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Adoptability of high yielding three line rice (*Oryza sativa* L.) hybrids

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Abstract

A study on adoptability of rice hybrids was carried out through analysing the data on grain yield and other important traits according to Eberhart and Russell Model. For this, multi locational trial was carried out with 33 hybrids at three locations *viz.,* Hyderabad, Maruteru and Bargarh. Eight characters were studied and all the characters including grain yield were showing significant difference in their phenotypic expression across environments except number of panicles and panicle length which were less influenced. Based on the linear component (bi), non-linear response (s2di) and high mean performance (X), six hybrids*viz.* RP6AxRP58R, RP6AxRP49R, RP6AxRP5R, RP2AxRP2R, RP6AxRP60R and RP11AxRP16R were found to be stable across environments.

Keywords: Genotype x environment interaction, regression coefficient, stability parameters

Introduction

Rice (*Oryza sativa* L.) is an important and stable food of almost half of the world. Rice is grown worldwide over an area of 154 million hectares with total production of 672 million tonnes. It continues to be the single most important source of calories for a majority of the human population. While rice is being cultivated in 113 countries, it is the staple food for 17 countries in Asia and pacific. The average rice yield in Asia is 1.3 t/ha compared to 3.8 t/ha in the world, 10.1 t/ha in Australia, 6.4 t/ha in Japan, 6.3 t/ha in China and 2.1 t/ha in India. India annually plants rice on a total area of 43 million hectares, which produces approximately of 130 million tons of rice. Not withstanding past achievements in rice production, which made India self-sufficient, the future years warrant refined approaches to overcome the already attained yield plateau and stagnant genetic potential. In the task of developing improved rice hybrids, assessments of genotype - environment interaction (GEI) form an important basic tool in the hands of plant breeders and it is the greatest challenge for them to identify genotypes with an ideal performance and stability under different environmental conditions. Many times, the interaction effects have camouflaged the value of a genotype and this has considerably affected the selection criteria in breeding programme. Young and Virmani (1990) [5] observed varying magnitude of GEI and stressed the need to evaluate hybrids across environments.Thus, this study was planned to evaluate and screen out the most stable and high yielding genotypes over different environments.

Materials and method

The experimental material consisted of 30 hybrids and 2 hybrid checks *viz.,* US 312 and 27P63 and a varietal check, BPT5204. These were grown under transplanted conditions in randomized block design with three replications at three locations namely, Hyderabad, Maruteru and Bargarh. Each plot (4 x 3 =12 sqm.) consisted of rows spaced 20 cm apart and plant to plant distance was 15 cm. The cultural practices as per the recommended package of practices were followed to raise good crop. Observations on grain yield (kg/ha), plant height (cm.), number of panicles per plant, panicle length (cm.), number of grain per panicle, spikelet fertility percentage and days to 50% flowering were recorded on five randomly selected plants. The days to 50 % flowering and grain yield were recorded on net plot basis. The mean of pooled data were used to compute the stability analysis and stability parameters of varieties under different environments according to formulas used by Eberhart and Russell (1966) [1].

Results and discussion

The Environment + (Genotype x Environment) was significant for all the characters except number of panicles per plant and panicle length, indicating distinct nature of environments and genotype x environment interactions in phenotypic expression. Similar results were reported by Parray *et al.* (2008) [6] for plant height, number of productive tillers per plant, number of grains per panicle and single plant yield. ANOVA for stability for the entire three environments had revealed that the Environments + (Genotypes X Environment) and environment effects alone had the significant mean values while Genotypes x Environment, pooled error and total mean squares were not significant (Table 1).

