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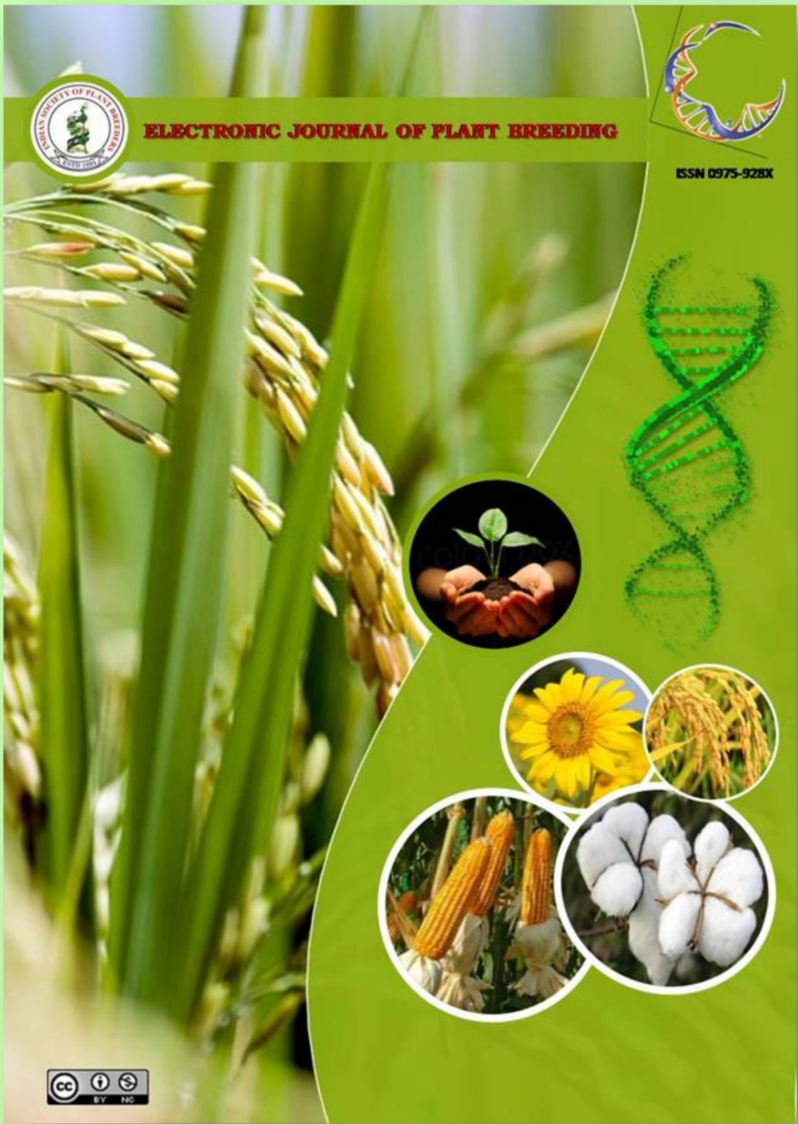

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Research Article

Gene action and combining ability studies for protein content and grain quality traits in rice (*Oryza sativa* L.)

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Abstract
Combining ability analysis was carried out with ten parents and twenty four F_1' s in Line × Tester mating design for the grain quality and nutritional traits *viz.*, protein content, iron content and zinc content. The results showed that the dominance genetic variance is higher than that of additive genetic variance which indicated the predominance of non additive gene action for protein content, iron content, zinc content, hulling percentage, milling percentage, head rice recovery, kernel length, kernel breadth, kernel L/B ratio, linear elongation ratio, amylose content, gel consistency and gelatinization temperature whereas additive gene action was observed for kernel length after cooking. Among the lines, NLR 34449 was the best parent as it exhibited significant *per se* and *gca* effects for iron content, zinc content and important quality traits. In testers, CR Dhan 310 was found to be the best general combiner for protein content and Kodai for iron and zinc content which recorded highly significant positive *gca* effects. The hybrid ASD 16/ Kodai showed significant and desirable *per se* performance and *sca* effects for the nutritional traits *viz.*, protein content, iron and zinc content. The hybrid RNR 15048/CB 14740 was adjudged as the best for the characters *viz.*, kernel length, kernel L/B ratio, kernel length after cooking. These hybrids could be recommended for heterosis breeding to improve the nutritional and grain quality traits.

