



Combining ability estimation for quality components in tomato (*Solanum lycopersicum* L)

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Abstract

General and specific combining abilities (GCA and SCA) were estimated using six diverse lines of tomato. To obtain F₁s lines were crossed in full diallel mating fashion (Including reciprocal) to know combining ability effects for quality traits. The results indicated in general, that a particular cultivar or hybrid cannot be used to evaluate all studied characters with equal efficiency. Based on gca effects, parent P₆ and P₅ were found to be the good general combiner for shelf-life and titratable acidity whereas, parent P₅ and P₃ for ascorbic acid and P₅ for lycopene. The obtained results further illustrated that the best hybrid combination that exhibited highest positive values of SCA can combine to produce a hybrid with good general performance. F₁ hybrids from cross combinations, P₁ × P₆, P₃ × P₁ and P₆ × P₂ were recorded with good specific combiner for fruit shape index; P₁ × P₆, P₂ × P₅ and P₁ × P₅ for shelf-life; P₁ × P₃ and P₂ × P₃ for total soluble solids; P₁ × P₃, P₅ × P₆ and P₅ × P₂ for ascorbic acid; P₁ × P₄ for lycopene; P₄ × P₂, P₁ × P₅ and P₁ × P₆ for titratable acidity; P₁ × P₆ and P₂ × P₁ for number of locules per fruit; P₁ × P₅, P₆ × P₁ and P₂ × P₃ for pericarp thickness; P₁ × P₅, P₅ × P₂ and P₅ × P₄ for fruit colour.

Keywords: combining ability (GCA), Specific combining ability (sca), Diallel fashion, quality traits.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most popular and extensively consumed vegetable crops. It tops the list of processed vegetables as, several items like puree, paste, sauce, ketchup, soup, juice and peeled tomatoes are prepared on a large scale. Apart from contributing nutritive elements, colour and flavour to the diet, tomatoes are also a valuable source of antioxidants or chemo-protective compounds and may thus be termed as "functional food" (Ranieri *et al.*, 2004) [17]. Processing in tomato has not gained much importance in India though there is a considerable scope for processing for earning foreign exchange. India, in particular Karnataka, has favorable weather conditions for growing tomato round the year and produce can be continuously supplied to processing factories. It is reported to have antiseptic properties against intestinal infestations. In the present days, it is gaining more medicinal importance because of the antioxidant property of ascorbic acid and lycopene content. Already, some industries have started processing tomato in and around major cities of Karnataka state. Hence, the demand is rising for identifying a suitable variety/ hybrid for processing.

Genetic analysis provides a guide line for the assessment of relative breeding potential of the parents or identify best combiners in crops (Khattak *et al.*, 2004 [7]; Sulodhani Devi *et al.*, 2005) [22] which could be utilized either to exploit heterosis in F₁ or the accumulation of fixable genes to evolve variety. Such studies not only provide necessary information regarding the choice of parents but also simultaneously

illustrate the nature and magnitude of gene action involved in the expression of desirable traits.

Combining ability is an effective tool, which gives useful genetic information for the choice of parents in terms of performance of their hybrids (Chezhian *et al.*, 2000) [3]. The term GCA is used to designate the average performance of a line in hybrid combination, whereas, SCA is used to designate those cases in which certain combinations do selectively better or worse than would be expected on the basis of average performance of the lines involved (Sprague and Tatum, 1942) [21]. The higher side of SCA directs the importance of the magnitude of non-additive gene effects to the total genetic variance (Falcaoner and Mackay, 1996) [5]. Hence, the present study was aimed to evaluate the parents for their combining ability and to develop hybrids. Further, to evaluate the combining ability for quality components in tomato F₁s.

