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GENETIC COMPONENT OF VARIANCE AND COMBINING ABILITY USING DIALLELE ANALYSIS IN CHERRY TOMATO FOR YIELD AND QUALITY (*Solanum lycopersicum* L. var. *Cerasiforme* Mill)

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ABSTRACT
Cherry tomato (*Solanum lycopersicum* L. Var. *Cerasiforme* Mill.) has the potential for improvement through heterosis breeding which can further be utilized for development of desirable recombinants. An 8 × 8, diallel mating design was used to determine gene action for ten characters in cherry tomato. Preponderance of non-additive gene action was evident for control of all characters in this study. Amongst the eight parental lines, L 00427 , L 00398 , L 01696 and L 04780 were the best combiner for plant height , number of fruits per cluster, number fruits per plant, fruit yield per plant and other quality parameters (lycopene content, ascorbic acid, total soluble solids and reducing sugar) and thus could be used in cherry tomato hybridization programs. Crosses showing high specific combining ability (SCA) for plant height L 04780 x L 03686 , for number of fruits per cluster, number of fruits per plant and total soluble solids (L 00427 x Arka Vikas) and the hybrids L 00427 x L 03686 , L 01696 x L 03686 for ascorbic acid and lycopene content respectively..

KEY WORDS: Combining ability, gene action, yield, quality, cherry tomato.

INTRODUCTION
Tomato (*Solanum lycopersicum*) is one of the important Solanaceous vegetable crops of Peru-Ecuador origin (Rick, 1969) and used as fresh vegetable as well as raw material for processed products such as juice, ketchup, sauce, canned fruits, puree, paste, etc. 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). Tomato is one of the most popular and widely grown vegetables in the world ranking second important to potato in many countries. Tomato is considered as a favorite crop for research in physiology, breeding and Cytogenetics because of its wider adaptability and stability and is grown throughout the world either in outdoors or indoors. Genetic analysis provides a guide line for the assessment of relative breeding potential of the parents or identify best combiners and gene action the pace of work on development of tomato hybrid on commercial basis have been limited due to lack of superior combiners in India. Diallel analysis without reciprocal (Griffing, 1956) is one of the best techniques that provide information about general and specific combining ability of the parents and at the same time, it is helpful in estimating various types of gene effects. Keeping in view the importance of the above studies, the present research program has been undertaken to determine the nature of gene action for these traits with a view to identify good general combiners, as well as to frame the breeding strategies for the genetic improvement of such characters.

MATERIALS & METHODS
The experiment was conducted at Department of Crop Improvement and Biotechnology, Kittur Rani Channamma College of Horticulture, Arabhavi. Gokak Taluk, Belgaum District, Karnataka (India) during Rabi season of 2011-2012 with 8 cherry tomato lines collected from AVRDC, Taiwan. The experiment was conducted in RCB design with two replications. Seeds were sown on 23 November, 2012 in portray and transplanted in the field on 28 December, 2012. Land was prepared properly and fertilized with cow-dung, urea DAP, M0P at the rate of 10 ton, 250, 440 and 250 kg/ha, respectively. Entire amount of cow-dung DAP and MOP were applied during land preparation while urea was top dressed twice at 30 and 45 days after transplanting. Unit plot size was 7.2Sq m × 5.6 Sq m with space at 60 cm × 45 cm between row to row and plant to plant, respectively. Irrigation, weeding and other intercultural operations were done as and when necessary. Eight plants were selected randomly from each plot for collecting data on growth and yield attributes for statistical analysis. The analysis of variance for each of the characters was performed using MSTAT software. The combining ability analysis and gene action was done using Griffign's (1956) and Hayman's (1954) approach.

RESULTS & DISCUSSION
Analysis of variance for general (gca) and specific combining ability (sca) showed highly significant differences for all the traits under study (Table 1), suggesting importance of both additive and non-additive components of gene action. The estimates of effects due to gca of parents and sca of crosses have been presented in Tables 2 & 3, respectively.

TABLE 1: Analysis of variance and genetic components of variation for growth, yield and quality characters in cherry tomato

Source of Variations	Plant height 60(cm) DAT	Days to 50% flower	Number of fruits/ cluster	Number of fruits /plant	Average fruit wt/g	Fruit yield/ Plant (kg)	TSS in ^{0}Brix	Ascorbic acid (mg/100g)	Lycopene content (mg/100g)	Reducing sugar (g/100g)
GCA	758.38 **	47.8**	74.33**	1.25 **	14353.15 **	39.32 **	2.379 **	156.841 **	6.927 **	11.240 **
SCA	432.07 **	9.87**	12.96**	1.36 **	15026.43 **	37.89 **	0.952 **	43.021 **	1.929 **	6.392 **
Error	23.27	0.338	1.029	0.11	173.71	0.294	0.01	3.61	0.044	0.05

