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Study of heterosis in different cross combinations of tomato for yield and yield components

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Abstract

Abstract

The purpose ofconducting present study was to evaluate the performance of different cross combinations of tomato for mid parent heterosis and better parent heterosis regarding yield and yield related traits. Forthe parameters: No of fruits/clusters, No of fruits/plants, Fruitweight, plant height and yield/plant,some of the combinations showed significant positive mid parent heterosis. No positive significant mid-parent heterosis was observed for the parameters like fruit length and fruit size. Significant better-parent heterosis was observed in some cross-combinations for the parameters: No of fruits/clusters, No of fruits/plants and yield/plant. While, no significant positive heterosis was observed for the parameters like fruit-length, fruit diameter,fruit size and fruit weight. For fruit length and fruit diameter all the combinations showed negative value of heterosis. Significant positive heterosis for yield/plant is great achievement in our study as yield/plant is the ultimate goal of tomato growers.

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Introduction

Tomato(Lycopercicum esculentum) belonging to Solanacea family is one of the most important vegetable crops of Pakistan, where it is consumed on daily basis and is co-cooked with vegetables ,meats and pulses and is cultivated on area of 52.30 thousand hectares with average production of 10.10 tons/hectare (Ramzan *et al.* 2014) . While, it is the world's second most important crops after potato.It contributes important components in human diet like potassium, phosphorous, magnesium and iron as well as antioxidants such as carotenoids, lycopene and phenolics. It is also source of vitamins like small amounts of ascorbic acid, vitamins B1, B6, PP vitamin and vitamin E. (Hasan *et al.*2014).

There is dire need to pay attention on increasing the yield of the crop keeping in view the increasing consumption requirements by the world population.Existing tomato cultivars may not retain the ability to yield at desired levels (Gul *et al* 2013) .Therefore ,tomato breeders are paying attention to develop more and more variations in the existing population and they are are also strugglingin developing vigorous hybrids by crossing different genotypes. The use of standard breeding methods in tomato throughout the last century has led to development of improved tomato cultivars and hybrids having high quality and yield attributes (Chattopadhyay 2012). The commercial exploitation of heterosis, however, was recorded first in1930s with maize in USA (Ahmad, 2002). The exploitation of heterosis in the breeding and development of crophybrids has made an enormous contribution to 20th century agriculture, although the genetic basis of the phenomenon remains unclear (Rood *et al.*, 1988). Geneticist and plant breeders described heterosis as the manifestation of greater vigour in height, leaf area, growth, dry matter accumulation, and yield in a F1 hybrid in comparison with the parents (Hageman *et al*, 1967). Since the discovery of hybrid vigour by Shull (1908) a tremendous progress has been made in the development of potential hybrids in tomato. Heterosis in tomato was first observed by Hedrick and Booth. (1968) .Although it is self-pollinated and autogamous species, however, hybrid-vigour can be exploited from it and seed production is easy (Singh *et al* 2012).Positive heterosis may be observed for the traits like yield/plant number of fruits/plant plant height etc however, there may be reduction in fruit size weight in some combinationwhile,overall increase in yield may be observed.Choudhary *et al.* (1965) also recommended the exploitation of heterosis for high yield in tomato.

In our research, our main focus is to estimate the degree of heterosis for yield and yield components for different cross combinations and to find the combination having highly yield potential to be used in further breeding progamme.

Materials and methods

Crossing

During the sowing season April 2013, seed of tomatovarieties (Newyaorker, Zhezha, Sashaaltai ,Nepoli, Continental, Bushbeef-steak,Riogrande and Nagina) was sown as nursery at Hazara Agricultural Research station Abbottabad and the plantlets were transplanted in the field in June 2013. The varieties started flowering after a month of transplantation and breeding work was initiated, consequently.Crosses were made among the varieties in the following combinations: Zhezha x Riograde, Nepoli x Newyorker, Sashaaltai x Nepoli, VCT1 x continental, Bushbeefsteak x Nangina Zhezha x Nagina and Continental x Nagina .The seed was collected from the successful crosses.

F1 evaluation

Then the collected F1 seed along with their parentalvarieties wassown as nursery at Agricultural Research Center Haripur(Sub Station of Hazara Agricultural Research Station) during the year January 2014 and plantlets weretransplanted in march 2014.Plant to plant distance was kept as 30 cm and Row –Row distance was 1m.While row length was kept as 2.5 meterusing RCBD design. The data was collected on the following parameters: No of flowers/cluster, No of fruits/cluster, Fruit weight(grams), Fruit diameter(cm) ,Fruit-length(cm) ,Fruit size (cm)·No of fruits/plant and yield/plant(grams).