Material and Methods

Experiment material containing six genotypes (inbred lines) of tomato *viz.*, P₁, P₂, P₃, P₄, P₅ and P₆ were selected on the basis of contrasting morphological and quality characters. These six genotypes were crossed by following full diallel fashion (Including reciprocals), to obtain 30 F₁ crosses wherein the experiment was laid in Randomized Block Design (RBD) with two replications in open field. All the 30 F₁ hybrids along with their parents and standard check (Indam 13201) were raised during *Kharif* season, 2018. The observation like shelf-life (days) of fruits was estimated by keeping one kg of fruits from

each treatment at ambient room temperature conditions till the day they shrink and become unfit for consumption, Total soluble solids (⁰ Brix) by using digital refractometer, ascorbic acid (mg/100 g) was analyzed using the method suggested by Ranganna (1977), lycopene (mg/100 g) was estimated using the procedure outlined by Adsule and Ambadan (1976), total acidity/ per cent citric acid (mili equivalent/100 g), fruit shape index, number of locules per fruit, pericarp thickness (mm) by using vernier calipers and fruit colour was measured by using Hunter's lab colorimeter (Model: Colour Flex EZ). It provides reading in terms of *L**, *a** and *b**, where luminance (*L**) forms the vertical axis that indicates whiteness (+) to darkness (-). In the same way, *a** indicates redness (+) to greenness (-) and *b** indicates yellowness (+) to blueness (-). Formulas used for certain observations:

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Titre value} \times \text{Dye factor} \times \text{Vol. made up} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{Weight of sample taken for estimation}} \times 100$$

$$\text{Lycopene (mg/100 g)} = \frac{3.1206 \times \text{OD of sample} \times \text{Volume} \times \text{Dilution (ml)}}{1 \times \text{Weight of sample} \times 1000 \text{ (g)}} \times 100$$

$$\text{Titrate acidity (TA) (mili equivalent/100 g)} = \frac{\text{ml} \times \text{Normality of NaOH} \times 100}{\text{Sample Vol. (ml)}}$$

$$\text{Fruit shape index} = \frac{\text{Polar diameter}}{\text{Equatorial diameter}}$$

Results and Discussion

The estimates of general combining ability (gca) effects of parents for various characters are presented in Table 1. The specific combining ability (sca) effects of each crosses estimated for various characters presented in Table 2 to 4.

Table 1: Estimation of GCA effects of parents for various characters in tomato

Parents	Shelf-life	TSS	Ascorbic acid	Lycopene	Titrate acidity	Fruit shape index
P ₁	0.042	0.193*	-0.678	0.017	-5.181**	0.278
P ₂	-1.167**	-0.328**	-0.781*	-0.513*	-4.972**	-2.264
P ₃	-0.125	0.381**	1.360**	0.245	-4.556*	-0.972
P ₄	-1.458**	-0.107	-0.943*	0.191	-2.097	-7.431
P ₅	1.167**	0.056	0.849*	0.440*	10.028**	1.611
P ₆	1.542**	-0.194*	0.192	-0.380	6.778**	8.778
G _i -G _j @ 5%	0.914	0.371	1.384	0.783	6.878	6.044
G _i -G _j @ 1%	1.434	0.582	2.171	1.228	10.788	9.481
Parents	Number of locules/ fruit	Pericarp thickness	Fruit colour L*	Fruit colour a*	Fruit colour b*	
P ₁	-0.608	-0.055	0.315	-0.180	0.216	
P ₂	-0.097	-0.434*	-3.606	-2.966	-4.519	
P ₃	0.430	0.064	-1.061	-0.117	-0.482	
P ₄	0.137	-0.081	0.578	0.362	0.178	
P ₅	0.518	0.322	2.792	2.116	3.439	
P ₆	-0.380	0.184	0.982	0.785	1.168	
G _i -G _j @ 5%	0.124	0.755	2.790	0.284	0.649	
G _i -G _j @ 1%	0.195	1.185	4.376	0.446	1.018	

* Significance at 5% and ** Significance at 1% level.

