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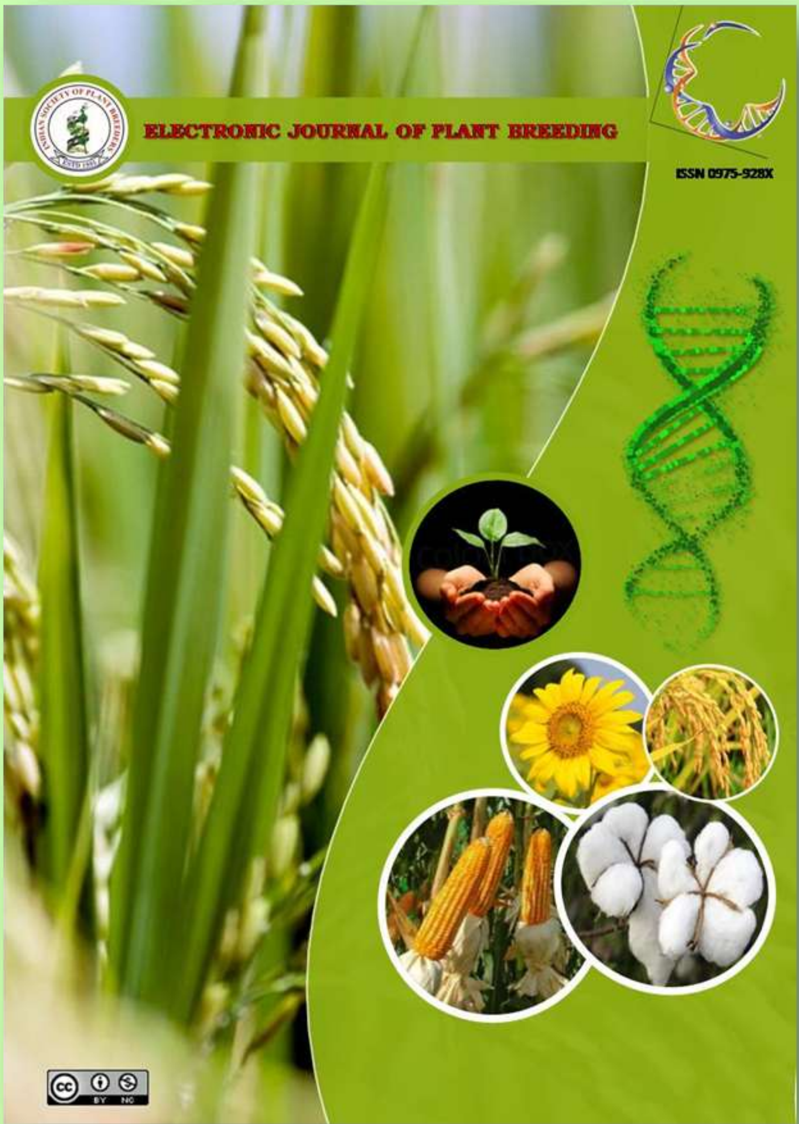

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Research Article

Stability analysis over different environments for grain yield and its components in hybrid rice (*Oryza sativa* L.)

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Abstract
The study was undertaken to assess the genotype x environment interaction in rice by evaluating 79 genotypes comprising of five lines, twelve testers, sixty hybrids and two checks in three different locations of Telangana State. Analysis of variance reveals that the G x E interaction was significant for all the characters studied except for 1000 grain weight indicating differential behaviour of genotypes in changing environments. Environmental indices revealed that Rajendranagar was found to be the most favourable location for most of the yield component traits. Among the 60 hybrids evaluated, the hybrids, IR-58025A x RNR-15038, IR-58025A x RNR-2781 and APMS-6A x RNR-15038 for grain yield per plant, IR-58025A x RNR-15398, IR-58025A x RNR-2781, IR-80555A x RNR-15038 and APMS-6A x RNR-15038 for number of productive tillers per plant, IR-58025A x RNR-15038, IR-58025A x RNR-2781, IR-79156A x NWGR-3132, APMS-6A x RNR-15038 and APMS-6A x RNR-2781 for number of filled grains per panicle and IR-58025A x RNR-15038, IR-79156A x WGL-3962, IR-80555A x RNR-15028 and IR-68897A x RNR-2781 for spikelet fertility percentage were identified as stable genotypes. The cross, IR-68897A x RNR-2781 exhibited superior mean performance for days to 50% flowering, panicle length, number of filled grains per panicle and grain yield per plant and it was identified as promising for favourable environment based on stability parameters. In poor environment the hybrid, IR-58025A x RNR-17462 was found to be good for number of productive tillers per plant and grain yield per plant and the cross, IR-79156A x RNR-2781 exhibited better performance for number of filled grains per panicle. Based on stability analysis the hybrids, IR-58025A x RNR-15038, IR-58025A x RNR-2781 and APMS-6A x RNR-15038 were identified as stable for most of the yield components and these hybrid combinations could be evaluated over large number of environments before it is exploited commercially.

