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STABILITY ANALYSIS IN RICE LANDRACES GROWN UNDER DRY DIRECT SEEDED CONDITION

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Abstract

In the present study the genotype x environment interaction and stability performances of 15 rice landraces in *Rabi* season during 2017-18 to 2021-22 at Agricultural Research Station, Tamil Nadu Agricultural University, Tamil Nadu, India were evaluated. Eberhart - Russel model was used for stability analysis in rice. In this model, genotype mean across environments, regression of genotype on environmental index and function of the squared deviation from the regression were determined. Mean sum of squares against environment source of variation as well as linear component of environment were significant for all the studied characters suggesting a presence of variation among the environments tested. The linear component of genotype x environment interaction was also found significant for all the traits studied which indicated presence of significant differences between the genotypes. The landraces Kallurundaikar and Kattanur responded favourably to better environments but gave poor yield in an unfavourable environment. Hence, they are suitable for favourable environments. Sivappuchithiraikar and Mysore malli recorded the highest grain yield with b_i value closer to unity and non-significant deviation from regression. They were reported as stable genotypes and recommended for cultivation in southern districts of Tamil Nadu.

Introduction

Rice (*Oryza sativa* L.) is the self-pollinated short-day annual plant of family *Poaceae* with chromosome number 2n = 2x = 24. Rice feed the world by standing as topper on table of the stable food crops. Indian farmers are witnessing severe problems associated with the scarcity of water, labour, and resources with changing climatic conditions. Dry direct-seeded rice (DDSR) can effectively address the problem of water-labour shortage in both rainfed and irrigated areas through reduced use of water for land preparation. In India 12 mha area is occupied by direct seeded rice and 28% of the total rice area. Although many more rice varieties have been released, many of them were no longer cultivated within a few years due to inconsistent performances in diverse environments and only a few varieties with stable performances are being continued under cultivation for prolonged time (Bose *et al.* 2014).

Performance of a plant character is a combined effect of genotype (G), environment (E) and their interaction (G × E). To evaluate the consistency of rice grain yield and develop genotypes that respond optimally and consistently across the years and the geographic regions, it is important to carry out research on yield stability and GE interactions (Blanche *et al.* 2009). Better understanding of GE interactions and stability in crops was used as a decision tool, particularly at the final stage of variety introduction process, to generate essential information on pattern of adaptation in breeding lines, screen new varieties for release, and determine the recommendation domains for released varieties (Yan and Kang 2003).

A genotype is considered to be stable if its environmental variance is small. The level of performance of a character is a result of the genotype of cultivar, the environment in which it is

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grown and interaction of G and E. Interaction between these two explanatory variables gives insight for identifying genotypes suitable for specific environments. The environmental effect is typically a large contribution to total variation (Blanche *et al.* 2009). Moreover GE interaction greatly affects phenotype of a variety and informs researchers to perform stability analysis for knowing the performance of varieties in different environments with those knowledge they would be able to help the plant breeders in selecting desirable genotypes. Multi-Environment Trials (MET) are included in breeding programs to evaluate potentially stable and adapted lines with the aim of producing high yielding and stable genotypes. Evaluating genotypes under various contrasting environments with uncertain variation is a recognized approach for choosing stable genotypes. A stable variety can be defined as the one having unit regression coefficient (b) and the least possible departure from the regression line (S^2d) (Eberhart and Russel 1966).

Materials and Methods

Fifteen rice landraces (Table 1) were evaluated in a randomized complete block design (RCBD) with three replications at Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi during Rabi season of five years from 2017-18 to 2021-22. The experimental site is located at 9" 21' N latitude, 78" 22' E longitude and an altitude of 42 m above mean sea level with average annual rainfall of 840 mm. This site has clay loam soil texture with 8.0 soil pH. Each genotype was raised in 5 x 2 m^2 plot keeping 15 cm x 10 cm spacing. The recommended agronomic practices were followed throughout the crop growth period. Data were recorded on ten randomly selected plants from each replication for various quantitative traits *viz,* days to 50% flowering, plant height (cm), number of productive tillers per plant, panicle length (cm), number of filled grains per panicle, number of chaffy grains per panicle, spikelet fertility (%), grain yield (t/ha), straw yield (t/ha) and harvest index.

Table 1. The details of rice landraces and environment.