Table 2: Estimation of SCA effects of crosses on shelf-life, TSS, ascorbic acid and lycopene in tomato

Crosses	Shelf-life	TSS	Ascorbic acid	Lycopene
P ₁ × P ₂	-2.000*	-5.054	1.640	-0.462
P ₁ × P ₃	-2.438**	14.884**	4.609**	-0.620
P ₁ × P ₄	-2.125*	-2.241	-4.966**	2.270**
P ₁ × P ₅	1.000	3.259	0.500	1.355
P ₁ × P ₆	3.313**	-4.241	-1.288	-1.750*
P ₂ × P ₁	-2.063*	-4.366	0.276	0.765
P ₂ × P ₃	1.250	11.009**	-1.118	1.229
P ₂ × P ₄	-2.125*	8.009*	-3.962*	0.669
P ₂ × P ₅	2.188**	-0.991	1.430	-0.996
P ₂ × P ₆	1.313	-3.554	-0.760	0.342
P ₃ × P ₁	1.438	0.946	1.352	0.252
P ₃ × P ₂	-2.250**	0.946	-1.396	0.667
P ₃ × P ₄	0.250	-3.179	0.507	-1.749*
P ₃ × P ₅	0.063	-4.679	0.104	0.396
P ₃ × P ₆	-2.313**	0.321	-0.195	-1.029
P ₄ × P ₁	-0.958	-0.535*	-2.206*	0.591
P ₄ × P ₂	-0.250	-0.668**	-2.995**	0.313
P ₄ × P ₃	-1.917**	0.044	0.924	-0.206

P ₄ × P ₅	-1.792**	-0.693**	1.219	-2.123**
P ₄ × P ₆	1.125*	-0.118	-0.827	0.825
P ₅ × P ₁	0.708	-0.722**	-0.682	0.030
P ₅ × P ₂	-0.458	0.015	1.679*	-0.368
P ₅ × P ₃	0.917	0.078	-2.148*	-0.043
P ₅ × P ₄	-1.958**	-0.447	0.071	-0.980*
P ₅ × P ₆	1.000	-0.018	2.288*	-0.816
P ₆ × P ₁	1.583**	-0.606*	-0.677	0.149
P ₆ × P ₂	-0.250	0.119	0.750	1.279*
P ₆ × P ₃	0.958	-0.293	0.319	0.178
P ₆ × P ₄	-0.417	-0.768**	-1.901*	-1.307*
P ₆ × P ₅	-0.292	0.219	1.261	1.054*
Sij C.D. @ 5%	1.123	0.456	1.700	0.961
Sij C.D. @ 1%	1.558	0.633	2.359	1.334
Sij-Sik C.D. @ 5%	1.705	0.693	2.582	1.460
Sij-Sik C.D. @ 1%	2.367	0.961	3.584	2.026

* Significance at 5% level, **Significance at 1% level.

Table 3: Estimation of SCA effects of crosses on titratable acidity, fruit shape index, number of locules per fruit and pericarp thickness in tomato

