*Indian J. Genet.*, **58**(3): 297-306 (1998)

# AN ALTERNATIVE APPROACH TO ANALYSIS OF GENOTYPIC ADAPTATION IN RICE

K. C. MAHAPATRA AND S. DAS

*Department of Plant Breeding and Genetics,*
*Orissa University of Agriculture and Technology, Bhubaneswar 751 003*

**(Received: July 3, 1997; accepted: October 10, 1998)**

## ABSTRACT

**Twelve rice varieties grown under 30 environments were evaluated for their adaptation through different approaches. Stratification of environments and considering mean yield of the genotypes in different grades of environment, the metroglyph analysis was done which showed that five genotypes were agronomically superior with wide adaptation and one with specific adaptation to favourable environments. This metroglyph analysis of stratified environmental average is considered to be a simple method which may be used even in preliminary evaluation of crop genotypes for their adaptation.**

**Key words :** *Oryza sativa*, rice, stratified environment, regression analysis, metroglyph analysis, adaptation.

Genotypes in any crop plant are known to exhibit inconsistent performance relative to each other in different environments. Such differential responses of genotypes and more particularly in rice which is grown under much diversified agro-ecosystems, pose problems for the breeders to decide which genotypes should be selected as cultivar. Of the numerous methods proposed to solve the problem of genotypes × environmental interaction, the linear regression analysis proposed originally by Yates and Cochran [1] and developed by Eberhart and Russell [2] is the most widely used method. A descriptive method proposed by Francis and Kannenberg [3] for grouping genotypes on the basis of mean yield and consistency of performance measured through coefficient of variation (CV) has also been used in the breeding programme. Recently a new approach has been suggested by Sinha [4] for evaluation of adaptation through metroglyph analysis. The purpose of this study is to assess adaptability of a set of 12 rice varieties through different methods and to compare relative importance of the methods.

## MATERIALS AND METHODS

The materials consisting of nine semidwarf varieties and three traditional tall cultivars (N22, Blackgora and Kalakeri) were grown under 30 environments created through combination of five dates of seedlings at 10 days intervals and two methods of planting (direct seeding and transplanting) in wet (kharif) season with a fertiliser dose of 80:40:40 kg/ha N:P:K. The same set of experiment was repeated in dry (rabi) season with two doses of fertilizer i.e., 40: 20: 20 and 80:40:40 kg/ha N:P:K. The experiment was conducted in a randomized complete block design with three replications. The plot size was 2.15 m × 0.75 m with a row to row spacing of 15 cm under both the methods of planting. In transplanted experiment, 25-day-old seedlings were planted 15 cm apart with one seedling per hill. The grain yield per plot was recorded and utilised for analysis.

The stability of performance of the genotypes for their grain yield was analysed following Eberhart and Russell [2]. On the basis of mean and coefficient of variation (CV), the genotypes were grouped into four categories following Francis and Kannenberg[3]. A semigraphic method termed as metroglyph analysis of stratified environmental averages (MASEA) by Sinha [4] was followed for evaluating pattern of adaptation of the genotypes. In this method,the environmental mean yields were scaled by Gower's method of ranging [5] for classification of environments.

$$\text{Gower's scale value} = \frac{\text{Real value} - \text{Minimum value}}{\text{Range}}$$

Through Gower's method, 16 environments had a scale value less than 0.5 and were categorized as low-yielding environments (LYE) and the remaining 14 with scale value 0.5 to 1.0 as high-yielding environments (HYE). Mean yield of 12 varieties in LYE and HYE were used as coordinates for scatter plots. Further, for scoring the yield performance of the genotypes in different grades of environments, the 30 test environments were classified into five groups, such as, very poor with scale value 0.0 to 0.19, poor 0.20 to 0.39, moderate 0.40 to 0.59, high 0.60 to 0.79 and very high 0.80 to 1.0 comprising 4, 6, 8, 9 and 3 environments, respectively. The mean yield of the varieties in each group were scored as 1 for low range, 2 for medium and 3 for high range, and depicted by rays in the scatter points of each variety. Adaptation index was calculated as the sum of index scores for yield in each class of environments. Groups of genotypes with different patterns of adaptation with reference to the grand mean in LYE/HYE and adaptation index values were identified.

