NIGERIAN JOURNAL OF GENETICS

VOLUME 25, 2011

Published by The Genetics Society of Nigeria

ISSN 0189-9686

PRINTED IN NIGERIA

BY

MASTER PRINTS INC., KADUNA.
08033146904, 08097241505

TABLE OF CONTENTS

PERFORMANCE OF OPEN-POLLINATED MAIZE VARIETIES IN THE DRIER AREAS OF SOUTH-WESTERN NIGERIA

***Akande, S. R., Balogun, M. O., Idowu, B. and Olowoyo, R. B.**
Institute of Agricultural Research and Training,
Obafemi Awolowo University, Moor Plantation, Ibadan, Oyo State, Nigeria
Author for Correspondence: remiajibade2002@yahoo.com

ABSTRACT

The effects of genotype x environment interactions on grain yield of six open-pollinated (OP) maize varieties in two locations within the derived and southern Guinea savanna agro-environments of southwest Nigeria were investigated using genotype plus genotype x environment interaction (GGE) biplot analysis. Significantly higher grain yields and taller plants were observed at Ilora (derived savanna) than Ballah (southern Guinea savanna). Grain yields ranged from 1.36 to 3.17 t/ha at Ballah and from 1.59 to 3.27 t/ha at Ilora. Results of GGE analysis showed that genotype, location and genotype x location interactions accounted for 46.11%, 13.80% and 40.07% of the total variation, respectively. Two of the best yielding varieties, DTSR-Y and ACR 91 Swan 1-SR, were well-adapted to Ilora environment, while TZB-SR SGY was more suitable for cultivation at Ballah.

Key words: Maize, Grain yield, GGE, Derived savanna, Southern Guinea savanna

INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop for livestock feeds and human nutrition in Nigeria. Recent data suggest that maize is cultivated on total land area of about 4.7 million ha with an estimated grain yield of about 1.66 tonnes per hectare or a total production of about 7.8 million tones (FAO, 2009). Results from many studies carried out in different parts of the country have shown that regardless of variety grown, highest grain yield occurs in northern guinea savanna (NGS) agro-ecology (Fakorede *et al.*, 1993). This is because of the favorable environmental conditions in the zone which favour maize production. These environmental conditions include high incident of solar radiation that enhances photosynthesis, natural and uniform drying of seeds at time of harvest which improves quality and reduces losses (Kim *et al.*, 1993; Ajibade and Ogunbodede, 2001). It was reported that incoming solar radiation increases with latitude (Kassam and Kowal, 1973), meaning that dry matter production and grain yield of maize would be expected to be greater in the northern drier areas than in the southern forest. There is also low incidence of biotic stresses such as diseases because of low relative humidity in the NGS (Ajibade and Ogunbodede, 2001; Kim *et al.*, 1993).

Hybrid maize varieties have been shown to have some proven advantages over open pollinated (OP) varieties. These advantages include higher grain yield of about 22 to 44% over OP, higher shelling%, higher nitrogen-use-efficiency and better tolerance to diseases and fluctuations in environmental conditions (Kim *et al.*, 1993; Ajibade and Ogunbodede, 2000; Ajibade and Ogunbodede, 2001). The high cost of recommended inputs such as seeds, fertilizer and pesticides for hybrid production is however, unaffordable to many resource poor farmers. Hence, many of these farmers still cultivate the OP. Since the ultimate goal of every farmer is to optimize yield under minimal inputs (Olakojo *et al*., 2005), it is therefore important to evaluate new OP maize varieties at different environments to identify high yielding genotypes for their use.

