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Genotype X Environment Interaction and Stability Parameters in New Rice Hybrids *(Oryza sativa L.)*

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Abstract

G x E interaction and stability parameters were estimated in ten newly developed rice hybrids along with four checks. They were grown in *Kharif* 2013, 2014 and *Rabi* 2013-14 at RJ Biotech R&D centre Aushapur. Mean squares due to varieties and environment linear were significant for grain yield, yield components and physical grain quality characters. Environment linear was very high for flowering, plant height, panicle length, grain yield, milling percent and kernel length. G x E (linear) interaction was significant for flowering, plant height, grain yield and milling percent. Pooled deviations were significant for all characters except panicle length and kernel length. Simultaneous consideration of stability parameters for grain yield indicated that among test hybrids IR 58025A/RJ-2, IR 58025A/R-19 with long slender grains were stable with non-significant bi and S2 di Estimates. IR 58025A/OVT-89 was also stable hybrid with short slender grains and well adapted to *Rabi* season. These three hybrids recorded 7240 to 7760 kg/ha grain yield and were superior to all checks including PA 6444 hybrid. They are recommended for multi-location testing before commercially released. The milling percent of hybrids ranged from 68-72 percent with goodhead rice recovery.

Key words: Regression coefficient, Environment (linear), pooled deviations, stability

Introduction

In India rice production was increased almost four times due to adaption of high yielding semi-dwarf varieties. But, from last one decade plateauing of yield and decline in natural resources necessitated to break these yield barriers. Hybrid rice has potential technology to enhance the rice production and China has successfully exploited it. In India also it has been tested and beginning has been made by ushering in to an era of hybrid rice. Many hybrids have been developed and released by public and private sector. Since advent of hybrid rice technology the rate of adaption is steadily increasing but study on the stability of hybrid performance is limited. Panwar *et al* (2008) have stressed the need to evaluate hybrids over environments to identify stable hybrid. It is difficult to establish superiority of any particular hybrid in absence of information on adaption and stability performance. Consistency of a hybrid over wide range of environments is primary consideration in breeding programmes. Identification of hybrids with stable performance is important before it is recommended for cultivation. Stability analysis provides good measure of adaptability of different crop varieties (Morales *et al*., 1991). Therefore, Present study with promising new hybrids was attempted to understand the G x E interaction and consistency in performance through stability analysis

Materials and Methods

The popular CMS line IR 58025A was crossed with several restorers with good agronomic background identified by RJ Biotech limited. These hybrids were evaluated initially for two years. Ten hybrids involving RJ-2, R-18, R-19, RJ-35, RR-46, R-9, R-15, R-18, R-78 and OVT-89 as restorer lines were found promising. These hybrids with PA 6444, Maruti-115 as hybrid checks and MTU-1010, Samba Mahsuri as varietal checks were grown in three seasons *viz*. 2013 and 2014 *Kharif*, and 2013-14 *Rabi* at research and development centre Aushapur. The design was randomised block with three repeats. The plot size was 10.8 m^2 for each hybrid and all the package of practices for hybrid rice cultivation were followed. The data was collected on days to 50% flowering, plant height, number of productive tillers /hill, panicle length and grain yield/plot in each replication and season. The data was also collected on physical quality characters *Viz.,* milling percent, head rice recovery, kernel length, kernel breadth and L/B ratio. The g x e interaction and stability analysis was done following Eberhart and Russell (1966).

