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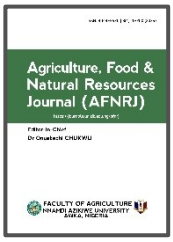

Original Article

Grain and fodder yield performance of Maize (*Zea mays* [L.]) genotypes in humid agroecology

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Abimbola Adesile BADMUS, Olawale Taiwo ADENIJI & Ayodele OWOSENI

Department of Crop Science and Horticulture, Federal University Oye Ekiti, Nigeria

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ABSTRACT

Productivity of maize in sub-Saharan Africa is declining due to poor soil health and fertility, low seed yield, and biotic and abiotic stresses. Baby trials were established on farms in humid agro-ecology during 2020-2021. Morpho-physiological, fodder and seed yield differences among maize genotypes grown on farmers' fields and preferences for traits across years were investigated. A completely randomized design with each farmer's location as a replicate was used. The weather attributes, soil physical and chemical properties, agronomic, fodder and seed yield were measured. The analysis of variance for 2020 and 2021 data was performed using PROC GLM procedure of Statistical Analysis System (Version 9.0). Farmers' assessment was used to identify preferences for traits and challenges to production. Findings showed high variability for earliness, fodder and seed yield traits. Ear length and width, kernel row-1 were responsive to environmental factors over the years. The year effect was important in defining earliness, seed yield and yield traits. Across years 'DMR-ESR-Y' was earlier with short anther-silk-interval. 'DMR-LSR-Y' performed best for seed yield compared to 'Oba super 6' and 'LNTP-SR-Y'. 'Oba super 2' gave the highest mean value for stover dry yield. Baby trials at Ado-Odo, Isaboro and Ayetoro villages had the highest seed yield. The stover dry weight peaked in Ayetoro. Findings support the development of extra early and early maturing varieties. 'DMR-ESR-Y', 'DMR-LSR-Y' and 'LNTP-SR-Y' are recommended for short cycle production, and as donor parents for fodder, seed yield, and total dry yield.

KEYWORDS: *Farmers' fields, Mother-baby trial, Phenological traits, Seed yield, Stover dry weight yield*

INTRODUCTION

Maize is the largest cereal crop in terms of area and production volume and is grown in mixtures with cassava, yam, coco yam, okra and tomatoes in small homesteads plots, medium or large-scale farms under rain-fed conditions (Onumah et al., 2021). It is by far a reliable source of carbohydrates and is widely used for human consumption, in animal feed, pharmaceutical industries, food manufacturers, breweries, flour mills and other industries. Nearly 80 percent of the maize grain is used for human consumption and animal feed with the remaining 20 percent utilized for industrial processing of diverse products (Onumah et al., 2021). The global production of maize in the world was about 1.1 billion metric tonnes (MMT) in with a global demand of 3 billion MMT, and a deficit of 1.9 billion MMT (FAOSTAT, 2023). Maize is an important crop in Nigeria, where it is largely cultivated by smallholder farmers. In 2024, Nigeria produced 11.05 MMT (FAOSTAT, 2024) from over 6.5 million hectares of land across diverse agro-ecological zones of the country (Onumah *et al*., 2021; PWC, 2021; FAOSTAT, 2022). The seed yield of about 3 t ha^{-1} (FMARD, 2020) is low compared to 5 t ha^{-1} as the world average, and national average of Africa, Europe and Asia. Growers across tropical Africa plant local varieties, others recycled harvested grains of hybrids or open pollinated varieties from previous planting (Abera *et al*., 2018). Seed yield on farmers' fields depends on nutrition, crop rotation, incorporation of crop residues, planting cover crops and

*Corresponding author: waleniji@gmail.com

fertilization (using inorganic fertilizers) in split application and managing weeds. Nigeria still faces critical challenges: yields per hectare remain low (1.9–2.2 t/ha), post-harvest losses can exceed 20%, and regional insecurity disrupts supply chains (Oyinbo *et al*., 2019). In addition, maize growing agro-ecologies of Africa is characterized by poor crop husbandry practices, poor fertility of soils and inadequate innovation in production and value addition. Also, there is the considerable impact of delayed on-set of the rainfall, early cessation of rainfall, within-season drought and prolonged dry season, and flash floods, high humidity caused the build-up of maize diseases viz. streak virus (MSV), bacterial blight (MBB) and common rust (Bamiteko, 2017) and insect attacks. These affect crop duration, assimilate reserves and partitioning to sink organs and dry seed yield. In addition, the COVID-19 pandemic had far-reaching negative consequences on maize productivity, product prices and household livelihoods (FMARD, 2020). To increase production of grain and fodder in the humid agro-ecology, it is imperative to compare seed yield and yield component traits of popular farmers' variety, commercial hybrid and open pollinated varieties, identify farmer's location(s) suitable for high fodder and seed yield, select and deploy high seed yielding, nutrient dense, diseases and insect resistant varieties. Collaborative research and variety testing efforts among national and international research institutes have culminated in deployment of early maturing, nutrient dense, high seed yielding and disease resistant varieties. In sub–Saharan Africa, commercial maize varieties are as old as 20 years while some are as young as seven years (Abate *et al*., 2017). Popular maize cultivars viz. open pollinated (OP) varieties, hybrids or local cultivars available to farmers are aged (older than eight years) and have been maintained through farmers saved seeds or purchased from seed vendors.

