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Heterosis Breeding for Quality Improvement in Hybrids to be Developed Specifically for Garhwal Hills in Tomato (*Lycopersicon esculentum* Mill.)

Pawan Kumar[1], Ajaya Paliwal[2]

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

Abstract: ***Tomato (Solanum lycopersicum L.),a solanaceae family vegetable, ranks second in importanceafter potato but tops the list of processed vegetables. Heterosis breeding is reliable and quick approach to gain maximum crop improvement. 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. Three cross combinations viz, Arka Meghali x Punjab Chhuhara, Arka Saurabh x Arka Abha and Arka Saurabh x Punjab Chhuhara resulted in significantly positive heterobeltiosis for pericarp thickness. For total soluble solids, positive and significant heterobeltiosis were observed in three cross combinations, viz, Arka Saurabh x Arka Meghali, Punjab Chhuhara x Best of All and Arka Meghali x Sioux. Best of All x Sioux and Punjab Chhuhara x Sioux showed highest significant positive heterosis over better parent for shelf life. While, for one of the most important quality trait lycopene content, Arka Saurabh x Arka Meghali, Arka Saurabh x Punjab Chhuhara, Arka Saurabh x Best of All and Arka Abha x Best of All resulted in significantly positive heterobeltiosis.Arka Saurabh x Arka Meghali was the best cross combination for Lycopene content and total soluble solids.***

Keywords: Tomato, heterosis, lycopene, TSS, shelf life, pericarp thickness

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 (NHB 2013-14). 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, it is imperative to develop such hybrids which are good in both yield and quality of the produce.

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 vigor, 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).

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 heterosis for quality traits like lycopene content, TSS and pericarp thickness in order to get better quality hybrids along with improved yield.

2. Materials and Methods

Six diverse tomato cultivars, *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 experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The seedlings were raised in August-2014

and transplanting of each entry in the block was done on 25th August-2014. 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 per 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 mean performance of fifteen F1 and the magnitude of heterosis over better parent has been presented character-wise in table given below and described as follows:

Table 1: Heterobeltiotic response for different quality traits in tomato

Cross	Pericarp Thickness (mm)	TSS (Brix°)	Shelf Life (days)	Lycopene (mg/100g)
Arka Saurabh x Arka Abha	24.57*	2.63	4.71	-13.59
Arka Saurabh x Arka Meghali	20.11	19.86*	5.26	46.80*
Arka Saurabh x Punjab Chhuhara	27.19*	5.66	1.14	58.10*
Arka Saurabh x Best of All	-3.44	-6.89	5.14	45.25*
Arka Saurabh x Sioux	16.44	8.33	-2.19	29.60
Arka Abha x Arka Meghali	11.08	8.55	-0.52	7.76
Arka Abha x Punjab Chhuhara	-0.96	8.29	-8.15	26.69
Arka Abha x Best of All	-14.93	-19.23	-1.71	36.40*
Arka Abha x Sioux	3.37	12.82	-8.43	-1.54
Arka Meghali x Punjab Chhuhara	28.29*	-11.53	-1.06	-7.97
Arka Meghali x Best of All	14.01	7.69	-5.66	-14.36
Arka Meghali x Sioux	4.50	32.26*	2.86	11.17
Punjab Chhuhara x Best of All	4.12	34.41*	-8.64	54.60*
Punjab Chhuhara x Sioux	3.18	0.40	14.19*	38.09
Best of All x Sioux	-17.50	11.53	15.17*	41.49*
SE(d)±	0.35	0.36	0.58	0.30

* Significant at 5% level

Pericarp thickness (mm)

Pericarp thickness has been globally identified as an important component for keeping quality and whole fruit firmness in tomato.For this trait, heterosis over better parent ranged from -17.50% (Best of All x Sioux) to 28.29% (Arka Meghali x Punjab Chhuhara). The three cross combinations*viz,* Arka Meghali x Punjab Chhuhara (28.29%), Arka Saurabh x Punjab Chhuhara (27.19%) and Arka Saurabh x Arka Abha (24.57%) resulted in significant positive heterosis over better parent. In the present studies, only three *viz,* Arka Meghali x Punjab Chhuhara, Arka Saurabh x Arka Abha and Arka Saurabh x Punjab Chhuhara gave significant positive heterosis estimates over better parent. Similar findings were also observed in the works of Kulkarni (2003), Prashanth (2004) and Kumar *et al.* (2006), Bhutani and Kalloo (1991), Ghosh *et al.* (1997), Uppal *et al.* (1997), and Gunasekera and Parera (1999).

Total soluble solids (^{0}Brix)

Total soluble solids content is one of the most important quality parameters in the processing industry. It represents the sum total of all fruit components other than water and volatile compounds.For this trait, heterobeltiosis ranged from -19.23% (Arka Abha x Best of All) to 34.41% (Punjab Chhuhara x Best of All). Three cross combination*viz,* Punjab Chhuhara x Best of All (34.41%), Arka Meghali x Sioux (32.26%) and Arka Saurabh x Arka Meghali (19.86%) resulted in significant positive heterosis over better parent. Positive heterosis for this trait has also been reported by Legon *et al.* (1984), Bhatt *et al.* (1998), Gunasekera and Parera (1999), Bhatt *et al.* (2001), Joshi and Thakur (2003), Tiwari and Lal (2004), Singh *et al.*(2005a), Anita *et al.* (2005), Hannan *et al*. (2007) and Kumari and Sharma (2011).

Shelf life

Shelf life has been globally identified as an important component of keeping quality and whole fruit firmness in tomato. The heterosis over better parent for shelf life ranged from –8.64 to 15.17 percent, maximum in Best of All x Sioux. Out of fifteen cross combinations, two crosses *viz*, Best of All x Sioux (15.17%) and Punjab Chhuhara x Sioux (14.19 %) exhibited significantly positive heterobeltiosis.The significant positive heterosis over mid and better parent for shelf life was also observed by Premalakshmi *et al*. (2002) and Reddy and Reddy (1994), Patwary *et al*. (2013) and Yadav *et al*. (2013)

Lycopene Content (mg/100g)

Lycopene content, a quality parameter of vital importance in the processing industry and in the marketing the tomato. For this trait, heterobeltiosis ranged from -14.36 % (Arka Meghali x Best of All) to 58.10 % (Arka Saurabh x Punjab Chhuhara). Among the fifteen cross combinations five crosses *viz,* Arka Saurabh x Punjab Chhuhara (58.10 %), Punjab Chhuhara x Best of All (54.60%), Arka Saurabh x Arka Meghali (46.80%), Arka Saurabh x Best of All (45.25%) Arka Abha x Best of All (36.40%) resulted in significant positive heterosis over better parent. The significant positive heterosis over better parent for lycopene was also observed by Kumar *et al*. (2013), Dagade *et al.* (2015), Pemba *et al*. (2014), Kumar *et al.* (2006) and Singh *et al.* (2013).

4. Conclusion

Arka Saurabh x Arka Meghali was proved to be the best cross combination for quality traits,lycopene content and total soluble solids, as it have positive and significant heterobeltiosis. Three cross combinations which have expressed maximum significant pericarp thickness are Arka Saurabh x Arka Abha, Arka Meghali x Punjab Chhuhara and Arka Saurabh x Punjab Chhuhara but significant improvement in shelf life of cross combinations was observed in Punjab Chhuhara x Sioux and Best of All x Sioux.

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