NIGERIAN STATISTICAL ASSOCIATION

2009 CONFERENCE PROCEEDINGS

THEME

STATISTICS AND IMPLEMENTATION OF THE SEVEN POINT AGENDA OF THE FEDERAL GOVERNMENT

VENUE: CITY KING HOTEL AND TOWERS, GUSAU, ZAMFARA STATE

DATE: 12TH - 14TH AUGUST, 2010

TABLE OF CONTENTS

1. RA. Adeyemi is lecturer and Biometrician in the School Agric and Agric Technology, FUT. Minna

Additive Main Effects And Multiplicative Interactions Analysis Of Paddy Yield Performance Of Rice Cultivars Across Locations Under The Influence Of *Rice Yellow Mottle Sobemovirus*

[1]Rasheed A. Adeyemi*, [2]Muhammadu T. Salaudeen, [2]Basheer Bature,
[1]Department of Crop Production, Federal University of Technology, P.M.B. 65, Minna, Nigeria
[1]Department of Mathematics and Statistics, Nuhu Bamalli Polytechnic,, Zaria, Nigeria

* Correspondence Author:
Mobile: +234 08035861447
Email: adeyemira@yahoo.ca

Abstract: This study was carried out under the paddy yield performance of 14 rice cultivars resistance to ***Rice yellow mottle*** sobemovirus (RYMV) across two locations in northern Nigeria in 2005/2006 planting season. The experimental layout was randomized complete block design with three replications. Additive main effects and multiplicative interactions (AMMI) analysis indicated that the paddy yield of the cultivars (genotypes) was under major location (environmental) influence and cultivar x environmental interactions. The first principal component (PCA I) was significant (P< 0.05) while second principal component (PCA 2) was not significant (P> 0.05) and it had a cumulative contribution of 80 % to the total variance in paddy yield performance by environmental interactions. Genotype and environmental interaction was also significant (P<0.05). A biplot using cultivar means and environment scores of the first 2 AMMI components showed that cultivars with larger PCA1 and lower PCA 2 score gave higher yield value (stable cultivar). FARO 37 (G9) was found to be most stable cultivar and cultivar with lower PCA1and larger PCA 2 scores had low paddy yield (unstable cultivar, that is G6) with respect to the locations.

Key Words: Principal Component Analysis, AMMI, *Rice yellow mottle* sobemovirus, paddy yield,

INTRODUCTION

Rice yellow mottle sobemovirus (RYMV) is a major biotic constraint to rice (*Oryza sativa* L.) production in Africa (Pinel – Galzi and Fargette, 2006). RYMV was first reported at Otonglo, Kenya in 1966 (Bakker, 1970) and has been subsequently reported in at least 24 African countries (Salaudeen *et al*., 2008c) and Europe (Koklu and Yilmaz, 2004). Incidences and yield losses of 5 to 100 % and 20 to 100 % respectively have been reported in rice fields (Alegbejo *et al*., 2006; Salaudeen *et al.*, 2008b). The virus is best managed by planting resistant cultivars (Onasanya *et al*., 2004). Genetic breeding approach and designing with appropriate statistical methods can be used for planning to harness plants natural resistance against virus to develop a boarder range of resistant cultivars.

Analysis of variance (ANOVA) was invented by Fisher (1918). For a two-way factorial design, ANOVA partitions the variation into the row main effects, column main effects, and row x column interaction effects. For yield trials, the most common outcome is that the environment main effects are largest, followed by the interaction effects and then the genotype main effects. In this work, AMMI was employed as a multivariate statistical technique to estimate the cultivar stability in paddy yield performance of rice cultivars in the two locations. However, a combined analysis of variance can quantify the interactions and describe the main effects. ANOVA may not be informative enough to explain the genotypes and environment interactions (GEI) (Yuksel Kaya *et al*., 2002).

