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Evaluation of Maize Varieties in Maturity Classes For Grain Yield Potentials And Adaptation in The Southern Guinea Savanna Agro-ecology of Gombe State, Nigeria.

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Abstract

Field experiments were conducted in the raining season of 2018 at Billiri and Kashere to evaluate nine varieties of Maize (Zea mays L.) for yield potentials and adaptation in the Southern Guinea Savanna agro-ecology of Gombe State, Nigeria. The varieties were distributed into three maturing classes: late maturing (Sammaz-14, Sammaz-37 and Oba super 6), early maturing (Sammaz-16, TZEWDTSTR 2011 and TZECOMP3TC3), and extra-early maturing (Sammaz-29, Sammaz-33 and TZEEWDSTR 2013). These were laid out in the field using Randomized Complete Block Design (RCBD) with five replications. Data recorded on various parameters were subjected to Analysis of Variance using Computer Software Statistical Analysis System SAS, V8, 2000 and significant means were separated using Duncan's Multiple Range Test (DMRT). At both locations, onset of flowering, days to 50 percent tasselling and 50 percent silking were earlier in the extra early varieties than in the medium and late maturing varieties. Mean values of data indicate that, late maturing varieties produced more number of kernels per cob, higher 1000 seed weight and higher grain yield than others at both location. The total grain yield was significantly higher in the late maturing varieties Sammaz-37 (6.18 t ha^{-1}) and Sammaz-14 (6.02 t ha^{-1}) than in medium and extra early maturing varieties at both locations. From the result obtained in this study, it can be concluded that,

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the late maturing varieties have demonstrated the potential for better performance than medium and extra-early maturing varieties at Billiri and Kashere in the savanna agro-ecological zone of Gombe State, Nigeria. Maize Farmers in the agro-ecological zone of Gombe State are therefore advice to grow late maturing varieties Sammaz-37 and Sammaz-14 for maximal yield.

Key Word: Adaptation, Maize Varieties, Maturity Classes, Yield Potential, Savanna Agro-ecology

Introduction

Maize is a major cereal and one of the most important food crops in Nigeria. Its genetic plasticity has made it the most widely cultivated crop in the country from the wet evergreen climate of the forest zone to the dry ecology of the Sudan savanna. Being photoperiod insensitive, it can be grown any time of the year, giving greater flexibility to fitting into different cropping patterns. It is one of the dominant cereal crops in the Guinea and Sudan savannas in northern Nigeria (Kamara *et al*., 2020). Over the years, maize has become an important crop, taking over acreages from traditional crops such as millet and sorghum. In 2018, about 10.2 million tons of maize was produced from 4.8 million hectares, making Nigeria the highest producer in Africa (FAO, 2018).

An IITA Nigeria Food Consumption and Nutritional Survey conducted in 2003 showed that maize is the most consumed staple food in households at about 20%, followed by cassava – 16.5%, rice – 11.9% and cowpea grain – 11.8% (Adedotun, 2022). While Agriculture contributes 22.35 % of the total Gross Domestic Product GDP between January and March, 2021, maize alone accounts for 5.88% of the Nigeria's Agricultural GDP (Adedotun, 2022). Maize is used for multiple purposes like bread making, corn flakes, corn syrup, corn starch, textile, paper making and in food industries. Corn oil is suitable for human consumption due to the presence of unsaturated fatty acids. Maize is the leading cereal crop, which covers 4.8% area and 3.5% of the value of agricultural output. Maize is an important source of edible oil. Starch is the main product of maize from which dextrin, liquid glucose, solid glucose, powder glucose and crystalline dextrose are prepared (Eltelib *et al*., 2006; Masood *et al*., 2011).

