# Asian Journal of Plant Sciences

ISSN 1682-3974

OPEN ACCESS Asian Journal of Plant Sciences
ISSN 1682-3974
DOI: 10.3923/ajps.2021.305.312

# Research Article
# Growth and Yield Traits Variation of African Maize (*Zea mays* L.) Accessions in the Humid Tropical Rainforest of South-Eastern Nigeria

Ekemini Edet Obok, Idorenyin Asuquo Udo, Macauley Asim Ittah, Mary Njei Abua, Godfrey Akpan Iwo, Ojubi Usang Enang and Justina John Ulafor

Crop Improvement Unit, Department of Crop Science, Faculty of Agriculture, Forestry and Wildlife Resources Management, University of Calabar, PMB 1115 Calabar, Cross River State, Nigeria

## Abstract
**Background and Objective:** There is limited research on the evaluation of genetic diversity in maize accessions in the humid tropical rainforest zone of Nigeria. There could be beneficial genes and traits of interest in the exiting IPGRI maize germplasm. The main objective of the present study was to assess the growth and yield traits performance of IPGRI maize accessions and estimate the variance components of these traits in the humid tropic agroecological zone of South-eastern Nigeria. **Materials and Methods:** The experiment was laid out in a Randomized Complete Block Design with three replications and 11 treatments. *Ikom white* maize variety was used as the "check'. Analysis of variance for mean data on growth and yield traits were conducted at 95% confidence limit and post-ANOVA mean separation was conducted using Duncan's New Multiple Range Test. **Results:** The genetic variability estimates of these maize genotypes revealed low Phenotypic Coefficient of Variability (PCV) with corresponding low Genotypic Coefficient of Variability (GCV) for some of the agronomic traits. Moderate (50.11%) to high (99.98%) broad sense heritability ($H_b$) range was observed for all the traits, except number of leaves per plant, stem width, leaf area, leaf area index and anthesis-silking interval. Seedling emergence, plant height, number of cobs per plant, cob length, cob width, 1000-grain weight and grain yield recorded high (>25%) to very high (>95%) genetic advance estimate at 5% selection intensity. TZm-299 (4.521 t ha$^{-1}$) and TZm-378 (3.766 t ha$^{-1}$) produced the highest grain yields and were apparently superior to other accessions in their growth and yield potentials. **Conclusion:** The establishment, growth and yield of IPGRI maize accessions with African origins were not hindered in Calabar. Four of the IPGRI maize accessions, TZm-299, TZm-109, TZm-1553 and TZm-378, in various growth and yield traits, outperformed *Ikom white*.

Key words: Agronomy, heritability, humid tropics, *Ikom white*, IPGRI

Citation: Obok, E.E., I.A. Udo, M.A. Ittah, M.N. Abua, G.A. Iwo, O.U. Enang and J.J. Ulafor, 2021. Growth and yield traits variation of African maize (*Zea mays* L.) accessions in the humid tropical rainforest of South-Eastern Nigeria. Asian J. Plant Sci., 20: 305-312.

Corresponding Author: Ekemini Edet Obok, Crop Improvement Unit, Department of Crop Science, Faculty of Agriculture, Forestry and Wildlife Resources Management, University of Calabar, PMB 1115 Calabar, Cross River State, Nigeria



Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Maize (also referred to as corn) (*Zea mays* L.) is an important cereal crop in the family of *Poaceae*. It is a domesticated monoecious annual crop which could grow to a height of 3 m or more[1]. It is the third most important cereal crop in the tropics and sub-tropics after wheat and rice which serves as a primary staple food in most developing countries[2]. Maize is rich in carbohydrate, protein, iron, Vitamin B and minerals[3], a multi-purpose crop providing food, fuel for human beings and feed for animals[4]. Maize forms 40-75% of the ration of animals (livestock and poultry) which gets converted into meat, eggs and dairy products[5]. Not many cereals can be used in diverse ways as maize. Apparently as one of the worlds's widely grown green cereal, it reflects on maize's ability to adapt to a wide range of production environments. Therefore, it is crucial to continuously maintain significant effort on maize germplasm improvement because this is where the vast majority of allele impacting traits of agronomic importance resides. Maize possesses diverse morphological traits from a wide genetic base available for selection and thus, is adapted to a wide range of growing conditions[6]. It has been selected for its desirable traits by farmers and breeders for over 150 years[1,6,7] and breeding has been and is still being used to either improve or alter traits such as plant height, ear number, yield, maturity, kernel properties, diseases and pest resistance in maize[6,8]. Apart from a 4 week field study which looked at the response of the following IPGRI maize accessions, TZm-109, TZm-299, TZm-304, TZm-378, TZm-687, TZm-1097, TZm-1153, TZm-1163, TZm-1241 and TZm-1241, to natural infestation by the fall armyworm (*Spodoptera frugiperda* J.E. Smith)[9], there is no other documented literature on their growth and yield performances in Calabar, Cross River State, Nigeria. Hence, the primary goal of the present study was to evaluate the growth and yield trait, estimate the variance components, phenotypic and genotypic coefficient of variability and broad sense heritability of these maize accessions in Calabar, a humid tropical rainforest agroecology of Nigeria.

