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Line x tester analysis for combining ability in okra [*Abelmoschus esculentus* (L.) Moench.]

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Abstract

Combining ability effects were estimated for different characters in a line x tester crossing programme comprising 45 hybrids produced by crossing of 15 lines and 3 testers. Parents and hybrids differed significantly for gca and sca effects, respectively. High average degree of dominance revealed predominance of non-addiive gene effects for all the traits. The parents Swati-10, Heritage green, Punjab Padmini, Ankur-40, VRO-6 and Arka Anamika were good general combiner for majority of characters in various environments. Therefore, these lines can be used for hybridization for producing promising recombinants. This indicates that parent showing high gca for fruit yield per plant might be due to high gca for fruit weight, fruit length, fruit girth and number of fruits per plant. High sca effects were reported for cross combinations, BO-3 x Arka Anamika in E_1, Swati-10 x Parbhani Kranti and heritage Green x Arka Abhay in E_2 and BO-3 x Parbhani Kranti in E_3 environment

Key words: Combing stability, Line, Tester, Gca effects, Sca effects, Gene effects, Non-additive, Dominance, parents and Hybrids.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench], commonly known as bhindi has a prominent position among vegetable due to its wide adaptability, year round cultivation, export potential and high nutritive value. In any sound breeding programme, the proper choice of parents based on their combining ability is a prerequisite. As such studies intended to determine the combining ability not only for necessary information regarding the choice of parents but also the simultaneous nature and magnitude of desirable traits. Accordingly the present investigation was undertaken to have an idea of the nature of the gene action for green fruit yield and other important attributes in okra. Line x tester analysis is a useful tool for preliminary evaluation of genetic stock for use as combiners, which may be used to build up a population with favourable fixable and genes for effective yield improvement.

Materials and methods

The experimental material comprised of 15 female parents (lines) viz. Heritage green, Go-2, Bo-2, Punjab Padmini, Swati-10, Swati-25, Ankur-40, Pusa Sawni, VRO-5, VRO-6, Varsha Uphar, and 3 Pollen parents (testers) viz. Parbhani kranti, Arka abhay and Arka anamika were selected on the basis of per se performance, adoption and geographical diversity. They were crossed in the line x tester design thus 45 hybrids were produced. The 45 F_1s and their parents were grown in randomized block design with three replications at Horticulture Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, (24°-35'N and 73°-42' E) at an elevation of 582.17above mean sea level. The climate of Udaipur is semi-arid sub-tropical, characterized by hot summers and cold winters. The hottest months are April, May and June (Maximum temperature 43-44° C), whereas during December and January, the minimum temperature often goes below 5 °C. The average annual rainfall is 750 mm, 70-80 % of which is received through the north-west monsoon during July-September. The soil was sandy loam in texture consisting 62.3 % sand, 21.6 % silt and 16.5 % clay having soil pH 7.8, electrical conductivity 0.46 dS/m, organic carbon 0.54 %, available N 73 mg/kg, Olsen P 14.3 mg/kg and available K 70.2 mg/kg of soil. The experiment was conducted in three environments viz., summer 2005 (E_1), rainy 2005 (E_2) and summer 2006 (E_3). The seeds were sown in single row of 3.6 m length keeping 45 cm distance between row and 30 cm within row. The observations were recorded for yield and yield contributing traits viz. plant height (cm), number of branches per plant, height of first effective fruiting node (cm), days to 50 per cent flowering, number of fruits per plant, fruit length (cm), fruit girth (cm), days to harvest, fruit weight (g) and yield per plant (g). Combining ability analysis was computed according to the model given by Kempthrone (1957).

Results and discussion

The analysis of variance revealed highly significant difference among all the traits which indicated the presence of considerable amount of genetic variability (Table 1). The mean square due to crosses, lines and testers

