Journal of Experimental Research

JUNE 2024, Vol 12 No 2

Email: editorinchief.erjournal@gmail.com
editorialsecretary.erjournal@gmail.com

Received: January, 2024
Accepted for Publication: February, 2024

Yield, Agronomic Potential And Disease Resistance Of Indigenous Maize (*Zea mays L.*) Accessions In Tropical Humid EnvironmenT

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ABSTRACT

Maize is an important crop in many parts of the tropical environment providing energy source for poultry and staple food supply for human as well as for industrial uses because of its diverse utilization potential. Nigeria is characterized with diverse accessions such as land, cultivars, and farmers' selected lines from many years of cropping maize for improved yield and adaptation through informal breeding programmes. The objectives of this study therefore were to evaluate white and yellow maize accessions for yield performance, disease reactions and agronomic attributes, and to further characterize them for use in planned maize breeding programmes. One hundred and sixty-five maize accessions (85 white) and (80 yellow) were used for performance evaluation and reactions to prevailing diseases of hot tropical environment, under natural field infection. The results from analysis of variance of the white and yellow maize accessions showed significant differences for plant height (3144.75 cm and 1901.54 cm), ear height (1462.98 cm and 982.76 cm), ear harvest (12.64 and 8.74), husk cover (0.83 and 0.67) and grain yield (4743.49 kg/ha and 3851.67 kg/ha) and disease syndrome ratings. This study revealed the variability in agronomic traits which will in no doubt expand the gene pool of the Institute of Agricultural Research and Training of Obafemi Awolowo University for breeders developing early, medium and late maturing white and yellow maize populations for improved agronomic potential, yield, disease resistance and adaptation to hot humid ecologies of the tropical ecosystems.

Keywords: *Zea mays*; Indigenous accession, Disease ratings, Agronomic traits, Variability.

INTRODUCTION

Maize (*Zea mays L.)* belongs to the family Gramineae and is one of the most important cereal crops in Africa (Lyon, 2000). It occupies less land area than either wheat or rice but has a greater average yield per unit area of about 5.5 tonnes per hectare (Ofori *et al.,* 2004). Maize (*Zea mays* L.) is a cereal with a remarkable production potential, it is the third most important grain crop after wheat and rice (Anon, 2000; Lyon, 2000). It accounts for 4.8% of the total cropped land area and 3.5% of the value of agricultural output (Ahmad *et al.,* 2011). Maize (*Zea mays* L.) is an important staple food crop that provides bulk of raw materials for the livestock and many agro-allied industries in the world (Bello *et al.,* 2010; Randjelovic *et al.,* 2011). It is an important food crop widely grown in both temperate and tropical environments globally except Antarctica (Scott and Emery, 2016). It is a staple crop of many Sub-Saharan Africa and Latin American people (Dowswell *et al.,* 1996). In West Africa, *Zea mays* L. has become an important staple food and mostly consumed as pap as well as steamed or roasted as green cob (Olakojo *et al.,* 2007; Feyisola *et al.,* 2019). Maize is one of the most important cereal crops due to its high grain yield, ease of processing, and reduced cost of production. It is also easily digestible when compared to other crops such as Wheat, rice, millet (Jaliya *et al*., 2008). Apart from food, maize is used for the production of feed in livestock industrial products such as plastics, foams and adhesives and pharmaceuticals. The maize stalk and leaves is used for chemical and biofuel production. Between 90 and 95 percent of the crop is harvested for grain, the remaining 5-10 percent is grown for silage (Jaliya *et al*., 2008). Maize is also a component of canned corn, baby food, mush, puddings and many more human foods. Many people from these regions depend on maize for subsistence probably because it is relatively cheaper to produce compared to other cereals such as rice, sorghum or millet. Nigeria is the 10^{th} largest producer of maize in the world, and the largest maize producer in Africa followed by South Africa (IITA, 2012; USAID, 2010). Maize is not without its own production, storage and nutritional challenges like other cereals. Over 96 million metric tonnes of maize grains are destroyed annually all over the world by *Sitophilus* spp. (FAO, 1961), while low essential amino acids such as lysine and tryptophan is a major problem in none quality protein field corn (Salami *et al.,* 2007). It was observed that yield potential of maize in farmers' field in tropical Africa is generally lower compared to those obtained in western world. The reasons for this among others include low yield potential of available germplasm, poor adaptation, poor inputs, intercropping farming system and pressure from pests and diseases of hot humid tropical environment. Therefore, the objectives of this study was to screen some Nigerian indigenous maize accessions for desirable agronomic characters, yield performance, diseases reactions and possibility of extracting inbred lines for further use in planned breeding program aiming at higher yield/ha, disease resistance and, adaptation to tropical agro- environments.

