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RELATIVE USEFULNESS OF STABILITY PARAMETERS IN ASSESSING ADAPTABILITY IN RICE

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ABSTRACT

Twelve rice varieties were grown under 30 environments created through the combination of different dates of seeding, methods of planting, doses of fertilizer and growing seasons. The stability of performance for grain yield of the varieties was assessed using nine different parameters. Variations due to genotypes, environments, and genotype x environment interactions were highly significant and a large portion of these interactions was due to linear regression. Highly significant mean squares were observed for linear as well as nonlinear components. The genotypes were grouped into low, medium and high stability classes for each of the nine parameters and numerically scored on three-point scale. It was evident from the computation of total score that the parameters $\overline{X}$, b, s^2_d, and a were adequate in assessing the yield stability of the genotypes. Five varieties, Annapurna, Parijat, Sarathi, Keshari, and IR 36, were the most stable genotypes with high yield potential.

Key words: Rice, regression analysis, stability parameters, yield stability.

Crop breeding presently aims at developing varieties with high yield potential coupled with wide adaptability. Evaluation of varieties for stability of performance through regression analysis was first done in barley by Finlay and Wilkinson [1] and subsequently by Eberhart and Russell [2] in maize. Since then, the method has been used in evaluating stability of performance in different field crops including rice. In most of these studies the test entries were evaluated over locations and years or cropping seasons. Thus, variation in environment is created due to differences in edaphic and climatic factors. It is equally important to consider differences in cultural practices as a result of change in date and method of planting, fertilizer application, etc. This study was undertaken to assess the stability of performance of rice genotypes grown under different dates, methods of planting and doses of fertilizer application. Attempt was also made to examine the relative usefulness of different parameters in evaluating varietal stability for grain yield.

MATERIALS AND METHODS

Twelve early rice varieties, including three traditional tall genotypes, namely, Blackgora, Kalakeri and N 22, and nine semidwarfs were grown under 30 environments created through the combination of five dates of seeding at 10 days intervals and two methods of planting (direct seeding and transplanting) repeated in kharif and rabi seasons and with two doses of fertilizer only in rabi, i.e., 80:40:40 and 40:20:20 kg/ha N:P:K. The field layout was done in RBD with three replications, with the plot size of 2.15 x 0.75 m, and row to row spacing of 15 cm both under direct seeding and transplanting. In the latter case 25-day-old seedlings were transplanted 15 cm apart with one seedling per hill.

Analysis was carried out following Eberhart and Russell [2]. Stability of performance of the varieties was assessed using $\overline{X}$, b and S^2_d parameters of Eberhart and Russell [2] and six other parameters like intercept (a) in the regression model, coefficient of determination (r^2) of Pinthus [3], difference between the minimum and maximum values for varietal means (R_1), and difference between varietal means in the least favourable and the most favourable environments (R_2) as proposed by Langer et al. [4], ecovalence (w) following Wricke [5] and coefficient of variation (CV).

The estimates of stability parameters of individual genotypes were ranked as low, medium and high, and numerically scored on three-point scale as 1, 2 and 3, respectively. Delimitation of the three classes were done on the basis of the mean (M) and standard error (SE) of the estimates of all the parameters. Numerical score 1 was assigned to the lower class with values < (M-SE), score 2 for (M $\pm$ SE), and score 3 for the upper class with values > (M+SE) for the parameters $\overline{X}$ and a. Low estimates of the remaining seven parameters were desirable for high stability and numerical score of these parameters was in reverse order, i.e., values > (M+SE) = 1, (M$\pm$SE) = 2, and < (M- SE) = 3. Finally, stability of each genotype was assessed by computing total score on the basis of (i) $\overline{X}$, b and S^2_d; (ii) $\overline{X}$, b, S^2_d and a; and (iii) all the nine parameters. Higher total score indicated higher stability of performance of the genotype.

RESULTS AND DISCUSSION

Pooled analysis of variance for grain yield (Table 1) showed highly significant differences due to genotypes and environments, indicating presence of variation among genotypes as well as among environments. Significant G x E interaction component indicated differential response of genotypes to environmental changes. Regression analysis indicated that the mean sum of squares due to environment (linear) was highly significant, indicating that a major part of variation could be attributed to linear regression. The significant G x E interaction (linear) suggested that the genotypes differed greatly in their linear response to different environments.