Data analysis and calculation

Data was analyzed by using the soft-ware Statistix.8 . Mid- parent heterosis (MPH) was foundby using the following formula suggested by Fehr (1987).

MPH (%) = [F1-MP /MP]*100

Similarly, heterobeltiosis or better parent heterosis (BPH) was estimated by using the following formula.

BPH (%) = [F1-BP/BP]*100

Significance of mid and better parent heterosis was determinedbyusing the "t" test suggested by Wynne *et al.* (1970).

MP (t) = F1-MP/ √(3/2r)EMS

BP (t) =F1-BP/ √(2/r)EMS

Where F1 = Mean of the F1 hybrid for a specific trait, MP = midparent value for the cross, BP = Mean of better parent in the cross and EMS = Error mean square.

Results and discussions

All the parameters showed significant difference among the F1 and parental genotypes except flowers/cluster, where the difference was non-significant (Table-1).

Table 1. Mean Square values for flowers/cluster(fpc),No of fruits/cluster(frpc),fruit length(frl),fruit diameter(frd ,fruit size(frs),)plant height(pl.ht) ,no of fruits/plant(nof),fruit weight(fwt) and yield/plant(yield/pl) for parental genotypes and F1.

Source	df	fpc	frpc	frl	frd	frs	Pl.ht	nof	fwt	Yield/pl
treatment	1	3.55111	0.10928	0.43945	0.30225	45.6968	1.170	102.031	432.18	344948
replication	15	2.33523	2.19114	1.41176	1.71150	72.8207	240.833	389.304	1508.46	373722
error	15	2.18821	0.98268	0.10071	0.15555	5.1569	24.676	44.336	134.87	107341

Heterosis percentage also differed among the cross combinations for different parameters. ForNo of flowers/cluster, positive value of mid parents hetrosis was observed in all F1 combinations exceptcross combination Nepoli x Newyorker where the negative value of hetrosis was calculated i.e. -10.20 % (Table-2 and Table-3), while, among the 7 F1 combination only one cross combination VCT1 x continental showed highly significant value of mid parent heterosis i.e61.15 % and better parent heterosis i.e 60%.While, lowest value of better parent heterosis i.e -20% was calculated in cross combinations Zhezha x Nagina and Nepoli x Newyorker (table-4). Sekhar *et al.*(2010)also found the negative value of heterosis as well as significant positive heterosis in his study.

For No of fruits/cluster, mid parent negative hetrosis was shown by cross-combination :Nepoli x Newyorker (-2.43%) while 2 of 7 comibantions showed highly significant positive mid-parent heterosis and the highest heterosis% was observed in cross combination VCT1 x continental (81.81 % hetrosis)(table- 2 and table-3). Soleiman *et al.*(2013) also reported the range of hetrosis for the parameter from negative value to positive. While,3 of 7 combinations showed significant and highly significant positive heterosis over better parents, Bushbeefsteak x Nangina showing the highest value of better parent heterosis i.e. 100 % while lowest value was noted in combination Nepoli x Newyorker i.e -9.09% (table-2 and table-4).

Data for plant height indicates that cross

combinations Nepoli x Newyorker, VCT1 x continental and Bushbeefsteak xNangina showed negative value of mid parent heterosis for the parameter i.e -19.35, -17.94 and -3.35, respectively.

While,3 of the 7 combinations showed highly significant mid-parent heterosis for the parameter.Highest value of positive heterosis was observed in Sashaaltai x Nepoli i.e 37.47%(Table-2and Table-3).Kumari and Sharma(2011) also reported mid parent positive hetrosis for the parameter in most of the lines and negative hetrosis in some lines. 2 combinations exhibited highly significant value for better parent hetrosis , the combination Zhezha x Riogrande was noted with highest value i.e 26.96% . 5 combinations showed negative value of better-parent heterosis, the lowest value i.e -36.96 was noted in combination VCT1 x continental (Table-2 and Table-4),Ahmad*et al*(2011) reported better parent heterosis for maximum number of cross-combinations.

Table 2. Heterosis range and No of combinations showing Significant MPH and BPH.