Table 1. Summation of combining ability in various environments

Source	Plant height	Number of branches Per plant	Height of first effective fruiting node	Days to 50% flowering	Number of fruits per plant	Fruit length	Fruit girth	Days to harvesting	Fruit weight	Yield per plant
E-1 Environment										
Σ^2 GCA T	24.168**	-0.005	0.15631	-0.07713	4.115**	0.15479*	0.037526**	-0.03922	0.19582**	1411.6**
Σ^2 GCA L	1097.1**	0.65395**	4.2829	23.463**	28.442**	3.8868**	0.39772**	21.832**	18.469**	14049**
Σ^2 SCA	2985.3**	5.4193**	99.878**	111.55**	200.76**	32.276**	2.0932**	116.38**	90.398**	79631**
E-2 Environment										
Σ^2 GCA T	32.766**	0.061853**	0.10106	0.1019	0.42326*	0.020297	0.02916**	0.16089**	3.0436**	-60.93
Σ^2 GCA L	886.55**	1.4979**	8.0278*	70.209*	16.064**	2.8888**	0.42754**	70.797**	31.065**	5841.6**
Σ^2 SCA	1751.1*	10.966**	74.471**	258.22**	87.393**	26.417**	1.6944**	272.59**	157.75**	33306**
E-3 Environment										
Σ^2 GCA T	32.738**	0.093974**	0.5839**	0.22308*	1.9553**	0.03022	0.038759**	0.12262	0.77404**	583.9**
Σ^2 GCA L	939.01**	1.1056**	9.294**	11.047**	17.656**	3.7167**	0.4354**	10.983**	7.6846**	9325**
Σ^2 SCA	2348.7**	10.69**	88.699**	55.557**	120.64**	31.122**	2.0524**	60.909**	53.7**	50453**

Table 2. Best parents identified on the basis of per se performance and GCA effects for various traits in different environment in okra

S. No.	Character		Per Se	GCA	Common
1.	Plant Height	E_1	L_1, L_{13}, L_9, L_4	$L_4, L_{11}, L_{13}, L_9, L_1$	All
		E_2	$L_{14}, L_1, T_1, L_4, T_2$	$L_4, L_{11}, L_1, L_{13}, L_9$	L_1, L_4
		E_3	$L_1, L_{13}, T_1, L_{11}, L_9$	$L_4, L_{11}, L_9, L_1, L_{13}$	$L_1, L_{11}, L_{13}, L_9, L_4$
2.	Number of branches per plant	E_1	$L_{14}, L_9, L_{13}, L_7, T_3$	$L_6, L_7, L_1, L_8, L_{11}$	L_7
		E_2	$L_9, L_{14}, L_{13}, L_4, T_3$	$L_9, L_6, T_3, L_{13}, L_1$	L_9, T_3
		E_3	$L_4, L_{14}, L_{13}, T_1, T_3$	$L_6, L_9, L_{13}, T_3, T_{11}$	L_{13}, T_3
3.	Height of first effective fruiting node	E_1	$L_4, L_{15}, L_1, L_{11}, L_5, L_6$	$L_4, L_7, L_{12}, L_1, L_{10}$	L_4, L_1
		E_2	L_8, L_5, L_3, L_2, L_1	$L_{15}, L_4, L_5, L_1, T_3$	L_5, L_1
		E_3	$L_2, L_5, L_{12}, L_8, T_2$	L_1, L_6, L_2, L_7, T_2	L_2, T_2
4.	Days to 50% flowering	E_1	$L_{11}, T_3, T_2, L_{12}, L_8$	$L_9, L_6, L_{11}, L_1, L_7$	L_{11}
		E_2	$L_4, L_{11}, L_{13}, T_3, L_6, L_8$	$L_{11}, L_{13}, L_1, L_9, T_1$	L_{11}, L_{13}
		E_3	$L_4, L_5, L_{11}, T_1, L_9$	$L_{13}, L_9, L_{11}, T_1, L_4$	L_4, L_{11}, T_1
5.	Number of fruits per plant	E_1	$T_2, L_9, L_{15}, L_4, L_8,$	$L_{11}, L_4, L_{13}, L_1, T_3$	L_4
		E_2	$L_{11}, T_3, L_4, L_9, L_3$	$L_{11}, L_4, L_9, L_{13}, T_3$	L_{11}, L_4, L_9, T_3
		E_3	L_1, L_3, T_2, T_3, L_9	$L_{13}, L_{11}, L_9, L_1, T_3$	L_1, L_9, T_3
6.	Fruit Length	E_1	$L_1, L_6, L_{15}, L_1, L_{11}, L_6, L_1, L_{11}, L_{15}, L_{12}$	$L_1, L_6, L_8, L_{10}, L_4$	L_6
		E_2	L_6, L_1, L_{15}, L_{12}	$L_6, L_4, L_{12}, L_{10}, L_1$	L_6, L_{12}
		E_3	$L_1, L_6, L_{15}, L_{11}, L_{12}$	$L_4, L_1, L_{12}, L_6, L_{10}$	L_1, L_6, L_{12}
7.	Fruit girth	E_1	$T_2, L_3, L_{14}, L_{15}, L_{10},$	$L_3, L_{14}, T_2, L_{15}, L_{10}$	$L_3, L_{14}, L_{15}, L_{10}, T_2$
		E_2	$T_2, L_3, L_{14}, L_{15}, L_{10}, T_2, L_3,$	$L_{14}, L_3, L_{15}, L_8, T_2$	L_3, L_{14}, L_{15}, T_2
		E_3	L_{14}, L_{15}, L_{10}	$L_{14}, L_{15}, L_{15}, T_2, L_8$	L_3, L_{14}, L_{15}, T_2
8.	Days to harvesting	E_1	$L_{11}, T_3, L_{12}, T_2, L_3, L_8$	$L_9, L_6, L_7, L_{11}, L_1$	L_{11}
		E_2	$L_4, L_{11}, L_{13}, T_3, L_8$	$L_{11}, L_{13}, L_1, L_9, T_1$	L_{11}, L_{13}
		E_3	$L_4, L_5, T_1, L_{11}, L_9$	$L_{13}, L_9, L_{15}, L_1, L_{11}$	L_{11}, L_9
9.	Fruit weigh	E_1	$L_2, L_{11}, T_3, L_9, L_4$	$L_9, L_{11}, L_1, L_4, L_{13}$	L_{11}, L_4
		E_2	L_2, L_4, T_3, L_6, L_9	$L_{11}, L_9, L_4, L_4, L_1, T_3$	L_4, T_3
		E_3	L_4, L_7, L_9, L_2, T_3	$L_9, L_{13}, L_4, L_1, T_3$	L_4, L_9, T_3
10.	Yield per plant	E_1	$L_9, L_4, L_2, L_{11}, T_3$	$L_{11}, L_{13}, L_9, L_1, L_4$	L_{11}, L_4
		E_2	$L_9, T_3, L_4, L_{13}, L_{11}$	$L_4, L_{11}, L_9, L_1, L_3$	L_{11}, L_4, L_9
		E_3	$T_1, T_2, T_3, L_4, L_{12}$	$L_{12}, L_{14}, L_1, L_7, L_4$	L_4

