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Stability Analysis for Grain Yield and Yield Attributing Traits in Basmati Rice Varieties

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A B S T R A C T

A field experiment was conducted to evaluate 30 basmati rice genotypes for their stability for yield and yield attributing traits over three growing seasons. Fifteen randomly selected plants were sampled in the middle row of each plot and were used for the analysis. The study indicated that environment + (genotype x environment) was significant for all the characters studied thereby validating the distinctness of the environments considered. 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, UPR 2825-30-1-2, UPR 3717-4-1-1, Hansraj, IR 36 and IR 64 were found to be stable for yield in all the three environments considered.

Introduction

Rice, *Oryza sativa* L. (2n=24) is the most important cereal crop of India. Worldwide, more than 3.5 billion people depend upon rice for more than 20% of their daily calories (Khush, 2013). In most of the developing world, rice availability is equated with food security and closely connected to political stability. Also the genetic and functional syntenies among cereal crops over the years has made rice the most important cereal crop for the discovery and utilization of agronomically important genes for crop improvement. India, being one of the original centres of rice cultivation is the second largest producer and consumer of rice in the world (USDA- ERS, 2013). Rice is the most important agricultural operation in the country, not only in terms of food security but also in terms of livelihood. It plays a major part in the diet, economy, employment, culture and history of India.

As this crop is grown under a varied range of agro-climatic conditions ranging from upland to lowland and irrigated to rainfed situations, their phenotypic responses vary greatly in accordance with the environment. The major efforts in crop technology, under unfavourable environment should be yield stabilizing, cost reducing, risk minimizing and returns enhancing. The genotypes should therefore be high stability cultivars besides high yielding cultivars. As a result, several methods of measuring and describing genotypic response across environments have been developed a utilized. For this purpose, multilocational trials, over a number of years are conducted. Sometimes unilocational trials can also serve the purpose provided different environments are created by planting experimental materials at different dates of sowing, using various spacing, doses of fertilizers and irrigational levels, etc. Many methods (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966; Perkins and Jinks, 1968; Freeman and Perkins, 1971) are available for assessing the stability of performance of crop varieties. These models are helpful in the identification of adaptable genotypes over a wide range of environments; achieving stabilization in crop production over locations; developing phenotypically stable high potential cultivars; effective selection for yield stability and prediction of varietal responses under changing environments. 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. Thus, evaluation of genotypes for stability of performance under varying environmental conditions for yield has become an essential part of any breeding programme. Keeping the above views in mind, the present investigation was conducted to analyse the stability of the rice genotypes across three growing seasons.

Materials and Methods

Experimental site

The present study was carried out in the fields of Norman E Borlaug Crop Research Centre (NEBCRC), Govind Ballabh Pant University of Agriculture and Technology, Pantnagar over three growing seasons 2012, 2013 and 2014. Pantnagar is located at the foothills of the Shivalik ranges of the Himalayas in a narrow belt called ‘Tarai’. It falls under the humid subtropical climate zone. Geographically, it is situated at 29 ^{0}51’ N latitude, 79^{0} 31’ E longitudes and at an altitude of 243.84 meters above the mean sea level.

Experimental materials

The plant material comprised of 4 landraces, 7 advanced breeding lines from rice breeding programme of Pantnagar, 2 germplasm accessions from Pantnagar Centre of Plant Genetic Resources (PCPGR, Pantnagar, Uttarakhand) collected from hills of Uttarakhand, 6 released varieties from various research stations and State Agricultural Universities (SAUs), 11 kalanamak local accessions collected under DBT-PMS Project. Two additional genotypes namely IR 64 and Pusa Basmati 1 were included as resistant and susceptible checks for blast resistance respectively making a total of 30 rice genotypes (Table 1). The mean values for different quantitative traits such as Days to 50% flowering, Plant height, Number of panicles per plant, Length of panicle, 1000 grain weight and Grain yield per five plants were used for stability analysis. The stability parameters were calculated as per the procedure given by Eberhart and Russell (1966).

