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# Genotype Main Effect and Genotype x Environment (GGE Bi-Plot) Model of Multi-Environmental Trial of Melon (*Citrullus lanatus*)

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**Abstract:** The analysis of yield data of eighteen accessions of "egusi" melon across four environments was determined. Genotype main effects and genotype x environment interaction (GGE biplot) method has been described as a very efficient tool for the analyses of multi-environment yield trial of crop varieties, especially where there exists a genotype x environment interaction. Thus, eighteen accessions of "egusi" melon (*Citrullus lanatus*) were evaluated in four environments in Southwest Nigeria. Strong genotype x environment interaction was confirmed. Among the accessions, DL99/75, DL 99/76 and DD98/506 performed best in Abeokuta 2 environment while L1, DD98/4, DD98/3, 131DA and L4 performed best in Abeokuta 1, Ilaro 1 and Ilaro 2. Accession DD98/550, DD98/7, DD98/533, DD98/511, DD95/549, L3, DL99/71, V2, L2 and L6 did not perform well in all the environments. GGE biplot also ranked the accessions in their order of greater value. Accession DL99/75 was ranked first followed by DD98/506 and the least performed accession was DD98/511.

**Keywords:** GGE biplot, melon, multi-environment, yield trial

## INTRODUCTION

"Egusi" melon is widely cultivated in Nigeria (Anuebunwa, 2000; Jolaosho *et al*., 1996). In West Africa, "egusi" seed yield vary from 225kg/ha in Senegal to 1100kg/ha in Nigeria. In Namibia, the seed yield ranges from 550kg/ha to over 3000kg/ha, depending on the cultivar and cultural practices (Van der Vossen *et al*., 2004).

*Citrullus lanatus* seeds are used for extraction of oil (as vegetable oil) and this oil is increasingly being used in cosmetic and pharmaceutical industries. There is prospect for the use of the seed in the improvement of infant nutrition in view of the high protein and fat content (FAO, 2004).

Recent studies by Idehen *et al.* (2006) on "egusi" melon have shown the existence of strong and significant Genotype by Environment Interaction (GEI) in melon. GEI reduces the correlation between phenotype and genotype values resulting in inconsistent performance of genotypes in different environments. This makes the job of a breeder difficult because no genotype is consistently superior in all environments. This increases the cost of evaluating the genotypes as the genotypes have to be tested in several diverse environments to arrive at reasonably reliable results. In such situations, plant breeders may look for genotypes that perform relatively consistently across test environments, stable or broadly adapted genotype, or choose specific genotypes that are adapted to different environments.

There are several statistical models that can be used in situations where there is significant G x E interaction (Zobel, 1988). Lin *et al.* (1986), discussed many of these concepts varying from the Francis and Kannenberg (1978) coefficient of variability (CV) to Finlay and Wilkinson (1963) regression coefficient. The additive main effects and multiplicative interaction (AMMI) model of Gauch (1992) is one of the most recent stability analytical tools which has been described as efficient in determining the most stable and high yielding genotypes in a multi -environment trial than these other earlier methods. Yet, it has its own limitations as recognized by Yan and Kang (2003).

The GGE biplot methodology [Genotype main Effect (G), plus genotype by environment interaction (GE)] of Yan and Hunt (2001), is a recent addition to the tools for analyzing multi- environment trials. Many authors have acknowledged it to be very efficient. With the GGE biplot, both genotypes and/or environments occur on the same bi-plot in a graphic form, and inferences about their interactions can be made.

In this study therefore, GGE biplot method was used in analysis of yield data of eighteen accessions of "egusi" melon across four environments.