The savanna agro-ecology of Nigeria has a great potential for food production because of its high solar radiation that favours maize production. In the Southern Guinea Savannah (SGS) however, maize is grown twice due to bimodal rainfall pattern (a short early growing season followed by fairly long late season) (Bello *et al*., 2012). The short early growing season (beginning April/May in Gombe Environs) is characterized by abrupt cessation of rains during crop cycle while the late season is normally affected by terminal drought. The occurrence of extreme environmental events impose different degrees of drought stresses on crops thereby affecting growth duration, plant size, dry matter accumulations, assimilate reserves and partitioning to grains (Bello *et al*., 2012). As the episodes of water resources for agronomic uses become more limiting, the development of drought-tolerant (DT) lines becomes increasingly necessary. Drought occurring during or shortly before flowering in crops, may lead to estimated yield loss in the range of 21 to 50% (Olaoye *et al*., 2009). The soil in the SGS is also fragile with low organic matter, poor buffering and water holding capacity, resulting in low nitrogen availability (Fakorede*et al*., 2003). The Southern guinea savanna agro-ecological zone of Gombe state is characterized by a bi-modal rainfall distribution and a length of growing season ranging from five to seven months. Wanah and Mbaya (2012) noted increasing trend of rainfall and decreasing trend of rainy days in Gombe State, Msheliza and Bello (2016) reported increasing trend of temperature at the rate of 0.092 ^{0}C per^{-1} and a decreasing trend of rainfall at -1.705 mm per^{-1} in Gombe state. Trend of this nature could affect soil moisture, crop water requirement and subsequently lead to ecological change. The occurrence of extreme environment events imposes different degrees of drought stresses on crops thereby affecting growth duration, plant size, and dry matter accumulation; assimilate reserves and partitioning to grains Bello *et al*., (2012).Since the timing of mid-season drought is unpredictable, early maize cultivars that can tolerate the effects of reduced moisture supply during flowering could reduce farmers' risk in drought-affected ecologies (Olaoye *et al*., 2009; Hussain *et al*., 2011). Early maturing DT maize varieties are ideal for intercropping by providing less competition for moisture, light, and nutrients than late maturing ones. They also offer flexibility in planting dates, which enables: (i) multiple plantings in a season to spread risk of losing a single crop to drought (ii) late plantings during delayed onset of rainfall, and (iii) avoidance of known terminal drought periods during the cropping season (International Maize and Wheat Improvement Center CIMMYT, 2000). The occurrence of drought in most parts of West and Central Africa has now made the production and utilization potential of DT maize varieties attract the attention of the national and international researchers to developing, testing and transferring high yielding and adapted maize cultivars to farmers (Olaoye and Omueti, 2006).

The development of early maturity varieties has reduced the time of maturity so that crops can escape the period of unreliable rainfall at the beginning and end of the rainy seasons. The late-maturing varieties, however, produce higher grain yield than the early-maturing varieties as observed by Agele (2006). Early-maturing varieties are a source of food security to the farming families with low or short rainfall. With early-maturing varieties, two or more crops can be grown in relays in the moist savanna due to prolonged bimodal rainfall or irrigation could be practiced in the dry savanna where facilities are available. Late-maturing varieties are most appropriate for sole cropping to utilize the four to five months cropping season effectively. They are useful when the cropping system permits them and management is good.

Maize hybrids, however, have gained slow acceptance by famers due to the cost involved in growing good crops and the time and effort involved despite their high yields. The yield of maize however, varies from variety to variety, location to location and also depends on the availability of essential factors such as soil nutrient status, fertilizer application rates and timing, and combinations(Kogbe and Adediran, 2003).

The seed of improved variety and fertilizer are the main factors in enhancing the output of maize (Dowswell*et al*., 1996). A good variety having a high yield potential is a key towards improving maize yield (Saleem *et al*., 2003). Yield is the primary objective in breeding maize hybrids.It is quantitatively inherited and its expression is influenced by several components or traits. These traits differ with seasons and locations as they are affected by environmental factors. With the continued development and release of hybrids of different maturity periods, also given the fact thatthere are little or no information with regards to the yield and adaptability of the maize varieties in Billiri and Kashere, guinea savanna agro-ecological zone of Gombe State; there is need to evaluate varieties readily available to ascertain their yield and adaptability in Guinea savanna agro-ecological zone of Gombe State, Nigeria.