The mother (M) and Baby (B) Trial (MBT) developed by Snapp, (1999; 2002) was adopted to select and deploy maize varieties in southern Africa (Banzinger and Diallo, 2004), and cowpea varieties in Nigeria (Kamara *et al*., 2010). Also, on-farmer participatory assessments identified market traits and traits of high preference (Snapp, *et al*., 2002; Adeniji and Aloyce 2013) for crop improvement plans that will enhance the adoption of improved crop varieties. On-farm field evaluation and participatory assessment of maize breeding lines and commercial hybrids under farmers' condition will identify productive maize genotypes that outperform existing and old commercial varieties (OP and hybrids) and farmer's cultivars and location(s) promising for high fodder and seed yield. The on-farm field evaluation and participatory assessment was used to 1) quantify variability for agronomic, seed yield and yield component traits among maize genotypes farmers' fields during 2020 and 2021 planting seasons, 2) evaluate association between seed yield and other traits and 3) identify best farmer's location(s) for fodder and seed yield, and promising maize genotypes for fodder and seed yield for each farmers location and across locations for promotion.

MATERIALS AND METHODS

Agro-ecology and experimental materials

The baby trial (BT) locations are within the rain forest and derived savannah agro ecologies of Ekiti state, Nigeria. These locations have contrasting soil and meteorological factors (Table 1), high cultivation of maize and consumption of maize products. The BT was carried out in Are, Ikole-Ekiti LGA (long. 50 30' E, lat. 70 46' N, elevation 570.5 m); Ado-Odo, Orin-Ekiti, Ido/Osi LGA, (long. 50 16' E, lat. 70 49' N, elevation 476.7 m) in the northern Guinea savanna agro ecology; Ayetoro, Ilumoba, Gbonyin LGA (long. 50 25' E, lat. 70 38' N, elevation 377.6 m) in rain forest agro-ecology; Osun kurudu, Ifaki-Ekiti, Ido/Osi LGA (long. 50 15' E, Lat. 70 45' N elevation 341.2 m) in the northern guinea savannah; Isaboro, Ido-Ekiti, Ido/Osi LGA (long. 50 12' E, lat. 70 51' N, elevation 633.2 m) in northern guinea savannah agro ecological zone; Ijesa-modu, Iye-Ekiti, Ilejemeje LGA (long. 50 14' E, lat. 70 57' N, elevation 551.7 m) in northern guinea savannah agro ecological zone; Ogbese, Ise/Orun LGA (Ekiti south, tropical rainforest) (long. 50 18' E, latitude 70 26' N, elevation 342.4 m) in the rainforest agro ecological zone and Ikole, Ikole Ekiti LGA, Ekiti state (long. 50 29' E, lat. 70 48' N, altitude 535.5 m). The rainfall commences in April to October annually with a dry spell in August. The BT and participatory selection exercises were carried out in eight locations between May and October of 2020 and 2021.

