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Kernel Characterisation of Indigenous Maize Landraces (*Zea mays* L.) from Niger and Kogi States

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Abstract

Maize (*Zea mays* L.) is an annual grass belonging to the Poaceae family, commonly known as the grass family. The maize Kernels show variations that may arise due to genetic factors, environmental conditions, and genotype × environment interactions. The aim of this study is to characterise selected maize landraces from Niger and Kogi States using their kernel characteristics. In this study, the kernels of maize landraces obtained from Niger and Kogi States were characterised using Standard morphological descriptors; like kernel shape, colour, length, width and 1000 seed weight. The length and weight were taken with the use of vernier caliper and the weight with an electronic weighing scale. The data were subjected to analysis and results revealed the presence of variation in kernels of the maize landraces. Three (3) kernel shapes; flat, round to flat and pointed were observed and the dominant shape was round to flat in ten (10) of the landraces, the kernel colour showed variations; with white kernel colour, closely followed by yellow kernel colour, being dominant. The kernel length among the landraces ranged from 8.05mm (in NG-SHIR-006) to 10.65mm (in NG-GIDA-009), kernel width from 7.50mm (in NG-AGAI-002 and NG-BOSS-007) to 10.75mm (in NG-RAFI-011) and weight of 1000 kernels from 140.14g (in NG-BOSS-007) to 300.96 (in NG-RAFI-011). The Unweighted Pair Group Method with Arithmetic Means (UPGMA) similarity index cluster analysis based on the kernel characteristics grouped the maize landraces into two distinct Clusters at an approximate distance of 6.0. Cluster I comprised 14 landraces while Cluster II consist of only one landrace (NG-BOSS-007). These findings suggest variations in the landraces with NG-BOSS-007 seems to have a high genetic variability among the studied landraces.

Introduction

Maize (*Zea mays* L.) is an annual grass belonging to the Poaceae family, commonly known as the grass family. It is a domesticated crop species that originated from accumulation of several spontaneous mutation of the wild grass teosinte

(*Zea mexicana*) in Mexico and Central America (Hufford et al., 2021). It is the most adaptable crop having wider acceptability under varied agro-climatic conditions. Universally, maize is known as "Queen of cereals" because of its high genetic yield potential among the cereals and third important cereal crops next to wheat and rice in the world (Kumar et al., 2020). In Nigeria, it contributes significantly to daily caloric intake and is consumed in various processed and unprocessed forms, including pap (ogi), tuwo, and roasted grains (IITA, 2022). It is also used for animal feed and other industrial applications (FAO, 2024).

Maize kernel consisting of pericarp, endosperm, and embryo is botanically a caryopsis with fused seed coat and fruit wall (Morris et al., 2020). Maize Kernel show variations that may arise due to genetic factors, environmental conditions, and genotype × environment interactions (Badu-Apraku et al., 2022). These variations such as kernel colour, shape and texture are easily observable and highly heritable traits (Menkir et al., 2021). The traits help traditional farmers to identify cultivars while breeders use the traits as descriptors (Biodiversity International, 2009; Joshi et al., 2012). Morphological descriptors remain the first step in the systematic description of genetic resources because they are inexpensive and directly observable, other descriptors used for characterization are agronomic, biochemical and molecular markers (Prasanna et al., 2020).

The major gap is that indigenous maize landraces from Niger and Kogi States have not been sufficiently characterized and documented based on their kernel morphological and physical attributes. Although previous studies have investigated maize diversity using morphological traits, agronomic characteristics, genetic markers, and kernel traits, much of the available literature is either geographically broad, focused on improved/inbred germplasm, or does not specifically document indigenous landraces from these two Nigerian states.

Characterisation reveals valuable alleles present in traditional landraces that may be absent from elite breeding materials. (Prasanna et al., 2020). Landraces are farmer-maintained varieties that function as reservoirs for important genes. The concerns about genetic erosion and climate change have made characterisation of maize germplasm a priority for breeding programs (Prasanna et al., 2020). Therefore, this study was aimed at characterisation of landraces of maize from Niger and Kogi States using a standard kernel descriptor.

Materials and Methods

Study area

Fifteen (15) landraces were collected from both Niger and Kogi states; the collection of thirteen (13) maize landraces was from different farmers across seven Local Government Areas (LGAs) in Niger State (10°00'N6°00'E) namely Bida. Agaie, Shiroro, Bosso, Zungeru, Kagara, Kontagora, and two landraces from Okene LGA in Kogi State (07°30'N6°42'E).

Collection of Maize kernel

Kernels of fifteen different maize landraces were collected from farmers in selected locations of Niger State and placed in well-labelled bags indicating the location and date of collection. The kernels were cleaned by manually removing debris and visibly unhealthy seeds. Each maize landrace was assigned a unique accession number for identification and subsequent analysis.