The differential response of genotypes to changes in the environment is referred to as genotype × environment interactions (GE) (Comstock and Moll, 1963). Genotype × environment interaction reduces the association between phenotypic and genotypic values, resulting in non-stable performance of genotypes across environments. It is important to understand the nature of GE interaction to be able to select superior genotypes for specific environments (Sallah *et al*., 2004). Many methods have been used to identify and to compare patterns of performance of crop genotypes across environments with the aim of describing genotypic responses from multi-environment trials (Byth, 1981; Westcott, 1987). One of such methods used in recent time is genotype plus genotype × environment interaction (GGE) biplot analysis. The GGE biplot analysis partitions G + GE into principal components through singular value decomposition of environmentally centred yield data (Yan *et al*., 2000). The GGE biplot graphically displays the two-way data and allows visualization on the interrelationships among each of varieties, environments and their interaction. It therefore enables the breeder to know the performance of genotypes in specific environment. It can also show the ideal test environment for selecting generally adapted genotypes. The GGE biplot analysis has been demonstrated to be effective in understanding genotype × environment (Yan *et al*., 2000; Yan and Hunt, 2001). Hence, the objectives of this study were to compare the yield performance of six open-pollinated maize varieties at two sites within the drier environment of south-west Nigeria and to identify suitable varieties for each of the target sites.

MATERIALS AND METHODS

Six open-pollinated (OP) maize varieties were evaluated over two years (2004 and 2006) at Ballah and Ilora during the growing season. All the maize varieties have flint / dent grain type except ACR 91 Swan 1-SR and ACR 9943-DM SR which are flint and dent, respectively. DTSR-Y, TZB-SR-SGY and ACR 91 Swan 1-SR have yellow grains while the others are white. Ilora falls within the derived savanna agro-ecology with latitude/longitude 7°45'N/3°55'E. Ballah is within the southern Guinea savanna ecology with latitude/longitude 8°30' N/4°33'E. Total annual rainfalls for Ilora in 2004 and 2006 were 1049.8 and 1111.0 mm, respectively, while those of Ballah were 1010.46 and 1208.8 mm for the two years, respectively. The OP maize variety seeds were provided by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.
Plantings were done in July each year in a randomized complete block design with three replicates. Three seeds were planted per hole but thinned to two three weeks after seedling emergence. Each plot consisted of four rows with each row being 5 m long and spaced 0.75 m apart with 0.50 m intra-row spacing to give a plant population of about 53,333

plants per ha. Primextra (a. i. 300g/L metalochlor and 170g/L Atrazine) and Gramozone (200g/L Paraquat) were applied as herbicides at planting and supplemented with manual weeding three times before harvest. NPK fertilizer was applied as side dressing three weeks after planting at the rate of 80 kg nitrogen, 40 kg phosphorous and 40 kg potassium per ha at each location for optimum plant growth.

To reduce border effects, data were collected from the two inner rows. Data collected included days to 50% tasling and silking, plant and ear heights. At full maturity, dried ears were harvested from the two central rows, mechanically shelled to measure grain yield per plot from which grain yield per hectare was estimated at 15% moisture content.

Data collected were subjected to analysis of variance using general linear model (GLM) procedure of SAS (1997). Means were separated using Duncan Multiple Range Test. To display the performance of each OP variety at each location, GGE biplot analysis was used. The GGE biplot was constructed by the two symmetrically scaled principal components (PC1 and PC2) derived from singular value decomposition of environmentally centred yield data (Yan *et al*., 2000). Environmental effects were defined as the combination of the location and years.

RESULTS AND DISCUSSION

Average performance of the open pollinated maize varieties across years and locations are presented in Table 1. Grain yield ranged from 1.48 to 2.84 t/ha with an average value of 2.18 t/ha. The variety TZB-SR SGY had the highest grain yield while ACR 9943 DMR SR produced the least. Average grain yield of 2.32 t/ha had earlier been reported (Ajibade *et al*., 2002) for OP maize varieties evaluated across different ecologies of Nigeria. Number of days to 50% tasling and silking ranged from 55.17 to 57.83 and from 58.0 to 60.50 cm, respectively. Plant and ear heights varied from 157.25 to 168.42 and from 64.58 to 70.58 cm, respectively the variety CMS8501 had the tallest plants.

