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Research Article

Combining ability analysis in sesame (*Sesamum indicum* L.)

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Abstract
An attempt was made to study the general and specific combining ability in sesame (*Sesamumindicum* L.) through Linex Tester analysis by using five lines and nine testers. A total of forty five crosses were developed and ten quantitative traits were studied. Based on the general combining ability effects, the line TMV 5 was found to be a good general combiner for more number of traits like single plant yield, total number of capsules per plant, number of capsules on main stem, number of primary branches, number of secondary branches and days to first flowering. Among the testers, CO 1 exhibited good combining ability for single plant yield, 100 seed weight, plant height and number of secondary branches. The tester ORM 7 was also found to be a good general combiner for single plant yield, total number of capsules per plant, number of capsules in main stem and days to first flowering. The cross combination TMV 5 x ORM 7 had expressed the highly significant and positive *sca* effect for single plant yield, total number of capsules per plant and plant height but negative *sca*effect for 100 seed weight. Also, the cross TMV 6 x VRI 1 was found to have significant and positive*sca* effects for more number of traits like single plant yield, 100 seed weight, total number of capsules per plant and number of primary branches and hence these crosses could be utilized for yield improvement through heterosis and pedigree breeding.

Keywords : Sesame, Line x Tester, GCA, SCA

Introduction

Sesame (*Sesamumindicum* L.) is atraditional oilseed crop of India and its seeds are rich in oil and protein content. Sesame oil is noted for its stability, quality and medicinal properties. It offers several advantages by virtue of its fastergrowth, short duration, cultivated throughout the year in sub-tropical and tropical conditions. In spite of all these, it has not contributedenormously to the total oilseed production in India, mainly becauseof low productivity (376 kg/ha) in comparison with world average productivity of 559 kg/ha (FAOSTAT, 2012)and someother countries like China and Egypt (1304 kg/ha), Ethiopia (757 kg/ha),Thailand(575 kg/ha)and Myanmar (554 kg/ha).Therefore, there is anurgent need to augment sesame productivity through theexploitation of high yield potential by selecting suitable parents.The performance and adaptation of parents is not always atrue indicator of superior combining ability as it depends uponcomplex interaction of genes.The concept of combining ability analysis gives precise estimates of the nature and magnitude of gene actions involved in the inheritance of quantitative characters. This facilitates identification of parents with good general combining ability effects and the cross combinations with good specific combining ability effects. The knowledge on combining ability and type of gene actionhelps in selecting the most suitable breeding procedure and in turn for the proper planning of a successful breeding programme. Hence, the presentinvestigation was carried out to identify the best generalcombiners and specific cross combinations for increasing the seed yield andits components in sesame.

Materials and Methods

The material for the present study consisted of five females, which were released varieties *viz.*, TMV 3, TMV 4, TMV 5, TMV 6, Paiyur 1 and nine males*viz.*, CO 1, SVPR 1, TMV 7,VRI 1, VRI 2, Jaumer, ORM 7, ORM 14 and ORM 17. Crosses were made between these parents in Line x Tester mating design to develop 45 F_1 hybrids at the Department of Oilseeds, Tamil Nadu Agricultural University, Coimbatoreduring Rabi-Summer 2010-11. Individual cross combinations along with their parents were raised in Randomized Block Design with two replications, in four meter row with spacing of 30 x 30 cm, during Kharif 2011. The recommended package of practices for sesame was followed throughout the crop growing period. Observations were recorded for ten traits *viz.*, days to first flowering, days to maturity, plant height (cm), number of primary branches, number of secondary branches, number of capsules in main stem, total number of capsules per plant, number of seeds per capsule, single plant yield (g) and 100 seed weight (mg). Ten plants in parents and hybrids were randomly selected in each replication and observations on the quantitative traits were recorded. The mean values were subjected to line

x tester analysis as suggested by Kempthorne (1957).

