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Combining Ability Analysis in Rice (*Oryza sativa* L.)

U. M. Patel[1*], G. O. Faldu[2], P. B. Patel[3] and Savankumar N. Patel[1]

[1]Department of Genetics and Plant Breeding, N. M. College of Agriculture, Navsari Agricultural University, Navsari-396450, Gujarat, India

[2]Main Cotton Research Station, Navsari Agricultural University, Surat-385007, Gujarat, India

[3]Main Rice Research Center, Navsari Agricultural University, Navsari-396450, Gujarat, India

*Corresponding Author E-mail: umangpatel171@yahoo.com

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ABSTRACT

The experimental material, comprising of 3 females x 11 males conducted to study the nature and magnitude of gene action i.e. general combining ability (GCA) and specific combining ability (SCA) of sixteen yield and yield contributing character in rice at Navsari Agricultural University, Navsari, India during kharif 2017. Highly significant genotypic differences were observed that revealed the wild range of variability among the genotypes studies. The SCA variance were found significant for all the characters While GCA variance were not significant for all the characters. The higher ratio of σ2gca/σ2sca indicated the preponderance of non-additive gene action for all the characters, except for plant height. Among the Parents viz., NVSR-319, IET-24333, NVSR-371 and NVSR-2103 were good general combiners for grain yield per plant as well as one or more of its yield contributing traits. Cross combination, NVSR-319 x NVSR-2101, GNR-3 x NVSR-359 and IET-24333 x NVSR-2120 were observed to be good specific cross combination for grain yield per plant and most of its yield attributes.

Key words: *Line x tester, General combining ability, Specific combining ability, Rice*

INTRODUCTION

Rice improvement programmers have been in operation across India since the early 1900s. Initially, the improvement was aimed mainly for improvement of popular local varieties through pure line selection. Exploitation of heterosis in rice has been recognized as practical tool improving yield and other important traits for developing promising varieties through hybridization. In breeding point of view, selection of right type of breeding material is crucial step for plant breeder in developing the high yielding variety or hybrid. Further the breeding methods to be adopted for improvement of any crop depends on the nature of gene action involved in the inheritance of economically important traits. The line x tester analysis is a powerful tool in selecting appropriate parental material and predicting type of gene action involved in the inheritance of various traits.

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It also helps in distinguishing good as well as poor combiners. Besides its use in selection of potential parents, superior crosses and combining ability studies, it also provide information on the nature and magnitude of gene effects involved in the expression of quantitative traits. Such information is of immense importance in formulating as well as executing the efficient breeding programme for obtaining maximum improvement in grain yield and its contributing traits within minimum resources and time.

The line x tester analysis technique has been extensively used to assess the combining ability of parents and crosses for different quantitative characters. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploration of heterosis.

MATERIALS AND METHODS

Three females *viz.*, GNR-3, NVSR-319 and IET-24333 and eleven males viz., NVSR-317, NVSR-350, NVSR-313, NVSR-359, NVSR-371, NVSR-381, IET-24324, NVSR-2101, NVSR-2103, NVSR-2106 and NVSR-2120 were used as testers in line x tester design to generate 33 hybrids. These 33 F1 hybrids, fourteen parents and standard check (GNR-5) were grown in a randomized block design with three replications at Main Rice Research Station, Navsari Agriculture University, Navsari, India. Thirty day-old seedlings of the 33 F1 hybrids, fourteen parents and standard check were transplanted with a spacing 20 cm between rows and 15 cm between plants. Each test entry consisted single row of 3m length. The observations were recorded on five plants per plot selected at random from each treatment in each replication for days to 50% flowering, plant height (cm), panicle length (cm), productive tillers per hill, grains per panicle, grain yield per plant (g), straw yield per plant (g), 1000 grain weight (g), harvest index (%), days to maturity, hulling (%), milling (%), head rice recovery (%) kernel length (mm), kernel breath (mm) and L:B ratio. The line x tester analysis was done based on the procedures developed by Kempthorne[3].