The stability of performance of the genotypes for grain yield was assessed on the basis of nine parameters, including three of Eberhart and Russell [2]. The genotypes differed greatly with respect to each of the nine stability parameters (Table 2). The coefficient of variation of the estimates due to genotypes was maximum for intercept, followed by S^2_d, w, R_2, b, r^2, R_1, $\bar{X}$ and CV in descending order.

Table 1. Pooled analysis of variance for grain yield in rice

Source	d.f.	Mean squares
Genotype (G)	11	452.0**
Environment (E)	29	444.1**
G x E	319	16.5**
E + (G x E)	348	—
Environment (linear)	1	12878.4**
G x E (linear)	11	40.8**
Pooled deviation	336	14.3**
Pooled error	660	1.9

**Significant at 1% level.

Table 2. Estimates of stability parameters for grain yield (q/ha) of 12 rice varieties

Variety	$\bar{X}$	b	S^2_d	a	r^2	R_1	R_2	w	CV
Annapurna	30.1	1.02	12.2	5.45	0.74	27.8	24.4	398.4	23.9
Parijat	24.6	0.85	12.0	3.91	0.67	22.9	19.8	412.7	25.4
Suphala	24.7	1.18	7.6	−4.05	0.85	28.8	24.3	295.9	31.1
Blackgora	19.4	0.91	10.4	−2.76	0.72	25.8	12.9	355.0	33.2
Kalakeri	20.3	0.77	15.1	1.61	0.57	21.2	11.9	532.9	30.0
CR 143-2-2	23.9	1.06	19.4	−1.81	0.67	30.8	23.8	592.3	33.0
OR 165-18-8	21.3	1.06	19.5	−4.26	0.67	26.7	22.7	601.1	36.9
Sarathi	27.6	1.09	8.2	1.12	0.82	28.6	28.6	296.3	26.6
Keshari	26.8	1.26	6.3	3.63	0.88	30.0	27.3	305.5	30u3
N22	17.6	0.62	11.3	2.53	0.53	20.9	13.5	530.4	29.5
Rasi	27.2	1.22	8.1	−2.46	0.88	35.9	35.9	196.5	29.2
IR 36	27.7	0.98	22.6	4.01	0.62	28.0	26.7	633.2	27.3
Mean	24.3	1.00	12.6	0.58	0.72	27.3	22.7	429.2	29.7
SE	0.9	0.05	1.5	1.00	0.03	1.2	2.1	41.8	1.1
CV	16.0	18.9	42.6	597.3	16.5	16.2	31.5	33.7	12.2

$\bar{X}$ — mean grain yield in q/ha of each variety over environments, b — regression coefficient, S^2_d — deviation mean square, a — intercept, r^2 — coefficient of determination, R_1 — difference between extreme values for varietal mean, R_2 — difference between varietal means in extreme environments, w — ecovalence, CV — coefficient of variation.

The correlation coefficients among the nine stability parameters (Table 3) indicated that mean ($\overline{X}$) exhibited significant positive correlation with b, r^2 and R_2 and negative correlation with CV. The regression coefficient (b) showed highly significant positive correlation with

Table 3. Correlation coefficients between different stability parameters in rice

Parameter	b	S^2_d	a	r^2	R_1	R_2	w	CV
$\overline{X}$	0.66*	−0.19	0.24	0.60*	0.50	0.81**	−0.37	−0.60*
b		−0.33	−0.57	0.90**	0.85**	0.83**	0.53	0.12
S^2_d			0.23	−0.70*	−0.24	−0.25	0.94**	0.28
a				−0.50	−0.56	−0.18	0.23	−0.81**
r^2					0.74**	0.73**	−0.85**	−0.06
R_1						0.78**	−0.45	0.20
R_2							−0.44	−0.21
w								0.27

*,**Significant at 5% and 1% levels, respectively.

r^2, R_1 and R_2. The S^2_d showed highly significant positive correlation with w. The correlation coefficients of r^2 with S^2_d and w were significantly negative. The significant correlation of r^2 with b (positive) and S^2_d (negative) in the study indicated that r^2 did not provide any additional information over the combined use of b and S^2_d. The high value of r^2 only confirms linear response of the varieties to change in environment. It was further observed that intercept (a) had highly significant negative correlation only with CV. Out of the six additional parameters, five showed significant correlation with either of the three stability parameters of Eberhart and Russell, while intercept was an exception. Thus, it is clear that the parameters $\overline{X}$, b, S^2_d and a were adequate in assessing the yield stability of the genotypes.