TABLE 2: Estimation of gca effects of parents with respect to growth, yield and quality characters in cherry tomato

Parents	Plant height 60(cm) DAT	Days to 50% flower	Number of fruits/cluster	Number of fruits/ Plant	Average fruit wt/g	Fruit yield/plant (kg)	TSS in ^{0}Brix	Ascorbic acid (mg/100g)	Lycopene content (mg/100g)	Reducing sugar (g/100g)
L 04780	0.53	-4.30**	0.215*	4.925	0.05	0.084*	-0.597 **	8.384 **	-1.374 **	-1.963 **
L 02846	7.76 **	-2.24 **	-0.56 **	-55.7 **	3.21 **	0.10 **	-0.498 **	-1.048	-0.826 **	-0.078
L 00398	6.92 **	-1.99 **	0.53 **	49.92 **	-1.37**	0.29 **	-0.302 **	-3.775 **	1.299 **	0.228 **
L 00427	10.9 **	0.63 *	-0.005	5.025	-0.9 **	-0.03	0.531 **	0.201	0.714 **	0.147 *
L 01696	-0.37	1.17 **	0.045	18.97 **	-2.6 **	-0.21 **	0.818 **	0.114	0.204 **	1.323 **
L 03686	-4.8 **	0.28	-0.30 *	-41.3 **	0.73 **	-0.12 **	0.107 **	0.801	-0.163 *	1.288 **
L 00196	-5.16 *	2.29 **	0.29 *	41.9 **	-1.27 **	-0.04	-0.084 **	0.164	0.113	-0.678 **
Arka Vikas	-15.8 **	4.16 **	-0.21 *	-23.6 **	2.23 **	-0.06 *	0.025	-4.841 **	0.033	-0.267 **
S.Em±	1.427	0.300	0.098	3.898	0.160	0.032	0.02	0.561	0.062	0.06
CD at 5%	2.897	0.609	0.199	7.914	0.325	0.065	0.06	1.14	0.126	0.13

TABLE 3: Estimation of sca effects of parents with respect to growth, yield and quality characters in cherry tomato

Parents	Plant height (cm) DAT	Days to 50% flower	Number of fruits/ cluster	Number of fruits/plant	Average fruit wt/g	Fruit yield/pl (kg)	TSS in ^{0}Brix	Ascorbic acid(mg/100g)	Lycopene content (mg/100g)	Reducing sugar (g/100g)
P1XP2	-0.146	2.63**	0.911**	124.211**	-1.223**	1.428**	0.381**	8.541**	1.568**	0.043
P1XP3	-60.5**	-2.55**	1.311**	156.511**	-4.883**	-0.212**	0.015	6.728**	-0.933**	-2.712**
P1XP4	-1.216	0.41	0.451	-32.589**	-3.038**	-0.677**	-0.358**	3.883**	0.652**	-0.632**
P1XP5	13.14**	-3.22**	0.401	-10.539	-2.558**	-0.497**	-0.895**	1.704	-0.753**	-1.507**
P1XP6	28.42**	-1.98**	0.751**	79.811**	-6.143**	-0.487**	-0.174**	4.422**	0.91**	-1.372**
P1XP7	-6.911	-4.25**	-1.849**	-153.53**	9.567**	0.433**	-0.503**	-1.756	-1.742**	0.443**
P1XP8	17.98**	-7.21**	-0.439	-78.889**	5.007**	0.103	0.038	-12.661**	-1.062**	-0.917**
P2XP3	-1.286	-0.17	-0.809**	-71.789**	2.357**	-0.287**	0.306**	-3.16**	-0.915**	2.803**
P2XP4	-3.596	-2.75**	0.731**	100.611**	-5.348**	0.148*	-0.467**	-1.451	-1.335	2.233**
P2XP5	6.669	-1.79**	0.181	-10.839	0.332	0.078	-0.124**	2.041	-0.34**	-0.192
P2XP6	6.444	2.94**	-0.969**	-46.489**	7.197**	-0.462**	-0.083	-0.916	-1.232**	-1.707**
P2XP7	-14.0**	1.93**	-1.069**	-52.339**	0.357	0.208**	-0.502**	-2.554	-0.199	1.108**
P2XP8	25.40**	1.06	0.441	-33.189**	-5.903**	-0.922**	-0.091	-2.094	0.231	-4.302**
P3XP4	8.494**	0.70	-0.369	-76.589**	3.942**	0.808**	-0.853**	-7.814**	0.105	-2.372**
P3XP5	12.50**	3.56**	-0.919**	-110.53**	9.072**	1.038**	-1.19**	-0.912	0.145	-5.147**
P3XP6	13.68**	-3.64**	-0.069	10.811	-5.113**	-1.152**	0.531**	2.946	1.817**	0.888**
P3XP7	49.04**	-0.21	1.831**	245.46**	-5.253**	-0.182**	0.622**	0.178	1.326**	1.303**
P3XP8	-0.006	-0.32	-0.159	-48.889**	-1.413**	-0.062	0.653**	2.903	1.025**	1.943**
P4XP5	22.29**	0.43	0.121	-19.139	-2.533**	-0.727**	0.737**	5.332**	-0.35**	0.883**
P4XP6	1.724	3.82**	-0.029	88.711**	-1.518**	0.983**	1.118**	10.33**	-0.338**	1.218**
P4XP7	7.589	-1.59	-0.129	-103.63**	6.142**	0.403**	0.999**	0.742	-0.474**	4.283**
P4XP8	-12.1**	-5.95**	2.881**	316.01**	-9.318**	-0.027	1.84**	8.017**	0.67**	3.373**
P5XP6	-0.361	0.53	0.421	-5.239	-3.338**	-0.087	-1.079**	-0.628	2.907 **	-0.657**
P5XP7	-33.5**	4.11**	-1.179**	-147.58**	2.172**	-0.417**	-0.268**	-4.851**	-2.974**	1.508**
P5XP8	-15.0**	4.80**	-0.169	-42.939**	-2.538**	0.003	1.243**	-8.981**	-0.775**	1.798**
P6XP7	-22.7**	-3.4**	-1.329**	-102.23**	5.337**	0.293**	-1.507**	-8.948**	0.598**	-0.357**
P6XP8	-5.526	0.79	0.681**	42.411**	-7.073**	0.063	-0.786**	-3.943**	0.618**	1.233**
P7XP8	9.089**	0.52	0.581**	67.061**	-7.413**	-0.467**	1.075**	-15.63**	0.201	-2.902**
S.Em±	3.805	0.80	0.262	10.39	0.427	0.085	0.079	1.498	0.165	0.176
CD at 5%	7.725	1.62	0.533	21.105	0.868	0.174	0.162	3.042	0.336	0.358

