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MORPHOLOGICAL ANALYSIS OF INDIGENOUS AND HYBRIDS MAIZE GENOTYPES COMMONLY CULTIVATED IN SOURTHERN GUINEA SAVANNA AGRO-ECOLOGY OF NIGERIA

By

***Ibirinde, D. O[1]., Nuhu, J. A[2]., Iliya, M. N[3]., Yohanna, D[4] and Abubakar, M. S[5].**

Department of Crop Production and Protection, Federal University Wukari, Nigeria

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Abstract

The research was conducted to analyse the morphological characteristics of some indigenous as well as hybrid maize genotypes, commonly grown in the Southern Guinea Savannah Agro-ecology of Taraba state. Ten maize genotypes comprising of six hybrids (Sammaz 52, Sammaz 53, Sammaz 16, Sammaz15, Sammaz 17 and Sammaz 51) as well as four landraces; Chipyan-Nyonyo (CN), Chipyan-Mbumbu (CM), Zapkpa-Fyen (ZF) and (Zakpakan). The experiment was laid out in a Randomized Complete Block Design (RCBD), replicated three times. At anthesis, pollination was controlled in order to prevent indiscriminate pollination. Data collected on morphological and yield traits were statistically analyzed, with the mean separated by Duncan Multiple Range Test (DMRT). Analysis of Variance (ANOVA) at 5% probability level indicated significant differences among the ten genotypes with respect to the traits measured, where CN recorded the least number of days to tasselling (53.50), silking (57.28), physiological maturity (75.00), height at maturity (1.78m) and ear heights (70.56cm). However, highest values for ear weight with husk (159.89g) and ear weight without husk (130.39g) were recorded by Sammaz 16, while the highest value for number of kernel per row (30.78) was obtained in Sammaz 15. It was concluded, that, Chipyan-nyonyo may be recommended for selection in maize improvement programmes for earliness and moderate height at maturity. Also Sammaz 16 and Sammaz 15 are recommended for improvement programmes targeted at yield and kernel size in maize.

Keywords: *Morphology, Maize, landraces, hybrids, Agro-ecology*

INTRODUCTION

The Poaceae family includes the widely grown cereal crop maize (*Zea mays L.*), which has its roots in central and southern America. Muhammad *et al.* (2017) states that maize is the third most important cereal crop, following rice and wheat, with a global production share of 9%. Its adaptability to many climes makes it a popular crop for farmers all around the globe. Worldwide, 197 million hectares of land were used to grow 1047 million metric tonnes of maize. Brazil accounted for 8% of this total, China for 25%, and the United States for 37% (FAOSTAT, 2018). With a production of over 22 million metric tonnes, Western Africa contributed significantly to Africa's overall maize output of over 78 million metric tonnes, which accounted for 7% of the global total (FAO, 2018). Of the 22.39 million metric tonnes of maize grown in West Africa, 10 million metric tonnes were produced by Nigeria, making up about half of the region's total (FAOSTAT, 2018). West African total maize output averaged 13.7 million metric tonnes from 2006–2010 and 17.6 millionmetric tonnes from 2011–2015 (FAO, 2016). A staple crop for humans and animals alike, maize (Zea mays L.) also provides valuable industrial raw materials for a wide range of products, including paper, textiles, and processing (Kumar and Jhariya, 2013).

Despite advancements in agricultural practices and breeding techniques, achieving consistent and substantial increases in maize yield remains a significant challenge (Mulungu and Ng'ombe, 2019, Saha *et al.*, 2019). The low yields are attributable to various abiotic and biotic stresses coupled with unpredictable climate, particularly in terms of moisture deficits, rising temperature and poor soil fertility and poor management system (Sharma and Misra, 2011). Abiotic factors limiting maize production include drought and low soil fertility. The most important biotic stresses limiting maize production are diseases, insect pests and parasitic weeds (Pratt

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et al. 2003; Badu-Apraku and Fakorade 2017; Das *et al*., 2019).

In order to develop breeding methods for crops with high yields, scientists (Breeders) need accurate information on genetic parameters like heritability estimates, phenotypic coefficient of variation (PCV), and genotypic coefficient of variation (GCV) (Singh *et al.*, 2017). By identifying morphological markers linked to yield-associated traits, breeders can expedite the selection process and improve the accuracy of genotype prediction (Nelimor *et al.*, 2019). This would accelerate the development of high-yielding maize varieties while reducing the time and resources required for conventional phenotypic evaluation. Furthermore, the full extent and distribution of genetic diversity for improved yield traits across diverse maize populations remain inadequately understood. This knowledge gap hinders targeted breeding efforts aimed at developing high-yielding maize varieties capable of withstanding biotic and abiotic stresses while meeting the demands of a growing global population. However, this research aimed at assessing the morphological variance of the targeted genotypes.

MATERIALS AND METHODS

Experimental Site

The Teaching and Research Farm of the Federal University Wukari in Taraba State of Nigeria, was the site of the experiment during the 2021 and 2022 growing seasons. The coordinates of Wukari are 7052°17.000N and 9046°40.300E, located in the Guinea Savannah Agro-ecology of the North-eastern Nigeria and has temperatures between 28^0 and 30^0 as well as a yearly rainfall of 1058 to 1300 millimeters, and a relative humidity of approximately 15%. According to Ibirinde *et al*. (2020) and Jakada and Adepoju (2023), Wukari is considered suitable for the cultivation of diverse range of crops, such as rice, yam, sorghum maize with different fruit and vegetable crops.

Genetic Materials

The genetic materials consisted of ten maize genotypes (Six hybrids and four local varieties) that are commonly cultivated within the Southern Guinea Savanna Agro-ecology of Nigeria.

Sources and Characteristics of Genetic Materials

The source of genetic materials is presented in the Table 3.1, while their characteristics are presented in Table 3.2.

