Combining ability analysis for fruit yield and yield components in okra {*Abelmoschus esculentus* (L) Moench}

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ABSTRACT

A line × tester analysis involving six lines, four testers, 24 crosses and one standard check variety was conducted during kharif 2021 in Junagadh, Gujarat, to assess combining ability and the nature of gene action for fruit yield and its component traits in okra (*Abelmoschus esculentus*). Analysis of variance for combining ability revealed highly significant mean squares due to line × tester interaction for all characters studied, indicating the predominance of non-additive gene action. This was further supported by specific combining ability (SCA) variances being generally higher than general combining ability (GCA) variances for most traits. No single parent was found to be a universal good general combiner. However, specific lines (AOL-8-05, 2017/OKYVRES-1, NOL-17-9 and 2018/OKYVRES-3) and testers (HRB-108-2, AOL-16-04 and Kashi Kranti) were identified as good general combiners for various desirable traits, including fruit yield and its components. While no single cross was consistently superior across all characters, the cross 2017/OKYVRES-1 × HRB-108-2 emerged as a superior specific combiner for fruit yield and its attributing traits. This hybrid, derived from a poor × good GCA parental combination, also exhibited high per se performance with significant positive heterosis. The findings suggest that hybridization and exploitation of heterosis are crucial strategies for okra improvement, and the identified parents and promising hybrid hold significant potential for commercial breeding programmes.

Keywords: Okra; GCA; SCA; gene action; heterosis; line × tester analysis; hybridization; yield components

INTRODUCTION

Okra, an important annual vegetable, is cultivated for its immature, green and fibrous edible fruits in tropical and subtropical regions globally. These fruits are notably nutritious; a 100 g edible portion contains 10.4 g dry matter, 3,100 calories, 1.8 g protein, 90 mg calcium, 1.0 mg iron, 0.1 mg carotene, 0.07 mg thiamin, 0.08 mg riboflavin and niacin and 18 mg vitamin C. Its leaves also offer comparable constituents, with minor variations (Grubben 1977). Furthermore, okra seeds boast a high oil content (18-20%), yielding approximately 794 kg of oil per hectare (Mays et al 1990).

Chromosomally, okra most frequently exhibits a somatic number of 2n = 130, though numbers such as 2n = 72, 108, 120, 132 and 144 are also observed, fitting a regular polyploid series with n = 12 (Datta and Naug 1968). As a seed-propagated, warm-weather crop, okra is sensitive to frost, low temperatures (below 15°C), water-logging and drought. It thrives in hot, humid climates characteristic of tropical and subtropical areas and warmer parts of temperate zones. Optimal plant growth and fruiting occur at average temperatures around 25°C coupled with high relative humidity (65-85%) (Dhankhar and Mishra 2005). Understanding the nature and magnitude of both fixable and non-fixable gene effects governing yield and its components is crucial for designing an efficient and effective breeding programme aimed at maximizing genetic improvement (Vekariya et al 2019). The line × tester analysis is a valuable approach for breeders interested in simultaneously determining the combining ability of multiple lines.

Success in a crop improvement programme hinges on identifying and isolating valuable gene combinations, particularly lines with high combining ability. Parents that consistently produce superior progenies upon crossing are of immense value. Knowledge of gene action and combining ability aids in pinpointing the best combiners, which can then be hybridized to exploit heterosis. Therefore, identifying and assessing parental combinations based on their general and specific combining abilities, along with understanding the gene actions involved in the inheritance of fruit yield and its component characters, are paramount for a successful hybridization programme (Pallavi et al 2018).

MATERIAL and METHODS

The experimental material consisted of 35 genotypes, which included six lines viz 2017/OKYVRES-1, 2017/OKYVRES-9, 2018/OKYVRES-3, 2018/OKYVRES-4, NOL-7-9 and AOL-8-05 and four testers namely HRB-108-2, AOL-12-59, AOL-16-04 and Kashi Kranti. Additionally, 24 crosses and one standard check variety (GJOH-4) were used. The experiment was conducted in a randomized block design with three replications during kharif 2021 at the Vegetable Research Station, Junagadh Agricultural University, Junagadh, Gujarat. Each genotype was represented by a double-row plot of ten plants, with a spacing of 45 cm × 20 cm.