TABLE 4: Estimates of genetic components of variation for growth, yield and quality traits in cherry tomato

Genetic components	Plant height (cm) 60 DAT	Days to 50 % flower	Number of fruits/ Cluster	Number of fruits/plant	Average fruit wt/g	Fruit yield/ Plant (kg)	TSS in ^{0}Brix	Ascorbic acid (mg/ 100g)	Lycopene content (mg/100g)	Reducing sugar (g/100g)
D (Additive Effect)	273.92	12.303	30.581	1.994 *	22414.8 *	72.56 *	1.753 *	46.742 *	3.483 *	9.402 *
F (Mean Fr over arrays)	22.12	-0.96	17.32	3.639 *	35272.7 *	112.9*	2.501 *	-0.744	3.48 *	13.986 *
H_1(Dominance Effect)	1682.25 *	42.725*	60.256*	6.455 *	70331.03*	176.87*	4.902 *	174.27 *	9.543 *	31.227 *
H_2(dominance variance due to + ve (u) and - ve (V) effects of genes)	1620.49 *	33.38*	40.371*	4.283*	52382.35*	124.63*	3.033 *	152.027 *	6.324 *	21.448 *
h^2 (Heritabillity)	151.13	12.548	9.024	0.339	476.50	42.20*	0.03067	10.99*	0.014	-0.033
E (Envt .Comp.)	27.12	0.329	1.008	0.107	205.22	0.287	0.00998	4.144	0.043	0.09
$(H_1/D)^{1/2}$ (mean degree of dominance over all loci)	2.47	1.864	1.404	1.799	1.771	1.561	1.672	1.931	1.655	1.822
$H_2/4H_1$ (the proportion of genes with + ve and - ve effect)	0.24	0.195	0.167	0.166	0.186	0.176	0.155	0.218	0.166	0.172
KD/KH (proportion of dominant and recessive genes in the parents)	1.03	0.959	1.505	3.058	2.598	2.987	2.488	0.992	1.865	2.379
h^2 / H_2 (No. of Gene Groups)	0.09	0.376	0.224	0.079	0.009	0.339	0.01	0.072	0.002	-0.002
h^2(Narrow Sense)	0.26	0.566	0.599	0.183	0.161	0.159	0.422	0.453	0.498	0.323