Table 3. Best hybrids identified on the basis of per se performance and SCA effects for various traits in different environments in okra

S. No.	Character		Per Se	SCA	Common
1.	Plant Height	E_1	$L_{11} \times T_3$, $L_4 \times T_3$, $L_4 \times T_2$, $L_{11} \times T_2$, $L_1 \times T_3$	$L_8 \times T_1$, $L_5 \times T_2$, $L_1 \times T_3$, $L_{12} \times T_3$, $L_{11} \times T_3$	$L_{11} \times T_3$, $L_1 \times T_3$
		E_2	$L_{11} \times T_3$, $L_4 \times T_3$, $L_4 \times T_2$, $L_1 \times T_3$, $L_4 \times T_2$	$L_4 \times T_3$, $L_9 \times T_2$, $L_5 \times T_1$, $L_4 \times T_1$, $L_7 \times T_3$	$L_4 \times T_3$, $L_9 \times T_4$
		E_3	$L_{11} \times T_3$, $L_4 \times T_3$, $L_9 \times T_3$, $L_{11} \times T_2$, $L_1 \times T_3$	$L_8 \times T_1$, $L_9 \times T_3$, $L_{15} \times T_2$, $L_{14} \times T_2$, $L_1 \times T_3$	$L_9 \times T_3$, $L_1 \times T_3$
2.	Number of branches per plant	E_1	$L_4 \times T_3$, $L_9 \times T_1$, $L_6 \times T_2$, $L_7 \times T_2$, $L_5 \times T_2$	$L_4 \times T_3$, $L_9 \times T_2$, $L_{10} \times T_3$, $L_5 \times T_2$, $L_{14} \times T_1$	$L_4 \times T_3$, $L_9 \times T_1$, $L_5 \times T_2$
		E_2	$L_9 \times T_1$, $L_9 \times T_3$, $L_6 \times T_3$, $L_{13} \times T_3$, $L_{11} \times T_2$	$L_{10} \times T_3$, $L_{11} \times T_2$, $L_5 \times T_2$, $L_9 \times T_1$, $L_6 \times T_2$	$L_9 \times T_1$, $L_6 \times T_3$, $L_{11} \times T_2$
		E_3	$L_{11} \times T_3$, $L_6 \times T_3$, $L_{15} \times T_2$, $L_1 \times T_1$, $L_3 \times T_3$	$L_{15} \times T_2$, $L_5 \times T_2$, $L_7 \times T_1$, $L_1 \times T_1$, $L_{13} \times T_3$	$L_{15} \times T_2$, $L_1 \times T_1$
3.	Height of first effective fruiting node	E_1	$L_8 \times T_2$, $L_7 \times T_1$, $L_4 \times T_2$, $L_3 \times T_3$, $L_{13} \times T_1$	$L_8 \times T_2$, $L_3 \times T_3$, $L_{14} \times T_3$, $L_{13} \times T_1$, $L_7 \times T_1$	$L_8 \times T_2$, $L_7 \times T_1$, $L_3 \times T_3$, $L_{13} \times T_1$
		E_2	$L_4 \times T_1$, $L_{11} \times T_2$, $L_{15} \times T_2$, $L_3 \times T_3$, $L_6 \times T_3$	$L_{11} \times T_2$, $L_4 \times T_3$, $L_8 \times T_2$, $L_6 \times T_3$, $L_1 \times T_1$	$L_{11} \times T_2$, $L_6 \times T_3$
		E_3	$L_7 \times T_3$, $L_1 \times T_2$, $L_9 \times T_1$, $L_{12} \times T_1$, $L_{13} \times T_2$	$L_{12} \times T_1$, $L_3 \times T_3$, $L_9 \times T_1$, $L_7 \times T_3$, $L_8 \times T_2$	$L_7 \times T_3$, $L_9 \times T_1$, $L_{12} \times T_1$
