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Heterosis breeding for quality improvement in tomato (Lycopersiconesculentum Mill.) for cultivation in mid hills of Uttarakhand

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***Abstract*— Tomato (SolanumlycopersicumL.), an annual vegetable,second in production after potato of solanaceae family. Tomato is number one in processed vegetables. For the improvement in the genetic architecture, Heterosis breeding is most popular and successful approach in tomato. For the present study, six diverse tomato cultivars viz, ArkaSaurabh, ArkaAbha, ArkaMeghali, 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. 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, for pericarp thickness. For total soluble solids, positive and significant heterosis over mid and better parents were observed in three cross combinations viz,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 and better parentfor 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 better parent and mid parent heterosis.ArkaSaurabh x ArkaMeghali was the best cross combination for Lycopene content and total soluble solids.**

***Index Terms*— Heterosis, Lycopene, Shelf Life,Tomato,TSS.**

I. INTRODUCTION

Tomato (SolanumlycopersicumL.) 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 verygood source of income for small and marginal farmers andalso 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. 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.Hybrids which better in both yield and quality is need of the hour to provide better marketing opportunities to the marginalised farmers of hills.

Heterosis in tomato was first observed by Hedrick and Booth (1907) for higher yield and more number of fruits per plant. It manifests in tomato in form of greater vigor, faster growth and development, earliness in maturity, increased productivity, improved quality 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).

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 along with improved yield.

II. MATERIALS AND METHODS

Six diverse tomato cultivarsviz, 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 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. Two checks were taken to get maximum accuracy in estimation of heterosis which is commercially utilizable. 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 m2 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).

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III. RESULT AND DISCUSSION

The analysis of variance for all the traits under study showed significant differences among parents and crosses. The performance of fifteen F1, the magnitude of heterosis over mid parent and better parent has been presented character-wise in Table 1. The results obtained for different traits are described below:

Table 1: Heterotic response for pericarp thickness (mm) in tomato

Crosses	Pericarp Thickness (mm)		Total Soluble Solids		Shelf Life		Lycopene	
	MP	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
ArkaSaurabh x ArkaAbha	35.48*	24.57*	3.00	2.63	6.82	4.71	-7.33	-13.59
ArkaSaurabh x ArkaMeghali	26.83*	20.11	20.47*	19.86*	7.14	5.26	50.63*	46.80*
ArkaSaurabh x Punjab Chhuhara	30.02*	27.19*	10.20	5.66	6.59	1.14	90.93*	58.10*
ArkaSaurabh x Best of All	0.54	-3.44	7.92	-6.89	8.23	5.14	62.35*	45.25*
ArkaSaurabh x Sioux	21.10*	16.44	10.05	8.33	1.45	-2.19	42.37*	29.60
ArkaAbha x ArkaMeghali	27.18*	11.08	9.42	8.55	-0.29	-0.52	12.67	7.76
ArkaAbha x Punjab Chhuhara	5.51	-0.96	12.62	8.29	-5.05	-8.15	61.63*	26.69
ArkaAbha x Best of All	-3.98	-14.93	-6.72	-19.23	-0.86	-1.71	62.17*	36.40*
ArkaAbha x Sioux	8.41	3.37	14.26*	12.82	-6.85	-8.43	14.49	-1.54
ArkaMeghali x Punjab Chhuhara	38.46*	28.29*	-7.21	-11.53	2.53	-1.06	13.67	-7.97
ArkaMeghali x Best of All	15.82	14.01	25.29*	7.69	-4.62	-5.66	-1.89	-14.36
ArkaMeghali x Sioux	14.61	4.50	35.02*	32.26*	4.87	2.86	25.06	11.17
Punjab Chhuhara x Best of All	10.65	4.12	18.78*	34.41*	-6.40	-8.64	69.12*	54.60*
Punjab Chhuhara x Sioux	4.89	3.18	3.04	0.40	16.02*	14.19*	53.25*	38.09
Best of All x Sioux	-10.78	-17.50	-4.33	11.53	16.14*	15.17*	44.24*	41.49*
SE(d)±	0.30	0.35	0.31	0.36	0.50	0.58	0.26	0.30

A. Pericarp thickness (mm)

Pericarp thickness has been globally identified as an important component for keeping quality and whole fruit firmness in tomato. 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 combinationsviz, 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 combinationsviz,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. In the present studies, six cross combinations exhibited positive significant heterosis over mid 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), Uppalet al. (1997), and Gunasekera and Parera (1999).

B. Total soluble solids (0Brix)

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.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 combinationviz, 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.

Positive significant heterosis over mid and better parent 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 Legonet 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.(2005), Anita et al. (2005), Hannanet al. (2007) and Kumari and Sharma (2011).

C. Shelf life

Shelf life has been globally identified as an important component of 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 crossesviz, 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 Alx 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 Premalakshmiet al. (2002) and Reddy and Reddy (1994), Patwaryet al. (2013) and Yadav et al. (2013)

D. Lycopene Content (mg/100g)

Lycopene content, a quality parameter of vital importance in the processing industry and in the marketing the tomato. The magnitude of 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.

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. The significant positive heterosis over better parent and standard heterosis for lycopene was also observed by Kumar et al. (2013), Dagadeet 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 for both mid and better parent. Three cross combinations which have expressed significant heterosis of both 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 both types.

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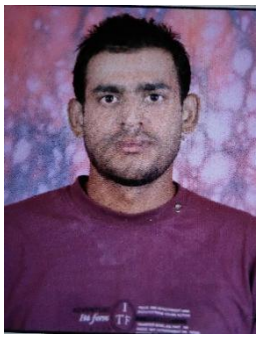

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