Stability parameters for characters *viz*., days to fifty percent flowering, plant height, number of panicles per plant, panicle length, number of grains per panicle, spikelet fertility, thousand grain weight and grain yield in kg/ha are depicted in Table 2. Two checks and sixteen hybrids recorded more than the plant height of general mean (112.68 cm). All the hybrids and checks had the positive Bi values. All checks and twentyeight hybrids had the negative deviation from regression values. One check and sixteen hybrids produced more number of panicles per plant than their general mean value of 7.70. Eleven hybrids had the negative Bi values and all the checks have positive values.Two hybrids had the positive deviation from the regression while all other hybrids recorded negative values. All the entries are non significant in deviation from regression. General mean value for days to 50% flowering was 99.2 days among the genotypes. Five hybrids tell under early group. All of the hybrids including checks showed positive value denoting their regression deviation. Except RP2AxRP2R, RP2AxRP49R and RP6AxRP44R, all other genotypes had negative variation from the regression value and two of them are showing significant deviation. Mean value for primary panicle length was 26.30 cm. Seventeen hybrids and two checks had the above average panicle length.Twelve hybrids and a check hybrid (US 312) had the significant regression though the later had the maximum panicle length of 30.11 cm. Fourteen hybrids and a check had the positive deviation from regression value. Except RP5AxRP60R, all other entries are showing non significant deviation from regression.

The genotypes produced an average of 273.45 grains per panicle. Except BPT5204 and three hybrids, rest all are non significant in regression value. The hybrids viz., RP2AxRP11R, RP5AxRP40R, RP6AxRP58R, RP6AxRP60R and RP9AxRP61R are significantly deviating from regression. Eighteen hybrids and one check had positive deviation from regression.Genotypes had 85.17 per cent spikelet fertility and except two checks and twelve hybrids, all other hybrids had less than the average spikelet fertility. Eight hybrids and one check had the negative regression while others had positive values. Except the hybrids RP2AxRP59R, RP2AxRP8R and BPT5204 all others had negative deviation from the regression. All hybrids are non-significant deviation from regression values except the check, BPT5204.Genotypes had general mean value of 14.98 g of thousand grain weight. Twelve hybrids and two checks had the above average 1000 grain weight value and except seven hybrids rest all and checks are having non-significant regression and Nine hybrids had positive deviation from the regression value. Average mean yield of 6476.85 kg/ha was obtained by the genotypes. Thirteen hybrids *viz*., RP2A x RP5R, RP2A x RP6R, RP2A x RP49R, RP2A x RP59R, RP6A x RP5R, RP6A x RP21R, RP6A x RP44R, RP6A x RP49R, RP6A x RP50R, RP6A x RP58R, RP6A x RP60R, RP11A x RP16R and RP6A x RP21R out yielded the mean yields with maximum of 7048.33 produced by the hybrid, RP6A x RP58R. Among the checks, except 27P63, all others yielded only the below mean value. All entries had positive Bi values and three hybrids and one check showed significant regression values. All the entries showed non significant deviations from the regression. The results for most of the traits discussed above are in line with the outcome of studies by Verma *et al*., (2013) [9] and Patel *et al*., (2015) [10].

Among all the traits discussed above, grain yield is the most important trait in the development of rice hybrids. Identification of a hybrid with high grain yield, stability and average response is of immense value. Therefore, it is appropriate to discuss the performances of the genotypes for their quantitative traits in separate environments so that it may be useful for studying their stability performances over multi locations but also to identify best hybrids under each location. Eberhart and Russell (1966) [1] defined a stable genotype as the one which showed high mean yield, regression co-efficient (b_i) around unity and deviation from regression near to zero. Later, Breese (1969) [2] and Jatsara and Paroda (1981) [4] have emphasized the use of deviation from regression as a measure of stability, whereas the linear regression could be treated as a measure of varietal response to environments.

As genotypes with high mean, $b_i = 1$ with non-significant δ^2_{di} are adapted to all environments and stable in yield performance, the hybrids, RP6AxRP5R and RP11AxRP16R fell under group one (bi value 1.03 and 1.09 considered to be as bi value 1), apparently responded favourably to all environmental conditions and hence could be regarded as stable hybrids. This model was also used to analyse the stability of few CGMS hybrids by Umadevi *et al.* (2010) [7] and results by using this model are in conformation with Koli *et al* (2016) [11] and Wasan Juruchai (2017) [12].

