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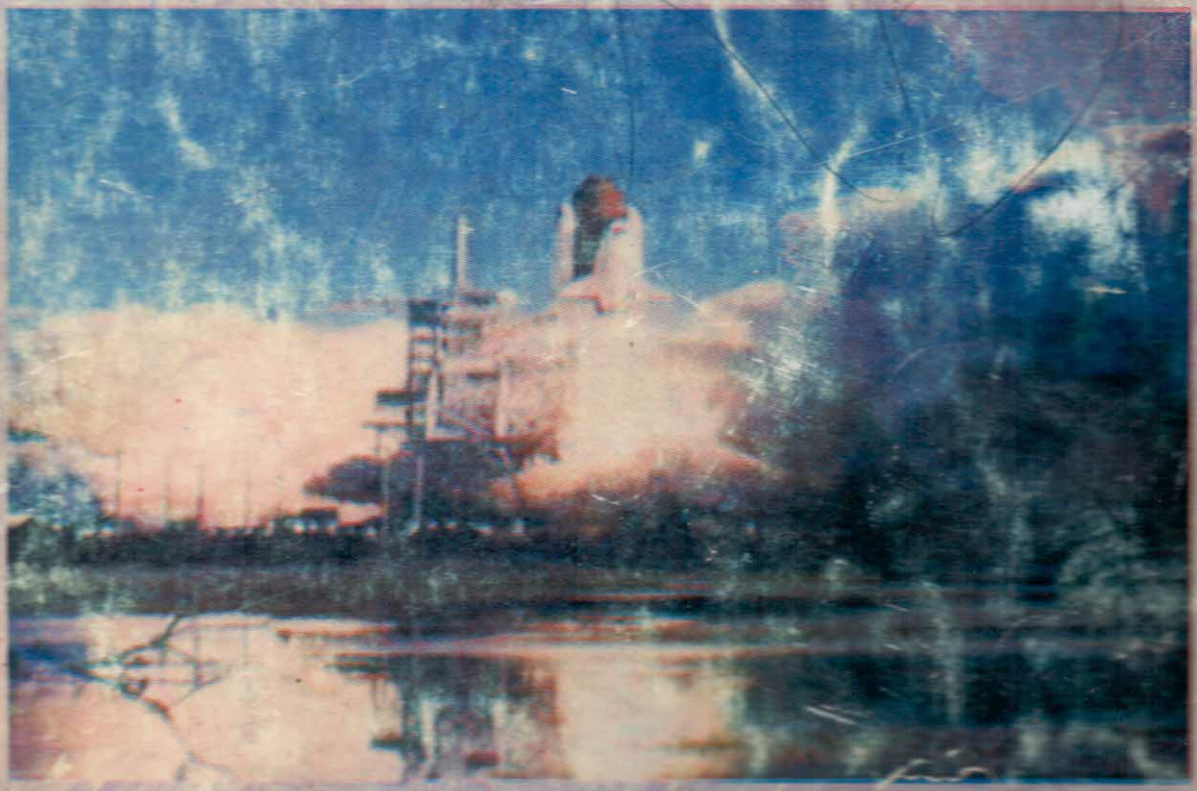

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Rainfall Variability and Its Effects on Maize Production in Northern Nigeria.

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Abstract.
Rainfall pattern has always been one of the major responsible factors for the performance of crops within the tropics and the failures of some major agricultural development schemes points to the urgent need for studying the variability of precipitation effectiveness as it affects agricultural production. Daily rainfall data and other rainfall related parameters and maize yield for ten (10) years were used for this study. These data covers twelve (12) stations in the northern part of Nigeria. These data were subjected to agro meteorological and statistical analysis. Correlation analysis reveals that out of eight observed and derived parameters, onset dates of rain (0.62), cessation dates (0.61), length of rainy season (0.85) and rainfall amount during the growing season (0.62) have significant relationship with maize yield. Simple regression analysis reveals that precipitation effectiveness accounted for 65.8% of the variation in the yield of maize in the region. The implications of these statistical findings was that the spread of the rainy season is one of the most contributing factors to high yield of maize in the region under consideration, also the time the rain starts(onset) and stops(cessation) also play a significant role in what the yield will look like in any maize farm.