## MATERIALS AND METHODS

**Study area:** The entire study was conducted in two seasons between March and June 2018 and between September and December, 2018 in Calabar (4°57'N 8°21'E). Calabar is located in the humid tropical rainforest region of South-eastern Nigeria. These studies were conducted under rainfed conditions and during these experiments, the total rainfall amounts ranged from 536.91-1623.8 mm. The average monthly relative humidity was between 78 and 90% with an average monthly temperature ranging from 25-32°C. These weather data were documented by World Weather Online database at https://www.worldweatheronline.com/.

**Research materials and methodology:** The following International Plant Genetic Resources Institute (IPGRI) maize accessions were obtained from the International Institute of Tropical Agricultural (IITA) germplasm bank, Ibadan, Oyo State, Nigeria, namely TZm-109 (Republic of Benin), TZm-299 (Republic of Chad), TZm-304 (Republic of Chad), TZm-378 (Republic of Congo), TZm-687 (Ghana), TZm-1097 (Unconfirmed African Origin), TZm-1153 (Unconfirmed African Origin), TZm-1163 (Burkina Faso), TZm-1241 (Unconfirmed African Origin) and TZm-1427 (Republic of Congo). Full descriptors for each of the accessions can be found at http://my.iita.org/accession2/browse.jspx.The check variety *Ikom white* was obtained from the Cross River Agricultural Development Programme (CRADP) seed unit in Calabar. The eleven maize genotypes in Fig. 1 were evaluated, under rainfed conditions in the field in the 2018 maize cropping seasons at the CRADP demonstration plot. Soil samples from the demonstration plot were analyzed for physical and chemical properties given in Table 1. Randomized Complete Block Design (RCBD) with 3 replications was used for the study. One maize seed was planted per hole at a maximum depth of 3 cm at an inter-row and an intra-row spacing of 0.75 and 0.25 m, respectively.

At 2 WAP, after weeding, 80 kg N ha$^{-1}$(NPK 20:10:10) fertilizer was applied in bands at a depth of 2-3 cm and at 6 WAP, 40 kg N ha$^{-1}$ (Urea 46% N) was applied by topdressing. Seedling emergence at 7 DAP (EM), Plant Height (PH), Number of Leaves (NL), Leaf Area (LA), Leaf Area Index (LAI), Stem Width (SW), days to 50% anthesis and silking (DA and DS), Anthesis-silking Interval (ASI), Cob Length (CL) and Width (CW), Number of Cobs Per Plant (NCPP), Number of Grains Per Cob (NGC), 1000-seed weight (X1K) and Grain Yield (GY) were traits measured. With the exception of data on percentage emergence at 7 DAP and records on number of days from planting to harvest, all other yield and yield-related data were not collected beyond 11 WAP (i.e., 77 DAP).

**Statistical analysis:** Analysis of variance (ANOVA) was conducted with GenStat 16th edition. Duncan's New Multiple Range Test (DNMRT) at 95% confidence limit was used for post-ANOVA test to separate (group) significant mean differences. Variance components (i.e., phenotypic variance,

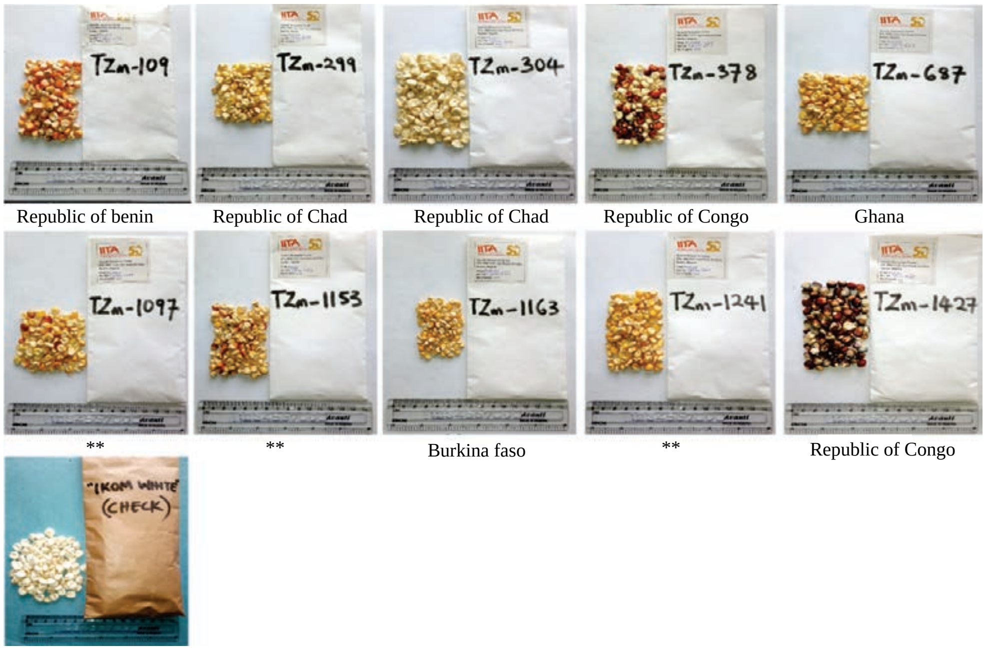


Fig. 1: Seeds of IPGRI maize accessions and their countries of origin obtained from IITA and seeds of *Ikom white* maize variety used as check obtained from cross river state Agricultural development programme seeds unit, calabar. **Unconfirmed African country of origin