Key words
Hybrid rice, stability analysis, environmental indices, grain yield

Introduction

Stability is one of the most desirable properties of a genotype to be released as a variety for wide cultivation or for use as a parent in crop improvement programmes. The phenotypic performance of a genotype is not necessarily being same under diverse agro-ecological conditions and all genotypes may not reach the same level of phenotypic expression under all environmental conditions. The interaction between genetic and non-genetic effects reduces the correlation between the genotype and phenotype, which in turn reduces the accuracy with which the environmental data can be interpreted. Thus the genotype-environment interaction is of major concern to a plant breeder, because such interactions limit the selection of superior cultivars by altering their relative productiveness in different environments (Eaggles and Frey, 1977). The low magnitude of genotype x environment interaction indicates consistent performance of a population over variable environments. Several statistical techniques have been developed to describe G x E interaction and measure the stability of genotypes in which Eberhart and Russell's model (1966) is simple in evaluation and included the parameter deviation from the regression. Sreedhar *et al*. (2011) conducted a study to assess the stability of genotypes in different agro climatic zones by using 60 rice hybrids and found that stability in single plant yield was due to plasticity and stability in yield components. Mosavi (2013) also noticed significant yield differences among rice genotypes, environment and genotype by environment interaction. Therefore, the present investigation was carried out to identify stable genotypes with high yield potential in rice hybrids.

Material and Methods

In the present investigation five CMS lines and twelve elite testers were crossed in line x tester design during *rabi*, 2013-14. The testers were selected based on fertility restorability (pollen fertility and spikelet fertility percentage), flowering duration, plant stature and number of filled grains per panicle. The resulting 60 hybrids along with their parents and two checks (KRH-2 and MTU-1010) were evaluated at three different locations which represent the two agro climatic zones of Telangana *viz*., Rajendranagar and Kampasagar (Southern Telangana Zone); Jagtial (Northern

Telangana Zone) to study the G x E interaction among the genotypes during *kharif*, 2014. The trial was laid out in randomized block design with three replications and each entry was planted in a row of 4 m length with a spacing of 20 x 15 cm between plants and rows respectively. The observations were recorded for eight quantitative characters *viz.*, days to 50% flowering, plant height (cm), number of productive tillers per plant, panicle length (cm), number of filled grains per panicle, spikelet fertility (%), 1000 grain weight (g) and grain yield per plant (g). Pooled data from all the three locations were subjected to statistical analysis by following the Eberhart and Russell model (1966) to study the stability performance of genotypes over locations.

Results and Discussion

The analysis of variance revealed that the genotypes and environments were significant for all the eight characters, indicating the diversity among the genotypes and environments (Table-1). The G x E interactions were significant for all the characters studied except for 1000 grain weight. Sanjay and Singh (2011) and Somsana *et al*. (2013) noticed the differential response of genotypes due to G x E interaction. The G x E interaction for 1000 grain weight was found to be non-significant. Therefore, further analysis of stability was not carried out for this trait. Significant variation due to environment (linear) was observed for the characters studied revealing the linear contribution of environmental effects and additive environmental variance on these characters. The linear component of genotype x environment was significant for all the characters except for 1000 grain weight indicating that the genotypes significantly differing for their linear response to environments. Sriram *et al*. (2017) also reported significant differences due to environment (linear) and genotype x environment (linear) in his studies. The mean sum of squares for pooled deviation was significant for all the characters except for 1000 grain weight indicating the non-linear response and unpredictable nature of genotypes by significantly differing for stability. This0 reveals the importance of both linear and non-linear components in determining interaction of the genotypes with environments in the present study. Similar results were observed by Das *et al.* (2010), Sreedhar *et al.* (2011), Waghmode and Mehta (2011) and Padmavathi *et al*. (2013). Environmental indices revealed that Rajendranagar was found to be the most favourable location for number of filled grains per panicle, spikelet fertility (%), 1000 grain weight and grain yield per plant while Jagtial was the best favourable location for days to 50% flowering, number of productive tillers per plant and panicle length (Table-2).

Mean performance and stability parameters for grain yield and its components are presented in Table-3. For the traits days to 50% flowering, five lines and 12 testers showed non-significant deviation from regression (S^2di) values as such their performance can be predicted. Among the lines, IR-68897A (92 days) and the tester, RNR-15028 (97 days) with short duration and regression coefficient (bi) less than one and found to be adaptable to poor environments as such, only part of variation in performance can be predicted. The hybrids *viz*., IR-80555A x NWGR-3132 (98 days), IR-68897A x D-4098 (91 days) and IR-68897A x RNR-2458 (99 days) with short duration were identified as a stable in view of regression coefficient near 'unity' and non-significant deviation from regression and their performance is not expected to change with the change in environment.

For the trait plant height, the line IR-58025A (μ=85.40, b_i =1.32, S^2di=2.00) and the tester NWGR-3132 (μ=99.40, b_i =1.18, S^2di=-1.80) showed desirable mean values for plant height, regression coefficient greater than 'unity' and non-significant deviation from regression and found suitable for better environment. While the testers, D-4098 and RNR-2456 were found to be good for poor and favorable environments respectively. Among the hybrids, IR-79156A x D-4098 (μ=95.50, b_i =1.26, S^2di=-14.70), IR-80555A x IR-83142-B-57-B (μ=92.20, b_i =0.94, S^2di=-1.50), IR-68897A x RNR-15351 (μ=98.40, b_i =1.15, S^2di=-4.0) and IR-68897A x IR-83142-B-57-B (μ=98.70, b_i =0.94, S^2di=-2.70) were considered as stable.