Table 1: Average performance of the OP maize varieties evaluated in the derived and southern guinea savanna agro-ecologies of Nigeria

Variety	Grain yield (t/ha)	Days to 50% tasling	Days to 50% silking	Plant height (cm)	Ear height (cm)
DTSR-Y	2.44^{b}	55.17^{a}	58.17^{a}	157.25^{a}	68.08^{a}
TZB-SR SGY	2.84^{a}	57.00^{a}	59.50^{a}	162.15^{a}	69.76^{a}
ACR 91 Swan 1-SR	2.42^{b}	55.42^{a}	58.00^{a}	161.96^{a}	65.04^{a}
ACR 9943 DMRSR	1.48^{d}	57.58^{a}	60.50^{a}	165.55^{a}	64.58^{a}
TZB-SR	1.94^{c}	55.25^{a}	58.00^{a}	158.63^{a}	64.54^{a}
CMS8501	1.96^{c}	57.83^{a}	60.33^{a}	168.42^{a}	70.58^{a}
Mean	2.18	56.38	59.08	162.33	67.10
S E M	0.03	0.33	0.31	1.59	1.38

a, b, c, d: Values in the same column with different superscripts differ significantly (P<0.05).

Mean values of the characters evaluated in each year at each location are presented in Table 2. Significantly higher grain yields and taller plants were observed at Ilora (derived savanna) than Ballah (southern guinea savanna), while the OP varieties took longer period to flower at Ballah. At both locations, significantly higher grain yields and taller plants were obtained in 2004 than 2006. The maize varieties however flowered late in 2006.

Table 2: Average values of the agronomic characters of the OP maize evaluated in each year at each location

Character	Ballah		Ilora		Mean Ballah	Mean Ilora	SEM
	2004	2006	2004	2006			
Grain yield (t/ha)	2.43[a]	1.44[b]	2.98[a]	1.86[b]	1.93[b]	2.42[a]	0.37
Days to 50% tasling	56.11[b]	58.22[a]	53.17[b]	58.00[a]	57.17[a]	55.58[b]	0.47
Days to 50% silking	59.61[b]	60.56[a]	55.67[b]	60.50[a]	60.08[a]	58.08[b]	0.44
Plant height (cm)	154.44[a]	140.78[b]	184.67[a]	169.41[b]	147.61[b]	177.04[a]	2.24
Ear height (cm)	61.61[a]	50.67b	81.22[a]	74.89[b]	56.14[b]	78.06[a]	1.95

[a, b]: Values in the same row within the same location with different superscripts differ significantly (P<0.05)

Higher precipitations were received in 2006 than 2004 hence higher relative humidity in the environments of 2006 at both locations. High relative humidity caused by excessive rainfall in the forest was found to be detrimental to maize grain production (Ajibade and Ogunbodede, 2001). However, in the Sudan savanna ecology of the northern part of Nigeria, where water is limiting and rainfall erratic, significantly higher grain yield was reported for maize in the year with higher precipitation (Onyibe *et al.*, 2003). Grain yield of each of the varieties at each location are presented in Table 3. At Ballah, grain yield ranged from 1.36 for ACR 9943 DMRSR to 3.17 t/ha for TZB-SR SGY, while at Ilora, grain yield varied between 1.59 for ACR 9943 DMRSR and 3.27 t/ha for DTSR-Y (Table 3).

Table 3: Grain yields of the OP maize varieties at the two locations (ha^{-1})

Variety	Location	
	Ballah	Ilora
DTSR-Y	1.61c	3.27a
TZB-SR SGY	3.17a	2.52b
ACR 91 Swan 1-SR	1.70c	3.13a
ACR 9943 DMRSR	1.36d	1.59d
TZB-SR	2.00b	1.89c
CMS8501	1.80bc	2.12c
Mean	1.93	2.42
S E M	0.04	0.04

[a, b, c, d]: Values in the same column with different superscripts differ significantly (P<0.05).

The results of the GGE biplot analysis showed that variation among genotypes was responsible for 46.11% of the total variation due to genotype, location and genotype x location interaction.

