Research Article

Reproductive Characters and Yield of Selected Drought Tolerant Maize Varieties in a Rainforest Agroecology of Nigeria

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Abstract | Soil moisture deficit in the rainforest agroecology of Nigeria emanates from altered rainfall pattern caused by climate variability and change. Selected maize *(Zea mays)* varieties developed for drought tolerance were evaluated over two years to identify those which could be included in the strategy for adapting to climate variability and change in the rainforest agroecology of Nigeria. The treatments were ten (10) maize varieties (eight drought tolerant varieties, an improved hybrid adapted to the location and a landrace) and two planting years. The experiment conducted in the field was according to split-plot arrangement in a randomized complete block design. Treatments were established in three (3) replicates. The time to anthesis, time to silking, interval between anthesis and silking (ASI), time to maturity and time to filling of grains were measured. Other parameters measured were the rows of grain per cob, grains per row, grains per cob, 100 seed weight and grain yield. Results showed difference in the time of occurrence of maize developmental stages (flowering and maturity) between the years (2010 and 2011). This was attributed to inter-annual variability in climatic factors within the study area. Maize grown in 2011 flowered (anthesis) 3 days earlier and matured 5 days later than maize grown in 2010.Therefore, grain filling duration was 6 days greater in 2011 and led to 33.1 % higher yield when compared to 2010. Based on superior grain yield and kernel number in addition to lower ASI, five varieties (TZECOMP3C2DT, DTSYN-11-YF2, DTSYN-7-WF2, OBA SUPER 2, and DTSR-WCQ) were selected from this set of drought tolerant maize varieties. These were recommended for planting as part of strategy for adapting to climate variability and change in the rainforest agroecology.

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Introduction

In Nigeria, maize (*Zea mays* L.) has transformed from an insignificant crop which is found within the home stead, to a cereal of national significance in competition with sorghum and millet (Olasehinde *et al*., 2023). While significant increase in maize production was reported in Nigeria (Shaibu *et al*.,2015;

Wossen *et al*., 2023), consumption was estimated to rise annually by 37 M t worldwide by 2050 (Erenstein *et al*., 2022). This surge in consumption was expected largely from increase in population, and demand for livestock and poultry feed as well as industrial raw material.

Maize production is currently threatened by climate variability and change across the world generally and in Nigeria particularly. Several reports from studies conducted in the rainforest agroecology in Nigeria (Odjugo, 2010; Obot *et al*., 2010; Ayanlade *et al*., 2018; Gbode *et al*., 2019; Ogbu *et al*., 2020) allude to the fact that this threat emanates from alteration in the pattern of rainfall which had existed over the years. Among the parameters of climate change in Nigeria, rainfall is the most important (Ayinde *et al*., 2010; Sam *et al*., 2023). Consequent upon the reported alteration in rainfall pattern, the humid areas in Nigeria (including the location of the present study) have become prone to spells of moisture deficit (Layi-Adigun *et al*., 2020). To avoid the period of moisture deficit, most farmers now delay planting till between end of April and early May when the rain is established. Prior to this time, planting in the study location conventionally started in March.

Moisture deficits occur when the water loss through transpiration exceeds absorption or when there is difficulty in water supply to the roots (Anjum *et al*., 2011). This causes several changes in plants, which are mostly resistance mechanisms that allow the plant to survive under the unfavourable environment. In maize, moisture deficit affects growth at all stages of development and ultimately leads to yield reduction (Munyiri *et al*., 2010; Sah *et al*., 2020). But with regard to sensitivity the reproductive stage is the most important. Moisture deficit during tasseling and silking in maize reduces yield two times as much as when the same level of stress occurs during the period of vegetative growth or ear development (Huang *et al*., 2023).