## RESULTS AND DISCUSSION

The environments created for the study gave a wide range of mean yields (13.0 to 35.7 q/ha) caused by variable dates of sowing, methods of planting, fertilizer application and seasons. The combined analysis of variance for grain yield over 30 environments indicated significant differences among the genotypes and environments, and also presence of significant genotype × environment interaction (Table 1).

**Table 1. ANOVA for stability for grain yield in rce**

| Source | d.f. | M.S. |
|---|---|---|
| Genotypes (G) | 11 | 452.0** |
| Environments (E) | 29 | 440.1** |
| G × E | 319 | 16.5** |
| Environment (linear) | 1 | 12878.4** |
| G × E (linear) | 11 | 40.8** |
| Pooled deviations | 336 | 14.5** |
| Pooled error | 660 | 1.9 |

**Significant at 1% level

The interaction component was attributed to significance of both linear response of the genotypes and deviation from linearity. According to Finlay and Wilkinson [6] a rice genotype with general adaptation should have high mean and a regression coefficient of unity. Among the tested genotypes, Annapurna, IR 36 and Sarathi recorded higher mean yields with regression coefficient (b) close to unity (Table 2, Fig. 1A). But in presence of significant deviation from regressions, a widely adapted genotype must show a non-significant mean square deviation ($s_d^2$) as suggested by Eberhart and Russell [2]. The scatter points for individual genotypes in respect of mean yield and mean square deviation (Fig. IB) shows that Keshari had the lowest $s_d^2$ value (6.3) and IR 36 the highest (22.6). As the deviation square of all the genotypes in the present study were homogeneous as indicated by Bartlett's test and significantly different from zero, among the genotypes with high mean and b value close to unity, it was Annapurna followed by Sarathi which had relatively lower $s_d^2$ and they were considered to have better adaptation. However, the measurement of over all deviations from regressions is not strictly valid because the extent of deviation from regression is specific to and a characteristic of a particular genotype. It is observed that the mean yield of the genotype was positively associated with their production response, (b value) with r = 0.695*, while it did not exhibit any significant relation with the mean deviation from linearity (r = 0. 017). Thus high mean with high response warrants search for genotypes with moderately high yield with average response for wide adaptation.

**Table 2. Stability parameters for grain yield (q/ha) in rice**

| Variety | X | b | SE(b) | $S_d^2$ | CV(%) |
|---|---|---|---|---|---|
| Annapurna | 30.1 | 1.02 | 0.013 | 12.2 | 23.9 |
| Parijat | 24.6 | 0.85 | 0.013 | 12.0 | 25.4 |
| Suphala | 24.7 | 1.18* | 0.008 | 07.6 | 31.1 |
| Rasi | 27.2 | 1.22* | 0.009 | 08.1 | 29.2 |
| IR 36 | 27.7 | 0.98 | 0.023 | 22.6 | 27.3 |
| CR 143-2-2 | 23.9 | 1.06* | 0.019 | 19.4 | 33.0 |
| OR 165-18-8 | 21.3 | 1.06* | 0.019 | 19.5 | 36.9 |
| Sarathi | 27.6 | 1.09* | 0.009 | 08.2 | 26.6 |
| Keshari | 26.8 | 1.26* | 0.007 | 06.3 | 30.3 |
| N 22 | 17.6 | 0.62* | 0.012 | 11.3 | 29.5 |
| Blackgora | 19.4 | 0.91 | 0.011 | 10.4 | 33.2 |
| Kalakeri | 20.3 | 0.77 | 0.016 | 15.1 | 30.0 |
| Mean | 24.3 | 1.00 | | 12.6 | 29.7 |

*Significantly different from 1 at 5 per cent level

When exposed to different environments, the responsive genotype is not necessarily unstable rather more desirable if there is consistency in yield as measured by coefficient of variation (CV). The estimates of CV for 12 genotypes were high, ranging from 23.9 in Annapurna to 36.9 in OR 165-18-8 (Table 2). Following Francis and Kannenberg [3] when mean yield of the genotypes was plotted against coefficient of variation (Fig. 2), all the 12 genotypes were grouped into four classes. It shows that among 5 genotypes in group-1 (Annapurna, Parijat, Rasi, IR 36 and Sarathi) having mean yield above average (grand mean) and lower magnitude of variation (below average CV), Annapurna had the highest mean yield and lowest CV, thus indicating its wider adaptability as compared to others.