Description of Qualitative Traits of the Studied Genetic Materials

The description of qualitative traits of the studied maize genotypes is shown in Table 3.3

Table 1: Sources of Genetic Materials

S/No	Genotypes	Source
1.	Sanmaz 15	IAR, ABU Zaria, Kaduna State.
2.	Sammaz 16	IAR, ABU Zaria, Kaduna State
3.	Sammaz 17	IAR, ABU Zaria, Kaduna State
4.	Sammaz 51	IAR, ABU Zaria, Kaduna State
5.	Sammaz 52	IAR, ABU Zaria, Kaduna State
6.	Sammaz 53	IAR, ABU Zaria, Kaduna State
7.	Chipyan-nyonyo (CN)	Local maize farmer, Wukari, Taraba State. (Tsinipanbea village, Wukari LGA)
8.	Chipyan-mbumbu (CM)	Local maize farmer, Wukari, Taraba State. (Tsinipanbea village, Wukari LGA)
9.	Zakpa-kan (ZK)	Local maize farmer, Ibi, Taraba State. (Bakyu village, Ibi LGA)
10.	Zakpa-fyen (ZF)	Local maize farmer, Wukari, taraba state. (Gakundo village, Wukari LGA)

Table 2: Characteristics of the Genetic Materials

S/NO	GENOTYPES	Kernel type	Kernel colour	Resistibility
1.	Sammaz 15	Flint	White	Tolerance to Striga
2.	Sammaz 16	Flint	White	Tolerance to Striga
3.	Sammaz 17	Flint	White	Tolerance to Striga
4.	Sammaz 51	Flint	White	Striga/Drought Resistance
5.	Sammaz 52	Flint	Yellow	Striga/Drought Resistance
6.	Sammaz 53	Flint	White	Striga/Drought Resistance
7.	Chipyan-nyonyo (CN)	Flint	Yellow	
8.	Chipyan-mbumbu(CM)	Flint	White	
9.	Zakpa-kan (ZK)	Flint	Red	
10	Zakpa-	Dent	White	

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. fyen(ZF)

Table 3: Qualitative Traits of the Studied Genetic Materials

Genotypes	Cob colour	Pericarp colour	Endosperm colour
Sammaz 52	Creamy white	Yellow	Yellow
Sammaz 16	Creamy white	Creamy white	White
Sammaz 15	Creamy white	Creamy white	White
Sammaz 17	Creamy white	Creamy white	White
Chipyannyonyo	Creamy white	Yellow	Yellow
Zakpakan	Creamy white	Red	White
Sammaz 51	Creamy white	Creamy white	White
Sammaz 53	Creamy white	Creamy white	White
Zakpafyen	Red	Creamy white	White
Chipyanmbumbu	Creamy white	Creamy white	White

Experimental Design

A Randomised Complete Block Design (RCBD) was used for the experiment in both seasons (2021 and 2022). The bed size was 1.5m x 3m (4.5 m^2). Each of the plots is comprised of thirty plant stands at 30cm by 75cm intra and inter row spacing, for each of the genotypes respectively. The plots were replicated three times, thus giving ten beds per plot and a total of thirty beds for the entire experimental plots.

Seed Treatment and Sowing

Before sowing, seeds were treated with apron star 50DS at the rate of 1g/2kg of seeds before sowing. After the seed treatment, the treated seed were sown at the rate of 2-3 seeds per hole at the depth of 2-4cm deep and later thinned to one plant per stand. Vacant plant stands were supplied at six to eight days after sowing depending on the variety.

Cultural (Agronomic) Practices

Fertilizer Application: Fertilizer was applied at the recommended rate of N:P:K (120:60:60). Also, the fertilizer application was split into two doses, first dose was applied at two weeks after sowing using N60, P60, K60 and the second dose was applied at six weeks after sowing using the remaining N60. However, top dressing method of application was adopted.

Weed control: Manual weeding was done at three and seven weeks respectively.

Pest control: Furadan powder was applied to the maize to control the incidence of stem borer.

Pollination

Pollen grains were collected from the maize plant's inflorescence (the tassels) to the stigma (the silk). According to Ibirinde *et al*. (2020), fertilisation can't take place until the pollen's male reproductive cells fuse with the ovule's female reproductive cells via the silk.

Tagging

In order to have good representation of the total population, five plant were randomly sampled and tagged per bed across the field for data collection and other operations.

Ear bagging for Hand Pollination

For avoidance of indiscriminate pollination by foreign pollinators, and to keep the genotypes pure, ear bag was improvised to quickly cover the newly ear shoots by placing improvised bag firmly over the newly ear shoots.

Tassel bagging and pollen grain collection

As soon as the tassel are fully matured and ready to shed pollen grains, between 7am to 11am in everyday of pollination when dew has escaped from plant, the tassel of the tagged plant were bagged using big brown envelop. Pollen grains was collected by bending the bagged tassel over gently and the bag was tapped several times to shake the pollen grains from the tassel (anther) to the bag and the bag was tilted enough to disallowed the pollen grain to fallout. This was achieved by following the method adopted by Nielson (2010).

Pollination procedure

After the collection of pollen grains as the silk is ready to receive pollen grains with trichome (Pollen grains receptive component of the silk) visible on the silk, the ear bag used in covering the ear was quickly removed and if the silk are too lengthy, it will be trimmed with scissor and the collected pollen grains will be evenly poured onto the silk and covered back again promptly with the ear shoot bag in order to forestall undesirable pollination. Appropriate measured was taken into cognizance to ensure that the pollen get into the silk having all of them pollinated. This is by ensuring that all the silk were touched by pollen grain that was pour onto the silk. This process was repeated thrice, following the recommendations in the work done by Ibirinde *et al.,* (2020).

