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Research Article

Combining ability analysis for yield and its component traits in groundnut (*Arachis hypogaea* L.)

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Abstract
Line × tester analysis was carried out involving six lines and three testers in groundnut for assessing the combining ability for yield and its component characters. Hybrids recorded significant variance for all characters studied. Variance due to parents showed significance for all characters except for shell weight, pod yield per plant, kernel yield per plant and oil yield per plant. The variance due to hybrids vs parents had significance for all characters except for plant height, shelling percentage, oil content and rust disease scores. In case of combining ability ANOVA, lines showed significant variance for all characters except for sound mature kernel. Significant differences were present among the testers for characters viz., plant height and number of pods per plant. The variance due to line x tester had significance for all characters except for 100-kernel weight, oil content, late leaf spot and rust disease scores. The SCA variances were higher than GCA variances indicating the predominance of non-additive gene action for all the characters studied. The parent ICGV 03128 proved to be a good general combiner for oil yield and other economic traits and hence need to be included in the oil yield improvement programmes. The hybrid combinations *viz.,* ICGV 00350 × VRI Gn 6, CO 7 × GPBD 4, ICGV 03128 × GPBD 4, ICGV 03128 × COG 0437 and ICGV 03128 × VRI Gn 6 recorded superior *per se* for oil yield per plant. Among these crosses ICGV 03128 × GPBD 4 and ICGV 03128 × VRI Gn 6 exhibited additive type gene action with one good general combining ability parent for oil yield per plant, oil content, kernel yield per plant and other characters. Hence, selection can be made in these crosses in early generation itself. The disease scores *viz.,* late leaf spot and rust also recorded non significant *sca* values indicating that these traits are controlled by additive gene action.

Keywords: Groundnut, combining ability, gene action, oil yield, foliar diseases.

Introduction:

Groundnut (*Arachis hypogaea* L.) is one of the leading oilseed crops of India and is a rich source of edible oil and protein for human diet. In general, the *per se* performance of parents is not always a true indicator of its potential in hybrid combinations. Combining ability is the relative ability of a genotype to transmit its desirable performance to its crosses. Combining ability analysis is not only the quickest method of understanding the genetic nature of quantitatively inherited characters, but also gives essential information about the selection of parents which in turn throws better segregants. The knowledge of the type of gene action involved in the expression of yield and yield components is essential to choose an appropriate breeding strategy to isolate desirable segregants in the later generations. An investigation was taken up in groundnut to study the general and specific combining ability and the gene action determining the yield and yield components using line x tester design.

Material and Methods

The material for the study consisted of six released/advanced breeding lines *viz.,* ICGV 00350, CO 7, ICGV 03128, TMV 2, TMV Gn 13 and VRI 2 and three testers *viz.,* GPBD 4, COG 0437 and VRI Gn 6. The lines are susceptible to foliar fungal diseases namely late leaf spot and rust. However, testers are resistant/moderately resistant to these diseases. Crosses were made between theses lines and testers in order to develop foliar disease resistant genotypes with high yield. The parents were crossed in line x tester mating fashion to synthesize 18 F_1 hybrids at the Regional Research Station, Vridhachalam, during Rabi 2012-13. 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 10 cm, at Oilseeds farm, Tamil Nadu Agricultural University, Coimbatore, during Kharif 2013. The package of practices recommended for the groundnut cultivation in Tamil Nadu was followed throughout the crop growing period.

Ten plants in parents and hybrids were randomly selected in each replication and observations were recorded for plant height (cm), number of pods per plant, 100-pod weight (g), 100-kernel weight (g), shell weight (g), shelling percentage, sound mature kernel (SMK) (%), pod yield per plant (g), kernel yield per plant (g), oil content (%), oil yield per plant (g), late leaf spot (LLS) score and rust score. The mean values were subjected to line x tester analysis as suggested by Kempthorne (1957).

Results and Discussion

Analysis of variance indicated presence of significant differences among genotypes for all the characters studied (Table 1). Significant variances were observed among hybrids for all the characters. Whereas, the variance due to parents showed significance for all characters except for shell weight, pod yield per plant, kernel yield per plant and oil yield per plant. The variances due to hybrids vs parents had significance for all characters except for plant height, shelling percentage, oil content and rust disease scores, indicating the existence of high level of heterosis for these characters.