## MATERIALS AND METHODS

Eighteen accessions were used in this study (Table 1). Thirteen out of them were collected from the National Horticultural Research Institute (NIHORT),

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Table 1: The eighteen '*Egusi*' melon accessions used and their sources

| Accession No. | Accession | Source |
|---|---|---|
| 1 | V2 | NIHORT |
| 2 | 131DA | NIHORT |
| 3 | DL99/71 | NIHORT |
| 4 | DL99/75 | NIHORT |
| 5 | DL99/76 | NIHORT |
| 6 | DD95/549 | NIHORT |
| 7 | DD98/3 | NIHORT |
| 8 | DD98/4 | NIHORT |
| 9 | DD98/7 | NIHORT |
| 10 | DD98/506 | NIHORT |
| 11 | DD98/11 | NIHORT |
| 12 | DD98/533 | NIHORT |
| 13 | DD98/550 | NIHORT |
| 14 | $L_1$ | Okene, Kogi State |
| 15 | $L_2$ | Minna, Niger State |
| 16 | $L_3$ | Benin, Benin City |
| 17 | $L_4$ | Saki, Oyo State |
| 18 | $L_6$ | Abeokuta, Ogun state |

Ibadan and the remaining five were sourced from different parts of Nigeria viz: Benin City, Saki and Abeokuta.

The experiments were carried out in two locations of Abeokuta and Ilaro, both in Ogun State, Nigeria in 2006 and 2007 in late and early planting season, respectively. The Teaching and Research Farm, University of Agriculture Abeokuta was used for Abeokuta plantings while Federal Polytechnic, Ilaro Farm was used for Ilaro plantings.

Two plantings (early and late seasons) were done in each location. Two seeds were planted and later thinned to one plant per stand on establishment. The seeds were sown at a distance of 1 m × 1 m making 10,000 plants per hectare and it was laid out in one row per plot with 8 stands in each row. Eighteen accessions were used making 18 plots per replicate. The experiment was replicated 3 times. A replicate was 119 $m^2$ while the total land area was 425 $m^2$. Weed control was done manually using hoes and cutlasses when necessary.

Morphological and yield data were collected from 6 inner row plants.

The quantitative characters were analyzed using GGE biplot software (Yan and Hunt, 2001) and the Analysis of Variance (ANOVA) was computed using (Statistical Analysis System, 1999).

## RESULTS AND DISCUSSION

The combined analysis of variance (Table 2) showed significant accession effects for all the characters. The effect of location is significant for all the characters except for days to 50% flowering and yield/plant. Accession x location interaction was significant for all the characters except days to 50% flowering. There was no significant effect of replication except for days to 50% flowering.

The GGE bi-plot analysis of YPP generated several graphic bi-plots in (Fig. 1). The bi-plots explained 84.3% of the total variations. The bi-plot of Fig. 1 indicated that accessions DL99/75, DL99/76 and DD98/506 performed best in the Abeokuta 2 environment while L1, DD98/4, DD98/3, 131DA and L4 performed best in Abeokuta 1, Ilaro 1 and Ilaro 2. Accession DD98/550, DD98/7, DD98/533, DD98/511, DD95/549, L3, DL99/71, V2, L2 and L6 did not perform well in all the environments.

Figure 2 which accession won where or best for which location also defined the accession that performed best in the various locations i.e. (which accession won in which environment). The polygon was drawn to join accessions L4, DL99/75, DL99/76, L6, L2, DD98/533 and DD98/550 which was the accessions located farthest from the origin of the bi-plot and perpendicular to the sides of the polygon. (in this case heptagon) effectively divided the bi-plot into seven sectors; the L2 vertex sector, the DD98/533 vertex sector and DD98/550 vertex sector (Yan and Kang, 2003).

Thus DD99/75, DL99/76, DD98/506 and L1 won in Abeokuta 1, Abeokuta 2 and Ilaro 1 environments while the remaining accessions did not perform well in any of the environments (they did not win in any environment). Only L4 won in Ilaro 2.

Figure 3 the mean performance vs. stability of the 'eighteen accessions across the test environments represents the average tester coordination view, showing the performance of the accessions across the locations and their stability. The small circle near Ilaro 1 environment is indicating Ilaro 1 as the average environment in term of performance. The line connecting the bi-plot origin and the circle (Ilaro 1) is

