THE EFFECT OF RAINFALL AND TEMPERATURE ON MAIZE YIELD IN KOGI STATE, NIGERIA

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ABSTRACT

The study analyzed the effect of rainfall and temperature on maize yield in Kogi state, Nigeria. The study depends on secondary data for a period of 10 years up to 2010. Data collected included: monthly rainfall, monthly temperature, output of maize and yield of maize. Descriptive statistics and multiple regression analysis were used to analyze the findings. The study showed that the rainfall range for the ten years period was 62cm, while the temperature range was 30^0C. Variations in both rainfall and temperature were found not to directly relate to the variations noticed in the output and yield of maize during the ten year period. It was then recommended among other things that the Extension agents should liaise with the Nigeria Meteorological Agency to advise farmers in the state to stabilize their maize cropping calendar in accordance with the weather forecast since both temperature and rainfall had no effect on maize output.

K**eywords:** Climate, Rainfall, Temperature, Output, Yield.

INTRODUCTION

Maize or Corn (*Zea mays*) is a member of the grass family (gramineace). It is a cereal crop that is grown all over the world in a range of agro-ecological environments. Over 50 species of maize exist and consist of different colors, textures, grains, shapes and sizes. Yellow, white and red species are the most common types but most people prefer the yellow and white species (Ojo, 2000). Maize was introduced into Africa in more than 150 decades ago and has since become one of the dominant food crops in Africa. It originated from South and Central America and was introduced to West Africa by the Portuguese in the 10^{th} century (FAO, 2013).

Maize is one of the major staple crops, especially in developing countries of the world. In some places, it accounts for up to 80-90 percent total calorie intake of the rural population (Ayoola, 2001). Every part of the Maize plant has economic value. The grain, leaves, stalk, tassel and cob all can be used to produce a large variety of food and non-food products (IITA, 2009). Maize is prepared and consumed in a multitude of ways which vary from region to region and from one ethnic group to the other. Maize can be boiled or roasted on the cob. The grain can also be grounded into maize flour and can also be made into Popcorn. Industrial utilization of maize include: production of flour, starch, alcohol, spirit and other value added resulting from milling of corn. Maize is a major raw material for livestock feeds. According to Ayoola (2001) maize can be hydrolyzed and enzymatically treated to produce syrups, sweetener and in some cases fermented and distilled to produce grain alcohol. Sweet corn is a generic variation that can be served as vegetable because it is high in sugars and low in starch content. Another common food made from maize is cornflakes. Maize is used as meal pap in Africa. Corn bread is also made from maize.

Nigeria is the 10th largest producer of maize in the world and the largest producer in Africa (FAO, 2013). The North central region in which Kogi State is situated is the main producing area in Nigeria. The region accounted for about 31% of the total national production in the years 2006 and 2007, 58% in 2008 and 44% in 2009 (Cadoni & Angeluci, 2013). In Nigeria, the estimated corn production in 2010 was put at about 8,800 metric tons with growth rate of 1.68%, in 2012, it rose to about 9,410 metric tons for which the growth rate was put at 1.73% (USDA,2012).

Despite the economic importance of maize, many factors were identified to affect its production in Nigeria. Ojo (2000) opined that capitalization, price fluctuation, pests and diseases, poor storage facilities and inefficiency of resources utilization are some of the problems affecting maize production in Nigeria. One other major factor is climate especially rainfall. Climate limits the production area of maize and lack of rainfall (drought) or too much of it (flood) can result in 100% loss of maize output (Chi-chung and Mccarl, 2004). Similarly, it is projected that crop yield in Africa for many other crops may fall by 10-20% by 2020 due to climate change (Ajetumobi and Abiodun 2010; Ajetumobi, Abiodun and Hassan, 2010 and BNRCC, 2008). This is because African agriculture is predominantly rain-fed and therefore dependent on the vagaries of weather.