Table 1: Mean pre-planting physical and chemical soil properties of the experimental site

| Soil property | Mean | SE Mean | CV (%) | Minimum | Maximum |
|---|---|---|---|---|---|
| **Particle size distribution (g kg$^{-1}$)** | | | | | |
| Sand | 800 | 3.30 | 0.72 | 793 | 803 |
| Silt | 123 | 3.30 | 4.68 | 120 | 130 |
| Clay | 77 | † | † | 77 | 7.7 |
| pH (in Soil: $H_2O$) | 5.2 | 0.09 | 3.03 | 4.9 | 5.2 |
| Total organic carbon (%) | 1.59 | 0.018 | 1.93 | 1.56 | 1.62 |
| Total nitrogen (%) | 0.11 | 0.003 | 5.09 | 0.11 | 0.12 |
| Available P (mg kg$^{-1}$) | 21.16 | 1.020 | 8.37 | 19.12 | 22.25 |
| **Exchangeable bases (cmol kg$^{-1}$)** | | | | | |
| $Ca^{2+}$ | 3.53 | 0.067 | 3.27 | 3.40 | 3.60 |
| $Mg^{2+}$ | 1.53 | 0.067 | 7.53 | 1.40 | 1.60 |
| $K^+$ | 0.12 | 0.007 | 9.36 | 0.11 | 0.13 |
| $Na^+$ | 0.06 | 0.003 | 9.12 | 0.06 | 0.07 |
| **Exchangeable acidity (cmol kg$^{-1}$)** | | | | | |
| $Al^{3+}$ | 0.80 | † | † | 0.80 | 0.80 |
| $H^+$ | 1.13 | 0.067 | 10.19 | 1.00 | 1.20 |
| Effective cation exchange capacity (cmol kg$^{-1}$) | 7.19 | 0.110 | 2.65 | 6.99 | 7.37 |
| Base saturation (%) | 72.9 | 0.58 | 1.38 | 72.0 | 74.0 |

† Not calculated as the values were exact same across the blocks (i.e., minimum = maximum)

genetic variance and environmental variance), genetic advance, phenotypic coefficient of variability, genotypic coefficient of variability and broad sense heritability ($H_b$) were also calculated for each of the traits[10,11].

## RESULTS AND DISCUSSION

**Soil physical and chemical properties at the experimental site in Calabar:** Results of the representative soil samples were presented as means with Standard Error of Means (SEM) and percentage coefficient of variation (CV) in Table 1. The distribution of soil particles in each of the blocks was relatively similar in terms of sand (CV = 0.72%) and silt (CV = 4.68%) contents, where as clay content was constant. This result further confirmed the soil texture class i.e., sandy loam which is peculiar to Calabar soils. The mean soil pH (in soil-water extract) was 5.2. Soil pH is important, it also provides a functional information and relationship on soil

Table 2: Mean growth traits evaluation of IPGRI maize accessions grown in Calabar