Crosses	Titratable acidity	Fruit shape index	Number of locules/ fruit	Pericarp thickness
P ₁ × P ₂	-0.822	0.661	3.528**	-0.115
P ₁ × P ₃	-2.135**	-26.714**	11.659**	-0.156
P ₁ × P ₄	0.109	-18.527**	1.728	0.853
P ₁ × P ₅	3.709**	-2.402	16.684**	0.813*
P ₁ × P ₆	3.296**	23.911**	-11.941**	0.514
P ₂ × P ₁	0.771	3.911	-10.585**	0.062
P ₂ × P ₃	1.165	-5.402	5.084**	0.612*
P ₂ × P ₄	-1.135	-3.777	4.440**	-0.373
P ₂ × P ₅	-0.347	3.036	-1.735	-0.433
P ₂ × P ₆	0.553	-2.277	13.215**	0.185
P ₃ × P ₁	0.353	15.848**	-4.829**	-0.490
P ₃ × P ₂	-0.76	-2.839	10.246**	-0.554
P ₃ × P ₄	-0.654	-10.964*	-5.760**	0.155
P ₃ × P ₅	-0.366	-9.652*	-3.035**	-0.835
P ₃ × P ₆	-1.266*	-12.027**	4.571**	-0.605
P ₄ × P ₁	3.347	-5.028	0.475**	0.042
P ₄ × P ₂	13.181**	-7.819*	0.316**	-0.281
P ₄ × P ₃	-3.278	-3.861	-0.023	-0.563
P ₄ × P ₅	-5.653	-12.153**	-0.426**	-1.044*
P ₄ × P ₆	-9.403*	-6.569	-0.038	0.512
P ₅ × P ₁	-0.778	-1.528	-0.591**	-0.329
P ₅ × P ₂	-1.736	-0.819	0.207*	-0.319
P ₅ × P ₃	-0.861	14.639**	0.537**	-0.453
P ₅ × P ₄	-7.361	-22.778**	-0.403**	-0.682
P ₅ × P ₆	6.347	2.389	0.483**	-0.432
P ₆ × P ₁	-3.528	9.597*	-0.480**	0.652*
P ₆ × P ₂	3.222	15.431**	0.451**	0.431
P ₆ × P ₃	-3.486	-1.694	-0.919**	0.265*
P ₆ × P ₄	-7.486	-1.861	0.206*	-0.842
P ₆ × P ₅	-7.361	-8.153*	0.543**	-0.428
C.D. Sij @ 5%	8.447	7.423	0.153	0.928
C.D. Sij @ 1%	11.723	10.303	0.212	1.287
C.D. Sij-Sik @ 5%	12.831	11.277	0.232	1.409
C.D. Sij-Sik @ 1%	17.809	15.652	0.322	1.956

* Significance at 5% level, **Significance at 1% level.

Table 4: Estimation of SCA effects of crosses on fruit colour L*, a* and b* in tomato

Crosses	Fruit colour L*	Fruit colour a*	Fruit colour b*
P ₁ × P ₂	-14.054**	-119.35**	-14.461**
P ₁ × P ₃	-3.114	-18.736**	-2.664*
P ₁ × P ₄	-0.569	-30.064**	-1.447
P ₁ × P ₅	14.541**	93.489**	13.622**

P ₁ × P ₆	2.591	-15.392**	1.074
P ₂ × P ₁	1.734	1.683	3.092*
P ₂ × P ₃	1.514	19.058**	2.660*
P ₂ × P ₄	3.144	25.558**	5.203**
P ₂ × P ₅	-0.986	-13.373**	-0.095
P ₂ × P ₆	1.625	9.527**	1.807
P ₃ × P ₁	-4.400	-17.773**	-7.295**
P ₃ × P ₂	3.684	47.196**	4.282**
P ₃ × P ₄	3.705	53.552**	5.962**
P ₃ × P ₅	-1.896	-8.379**	-2.130
P ₃ × P ₆	-0.261	-1.829	1.158
P ₄ × P ₁	1.668	2.476**	2.576**
P ₄ × P ₂	2.120	3.281**	1.909**
P ₄ × P ₃	-0.165	1.858**	0.482
P ₄ × P ₅	-9.681**	-7.232**	-11.917**
P ₄ × P ₆	-2.118	0.737**	-0.181
P ₅ × P ₁	-6.992**	-5.705**	-10.041**
P ₅ × P ₂	5.454**	7.736**	7.188**
P ₅ × P ₃	0.928	1.867**	1.385**
P ₅ × P ₄	3.408*	4.220**	4.783**
P ₅ × P ₆	0.724	0.887**	1.049*
P ₆ × P ₁	1.713	3.400**	6.956**
P ₆ × P ₂	2.313	4.310**	2.529**
P ₆ × P ₃	-1.689	0.649**	-1.774**
P ₆ × P ₄	-8.394**	-6.625**	-9.911**
P ₆ × P ₅	-2.008	1.395**	-0.89*
Sij C.D. @ 5%	3.426	0.349	0.797
Sij C.D. @ 1%	4.755	0.484	1.107
Sij-Sik C.D. @ 5%	5.205	0.530	1.211
Sij-Sik C.D. @ 1%	7.224	0.736	1.681

* Significance at 5% level, **Significance at 1% level.