Climate is perhaps the most serious environmental threat to the fight against hunger, malnutrition, diseases and poverty in Africa. The effect is manifested mainly through serious reduction in agricultural productivity. Climate change which is attributable to the natural climate cycle and human activities, has adversely affected agricultural productivity in Africa. Available evidence shows that climate change is global, likewise its impacts but the most adverse effects will be felt more by developing countries especially those in Africa due to their low level of coping capabilities (Ohajianya and Osuji, 2012 and Ellen and Barry, 2005). As the people of Nigeria strive to overcome poverty and advance economic growth, there is the need to study the effect of weather variability on agriculture in the country so that concerted effort will be made towards combating the menace. This forms the basis of this study as it aims to quantify the effects of weather variability (particularly rainfall and temperature) on maize production and productivity, in the context of Kogi state.

THE STUDY AREA

The study area is Kogi State of Nigeria. Kogi State was created out of Kwara and Benue States on the 27th August, 1991. The State currently has 21 Local Government Areas (LGAs) with Lokoja town as the headquarter. Kogi State is located in the middle-belt of Nigeria. It extends from latitude $6^{'}33^{°}$ N to $8^{'}44^{°}$ N and longitude $5^{'}40^{°}$ E to $7^{'}49^{°}$ E. The state has a current population of about 3,278,487 people with an average of 172,000 farming families (FGN, 2006). Kogi State is made up of various ethnic groups, the major ones are; Igala, Ebira, Yoruba and Nupe.

Kogi State has a tropical climate and one of the largest producers of maize in Nigeria (KADP, 2011). The climate is divisible into two major seasons-dry and wet seasons. The wet season begins towards the end of March and ends towards the end of October. In very dry year, rainfall may not start until the month of April. Dry season begins in the month of November and lasts until late February. The harmattan wind is experienced during the dry season for about two months (December and January). The average annual rainfall ranges from 850mm to 2000mm. During the rainy season the daily mean temperature is about 28^{0}C

while in the hot season, the average temperature is about 35^0C. High humidity is also common (KADP, 2011).

The vegetation consists of rainforest in the southern part of the state and the woody derived savannah and Guinea savannah in the northern extreme. Generally the land mass is flat or gently undulating and lies at 50m to 700m above sea level. The two largest rivers in Nigeria (Rivers Niger and Benue) flow through the state. River Niger forms a confluence with the Benue at Lokoja the state Headquarter.

DATA COLLECTION AND ANALYSIS

This study depended mainly on secondary data. The data used for the study were collected from the Nigeria meteorological data station in Lokoja and Kogi State Agricultural Development Project headquarter also in Lokoja. The meteorological time series data collected include; the average monthly rainfall and temperature between the year 2001 and 2010. The mean from three metrological stations were used for the study. The metrological centre in Lokoja captured the weather condition of Kogi central and is under the management of Nigerian Meteorological Agency. The meteorological station in Aiyetoro-gbede captured the weather condition in Kogi West and is under the control of Kogi State Agricultural Development Project. The third weather station which is situated at Anyigba captured the weather condition of Kogi east and is also under the control of Kogi State Agricultural Development Project. Similarly, the time series agronomic data collected from Kogi State Agricultural Development Project included; the output of maize from 2001 to 2010. Descriptive statistics and multiple regression analysis were used to analyze the findings. The multiple regression analysis is specified thus:

$Y = f(X_1, X_2)$

$Y_t = \beta + \beta_1 X_{1t} + \beta_2 X_{2t} + e_{it}$

Where: Y = Maize output (mt);

β_1 and β_2 = Coefficient of variables X_1 and X_2 respectively

X_1 = Annual mean rainfall

X_2 = Mean temperature

e = unexplained variables

RESULTS AND DISCUSSION

The monthly rainfall distribution in Kogi State between the years 2001 and 2010 is presented in Table 1. Results showed that the rainy season starts from the month of April and ends in October. Two years (2006 and 2009) recorded rainfall in January. The years 2003, 2005 and 2006 had rainfall in February. There was no rain throughout the ten years period in the month of December. The year 2006 recorded the heaviest rainfall during the period with an average of 140.30cm while the least rainfall was recorded in the year 2005 with an average rainfall of 78.30cm. The rainfall range during the ten years period was 62.0cm.