Attempts to reduce yield losses arising from moisture deficits and improve African farmers' livelihoods led to a project (DTMA) intended to promote drought tolerant maize (DTM) in sub-Saharan Africa (Ayedun, 2018). This effort led to the development of a number of DTM varieties with different maturity (early and intermediate) (Bello *et al*., 2014). Available DTM varieties have shown good performance in the field with yield of 2.44 – 3.69 t/ha under rainfed conditions (Oluwaranti and Ajani, 2016). Simulation studies indicate that optimum yield in excess of 4.0 t/ha for early maturing varieties can be attained using 90 to 120 kg/ha N depending on location. For intermediate varieties, optimum yields in excess of 5.0 t/ha can be attained using 120 kg/ha N (Beah *et al*., 2021). According to Kamara *et al*. (2023) adoption of DTM has increased maize yield significantly and impacted positively on household income.

Introduction of DTM varieties to the rainforest agroecology may be necessary as an adaptation strategy. In Nigeria, reports show that adoption of DTM varieties by farmers is on the increase in the northern region (savannah agroecology) (Ayedun, 2018; Obayelu *et al*., 2019). In the southern region (rainforest agroecology) however, adoption of DTM varieties is more in the southwest (Ajani *et al*., 2016; Oluwaranti and Ajani, 2016), while there is no evidence of adoption in the southeast. Consequently, the study intended to assess the performance of some DTM varieties with a view to identify those which could be included in the climate change adaptation strategy for Owerri southeast Nigeria. Therefore, the objectives of the study were to assess the DTM varieties for reproductive characteristics, select DTM varieties with high yield after exposure to a period of low moisture (under rainfed conditions) and determine if the productivity of DTM varieties are affected by the year of cropping.

Materials and Methods

Location of experiment and soil analysis

The experiment took place at the Federal University of Technology Owerri, Nigeria which is geographically situated between latitudes 5° 20" N and 5° 27" N and Longitude 7° 00" E and 7° 07" E. Owerri is the capital of Imo state in the South east region of the country (Figure 1).

The location experiences rainfall between 2300 and 2700mm annually, while average temperatures are 18°C (minimum) and 33°C (maximum) with the month of March as the warmest month. Soil samples from the location of experiment were taken from several points (0 – 20 cm depth) to form a composite. Physicochemical analysis was later conducted on the composite sample. Determination of sand, silt and clay fractions was achieved using the procedure of

Gee and Or (2002), pH in water by means of glass electrode pH meter, available P (Olsen and Sommers, 1982), total N (Bremner, 1996), organic matter (Nelson and Sommers, 1996) and exchangeable cations (Thomas, 1996).

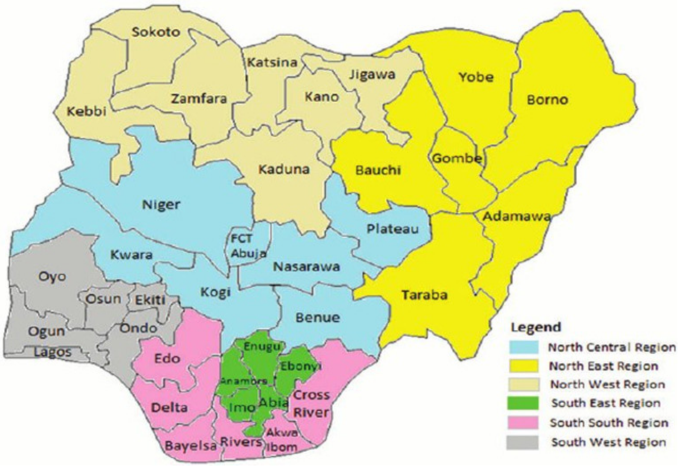

Figure 1: *Map of Nigeria showing the 36 states and Federal Capital Territory (FCT), Abuja.*

Treatments and experimental design

The treatments comprised ten (10) maize varieties and two planting years (2010 and 2011). Eight (8) of the varieties were among DTM varieties developed and released as part of the DTMA project. The other varieties were an improved hybrid adapted to the location (OBA SUPER 2) and a landrace (OKA AWAKA). The maize varieties and some of their characteristics are presented in Table 1.