Materials and Methods

Experimental Sites

Field experiment was conducted at Billiri and Kashere in Gombe State, Billiri is located at 9°51′53″N11°13′31″E. While *Kashere* lies on the geographical coordinates of 9° 46' 0" N, 10° 57' 0" E. Both locations have a Maximum Temperature of between 27^0C to 40^0C, and Annual Average Rainfall of 600 mm.

(GSAP, Ladongor Metrological Section, Billiri, 2018)

Experimental Materials

Nine varieties of maize used in the experiment were obtained from the Institute of Agricultural Research (IAR), Ahmadu Bello University (ABU), Zaria, and Research Farm, Bayero University, Kano, Nigeria. The Varieties, which were distributed in three (3) maturity classes were designated as shown in Table 1.

Table 1: Hybrid Varieties of Maize used in the Field Experiment in 2018

Designation	Variety	Maturity Class
V_1	Sammaz -14	Late –maturing
V_2	Sammaz -37	Late –maturing
V_3	Oba super 6	Late –maturing
V_4	Sammaz -16	Early –maturing
V_5	2011 TZEWDTZTR	Early –maturing
V_6	TZECOMP3TC3	Early –maturing
V_7	Sammaz -29	Extra-early maturing
V_8	Sammaz- 33	Extra-early maturing
V_9	2013 TZEEWDSTR	Extra-early maturing

Source: Institute for Agricultural Research, Ahmadu Bello University, Zaria

Table 2: Agronomic characteristics of hybrid varieties of maize used in the field experiment

Variety	Agronomic characteristics
Sammaz -14	Seed is white in colour, seed and cob are large, husk cover is good. It matures between 110-120 days and attains a plant height of 180-200 cm. It is a Quality Protein Maize (QPM). Resistant to stem borer, maize streak and striga. Potential yield of 6.0 t ha^{-1}
Sammaz -37	Seed is of yellow endosperm, seed is large. Cob is long and husk cover is good. It matures between 110-120 days. It attains a height of 220 cm and is tolerant to streak virus. It is QPM with a potential yield of 6.0 t ha^{-1}.
Oba super 6	Seed is of yellow endosperm, seed is large. Cob is long and husk cover is good. It matures between 110-120 days. It attains a height of 220 cm and is tolerant to drought and heat, and it is resistant to Striga. It is a Pro-vitamin A maize variety with a potential yield of 4.0 t ha^{-1}
Sammaz -16	Grain colour is white. A plant height of 180-220 cm. It matures about 100 days. Highly tolerant to *Striga hermonthica*. It is QPM with a potential yield of 4.0 t ha^{-1}
TZEWDTSTR 2011	Grain colour is white; seed is medium in size and dented. Cob is large with good husk cover. A plant height of 180-200 cm. It matures between 95-100 days. Potential yield of 5.7 t ha^{-1}
TZECOMP3TC3	Grain colour is white; cobs and seeds are medium in size and dented. It matures between 95-100 days. Husk cover is good and plant height is 180-200 cm. Potential yield of 4.2 tha^{-1}
Sammaz- 29	Grain colour is white with a plant height of 200-225 cm. It takes 85-90 days to mature. It is tolerant to *Striga hermonthica*. It is QPM with a potential yield of 3.3 tha^{-1}.
Sammaz -33	Grain colour is white, medium seeds, attains a height of 185-220 cm and potential yield of 3.2 t ha^{-1}. 85 days to mature. It is tolerant to streak and striga.
TZEEWDSTR 2013	Grain colour is white; seed is small in size and dented. Cob is large with good husk cover. A plant height of 170-195 cm. It mature 85 days. Potential yield of 3.5.0 tha^{-1}

Source: Institute for Agricultural Research, Ahmadu Bello University, Zaria

Experimental Design

The treatments were laid out in a Randomized Complete Block Design (RCBD) with five replications. The gross plot size was 50 m x 26 m. All varieties were planted at 75 cm x 25 cm inter and intra row spacing respectively. The dimensions of the plots were 5 m x 4 m. One seed was sowed per hole, this will give a total of 20 stands per row and 6 rows per plot, which will give a plant population of 60, 000 ha^{-1}. Each plot was separated from another by 0.5 m while the blocks were separated by 1 m.