Field Data Collection

The method developed by the regional maize course for technicians in Arusha, Tanzania in 1997 was used both in the field and in the lab to collect data on morphological, reproductive, seed, and nutritional factors.

The quantitative traits that were considered in the field for data collection and the instruments utilised are listed below:

Days to emergence (DTE): Recorded as number of days from sowing to the emergence of the sown seed was counted and recorded.

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Height at three and six weeks after sowing: Was Measured in meter (m) using meter rule. Measured from the soil surface to the arc leaves.

Days to tasselling (DTT): This was determined by counting the number of days from sowing to extruding of the tassels and was recorded.

Days to Silking (DTS): It was estimated as the number of days from sowing to the day of visible expression of silk.

Ear height: Measured in centimetre (cm) with the used of meter rule, measured from the soil surface to the node that the ears were emerged.

Ear leaf Width: Determine with the use of measuring tape, in centimeter (cm), and was measured perpendicular to the ear leaf length.

Ear leaf Length: Measured in centimeter (cm) using measuring tape. Was measured and recorded from the base to the tip of the ear leaf.

Ear insertion angle: Measured in degrees (^{0}) with the help of protractor. Achieved by measuring the angle between the plant stem and the ear.

Height at maturity: Measured in meter (m) using meter rule. Measured from the soil surface to the flag leaves of the plant.
Days to physiological maturity (DTPM): Number of days taken by the ears to attain physiological maturity from the sowing date was counted and recorded.

Number of Tassel branches: Tassel branches per plant stand were counted and recorded, when tassel branches were fully expressed and started shading pollen grains.

Harvesting
Harvesting was manually done and labelled when the crop had attained full physiological maturity and appropriate moisture contents.

Post-harvest Data Collection
After harvest, the following data were collected;

Ear length: Measured in centimeter (cm) using meter rule, from the base of the ear to the tip of the ear.

Ear diameter: Measured in centimeter (cm) using verniercaliper, by measuring the circumference of the dehusk ear.

Ear weight (with husk and without husk): Measured in gram (g) using sensitive weighing scale, by placing the ear on the sensitive weighing scale where the weight of the ear was determined and recorded.

Length of ear peduncle: Measured in centimeter (cm) using meter rule, from the base of the peduncle to a point where the cob emerged.

Weight of 100 seeds: Measured in gram (g) using sensitive scale. This was achieved by counting hundred seed and placed on the sensitive scale, where the weight was determined.

Kernel Length: Measured in millimeter (mm) using verniercaliper.

Kernel Width: Measured in millimetre using verniercaliper (mm).

Kernel thickness: Measured in millimetre using verniercanliper (mm).

Number of nodes: Nodes per plant stand were counted and recorded. It was determined by counting from the first node from the base of the stem to last node at the top where tassel peduncle emerged.

Number of rows per cob: All the number of rows on each cob were counted and recorded after determination of ear weight with husk and without husk.

RESULTS

Description of Agronomic Traits of Maize Genotypes
Significant differences ($P < 0.05$) were observed across the genotypes for all the traits measured for the two seasons (Table 3.1). In 2021 cropping season, Sammaz 53 recorded the least (4.56) days to emergence and this was significantly lower when compared with the other genotypes. Plant height at three weeks after sowing were significantly different, with Sammaz 15 and Sammaz 17 recording the highest values (0.26 m, 0.27 m) in the 2021 and 2022 planting seasons respectively. Meanwhile, plant height at six weeks after sowing showed that Sammaz 17 (1.03 m and 1.07 m), in the 2021 and 2022 planting seasons respectively, was significantly taller than other genotypes. The differences in number of days to tasseling, days to silking and days to physiological maturity were statistically significant. Chipyannyonyo tasselled (53.44), initiated silking (57.22) as well as attained physiological maturity (75.11) earlier than the other genotypes under review.

Plant height at maturity indicated significant ($P<0.05$) differences among the genotypes used. The result obtained in season one indicated that Zakpakan had the highest value (2.33m) and Chipyannyonyo which recorded 1.80m as the shortest to attained maturity. However, in season two, Sammaz 52, Sammaz 17, Zakpakan and Zakpafyen are statistically similar but Zakpakan and Zakpafyen recorded the highest and equal value of 2.23m and the least value was observed in Chipyannyonyo (1.78m). Ear height was observed with noticeable variations across the seasons. Zakpakan recorded the largest value (108cm and 109cm) in both 2021 and 2022 cropping seasons, and significantly ($P<0.05$) higher than other studied genotypes with exception of Chipyannyonyo with the value of 69.22cm and 71.89 in 2021 and 2022 respectively.