Combining ability analysis is a powerful tool for discerning good and poor combiners, enabling the selection of appropriate parental material for crop breeding programmes. It also clarifies the nature of gene action governing character inheritance. The relative magnitudes of general combining ability (GCA) and specific combining ability (SCA) effects are crucial (Vekariya et al 2019). SCA specifically indicates loci with dominance variance (non-additive effects) and, if present, all three types of epistatic interaction components (Fasahat et al 2016). These include additive × dominance and dominance × dominance interactions. The presence of non-additive genetic variance is a well-established justification for initiating a hybridization programme (Cockerham 1961). For okra, where hybrid seed production is economical and commercially feasible, selecting suitable parents with desirable characteristics is essential for exploiting heterosis.

Observations were recorded from five randomly selected plants per replication for several traits: number of branches per plant, number of nodes per plant, number of fruits per plant, plant height, internodal length, fruit length and fruit girth. Additionally, data for days to 50 per cent flowering, days to first picking, number of pickings, days to last picking, ten fruits weight, fruit borer infestation and fruit yield per plant were collected on a plot basis.

RESULTS and DISCUSSION

Analysis of variance for combining ability (Table 1) revealed highly significant mean squares due to lines for days to 50 per cent flowering, days to first picking, number of branches per plant, plant height, internodal length and fruit borer infestation. However, mean squares due to testers were significant for only two characters: days to 50 per cent flowering and days to first picking. Critically, mean squares due to line × tester interaction were highly significant for all characters investigated. These results strongly suggest a greater importance of non-additive gene action in the expression of fruit yield and its component traits.

The variance due to the line component ($\sigma l2$) was highly significant for days to 50 per cent flowering, days to first picking, number of branches per plant, plant height, internodal length and fruit borer infestation, but non-significant for all other characters. For the tester variance component ($\sigma t2$), significance was observed only for days to 50 per cent flowering and days to first picking, with other characters showing non-significance. Crucially, the variance for line × tester interaction ($\sigma lt2$) was found to be highly significant for all characters under investigation.

For most characters in this experiment, the magnitude of SCA variances was greater than their respective GCA variances. The exceptions were days to 50 per cent flowering, days to first picking, plant height and internodal length. This pattern indicates that non-additive gene action was predominant in the inheritance of most traits studied.

The preponderance of non-additive gene action for fruit yield per plant and other contributing traits was also reported by Kumari et al (2020), Vekariya et al (2020), Yadav et al (2020), Kalaiselvan and Anuja (2021), Mudhalvan and Senthilkumar (2021) and Patel et al (2021).

The estimates of GCA effects revealed that none of the parents served as a good general combiner for all traits studied (Table 2). Among the lines, AOL-

Table 1. Analysis of variance for combining ability and variance components for fruit yield and its contributing characters in okra

Source	df	Days to 50% flowering	Days to first picking	Number of branches/plant	Number of nodes/plant	Number of fruits/ plant	Number of pickings	Days to last picking
Replications	2	1.85	2.39	0.14*	6.91**	2.14*	1.26	19.68
Lines	5	52.45**++	57.32**++	3.88**++	6.14	10.59	5.71	48.49
Testers	3	42.60*+	32.09*	0.95	7.22	6.99	3.38	15.00
Lines × testers	15	10.51**	7.09**	0.65**	7.57**	12.39**	16.30**	130.82**
Error	46	3.51	1.78	0.03	1.29	0.62	0.64	8.14
Estimates of genetic components of variance								
σ^2		14.08**	4.63**	0.32**	0.40	0.83	0.42	3.36
σ^2t		2.17*	1.68*	0.05	0.32	0.35	0.15	0.38
σ^2lt		2.33**	1.77**	0.20**	2.09**	3.93**	5.22**	40.89**
σ^2GCA		2.93**	2.86**	0.16**	0.36	0.54	0.26	1.57
σ^2SCA		2.33**	1.77**	0.20**	2.09**	3.93**	5.22**	40.89**
σ^2GCA/σ^2SCA		1.26	1.62	0.8	0.17	0.14	0.05	0.04

Table 1. Contd…..