RESULTS AND DISCUSSION

The genetic variances were estimated from the analysis of variances for combining ability for fifteen characters as suggested by Kempthorne[3]. The results are presented in Table 1. The variation present in the hybrids was partitioned into portions attributable to females, males and female x male sources. Analysis of variance for combining ability revealed that mean squares due to females were significant or non-significant for various characters in rice.

The estimation of general combining ability (gca) variances for females (σ^2f) were significant for all the characters except grain yield per plant, grains per panicle, harvest index, 1000 grain weight, hulling %, milling %. Head rice recovery, kernel length, kernel breadth and L:B ratio, also general combining ability (gca) variances for males (σ^2m) not significant for all traits. On the other hand, specific combining ability (sca) variances for f x m interaction were highly significant for all characters except plant height and harvest index. The magnitude of gca variances was lower than sca variances for various characters except plant height, which indicated the predominance of non-additive gene action. This was further supported by low magnitude of σ^2gca/σ^2sca ratios. General combining ability effects of females (gi) and of males (gj) as well as specific combining ability effects of crosses (Sij) for all the characters were also estimated. This was further reflected through low magnitude of σ^2gca/σ^2sca ratios for all the traits except plant height. Preponderance of non-additive variance in the expression of different traits in rice have also been reported by Latha *et al.*[4], Dar *et al.*[2], Bhatti *et al.*[1], Rahaman[5], Sala *et al.*[7], Satheeshkumar *et al.*[8], Rumanti *et al.*[6].

The general combining ability effect enables the identification of desirable male and female parents. Female Parent, NVSR-319 was found to be good general combiner for days to 50 per cent flowering, panicle length, productive tillers per plant, grains per panicle, grain yield per plant, straw yield per plant, days to maturity, milling per cent and head rice recovery, while male parent, NVSR-317 emerged out as good general combiner for days to 50 per cent flowering, productive tillers per plant, grains per panicle, 1000 grain weight, days to maturity, hulling per cent and head rice recovery. Parents *viz.*, NVSR-319, IET-24333, NVSR-371 and NVSR-2103 were good general combiners for grain yield per plant as well as one or more of its yield contributing traits (Table 2).

Table 1: Analysis of variance combining ability for different characters in rice

Source	D. f.	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Productive tillers per plant	Number of grains per panicle	Grain yield per plant (g)	Straw yield per plant (g)	Harvest Index (%)
Replication	2	1.13	246.19	17.71*	4.31**	441.85	1.25	1.31	1.64
Crosses	32	176.52**	408.24**	18.81**	25.02**	6578.31**	19.26**	14.47**	10.81*
Line effect	2	868.40**	3993.28**	109.16**	99.38*	15366.91	37.53	39.62*	4.89
Tester effect	10	111.11	183.59	9.98	25.88	6564.36	23.95	17.93	14.19
Line * tester eff.	20	140.04**	162.05	14.19**	17.16**	5706.43**	15.09**	10.23**	9.71
Error	64	17.79	105.65	4.33	0.17	144.55	2.29	3.78	6.06
σ^2 line		25.71 **	117.05 **	3.18 **	3.01 *	461.99	1.07	1.10 *	-0.01
σ^2 tester		10.14	5.87	0.65	2.86	715.90	2.42	1.62	1.01
σ^2 gca		22.38 **	93.22 **	2.64**	2.98 **	516.40 *	1.39 *	1.21 **	0.21
σ^2 sca		40.08 **	10.43	3.34 **	5.66 **	1861.72 **	4.29 **	2.29 **	1.53 *
σ^2 gca/ σ^2 sca		0.56	8.94	0.79	0.53	0.27	0.32	0.53	0.14

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

Contd. ….