Shelf-life

The general combining ability effects for shelf-life varied between -1.458 (P₄) to 1.542 (P₆). Parents P₆ (1.542) and P₅ (1.167) as showed highly significant positive gca effect for shelf-life indicating good general combining ability for this trait. Whereas, parents P₄ (-1.458) and P₂ (-1.167) were poor combiners for this trait by recording lower levels.

Shelf-life for sca effect varied between -2.438 (P₁ × P₃) to 3.313 (P₁ × P₆). On the basis of specific combining ability effects, crosses P₁ × P₆ (3.313), P₂ × P₅ (2.188) and P₆ × P₁ (1.583) were found to be the best for shelf-life as they showed highly significant positive sca effect.

Shelf-life of the fruit has been considered as an important component of keeping quality and whole fruit firmness in tomato with higher pericarp thickness, which in turn helps is longer storability. Thus higher shelf-life in case of P₆ and P₅ parents may be due to the higher pericarp thickness. The results are in confirmatory with the findings of Kulkarni (2003)^[8], Premalakshmi *et al.* (2006)^[15], Yadav *et al.* (2013)^[24] and Kumar and Gowda (2016)^[9] in tomato crop.

Total soluble solids

The general combining ability effects for total soluble solids varied between -0.328 (P₂) to 0.381 (P₃). The parents P₃ (0.381) and P₁ (0.193) represented positive significant GCA effect for total soluble solids. The negative gca effect was observed by the parents P₂ (-0.328) and P₆ (-0.194) indicating poor combiners for total soluble solids.

The sca effects for total soluble solids varied from -0.768 (P₆

× P₄) to 14.884 (P₁ × P₃). Out of 30 cross combinations, only three cross combinations P₁ × P₃ (14.884), P₂ × P₃ (11.009) and P₂ × P₄ (8.009) exhibited positive significant sca effects, whereas, the crosses P₆ × P₄ (-0.768), P₅ × P₁ (-0.722), P₄ × P₅ (-0.693) and P₄ × P₂ (0.668) showed negative significant sca effects.

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. Similar findings were also noted by Sharma and Thakur (2008)^[19], Kumar *et al.* (2015)^[10] and Triveni *et al.* (2017)^[23] in tomato crop.

Ascorbic acid

The general combining ability effects for ascorbic acid varied between -0.943 (P₄) to P₃ (1.360). Parents P₃ (1.360) and P₅ (0.849) as recorded highly significant positive gca effect indicating good general combining ability for ascorbic acid. Whereas, parents P₄ (-0.943) and P₂ (-0.781) recorded negative gca effect and in considered as poor general combiners for ascorbic acid.

Magnitude of sca effects for ascorbic acid varied between -4.996 (P₁ × P₄) to 4.609 (P₁ × P₃). On the basis of specific combining ability effects, crosses P₁ × P₃ (4.609), P₅ × P₆ (2.288) and P₅ × P₂ (1.679) were found to be good for ascorbic acid as they showed highly significant positive sca effect.

The ascorbic acid content of tomato fruits is associated with the expression of genes involved in pectin degradation. It is used to treat and prevent vitamin C deficiency. High levels of

ascorbic acid in tomato fruits provide health benefits for humans and also play an important role in several aspects of plant life. From the present results the significant positive gca and sca effects for ascorbic acid are well supported by the findings available in literature of Sharma *et al.* (2006)^[20], Dharva *et al.* (2018)^[4] and Madhavi *et al.* (2018)^[11] in tomato crop.

