# GENOTYPE x ENVIRONMENT IN SORGHUM *{Sorghum bicolor* (L.) Moench) TRIAL

BY

**D.A. ABA,** F.A. **SHOWEMIMO and M. YEYE**
***Plant*** *Science Department,*
*Faculty of Agriculture,*
*Institute for Agricultural Research,*
***Ahmad****u* ***Bello*** *University, Zaria*

## ABSTRACT

The results obtained from four locations for three year testing of seven lines (genotypes) were used to estimate genotype x year, genotype x location and genotype x year x location interactions for sorghum yield trials. The three main effects (years, locations and genotypes) and their interactions were highly significant (P = 0.01), thus indicating differential genotype response to the environments used. The variance components were relatively small with the second order interaction variance component larger than the first order types involving genotypes. Environmental variance was larger than the interaction variances. Computation of theoretical standard error for cultivar (genotype) means suggest that four replications, six locations and two years is an ideal testing procedure for sorghum in term of cost and time.

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## INTRODUCTION

Sorghum is the fourth most important cereal crop in Nigeria on about 6 million hectares of land with a total annual production of 4.8 to 6 million tonnes, and a projected demand of over 8 million tones (Nwasike, 1982; IAR, 1984). The rapid expansion, the economy and human consumption has actually increased the deficit between projected supply and demand. Therefore, the plant breeder is responsible for the release of improved varieties that will perform better than the existing ones with general or specific adaptation to environments. Before lines and strains or genotypes are released as varieties for commercial production, they are yield tested in multilocational and macroplot experiments for several years and locations in order to measure the genotypic response to environments (Genotype x environmental interaction).

Several workers including Obilana and El-Rouby (1979), Nwasike and Abed (1981), Alabi and Echekwu (1989) reported meaningful biological complications, implications and interpretations of the different components involved in genotype x environmental interactions in their various studies. Adaptation and stability of genotypes in different environments have been established using different methods of analysis, notably are those of Wricke, 1962; Finley and Wilkinson, 1963; Eberhart and Russel, 1966.

The purpose of this paper is to estimate yield stability and adaptation, to identify testing procedures appropriate for sorghum before new improved varieties are released, and to evaluate the amount and relative importance of various genotype x environment interaction component in sorghum yield trials repeated over years and locations.

## MATERIALS AND METHODS

Seven sorghum lines: NR 71153, NR 7115, NR 71194, NR 71197, NR 71167, NR 71176 and NR 71213, developed at the Institute for Agricultural Research, Zaria, Nigeria were included in yield trials for three years at four locations: Samaru (Northern Guinea savanna), Kano (Sudan savanna), Landanawa (Sudan savanna) and Malmaduri (Sudan savanna). Seasonal variations are seen in Table 1.

The experiments were conducted in randomized complete block designs replicated four times with five rows per plot, 6 meters long and inter and intra row spacing of 0.75m and 0.30m respectively. Three center row were harvested for yield.

Each row was over planted and thinned to two plants per stand about two weeks after emergence. The yield data were subjected to regression analysis to estimate adaptation parameters, including linear response (b), deviation from regression ($S^2d$) and the coefficient of determination ($R^2$). The regression of yield of each genotype on the mean yield of all genotypes in each environments (Finlay and Wilkinson, 1963). For regression coefficient (b) not significantly different from 1.0 (=1.0), the variety is adapted to all environments; for (b) significantly larger than 1.0 (b > 1.0), the variety is adapted to higher yielding environments; while for (b) significantly lower than 1.0 (b < 1.0), the variety is adapted to low yielding environments.

The combined analysis of variance computed over four locations and three years (Table 3) was used to estimate pertinent variance components. These were then used to calculate the theoretical covariance of a variety mean with different combinations of number of replications, locations and years (Radmusson and Lambert, 1961) as

$$\delta^2_x = \frac{\delta^2_{gl}}{l} + \frac{\delta^2_{gy}}{y} + \frac{\delta^2_{gly}}{ly} + \frac{\delta^2_e}{rly}$$

The form of analysis of variance with mean squares and their expectations follow that described by Comstock and Moll (1963).