Three lines and eight testers recorded non-significant S^2di values for number of productive tillers per plant. Among the parents, two lines *viz*., IR-80555A (10.29) and APMS-6A (10.66) and three testers *viz.*, RNR-15398 (10.93) and RNR-2781 (10.10) were found to be suitable for favourable environment as they recorded high mean with regression coefficient greater than unity and non-significant deviations from regression. Out of 60 hybrids evaluated, five hybrids *viz*., IR-58025A x RNR-15398 (μ=11.02, b_i=1.10), IR-58025A x RNR-2781 (μ=13.22, b_i=0.95), IR-79156A x NWGR-3132 (μ=13.01, b_i=1.13), IR-80555A x RNR-15038 (μ=11.80, b_i=0.93) and APMS-6A x RNR-15038 (μ=11.86, b_i=0.93) were considered as stable for number of productive tillers per plant which would be expected to perform uniformly well over variable environments. Umadevi *et al.* (2010) and Sreedhar *et al.* (2011) also reported stable hybrids for this trait. Nine cross combinations recoded mean values above grand mean with regression coefficient less than unity and non-significant deviation from regression and hence these hybrids are suitable to poor environments.

The lines, IR-58025A (24.2) and IR-79156A (24.26) were found to have higher mean respectively than general mean (23.75) for panicle length but their performance was found to be highly unpredictable, as they recorded significant deviations from regression. The tester, IR-83142-B-57-B (24.75cm) recorded higher panicle length than best check KRH-2 (22.30 cm) with unit regression coefficient (bi) and are rated as widely adaptable with average stability. The hybrids, IR-58025A x RNR-15038 (26.54), IR-79156A x RNR-2781 (26.39) and IR-79156A x NWGR-3132 (25.60) showed significantly higher panicle length than the best check, KRH-2 (22.30 cm) and recorded unit regression coefficient (bi) values hence they were considered to be widely adaptable to different environments.

For the character number of filled grains per panicle**,** five lines, four testers and 41 hybrids exhibited non-significant deviation from regression. Five hybrids *viz*., IR-58025A x RNR-15038, IR-58025A x RNR-2781, IR-79156A x NWGR-3132, APMS-6A x RNR-15038 and APMS-6A x RNR-2781 were considered as stable over environments based on stability parameters and also as they recorded significantly higher mean than both the checks (KRH-2 and MTU-1010) and grand mean. For this trait stable hybrids were also reported by Saidaiah *et al.* (2010) and Waghmode and Mehta (2011). Nine hybrids were found to be significantly superior over best check, KRH-2 (139.60) and possessed regression coefficient (bi) values less than ‘unity’ and these hybrids are highly suitable for poor environments.

Based on stability parameters, the line, APMS-6A (μ=89.03, b_i=1.42, S^2di=0.78) and tester, IR-83142-B-57-B (μ=89.70, b_i=1.83, S^2di=-1.50) were identified for better environment for spikelet fertility percentage. Whereas the tester, D-4098 (μ=93.99, b_i=0.74, S^2di=0.82) observed to be suitable for poor environment based on the stability parameters. The stable hybrids identified for this trait were IR-58025A x RNR-15038, IR-791456A x WGL-3962, IR-80555A x RNR-15028 and IR-68897A x RNR-2781 having high mean than grand mean, regression coefficient near to ‘unity’ and non–significant deviation from regression. Waghmode and Mehta (2011) also identified stable hybrids for spikelet fertility percentage.

Among the parents studied, the line, APMS-6A and the testers, RNR-15351, WGL-3962, NWGR-3132, RNR-2458 and RNR-2781 exhibited higher mean than grand mean for grain yield per plant with regression coefficient less than ‘unity’ and non-significant deviation from regression and hence they are adaptable for poor environments. Among the sixty cross combinations evaluated, 18 hybrids exhibited superior mean performance over the best check MTU-1010 for grain yield per plant over the locations. Three hybrids *viz.,* IR-58025A x RNR-15038 (μ=47.37, b_i=1.1, S^2di=-0.89), IR-58025A x RNR-2781 (μ=44.51, b_i=1.03, S^2di=1.94) and APMS-6A x RNR-15038 (μ= 42.42, b_i=1.15, S^2di=2.1) manifested significantly higher grain yield per plant than the best check, KRH-2 (32.03 g) and recorded unit bi values with non-significant deviation from regression. Hence, these were considered as highly adaptable hybrids and expected to perform well in all the environments. The hybrid, IR-58025A x RNR-17462 exhibited high mean (33.09) with regression coefficient less than ‘unity’ (0.48) and non–significant deviation (-0.80) from regression was considered useful for poor environments. The hybrids, IR-68897A x RNR-2781 (μ=39.46, b_i=1.43) and APMS-6A x RNR-15028 (μ=36.69, b_i=1.36) were ideal for better environments with predictable performance. Saidaiah *et al.* (2010), Sreedhar *et al.* (2011) and Padmavathi *et al*. (2013) also reported high yielding stable hybrids for grain yield per plant in their studies.

From stability study it can be concluded that the yields of the most of the genotypes varied with the changes of growing environments. The difference in yield among genotypes indicated their differential yielding ability under different environmental conditions. The hybrids, IR-58025A x RNR-15038, IR-58025A x RNR-2781 and APMS-6A x RNR-15038 were identified as stable for grain yield and of the yield components and these hybrids were recommended for further extensive testing in different agro-climatic zones over seasons for their superiority and stability before commercial release.

