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ASSESSMENT OF ADAPTABILITY IN EARLY RICE VARIETIES

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ABSTRACT

Twelve early maturing rice varieties were evaluated for their yield performance over 30 environments created through combination of different cultural practices both in wet (kharif) and dry (rabi) seasons. Highly significant genotype-environment interaction indicated differential response of the genotypes to environmental changes. The stability analysis showed significance of linear component of variation for grain yield. Annapurna followed by Sarathi combine high yield with high stability. Parijat and Keshari with medium yield exhibited high stability. IR 36 with high yield was moderately stable. By stratifying the test environments into low, medium and high yielding ones, the results obtained by separate regression analysis brought out Annapurna, Parijat and Keshari adaptible to all environments while Sarathi and IR 36 to high yielding environments, and three tall varieties to low yielding environments. Parijat followed by Keshari were identified as unique genotypes showing relatively low response in unfavourable environments and high response to favourable ones. The usefulness of stability analysis in different categories of environments for assessment of adaptability of early rice varieties under rainfed uplands and its breeding implications for yield improvement are discussed.

Key words: *Oryza sativa*, rice, environment, regression analysis, stability, adaptability.

The early varieties of rice (*Oryza sativa* L.) are usually direct seeded under rainfed conditions in the wet season (kharif) and transplanted in dry season (rabi) under irrigated conditions. The management practices vary greatly from season to season and even in a season depending on the socioeconomic status of the farmers. The economically backward farmers adopt poor management practices not favourable for proper growth of the crop, while the well-to-do farmers can afford to raise the crop under more favourable conditions. Wide adaptability to various environmental conditions is, therefore, very important for early rice varieties because they are expected to be grown over a wide range of agro-ecosystems. This calls for evaluation of early rice varieties over a wide range of environments in order to assess their adaptability. The stability analysis following Eberhart and Russell [1] has been used extensively in many crop plants including rice to quantify the response of genotypes to different environments and also to assess the stability of performance [2–5]. According to this model, the genotypes having similar yield levels over all environments, same regression coefficient and same deviation from regression are considered to have similar adaptability. However, this may not always hold good when genotypes differ in their regression response on stratification of variable environments into two or three classes such as low, medium and high yielding ones as shown in Fig. 1 [6]. The present investigation aims at analysing the yield performance of the genotypes in such stratified environments which will permit detection of genotypes suitable for general adaptability and/or for specific adaptation.

MATERIALS AND METHODS

Grain yield of 12 early rice varieties including three traditional upland cultivars was evaluated in randomized block design with three replications at Central Research Station, O.U.A.T., Bhubaneswar. The materials were grown in wet (kharif) season under 10 environments created by combining five dates of seeding with two methods of planting, i.e., direct seeding and transplanting, with the fertilizer dose of 80:40:40 kg NPK/ha. The same set of experiments was repeated in dry (rabi) season with two fertilizers doses, i.e., 80:40:40 and 40:20:20 kg NPK/ha, thus creating 20 environments. The grain yield per plot in all the 30 environments was used for stability analysis following Eberhart and Russell [1].

Mean yield of all the varieties for each experiment was used for quantitative grading of the environments. The 30 environments were grouped into low, medium and high yielding classes on the basis of the mean (M) of all the experimental means and their standard deviation (S):

(i) Environments with mean yield less than (M – 0.7 S) were considered as low yielding environments.

(ii) Environments with mean yield more than (M + 0.7 S) were considered as high yielding environments.

(iii) The remaining environments with mean yield of (M $\pm$ 0.7 S) were categorized as medium yielding environments.

This method was considered appropriate as M $\pm$ 0.7 S covers 51.6% of the area in a normally distributed population. Following this method, the 30 environments were classified into the following three groups, each with 10 environments:

Low yielding (< 20 q/ha) environments: 1, 2, 3, 4, 5, 11, 15, 24, 28, 30.

Medium yielding (20–28 q/ha) environments: 9, 10, 14, 18, 20, 22, 25, 26, 27, 29.

High yielding (> 28 q/ha) environments: 6, 7, 8, 12, 13, 16, 17, 19, 21, 23.

