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Hybridization experiment in tomato for the improvement in vital quality traits under near temperate conditions of Garhwal Himalaya

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Abstract

In the present study, total 23 entries consisting of six diverse parental tomato cultivars viz, ArkaSaurabh, ArkaAbha, ArkaMeghali, Punjab Chhuhara, Best of All and Sioux, and their 15 hybrids obtained half diallel fashion crosses including onecheck cultivars TS-15 were grown in 2013-14 for the analysis of all three types of hereosis.Three cross combinations viz, ArkaMeghali x Punjab Chhuhara, ArkaSaurabh x ArkaAbha and ArkaSaurabh x Punjab Chhuhara resulted in significantly positive heterosis over mid parent, better parent, check cultivar for pericarp thickness. For total soluble solids, positive and significant heterosis over mid, better and check were observed in three cross combinationsviz,ArkaSaurabh x ArkaMeghali, Punjab Chhuhara x Best of All and ArkaMeghali x Sioux. Best of All x Sioux and Punjab Chhuhara x Sioux showed highest significant positive heterosis over mid parent, better parent, check cultivar for shelf life. While, for one of the most important quality trait lycopene content, ArkaSaurabh x ArkaMeghali, ArkaSaurabh x Punjab Chhuhara, ArkaSaurabh x Best of All and ArkaAbha x Best of All resulted in significantly positive heterosis of all types analysed.ArkaSaurabh x ArkaMeghali was the best cross combination for Lycopene content and total soluble solids.

Keywords: Tomato, Heterosis, quality, breeding, lycopene

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).

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 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).

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. The present study was under taken to estimate the extent of heterosis for quality traits like lycopene content, TSS, shelf life and pericarp thickness in order to get better quality hybrids.

Materials and methods

Six diverse tomato cultivars*viz*, ArkaSaurabh, ArkaAbha, ArkaMeghali, 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 seeds for F1.The seeds of crosses were harvested in April-June, 2014. The F1 seeds along with parents and two check hybrid varieties TS-15 (Commercial F1 hybrids from Ocean Crop Sciences) 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).

Results 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 mid parent, over better parent check cultivar TS-15, respectively have been presented character-wise in Table 1 and 2. The results obtained for different traits are described below:

Table 1: Heterotic response for pericarp thickness and TSS in tomato.

Cross	Pericarp Thickness (mm)			Total Soluble Solids (^{0}Brix)		
	MP	BP	CC	MP	BP	CC
ArkaSaurabh x ArkaAbha	35.48*	24.57*	37.71*	3.00	2.63	8.32
ArkaSaurabh x ArkaMeghali	26.83*	20.11	11.35	20.47*	19.86*	25.57*
ArkaSaurabh x Punjab Chhuhara	30.02*	27.19*	23.33*	10.20	5.66	20.64*
ArkaSaurabh x Best of All	0.54	-3.44	-10.38	7.92	-6.89	34.36*
ArkaSaurabh x Sioux	21.10*	16.44	17.07	10.05	8.33	17.25*
ArkaAbha x ArkaMeghali	27.18*	11.08	22.89*	9.42	8.55	14.48
ArkaAbha x Punjab Chhuhara	5.51	-0.96	9.40	12.62	8.29	23.72*
ArkaAbha x Best of All	-3.98	-14.93	-5.94	-6.72	-19.23	16.48
ArkaAbha x Sioux	8.41	3.37	14.37	14.26*	12.82	22.18*
ArkaMeghali x Punjab Chhuhara	38.46*	28.29*	24.40*	-7.21	-11.53	1.07
ArkaMeghali x Best of All	15.82	14.01	-2.57	25.29*	7.69	55.31*
ArkaMeghali x Sioux	14.61	4.50	5.05	35.02*	32.26*	43.14*
Punjab Chhuhara x Best of All	10.65	4.12	0.88	18.78*	34.41*	53.46*
Punjab Chhuhara x Sioux	4.89	3.18	3.54	3.04	0.40	14.63
Best of All x Sioux	-10.78	-17.50	-17.03	-4.33	11.53	20.80*
SE(d)±	0.30	0.35	0.35	0.31	0.36	0.36

* Significant at 5% level, BP-Better Parent, MP-Mid Parent, CC-Check Cultivar

Table 2: Heterotic response for shelf life in tomato.