As six hybrids *viz.,* RP2AxRP49R, RP2AxRP6R, RP6AxRP50R, RP6AxRP21R, RP6AxRP49R, RP2AxRP59R fell under group two and performed well under favourable environments. Since other five hybrids *viz.,* RP6AxRP58R, RP2AxRP2R, RP6AxRP60R, RP6AxRP44R, RP2AxRP5R and a check 27P63 fell under group three, these could be regarded as specifically adapted to poor environments. However, in the location we studied, LSD comparison showed that the environments E_2 and E_3 had almost similar mean and E1 had a little edge over these environments (Fig. 1). Therefore, all six rice hybrids *viz.,* RP6AxRP58R, RP6AxRP49R, RP6AxRP5R, RP2AxRP2R, RP6AxRP60R and RP11AxRP16R were those exhibited high yield within their group, showed stability and adaptability to all environments.

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Table 1: Analysis of variance for stability performance for important traits in rice

Sources	DF	Days to 50% Flowering	Plant height (cm)	Number of panicles per plant	Panicle length (cm)	Number of gains per panicle	Spikelet Fertility %	Thousand grain weight	Yield kg/ha
Rep within Env.	6	4.59*	2.61	0.58**	0.79	80.04	4.91	0.22	331227.03***
Genotypes	32	173.46**	531.14***	2.36***	10.71***	3468.34***	9.13**	12.83***	236847.5***
Env.+ (Var.* Env.)	66	47.20**	71.91***	0.12	2.2	430.13**	8.85***	0.71**	533902.06***
Environments	2	1502.33**	2296.02***	0.56*	26.4***	2420.33***	78.48***	15.58***	15877604***
Var.* Env.	64	1.72	2.41**	0.11	1.44	367.94*	6.68**	0.25	54411.36
Environments (Lin.)	1	3004.65**	4592.05***	1.11**	52.79***	4840.65***	156.96***	31.15***	31755208***
Var.* Env.(Lin.)	32	1.79	3.69***	0.1	1.43	555.87***	10.28***	0.21	69573.08*
Pooled Deviation	33	1.6	1.1	0.12	1.42	174.55**	2.98	0.27	38060.26
Pooled Error	192	3.66	4.88	0.48	1.1	86.92	4.17	0.32	250561.95
Total	98	88.43	221.87	0.86	4.98	1422.2	8.94	4.67	436904.66

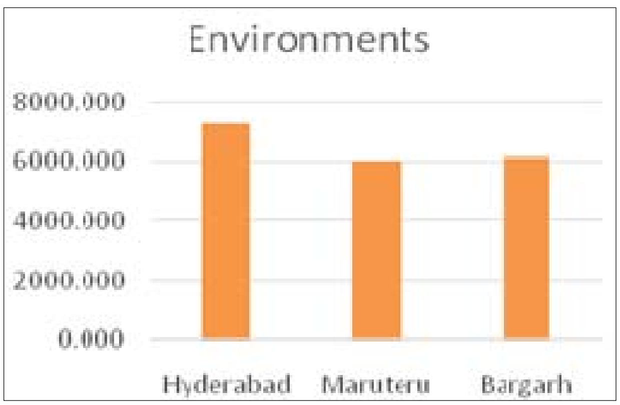
Table 2: Estimates of stability parameters of important traits in rice hybrids