Characterisation of Maize kernel

The maize kernels were characterised using standard descriptors following Menkir et al. (2021). The traits assessed included kernel shape, kernel colour, kernel length, kernel width, and 1000-seed weight. Kernel shape was assessed using the following scale: 1 = round, 2 = round to flat, 3 = flat, 4 = pointed, and 5 = shrivelled. Kernel colour was classified as follows: 1 = white, 2 = yellow, 3 = orange, 4 = red, 5 = purple, 6 = variegated, and 7 = blue/black. Kernel length and width were measured using a vernier caliper, while the weight of 1000 seeds was determined using a digital weighing balance. Representative samples of each landrace were photographed using a digital camera.

Data analysis

Data collected on kernel length and width were subjected to analysis of variance (ANOVA) using

IBM SPSS Statistics for Microsoft Windows, version 27.0. Differences among means were considered statistically significant at $p < 0.05$. Where significant differences were detected, means were separated using Duncan's Multiple Range Test (DMRT). Values were expressed as means ± standard deviation (SD). To assess phenotypic relationships among the maize landraces, a dendrogram was constructed using the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) clustering method in PAST software, version 4. Each of the qualitative descriptor were scored and the values were used for the analyses.

Results and Discussion

The result presented in Table 1 below for the kernel descriptors of the maize landraces shows that there is variation in kernel morphology by the presence of three (3) kernel shapes; flat, round to flat and pointed (Figure 1). The dominant kernel shape was round to flat in ten (10) of the landraces and the shape can be observed in all the LGA. The genetic constitution of the landraces may be associated with the kernel morphology and this with other morphological descriptors are sufficient in accessing phenotypic diversity (Garg et al., 2026). The round to flat kernels is mostly floury or flint, they store well and are good for consumption. This could be the reason for its abundance among farmers whose local population consumed maize a lot as processed foods called "tuwo, masa,", and roasted grains. The kernel colour showed variation with white closely followed by yellow been dominant, most Nigerian cultivars and landraces in evaluation are white. Adebowale and Olu-owolabi (2012) reported that white flint maize is the most preferred for processed food while yellow grains are used largely for animal feed. Kernels that are red in colour (see additional material) though very rare among farmers are useful culturally or traditionally. Kernel colour are genetically significant as numerous quantitative trait loci are identified to be associated with kernel colour, therefore variation in kernel colour is not just superficial morphological differences but have underlying genetic basis (Chen et al., 2024). Kernel colour also has nutritional significance, yellow and orange maize kernels are generally associated with carotenoid accumulation, while other coloured kernels may contain anthocyanin pigments, this may be particularly useful in nutritional breeding (Owens et al., 2019).

Table 1: Sources and Description of kernel of the Maize Landraces

Accession No.	LGA	Kernel Shape	Kernel Colour	Kernel Length (mm)	Kernel Width mm)	1000 Kernel Weight (g)
NG-BIDA-001	Bida	3	1	10.46 [a]	8.90 [ab]	270.92 [b]
NG-AGAI-002	Agaie	2	2	9.40 [a]	7.50 [b]	210.65 [d]
NG-EREG-003	Bida	3	2	9.40 [a]	10.40 [a]	260.94 [b]
NG-EREG-004	Bida	3	1	10.10 [a]	8.50 [ab]	250.80 [c]
NG-GIDA-005	Bosso	3	6	9.85 [a]	9.00 [ab]	260.01 [bc]
NG-SHIR-006	Shiroro	2	1	8.05 [b]	9.35 [ab]	240.68 [c]
NG-BOSS-007	Bosso	4	2	8.50 [b]	7.50 [b]	140.14 [e]
NG-GIDA-008	Bosso	2	4	9.15 [ab]	9.50 [ab]	260.44 [bc]
NG-GIDA-009	Bosso	2	1	10.65 [a]	9.25 [ab]	260.09 [bc]
NG-ZUNG-010	Zungeru	2	1	9.50 [a]	9.75 [ab]	250.88 [c]
NG-RAFI-011	Kagara	2	2	10.00 [a]	10.75 [a]	300.96 [a]
NG-WAWA-012	Kotangora	2	2	10.50 [a]	8.50 [ab]	300.12 [a]
NG-KAWO-013	Kotangora	2	1	10.20 [a]	10.75 [a]	280.18 [b]
NG-OKEN-014	Okene	2	2	10.00 [a]	8.50 [ab]	270.63 [b]
NG-OKEN-015	Okene	2	1	9.15 [ab]	9.70 [ab]	220.78 [d]
			S.E	1.06	1.23	1.44

Kernel shape: 1= round, 2= round to flat, 3= flat, 4= pointed, & 5= shriveled
Kernel colour: 1= White, 2= yellow, 3= orange, 4= red, 5= purple, 6= variegated, 7= Blue/Black