Cross	Shelf Life (Days)			Lycopene Content (mg/100g)		
	MP	BP	CC	MP	BP	CC
ArkaSaurabh x ArkaAbha	6.82	4.71	-1.63	-7.33	-13.59	11.11
ArkaSaurabh x ArkaMeghali	7.14	5.26	-1.63	50.63*	46.80*	72.24*
ArkaSaurabh x Punjab Chhuhara	6.59	1.14	1.63	90.93*	58.10*	76.60*
ArkaSaurabh x Best of All	8.23	5.14	0.54	62.35*	45.25*	61.85*
ArkaSaurabh x Sioux	1.45	-2.19	-4.91	42.37*	29.60	44.88*
ArkaAbha x ArkaMeghali	-0.29	-0.52	-6.55	12.67	7.76	38.16*
ArkaAbha x Punjab Chhuhara	-5.05	-8.15	-7.65	61.63*	26.69	62.87*
ArkaAbha x Best of All	-0.86	-1.71	-6.01	62.17*	36.40*	75.08*
ArkaAbha x Sioux	-6.85	-8.43	-10.92*	14.49	-1.54	26.32
ArkaMeghali x Punjab Chhuhara	2.53	-1.06	-0.54	13.67	-7.97	8.21
ArkaMeghali x Best of All	-4.62	-5.66	-9.83*	-1.89	-14.36	0.45
ArkaMeghali x Sioux	4.87	2.86	0	25.06	11.17	30.65
Punjab Chhuhara x Best of All	-6.40	-8.64	-8.19	69.12*	54.60*	36.21
Punjab Chhuhara x Sioux	16.02*	14.19*	14.75*	53.25*	38.09	26.61
Best of All x Sioux	16.14*	15.17*	12.02*	44.24*	41.49*	29.55
SE(d)±	0.50	0.58	0.58	0.26	0.30	0.30

* Significant at 5% level, BP-Better Parent, MP-Mid Parent, CC-Check Cultivar

Pericarp thickness (mm)

Pericarp thickness determined keeping quality and whole fruit firmness in tomato, that further help in protecting the tomato during transportation to markets. The heterotic effects of pericarp thickness over mid parent ranged from -10.78% to 38.46%. The minimum was recorded in cross Best of All x Sioux and the maximum in ArkaMeghali x Punjab Chhuhara. The six cross combinations*viz,*ArkaMeghali x Punjab Chhuhara (38.46%), ArkaSaurabh x ArkaAbha (35.48%), ArkaSaurabh x Punjab Chhuhara (30.02%) ArkaAbha x ArkaMeghali (27.18%), ArkaSaurabh x ArkaMeghali (26.83%) and ArkaSaurabh x Sioux (21.10%) resulted in significant positive heterosis over mid parent.

For this trait, heterosis over better parent ranged from -17.50% (Best of All x Sioux) to 28.29% (ArkaMeghali x Punjab Chhuhara). The three cross combinations *viz,* ArkaMeghali x Punjab Chhuhara (28.29%), ArkaSaurabh x Punjab Chhuhara (27.19%) and ArkaSaurabh x ArkaAbha (24.57%) resulted in significant positive heterosis over better parent.

The economic heterosis varied from -17.03% (Best of All x Sioux) to 37.71% (ArkaSaurabh x ArkaAbha). Significant positive heterosis over the check was shown by four cross combinations *viz,*ArkaSaurabh x ArkaAbha (37.71%), ArkaMeghali x Punjab Chhuhara (24.40%), ArkaSaurabh x Punjab Chhuhara (23.33%) and ArkaAbha x ArkaMeghali (22.89%).

In the present studies, six cross combinations exhibited positive significant heterosis over mid parent while only three *viz,* ArkaMeghali x Punjab Chhuhara, ArkaSaurabh x ArkaAbha and ArkaSaurabh x Punjab Chhuharagave significant positive heterosis estimates over better parent and Check cultivar.