Introduction.

Developing countries within the tropics have been misled by the amount of annual rainfall experienced, especially for the fact that the precipitation has not been accorded the deserved priority in Agricultural planning. Until the 1969-1973, drought in the sub-Saharan belt of west

Africa, serious thought were not given to the characteristics and distribution patterns of rainfall even though drought were observed to have occurred.

The dwindling returns from the Agricultural sector within the last 20years have shown that even when the actual record of rainfall of a particular location may show no anomalies, drought conditions can still affect agricultural operations in certain areas. Thus, the deficit in annual rainfall may be accompanied by a corresponding poor crop performance especially in the Northern part of the country.

In Nigeria, the two distinct seasons(dry and wet) usually play a predominant role in determining the nature of vegetation zones, type of crop to cultivate, the method to employ and the periods of growing and harvesting of such crops.

Several factors tend to affect agricultural production in an area; such factors include the influence of topography, soil fertility, management practices and weather among others. Special attention has to be given to the characteristics of crop species and varieties such as their water requirement in order to exploit rationally all favorable climatic resources. Maize is one of the world's three most important cereal crops (others are rice and wheat) and it has the widest distribution. The crop is primarily grown from its grain, which is consumed as

human food. In some developed countries maize is also grown for animal feed and a base for industrial products such as oils, syrup and starch. It has a wide adaptation to latitude 500N to 400S and altitude of about 2200m-3000m above sea level. Maize is strong, annual grass, usually producing one stem and growing to 1.5-3m in height (Duvick, 1997).Older variety of the crops mature after 100-120 days; but more early maturing varieties are now available. The male inflorescence, called a tassel, is produced after 50-60 days as a continuation of the main stem. Maize is highly sensitive to environmental stress, competition, nutrition and moisture conditions; as a result, large variation in yields occurs, both within and between areas of production.

Yields of up to 8000kg/ha have been achieved in many areas under optimal conditions. Maize is generally in rotation with other crops or intercropped with a legume. Maize requires an average temperature of 14-30^{0}C, it does well at high temperatures and cannot withstand frost. Maize therefore grows well at high altitudes up to 2200m or 3000m (Dunchon, 1986).A rainfall of 600-1200mm per year is needed and this should be well distributed throughout the growing season.Moisture is practically important when the seed is settling and a dry period at this time will reduce the yield. Very humid conditions are not suitable for maize and tend to encourage diseases. In very humid areas, planting should be timed so that cobs will be ripening at the beginning of the dry season.

Adefolalu,(1987), in his contribution explained that during the wet season everywhere gets wet, rivers and streams filled up to their pauses and in some cases over flowing their banks. This implies that it is not the amount of rains that falls that count, but how effective is the distribution and how much the moisture is retained for plants to use for maximum growth and maturity. Thus, the effects of precipitation effectiveness cannot be taken for granted in order to achieve high yields of any crop. Apart from precipitation effectiveness, other Agro-climatic parameters such as effective temperature, sun- heat, wind, chill factor, soil moisture, evaporation, relative humidity etc, all have both direct and indirect effects on crop performance and should not be neglected in any agricultural operation. Duchon (1986) attempted to predict the yield of maize using climatological data. He developed a method to predict maize yield during the growing season using a plant process model, current weather data and climatological data. The procedure is to place the current year daily weather(Temperature and Precipitation) into the model up to the time yield prediction is to be made and sequence to historical data(one sequence per year) after time until the end of the growing season. to produce yield estimates.

In India, Gangopadhgeya et al (1965) employed the fisher technique to investigate the influence of rainfall distribution on the yield of maize crop at different crop-weather observatory. Their study clearly established the influence of rainfall distribution on yield. It was found that about 75% of the total variation in yield was accounted for by the rainfall distributions. One would not have expected a contrary result. This sequel to the fact that it has been established by some authors such as Olaniran et al, (1987) Pitter (1977) that it is not the total rainfall that matters but their distribution during the growing season.
Onset and cessation dates and length of the rainy season or the hydrological growing season) are important pieces of information for planning the cropping calendar each year.

Statement of Problem.

