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POTENTIAL OF MAIZE (*Zea mays*) YIELD IN THE SAVANNA OF KANO STATE, SEMI-ARID REGION OF NIGERIA

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ABSTRACT
This study examined the Savanna agro-ecologies potential of maize yield in Kano State. Field experiment consisted of five different fertilizer treatments namely were replicated three times in a Randomized Complete Block Design. The trial was established at three different locations namely: Doguwa (Northern Guinea Savanna), Bunkure (Sudan Savanna 2) and Dambatta (Sudan Savanna1) with a total of fifteen treatments(Five fertilization for three locations). White maize hybrid cultivar (SC651) was planted at 25cm and 75cm intra plants and inters ridges respectively. The results showed that highest maize yield potential was in the Northern Guinea Savanna with mean yield of 4.284 t/ha while lowest in the Sudan Savanna 1 with mean yield of 1.927 t/ha. Fertilization using Nutrients Expert (NE) has the highest maize yield while lowest maize yield of was observed in Regional Recommendation (RR) fertilization in all the three locations. It further revealed that there is significant maize yield difference between Doguwa (NGS), Bunkure (SS2) and Dambatta (SS1) with p value <0.001 at 0.05 significant level.

Keywords: Potential; Maize; Yield; Savanna; Semi-Arid

INTRODUCTION
Maize (Zea Mays L.) is the world's best adapted crop, growing between Latitude 58^{o}N and 40^{o}S of the equator (Alofe et al., 1993). The Nigeria's savanna covering Latitude 8^{o}N to 14^{o}N is basically a Sub-humid to Seni-arid (FAO, 1982) and consists of the derived Savanna, Southern and Northern Guinea, Sudan and Sahel agro-ecological zones in that order northwards (Kowal and Knabe, 1972).Three types of Savanna could be identified in Kano State which responds to variation in the amount of rainfall received that decreases from south to north (Badamasi, 2014). Towards the southern tip of the Region where the amount of rainfall is high, the Northern Guinea Savanna is found and in the extreme northern part with low rainfall, the Sahel Savanna is the agro-ecology, while much of the central part of the State is characterized by the Sudan Savanna.

It is important to note that the major controlling factor influencing this agro-ecological variation is water supply i.e. rainfall; and of all the climatic variables, rainfall is the most determinant of agricultural activity. The onset of rains which marks the beginning of the growing season starts in April in the Southern Guinea through May in the Northern Guinea and June in the Sudan agro-ecological zones. The length of the growing period (LGP) spreads from a range of 187-244 days in the Southern Guinea through 140-200 days in the Northern Guinea and 95-140 days in the Sudan (Elemo, 1993). Optimum planting time of maize varies in each of the agro-ecological zones of Nigeria (Iken and Amusa, 2004) and variations in crop yields have been linked with planting date (Ibrahim, 2010; Uzoma et al., 2010).The duration of rainy season (length of the growing period) as well as the annual amount, distribution and number of rain days also varied significantly across the agro-ecologies, that's why the research into the potentials of maize yield in the Savanna agro-ecological zones of Kano State is perceived and the research outcome would help in improving food security through boosting maize yield.

MATERIALS AND METHODS
The study was carried out at three locations within Kano State. The locations have tallies with three Savanna ago-ecologies that could be found in Kano State. They are Bangel, Dambatta (Lat 12.37942 N, Long 8.51585 E) represented as Sudan Savanna 1 (SS1), Falingo, Bunkure (Lat 11.73551 N, Long 8.53755 E) standing for Sudan Savanna 2 (SS2) and Katsalle, Doguwa (Lat 10.77973 N, Long 8.59347 E) serving as a Northern Guinea Savanna (NGS) (figure 1).The climate of the area is the Tropical wet and dry (Koppen AW) type. Annual average rainfall in the area ranges from 884 – 1200 mm (from north to south of the state) which is characterized by one peak rainfall period, usually reached in August (Buba, 2009). The rains last for 3 – 5 months. In terms of rainfall distribution, the State is divided into 3 zones