Germplasm

The maize genotypes were recommended by the Maize Improvement Unit, Institute of Agricultural Research and Training Ibadan, Nigeria and the Ekiti State Agricultural Development Project (ESADP) and researchers with experience in maize production in the rain forest agro-ecology. 'SWAN 1 SR-Y' was commercialized in 2009, is open pollinated, with resistance to downy mildew and maize streak virus, and grain yield from 5 to 9 t ha^{-1}. Genotype 'DMR-ESR-Y' (Downy mildew resistant early streak resistant yellow) is a breeding line developed by IITA in partnership with the IAR&T Ibadan. It is early maturing, open-pollinated, and resistant to downy mildew, streak virus, rust and blight. 'BR-9928-DMR-SR-Y' (Borer, Downy mildew and Streak resistant) is open pollinated with 100 to 105 days to maturity, and adapted to rain forest and derived savanna agro-ecology and average grain yield from 3 to 4 t ha^{-1}. 'DMR-LSR-Y' (Downy mildew resistant late streak resistant yellow) is a breeding line from IITA, orange-fleshed, sturdy and vigorous, resistant to downy mildew and streak virus, and late maturing type. 'LNTP-SRY-C5' (low nitrogen tolerant and Streak resistant yellow) is a breeding line sourced from IITA, OP with mean seed yield from 3.5 to 4 t ha^{-1}, highly tolerant to low soil nitrogen, resistant to streak virus, and high pro-vitamin A content. Genotype 'Oba super 6' is orange fleshed hybrid variety developed and commercialized by International Institute of Tropical Agriculture (IITA) in partnership with Premier Seeds Nigeria in 2007. It is adapted to the Guinea and Sudan savanna agro-ecologies, adapted to drought and nitrogen deficient soil, biofortified with Pro-Vitamin A with mean seed

yield spanning from 7 to 8 t ha^{-1}. Genotype 'Oba super 2' is a hybrid variety developed and commercialized by IITA in partnership with Premier Seeds Nigeria in 2007. It is orange-fleshed, adapted to the rain forest and derived savanna agro-ecologies with grain yield spanning from 5 to 7 t ha^{-1}. The check (white-fleshed) is a maize cultivar popular among maize farmers in BT locations. All the genotypes were orange fleshed except the 'Farmer's variety (Check).

Characteristics of soils from BT locations

Prior to field establishment, soil samples were collected from each BT location from 0 – 30 cm deep. A composite sample from each baby trial location was analyzed for soil physical properties, and soil pH (1:2.5 in water), electrical conductivity (1:2.5 in water), texture; Bouyousos hydrometer method (Day, 1965), Organic carbon; (Walkley-Black method 1934; Nelson and Sommers, 1996), total nitrogen, Kjeldahl method (Wilke, 2005), phosphorus: Bray 1 method (Bray and Kurtz, 1945). Also, exchangeable potassium, calcium, magnesium and sodium: IM ammonium acetate extractants (pH 7.0) was analyzed with quantification in an atomic absorption spectrometer (Sumner and Miller, 1996). Further, Ibitoye (2005) noted that organic matter (%) of 1.5% in the soil is rated as low,1.5 to 3 % (medium) and 3 % (high); nitrogen (%) of 0.08 % is (low), 0.08 % - 0.15 % is medium and ≥ 0.15 % is high.

Experimental design and layout, Field Planting and Crop Husbandry

The experimental area for each BT location was 60 m^2 (12 m length × 5 m width) and each plot was manually cleared and tilled, and double ridged rows with 12 m long and 0.75 m between ridges were made. In each farmer's location and across years a completely randomized design (CRD) with each farmer as a replicate (Schmidt *et al*., 2018) was used to allocate the treatment to the experimental plots. Each genotype was sown according to spacing of 0.50 m plant to plant and 0.75 m between rows (IAR&T, 2020). Crop husbandry practices for maize described by IAR&T (2020) were applied. Baby trials located in Are, Ado-Odo, Ayetoro and Ijesa-modu villages were planted on the 2nd of May 2020 while trials located in Ogbese, Osun kurudu, Ikole and Isaboro villages were established on the 3rd of May 2020 by farmers under the supervision of the researcher and research assistants. During the 2021 evaluation, BT in Are, Ado-Odo, Ayetoro and Ijesamodu villages were established on the 2nd of May 2021, while trials located in Osun kurudu, Ikole, Isaboro and Ogbese villages were planted on the 3rd of May 2021. Two weeks after planting (WAP), thinning was carried out to maintain two plants per hill. This gave 22 plants/plot (53,333 per hectare). The experiments were maintained weed free by hand weeding with traditional hoe. 10 g of insecticide Caterpillar force® (a.i. 5 % Emamectin Benzoate, WDG Corporations S.A, Switzerland) was dissolved in 15 L of water to control fall armyworm (FAW) attacks. A split application of compound mineral fertilizer (N20: P10: K10) was applied at 200 kg/ha (40 Kg N, 20 Kg P_2O_5 and 20 Kg K_2O) at 3 WAP. Side placement of Urea (46% kg N/ha) fertilizer at 100 kg/ha at 6 WAP by opening the soil and covering thereafter. Each baby trial was managed by the farmers using local management practices.

