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Experiments in Hybridization to Develop Hill Specific Hybrids in Tomato (*Lycopersicon Esculentum* Mill.)

Pawan Kumar, Ajaya Paliwal

Department of Crop Improvement, College of Horticulture, VCSHUUHF, Bharsar

Abstract: **Six diverse tomato cultivars/ lines viz, Arka Saurabh, Arka Abha, Arka Meghali, Punjab Chhuhara, Best of All and Sioux, selected on the basis of high yield coupled with high quality, were crossed in a half diallel fashion to obtain fifteen cross combinations which were tested with two check cultivars HYB-Roop-666 and TS-15. Two crosses viz, Punjab Chhuhara x Best of All (15.82 %) and Arka Saurabh x Punjab Chhuhara (11.45 %) exhibited significantly positive heterobeltiosis for number of fruits per plant. Only two cross combinations viz, Best of All x Sioux (12.26%) and Arka Abha x Arka Meghali (11.32%) showed significant positive heterosis over better parent for fruits per cluster. While crosses, Arka Abha x Arka Meghali and Arka Meghali x Punjab Chhuhara showed significantly positive heterobeltiosis for fruit weight. Six cross combinations have significant estimates of heterobeltiosis in favourable direction for number of clusters per plant. Only one cross combination viz, Arka Meghali x Best of All (11.47%) resulted in significantly positive heterosis over the better parent for fruit length while four cross combinations comes up for fruit breadth. In the present studies, among the fifteen cross combinations, five crosses, viz., Arka Abha x Arka Meghali, Arka Abha x Punjab Chhuhara, Arka Meghali x Punjab Chhuhara, Arka Meghali x Best of All and Punjab Chhuhara x Best of All resulted in significant positive heterosis over better parent for fruit yield per plant. Maximum yield improvement was realized to the extent of 31.82% for the cross Punjab Chhuhara x Best of All.**

Keywords: **Tomato, heterosis, yield, hills.**

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) 2n=2x=24 is one of the most important vegetable crop grown widely all over the world. It is a member of *Solanaceae* family and is native to Central and South America (Vavilov, 1951). In the world, it ranks second in importance after potato but tops the list of processed vegetables (Chaudhary, 1996). It is a very good source of income for small and marginal farmers and also contributes to the nutrition of the consumer (Singh *et al.,* 2010). The ripe fruits are taken as raw or made into salads, soups, preserve, pickles, ketchup, puree, paste and many other products (Chadha, 2001).

Tomato is grown as autumn-winter, winter and spring-summer crop in many parts of country but owing to high temperature and rains, tomato cannot be grown commercially in the North Indian plains from May to October. In India, it occupied an area of 8.82 lakh hectares with a production of 18.73 million metric tonnes with an average productivity of 21.23 metric tonnes per hectare. It occupied second position among the vegetable crops in terms of production after potato. Uttarakhand is one of the tomato growing state covering an area of 9.08 thousand hectare with a production of 113.65 thousand metric tonnes and an average productivity of 12.51 metric tonnes per hectares (NHB 2013-14). The productivity level of the state is much lower to nation which further raised the need to develop location specific superior cultivars adapted for the region to meet the ever-increasing demand for this vegetable in fresh market and processing industries.

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Heterosis in tomato was first observed by Hedrick and Booth (1907) for higher yield and more number of fruits per plant. Subsequently, heterosis for yield and its component traits has been demonstrated by many workers (Wellington, 1912; Burdick, 1954; Daskalef *et al*., 1967). Larson and Currence (1944) observed that average yield of all tested F_1 hybrids was 39 % above the average yield of the parental lines. Power (1945) found that the mean value of total yield of red fruits of the hybrid surpassed by 60% of the mean value of the parental lines. It manifests in tomato in form of greater vigour, faster growth and development, earliness in maturity, increased productivity and higher levels of resistance to biotic and abiotic stresses. Tomato is a self-pollinated crop, the unusual high heterosis observed in it has been attributed to the fact that originally tomato was a highly cross pollinated genus which has later evolved into a self-pollinated one (Rick 1965).