Source	df	Plant height (cm)	Internodal length (cm)	Fruit length (cm)	Fruit girth (cm)	Ten fruits weight (g)	Fruit borer infestation (%)	Fruit yield/ plant (g)
Replications	2	17.01	1.02**	0.25	0.02	24.95	2.25	2442.87**
Lines	5	1065.72**++	7.01**++	7.39	0.57	1445.20	199.88**++	2631.56
Testers	3	579.49	1.51	5.44	0.12	2137.09	38.02	3837.12
Lines × testers	15	179.53**	0.69**	7.93**	0.42**	2048.75**	42.65**	3103.22**
Error	46	41.43	0.08	0.20	0.14	71.99	2.24	310.47
Estimates of genetic components of variance								
σ^2l		85.36**	0.57**	0.59	0.04	114.43	16.47**	193.42
σ^2t		29.89	0.07	0.29	0.001	114.73	1.99	195.92
σ^2lt		46.03**	0.20**	2.57**	0.09**	658.91**	13.47**	930.92**
σ^2GCA		52.07**	0.28**	0.41	0.01	114.61	7.78**	194.92
σ^2SCA		46.03**	0.20**	2.57**	0.09**	658.91**	13.47**	930.92**
σ^2GCA/σ^2SCA		1.13	1.4	0.16	0.11	0.17	0.57	0.21

*Significant at 5% LoS and**Significant at 1% LoS when tested against error mean square; +Significant at 5% LoS and ++Significant at 1% LoS when tested against lines × testers interaction mean square

8-05 was identified as the best general combiner for days to 50 per cent flowering, days to first picking, number of nodes per plant, number of fruits per plant, ten fruits weight and fruit yield per plant.

Line 2017/OKYVRES-1 showed excellence for number of branches per plant and internodal length, while NOL-17-9 was optimal for number of pickings, days to last picking, plant height and fruit borer infestation. Furthermore, 2018/OKYVRES-3 proved to be a good general combiner for fruit length and fruit girth. In the testers, HRB-108-2 was the best general combiner for days to 50 per cent flowering, days to first picking, number of nodes per plant, number of fruits per plant, fruit length, ten fruits weight, fruit borer infestation and fruit yield per plant. AOL-16-04 was noted for number of branches per plant and number of pickings and Kashi Kranti for plant height and internodal length.

It was observed that parents, which were good general combiners for fruit yield per plant, were also effective for one or more component traits. Consequently, these parents hold significant potential

Table 2. Estimation of general combining ability effects of parents for fruit yield and its contributing characters in okra

Parent	Days to 50% flowering	Days to first picking	Number of branches/ plant	Number of nodes/plant	Number of fruits/plant	Number of pickings	Days to last picking
Line							
2017/OKYVRES-1	–0.403	–0.806*	0.836**	0.153	0.523*	–0.014	–0.028
2017/OKYVRES-9	–1.069	0.611	–0.197**	–0.247	–1.025**	–0.597*	–1.778*
2018/OKYVRES-3	–0.986	–1.639**	–0.397**	0.203	0.627**	0.403	1.139
2018/OKYVRES-4	1.014	0.778*	–0.664**	0.136	0.586*	–0.847**	–2.528**
NOL-17-9	3.681**	3.611**	0.519**	–1.214**	–1.380**	1.069**	3.056**
AOL-8-05	–2.236**	–2.556**	–0.097	0.969**	0.669**	–0.014	0.139
SE(gi)±	0.54	0.38	0.05	0.33	0.23	0.23	0.82
SE(gi – gj)±	0.76	0.54	0.07	0.46	0.32	0.33	1.16
Tester							
HRB-108-2	–2.125**	–1.528**	0.053	0.758**	0.741**	–0.542**	–1.333*
AOL-12-59	–0.125	–0.583*	–0.292**	0.269	0.176	0.069	0.222
AOL-16-04	1.264**	1.528**	0.264**	–0.631**	–0.746**	0.514**	0.722
Kashi Kranti	0.986*	0.583*	–0.025	–0.397	–0.171	–0.042	0.389
SE(gi)±	0.44	0.31	0.04	0.27	0.18	0.19	0.67
SE(gi – gj)±	0.62	0.44	0.06	0.38	0.26	0.27	0.95

Table 2. Contd…..