Table 1: *Characteristics of Maize varieties used in the study.*

Varieties	Color	Duration (days)	Type
2008DTMA- YSTR	Yellow	90	Early
DTSR-WCQ	White	110	Late
IWDC2SYN-F2	White	110	Intermediate
EVDTY2000 STRCO	Yellow	90	Early
DT-SYN-7-WF2	White	110	Late
IWDC3SYN/ DTSYN	White	110	Intermediate
DT-SYN-11-YF2	Yellow	110	Late
TZECOMP 3C2DT	White	90	Early
OBA SUPER2	Yellow	110	Late
OKA AWAKA	Yellow	120	Late

The experiment conducted in the field was according to split-plot arrangement in a randomized complete block design. Treatments were established in three (3) replicates. Planting year constituted the main plot treatments while varieties of maize were in the subplots. The main plots were 112.5 m^2 (37.5 x 3.0m) in size while each subplot measured 11.25 m^2 (3.75 x 3.0m) with 1.0m alley maintained between main plots and subplots. Planting took place in both years on the 5th of March. The reason for planting at this time was to expose the maize varieties to dry spells (low soil moisture) which usually occur at this time due to alteration in the rainfall pattern. This provided the opportunity to select best performing DTM varieties under the prevailing low moisture condition. Two seeds were planted per hole using zero tillage at 0.75 x 0.25 m spacing. At 3 weeks after planting (WAP) the seedlings were reduced to 1 per stand giving 53,333 plants per hectare (60 plants per plot). Fertiliser (NPK 20:10:10) application was in split doses (2WAP and tasseling). The rate of application was 0.675 kg per plot (600 kg per hectare).

Collection and analysis of field data

The reproductive characters of the maize varieties were evaluated by measuring the time to anthesis, time to silking, interval between anthesis and silking (ASI), time to maturity and time to filling of grains. The time to anthesis and silking were reckoned from sowing to time of occurrence of anthesis and time of occurrence of silking in half of the plants in each plot. The time of occurrence of silking minus time of occurrence of anthesis was determined as ASI. To measure time to maturity, the days from sowing to the occurrence of black layer in the grains was reckoned, while the difference between the days to black layer formation (physiological maturity) and time to silking was reckoned as time to filling of grains. At harvest, rows of grain per cob, grains per row, grains per cob, 100 seed weight and grain yield were measured for determination of maize yield and yield components. All data were statistically analysed using Genstat (Discovery Edition 4) software. Separation of the means was conducted by employing the least significant difference (LSD).

Results and Discussion

Pre-planting soil properties

The pre-planting properties of the soil as presented in Table 2, showed a slightly acidic soil reaction (pH 5.0 in water). It was also sandy (> 80 %), low in nitrogen (0.1 %) and phosphorus (< 18 mg kg^{-1}). This is typical of the soils in Owerri southeast Nigeria (Uzoho and Oti, 2005). Therefore, maize grown in the location will benefit from application of soil amendments.

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Table 2: *Some physical and chemical properties of soil from the study site (0 – 20 cm).*

Soil property	2010	2011
Sand (%)	84.1	87.5
Silt (%)	5.1	5.88
Clay (%)	10.8	6.62
pH (H_20)	5.0	5.0
P (mg kg^{-1})	17.8	17.6
N (%)	0.1	0.1
Organic carbon (%)	1.6	1.6
Organic matter (%)	2.8	2.5
C mol Kg^{-1}		
Ca	1.6	1.5
Mg	1.2	1.1
K	0.02	0.1
Na	0.3	0.55

Effects of variety and planting years on maize reproductive characters

All reproductive characters except time to silking were significantly influenced by years. Maize grown in 2011 attained 50 % anthesis 3 days earlier and attained physiological maturity 5 days later than the maize grown in 2010. ASI and grain filling duration were greater in 2011 than 2010 by 2 and 6 days respectively (Table 3). Significant differences occurred among maize varieties in the reproductive characters (Table 3). All DTM varieties attained anthesis, silking and maturity earlier than the landrace. The varieties EVDTY2000STRCO and TZECOMP3C2DT attained 50% anthesis in 58 days. They were significantly earlier than all other varieties except DTSYN-7-WF2. The ASI in DTSYN-11-YF2 (4 days) was the lowest and significantly lower than the ASI in TZECOMP3C2DT (5 days), DTSR-WCQ (6 days),