Results and Discussion

Variability for yield and yield component traits over the three growing seasons

Analysis of variance indicated significant variation for all the characters studied in all the three growing seasons, suggesting the availability of wider genetic variation. Presence of similar variation was reported in earlier studies (Tariku *et al.,* 2013, Akter *et al.,* 2014, Lakew *et al.,* 2014), indicating that the genetic behavior of the genes influencing the characters such as days to 50% flowering, plant height, number of panicles per plant, panicle length and 1000 grain weight and yield per five plants gives enough opportunity for the improvement of these traits by following conventional plant breeding methods. The days to 50% flowering during 2012 varied from 90.66 -133.6, while it ranged from 91.66- 135.66 and 92-134.33 during 2013 and 2014 respectively. In case of plant height, during 2012 the values ranged from 73-144.36, 70.8 -145.1 and 76.86-142.16 during 2013 and 2014 respectively. The value for number of panicles were 5-8.66 during 2012, 5-8.33 during 2013 but in 2014, the values were comparatively less which was 4-8.66. During 2012, the variation for panicle length was 21.93-32.03 while it was 14.12-29.92 during 2013 and 23.36- 33.38 during 2014 The 1000 grain weight showed wide variation with the following range during 2012, 2013 and 2014; 7.84 -26.09, 11.24-27.04 and 10.96-25.49 respectively.

The yield per five plants also varied widely between 10.11-47.04 in 2012, 6.39-40.22 in 2013 and 5.55-47.09 during 2014. Genotypes contributing to high diversity for grain yield was found at environment 1 (Kharif 2012), while narrow diversity at environment 2 (Kharif, 2013) and environment 3 (Kharif 2014). Mean grain yield of the genotypes varied in every environment ranging from 22.93g for environment 1 to 20.66 g for environment 2 with a grand mean of 21.56g. Variations of this kind may be caused by several factors such as rainfall, soil fertility etc. Unpredictable environmental factors such as temperature and rainfall even in a single year may contribute to genotype by environmental interaction over year. In the present study, the years during which the field experiments were conducted, the weather conditions varied significantly; thus, a large effect due to environment was expected. Therefore testing genotypes over different years differing in unpredictable environmental variation is a suitable approach for selecting stable genotypes (Eberhart and Russel, 1966).

Stability analysis

The analysis of variance of stability (Table 2) following Eberhart and Russell's model showed that the variance due to genotypes was found to be significant only for yield per five plants and was non-significant for all the other characters studied. This indicates that the performance of the genotypes did not vary significantly over the three growing seasons (Kharif, 2012, Kharif, 2013 and Kharif, 2014) with respect to these traits except yield per five plants. Similar results were reported by Ramanjaneyalu *et al.,* (2014). The variance due to environments interaction was highly significant for all the characters. The significant and relatively large percentage of the total variation attributable to environment suggests that the environments (three growing seasons) considered were significantly different. Highly significant mean squares due to genotype × environment (G×E) interaction for yield per plant revealed that the genotypes interacted considerably with environmental conditions and that yield per plant differed significantly in each of the growing seasons considered. The characters such as Days to 50% flowering, plant height, number of panicles per plant, panicle length and 1000 grain weight showed non-significant GXE value indicating that the performance of the genotypes was stable over the three growing seasons for these traits. The variation due to environment (linear) was highly significant for all the characters under study indicating differences between environments and their influence on genotypes for expression of these characters. The significant environment (linear) variance implies that the variation among environments were linear, which signify unit changes in environmental index for each unit change in the environmental conditions. This is in accordance with previous reports on rice by Masavi *et al.*, (2012). The GXE (linear) was highly significant for all the traits considered. This indicated significant differences among the genotypes for linear response to environments (bi) behaviour of the genotypes could be predicted over environments more precisely and G X E interaction was outcome of the linear function of environmental components. Both linear and non-linear components of genotype-environment interaction were found to be significant for grain yield as indicated by highly significant mean squares due to GXE and G×E (linear) interaction of 128.330 and 213.70 respectively. The existence of genotype x environment interactions and contribution of both linear and non-linear components for yield was reported by Bose *et al.,* 2012. The pooled deviations were found highly significant for 1000 grain weight and yield per plant.