TABLE I: MONTHLY RAINFALL (mm) PATTERN IN KOGI STATE NIGERIA [2001-2010]

MONTHS	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
JAN	0.0	0.0	0.0	0.0	0.0	12.4	0.0	0.0	35.1	0.0
FEB	0.0	0.0	15.3	0.0	32.7	19.3	0.0	0.0	0.0	0.0
MAR	4.0	2.9	9.4	3.4	0.0	40.9	11.6	21.8	5.0	0.0
APR	112.0	162.2	38.5	157.5	93.4	61.8	82.3	163.6	243.6	132.8
MAY	77.3	79.6	92.7	246.0	134.3	370.0	277.3	161.6	108.4	125.0
JUN	125.1	93.2	180.9	168.4	170.8	62.1	184.5	166.3	220.1	104.4
JUL	198.3	325.9	271.4	225.5	60.9	303.9	231.8	213.8	212.8	255.6
AUG	157.9	278.0	53.1	78.6	132.9	352.8	225.0	274.7.	369.8	133.2
SEP	282.1	193.4	163.1	252.1	143.5	290.6	246.0	170.2	255.8	148.2
OCT	46.2	139.0	147.1	203.1	167.5	169.3	240.7	87.8	206.4	167.4
NOV	0.0	1.8	14.7	0.0	3.4	0.0	2.2	0.0	0.0	7.4
DEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	1002.9	1276	986.2	1334.6	934.4	1683.1	1501.4	1259.8	1627	1074
AVERAGE	83.58	106.33	82.18	111.22	78.28	140.26	125.12	104.98	135.58	89.5

Source: Nigeria Meteorological Agency, Lokoja

Table II showed the average monthly temperature in Kogi State between the years 2001 and 2010. The temperature records were not available for five years (2003-2007). The minimum average temperature of 31^0C was recorded in 2010 while the maximum average temperature was 34^0C. The temperature range of 3^0C showed that there were very little fluctuations in temperature for the years under consideration. Any variation in the output and yield of maize may not be the result of variation in temperature.

TABLE II SHOWING THE AVERAGE MONTHLY TEMPERATION (^{0}C) PATTERN IN KOGI STATE NIGERIA [2001-2010]

MONTHS	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
JAN	35.3	34.2	**	**	**	**	**	**	35.1	36.2
FEB	37.1	37.2	**	**	**	**	**	**	37.3	37.9
MAR	38.4	37.8	**	**	**	**	**	**	38.6	38.4
APR	36.2	34.9	**	**	**	**	**	35.9	34.8	37.2
MAY	34.4	33.4	**	**	**	**	**	36.0	33.2	33.9
JUN	31.8	32.2	**	**	**	**	**	32.0	31.7	32.8
JUL	30.7	30.9	**	**	**	**	**	30.6	31.1	30.8
AUG	29.9	23.5	**	**	**	**	**	30.6	30.7	30.7
SEPT	30.3	**	**	**	**	**	**	31.1	31.3	31.2
OCT	32.7	**	**	**	**	**	**	32.9	31.4	32.0
NOV	35.3	**	**	**	**	**	**	35.6	33.5	34.0
DEC	35.5	**	**	**	**	**	**	34.7	35.4	34.9
TOTAL	407.6	264.1	NA	NA	NA	NA	NA	294.4		
AVERAGE	34.0	33.01	NA	NA	NA	NA	NA	33.3	34.0	31.0

Source: Nigeria Meteorological Agency, Lokoja

The annual mean rainfall, mean temperature, maize output and maize yield between the period of 2001 and 2010 were presented in Table III. The temperature is fairly stable throughout the five years that temperature measurements were conducted. Therefore, any variation in maize output and yield may not directly be the result of temperature variation. Table III showed that variations in the annual mean rainfall have no serious relation with variations in the output and yield of maize in the State for the period under review. For

instance, while the mean annual rainfall decreased from 106.30cm in 2002 to 82.18cm in 2003, both maize output and yield increased from 241.0 metric tons and 1.85 m/ha in 2003 to 250.0 metric tons and 1.94 mt/ha in 2003 respectively. Similar discrepancies were recorded between the annual mean rainfall and output yield of maize in 2007, 2008 and 2009.