Parent	Plant) height (cm)	Internodal length (cm)	Fruit length (cm)	Fruit girth (cm)	Ten fruits weight (g)	Fruit borer infestation (%)	Fruit yield/ plant (g)
Line							
2017/OKYVRES-1	–2.506	–1.036**	0.682**	–0.109	9.434**	2.374**	–2.792
2017/OKYVRES-9	3.894*	0.450**	–0.280*	0.235*	–10.399**	–1.965**	–7.042
2018/OKYVRES-3	0.444	–0.150	0.973**	0.303**	2.826	2.922**	6.458
2018/OKYVRES-4	14.578**	1.217**	–0.438**	–0.139	–0.120	–4.282**	9.042
NOL-17-9	–14.339**	–0.351**	–1.162***	–0.052	–14.933**	–4.344**	–24.042**
AOL-8-05	–2.072	–0.130	0.225	–0.239*	13.192**	5.296**	18.375**
SE(gi)±	1.85	0.08	0.13	0.10	2.45	0.43	5.08
SE(gi – gj)±	2.62	0.12	0.18	0.15	3.46	0.61	7.19
Tester							
HRB-108-2	–0.983	–0.144*	0.401**	–0.010	11.734**	–1.667**	16.292**
AOL-12-59	–3.228*	0.332**	0.263**	–0.099	5.303**	1.697**	8.347*
AOL-16-04	8.283**	0.134*	0.146	0.096	–13.274**	0.568	–12.986**
Kashi Kranti	–4.072**	–0.322**	–0.810**	0.013	–3.763*	–0.598	–11.653**
SE(gi)±	1.51	0.07	0.10	0.08	1.99	0.35	4.15
SE(gi – gj)±	2.14	0.09	0.15	0.12	2.82	0.49	5.87

*Significant at 5% LoS, **Significant at 1% LoS

for exploitation in future breeding programmes. These findings are consistent with the results of Annapurna and Singh (2018), Kayande et al (2018), Javiya et al (2020), Kumari et al (2020), Vekariya et al (2020) and Patel et al (2021).

SCA is associated with interaction effects, which may be due to dominance and epistatic components of variation that are non-fixable in nature. Thus it can be utilized in F1 in evolving the best F1 hybrids (Sprague and Tatum 1942, Griffing 1956).

The estimates of SCA effects revealed that none of the crosses consistently exhibited superior performance for all characters studied (Tables 3, 4). This finding, particularly where crosses with high SCA effects did not always involve parents with high GCA effects, suggests the significant importance of interallelic interactions in the expression of these characters. As for specific superior cross combinations, AOL-8-05 × HRB-108-2 was identified as the best for days to 50 per cent flowering. Cross 2017/OKYVRES-1 × HRB-108-2 showed excellence for days to first picking, number of branches per plant, number of fruits per plant, ten fruits weight and fruit yield per plant. Furthermore, AOL-8-05 × Kashi Kranti was optimal for number of nodes per plant, while NOL-17-9 × Kashi Kranti performed best for number of pickings, days to last picking and plant height. Cross 2017/OKYVRES-1 × Kashi Kranti excelled in internodal length, 2018/OKYVRES-3 × AOL-12-59 was superior for fruit girth and 2017/OKYVRES-9 × Kashi Kranti proved to be the best combination for fruit borer infestation.

The cross combination 2017/OKYVRES-1 × HRB-108-2 was identified as a superior specific combiner for fruit yield per plant and its attributing characters. This hybrid, derived from a cross between a poor and a good general combining parent, also achieved the highest rank in per se performance, exhibiting significant positive heterobeltiosis and standard heterosis for fruit yield per plant. Therefore, this cross combination holds considerable potential for the commercial exploitation of heterosis in okra for fruit yield improvement. These findings are consistent with those reported by Balakrishnan et al (2009), Jupiter and Kandasamy (2017), Javiya et al (2020) and Patel et al (2021).

CONCLUSION

These investigations on okra, utilizing line × tester analysis, have provided valuable insights into the genetic architecture governing yield and its component traits. The analysis of variance and combining ability estimates consistently revealed a preponderance of non-additive gene action for the inheritance of most characters, including fruit yield per plant. This is evidenced by the higher magnitude of specific combining ability (SCA) variances over general combining ability (GCA) variances for the majority of traits and the highly significant line × tester interactions. No single parent was found to be a universal good general combiner for all desirable traits. However, specific lines (AOL-8-05, 2017/OKYVRES-1, NOL-17-9 and 2018/OKYVRES-3) and testers (HRB-108-2, AOL-16-04 and Kashi Kranti) were identified as good general combiners for fruit yield and several contributing characters. These parents hold significant potential for incorporation into future breeding strategies.