The highly significant pooled deviation for both the traits suggests the importance of non – linear component in the manifestation of GXE interaction, or in other words, expression of some of the genotypes fluctuated significantly from their respective linear path of response to environments. The performance of the genotypes was entirely unpredictable in nature for these two traits. The pooled deviation was insignificant for other traits such as Days to 50% flowering, plant height, number of panicles per plant and panicle length indicating that these traits had linear sensitivity. These results were consistent with the findings of Ramanjaneyalu *et al.*, 2014.

The environmental index is defined as the deviation of the mean of all the genotypes at the regression of the i^{th} environment from the overall mean. In other words it indicates the favorability of an environment or growing season over the others considered. The environmental index was positive for Kharif, 2012 indicating better overall environment or favorable environment than the other two growing seasons which had environmental index values -0.45 and -0.77 respectively.

Stability parameters

The GXE interaction was highly significant only for yield per five plants. Therefore stability parameters were studied further. Relatively higher value of the linear component as compared to non-linear one suggested the possibility of prediction of performance for yield over the environments.

Therefore, linear (*bi*) and nonlinear (*S2di*) component of G x E interactions were considered while judging the phenotypic stability of a genotype (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966). In this study, the mean performance coupled with the stability parameters of each rice genotype represented its stability are showed in Table 3.

Stability parameters like regression coefficient (*bi*), and deviation from regression (*S2di*) of the genotypes were estimated following simple linear regression method “LR model” (Finlay and Wilkinson, 1963; Eberhart and Russell, 1966).

Eberhart and Russell (1966) 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 δ2 di are suitable for general adaptation, *i.e.,* suitable over all environmental conditions and they are considered as stable genotypes.

Table.1 List of rice genotypes studied

S. No	Genotypes	S. No	Genotypes
1.	Hansraj	16.	Kalanamak 3216-SN
2.	Tilakchandan	17.	Kalanamak 3128-SN
3.	Daniya	18.	Kalanamak 3114-1-SN
4.	Sarbati	19.	Kalanamak 3131-P
5.	UPR 3488-6-2-1	20.	Kalanamak 3259-SN
6.	UPR 3716-1-1	21.	Kalanamak 3131-SN
7.	UPR 3713-16-1-2	22.	Kalanamak 3124-P
8.	UPR 3717-4-1-1	23.	Kalanamak 3121-1
9.	UPR 2825-30-1-2	24.	Kalanamak 3119-P
10.	UPR 2892-4-1-1	25.	Kalanamak 3089-P
11.	UPR 3618-15-1-2	26.	Pusa Basmati 1 (Susceptible control)
12.	Pant Basmati 1	27.	IR 64 (Resistant control)
13.	GP 2011-56(A)	28.	IR 36
14.	GP 2011-24	29.	Taraori Basmati
15.	Kalanamak 3216-N	30.	Pant Sugandh Dhan 17

Table.4 Top three performing genotypes for yield and yield components during Three growing seasons

Trait	Kharif 2012	Kharif 2013	Kharif 2014
Yield per five plants	UPR 3717-4-1-1	UPR 2825-30-1-2	UPR 3618-15-1-2
	UPR 3618-15-1-2	Kalanamak 3216-SN	Hansraj
	UPR 3488-6-2-1	UPR 3618-15-1-2	Kalanamak 3216-N
1000 grain weight	IR 36	IR 36	IR 64
	UPR 2892-4-1-1	IR 64	IR 36
	UPR 3716-1-1	Taraori basmati	UPR 3618-15-1-2
Panicle length	Kalanamak 3216-N	Pant Sugandh Dhan 17	Kalanamak 3216-N
	Kalanamak 3131-P	Taraori basmati	Kalanamak 3131-P
	UPR 2825-30-1-2	IR 36	Pant Sugandh Dhan 17
No. of panicles	UPR 2825-30-1-2	Hansraj, UPR 2825-30-1-2	Hansraj
	Hansraj	Sarbati, Pant Basmati 1	UPR 2892-4-1-1, IR 64
	IR 64	Tilakchandan, Kalanamak 3216-N	UPR 3488-6-2-1, Pant Basmati 1

Table.2 Analysis of variance for yield and yield attributing traits (Eberhart and Russell Model, 1966)