Lycopene

With regards to lycopene only one parent P₅ (0.440) as recorded gca effect in positive direction and is regarded as good general combiner for lycopene, whereas parent P₂ (-0.513) as showed gca effect in negative direction which is regarded as poor general combiner for lycopene. The sca effects for lycopene varied from -2.123 (P₄ × P₅) to 2.270 (P₁ × P₄). The cross combinations *viz.*, P₁ × P₄ (2.270), P₆ × P₂ (1.279) and P₆ × P₅ (1.054) exhibited positive significant sca effects. Whereas, the crosses P₄ × P₅ (-2.123) and P₁ × P₆ (-1.750) showed negative significant sca effects for lycopene.

Lycopene, a carotenoid used as a natural colorant for decades, is a powerful antioxidant presented abundantly in tomatoes and other red fruits. Lycopene is emerging as a valued antioxidant, with many new applications as a nutritional supplement and an active ingredient in cosmetic products. Lycopene content is one of the vital important quality parameter in processing industry. The results are in agreement with the findings of Mohmoud and El-Eslamboly (2014)^[13], Kumar *et al.* (2015)^[10], Dharva *et al.* (2018)^[4] and Madhavi *et al.* (2018)^[11] in tomato crop.

Titrateable acidity

The general combining ability effects for titrateable acidity varied between -5.181 (P₁) to 10.028 (P₅). Parents P₅ (10.028) and P₆ (6.778) as showed highly significant positive gca effect indicating their good general combining ability for titrateable acidity. Whereas, parents P₁ (-5.180) and P₂ (-4.972) as showed gca effect in negative direction which is regarded as poor general combiner for titrateable acidity.

Titrateable acidity for sca effect varied between -9.403 (P₄ × P₆) to 13.181 (P₄ × P₂). On the basis of specific combining ability effects, crosses P₄ × P₂ (13.181), P₁ × P₅ (3.709) and P₁ × P₆ (3.296) were found to be the best for titrateable acidity as they showed highly significant positive sca effect.

Titrateable acidity is an important parameter in determining fruit maturity and sour taste in fruits. Titrateable acidity in tomato plays a vital role in processing industry, which is gaining much importance in preparation of ketchups, pastes *etc.* The results of the present study related to the gca and sca effects for titrateable acidity are in accordance with the findings of Bhatt *et al.* (2001)^[2], Kumar *et al.* (2015)^[10] and Savale and Patel (2017)^[18] in tomato crop.

Fruit shape index

None of the parent as showed either good or poor combining ability effect for fruit shape index. But parents P₄ (-7.431) and P₂ (-2.264) exhibited the non-significant negative gca effects and is regarded as average general combiner for fruit shape index.

Magnitude of sca effects for fruit shape index varied between -26.714 (P₁ × P₃) to 23.911 (P₁ × P₆). The top three crosses P₁

× P₆ (23.911), P₃ × P₁ (15.848) and P₆ × P₂ (15.431) exhibited positive significant sca effects at higher level for the character fruit shape index. Whereas, crosses P₁ × P₃ (-26.714) and P₅ × P₄ (-22.778) exhibited negative significant sca effects at higher level.

Fruit shape index provides definite fruit shape in terms of quantitative character. Higher the fruit shape index is the higher fruit weight and ultimately leads to higher yield of a particular parental line and *vice-versa*. So that selection of the parental lines with higher fruit shape index is desirable for breeding programme. The gca and sca effects results for fruit shape index are in confirmatory with the findings of Bhatt *et al.* (2001)^[2], Kumar *et al.* (2015)^[10] and Panchal *et al.* (2016)^[14] in tomato crop.

Number of locules per fruit

The parents P₁ (-0.608) and P₆ (-0.380) recorded non-significant negative gca effect for number of locules per fruit, which is desirable for this trait indicating their average general combining ability.