Analysis of variance for combining ability analysis (Table 2) indicated the presence of **s**ignificant differences among the lines for all the characters studied except for sound mature kernel. While, significant differences were present among the testers for the characters like plant height and number of pods per plant. The significant variance of line × tester interaction indicated the importance of specific combining ability. The mean squares due to lines were of a larger magnitude than those of testers and line × tester for all the characters indicating greater diversity among the lines for combining ability. The magnitude of specific combining ability variances was much greater than those of general combining ability variances for all the characters, which indicated the preponderance of non-additive gene action for all the characters. Hence improvement of these yield related characters could be accomplished by selection at later filial generations. The role of non-additive gene action for these characters have been reported by Vindhiyavarman (2000), Rudraswamy *et al.* (2001), Jayalakshmi *et al*. (2002), Dasaradha Rami Reddy *et al.* (2004), Vasanthi *et al.* (2004), Yadav *et al.* (2006), Manivannan *et al*. (2008), Rekha *et al.* (2009), Ganesan *et al.* (2010), Mothilal and Ezhil (2010), Savithramma *et al.* (2010), John *et al.* (2011) and Pavithradevi (2013).

<u>*Choice of parents*</u>*:* The success of any breeding programme largely depends on the choice of the parent used in the hybridization. In addition to it, high mean was also considered as the main criterion for the selection of superior parents for breeding programme. Further, the parents having high general combining ability (*gca*) effects could be useful as, the *gca* effect is due to additive gene action and is fixable.

The *per se* performance of parents for yield and its component characters are presented in Table 3 and compared with general mean. Based on *per se*, parent ICGV 03128 recorded higher mean for 100-pod weight, shell weight, pod yield per plant, kernel yield per plant, oil content and oil yield per plant. TMV 2 registered higher mean for plant height and 100-kernel weight whereas, TMV Gn 13 recorded higher mean for late leaf spot and rust disease scores. The tester parent GPBD 4 recorded higher mean for shelling percentage and sound mature kernel and for the character number of pods per plant by COG 0437. Hence these parents were considered as more superior than other parents.

The estimates of *gca* effect (Table 4) showed that among the lines, ICGV 03128 was found to be superior as it showed significant and positive *gca* effect for number of pods per plant, 100-pod weight, 100-kernel weight, shell weight, pod yield per plant, kernel yield per plant, oil content oil yield per plant and late leaf spot score. The line parent TMV 2 was a good general combiner for plant height, 100-pod weight and 100-kernel weight, while CO 7 was a good combiner for number of pods per plant and oil content. Good general combiner for shell weight and shelling percentage were ICGV 00350 and TMV Gn 13, respectively. The parent ICGV 00350 was a good combiner for both diseases while CO 7 had good combining ability for late leaf spot score and moderate combining ability for rust disease score. Among the tester parents, VRI Gn 6 recorded significant positive *gca* effect for number of pods per plant. Since, high *gca* effect is attributed to additive gene actions, these parents could be used in breeding programme for yield improvement through pedigree breeding.

<u>Choice of crosses:</u>The specific combining ability is the deviation from the performance predicted on the basis of general combining ability. The specific combining ability (*sca*) effect alone may not be the appropriate choice for exploitation of heterosis because the hybrid with low mean value may also possess high *sca* effect. Hence, the cross combinations were identified based on two criteria *viz*., *per se* performance and the gene action involved in the crosses for further exploitation.

The *per se* performance of hybrids for yield and its component characters are presented in Table 5. The crosses ICGV 00350 × VRI Gn 6, CO 7 × GPBD 4, ICGV 03128 × GPBD 4, ICGV 03128 × COG 0437 and ICGV 03128 × VRI Gn 6 manifested higher *per se* performance for pod yield per plant, kernel yield per plant, oil content and oil yield per plant. Hence based on oil yield per plant and component characters, the crosses ICGV 00350 × VRI Gn 6, CO 7 × GPBD 4, ICGV 03128 × GPBD 4, ICGV 03128 × COG 0437 and ICGV 03128 × VRI Gn 6 were considered as desirable crosses.