Table 3.1a: Agronomic Traits Descriptive

GENOTYPES	DTE	PH3WKS(m)	PH6WK(m)	DTT

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	2021	2022	2021	2022	2021	2022	2021	2022
Sammaz 52	5.00^{b}	$5.00^{b}\pm_{0.00}$	0.25^{a}	$0.25^{ab}\pm_{0.0.03}$	0.94^{abc}	$0.93^{abc}\pm_{0.22}$	53.33^{cd}	$55.67^{cde}\pm_{2.50}$
Sammaz 16	5.00^{b}	$5.00^{b}\pm_{0.00}$	0.24^{ab}	$0.24^{bc}\pm_{0.04}$	0.77^{cd}	$0.73^{d}\pm_{0.10}$	57.00^{bc}	$56.67^{bcd}\pm_{3.35}$
Sammaz 15	5.00^{b}	$5.00^{b}\pm_{0.00}$	0.26^{a}	$0.25^{abc}\pm_{0.03}$	0.92^{abcd}	$0.97^{ab}\pm_{0.17}$	52.22^{cd}	$54.78^{de}\pm_{2.78}$
Sammaz 17	5.00^{b}	$5.00^{b}\pm_{0.00}$	0.26^{a}	$0.27^{a}\pm_{0.03}$	1.03^{a}	$1.07^{a}\pm_{0.32}$	55.56^{cd}	$55.78^{cde}\pm_{2.73}$
CN	5.00^{b}	$5.00^{b}\pm_{0.00}$	0.22^{b}	$0.23^{bcd}\pm_{0.02}$	0.97^{ab}	$0.96^{ab}\pm_{0.15}$	53.44^{d}	$53.56^{e}\pm_{2.35}$
ZK	5.78^{a}	$5.56^{a}\pm_{0.52}$	0.22^{b}	$0.22^{cd0.}\pm_{0.01}$	0.80^{bcd}	$0.84^{bcd}\pm_{0.08}$	63.22^{a}	$63.22^{a}\pm_{4.57}$
Sammaz 51	4.67^{bc}	$4.67^{b}\pm_{0.50}$	0.24^{ab}	$0.23^{bcd}\pm_{0.03}$	0.74^{d}	$0.78^{cd}\pm_{0.10}$	59.11^{b}	$58.11^{bc}\pm_{1.62}$
Sammaz 53	4.56^{c}	$5.00^{b}\pm_{0.00}$	0.24^{ab}	$0.23^{bcd}\pm_{0.04}$	0.79^{bcd}	$0.85^{bcd}\pm_{0.13}$	56.78^{bc}	$56.33^{cde}\pm_{2.00}$
ZF	5.44^{a}	$5.56^{a}\pm_{0.52}$	0.24^{ab}	$0.23^{bcd}\pm_{0.03}$	0.80^{bcd}	$0.81^{bcd}\pm_{0.10}$	59.33^{b}	$59.44^{b}\pm_{3.12}$
CM	4.78^{bc}	$4.89^{bc}\pm_{0.33}$	0.22^{b}	$0.20^{d}\pm_{0.01}$	0.75^{cd}	$0.73^{d}\pm_{0.07}$	57.89^{bc}	$56.78^{bcd}\pm_{2.543}$
MEAN	**5.02**	**5.07**$\pm_{0.39}$	**0.24**	**0.24**$\pm_{0.03}$	**0.85**	**0.87**$\pm_{0.19}$	**57.29**	**57.03**$\pm_{3.75}$

Table 3.1b: Agronomic Traits Descriptive

GENOTYPES	DTS		DTPM		PHM(m)		EH(cm)	
	2021	2022	2021	2022	2021	2022	2021	2022
Sammaz 52	60.11^{cde}	$59.00^{cde}\pm 2.68$	95.44^{b}	$96.33^{a}\pm_{2.50}$	2.13^{bc}	$2.18^{a}\pm_{0.18}$	99.33^{a}	$89.44^{b}\pm_{15.40}$
Sammaz 16	59.67^{de}	$59.78^{cde}\pm_{3.70}$	84.89^{e}	$84.33^{d}\pm\pm_{2.92}$	2.00^{cd}	$1.96^{bc}\pm_{0.25}$	67.78^{d}	$65.44^{d}\pm_{10.35}$
Sammaz 15	57.44^{e}	$57.89^{de}\pm_{2.90}$	84.22^{e}	$84.33^{d}\pm_{2.00}$	2.05^{bc}	$2.09^{ab}\pm_{0.18}$	81.22^{b}	$82.33^{bc}\pm_{7.96}$
Sammaz 17	59.78^{de}	$60.22^{cde}\pm_{4.12}$	88.11^{cd}	$87.89^{c}\pm_{3.68}$	2.14^{bc}	$2.19^{a}\pm_{0.17}$	80.11^{c}	$85.67^{b}\pm_{8.68}$
CN	57.33^{e}	$57.22^{e}\pm_{2.59}$	75.11^{f}	$74.89^{e}\pm_{3.11}$	1.80^{e}	$1.78^{d}\pm_{0.12}$	69.22^{d}	$71.89^{cd}\pm_{8.48}$
ZK	69.22^{a}	$68.22^{a}\pm_{3.50}$	98.67^{a}	$97.78^{a}\pm_{1.78}$	2.33^{a}	$2.23^{a}\pm_{0.25}$	108.67^{a}	$109.11^{a}\pm_{15.94}$
Sammaz 51	63.11^{bc}	$61.89^{bc}\pm_{1.46}$	88.00^{cd}	$88.11^{bc}\pm_{2.15}$	2.10^{bc}	$2.08^{ab}\pm_{0.10}$	88.11^{b}	$89.22^{b}\pm_{6.36}$
Sammaz 53	61.00^{cd}	$59.44^{cde}\pm_{2.18}$	90.78^{c}	$90.56^{b}\pm_{2.65}$	2.05^{bc}	$2.12^{ab}\pm_{0.13}$	82.11^{b}	$82.00^{bc}\pm_{13.67}$
ZF	64.33^{b}	$64.44^{b}\pm_{3.67}$	100.44^{a}	$96.67^{a}\pm_{2.18}$	2.22^{ab}	$2.23^{a}\pm_{0.17}$	88.56^{b}	$93.00^{b}\pm_{3.75}$
CM	61.11^{cd}	$61.00^{cd}\pm_{2.39}$	85.56^{de}	$87.22^{c}\pm_{3.08}$	1.86^{ed}	$1.84^{cd}\pm_{0.08}$	80.44^{c}	$82.00^{bc}\pm_{7.54}$
MEAN	**61.31**	**60.9**	**89.12**	**88.81**	**2.07**	**2.07**	**84.56**	**85.01**

DTE=Days to emergence. PH3WKS=Plant height at three weeks. PH6WKS=Plant height at six weeks. DTT=Days to tasseling. DTS=Days to silking. DTPM=Days to physiological maturity. PHM= Plant height at maturity. EH=ear height

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Vegetative Characters of the Studied Genotypes in 2021 and 2022 Planting Seasons

Among the genotypes studied, there were notable variations in the number of nodes; Sammaz 52 had the highest (14.22 and 14.89) number of nodes in 2021 and 2022 cropping seasons. However, the least (11.67) number of nodes were produced by Sammaz 15 and Sammaz 51 in 2021 and 2022 respectively. Ear insertion angle varied significantly among the studied genotypes. The result showed that Zakpakan had the lowest value (27.56^{0}) in the 2021 cropping while Chipyannyonyo recorded the highest values (51.67^{0} and 46.11^{0}) across the two cropping seasons. (51.67^{0}).