Identification and selection of potential parental lines is required, which can be used in any hybridization programme to produce genetically improved and potentially rewarding germplasm by assembling fixable gene effects in a homozygous line. Exploitation of heterosis is primarily dependent on the screening and selection of available germplasm that could produce better combinations of important agronomic characters. The present study was under taken to estimate the extent of improvement in yield by heterosis in available in the cross combinations made.

2. MATERIALS AND METHODS

Six diverse tomato cultivars/ lines *viz*, Arka Saurabh, Arka Abha, Arka Meghali, Punjab Chhuhara, Best of All and Sioux were selected on the basis of high yield coupled with high quality, and crossed in a half diallel fashion to obtain fifteen cross combinations. The seedlings of parents were raised in November, 2013 and further transplanted in polyhouse to attempt crossing and generate F1. The seeds of crosses were harvested in April-June, 2014. The F1 seeds along with parents were planted during August, 2014 for their evaluation and generation of data. The seedlings were raised in August-2014 and transplanting of each entry in the block was done on 25th August-2014. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were twelve plants of each entry in each replication in a plot of 1.8 x 1.8 m^2 with a spacing of 60 cm x 45 cm. The standard cultural practices were followed to raise the tomato crop. Analysis of variance (ANOVA) was performed as explained by Gomez and Gomez (1983) while the heterosis was analysed and tested for significance as explained by Nadarajan & Gunasekaran (2012).

3. RESULT AND DISCUSSION

The analysis of variance for all the traits under study showed significant differences among parents and crosses. The magnitude of heterobeltiosis obtained for various yield and various yield attributing traits been presented character-wise in Table 1-4. The results obtained for different traits are described below:

Table 1: Estimates of heterosis for horticultural traits

Cross	Number of Fruits per plant	Number of fruits per cluster	Average fruits weight (g)	Number of fruit clusters per plant
Arka Saurabh x Arka Abha	-9.52	-3.49	5.05	12.11*
Arka Saurabh x Arka Meghali	2.78	-14.22*	-1.23	16.60*
Arka Saurabh x Punjab Chhuhara	11.45*	-2.42	-9.47	14.61*
Arka Saurabh x Best of All	4.76	0.08	1.37	25.84*
Arka Saurabh x Sioux	-4.76	3.40	8.52	-9.94
Arka Abha x Arka Meghali	-11.57*	11.32*	21.63*	-5.76
Arka Abha x Punjab Chhuhara	6.77	-10.04*	10.90	1.92
Arka Abha x Best of All	0.17	-3.09	13.04	0
Arka Abha x Sioux	-11.37*	-0.38	7.61	21.73*
Arka Meghali x Punjab Chhuhara	-1.05	-13.19*	26.70*	32.66*
Arka Meghali x Best of All	-5.10	6.61	-0.03	7.33
Arka Meghali x Sioux	-4.92	3.65	8.87	10.00
Punjab Chhuhara x Best of All	15.82*	-4.77	11.16	6.60
Punjab Chhuhara x Sioux	-7.99	1.21	-6.90	8.82
Best of All x Sioux	-0.53	12.26*	-2.58	1.33
SE(d)±	2.07	0.13	4.11	0.53

* Significant at 5% level

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Number of Fruits per Plant:

Number of fruits per plant is the most important component trait, which is directly related with increased fruit yield per plant. The heterosis over better parent ranged from -11.57 to 15.82 percent, with maximum in Punjab Chhuhara x Best of All. Only two crosses *viz*, Punjab Chhuhara x Best of All (15.82 %) and Arka Saurabh x Punjab Chhuhara (11.45 %) exhibited significant positive heterosis over better parent for this trait.

Positive heterosis over better parent for this trait has also been reported by Ahmed *et al.* (1988), Dev *et al.* (1994), Singh *et al.* (1995), Mirshamssi *et al.*(2006), Hannan *et al*. (2007), Rani and Veeraragavathatham (2008), Kumar *et al*. (2009), Kumari *et al*. (2010), Kumari and Sharma (2011), Ahmed *et al.* (2011).