Source of variation	d.f.	Days to 50% flowering	Plant height	No. of panicles per plant	Panicle length	1000 grain weight	Yield per plant
Genotype (G)	29	113.227	120.51	119.653	100.59	157.177	200.32*
Environment (E)	2	83,221**	88,863.57**	96,083.159**	92002.36**	92998.86**	87,989.96**
Genotype X Environment	58	132.663	163.463	109.617	115.60	113.80	128.330**
Environment + (Genotype X Environment)	60	2902.28**	3120.13**	3308.73**	3178.49**	3209.970**	3056.95**
Environment (Linear)	1	166’442.87**	177,727.150**	192,166.31**	184,004.726**	185,997.73**	175973.92**
Genotype X Environment (Linear)	29	208.711**	264.82**	165.55**	176.303**	164.92**	213.70**
Pooled deviation	30	54.728	60.03	51.890	53.076	60.589**	41.52**
Pooled error	174	195.986	195.068	114.551	115.117	98.617	67.801
Total	89						

* Significant at 5 % level ** Significant at 1 % level

Table.3a Stability parameters for days to 50% flowering, plant height and No. of panicles per plant in different genotypes over environments

Genotypes	Days to 50% flowering			Plant height			No. of panicles per plant		
	$\bar{X}_i$	b_i	S^2dii	$\bar{X}_i$	b_i	S^2dii	X_i	b_i	S^2dii
Hansraj	44.12	0.48	201.91	56.02	0.84	182.25	45.70	0.97	35.89
Tilakchandan	43.31	0.94	24.54	44.67	0.95	26.90	44.64	0.93	21.77
Daniya	45.11	1.03	21.75	49.85	1.14	-8.53	50.56	1.13	9.37
Sarbati	50.27	1.34	-55.52	50.80	1.30	-48.62	50.24	1.26	-35.84
UPR 3488-6-2-1	44.25	1.04	-12.64	45.23	1.03	-17.86	45.49	0.97	10.86
UPR 3716-1-1	42.23	1.00	-45.38	44.19	1.02	-36.06	45.21	0.99	-0.95
UPR 3713-16-1-2	43.41	0.96	2.48	44.81	0.96	18.93	43.36	0.90	12.84
UPR 3717-4-1-1	47.09	1.07	2.84	50.11	1.16	28.59	49.01	1.10	4.72
UPR 2825-30-1-2	51.01	1.33	-60.87	50.77	1.32	-45.50	51.61	1.26	-27.06
UPR 2892-4-1-1	44.42	1.07	-33.13	43.93	1.01	-19.70	44.81	0.98	0.50
UPR 3618-15-1-2	42.58	1.00	-38.02	44.15	1.03	-37.18	44.72	0.98	7.19
Pant Basmati 1	43.20	0.93	20.50	44.89	0.96	26.66	42.26	0.88	10.61
GP 2011-56(A)	45.88	1.06	24.93	50.96	1.17	-9.50	49.72	1.12	14.69
GP 2011-24	50.61	1.36	-49.05	50.80	1.30	-48.62	51.14	1.25	-28.62
Kalanamak 3216-N	45.36	1.07	-13.77	44.79	1.01	-17.51	44.50	0.97	7.59
Kalanamak 3216-SN	42.88	0.76	-64.67	34.35	0.41	-63.18	51.96	0.93	-38.16
Kalanamak 3128-SN	58.71	0.99	-61.70	49.53	0.69	-65.02	49.57	0.73	-5.98