| Genotype | EM (%) | NL | PH (cm) | SW (mm) | LA ($cm^2$) | LAI | DA | DS | ASI |
|---|---|---|---|---|---|---|---|---|---|
| **Accession** | | | | | | | | | |
| TZm-109 | 77.78$^{ab}$ | 12.00 | 123.6$^{cd}$ | 17.99 | 1427 | 9.01 | 59.00$^{ab}$ | 61.67$^{ab}$ | 2.67$^{ab}$ |
| TZm-299 | 90.74$^{a}$ | 12.67 | 140.2$^{c}$ | 18.02 | 1065 | 6.39 | 55.33$^{b}$ | 59.00$^{b}$ | 3.67$^{a}$ |
| TZm-304 | 94.44$^{a}$ | 13.42 | 177.5$^{a}$ | 19.63 | 1254 | 8.65 | 60.00$^{a}$ | 63.00$^{a}$ | 3.00$^{ab}$ |
| TZm-378 | 79.63$^{ab}$ | 11.75 | 112.6$^{d}$ | 17.48 | 964 | 5.83 | 58.00$^{ab}$ | 61.00$^{ab}$ | 3.00$^{ab}$ |
| TZm-687 | 88.89$^{ab}$ | 12.17 | 132.8$^{cd}$ | 17.39 | 1182 | 7.24 | 59.00$^{ab}$ | 62.00$^{ab}$ | 3.00$^{ab}$ |
| TZm-1097 | 51.85$^{cd}$ | 12.83 | 146.9$^{bc}$ | 18.13 | 1491 | 8.82 | 60.00$^{a}$ | 63.00$^{a}$ | 3.00$^{ab}$ |
| TZm-1153 | 68.52$^{bc}$ | 12.00 | 132.0$^{cd}$ | 16.11 | 1141 | 7.10 | 49.00$^{c}$ | 51.00$^{c}$ | 2.00$^{b}$ |
| TZm-1163 | 33.33$^{d}$ | 12.00 | 108.2$^{d}$ | 17.98 | 1090 | 6.86 | 60.00$^{a}$ | 63.33$^{a}$ | 3.33$^{ab}$ |
| TZm-1241 | 74.07$^{ab}$ | 10.67 | 146.9$^{bc}$ | 17.91 | 1460 | 8.26 | 60.00$^{a}$ | 63.00$^{a}$ | 3.00$^{ab}$ |
| TZm-1427 | 83.33$^{ab}$ | 12.00 | 145.2$^{bc}$ | 19.76 | 1382 | 8.45 | 58.00$^{ab}$ | 61.00$^{ab}$ | 3.00$^{ab}$ |
| **Check** | | | | | | | | | |
| *Ikom white* | 79.63$^{ab}$ | 12.17 | 168.9$^{ab}$ | 19.57 | 1099 | 7.12 | 61.00$^{a}$ | 63.67$^{a}$ | 2.67$^{ab}$ |
| Grand mean | 75.00 | 12.00 | 139.5 | 18.18 | 1232 | 7.60 | 58.12 | 61.06 | 2.94 |
| SE mean | 6.40 | 0.80 | 8.44 | 1.24 | 186.4 | 1.45 | 1.35 | 1.07 | 0.44 |
| CV (%) | 14.9 | 11.7 | 10.5 | 11.8 | 26.2 | 33.0 | 4.0 | 3.0 | 25.8 |
| F pr. | <0.001 | 0.704$^{ns}$ | <0.001 | 0.640$^{ns}$ | 0.516$^{ns}$ | 0.838$^{ns}$ | <0.001 | <0.001 | 0.042 |

Mean values in the same column with the same letters are not significantly different (p>0.05)using Duncan's New Multiple Range Test, EM: Percentage emergence at 7 days after planting (%), NL; Number of leaves at maturity, PH: Plant height at maturity, SW: Stem width at maturity, LA: Leaf area at maturity, LAI: Leaf area index at maturity, DA: Days to 50% anthesis, DS: Days to 50% silking, ASI: Anthesis-Silking interval, ns: Non-significant ANOVA at 95% confidence limit

liming and fertilizer use requirements. The Total Organic Carbon (TOC) ranged from 1.56-1.62%. The TOC is closely linked with the health status of the soil and soils with increased TOC do have an increased soil Effective Cation Exchange Capacity (ECEC). The desired ECEC range is between 5 and 25 cmol $kg^{-1}$, an indication of a fertile soil. From the present study, the mean ECEC ranged from 6.99-7.37 cmol $kg^{-1}$. The ECEC is of importance in influencing soil structure stability, nutrient availability, soil pH and soil reactions to fertilizer and ameliorants (e.g., lime). The mean Total Nitrogen (TN) recorded for soils in the demonstration plot was 0.11%. However, a certain amount of nitrogen could still be locked up in the organic matter component of the soil which makes it not immediately available to plants. Nitrogen is only available to plants in mineralised forms as nitrate and/or ammonia at a desired range of 10-50 mg $kg^{-1}$ and 0-5 mg $kg^{-1}$, respectively. The recorded soil TN was considered low as it was less than 0.15%. These results were useful in determining total fertilizer (120 kg N $ha^{-1}$) and agricultural lime (1000 kg $ha^{-1}$) application rates in the present study.

**Growth traits of IPGRI maize accessions evaluated in Calabar:** Mean growth performances of the maize accessions are presented in Table 2. The analysis of variance for these growth traits had revealed that there were non-significantly differences (p>0.05) in the Number of Leaves (NL), Stem Width (SW), Leaf Area (LA) and Leaf Area Index (LAI) of the maize genotypes. The NL reported in the present study ranged from 10.67-13.42 with an overall mean of 12.00±0.8 leaves per plant. Although TZm-1427 had the thickest stems (19.76 mm), TZm-1097 and TZm-109 had the largest LA (1491 $cm^2$) and LAI (9.01) respectively. Significant differences ($p \leq 0.05$) were reported for the percentage of seedlings that emerged (after germination) (EM) at 7 DAP, Plant Height (PH) at full maturity (i.e., at harvest), days to 50% anthesis and silking (DA and DS) and Anthesis-silking Interval (ASI). TZm-304 recorded the highest EM (94.44%) and had the tallest plants (177.5 cm) but these records were not significantly different from the check (EM = 79.63% and PH = 168.9 cm). This variation in PH could be attributed to the geographic as well as the genetic background information of the maize being that these accessions came from different locations within maize growing countries in Africa. Results from the present study are in consonance with an earlier report on the variation of plant height among different maize genotypes[12]. Meanwhile, it was observed that all the maize genotypes (accessions and the check) reached 50% anthesis between 49 and 61 days after planting. TZm-1153 was the earliest accessions to reached 50% DA (i.e., 49 DAP), slightly above the overall genotype mean (58.12±1.35 DAP).It took *Ikom white* 61 days after planting to reach 50% anthesis, a duration between 48 and 88 hrs to silking after anthesis was required for all the genotypes. Though the mean ASI was 70.56±10.56 hours, TZm-299 had the highest ASI (3.67 days) and was not significantly different (p>0.05) from *Ikom white* (2.67 days) and other accessions, except TZm-1153 (2.00 days). It has been established that for a successful pollination to take place in maize, there must be synchronization between pollen shed and silk emergence, this apparently leads to higher seed