Regression coefficient and mean yield of the varieties over the 10 environments in each group were computed.

RESULTS AND DISCUSSION

The pooled analysis of variance for grain yield over 30 environments showed highly significant differences due to genotypes, environments and genotype x environment interactions and also in all the three sets of environments (low, medium and high yielding). Highly significant interaction component indicated differential reaction of the genotypes to environments. The analysis of variance for stability of performance over 30 environments as well as in each set of environments showed that a major portion of the variation could be attributed to linear response of the genotypes to environmental changes. Significant pooled deviation indicated differences among the genotypes in respect of their deviation from linear regression.

Mean grain yield over 30 environments indicated that Annapurna was the top yielder, followed by IR 36 and Sarathi and the three tall varieties N 2, Blackgora and Kalakeri, yielded even lower than the lowest yielding semidwarf, OR 165-18-8 (Table 1). Annapurna also recorded the highest yield in three sets of environments and N 22, the lowest (Table 2 and Fig. 2). Consistently higher yield than the average in all the three sets of environments indicated that Annapurna, Rasi, IR 36, Sarathi and Keshari had high yield potential. On the other hand, the yield potential of the three tall varieties and OR 165-18-8 was low in all types of environments.

Table 1. Stability parameters for grain yield (q/ha) of rice varieties grown under 30 different environments

Variety	Plant type	$\overline{X}$	b	S^2_{di}	a
Annapurna	Dwarf	30.1	1.02	12.2	5.45
Parijat	Dwarf	24.6	0.85	12.0	3.91
Suphala	Dwarf	24.7	1.18	7.6	– 4.05
Rasi	Dwarf	27.2	1.22	8.1	– 2.46
IR 36	Dwarf	27.7	0.98	22.6	4.01
CR 143-2-2	Dwarf	23.9	1.06	19.4	– 1.81
OR 165-18-8	Dwarf	21.3	1.06	19.5	– 4.26
Sarathi	Dwarf	27.6	1.09	8.2	1.12
Keshari	Dwarf	26.8	1.26	6.3	3.63
N 22	Tall	17.6	0.62	11.3	2.53
Blackgora	Tall	19.4	0.91	10.4	– 2.76
Kalakeri	Tall	20.3	0.77	15.1	1.61
Mean		24.3	1.00	12.6	0.58
S.E.		1.8	0.05	1.5	1.00

The estimates of the three stability parameters following Eberhart and Russell [1] and the intercept according to Blum [7] revealed that the variety Annapurna was the most stable line having above average mean ($\bar{X}$ and regression coefficient (b) close to unity (Table 1). However, mean deviation (S^2_{di}) was moderate but additional evidence of its stability of performance was provided by high magnitude of intercept (a = 4.45). The variety Sarathi also combined high yield with high stability. With moderate yield and regression slope less than one, Parijat can also be considered to be stable because of high intercept (a = 3.91) and moderate mean deviation (S^2_{di} = 12.0). The variety Keshari combined above average mean with high intercept and high value of b, indicating high response to favourable environmental conditions. It also had the lowest S^2_{di} (6.3), suggesting high predictability. The variety IR 36 showed the most suitable combination for mean, a and b, but due to the highest value of S^2_{di} its performance was unpredictable while Rasi combined high predictability with good response to better growing conditions. On the other hand, the entries CR 143-2-2 and OR 165-18-8 showed the value of b close to unity but showed low stability as indicated from very high S^2_{di} and low intercept, and the variety Suphala with low S^2_{di}, had b value more than one and low intercept (– 4.05), therefore, it was less stable. Three tall cultivars with low values of b