Table 3: *Reproductive characters of drought tolerant maize varieties in 2010 and 2011.*

Year	Maize varieties										
	2008DTMA-YSTR	DTSR-WCQ	IWDC2SYN-F2	EVDTY2000STRCO	DTSYN7-WF2	OBA SUPER2	IWDC3SYN/DTSYN	DTSYN-11-YF2	TZECOMP3C2DT	OKA AWAKA	Mean
50 % Anthesis (in days)											
2010	66.33	68.33	65.00	58.00	63.67	65.00	65.67	63.67	58.00	83.67	65.73
2011	61.00	61.67	60.00	58.33	58.67	63.00	61.00	64.33	58.67	83.33	63.00
Mean	63.67	65.00	62.50	58.17	61.17	64.00	63.33	64.00	58.33	83.50	
LSD(0.05): Year=1.33; Variety=2.98; Year x Variety=n.s											
50 % Silking											
2010	71.00	72.67	69.67	61.00	67.00	68.67	70.67	67.00	60.67	93.33	70.17
2011	68.00	68.67	67.00	64.33	64.00	68.00	67.67	68.00	66.00	92.67	69.43
Mean	69.50	70.67	68.33	62.67	65.50	68.33	69.17	67.50	63.33	93.00	
LSD(0.05): Year=n.s; Variety=3.45; Year x Variety=n.s											
Anthesiss-silking interval											
2010	4.67	4.33	4.67	3.00	3.33	3.67	5.00	3.33	2.67	9.67	4.43
2011	7.00	7.00	7.00	6.00	5.33	5.00	6.67	3.67	7.33	9.33	6.43
Mean	5.83	5.67	5.83	4.50	4.33	4.33	5.83	3.50	5.00	9.50	
LSD(0.05): Year=0.59; Variety=1.32; Year x Variety=1.87											
Physiological maturity											
2010	107.67	114.33	110.67	99.33	107.33	112.33	108.00	109.00	98.00	138.67	110.53
2011	113.67	117.00	111.33	110.67	110.67	115.00	111.33	115.00	110.00	141.33	115.60
Mean	110.67	115.67	111.00	105.00	109.00	113.67	109.67	112.00	104.00	140.00	
LSD(0.05): Year=2.02; Variety=4.51; Year x Variety=n.s											
Grain filling duration											
2010	36.67	41.67	41.00	37.00	39.67	43.67	37.33	42.00	37.33	45.33	40.17
2011	45.33	48.67	44.33	47.00	46.00	46.33	44.67	47.67	46.67	48.67	46.53
Mean	41.00	45.17	42.67	42.00	42.83	45.00	41.00	44.83	42.00	47.00	
LSD(0.05): Year=1.25; Variety=2.80; Year x Variety=n.s											

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Table 4: *Grain yield and yield components of drought tolerant maize varieties in 2010 and 2011.*