Results and Discussion

The analysis of variance in respect of ten quantitative characters under study is presented in Table 1, which indicated the presence of significant variation among the genotypes utilized for all the ten quantitative traits studied. Significant variances were observed among hybrids for all the characters except for days to maturity. The variances due to hybrids vs parents had significance for all characters except for number of secondary branches per plant indicating the higher level of variation for the traits observed.

Analysis of variance for combining ability analysis (Table 2) indicated the presence of significant differences among the lines, testers and line x tester interaction for all the characters studied. The significant variance for line × tester interaction indicates the importance of specific combining ability. Apart from this, the estimates of GCA and SCA variances are useful to understand the type of gene action and which breeding method to be followed for the crop improvement. In this study, the magnitude of specific combining ability variances was much greater than those of the respective general combining ability variances for all the characters and hence the ratio between GCA and SCA variance was less than one, which indicated the preponderance of non-additive gene action for the quantitative characters studied. Thiyagarajan and Ramanathan (1995), Manivannan and Ganesan (2001), Krishnaiah*et al*., (2002),Vidhyavathi *et al.* (2005) and Bharathikumar and Vivekanandan, (2009) also reported the role of non-additive gene action for the traits studied especially for seed yield. Hence improvement of these yield related characters could be accomplished by selection at later filial generations.

Contribution of parents and their hybrids towards total variance is given in Table 3. From the table, it was found that the interaction between lines and testers contributed more to the total variance for all the traits studied except number of capsules in main stem where the contribution of female parent is comparatively higher. Interaction between the lines and testers contributed more than 60 per cent for number of primary branches (79.71%), days to maturity (69.73%), total number of capsules per plant (60.78%) and plant height (60.37%). When the parents are compared, the contribution of testers were higher for days to first flowering, days to maturity, number of primary branches, number of secondary branches, single plant yield and 100 seed weight to the total variance. For number of seeds per capsule, the contribution of lines (34.68%) was much higher than tester (8.22%).

Since the mean value is also considered for the selection of parents apart from *gca* effect, the mean performance of parents for yield and its component characters are presented in Table 4 and compared with the general mean. Based on meanperformance, the line TMV 5 is having more number of capsules on main stem as well as number of seeds per capsule and in turn, the highest single plant yield. Among the testers, the entry TMV 7 has the highest single plant yield along with more number of capsules per plant.

Though high mean value is the main criterion of selection for the breeders, since the parents with good mean performance would result in good performing off springs as reported by Gilbert (1958), the study of general combining ability will give the overall information about each of the parents used. Dhillon (1975) reported that combining ability of parents gives useful information on the choice of parents in terms of expected performance of the hybrids and their progenies. The estimates of *gca* effect showed that the lines Paiyur1, TMV 5 and the testers like SVPR 1, VRI 1, Jaumer and ORM 7 expressed significant and negative *gca* effect for days to first flowering. The line TMV 3 and the male parents such as SVPR 1 and VRI 1 had shown significant and negative *gca* effects for days to maturity. Hence the parents SVPR 1 and VRI 1 can be utilized as parents to breed for early duration varieties. Regarding plant height, the line TMV 4 and the testers SVPR 1 and TMV 7 were found to have significant and negative *gca* effect whereas, the line Paiyur 1 and the tester CO 1 had expressed highly significant and positive *gca* effect, which would help to breed for tall plants. For number of primary and secondary branches, the female parent TMV 5 alone is found to be the good general combiner. For number of capsules in main stem and total number of capsules per plant, the lines TMV 5, Paiyur 1 and the testers Jaumer and ORM 7 had expressed highly significant and positive *gca* effect. For number of seeds per capsule and 100 seed weight, the lines TMV 3 and Paiyur 1had shown significant and positive *gca* effects apart from the testers like CO 1, VRI 1, VRI 2, Jaumer and ORM 17 for 100 seed weight alone. For single plant yield, the female parent TMV 5 and the male parents like CO 1 and ORM 7 were found to be the good general combiners. Since, high *gca*effect is attributed to additive gene action, the parents having highly significant and positive *gca* effect could be used in breeding programme for yield improvement through pedigree breeding.