Data measurement and computation

Data collection was done by the researcher and trained research assistants alongside farmers. Ten maize plants were randomly picked in each plot for measurement at phenological stages. The duration (days) for 50 % appearance of male flowers was estimated as days from planting until 50 % of the plants have developed male flowers (d) while days at 50 % silk appearance was counted as days from planting until half of the plants in each plot have emerged silk (d). The anthesis-silk interval (ASI) was the difference between the dates of pollen appearance and silking (d) (Table 4). The plant length (cm) was determined with a meter rule from the base of the plant to the apical part (tassels branch). At the R6 growth phase and maturity, 10 ears were randomly harvested/plot, dried, shelled and weighed on electronic weigh machine. Seed samples were taken for measuring seed moisture content (15 %) using a Dickey–John moisture meter, Mini GAC® 2500, United States. The seed yield/plot (t ha^{-1}), seed yield adjusted to 15 % MC (t ha^{-1}) and seed dry weight (t ha^{-1}) from the whole harvest area (t ha^{-1}) and stover dry weight (t ha^{-1}) were carried out. The BT data for 2020 and 2021 was tested for variance homogeneity, thereafter the analysis of variance for 2020 and 2021 data was performed using PROC GLM procedure of Statistical Analysis System version 9.2 (SAS, 2012) to split the total variability into genotype (G), year (Y), and genotype x year interaction (GYI) effects. The year was a random factor while the genotype was fixed factor. If the interaction was not significant the multiple comparisons of the main effect were performed using Tukey's HSD test at 5% and 1% of probability.

RESULTS

Soil physical and chemical properties in BT locations

High organic matter (OM) in BT soils in Ado-Odo, Ijesha-Modu and Osun kurudu and high total N (%) in Ogbese, Osun-kuduru, Aiyetoro and Ado-Odo (Table 1). The soils from Osun-kuduru had high values for OM, N % and P %. The P (%) content was generally low (mg) in all BT locations except Ado-Odo which had a moderate (7-20%C mol/kg) concentration of P in the soil. The calcium (Ca %) content in the soil was medium (5.71 to 17.5 C mol/kg) in Adodo and Ijesha-Modu. The available potassium in the soil spanned from 0.10 - 0.15 across BT locations. The ECEC was highest in Ado-Odo (10.39 C mol/kg), Ijesha-Modu (8.59 C mol/kg) and Osun-kuduru (4.38 C mol/kg). The soil pH was slightly acidic and alkaline for BT locations. Across BT locations the soil textural class is sandy-loam in all locations except Aiyetoro which is sandy. The soil in Isaboro, Ikole, Osun-kuduru, Ogbese are slightly acidic (pH 5.8-6.8) while soil samples from Aiyetoro, Ijesha-Modu and Ado-Odo are slightly alkaline (pH 7.1 to 7.9).

Table 1a. Characteristics of Soils samples (0 – 30) from BT locations in 2020

BT locations	Soil particle size analyses ($g^{-1}kg$)			
	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Textural class
Isaboro	798.40	149.2	52.4	Loamy sand
Osun kurudu	778.40	149.2	72.4	Loamy sand
Are	868.40	79.2	52.4	Loamy sand
Ayetoro	878.40	69.2	52.4	Sand
Ijesa-modu	818.4	119.2	62.4	Loamy sand
Ogbese	798.40	149.2	52.4	Loamy sand
Ado-Odo	798.40	139.2	62.4	Loamy sand

Table 1b. Characteristics of Soils samples (0 – 30) from BT locations in 2020

	Elemental composition									
BT locations	pH in H_2O	OM (%)	TN (%)	P (mg/ Kg)	K (C Mol/kg)	Na (C Mol/kg)	Ca (C Mol/ kg)	Mg (C Mol/kg)	ECEC (C Mol/kg)	Exch. Acidity (C Mol/kg)
Isaboro	6.8	1.68	0.10	6.63	0.12	0.04	0.98	0.20	2.26	0.92
Osun kurudu	6.3	3.81	0.18	4.61	0.26	0.04	2.98	0.26	4.38	0.84
Are	5.8	2.92	0.15	3.67	0.10	0.04	1.74	0.26	2.93	0.8
Ayetoro	7.1	1.44	0.10	6.70	0.14	0.04	1.52	0.24	2.55	0.6
Ijesa-modu	7.1	3.87	0.15	5.65	0.12	0.04	7.30	0.29	8.59	0.84
Ogbese	6.8	3.74	0.18	3.91	0.20	0.04	3.77	0.30	5.09	0.78
Ado-Odo	7.9	4.46	0.20	9.48	0.26	0.04	9.43	0.32	10.99	0.94

