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Stability analysis for yield and its components of rice landraces under dry direct seeded rice cultivation

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Abstract
In order to study the stability performance of fifteen rice landraces, the experiment was conducted in five consecutive years from 2015-16 to 2019-20 in rabi season at Agricultural Research Station, Paramakudi, Tamil Nadu. Data was subjected to the combined analysis of variance, results indicated that the availability of wider genetic variation and the genetic behavior of the genes influencing the characters such as days to 50% flowering, plant height, panicle length, spikelet fertility and grain yield gives enough opportunity for the improvement of these traits by following conventional plant breeding methods. The GXE (linear) was highly significant for all the traits considered. This implies that the genotypes varied in linear response to the environments and hence the behaviour of the genotypes could be predicted over environments more accurately. Based on stability parameters and mean, the landrace, G8 (Kallurundaikar), has high mean yield with stable performance over five years being the overall best can be considered for the direct seeded rice cultivation in the rainfed ecosystem.

Keywords: direct seeded rice; landraces; G x E interaction; stability

Introduction
Rice (*Oryza sativa* L.) 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% to 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 performance in diverse environments and only a few varieties with stable performance continue under cultivation after many years (Bose *et al*. 2014) [1].

The performance of any character is a combined result of the genotype (G) of the variety, the environment (E) and the interaction between genotype and environment (GE). To evaluate the consistency of rice grain yield and develop genotypes that respond optimally and consistently across years and geographic regions, it is necessary to research on yield stability and GE interactions (Blanche *et al.* 2009) [2]. 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) [3].

A genotype may be considered to be stable if itsenvironmental variance is small. The level of performance of a character is a result of the genotype of cultivar, the environment in which it is 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) [1]. Moreover GE interaction greatly affects the phenotype of a variety and informs us to perform stability analysis to know the performance of varieties in different environments to help the plant breeders in selecting desirable genotypes.

A variety or genotype is considered to be more adaptive or stable one, if it has a high mean yield but a low degree of variation in yielding capacity when grown over varied environments (Ashraf *et al*., 2003) [4]. Eberhart and Russell (1966) [5] suggested a model to test the stability of genotypes under different environments. They distinct a stable variety as having unit regression over the environments (b=1) and minimum variation from regression (S^2d_i= 0). Consequently, a variety with a high mean yield over the environments, unit regression coefficient (b=1) and variation from regression as small as possible (S^2d_i = 0), will be a superior choice as a stable variety. Keeping the above views in mind, the present investigation was conducted to analyze the stability of the rice landraces across five growing seasons under dry direct seeded condition.

Materials and Methods

The experimental material comprised with fifteen rice landraces which were evaluated in a randomized block design with three replications at Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi during Rabi 2015-16, Rabi 2016-17, Rabi 2017-18, Rabi 2018-19and Rabi 2019-20. The experimental site is located at 9” 21’ N latitude, 78” 22’ E longitudes 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 pH of 8.0. Each genotype was raised in 5x2 m plot keeping 15 x 10 cm spacing. The recommended agronomic practices followed to raise good crop stand. The data on days to 50% flowering, plant height (cm), panicle length (cm), spikelet fertility (%) and grain yield (kg/ha) were recorded on ten randomly selected plants from each replication.

The data was subjected to analysis of variance and then pooled analysis of variance was proceeded to look at G × E and stability of the genotypes across all environments. The stability parameters were calculated as per the procedure given by Eberhart and Russell (1966) [5].

Results and Discussions

The details of the rice landraces and testing years / seasons presented in Table 1. The combined analysis of variance for genotype, environments and genotype x environment interactions of fifteen landraces in five production years / seasons were highly significant for all the traits studied (Table 2), suggesting the availability of wider genetic variation. Presence of similar variation was reported in earlier studies (Lakew *et al.*, 2014 [6]; Chandra and Deo, 2018 [7]), indicating that the genetic behavior of the genes influencing the characters such as days to 50% flowering, plant height, panicle length, spikelet fertility and grain yield gives enough opportunity for the improvement of these traits by following conventional plant breeding methods.

The GxE interaction when tested by collective error it was significant for all the factors, indicating that the majority of interaction was linear in nature and forecast over the environments was possible (Satit *et al.*, 2000 [8] and Sarawgi *et al.*, 2000 [9]). The variation in both liner trend and non-liner trend relative to grain yield and other yield contributing traits were significant, where it was corroborated by Kulkarni *et al.*, (2000) [10]. Eberhart and Russell (1966) [5] confirmed that a need for considering both the linear and non-linear trend in order to evaluate yield and other parameters of stability of genotypes as well as both the linear regression coefficient and deviation from regression for phenotypic stability. The data on the three stability parameters including mean performance, regression coefficient (b_i) and deviation from regression (S^2d_i) have been shown in the table 3 relative to various factors.

Stability parameters like regression coefficient (*bi*), and deviation from regression (S^2d_i) of the genotypes were estimated following simple linear regression method “LR model” (Finlay and Wilkinson, 1963 [11]; Eberhart and Russell, 1966 [5]). Eberhart and Russell (1966) [5] defined a stable genotype as the one which showed high mean yield, regression co-efficient (bi) around unity and deviation from regression near to zero. Accordingly, the mean and deviation from regression of each genotype were considered for stability and linear regression was used for testing the varietal response.