The specific combining ability is the deviation from the performance predicted on the basis of general combining ability (Allard, 1960). The *sca* effect is an important criterion for the evaluation of hybrids. Hence, the cross combinations were identified based on mean performance and the gene action involved, for further utilization in our breeding programme. The meanperformance and *sca* effects of hybrids for yield and its component traits are given in Table 5. Among the crosses studied, TMV 5 x ORM 7 had recordedthe highest singleplant yield, more number of capsules on main stem and total number of capsules per plant. The crosses TMV 3 x CO 1 and TMV 6 x VRI 1 also had recorded high single plant yield along with more number of primary and secondary branches, more number of seeds per capsule and high 100 seed weight, which are considered as desirable crosses based on mean performance.

When the *sca* effects are observed, the cross TMV 5 x ORM 7 had expressed the highly significant and positive *sca* effect for single plant yield, total number of capsules per plant and plant height but negative effects for 100 seed weight. Also, the cross TMV 6 x VRI 1 was found to have the highest estimates for more number of traits like single plant yield, 100 seed weight, total number of capsules per plant and number of primary branches based on *sca* effect. Apart from this, the line TMV 6with the testers, TMV 7 and VRI 2 also had expressed highly significant and positive *sca* effects for single plant yield and number of primary branches. The cross TMV 3 x ORM 17 had shown highly significant and positive *sca* effect for single plant yield and total number of capsules per plant but negative effect for 100 seed weight. TMV 4 x VRI 2 also had highly significant and positive *sca* effect for single plant yield along with earliness. These crosses could be utilized for heterosis and pedigree breeding to obtain better recombinants for desirable traits in later generations.

References

Allard, R.W. 1960. Principles of plant breeding. John Wiley and Sons, Inc., New York,London.

Bharathi Kumar, K and Vivekanandan, P.2009.Studies on combining ability studies in sesame (*Sesamumindicum L.*).*Electron. J. Plant Breed.*,1: 33-36

Dhillon, B.S. 1975. The application of partial-diallel crosses in plant breeding-A review. *CropImprov.*, 2: 1-7.

FAOSTAT. 2012. http://faostat.fao.org/site/567/default.aspx#anc or

Gilbert, N.E.G. 1958. Diallel cross in plant breeding. *Heredity*, 12: 477 – 492.

Kempthorne. O. 1957. An introduction to Genetic statistics. John Wiley and Sons, Inc., New York.

Krishnaiah, G., Reddy, K. R., Reddy, G.L.K. and Sekhar, M.R. 2002.Combining ability in sesame.*Crop Res.*, Hisar, 24:72-76.

Manivannan, N. and Ganesan, J. 2001. Line x Tester analysis in sesame (*Sesamumindicum* L.). *Indian J.Agric. Res*., 35:90-94.

Vidhyavathi, R.,Manivannan, N. and Muralidharan, V. 2005.Line x Tester analysis in sesame (*Sesamumindicum* L.).*Indian J. Agric. Res*., 39:225-228.

Thiyagarajan, K. and Ramanathan, T. 1995. Combining ability analysis for yield components of sesame in different environments.*Madras Agric. J.* 82:445-

Table 1. Analysis of variance for parents and hybrids for yield and its component characters

Source of variation	d.f	Days to first flowering	Days to maturity	Plant height	No. of primary branches	No. of secondary branches	No. of capsules in main stem	Total no. of capsules	No. of seeds /capsule	Single Plant Yield	100 Seed Weight
Replications	1	6.46	4.33	41.05	0.26	0.22	4.37	0.20	0.19	3.29	4.10
Hybrids	44	10.6**	4.24	251.96**	0.82**	1.19**	54.22**	847.97**	23.71**	101.39**	941.58**
Parents	13	21.06**	147.64**	579.96**	2.59**	1.66**	29.77**	681.87**	20.31**	19.20*	166.92**
Hybrids vs Parents	1	1008.12**	453.61**	2110.58*	2.64**	14.40	366.66**	4854.28**	133.53**	18.76*	2327.27**
Error	58	1.71	2.99	49.56	0.30	0.52	9.44	25.35	5.35	7.86	15.27