Table 2: Combined analysis of variance of seed yield and related characters in the four environment for eighteen "*Egusi*" Melon accessions

| Sources of variation | Df | 100 seed (g) | Fruit circum.(cm) | Days to flowering | Days to germ. | Days to maturity | Fruit wt.(kg) |
|---|---|---|---|---|---|---|---|
| Rep | 2 | 0.05 | 0.27 | 0.66 | 0.83 | 0.58 | 0.05 |
| Accession (A) | 17 | 41.92** | 77.15** | 32.61** | 2.53** | 146.32** | 0.69** |
| Location (L) | 3 | 1.12** | 55.67** | 140.43** | 5.25** | 65.48** | 0.54** |
| A x L | 51 | 4.22** | 61.27** | 33.02** | 2.44** | 16.82** | 0.29** |
| Error | 142 | 0.06 | 3.53 | 0.73 | 0.52 | 1.27 | 0.03 |
| CV% | | 1.97 | 5.02 | 2.27 | 11.3 | 1.27 | 20.73 |
| **Sources of variation** | **Length of vine (cm)** | **No of branches** | **No of fruit/plt** | **Days to 50% flowering** | **No of seed/pod** | **Seed weight /pod** | **Yield/plant** |
| Rep | 388.45 | 0.95 | 0.03 | 19.63** | 179.72 | 0.48 | 25.56 |
| Accession (A) | 1391.52** | 1.99** | 0.89** | 13.64** | 1928.60** | 100.24** | 30.31** |
| Location (L) | 1647.27** | 23.98** | 0.89** | 0.38 | 1626.65** | 28.64* | 18.97 |
| A x L | 9195.53** | 1.54** | 0.42** | 0.19 | 6749.06** | 20.09** | 73.48** |
| Error | 832.44 | 0.21 | 0.04 | 1.87 | 470.47 | 7.82 | 49.10 |
| CV% | 13.08 | 12.81 | 11.83 | 2.78 | 10.21 | 16.710.809 | 16.80 |