All the 12 genotypes were grouped into three stability classes, i.e., low, medium and high, for each of the nine parameters and numerically scored on three-point scale (Table 4). The stability of performance of each genotype was assessed by computing numerical index score. Delimitation of the three stability classes, i.e., low, medium and high, based on nine parameters was in broad agreement with that based on three parameters ($\overline{X}$, b and S^2_d). Moreover, addition of the intercept (a) to the three parameters resulted in close correspondence with the differentiation obtained on the basis of all the nine parameters. Thus, it is now

Table 4. Numerical score of stability parameters for grain yield of 12 rice varieties

Variety	Numerical score for the parameters											
	$\overline{X}$	b	S^2_d	cumulative total	a	cumulative total	r^2	R_1	R_2	w	CV	grand total
Annapurna	3	2	2	7	3	10	2	2	2	2	3	21
Parijat	2	3	2	7	3	10	3	3	3	2	3	24
Suphala	2	1	3	6	1	7	1	1	2	3	1	15
Blackgora	1	3	3	7	1	8	3	3	3	3	1	21
Kalakeri	1	3	1	5	3	8	3	3	3	1	2	20
CR 143-2-2	2	1	1	4	1	5	3	1	2	1	1	13
OR 165-18-8	1	2	1	4	1	5	3	2	2	1	1	14
Sarathi	3	1	3	7	2	9	1	1	1	3	3	18
Keshari	3	1	3	7	3	10	1	1	1	3	2	18
N 22	1	3	2	6	3	9	3	3	3	1	2	21
Rasi	3	1	3	7	1	8	1	1	1	3	2	16
IR 36	3	2	1	6	3	9	3	2	1	1	3	19

Note. 1 — Low stability, 2 — medium stability and 3 — high stability.

clear that the intercept had its contribution in assessing stability of performance of the genotypes.

From the above computation done in three ways, it was seen that varieties Annapurna and Parijat appeared to be highly stable while Suphala, CR 143-2-2 and OR 165-18-8 were least stable. In the two stable genotypes, Annapurna and Parijat, $\overline{X}$ and b conformed well to the required criteria for stability of performance, i.e. above average mean ($\overline{X}$) and b close to unity (Table 2). However, S^2_d was high but less than the average (12.6). While examining the utility of S^2_d, Kikuchi et al. [6] and Lin et al. [7] were of the opinion that it was not proper to attribute much importance to deviation from regression as it was considerably confounded with experimental error. Further, additional evidence for stability of performance of Annapurna and Parijat was supplied by high magnitude of intercept (a = 5.45 and 3.91) against the overall average of 0.58. Among the nine parameters, intercept gave a distinct picture. It did not show any significant correlation with any of the stability parameters except CV. Further, genotypic differences appeared to be the highest in respect of this parameter (Table 2). Biological implication of this parameter is hard to interpret. However, it is evident from the formula ($a = \overline{Y} - b\overline{X}$) that the magnitude of intercept of a genotype reflects its mean performance and its response. Therefore, it may be argued that intercept is not likely to provide any additional information over and above what is provided by mean and regression coefficient. But while assessing stability of performance of rice cultivars under moisture stress, Blum [8] emphasized the merit of intercept besides regression coefficient. In the present study, environmental stress was not specific (like drought) but of general type involving combined effect of soil and atmospheric factors associated with season, staggered sowing and fertilizer dose. When varieties are grown over several locations and years for evaluation of their stability of performance, the effect of environmental stress cannot be ignored, more particularly for early rice varieties grown in uplands. Hence, the usefulness of intercept in assessing yield stability of the varieties in the present study cannot be underestimated.

The three traditional tall varieties, Blackgora, Kalakeri and N 22, were fairly stable but with low level of production. These varieties with low values of b were least responsive to change in environment and may be preferred to agroclimatic situations of low productivity. The varieties Sarathi and Keshari were fairly stable even at high level of production as indicated by high mean and intercept, and low value of S_d^2 with b more than unity. These varieties may be preferred for areas of high productivity. The variety IR 36 showed fairly high stability with the most favourable combination of $\overline{X}$, b and a but had the highest value for S_d^2. On the other hand, the variety Rasi was considered to be fairly unstable as indicated by high b and low intercept. It is, therefore, concluded that the varieties Annapurna, Parijat, Keshari, Sarathi and IR 36 may be utilized in future breeding programme to develop high yielding genotypes with stable performance.

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