* Significant at 5% and ** Significant at 1%

Table 2. Analysis of variance for combining ability analysis

Source of variation	d.f	Days to first flowering	Days to maturity	Plant height	No. of primary branches	No. of secondary branches	No. of capsules in main stem	Total no. of capsules	No. of seeds /capsule	Single Plant Yield	100 Seed Weight
Replications	1	0.28	18.68	36.35	0.07	0.07	8.22	6.45	1.11	11.59	11.38
Lines	4	21.97**	4.77*	488.46**	0.64*	2.23**	233.31**	2191.37**	90.46**	188.37**	2242.9**
Testers	8	22.17**	4.68**	305.03**	0.60*	2.09**	82.65**	733.70**	10.73	139.38**	1975.16**
LinexTester	32	6.38**	4.07**	209.13**	0.90**	0.84*	24.72**	708.61**	18.62**	81.02**	520.52**
Error	44	1.73	1.50	56.01	0.22	0.44	9.27	22.66	5.47	9.69	4.54
GCA		0.1034	0.0042	1.0331	-0.0019	0.0086	0.7115	3.3617	0.1229	0.4914	10.1572
SCA		2.3262	1.2854	76.5609	0.3406	0.1982	7.7289	342.98	6.5758	35.6662	257.9909
GCA/SCA		0.0445	0.0033	0.0135	0.0056	0.0434	0.0921	0.0098	0.0187	0.0138	0.0394

* Significant at 5% and ** Significant at 1%

Table 3. Proportional contribution of lines, testers and their interaction to total variance

Characters	Contribution (%)		
	Lines	Testers	Line x Tester
Days to first flowering	18.72	37.77	43.51
Days to maturity	10.22	20.05	69.73
Plant height	17.62	22.01	60.37
No. of primary branches	7.05	13.24	79.71
No. of secondary branches	17.05	31.96	50.99
No. of capsules in main stem	39.12	27.72	33.16
Total no. of capsules	23.49	15.73	60.78
No. of seeds /capsule	34.68	8.22	57.10
Single Plant Yield	16.89	24.99	58.12
100 Seed Weight	21.66	38.14	40.20

Table 4. Mean and General combining ability effects of parents for yield and component characters in sesame