Contd……

Genotypes	Days to 50% flowering			Plant height			No. of panicles per plant		
	$\bar{X}_i$	b_i	S^2dii	$\bar{X}_i$	b_i	S^2dii	X_i	b_i	S^2dii
Kalanamak 3114-1-SN	56.79	0.91	-65.20	55.52	0.90	-63.78	61.40	1.02	-37.09
Kalanamak 3131-P	56.94	1.06	-7.81	63.33	1.27	7.65	62.38	1.19	53.27
Kalanamak 3259-SN	50.71	1.01	65.01	51.69	0.95	42.43	50.29	0.91	130.76
Kalanamak 3131-SN	52.50	0.97	-29.59	51.82	0.80	-44.42	51.93	0.86	-0.40
Kalanamak 3124-P	57.26	0.96	-63.82	54.69	0.94	-35.60	49.97	0.75	-7.87
Kalanamak 3121-1	57.01	0.97	-65.32	55.85	0.89	-64.11	62.52	1.07	-35.46
Kalanamak 3119-P	56.36	1.09	14.00	63.07	1.25	38.21	64.05	1.28	29.46
Kalanamak 3089-P	49.93	1.00	54.32	51.36	1.02	96.01	50.24	0.90	133.823
Pusa Basmati 1	48.16	0.78	-26.46	49.29	0.71	-41.18	46.83	0.66	-13.49
IR 64	43.40	0.63	-54.38	48.17	0.71	-28.89	49.88	0.76	-10.83
IR 36	55.84	0.90	-63.38	55.84	0.90	-63.98	63.24	1.09	-38.05
Taroari Basmati	64.42	1.36	11.60	62.76	1.28	12.30	57.69	1.05	54.83
Pant Sugandh Dhan 17	44.52	0.82	48.85	50.57	0.96	129.70	51.92	0.97	152.73
MEAN	49.31	1.00		50.47	1.00		50.89	1.00	
SE	5.23	0.09		5.48	0.10		5.09	0.09	

Table.3b Stability parameters for Panicle length, 1000 grain weight and Yield per five plants in different genotypes over environments

Panicle length			1000 grain weight			Yield per five plants		
X_i	b_i	S^2dii	X_i	b_i	S^2dii	X_i	b_i	S^2dii
46.24	.98	7.76	42.32	0.99	-29.38	44.31	0.99	-3.43
44.77	0.94	16.12	43.99	0.92	37.85	43.65	0.93	46.40
49.62	1.14	24.34	48.72	1.08	62.84	46.77	1.12	5.40
50.31	1.25	-38.15	51.03	1.28	-27.29	51.24	1.30	-9.1
45.51	0.97	13.15	41.82	0.87	46.34	40.98	0.88	37.13
44.83	1.00	-18.63	44.52	0.96	-3.45	43.93	1.00	-2.26
42.26	0.90	-2.64	42.57	0.89	21.49	43.86	0.92	42.54
49.50	1.15	3.23	47.06	1.08	45.58	47.21	1.16	9.48
51.36	1.27	-36.89	49.92	1.26	-9.99	51.08	1.31	-12.79
44.83	0.99	-13.65	39.99	0.83	26.74	40.41	0.88	29.79
45.67	1.00	-19.40	44.34	0.97	2.31	43.84	1.01	-4.24
44.77	0.94	16.21	43.54	0.91	38.46	43.87	0.93	50.51
49.07	1.13	28.90	48.28	1.07	63.54	47.80	0.16	28.31
50.09	1.29	-33.49	50.69	1.27	-27.16	50.35	1.28	-15.77
46.18	1.00	15.08	41.38	0.85	47.07	41.17	0.89	28.78
47.21	0.73	-29.53	53.22	0.78	-28.48	44.11	0.63	-12.80
56.18	0.72	-23.96	53.35	0.75	-4.30	46.87	0.70	-9.51
60.16	1.08	-22.96	62.10	1.08	-14.43	59.62	1.03	-12.62
57.36	1.05	42.22	62.33	1.21	49.62	63.26	1.27	66.28

Contd……

Panicle length			**1000 grain weight**			**Yield per five plants**		
X_i	b_i	S^2dii	X_i	b_i	S^2dii	X_i	b_i	S^2dii
52.41	0.98	198.10	51.30	0.98	56.72	42.59	0.73	69.38
49.32	0.64	-37.12	47.21	0.76	15.26	52.39	0.81	-22.27
55.05	0.70	-23.60	47.88	0.83	13.89	51.55	0.83	-0.62
62.93	1.12	-36.30	63.75	1.10	-15.70	59.31	1.03	-14.15
57.32	1.08	90.30	63.51	1.24	101.24	66.29	1.37	64.46
52.01	0.98	170.93	50.15	0.99	125.19	43.71	0.79	59.59
56.83	0.88	-33.83	51.74	0.81	-28.57	53.90	0.90	5.26
49.46	0.75	-8.88	49.02	0.82	49.75	52.77	0.97	-0.39
60.08	1.06	-28.64	62.63	1.07	-18.03	59.72	1.02	-11.22
64.24	1.22	83.46	62.03	1.21	82.97	58.78	1.14	64.64
50.65	0.92	144.39	50.68	0.98	151.29	45.38	0.85	91.12
51.17	1.00		50.38	1.00		49.37	1.00	
5.15	0.09		5.50	0.09		4.56	0.08	