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Table 1. ANOVA for yield and yield components of stability in rice

Source	DF	Days to 50% flowering	Plant height	No. of productive tillers / plant	Panicle length	No. of filled grains / panicle	Spikelet fertility (%)	1000 grain weight	Grain yield / plant
Replication within environment	6	4.64	5.26	4.403	1.93	46.61	2.52	0.23	3.27
Genotypes	78	87.41**	243.93**	6.41**	8.31**	4031.28**	26.65**	28.58**	147.67**
Environments	2	14.55*	4412.64**	84.43**	170.10**	8189.72**	264.71**	0.55*	2247.06**
Genotype x Environment	156	6.91**	112.53**	3.82**	3.92*	395.96*	5.26*	0.14	28.12*
Environment + (Genotype x Environment)	158	7.01**	166.96**	4.84**	6.02**	494.616**	8.54**	0.14	56.21**
Environment (linear)	1	29.11**	8825.28**	168.86**	340.21**	16379.46**	529.43**	1.10**	4494.13**
Genotype x Environment (linear)	78	10.08**	168.03**	5.69**	5.58**	543.09**	7.46**	0.15	38.30**
Pooled Deviation	79	3.69*	56.31**	1.93**	2.23**	245.67**	3.02*	0.12	17.71**
Pooled Error	468	2.61	5.30	0.56	0.52	30.816	1.85	0.12	1.69
Total	**236**	**33.63**	**192.40**	**5.36**	**6.78**	**1663.51**	**14.53**	**9.54**	**86.44**

* Significant at 5 % level, ** significant at 1 % level

Table 2. Environmental indices for yield and yield components in rice

Character	Locations		
	Rajendranagar	**Jagtial**	**Kampasagar**
Days to 50% flowering	0.473	-0.363	-0.110
Plant height	4.858	3.748	-8.606
No. of productive tillers per plant	0.435	0.745	-1.180
Panicle length	0.481	1.167	-1.647
No. of filled grains per panicle	10.644	-0.997	-9.647
Spikelet fertility (%)	2.112	-1.144	-0.968
1000 grain weight	0.083	0.003	-0.086
Grain yield per plant	5.719	-0.880	-4.838

Table 3. Mean performance and stability parameters for grain yield and its components in rice

Parent / Hybrid	Days to 50% flowering			Plant height (cm)			No. of productive tillers / plant			Panicle length (cm)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
Lines												
IR-58025A	98	7.14	-1.30	85.40	1.32	2.00	13.82	0.62	13.70**	24.20	1.04	4.67**
IR-79156A	99	6.98	-2.20	96.30	1.64	53.40**	11.12	1.46	1.91*	24.26	1.63	6.42**
IR-80555A	97	4.01	-1.60	81.40	1.19	70.30**	10.29	1.53	-0.47	20.31	2.29	5.27**
IR-68897A	92	0.38	2.00	82.10	0.64	235.40**	7.76	1.04	0.47	21.23	1.45	-0.46
APMS-6A	106	3.72	-0.50	95.60	1.09	40.80**	10.66	1.26	0.48	23.46	0.61	-0.40
Testers`												
RNR-15351	103	-0.22	-2.40	98.20	0.72	16.70*	9.63	1.92	0.95	21.73	1.56	2.65*
WGL-3962	109	-2.39	-2.70	108.00	1.07	-5.20	8.93	1.04	2.03*	24.63	-0.62	-0.19
IR-83142-B-57-B	98	2.17	4.30	100.10	1.30	44.20**	8.70	0.26	0.1	24.75	0.93	-0.53
RNR-15398	111	-1.14	-1.00	116.50	0.14	14.60	10.93	1.50	-0.17	23.30	0.76	-0.42
D-4098	97	5.36	-2.30	95.30	0.66	-4.00	9.12	0.46	5.91**	24.16	1.517*	-0.53
NWGR-3132	109	-1.83	-2.30	99.40	1.18	-1.80	9.15	0.85	0.84	22.34	1.02	1.82*
RNR-15028	97	0.15	-0.30	94.50	0.97	44.0**	10.25	1.08	5.48**	21.00	2.29	10.40**
RNR-15038	108	-7.54	2.50	110.70	0.98	15.50*	9.99	1.22	2.53*	23.77	-0.28	0.41
RNR-2458	108	2.19	-0.20	105.00	1.81	46.80**	8.90	0.62	0.45	21.98	1.23	-0.43
RNR-2456	108	2.75	2.20	97.10	1.41	-1.00	8.31	0.60	-0.49	19.63	0.56	-0.24
RNR-17462	114	7.64	-2.50	110.60	1.76	90.70**	8.14	0.82*	-0.61	20.72	2.26	3.84**
RNR-2781	114	2.40	2.20	116.00	2.14	5.60	10.10	1.24	0.35	22.86	0.79	-0.17
Crosses												
IR-58025A x RNR-15351	104	-1.04	-0.30	99.90	1.48	-4.90	11.29	-0.35	-0.54	24.27	-0.14	-0.13
IR-58025A x WGL-3962	104	0.51	-2.50	94.20	0.02	28.50*	10.82	0.16	0.57	24.58	0.81	0.26
IR-58025A x IR-83142-B-57-B	93	-0.44*	-2.60	101.20	-0.15	29.80*	10.17	0.89	0.66	23.50	-0.29	1.73*
IR-58025A x RNR-15398	104	1.24	-1.10	114.30	1.11	38.70**	11.02	1.10	-0.42	25.12	0.15	-0.19
IR-58025A x D-4098	96	1.23	1.30	96.30	1.56	-3.30	7.66	0.04	1.15	25.06	0.96	4.78**
IR-58025A x NWGR-3132	104	0.31	-2.60	104.50	1.35	66.60**	10.04	1.41	0.65	24.13	0.83	-0.41
IR-58025A x RNR-15028	103	2.43	-1.20	107.00	-0.15	347.80**	12.92	1.38	4.78**	25.44	0.72	-0.50
IR-58025A x RNR-15038	108	1.09	17.4 **	105.40	1.27	-4.30	13.50	1.91	4.83**	26.54	1.16	-0.28
IR-58025A x RNR-2458	106	0.31	-2.60	101.50	1.59	17.60*	10.56	1.83	1.14	25.38	0.59	2.47*
IR 58025 A x RNR-2456	103	1.17	-2.60	103.70	1.72	77.50**	11.27	1.65	0.60	23.27	0.86	-0.51