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 solids other volatile compounds. Among the fifteen cross combinations, twelve crosses showed positive mid parent heterosis out of which five crosses were significantly positive. The heterosis over mid parent ranged from -7.21% (ArkaMeghali x Punjab Chhuhara) to 35.02% (ArkaMeghali x Sioux). The significantly positive heterosis was observed in the crosses ArkaMeghali x Sioux (35.02%), ArkaMeghali x Best of All (25.29%), ArkaSaurabh x ArkaMeghali (20.47%), Punjab Chhuhara x Best of All (18.78%) and ArkaAbha x Sioux (14.26%).

For this trait, heterobeltiosis ranged from -19.23% (ArkaAbha 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%), ArkaMeghali x Sioux (32.26%) and ArkaSaurabh x ArkaMeghali (19.86%) resulted in significant positive heterosis over better parent.

Standard heterosis ranged from 1.07% (ArkaMeghali x Punjab Chhuhara) to 55.31% (ArkaMeghali x Best of All). Significant positive heterosis over the check cultivar was revealed by nine and ten cross combinations, respectively.

Positive significant heterosis over mid, better and check were observed in three cross combinations *viz,* ArkaSaurabh x ArkaMeghali, Punjab Chhuhara x Best of All and ArkaMeghali x Sioux 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 represents the keeping quality and whole fruit firmness in tomato. The mid parent heterosis for shelf life varied from -6.85 % (ArkaAbha x Sioux) to 16.14 % (Best of All x Sioux). Out of fifteen cross combinations, nine crosses showed positive heterosis over mid parent but only two crosses *viz,* Best of All x Sioux (16.14 %) and Punjab Chhuhara x Sioux (16.02 %) showed significant positive heterosis over mid parent.

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 increase or decrease over in standard heterosis ranged from -10.43 % (ArkaAbha x Sioux) to 15.38 % (Punjab Chhuhara x Sioux). Out of fifteen cross combinations, two crosses *viz,* Best of All x Sioux and Punjab Chhuhara x Sioux showed highest significant positive heterosis over mid parent, better parent, check cultivar.

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 of tomato showed decent level of heterosis in the present study. The magnitude of mid parent heterosis for lycopene content (mg/100g) ranged from -1.89 % (ArkaMeghali x Best of All) to 90.93 % (ArkaSaurabh x Punjab Chhuhara). Out of fifteen cross combinations, fourteen crosses showed positive heterosis over mid parent and out of them only nine crosses showed significantly positive heterosis over mid parent.

For this trait, heterobeltiosis ranged from -14.36 % (ArkaMeghali x Best of All) to 58.10 % (ArkaSaurabh x Punjab Chhuhara). Among the fifteen cross combinations five crosses *viz*,ArkaSaurabh x Punjab Chhuhara (58.10 %), Punjab Chhuhara x Best of All (54.60%), ArkaSaurabh x ArkaMeghali (46.80%), ArkaSaurabh x Best of All (45.25%) ArkaAbha x Best of All (36.40%) resulted in significant positive heterosis over better parent.

The estimates of standard heterosis over the check cultivar ranged from 0.45 % (ArkaMeghali x Best of All) to 76.60% (ArkaSaurabh x Punjab Chhuhara). Among the fifteen cross combinations, six crosses showed significantly positive heterosis over the Check.

It was observed to have nine cross combinations with significant positive heterosis over mid parent. Among the fifteen cross combination five cross combinations *viz,* ArkaSaurabh x ArkaMeghali, ArkaSaurabh x Punjab Chhuhara, ArkaSaurabh x Best of All, ArkaAbha x Best of All and Punjab Chhuhara x Best of All resulted in significant positive heterosis over better parent. Seven crosses showed significant positive heterosis over the check cultivar, F1 TS-15. The significant positive heterosis over better parent and standard heterosis 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).

ArkaSaurabh x ArkaMeghali was proved to be the best cross combination for quality traits,lycopene content and total soluble solids, as it have positive and significant heterosis of all three types. Three cross combinations which have expressed significant heterosis of all three kinds for pericarp thickness are ArkaSaurabh x ArkaAbha, ArkaMeghali x Punjab Chhuhara and ArkaSaurabh 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 as they have significant positive heterosis of all three types.

Conflict of Interest: None

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