Source	D.f.	1000 grain weight (g)	Days to maturity	Hulling (%)	Milling (%)	Head rice recovery (%)	Kernel length (mm)	Kernel breadth (mm)	L:B ratio
Replication	2	1.62	12.44	12.89	6.98	32.19*	0.26	0.01	0.06
Crosses	32	21.44**	157.10**	122.15**	207.34**	120.86**	0.21 **	0.04 **	0.14**
Line effect	2	47.75	910.90**	47.00	211.95	163.57	0.75 *	0.16 *	0.06
Tester effect	10	17.94	58.51	122.12	152.33	86.55	0.18	0.03	0.10
Line * tester eff.	20	20.56**	131.02**	129.69**	234.39**	133.74**	0.17 *	0.04 **	0.16**
Error	64	0.74	12.55	7.29	7.76	8.46	0.09	0.01	0.02
σ^2 line		1.43	27.05 **	1.23	6.20	4.70	0.02 *	0.005 *	0.00
σ^2 tester		1.91	4.47	12.85	16.12	8.66	0.01	0.002	0.01
σ^2 gca		1.52 *	22.21 **	3.72	8.33	5.55	0.02 **	0.004 *	0.00
σ^2 sca		6.61 **	37.59 **	41.09 **	75.71**	41.72 **	0.03 **	0.010 **	0.05**
σ^2 gca/ σ^2 sca		0.23	0.59	0.09	0.11	0.13	0.66	0.40	0.06

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

Table 2: Estimation of general combining ability effects of parents for different characters in rice

Parents	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Productive tillers per plant	Grains per panicle	Grain yield per plant (g)	Straw yield per plant (g)	Harvest index (%)
Females								
GNR-3	0.34	-10.37 **	-2.10 **	-1.87 **	-22.24 **	-1.23 **	-1.27 **	-0.44
NVSR-319	-5.29 **	11.54 **	1.11 **	1.56 **	20.85 **	0.66 *	0.64 *	0.29
IET-24333	4.95 **	-1.162	0.99 **	0.32 **	1.39	0.57 *	0.63	0.15
S Em. ± (gi-gj)	1.10	2.82	0.50	0.10	2.71	0.37	0.45	0.56
Males								
NVSR-317	-3.57 *	1.79	0.42	0.98 **	11.82 **	-1.54 **	-0.67	-1.88 *
NVSR-350	1.33	0.58	1.31	-0.91 **	-23.83 **	-1.79 **	-1.34 *	-1.24
NVSR-313	1.42	-1.43	-0.92	-2.59 **	-38.96 **	-0.95	-0.63	-0.88
NVSR-359	1.65	-1.20	1.00	0.07	9.26 *	-0.14	-0.79	1.07
NVSR-371	2.54	-2.76	-1.02	-1.02 **	-25.74 **	2.14 **	1.22 *	2.29 **
NVSR-381	-4.24 **	1.24	1.31	2.63 **	57.15 **	0.56	0.21	0.79
IET-24324	-2.47	-2.43	-1.24	-1.70 **	-10.29 **	-1.22 *	-1.45 *	-0.05
NVSR-2101	-0.80	0.69	1.09	-0.70 **	-8.63 *	0.85	1.31 *	-0.34
NVSR-2103	6.87 **	-4.87	-1.13	-0.37 **	-4.07	3.32 **	2.94 **	1.43
NVSR-2106	1.98	-3.65	-0.74	2.87 **	28.93 **	0.19	0.67	-0.58
NVSR-2120	-4.69 **	12.02 **	-0.07	0.74 **	4.37	-1.41 **	-1.47 *	-0.62
S Em. ± (gi-gj)	2.10	5.39	0.96	0.19	5.19	0.70	0.86	1.07