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Table 3 Contd.,

Parent / Hybrid	Days to 50% flowering			Plant height (cm)			No. of productive tillers / plant			Panicle length (cm)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
IR-58025A x RNR-17462	105	1.01	0.20	106.70	1.38	1.00	10.67	0.79	-0.25	25.62	1.88	1.74*
IR-58025A x RNR-2781	104	0.81	-1.30	107.00	1.49	39.40**	13.22	0.95	0.22	26.40	0.41	0.12
IR-79156 A x RNR-15351	98	3.99	7.8 *	95.80	1.36	10.20	9.07	1.91	9.625**	24.46	2.09*	-0.53
IR-79156 A x WGL-3962	100	2.17	4.30	107.00	1.53	35.0 **	8.92	1.13	-0.60	24.47	0.38	-0.52
IR-79156 A x IR-83142-B-57-B	99	1.89	2.90	92.50	0.25	128.90**	7.84	-0.06	-0.41	22.06	1.13	0.68
IR-79156 A x RNR-15398	101	3.46	5.70	112.60	2.07	63.30**	9.72	2.89	15.26**	22.91	1.74	2.05*
IR-79156 A x D-4098	94	-0.58	4.00	95.90	1.26	14.70	11.30	1.30	3.78**	23.05	1.37	1.47
IR-79156 A x NWGR-3132	100	-1.10	-2.60	87.80	0.16	67.10**	13.01	1.13	-0.29	25.60	1.03	-0.34
IR-79156 A x RNR-15028	97	-2.59	-2.40	96.40	1.37	-1.80	8.57	-0.43	-0.30	23.20	1.28	3.73**
IR-79156 A x RNR-15038	103	0.54	-2.20	91.70	-0.18	18.2 *	11.70	0.28*	-0.61	25.64	0.06	-0.18
IR-79156 A x RNR-2458	105	-0.09	-1.10	81.80	-0.36	19.4 *	7.06	0.32	-0.23	22.52	1.33	0.75
IR-79156 A x RNR-2456	101	2.22	3.90	95.80	0.67	120.90**	12.15	1.28	1.76*	24.57	0.12	1.17
IR-79156 A x RNR-17462	105	-0.98	-2.50	114.20	0.52	17.7 *	10.72	0.78	2.17*	24.24	0.17	-0.28
IR-79156 A x RNR-2781	101	4.44	-1.80	112.40	1.83*	-5.30	12.68	1.77	4.35**	26.39	1.12	1.45
IR-80555 A x RNR-15351	95	-1.53	-2.60	90.30	0.38	3.40	11.41	-0.08	0.97	22.42	1.78	2.34*
IR-80555 A x WGL-3962	94	-0.15	3.60	110.60	1.30	31.8 **	9.97	0.95	0.66	24.41	0.58	5.92**
IR-80555 A x IR-83142-B-57-B	92	2.79	-2.60	92.20	0.94	-1.50	9.92	0.04	-0.48	24.05	0.01	-0.37
IR-80555 A x RNR-15398	103	2.01	16.1 **	96.80	0.65	-5.10	10.69	2.31	0.53	23.33	0.07	-0.43
IR-80555 A x D-4098	91	-0.67	-2.50	94.90	1.37	-4.60	9.22	-0.02	-0.23	22.26	0.90	-0.53
IR-80555 A x NWGR-3132	98	1.00	-0.30	88.10	-1.15	6.00	9.58	-0.05	-0.51	21.71	1.76	1.12
IR-80555 A x RNR-15028	91	-0.38	1.50	95.20	1.58	103.00**	11.01	2.08	0.93	24.47	1.87	-0.42
IR-80555 A x RNR-15038	103	-1.17	-1.70	95.80	0.29	147.10**	11.80	0.93	0.06	23.47	1.10	3.93**
IR-80555 A x RNR-2458	103	-0.91	3.10	91.10	-2.78	118.20**	10.97	0.69	-0.58	25.18	1.77	4.15**
IR-80555 A x RNR-2456	99	0.77	-1.40	91.70	2.010*	-5.00	10.37	0.35	-0.55	21.53	0.61	1.57*
IR-80555 A x RNR-17462	99	0.70	2.80	102.70	-0.37	559.30**	9.76	0.79	-0.58	20.61	1.22	18.01**
IR-80555 A x RNR-2781	102	-0.41	2.00	115.50	2.52	13.30	10.77	2.37	-0.24	26.05	1.69	1.75*
IR-68897 A x RNR-15351	97	4.54	-2.20	98.40	1.15	4.00	9.25	1.74	-0.42	23.78	0.95	-0.53
IR-68897 A x WGL-3962	101	0.58	-0.10	105.50	1.24	-4.30	10.70	-0.11	8.41**	26.28	0.89	-0.52
IR-68897 A x IR-83142-B-57-B	92	-0.61	0.00	98.70	0.94	-2.70	9.26	1.27	0.33	25.37	1.42	0.99
IR-68897 A x RNR-15398	101	2.16	-2.30	112.20	2.22	190.10**	10.15	1.45	0.84	25.32	0.79	9.24**
IR-68897 A x D-4098	91	1.10	-1.00	92.20	1.35	53.10**	9.89	0.07*	-0.61	24.48	0.90	1.37
IR-68897 A x NWGR-3132	96	0.28	-2.00	100.30	2.23	3.00	9.83	2.08	5.75**	22.70	0.70	21.97**