TABLE 3.2a: Vegetative Traits Descriptives

GENOTYPES	ELL(cm)		ELW(cm)		EP(cm)		TB	
	2021	2022	2021	2022	2021	2022	2021	2022
Sammaz 52	90.78^{a}	86.33^{ab}c±$_{7.93}$	9.49^{ab}	9.48±$_{0.75}$	8.39^{ab}	8.83^{b}±$_{1.77}$	23.78^{a}	20.78^{a}±$_{4.09}$
Sammaz 16	80.11^{bc}	80.78^{c}±$_{8.92}$	9.29^{ab}	9.53±$_{1.08}$	10.06^{a}	10.78^{a}±$_{3.89}$	12.44^{c}	11.78^{b}±$_{3.89}$
Sammaz 15	92.44^{a}	94.22^{a}±$_{7.02}$	9.39^{ab}	9.83±$_{0.85}$	9.17^{ab}	9.22^{ab}±$_{1.80}$	18.11^{b}	20.67^{a}±$_{2.66}$
Sammaz 17	91.78^{a}	89.11^{abc}±$_{8.74}$	9.66a	9.51±$_{1.56}$	8.11^{ab}	7.61^{b}±$_{0.93}$	19.11^{ab}	19.44^{a}±$_{5.29}$
CN	76.33^{c}	84.00^{bc}±$_{4.03}$	8.47^{b}	9.13±$_{1.08}$	9.00^{ab}	9.50^{ab}±$_{1.11}$	19.78^{ab}	18.78^{a}±$_{6.83}$
ZK	92.11^{a}	92.56^{ab}±$_{11.11}$	8.88^{ab}	9.24±$_{0.83}$	8.22^{ab}	8.72^{b}±$_{1.28}$	18.44^{b}	17.78^{a}±$_{2.63}$
Sammaz 51	89.67^{a}	84.67^{bc}±$_{5.94}$	9.46^{ab}	9.56±$_{0.57}$	8.67^{ab}	8.56$_{b}$±$_{1.52}$	18.44^{b}	19.56^{a}±$_{3.29}$
Sammaz 53	85.56^{ab}	86.78^{abc}±$_{9.28}$	8.93^{ab}	8.89±$_{1.04}$	7.33^{b}	7.72^{b}±$_{1.53}$	18.56^{b}	19.33^{a}±$_{4.50}$
ZF	90.67^{a}	90.11^{ab}±$_{8.70}$	9.06^{ab}	9.11±$_{1.05}$	8.39^{ab}	8.06^{b}±$_{1.23}$	20.78^{ab}	19.11^{a}±$_{3.82}$
CM	86.89^{ab}	88.56^{abc}±$_{6.18}$	9.70^{a}	9.72±$_{0.90}$	8.11^{ab}	9.00^{ab}±$_{0.97}$	18.78^{b}	18.89^{a}±$_{2.21}$
MEAN	**87.73**	**87.71**	**9.23**	**9.40**	**8.54**	**8.801**	**18.82**	**18.61**

TABLE 3.2b: Vegetative Traits Descriptives

GENOTYPES	TP(cm)		NON		EIA(^{0})	
	2021	2022	2021	2022	2021	2022
Sammaz 52	5.78^{ab}	6.89$^{ab±}$$_{3.40}$	14.22^{a}	14.89^{a}±$_{1.69}$	41.11^{b}	38.33^{b}±$_{6.12}$
Sammaz 16	5.67^{ab}	5.67^{ab}±$_{1.81}$	11.56^{c}	12.33^{bc}±$_{1.73}$	34.44^{bcd}	34.44^{bc}±$_{5.83}$
Sammaz 15	7.11^{ab}	6.44^{ab}±$_{1.74}$	13.11^{abc}	13.44^{ab}±$_{1.58}$	35.56^{bc}	37.22^{b}±$_{4.41}$
Sammaz 17	7.44^{ab}	6.67^{ab}±$_{2.45}$	12.78^{abc}	12.44^{bc}±$_{1.23}$	38.22^{bc}	37.89^{b}±$_{9.55}$
CN	8.22^{a}	7.89^{ab}±$_{2.37}$	12.56^{bc}	12.56^{bc}±$_{0.72}$	51.67^{a}	45.00^{a}±$_{4.33}$
ZK	6.67^{ab}	6.78^{ab}±$_{1.09}$	13.67^{ab}	13.78^{ab}±$_{1.49}$	27.56^{d}	27.78^{c}±$_{8.70}$
Sammaz 51	6.56^{ab}	8.89^{a}±$_{1.69}$	12.44^{bc}	11.67^{c}±$_{1.50}$	30.56^{cd}	35.67^{b}±$_{5.93}$
Sammaz 53	8.33^{a}	6.56^{ab}±$_{2.18}$	13.22^{abc}	12.44^{bc}±$_{1.33}$	35.67^{bc}	32.78^{bc}±$_{4.97}$
ZF	7.89^{ab}	7.44^{ab}±$_{3.12}$	12.00^{bc}	13.11^{bc}±$_{1.54}$	35.11^{bcd}	34.22^{bc}±$_{3.92}$
CM	5.22^{b}	5.44^{b}±$_{2.40}$	12.11^{bc}	11.67^{c}±$_{1.87}$	37.33^{bc}	46.11^{a}±$_{10.83}$
MEAN	**6.89**	**6.87**	**12.77**	**12.83**	**36.72**	**36.94**

ELL=TP=Tassel peduncle. NON=Number of Node. EIA=Ear insertion Angle.