AMMI model is effective statistical tool that incorporates both the additive and multiplicative components of the two-way data structure. AMMI biplot analysis considered is used to diagnose GEI pattern graphically. Then, the principal component analysis (PCA), which is incorporated in AMMI, takes care of the interaction effect from the additive ANOVA model. The biplot display of PCA scores plotted against genotype means provides a visual display for inspection and easy interpretation of the GEI components.

The biplot displayed and genotypic stability estimate enable genotypes to be grouped based on similarity of performance across the environments as suggested by Thillainathan and Fernandiz (2001). This idea was employed in this work to study rice cultivars paddy yield performance in response to locations.

There are past documents on the use of AMMI in multi-environmental traits, which partition the GEI matrix into individual genotypic and environmental scores. An example was provided by Yan *et al*. (2001), who applied AMMI on yield data of Ontario winter wheat performance traits, and suggested two winter wheat mega-environments in Ontario. Another example was provided by Yan and Rajian (2002), who applied the method, to genotype by trait biplot analysis soybean multiple traits and MET data found that selection for seed yield alone was not only the simplest, but also the most effective strategy in the early stages of soybean breeding.

The objectives of this study were to (i) interpret cultivars and location interaction (ii) obtain by AMMI analysis paddy yield performance of 14 rice cultivars across two locations/ environments (iii) virtually assess how to vary these two parameters observed based on the biplot and (iii) determine cultivars with high stability with respect to paddy yield in response to environments.

MATERIALS AND METHODS

Agronomic practices

The planting materials used in this study were obtained from National Cereal Research Instiute (NCRI), Badeggi, Niger state. Fourteen commonly grown rice cultivars in Nigeria were considered. The cultivars are: Bouaké 189, FARO 29 (BG 90-2), FARO 35(ITA212), FARO 37 (ITA 306), FARO 44 (SIPI 692033), FARO 46 (ITA 150), FARO 52 (WITA 4), FARO 54 (WAB 181 – B- B –B -B), FARO 55(NERIKA 1), Gigante (Tété)), WAB 189 – B 38HB, WAB 450-38HB, WAB 450-160HB, and YARDAS.

Field experiments were carried out at Bomo $\left(11^0 11^/ N;7^0 38^/ E\right)$ 695m above sea level, Gobirawa $\left(10^0 59^/ N;7^0 47^/ E\right)$ 650m above sea level, and Soba $\left(09^0 15^/ N;7^0 28^/ E\right)$ northern Nigeria, under low land conditions. Seeds were sown at 65kg /ha in 1 x 1.5 m^2 plots at intra and inter rows spacing of 0.20m. A randomized complete block design with three replicates was used. Plots were separated by 0.10m gap while replicates were 0.05m apart sowing was done on 9 , 10 and 11 June , 2006 at Bomo , Gobirawa and Soba respectively. Seedlings were tinned to 1 plant per stand giving a total of 28 plants per plot. Prior to experimentation the soil of the locations was tested for physiochemical properties (Table 1). N.P.K fertilizer (15- 15- 15) was applied at 4 and 8 weeks after sowing at the rate of 200kg/ha.

The test plants were inoculated at 3 WAS with Gwargwaji isolate of the virus. Inoculums was prepared by grinding 1g of the infected leaf tissue in 0.1 M phosphate (pH =7.4) using sterile mortar and pestle. Carborundum powder (600 mesh) was then added to the crude extract. The two outermost rows served as guard rows while ten plants from the two inner rows were inoculated and used by soaking a piece of cheese cloth in the homogenate and then using it to gently rub the upper surface of the older leaves thrice. Excess inoculum was washed with distilled water. The test plants were harvested when they fully matured and the paddy colour turned yellow.

Additive main effect and multiplicative interaction (AMMI) models

There are multivariate methods for study of genotypic stability including AMMI as discussed by Crossa (1990), Gauch Junior (1985), Gauch Junior and Zobel (1988), Zobel *et al*. (1988). Many studies have applied both multivariate and univariate techniques and these methods have been useful for identifying stable and adapted genotypes (Dias & Krzanowski, 2003; Flores *et al*., 1998; Vargas *et al.*,1999).