Malaysia Agricultural Research Development Institute (MARDITECH, 2011) as: the Northern most Rainfall zone 1 with 110 – 130 rainy days a year, the second is Rainfall zone 2 which lies south of the first with 120 – 130 days a year and Rainfall zone 3 in the southern most part of the state with 130 – 150 rainy days a year. This coincides with the 3 agro ecologies in Kano State viz: Sahel, Sudan and Northern Guinea Savanna.The temperature is averagely warm to hot throughout the year ranging from 21 – 31^{o}C (Olofin and Tanko, 2002).The soils of the three zones is distinctive, as Sandy soil is predominant in the northern part while sandy-loam formed the soils of center and southern part of Kano State. Soils in the Northern Nigeria's Savanna are the major limitations for maize production (FDALR, 1999; FFD, 2012), as there is generally low fertility in the soils (Essiet, 2014; Shehu et al., 2018).

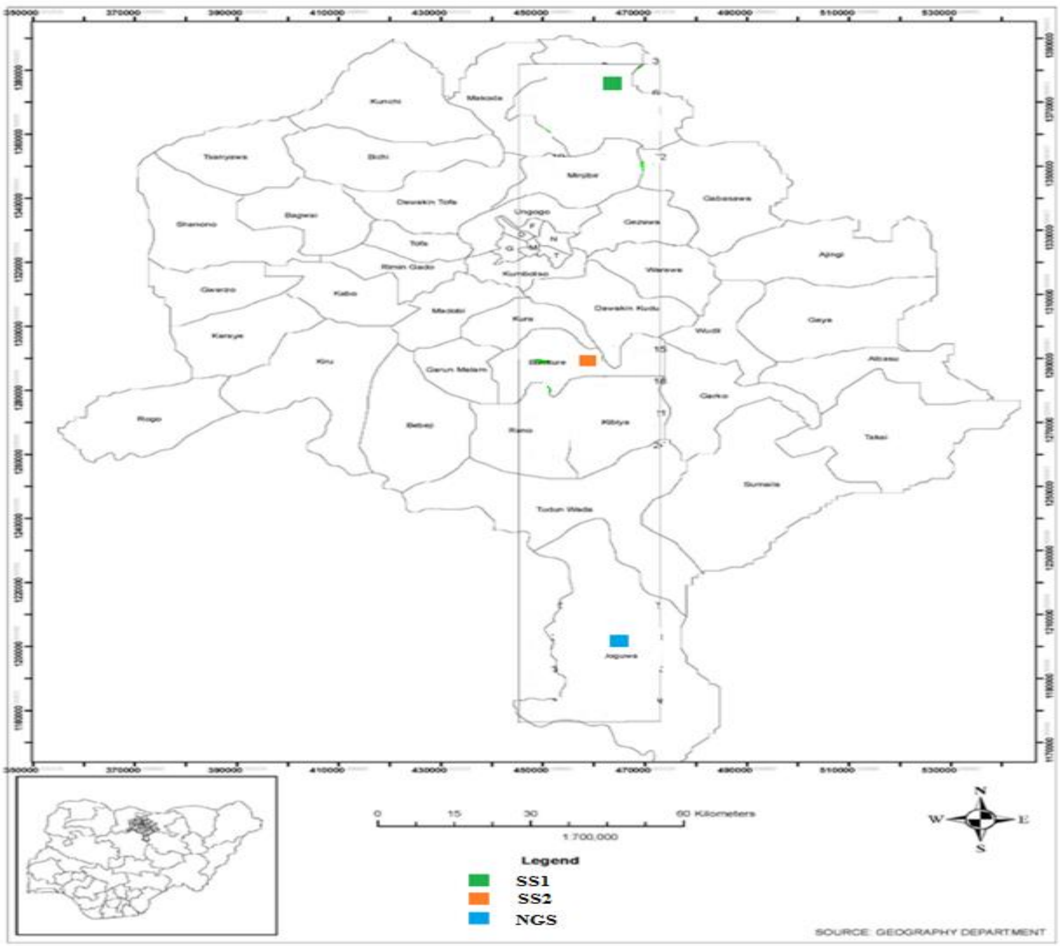

Figure 1: Map of Kano State showing the trial locations

Experimental Design and Treatments

The field experiments were conducted during 2019 growing season at Dambatta (SS1), Bunkure (SS2) and Doguwa (NGS). The trials consisted of five (5) fertilizer treatments replicated three locations and laid in a randomized complete block design. Experimental plot size wasthree meter by four meter (gross) and one and half meter by three meter (net) withfour ridges per each plot as gross and two ridges as net and the test crop was SC651, a white seeded maize hybrid cultivar which is a medium maturity variety (85-100 days maturity period) obtained from SEED-CO Company that is certified by National Agricultural Seed Council (NASC). The description of the experimental treatments is presented in (Table 1).

Table 1: Description of Experimental Treatments

Treatments	Treatment Descriptions
Treatment 1 (T1)	100kgha^{-1} of DAP 18:44:0 and 50kgha^{-1} of Urea 46:0:0 were first applied at 10-14 Days After Sowing (DAS). Secondly, 250kgha^{-}1 of Urea 46:0:0 were applied at 42-56 Days After Sowing.
Treatment 2 (T2)	250kgha^{-1} of NPK 20:10:10 were first applied when maize plant has 2-3 ears (10 – 14 Days After Sowing). Secondly, 150kgha^{-1}of Urea 46:0:0 were applied at 42-56 DAS.