Genotypes	Days to 50% Flowering			Plant height (cm)			Number of panicles per plant			Panicle length (cm)		
	m Mean	bi	s^2di	m Mean	Bi	s^2di	m Mean	bi	s^2di	m Mean	bi	s^2di
RP2A x RP2R	103.56	1.15	1.18	105.67	0.72	-3.73	8.22	0.89	-0.44	27.22	0.65	-0.80
RP2A x RP5R	102.56	1.00	-3.05	117.11	0.98	-3.85	8.00	2.06	-0.41	28.11	1.32	-0.71
RP2A x RP6R	98.78	1.07	-3.36	95.89	0.82	-4.66	8.00	2.06	-0.41	26.78	1.24	0.07
RP2A x RP11R	99.78	0.93	-3.15	121.22	0.94	-4.63	9.00	2.06	-0.41	25.78	0.78	-1.09
RP2A x RP49R	104.22	1.15	11.57*	100.56	0.84	-4.12	7.11	3.53	-0.39	28.00	2.00	2.06
RP2A x RP59R	100.11	0.80	-3.06	125.56	0.92	-2.11	8.33	4.42	-0.48	26.89	0.68	0.25
RP2A x RP68R	104.33	0.88	-1.19	123.33	0.98	-4.80	8.44	-0.29	0.03	29.00	1.07	-0.91
RP5A x RP40R	101.56	1.19	-3.55	113.78	0.96	-4.49	7.89	2.95	-0.48	25.56	1.20	-1.08
RP5A x RP60R	106.00	1.22	-3.49	122.67	1.10	-4.03	7.11	-0.59	-0.42	24.44	-1.06	6.29**
RP6A x RP2R	101.33	0.96	-1.77	104.11	1.00	-3.71	8.11	-0.59	-0.42	25.78	2.42	2.50
RP6A x RP5R	103.78	1.21	-1.38	122.44	1.11	0.25	8.22	-1.17	-0.24	28.11	0.86	-0.86
RP6A x RP11R	104.78	1.18	-3.67	117.78	1.04	-2.82	6.78	-0.59	-0.42	26.67	1.81	-0.10
RP6A x RP21R	104.22	1.15	-3.43	128.56	1.31	1.87	9.00	0.00	-0.49	27.11	1.68	-0.86
RP6A x RP44R	101.67	0.76	10.77*	105.33	0.98	-4.31	7.33	0.30	-0.27	28.22	-0.18	1.16
RP6A x RP49R	99.22	1.00	-2.88	100.11	1.00	-3.71	8.33	-1.76	0.08	27.44	2.23	0.15
RP6A x RP50R	103.00	0.96	-3.59	123.89	1.22	-4.72	7.78	-0.59	-0.42	25.11	0.39	1.41
RP6A x RP58R	92.89	0.85	-3.69	129.44	1.06	-4.42	9.00	2.06	-0.41	26.89	0.45	0.66
RP6A x RP60R	101.44	1.10	-3.57	104.56	0.90	-4.65	7.33	2.36	-0.45	27.44	-0.13	-0.82
RP6A x RP66R	104.44	0.93	-2.75	121.22	1.18	-4.56	6.11	-0.59	-0.42	26.33	0.44	-0.73
RP7A x RP6R	90.22	0.90	-3.68	92.11	0.80	-3.03	7.78	1.17	-0.24	22.78	1.60	-0.21
RP7A x RP21R	105.78	0.98	-2.99	126.78	1.26	-4.49	7.00	0.00	-0.49	25.22	-0.18	1.16
RP9A x RP61R	98.67	1.26	-3.10	96.67	0.94	-1.75	7.78	1.17	-0.24	27.33	0.44	-0.73
RP11A x RP16R	90.78	1.00	-3.68	135.89	1.26	-3.59	7.96	1.47	-0.41	26.92	-0.13	-1.01
RP11A x RP40R	85.33	0.93	-3.69	115.33	1.06	-4.80	7.11	-0.59	-0.42	28.33	2.08	0.64
RP13A x RP6R	102.44	1.06	-3.24	103.33	1.04	-3.09	8.11	-0.59	-0.42	22.11	0.86	-0.86
RP14A x RP21R	100.56	0.91	-3.40	119.67	1.20	-4.61	8.22	5.01	-0.37	23.56	-0.45	2.22
RP15A x RP6R	84.78	0.86	-3.59	88.78	0.66	-4.25	6.78	1.17	-0.24	23.67	0.16	-0.24
RP15A x RP8R	83.67	0.97	-1.27	92.78	0.78	-4.31	5.78	1.17	-0.24	24.11	1.68	-0.86
RP15A x RP59R	84.22	0.83	-3.15	100.33	0.88	-4.52	7.22	2.95	-0.48	24.67	2.63	2.73
RP15A x RP61R	85.67	0.83	-3.63	97.89	0.88	-4.14	6.89	-1.47	-0.48	25.56	2.84	2.96
27P63	108.44	1.10	-3.57	130.78	1.20	-4.40	9.78	1.17	-0.24	28.44	1.29	0.08
BPT5204	112.89	1.10	-2.56	106.44	0.88	-3.63	6.22	0.89	-0.44	24.22	0.65	-0.80
US312	102.56	0.79	-3.27	128.33	1.10	-4.81	7.22	2.95	-0.48	30.11	1.68	-0.86
Population Mean	99.20			112.68			7.70			26.30		
Std.Err. Mean	0.90			0.70			0.25			0.84		
Std.Err. Bi	0.10			0.10			1.90			0.94		