The environments where rice is usually grown include both predictable and unpredictable factors. Hence, there is a great need to evaluate adaptation of the genotypes in different grades of environment. The thirty test environments were broadly classified into low yielding and high-yielding ones comprising 14 and 16 environments, respectively following Gower's ranging method as suggested by Sinha [4]. The mean yields of the 12 varieties in low and high yielding environments

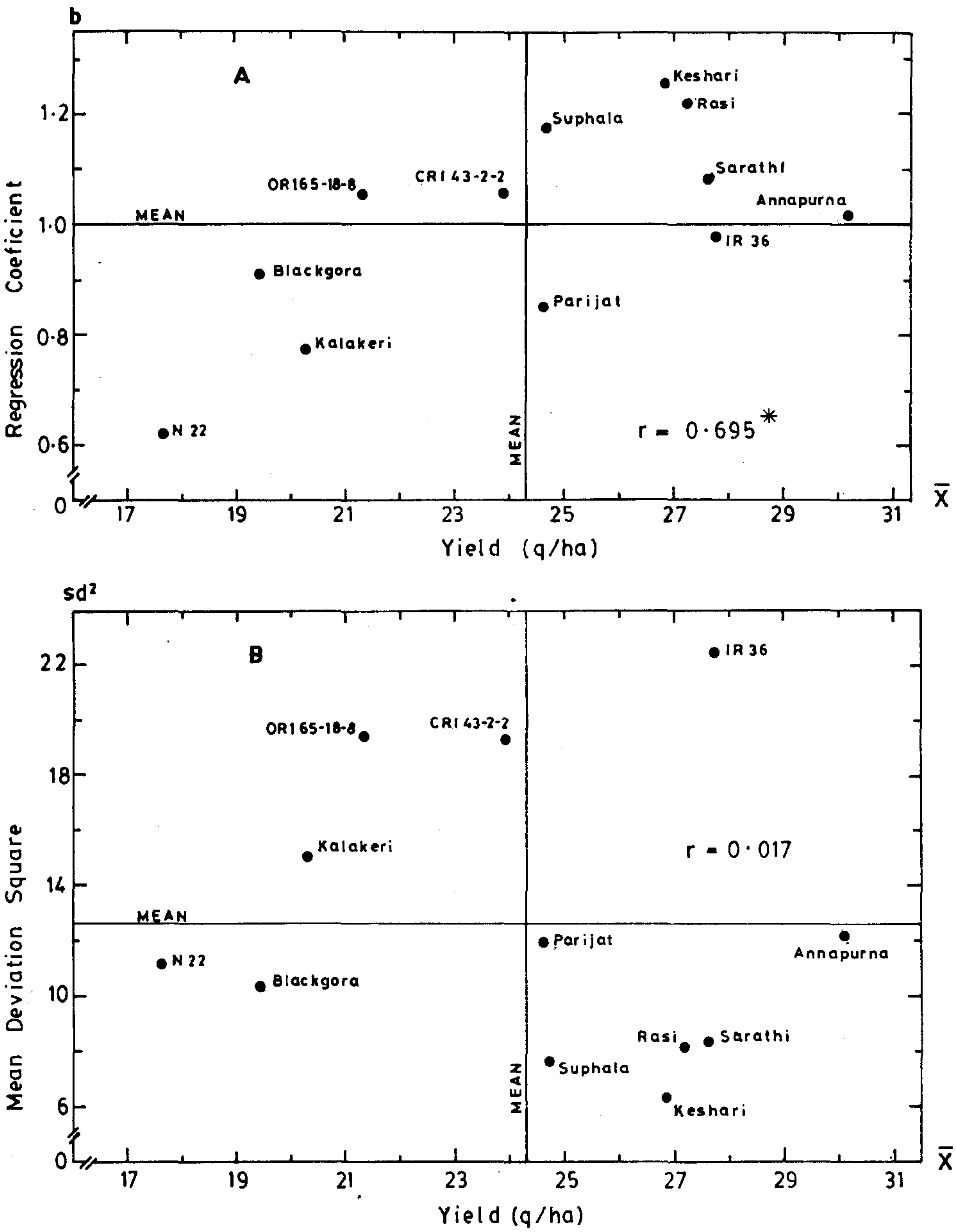


Fig. 1. (a) Scatter diagram showing relatonship of mean grain yield wth regression coefficient (b) (A) and mean square deviation $Sd^2$ (B) for 12 rice varieties in 30 environments