Results and Discussion

The genotypic differences were significant for grain yield; yield components and physical grain quality characters (table-1) indicating presence of genetic variability among the hybrids tested. Environment (linear) was also significant and proportionately higher and significant mean squares due to environment (linear) indicated the difference between seasons and their considerable influence on these characters .Proportion of environment (linear) was15 to 87times higher to g x e (linear) interaction for flowering, plant height, panicle length, grain yield, milling percent, kernel length, and kernel breadth. For other characters also it was higher but with lower magnitude. Number of productive tillers per plant is known to directly contribute to grain yield and environment (linear) was non-significant for this character and also for L/B ratio and head rice recovery. Arumugam *et al* (2007) and Ramya and Senthil Kumar (2008) reported interaction of grain yield and important yield components. Since panicle length and kernel length did not exhibit g x e interaction in pooled analysis the stability analysis was not carried out. Non-existence of g x e interaction for these characters was also reported by Sreedhar *et al* (2011). Pooled deviations were significant for all characters except panicle length and kernel length indicating that the hybrids differed considerably for their stability. Thus the seasons used in the study differed in physical parameters resulting in differential response of hybrids to different environmental conditions. Environmental indexes and means are presented in table-2. The comparative study of means among seasons indicated that flowering duration increased in *Rabi* season by about 13 days, but plant height decreased by 15-21cms.Number of productive tillers and panicle length almost remained same over seasons. The grain yield was higher in *Rabi* season but milling percent was less. L/B ratio remained same across seasons but kernel length and kernel breadth was reduced in *Rabi* compared to *Kharif*. Kernel length and breadth forms the core of the physical grain quality characters. Lesser length and breadth gives slender appearance and will have superior cooking quality. Grading of rice was also done on L/B ratio only. For this important character IR 58025A/OVT-89 and IR 58025A/ RJ-35 have appearance akin to Samba Mahsuri and possess slender grains. Among these former hybrid has high yield and is stable for grain yield. Flowering duration of hybrids ranged from 96 to 108 days (table-3). The hybrid IR 58025A/ RJ-35 and IR 58025A/GP-78 were stable over seasons with unit regression coefficient (bi) and non-significant deviation from regression (S^2di), while other hybrids were not stable. For plant height among the test hybrids IR 58025A/ R-18, IR 58025A/ RJ-46 and IR 58025A/ RJ-35 were considered as stable with unit regression and least S^2di estimates. Number of productive tillers had non-significant bi and only two hybrids viz. IR 58025A/ R-33 and IR 58025A/ RJ-2 deviated significantly from regression. The hybrids recorded grain yield of 6355 to 7761 kg/ha, while checks 5972 to 7317 kg/ha. Both linear and non-linear components of g x e interactions were accountable for grain yield. Five hybrids exhibited stable performance with unit bi and least S^2di estimates. Sinha and Biswas (1986) regarded a variety well buffered which produces high mean and stable under fluctuations of the environment. This property in adapted genotype is result of balanced combination of different traits which helps to function co-ordinately in complex conditions. In the present study IR 58025A/ RJ-2 (7761 kg/ha) and IR 58025A/ R-9 (7003 kg/ha) with higher mean grain yield and non-significant bi and S^2di and thus were stable across seasons. Their grain yield and grain type is better than check hybrid PA 6444 which is popular commercial hybrid and also stable. Panwar *et al* (2008) also stressed the need for evolving stable hybrids across environments that shows least interaction with environment. Hariprasad *et al* (2011) have pointed out that hybrid in south India have not been adapted on large scale due to grain quality requirement i.e. farmers like medium slender grains like Samba Mahsuri. In the present study the hybrid IR 58025A/OVT-89 is equally a good hybrid with comparable yield with check hybrid and 16.8 percent higher to Samba Mahsuri has significant bi indicating only linear component of g x e interaction was accountable and its suitability to higher environment in the present case it is *Rabi* season. This hybrid was also stable for plant height and number of productive tillers and possesses short slender grains which are preferred by farmers and consumers. There is need of medium/ short slender grain hybrids particularly in south India and because of this hybrids are not popular in these states. Further the restorer parent OVT-89is high yielding variety with good grain quality which will fetch extra income to hybrid seed producer. Most of the hybrids were stable for milling out turn and ranged from 68-71 percent (table-3). Among checks MTU-1010 was not stable. Head rice recovery in hybrids is an important character as hybrids have generally lower recovery. All hybrids were superior to check hybrid PA 6444 for head rice recovery and ranged from 37 to 63 percent. Three hybrids *viz*. IR 58025A/R-18, IR 58025A/RJ-35, and IR58025A/ RJ-19 were stable for head rice recovery. For kernel breadth except three hybrids all test hybrids exhibited stability. Most of the hybrids were stable for L/B ratio. Based on L/B ratio two hybrids IR 58025A/RJ-35, IR 58025A/ OVT-89 belong to short slender grain types. The hybrid IR 58025A/ RJ-2 has long bold grains and higher head rice recovery of 55.8 percent. Thus, considering grain yield and physical grain quality characters three hybrids viz. IR 58025A/RJ-2, IR 58025A/ RJ-19and IR 58025A/ OVT-89 can be recommended for multi-location testing before their release for commercial cultivation.