Cultural Practice

The experiments were conducted at Kalmia, Billiri and the Teaching and Research Farm of the Faculty of Agriculture, Federal University, Kashere. Glyphosate was applied using knapsack sprayer 12 days before ploughing and Atrazine was applied 1 day after sowing at 5 L ha^{-1} The fertilizer NPK (2:1:1) was applied to all the plots at the rate of 100 kg N; 50 kg P_2O_5;50 kg K_2O ha^{-1} at 2 weeks after sowing (WAS). This was equivalent to 385 grams per plot. The plots were earthen up at 6 WAS at which time nitrogen was supplied in the form of urea at the rate of 60 kg ha^{-1}. This was equivalent to 115.5 g per plot.

Method of Data Collection

Data collection commenced from the onset of germination till the harvest period of the plant. The parameters for which data were collection included:

3.5.1 Mean Number of Days to Onset of Flowering
3.5.2 Mean Number of Days to 50% Tasseling
3.5.3 Mean Number of Days to 50% Silking
3.5.4 Mean Number of Kernels per Cob
3.5.5 One Thousand Seed Weight
3.5.6 Total Grain Yield

Methods of Data Analysis

Data recorded on various parameters were subjected to Analysis of Variance (ANOVA) using Computer software SAS, V8, 2000 and significant means were separated using Duncan's Multiple Range Test (DMRT).

Table 3: Physical and Chemical Ppropertie s of soil within 0-15 cm of the experimental sites

Physical composition	Billiri	Kashere
Clay (%)	7	13
Silt (%)	6	14
Sand (%)	87	73
T. porosity (%)	38	42
Texture class	Loamy sand	Loamy sand
<u>Chemical Composition</u>		
pH (1:2)	6.71	6.65
Organic Matter (%)	0.19	2.12
Total Nitrogen (%)	0.01	0.12
Available phosphorus (mg/kg)	8.81	7.02
<u>Exchangeable bases (cmol kg^{-1})</u>		
Calcium	1.20	3.99
Magnesium	2.88	1.07
Potassium	0.46	0.51
Sodium	0.48	0.56
H	0.65	0.55
Al	0.75	0.35

Key: CEC = Cation exchange capacity

Table 4: Meteorological data covering the experimental site during 2018 rainy season

Year	Month	Rainfall (mm)	Temperature		Relative humidity	
			(Min)	(Max)	(Min)	(Max)
	April	20.21	21	38	21	85
	May	22.22	21	34	42	81
	June	72.31	20	32	38	80
	July	219.11	20	35	33	88
	August	314.01	19	31	40	82
	September	221	20	35	42	90
	October	3.1	18	36	29	20

Source: Gombe State Agricultural Development Project, Ladongor Metrological Section, Billiri, Gombe State, Nigeria.

Table 5: Mean values of Days to onset of Flowering, 50% tasseling, 50%

Silking, Number of Kernel/ear, One thousand seed weight (g) and Grain yield (t ha^{-1}) Performance of Difference Maize (Zea mays L.) Genotype at the dry agro-ecological zone of Gombe state.

Variety	Maturity Class	Days to onset of flowering	50 % Tasseling	50 % Silking	Number of kernel/Ear	1000 Seed weight (g)	Grain Yield (t ha^{-1})
Sammaz 14	Late	53.80^{a}	58.30^{a}	62.00^{a}	482.20^{a}	372.20^{ab}	6.02^{a}
Sammaz 37	Late	53.60^{a}	56.50^{b}	60.90^{ab}	501.58^{a}	377.90^{a}	6.18^{a}
Oba Super 6	Late	54.00^{a}	56.40^{b}	59.80^{bc}	514.93^{a}	359.80^{b}	3.86^{d}
Sammaz 16	Medium	51.20^{b}	54.60^{c}	58.80^{cd}	387.30^{c}	275.63^{d}	4.00^{cd}
TZEWDTSTR 2011	Medium	51.20^{b}	53.40^{d}	58.70^{cd}	380.03^{c}	307.70^{c}	5.69^{b}
TZECOMP3TC3	Medium	51.60^{b}	53.90^{cd}	58.10^{d}	433.36^{b}	280.00^{d}	4.21^{c}
Sammaz 29	Extra Early	46.60^{c}	50.60^{e}	54.40^{e}	401.09^{bc}	174.00^{g}	3.31^{e}
Sammaz 33	Extra Early	46.40^{c}	50.00^{e}	53.60^{ef}	393.10^{bc}	246.80^{e}	3.15^{e}
TZEEWDSTR 2013	Extra Early	46.60^{c}	48.70^{f}	52.30^{f}	399.82^{bc}	277.50^{f}	3.41^{e}
LSD		**	**	**	NS	**	**
S.E.		±0.51	±0.50	±0.69	±022.77	±6.34	±026