Treatment 3 (T3)	283kgha^{-1} of NPK 15:15:15 were first applied on Planting Day, followed by 100kgha^{-1} of Urea 46:0:0 at 33-35 DAS and 53-55 DAS respectively.
Treatment (T4)	400kgha^{-1} of NPK 15:15:15 were first applied at 21 DAS, followed by 130kgha-1 of Urea 46:0:0 at 42-56 DAS.
Treatment Control (TC)	This one is control with no any fertilizer application. Only weeding on demand and insecticides spray.

Planting dates varies across the trial locations (agro-ecologies) as the rainfall onset period differs (Iken and Amusa, 2004). Planting were done on ridges at 25 cm by 75 cm intra plants and inter ridges respectively on the 8th and 11th of June, 2019 at Doguwa and Bunkure while on the 5th July, 2019 at Dambatta. Manual weeding with the use of hoe was carried out at all the three experimental sites when due.Also, insecticides Sharp-Shooter (Profenopos 40% + Cypermethrin 4% E.C.) 100ml and Marshal (Lambda-Cyhalothrin 2.5% EC) 250ml were sprayed to tackled Boll Worm at all the locations.

Yield Determination

At maturity, the harvest and yield determination were done in steps and scientifically as follows: firstly, at physiological maturity, all the maize stands (minus 0.5 m from each end) from the two middle rows/ridges(net) of each plot(4.5 m^2 that is one and half meter width of two ridges and three meter length) were selected and counted. Secondly, all the maize cobs from those rows were removed from the stand, dehusked, counted and put into a log bag then measured using a sensitive scale in (kg). Thirdly, the cobs were air dried, shelled, winnowed and grain weights were recorded and expressed in kilogram per hectare (kg/ha) as reportedbyAlimi and Alofe, 1993; Beah, 2019. The grain moisture content was determined using Farmex MT 16 grain moisture tester and adjusted to 12% moisture content, using the formula by Gambo, 2019; Beah, 2019.

$$Grainyield\left(\frac{kg}{ha}\right) = Totalgrainwieghtpernetplot(g) \times \left(\frac{100-mc}{100-12\%}\right) \times \frac{10000m2}{Netplotarea(m2)} - 1000 \text{ ---- (i)}$$

Where: mc = grain moisture content

Data Analysis

Grain yield data obtained from the five treatments across the three experimental sites were tabulated and subjected to both descriptive and inferential statistics.

