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Stability Analysis for Grain Yield and Yield Contributing Traits in Hybrid Rice

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ABSTRACT: An experiment was conducted using 56 rice genotypes along with two standard checks (hybrid check, US 314 and Varietal check, Tellahamsa) in three different locations of Telangana state to assess their stability in terms of grain yield and number of productive tillers per plant in diverse environments during *Rabi* 2020-21 (Jagtial, Rudrur and Rajendranagar). Aim of this study is to identify the high yielding stable hybrids tolerant to blast and cold suitable to *rabi* season for Telangana state. The analysis of variance for number of productive tillers per plant and grain yield per plant for genotypes, environment and genotype-environment interaction were highly significant indicating the variable response of genotypes and environments. Among the parents JGL 35126, IR 72 and JGL 34551 were stable for the characters grain yield per plant, number of productive tillers per plant. The hybrids, JMS 13A × RNR 2354 (37.41 g), CMS 46A × JGL 34551 (35.06 g) and JMS 13A × ZGY 1 (34.78 g) shown significantly higher grain yield per plant over hybrid check US 314 (28.23 g) and recorded near to unity bi values with non-significant deviation from regression, hence considered as stable hybrids. CMS 59A × IR 72 (34.71) and CMS 59A × JGL 35126 (33.96) manifested significantly higher grain yield per plant over hybrid check US 314 (28.23 g) and recorded near to unit bi values but deviation from regression was significant. Hybrids, CMS 13A × JGL 35126 (33.12), JMS 13A × JGL 35047 (33.36 g), CMS 23A × RNR 28359 (31.33 g), CMS 46A × RNR 2354 (31.70 g) and CMS 59A × ZGY 1 (33.91) were exhibited with high mean, regression coefficient greater than 'unity' and non–significant deviation from regression. Hence these hybrids can perform well under better environment.

Keywords: Hybrids, Grain yield and stability.

INTRODUCTION

Rice is grown in almost all the latitudes and contributes approximately 28.55 % of world cereal production, occupies the second place in production and planted area and is consumed by more than 50% of the world population (FAO, 2019). This population will increase to over 4.6 billion by 2050, which demands 50% more of present production to cope with the growing population (Srividya *et al.*, 2010).

Among the many available genetic approaches being exploited to break the yield barrier in rice, hybrid rice technology is considered as one of the promising, practical, sustainable and eco-friendly options to break the yield ceiling in rice. Hybrid rice often has a 10-20 % rise in grain yield per unit area compared to the inbred line (Liu *et al.*, 2019).

In Telangana most of the area under *rabi* rice gets effected by cold injury at nursery stage and blast incidence during nursery stage and to the main field. To address this problem, 4 CMS lines along with 10 cold and blast tolerant restorers were used to develop 40 hybrids. These hybrids may not produce uniform yields across different environment as a result of the existence of genotype x environment (G x E) interaction. Yield is a complex quantitative character and is greatly influenced by environmental fluctuations, hence the selection for superior genotypes based on yield *per se* at a single location in a year may not be very effective (Shrestha *et al.*, 2012). Multilocation experiments are important to obtain genotypes that are adapted to a specific location or tend to be stable under various environmental conditions (Ponnuswamy *et al.*, 2018). Using several stability methods helps them make the right decision about the stability of a genotype by comparing statistical relationships between them (Shukla *et al.*, 2015; Goksoy *et al.*, 2019).

This study was conducted in view of providing superior hybrids originating from breeding programs for high yield, wide adaptation, stability and resistance to biotic and abiotic stress. The objective of this work was to analyze the GEI and identify adaptability and stability of rice genotypes in three environments in the main producing regions of Telangana state.

MATERIALS AND METHODS

During Rabi 2020-21, the experiment was carried out in three different locations covering two zones of Telangana state, namely NTZ (Jagtial and Rudrur) and STZ (Rajendranagar). There are 56 genotypes in the material (14 parents, 40 hybrids and 2 checks). During Kharif 2020, forty hybrids were developed by crossing four CMS lines with ten known restorers. These hybrids were tested against the varietal check Tellahamsa and the popular hybrid check US 314. This experiment was carried out in a randomized complete block design with three replications. Each genotype was planted in two rows of three metres each, with 20 × 15 cm spacing. Nursery sowing was done on December 5, 2020, in Rudrur and Rajendranagar, and on December 10, 2020, in Jagtial. Transplanting was done on 8th January, 2021 at Rudrur and Rajendranagar. At Jagtial transplanting was done on 13th January, 2021. Standard agronomic practices were followed and plant protection measures were taken as required. Data was collected on grain yield and number of productive tillers per plant. Eberhart and Russell's model (1966) was used to quantify the parameters of stability namely (i) overall mean of each genotype over a range of environments, (ii) the regression of each genotype on the environmental index and (iii) a function of the squared deviation from the regression were estimated.