S. No	Entries	Days to first flowering	Days to maturity	Plant height	No. of primary branches	No. of secondary branches	No. of capsules in main stem	Total no. of capsules	No. of seeds /capsule	Single Plant Yield (g)	100 Seed Weight (mg)
	Lines										
1.	TMV3	40.00	104.50	109.30	5.65	2.80	25.65	74.45	65.60	19.30	298.0
		0.33	-0.80**	2.09	0.04	-0.42**	4.26**	-4.58**	2.44**	-0.89	13.99**
2.	TMV4	38.00	100.00	116.0	4.40	3.20	24.70	80.80	64.35	21.55	307.0
		-0.22	0.26	-8.80**	-0.17	-0.32*	-4.25**	-9.97**	-3.16**	-4.22**	-13.34**
3.	TMV5	38.90	100.20	134.70	4.40	3.00	29.20	79.85	65.65	21.80	311.0
		-0.72*	0.59*	0..86	0.31**	0.33*	1.70*	6.21**	-0.72	4.82**	-0.40
4.	TMV6	37.60	98.65	140.05	4.40	1.90	24.40	81.80	63.40	20.90	317.0
		1.72**	0.03	0.82	-0.08	0.31	-3.23**	-7.94**	-0.43	0.28	-8.01**
5.	Paiyur1	39.20	100.80	133.80	6.10	3.10	20.70	84.00	64.20	18.70	311.0
		-1.11**	-0.08	5.03**	-0.10	0.10	1.52*	16.28**	1.86**	0.01	7.77**
	Testers										
1.	CO1	41.50	105.95	131.75	6.60	3.60	24.50	79.00	75.00	24.10	311.0
		0.32	0.76	13.10**	0.22	0.52*	-0.44	-8.05**	1.19	5.45**	13.19**
2.	SVPR1	30.50	79.50	75.25	2.50	0.50	17.00	32.00	68.00	15.00	331.0
		-1.68**	-1.14**	-6.22*	-0.43**	-0.14	-1.80	-0.63	-1.69*	-1.57	-0.11
3.	TMV7	42.50	86.00	107.70	4.60	1.70	20.50	93.00	68.00	24.55	316.5
		2.02**	0.26	-4.76*	-0.09	-0.54*	0.04	-4.22**	-0.33	-5.21**	-5.91**
4.	VRI1	33.00	79.50	121.75	3.00	2.05	24.50	74.00	66.90	18.20	306.5
		-1.23**	-0.84*	-0.12	0.34*	0.22	-3.52**	-2.50	0.39	-2.41*	17.69**
5.	VRI2	36.70	95.40	128.50	4.25	2.15	22.00	60.50	65.25	23.45	313.0
		1.12**	0.26	0.24	0.26	0.74**	-3.38**	-7.23**	-1.21	0.27	6.19**
6.	Jauamer	39.65	98.80	136.90	3.80	1.15	21.60	59.90	63.60	18.45	309.0
		-1.08**	-0.14	-3.20	-0.05	0.08	2.86**	9.09**	-0.17	-0.14	7.19**
7.	ORM7	39.00	104.50	122.50	5.00	2.00	23.50	61.15	68.00	17.85	299.0
		-1.28**	0.16	-0.18	-0.19	0.07	5.50**	15.62**	1.43	6.23**	-25.01**
8.	ORM14	41.00	96.00	135.00	4.00	1.00	23.50	71.40	69.50	17.65	294.0
		-0.38	0.96*	0.70	0.04	-0.32	0.66	6.62**	0.67	0.15	-17.91**
9.	ORM17	40.15	96.10	128.50	5.65	2.65	21.00	63.00	62.45	18.50	309.0
		-0.28	-0.24	0.48	-0.12	-0.62**	0.08	-8.66**	-0.25	-2.73**	4.69**
	General mean	43.65	99.65	115.40	4.86	2.83	25.86	81.42	67.90	20.57	334.70
	S.E	0.92	1.22	4.98	0.39	0.51	2.17	3.56	1.63	1.98	2.77
	S.E(Lines)	0.3102	0.2883	1.7640	0.1105	0.1562	0.7175	1.1219	0.5511	0.7336	0.5020
	S.E(Tester)	0.4162	0.3868	2.3667	0.1483	0.2095	0.9626	1.5052	0.7394	0.9842	0.6736
	C.D (p=0.05)	2.5873	3.4216	13.9390	1.0862	1.4331	6.0829	9.9685	4.5789	5.5504	7.7383
	C.D (p=0.01)	3.4366	4.5448	18.5150	1.4428	1.9036	8.0798	13.2409	6.0821	7.3725	10.2786

* Significant at 5% and ** Significant at 1% *gca* effectsgiven in italics

Table 5. Mean performance and specific combining ability effects of hybrids for yield and its component characters in sesame