Fig. 2: Harvested and dehusked ears of the ten maize accessions under study

Table 3: Mean yield traits evaluation of IPGRI maize accessions grown in Calabar

| Genotype | DTH | NCPP | CL (cm) | CW (cm) | NGC | X1K (g) | GY (t ha$^{-1}$) |
|---|---|---|---|---|---|---|---|
| **Accession** | | | | | | | |
| TZm-109 | 72.33$^{b}$ | 1.00$^{b}$ | 11.01$^{abc}$ | 3.31$^{b}$ | 348.5$^{bcde}$ | 130.3$^{d}$ | 2.404$^{ab}$ |
| TZm-299 | 73.17$^{ab}$ | 1.10$^{b}$ | 9.92$^{bc}$ | 5.76$^{ab}$ | 506.7$^{abc}$ | 145.0$^{b}$ | 4.521$^{a}$ |
| TZm-304 | 75.33$^{a}$ | 1.59$^{a}$ | 14.58$^{a}$ | 5.24$^{b}$ | 456.2$^{abcd}$ | 71.0$^{i}$ | 2.708$^{ab}$ |
| TZm-378 | 73.50$^{ab}$ | 1.30$^{ab}$ | 8.46$^{c}$ | 4.12$^{b}$ | 592.2$^{ab}$ | 97.0$^{g}$ | 3.766$^{ab}$ |
| TZm-687 | 73.17$^{ab}$ | 1.27$^{ab}$ | 10.13$^{abc}$ | 5.22$^{b}$ | 279.2$^{cde}$ | 114.0$^{e}$ | 2.030$^{b}$ |
| TZm-1097 | 75.50$^{a}$ | 1.36$^{ab}$ | 13.87$^{ab}$ | 4.07$^{b}$ | 656.4$^{a}$ | 71.0$^{i}$ | 2.888$^{ab}$ |
| TZm-1153 | 72.00$^{b}$ | 1.11$^{b}$ | 8.72$^{c}$ | 8.38$^{a}$ | 303.5$^{cde}$ | 130.0$^{d}$ | 2.319$^{ab}$ |
| TZm-1163 | 72.33$^{b}$ | 1.00$^{b}$ | 11.82$^{abc}$ | 3.78$^{b}$ | 197.4$^{e}$ | 141.7$^{c}$ | 1.533$^{b}$ |
| TZm-1241 | 72.00$^{b}$ | 1.03$^{b}$ | 10.6$^{abc}$ | 4.08$^{b}$ | 286.5$^{cde}$ | 103.7$^{f}$ | 1.606$^{b}$ |
| TZm-1427 | 73.17$^{ab}$ | 1.61$^{a}$ | 8.13$^{c}$ | 6.18$^{ab}$ | 231.1$^{de}$ | 90.3$^{h}$ | 1.785$^{b}$ |
| **Check** | | | | | | | |
| *Ikom white* | 73.50$^{ab}$ | 1.53$^{a}$ | 13.42$^{ab}$ | 3.84$^{b}$ | 137.5$^{e}$ | 283.7$^{a}$ | 3.247$^{ab}$ |
| Grand mean | 73.0 | 1.26 | 10.60 | 4.91 | 363.0 | 125.24 | 2.62 |
| SE mean | 0.7 | 0.12 | 1.36 | 0.89 | 76.9 | 0.78 | 0.66 |
| CV (%) | 1.7 | 16.3 | 21.5 | 31.6 | 36.7 | 1.1 | 43.8 |
| F pr. | 0.028 | 0.005 | 0.029 | 0.028 | 0.002 | <0.001 | 0.044 |

Mean values in the same column with the same letters are not significantly different (p>0.05) using Duncan's New Multiple Range Test, DTH: Days to harvest, NCPP: Number of cobs per plant, CL: Cob length, CW: Cob width, NGC: Number of grains per cob, X1K: 1000-grain weight, GY: Grain yield

setting and higher grain yields[13]. The present result on ASI obtained from this study is in contrast with Khalil *et al.*[14], where they reported non-significant difference (p>0.05) for ASI among different maize genotypes evaluated for yield stability.