RESULTS AND DISCUSSIONS

A. Analysis of Variance

Fifty six genotypes comprising 40 hybrids, 14 parents and two checks were subjected to pooled analysis of variance for number of productive tillers per plant and grain yield per plant (Table 1). The analysis of variance revealed that the genotypes and environments are significant for both the characters indicating the existence of diversity among the genotypes and environments. The G × E interaction was significant for grain yield and number of productive tillers when tested against pooled deviation, indicating wide differential behaviour of genotypes in changing environments (Jagtial, Rudrur and Rajendranagar).

Table 1: Analysis of variance for Number of productive tillers per plant and grain yield for stability in rice.

Source	Degrees of freedom	Number of productive tillers per plant	Grain yield (g)
Rep within Env.	6	0.39	0.95
Genotypes	55	6.22**	78.54**
Env.+(Var.'Env.)	112	1.56**	22.84**
Environments	2	23.47**	596.18**
Genotype* Env.	110	1.16**	12.43*
Environments (Lin.)	1	46.94**	1192.37**
Genotype*Env.(Lin.)	55	1.88**	16.82**
Pooled Deviation	56	0.44**	7.87**
Pooled Error	330	0.24	1.26

*Significant at P=0.05 level ** Significant at P=0.01 level

Sum of squares due to environment + (genotype × environment) was further partitioned into that of environment (linear), genotype × environment (linear) and pooled deviation. Significant variation due to environment (linear) was observed for both the characters studied revealing the linear contribution of environmental effects and additive environmental variance on these characters. Similar results were reported by Vijayalaxmi *et al.*, (2014); Anowara Akter *et al.* (2019).

The mean sum of squares for pooled deviation was significant for number of productive tillers per plant and grain yield indicating the non-linear response and unpredictable nature of genotypes by significantly differing for stability. This reveals the importance of both linear and non-linear components in determining interaction of the genotypes with environments in the present study. Similar reports were given by Das *et al.*, (2010); Dushyanth kumar *et al.* (2010); Saidaiah *et al.* (2010b); Biswas *et al.* (2011); Sreedhar *et al.* (2011); Subudhi *et al.* (2012); Madhukar (2014); Vijayalaxmi *et al.* (2014); Anowara Akter *et al.* (2019).

B. Grain yield per plant

Pooled analysis of variance indicated existence of significant G × E interaction for grain yield per plant. Both linear and non-linear component of G × E interaction were significant which revealed that only part of performance could be predicted. Among the genotypes, one line, five testers and 32 hybrids and both the checks exhibited non-significant deviation from the regression (S^2di) values (Table 2).

Table 2: Mean performance and stability parameters for Grain yield per plant (g) and Number of productive tillers per plant.