S. No.	Entries	Days to first flowering	Days to maturity	Plant height	No. of primary branches	No. of secondary branches	No. of capsules in main stem	Total no. of capsules	No. of seeds /capsule	Single Plant Yield (g)	100 Seed Weight (mg)
1.	TMV 3 x CO 1	43.50	99.50	162.20	5.35	4.40	29.90	57.45	70.00	31.70	354.5
		-2.43 *	0.40	33.97**	0.14	1.28**	-0.76	-14.91**	-2.12	6.35**	-15.19**
2.	TMV 3 x SVPR 1	43.50	98.50	101.50	4.40	2.30	24.20	65.80	66.00	12.70	362.0
		-0.43	-0.30	-7.41	-0.16	-0.16	-5.10*	-13.98**	-3.24	-5.63*	5.61**
3.	TMV 3 x TMV 7	46.00	100.00	106.00	4.50	1.40	30.10	77.40	76.00	20.70	368.0
		-1.63	-0.20	-4.37	-0.40	-0.66	-1.04	1.21	5.40**	6.01**	17.41**
4.	TMV 3 x VRI 1	47.50	100.00	112.00	6.00	3.20	33.60	93.00	76.80	14.20	371.5
		-0.13	-0.70	-3.01	0.67*	0.38	6.02**	15.09**	5.48**	-3.29	-2.69
5.	TMV 3 x VRI 2	50.50	102.50	112.60	5.20	3.10	31.90	81.50	65.20	16.40	364.0
		3.77 **	2.30*	-2.77	-0.05	-0.24	4.18	8.32*	-4.52*	-3.77	1.31
6.	TMV 3 x Jauamer	44.50	99.50	102.60	4.60	2.30	30.60	71.60	69.20	15.90	375.5
		0.77	-0.30	-9.33	-0.34	-0.38	-3.36	-17.90**	-1.56	-3.86	11.81**
7.	TMV 3 x ORM 7	46.50	100.00	102.40	4.60	2.20	35.20	78.30	67.20	17.90	326.0
		2.17 *	-0.10	-12.55*	-0.20	-0.477	-1.40	-17.73**	-5.16**	-8.23**	-5.49**
8.	TMV 3 x ORM 14	44.50	100.00	118.10	5.25	2.60	31.80	117.80	74.40	23.60	336.0
		-0.73	-0.90	2.27	0.22	0.32	0.04	30.77**	2.80	3.55	-2.59
9.	TMV 3 x ORM 17	44.00	99.50	118.80	5.00	1.90	32.60	80.90	73.60	26.00	351.0
		-1.33	-0.20	3.19	0.13	-0.08	1.42	9.15**	2.92	8.83**	-10.19**
10.	TMV 4 x CO 1	47.00	99.50	115.10	5.50	3.60	23.20	93.40	67.60	21.40	356.5
		1.62	-0.66	-2.24	0.50	0.38	1.05	26.43**	1.08	-0.62	14.14**
11.	TMV 4 x SVPR 1	43.50	102.00	100.00	5.20	2.60	22.50	81.40	64.00	16.20	320.5
		0.12	2.14*	1.98	0.85*	0.04	1.71	7.01*	0.36	1.20	-8.56**
12.	TMV 4 x TMV 7	49.50	102.00	99.80	4.60	2.10	26.60	55.95	62.40	7.00	298.0
		2.42 *	0.74	0.32	-0.09	-0.06	3.97	-14.85**	-2.60	-4.36	-25.26**
13.	TMV 4 x VRI1	48.50	101.50	99.30	4.10	1.90	17.00	71.00	64.00	8.00	303.5
		1.42	-0.26	-4.82	-1.02**	-1.02*	-2.07	-1.52	-1.72	-6.16**	-43.36**
14.	TMV 4 x VRI 2	43.00	100.00	110.10	5.00	3.60	21.60	69.60	64.80	25.40	333.0
		-3.18 **	-1.26	5.62	-0.04	0.16	2.39	1.81	0.68	8.56**	-2.36
15.	TMV 4 x Jauamer	41.50	99.50	103.30	4.80	3.20	25.30	90.20	68.00	17.50	354.0
		-1.68	-1.36	2.26	0.07	0.42	-0.15	6.09	2.84	1.07	17.64**
16.	TMV 4 x ORM 7	43.00	102.00	105.40	4.60	2.80	27.20	91.85	68.80	27.00	341.5
		-0.78	0.84	1.34	0.01	0.03	-0.89	1.21	2.04	4.20	37.34**
17.	TMV 4 x ORM 14	43.00	101.00	94.70	4.50	2.30	20.00	62.30	65.60	16.30	311.0
		-1.68	-0.96	-10.24*	-0.32	-0.08	-3.25	-19.34**	-0.40	-0.42	-0.26