Number of fruits per cluster:

The heterosis over better parent ranged from -14.22% (Arka Saurabh x Arka Meghali) to 12.26% (Best of All x Sioux). Only two cross combinations *viz*, Best of All x Sioux (12.26%) and Arka Abha x Arka Meghali (11.32%) showed significant positive heterosis over better parent.

Average fruits weight (g):

Average fruit weight is also a direct contributing trait to yield. Among the fifteen cross combinations, eleven crosses showed positive heterobeltiosis and out of them only two crosses showed significant positive heterobeltiosis for average fruit weight (g). The heterosis over better parent ranged from -9.47 to 26.70 percent, being lowest in Arka Saurabh x Punjab Chhuhara and highest in Arka Meghali x Punjab Chhuhara. The maximum significant positive heterobeltiosis was exhibited by the cross Arka Meghali x Punjab Chhuhara (26.70%) and Arka Abha x Arka Meghali (21.63%).

The significant heterobeltiosis estimates were obtained in two cross combinations namely, Arka Abha x Arka Meghali and Arka Meghali x Punjab Chhuhara.

For average fruit weight, expression of significant positive heterosis over better parent was corroborated with the findings of Singh *et al*. 2008, Ahmed *et al.* (1988), Pujari and Kale (1994), Mirshamssi *et al.*(2006), Hannan *et al.*(2007), Rani and Veeraragavathatham (2008), Kumar *et al.* (2009), Kumari *et al.* (2010), Gul *et al.* (2010), Ahmed *et al.* (2011), and Kumari and Sharma (2011).

Number of fruit clusters per plant:

Number of fruit clusters per plant is one of the important yield component. The range of heterobeltiosis for number of fruit clusters per plant varied from -9.94 % (Arka Saurabh x Sioux) to 32.66% (Arka Meghali x Punjab Chhuhara) and six cross combinations resulted in significantly positive heterobeltiosis. Similar trend was noticed by Sajjan (2001), Kulkarni (2003) and Duhan *et al.* (2005).

Table 2: Estimates of heterosis for horticultural traits

Cross	Plant height at last harvest (cm)	Fruit length (mm)	Fruit Breadth (mm)	Fruit yield per plants (g)
Arka Saurabh x Arka Abha	11.23	5.71	-5.80	-0.40
Arka Saurabh x Arka Meghali	20.72*	8.16	7.85*	4.37
Arka Saurabh x Punjab Chhuhara	35.88*	-4.31	-1.43	3.83
Arka Saurabh x Best of All	-8.70	3.79	-5.53*	4.55
Arka Saurabh x Sioux	6.31	1.33	10.24*	3.28
Arka Abha x Arka Meghali	13.00	-4.34	-11.47*	20.83*
Arka Abha x Punjab Chhuhara	14.34	-9.23*	-11.97*	29.23*
Arka Abha x Best of All	40.50*	6.75	-6.04*	14.37
Arka Abha x Sioux	10.29	-2.67	-8.99*	7.06
Arka Meghali x Punjab Chhuhara	10.66	-13.96*	4.34	30.99*
Arka Meghali x Best of All	-4.77	11.47*	4.51	17.47*
Arka Meghali x Sioux	11.52	-1.45	5.33*	-11.11
Punjab Chhuhara x Best of All	13.59*	-17.20*	-1.75	31.82*
Punjab Chhuhara x Sioux	11.91	-15.61*	8.05	-16.44*
Best of All x Sioux	10.22	0.30	0.56	1.01
SE(d)±	9.70	1.83	1.16	200.11

* Significant at 5% level

Plant height at last harvest (cm):

Taller plant is considered to be desirable because it leads to more number of branches and ultimately result in increased productivity. Heterosis over better parent for plant height at last harvest ranged from -8.70% (Arka Saurabh x Best of All) to 40.50% (Arka Abha x Best of All). Only four cross combinations *viz,* Arka Abha x Best of All (40.50%), Arka Saurabh x Punjab Chhuhara (35.88%), Arka Saurabh x Arka Meghali (20.72%) and Punjab Chhuhara x Best of All (13.59%) revealed significant positive heterosis over better parent.