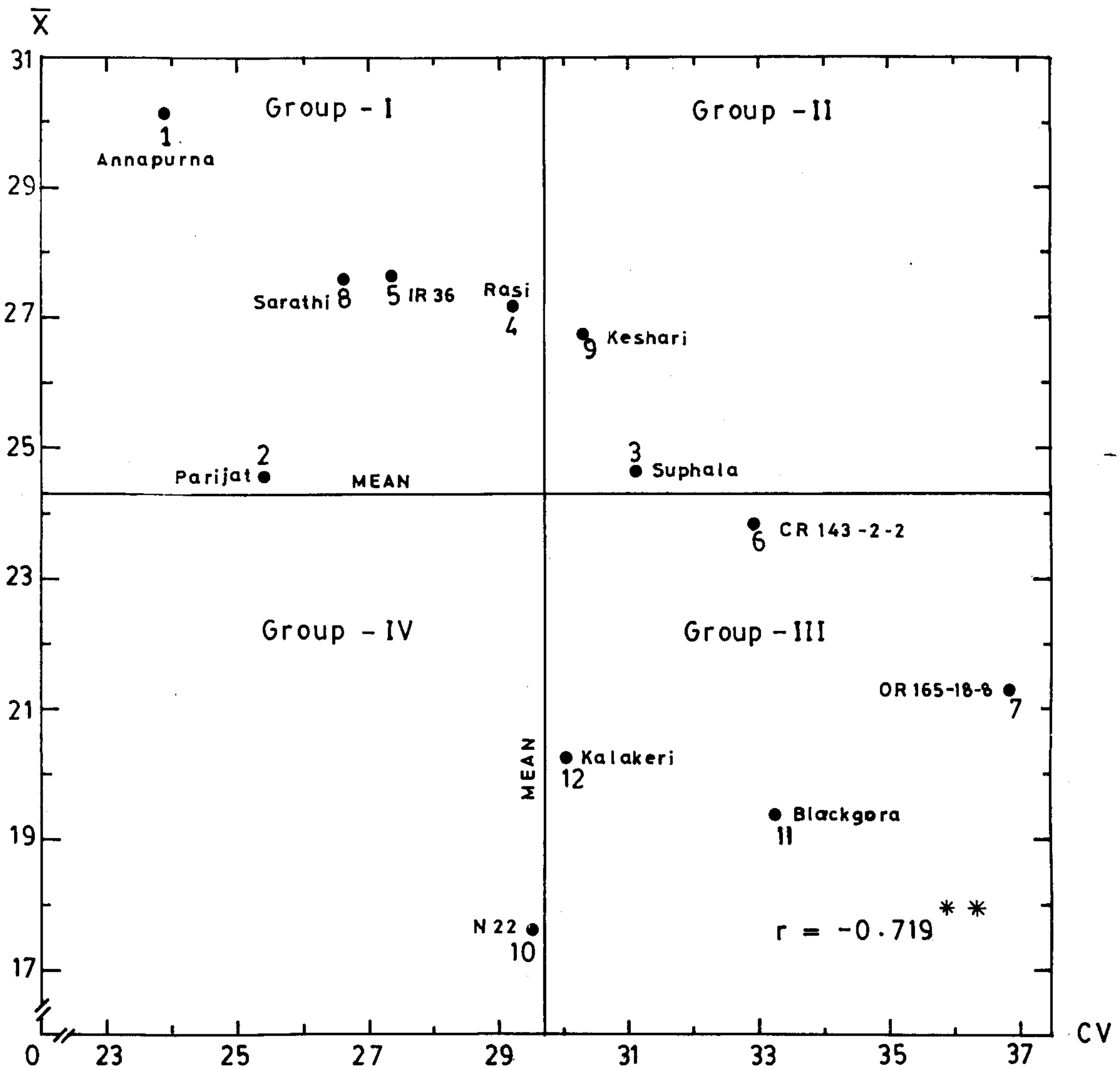


Fig. 2. Mean grain yield ($x$ in q/ha) plotted against cv for 12 varetes tested in 30 environments