Year	Maize varieties									
	2008DTMA-YSTR	DTSR-WCQ	IWDC2SYN-F2	EVDTY2000STRCO	DT-SYN7-WF2	OBA SU-PER2	IWDC3SYN/DTSYN	DTSYN-11-YF2	TZECOMP3C2DT	OKA AWAKA	Mean
Grain rows per cob											
2010	11.31	12.17	10.90	12.73	11.97	12.22	10.94	12.33	12.05	11.93	11.86
2011	11.47	12.27	10.53	12.93	12.53	12.27	10.53	13.20	12.13	11.33	11.92
Mean	11.39	12.22	10.72	12.83	12.25	12.24	10.74	12.77	12.09	11.63	
LSD(0.05): Year=n.s; Variety=1.15; Year x Variety= n.s											
Grains per row											
2010	24.00	24.00	21.67	22.00	27.67	26.00	20.67	25.33	27.67	16.33	23.53
2011	21.87	22.53	21.13	22.47	27.60	24.87	20.93	25.00	27.73	15.80	22.99
Mean	22.93	23.27	21.40	22.23	27.63	25.43	20.80	25.17	27.70	16.07	
LSD(0.05): Year=n.s; Variety=2.47; Year x Variety= n.s											
Grains per cob											
2010	265.70	287.90	226.00	252.30	345.60	313.10	216.20	307.30	377.10	184.10	277.50
2011	250.70	276.40	222.60	290.70	345.90	305.20	220.60	330.00	336.50	179.10	275.80
Mean	258.20	282.10	224.30	271.50	345.70	309.10	218.40	318.70	356.80	181.60	
LSD(0.05): Year=n.s; Variety=43.53; Year x Variety = n.s											
Weight of hundred seeds (g)											
2010	17.03	21.29	21.75	20.63	24.67	23.48	19.13	22.71	25.63	22.14	21.85
2011	23.97	25.43	23.87	25.07	25.50	25.03	25.13	26.17	27.10	20.73	24.80
Mean	20.50	23.36	22.81	22.85	25.08	24.26	22.13	24.44	26.36	21.44	
LSD(0.05): Year=1.36; Variety=3.04; Year x Variety = n.s											
Grain yield ($t\ ha^{-1}$)											
2010	2.34	3.16	2.20	2.26	3.31	3.08	1.88	3.61	3.76	2.21	2.78
2011	3.20	3.74	2.83	3.98	4.71	4.07	3.02	4.61	4.86	1.98	3.70
Mean	2.77	3.45	2.52	3.12	4.01	3.58	2.45	4.11	4.31	2.10	
LSD(0.05): Year=0.32; Variety=0.71; Year x Variety= n.s											

IWDC2SYN-F2 (6 days), 2008DTMA-YSTR (6 days), IWDC3SYN/DTSYN (6 days) and OKA AWAKA (10 days). The varieties DTSYN-7-WF2 and OBA SUPER 2 had significantly lower ASI (4 days) when compared to DTSR-WCQ, 2008DTMA-YSTR, IWDC2SYN-F2, IWDC3SYN/DTSYN and OKA AWAKA. The landrace OKA AWAKA matured later (140 days) than all other varieties, while TZECOMP3C2DT matured earlier (104 days) than all other varieties except EVDTY2000STRCO (105 days). Maturity period of 105 days in EVDTY2000STRCO was significantly earlier than 110 days in IWDC3SYN/DTSYN, 111 days in 2008DTMA-YSTR and IWDC2SYN-F2, 112 days in DTSYN-11-YF2, 114 days in OBA SUPER 2 and 116 days in DTSR-WCQ. The greatest grain filling duration of 47 days observed in the landrace, was significantly greater than the grain filling duration in DTSYN-7-WF2 (43 days), IWDC2SYN-F2 (43 days), EVDTY2000STRCO (42 days), TZECOMP3C2DT (42 days), 2008DTMA-YSTR (41 days) and IWDC3SYN/DTSYN (41 days). The year x variety interaction had significant effect on the ASI. The ASI in DTSYN-7-WF2, EVDTY2000STRCO, 2008DTMA-YSTR, DTSR-WCQ, IWDC2SYN-F2 and TZECOMP3C2DT were greater in 2011 when compared to 2010.