Key words
Combining ability; protein content; quality characters; Line × Tester mating design

Introduction

Rice is the major energy source of more than half of the world population, though it lacks many essential nutrients. Protein, iron and zinc deficiencies are common in rice consuming regions. Grain protein accumulation is important for determination of grain quality and grain yield and improvement in grain protein content has been the major concern of plant breeders. Rice grain quality is influenced by the total protein but the extent to which it influences the grain quality is not known. In order to improve the efficiency of breeding for rice nutrient quality, understanding the genetic architecture of nutritional quality and its influence on other grain quality character is essential. The present experiment was undertaken with the aim to study the gene action for nutritional quality traits *viz.*, protein content, iron, zinc content and other grain quality traits and also for developing nutritionally superior lines with good quality and high yield.

Materials and Methods

Six rice varieties *viz.*, ASD 16, ADT 49, CO 52, RNR 15048, NLR 34449 and WGL 32100 were used as lines and four genotypes *viz.*, CR Dhan 310, CB 13543, CB 14740 and Kodai were used as testers. The study was carried out at Agricultural College and Research Institute, Madurai during 2017-18. Crosses were made in Line × Tester mating design by crossing six lines and four testers during kharif 2017. Twenty four hybrids along with ten parents were evaluated in randomized block design with three replications and spacing of 20 cm × 15 cm was adopted and the study was conducted during *Rabi* 2017. Recommended agronomic and plant protection measures were followed. Observations on yield and yield related characters and other quality traits *viz.*, hulling percentage, milling percentage, head rice recovery, kernel length, kernel breadth, kernel L/B ratio, kernel length after cooking, linear elongation ratio, amylose content, gel consistency, gelatinization temperature, protein content, iron content and zinc content were recorded in the parents and hybrids and results are analysed for combining ability. The iron and zinc content was analysed by using the Energy Dispersive – X ray Fluorescence Analyzer. 4 grams of brown rice samples were taken in the primary window cup with equal distribution of sample upto 3/4th of the cup. For analysing iron content 7.8 KeV was used and the resulting counts per second value was calibrated into ppm. For analyzing zinc content 8.6 KeV was used and the resulting counts per second was calibrated into ppm. Protein estimation was analysed by Micro Kjeldhal method. The nitrogen content of the sample was calculated. By multiplying the total nitrogen value with 6.25, crude protein content was obtained which also includes non-protein nitrogen. True protein content was calculated after deducting the non-protein nitrogen from the total nitrogen and then multiplied with the factor.

Results and Discussion

Analysis of Variance for all the traits studied indicated that significant differences exist among the parents used in hybridization programme (Table 1). The proportion of dominance genetic variance is higher than that of additive genetic variance indicated the predominance of non additive gene action for hulling percentage, milling percentage, head rice recovery, kernel length, kernel breadth, kernel L/B ratio, linear elongation ratio, amylose content, gel consistency, gelatinization temperature, protein content, iron content and zinc content except kernel length after cooking. This was in accordance with findings of Gnanamalar and Vivekanandan (2013), Devi *et al.*, (2018) and Upadhyay *et al.*, (2015). Predominance of non-additive gene action for protein and iron content was reported by Kumar *et al.* (2005), Sharifi *et al.* (2013) and Adilakshmi and Upendra (2014). Predominance of non-additive gene action was reported for zinc content which was contrary to the findings of Sala *et al.*(2015) and Chowdhury *et al.* (2016). In situation of this kind, simple pedigree method of selection is ineffective and probably this could be one of the reasons for the inability of rice breeders to effectively combine quality characteristics. To overcome this problem, selection of superior segregants has to be postponed to later generations until the progenies attain homozygosity.

Among the lines, ADT 49 recorded higher *per se* values for the grain quality traits *viz.*, kernel L/B ratio (3.26), linear elongation ratio (1.69), amylose content (24.10 per cent), Alkali spreading value (6.00) and zinc content (27.8 ppm). NLR 34449 showed significant mean performance for head rice recovery (61.81 per cent), kernel length (6.02 mm), kernel breadth (1.68 mm), kernel L/B ratio (3.59), gel consistency (90 mm) and alkali spreading value (5.00) whereas RNR 15048 recorded superior mean performance for kernel breadth (1.46 mm), kernel L/B ratio (3.8), Protein (9.09 per cent) and Iron content (13.2 ppm). Among the testers, Kodai recorded higher *per se* performance for protein (9.71 per cent), iron (19.55 ppm) and zinc content (34.95 ppm) whereas CR Dhan 310 showed desirable values for head rice recovery (60.94 per cent), gel consistency (86 mm) and protein content (11.19 per cent) (Table 2-3).