Cont…

Genotypes	Number of gains per panicle			Spikelet Fertility %			Thousand grain weight			Yield kg/ha		
	m Mean	bi	s^2di	m Mean	Bi	s^2di	m Mean	bi	s^2di	m Mean	Bi	s^2di
RP2A x RP2R	293.89	1.60	-86.49	82.44	-0.11	-4.18	15.73	1.21	-0.31	6891.56	0.81	-243127.84
RP2A x RP5R	337.44	1.09	78.22	86.33	-1.18	-3.91	14.47	0.27	1.84*	6662.44	0.77	-181179.33
RP2A x RP6R	228.67	2.42	75.36	83.89	1.19	-4.19	13.71	1.31	0.81	6558.22	1.42	-236120.77
RP2A x RP11R	275.67	2.57	324.62*	85.67	-0.08	-2.67	14.13	0.87	0.22	6404.56	1.30	-251050.59
RP2A x RP49R	294.78	1.23	22.12	85.56	2.02	-1.28	15.34	0.89	0.10	6671.67	1.60	-246859.28
RP2A x RP59R	321.56	-1.85	2.70	84.33	2.97	3.42	13.77	0.85	-0.18	6581.00	1.25	-184547.55
RP2A x RP68R	324.33	0.10	76.00	88.11	-0.11	-4.18	16.63	1.55	-0.31	6438.33	1.12	-250933.89
RP5A x RP40R	273.56	0.33	451.67*	82.78	2.01	-0.28	14.06	0.74	-0.30	6257.44	1.17	-249355.52
RP5A x RP60R	272.11	2.35	7.62	87.22	-0.19	-2.28	13.02	0.63	-0.02	6082.44	0.94	-252908.75
RP6A x RP2R	273.56	1.75	153.68	85.11	1.93	-3.64	15.33	1.43	-0.32	6138.44	0.53	-252279.64