Phenological, agronomic and seed yield traits among the maize genotypes in BT during 2020 and 2021

Differential response by the maize genotypes was recorded for time (days) to 50 % pollen appearance and 50 % silk appearance, anther-silk interval, 100 seed weight, plot seed yield, adjusted seed yield, stover yield and total dry yield (Table 2) across years. Statistically significant mean squares ($P \leq 0.05$) were found for 100-seed weight, plot seed yield, adjusted seed yield, stover dry yield and total dry yield. The mean squares for year effect showed statistically significant ($P \leq 0.05$) men squares for length of time (days) to 50 % silk appearance, ASI, 100-seed weight, plot seed yield, adjusted seed yield and total dry yield. Insignificant ($P \geq 0.05$) GYI mean squares were recorded for duration (days) to 50 % silking, ASI, 100-seed weight, plot seed yield, adjusted seed yield and total dry yield. Across 2020-21, the number of days to anthesis was 45 d (DMR-ESR-Y), 49 d ('SWAN 1 SR Y', 'BR 9928 DMR SR-Y'), 50 d ('DMR LSR Y'), 51 d ('Oba super 2' and 'Oba super 6'), and 53 d ('Farmers variety') (Table 3). The breeding line 'DMR-ESR-Y' had 47 d to silk appearance from sowing. The farmer's variety recorded 57 d to 50 % silk, 'SUWAN 1-SR-Y' had 53 d, and 54 d in 'BR 9928-DMR-Y', 'Oba super 2' and 'DMR-LSR-Y'. The ASI was 2 d in 'DMR-ESR-Y', 3 d in 'Oba super 6 and 'Oba super 2', and 4 d in 'SUWAN 1-SR-Y', 'DMR-LSR-Y' and 'LNTP-SR-Y'. The maize genotypes expressed ranges for seed yield across years. 'DMR-LSR-Y' showed relatively superior plot seed yield (3.87 t ha-1), adjusted seed yield at 15 % MC (8.61 t ha-1) next was 'Oba super 6' (3.76 t ha-1 and 8.36 t ha-1) and 'LNTP SR-Y' and 'Oba super 6' (3.66 t ha-1 and 7.60 t ha-1) compared to farmer's cultivar check. The genotype 'DMR-LSR-Y' recorded high percent seed yield (85 %) compared to the check while 'DMR-ESR-Y' had least percent increase (37 %) in seed yield over the check. The harvest index ranged from 0.29 % ('Farmer variety' and 'LNTP SR-Y', 'DMR-ESR-Y' and 'Oba super-2') to 0.35 % ('SUWAN 1-SR-Y'). The medium to late maturing genotypes ('SUWAN', DMR LSR Y' and 'SUWAN') produced greater seed yield. Two genotypes viz. 'Oba super 2' (16.35 t ha-1) and 'LNTP SR-Y' (15.70 t ha-1) had high mean values for stover dry weight. For multiple traits plot seed yield (t ha-1), stover dry weight (t ha-1) and total dry weight, three genotypes viz. 'Oba super 6', 'LNTP SR-Y' and 'DMR-LSR-Y' recorded high mean values.

Table 2. Sources of Variation, Degree of freedom and Mean squares for Phenological and Seed Yield Traits in eight Maize Genotypes Grown in On-farm Baby Trials during 2020 and 2021 cropping seasons, Nigeria

Source of variation	df	Day to 50% tasseling (d)	Day to 50% silking (d)	Anther-Silk Interval (d)	100 seed yield (g)	Plot seed yield (Kg)	Seed yield adjusted 15% MC (t ha^{-1})	Stover dry weight yield (t ha^{-1})	Total dry weight yield (t ha^{-1})
Genotype (G)	7	74.31**	115.73**	18.69**	53.75**	5.00**	27.73**	109.38*	198.50**
Year (Y)	1	23.22	14.23**	42.50**	116.03**	1.64*	8.09*	32.57	91.91*
G × Y	7	5.30	3.41	3.54	5.36	0.09	0.46	3.74	2.25
Error	96	8.09	2.29	2.66	7.45	0.28	1.89	14.79	20.05
CV (%)		5.66	4.97	42	8.85	18.90	18.90	29.32	21.23
Mean		50	54	3	30.8	3.27	7.28	13.11	21.09

Table 3a. Average of Phenological, Seed Yield and Stover Dry Weight in Maize Grown in Baby Trials during and 2020 and 2021 Cropping season.