The AMMI model was developed by Gabriel (1971) and Gollob (1968) and has been applied by many other authors. This model is defined by:

$$Y_{ij} = \mu + \alpha_i + \beta_j + \sum_{i=1}^{m} \lambda_k r_{ik} S_{jk} + \delta_{ij} + \varepsilon_{ij}$$

The interaction effect is $\alpha_i \varepsilon_{ij} = \sum_{i=1}^{m} \lambda_k r_{ik} S_{jk}$

Where

Y_{ij} = observed paddy yield for the ith cultivar type and jth environment.

μ= grand mean

α_i = deviation of cultivar type (i) mean from grand mean

β_j= deviation of environment (j) from grand mean

λ_k= singular value for interaction kth principal component axis (IPCA)

r_{ik} = cultivar type (i) eigenvector value for kth PCA axis

S_{jk} = environment (j) eigenvector value for kth PCA axis, δ_{ij}= residual effect and

ε_{ij}= error-term , (Gauch and Zobel, 1996)

Cultivars (genotypes) were used as nominal variable to produce a cultivar type-environment biplot. On the biplots, location with similar cultivar performance lies close to each other (Ter Brak and Prentice, 1988). Sites located in the sector of the biplot were associated with species located in that sector cultivar located far away from the origin are the most important in the analysis compared to those near the centre of the biplot (Ter Brack, 1996).

Let X be the matrix of GE interactions parametric effects defined by

$$X = \begin{bmatrix} ge_{11} & \cdots & ge_{1p} \\ \vdots & \ddots & \vdots \\ ge_{n1} & \cdots & ge_{np} \end{bmatrix}$$

The X matrix (n x p) with rank $r = [n-1, p-1]$ is submitted to the singular value decomposition in the following way:

$$X = R\Lambda S'$$

where R (n x r) and S (p x r), R and S are column orthonormal, $R'R = S'S = I$ and $\Lambda = diag\left\{\lambda_k^{\frac{1}{2}}\right\}$, $k = 1,2, \ldots, r$, λ_k is the k^{th} non null eigenvalue of XX' or $X'X$, R and S are matrix of eigenvector of the related r *eigenvalues*.

Let $m \leq r$ non – null eigenvalues retained, these variables will explain most of the total variation given by $tr(XX' = tr(X'X) = \sum_{i=1}^{n} \sum_{j=1}^{p} \delta_{ij}^2) = \frac{SSGE}{n}$.

If the proportion of explanation is large for small m , the technique is considered efficient. There, the interaction effects can be predicted by:

$$\hat{\delta}_{ij} = \sum_{k=1}^{m} \lambda_k \acute{r}_{ik} \acute{S}_{jk}$$

For a formal evaluation to lack of fit for the AMMI model , an analysis of variance can be accomplished as predicted for m kept principal components.

RESULTS AND DICUSSION

Table 3: Environment means and variances

	Number of observation	Mean	Variance
Location			
1	42	2.307	0.800
2	42	1.940	0.4864
Combine	84	2.124	0.6695

Table 4: The ANOVA table for AMMI model

Source	df	SS	MS	F	F_prob
Treatments	27	33.61	1.2447	3.45	0.00006
Genotypes	13	18.76	1.4430	4.01	0.00016
Environ.	1	2.82	2.8233	3.49	0.0672
Block	4	3.23	0.8080	2.24	0.0770
Interactions	13	12.02	0.9249	2.57	0.00812
IPCA 1	13	12.02	0.9249	2.57	0.00812
IPCA 2	11	0.00	0.0000	0.00	1.00000
Residuals	0	0.00	0.0000	0.00	
Error	52	18.73	0.3603		
Total	83	55.57	0.6695		