depicted in Fig. 3 shows that five varieties namely Annapurna, Rasi, IR 36, Sarathi and Keshari in group-II had high yield both in unfavourable (low yielding) and favourable (high-yielding) environments and they are agronomically superior. On the other hand four varieties namely OR 165-18-8, N 22, Blackgora and Kalakeri in group IV yielded less than the average in both and they are agronomically inferior and undesirable. Among the remaining three varieties, Parijat had average yield in favourable environment and above average in unfavourable environments, whereas Suphala and CR 143-2-2 had above average in favourable environments and below average in unfavourable environments. The thirty environments were further classified in to five subtle groups such as very poor, moderate, high and very high yielding environments to study the pattern of adaptation of the varieties through metroglyph analysis [4]. Mean yield of a variety in each environmental group was depicted as a ray in the metroglyph on the basis of index score as 1, 2 and 3 for low, medium and high range respectively. From the metroglyph diagram (Fig. 3) it is clear that among five varieties in group-II, only Annapurna had the best yield performance in all five categories of environments scoring maximum adaptation index of 15 (Table 3) thus showing its wider adaptability. Rasi and Sarathi each with adaptation index 14, and R 36 and Keshari each with a score of 13 for adaptation index were next to Annapurna in order of importance for their adaptability. However, the two varieties namely IR 36 and Sarathi having higher productivity in LYE are considered to have better adaptability rather than Rasi and Keshari (Fig. 3). Further, it is evident from Table 3 that Sarathi had higher adaptation index than IR 36 and also higher yield performance in four out of five categories of environments as against three in case of IR 36. Parijat is considered to be unique possessing higher level of production in two extreme categories of environments.

**Table 3. Adaptation index scores for 12 varieties in five classes of environment**

| Variety | Very poor | Poor | Moderate | High | Very high | Adaptation index |
|---|---|---|---|---|---|---|
| Annapurna | 3 | 3 | 3 | 3 | 3 | 15 |
| Parijat | 3 | 2 | 2 | 2 | 3 | 12 |
| Suphala | 1 | 2 | 2 | 2 | 3 | 10 |
| Rasi | 2 | 3 | 3 | 3 | 3 | 14 |
| IR 36 | 2 | 3 | 3 | 3 | 2 | 13 |
| CR 143-2-2 | 3 | 1 | 1 | 3 | 2 | 10 |
| OR 165-18-8 | 1 | 1 | 2 | 2 | 2 | 8 |
| Sarathi | 2 | 3 | 3 | 3 | 3 | 14 |
| Keshari | 2 | 2 | 3 | 3 | 3 | 13 |
| N 22 | 1 | 1 | 1 | 1 | 1 | 5 |
| Blackgora | 1 | 1 | 1 | 1 | 1 | 5 |
| Kalakeri | 2 | 1 | 1 | 2 | 1 | 7 |