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Table 1. Pooled analysis of variance across three seasons for yield, its contributing characters and physical quality characters in rice hybrids

Source	D.F.	Days to 50% flowering	Plant height (cm)	No. of Productive Tillers /plant	Panicle Length (cm)	Grain Yield/ plot Kg/plot	Milling (%)	Head Rice Recovery (%)	Kernel Length (mm)	Kernel Breadth (mm)	L/B ratio
Genotypes	13	193.08**	139.59**	1.64**	3.13**	3.68**	4.87**	256.46**	1.27**	0.050**	0.266**
Environment (Linear)	1	2083.35**	3202.5**	1.23	5.59**	247.44**	80.91**	68.99	0.860**	0.118**	0.003
G x E	26	27.92**	24.49**	0.70**	0.59	0.85**	1.67**	15.34**	0.003	0.046**	0.024**
G x E (linear)	13	47.03**	36.47**	0.57	0.37	1.07*	2.42*	12.37	0.058	0.003	0.017
Pooled deviations	14	6.01**	10.36**	0.65*	0.78	0.60**	0.86**	16.99**	0.032	0.004*	0.029*
Pooled error	84	0.21	2.47	0.29	0.55	0.20	0.28	0.31	0.004	0.002	0.009

*,**= Significant at 5 and 1% respectively

Table 2. Means of seasons (M) and environmental indexes (I) for grain yield, yield Components and physical grain quality characters

S.No.	Character		2013 *Kharif*	2013-14 *Rabi*	2014 *Kharif*
1	Days to 50% flowering	M	100.8	112.7	95.9
		I	-2.355	9.559	-7.204
2	Plant height (cm)	M	108.2	87.5	102.4
		I	8.858	-11.881	3.023
3	Number of productive	M	12.8	12.4	12.4
	Tillers /plant	I	0.285	-0.167	-0.118
4	Panicle length (cm)	M	25.0	24.8	24.9
		I	0.1	-0.1	0.0
5	Grain yield (kg/plot)	M	4.05	9.48	8.69
		I	-3.41	1.99	1.424
6	Milling (%)	M	70.9	67.9	70.9
		I	0.99	-1.96	0.97
7	Head rice recovery (%)	M	51.1	48.9	48.0
		I	1.74	-0.44	-1.30
8	Kernel length (mm)	M	6.53	6.22	6.51
		I	0.108	-0.202	0.094
9	Kernel breadth (mm)	M	1.96	1.87	1.99
		I	0.021	-0.073	0.052
10	L / B ratio	M	3.31	3.33	3.32
		I	-0.009	0.012	-0.003

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

S. NO.	Hybrids	Days to 50% flowering			Plant height (cm)			No. of productive tillers/plant			Grain yield (kg/plot)			Milling (%)		
		Mean	Bi	S^2 di	Mean	bi	S^2 di	Mean	Bi	S^2di	Mean	bi	S^2 di	Mean	bi	S^2 di
1	IR 58025A/ R-18	95.7	0.85	5.07**	94.4	1.04	5.95	13.0	2.03	0.75	7.11	0.90	-0.03	72.1	-0.52**	-.018
2	IR 58025A / RJ-2	113.7	1.79**	0.93*	117.4	1.05	8.35*	13.1	1.59	1.23*	8.39	1.13	0.02	71.1	0.45	1.71*
3	IR 58025A / R-15	95.5	0.47	17.45**	103.3	0.57*	3.57	12.9	-2.00	-0.25	7.44	1.08	0.26	69.1	0.24*	0.64
4	IR 58025A / RJ-46	98.4	1.02	8.43**	97.9	1.09	4.82	12.6	1.55	-0.29	6.87	0.62*	-0.16	70.8	0.93	0.37
5	IR 58025A / R-33	103.3	0.93	5.27**	103.7	1.75**	0.06	12.1	-3.99*	3.73**	8.22	1.02	0.89*	67.8	1.37	-0.21
6	IR 58025A / RJ-35	107.8	0.78	-0.08	100.0	1.39	3.18	12.3	4.89	0.34	7.23	1.01	-0.13	71.1	1.39	-0.07
7	IR 58025A / OVT-89	104.8	0.56*	15.44**	95.9	0.81	3.18	13.3	0.89	-0.10	7.82	1.33	-0.08	70.3	0.93	-0.31
8	IR 58025A / R-19	105.1	0.64	0.62**	102.1	1.25	7.46*	12.6	-0.64	0.04	7.99	0.45**	-0.01	70.7	1.67	-0.07
9	IR 58025A / R-9	104.2	2.22**	6.34**	89.1	0.43**	53.48**	13.4	0.77	-0.29	7.57	1.03	0.10	69.6	0.98	-9.08
10	IR 58025A / GP-78	100.3	1.75	-0.20	97.7	1.419*	20.56**	13.1	0.64	-0.04	7.79	1.35	1.49**	69.2	0.48	0.26
11	PA-6444 (check)	103.8	0.52*	16.30**	102.9	0.92	0.45	12.7	0.15	-0.07	7.91	0.92	0.37	68.8	1.74	0.51
12	RJ-115	95.0	0.42**	2.60**	99.7	1.18	-1.32	11.1	1.99	-0.26	7.33	1.24	1.27**	67.8	1.30	0.79
13	Samba Mahsuri	122.9	1.33**	3.12**	94.9	0.23**	-2.23	12.7	0.25	0.58	6.69	1.02	1.42**	69.6	1.33	-0.23
14	MTU-1010	93.3	0.72	-0.21	91.8	0.86	3.04	11.0	5.86*	-0.29	6.45	0.49**	0.54*	70.4	1.70	4.17**
	S.E. +/-	0.27	0.20	-	0.91	0.21	-	0.31	2.29	-	0.26	0.18	-	0.65	0.38	-