Effects of variety and planting years on maize yield and yield components

The weight of 100 maize seeds in 2011 (24.80 g) was significantly greater than the weight of 100 maize seeds in 2010 (21. 85 g). Similarly, the grain yield produced in 2011 (3.70 $t\ ha^{-1}$) was significantly greater than grain yield produced in 2010 (2.78 $t\ ha^{-1}$) (Table 4). Maize varieties differed in grain yield and yield components (Table 4). The variety EVDTY2000STRCO had the greatest grain rows cob^{-1} (12.83) which was significantly greater than the grain rows cob^{-1} in OKA AWAKA (11.63), 2008DTMA-YSTR (11.39), IWDC3SYN/DTSYN (10.74) and IWDC2SYN-F2 (10.72). The grains row^{-1} was greatest in TZECOMP3C2DT (27.70) and this was significantly greater than the grains row^{-1} in all other varieties except DTSYN-7-WF2 (27.63) and OBA SUPER 2 (25.43). The landrace had the lowest grains row^{-1} (16.07). The greatest grains cob^{-1} (kernel number) was produced by TZECOMP3C2DT (356.80). This was significantly greater than the grains cob^{-1} in other varieties except DTSYN-7-WF2 (345.70) and DTSYN-11-YF2 (318.70). The landrace had the lowest grains cob^{-1} (181.60) and this was significantly lower than all other varieties except IWDC2SYN-F2 (224.30) and IWDC3SYN/DTSYN (218.40). The weight of hundreds of seeds was greatest in TZECOMP3C2DT (26.36 g). This value was significantly greater than the weight of hundred seeds in all other varieties except DTSYN-7-WF2 (25.08 g), DTSYN-11-YF2 (24.44 g), OBA SUPER 2 (24.26 g) and DTSR-WCQ (23.36 g). The variety 2008DTMA-YSTR had the lowest (20.50 g) weight of hundred seeds. Grain yield was highest in TZECOMP3C2DT (4.31 t ha^{-1}) and this was significantly higher than grain yield in other varieties except DTSYN-11-YF2 (4.11 t ha^{-1}) and DTSYN-7-WF2 (4.01 t ha^{-1}). The landrace had the lowest grain yield (2.10 t ha^{-1}). Grain yield and yield components were not affected by year x variety interaction.

The difference between 2010 and 2011 in the time of occurrence of maize developmental stages (flowering and maturity) indicates inter-annual variability in climatic factors within the study location. This variation in climatic conditions must have been responsible for the 33.1 % difference in grain yield between the years.

In Nigeria, rainfall is the most critical climatic variable affecting crop growth and development. Analyses of rainfall patterns over decades, (Obot *et al*., 2010; Odjugo, 2010) have revealed a progressive change in climatic conditions and in particular with regard to inter-annual rainfall variability across the country (Okeowo *et al*., 2015; Yamusa *et al*., 2015). Due to variability in rainfall, especially in the onset (Yamusa *et al*., 2015), time of planting is being altered with the consequence being a reduction in maize yield (Okeowo *et al*., 2015). Oluwaranti *et al*. (2015) reported that climatic factors (particularly temperature) had significant effects on maize development in the rainforest agroecology. According to Adikuru *et al*. (2020) a shift in the pattern of rainfall in the study location introduced soil moisture deficit conditions at the early growing season when maize was at the early vegetative stage of development. Consequently, maize was more affected by change in climatic factors during vegetative growth than reproductive growth (Adikuru and Ogoke, 2021). This was because at the reproductive stage the rains had established.

Anthesis was delayed in 2010 when compared to 2011, while silking remained unaffected. Therefore, ASI increased by 45.1 % in 2011. In maize, increase in ASI usually occurs in response to stress factors like soil moisture deficit (Olaoye *et al*., 2009) and soil acidity (Adikuru *et al*., 2019). The difference in time of anthesis between the years which resulted in an increase in ASI suggests a difference in the severity of soil moisture deficit due to inter-annual variability in rainfall. A reduced ASI is usually associated with increase in yield (Bello *et al*., 2012). Therefore, selection for ASI has been the basis for increasing maize drought tolerance (Benchikh-Lehocine *et al*., 2021). On the basis of reduced ASI therefore, the drought tolerant varieties all performed significantly better than the landrace. When the average ASI (5 days) was considered, five varieties (with the lowest ASI) were the best performing in the order DTSYN-11-YF2 (4 days), DTSYN-7-WF2 (4 days), OBA SUPER 2 (4 days), EVDTY2000STRCO (5 days) and TZECOMP3C2DT (5 days). Grain yield was 33.1 % greater in 2011 than 2010. This may be attributed to a 15.8 % greater period available for grain filling and a 13.5 % greater weight of 100 seeds in 2011.