MATERIALS AND METHODS

Germplasm collections for performance evaluation trials.

One hundred and sixty-five (165) indigenous maize (*Zea mays* L.) accessions (yellow and white) (Table 1) were collected from the Gene Banks of the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan, Local markets and Farmers' fields in eleven different towns such as Isara, Ado-Ekiti, Kila, Ifo-Odeda, Bodija, Eruwa, Ago-Iwoye, Ijebu-Ode, Abeokuta, Badagry, Kishi, and Ikole respectively covering the major agro-ecologies of High rainforest, rainforest, Derived savanna, and Northern Guinea Savanna of Southwestern Nigeria.

These maize grains collected were sorted based on kernel shape, size and colour resulted into 85 white and 80 yellow accessions. The experiment was sited at the Southern Farm of the Institute of Agricultural Research and Training (IAR&T), Moor Plantation, and Ibadan, Nigeria (Latitude $7^{o}26^{'}$N, Longitude $3^{o}54^{'}$E in altitude 224 m above sea level). For the field experiment, land preparation activities such as ploughing and harrowing were carried out mechanically before planting.

An Official Publication of Enugu State University of Science & Technology ISSN: (Print) 2315-9650 ISSN: (Online) 2502-0524

Table 1: List of all the indigenous yellow and white maize accessions collected for the preliminary evaluation and characterization

SN	Yellow Maize Accessions			SN	White Maize Accessions		
1	Golden yellow (IAR&T)	68	AGO – IWOYE 13	1	ISARA 1	68	NACGRAB 16
2	NACGRAB 1	69	AGO – IWOYE 14	2	KISHI 1	69	NACGRAB 17
3	NACGRAB 2	70	ABEOKUTA 1	3	KISHI 2	70	IJEBU IGBO 1
4	NACGRAB 3	71	ABEOKUTA 2	4	IJEBU ODE 1	71	IJEBU IGBO 2
5	NACGRAB 4	72	ABEOKUTA 3	5	IJEBU ODE 2	72	IJEBU IGBO 3
6	NACGRAB 5	73	ABEOKUTA 4	6	KILA 1	73	IJEBU IGBO 4
7	NACGRAB 6	74	ABEOKUTA 5	7	KILA 2	74	IJEBU IGBO 5
8	NACGRAB 7	75	IREE 1	8	ADO EKITI 1	75	IJEBU IGBO 6
9	NACGRAB 8	76	IREE 2	9	ADO EKITI 2	76	IJEBU IGBO 7
10	NACGRAB 9	77	IREE 3	10	ADO EKITI 3	77	IJEBU IGBO 8
11	NACGRAB 10	78	IREE 4	11	IFO – ODEDA 1	78	IJEBU IGBO 9
12	NACGRAB 11	79	IREE 5	12	BODIJA 1	79	IJEBU IGBO 10
13	NACGRAB 12	80	IREE 6	13	BODIJA 2	80	IJEBU IGBO 11
14	NACGRAB 13			14	ERUWA 1	81	IJEBU IGBO 12
15	NACGRAB 14			15	ERUWA 2	82	IJEBU IGBO 13
16	NACGRAB 15			16	ERUWA 3	83	IJEBU IGBO 14
17	NACGRAB 16			17	ERUWA 4	84	IJEBU IGBO 15
18	NACGRAB 17			18	ERUWA 5	85	IJEBU IGBO 16
19	NACGRAB 18			19	ERUWA 6		
20	NACGRAB 19			20	ERUWA 7		
21	BADAGRY 1			21	ERUWA 8		
22	IJE BU IGBO 1			22	ERUWA 9		
23	IJEBU IGBO 2			23	AGO – IWOYE 1		
24	IJEBU IGBO 3			24	AGO – IWOYE 2		
25	IJEBU IGBO 4			25	AGO – IWOYE 3		
26	IJEBU IGBO 5			26	AGO – IWOYE 4		
27	IJEBU IGBO 6			27	AGO – IWOYE 5		
28	IJEBU IGBO 7			28	AGO – IWOYE 6		
29	IJEBU IGBO 8			29	AGO – IWOYE 7		
30	IJEBU IGBO 9			30	AGO – IWOYE 8		
31	IJEBU IGBO 10			31	AGO – IWOYE 9		
32	IJEBU IGBO 11			32	AGO - IWOYE 10		
33	IJEBU IGBO 12			33	BADAGRY 1		
34	IJEBU IGBO 13			34	BADAGRY 2		
35	IJEBU IGBO 14			35	BADAGRY 3		
36	IJEBU IGBO 15			36	BADAGRY 4		
37	IJEBU IGBO 16			37	BADAGRY 5		
38	IJEBU IGBO 17			38	BADAGRY 6		
39	ADO EKITI 2			39	IKOLE 1		
40	ADO EKITI 3			40	IKOLE 2		
41	ISARA 1			41	KISHI PURPLE 1		
42	IJEBU ODE 1			42	KISHI PURPLE 2		
43	KILA 1			43	KISHI PURPLE 3		
44	KILA 2			44	ABEOKUTA 1		
45	KILA 3			45	ABEOKUTA 2		
46	ADO EKITI 1			46	ABEOKUTA 3		
47	IFO – ODEDA 1			47	ABEOKUTA 4		
48	IFO – ODEDA 2			48	ABEOKUTA 5		
49	BODIJA 1			49	IREE 1		
50	BODIJA 2			50	IREE 2		
51	ERUWA 1			51	IREE 3		
52	ERUWA 2			52	IREE 4		
53	ERUWA 3			53	NACGRAB 1		
54	ERUWA 4			54	NACGRAB 2		
55	ERUWA 5			55	NACGRAB 3		
56	AGO – IWOYE 1			56	NACGRAB 4		
57	AGO – IWOYE 2			57	NACGRAB 5		