**Yield traits of IPGRI maize accessions evaluated in Calabar:** Results of the study revealed that, there were significant differences ($p\leq0.05$) among the maize accessions in terms of yield and yield-related traits such as the duration in days from planting to harvest (DTH), Number of Cobs Per Plant (NCPP), Cob Length (CL), Cob Width (CW), Number of Grains Per Cob (NGC), 1000-grain weight (X1K) and Grain Yield (GY). The maize genotypes had an average of 1.20+0.12 NCPP. Tzm-1427 had the highest NCPP (1.61) followed by TZm-304 (1.59), while TZm-109 and TZm-1163 had the lowest NCPP (1.00). Figure 2 showed the morphological differences, especially in the average length and width of dehusked cobs, of the various maize accessions which were harvested at full maturity. TZm-304 had the longest cobs (14.58 cm) followed by TZm-1097 (13.87 cm), these two accessions were not significantly different (p>0.05) in terms of CL. Conversely, TZm-1427 had the shortest cobs (8.38 cm) which were not significantly different from other maize genotypes, except TZm-304 and TZm-1097. For average CW, TZm-1153 had wider cobs (8.38 cm), whereas narrower cobs were recorded for TZm-109 (3.31cm) in Table 3. In terms of X1K, an average range of 71.0-283.7 g per 1000 grains of threshed maize was recorded.

Table 4: Variance components and variability estimates of IPGRI maize accessions

| Trait | Grand mean | $\delta^2_p$ | $\delta^2_g$ | $\delta^2_e$ | PCV (%) | GCV (%) | $H_b$ (%) | GAM (k = 5%) (%) |
|---|---|---|---|---|---|---|---|---|
| EM (%) | 75 | 321.87 | 280.67 | 41.20 | 23.92 | 22.34 | 87.20 | 42.97 |
| NL | 12 | 0.46 | -0.22 | 0.68 | 5.67 | –† | –† | –† |
| PH (cm) | 139.50 | 451.33 | 380.07 | 71.27 | 15.23 | 13.98 | 84.21 | 26.42 |
| SW (mm) | 18.18 | 1.21 | -0.33 | 1.54 | 6.05 | –† | –† | –† |
| LA ($cm^2$) | 1232 | 32830.67 | -1891.00 | 34721.67 | 14.71 | –† | –† | –† |
| LAI | 7.6 | 1.17 | -0.93 | 2.10 | 14.24 | –† | –† | –† |
| DA | 58.12 | 11.50 | 9.69 | 1.81 | 5.83 | 5.35 | 84.25 | 10.12 |
| DS | 61.06 | 13.00 | 11.84 | 1.15 | 5.90 | 5.64 | 91.12 | 11.08 |
| ASI | 2.94 | 0.17 | -0.02 | 0.19 | 14.18 | –† | –† | –† |
| DTH | 73 | 1.82 | 1.11 | 0.72 | 1.85 | 1.44 | 60.81 | 2.32 |
| NCPP | 1.26 | 0.05 | 0.04 | 0.01 | 18.55 | 15.99 | 74.24 | 28.38 |
| CL (cm) | 10.60 | 4.95 | 3.11 | 1.85 | 20.99 | 16.62 | 62.69 | 27.11 |
| CW (cm) | 4.91 | 2.16 | 1.36 | 0.80 | 29.92 | 23.73 | 62.94 | 38.79 |
| NGC | 363 | 28014.67 | 22112.67 | 5902.00 | 46.11 | 40.97 | 78.93 | 74.97 |
| X1K (g) | 125.24 | 3429.97 | 3429.37 | 0.60 | 46.76 | 46.76 | 99.98 | 96.31 |
| GY (t $ha^{-1}$) | 2.62 | 0.88 | 0.44 | 0.44 | 35.79 | 25.34 | 50.11 | 36.95 |

† = Negative estimate from a negative estimate of variance. Negative estimates were considered equal to zero. Negative estimates derived from other negative values were considered close to zero and omitted[10], EM: Emergence at 7 days after planting, NL: Number of leaves at maturity, PH: Plant height at maturity, SW: Stem width at maturity, LA: Leaf area at maturity, LAI: Leaf area index at maturity, DA: Days to 50% anthesis, DS: Days to 50% silking, Phenotypic variance: Genetic variance, Environmental variance, GAM: Genetic advance as percentage of trait mean, ASI: Anthesis-Silking interval, DTH: Days to harvest, NCPP: Number of cobs per plant, CL: Cob length, CW: Cob width, NGC: Number of grains per cob, X1K: 1000-grain weight, GY: Grain yield, PCV: Phenotypic coefficient of variability, GCV: Genotypic coefficient of variability, $H_b$: Broad sense heritability, k: Selection differential constant at 5% = 2.06

*Ikom white* variety produced seeds that were heavier, slightly more than doubled (283.7g) the overall average X1K (125.24±0.78 g) and was significantly different ($p \le 0.05$) from all the maize accessions. Meanwhile, *Ikom white* had the lowest NGC and was significantly different ($p \le 0.05$) from TZm-1097 with the highest NGC (656.4). TZm-378, TZm-304 and TZm-299 were not significantly ($p > 0.05$) in NGC though TZm-304 (71.0 g) and TZm-1097 (71.0 g) had the lowest X1K (71.09 g).