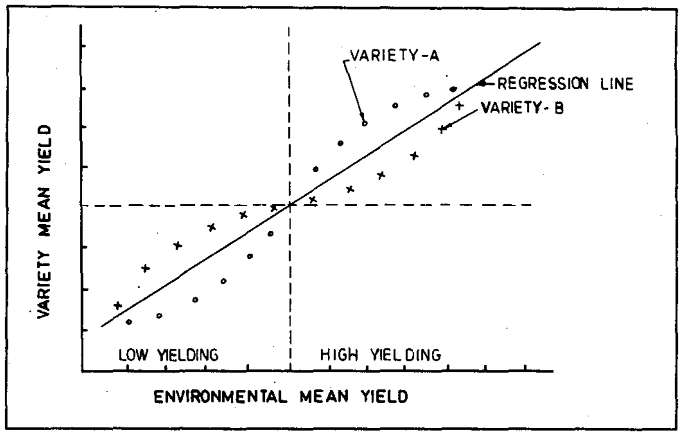


Fig. 1. Schematic yield trends of two varieties (A & B) and their regression lines showing the relationship between mean yields of the two varieties and environmental means.

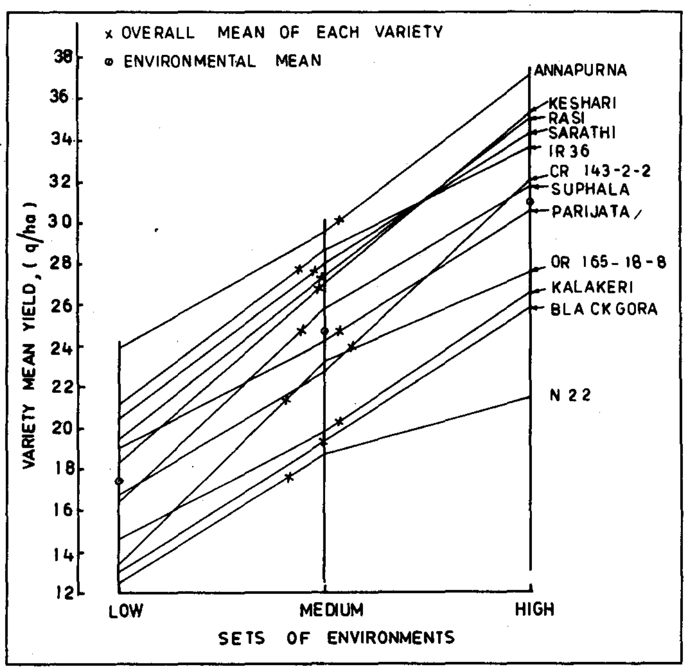


Fig. 2. Mean yield of varieties in three sets of environments.

Table 2. Stability parameters for grain yield (q/ha) of rice varieties in three sets of environments

Variety	Plant type	Low yielding set				Medium yielding set				High yielding set			
		$\bar{X}$	b	S^2_{di}	a	$\bar{X}$	b	S^2_{di}	a	$\bar{X}$	b	S^2_{di}	a
Annapurna	Dwarf	23.9	1.09	29.1	4.91	29.4	1.30	8.9	−2.44	37.1	0.78	11.9	12.96
Parijat	Dwarf	19.0	0.08	14.0	17.65	24.2	1.77	10.9	−19.17	30.5	1.65	5.9	−20.57
Suphala	Dwarf	16.4	1.41	16.8	−8.11	25.8	1.79	3.3	−18.00	31.8	1.39	2.1	−11.20
Rasi	Dwarf	19.4	1.74	4.1	−10.83	27.2	1.54	2.7	−10.50	35.1	1.51	11.3	−11.60
IR 36	Dwarf	21.1	2.15	4.3	−16.24	28.4	0.17	29.1	24.22	33.6	0.62	22.2	14.42
CR 143-2-2	Dwarf	16.7	0.31	21.1	11.35	22.8	1.80	14.5	−21.22	32.0	0.58	20.5	14.07
OR 165-18-8	Dwarf	13.2	0.59	14.2	2.98	23.2	0.86	21.1	2.16	27.6	1.86	22.3	−29.96
Sarathi	Dwarf	20.4	1.94	5.3	−13.36	28.0	0.44	4.6	17.24	34.3	1.23	10.5	−3.70
Keshari	Dwarf	18.3	1.03	10.1	0.38	27.0	1.68	8.3	−14.16	35.2	1.44	3.5	−9.30
N 22	Tall	12.4	0.00	7.2	12.41	18.7	−0.32	11.1	26.54	21.5	0.60	16.4	2.99
Blackgora	Tall	13.0	0.89	10.0	−2.43	19.4	0.45	6.1	8.33	25.8	0.75	20.0	2.59
Kalakeri	Tall	14.6	0.09	8.3	13.03	19.7	0.68	9.9	3.06	26.6	−0.25	21.9	34.36
Mean		17.4	1.00	12.0	0.98	24.5	1.01	10.9	−0.33	30.9	1.01	14.0	−0.41
S.E.		1.0	0.21	2.2	3.28	1.1	0.21	2.2	4.87	1.4	0.17	2.2	5.11