Table 2: Mean Square of the agronomic and yield-related characters of the indigenous white maize accessions

Source of Variation	DF	Plant height (cm)	Ear height (cm)	Days to 50% silk	Plant harvest	Ear harvest	Husk cover (1-5)	Grain yield (Kg/ha)
Replication	2	424.50	774.51	0.50	144.17	8.27	0.00	65.84
Variety	84	3144.75**	1462.98**	2.87**	3.06	12.64**	0.83**	4743.49**
Error	168	614.26	441.72	0.50	3.70	1.89	0.01	1089.59
Total	254							

*, **, significant at P<0.05 and P<0.01 respectively

Table 3: Mean Square of the agronomic and yield-related characters of the indigenous yellow maize accessions

Source of Variation	DF	Plant height (cm)	Ear height (cm)	Days to 50% silk	Plant harvest	Ear harvest	Husk cover (1-5)	Grain yield (Kg/ha)
Replication	2	1023.70	642.82	1.72	1.53	118.85	1.07	338.19
Variety	79	1901.54**	982.76**	2.69*	0.67	8.74**	0.67**	3851.67**
Error	158	590.35	388.67	1.48	0.72	4.05	0.22	541.13

*, **, significant at P<0.05 and P<0.01 respectively

Table 4: Mean Square for the diseases observed among the indigenous white maize accessions

Source of variation	Df	Maize Streak Virus (1-5)	Rust (1-5)	Blight (1-5)	*Curvularialunata* (1-5)
Replication	2	0.00	0.95	0.00	0.01
Variety	84	0.04**	1.36**	1.28**	0.93**
Error	168	0.00	0.14	0.03	0.04
Total	254				

*, **, significant at P<0.05 and P<0.01 respectively

Table 5: Mean Square for the diseases observed from the indigenous yellow maize accessions

Source of variation	Df	Maize streak virus (1-5)	Rust (1-5)	Blight (1-5)	*Curvularialunata* (1-5)
Replication	2	0.00	0.34	0.00	0.00
Variety	79	0.15**	0.89**	1.86**	1.66**
Error	158	0.00	0.06	0.00	0.00
Total	239				

*, **, significant at P<0.05 and P<0.01 respectively

Mean performance and range of values of agronomic and yield related traits of the indigenous white and yellow maize accessions

The mean, and range of values of the agronomic characters and yield for the white and yellow maize accessions are shown in Tables 6 and 7 respectively. Plant height ranged from 171.67 to 314.33 cm with mean value of 229.13 cm for white maize accessions (Table 6) while it ranged from 132.00 to 279.33 cm with the mean value of 204.46 cm (Table 7) for the yellow maize accessions. For days to 50% silking, it was observed that the white maize accession had the range of 54.00 to 60.00 days with the mean value of 57.59 days (Table 6) while the yellow accessions had the range of 55.67 to 60.67 days and the mean value of 57.29 days (Table 7). Plant harvest values ranged from 21.00 to 24.67 with the mean value of 22.60 (Table 6) for white maize accessions while the values ranged from 20.00 to 22.00 with mean value of 21.42 in yellow maize accessions (Table 7). Ear harvest values ranged from 20.33 to 27.67 with the mean value of 22.72 (Table 6) for white accessions while it ranged from 22.33 to 26.33 with the mean value of 22.68 for yellow accessions (Table 7). The husk cover rating ranged from 1.00 to 3.00 in both the white and yellow maize accessions (Table 6 & 7). Considering the grain yield, the values of the white maize accessions ranged from 29.70 - 284.57 kg/plot with the mean grain yield of 96.86 kg (Table 6) while that of the yellow accessions ranged from 48.19 to 300.94 kg/plot with the mean of 99.57 kg/plot (Table 7).