Sl..No.	Genotype code	Genotype name	Environment code	Cropping season
1.	G1	Norungan	E1	Rabi 2017-18
2.	G2	Nootripathu	E2	Rabi 2018-19
3.	G3	Vellaichithiraikar	E3	Rabi 2019-20
4.	G4	Sivapuchithiraikar	E4	Rabi 2020-21
5.	G5	Kuruvaikalanjiyam	E5	Rabi 2021-22
6.	G6	Kuliyadichan	-	-
7.	G7	Mattaikar	-	-
8.	G8	Kallurundaikar	-	-
9.	G9	Arubadhanguruvai	-	-
10.	G10	Chandikar	-	-
11.	G11	Kattanur	-	-
12.	G12	Poongar	-	-
13.	G13	Mysore malli	-	-
14.	G14	Kala namak	-	-
15.	G15	Kichali samba	-	-

Eberhart and Russel (1966) model was utilized for stability analysis. In this model, three parameters were determined, *viz.* genotype mean across environments, regression of genotype on environmental index and the function of the squared deviation from the regression. A genotype having regression coefficient as unit *i.e.*, b=1 and non-significant deviation from Zero *i.e.*, S^2di = 0, was considered as stable with uniform response.

Results and Discussion

All the genotypes were recorded to be highly significant for all the ten characters studied, *viz.*, days to 50% flowering, plant height (cm), number of productive tillers per plant, panicle length (cm), number of filled grains per panicle, number of chaffy grains per panicle, spikelet fertility (%), grain yield (t/ha), straw yield (t/ha) and harvest index, after partitioning of mean sum of squares into genotypes, environment + (genotypes x environment) and pooled error, which indicated the presence of genetic variability in the experimental material. Mean sum of squares due to environment as well as linear component of environment were significant for all the characters suggesting a variation among the environments tested. The linear component of genotype x environment interaction was also found to be significant for all the traits studied. This indicated a significant difference between the genotypes for a linear response to environments and the interaction between genotype and environment was due to the linear function of environmental components. Therefore, stability parameters could be used reliably for predicting genotypes performances. Similar findings were reported by Sreedhar *et al*. (2011), Wasan *et al*. (2018) and Pandey *et al.* (2020). The pooled analysis of variance has been presented in Table 2. Mean performance and stability parameters of all the ten traits studied were explained, data presented in Tables 3, 4 and 5.

The genotypes Mattaikar and Kichali samba are found suitable for short duration with bi value closer to unity and non-significant deviation from regression. For short plant height, Nootripathu was considered stable and better adapted to favorable environments, with regression coefficient near unity and non-significant deviation from regression. Kuruvaikalanjium was the most stable genotype across the environments for moderate productive tillers with regression coefficient around unity and non-significant deviation from regression. Kuzhiyadichan and kichali samba genotypes were considered as stable for medium panicle length and better adapted to favorable environments, with regression coefficient near unity and non-significant deviation from regression.

It is difficult to generalize stability for all genotypes relative to all observations as because the genotypes used in this study did not exhibit a uniform stability and response pattern for different observations. Eberhart and Russell (1966) stated that if the observations were associated with high performance of yield so properly the selection of genotype only for yield will be effective. There was no significant correlation between regression (S^2d_i) with mean performance (x_i) and regression deviation (S^2d_i) with regression coefficient (b_i) and from this point it can be inferred that these stability parameters might be under the control of different genes located on different chromosomes where it was confirmed by Reddy and Choudhary (1991), Singh *et al.* (1995) and Ahmad and Masoud (2011).

Eberhart and Russel (1966) 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. Accordingly, the mean and deviation from regression of each genotype were considered for stability index and linear regression was used for testing the varietal response.

Table 2. Pooled analysis of variance (MS) for yield and yield attributing traits.

Source of Variation	D.F.	Days to 50% flowering	Plant height	Productive tillers/plant	Panicle length	Filled grains /panicle	Chaffy grains / panicle	Spikelet fertility	Grain yield	Straw yield	Harvest index
Genotypes (G)	14	346.14**	434.46**	2.83**	8.79**	928.52**	72.01**	65.91**	0.67**	3.82**	0.01**
Environments (E)	4	6.72**	6026.44**	41.16**	12.27**	693.87**	303.34*	448.48**	0.08**	0.24**	0.00*
G x E	56	0.91**	96.76**	1.43*	2.86**	356.48**	56.32*	87.70**	0.07*	0.16*	0.00**
E + (G x E)	60	1.30*	492.07**	4.08**	3.48**	378.97*	72.78**	111.75*	0.07**	0.17**	0.00**
E (Linear)	1	26.86**	24105.76**	164.65**	2.38**	2775.49**	1213.36**	1793.91**	0.33**	0.97**	0.00*
G x E (Linear)	14	1.92**	79.95*	2.27**	3.76*	206.43**	58.39**	118.07**	0.05*	0.38**	0.00**
Pooled Deviation	45	0.53**	95.54**	1.07*	2.38**	379.39**	51.91*	72.40**	0.07**	0.09*	0.00**
Pooled Error	140	0.95	14.50	2.19	2.07	189.83	53.39	52.99	0.03	0.23	0.00

*Significant at 5% level of significance; ** Significant at 1% level of significance.