Parameters	Mid parent heterosis% (MPH)		No of significant MPH	Better parent heterosis% (BPH)		No of significant BPH
	Min	Max		Min	Max	
No of flowers/cluster	-10.23 -	61.15	1	-20 -	60	1
No fruits/cluster	-2.43 -	81.81	2	-9.09 -	100	3
Fruit length	-89.49 -	-51.64	0	-34.40 -	-10.4	0
Fruit diameter	-29.52 -	18.60	2	-29.52 -	0	0
Fruit size	-34.73 -	5.69	0	-43.62 -	0	0
Plant height	-17.94 -	37.47	3	-36.96 -	26.95	1
No of fruits/plant	-49.53 -	127.11	4	-65.71 -	77.09	3
Average fruit weight	-47.31 -	31.59	1	-0.57 -	0.29	0
Yield/plant	-61.24 -	134.4	4	-72.77 -	111.82	3

Analyzed data for fruit weight revealed that only one combination i.e VCT1 x continental showed highly significant value for mid parent heterosis i.e 31.56 %. 4 out of 7 cross combinations showed negative value for mid parenthetrosis i.e Nepoli x Newyorker(-47.31%), Sashaaltai x Nepoli(-9.72%), Bushbeefsteak xNangina(-50.61%) and Continental x Nagina (-8.24%)(Table-2 and Table-4).None of the combination showed significant positive better parent heterois, the highest value was noted as 0.29% in cross combination VCT1 x continental while, in all other combinations negative value of heterosis over better parents was calculated, the lowest value i.e -0.57% was noted in combination Nepoli x Newyorker(Table-3 and Table-4).Agarwal *et al.* (2014) found positive and significant hetrosis for fruit weight and yield ,however, he did not report negative heterosis for any combination. While, in the findings of Soleiman *et al.*(2013) significant negative heterosis was found for the parameter.

Table 3. Mid parent Hetrosis %age for No flowers/cluster(fpc),No of fruits/cluster(frpc),fruit length(frl),fruit diameter(frd ,fruit size(frs),)plant height(pl.ht) ,no of fruits/plant(nof),fruit weight(fwt) and yield/plant(yield/pl).

S.NO	Hybrid combination	fpc	frpc	frl	frd	frs	Pl.ht	nof	fwt	Yield/pl
1	Zhezha x Riogrande	2.04	27.5	-51.64	8.11*	4.473	32.15**	49.65	8.03	34.60
2	Nepoli x Newyorker	-10.23	-2.43	-84.98	-29.52	-34.73	-19.35	-49.53	-47.31	-61.24
3	Sashaaltai x Nepoli	9.84	38.27	-89.49	-15.78	-26.72	37.47**	45.22**	-9.72	24.78
4	VCT1 x continental	61.15**	81.81**	-74.90	18.60**	5.69	-17.94	17.37	31.59**	41.84*
5	Bushbeefsteak x Nangina	23.07	65.51*	-62.38	0	-5.75	-3.35	80.76**	-50.61	89.11**
6	Zhezha x Nagina	3.36	4.76	-61.86	5.55	-1.140	5.73	127.11**	3.61	134.4**
7	Continental x Nagina	9.09	45.45	-64.95	-1.44	-4.68	26.13**	90.33**	-8.24	112.62**

*: Significant value of heterosis% at α=0.05.

**: Highly significant heterosis% at α=0.025.

for fruit diameter(cm)Significant negative value of mid parent hetrosis was calculated in three cross combinations Nepoli x Newyorker, Sashaaltai x Nepoli and Continental x Nagina i.e -29.52%,-15.78 and -1.44,respectively.While,cross-combination VCT1 x continental showed highly significant mid-parent heterosis i.e 18.60 % followed by cross-combination Zhezha x Riogrande, which showed significant hetrosis i.e 8.11 %(Table-2 and Table-4).While none of the cross-combinations showed positive heterosis for better parents and all the combinations fell in negative value except one combination.Minimum value for negative better parent heterosis was calculated in combination Nepoli x Newyorker i.e. -35.24%.(Table-3 and Table-4)Chauhan*et al.*(2014) also found negative heterosis in some combinations however his results are different from our results that he also found significant better parent heterosis and also in his study maximum number of lines showed heterosis for mid-parents.

Table 4. Better parent Hetrosis %age for flowers/cluster(fpc),No of fruits/cluster(frpc),fruit length(frl),fruit diameter(frd ,fruit size(frs),)plant height(pl.ht) ,No of fruits/plant(nof),fruit weight(fwt) and yield/plant(yl/pl).