4.	Days to 50% flowering	E_1	$L_{11} \times T_3$, $L_9 \times T_1$, $L_{13} \times T_1$, $L_9 \times T_2$, $L_1 \times T_2$	$L_{11} \times T_3$, $L_{13} \times T_1$, $L_{15} \times T_3$, $L_{14} \times T_2$, $L_{10} \times T_1$	$L_{11} \times T_3$, $L_{13} \times T_1$
		E_2	$L_1 \times T_1$, $L_{11} \times T_3$, $L_{11} \times T_1$, $L_9 \times T_2$, $L_1 \times T_2$	$L_8 \times T_1$, $L_6 \times T_3$, $L_{14} \times T_1$, $L_4 \times T_1$, $L_{15} \times T_3$	Nil
		E_3	$L_9 \times T_2$, $L_{13} \times T_3$, $L_{15} \times T_3$, $L_{13} \times T_1$, $L_{13} \times T_3$	$L_{15} \times T_3$, $L_{11} \times T_3$, $L_2 \times T_3$, $L_{13} \times T_3$, $L_8 \times T_1$	$L_{13} \times T_3$, $L_{15} \times T_3$, $L_{13} \times T_3$
5.	Number of fruits per plant	E_1	$L_4 \times T_3$, $L_{11} \times T_3$, $L_1 \times T_3$, $L_9 \times T_3$, $L_{13} \times T_3$	$L_2 \times T_1$, $L_8 \times T_1$, $L_7 \times T_3$, $L_{14} \times T_3$, $L_5 \times T_2$	Nil
		E_2	$L_{11} \times T_3$, $L_{11} \times T_2$, $L_4 \times T_3$, $L_1 \times T_3$	$L_2 \times T_1$, $L_{12} \times T_2$, $L_5 \times T_2$, $L_1 \times T_3$, $L_6 \times T_1$	$L_1 \times T_3$
		E_3	$L_9 \times T_3$, $L_{13} \times T_3$, $L_1 \times T_3$, $L_{11} \times T_2$, $L_{14} \times T_3$	$L_2 \times T_1$, $L_3 \times T_1$, $L_7 \times T_3$, $L_{14} \times T_3$, $L_{11} \times T_2$	$L_{11} \times T_2$, $L_{14} \times T_3$
6.	Fruit Length	E_1	$L_3 \times T_3$, $L_{13} \times T_2$, $L_{13} \times T_3$, $L_{10} \times T_1$, $L_9 \times T_3$	$L_{13} \times T_2$, $L_9 \times T_3$, $L_{14} \times T_1$, $L_{11} \times T_3$, $L_3 \times T_3$	$L_3 \times T_3$, $L_{13} \times T_2$
		E_2	$L_3 \times T_3$, $L_9 \times T_3$, $L_{13} \times T_2$, $L_3 \times T_2$, $L_{14} \times T_1$	$L_9 \times T_3$, $L_{11} \times T_3$, $L_{13} \times T_{32}$, $L_{14} \times T_1$, $L_7 \times T_1$	$L_9 \times T_3$, $L_{13} \times T_2$, $L_{14} \times T_1$
		E_3	$L_3 \times T_3$, $L_{13} \times T_2$, $L_{11} \times T_3$, $L_9 \times T_3$, $L_3 \times T_2$	$L_9 \times T_3$, $L_{11} \times T_3$, $L_{14} \times T_1$, $L_7 \times T_1$, $L_{13} \times T_2$	$L_{11} \times T_3$, $L_9 \times T_3$
7.	Fruit girth	E_1	$L_6 \times T_2$, $L_3 \times T_2$, $L_{14} \times T_2$, $L_3 \times T_1$, $L_{14} \times T_1$	$L_6 \times T_2$, $L_7 \times T_2$, $L_8 \times T_1$, $L_1 \times T_2$, $L_5 \times T_2$	$L_6 \times T_2$
		E_2	$L_3 \times T_2$, $L_{15} \times T_2$, $L_{14} \times T_2$, $L_{14} \times T_1$, $L_4 \times T_2$	$L_1 \times T_2$, $L_{14} \times T_1$, $L_{13} \times T_3$, $L_8 \times T_1$, $L_2 \times T_3$	$L_{14} \times T_1$