In addition to superior *per se* performance, the nature of gene action is an important criterion to select the crosses for pedigree breeding (Table 6). Crosses with additive type of gene action are desirable as this facilitates early generation selection. None of the crosses was found desirable simultaneously for all the characters. In case of other two high oil yielding crosses *viz.*, ICGV 03128 × GPBD 4 and ICGV 03128 × VRI Gn 6, non significant *sca* was observed for kernel yield per plant, oil content, oil yield per plant and other component characters. It indicated the presence of additive gene action and hence selection can be effective in these crosses in early generation itself. The disease scores *viz.*, late leaf spot and rust scores also recorded non significant *sca* values indicating that above crosses can be best utilized for resistance breeding due to additive gene action. Among the high oil yielding crosses ICGV 00350 × VRI Gn 6, CO 7 × GPBD 4 and ICGV 03128 × COG 0437 recorded significant *sca* effects for pod yield per plant and kernel yield per plant and non significant *sca* effect for other characters. One of the parents involved in this cross ICGV 03128 was a good general combiner for these characters, indicating the presence of additive type of epistasis for pod yield per plant, kernel yield per plant, oil content, oil yield per plant and late leaf spot score. Due to the presence of additive type epistasis, selection needs to be postponed to later generations.

From the foregoing discussion, it might be concluded that the parent ICGV 03128 was considered as good combining parent for oil yield per plant and component characters and could be utilized in breeding programme. Most of the high oil yielding crosses exhibiting desirable *sca* effects involved parents with high and low *gca* effects, indicating the influence of non-additive gene interactions in these crosses. Among the hybrids , ICGV 03128 × GPBD 4 and ICGV 03128 × VRI Gn 6 exhibited superior *per se* performance and one of the parent with good general combining ability and additive type of gene action. Hence, selection can be made in early generation itself, in these crosses. These crosses could be exploited by pedigree method to yield transgressive segregants integrated with late leaf spot and rust disease resistance.analysed. The crosses ICGV 00350 × VRI Gn 6, CO 7 × GPBD 4 and ICGV 03128 × COG 0437 recorded superior *per se* performance and non additive type of gene action, indicating that the progenies should be advanced to later filial generations.

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

Source	df	Plant height (cm)	Number of pods per plant	100- pod weight (g)	100- kernel weight (g)	Shell weight (g)	Shelling percentage	SMK (%)	Pod yield per plant (g)	Kernel yield per plant (g)	Oil content (%)	Oil yield per plant (g)	LLS score	Rust score
Replications	1	6.47	8.32	9.36	12.80	2.24	5.64	7.13	3.36	3.97	4.56	3.74	1.28	1.06
Hybrids	17	22.03**	123.59**	326.05**	25.16**	11.86**	18.64**	26.11*	108.29**	88.74**	25.67**	28.84**	2.25**	1.82**
Parents	8	64.22**	44.30**	324.93**	61.45**	1.46	18.28**	82.27**	13.90	8.51	56.93**	4.13	5.31**	3.43**
Hybrids vs Parents	1	9.52	187.07**	155.26*	123.78**	31.51**	8.48	71.23*	306.97**	371.63**	10.12	106.23**	5.37**	0.19
Error	26	2.48	11.92	31.00	7.53	1.12	4.73	12.73	8.58	8.40	8.19	2.53	0.40	0.63

***,** significant at 5% and 1% levels, respectively**

Table 2. Analysis of variance for combining ability analysis for yield and its component characters in groundnut

Source	df	Plant height (cm)	Number of pods per plant	100- pod weight (g)	100- kernel weight (g)	Shell weight (g)	Shelling percentage	SMK (%)	Pod yield per plant (g)	Kernel yield per plant (g)	Oil content (%)	Oil yield per plant (g)	LLS score	Rust score
Replication	1	8.42	32.11	30.38	11.36	0.21	0.11	31.23	0.65	2.01	0.15	4.33	0.99	0.75
Line	5	54.08**	325.83**	681.52**	65.07**	27.61**	27.18**	15.51	261.11**	175.55**	63.26**	61.91**	6.30**	3.43**
Tester	2	12.33*	55.33*	106.58	2.41	1.45	11.16	8.62	13.13	16.96	10.78	2.75	0.51	1.02
L x T	10	7.95**	36.12*	192.20**	9.74	6.07**	15.86*	34.91*	50.92**	59.68**	9.85	17.53**	0.57	1.18
Error	17	2.07	11.34	35.07	7.57	1.28	4.89	11.55	7.52	9.75	7.96	2.71	0.50	0.79
GCA		0.63	3.93	6.02	0.69	0.26	0.12	-0.40	2.58	1.31	0.71	0.51	0.08	0.03
SCA		2.94	12.39	78.56	1.09	2.40	5.49	11.68	21.70	24.97	0.95	7.41	0.03	0.20
GCA/SCA		0.21	0.32	0.08	0.63	0.11	0.02	-0.03	0.12	0.05	0.75	0.07	2.67	0.15