The differences among maize varieties in all parameters measured provide evidence of variability in drought tolerance capacity among DTM varieties (Olaoye *et al*., 2009). This provides opportunity for selection. Therefore, with regard to yield, the maize varieties may be categorized into low yielding (2.0 – 2.99 tons ha^{-1}), medium yielding (3.0–3.99 tons ha^{-1}) and high yielding (4.0 tons ha^{-1} and above). Based on this categorization TZECOMP3C2DT, DTSYN-11-YF2 and DTSYN-7-WF2 are high yielding, OBA SUPER 2, DTSR-WCQ and EVDTY2000STRCO are medium yielding and 2008 DTMA-YSTR, IWDC2SYN-F2, IWDC3SYN/DTSYN and OKA AWAKA are low yielding. The drought tolerant varieties all out yielded the landrace but only six of these varieties (TZECOMP3C2DT, DTSYN-11-YF2, DTSYN-7-WF2, OBA SUPER 2, DTSR-WCQ and EVDTY2000STRCO) were significantly higher in yield. These are the varieties categorized as high and medium yielding. When the average yield (3.24 tons ha^{-1}) was considered, five varieties were the best performing in the order TZECOMP3C2DT (4.31 tons ha^{-1}), DTSYN-11-YF2 (4.11 tons ha^{-1}), DTSYN-7-WF2 (4.01 tons ha^{-1}), OBA SUPER 2 (3.58 tons ha^{-1}), and DTSR-WCQ (3.45 tons ha^{-1}). These five varieties were also the best relative to average kernel number (276.64) and in almost exactly the same order- TZECOMP3C2DT (356.80), DTSYN-7-WF2 (345.70), DTSYN-11-YF2 (318.70), OBA SUPER 2 (309.10), and DTSR-WCQ (282.10). This confirms that kernel number is most closely associated with grain yield among the yield components in maize (Adikuru *et al*., 2019).

Conclusions and Recommendations

Soil moisture deficit at the early season has become a problem in maize production within the humid region of Nigeria. This study produced two major findings. First, productivity of maize in this region differed from year to year depending on the severity of moisture deficit. Second, planting of DTM varieties is clearly a strategy for increasing maize yield under the uncertain climatic conditions prevalent in the location. In this regard, five varieties (TZECOMP3C2DT, DTSYN-11-YF2, DTSYN-7-WF2, OBA SUPER 2, and DTSR-WCQ) were selected from this set of DTM varieties. Selection was based on superior grain yield and kernel number in addition to lower ASI. As part of measures to combat the problem of moisture deficit in the location, we recommend that seasonal rainfall predictions by the meteorological agency be strictly followed in determining the appropriate time for planting maize in the region. As a matter of policy DTM varieties should be adopted as part of strategy for adapting to climate variability and change in the region and should depend on location specific varietal screening. Further work should now focus on popularizing the use of DTM varieties among local farmers in the rainforest of Nigeria.

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Novelty Statement

No data exists to promote the adoption of DTM varieties by farmers in Southeast Nigeria where moisture deficit is a problem during the early season. This study provides data to fill this gap.

Author's Contribution

Ndubuisi Chinedu Adikuru: Conceived the idea, arranged the study, compiled the data and prepared the initial manuscript.
Paul Inyang: Supervised the field experiment and data collection, contributed to literature review and writing of manuscript.
Abraham Agwu Ngwuta: Assisted in selection of appropriate design and conducted the statistical analysis.
Chinyere Prisca Anyanwu: Read and made input into the preparation of the manuscript.
Rosemond Adaohuru Alagba: Executed the last reading of the manuscript.

Conflict of interest

The authors have declare that there is no conflict of interests regarding the publication of this article.

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