were least responsive to change in environments and may be suitable for agroclimatic regions of low productivity. However, among the three, the variety N 22 with high intercept (a = 2.53) and moderate S^2_{di} was comparatively more stable.

The high magnitude of genotype-environment interaction made it possible to categorize environments into homogeneous groups and identify genotypes adaptable to specific and/or varied environmental conditions. The differences in regression responses of a genotype in favourable versus unfavourable environments were further examined after grouping the 30 environments into low, medium and high yielding environments. The regression slopes with respect to all genotypes indicated that the magnitude of response of different varieties was not constant over the three sets of environments (Table 2). The rank correlations between the values of b in the three sets were not significant (r = – 0.098, 0.189 and 0.329 between low and medium, low and high, and medium and high, respectively), indicating differential response of at least some of the genotypes which could not be detected by computing the regression coefficient over all the 30 environments. The regression slope of the genotypes with positive intercept in overall analysis varied greatly in low and high yielding sets of environments (Fig. 3). Unlike tall varieties showing low value of b in three sets of environments, Parijat exhibited low response in unfavourable (low yielding) environments and high response when environmental conditions improved (medium and high yielding environments). Next to Parijat, Keshari was found to show average response to change in growth conditions under low yielding set of environments and high response under favourable environments.

Based on the results of the analysis, the varieties tested were grouped as follows:

(i) Adapted to all environments: Annapurna, Parijat and Keshari.

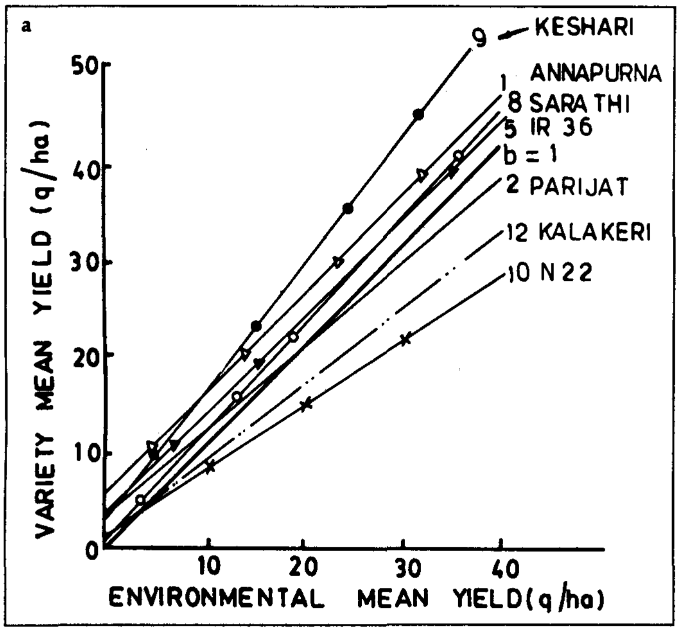
(ii) Adapted to high yielding environments: Sarathi and IR 36.

(iii) Adapted to low yielding environments: N 22, Blackgora and Kalakeri.

(vi) Poor adaptability to all environments: Suphala, Rasi, CR 143-2-2 and OR 165-18-8.