***,** significant at 5% and 1% levels, respectively**

Table 3. *Per se* performance of parents for yield and its component characters in groundnut

Parents	Plant height (cm)	Number of pods per plant	100-pod weight (g)	100-kernel weight (g)	Shell weight (g)	Shelling percentage	SMK (%)	Pod yield per plant (g)	Kernel yield per plant (g)	Oil content (%)	Oil yield per plant (g)	LLS score	Rust score
Lines													
ICGV 00350	14.88	21.27	94.91	39.04	4.62	69.69	97.98	15.99	13.38	48.40	6.55	4.20	4.53
CO 7	12.88	14.30	89.87	35.03	3.77	65.88	93.86	12.36	11.78	53.23	6.28	3.95	4.39
ICGV 03128	22.54	23.45	123.55	44.60	6.47	69.78	97.89	21.55	17.65	55.94	9.85	5.84	4.94
TMV 2	26.16	13.30	107.39	47.14	3.97	71.63	97.82	14.50	12.48	50.01	6.24	5.93	4.92
TMV Gn 13	23.31	18.00	110.28	44.56	4.38	73.20	97.13	17.85	13.81	52.01	7.22	6.30	6.22
VRI 2	24.39	14.23	102.77	43.74	4.03	70.76	96.98	14.40	14.34	38.80	5.56	6.12	5.71
Testers													
GPBD 4	10.08	18.50	91.95	33.58	3.83	73.44	99.50	14.36	10.53	43.61	4.60	2.50	2.00
COG 0437	22.81	26.25	90.26	38.50	5.18	65.05	78.70	16.50	13.00	48.60	6.30	2.10	3.10
VRI Gn 6	19.38	23.64	82.88	31.61	4.44	67.28	91.95	15.29	11.51	53.35	6.12	3.30	3.59
General mean	19.01	21.85	101.72	41.90	5.60	69.07	93.02	19.24	16.87	49.94	8.51	4.02	4.29
S.E.	1.11	2.44	3.94	1.94	0.75	1.54	2.52	2.07	2.05	2.02	1.12	0.45	0.56
CD (P=0.05)	3.24	7.11	11.47	5.65	2.18	4.48	7.35	6.03	5.97	5.90	3.28	1.31	1.63
CD (P=0.01)	4.37	9.60	15.48	7.63	2.94	6.05	9.92	8.14	8.06	7.96	4.42	1.76	2.20

Table 4. Estimates of general combining ability (*gca*) effects for yield and its component characters in groundnut

Parents	Plant height (cm)	Number of pods per plant	100-pod weight (g)	100-kernel weight (g)	Shell weight (g)	Shelling percentage	SMK (%)	Pod yield per plant (g)	Kernel yield per plant (g)	Oil content (%)	Oil yield per plant (g)	LLS score	Rust score
Lines													
ICGV 00350	-3.14**	0.96	0.37	-2.52*	1.48**	-0.75	1.36	1.92	0.42	1.19	0.21	-1.32**	-1.06**
CO 7	-2.33**	4.29**	-8.93**	-3.89**	0.45	-2.36*	-2.78	0.58	0.16	3.74**	0.89	-0.88**	-0.63
ICGV 03128	-0.65	11.83**	15.74**	4.01**	3.27**	0.26	1.19	11.40**	9.81**	3.31*	5.72**	0.68*	0.66
TMV 2	5.39**	-5.32**	5.68*	3.18*	-1.21*	0.89	0.18	-3.07*	-2.09	-4.19**	-1.86*	1.44**	0.79*
TMV Gn 13	0.49	-3.16*	1.48	1.38	-1.51**	3.60**	0.99	-2.64*	-1.81	-2.59*	-1.42*	-0.27	-0.23
VRI 2	0.25	-8.60**	-14.35**	-2.15	-2.49**	-1.64	-0.95	-8.20**	-6.49**	-1.46	-3.54**	0.35	0.47
Testers													
GPBD 4	-1.15*	-1.09	1.54	0.11	-0.35	0.89	0.98	-0.38	0.11	0.49	0.17	-0.10	-0.33
COG 0437	0.41	-1.39	-3.44	-0.49	0.34	-1.03	-0.52	-0.80	-1.24	0.60	-0.54	-0.14	0.09
VRI Gn 6	0.75	2.47*	1.89	0.38	0.01	0.14	-0.46	1.18	1.13	-1.09	0.37	0.24	0.24
S.E. (Lines)	0.59	1.37	2.42	1.12	0.46	0.90	1.39	1.12	1.27	1.15	0.67	0.29	0.36
S.E. (Testers)	0.42	0.97	1.71	0.79	0.33	0.64	0.98	0.79	0.90	0.81	0.48	0.20	0.26