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

Contd………

Parents	1000 grain weight (g)	Days to maturity	Hulling (%)	Milling (%)	Head rice recovery (%)	Kernel length (mm)	Kernel breath (mm)	L:B ratio
Females								
GNR-3	1.32 **	2.29 **	1.35 **	1.61 **	-1.83 **	0.17**	0.08**	-0.03
NVSR-319	-0.28	-6.01 **	-0.42	1.32 **	2.48 **	-0.06	-0.06**	0.05
IET-24333	-1.04 **	3.71 **	-0.91 *	-2.92 **	-0.65	-0.12*	-0.02	-0.02
S Em. ± (gi-gj)	0.21	1.05	0.62	0.66	0.72	0.08	0.03	0.04
Males								
NVSR-317	0.64 *	-4.10 **	2.76 **	-4.57 **	2.22 *	0.11	0.02	0.01
NVSR-350	-0.39	-0.11	1.25	7.50 **	3.36 **	-0.17	0.11 **	-0.23 **
NVSR-313	-2.99 **	1.67	-0.59	2.48 **	-3.51 **	0.01	0.00	0.01
NVSR-359	-0.69 *	1.89	-7.52 **	-1.49	0.27	0.18 *	0.02	0.05
NVSR-371	-0.93 **	2.34	2.49 **	-0.23	-2.42 *	-0.12	-0.03	-0.01
NVSR-381	2.19 **	-1.23	1.79 *	0.78	-3.82 **	-0.05	-0.10 **	0.12 *
IET-24324	0.28	-3.10 *	1.36	6.13 **	5.96 **	0.08	-0.01	0.05
NVSR-2101	-1.06 **	-1.76	-6.45 **	0.84	0.61	0.09	0.02	0.01
NVSR-2103	0.74 *	3.78 **	1.76 *	-4.22 **	-1.69	0.05	-0.04	0.09
NVSR-2106	0.91 **	2.23	3.66 **	-4.25 **	-2.45 *	-0.28 **	0.04	-0.16 **
NVSR-2120	1.28 **	-1.65	-0.51	-2.98 **	1.47	0.09	-0.03	0.06
S Em. ± (gi-gj)	0.40	2.01	1.20	1.27	1.38	0.13	0.05	0.07

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

The estimates of sca effects revealed that none of the crosses was superior for all the characters. However, best three hybrids on the basis of significant and positive sca effects for grain yield per plant were NVSR-319 x NVSR-2101, GNR-3 x NVSR-359 and IET-24333 x NVSR-2120. These crosses also registered high and positive sca effects for most of its yield attributes. The highest significant sca effects in desired direction for various characters was exhibited by different hybrids viz., IET-24333 x NVSR-317, NVSR-319 x NVSR-2101 and NVSR-319 x NVSR-2103 for days to 50 per cent flowering, NVSR-319 x NVSR-2101, NVSR-319 x NVSR-381 and IET-24333 x NVSR-2120 for panicle length, IET-24333 x NVSR-2103, GNR-3 x NVSR-371 and NVSR-319 x NVSR-359 for productive tillers per plant, GNR-3 x NVSR-371, NVSR-319 x NVSR-359 and IET-24333 x NVSR-2103 for grains per panicle, NVSR-319 x NVSR-317, GNE-3 x NVSR-371 and IET-24333 x NVSR-2103 for 1000 grain weight, GNR-3 x NVSR-359, GNR-3 x NVSR-317 and NVSR-319 x NVSR-2101 for straw yield per plant, IET-24333 x NVSR-317, NVSR-319 x NVSR-2101 and NVSR-319 x NVSR-2103 for days to maturity, NVSR-319 x NVSR-2103, NVSR-319 x NVSR-2106 and IET-24333 x IET-24324 for kernel length, IET-24333 x NVSR-2106 and NVSR-319 x NVSR-381 for kernel breadth, NVSR-319 x NVSR-2106, NVSR-319 x NVSR-2103 and NVSR-319 x NVSR-313 for L:B ratio, NVSR-319 x NVSR-2120, GNR-3 x NVSR-313 and IET-24333 x NVSR-2101 for hulling per cent, IET-24333 x NVSR-2103, GNR-3 x NVSR-359 and NVSR-319 x NVSR-2120 for milling per cent, IET-24333 x NVSR-2101, NVSR-319 x NVSR-313 and NVSR-319 x NVSR-371 for head rice recovery (Table 3).