The sca effects for number of locules per fruit varied from -11.941 (P₁ × P₆) to 16.684 (P₁ × P₅). Out of 30 crosses, three cross combinations *viz.*, P₁ × P₅ (16.684), P₂ × P₆ (13.215) and P₃ × P₂ (10.246) exhibited highly significant positive sca effects, whereas, crosses P₁ × P₆ (-11.941) and P₂ × P₁ (-10.585) exhibited negative significant sca effects for number of locules per fruit which is desirable.

Number of locules per fruit decides the fruit shape and amount of juice which is therefore preferred by processing industries. In contrast, less number of locules is favoured by farmers and consumers because these fruits will be firm. The results of the present study are in accordance with the findings of Katkar *et al.* (2012)^[6], Mali *et al.* (2014)^[12] and Kumar *et al.* (2015)^[10] in tomato crop.

Pericarp thickness

The highly significant and negative gca effect was recorded by parent P₂ (-0.43), which is found to be poor general combiner has it showed significant negative GCA effect. The parents P₆ (0.184) and P₅ (0.322) have recorded non-significant positive GCA effect and is regarded as average general combiner for pericarp thickness.

Magnitude of sca effects for pericarp thickness varied between -1.044 (P₄ × P₅) to 0.813 (P₁ × P₅). On the basis of specific combining ability effects, crosses P₁ × P₅ (0.813), P₆ × P₁ (0.652) and P₂ × P₃ (0.612) were found to be the best for pericarp thickness as they showed significant positive SCA effect.

Pericarp thickness has been considered as an important direct contributing to keeping quality and whole fruit firmness in tomato. It is one of the important quality parameter which helps in increasing the shelf life of the harvested tomato fruits. Similar results with respect to gca and sca effects for Pericarp thickness was also achieved by Panchal *et al.* (2016)^[14] and Savale and Patel (2017)^[18] in tomato crop.

Fruit colour L*, a* and b*

None of the parent has showed either good or poor general combining ability effect for fruit colour L*, a* and b*. But parents P₂ [L* (-3.606), a* (-2.966) and b* (-4.519)] and P₃

[L* (-1.061), a* (-0.117) and b* (-0.482)] found to be poor general combiner has it showed negatively significant gca effect.

Magnitude of sca effect for fruit colour L*, a* and b* (Table 15) varied from -14.054 (L*), -119.35 (a*) and -14.461(b*) ($P_1 \times P_2$) to 14.541(L*), 93.489(a*) and 13.622 (b*) ($P_1 \times P_5$). Out of 30 crosses, three cross combinations viz., $P_1 \times P_5$ (14.541 L*, 93.489 a* and 13.622 b*), $P_5 \times P_2$ (5.454 L*, 7.736 a* and 7.188 b*) and $P_5 \times P_4$ (3.408 L*, 4.220 a* and 4.783 b*) exhibited positive and highly significant sca effects, whereas crosses $P_1 \times P_2$ (-14.054 L*, -119.35 a* and -14.461 b*), $P_4 \times P_5$ (-9.681 L*, -7.232 a* and -11.917 b*) and $P_6 \times P_4$ (-8.394 L*, -6.625 a* and -9.911 b*) exhibited negative and highly significant sca effects for fruit colour L*, a* and b*.

Conclusion

This study can be used to select the parents to be involved in hybrid combinations to predict the best hybrid. Parents with good GCA do not successively produce superior cross with good SCA in all the combinations. A particular line and hybrid cultivar cannot be used to evaluate all the characters with equal efficiencies. Thus, parents selection should be made after detailed evaluation of GCA and SCA effects. The results indicated that the cross $P_1 \times P_6$ found to be good specific combiner for fruit shape index, shelf-life, titratable acidity and number of locules per fruit; $P_1 \times P_5$ for shelf-life, titratable acidity, pericarp thickness and fruit colour; $P_1 \times P_3$ for total soluble solids and ascorbic acid; $P_5 \times P_2$ for ascorbic acid and fruit colour.

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