RESULTS

Grain Maize Yield across Savanna Agro-ecologies for Various Treatments

Maize grain yields statistics for various treatments under three different Savanna ecological zones found in the study area is presented in (Table 2). The result shows that there is significant difference in mean maize yield for all the practices and across all the study locations with p-values of <0.001, 0.013, 0.001, <0.001 and 0.005 for T1, T2, T3, T4 and TC respectively.

Table 2:Maize grain yield for various fertilizers (Treatments) across the locations

Treatment	Location	Mean ± SD (t/ha)	*F* statistics (df)	*p* value*
T1	Doguwa(NGS)	4.939 ± 0.363	190.893 (2, 9)	< 0.001
	Bunkure(SS2)	4.544 ± 0.209		
	Danbatta (SS1)	1.151 ± 0.169		
T2	Doguwa(NGS)	5.028 ± 0.235	9.899 (2, 9)	0.013
	Bunkure(SS2)	4.359 ± 0.910		
	Danbatta (SS1)	2.954 ± 0.367		
T3	Doguwa(NGS)	5.283 ± 0.688	28.190 (2, 9)	0.001
	Bunkure(SS2)	4.273 ± 0.521		
	Danbatta (SS1)	2.180 ± 0.233		
T4	Doguwa(NGS)	4.093 ± 0.197	78.021 (2, 9)	< 0.001
	Bunkure(SS2)	3.872 ± 0.066		
	Danbatta (SS1)	2.272 ± 0.266		
TC	Doguwa(NGS)	2.077 ± 0.146	14.404 (2, 9)	0.005
	Bunkure(SS2)	1.886 ± 0.370		
	Danbatta (SS1)	1.077 ± 0.133		

*One Way ANOVA Significant level 0.05

For post hoc analyses of T1, there is no significant maize yield difference between NGS and SS2 with p value = 0.412 but there is significant maize yield difference between SS1,NGS and SS2with p value of <0.001 and 0.002 respectively.

For T2, no significant maize yield difference was observed between NGS and SS2 with p value of 0.608 but a significant yield difference was noticed between SS1 and NGS with p value of 0.006 while no significant yield difference with SS2 with p value of 0.218.

For T3, between NGS and SS2 no significant yield difference was observed with p value of 0.268 but between SS1: NGS and SS2 there is observed significant maize yield difference with p values of 0.022 and 0.023 respectively.

For T4, significant maize yield difference was not observed between NGS and SS2 with p value of 0.371 but there is significant maize yield difference between SS1: NGS and SS2 with p values of 0.003 and 0.014 respectively.

Lastly, for TC, there is no observed significant maize yield difference between NGS and SS2 with p value of 0.797 but there is significant yield difference between SS1 and NGS with p value of 0.002 while no significant yield difference with SS2 with p value of 0.110.

Grain Maize Yield across the Savanna Agro-ecologies Irrespective of the Treatment

Maize yield statistics across the three Savanna agro-ecological zones of the study area irrespective of the treatments is presented in (Table 3). The result show that there is significant maize yield difference across the three Savannas i.e. NGS, SS2 and SS1 with p value of <0.001.

Table 3: Mean Grain Maize yield for the three savannas irrespective of treatment

Location	Mean ± SD (t/ha)	*F* statistics (df)	*p* value*
Doguwa(NGS)	4.284 ± 1.256	20.580 (2, 45)	< 0.001
Bunkure(SS2)	3.787 ± 1.097		
Danbatta (SS1)	1.927 ± 0.770		

*One Way ANOVA Significant level 0.05

Presented in (Figure 2) is the chart displaying the mean maize yield for the three Savanna agro-ecologies. Highest grain maize yield of 4.284 t/ha was observed in the Northern Guinea Savanna agro-ecology while lowest yield of 1.927 t/ha was noticed in the SS1. Post hoc analysis revealed that there is no significant maize yield difference between Doguwa(NGS) and Bunkure (SS2) but there is significant yield difference between Dambatta (SS1) Doguwa(NGS) and Bunkure (SS2) with p value of <0.001.