Table 3: Estimation of specific combining ability for different characters in rice

Crosses	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Productive tillers per plant	Grains per panicle
GNR-3 x NVSR-317	3.21	-2.41	0.54	0.08	-7.76
GNR-3 x NVSR-350	-5.68 *	2.49	-2.01	0.97 **	17.58 **
GNR-3 x NVSR-313	-4.46	-6.18	1.52	1.65 **	4.02
GNR-3 x NVSR-359	-2.34	-0.74	2.37 *	-2.01 **	-49.87 **
GNR-3 x NVSR-371	-6.90 **	5.82	0.99	3.08 **	66.13 **
GNR-3 x NVSR-381	1.21	-2.52	-1.68	-1.95 **	-61.42 **
GNR-3 x IET-24324	7.10 **	1.82	1.54	1.76 **	25.02 **
GNR-3 x NVSR-2101	6.43 *	-1.30	-3.79 **	-0.24	6.35
GNR-3 x NVSR-2103	4.43	5.93	1.43	0.09	0.80
GNR-3 x NVSR-2106	-3.68	4.37	-0.96	-2.14 **	-11.54
GNR-3 x NVSR-2120	0.66	-7.29	0.04	-1.35 **	10.69
NVSR-319 x NVSR-317	10.85 **	11.02	1.33	2.02 **	45.49 **
NVSR-319 x NVSR-350	5.29 *	-9.09	0.11	-1.46 **	-15.18 *
NVSR-319 x NVSR-313	6.18 *	-1.42	-1.66	-1.11 **	-4.74
NVSR-319 x NVSR-359	-0.37	-2.65	-0.91	2.57 **	63.04 **
NVSR-319 x NVSR-371	4.74	-4.76	0.45	-1.68 **	-50.63 **
NVSR-319 x NVSR-381	-2.15	-0.76	2.78 *	0.33	26.49 **
NVSR-319 x IET-24324	-4.60	-2.76	-1.00	-2.33 **	-48.07 **
NVSR-319 x NVSR-2101	-9.93 **	2.80	3.67 **	2.33 **	26.26 **
NVSR-319 x NVSR-2103	-7.60 **	-3.65	-1.44	-4.00 **	-63.63 **
NVSR-319 x NVSR-2106	2.96	-5.53	-0.83	0.77 **	6.71
NVSR-319 x NVSR-2120	-5.37 *	16.80 *	-2.50 *	2.56 **	14.26 *
IET-24333 x NVSR-317	-14.06 **	-8.61	-1.88	-2.11 **	-37.73 **
IET-24333 x NVSR-350	0.38	6.61	1.90	0.48 *	-2.39
IET-24333 x NVSR-313	-1.73	7.60	0.13	-0.54 *	0.72
IET-24333 x NVSR-359	2.72	3.38	-1.46	-0.56 *	-13.17 *
IET-24333 x NVSR-371	2.16	-1.06	-1.43	-1.405 **	-15.51 *
IET-24333 x NVSR-381	0.94	3.27	-1.10	1.57 **	34.94 **
IET-24333 x IET-24324	-2.51	0.94	-0.54	0.57 *	23.05 **
IET-24333 x NVSR-2101	3.50	-1.50	0.12	-2.09 **	-32.62 **
IET-24333 x NVSR-2103	3.16	-2.28	0.01	3.91 **	62.83 **
IET-24333 x NVSR-2106	0.72	1.16	1.79	1.37 **	4.83
IET-24333 x NVSR-2120	4.72	-9.50	2.46 *	-1.21 **	-24.95 **
SE (Sij)	2.57	6.60	1.18	0.23	6.36
SE (Sij-Skl)	3.63	9.33	1.67	0.33	8.99