Parent /Cross	Grain yield per plant (g)			Number of productive tillers per plant		
Parent	**Mean**	**bi**	**S^2di**	**Mean**	**bi**	**S^2di**
LINES						
JMS 13A/B	23.62	-0.03	4.263*	14.00	2.64	0.15
CMS 23A/B	21.64	-0.58	-0.75	9.67	2.64	0.15
CMS 46A/B	22.98	0.85	7.25**	9.22	2.08	-0.23
CMS 59A/B	22.63	0.20	8.16**	11.00	3.59	-0.18
TESTERS						
RNR 26085	20.03	-1.39	14.10**	9.33	0.43	-0.18
ZGY 1	21.78	-1.57	2.71	7.11	1.45	0.06
RNR 2354	21.84	-1.06	7.77**	9.11	1.45	0.06
RNR 28359	20.74	-0.76	-0.71	9.33	0.00**	-0.25
RNR 21571	23.20	1.03	4.57*	9.89	0.76	-0.21
IR 72	24.42	1.18	0.66	13.89	-1.85	1.41 *
JGL 35126	25.08	1.24	0.31	9.89	0.76	-0.21
JGL 35047	21.78	-1.77	28.93**	9.11	1.09	0.17
JGL 34551	24.97	1.47	-1.08	9.44	0.07	1.15 *
RNR 28411	22.93	0.40	10.27**	11.00	3.03	1.60 **
CROSSES						
JMS 13A × RNR 26085	22.94	1.69	0.001	7.67	2.64	0.15
JMS 13A × ZGY 1	34.78	1.50	-0.74	11.22	2.93	0.17
JMS 13A × RNR 2354	37.41	1.01	3.09	10.89	3.00	-0.16
JMS 13A × RNR 28359	23.69	0.94	-1.10	9.22	2.08	-0.23
JMS 13A × RNR 21571	21.87	-1.27**	-1.21	10.11	-1.62	-0.14
JMS 13A × IR 72	23.23	1.26	-0.34	11.67	-0.46	-0.21
JMS 13A × JGL 35126	33.12	2.54	-0.58	9.67	-0.43	-0.18
JMS 13A × JGL 35047	33.36	2.09*	-1.15	10.11	1.48	-0.24
JMS 13A × JGL 34551	23.72	1.17	2.40	7.56	1.58	0.39
JMS 13A × RNR 28411	28.03	2.45	-0.53	9.33	1.35	-0.22
CMS 23A × RNR 26085	23.79	1.31	-1.14	10.89	1.19	-0.24
CMS 23A × ZGY 1	25.38	1.95	-0.10	8.67	-0.890*	-0.25
CMS 23A × RNR 2354	23.13	1.28	3.10	9.44	1.06	-0.22
CMS 23A × RNR 28359	31.33	1.84	-0.98	9.56	1.65	-0.23
CMS 23A × RNR 21571	24.24	1.35	-0.32	10.67	2.27	0.08
CMS 23A × IR 72	23.11	1.19	-0.39	9.11	-1.58	0.39
CMS 23A × JGL 35126	24.70	2.04	-1.086	8.00	-0.46	-0.21
CMS 23A × JGL 35047	23.29	-2.16*	-0.79	9.00	2.18	0.45
CMS 23A × JGL 34551	29.39	2.56	-0.58	8.00	1.29	0.37
CMS 23A × RNR 28411	25.03	1.37	-1.20	9.78	-0.297**	-0.25
CMS 46A × RNR 26085	26.09	2.09	0.05	7.56	0.26	-0.01
CMS 46A × ZGY 1	26.46	2.18	4.11*	8.78	1.91	-0.13
CMS 46A × RNR 2354	31.70	2.34	1.61	9.67	3.92	1.74 **
CMS 46A × RNR 28359	29.03	1.36	10.02**	8.67	2.64	0.15
CMS 46 A × RNR 21571	21.32	-2.24	6.07*	11.11	3.72**	-0.25
CMS 46A × IR 72	23.93	-0.35	2.30	9.33	1.91	2.90**
CMS 46A × JGL 35126	30.23	2.18	-1.11	8.22	-1.06	-0.22
CMS 46A × JGL 35047	23.92	1.26	14.32**	8.11	0.20	0.24
CMS 46A × JGL 34551	35.06	1.59	-0.45	8.56	-0.17	-0.20
CMS 46A × RNR 28411	25.34	1.41	-0.60	7.11	-0.76	-0.21
CMS 59A × RNR 26085	23.90	1.35	-0.42	8.89	1.65	-0.23
CMS 59A × ZGY 1	33.91	2.06*	-1.21	8.00	1.95	4.80 **
CMS 59A × RNR 2354	25.18	1.85	0.96	7.22	0.73	-0.17
CMS 59A × RNR 28359	30.40	2.61	0.36	8.11	-0.26	-0.01
CMS 59A × RNR 21571	30.50	1.79*	-1.21	7.89	-1.88	0.42
CMS 59A × IR 72	34.71	1.45	10.60**	9.89	-0.10	0.26
CMS 59A × JGL 35126	33.96	1.38	13.03**	10.56	1.65	-0.23
CMS 59A × JGL 35047	24.42	0.64	0.90	8.67	2.24	-0.24
CMS 59A × JGL 34551	26.32	2.26	2.24	7.78	-0.26	-0.01
CMS 59A × RNR 28411	31.23	1.10	27.43**	10.00	-0.43	-0.18
Checks						
US 314	28.23	0.77	-1.08	8.44	-1.187*	-0.24
Tellahamsa	25.29	0.52	-1.12	10.67	2.24	-0.24
Population Mean	26.31	-	-	9.38	-	-
SE of bi	-	0.65	-	-	0.72	-
CD at 5%	3.39	-	-	1.08	-	-