Over the years, the production of Maize in Northern part of Nigeria has benefited from the advances in Agricultural Technology such as the introduction of high yield

varieties, the application of fertilizers and extension services. It was gathered from the various Agricultural Development projects offices from the region under consideration that the annual production of Maize on the average is going to about 300 thousand Tons per annum.

There are several variations in the annual, monthly, and daily rainfall. These variations result in departure from the normal and consequently have direct adverse effect on crop performance. Hence precipitation has not been accorded the deserved priority in agricultural planning in Nigeria most especially in the production of maize

Apart from the socio- economic problems facing rural farmers, climatic factors like temperature, pressure, relative humidity, wind, evaporation constitutes major limiting factors in the production of maize.

Maize production therefore, is determined by the interaction of several factors: climate, drought, flood, and soil condition, management practices of the farmer, pets and diseases.

However, this study attempts to examine the effects of rainfall on the production of maize in the region under study. Hence the focus is to seek an understanding of the inter-relationships between rainfall and maize production subject to the constraints imposed by the quality and quantity of relevant data available.

Aims and Objectives of the Study.

i. To assess the significant relationships between amount of rainfall and maize Production
ii. To determine the correlation between some agro- climatic variables such as, onset date, cessation date, length of rainy season (LRS) and maize production.

Area of Study.

The study covers 12 Nigerian stations (Bauchi, Gusau, Kano, Katsina, Kaduna, Yola, Maiduguri, Nguru, Sokoto, Jos, Minna and Yelwa) north of latitude 10^0. All the twelve stations have two distinct dry and wet seasons. The dry season covers a period of about seven(7) to eight(8) months from October to April/May, while the wet season is between four(4) and Five(5) months from May to September. It can also be seen that rainfall has been erratic over the area and this has serious implications on water resources management. The annual rainfall varied from 269.5mm to 1869.3mm.Bauchi had a lowest rainfall of 796.5mm and recorded the highest value of 1230.4mm.Gusau reported the least rainfall value of 446mm and the maximum value of 1020mm.Kano had low rainfall of 559.6mm and high value of 1869mm.Over katsina the lowest rainfall recorded was 851mm and the highest value was 1190.7mm.Yola reported the lowest rainfall amount of 559.6mm and the highest value of 1869.3mm.Maiduguri had a low value of 446.2mm and a high value of 1344.2mm.The minimum rainfall recorded over Nguru was 507.1mm while the maximum value was 1344.2 mm.For Sokoto the low and high values are 336.8mm and 857.63mm respectively.Yelwa reported the lowest rainfall of 885.1mm and a maximum value of 1235.68mm.Kaduna recorded a minimum of 269.5mm and a maximum of 461mm.The unimodal rainfall pattern is exhibited but there were years when we have marked bimodal.

Classification of Rainfall Regime.

The regime of rainfall is the way in which the rainfall is arranged throughout the year. We find this by examining the frequency of the rainfall, the rise and fall in its monthly distribution. When the rainfall rises and falls once in the year, we say we have a single peak or single maximum rainfall regime, but when it rises and falls twice we say we have a double peak or double maximum regime. In Nigeria there is a single peak regime in the North and double peak regime in the south.

Rainfall patterns in Nigeria is generally governed by the movement of the inter-tropical convergence zone (ITCZ) which shows a steady decrease from south to the North, (Walter, 1967).

Rainfall in West Africa varies with latitude and to a very great extent determines the nature of the vegetation zones, which consequently affect the length of dry and wet seasons. The seasonal distribution of rainfall is determined by the movement of two air masses (Tropical maritime air mass and Tropical continental air mass.

When the two air masses meet, a region of climatic instability results. As the inter-tropical front moves Northwards over a particular place, the humidity of that place increases and rain begins to fall. In Nigeria, over 2500mm of rainfall may be recorded annually in Niger Delta, But further North, the record of rainfall annually may be less than 250mm.In effect, moisture decreases progressively as one goes from South to Northern part of Nigeria as classified by Walsh and Lawler(1981).Kowal and Kassam (1973) investigated maize yield in samaru, Nigeria by considering the radiant energy and moisture balances for some period of time.Kowal et al (1973) used the water balance and the radiation income to study the yield of maize. In the study, the magnitude of water surplus (WS) and water deficit (WD) during the growing season in tendency period (decade) was calculated as the difference between the measured evapo-transpiration (ET) and precipitation (P).Their results showed that, rainfall during the pre-sowing moist period in May was sufficient to allow easy cultivation of the soil. About 100mm of the water in excess of the evaporative demand was available to recharge the soil profile down to a depth of 760m. They observed that, the high evaporative demand of the atmosphere at Samaru is capable of reducing growth if there is a dry period of more than five days.