Genotypes	Days to 50% tasselling	Days to 50% silking	Anther-Silk-Interval	100 seed yield (g)	Harvest index
SUWAN 1-SR-Y	49b	53bc	4a	31.35ab	0.35a
BR-9228-DMR-SR-Y	49b	54ab	5a	31.00ab	0.31b
Oba super 2	51ab	54ab	3ab	31.21ab	0.29b
DMR-LSR-Y	50ab	54ab	4ab	33.64a	0.32ab
DMR-ESR-Y	45c	47c	2b	28.28bc	0.29b
LNTP-Y	41ab	55b	4ab	31.93a	0.29b
Oba super 6	51ab	54ab	3ab	31.64a	0.30b
Farmer variety	53a	57a	4a	27.64c	0.29b

Table 3b. Average of Phenological, Seed Yield and Stover Dry Weight in Maize Grown in Baby Trials during and 2020 and 2021 Cropping season.

Genotypes	Plot seed yield (kg)	Percent increase in plot seed yield over farmer's variety (%)	Seed yield adjusted at 15% MC (t/ha^{-1})	Stover dry weight (t/ha^{-1})	Total dry weight from whole (t/ha^{-1})
SUWAN 1-SR-Y	3.48a	67	7.74a	11.10bc	19.41bc
BR-9228-DMR-SR-Y	3.46a	67	7.69a	13.27ab	21.51abc
Oba super 2	3.22ab	58	7.16ab	14.81ab	22.45abc
DMR-LSR-Y	3.87a	85	8.61a	14.71ab	23.82ab
DMR-ESR-Y	2.72bc	30	6.05bc	10.36bc	18.21cd
LNTP-Y	3.66a	75	8.02a	15.70a	24.10ab
Oba super 6	3.76a	75	8.36a	16.35a	25.24a
Farmer variety	2.09c	-	4.63c	8.61c	13.89d

Table 4. Average values for Plot Seed Yield for Maize Genotypes in each BT Location and across BT Locations for 2020 and 2021

Genotypes	Adodo village, Ido/Osi LGA, Orin-Ekiti	Isaboro village, Ido-Ekiti, Ido/Osi LGA	Osun kurudu village, Ifaki-Ekiti, Ido/Osi LGA	Ijesa-modu village Iye-Ekiti, Ilejemeje LGA	Are village, Ikole, Ikole-Ekiti LGA	Ayetoro village, Iluomoba, Gbonyin LGA	Ogbese village, Ise/Orun LGA
SWAN 1 SR-Y	4.45	3.29	2.93	3.27	2.82	3.59	3.74
BR-9928-DMR-SR-Y	4.26	3.44	2.85	3.23	2.88	4.16	3.43
Oba super2	3.89	3.25	2.74	3.49	3.09	3.80	2.83
DMR-LSR-Y	4.93	4.28	3.19	3.87	3.35	3.99	3.54
DMR-ESR-Y	3.17	2.36	2.42	2.63	2.38	3.68	2.47
LNTP-Y	4.55	4.36	2.49	4.20	2.61	4.29	2.76
Oba super 6	4.02	4.18	3.85	4.49	2.97	4.02	3.82
Farmers variety	2.33	2.07	1.93	2.14	1.93	2.20	2.02
Mean	3.95	3.04	2.08	3.42	2.75	3.72	3.08

Table 5. Average values for Seed and Fodder Yield among Maize Genotypes in each BT Location across 2020 and 2021

Locations	Plot seed yield	Rank	Seed dry weight yield 15 % MC	Rank	Stover dry weigh t yield (t ha^{-1})	Rank	Seed dry weight yield	Rank	Total dry weight yield (t ha^{-1})	Rank
Are village, Ikole, Ikole-Ekiti L.G.A	2.75		6.01		12.65		5.80		19.34	
Ado-odo village, Ido/Osi L.G.A, Orin-Ekiti	3.94	1	8.95	1	13.10	3	9.27	1	22.14	3
Ayetoro village, Ilumoba, Gbonyin L.G.A	3.67	2	8.15	2	17.23	1	6.55		25.99	1
Osun kuduru village, Ifaki-Ekiti, Ido/Osi L.G. A	2.64		5.87		12.47		5.79		19.24	
Isaboro village, Ido-Ekiti, Ido/Osi L.G. A	3.29		7.32	3	9.07		8.82	2	16.65	
Ijesa-modu village, Iye-Ekiti, Ilejemeje L.G.A	3.35	3	7.45		10.49		8.37	3	18.40	
Ogbese village, Ise/Orun L.G. A	3.07		6.81		16.54	2	5.04		24.01	2