Table 6: Means and the range of values of agronomic and yield-related traits of the indigenous white maize accessions

Traits	Mean	Range of values
Grain yield (kg)	96.86±3.00	29.70 - 284.57
Plant height	229.13±2.38	171.67 - 314.33
Days to 50% silking	57.59±0.07	54.00 - 60.00
Plant harvest	22.60±0.13	21.00 - 24.67
Ear harvest	22.72±0.15	20.33 - 27.67
Husk cover	1.20±0.03	1.00 – 3.00

Table 7: Means and ranges of agronomic and yield-related traits of the indigenous yellow maize accessions

Traits	Mean	Range of values
Grain yield (kg)	99.57±2.61	48.19 - 300.94
Plant height	204.46±2.07	132.00 - 279.33
Days to 50% silking	57.29±0.09	55.67 - 60.67
Plant harvest	21.42±0.05	20.00 – 22.00
Ear harvest	22.68±0.17	22.33 – 26.33
Husk cover	1.26±0.04	1.00 – 3.00

DISCUSSION

Information about variation in germplasm and relationships between diverse germplasm is very important for plant breeders; it assists in selecting suitable genotypes for crossing during hybridization (Dwivedi *et al.,* 2001). The highly significant genotype effect obtained for the agronomic parameters indicates that enough variability exists to allow selection of appropriate germplasm with reasonable levels of desirable characters. This observation supports the earlier report by Ngwuta *et al.* (2001) that locally available germplasm can serve as sources of hybrid maize development, provided the breeding strategy is applied and resources for inbred extraction and hybridization is available to pursue hybrid maize development.

The main objective of a maize breeding program is to improved agronomic and yield-related traits for enhanced grain yield. The white and yellow indigenous maize accessions showed considerable variability for all examined agronomic and yield related traits in the working populations except for plant harvest. Similarly, Lucchin *et al.,* (2003) found significant differences within and between populations for all the traits measured while characterizing twenty (20) Italian maize populations for thirty-four (34) morphological and agronomic traits. This suggests the high level of variability that exist in maize plants especially the Nigerian indigenous accessions, and the opportunity the accessions may offer to breeders during genetic manipulation that can bring about considerable improvement for desirable traits. The level of infection of the diseases studied for both white and yellow indigenous maize also revealed substantial differences and variations. Leaf blight is caused by the fungus *Helminthosporium maydis*. The causative organism of the *Curvularia* leaf spot is *Curvularialunata,* while maize rust is incited by *Puccinia polysora* (Akande and Lamidi, 2006). The three diseases often occur together in South-West Nigeria on maize plants as complex infections and their occurrence are favoured by warm and humid climate (Ladipo *et al.,* 1993). The three diseases are of major economic importance in Nigeria (Akande and Lamidi, 2006). Incidentally, many of the accessions were generally tolerant to these diseases making them good parent materials for inbred extraction and candidates for hybrid maize development.

The wide range in grain yield suggests variability for the improvement of these accessions. The plant height was highly significant among the maize collections from different locations. Earlier reports of Nazir *et al.,* (2010) and Salami *et al.,* (2007), Mahmood *et al.,* (2004) and Turi *et al.,* (2007) also showed highly significant variability in plant height in various maize genotypes. Gyenes-Hegyi *et al.,* (2002) showed that plant height and height of the main ear are important variety traits, and are in close connection with each other (Beyene *et al.,* 2005). It was found that hybrids grew tallest when the genetic distance between the parents are very high, but, the shorter hybrids were the ones developed from related lines. This information probably serves as data for maize breeder selecting for plant and ear heights in hybrid maize development. Combination of different genotypes of various heights from the sample populations in this study will no doubt produce ideal and desirable height for maize breeders working on maize for adaptation to the humid tropical environment. These significant variations provide opportunity of genetic manipulation for different plant heights that may suit different ecologies especially in time like this when climate change and strong storm causes serious stem and root lodging in maize.

Similarly, days to 50% silking also showed slight variations that ranged from 54 to 60 days. Significant differences in flowering days will enable breeders to develop early and medium maturing maize genotypes that can escape the effect of drought occasioned by sudden cessations of rains in the tropical environments.

CONCLUSION

The observed variability in agronomic traits will no doubt expand the gene pool of the Institute of Agricultural Research and Training of Obafemi Awolowo University for breeders who may be developing early, medium and late maturing maize populations for improved agronomic potential, yield, disease resistance and adaptation to hot humid ecologies of the tropical ecosystems. The relatively low disease syndrome ratings in the tested genotypes further affirm that the prevailing foliar diseases of the tropical humid environment are still under controllable threshold. Monitoring these disease pathogens should however continue in order to tract their re-resurgence as at when necessary.

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