The lines L 00427,L 02846 and L 00398 were found to be good general combiners for plant height and can be used for breeding tall cultivars. The cross combination, L 04780 x L 03686 exhibited the highest positive sca estimates,. The variance ratio of gca and sca (Vg/Vs) was less than unity, indicating the preponderance of non-additive gene effects for plant height. These results are in agreement with the findings of Barar *et al.* and Sharma and Sharma. Early flowering is a desirable trait as it results in early supply of the produce without much competition and escape from pest and diseases and consequently making the crop more profitable to the farmers. General combining ability of the parents revealed that the line L 04780 found to be good general combiners for days to50 per cent flowering. However, the cross combination L 04780 x Arka Vikas exhibited highest negative sca estimates followed by L 04780 x L 00196 Similar results has also been reported by Cheema *et al.* and Sharma and Sharma. For the trait, number of fruits per cluster, the lines L 00398, L 00196 and L 04780 were showed with good general combining ability. The crosses, L 00427 x Arka Vikas, L 00398 x L 00196 and L 04780 x L 00398 were the best three specific combiners for number of fruits per clusters. General combining ability estimates of the lines L 00398 and L 00196 were positive and significant which in turn appeared to be good general combiners. Hybrids, L 00427 x Arka Vikas and L 00398 x L 00196 exhibited high sca effects for number of fruits per plant. For average fruit weight the line L 02846 performed good general combiner. The hybrid L 04780 x L 00196 and L 00398 x L 01696 exhibited high sca effects. These fruits therefore can be used for developing cultivars with bigger fruits. The parent L 01696 showed good general combiner for total soluble solids and reducing sugars . the hybrid L 00427 x Arka Vikas and L 00427 x L 00196 performed high positive significant sca effects for TSS and reducing sugar respectively. For the ascorbic content the line L 04780 exhibited as good general combiner and the hybrids L 00427 x L 03686and L 04780 x L 02846 with high positive significant sca effects and for lycopene content L 00398 is the good general combiner and among the hybrids L 01696 x L 03686 and L 04780 x L 02846 exhibited positive significant sca effects. Preponderance of non-additive gene action was observed for all the traits. Hence, heterosis breeding would be the best option for improvement of these traits and same results were reported by Ahmad *et al.,* 2009 , Garg *et al.,* 2007 and Mahendrakar *et al.,* 2005

The results presented in Table 4 indicated that the additive (D) genetic variance was significant for number of fruits per cluster, number of fruits per plant, average fruit weight, total soluble solids, ascorbic acid, lycopene content, reducing sugar and remaining characters in non-significant representing predominance of non-additive gene action. The similar results were given by Thakur and Kohli,(2005).The sum of dominance effect over all loci (h2) was significant for days to fifty per cent flowering, average fruit weight, and for rest of the characters it was non-significant. The similar results were studied by Thakur and Kohli,(2005). Dominant components (H1 and H2) were showed significantly difference for plant height at 60 DAT, days to fifty per cent flowering, number of fruits per cluster, number of fruits per plant, average fruit weight, fruit yield per plant, total soluble solids, ascorbic acid, lycopene content and reducing sugar. Magnitude of dominance effect is more compare to the additive component, hence solution may be practiced in the segregating population and also intermating of the selected plants in segregating population or recurrent selections and pedigree selection may be practiced to improve the yield and quality.

The degree of dominance $(H1/D)^{1/2}$ was more than one for all the characters which indicates all these characters were had over dominance. The similar results were reported by Thakur and Kohli, (2005). If the ratio of degree of dominance component is zero, it indicates no dominance , ratio is greater than zero and less than one indicates there is a partial dominance, if this ratio is more than one means there is a over dominance.

The proportion of genes with positive and negative effects in the parent (H2/4H1) was equal to 0.25 for plant height 60 DAT, fruit yield per plant and ascorbic acid. It indicates that positive and negative alleles were symmetrically distributed. If this ratio is showing less than 0.25 indicates unequal distribution of genes with positive and negative effect. The similar results were recorded by Thakur and Kohli, (2005).The negative effects of alleles in parents were compensated by positive alleles in the hybrid resulting over dominance. Hence, selection of parent with high positive alleles, dominant genes manifests dominance in hybrid. The proportion of dominance and recessive genes in parents is equal to unity plant height at 60 DAT and ascorbic acid, It indicates equal proportion of dominance and recessive genes are distributed in parents. If the ratio is less than one indicates excess of recessive genes and more then indicates excess of dominant genes in the parents. Number of alleles or allelic groups and narrow sense heritability was showing non-significant for all the characters. The high narrow sense heritability was recorded for days to fifty per cent flowering (0.599) and lowest in fruit yield per plant (0.159). It is evidenced that both additive and non additive gene effects are involved in the genetic control of the traits. So both gene effects should be considered when developing superior lines.

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