Genotypes with high mean, bi = 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. Unfortunately, none of the genotypes were shown high mean, unity regression co-efficient and non-significant deviation from regression for grain yield and other yield contributing characters. From this point in can be observed that these stability parameters might be under the control of different genes located on different chromosomes where it was confirmed by Reddy and Chaudhary (1991) [12], Singh *et al*. (1995) [13] and Chandra and Deo (2018) [7].

Genotypes with high mean, bi > 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. Hence, they are suitable for favourable environments. In this study, G8, G4 and G11 were exhibited high mean, bi > 1 and non-significant deviation from regression for grain yield and they are adjudged as below average stable genotypes and they respond better in favourable environments and they will give poor yield in unfavourable environments. Genotypes with low mean, bi < 1 with non-significant S^2d_i do not respond favourably to improved environmental conditions and hence, it could be regarded as specifically adapted to poor environments. The genotypes G12, G13, G14 and G3 were found to be adapted specifically for poor environments as they shows low mean, bi < 1 with non-significant S^2d_i. Genotypes with any bi value with significant S^2d_i are unstable. In this experiment, G1, G2, G5, G6, G7, G9, G10 and G15 were observed as unstable genotypes and not suitable for any environment. Based on results, mean values of grain yield, plant height and panicle length were high in genotypes G8 (Kallurundaikar) and G4 (Sivappuchithiraikar), but these genotypes have average stability. The genotypes with high yield and average yield stability are recommendable for favourable environments. The rice genotype G8 (Kallurundaikar) not only exhibited a high grain yield over the population mean, but also the regression coefficient and deviation from regression was minimum so that it was stable than other genotypes. Thus, it is concluded that the rice genotype G8 (Kallurundaikar) is ideally adaptable and stable and could be recommended for dry direct seeding in rainfed ecosystem of Tamil Nadu.

Table 1: The details on rice landraces and environment

S. No.	Genotype Code	Genotype Name	Environment Code	Environment Name
1.	G1	Norungan	E1	Rabi 2015-16
2.	G2	Nootripathu	E2	Rabi 2016-17
3.	G3	Vellaichithiraikar	E3	Rabi 2017-18
4.	G4	Sivapuchithiraikar	E4	Rabi 2018-19
5.	G5	Kuruvaikalanjiyam	E5	Rabi 2019-20
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	-	-

Table 2: ANOVA for grain yield and its components over five years / seasons

Source of Variation	D.F.	Days to 50% flowering	Plant Height (cm)	Panicle Length (cm)	Spikelet Fertility (%)	Grain Yield (kg/ha)
Genotypes (G)	14	346.14**	434.46**	8.79**	65.91**	665.37**
Environments (E)	4	6.72**	6026.44**	12.27**	448.48**	83.46**
G x E	56	0.91*	96.76**	2.86*	87.70**	72.61**
Env. (linear)	1	26.86**	24105.76**	49.09**	1793.91**	334.00**
Pooled deviation	45	0.53	95.54	2.38	72.40	73.70
Pooled error	140	0.95	14.50	2.07	52.99	33.70

* & ** Significant at P=0.05 and P=0.01 respectively when tested against pooled error

Table 3: Stability parameters for yield and its components in fifteen rice landraces

Genotype	Days to 50% flowering			Plant Height (cm)			Panicle Length (cm)			Spikelet Fertility (%)			Grain Yield (kg/ha)		
	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i	Mean	b_i	S^2d_i
G1	76	0.61	0.47	106	1.01	130.74	21.5	1.63	0.95	90	0.43	-1.54	2795	2.68	13.1
G2	64	2.11	0.39	103	0.95	13.32	21.9	2.51	0.10	90	0.12	3.20	2747	3.15	178.5
G3	70	2.20	-0.27	110	1.43	75.25	19.7	-0.48	4.62	86	1.82	43.08	2550	0.31	7.50
G4	73	0.50	0.08	118	1.31	7.97	22.8	0.55	0.24	83	2.15	-5.95	3387	1.76	90.30
G5	76	-0.36	0.64	113	0.90	46.42	20.8	-0.11	3.01	90	0.77	-6.61	3298	-2.49	190.30
G6	74	-0.40	-0.22	111	1.16	57.14	21.0	1.01	1.41	92	-0.24	15.49	2883	0.51	18.80
G7	75	0.81	0.06	104	1.06	44.19	22.6	0.20	7.04	88	0.42	55.98	3192	-1.47	262.80
G8	75	0.70	0.10	111	1.09	30.51	21.9	-0.47	0.66	89	-0.42	-6.05	3475	1.83	-10.20
G9	72	1.91	0.28	94	1.03	26.98	18.6	2.26	2.60	88	1.40	20.36	2874	1.79	8.01
G10	70	2.56	0.02	80	0.58	343.60	19.9	1.57	2.67	88	1.56	-0.37	2706	0.32	187.9
G11	76	0.06	-0.02	112	1.10	57.83	19.0	0.64	1.59	85	0.56	-0.02	3376	3.11	1.82
G12	66	-0.37	0.37	102	0.86	112.27	20.7	3.19	0.63	82	1.22	13.80	2399	0.53	-3.54
G13	101	2.29	1.19	103	0.69	109.52	20.8	0.74	-0.12	82	0.87	546.83	2499	0.91	12.11
G14	75	1.54	0.09	103	0.76	155.44	19.6	0.68	-0.39	88	0.76	64.28	2535	0.78	10.52
G15	74	0.83	0.06	95	1.06	149.42	19.0	1.08	0.41	79	3.45	78.63	2605	1.28	-9.44

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