Singh and Singh (1985) suggested that parents with high *gca* would produce transgressive segregants in F_2 or in later generations. NLR 34449 showed positive significant *gca* effects for iron and zinc content, head rice recovery, kernel length, kernel breadth, kernel L/B ratio, kernel length after cooking, amylose content and gel consistency. ADT 49 showed desirable *gca* effects for protein content, iron content, kernel breadth, kernel L/B ratio, kernel length after cooking and linear elongation ratio whereas RNR 15048 was the best for quality traits *viz.*, kernel length, kernel length after cooking and linear elongation ratio. Among the testers, Kodai was superior for nutritional traits *viz*., iron, zinc content and protein content which possessed favourable *gca* effects and CR Dhan 310 recorded significant positive *gca* for milling percentage, head rice recovery, gel consistency and protein content.

Based on *per se* and *gca* effects NLR 34449 and ADT 49 were the best combiners among the lines for many of the quality traits. In testers, Kodai and CR Dhan 310 were the best combiners for iron, zinc content and protein content respectively. Among the hybrids, NLR 34449/Kodai had high *per se* value for kernel length (6.21 mm), kernel L/B ratio (3.06), kernel length after cooking (9.23 mm), amylose content (23.23 per cent), gel consistency (97.5 mm), protein content (8.97 per cent) and iron (18.45 ppm). The hybrid NLR 34449/CR Dhan 310 exhibited higher *per se* values for hulling percentage (81.96 per cent), milling percentage (74.24 per cent), head rice recovery (67.73 per cent), kernel length after cooking (5.88 mm), linear elongation ratio (1.63), amylose content (22.54 per cent), gel consistency (93.5 mm), protein (9.12 per cent) and zinc content (44 ppm). RNR 15048/ CB 14740 had desirable *per se* performance for zinc (44 ppm), kernel length (6.36 mm), kernel breadth (1.98 mm), kernel L/B ratio (3.23), kernel length after cooking (9.73 mm), linear elongation ratio (1.64) and gel consistency (92 mm). The hybrid ASD16/ Kodai showed siginificant mean performance for protein content

(9.09 per cent), iron (20.90 ppm) and zinc content (46.60 ppm).

The hybrid NLR 34449/CR Dhan 310 have recorded significant *sca* for kernel length, kernel L/B ratio, kernel length after cooking and iron content (Table 4-5). The hybrid ASD 16/Kodai had recorded positive significant *sca* effects for hulling percentage, head rice recovery, kernel length, Kernel length after cooking, protein, iron and zinc content whereas RNR 15048/CB 14740 recorded positive significant *sca* effects for kernel length, kernel L/B ratio, kernel length after cooking and linear elongation ratio.

Based on *per se* performance and *sca* effects, NLR 34449/ CR Dhan 310 and RNR15048/CB14740 were found to be best for kernel length, kernel L/B ratio, kernel length after cooking which are mainly important in the consumer point of view. The hybrid ASD 16/ Kodai showed significant and desirable *per se* performance and *sca* effects for the nutritional traits *viz.,* protein content, iron and zinc content. These hybrids could be recommended for heterosis breeding for the simultaneous improvement of quality and nutritional traits.

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Table 1. Analysis of variance for grain quality and nutritional traits

Source of Variation	Mean squares														
	df	HP	MP	HRR	KL	KB	KLBR	KLAC	LER	AC	GC	ASV	PC	Fe	Zn
Replication	2	0.29	0.55	0.75	0.01	0.02	0.002	0.03	0.002	0.17	55.65	0.26	0.001	0.53	0.25
Genotypes	33	16.32 **	30.52 **	16.86 **	0.15 **	0.26 **	0.21 **	1.12 **	0.02 **	8.61 **	264.74 **	3.34 **	3.09 **	26.03 **	146.39 **
Error	66	0.76	1.48	0.94	0.01	0.004	0.002	0.02	0.0005	0.29	13.67	0.63	0.02	0.25	1.75