Genotypes with high mean, bi > 1 with non-significant δ2 di 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. Genotypes with low mean, bi < 1 with non-significant δ2 di do not respond favourably to improved environmental conditions and hence, it could be regarded as specifically adapted to poor environments.

Genotypes with any bi value with significant δ2 di are unstable

Among the 30 genotypes, the regression coefficient for yield per five plants was near to unity in six genotypes namely, Hansraj, UPR 3716-1-1, UPR 3618-15-1-2, Kalanamak 3114-1-SN, Kalanamak3124-P and IR 36. Hence, these genotypes are suitable for over all environmental conditions and they are considered as stable genotypes. Thus, these genotypes are considered to be adapted to all the three growing seasons, while the genotypes such as Daniya, Sarbati, UPR 3717-4-1-1, UPR 2825-30-1-2, GP 2011-24, Kalanamak 3131-P, Kalanamak 3119-P and Taroari Basmati showed b_i greater than one. Therefore the results suggests that these genotypes are adapted only to rich environments. The remaining 16 genotypes had b_i values less than one indicating that these are suitable for poor environments.

The S^2dii values were close to 0 in Hansraj, UPR 3716-1-1, UPR 3618-15-1-2, Kalanamak 3124-P and IR 64 suggesting that these genotypes were considered to possess stability of performance over the range of environments. Considering the regression coefficient and deviation from regression for yield per five plants, Hansraj, Kalanamak 3114-1-SN and UPR 3618-15-1-2, were found to be the stable genotypes. The mean values of these genotypes are 44.31, 43.93 and 43.84 respectively. The highest mean was observed for Kalanamak 3119-P but it showed (*bi*) value greater than one and highly significant deviation (S^2dii) and therefore it can be concluded that it may not be a stable variety. The genotype Kalanamak 3131-P had high mean value (63.26), *bi* close to one and low S^2dii value indicating that this genotype is more stable with high mean over all the growing seasons considered (Table 3a & b).

Categorization of genotypes

Taking into account the wide variability shown by yield and other component characters, top three performing genotypes under each growing season were categorized (Table 4). During 2012, UPR 3717-4-1-1, IR 36, Kalanamak 3216-N and UPR 2825-30-1-2 showed highest values for yield per five plant, 1000 grain weight, panicle length and number of panicles respectively. The genotype, UPR 2825-30-1-2 showed highest value for yield per five plants, IR 36 for 1000 grain weight, Pant Sugandh Dhan 17 for panicle length and Hansraj, UPR 2825-30-1-2 for number of panicles during 2013. During 2014, UPR 3618-15-1-2 had highest value for yield per five plants, IR 64 had for 1000 grain weight, while Kalanamak 3216-N and Hansraj for panicle length and number of panicles respectively. On the whole when all the three years are considered together, genotypes like UPR 2825-30-1-2, UPR 3717-4-1-1, Hansraj, IR 36 and IR 64 showed the best performance than others.

The present study provided an evaluation of genotypic and environmental performance of thirty rice genotypes over three environments. Significant differences among the genotypes and environment for yield trait suggested the presence of wide variability. Both components of genotypes x environment interaction were significant, indicating that the major portion of interaction was linear in nature and prediction about the environments was possible. Significant pooled deviations observed for 1000 grain weight and yield trait, suggested that there are considerable genotypic differences. Thus it can be concluded that GXE interactions have played a significant role in the expression of yield per five plants. As rice is grown in different soil types with varying levels of soil fertility and management in India, it is necessary to test the stability for yield across different soil types and over years. Though linear response to environmental conditions was observed, non-linear response was also equally evident, necessitating multilocation and multi- season evaluation of genotypes that can be used as donor parents in breeding programs.

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