Table 3. Mean performances and stability parameters of days to 50% flowering, plant height, productive tillers / plant and panicle length of rice landraces over five years / seasons.

Sl. No.	Genotype	Days to 50% flowering			Plant height			Productive tillers / plant			Panicle length		
		Mean	b_i	Sd_i^2	Mean	b_i	Sd_i^2	Mean	b_i	Sd_i^2	Mean	b_i	Sd_i^2
1.	Norungan	76.47	0.61	0.47*	106.63	1.01	130.74**	7.00	1.49	0.55	21.54	1.63	0.95
2.	Nootripathu	64.40	2.11	0.39*	103.13	0.95	13.32	7.20	1.08	-0.47	21.93	2.51	0.10
3.	Vellaichithiraikar	69.53	2.20	-0.27	110.53	1.43	75.25*	7.93	1.42	0.87*	19.71	-0.48	4.62*
4.	Sivapuchithiraikar	73.07	0.50	0.08	118.73	1.31	7.97	7.60	1.68	-0.09	22.87	0.55	0.24
5.	Kuruvaikalanjiyam	75.67	-0.36	0.64*	113.33	0.89	46.42*	7.27	0.92	0.60	20.86	-0.11	3.01*
6.	Kuliyadichan	74.20	-0.40	-0.22	111.47	1.16	57.14*	6.87	0.87	-0.48	21.05	1.01	1.41
7.	Mattaikar	75.27	0.81	0.06	104.93	1.06	44.19*	6.60	0.92	2.91*	22.57	0.20	7.04**
8.	Kallurundaikar	75.13	0.69	0.10	111.53	1.09	30.51*	7.53	1.33	-0.69	21.87	-0.47	0.66
9.	Arubadhanguruvai	72.60	1.90	0.28	94.13	1.03	26.98*	7.67	1.34	0.57	18.59	2.26	2.60*
10.	Chandikar	70.07	2.56	0.02	80.93	0.58	343.59**	8.00	1.46	0.97	19.90	1.57	2.67*
11.	Kattanur	76.00	0.06	-0.02	112.00	1.10	57.83*	6.87	0.80	0.45	19.03	0.64	1.59
12.	Poongar	66.60	-0.37	0.37	102.93	0.86	112.27**	9.13	0.72	0.23	20.69	3.19	0.63
13.	Mysore malli	101.80	2.29	1.19**	103.60	0.69	109.52**	7.07	0.42	-0.08	20.75	0.74	-0.12
14.	Kala namak	75.87	1.54	0.09	103.87	0.76	155.44**	5.80	0.36	-0.05	19.63	0.68	-0.39
15.	Kichali samba	74.87	0.83	0.06	95.87	1.06	149.42**	6.93	0.17	-0.15	19.05	1.08	0.41
Grand Mean		74.77	-	-	104.91	-	-	7.30	-	-	20.67	-	-

*Significant at 5% level of significance; ** Significant at 1% level of significance.

Table 4. Mean performance and stability parameters of days to filled grains / panicle, chaffy grains / panicle and spikelet sterility of rice landraces over five years / rabi seasons.

Sl. No.	Genotype	Filled grains / panicle			Chaffy grains / panicle			Spikelet fertility		
		Mean	b_i	Sd_i^2	Mean	b_i	Sd_i^2	Mean	b_i	Sd_i^2
1.	Norungan	78.07	0.19	-22.11	8.80	0.57	-4.32	90.13	0.43	-1.54
2.	Nootripathu	81.60	0.45	113.42*	8.67	0.03	-4.86	90.27	0.12	3.20
3.	Vellaichithiraikar	74.20	1.08	486.08**	11.73	1.84	23.87*	85.67	1.82	43.08*
4.	Sivapuchithiraikar	73.07	1.67	46.49	13.93	1.98	-0.62	83.40	2.15	-5.95
5.	Kuruvaikalanjiyam	72.67	1.08	176.36*	8.00	0.89	-13.25	90.20	0.77	-6.61
6.	Kuliyadichan	80.40	-0.21	117.58*	7.20	-0.33	-6.29	91.60	-0.24	15.49
7.	Mattaikar	107.73	0.62	-60.63	15.93	0.96	140.52**	87.93	0.42	55.98*
8.	Kallurundaikar	79.53	0.83	294.76**	10.33	-0.51	-4.15	88.67	-0.42	-6.06
9.	Arubadhanguruvai	72.73	1.71	215.78**	9.87	1.42	7.53	87.67	1.40	20.36
10.	Chandikar	72.27	0.44	220.12**	9.67	1.32	-9.34	87.93	1.56	-0.37
11.	Kattanur	59.87	0.05	28.21	11.00	0.52	-6.76	85.20	0.56	-0.02
12.	Poongar	65.27	0.45	282.64**	14.80	1.40	21.05*	81.93	1.22	13.80
13.	Mysore malli	108.93	0.63	2273.22**	19.67	1.57	280.55**	81.73	0.99	546.83**
14.	Kala namak	82.87	1.93	44.52	11.20	0.84	61.31*	88.13	0.76	64.28*
15.	Kichali samba	90.40	4.09	525.28**	18.40	2.49	26.55*	79.47	3.45	78.63*
	Grand Mean	79.97	-	-	11.95	-	-	86.66	-	-