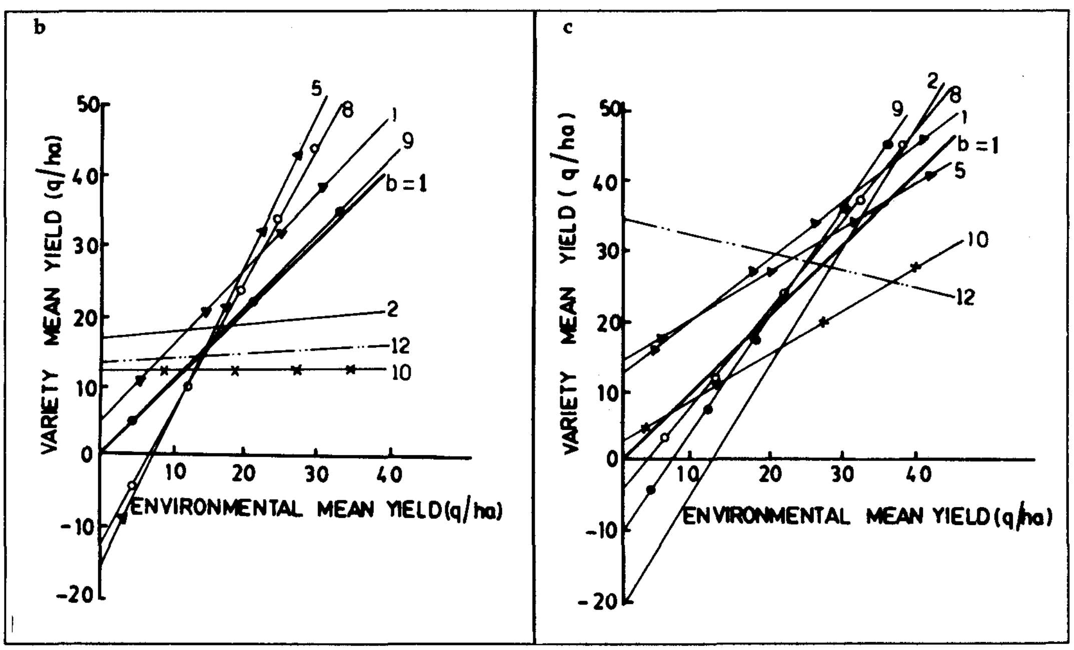
The traditional tall varieties are now not in wide cultivation because of their low productivity, whereas among the early semidwarf varieties grown in Orissa, Annapurna and Parijat owing to their wider adaptability occupy more area followed by Keshari, Annapurna even with red kernel, is grown over more area than Parijat because of its high yield potential and uniformly average response over environments.

The results suggest that in a given array of environmental conditions, categorization of the environments provides more information on adaptability of genotypes under a set of



Over all environments

field trials. Hence, selection under stratified environments would prevent biased estimates unlike selection based only on performance tests under different environments. The stability analysis in stratified environments enables the breeder to identify genotypes more precisely for direct use in appropriate environments and/or for utilization in breeding programme as parents. By growing segregating materials under varied environmental conditions such analysis would help to identify



Low yielding environments High yielding environments

Fig. 3. Regression of variety yields on environmental mean yield.

promising crosses and/or breeding lines for further evaluation. This procedure is simple and more convenient than the complicated curvilinear regression analysis. Further, curvilinear response is not necessarily favoured in the favourable environments because we would like to minimise the deviations from linearity under these environments.

Sufficient evidence is now available that productivity ($\bar{X}$) and production response (b) are two independent genetically controlled characters which can be manipulated for crop improvement [8–10]. The identification of genotypes with varying degree of productivity and production response suggests that response (b) has not only separate genetic control but also there may be two distinct sets of gene-systems controlling sensitivity in the contrasting environments in addition to some common genes. The variety Parijat in the present study was found to possess such gene combinations. Besides identification of genotypes like Annapurna, Parijat and Keshari for commercial cultivation in uplands, the results further suggest that the crosses of low yielding and less responsive tall varieties Blackgora, Kalakeri and N 22, with high yielding and more responsive Annapurna, Sarathi and IR 36 are likely to produce better genotypes with new combination of genes. It was observed in the F_1 generation that such crosses produced high yield and exhibited high heterosis, thus indicating the breeding potential of the crosses [11].

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