*,**=Significant at 5% and 1% respectively

Table 4. Mean and stability parameters for physical grain quality characters in rice hybrids and checks

S. No.	Hybrids	Milling (%)			Head rice recovery (%)			Kernel Length (mm)	Kernel breadth (mm)			L / B Raito		
		Mean	bi	S^2 di	Mean	bi	S^2 di	Mean	Mean	bi	S^2 di	Mean	bi	S^2 di
1	IR 58025A/ R-18	72.1	-0.52	-.018	39.1	2.71	0.48	7.18	1.94	1.42	0.012*	3.72	-0.37	-0.007
2	IR 58025A / RJ-2	71.1	0.45	1.71*	55.8	0.56	2.08*	6.08	2.09	0.89	-0.001	2.92	7.65	-0.002
3	IR 58025A / R-15	69.1	0.24*	0.64	42.8	2.44	39.64**	7.23	2.00	0.57	0.001	3.61	4.35	-0.005
4	IR 58025A / RJ-46	70.8	0.93	0.37	63.4	-1.03	13.26**	6.83	1.85	1.46	0.001	3.70	12.46	0.036*
5	IR 58025A / R-33	67.8	1.37	-0.21	53.2	-0.61	8.51**	6.23	2.09	0.95	0.003	2.97	-3.44	-0.003
6	IR 58025A / RJ-35	71.1	1.39	-0.07	48.6	0.68	0.09	5.42	1.77	0.89	-0.002	3.08	-6.71	-0.007
7	IR 58025A / OVT-89	70.3	0.93	-0.31	53.6	0.53	3.68**	5.77	1.76	0.50	0.008*	3.29	4.93	0.035*
8	IR 58025A / R-19	70.7	1.67	-0.07	37.9	1.45	-0.22	7.06	1.94	1.75	0.006*	3.73	-2.63	-0.007
9	IR 58025A / R-9	69.6	0.98	-9.08	44.6	-0.06	11.05**	6.56	1.88	1.09	-0.002	3.45	-6.10	0.038*
10	IR 58025A / GP-78	69.2	0.48	0.26	43.2	4.63	31.25**	6.87	1.96	0.29	0.000	3.51	-8.77	-0.003
11	PA-6444 (hybrid check)	68.8	1.74	0.51	36.8	2.15	44.89**	6.22	2.10	1.49	-0.002	2.94	14.47	-0.001
12	RJ-115	67.8	1.30	0.79	57.4	0.14	3.56**	6.52	2.03	2.06	-0.001	3.23	12.99	-0.008
13	Samba Mahsuri (check)	69.6	1.33	-0.23	48.6	1.34	71.44**	5.09	1.73	0.58	-0.001	3.10	-10.61	0.225**
14	MTU-1010	70.4	1.70	4.17**	65.9	-0.93	3.51*	6.74	2.06	0.06	0.008*	3.27	-4.36	-0.008
	S.E. +/-	0.65	0.38	-	2.91	1.86	-	0.13	0.044	0.68	-	0.12	11.2	-

*,**=Significant at 5 and 1% respectively.