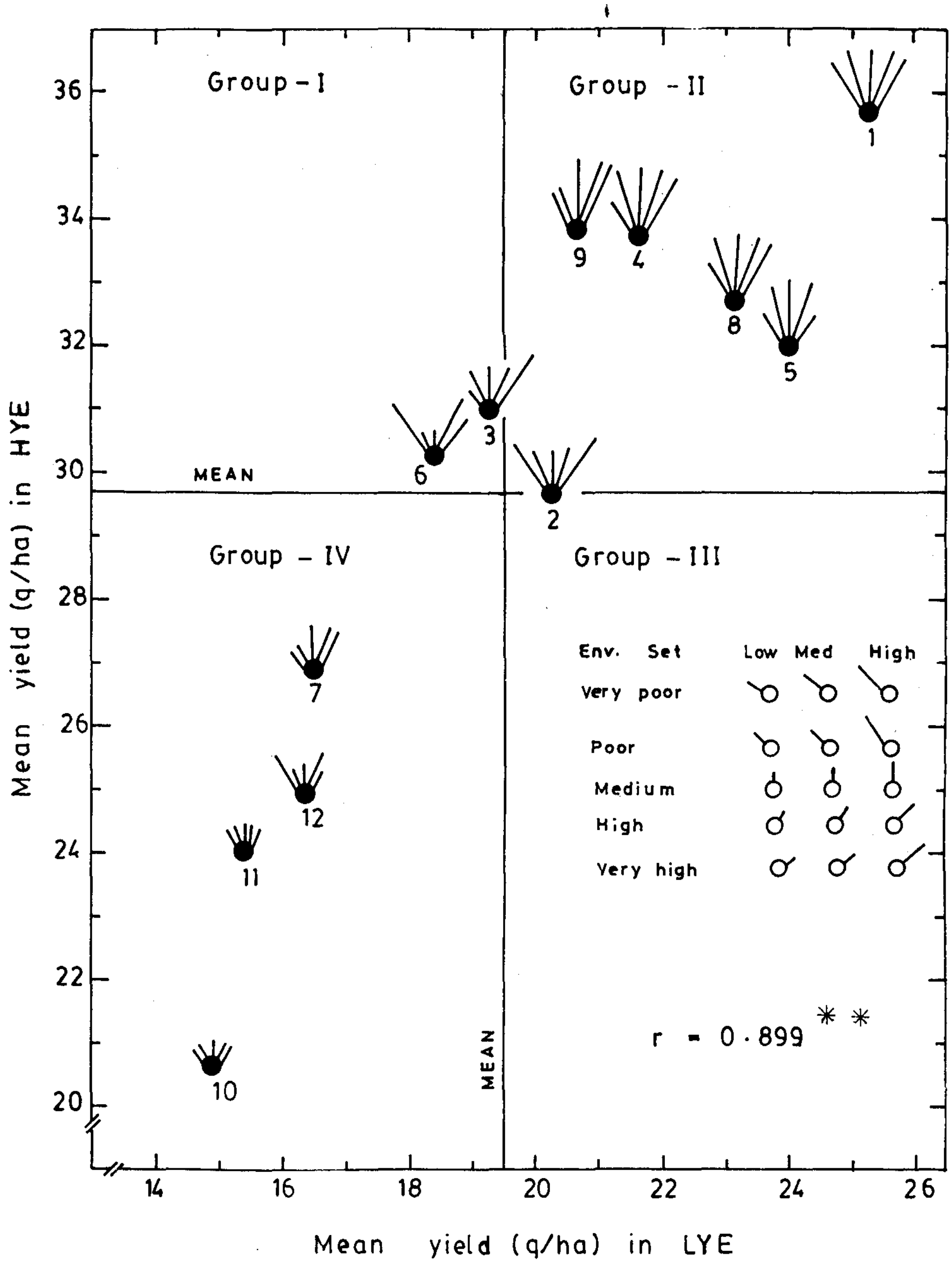


**Fig. 3. Metroglyph scatter diagram of 12 rice varieties based on mean yield in five sets of environments. Variety nos. as in Fig. 2.**