TZm-299 had the longest ASI and a correspondingly higher GY (4.52 t $ha^{-1}$) followed by TZm-378 (3.77 t $ha^{-1}$). Whereas TZm-1241 produced the lowest GY (1.61 t $ha^{-1}$), the overall mean GY for all the genotypes was 2.62±0.66 t $ha^{-1}$, lower than that of the *Ikom white* (3.247 t $ha^{-1}$). TZm-299 was significantly different ($p \le 0.05$) from TZm-687, TZm-1163, TZm-1241 and TZm-1427 in terms of GY. It was therefore evident that these maize genotypes were noticeably different in their performances regarding their yield and yield-related traits. These results are in consonance with the findings of Salami *et al.*[15] in which they reported variability among maize genotypes in yield traits such as NCPP and GY. In addition, these results also agree with the findings of Qamar *et al.*[16], Amad *et al.*[17] and Mahmood *et al.*[18] in which they reported considerable effect of genotype differences on growth and yield of maize.

**Variance components and coefficient of variability estimates for IPGRI maize accessions:** Positive phenotypic variances were observed for all growth and yield traits studied showed in Table 4. Meanwhile, negative genotypic variances were observed for Leaf Area (LA), Number of Leaves (NL), Stem Width (SW), Leaf Area Index (LAI) and Anthesis-Silking Interval (ASI). Positive environmental variances were observed for LA, NGC and PH. Estimates of Phenotypic coefficient of variability (PCV) and genotypic coefficient of variability (GCV) ranged from 1.85-46.76% and 1.44-46.76% respectively. However, negative GCV which were obtained from negative estimates of genotypic variance were omitted and excluded in the report as these were considered close to zero (Table 4). Singh and Chaudhary[11] had grouped PCV and GCV into three categories: low, moderate and high. Low PCV (6-10%) was observed for NL, SW, DA, DS and DTH. The following traits, NL, SW, LA, LAI and ASI had negative GCV, implying that the environmental variance could solely have contributed to the variation in these traits recorded by the maize genotypes. Moderately high PCV (11–20%) were observed for PH, LA, LAI, ASI and NCPP. Whereas, high PCV and correspondingly high GCV (i.e., > 20%) were recorded for EM, CW, NGC, NG and GY. Traits with higher PCV and GCV do offer considerable scope for improvement and quite useful for exploitation in plant breeding. Heritability values showed the proportion of observed variability which is due to environmental causes[19]. Broad sense heritability ($H_b$) with negative values obtained from negative genotypic variance was observed in NL, SW, LA, LAI and ASI. Overall, the reported $H_b$ ranged from 50.11% (GY) to 99.98% (XIK). Apart from GY which showed moderate $H_b$ i.e., >30<60% as described by Johnson *et al.*[20], all others traits had high $H_b$ (i.e., >60%). High Genetic Advance (GAM) was reported for XIK (96.31%) and NGC (74.97%). It was observed that NL, SW, LA, LAI and ASI had negative GAM estimates and other traits had GAM values that were below 43%. The lowest GAM was recorded for DTH (2.32%). The DA and DS showed moderate GAM, while EM, PH, NCPP, CL, CW, NGC, XIG and GY had high GAM values. Traits with high to relatively high $H_b$ and corresponding high GAM are products of additive genes effect[21], such traits often express high measure of variation[22,23]. Thus, these traits must be considered as significant sources of variation for selection in crop improvement. Given the diverse genetic background of these African maize accessions, accessions that have been identified with promising and heritable growth and yield traits that can be exploited to advance already existing maize germplasm in the humid tropics could further be evaluated for possible incorporation into maize breeding improvement programmes in the South-eastern maize growing areas of Nigeria.

## CONCLUSION

The results of this study have shown that despite the diverse geographical background of the maize accessions grown in Calabar, their establishment, growth and yield were not hampered. The following maize accessions, TZm-299, TZm-109, TZm-1553 and Tzm-378, were superior to other accessions and the 'check' in terms of growth and yield traits. Subsequent studies should consider the use of a multi-locational trial to further elucidate and evaluate the agronomic potentials and variance components (genetic and environmental) of these promising IPGRI maize accessions.

## SIGNIFICANCE STATEMENT

This study revealed that the ten maize accessions obtained from different Africa countries adapted well in terms of growth and yield in the humid tropical rainforest region of Nigeria. This could be beneficial to plant breeders in the search of useful traits that could be incorporated in breeding programs for the improvement of existing maize germplasm in the area.

## ACKNOWLEDGMENT

The authors thank the International Institute of Tropical Agriculture (IITA), Ibadan for providing seeds of the IPGRI maize accessions under the Standard Material Transfer Agreement (SMTA) No.: 00AF05-00AR29-180205.