Genotype x location interaction explained 40.07% of the variation while differences among locations accounted for only 13.81% of the variation. The first two principal components (PC1 and PC2) explained most of the variation (91.5%) caused by G + GL interaction with PC1 being responsible for 69.50% of the variation. In Fig. 1 the dispersion of the OP maize varieties and the two locations are shown.

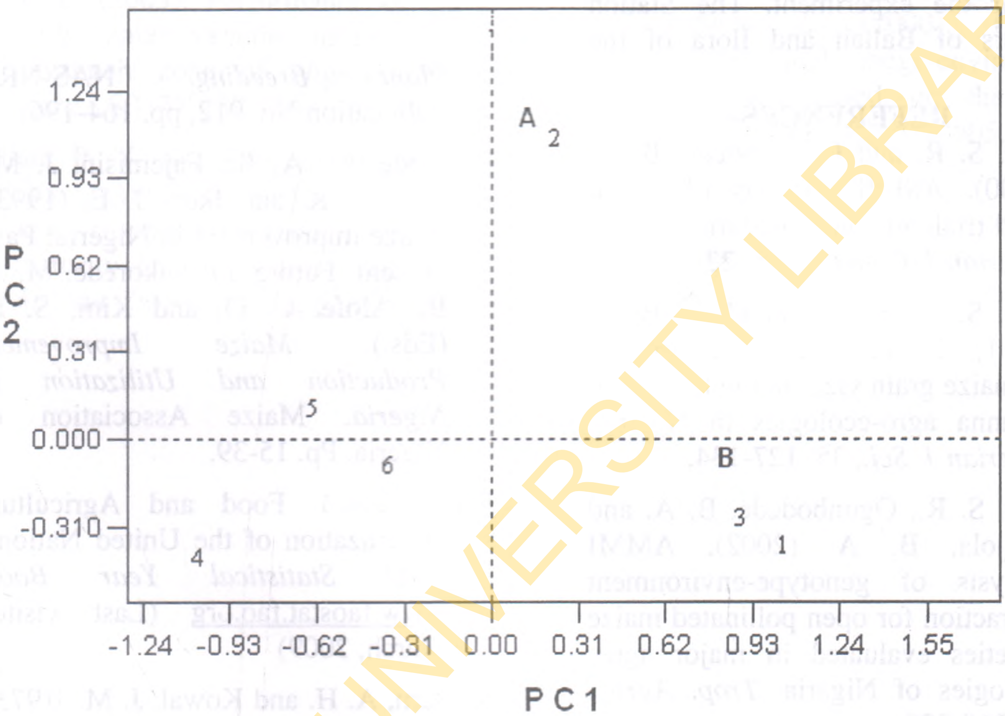

Fig. 1. Biplot of yield of 6 OP maize varieties in 2 locations.

The two locations were coded with letters A (Ballah) and B (Ilora) while the maize varieties were denoted with Arabic numerals 1 to 7 as in Table 1. Ilora (B) appeared to be the ideal test environment for OP maize evaluation as it had the largest PC1 and near zero PC2 values. It was reported that an ideal test environment should have large PC1 and near zero PC2 scores (Yan *et al.*, 2000). Ballah however, had high interaction effect. Two of the best yielding varieties DTSR-Y (1) and ACR 91 Swan 1-SR (3) with high PC1 values were well adapted to Ilora environment, while TZB-SR SGY was more suitable for cultivation at Ballah. Varieties TZB-SR (5) and CMS8501 (6) were stable in grain production but they were low yielding. ACR 9943-DMRSR had the lowest grain yields at the two locations.

CONCLUSION

In this study, significantly higher grain yields and taller plants were observed at Ilora (derived savanna) than Ballah (southern guinea savanna). Two of the best yielding varieties, DTSR-Y and ACR 91 Swan 1-SR, were identified to be well-adapted to Ilora environment, while TZB-SR SGY was more suitable for cultivation at Ballah.