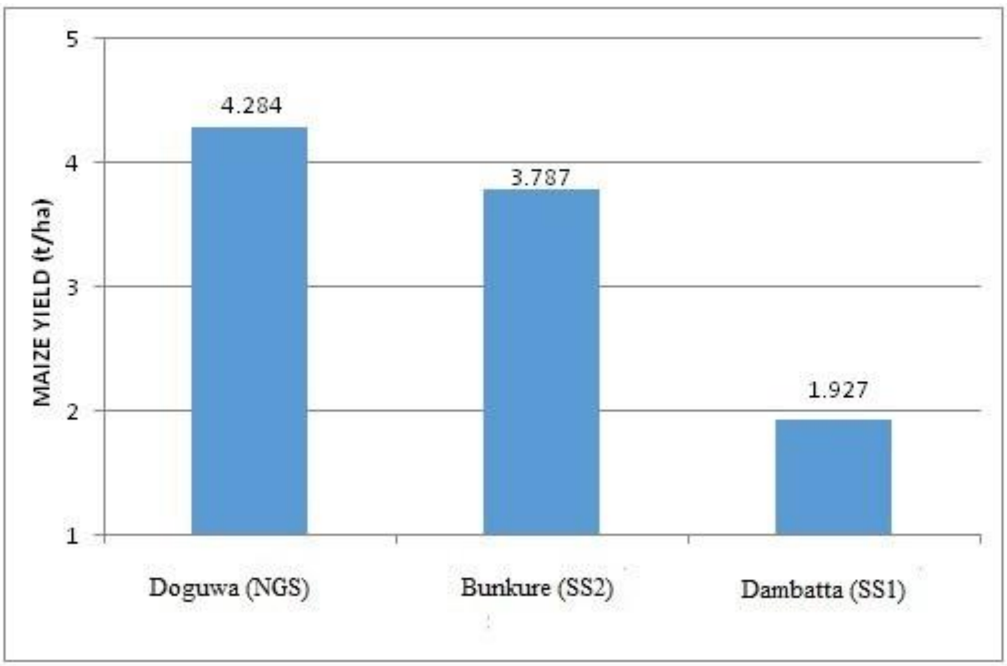

Figure 2: Maize grain yield across the three Savanna agro-ecologies

DISCUSSIONS

From the results of the analysis presented, it was observed that Doguwa (NGS) has the highest maize yield from all the treatments and irrespective of the treatments while lowest yield was observed in Dambatta (Sudan Savanna 1). The observed highest yield in Doguwa could be linked to climatic suitability of the location being in the Northern Guinea Savanna which was identified as a maize belt (TAMASA, 2016); because if its abundant solar radiation, adequate rainfall, moderate incidences of biotic stresses and natural dryness at the time of harvest (*Shehu et al., 2018*) while Dambatta lowest yield could be ascribed to less rainfall and much of its variability being in the Sahel.

The discovery of NGS having highest yield tallies with the finding of Fakorede et al., 1993 that assessed the yield potential of different agro-ecologies in Nigeria using white hybrid maize and discovered that yield increases as one moves from the forest to Savanna zones with Northern Guinea Savanna having highest yield and somewhat lower yield potential in the Southern Guinea Savanna and Sudan Savanna. They linked lower yield potential of Sudan Savanna to probably short season ecology.Also, Uniform maize trials conducted in 1967-1972 under the auspices of major cereals in Africa project of USAID-ARS in Nigeria revealed that yieldin Samaru Zaria (Lat 11° 11' N) representing northern Guinea Savanna was much higher than the yields of Ibadan (7° 22' N) representing forest and Mokwa (9° 19' N) representing Southern Guinea Savanna.

CONCLUSION

From the results obtained in this work, it could be concluded that Northern Guinea Savanna part of Kano State has the potential of producing highest maize yield relative to Sudan Savanna. It could therefore be recommended that maize cultivation should be concentrated within Northern Guinea Savanna agro-ecology for a production that would enhance food security in Nigeria. Furthermore, the use of Nutrients Expert (NE) fertilization produces high grain maize yield than Farmer Defined 1 and 2 (FD1 and 2) as well as Regional Recommendation (RR).

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