Among the parents, a line CMS 23B (21.64 g), testers ZGY 1 (21.78 g) and RNR 28359 (20.74) were found adaptable to poor environments with less mean, regression coefficient of less than 'unity' and non-significant deviation from regression. None of the parents were found significantly superior over hybrid check US 314. The hybrids, JMS 13A × RNR 2354 (37.41 g), CMS 46A × JGL 34551 (35.06 g) and JMS 13A × ZGY 1 (34.78 g) manifested significantly higher grain yield per plant over hybrid check US 314 (28.23 g) and recorded near to unity bi values deviation from regression was non-significant and considered as stable hybrids. CMS 59A × IR 72 (34.71 g) and CMS 59A × JGL 35126 (33.96 g) manifested significantly higher grain yield per plant over hybrid check US 314 (28.23 g) and recorded near to unit bi values but deviation from regression was significant. Hybrids, CMS 13A × JGL 35126 (33.12 g), JMS 13A × JGL 35047 (33.36 g), CMS 23A × RNR 28359 (31.33 g), CMS 46A × RNR 2354 (31.70 g) and CMS 59A × ZGY 1 (33.91 g) were exhibited with high mean, regression coefficient greater than 'unity' and non–significant deviation from regression performed well under better environment. Lal and Singh (2012); Madhukar (2014); Vijayalaxmi *et al.*, (2014); Banumurthy *et al.* (2016); Satoto *et al.* (2016); Hasan *et al.* (2018); Akter *et al*. (2019); Virender Jeet Singh (2020); Marco Acevedo-Baronal *et al.*, (2021) also reported high yielding stable hybrids for grain yield per plant based on stability parameters.

C. Number of productive tillers per plant

Productive tillers per plant is an important yield contributing character in rice. Highly significant MSS due to G × E interaction for this character revealed that the genotypes interacted considerably with all environments. The significant pooled deviation for this character indicated that the performance of genotypes for this character is highly unpredictable. Such results were also reported previously by Parry *et al.*, (2008) and Subhudhi *et al.*, (2012).

Out of the 56 genotypes evaluated, 50 genotypes including four lines, seven testers, 37 hybrids and two checks showed non-significant deviation from regression (S^2di) values *i.e.*, the genotypes are statistically within the range of 'minimum deviation from regression' and whose performance can be predicted (Table 2). Among parents, two lines JMS 13B (14.00) and CMS 59B (11.00) have recorded high mean, regression coefficient more than 'unity' and non–significant deviation from regression and were considered as average stability for this trait and are adaptable to favourable environments only. The hybrids JMS 13A × RNR 21571, JMS 13A × IR 72 and CMS 59A × RNR 28411 recorded high mean, regression coefficient less than 'unity' and non–significant deviation from regression were considered as average stability under poor environment. The hybrids JMS 13A × JGL 35047 (10.11) and CMS 23A × RNR 26085(10.89) have recorded high mean, regression coefficient near 'unity' and non–significant deviation from regression were considered as stable for this trait across locations. Four hybrids (JMS 13A × ZGY 1, JMS 13A × RNR 2354, CMS 23A × RNR 21571 and CMS 59A × JGL 35126) recorded more than one of regression coefficient (bi) values. Hence, considered to have less than average stability and are adaptable to favourable environments only. Stable hybrids for number of productive tillers per plant were also reported by Lal and Singh (2012); Vijayalaxmi *et al.* (2014); Madhukar (2014); Virender Jeet Singh (2020).

SUMMARY AND CONCLUSIONS

According to the findings of this study, stability analysis provided a good understanding of the adaptation level of rice genotypes across a wide range of environments. As a result, all genotypes interacted with the environment differently for different characters, and some genotypes were identified as stable for the various characters studied. Among the parents, JGL 35126 was found to be stable for the characters grain yield per plant and number of productive tillers per plant, whereas RNR 2354, RNR 21571, and JGL 35047 were stable for number of productive tillers per plant and IR 72 and JGL 34551 were stable for grain yield per plant. In contexts of hybrids, JMS 13A RNR 2354 was stable in terms of grain yield per plant and number of productive tillers per plant. CMS 49A × JGL 34551 was stable for grain yield, while JMS 13A × ZGY 1 was stable for grain yield per plant and number of productive tillers per plant.

The current study, however, was confined to one season and three locations: Jagtial, Rudrur, and Rajendranagar. To obtain more realistic information on stability, the identified promising cross combinations must be extensively tested for superiority and stability across different agro-climatic zones and across the years before commercial release.

Conflict of intrest. Authors have declared that no competing interests exist.

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