HP-Hulling percentage, MP - Milling percentage, HRR - Head rice recovery, KL - Kernel length, KB - Kernel breadth, KLBR - Kernel L/B ratio, KLAC - Kernel length after cooking, LER - Linear Elongation Ratio, AC - Amylose content, GC - Gel consistency, GT - Gelatinization temperature, PC - Protein content, Fe - Iron content and Zn - Zinc content

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Table 2. Mean performance of parents for grain quality and nutritional traits in Rice

Parents	HP (%)	MP (%)	HRR (%)	KL (mm)	KB (mm)	KLBR	KLAC(mm)	LER	AC (%)	GC (mm)	ASV	PC (%)	Fe (ppm)	Zn (ppm)
							Lines							
ASD 16	78.05 **	66.24	57.86	5.54	2.89	1.92	8.78	1.66	21.40	95.50 **	4.00	8.74 **	10.55	24.4
ADT 49	76.96	65.24	57.34	5.81	1.79 **	3.26 *	8.70	1.69 **	24.10 **	83.00	6.00 **	6.79	11.85	27.8 *
CO 52	77.38	68.33 **	58.37	5.98 **	1.91	3.14	9.30 **	1.75 **	22.10	74.50	4.00	7.16	12.1 **	27.5 *
RNR 15048	75.54	66.38	56.81	5.55	1.46 **	3.80 **	8.16	1.64	26.50 **	87.00	4.00	9.09 **	13.2 **	27
WGL 32100	76.17	66.81	59.81 **	5.92 **	1.79 **	3.31 **	9.26 **	1.74 **	20.55	86.00	1.00	7.43	10.2	24.25
NLR 34449	76.06	64.81	61.81 **	6.02 **	1.68 **	3.59 **	8.95	1.54	22.45	90 .00*	5.00 **	6.80	11.85	27.3
Mean	76.69	66.30	58.67	5.80	1.92	3.17	8.86	1.67	22.85	86.00	4.00	7.67	11.63	26.38
SEd	0.39	0.53	0.32	0.036	0.03	0.04	0.05	0.008	0.19	1.68	0.34	0.06	0.18	0.63
CD (0.05)	0.79	1.07	0.64	0.07	0.06	0.085	0.11	0.017	0.39	3.38	0.68	0.13	0.36	1.26
CD (0.01)	1.06	1.42	0.85	0.09	0.05	0.11	0.15	0.02	0.52	4.50	0.91	0.17	0.48	1.68
							Testers							
CR Dhan 310	76.72	64.64	60.94 **	5.90	2.11	2.79	8.78	1.51	20.15	86.00 **	3.00	11.19 **	12.85	30.3
CB 13543	76.57	65.97	60.00	6.10	1.83 **	3.33 **	8.83 **	1.57 **	19.95	77.50	5.00 **	7.56	15.85	30.1
CB 14740	78.63 **	64.88	61.67 **	6.02	1.74 **	3.45 **	8.96 **	1.55 **	25.80 **	89.50 **	5.00 **	7.27	16.05	28.35
Kodai	75.20	60.69	57.55	6.15	2.57	2.39	8.43	1.43	25.00 **	69.50	3.00	9.71 **	19.55 **	34.95 **
Mean	77.53	65.19	60.04	6.05	2.07	2.99	8.75	1.52	23.28	80.63	4.00	8.93	16.08	30.93
SEd	0.32	0.43	0.26	0.029	0.026	0.03	0.04	0.007	0.16	1.37	0.28	0.05	0.15	0.51
CD (0.05)	0.65	0.87	0.52	0.06	0.085	0.069	0.08	0.014	0.31	2.76	0.56	0.10	0.29	1.02
CD (0.01)	0.86	1.16	0.69	0.08	0.07	0.09	0.12	0.018	0.42	3.67	0.74	0.14	0.39	1.37

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Table 3. General combining ability effects of parents for grain quality and nutritional characters