Key: LSD = Least Significant Differences at 5% Level of Probability, ** = 95% level of probability, NS = Not Significant

Results and Discussion

Results

The soils of the experimental fields were both loamy sand texture in Billiri and Kashere (Table 3). The pH (6.71) in Billiri and (6.65) in Kashere indicated that the soils in both fields were acidic in reaction. Organic carbon (%) was 0.19 in Billiri and 2.12 in Kashere. Total nitrogen was 0.01 and 0.12 in Billiri and Kashere respectively. Available phosphorus (mg/kg) of the experimental soil was higher in Billiri (8.81) compared to Kashere (7.02). CEC in Billiri and Kashere were 6.42 and 7.04 respectively. There was maturity class difference with regards to the number of days to onset of flowering. Earliness to flowering was observed with the extra early varieties with number of days as 46.60, 46.40 and 46.60 with Sammaz 29, Sammaz 33 and TZEEWDSTR 2013 respectively. The extra early varieties with number of days to flowering are statistically similar but differ significantly with the medium and late maturing varieties. The extra early maturing varieties were followed by the medium varieties which also differ significantly with the late maturing varieties which number of days to flowering were observed as 53.80, 53.60 and 54.00 with Sammaz 14, 37 and oba super 6 respectively. The trend was slightly different with 50% tasseling and 100% silking. There were significant differences within and across the maturity group with the earliest to 50% tasseling and 100% sinking observed in extra early followed by medium and then late maturing varieties. The earliest days to 50% tasseling (48.70) and 100% sinking (52.30) were both observed in TZEEWDSTR 2013 (extra early maturing varieties) and latest days to 50% tasseling (58.30) and 100% sinking (62.00) were both observed in Sammaz 14 (late maturing varieties). The mean values for number of kernel shows that maize varieties differed significantly for number of kernels. The highest number of kernels per cob was produced by Oba super 6 (514.93) followed by Sammaz 37 (501.58) then followed by Sammaz 14 (482.20) which were statistically similar while the smallest number of kernel was produced by TZEWDTSTR 2011 (380.03) which is statistically at par with Sammaz 16. Sammaz 37 produced the heaviest 1000 seed weight (377.90 g) which was comparable with Sammaz 14 (372.20 g), the least 1000 seed weight was produced by Sammaz 29. There is significant variation in grain yield of the maize varieties. The highest grain yield was produced by Sammaz 37 (6.18 ton ha^{-1}) followed by Sammaz 14 (6.02 ton ha^{-1}) both are statistically comparable but differed significantly with TZEWDTSTR 2011. The lowest grain yielding varieties were Sammaz 29, Sammaz 33 and TZEEWDSTR 2013 which produced 3.31 ton ha^{-1}, 3.15 ton ha^{-1} and 3.41 ton ha^{-1} respectively and they are statistically comparable.