Regarding specific cross combinations, the study found no hybrid to be consistently superior across all characters. Importantly, crosses exhibiting high SCA effects did not always involve parents with high GCA effects, suggesting the crucial role of interallelic interactions in trait expression. Among the evaluated hybrids, the cross 2017/OKYVRES-1 × HRB-108-2 emerged as a particularly superior specific combiner for fruit yield per plant and its associated traits. This hybrid, originating from a poor × good general combining parental cross, also demonstrated top per se performance and significant positive heterosis. In essence, these findings highlight that while additive gene action is important for some traits, non-additive gene action plays a predominant role in the inheritance of most yield-contributing characters in okra. Therefore, a breeding strategy that effectively exploits both general and specific combining abilities, particularly through hybridization programmes aimed at capitalizing on heterosis, is most appropriate for achieving substantial genetic improvement in okra yield. The identified superior parents and the promising hybrid (2017/OKYVRES-1 × HRB-108-2) offer a strong foundation for the commercial exploitation of heterosis in okra breeding.

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Table 3. Specific combining ability (SCA) effects in hybrids for phenological and yield-related traits

Hybrid	Days to 50% flowering	Days to first picking	Number of branches/plant	Number of nodes/plant	Number of fruits/plant	Number of pickings	Days to last picking
2017/OKYVRES-1 × HRB-108-2	–2.042	–1.806*	0.364**	1.725*	2.301**	3.292**	8.917**
2017/OKYVRES-1 × AOL-12-59	–0.042	–0.083	0.508**	1.347*	2.449**	2.347**	6.361**
2017/OKYVRES-1 × AOL-16-04	0.236	0.472	–0.114	–0.753	–1.713**	–2.764**	–10.139**
2017/OKYVRES-1 × Kashi Kranti	1.847	1.417	–0.758**	–2.319**	–3.037**	–2.875**	–5.139**
2017/OKYVRES-9 × HRB-108-2	–0.708	–0.556	0.264*	0.658	0.906	–0.792	–2.000
2017/OKYVRES-9 × AOL-12-59	–0.042	1.167	–0.392**	0.014	–0.586	–1.069*	–2.889
2017/OKYVRES-9 × AOL-16-04	–1.431	–1.944*	0.519**	0.581	0.502	2.153**	6.611**
2017/OKYVRES-9 × Kashi Kranti	2.181*	1.333	–0.392**	–1.253	–0.822	–0.292	–1.722
2018/OKYVRES-3 × HRB-108-2	0.208	1.361	–0.203	–2.592**	–3.303**	–1.792**	-4.583**
2018/OKYVRES-3 × AOL-12-59	–0.458	–0.917	0.008	–0.569*	–1.322**	–1.069	–2.806
2018/OKYVRES-3 × AOL-16-04	–0.847	–1.361	–0.147	1.731*	2.600**	1.153*	3.694*
2018/OKYVRES-3 × Kashi Kranti	1.097	0.917	0.342**	1.431*	2.025**	1.708**	3.694*
2018/OKYVRES-4 × HRB-108-2	2.875*	1.611*	–0.069	0.808	0.655	3.125**	9.083**
2018/OKYVRES-4 × AOL-12-59	–0.458	–0.333	–0.258*	0.697	0.637	–0.819	–2.139
2018/OKYVRES-4 × AOL-16-04	–1.847	–0.444	0.186	–0.869	–0.358	–0.931*	–2.639
2018/OKYVRES-4 × Kashi Kranti	–0.569	–0.833	0.142	–0.636	–0.933*	–1.375**	4.306*
NOL-17-9 × HRB-108-2	0.875	–0.556	–0.053	0.158	0.371	–3.792**	–11.167**
NOL-17-9 × AOL-12-59	–0.458	–0.833	0.558**	0.314	0.436 –	0.931*	2.278
NOL-17-9 × AOL-16-04	1.486	2.722**	–0.597**	–0.986	–1.173*	0.819	3.444*
NOL-17-9 × Kashi Kranti	–1.903	–1.333	0.092	0.514	0.366	2.042**	5.444**
AOL-8-05 × HRB-108-2	–1.208	–0.056	–0.303**	–0.758	–0.928	–0.042	–0.250
AOL-8-05 × AOL-12-59	1.458	1.000	–0.425**	–1.803**	–1.613**	–0.319	–0.806
AOL-8-05 × AOL-16-04	2.403*	0.556	0.153	0.297	0.142	–0.431	–0.972
AOL-8-05 × Kashi Kranti	–2.653*	–1.500	0.575**	2.264**	2.400**	0.792	2.028
SE(S_{ij})±	1.08	0.77	0.10	0.66	0.45	0.33	1.65
SE($S_{ij} – S_{kl}$)±	1.53	1.09	0.15	0.93	0.64	0.65	2.33
SE($S_{ij} – S_{jk}$)±	2.02	1.44	0.20	1.23	0.85	0.86	3.08
Number of positive and significant crosses	3	2	7	5	5	8	9
Number of negative and significant crosses	1	2	7	4	7	7	4