TABLE III SHOWING THE MEAN MONTHLY RAINFALL, MEAN MONTHLY TEMPERATURE, MAIZE OUTPUT AND MAIZE YIELD IN KOGI STATE NIGERIA [2001-2010]

YEAR	MEAN MONTHLY RAINFALL (cm)	MEAN MONTHLY TEMPERATURE (^{0}C)	MAIZE OUTPUT (mt)	MAIZE YEILD (mt/ha)
2001	83.58	34.0	234.0	1.71
2002	106.3	33.0	241.0	1.85
2003	82.18	NA	250.0	1.94
2004	111.2	NA	255.0	1.93
2005	78.28	NA	214.0	1.65
2006	140.3	NA	262.0	1.76
2007	125.1	NA	289.3	1.60
2008	105.0	33.3	310.0	1.64
2009	138.1	34.0	333.2	1.61
2010	89.50	31.0	371.3	1.34

Source: 1. Kogi State Agricultural Development Project, Lokoja
2. Nigeria Meteorological Agency, Lokoja. 2013

Table IV: Regression result on the effect of rainfall and temperature on maize yield

Variables	Linear	Semi-log	Double-log
Constant	2.355(177.269)	**20.191(2.269)	2.133(7.630)
Mean rainfall	1.076(0.338)	1.251(0.386)	1.272(0.603)
Mean temperature	1.482 (0.465)	1.465(0.452)	-1.672(-0.792)
R^2	0.31	0.36	0.62
Adjusted R^2	0.12	0.15	0.24
F-value	1.594	1.760	1.626

Source: Computed from secondary data, 2014
Figures in parenthesis represent t-values

Table IV shows the regression results for the effect of annual mean rainfall and mean temperature on maize yield in the study area. After some econometric considerations, the result from the semi-log functional form was chosen as the lead equation. The result of the regression analysis showed that the regression coefficient of determination (R^2) was 0.36, it connotes that about 36% of variation in maize yield could be explained by mean rainfall and mean temperature. The remaining 64% were largely due to other variables outside the regression model that also affects maize yield. The regression result also reveals low R-values which indicated that there is no casual relationship between the variables. Both the mean monthly rainfall and mean temperature had a positive but not significant relationship with maize output. The implication of this finding is that the volume of rainfall and the mean temperature may not necessarily determine the output of maize in the area of study. The important determinant is the spread of the rainfall within the year. According to Ojo (2000) and IITA (2009), one month drought when maize is tasseling can result into serious reduction in the output of maize.

CONCLUSION

The study showed that, there were variations in the amount of rainfall over the ten years period (2001-2010). There were also variations in the output and yield of maize during the same period. However, temperature remains fairly steady during the period. The type of variations recorded in the annual mean rainfall for the ten years period were not related to the variation noticed in the output and yield of maize for the same period. Weather variations between 2001 and 2010 in Kogi State does not influence maize output and yield.

RECOMMENDATIONS

In order to maintain this minimum changes in the rainfall and temperature of the area, the following recommendations were made:

(i) The extension agents should advice the farmers in the area to adjust maize cropping calendar to synchronize planting and growing period with soil moisture availability based on rainfall forecast.
(ii) The cereal Research institute should develop drought resistant variety, early maturing variety and the use of genetically modified maize where acceptable.
(iii) The River Basin Development Authority should improve irrigation facilities; increase the agricultural land under irrigation and introducing water saving techniques for maize production.
(iv) Government should also allocate more funds to the National Meteorological centre to procure latest equipment for weather forecasting.

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