)	12.31	15.08	1.01	0.50	0.50	1.33
LSD(0.05)	9.27	11.36	0.77	0.38	0.40	0.85

* Significant at 5 % level of probability

** Significant at 1 % level of probability

B. Fruit quality attributes

Fruit shape

Among the crosses, only two hybrids P_2 x P_6 and P_6 x P_9 produced slightly flattened, eleven produced round, five produced high round fruits. Only one hybrid produced heart shaped fruits (Table 3). Shape of fruits in tomato was also reported by Morimoto *et al.* (2000).

Pedicel area

Among the nineteen hybrid, only one was flat, the rest were depressed (Table 3). These results also support the findings of Butler (1936).

Shape of pistil scar

Of the nineteen crosses, six were dot, twelve were stellate and only one was linear shape (Table 3). Khan *et al*. (1981) reported similar shape.

Blossom end shape

Among the nineteen crosses, five were indented, fourteen were flat shaped (Table 3). Blossom end shape of fruits in tomato was also reported by Vander Knaap and Tanksley (2003).

Table 3. External fruit characters of 19 hybrids of tomato.

Crosses	Fruit shape	Pedicel Area	Shape of pistil scar	Blossom end shape
P_1 X P_6	Round	Depressed	Stellate	Flat
P_1 X P_7	Round	Depressed	Stellate	Flat
P_1 X P_8	Round	Depressed	Dot	Flat
P_2 X P_6	Slightly flattened	Depressed	Linear	Flat
P_2 X P_7	Round	Depressed	Stellate	Flat
P_2 X P_8	High round	Depressed	Stellate	Flat
P_3 X P_6	Round	Depressed	Stellate	Flat
P_3 X P_8	Round	Depressed	Stellate	Flat
P_4 X P_6	High round	Depressed	Dot	Flat
P_5 X P_6	Round	Depressed	Stellate	Flat
P_6 X P_7	Round	Depressed	Dot	Flat
P_6 X P_8	High round	Depressed	Dot	Indented
P_6 X P_9	Slightly flattened	Depressed	Stellate	Indented
P_7 X P_8	High round	Flat	Dot	Flat
P_7 X P_9	Round	Depressed	Stellate	Flat
P_9 X P_{10}	Round	Depressed	Stellate	Indented
P_{11} X P_{12}	Heart shaped	Depressed	Stellate	Flat
P_{11} X P_{13}	High round	Depressed	Dot	Indented
P_{11} X P_{14}	Round	Depressed	Stellate	Indented

Table 4. Internal fruit characters of 19 hybrids of tomato.

Crosses	Fruit firmness	Fruit fleshiness	Fruit seediness	No. of locules
P_1 X P_6	Good	Good	Medium	3
P_1 X P_7	Good	Good	Medium	4
P_1 X P_8	Good	Good	Less	6
P_2 X P_6	Medium	Good	Less	4
P_2 X P_7	Good	Good	Less	5
P_2 X P_8	Medium	Medium	Medium	4
P_3 X P_6	Medium	Medium	Medium	3
P_3 X P_8	Poor	Poor	Medium	4
P_4 X P_6	Good	Good	Less	3
P_5 X P_6	Medium	Medium	Medium	5
P_6 X P_7	Medium	Good	Less	7
P_6 X P_8	Good	Good	Less	3
P_6 X P_9	Good	Medium	Highly	6
P_7 X P_8	Good	Good	Medium	4
P_7 X P_9	Medium	Poor	Highly	6
P_9 X P_{10}	Poor	Poor	Highly	3
P_{11} X P_{12}	Good	Medium	Medium	4
P_{11} X P_{13}	Good	Medium	Medium	3
P_{11} X P_{14}	Good	Good	Less	3

Fruit firmness

Fruit firmness of eleven hybrids were found good, six were medium and two were poor (Table 4). These results also support the findings of Harker *et al*. (1997).

Fruit fleshiness

Fruit fleshiness of ten hybrids was good, six had medium and three had poor (Table 4). We observed that fruit fleshiness of most of the hybrids was better. Fruit fleshiness in tomato was also reported by Harker *et al*. (1997).

Fruit seediness

Among the crosses, seven were less seeded, nine were medium and three were high seeded (Table 4). These results also support the findings of Sako *et al*. (2001).

Locules per fruit

Among all the crosses, seven had three locules, six had four lucules, two had five, three had six and one had seven locules (Table 4). Kurian *et al.* (2001) also reported heterosis number of loculer per fruit.

Considering all the parameters, the cross combinations P_1 x P_8, P_2 x P_6, P_2 x P_7, P_2 x P_8, P_3 x P_8, P_5 x P_6 showed high heterotic performance with better desirable characters, so recommended for further studies as new varieties of commercial cultivation.

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