*Significant at 5% LoS, **Significant at 1% LoS

Table 4. Stapecific combining ability (SCA) effects in hybrids for plant morphological traits, fruit characteristics and yield components

Hybrid	Plant height (cm)	Internodal length (cm)	Fruit length (cm)	Fruit girth (cm)	Ten fruits weight (g)	Fruit borer infestation (%)	Fruit yield/ plant (g)
2017/OKYVRES-1 × HRB-108-2	–0.950	0.082	1.261**	–0.085	33.399**	–2.270*	36.486**
2017/OKYVRES-1 × AOL-12-59	–10.772**	0.313	1.092**	–0.309	26.830**	3.687**	31.069**
2017/OKYVRES-1 × AOL-16-04	5.250	0.038	0.389	0.335	–15.759**	–3.058**	–18.264
2017/OKYVRES-1 × Kashi Kranti	6.472	–0.432*	–2.742**	0.059	–44.470**	1.641	–42.931**
2017/OKYVRES-9 × HRB-108-2	0.717	–0.178	–0.044	0.125	6.983	1.620*	17.042
2017/OKYVRES-9 × AOL-12-59	–8.372*	–0.087	1.407**	–0.213	–4.920	3.062**	1.319*
2017/OKYVRES-9 × AOL-16-04	–0.283	–0.322	0.038	0.119	7.324	2.128*	4.319
2017/OKYVRES-9 × Kashi Kranti	7.939*	0.587**	–1.400**	–0.031	–9.387	–6.810**	–22.681*
2018/OKYVRES-3 × HRB-108-2	–5.633	–0.605**	–0.251	0.177	–35.326**	–1.574	–57.458**
2018/OKYVRES-3 × AOL-12-59	2.811	0.340	–1.707**	0.653**	–10.728*	–0.151	–14.514
2018/OKYVRES-3 × AOL-16-04	7.700*	0.264	0.584*	–0.543*	31.133**	0.325	30.125**
2018/OKYVRES-3 × Kashi Kranti	–4.878	0.001	1.373**	–0.286	14.922**	1.400	35.486**
2018/OKYVRES-4 × HRB-108-2	3.833	0.089	–0.853**	–0.155	11.953*	2.783**	7.958
2018/OKYVRES-4 × AOL-12-59	4.811	–0.300	–0.388	0.101	7.967	–3.094**	11.569
2018/OKYVRES-4 × AOL-16-04	–8.100*	0.311	0.949**	0.192	–4.538	4.425**	–2.431
2018/OKYVRES-4 × Kashi Kranti	–0.544	–0.099	0.292	–0.138	–15.383**	–4.113**	–17.097
NOL-17-9 × HRB-108-2	9.283*	0.270	1.344**	–0.461*	4.016	0.899	13.375
NOL-17-9 × AOL-12-59	7.061	0.615**	0.942**	0.341	–0.220*	–2.232*	5.653
NOL-17-9 × AOL-16-04	–7.317	–0.567**	–2.434**	–0.075	–21.892**	–4.050**	–31.347**
NOL-17-9 × Kashi Kranti	–9.028*	–0.317	0.148	0.195	18.097**	5.383**	12.319
AOL-8-05 × HRB-108-2	–7.250	0.342	–1.456**	0.399	–21.026**	–1.458	–11.042
AOL-8-05 × AOL-12-59	4.461	–0.880**	–1.345**	–0.573*	–18.928**	–1.272	–35.097**
AOL-8-05 × AOL-16-04	2.750	0.278	0.473	–0.028	3.733	0.230	11.236
AOL-8-05 × Kashi Kranti	0.039	0.261	2.328**	0.202	36.222**	2.499**	34.903**
SE(S_{IJ})±	3.71	0.17	0.26	0.22	4.89	0.86	10.17
SE($S_{IJ} - S_{KL}$)±	5.25	0.24	0.37	0.30	6.93	1.22	14.38
SE($S_{IJ} - S_{JK}$)±	6.95	0.32	0.48	0.40	9.16	1.61	19.03
Number of positive and significant crosses	3	2	9	1	7	8	6
Number of negative and significant crosses	4	4	6	3	9	6	5

*Significant at 5% LoS, **Significant at 1% LoS

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