**: $p<0.01$; *: $p<0.05$

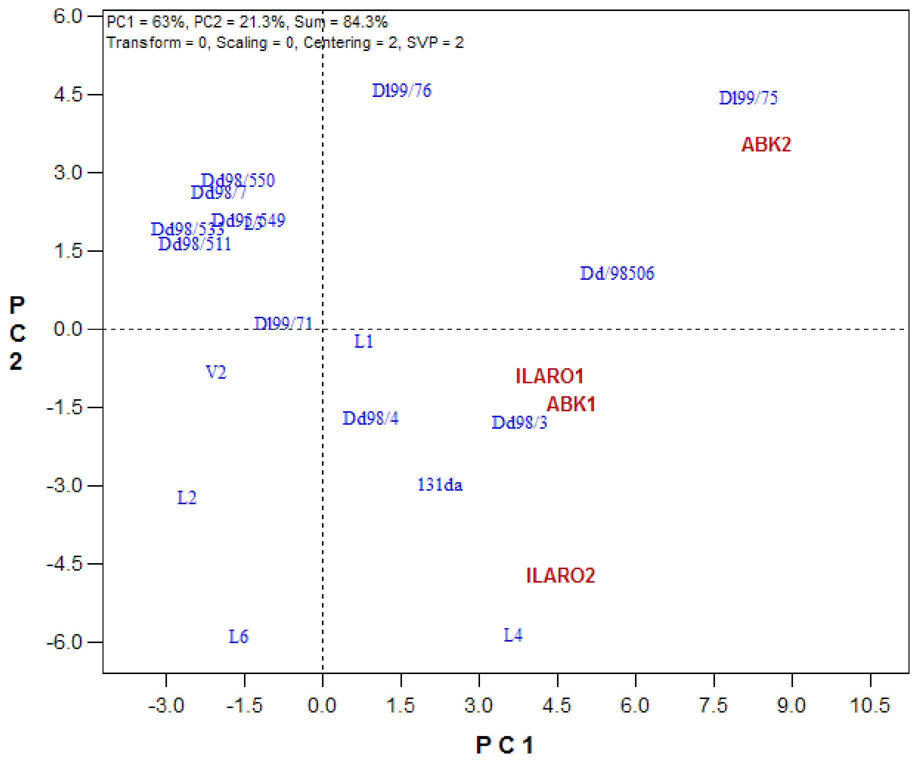


Fig. 1: GGE biplot analysis of YPP

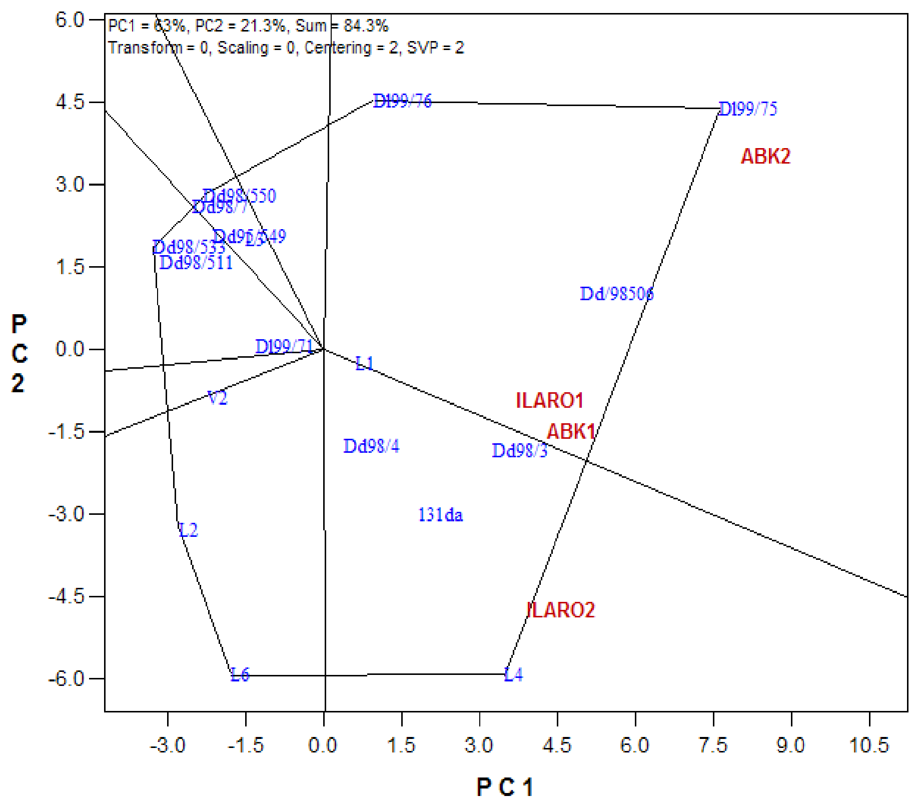


Fig. 2: Which accession won where or best for which location

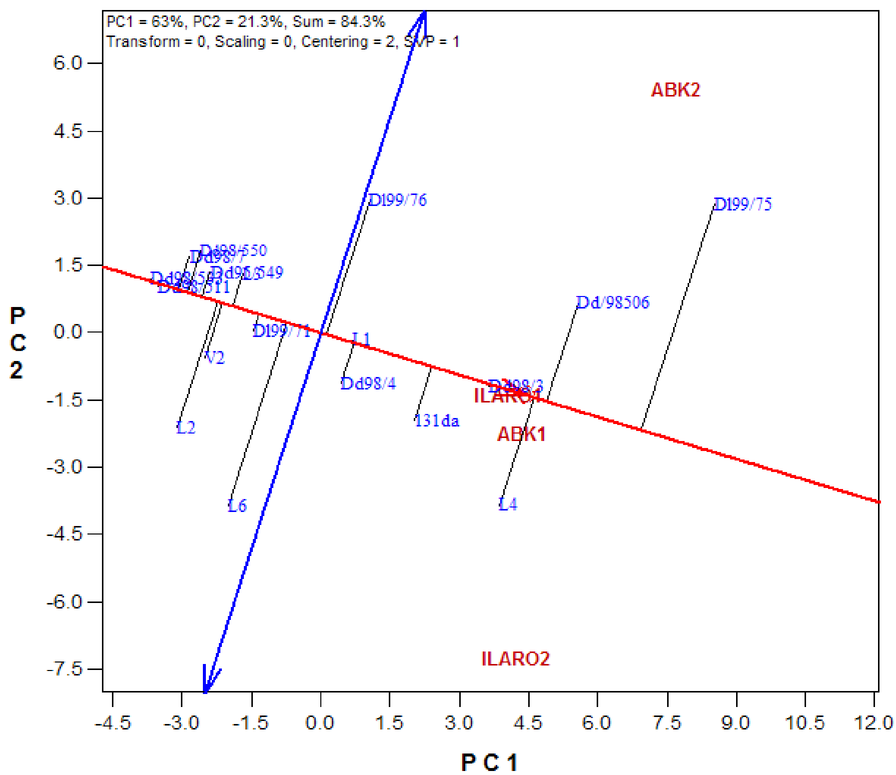


Fig. 3: The mean performance vs. stability of the 'eighteen' accessions across the test environment