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

Contd…

Crosses	Grain yield per plant (g)	Straw yield per plant (g)	Harvest index (%)	1000 grain weight (g)	Days to maturity
GNR-3 x NVSR-317	2.58 **	2.59 *	1.14	-0.95	4.04
GNR-3 x NVSR-350	0.74	0.15	1.17	1.25 *	-4.96 *
GNR-3 x NVSR-313	0.89	0.66	0.77	-0.65	-5.07 *
GNR-3 x NVSR-359	2.78 **	2.71 *	1.03	-4.10 **	-3.63
GNR-3 x NVSR-371	1.99 *	1.04	2.17	3.72 **	-6.74 **
GNR-3 x NVSR-381	-0.08	-0.01	-0.14	-0.11	3.15
GNR-3 x IET-24324	-1.20	-1.58	0.08	1.61 **	6.71 **
GNR-3 x NVSR-2101	-2.04 *	-2.62 *	0.24	-1.72 **	5.71 *
GNR-3 x NVSR-2103	-2.15 *	-1.38	-1.60	0.37	3.15
GNR-3 x NVSR-2106	-1.42	-0.33	-2.21	0.91	-2.63
GNR-3 x NVSR-2120	-2.10 *	-1.21	-2.64 *	-0.33	0.26
NVSR-319 x NVSR-317	-0.18	-0.45	0.51	3.88 **	9.68 **
NVSR-319 x NVSR-350	-0.78	0.09	-1.55	0.41	3.01
NVSR-319 x NVSR-313	-3.12 **	-2.35 *	-2.46	-0.72	4.23
NVSR-319 x NVSR-359	-0.85	-0.74	-0.37	3.50 **	0.34
NVSR-319 x NVSR-371	-1.20	-0.65	-1.08	-2.26 **	5.23 *
NVSR-319 x NVSR-381	0.39	0.05	0.57	-0.71	0.46
NVSR-319 x IET-24324	1.74 *	1.75	0.69	-2.33 **	-5.66 *
NVSR-319 x NVSR-2101	3.60 **	2.59 *	2.33	2.44 **	-10.66 **
NVSR-319 x NVSR-2103	1.92 *	1.72	0.67	-4.07 **	-6.88 **
NVSR-319 x NVSR-2106	-0.99	-1.37	0.34	-1.37 **	4.01
NVSR-319 x NVSR-2120	-0.52	-0.61	0.35	1.23 *	-3.77
IET-24333 x NVSR-317	-2.40 **	-2.13 *	-1.64	-2.93 **	-13.72 **
IET-24333 x NVSR-350	0.04	-0.25	0.38	-1.66 **	1.95
IET-24333 x NVSR-313	2.23 *	1.70	1.69	1.37 **	0.84
IET-24333 x NVSR-359	-1.93 *	-1.97	-0.65	0.60	3.29
IET-24333 x NVSR-371	-0.79	-0.38	-1.09	-1.46 **	1.51
IET-24333 x NVSR-381	-0.31	-0.05	-0.43	0.82	-3.61
IET-24333 x IET-24324	-0.54	-0.17	-0.76	0.73	-1.05
IET-24333 x NVSR-2101	-1.56	0.03	-2.57	-0.73	4.95 *
IET-24333 x NVSR-2103	0.23	-0.33	0.93	3.70 **	3.73
IET-24333 x NVSR-2106	2.41 **	1.70	1.87	0.46	-1.39
IET-24333 x NVSR-2120	2.62 **	1.83	2.29	-0.90	3.50
SE (Sij)	0.86	0.61	1.31	0.49	2.47
SE (Sij-Skl)	1.21	1.49	1.85	0.70	3.49

*, ** significant at 5% and 1% levels of probability, respectively.