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Yield Traits Performance of the Studied Genotypes in 2021 and 2022

There was a significant difference in the ear weight with husk. Sammaz 16 had the highest weight (176.89g) and Chipyanyonyo had the lowest weight (104.39g) in the first planting. In 2022, Sammaz 15 measured the highest ear weight with husk (185.56g) and the lowest weight (141.44g), was recorded by Sammaz 53. Sammaz 17 had the widest ear diameter (4.48 cm) in 2021 and 2022 assessments, while the least ear diameter value (3.52cm).was recorded by Zakpakan. Other yield traits (number of cob per plant, number of row per cob and number of kernel per row) revealed significant differences in the maize genotypes that were studied. Sammaz 16, Sammaz 17 and Zakpakan produced highest number of cobs per plant (2.22) in the first season (2021), while Chipyanmbumbu produced the highest number of cobs (2.33) in the second cropping season (2022). The result showed that Chipyanmbumbu produced the highest number of rows per cob (15.78 and 16.22) for both seasons. Meanwhile, Zakpafyen produced the lowest number of row (12.89) per cob.

In the 2021 cropping season, ear length varied significantly across the genotypes; Chipyannyonyo had the shortest ears, measuring 11.78 cm, while Sammaz 52 had the longest (15.72 cm). There was a significant difference in the kernel length of the maize genotypes. Chipyannyonyo had the shortest kernel in the first and second experiments, measuring 6.89 mm and 6.78 mm respectively. Similarly, in 2022, Zakpafyen recorded the longest kernel, measuring 8.33 mm.

Significant ($P<0.05$) variations in kernel width were noticed across the genotypes in 2021 cropping season. Sammaz 52 had the widest kernel (5.78 mm), but was not statistically different from the whole of the genotypes examined in this study except Chipyanmbumbu which had the clinched kernel (4.89mm). Similarly, Sammaz 52 in 2022 cropping season emerged the genotypes with the widest kernel (5.78mm) but was statistically same with Zakpafyen, Sammaz 51, Zakpakan, Sammaz 16, Sammaz 15, Sammaz 17, Chipyannyonyo and Sammaz 53 but significantly higher than Chipyanmbumbu which produced the most clinched kernel (4.56mm).

Significant difference was observed among the genotypes for kernel thickness and Hundred seed weight as shown in Table 4.3d. Significant ($P<0.05$) differences in the obtained values for kernel thickness across the genotypes in the first season showed that, Sammaz17 was measured with the highest value (2.89mm), and was statistically the same with the whole of the investigated genotypes with exception of Zakpakan which had the lowest (2.33mm). Consequently, in 2022 season, Chipyanmbumbu, Sammaz 53, Chipyannyonyo, and Sammaz 17 were observed with the highest and equal value (2.78mm) for Kernel thickness and they can also be compared with rest of the genotypes except Chipyannyonyo which had the least value (2.22mm). Additionally, there were notable variations in hundred seed weight among the genotypes. Sammaz16 had the uppermost value of 28.78g in 2021, though it makes no difference statistically with Sammaz 52, Sammaz 15, Sammaz 51, Sammaz 53, Zakpafyen and Chipyanmbumbu but significantly ($P<0.05$) higher than Sammaz 17 and Zakpakan had the smallest value (24.89g). Likewise in 2022, Chipyanmbumbu was observed with the largest value (28.78g) but was not statistically different from Sammaz 52, Sammaz 16, Sammaz 15, Sammaz 17, Sammaz 51 and Sammaz 53 but significantly higher than Chipyannyonyo, thus, the least value was found in Zakpakan (25.44g).

Table 3.3a: Yield Traits Description

GEN	EWWH(g)		EWWO(g)		ED(cm)		NOCPP	
	2021	2022	2021	2022	2021	2022	2021	2022
Sammaz 52	162.78^{a}	$171.67\pm_{40.90}$	131.11	$147.78\pm_{41.68}$	4.30^{b}	$4.41^{a}\pm_{0.19}$	1.11	$1.00^{b}\pm_{0.00}$
Sammaz16	176.89^{a}	$142.89\pm_{47.85}$	141.11	$119.67\pm_{40.90}$	4.37^{a}	$4.47^{a}\pm_{0.28}$	1.22	$1.11^{ab}\pm_{0.33}$
Sammaz 15	170.22^{a}	$185.56\pm_{38.33}$	141.00	$160.56\pm_{37.84}$	4.37^{a}	$4.12^{ab}\pm_{0.52}$	1.22	$1.22^{ab}\pm_{0.44}$
Sammaz17	132.33^{ab}	$166.22\pm_{56.60}$	109.00	$140.56\pm_{45.31}$	4.43^{a}	$4.48^{a}\pm_{0.46}$	1.11	$1.00^{b}\pm_{0.00}$
CN	104.33^{b}	$141.67\pm_{43.18}$	94.56	$130.00\pm_{40.10}$	3.83^{cd}	$3.87^{bc}\pm_{0.46}$	1.00	$1.00^{b}\pm_{0.00}$
ZK	145.11^{ab}	$146.00\pm_{68.99}$	126.89	$124.11\pm_{59.92}$	3.52^{d}	$3.61^{c}\pm_{0.58}$	1.22	$1.11^{ab}\pm_{0.33}$
Sammaz 51	158.89^{a}	$142.89\pm_{48.04}$	136.67	$124.22\pm_{41.90}$	4.02^{abc}	$4.31^{a}\pm_{0.43}$	1.00	$1.00^{b}\pm_{0.00}$
Sammaz 53	139.33^{ab}	$141.44\pm_{39.97}$	118.00	$119.78\pm_{35.55}$	3.71^{cd}	$3.83^{bc}\pm_{0.46}$	1.00	$1.00^{b}\pm_{0.00}$
ZF	151.11^{ab}	$165.11\pm_{69.99}$	129.44	$140.11\pm_{58.92}$	3.91^{bcd}	$4.13^{ab}\pm_{0.47}$	1.00	$1.00^{b}\pm_{0.00}$
CM	123.89^{ab}	$163.11\pm_{46.22}$	102.00	$133.67\pm_{46.46}$	4.08^{abc}	$4.40^{a}\pm_{0.36}$	1.11	$1.33^{a}\pm_{0.50}$
MEAN	**146.49**	**156.66**$\pm_{50.79}$	**123.68**	**134.04**	**4.05**	**4.16**	**1.10**	**1.08**