Parents	HP	MP	HRR	KL	KB	KLBR	KLAC	LER	AC	GC	ASV	PC	Fe	Zn
Lines														
ASD 16	-1.72**	-1.55**	-1.12**	-0.34*	0.32**	-0.52**	-1.39**	-0.16**	-0.73**	3.04**	0.13	-0.07	1.23**	-0.56
ADT 49	0.14	-0.16	-0.75**	0.00	-0.20**	0.27**	0.28**	0.06**	-0.23	-9.08**	0.38	0.67**	0.37**	-0.22
CO 52	1.05**	0.12	0.97**	-0.11**	-0.05	0.00	0.10*	0.05*	0.22	-10.08	0.38	-0.59**	0.48**	-0.40
RNR 15048	0.12	0.15	-0.49*	0.19**	0.02	0.05	0.49**	0.02**	-0.29*	1.42	-0.88**	-0.04	-1.85**	0.13
WGL 32100	0.35	1.05**	0.73**	0.09**	-0.02	0.04	0.12**	0.01*	0.24	8.04**	0.38	0.28**	-1.08**	0.10
NLR 34449	0.06	0.39	1.26**	0.17**	-0.08**	0.16**	0.40**	0.01	0.79**	6.67**	-0.38	-0.25**	0.85**	0.95*
SE	0.28	0.375	0.23	0.02	0.02	0.03	0.04	0.01	0.13	1.19	0.24	0.05	0.123	0.44
Testers														
CR Dhan 310	0.31	1.07**	0.72**	-0.11**	0.02	-0.09**	-0.14**	-0.01*	-0.06	3.54**	-0.04	0.76**	-3.08**	-4.17
CB 13543	0.00	-0.43	0.37**	-0.01	-0.07**	0.08**	0.04	0.00	-0.45**	2.04**	0.13	-0.47**	0.88**	-1.77
CB 14740	0.06	0.19	-0.58**	0.11**	-0.09**	0.18**	0.23**	0.03**	0.29*	-4.04**	0.29	-0.71**	0.04	1.75**
Kodai	-0.36	-0.82**	-0.51**	0.02	0.14**	-0.16**	-0.12**	-0.01**	0.22*	-1.54**	-0.38	0.42**	2.17**	4.19**
SE	0.22	0.306	0.18	0.02	0.02	0.02	0.03	0.00	0.11	0.97	0.19	0.04	0.10	0.36

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Table 4. Mean performance of hybrids for grain quality and nutritional characters