18.	TMV 4 x ORM 17	46.50	101.50	110.50	4.70	2.20	19.90	59.50	62.80	10.40	344.5
		1.72	0.74	5.78	0.04	0.12	-2.77	-6.86*	-2.28	-3.44	10.64**
19.	TMV 5 x CO 1	43.00	100.00	108.90	5.50	3.10	26.00	82.55	69.20	26.20	368.5
		-1.88 *	-0.49	-18.10**	0.02	-0.77	-2.10	-0.60	0.24	-4.86*	13.20**
20.	TMV 5 x SVPR 1	43.50	99.50	103.40	4.50	3.80	25.50	80.20	70.80	25.10	320.0
		0.62	-0.69	-4.28	-0.33	0.59	-1.24	-10.37**	4.72**	1.06	-22.00**
21.	TMV 5 x TMV 7	45.00	101.00	111.30	4.60	2.80	30.30	80.30	66.80	15.60	343.5
		-1.58	-0.59	2.16	-0.57*	-0.01	1.72	-6.68	-0.64	-4.80*	7.30**
22.	TMV 5 x VRI1	47.00	102.50	109.10	5.85	3.10	21.60	67.25	64.00	22.30	374.5
		0.42	0.41	-4.68	0.25	-0.47	-3.42	-21.45**	-4.16*	-0.90	14.70**
23.	TMV 5 x VRI 2	46.00	102.00	105.50	5.70	4.70	20.90	86.15	66.80	22.10	346.0
		0.32	0.41	-8.64	0.18	0.61	-4.26*	2.18	0.24	-3.78	-2.30
24.	TMV 5 x Jauamer	44.00	102.50	127.90	5.20	4.10	34.90	125.00	67.60	28.50	346.5
		1.32	1.31	17.20**	-0.01	0.67	3.50	24.71**	-0.00	3.03	-2.80
25.	TMV5 x ORM 7	42.00	102.00	124.70	5.00	3.40	37.30	122.40	68.80	44.50	305.0
		-1.28	0.51	10.98*	-0.07	-0.02	3.26	15.58**	-0.40	12.66**	-12.10**
26.	TMV5 x ORM 14	44.50	101.50	114.50	6.00	2.20	32.10	88.00	69.20	28.70	326.0
		0.32	-0.79	-0.10	0.70*	-0.83	2.90	-9.82**	0.76	2.94	1.80
27.	TMV 5 x ORM 17	46.00	101.00	119.80	4.95	3.00	28.30	89.00	66.80	17.50	349.0
		1.72	-0.09	5.42	-0.19	0.27	-0.32	6.46	-0.72	-5.38*	2.20
28.	TMV 6 x CO 1	48.50	101.00	117.00	5.30	3.90	22.70	71.10	70.40	27.70	345.0
		1.18	1.07	-9.96*	0.21	0.05	-0.47	2.10	1.15	1.18	-2.69
29.	TMV 6 x SVPR 1	43.00	97.50	105.70	3.60	2.00	24.40	70.60	65.20	17.00	356.5
		-2.32 *	-2.13*	-1.94	-0.84*	-1.19*	2.59	-5.82	-1.17	-2.50	22.11**
30.	TMV 6 x TMV 7	50.00	100.00	117.00	5.70	3.00	24.80	87.80	66.40	22.30	328.0
		0.98	-1.03	7.90	0.92**	0.21	1.15	14.97**	-1.33	6.44**	-0.59
31.	TMV 6 x VRI 1	49.00	102.00	121.80	5.90	4.40	22.60	107.80	70.40	30.20	365.5
		-0.02	0.47	8.06	0.69*	0.85	2.51	33.25**	1.95	11.54**	13.31**
32.	TMV 6 x VRI2	47.50	101.50	119.50	5.85	4.00	15.40	59.95	70.40	27.30	338.5
		-0.62	0.47	5.40	0.72*	-0.07	-4.83*	-9.87**	3.55*	5.96**	-2.19