Discussion

Precipitation pattern of rainfall has great impact in the expression of plants' potentials during period of flowering/ grain filling of the crop growth cycle, especially maize. It also plays significant role in stimulating plants to speed up the process of maturation (Bello *et al*., 2012). One most important environmental factor that did affect the overall performance of this study was rainfall distribution and its amount. Rainfall was evenly distributed throughout the flowering/grain filling period of August and September, 2018.This created favourable environment for seed set and translocation of assimilates to grain filling. The soil analysis of the experimental sites were both loamy sand and slightly acidic, favourable for maize growth, the soil nutrients especially nitrogen was very low. This may be due to continuous cropping of the land over some years without fallowing. With appropriate agronomical practices such as appreciable application of fertilizer, weeding and favourable rainfall probably gave individual genotype ample opportunity to express their yield potentials. The differences in performance of the genotypes, on the other hand, both between and within each maturity groups for number of days to onset of flowering, 50% tasseling, 100% silking, 1000 seed weight and grain yield, plant height confirmed the diversity of the genotypes and their differences for these characters. Furthermore, this wide variability observed for these yield parameters showed that they were quantitatively inherited and offered way for further improvement through selection (Bello and Olaoye, 2009).

The number of grain per is a genetically controlled factor but environmental and nutritional level may also influence the number of grain per cob. Grain yield is directly related to the number of grain per cob. The more number of grains per cob, the more the grain yield. A perusal of the data indicates significant effect of variety on number of grain per cob. Higher number of kernel per cob were recorded in Sammaz 14 (482.20), Sammaz 37 (501.58) and Oba super 6 (514.93) which are statistically at par and differed significantly from other varieties. These varieties has corresponding higher yield than other varieties except for oba super 6 where it number of plant stand per plot was drastically reduced to 49.40 against 95.60 and 109.00 of Sammaz 14 and Sammaz 37 respectively. These results were in line with the work of Tahir *et al*., (2008) which affirmed the number of kernel per cob is a genetically controlled factor.

1000-seed weight is an important factor directly contributing to the final grain yield of crop. There was highly significant variability with 1000-seed weight in this study. Maximum 1000 seed weight per cob were record with Sammaz 14 (372.20 g), Sammaz 37 (377.90 g) and Oba super 6 (359.80 g) and the least was Sammaz 29 (173.80 g). This was due to the fact that 1000 seed weight a genetically controlled factor. Similar results were also reported by Jing *et al*., (2003) and Tahir *et al*., (2008).

Grain yield (t ha^{-1}) of crop is probably the ultimate objective of most research of grain crops. Sumayea and Firoz, (2021) reported that grain yield per plant is positively and significantly correlated with the other traits such as days to female flowering, days to maturity, plant height, cob breadth, row per cob, seed per row, seed per cob, 1000 seed weight and yield per plant. The maximam grain yield (6.18 t ha^{-1}) and (6.02 t ha^{-1}) were obtained from Sammaz 37 and Sammaz 14 respectively. More grain yield in Sammaz 37 and Sammaz 14 was due to higher number of kernel per cob, and weightier 1000 seed weight in these varieties. These results are in line with the work of McCutcheon *et al*., (2001) and Tahir *et al*., (2008) who reported significant differences among maize cultivars for grain yield.

The experiment unveiled the superiority of late maturity class as compared to other Classes (Medium and extra early). Sammaz 37 and Sammaz 14 are two out of the three varieties of late maturity class used in this study that have surpassed other varieties in at least 5 out of 6 yield attributes assessed (days to onset of flowering, 50% tasseling, 100% sinking, number of kernel/cob, 1000 seed weight and grain yield). The prolong maturity obviously make more days available for canopy (collection of leaves) to intercepts sunlight and uses the light energy to assimilate CO_2 (Photosynthesis), leading to higher biomass production and thus higher crop yield. Wang *et al*., 2011 reported that, longer maturity variety produced greater yield to enable for a long duration in metabolic transformation into grain and stover yields. Early maturing varieties on the other hand, required fewer corn heat units to reach flowering, while late maturing cultivars exhibited extended vegetative period. Therefore, early flowering maize plants are smaller and have fewer leaves with low grain yield compared with late cultivars (Kamara *et al*., 2009; Wang *et al*., 2010; Khan *et al*., 2011).However, Bello *et al*., 2012 emphatically states that grain yield and earliness to silk are two important characters that can be used in ranking genotypes for their suitability as cultivars especially in a drought–prone ecology such as savannas. Earliness to anthesis and/ or silking allows short growth duration and maturity; and these could constitute important attributes of drought escape which often make earlier maturing maize genotypes adapt better to late season moisture stress than late maturing ones (Shi *et al*., 2008; Nazir *et al*., 2010; Majid *et al*., 2010). Reports from Bello *et al*., 2012, Anon, 2001 also showed a direct relationship between grain yield and maturity irrespective of the group, indicating that, that this situation is not peculiar to this study.