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Table 3 Contd.,

Parent / Hybrid	Days to 50% flowering			Plant height (cm)			No. of productive tillers / plant			Panicle length (cm)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
IR-68897 A x RNR-15028	92	2.25	9.8*	96.70	1.40	17.30 *	9.41	1.71	2.47*	21.88	0.59	1.92*
IR-68897 A x RNR-15038	100	3.29	-0.70	103.60	1.98	69.80**	10.55	2.18	-0.55	25.11	1.80	-0.42
IR-68897 A x RNR-2458	99	1.17	-2.60	104.60	1.66	7.20	9.74	0.45	-0.48	23.40	0.15	0.61
IR-68897 A x RNR-2456	95	-0.11	6.00	107.20	2.32	16.2 *	10.59	-1.22	1.75*	24.82	1.25	2.39*
IR-68897 A x RNR-17462	103	-0.41	2.00	121.40	0.95	273.10**	10.45	1.56	0.42	26.45	1.49	-0.18
IR-68897 A x RNR-2781	100	5.56	2.10	109.80	1.61	214.30**	11.94	0.16	-0.45	25.56	1.29	-0.14
APMS-6A x RNR-15351	102	0.32	6.50	93.30	0.67	-4.30	8.76	1.06	-0.19	25.46	0.62	2.17*
APMS-6A x WGL-3962	103	-0.51	0.90	107.80	1.62	201.90**	10.78	-0.74	0.66	24.63	1.89	0.31
APMS-6A x IR-83142-B-57-B	90	-1.71	17.7**	100.30	-0.34*	-4.30	9.12	2.06	0.94	22.49	1.58	0.10
APMS-6A x RNR-15398	102	1.81	11.8*	118.80	0.72	18.60 *	8.27	1.45	-0.31	24.39	1.27	0.89
APMS-6A x D-4098	92	-0.61	-0.10	93.80	1.24	-1.40	7.78	0.86	1.27	23.90	1.00	-0.36
APMS-6A x NWGR-3132	104	-0.42	-1.50	112.80	1.20	127.00**	7.98	0.47	-0.51	22.58	0.62	-0.33
APMS-6A x RNR-15028	97	1.63	-1.80	95.60	1.83	-1.70	9.90	2.93	0.11	23.60	2.975*	-0.48
APMS-6A x RNR-15038	104	-0.32	-2.00	108.20	-0.07	-2.70	11.86	0.93	-0.29	27.01	0.83	-0.49
APMS-6A x RNR-2458	104	-0.65	-2.30	85.60	-1.30	0.40	8.26	0.43	-0.43	20.60	0.75	3.05**
APMS-6A x RNR-2456	101	3.51	2.70	99.10	1.16	50.7**	8.78	2.71	2.56*	22.52	1.32	1.58*
APMS-6A x RNR-17462	101	2.10	-0.70	101.20	1.32	-2.60	7.59	1.43	0.35	23.71	0.63	1.59*
APMS-6A x RNR-2781	105	-1.47	0.40	94.50	-0.70*	-4.60	11.12	1.41	-0.59	24.43	0.46	1.22
Checks												
KRH-2	100	0.39	15.6**	108.90	1.16	58.80**	10.30	0.49	1.20	22.30	0.23	-0.23
MTU-1010	97	-1.99	-1.40	97.30	1.57	-3.10	8.81	0.20	0.39	21.03	0.46	0.62
Grand mean	**100.6**	-	-	**100.60**	-	-	**10.10**	-	-	**23.75**	-	-
SE of bi	-	3.2	-	-	0.7	-	-	0.95	-	-	0.72	-
CD	2.75	-	-	13.75	-	-	2.11	-	-	2.35	-	-

