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Estimation of Heterosis and Combining Ability in Tomato for Fruit Shelf Life and Yield Related Traits Using the Line X Tester Crossing Method

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ABSTRACT

Four commercial varieties and one germplasm accession were crossed with two testers in line x tester mating fashion to study combining ability effects and heterosis for plant height, number of branches, fruit per cluster, single fruit weight, total number of fruits per plant, fruit shelf life and total yield per plant during summer 2014 at UAS, GKVK, Bengaluru. The analysis of variance revealed the variation in lines effects and crosses were highly significant for fruit shelf life (days). In respect of GCA effects, it was found that Arka Alok had highest for shelf life and L121 had highest for total yield per plant. Among the crosses, Vaibhav × 1 Tester (RIL-160) and L121*×2 Tester (RIL-108) were the most valuable combiners for fruit shelf life and total yield per plant. Thus these two cross combination revealed good potential to be used as hybrid. The highest heterotic effect over mid parent were exhibited by the cross Vaibhav × 1 Tester, Arka Alok × 1 Tester and Arka Alok × 2 Tester for both characters.

IN India the post-harvest losses of tomatoes account for 13-26 per cent of the total produce which is major constraints to achieve the global production level (Kalidas and Akila, 2014). Post harvest losses are due to perishable nature of crop, method of harvesting, packaging and transportation etc. There are many approaches to reduce the tomatoes perishablity like early harvesting, exploiting mutant lines, Gene silencing and metabolomic approach. Exploration of genetic diversity within the available germplasm is a viable and environmentally safe option for improv-ing shelf life (Kramer and Redenbaugh, 1994; Xiong *et al*., 2005; Qaim, 2009; Batra *et al*., 2010; Meli *et al.,* 2010). Kopeliovitch *et al.* (1979) have used several ripening gene mutants, such as alcobaca (*alc*), non-ripening (*nor*), never ripe, and ripening inhibitor (*rin*) to develop lines and cultivars with delayed ripening through disruption of the ethylene signaling pathway. Considering this, in this study an investigation was undertaken to identify the best parental combination having extended shelf life with high yield per plant in tomatoes.

In this study we used two recombinant inbred lines 160 and 108 which have shown very high shelf life (more than 50 days) at room temperature. The tomato RILs 160 and 108 derived from L121 (*alc* line) X Vaibhav cross were selected by single seed descent method and used as testers. We have selected five tomato lines out of which four cultivar which have high yielding but poor shelf-life Sankranti (19 days), Pusa Ruby (14 days), Vaibhav (18 days), Arka Alok (21 days) and one high shelf-life *alc* line (44 days) Yogendra and Gowda, (2013) used as parental lines. Each lines were crossed with tester 1(RIL-160) and tester 2 (RIL-108) and total ten F_1 Hybrids developed using the line x tester (5 x 2) mating design during *rabi* 2013.

The 25 days old seedlings of 10 F_1 hybrids along with parents and two standard checks (NS2535 and INDAM 1004) were grown at UAS, GKVK, Bengaluru during *summer* 2014 in randomized block design, replicated thrice. DNA was isolated by CTAB method and true hybrids were confirmed by morphological and SSR Markers. The observations were recorded on five randomly selected plants from each replication for *viz.,* plant height (cm), number of branches, fruits per cluster, single fruit weight (g), total number of fruits per plant, fruit shelf life (days) and total yield per plant (g/plant). The data were subjected to combining ability analysis following Kempthorne (1957).

Analysis of variance for combining ability revealed that the variance due to lines effects were highly significant (@ P = 0.01) for fruit shelf life (days) whereas, mean squares due to testers were non-significant for all traits under study, since both testers have been derived from same parent and selected for high shelf life, fruit shape and single fruit weight. While the variance due to line x tester effects were highly significant (@P = 0.01) for plant height (cm), number of branches and fruit per cluster under study there is no substantial genetic diversity observed for fruit shelf life, single fruit weight and total fruit yield because all the crosses recorded increased fruit shelf life and fruit yield. In crosses the significant variance observed for plant height, number of branches, fruits per cluster and fruit shelf life.