RP6A x RP5R	315.44	-4.10	153.74	85.22	1.51	-4.01	13.95	1.57	0.59	6904.89	1.10	-133221.64
RP6A x RP11R	262.67	0.52	-86.58	82.89	1.84	-4.19	13.23	1.52	-0.19	6180.44	0.68	-251808.53
RP6A x RP21R	273.33	-3.39	166.90	83.67	0.73	-2.50	16.00	0.73	-0.29	6580.11	1.31	-220821.00
RP6A x RP44R	307.22	1.33	117.14	87.22	-0.83	-2.10	12.73	0.99	-0.23	6747.89	0.78	-114835.64
RP6A x RP49R	271.00	1.40	-77.33	82.78	-1.25	-0.04	14.22	1.78	-0.32	7020.67	1.26	-229891.83
RP6A x RP50R	264.33	3.50	92.01	85.11	0.30	-3.22	13.16	1.08	0.14	6519.44	1.41	-101002.57
RP6A x RP58R	322.67	1.26	752.40**	84.89	-0.83	-2.10	12.63	1.30	-0.32	7048.33	0.81	-250251.86
RP6A x RP60R	313.89	1.82	652.16**	84.44	0.02	-3.01	13.62	0.90	0.06	6829.22	0.79	-227687.66
RP6A x RP66R	288.89	-2.53	7.10	85.33	0.13	-2.72	15.94	0.36	-0.09	6386.78	1.47	-218537.31
RP7A x RP6R	285.89	1.66	61.88	83.89	1.60	-3.48	15.03	0.48	-0.02	6179.89	0.74	-243930.38
RP7A x RP21R	252.44	0.04	-53.10	84.44	2.58	-3.54	13.34	0.99	-0.24	6291.00	1.30	-246429.67
RP9A x RP61R	231.89	2.48	480.03*	87.22	1.49	-2.65	14.93	0.90	0.06	6147.11	0.77	-252773.41
RP11A x RP16R	224.67	2.42	-79.52	85.00	2.67	-1.94	18.17	0.16	0.02	6798.67	1.04	139218.89
RP11A x RP40R	251.78	-2.06	-77.26	86.56	2.78	-2.30	21.84	0.85	-0.18	6256.33	0.84	-252929.22
RP13A x RP6R	246.56	4.06	-79.51	83.67	2.79	-2.97	15.46	0.42	-0.32	6383.56	1.03	-222961.55
RP14A x RP21R	252.56	2.07	-85.47	85.11	0.67	-3.15	15.33	1.21	-0.31	6334.67	0.76	-212561.77
RP15A x RP6R	211.11	1.25	-66.16	85.33	0.78	-2.88	16.13	0.03	-0.17	6330.67	0.90	-249904.03
RP15A x RP8R	263.22	3.23	-49.48	85.22	3.94	3.22	13.15	1.73	-0.05	6211.89	0.83	-251506.95
RP15A x RP59R	244.11	1.18	-77.54	85.78	1.30	-4.17	13.46	1.55	-0.30	6168.44	0.74	-248923.83
RP15A x RP61R	234.00	3.79	95.66	84.11	2.15	-3.61	14.52	1.78	-0.32	6420.44	0.94	-252580.39
27P63	316.22	0.99	-38.02	86.00	1.11	-1.88	15.69	1.08	-0.29	6755.89	0.89	-221081.33
BPT5204	217.56	0.31	-86.47	91.11	-2.78	40.56*	14.79	1.11	-0.10	6092.89	0.73	-253004.38
US312	277.00	0.15	70.52	84.11	1.83	-4.09	20.83	0.77	-0.29	6460.89	0.99	-227431.70
Population Mean	273.45			85.17			14.98			6476.85		
Std.Err. Mean	9.30			1.22			0.37			137.90		
Std.Err. Bi	1.10			0.79			0.54			0.20		



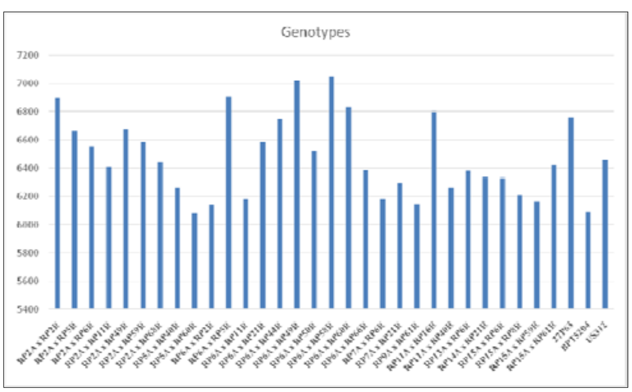


Fig. 1: LSD comparison for grain yield in kg/ha of genotypes and environments

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