* Significant at 5 % level, ** significant at 1 % level

Table 3 Contd.,

Parent / Hybrid	No. of filled grains / panicle			Spikelet fertility (%)			Grain yield / plant (g)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
Lines									
IR-58025A	133.90	0.14	46.40	88.95	0.00	0.32	27.40	0.06	87.45**
IR-79156A	123.20	0.21	-29.70	86.60	2.55	5.89*	25.22	0.50	12.97**
IR-80555A	86.90	-1.19	-12.30	85.64	2.46	17.89**	17.46	0.07	22.16**
IR-68897A	97.80	-0.26	16.30	86.70	2.56	2.37	14.17	0.37	2.87
APMS-6A	197.20	1.53	1.90	89.03	1.42	0.78	30.16	0.87	-0.48
Testers									
RNR-15351	199.70	0.77	-30.10	84.42	1.39	-1.61	27.07	0.79	-0.59
WGL-3962	135.20	0.05	176.90**	84.35	-0.69	-0.90	21.77	0.78	2.41
IR-83142-B-57-B	126.20	1.35	286.80**	89.70	1.83	-1.50	17.74	0.83	-1.67
RNR-15398	196.90	0.32	151.90*	85.51	0.45	-1.01	32.66	0.26	72.89**
D-4098	121.60	2.41	229.30**	93.99	0.74	0.82	26.58	1.20	7.95*
NWGR-3132	120.20	1.74	-11.00	89.69	1.94	47.78**	24.23	0.90	-1.58
RNR-15028	188.50	2.66	197.50**	91.14	1.53	31.95**	35.06	1.53	10.04**
RNR-15038	224.10	1.06	-21.50	91.28	0.23	7.65*	32.49	1.26*	-1.69
RNR-2458	197.60	-1.94	509.20**	86.45	0.72	-1.82	27.44	0.43	-1.37
RNR-2456	123.70	1.51	-14.20	84.56	2.13*	-1.84	20.99	0.97	-0.74
RNR-17462	160.80	-1.34	109.6 *	84.14	1.46	-1.70	23.84	0.45	-0.87
RNR-2781	174.10	1.59	593.50**	86.62	0.29	2.78	27.43	0.76	2.62
Crosses									
IR-58025A x RNR-15351	144.30	1.50	154.90*	83.97	1.24	-1.76	27.05	1.51	-0.26
IR-58025A x WGL-3962	161.70	-0.33	1320.30**	88.38	0.28	-1.55	30.79	0.50	31.94**
IR-58025A x IR-83142-B-57-B	141.50	2.42	388.30**	83.91	1.20	-1.84	26.34	0.95	82.70**
IR-58025A x RNR-15398	212.40	1.56	27.20	85.62	1.71*	-1.85	33.72	0.68	6.36*
IR-58025A x D-4098	128.80	1.67	15.60	86.43	1.68*	-1.85	25.86	1.14	3.74
IR-58025A x NWGR-3132	183.20	1.20	261.50**	85.50	1.57	-1.03	27.03	0.88	-1.36
IR-58025A x RNR-15028	209.30	0.82	7.90	88.73	0.83	-0.62	41.27	1.28	5.84*
IR-58025A x RNR-15038	240.50	1.19	-9.50	88.55	0.90	4.34	47.37	1.10	-0.89

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Table 3 Contd.,

Parent / Hybrid	No. of filled grains / panicle			Spikelet fertility (%)			Grain yield / plant (g)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
IR-58025A x RNR-2458	168.00	1.87	-27.40	85.80	1.58	-1.13	28.61	1.29	-1.36
IR 58025 A x RNR-2456	173.30	-0.24	-28.60	86.98	1.93	-1.79	32.21	1.25	12.23**
IR-58025A x RNR-17462	180.10	-0.15	-13.80	86.38	1.56	8.30*	33.09	0.48	-0.80
IR-58025A x RNR-2781	216.60	0.92	15.90	84.94	1.81	-1.24	44.51	1.03	1.94
IR-79156 A x RNR-15351	193.40	2.99	896.70**	85.82	1.03	-0.78	21.13	0.94	20.23**
IR-79156 A x WGL-3962	167.50	1.16	-25.50	89.90	1.16	-1.71	27.54	0.77	-0.97
IR-79156 A x IR-83142-B-57-B	122.40	-0.13	32.70	83.66	0.61	0.47	16.97	0.00	76.77**
IR-79156 A x RNR-15398	168.70	2.00	232.10**	82.38	1.01	-0.90	21.09	0.40*	-1.65
IR-79156 A x D-4098	181.40	0.45	82.70	84.80	0.72	-1.83	27.77	0.90	4.53
IR-79156 A x NWGR-3132	214.30	1.02	-29.70	87.57	0.77	4.17	44.83	0.53	9.76**
IR-79156 A x RNR-15028	205.30	2.47	34.40	91.16	1.24	3.66	29.04	1.68	-0.45
IR-79156 A x RNR-15038	231.00	-0.47	453.30**	90.18	1.44	-1.76	40.95	0.42	10.52**
IR-79156 A x RNR-2458	150.00	0.63	-22.60	83.27	0.48	-1.54	22.74	0.53	-0.41
IR-79156 A x RNR-2456	205.70	0.43	237.4**	82.80	0.64	-1.58	34.75	0.84	11.41**
IR-79156 A x RNR-17462	201.30	-0.39	10.50	83.48	-0.99*	-1.74	29.70	0.19	16.52**
IR-79156 A x RNR-2781	216.30	0.76	76.00	86.85	1.77	6.13*	44.12	0.67	37.90**
IR-80555 A x RNR-15351	185.60	2.84	7.80	82.59	1.56	-1.81	27.88	1.76	-0.74
IR-80555 A x WGL-3962	181.30	2.03	1922.30**	87.95	0.34	-0.17	29.49	1.05	81.17**
IR-80555 A x IR-83142-B-57-B	128.30	3.24	458.80**	85.98	1.33	-1.65	29.91	1.37	1.40
IR-80555 A x RNR-15398	141.30	-0.58	268.60**	83.43	0.91	-1.84	19.35	-0.09	58.46**
IR-80555 A x D-4098	109.20	0.500*	-30.80	85.37	0.54	1.09	22.06	0.74	-0.80
IR-80555 A x NWGR-3132	187.50	0.75	-26.20	87.44	0.49	-0.57	30.56	1.37	1.29
IR-80555 A x RNR-15028	200.10	2.30	-26.90	92.04	0.97	-0.68	38.19	2.26*	-1.71
IR-80555 A x RNR-15038	196.90	2.16	-28.50	90.42	0.75	5.15	33.04	1.72	7.64*
IR-80555 A x RNR-2458	216.60	1.74	198.7 **	82.66	0.623*	-1.86	23.60	0.74	12.46**
IR-80555 A x RNR-2456	153.80	1.10	-29.60	85.28	0.80	-1.09	24.37	1.31	-0.96
IR-80555 A x RNR-17462	144.40	1.00	901.70**	85.90	1.52	-1.30	26.06	0.80	18.66**
IR-80555 A x RNR-2781	225.60	0.35	451.90**	93.06	0.84	-0.35	38.93	1.73	8.75*
IR-68897 A x RNR-15351	193.70	1.22	101.30*	87.33	1.47	-1.62	29.31	1.56	0.64
IR-68897 A x WGL-3962	202.30	1.25	1175.50**	87.99	0.07	11.28**	36.33	0.90	86.56**