Figure 1: Variation in Kernel Colour of the Maize Landraces

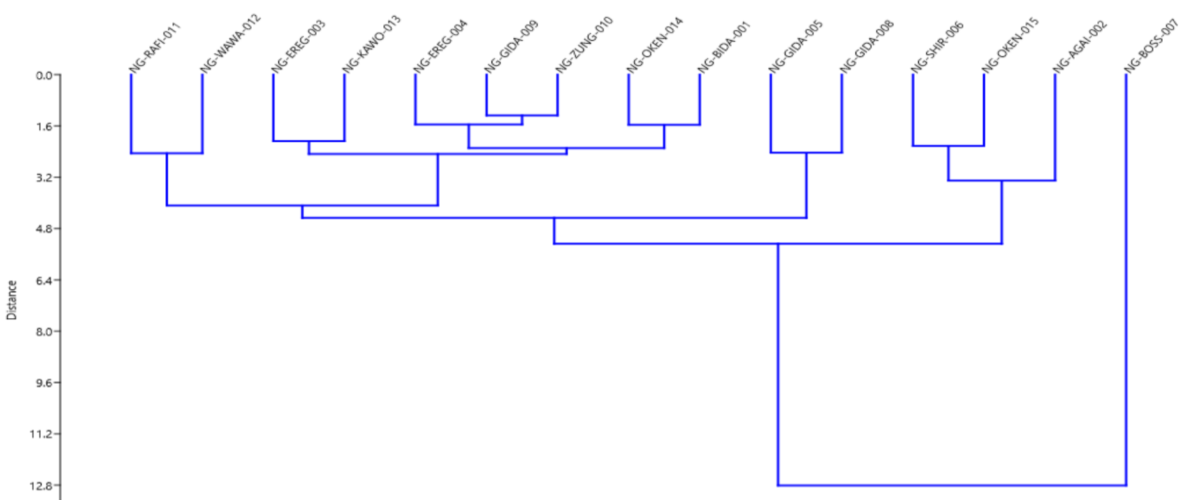

Figure 2: UPGMA Similarity Index of the Maize Landraces Based on Kernel Characterisation

The differences in kernel length among the landraces ranging from the least of 8.05mm (in NG-SHIR-006) to highest of 10.65mm (in NG-GIDA-009) and kernel width from 7.50mm (in NG-AGAI-002 and NG-BOSS-007) to 10.75mm (in NG-RAFI-011) indicate considerable quantitative variation, this is comparable with previous reports by Nkhoma et al. (2023) who reported 10-12mm in length and 7-8mm in width. The weight of 1000 kernel also had observable variation ranging from the 140.14g (in NG-BOSS-007) to 300.96 (in NG-RAFI-011). The length, width and weight of 1000 kernels are influenced by both the genetic makeup and environmental conditions during grain filling. Pan et al. (2017) evaluated kernel length, kernel width, kernel thickness, hundred-kernel weight and kernel test weight across 10 recombinant inbred populations derived from diverse maize inbred lines and identified numerous quantitative trait loci demonstrating that kernel size and weight have a substantial genetic basis.

The UPGMA similarity index based on kernel descriptor presented in Figure 2 below grouped the 15 maize landraces into two distinct Clusters at an approximate distance of 6.0. Cluster I comprised 14 landraces while Cluster II consist of only one landrace (NG-BOSS-007). The clustering pattern in cluster I indicates almost similar genetic structure that cut across different LGA for instance NG-BIDA-001 AND NG-OKEN-014 are similar despite been from different LGA. It could mean that farmers exchanged or shared seeds with others from a different LGA. The distance of NG-BOSS-007 in Cluster II from other landraces indicates a high genetic divergence. This landrace contains a unique allele (the only landrace with pointed kernel shape), it was also observed to have the least kernel width and weight. The landrace with this unique allele should be conserved as it could be very useful in future breeding programme. UPGMA is widely used in characterisation because it provides a clear hierarchical representation of genetic relationship. There are reports of its use in grouping African maize landraces into distinct clusters for heterosis exploitation (Ojo et al., 2023) (Figure 2).

Conclusion

The present study showed that genetic variability exists among the maize landraces studied from Niger and Kogi States. NG-BOSS-007 seems to have a distinct genetic divergence from other Landraces. The Landrace could become very important for future breeding programme of maize in the study areas.

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Conflicts of interest

There is no conflict of interest.

Authors Contributions

D.O.A.Y., Conceptualized the idea and coordinated the research; F.O.A., provided mentorship for the team; A.A., Provided his expertise in the statistical analyses of the results; G.A.A spear-headed the germplasm collection of the maize landraces from Niger state; M.J provided proof read the manuscript and E.O.I. participated in gathering of data and preparing first version of the manuscript.

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