**RESULTS AND DISCUSSION**

Table 1 shows seasonal variation for the locations used in the variety yield trials. The location mean yield ranges from 1.02 t/ha to 3.16 t/ha. As outlined by Finlay and Wilkinson (1963); (Obilana and El-Rouby, 1979); and Nwasike and Abed (1981), these seasonal variations with variations in management and soil cause differences in yield. The mean performance of each genotype or line, regression coefficient (b), standard error of b, deviation from regression ($S^2_d$) and coefficient of determination ($R^2$) are shown in Table 2. The regression coefficient is used here as on indication of adoption rather than stability as suggested by Finlay and Wilkinson (1963), while stability as described by Eberhart and Russel (1966) is applicable to high yielding environments. Therefore, the deviation from regression ($S^2_d$) and the coefficient of determination ($R^2$) are used in this study as stability parameter. The cultivars or lines characterized by regression coefficient of the order of 1.0 (b = 1.0), deviation from regression as small as possible ($S^2_d = 0$) and a high coefficient of determination ($R^2$ = 100%) are stable. For example NR 71194 is the

most stable and best yielder NR 71197 and NR 71167. They are stable because they have regression coefficients approximately 1.0 (b = 1.37, 0.87 and 1.00, respectively), and a low deviation from regression ($S^2_d$ = 0.016, 0.107 and –0.013, respectively), while the coefficient of determination for the genotypes are very high ($R^2$ = 98.8%, 82.6% and 100.0% respectively) (Table 1). NR71153 and NR71176 are below average yield performance. NR71178 and NR71213 are unstable varieties and may be adapted to low yielding environments. NR71153, 71213 and 71176 will behave better under favourable conditions, while NR71194 seems adapted to high yielding environments. NR71167 is more stable and adapted over a wide range of environments.

The analysis of variance for yield of sorghum lines in four locations are presented in Table 3. Three main effects (years, locations and genotypes) were highly significant. This was expected because of the diversity in the genetic background of the materials and between the four locations used. Genotype x year, genotype x location and genotype x year x location interactions were significant, thus, there is environmental interaction effect on the genotypes. Therefore the genotypes performed differently in different years and at different locations.

Estimated variance components for genotype ($\delta^2_g$) and genotype x year ($\delta^2_{gy}$) were relatively too low. The genotype x year x locations variance components ($\delta^2_{gly}$) was higher than the genotype x location variance ($\delta^2_{gl}$), while the environmental variance was the highest (Table 3). Similar observation have been reported by Obilana and Fatunla (1978) in maize; Obilana and El-Rouby (1979) in sorghum, and Nwasike and Abed (1981) in pearl millet. These estimates were used to calculate standard errors for various combination of replications, locations and years which may be most efficient in variety testing (Table 4). It was found that four replications, six locations and two years would allow for the detection of differences between varieties for yield. The most effective way of obtaining the true value of a variety is by increasing the number of years and locations, while the least effective is by increasing the number of replications. Since locations can be effectively substituted for years, increasing the number of locations will expedite the release of improve cultivars, while increasing the number of years is the most effective way of reducing error though it has a disadvantage of delaying the release of results.