		E_3	$L_3 \times T_2$, $L_{14} \times T_2$, $L_{14} \times T_1$, $L_{15} \times T_2$, $L_5 \times T_2$	$L_5 \times T_2$, $L_{12} \times T_1$, $L_1 \times T_2$, $L_7 \times T_2$, $L_{14} \times T_1$	$L_{14} \times T_1$, $L_5 \times T_2$
8.	Days to harvesting	E_1	$L_{11} \times T_3$, $L_9 \times T_1$, $L_{13} \times T_1$, $L_9 \times T_2$, $L_8 \times T_1$	$L_{11} \times T_3$, $L_{14} \times T_2$, $L_{13} \times T_1$, $L_{10} \times T_1$, $L_{15} \times T_3$	$L_{11} \times T_3$, $L_{13} \times T_1$
		E_2	$L_{11} \times T_3$, $L_{13} \times T_1$, $L_1 \times T_2$, $L_{11} \times T_2$, $L_{13} \times T_2$	$L_8 \times T_1$, $L_4 \times T_1$, $L_6 \times T_3$, $L_{15} \times T_3$, $L_{14} \times T_1$	Nil
		E_3	$L_{15} \times T_3$, $L_{13} \times T_3$, $L_{11} \times T_3$, $L_9 \times T_2$, $L_1 \times T_1$	$L_{15} \times T_3$, $L_8 \times T_1$, $L_{11} \times T_3$, $L_{10} \times T_2$, $L_2 \times T_3$	$L_{15} \times T_3$, $L_{11} \times T_3$
9.	Fruit weigh	E_1	$L_{11} \times T_1$, $L_1 \times T_3$, $L_9 \times T_2$, $L_1 \times T_2$, $L_9 \times T_1$	$L_2 \times T_3$, $L_{11} \times T_1$, $L_7 \times T_2$, $L_{13} \times T_1$, $L_1 \times T_3$	$L_{11} \times T_1$, $L_1 \times T_3$
		E_2	$L_1 \times T_3$, $L_{11} \times T_2$, $L_{11} \times T_3$, $L_9 \times T_3$, $L_4 \times T_3$	$L_{15} \times T_1$, $L_1 \times T_3$, $L_{13} \times T_1$, $L_6 \times T_2$, $L_7 \times T_2$	$L_1 \times T_3$
		E_3	$L_9 \times T_2$, $L_2 \times T_3$, $L_1 \times T_3$, $L_4 \times T_3$, $L_1 \times T_2$	$L_2 \times T_3$, $L_{11} \times T_1$, $L_{19} \times T_2$, $L_3 \times T_3$, $L_{13} \times T_1$	$L_9 \times T_2$, $L_2 \times T_3$
10.	Yield per plant	E_1	$L_1 \times T_3$, $L_{94} \times T_3$, $L_{13} \times T_2$, $L_3 \times T_3$, $L_{11} \times T_2$	$L_3 \times T_3$, $L_2 \times T_1$, $L_1 \times T_3$, $L_{12} \times T_2$, $L_2 \times T_3$	$L_1 \times T_3$, $L_3 \times T_3$
		E_2	$L_9 \times T_1$, $L_4 \times T_2$, $L_1 \times T_2$, $L_{13} \times T_1$, $L_4 \times T_1$	$L_9 \times T_1$, $L_1 \times T_2$, $L_{13} \times T_1$, $L_2 \times T_3$, $L_3 \times T_3$	$L_9 \times T_1$, $L_1 \times T_2$, $L_{13} \times T_1$
		E_3	$L_7 \times T_3$, $L_{12} \times T_3$, $L_4 \times T_3$, $L_1 \times T_3$, $L_{14} \times T_2$	$L_3 \times T_1$, $L_7 \times T_3$, $L_2 \times T_1$, $L_4 \times T_3$, $L_{13} \times T_2$	$L_7 \times T_3$, $L_4 \times T_3$