## REFERENCES

1. Piperno, D.R. and K.V. Flannery, 2001. The earliest archaeological maize (*Zea mays* L.) from highland Mexico: New accelerator mass spectrometry dates and their implications. Proc. Nat. Acad. Sci., 98: 2101-2103.
2. Khalil, I.A., H. Rahman, N.U. Rehman, M. Arif and I.H. Khalil *et al*., 2011. Evaluation of maize hybrids for grain yield stability in North-West of Pakistan. Sarhad J. Agric., 27: 213-218.
3. Hassan, W., A.M. Haqqani, M.S. Zahid and S. Shafeeq, 2003. Knocking the doors of Balochistan for fodder crops production. Agridigest-Anin House J. ZTBL (Pakistan), 23: 24-35.
4. Effa, E.B., D.F. Uwah, G.A. Iwo, E.E. Obok and G.O. Ukoha, 2012. Yield performance of popcorn (*Zea mays* L. *everta*) under lime and nitrogen fertilization on an acid soil. J. Agric. Sci., 4: 12-19.
5. Moran, J.B., 2011. Factors affecting high mortality rates of dairy replacement calves and heifers in the tropics and strategies for their reduction. Asian Australas. J. Anim. Sci., 24: 1318-1328.
6. Paliwal, R.L., 2000. Genetic Resources. In: Tropical Maize: Improvement and Production. Paliwal, R.L., G. Granados, H.R. Lafitte, A.D. Vlollc (Eds.)., United Nations Food and Agricultural Organisation, Rome, Italy, pp: 105-114.
7. Matsuoka, Y., Y. Vigouroux, M.M. Goodman, J. Sanchez, E. Buckler and J. Doebley, 2002. A single domestication for maize shown by multilocus microsatellite genotyping. Proc. Nat. Acad. Sci., 99: 6080-6084.
8. Poehlman, J.M., 1987. Breeding Corn (Maize). In: Breeding Field Crops, Sleper, D.A. and J.M. Poehlman, Springer, Dordrecht, pp: 451-507,.
9. Obok, E., M. Ittah, I. Udo, E. Ojubi, J. Ulafor and S. Umoetok 2020. Genetic variability and seasonal influence of fall armyworm (spodoptera frugiperda (j.e. smith)) damage to early vegetative growth of african maize accessions in the humid tropics of south-eastern Nigeria. J. Anim. Plant Sci., 31: 143-155 10.36899/JAPS.2021.1.0202.
10. Gusmini, G. and T.C. Wehner, 2007. Heritability and genetic variance estimates for fruit weight in watermelon. Hort. Sci., 42: 1332-1336.
11. Singh, R.K. and B.D. Choudhary, 1995. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, Pages: 318.
12. Beyene, Y., S. Mugo, C. Mutinda, T. Tefera and H. Karaya *et al*., 2011. Genotype by environment interactions and yield stability of stem borer resistant maize hybrids in Kenya. Afr. J. Biotechnol., 10: 4752-4758.
13. Edmeades, G.O., J. Bolanos, A. Elings, J.M. Ribaut, M. Bänziger and M.E. Westgate, 2000. The Role and Regulation of the Anthesis-Silking Interval in Maize. In: Physiology and Modelling Kernel Set in Maize, Westgate, Westgate, M.E. and K.J. Boote (Eds.)., Crop Science Society of America and American Society of Agronomy, America, pp: 43-73.

14. Rahman, H., Durreshawar, S. Ali, F. Iftikhar, I.H. Khalil, S.M.A. Shah and H. Ahmad, 2010. Stability analysis of maize hybrids across North West of Pakistan. Pak. J. Bot., 42: 1083-1091.
15. Salami, A.E., S.A.O. Adegoke and O.A. Adegbite, 2007. Genetic variability among maize cultivars grown in Ekiti-State, Nigeria. Middle-East J. Sci. Res., 2: 9-13.
16. Qamar, M., Z.A. Gurmani, H.N. Malik and S.K. Tanveer, 2007. Evaluation of maize hybrids/synthetics under double cropping zone of northern areas of Pakistan. Sarhad J. Agric., 23: 1009-1012.
17. Amad, S.Q., S. Khan and F. Ghaffar, 2007. Genetic diversity analysis for yield and other parameters in maize (*Zea mays* L.) genotypes. Asian J. Sci., 3: 386-388.
18. Mahmood, Z., S.U. Ajmal, G. Jilani, M. Irfan and M. Ashraf, 2004. Genetic studies for high yield of maize in chitral valley. Int. J. Agric. Biol., 6: 788-789.
19. Falconer, D.S., 1989. Introduction of Quantitative Genetics. 3rd Edn., Longman Scientific and Technical., Longman House, Burnt Mill. Harlow, Essex, England..
20. Johnson, H.W., H.F. Robinson and R.E. Comstock, 1955. Estimates of genetic and environmental variability in soybeans. Agron. J., 47: 314-318.
21. Pathak, H.C. and S.K. Dixit, 1992. Genetic variability and interrelationship studies in black seeded sesame (*Sesamum indicum* L.). Madras Agric. J., 79: 94-100.
22. Iwo, G.A. and E.E. Obok, 2010. Agronomic performance and estimate of genetic variability of upland rice genotypes on acid soil of Cross river state. Global J. Agric. Sci., 9: 1-7.
23. Iwo, G.A., A.A. Idowu and S. Misari, 2006. Genetic variability and correlation studies in sesame (*Sesamum indicum*). Global J. Pure Appl. Sci., 13: 35-38.