Conclusion

It can be concluded that, the late maturing varieties have demonstrated the potential for better performance than early and extra-early maturing varieties at Billiri and Kashere in the Savanna Agro-Ecological Zone of Gombe State – Nigeria.

Recommendation

Sammaz 37 (6.18 t ha^{-1}) and Sammaz 14 (6.02 t ha^{-1}) (late maturity class) having outperformed all other varieties used in the study could be used for maximum yield production of maize in Billiri and Kashere, Savanna Agro-Ecological Zone of Gombe State where average yield of 2 tons per hectare is a norm.

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References

Adedotun A. (2022). *"Maize farming in Nigeria: Exciting Facts You Should know"* https://babbangona.com

Agele S.O. (2006). Weather and seasonal effects on growth, seed yield and soluble carbohydrate concentrations in selected maize cultivars in the humid areas of Nigeria. *Africa Journal Agricultural Research*

4(1): 101-110.

Anon A. (2001). WECAMAN Regional uniform variety trials for 2000. Annual Report of West and Central Africa Maize Collaborative Research Network. 62 pp.

Bello O.B., Abdulmaliq S.Y., Ige S.A., Mahamood J.,Oluleye F., Azeez M.A. and Afolabi M.S. (2012). Evaluation of Early and late/intermediate Maize Varieties for Grain yield potential and Adaption to a Southern Guinea Agro-ecology of Nigeria, *International Journal of Plant Research* 2(2):14-21

Bello O. B. and Olaoye G. (2009). Combining ability for maize grain yield and other agronomic characters in a typical southern guinea savanna ecology of Nigeria. *Africa Journal of Biotechnology* 8(11): 2518-2522.

CIMMYT (2000). International Maize and Wheat Center – Zimbabwe: 2000 Research Highlighs, Harare, Zimbabwe

Dowswell C. R., Paliwal R. L., Cantrell R. P. (1996) Maize in the third world. West view Press, pp. 241-244.

Eltelib H. A., Hamad M. A. and Ali E. E. (2006). The effect of Nitrogen and Phosphorus fertilization on growth yield and quality of forage maize (Zea mays L.). *Journal of Agronomy* 5(3):515-518

Fakorede M.A.B., Badu-Apraku B, Kamara A.Y., Menkir A. and Ajala S.O. (2003). Maize revolution in West and Central Africa: An overview. In: Badu-Apraku B, Fakorede M.A.B., Ouedraogo M., Carsky R.J. and Menkir, A. (eds.). Maize revolution in West and Central Africa. Proceedings of a Regional Maize Workshop, 14 –18 May, 2001, IITA-Cotonou, Benin Republic, WECAMAN/IITA, pp. 3-5.

FAOSTAT, FAOSTAT statistics database (2018). https://search.library.wisc.edu/catalog/999882363002121.

GSAP, (2018). Gombe State Agricultural Development Project, Ladongor Metrological Section, Billiri, Gombe State, Nigeria.

Hussain N., Khan M.Y. and Baloch M.S. (2011) Screening of maize varieties for grain yield at Dera Ismail Khan. *Journal Animal and Plant Science* 21(3): 626-628.

Jing Q, BingwvW, YongM.A. (2003) Study on Comprehensive evaluation of maize hybrids. *Journal of Jilin agricultural University*

25: 139-142.

Kamara A.Y., Kamai N., Omoigui L.O., Togola A., Onyibe J.E. (2020). Guide to Maize production in Northern Nigeria, International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria 18pp.