DISCUSSION

Maize is a high-nutrient feeder, especially for nitrogen, supporting growth and seed yield. The nutrients acquired by the plant at each BT location were the result of crop rotation and the recycling of nutrients from preceding farmers' cultivation practices. Organic matter in BT soils is an index of soil nutrient status; it improves soil cation exchange capacity. A high proportion of OM (%), total N (%) and CEC in soil suggest that available nutrients are available to support crop growth and seed yield (Solomon *et al*., 2002). Low CEC in soils for BT locations was attributed to low organic carbon content. The soil's organic carbon and total N (%) contents are associated with high organic carbon decomposition from previous farming activities. Solomon *et al*., (2002) reported that they are necessary inorganic nutrients for maize production. The soil pH was

slightly acidic and alkaline for BT locations. Across BT locations, the soil textural class is sandy loam, except in Aiyetoro village, where it is sandy. The soil in Isaboro, Ikole, Osun-kuduru, and Ogbese is slightly acidic (pH 5.8-6.8), while soil samples from Aiyetoro, Ijesha-Modu and Ado-Odo are slightly alkaline (pH 7.1 to 7.9). Differential responses for 100-seed weight, plot seed yield, adjusted seed yield, stover dry yield, and total dry yield are similar to previous reports by Adnan *et al*. (2020), who noted morpho-physiological and seed yield differences among maize varieties evaluated in Ethiopia and Nigeria. Significant ($P \leq 0.05$) response for years for length of time (days) to 50 % silk appearance, ASI, 100-seed weight, plot seed yield, adjusted seed yield and total dry yield suggest that these traits were amenable to spatial variation in weather factors, soil physical and chemical properties, elevation and agro-ecological zones among years. The foregoing is consistent with previous reports by Kumar et al. (2016) on maize hybrids in tropical climates. Similar response ($P \geq 0.05$) for GYI for duration (days) to 50 % silking, ASI, 100-seed weight, plot seed yield, adjusted seed yield and total dry yield accentuate little influence of exogenous and environmental factors for trait manifestation across BT locations and years. Therefore, a high predictability of performance these traits. However, differences in crop husbandry practices and in biotic and abiotic stresses across BT locations and years to which the maize genotypes were exposed may have masked GYI for these traits. Therefore, the recommendation of promising genotypes across BT locations will account for stable seed yield.

Over the years, the number of days to anthesis was 45 d; DMR-ESR-Y is earlier, with high potential for 3 annual production cycles and may help circumvent drought. The Short ASI (2 d) among early-maturing genotypes was associated with moderate seed yield, and likely mitigates drought (Emeades, 2012). 'DMR-LSR-Y' is superior for plot seed yield (3.87 t ha-1), adjusted seed yield at 15 % MC (8.61 t ha-1) compared to the farmer's cultivar. The medium to late maturing genotypes ('SUWAN', DMR LSR Y' and 'SUWAN') produced greater seed yield. This is associated with a long period of metabolic transformation of photosynthates into seed and stover weight. In a similar study, Wang et al., (2011) and Badu-Apraku et al., (2013) noted high grain yield among medium- and late-maturing maize varieties. 'Oba super 2' (16.35 t ha-1) and 'LNTP SR-Y' (15.70 t ha-1) performed best for stover dry weight. 'Oba super 6', 'LNTP SR-Y' and 'DMR-LSR-Y' are promising as donor parents for plot seed yield (t ha-1), stover dry weight (t ha-1) and total dry weight.