Table 3.3b

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GEN	NORPC		NOKPR		EL (cm)		KL(mm)	
	2021	2022	2021	2022	2021	2022	2021	2022
Sammaz 52	14.44^{c}	$13.56^{b}\pm_{1.33}$	31.67^{a}	$29.00\pm_{3.97}$	15.72^{a}	$14.78\pm_{1.92}$	7.67^{abc}	$7.89^{a}\pm_{0.60}$
Sammaz16	15.56^{a}	$14.67^{ab}\pm_{3.00}$	27.44^{ab}	$27.33\pm_{4.53}$	15.00^{ab}	$14.56\pm_{1.42}$	7.67^{abc}	$7.78^{a}\pm_{0.83}$
Sammaz 15	14.00^{abc}	$13.78^{b}\pm_{1.56}$	30.56^{ab}	$31.00\pm_{6.06}$	15.67^{a}	$15.94\pm_{2.43}$	7.33^{bc}	$7.44^{ab}\pm_{0.88}$
Sammaz17	13.33^{bc}	$13.56^{b}\pm_{0.88}$	26.00^{ab}	$28.00\pm_{6.30}$	14.50^{ab}	$15.67\pm_{4.02}$	7.67^{abc}	$7.67^{ab}\pm_{0.71}$
CN	13.33^{bc}	$13.11^{b}\pm_{2.03}$	24.89^{b}	$29.11\pm_{5.37}$	11.78^{c}	$13.94\pm_{1.96}$	6.89^{c}	$6.78^{b}\pm_{1.56}$
ZK	14.67^{ab}	$13.33^{b}\pm_{1.73}$	24.78^{b}	$28.00\pm_{9.50}$	14.78^{ab}	$15.78\pm_{3.06}$	8.22^{a}	$8.11^{a}\pm_{0.60}$
Sammaz 51	14.00^{abc}	$13.78^{b}\pm_{1.20}$	28.11^{ab}	$26.22\pm_{5.17}$	15.50^{ab}	$14.11\pm_{1.27}$	7.56^{abc}	$7.44^{ab}\pm_{0.52}$
Sammaz 53	13.33^{bc}	$14.00^{b}\pm_{1.41}$	27.56^{ab}	$24.89\pm_{4.31}$	13.33^{bc}	$13.50\pm_{2.21}$	7.89^{abc}	$7.78^{a}\pm_{0.83}$
ZF	13.33^{bc}	$12.89^{b}\pm_{1.76}$	28.78^{ab}	$28.00\pm_{6.30}$	15.56^{ab}	$15.06\pm_{2.77}$	8.00^{ab}	$8.33^{a}\pm_{1.00}$
CM	15.78^{a}	$16.22^{a}\pm_{2.11}$	24.78^{b}	$27.78\pm_{5.80}$	12.33^{c}	$13.33\pm_{1.33}$	7.67^{abc}	$7.89^{a}\pm_{0.78}$
MEAN	**13.98**	**13.89**	**27.46**	**27.93**	**14.42**	**14.68**	**7.66**	**7.71**

NORPC=Number of Row Per Cob, NOKPR=Number of Kernel Per Row, EL=Ear length. KL= Kernel length.

Table 3.3c: Yield Traits Description

GEN	KW(mm)		KT(mm)		HSW (g)	
	2021	2022	2021	2022	2021	2022
Sammaz 52	5.78^{a}	$5.78^{a}\pm0.67$	2.78^{ab}	$2.56^{ab}\pm0.52$	28.22^{ab}	$28.56^{a}\pm1.59$
Sammaz16	5.56^{ab}	$5.33^{ab}\pm0.50$	2.78^{ab}	$2.67^{ab}\pm0.50$	28.78^{a}	$28.33^{a}\pm0.87$
Sammaz 15	5.33^{ab}	$5.33^{ab}\pm0.70$	2.78^{ab}	$2.44^{ab}\pm0.53$	27.67^{ab}	$27.78^{a}\pm1.92$
Sammaz17	5.11^{ab}	$5.11^{ab1.05}$	2.89^{a}	$2.78^{a}\pm0.44$	27.11^{b}	$27.22^{a}\pm1.78$
CN	5.11^{ab}	$5.22^{ab0.67}$	2.67^{ab}	$2.22^{b}\pm0.44$	$25’67^{c}$	$25.67^{b}\pm1.22$
ZK	5.56^{ab}	$5.44^{a}\pm0.88$	2.33^{b}	$2.78^{a}\pm0.44$	24.89^{c}	$25.44^{b}\pm1.24$
Sammaz 51	5.11^{ab}	$5.56^{a}\pm0.72$	2.56^{ab}	$2.67^{ab}\pm0.50$	28.22^{ab}	$28.11^{a}\pm^{1.54}$
Sammaz 53	5.56^{ab}	$5.11^{ab}\pm0.78$	2.67^{ab}	$2.78^{a}\pm0.44$	28.33^{ab}	$28.11^{a}\pm1.45$
ZF	5.44^{ab}	$5.56^{a}\pm0.52$	2.78^{ab}	$2.78^{a}\pm0.44$	27.56^{ab}	$27.89^{a}\pm1.27$
CM	4.89^{b}	$4.56^{b}\pm0.72$	2.56^{ab}	$2.67^{ab}\pm0.50$	27.89^{ab}	$28.78^{a}\pm1.48$
MEAN	**5.34**	**5.30**	**2.68**	**2.630**	**27.43**	**27.59**