***,** significant at 5% and 1% levels, respectively**

Table 5. *Per se* performance of hybrids for yield and its component characters in groundnut

Hybrids	Plant height (cm)	Number of pods per plant	100-pod weight (g)	100-kernel weight (g)	Shell weight (g)	Shelling percentage	SMK (%)	Pod yield per plant (g)	Kernel yield per plant (g)	Oil content (%)	Oil yield per plant (g)	LLS score	Rust score
ICGV 00350 x GPBD 4	12.46	17.26	95.42	38.74	5.02	66.26	91.71	17.00	14.72	52.35	7.63	2.11	2.32
ICGV 00350 x COG 0437	14.88	24.67	107.91	41.14	9.55	69.22	92.56	23.12	15.63	51.98	8.09	2.20	3.30
ICGV 00350 x VRI Gn 6	19.38	30.44	106.53	41.46	8.30	68.65	96.42	28.42	27.09	49.98	13.42	3.14	3.95
CO 7 x GPBD 4	17.03	28.97	101.07	38.36	7.76	70.60	96.02	25.67	26.69	57.29	15.26	3.16	4.35
CO 7 x COG 0437	15.86	21.39	94.95	37.92	5.52	66.33	89.76	17.84	15.60	54.21	8.37	2.86	3.76
CO 7 x VRI Gn 6	16.25	32.00	85.95	40.95	6.51	62.37	82.50	20.99	14.38	50.45	7.54	2.75	2.75
ICGV 03128 x GPBD 4	19.01	32.14	125.97	48.01	7.91	70.48	95.66	29.57	24.35	54.53	13.14	5.01	5.20
ICGV 03128 x COG 0437	17.60	38.42	114.18	47.16	12.03	68.76	94.47	38.48	33.13	54.05	17.94	3.84	4.84
ICGV 03128 x VRI Gn 6	17.60	34.43	115.83	45.76	8.29	67.93	90.08	28.93	28.15	52.09	14.59	4.61	4.69
TMV 2 x GPBD 4	23.24	21.51	121.27	49.52	6.55	69.10	94.06	23.37	22.00	45.69	10.06	5.18	4.57
TMV 2 x COG 0437	24.66	16.90	100.31	43.86	4.36	69.60	92.80	15.28	14.41	49.02	7.03	5.44	5.45
TMV 2 x VRI Gn 6	24.40	15.12	104.20	45.06	3.89	70.36	90.32	14.92	13.49	43.47	5.84	5.10	5.10
TMV Gn 13 x GPBD 4	15.87	18.08	94.11	43.74	3.44	72.17	89.31	14.48	14.45	47.79	6.90	2.87	2.80
TMV Gn 13 x COG 0437	20.57	17.13	97.57	41.96	4.50	70.80	91.83	16.12	17.23	45.61	7.87	4.07	4.54
TMV Gn 13 x VRI Gn 6	21.18	24.81	121.50	47.33	5.95	74.21	98.47	24.26	19.09	49.58	9.47	3.65	4.72
VRI 2 x GPBD 4	17.77	14.51	88.92	40.09	4.06	69.48	92.37	13.15	10.86	46.77	5.06	3.87	4.31
VRI 2 x COG 0437	21.16	12.16	81.96	42.80	2.95	61.90	88.72	9.91	8.92	50.22	4.46	3.59	4.14
VRI 2 x VRI Gn 6	17.96	17.03	94.83	39.55	3.95	70.08	92.70	15.12	16.94	49.35	8.35	4.99	5.71
General mean	19.01	21.85	101.72	41.90	5.60	69.07	93.02	19.24	16.87	49.94	8.51	4.02	4.29
S.E.	1.11	2.44	3.94	1.94	0.75	1.54	2.52	2.07	2.05	2.02	1.12	0.45	0.56
CD (P=0.05)	3.24	7.11	11.47	5.65	2.18	4.48	7.35	6.03	5.97	5.90	3.28	1.31	1.63
CD (P=0.01)	4.37	9.60	15.48	7.63	2.94	6.05	9.92	8.14	8.06	7.96	4.42	1.76	2.20