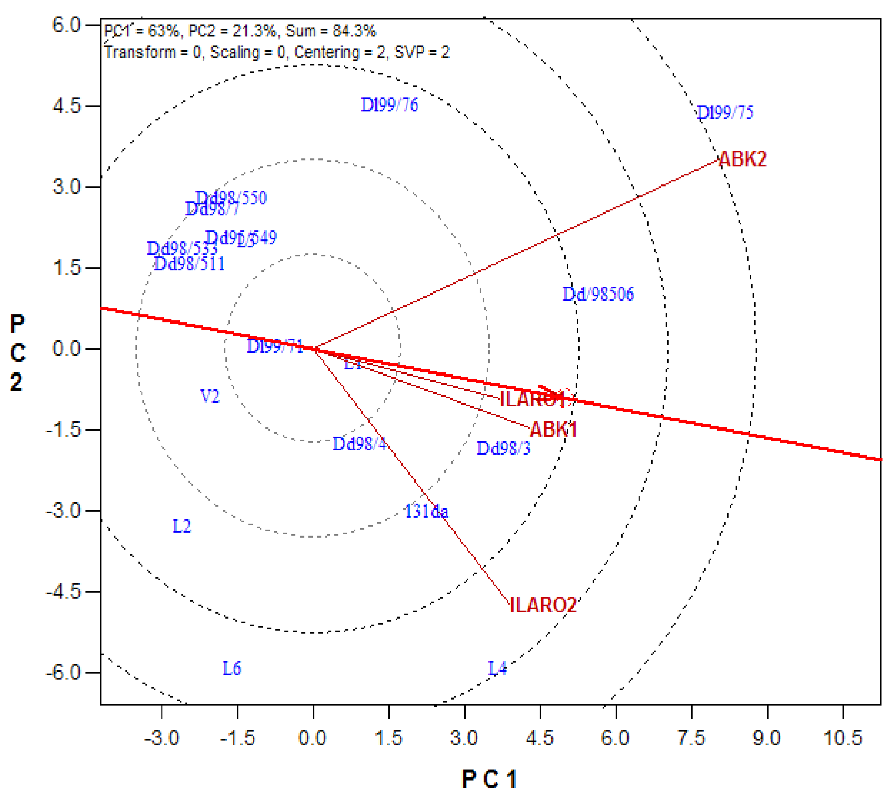


Fig. 4: Discrimitiveness vs representativeness of testers

referred to as the average–tester axis. Based on their mean performance, the accessions are ranked along the average-tester axis with the arrow pointing towards accessions with greater value. Based on this DL99/75 was rank first followed by DD98/506 and the least performed accession was DD98/511. A double arrowed line also divided the bi-plot into two, separating accession that performed above average from those that performed below average.

However, DL99/75 was ranked first followed by DD98/506 and L4 having longer projections parallel to the double arrowed line were more variable in performance (yield) and therefore less stable across the environments, while DD98/3, L1, 131DA and DD98/4 were more stable having shorter projections. Though DD99/71, DD98/511 performed below average but were very stable.

Figure 4 discrimitiveness vs. reresentativeness of testers shows the representativeness and discriminating ability of the accessions and the environments. The centre of the concentric circles is where an ideal accession or environment should be located; the projection on the x- axis was designed to be equal to the longest vectors of all the environments and the accession. However, accession DD98/3, 131DA and DD98/4 were the best accessions and location Ilaro 1 and Abeokuta 1 were the best environments. This ranking of accessions based on both mean and stability, as measured by the distance from the markers of the accessions to the ideal genotype on the GGE bi-plot was found to be highly correlated with the ranking based on Kang's Yield-Stability ($YS_i$) statistic (Kang, 1993).

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