KW=Kernel width. KT=Kernel thickness. HSW=Hundred Seed weight

4.1 DISCUSSION

Agronomic, Vegetative and Yield Traits

The knowledge of genetic variance component is important in order to understand the magnitude of genetic and environmental influences on crops. The significant variations found among the maize genotypes under study with respect to the traits measured such as early maturity, late maturity, earliness in tasseling and silking, wider leaves, narrow leaves, high and low number tassel branches, ear weight with and without husk, ear diameter, kernel row per cob, number of kernel per row, weight of hundred seed is a reflection of the diversity of their eco-geographical locations which offers a room for improvement of desirable characters through

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selection of the genotypes. This result corroborates the findings of Badu-Apraku *et al*. (2011b) and Badu-Apraku and Oyekunle (2012), Bhatnagar *et al*. (2004) also reported significant variation in performance among and between seven white and nine yellow QPM inbred lines for grain yield. The exceptional variations observed for the genotype Chipyannyonyo, chipyanmbumbu, and sammaz 15 for the traits such as earliness in tasselling and silking, earliness in maturity (as measured in days to physiological maturity), earliness in emergence, shorter height at maturity may provide a wealth of genetic variation for use in breeding inbred lines targeting at early mature and shorter in stature, which will facilitate easiness during harvest. This result is in agreement with those of Ngwuta *et al*. (2001).

Maize reproductive traits such as tassel branches, days to tasseling, silking and its receptivity are component of maize that affect the yield efficiency, as they determine the sufficiency and abundancy or otherwise of maize through pollen grain production, shedding and its receptivity by the silk. The shedding effect of tassel and the silk receptivity affect yield either positively or negatively. Although Sammaaz 16 has the potential for a higher yield, it was found to have inadequate tassel branches and shed pollen grains, which could negatively impact yield efficiency. Tassel features may affect grain yield physiologically, by competing for photosynthesis, and physically, by shading effect. This is in consonant with the discovery of Gue and Wasson (1996) where they stressed that, males in a maize breeding programme should have lots of tassels so they can produce lots of pollen grains, while females should have little tassels so they can partition more towards huge ears.

The ear insertion angle showed a fair amount of variance. Both the insertion angle and the plant's height at various developmental stages contribute to the plant's ability to stand upright, provide strong support against forces such as gravity, and facilitate the free flow of nutrients throughout the plant. The findings are consistent with those of Veci *et al*. (2015), who proposed that a balanced plant centre of gravity, enabled by proper ear insertion and height, reduced lodging and stem breakage, favoured nutrient delivery, and enhance plant yield. There is also variance among the genotypes with regard to the seed metrics, which include number of cob per plant (plant density), number of row per cob (row density), number of kernel per row (kernel density), kernel length, kernel width, kernel thickness, and hundred seed weight. Some kernels are shorter, longer, wider, and clenched, and they all serve as seed and food sources for both humans and animals. The elongated and wider kernels are better for agro-allied companies' raw material needs because they contain more endosperm, germinate more vigorously, and emerge from the soil more fully than the clenched kernels, which are narrower, have a lower concentration of endosperm, and emerge from the soil less vigorously. This is in line with the work done by Ibirinde *et al.* (2022) where they proposed that improved crop stand and production were seen when long grain and grain width were better indicators of high leaf area and appropriate germination %. Variations in ear leaf width and length were noted at specific levels.

To maximise production efficiency, it is important to consider the role that leaf area (Ear leaf length and ear leaf width) plays in plants. The plant's leaves are the primary organs responsible for photosynthetic processes. But the amount of sunlight a plant could absorb for development and growth is dependent on the leaf size and shape. A study conducted by Wu *et al*. (2018) found that plants can enhance their photosynthetic capability by increasing the area of their leaves, since the leaf is the primary organ responsible for photosynthesis.

Conclusion and Recommendation

It is crucial for every breeding programme to use multivariate statistical principles or methods (such as the morphological method, the clustering method, and the biochemical method) to describe and evaluate genetic diversity and relatedness of maize genotypes in order to identify areas that need improvement. This study characterised and evaluated all genotypes to see how similar or different they were. This will help with future maize development projects. When looking at morphological traits, yield aspects, and nutritional composition (biochemical features), all of the genotypes demonstrated a considerable amount of diversity. Potential sources of genetic variation for crop improvement through the development of cultivars resistant to biotic and abiotic stress were identified in landraces, which exhibited adaption features including early flowering and short height, among others. The importance of genetic variation in ensuring adequate nutrition has recently come to light. The question of what and where to preserve can be better answered with a deeper knowledge of genetic variation. Therefore, it is recommended that, Chipyannyonyo (CN) and Sammaz 16 should be selected for improvement as they portrayed morphological characters that may be exploited in order to enhance yield in maize breeding programmes. Also in the ecologies where the duration of rain is less, the cultivation of Chipyannyonyo and Chipyanmbumbu should be encouraged because of their ability to attain maturity early.

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*Corresponding Author: **Ibirinde, D. O**