Symbol used in the tables

Symbol	Name of line	Symbol	Name of Tester
L_1	Heritage Green	T_1	Parbhani Kranti
L_2	GO-2	T_2	Arka Abhay
L_3	BO-2	T_3	Arka Anamika
L_4	Punjab Padmini		
L_5	Harbhajan		
L_6	Nirmal-303		
L_7	CO-3		
L_8	Pusa Sawni		
L_9	Swati-10		
L_{10}	Swati- 25		
L_{11}	Ankur-40		
L_{12}	VRO-5		
L_{13}	VRO-6		
L_{14}	Ratnaraj		
L_{15}	Varsha Uphar		

were significant for all the characters in all the environments except due to lines for first effective fruiting node. The mean squares due to lines x tester were significant for all the traits in all the environments except for plant height in E_1, E_2 and E_3 and for fruit girth in E_2. The σ^2GCA effects due to lines and testers revealed that both the lines and testers contributed for various characters in different environments. Estimates of σ^2SCA effects were greater than σ^2GCA effects due to lines and testers for all characters in all the environments, which suggested the role of non-additive gene action in the inheritance of most of the characters. The preponderance of non-additive gene action was also reported by (Singh and Singh, 1978), (Arora, 1993), (Sood and Sharma, 2001) and Prakash *et al.* (2002). Recurrent selection could be used for the improvement of these characters. Out of ten traits under study, the negative gca and sca effects were estimated for three characters viz. days to 50 percent flowering, days to harvesting and height of first effective fruiting node were considered desirable, since these traits are negatively correlated with fruit yield per plant. However, positive estimates of gca and sca effects for the remaining traits were considered desirable. The estimates of 15 famale lines and 3 male testers for 10 characters (Table 2) indicated that parents

An overall appraisal of GCA effects of the parents (lines and testers) used in the present study indicated that, in general, none of the parent was a good general combiner for all the traits studied. Estimates of GCA effects showed that line L_9 was a good general combiner over the environment as it showed significant GCA effects in favourable direction for varying sets of 6, 7 and 4 characters in E_1, E_2 and E_3, respectively followed by line L_1, L_4, L_{11} and L_{13}. Among testers, T_3 was good combiner for a set of three characters in E_1; two in E_2 and four in E_3 including yield per plant except in E_2 environment.

A perusal of SCA effects among hybrids revealed that highest magnitude of positive SCA effects for yield per plant was revealed by L_3 x T_3 in E_1; L_9 x T_1 and L_1 x T_2 in E_2 and L_3 x T_1 in E_3 environment. None of the cross combination exhibited consistently high SCA effects for all the traits studied. The crosses showing high SCA effects did not always involve parents with high GCA effects suggesting that the interallelic interactions are important for the concerning characters. These findings are in agreement with the findings of Pratap *et al.* (1981 a), Poshiya and Shukla (1986), (Patel, 1988), (Poshiya, 1992), (Shinde *et al.*, 1995) and (Pawar *et al.*, 1999).

Besides yield, crosses L_3 x T_3 and L_9 x T_1 also revealed desirable SCA effects for number of branches per plant in E_3 and height of first effective fruiting node in E_1 and E_3. Likewise, cross L_1 x T_2 showed high positive SCA effects for number of fruits per plant in all the environments; and cross L_3 x T_1 for fruit weight in E_1 and E_2 environment.

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