ACKNOWLEDGEMENT

The International Institute of Tropical Agriculture (IITA) is highly acknowledged for providing the seeds used for the experiment. The Station Managers of Ballah and Ilora of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria are also acknowledged for their technical assistance.

REFERENCES

Ajibade, S. R. and Ogunbodede, B. A. (2000). AMMI analysis of maize yield trials in south-western Nigeria. *Nigerian J. Genetics*, 15: 22-28.

Ajibade, S. R. and Ogunbodede, B. A. (2001). Effects of climatic variables on maize grain yield in the forest and savanna agro-ecologies in Nigeria. *Nigerian J. Sci.*, 35: 127-134.

Ajibade, S. R., Ogunbodede, B. A. and Oyejola, B. A. (2002), AMMI analysis of genotype-environment interaction for open pollinated maize varieties evaluated in major agro-ecologies of Nigeria. *Trop. Agric.*, 79: 265-270.

Byth, D. E. (1981. A conceptual basis of G×E interactions for plant improvement. *In*: Byth, D. E. and Mongomery, V. E. (Eds.). *Interpretation of Plant Response and Adaptation to Agricultural Environments*. Australian Institute of Agricultural Science: Parkville, Vic., pp. 254-265.

Comstock, R. E. and Moll, R. H. (1963). Genotype - environment interactions. *In*: Hanson, W. D. and Robinson, H. F. (Eds.). *Statistical Genetics and Plant Breeding*. NAS-NRC Publication No. 912, pp. 164-196.

Fakorede, M. A. B., Fajemisin, J. M., Kim, S. K. and Iken, J. E. (1993). Maize improvement in Nigeria: Past, Present, Future. *In*: Fakorede, M. A. B., Alofe, C. O. and Kim, S. K. (Eds.). *Maize Improvement Production and Utilization in Nigeria*. Maize Association of Nigeria. Pp. 15-39.

FAO (2009). Food and Agriculture Organization of the United Nations. *FAO Statistical Year Book*, www.faostat.fao.org (Last visited March, 2009)

Kassam, A. H. and Kowal, J. M. 1(973). Productivity of crops in the savanna and rainforest zones in Nigeria. *Savanna*, 2 (1): 39-49.

Kim, S. K., Fajemisin, J. M., Fakorede, M. A. B and Iken, J. E. (1993). Maize improvement in Nigeria - Hybrid performance in the savanna zone. *In*: Fakorede, M. A. B., Alofe, C. O. and Kim, S. K. (Eds.). *Maize Improvement Production and Utilization in Nigeria. Maize Association of Nigeria*. Pp. 15-39.

Olakojo, S. A., Ogunbodede, B. A. and Ajibade, S. R. (2005). Yield assessment and disease reaction of some hybrid maize varieties evaluated under low fertilizer concentration in south western Nigeria. *Nigerian J. Sci.*, 39: 31-36.

Onyibe, J. E., Daudu, C. K., Akpoko, J. G., Gbadegesin, R. A. and Arokoyo, J. T. (2003). Performance of extra early maize varieties in the Sudan savannah zone of Nigeria. *Trop. Agric.*, 80 (3): 152-156.

Sallah, P. Y. K., Abdulai, M. S. and Obeng-Antwi, K. (2004). Genotype × environment interactions in three maturity groups of maize cultivars. *African Crop Sci. J.*, 12 (2): 95-104.

SAS (1997). *User's Guide.* SAS Institute Carry, NC.

Westcott, B. (1987). A method of analysis of the yield stability of crops. *J. Agric. Sci.* (Cambridge), 108: 267-274.

Yan, W., Hunt, L. A., Sheng, Q. and Szlavnics, Z. (2000). Cultivar evaluation and mega-environment investigation based on the GGE biplot. *Crop Sci.*, 40: 597-605.

Yan, W. and Hunt, L.A. (2001). Interpretation of genotype environment interaction for winter wheat yield in Ontario. *Crop Sci.*, 41: (1): 19-25.