Research Methodology and Data Analysis.

Data collection

In this research work the following data were collected from each of the station Nimet, Agricultural Development Project headquarters (ADP) and National cereals Research institute (NCRI).

The data are Rainfall on daily basis, the maize production data were obtained from the Agricultural development Agency that falls in each of the station. The areas under cultivation from each of the station were also taken into consideration. Other areas where important information was collected for this research were Federal University of Technology (FUT) Minna, where journals Textbooks, past works were used from the Library department. All these data covers from 1990- 1999 making it ten years in all.

Methods of data analysis.

In order to achieve the objective set above, the mean, standard deviation, coefficient of variation and percentage deviation from the mean all for rainfall values were employed.

Maps were used to illustrate some basic geographical locations and phenomena, for example, map of Nigeria showing all the stations used. Tables and graphs were also used to relate rainfall data on maize production in the study area. The graphs of rainfall variability for each of the stations under consideration were also presented.

The daily rainfall is used in calculating the mean monthly and annual rainfall for the study area. From the records of rainfall the following derived precipitation effectiveness indices were computed.

Onset, cessation and length of rainy season: The onset date of rainfall was regarded as the day when we have at least 20mm of rainfall and it is not followed by a dry spell of up to 20 days. Usually a ten years (Decades) are used to compute running sum for the year. Length of rainy season is from seed growing to plant maturity. It can also be defined as the months during which 50mm and more rainfall is received or the number of rainy days based on rainfall amount of 2.5mm in a day.

The length of rainy season (LRS) is given by:

$LRS = (\epsilon - \Phi)$

Where: ϵ = Cessation date of the rainy season

Φ = Onset date of the steady rain

(a) Mean and Mean Deviation.

The mean is a measure of average; it was computed by summing up all values in the data set and divide by the total number of observations. It is expressed mathematically as

$$X = \frac{\sum X}{N}$$

Where

X = Annual rainfall for a given period

N = Total number of years under consideration

$\sum$ = Sum of all the values of variable X.

Mean Deviation: This is another statistical method used and it can be expressed as

$$M.D = \frac{X - X}{N}$$

Where

(X-X) = difference between each values of X and the mean(X)

N = the number of values in the data set.

(c) Standard Deviation and Climatic Index (C.I).

Standard deviation is a measure of dispersion which can be expressed as:

$$C.I = \frac{X-X}{\partial}$$

Where

X = rainfall for a particular period

∂ = Standard deviation

The extent of variation of a parameter from an established normal is represented by the climatic index.

Climatic Indices.

Climatic Index	Degree of drought
0- 0.5	Mild drought
0.6-1.0	Severe drought
1.0	Extreme wetness
Climatic Index	Degree of wetness
0-0.5	Mild wetness
0.6-1.0	Severe Wetness
1 & above	Extreme wetness

Coefficient of correlation

Correlation coefficient is a statistical method used in this work.

This can be expressed as:

$$R = \frac{n\sum XY - (\sum X \sum Y}{\sqrt{n\sum x2-(\sum) 2]\ [n\sum y2-(\sum y) 2}}$$

Where

N = Number of years under consideration

X = Dependent variable (Yield)

Y = Independent variable.

Discussion of result.

Table 1.0: Average Onset, Cessation and Length of Rainy season (LRS) for the region.