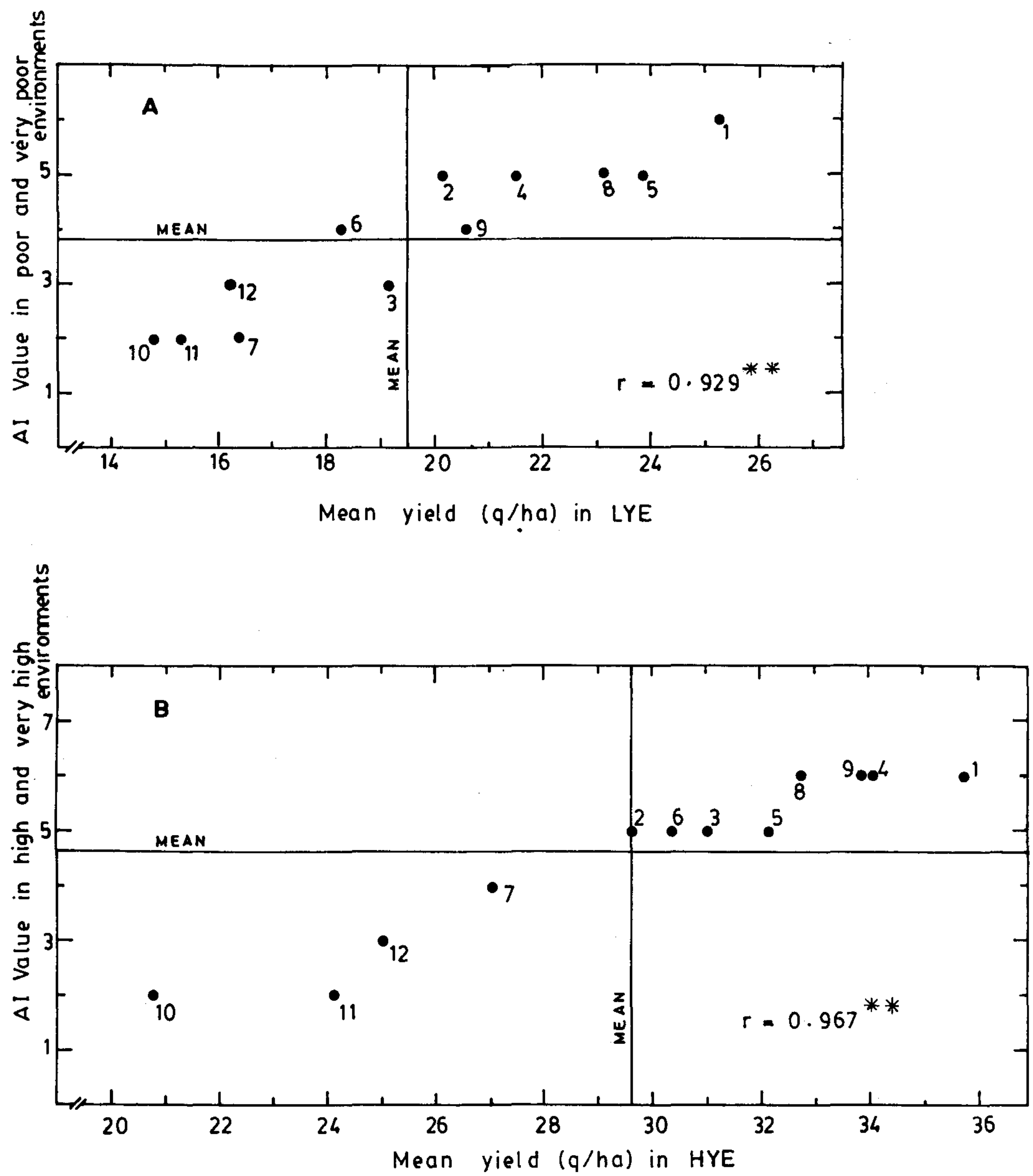


**Fig. 4. Scatter diagram of 12 rice varieties showng their performance in unfavourable (A), and favourable enviornments (B). Variety nos. as in Fig. 2.**

The performance of 12 varieties when analysed under unfavourable environments (LYE) in relation to adaptation index in poor and in very poor environment (Fig. 4A) and under favourable environments (HYE) in relation to adaptation index in high and in very high environments (Fig. 4B), it is evident from the scatter points of the genotypes that there was good agreement in performance of the varieties and Annapurna, Sarathi, IR 36, Rasi, Keshari, and Parijat exhibited above average performance in both favourable and unfavourable environments.

The investigation indicates that agronomically superior genotypes like Annapurna, Sarathi, Rasi, IR 36, and Parijat with wide adaptation and Keshari with specific adaptation to favourable environments could be identified easily through the metroglyph analysis of stratified environmental averages (MASEA). This method is considered to be simple and may be used for preliminary evaluation of crop varieties for their adaptation. However, classification of environment is the most important aspect of this method, for which numerical taxonomic method can also be applied for precision.

## REFERENCES

1. F. Yates and W. G. Cochran. 1938. The analysis of groups of experiments. J. Agric. Sci., (Camb.), **28**: 556-580.
2. S. A. Eberhart and W. A. Russell. 1966. Stability parameters for comparing varieties. Crop Sci., **6**: 34-40.
3. T. R. Francis and L. W. Kannenberg. 1978. Yield stability studies in short-season maize. I. A. descriptive method for grouping genotypes. Can. J. Plant. Sci., **58**: 1029-1034.
4. S. K. Sinha. 1996. Metroglyph analysis of adaptation in crop improvement : A new approach. Plant Sci. Abstract papers of National Seminar on Frontiers of Botany and their relevance to environmental management. Pp. 44.
5. G. C. Gower. 1971. A general coefficient of similarity and some of its properties, Biometrics., **27**: 857-871.
6. K. W. Finaly and G. M. Wilkinson. 1963. The analysis of adaptation in a plant breeding programme. Aust. J. Agric. Res., **14**: 742-754.