S.NO	Hybrid combination	fpc	frpc	frl	frd	frs	Pl.ht	nof	fwt	Yl/pl
1	Zhezha x Riogrande	0	27.58	-10.4	-6.24	-3.66	26.95**	33.30	-0.14	21.19
2	Nepoli x Newyorker	-20	-9.09	-34.40	-35.24	-38.15	-15.99	-65.71	-0.57	-72.77
3	Sashaaltai x Nepoli	0	30.23*	-31.10	-18.18	-43.62	13.95**	42.38**	-0.20	5.51
4	VCT1 x continental	60**	33.33**	-23.88	0	0	-36.96	-14.79	0.29	19.91
5	Bushbeefsteak xNangina	20	100**	-11.04	-14.17	-15.49	-6.73	45.92*	-0.27	80.14**
6	Zhezha x Nagina	-20	-2.94	-12.90	-8.8	-9.57	-8.98	77.09**	-0.20	125**
7	Continental x Nagina	0	17.64	-12.90	-12.06	-6.89	-1.27	44.98	-0.20	111.82**

*: Significant value of heterosis% at α=0.05.

**: Highly significant heterosis% at α=0.025.

For fruit length (cm) all the F1 combinations showed negative value of mid-parent heterosis;lowest hetrosis(-89.49%) was found for the cross combination Sashaaltai x Nepoli (Table-2 and Table-3).All the combinations showed negative value for better parent heterosis ,the lowest value was found in combination Nepoli x Newyorker ie -34.40% (Table-2 and Table-4) .The result shows that there is tendency in decrease in fruit length and pear-shaped x round shaped combination bears round shaped fruits in all F1 generation which ultimately causes reduction in fruit length. But our findings do not match the results of Islam *et al.*(2012) who mentioned significant positive heterosis for the parameter.

Data for fruit size revealed that none of the lines showed significant mid parent and better parent heterosis for the parameter .For mid parent heterosis all the F1 lines showed negative value except two F1 combinations i.e Zhezha x Riogrande and VCT1 x Continentalin which the value of heterosis was found to be 4.47% and 5.69%, respectively , while minimum value of negative mid parent hetrosis was calculated to be -34.73% for cross combination Nepoli x Newyorker (Table-2 and Table-3) .All the combinations except VCT1 x continental showed negative value of heterosis over better parents.Lowest value of negative better parent heterosis was calculated in the combination Nepoli x Newyorker i.e -0.57% (Table-2 and Table-4). Chauhan*et al.* (2014) reported highly significant negative heterosis in his study for the parameter.The data shows that there is also decrease in fruit size in F1 generation.

Highly significant Positive hetrosis for No of fruits/plant over mid parents and better parents was noted in four and three combinations, respectively. Minimum value of mid parent heterosis was calculated in Nepoli x Newyorker i.e -49.53%(Table-2 and Table-3) ,While maximum value of mid parent and better parent hetrosiswas calculated in combination Zhezha x Nagina i. e 77.09% and 127.11% ,respectively and minimum value of heterosis over better parents was noted in combination Nepoli x Newyorker i.e -65.71%(Table-2 and Table-4). Dharamatti *et al.*(1996)also reported negative hetrosis however, in his finding majority of the crosses showed negative hetrosis and he also reported positive hetrosis for the parameter.

For yield/plant (grams)3 out of 7 combinations showed highly significant value of heterosis overe mid parents and better parents and one combination showed significant value.Only one F1 line showed negative value of hetrosis over mid parents i.e Nepoli x Newyorker for which value of hetrosis was calculated to be -61.24 % while highest value of hetrosis over mid parentswas observed in cross combination Zhezha x Nagina i.e134.4 % (Table-2 and Table-3) . Highest value of heterosis over better parents was noted incross combination Continental x Nagina i.e 111.82 while lowest value was calculated in the combination Nepoli x Newyorker i.e -72.77%(Table-2 and Table-4) .Gul *et al*(2010) also found significant and highly significant positive heterosis over mid parents and bettert parents in some combinations in his study.Although F1 generation shows decrease in fruit size however there is positive hetrosis for yield/plant, commonly.Patwary*et al.*(2013) reported significant heterosis for better parent in only one combination and he also reported negative value of better parent heterosis.

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