Crosses	HP (%)	MP (%)	HRR (%)	KL (mm)	KB (mm)	KLBR	KLAC (mm)	LER	AC (%)	GC (mm)	ASV	PC (%)	Fe (ppm)	Zn (ppm)
ASD16 × CR Dhan 310	79.61	71.01	58.43	5.44	2.40**	2.27	7.33	1.43	21.05	95.00 **	3.00	9.15 **	11.80	37.10
ASD16 × CB 13543	78.9	69.84	59.55	5.60	2.32**	2.42	7.51	1.43	20.26	93.00 *	5.00	7.48	16.85 **	37.15
ASD16 × CB 14740	79.73	70.36	59.76	5.61	2.37**	2.39	7.52	1.42	19.94	72.50	5.00	7.95	18.35 **	37.60
ASD16 × Kodai	80.45	70.3	60.73	5.78	2.75**	2.11	7.52	1.41	20.86	89.50	3.00	9.09 **	20.90 **	46.60 **
ADT 49 × CR Dhan 310	81.89	73.63	59.71	5.82	2.00	2.92	8.77	1.62 *	20.92	73.00	4.00	9.95 **	12.55	32.50
ADT 49 × CB 13543	80.60	69.58	58.93	5.81	1.97 **	2.97	9.16 **	1.64 **	22.00 *	87.50	5.00	8.67	17.10 **	37.30
ADT 49 × CB 14740	81.51	71.52	60.70	6.31 **	1.79 **	3.52 **	9.85 **	1.71 **	21.27	72.50	4.00	8.37	16.60 *	39.90
ADT 49 × Kodai	82.12	72.34	63.01 *	5.86	2.01 *	2.92	8.8	1.61 *	19.93	68.50	4.00	9.65**	18.20	50.10 **
CO 52 × CR Dhan 310	82.3	72.68	63.61 **	5.81	2.10	2.77	8.86	1.58	20.88	91.00	5.00	8.74	12.00	33.50
CO 52 × CB 13543	83.68 **	72.61	65.29 **	5.86	1.96 **	3.00 *	9.18 **	1.66 **	20.15	72.50	5.00	7.29	18.00	38.60
CO 52 × CB 14740	81.57	71.95	59.25	5.92	2.04	2.90	9.28 **	1.70 **	22.34 **	63.50	3.00	7.62	18.20	41.80
CO 52 × Kodai	82.23	70.94	61.05	5.79	2.26	2.57	8.53	1.58	22.54 **	70.50	4.00	7.97	16.70 **	45.20 **
RNR 15048 × CR Dhan 310	81.60	71.21	59.21	5.94	2.26	2.63	9.15 **	1.61 *	20.53	83.50	3.00	9.19 **	10.40	34.30
RNR 15048 × CB 13543	82.97 *	73.24	61.14	6.14 **	2.06	2.99 *	9.25 **	1.55	20.78	83.00	2.00	8.17	12.60	37.70
RNR 15048 × CB 14740	81.56	72.65	62.06	6.36 **	1.98 **	3.23 **	9.73 **	1.64 **	21.64	92.00 *	4.00	7.60	14.79	44.00 **
RNR 15048 × Kodai	79.98	71.18	60.98	6.11 *	2.35**	2.61	9.26	1.59	20.93	85.00	3.00	8.84 **	17.70	45.20 **
WGL 32100 × CR Dhan 310	82.83	75.18	63.62 **	6.15 **	2.13**	2.89	9.06	1.56	21.27	92.00 *	5.00	9.37 **	14.60	34.70
WGL 32100 × CB 13543	82.45	74.09 *	64.75 **	6.01	2.14**	2.81	8.86	1.59	20.83	95.50 **	3.00	8.92 **	16.80 **	38.20
WGL 32100 × CB 14740	81.96	72.78	60.52	5.94	1.94 **	3.07 **	8.91	1.58	22.48 **	96.00 **	5.00	7.86	11.80	48.70 **
WGL 32100 × Kodai	79.72	69.84	59.36	6.06	2.29**	2.65	9.10 *	1.65**	21.40	86.50	4.00	8.93 **	15.50	39.60
NLR 34449 × CR Dhan 310	81.96	74.24 *	67.73 **	5.88	2.07	2.84	9.15 **	1.63 **	22.54 **	93.50 **	3.00	9.12 **	14.70	44.00 **
NLR 34449 × CB 13543	79.79	69.60	60.58	6.18 **	1.96	3.16 **	9.43 **	1.61 *	20.83	87.50	4.00	7.60	18.30 **	41.50
NLR 34449 × CB 14740	82.37	73.42	62.22	6.20 **	2.18**	2.84	9.25 **	1.58	21.59	86.00	4.00	7.29	15.00	39.60
NLR 34449 × Kodai	81.7	72.01	59.83	6.21 **	2.03**	3.06 **	9.23 **	1.55	23.23 **	97.50 **	3.00	8.97 **	18.45 **	39.50
Mean	81.39	71.92	61.33	5.95	2.14	2.81	8.86	1.58	21.26	84.46	3.88	8.49	15.74	40.17
SE_d	0.79	1.06	0.63	0.07	0.06	0.09	0.11	0.017	0.38	3.36	0.68	0.13	0.36	1.25
CD (0.05)	1.58	2.13	1.27	0.15	0.13	0.17	0.22	0.034	0.77	6.75	1.37	0.26	0.72	2.51
CD (0.01)	2.11	2.85	1.70	0.19	0.17	0.23	0.29	0.045	1.03	9.01	1.82	0.34	0.96	3.35

Table 5. Specific combining ability effects for grain quality and nutritional characters