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Table 6. Estimates of specific combining ability (*sca*) effects for yield and its component characters in groundnut

Hybrids	Plant height (cm)	Number of pods per plant	100-pod weight (g)	100-kernel weight (g)	Shell weight (g)	Shelling percentage	SMK (%)	Pod yield per plant (g)	Kernel yield per plant (g)	Oil content (%)	Oil yield per plant (g)	LLS score	Rust score
ICGV 00350 x GPBD 4	-1.96	-5.78*	-9.41*	-1.82	-2.25*	-2.67	-2.83	-5.46*	-4.54	0.42	-2.26	-0.27	-0.54
ICGV 00350 x COG 0437	-1.10	1.93	8.06	1.19	1.58	2.20	-0.48	1.07	-2.27	-0.06	-1.08	-0.15	0.02
ICGV 00350 x VRI Gn 6	3.06**	3.84	1.36	0.63	0.67	0.47	3.32	4.39*	6.82**	-0.36	3.34*	0.42	0.52
CO 7 x GPBD 4	1.80	2.60	5.53	-0.83	1.51	3.28	5.62*	4.55*	7.69**	2.82	4.70**	0.34	1.06
CO 7 x COG 0437	-0.93	-4.68	4.40	-0.66	-1.42	0.92	0.85	-2.86	-2.05	-0.38	-1.48	0.07	0.05
CO 7 x VRI Gn 6	-0.88	2.07	-9.93*	1.49	-0.09	-4.20*	-6.47*	-1.69	-5.64*	-2.44	-3.22*	-0.41	-1.11
ICGV 03128 x GPBD 4	2.10	-1.77	5.77	0.92	-1.15	0.54	1.28	-2.37	-4.31	0.48	-2.26	0.63	0.62
ICGV 03128 x COG 0437	-0.88	4.81	-1.04	0.68	2.28*	0.73	1.58	6.95**	5.83*	-0.11	3.26*	-0.51	-0.16
ICGV 03128 x VRI Gn 6	-1.22	-3.04	-4.72	-1.60	-1.13	-1.27	-2.86	-4.58*	-1.52	-0.37	-1.00	-0.11	-0.46
TMV 2 x GPBD 4	0.29	4.75	11.13*	3.26	1.97*	-1.47	0.69	5.90**	5.25*	-0.86	2.24	0.05	-0.15
TMV 2 x COG 0437	0.15	0.44	-4.85	-1.79	-0.92	0.94	0.93	-1.78	-0.98	2.36	-0.07	0.34	0.32
TMV 2 x VRI Gn 6	-0.44	-5.20*	-6.29	-1.47	-1.05	0.53	-1.61	-4.12*	-4.27	-1.50	-2.17	-0.38	-0.17
TMV Gn 13 x GPBD 4	-2.19*	-0.84	-11.83*	-0.71	-0.84	-1.11	-4.87	-3.42	-2.59	-0.36	-1.35	-0.56	-0.89
TMV Gn 13 x COG 0437	0.96	-1.49	-3.39	-1.89	-0.47	-0.57	-0.86	-1.37	1.55	-2.65	0.33	0.68	0.43
TMV Gn 13 x VRI Gn 6	1.23	2.33	15.21**	2.60	1.31	1.68	5.73*	4.79*	1.04	3.01	1.02	-0.11	0.46
VRI 2 x GPBD 4	-0.04	1.03	-1.19	-0.83	0.76	1.44	0.13	0.81	-1.50	-2.50	-1.07	-0.18	-0.08
VRI 2 x COG 0437	1.79	-1.02	-3.17	2.48	-1.05	-4.23*	-2.02	-2.02	-2.08	0.84	-0.96	-0.42	-0.67
VRI 2 x VRI Gn 6	-1.75	-0.01	4.37	-1.65	0.29	2.79	1.90	1.21	3.57	1.67	2.03	0.60	0.75
S.E. (*sca* effects)	1.02	2.38	4.19	1.95	0.80	1.56	2.40	1.94	2.21	2.00	1.16	0.50	0.63

***,** significant at 5% and 1% levels, respectively**