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Table 3 Contd.,

Parent / Hybrid	No. of filled grains / panicle			Spikelet fertility (%)			Grain yield / plant (g)		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
IR-68897 A x IR-83142-B-57-B	161.20	1.38	-21.00	90.66	0.57	-0.94	26.12	2.08	4.66
IR-68897 A x RNR-15398	176.70	2.34	-1.30	91.41	1.68	0.97	26.67	1.65	-1.31
IR-68897 A x D-4098	116.80	1.96	125.40*	90.00	0.57	0.32	18.31	1.92	37.72**
IR-68897 A x NWGR-3132	177.30	0.94	83.20	88.93	0.89	-0.34	29.38	1.41	57.41**
IR-68897 A x RNR-15028	124.80	1.36	297.50**	85.35	1.11	-1.76	24.14	0.80	89.75**
IR-68897 A x RNR-15038	196.20	1.71	735.00**	92.08	0.42	-1.73	28.69	0.20	88.23**
IR-68897 A x RNR-2458	114.10	-0.21	55.80	80.55	-0.17	-1.51	18.72	0.92	0.65
IR-68897 A x RNR-2456	184.50	0.13	28.70	88.52	0.40*	-1.85	30.24	-0.57	5.79*
IR-68897 A x RNR-17462	178.78	4.35*	-27.40	83.88	0.24	-1.66	30.75	2.75	32.71**
IR-68897 A x RNR-2781	210.78	1.32	-24.10	92.57	0.94	-1.42	39.46	1.43	3.64
APMS-6A x RNR-15351	202.72	3.30	145.80*	85.93	0.93	-1.85	24.52	1.78	6.20*
APMS-6A x WGL-3962	162.78	0.59	196.90*	84.90	1.46	-1.58	28.74	2.14	-1.05
APMS-6A x IR-83142-B-57-B	152.85	0.43	-17.30	85.68	1.50	-1.82	25.89	1.64	10.93**
APMS-6A x RNR-15398	161.00	-0.21	1809.20**	85.58	1.13	-1.49	28.07	2.08	4.02
APMS-6A x D-4098	128.88	1.26	-30.10	84.49	1.90	0.09	27.88	2.18	-0.58
APMS-6A x NWGR-3132	202.81	-0.68	761.40**	82.67	-0.04	0.03	25.66	0.21*	-1.53
APMS-6A x RNR-15028	213.25	1.82	386.20**	89.74	0.58	0.05	36.69	1.36	1.81
APMS-6A x RNR-15038	244.00	1.23	21.6	91.16	-0.38	2.51	42.42	1.15	2.10
APMS-6A x RNR-2458	200.88	-0.18	-2.30	90.33	0.88	-1.71	25.09	0.43	9.99**
APMS-6A x RNR-2456	186.21	-0.92	500.00**	88.10	1.80	-1.47	28.58	0.14	94.42**
APMS-6A x RNR-17462	192.57	1.71	276.20**	83.11	-0.54	0.00	25.34	1.41	-1.45
APMS-6A x RNR-2781	213.73	1.06	37.30	90.71	1.58	-1.70	42.09	0.74	12.32**
Checks									
KRH-2	139.60	0.52	9.70	85.33	1.44	-0.23	32.03	1.04	-0.40
MTU-1010	133.70	-0.07	-23.10	88.20	0.70	-1.85	27.12	0.92	-1.00
Grand mean	**173.0**	**-**	**-**	**87.0**	**-**	**-**	**20.01**	**-**	**-**
SE of bi	-	1.1	-	-	0.67	-	-	0.56	-
CD	26.0	-	-	2.91	-	-	7.21	-	-

* Significant at 5% level, ** significant at 1% leve

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