This research intends to select maize genotypes perceived to have improved agronomic traits and seed yield over commercial varieties and farmers' cultivars. 'DMR ESR Y' was earlier (44 d) in Osun-kuduru and Ijesha-Modu villages. In Ado-Odo and Isaboro , 'DMR LSR Y' had a plot seed yield which was two-fold of the value recorded for the farmers' variety, while 'LNTP- SR Y' recorded two-fold of the plot seed yield recorded for the check (Farmers' variety) in Aiyetoro. Genotypes 'DMR-LSR-Y', 'Oba super 6' and 'LNTP SR-Y' demonstrated uniform performance for phenological and agronomic traits within the farmer's field and across farmers' fields, as they performed better than the farmer's variety. Across BT locations and years, the plot seed yield and adjusted seed yield at 15 % MC for each genotype were either lower or higher than the seed yields described by the Premier Seed Company, IITA, and IAR&T. The genotype 'DMR-LSR-Y' showed relatively superior plot seed yield across BT locations. The potential of these BT locations for seed and fodder yield (t ha^{-1}) is associated with loamy soil characteristics, high OM, nitrogen, phosphorus, CEC, and ECEC, and previous crop husbandry practices. Boltro *et al*., (2022) reported the response of soil chemical properties to fodder yield. On the other hand, relatively smaller plot seed yield (t ha^{-1}) and adjusted seed yield (t ha^{-1}) were recorded in the 'Farmers variety' and 'DMR ESR Y'. The foregoing relates to the polygenic inheritance for these traits and, therefore, is subject to late selection (Kumar *et al.,* 2016). Dissimilar average values for plot seed yield (t ha^{-1}) and seed yield adjusted to 15 % MC (t ha^{-1}) across BT locations and years imply that some maize genotypes performed better in one location than the other. In another study, Oyekunle *et al*. (2017) reported significant influence of genotype × environment interaction for agronomic traits in maize varieties grown across multiple environments. Genotype 'Oba super 6' performed better in Osun-kuduru, Ijesha-Modu, and Ogbese than other genotypes. The genotype 'LNTP-SR-Y' performed best in Aiyetoro, 'DMR LSR Y' in Ado-Odo and Are, and these genotypes are location-specific. The split application of N: 20 P: 10 K: 10 at the rate of 200 Kg ha^{-1}, 49 Kg of N, 20 Kg of P_2O_5, and 20 Kg of K_2O, and Urea (45 %) 45 Kg N/ha at 100 Kg/ha in all BT locations was to equalize differences in soil nutrients across farmers' fields. Across BT locations and years, plot seed yield was best in Ado-Odo. This is sequel to elevation (498 m asl), soil pH (7.9), sandy-loam soil and chemical properties viz. organic matter greater than 4.46, total N % (0.20 %), P (9.48 C mol/kg) and exchangeable acidity (0.94). Williams *et al*. (2012) reported reduced seed yield at pH ≤ 5.5 and ≥ 8.0 in maize cultivated in East Timor. The study showed that soil pH increased with elevation (300 m asl) in BT locations, except in Osun-kuduru (341 m asl) and Ogbese (342 m asl) villages. BT locations with high elevation, viz. 517 and 633 (m asl) in Isaboro showed average seed yield performance.

In this investigation, the Ado-Odo, Ijesha-Modu, and Osun Kurudu are test sites abundant in organic matter, which supports crop production and productivity. Variability among maize genotypes for anthesis, anther-silk interval, seed yield, and stover yield across years is a result of genetic differences and the influence of environmental factors across BT locations and years. A high predictability of performance for seed and dry matter yield may be associated with differences in crop husbandry practices, biotic and abiotic stresses across BT locations and years, masking GYI for these traits. 'DMR ESR-Y' is earlier with poor seed yield, 'SUWAN' and 'DMR LSR Y' are medium to late maturing genotypes and produced greater seed yield. 'Oba super 2' and 'LNTP-SR-Y' are recommended for stover production. Ado-Odo, Isaboro, and Ayetoro villages are recommended for seed production, while Aiyetoro is best for stover production. Ado-Odo village is ideal for seed

production. 'Oba super 6', 'LNTP-SY-Y' and 'DMR-LSR-Y' are ideal for seed yield (t ha^{-1}) and stover dry weight (t ha^{-1}).

CONCLUSION AND RECOMMENDATIONS

This study demonstrated significant variability among maize genotypes for key agronomic traits and seed yield across multiple BT locations and years. In addition, high variability in soil fertility, especially organic matter and nutrient content, together with environmental factors such as elevation and pH, influenced genotype performance. 'DMR-LSR-Y', 'SUWAN', and 'Oba super 6', consistently outperformed farmers' varieties in seed yield, while 'Oba super 2' and 'LNTP-SR-Y' excelled in stover dry matter production. The results highlight the importance of genotype selection tailored to specific locations and environmental conditions. Based on the findings, it is recommended that 'DMR-LSR-Y', 'Oba super 6', and 'LNTP-SR-Y' be adopted for increased seed yield and stover production in the studied regions. Ado-Odo, Isaboro, and Ayetoro are best suited for seed production, while Aiyetoro is optimal for stover yield. Continued evaluation of genotype × environment interactions is recommended to further refine recommendations and maximize maize productivity across diverse agro-ecological zones.

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Authors' Contributions

OTA: Conceptualization, Methodology, Data curation. Writing - original draft, Writing - Review and Editing. AAB: Methodology, Conceptualization, Data analysis, Writing - Review and Editing. AO: Field establishment, Investigation and Methodology

Ethical Statement:

Not applicable

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