Hybrids	HP	MP	HRR	KL	KB	KLBR	KLAC	LER	AC	GC	GT	PC	Fe	Zn
ASD16 × CR Dhan 310	-0.37	-0.44	-1.90**	-0.06	-0.08	0.07	0.00	0.01	0.58*	3.96	-0.96	-0.03	-2.09**	1.66
ASD16 × CB 13543	-0.77	-0.11	-0.44	0.01	-0.07	0.05	0.00	0.01	0.18	3.46	0.88	-0.47**	-1.00**	-0.69
ASD16 × CB 14740	000	-0.20	0.72	-0.11*	0.00	-0.09	-0.17*	-0.03*	-0.87**	-10.96**	0.71	0.24**	1.33**	-3.76**
ASD16 × Kodai	1.13*	0.75	1.62**	0.16**	0.15*	-0.03	0.17*	0.00	0.11	3.54	-0.63	0.25**	1.76**	2.79**
RNR 15048 × CR Dhan 310	0.05	0.80	-1.60**	-0.02	0.04	-0.07	0.23**	-0.02	-0.05	-5.92*	-0.21	0.02	-0.48	-3.28**
RNR 15048 × CB 13543	-0.92	-1.76*	-2.03**	-0.12*	0.10*	-0.19**	-0.02	-0.00	1.4**	10.08**	0.63	-0.02	0.11	-0.88
RNR 15048 × CB 14740	-0.08	-0.44	0.70	0.25**	-0.06	0.27**	0.48**	0.04**	-0.04	1.17	-0.54	-0.08	0.45	-1.80*
RNR 15048 × Kodai	0.95	1.40	2.93**	-0.11*	-0.08	0.00	-0.22**	-0.02*	-1.32**	-5.33*	-0.13	0.07	-0.08	5.96**
ADT 49 × CR Dhan 310	-0.45	-0.43	0.59	0.08	-0.01	0.06	0.04	-0.04**	-0.54	13.08**	0.79	0.07	-1.14**	-2.10*
ADT 49 × CB 13543	1.23*	1.00	2.62**	0.03	-0.06	0.11	0.18*	0.03*	-0.88**	-3.92	0.63	-0.14	0.90**	0.60
ADT 49 × CB 14740	-0.93	-0.28	-2.47**	-0.03	-0.04	-0.09	0.09	0.04**	0.58*	-6.83**	-1.54**	0.42**	1.93**	0.27
ADT 49 × Kodai	0.15	-0.28	0.75	-0.08	-0.03	-0.08	-0.31**	-0.03**	0.84**	-2.33	0.13	-0.35**	-1.69**	1.23
WGL 32100 × CR Dhan 310	-0.21	-1.93*	-2.35**	-0.09	-0.08	-0.14*	-0.05	0.02	-0.38	-5.92*	0.04	-0.02	-0.40	-1.83*
WGL 32100× CB 13543	1.40*	1.60*	-0.08	0.02	-0.03	0.05	-0.13	-0.05**	0.26	-4.92*	-1.13*	-0.19*	-2.21**	-0.83
WGL 32100× CB 14740	-0.01	0.39	1.79**	0.12*	-0.10*	0.19**	0.15*	0.02	0.38	10.17**	0.71	-0.14	0.87**	1.95*
WGL 32100 × Kodai	-1.18*	-0.07	0.64	-0.05	0.05	-0.10	0.03*	0.01	-0.26	0.67	0.38	-0.03	1.65**	0.71
NLR 34449×CR Dhan 310	0.78	1.14	0.84	0.21**	-0.01	0.13**	0.22**	-0.02	-0.17	-4.04	0.79	-0.16	2.97**	-1.45
NLR 34449 × CB 13543	0.72	1.55*	2.31**	-0.02	0.09	-0.13**	-0.16*	-0.01	-0.21	0.96	-1.38**	-0.62**	1.26**	-0.30
NLR 34449 × CB 14740	0.16	-0.38	-0.96*	-0.21**	-0.10*	0.04	-0.30**	-0.04**	0.70*	7.54**	0.46	-0.20*	-2.90**	6.62**
NLR 34449 × Kodai	-1.66**	-2.31**	-2.19*	0.02	0.02	-0.04	0.24**	0.07**	-0.32	-4.46	0.13	0.26**	-1.33**	-4.86**
CO 52 × CR Dhan 310	0.20	0.86	4.4**	-0.13*	-0.01	-0.04	0.03	0.04**	0.55*	-1.17	-0.46	0.11	1.14**	7.200**
CO 52 × CB 13543	-1.66**	-2.28**	-2.39**	0.08	-0.03	0.11	0.13	0.02	-0.77**	-5.67*	0.38	-0.18	0.84**	2.10**
CO 52 × CB 14740	0.86	0.91	0.21	-0.02	0.21**	-0.31**	-0.24**	-0.04**	-0.74**	-1.08	0.21	-0.25*	-1.68**	-3.28**
CO 52 × Kodai	0.61	0.51	-2.25**	0.07	-0.17**	0.24**	0.09	-0.03*	0.96**	7.92**	-0.13	0.31**	-0.30	-5.82**
SE	0.55	0.75	0.45	0.05	0.04	0.08	0.07	0.01	0.27	2.37	0.48	0.09	0.25	0.88