Kamara AY, Friday E, David C and Lucky OO (2009). Planting date and cultivar effects on grain yield in dryland corn production. *Agronomy Journal* 101: 91-98.

Khan K, Sher H, Iqbal M and Al-Qurainy F (2011). Development and release of indigenous maize hybrids to enhance maize yield in Khyber-Pakhtoonkhua province of Pakistan. *Africa Journal of Agricultural Research* 6(16): 3789- 3792.

Kogbe J.O.S. and Adediran J.A. (2003) Influence of nitrogen phosphorus and potassium application on the yield of maize in savanna zone of Nigeria. African Journal of Biotechnology 2(10): 345-349.

Majid K, Zaefizadeh M, Gholamin R and Shahzad JS (2010). Study of genetic diversity and path analysis for yield in durum wheat genotypes under water and dry conditions. *Journal of World Applied Science* 9(6): 655-665.

Masood T., Gul R., Munsif F., Jalal F., Hussain Z. (2011). Effect of Different phosphorus levels on yield and yield components of maize. *Sarhad Journal of Agriculture* 27(2): 167-170

McCutcheon, J., Siegrist, H. and Rzenwncki P. (2001). Fair field, Licking, and Perry counties- osu extension commercial corn Hybrid side by side performance trials. *Special circular Ohio Agriculture Research and Development center* (179):54-56.

Msheliza, D.S. and Bello Y. (2016). Evidence of Climate Change and the perceived change in climate parameters by smallholder farmers in Gombe State, Nigeria. *Journal of Humanities and Social Science* (IOSR-JHSS) 21(11):29-35.

Nazir H, Zaman Q, Amjad M, and Aziz NA (2010). Response of maize varieties under agro-ecological conditions of Dera Ismail khan. *Journal of Agricultural Research* 48(1): 59-63.

Olaoye G. and Omueti H.E. (2006). Evaluation of short duration maize (*Zea mays* L.) varieties for adaptation to a typical Southern guinea savanna ecology of Nigeria. *Journal of Agricultural Research and Development*5 (2): 97-111.

Olaoye G., Menkir A., Ajala S.O. and Jacob S. (2009). Evaluation of local maize (*Zea mays* L.) varieties from Burkina Faso as source of tolerance to drought. *Journal of Applied Bioscience* 17: 887 – 898.

Saleem A, Javed H. I., Ali Z., Ullah I. (2003). Response of maize cultivars to different NP levels under irrigated condition in Peshawar valley. Pakistan Journal of Biological Science 6(14): 1229-1231.

Shi Z.S., Zhang S.H., Li F.H., Wang Z.P., Zhang X.H., Zhang Y.l., Zhu M. (2008). Comparison and analysis on maize yield performance of mid-maturing, mid-late maturing and late maturing varieties in Liaoning areas. *Journal of Maize Science* 16(6): 6-10.

Sleper D.A., And Poehlman J.M. (2006) Breeding Field Crops. Oxfoxd: The Blackwell Publishing, pp. 424 ISBN 1-56022-278-6

Sumayea K.. and Firoz M. (2021) Genetic Variability and Character Association of Yield Components in maize (Zea mays L.). *American Journal of Plant Sciences*, 1691-1704. Doi:10.4236/ajps.2021.1211118.

Tahir M., Tanveer A., Ali A., Abbas M., Wasaya A. (2008) Comparative yield performance of different maize hybrids under local conditions of Faisalabad-Pakistan. Pakistan Journal Life Social Science 6(2): 118-120.

Wanab B.B. & Mbaya L.A. (2012). Adaption to Climate change: Vulnerability Assessment for Gombe State Climate change and Sustainable Development proceedings of the 52nd Annual conference of the Association of the Nigeria Geographers, A publication of Department of Geography, UsmanuDanfodiyo University, Sokoto and the Association of Nigeria Geographers Funsho Printing Works pp 163-175.

Wang X, Chang J, Qin G, Zhang S, Cheng X and Li C (2011). Analysis on yield components of elite maize variety Xundan 20 with super high yield potential. *Africa Journal of Agricultural Research* 6(24): 5490-5495.