General combining ability refers to the average performance of a line in a series of cross combinations and it is attributable to additive (fixable) gene action.

The estimates of GCA effects provide a measure of general combining ability of each genotype, thus aids in selection of superior ones as parents for breeding programmes. The line Arka Alok registered highest GCA effect for fruit shelf life, fruit per cluster and plant height while Pusa Ruby recorded lowest GCA effect for fruit shelf-life (Table I). Among testers, RIL 108 registered positive GCA effect for fruit shelf life, plant height and fruit per cluster, whereas RIL 160 exhibited positive GCA effects for total number of fruits, total yield per plant, single fruit weight and number of branches. None of the testers were found to be good general combiner for all the characters studied. Comprehensive assessment of parents considering GCA effects for overall characters studied has resulted into identification of lines Arka Alok and Vaibhav as good general combiners for overall characters. Among testers, RIL 108 for shelf life and RIL 160 for yield per plant are good general combiners. Hence, these can be utilized in commercial breeding programme as good donors for yield and fruit shelf life. In another study, Yogendra and Gowda, (2013) observed *alc* is good general combiner with Vaibhav for fruit firmness and fruit shelf life. The specific combining ability (SCA) reveals the best cross combination among the genotypes which can be useful

TABLE I

Estimates of General combining ability (GCA) effects of lines and testers for fruit shelf life and yield associated traits in tomato

Lines	Plant Height	Number of Branches	Fruit Per Cluster	Single Fruit Weight	Total No. of Fruits	Shelf life	Total Yield
Sankranti	5.57	0.80 **	-0.50 **	0.10	-3.70	0.17	-158.66
Pusa Ruby	7.73	-0.53		-8.57	6.13	-9.83 ***	-339.33
Vaibhav,	-11.10 *	1.13 ***	0.33	2.10	-0.53	1.83	-19.33
Arka Alok	-1.10	-1.20 ***	0.50 **	-0.73	-9.03*	4.33 *	222.66
L121	-1.10	-0.20	-0.33	7.10	7.13	3.50	294.66
SE	4.93	0.28	0.17	5.36	4.28	1.73	171.00
			Tester				
(RIL-160)	3.40	0.17	-0.20	2.40	3.73	-0.50	144.03
(RIL-108)	-3.40	-0.17	0.20	-2.40	-3.73	0.50	-144.03
SE	3.12	0.17	0.10	3.39	2.71	1.09	108.15

*Significant at 5% level, ** Significant at 1% level and ***Significant at 0.1% level

TABLE II

Estimates of specific combining ability (SCA) of lines and testers for fruit shelf life and yield associated traits in tomato

Crosses	Plant Height	Number of Branches	Fruit Per Cluster	Single Fruit Weight	Total No.of Fruits	Shelf life	Total Yield
Sankranti * 1 Tester	-0.90	-2.33 ***	-0.30	6.10	-2.57	-1.16	161.80
Sankranti * 2 Tester	0.90	2.33 ***	0.30	-6.10	2.57	1.16	-161.80
Pusa Ruby * 1 Tester	-3.07	1.00 *	0.20	6.77	5.60	0.50	91.47
Pus Ruby* 2 Tester	3.06	-1.00 *	-0.20	-6.77	-5.60	-0.50	-91.47
Vaibhav * 1 Tester	15.77 *	0.00	-0.13	-2.23	5.27	2.17	201.13
Vaibhav * 2 Tester	-15.77 *	0.00	0.13	2.23	-5.27	-2.17	-201.13
Arka Alok * 1 Tester	-7.57	0.67	-0.30	3.60	0.43	-0.33	-141.20
Arka Alok * 2 Tester	7.57	-0.67	0.30	-3.60	-0.43	0.33	141.20
L121 * 1 Tester	-4.23	0.67	0.53 *	-14.23	-8.73	-1.17	-313.20
L121 * 2 Tester	4.23	-0.67	-0.53 *	14.23	8.73	1.17	313.20
CD 95% SCA	14.65	0.82	0.50	15.94	12.73	5.14	508.07