Positive heterosis for this trait has also been reported by Dev *et al.*, (1994), Srivastava *et al.*, (1998), Thakur *et al.*, (2004), Mirshamssi *et al.*, (2006); Rani and Veeraragavathatham, (2008), Sharma and Thakur (2008), Kumari *et al.* (2010), Singh and Asati (2011), Kumari and Sharma (2011) and Ahmed *et al* (2011).

Fruit length (mm):

Fruit length is an important component of yield that directly contribute to yield in tomato. The heterosis over better parent for fruit length (mm) ranged from -17.20 % (Punjab Chhuhara x Best of All) to 11.47% (Arka Meghali x Best of All). Out of fifteen crosses, only one cross combination *viz,* Arka Meghali x Best of All (11.47%) resulted in significantly positive heterosis over the better parent. Mahendrakar. (2004) also reported heterosis in fruit length in tomato. Significant positive heterosis over better parent was also reported by Gul *et al.* (2010), Islam *et al*. (2012) and Singh *et al*. (2012).

Fruit breadth (mm):

The heterosis over better parent for fruit breath (mm) ranged from -11.97 % (Arka Abha x Punjab Chhuhara) to 10.24% (Arka Saurabh x Sioux). Out of fifteen crosses, only four cross combination, *viz.,* Arka Saurabh x Sioux (10.24%), Punjab Chhuhara x Sioux (8.05%), Arka Saurabh x Arka Meghali (7.85%) and Arka Meghali x Sioux (5.33%) resulted in significant positive heterosis over the better parent. Mahendrakar. (2004), Baishya *et al.* (2001), Gul *et al.* (2010) and Islam *et al*. (2012) and Singh *et al*. (2012) also reported heterosis on fruit breadth in tomato.

Fruit yield per plant (g):

The range of heterobeltiosis for yield per plant varied from -16.44% (Punjab Chhuhara x Sioux) to 31.82% (Punjab Chhuhara x Best of All). Out of fifteen cross combinations, five crosses *viz,* Punjab Chhuhara x Sioux (31.82%), Arka Meghali x Punjab Chhuhara (30.99%), Arka Abha x Punjab Chhuhara (29.23%), Arka Abha x Arka Meghali (20.83%) and Arka Meghali x Best of All (17.47%) resulted in significant positive heterosis over better parent.

The ultimate goal of any breeding programme is target to achieve maximization of yield. This is also the key factor in adoption or rejection of a variety or hybrid by the farmer.

In the present studies, among the fifteen cross combinations, five crosses, *viz*., Arka Abha x Arka Meghali, Arka Abha x Punjab Chhuhara, Arka Meghali x Punjab Chhuhara, Arka Meghali x Best of All and Punjab Chhuhara x Best of All resulted in significant positive heterosis over better parent. For fruit yield per plant, significant positive heterosis over better parent were also reported by Sharma and Thakur (2008), Rani and Veeraragavathatham (2008), Kumar *et al.* (2009), Kumari *et al.* (2010), Gul *et al.* (2010), Ahmed *et al.* (2011), and Kumari and Sharma (2011) and many other researchers.

4. CONCLUSION

Top three cross combinations for fruit yield per plant as per their *per se* performance were Arka Abha x Punjab Chhuhara, Arka Meghali x Punjab Chhuhara, Punjab Chhuhara x Best of All. For average fruit weight, Arka Abha x Arka Meghali, Arka Meghali x Punjab Chhuhara proved to be the best hybrids which have expressed significant positive results heterobeltiosis. Overall, hybrids have reported greater plant heights as compared to check and mid parents which indicate that heterosis can be exploited for further improving the plant heights. Finally, Arka Meghali x Punjab Chhuhara was regarded as the best cross combination which have significant favourable heterosis for most vitals yield attributing traits *i.e*. number of fruits per cluster and number of fruit clusters per plant.

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