Contd…

Crosses	Hulling (%)	Milling (%)	Head rice recovery (%)	Kernel length (mm)	Kernel breath (mm)	L:B ratio
GNR-3 x NVSR-317	-2.64	5.14 **	6.12 **	0.05	0.04	-0.02
GNR-3 x NVSR-350	3.40 *	3.08	5.15 **	0.09	0.05	-0.01
GNR-3 x NVSR-313	9.14 **	8.46 **	2.54	0.09	0.05	-0.03
GNR-3 x NVSR-359	2.37	13.47 **	-6.46 **	0.15	0.05	0.00
GNR-3 x NVSR-371	2.993 *	-9.01 **	-2.27	0.06	0.07	-0.07
GNR-3 x NVSR-381	1.96	-1.05	0.83	0.10	-0.10	0.20 *
GNR-3 x IET-24324	1.96	1.95	4.80 **	-0.04	-0.10	0.12
GNR-3 x NVSR-2101	-10.40 **	7.26 **	-5.73 **	-0.13	-0.01	-0.05
GNR-3 x NVSR-2103	3.06 *	-14.07 **	4.87 **	0.03	0.03	-0.03
GNR-3 x NVSR-2106	1.19	-7.21 **	-7.90 **	-0.12	-0.02	-0.05
GNR-3 x NVSR-2120	-13.04 **	-8.08 **	-1.95	-0.28	-0.05	-0.07
NVSR-319 x NVSR-317	5.42 **	-4.73 **	1.21	-0.17	0.04	-0.14
NVSR-319 x NVSR-350	-2.74	0.47	-5.12 **	-0.12	-0.04	-0.01
NVSR-319 x NVSR-313	-1.00	1.56	7.88 **	0.10	-0.14 *	0.25 **
NVSR-319 x NVSR-359	-6.07 **	-14.88 **	0.99	-0.17	0.05	-0.15
NVSR-319 x NVSR-371	3.55 *	8.58 **	6.17 **	-0.13	0.07	-0.16
NVSR-319 x NVSR-381	-4.18 **	-2.74	-2.80	-0.10	0.13 *	-0.23 **
NVSR-319 x IET-24324	-1.61	-1.38	-2.70	-0.28	0.10	-0.27 **
NVSR-319 x NVSR-2101	4.90 **	-2.90	-5.42 **	0.02	0.08	-0.09
NVSR-319 x NVSR-2103	-6.15 **	0.20	-6.67 **	0.40 *	-0.08	0.32 **
NVSR-319 x NVSR-2106	-1.68	5.56 **	1.91	0.38 *	-0.22 ***	0.46 **
NVSR-319 x NVSR-2120	9.55 **	10.27 **	4.55 **	0.06	0.01	0.02
IET-24333 x NVSR-317	-2.78	-0.41	-7.33 **	0.12	-0.08	0.16
IET-24333 x NVSR-350	-0.67	-3.55 *	-0.03	0.03	-0.01	0.02
IET-24333 x NVSR-313	-8.14 **	-10.01 **	-10.41 **	-0.19	0.09	-0.22 *
IET-24333 x NVSR-359	3.70 *	1.41	5.47 **	0.02	-0.10	0.15
IET-24333 x NVSR-371	-6.55 **	0.44	-3.89 *	0.07	-0.14 *	0.23 **
IET-24333 x NVSR-381	2.22	3.79*	1.96	0.00	-0.03	0.03
IET-24333 x IET-24324	-0.35	-0.58	-2.09	0.32 *	0.00	0.15
IET-24333 x NVSR-2101	5.50 **	-4.37 **	11.14 **	0.11	-0.07	0.14
IET-24333 x NVSR-2103	3.09 *	13.81 **	1.77	-0.43 **	0.05	-0.29 **
IET-24333 x NVSR-2106	0.49	1.65	5.99 **	-0.26	0.24 ***	-0.41 **
IET-24333 x NVSR-2120	3.49 *	-2.18	-2.61	0.22	0.04	0.05
SE (Sij)	1.47	1.56	1.69	0.16	0.06	0.09
SE (Sij-Skl)	2.07	2.20	2.39	0.22	0.08	0.12

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

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