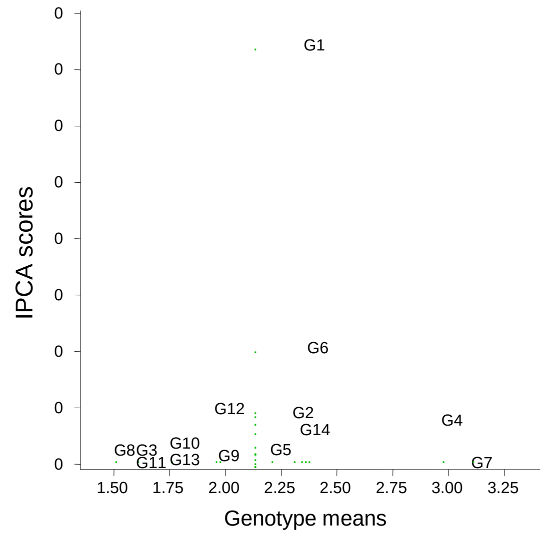

Fig. 2: Plot of Genotype IPCA 2 scores versus mean yield for the 14 cultivars

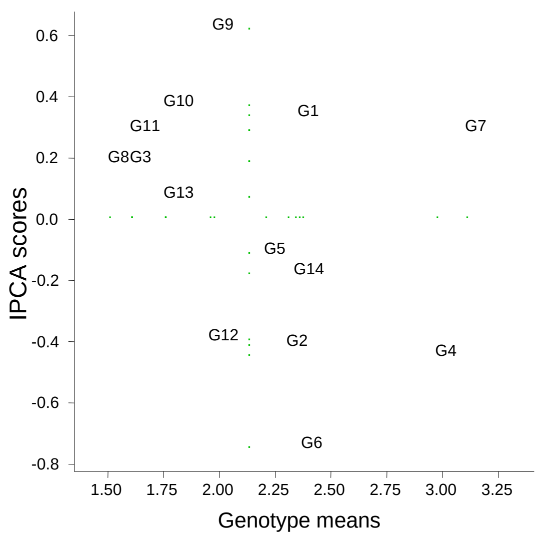

Fig.1: Plot of Genotype IPCA 1 scores versus mean yield for the 14 cultivars

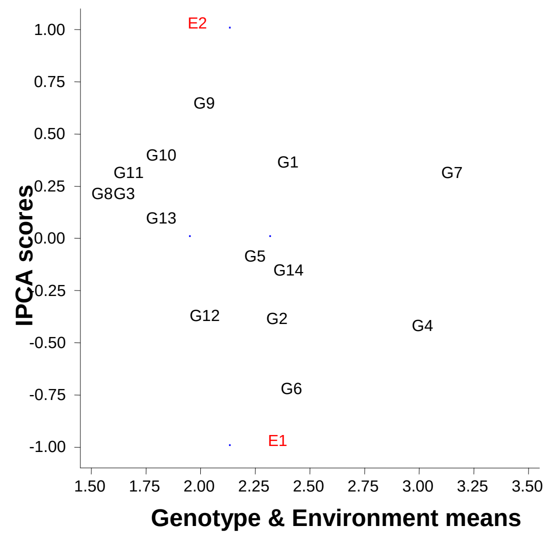

Fig. 3: Plot of Gen & Env. IPCA 1 scores versus mean yields for the 14 cultivars

CONCLUSION

A biplot using cultivar means and environment scores of the first 2 AMMI components showed that cultivars with larger PCA1 and lower PCA 2 score gave higher yield value (stable cultivar). FARO 37 (G9) was found to be most stable cultivar and cultivar with lower PCA1and larger PCA 2 scores had low paddy yield (unstable cultivar, that is G6) with respect to the locations.

REFERENCES

Yan, W.,.Cornelius, P.L., Crossa,, J., Hunt, L.A. (2001). Two types of GGE biplots for analyzing multi-environment trial data. Crop Sci., 41:656–663.

Yan, W., Rajcan., I. 2002. Biplot analysis of test sites and trait relations of soybean in Ontario. Crop Sci.. 42:11–20.