*Significant at 5% level, ** Significant at 1% level and ***Significant at 0.1% level

for developing hybrids with high vigor for the traits. Results revealed that there was no significant SCA effect for fruit shelf life and total yield per plant. In four cross combination *viz.*, Pusa Ruby × 1 Tester, Vaibhav × 1 Tester, Arka Alok × 2 Tester and L121 × 2 Tester have found positive SCA value for both characters of fruit shelf life and total yield (Table II).

All of the crosses recorded significant positive heterosis as well as standard heterosis for fruit shelf life except Pusa Ruby × 1 Tester and Pusa Ruby × 2 Tester. For total yield only cross, L121 × 2 Tester recorded significantly higher yield compared to standard check 1 (Table III). This result is supported by previous work of Kumari and Sharma (2011).

Our goal of this research is to improve the shelf life of commercial varieties without compromising the other desirable traits. In this research programme we have improved the shelf life of the commercial varieties through breeding strategy by exploiting the *alc* derived lines. We have succeeded in this approach, however we need further evaluation of hybrids under multilocation trials. Heterosis breeding is the only technically feasible method to exploit hybrid vigor for effective improvement in yield and yield associated traits.

TABLE III

Mid Parent Heterosis (MPH) and Standard Heterosis SH1 (NS2535), SH2 (INDAM 1004) Estimates (%) in tomato crosses

	Shelf life			Total yield			Single fruit weight			Total number of fruits		
Crosses	MPH	SH1	SH2	MPH	SH1	SH2	MPH	SH1	SH2	MPH	SH1	SH2
Sankranti * 1 Tester	2.00	23.81 *	13.00	128.36 **	22.19	12.34	27.17	46.67 *	41.94	62.43 *	1.38	-10.91
Sankranti * 2 Tester	5.70	33.33 **	21.74 *	83.25 *	-10.0s0	-17.26	9.03	12.67	9.03	57.30 *	-3.45	-15.15
Pusa Ruby * 1 Tester	-1.90	0.00	-8.70	103.67 **	8.98	0.19	26.45	30.67	26.45	69.62 **	38.62 *	21.82
Pusa Ruby * 2 Tester	-6.30	0.00	-8.70	71.42 *	-15.81	-22.6	2.92	-6.00	-9.03	23.93	0	-12.12
Vaibhav * 1 Tester	26.09 **	38.10 **	26.09 **	138.13 **	31.6	20.98	50.00 *	34.00	29.68	55.84 **	24.14	9.09
Vaibhav * 2 Tester	12.50	28.57 **	17.40	87.27 *	-4.74	-12.42	72.41 **	33.33	29.03	10.53	-13.1	-23.64
Arka Alok * 1 Tester	23.40 **	38.10 **	26.09 **	179.94 **	26.32	16.13	28.44	40.00	35.48	59.09 *	-3.45	-15.15
Arka Alok * 2 Tester	22.45 **	42.86 **	30.43 **	209.41 **	26.02	15.85	19.59	16.00	12.26	32.95	-20.69	-30.3
L121 * 1 Tester	-1.80	33.33 **	21.74 *	142.11 **	21.05	11.29	14.29	20.00	16.13	55.56 *	11.03	-2.42
L121 * 2 Tester	1.70	42.86 **	30.43 **	204.48 **	38.86 *	27.66	79.93 **	67.33 **	61.94 **	87.25 **	31.72	15.76

*Significant at 5% level, ** Significant at 1% level and ***Significant at 0.1% level

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