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Table 1: Locations and mean performance of the environments for three years variety trial.

| | Mean yield (t/ha) | Total rainfall (cm) | Mean temperature ($^{o}$ C) | Altitude (m) | Latitude |
|---|---|---|---|---|---|
| Samaru | 2.88 | 115.8 | 24.6 | 686 | 11$^{o}$ 11' |
| Kano | 2.51 | 85.0 | 25.7 | 472.4 | 12$^{o}$ 03" |
| Ladanawa | 1.02 | 68.2 | 28.0 | 360.5 | 13$^{o}$ 04" |
| Malmaduri | 3.16 | 74.5 | 26.1 | 450.7 | 12$^{o}$ 11" |

Table 2: Mean performance (t/ha) of genotypes over years and locations with stability measurements.

| Genotype | Mean yield (t/ha) | Regression coefficient (b) | SE (b) | Deviation for regression | Coefficient of determination $R^2$% |
|---|---|---|---|---|---|
| NR 71153 | 1.55 | 1.506 | ±0.302 | 0.045 | 92.7 |
| NR 71178 | 1.56 | 0.410 | ±0.263 | 0.029 | 89.9 |
| NR 71194 | 2.00 | 1.371 | ±0.226 | 0.016 | 98.8 |
| NT 71197 | 1.74 | 0.867 | ±0.417 | 0.107 | 82.6 |
| NR 71167 | 1.85 | 1.008 | ±0.113 | -0.013 | 100.0 |
| NR 71176 | 1.57 | 1.127 | ±0.30 | 0.044 | 97.4 |
| NR 71213 | 1.62 | 0.689 | ±0.365 | 0.77 | **90.1** |

Table 3: Combined analysis of variance for grain yield (t/ha) of seven genotypes grown over four environments for three years.

| Source of variation | d.f | Mean square | Expected mean square | Estimated variance (random model) |
|---|---|---|---|---|
| Year (y) | 2 | 14.55** | | |
| Location (l) | 3 | 20.66** | | |
| y x l | 6 | 4.90** | | |
| r/yl | 36 | 0.39** | | |
| Génotypes (g) | 6 | 0.43** | $\delta^2_e+4\delta^2_{gly}+12\delta^2_{gl}+16\delta^2_{gy}+48\delta^2_g$ | -0.007 |
| g x y | 12 | 0.19** | $\delta^2_e+4\delta^2_{gly}+16\delta^2_{gy}$ | -0.016 |
| g x l | 18 | 1.04* | $\delta^2_e+4\delta^2_{gly}+12\delta^2_{gl}$ | 0.050 |
| g x y x l | 36 | 0.44** | $\delta^2_e+4\delta^2_{gly}$ | 0.088 |
| Error | 216 | 0.09 | $\delta^2_e$ | 0.090 |

Table 4: Theoretical variance of a genotype mean in different combinations of rep, loc 7 years.

| Repns | Locations | Year | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | 2 | 0.275 | 0.224 | 0.205 | 0.194 | 0.187 |
| | 4 | 0.172 | 0.145 | 0.135 | 0.130 | 0.126 |
| **2** | 6 | 0.120 | 0.107 | 0.102 | 0.100 | 0.100 |
| | 8 | 0.094 | 0.081 | 0.080 | 0.080 | 0.080 |
| | 2 | 0.261 | 0.216 | 0.200 | 0.189 | 0.183 |
| | 4 | 0.161 | 0.139 | 0.130 | 0.126 | 0.123 |
| **3** | 6 | 0.110 | 0.101 | 0.098 | 0.962 | 0.952 |
| | 8 | 0.071 | 0.075 | 0.076 | 0.077 | 0.077 |
| | 2 | 0.253 | 0.211 | 0.195 | 0.187 | 0.181 |
| | 4 | 0.155 | 0.135 | 0.128 | 0.124 | 0.122 |
| **4** | 6 | 0.104 | 0.098 | 0.096 | 0.095 | 0.900 |
| | 8 | 0.064 | 0.072 | 0.074 | 0.076 | 0.076 |
| | 2 | 0.249 | 0.209 | 0.192 | 0.185 | 0.180 |
| **5** | 4 | 0.152 | 0.133 | 0.126 | 0.123 | 0.121 |
| | 6 | 0.100 | 0.096 | 0.094 | 0.094 | 0.093 |
| | 8 | 0.059 | 0.070 | 0.073 | 0.075 | 0.075 |