33.	TMV 6 x Jauamer	44.00	100.00	103.50	4.90	3.70	26.30	85.90	69.20	20.40	331.0
		-1.12	-0.63	-7.16	0.08	0.29	-0.17	-0.24	1.31	-0.53	-10.69**
34.	TMV 6 x ORM 7	45.50	102.00	109.30	5.10	3.85	27.20	71.30	66.80	17.30	297.5
		-0.22	1.07	-4.38	0.42	0.45	-1.91	-21.37**	-2.69	-10.00**	-11.99**
35.	TMV 6 x ORM 14	49.00	105.00	119.60	3.00	2.70	20.10	57.45	65.80	10.60	315.5
		2.38 *	3.27**	5.04	-1.91**	-0.31	-4.17	-26.22**	-2.93	-10.62**	-1.09
36.	TMV 6 x ORM 17	46.50	98.00	111.40	4.50	2.40	29.00	81.60	68.00	16.90	333.0
		-0.22	-2.53**	-2.94	-0.25	-0.31	5.31*	13.21**	0.19	-1.44	-6.19**
37.	Paiyur 1 x CO 1	46.00	99.50	127.50	4.20	2.70	30.20	80.20	71.20	24.20	354.0
		1.51	-0.32	-3.67	-0.87*	-0.94	2.28	-13.02**	-0.34	-2.05	-9.47**
38.	Paiyur 1 x SVPR 1	44.50	100.50	123.50	4.90	3.70	28.60	123.80	68.00	25.10	353.0
		2.01 *	0.98	11.65*	0.48	0.72	2.04	23.16**	-0.66	5.87*	2.83
39.	Paiyur 1 x TMV 7	46.00	102.00	107.30	4.90	3.10	22.60	102.40	69.20	12.30	345.5
		-0.19	1.08	-6.01	0.14	0.52	-5.80**	5.35	-0.82	-3.29	1.13
40.	Paiyur 1 x VRI1	44.50	101.50	122.40	4.60	3.60	21.80	73.40	69.20	17.20	386.0
		-1.69	0.08	4.45	-0.59*	0.26	-3.04	-25.37**	-1.54	-1.19	18.03**
41.	Paiyur 1 x VRI 2	45.00	99.00	118.70	4.30	3.40	27.50	91.60	69.20	14.10	362.0
		-0.29	-1.92*	0.39	-0.81*	-0.46	2.52	-2.44	0.06	-6.97**	5.53**
42.	Paiyur 1 x Jauamer	43.00	101.50	111.90	5.00	2.20	31.40	97.70	67.60	20.95	341.5
		0.71	0.98	-2.97	0.20	-1.00*	0.18	-12.66**	-2.58	0.29	-15.97**
43.	Paiyur 1 x ORM 7	43.00	98.50	122.50	4.50	3.20	34.80	139.20	78.00	28.40	317.5
		0.11	-2.32**	4.61	-0.16	0.01	0.94	22.31**	6.22**	1.37	-7.77**
44.	Paiyur 1 x ORM 14	43.50	101.00	121.80	6.20	3.70	33.50	132.50	70.80	25.50	334.5
		-0.29	-0.62	3.03	1.31**	0.90	4.48*	24.61**	-0.22	4.55*	2.13
45.	Paiyur 1 x ORM 17	42.00	102.50	107.10	5.00	2.50	24.80	70.65	70.00	19.50	358.5
		-1.89 *	2.08*	-11.45*	0.27	-0.00	-3.64	-21.96**	-0.10	1.43	3.53*
	General Mean	43.65	99.65	115.40	4.86	2.83	25.86	81.42	67.90	20.57	334.7
	S.E	0.92	1.22	4.98	0.39	0.51	2.17	3.56	1.63	1.98	2.77
	S.E (sca effects)	0.9307	0.8649	5.2921	0.3316	0.4685	2.1525	3.3658	1.6534	2.2007	1.5061
	C.D (p=0.05)	2.5873	3.4216	13.9390	1.0862	1.4331	6.0829	9.9685	4.5789	5.5504	7.7383
	C.D (p=0.01)	3.4366	4.5448	18.5150	1.4428	1.9036	8.0798	13.2409	6.0821	7.3725	10.2786

* Significant at 5% and ** Significant at 1% s*ca* effects given in ita