*Significant at 5% level of significance; ** Significant at 1% level of significance.

Table 5. Mean performances and stability parameters of days to grain yield, straw yield and harvest index of rice landraces over five years / rab seasons.

Sl. No.	Genotype	Grain yield			Straw yield			Harvest index		
		Mean	b_i	Sd_i^2	Mean	b_i	Sd_i^2	Mean	b_i	Sd_i^2
1.	Norungan	2.795	2.68	0.01	6.540	4.42	-0.07	0.29	1.45	-0.00
2.	Nootripathu	2.747	3.15	0.18	6.291	3.37	-0.05	0.30	3.18	0.00
3.	Vellaichithiraikar	2.550	0.31	0.01	6.027	-1.42	-0.01	0.29	1.38	-0.00
4.	Sivapuchithiraikar	3.387	1.06	0.09	6.983	-2.71	-0.02	0.33	4.97	0.00
5.	Kuruvaikalanjiyam	3.298	-2.49	0.19	6.553	0.52	0.06	0.33	-1.72	0.00
6.	Kuliyadichan	2.883	0.51	0.02	7.227	-1.49	-0.02	0.28	0.37	0.00
7.	Mattaikar	3.192	-1.47	0.26	6.587	3.54	-0.05	0.32	0.43	0.00
8.	Kallurundaikar	3.475	1.83	-0.01	7.300	0.13	0.09	0.32	-1.72	-0.00
9.	Arubadhanguruvai	2.874	1.79	0.01	5.367	0.89	-0.06	0.35	0.71	-0.00
10.	Chandikar	2.706	0.32	0.19	5.907	-0.81	0.19*	0.31	-0.13	0.00
11.	Kattanur	3.376	3.11	0.00	7.587	1.17	0.07	0.31	0.66	0.00
12.	Poongar	2.399	0.53	-0.00	7.820	2.16	0.07	0.24	-0.68	-0.00
13.	Mysore malli	2.499	0.91	0.01	8.097	-1.25	-0.06	0.24	-1.53	-0.00
14.	Kala namak	2.535	0.78	-0.01	5.380	5.65	0.09	0.32	6.13	0.00
15.	Kichali samba	2.605	1.28	-0.01	5.580	0.83	0.05	0.32	1.51	0.00
	Grand Mean	2.888	-	-	6.616	-	-	0.30	-	-

*Significant at 5% level of significance; ** Significant at 1% level of significance.

(i) Genotypes with high mean, $b_i = 1$ with non-significant S^2d_i are suitable for general adaptation, *i.e*., suitable over all environmental conditions and they are considered as stable genotypes. In this case, Sivappuchithiraikar and Mysore malli are recommended for all environments and reported as stable genotypes.

(ii) Genotypes with high mean, $b_i > 1$ with non-significant S^2d_i are considered as below average in stability. Such genotypes tend to respond favourably to better environments but give poor yield in unfavourable environments. Kallurundaikar and Kattanur are included in this group. Hence, they are suitable for favourable environments.

(iii) Genotypes with low mean, $b_i < 1$ with non-significant S^2d_i do not respond favourably to improve environmental conditions and hence, it could be regarded as specifically adapted to poor environments. Vellaichithiraikar, Kuzhiyadichan, Chandikar, Poongar and Kalanamak are considered as specific adapters to poor environments.

(iv) Genotypes with any bi value with significant S^2d_i are unstable. No one falls in this category.

Based on overall performances of the genotypes across five rabi seasons over the years tested in Paramakudi, the genotypes, Sivappuchithiraikar and Mysore malli it was recorded that highest mean grain yield with b_i value closer to unity and non-significant deviation from regression and are reported as stable genotypes and recommended for cultivation in southern region of Tamil Nadu state.

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