Stations	Onset			Cessation			LRS		
	Early	normal	Delayed	Early	Normal	Delayed	Shortest	Normal	Longest
Bauchi	Apr 12	Apr20	Apr 25	Sept 10	Oct 20	Oct 25	115	175	185
Gausau	Apr 13	Apr 25	May 31	Sept 18	Oct 12	Oct 25	160	200	207
Jos	Mar 10	Mar 25	Apr5	Sept 15	Oct 10	Oct 30	180	230	250
Kano	Apr 10	Apr 25	May 31	Sept 18	Oct 15	Oct 24	160	205	215
Kaduna	Apr 12	Apr 25	May 30	Sept 20	Oct 15	Oct 30	120	185	200
Katsina	Apr 15	Apr 25	May31	Sept 18	Oct 10	Oct 25	145	175	190
Minna	Apr 15	Apr 25	May 31	Sept 15	Oct 10	Oct 25	160	200	210
Maiduguri	Apr 18	Apr 25	May 30	Sep 15	Oct 10	Oct 28	80	100	180
Nguru	Apr 20	Apr 30	May 30	Sept10	Oct 15	Oct 20	120	185	200
Sokoto	May 5	May10	May18	Oct 10	Oct 20	Oct 25	71	96	107
Yelwa	Apr 18	Apr 20	May 20	Sept 10	Oct 20	Oct 30	85	100	125
Yola	Apr 28	May 5	May 30	Sept 15	Oct 15	Oct 30	70	95	100

Table 1.0.indicated the onset, cessation and the length of the raining season. It shows that for most of the station the onset of rain normally occurs around early April with an exception of Jos station with an earlier onset in March and Sokoto with a late onset in May. Also the early cessation for all the stations is September and if delayed occurred in late October. The shortest length of raining season was found in sokoto state with 71 days and the longest length of raining season of 250 days was found in Jos.

The onset, cessation and length of the raining season show simple variation from one station to another.

Weather-Maize yield Relationship

Relationships between maize yield and weather elements vary according to Geographical location.Kowal et al (1973) have confirmed that relationship with

precipitation-related parameters is the most crucial in the tropical areas. The result of simple correlation between agro meteorological elements and maize yield at these stations is presented in Table 2.0.

S/NO	Variables	Correlation Coefficient
1.	Onset dates of rain	0.62
2.	Cessation dates of rain	0.61
3.	Length of rainy season	0.85
4.	Dry spell	-0.65
5.	Rainfall in May	0.45
6.	Rainfall in growing period	0.62
7.	Relative humidity	0.32
8.	Air temperature	0.47

Table 2.0 shows that maize yield is significantly correlated with five out of the eight observed parameters.

The length of the rainy season (LRS) has the highest positive correlation with maize yield($r = 0.85$). This is expected because maize does very well when there is enough moisture in the soil and also indicates that with a shorter length of rainy season the yield could be reduced.

The onset and cessation has a considerable correlation with the yield of maize at the selected stations (0.62 and 0.61 respectively).This is an indication that maize does very well if there is enough moisture at the planting period and considerable moisture to nurture the growing young maize.

Dry spell has a negative correlation with the yield of maize (-0.65).This indicated that if there is a longer period of dryness there will be a reduction in maize production because there will be little or no moisture available for the plant. This is not surprising because maize does very well when there is no moisture stress.

Rainfall amount during the growing period has a significant role to play in the yield of maize with a value of 0.62.This is an indication that rainfall amount is an important tool that aid yield of maize as it help a lot during germination.

The other two agro meteorological variable such as Relative humidity and air temperature show a non-significant correlation with yield of maize during the study period.

To find out the meteorological variables that contributed mostly to the yield of maize at the selected stations, simple multiple linear regression was then carried out on those values that gave significant correlation. The result shows that the precipitation effectiveness (onset dates of rain, cessation date of rain, and length of the growing period) together accounted for 65.8% of the variations of the yield of maize in some selected stations in the sudano-sahelian region of Nigerian.

Table 3.0 Total and mean annual rainfall for the region.

YEARS	Total (mm)	Mean(mm)
1990	9971.094	830.9245
1991	12489.18	1040.765
1992	12003.18	1000.265
1993	9757.764	813.147
1994	9655.97	804.6642
1995	10040.25	836.6872
1996	10301.36	858.447
1997	11086.09	923.8412
1998	12484.83	1040.403
1999	11057.05	921.4207

Table 3.0 shows the Total and the annual rainfall for the region under consideration, it shows that the region experience a very high rainfall in years 1997, 1998 and 1999, with the highest value of 1040.403mm in the year 1998.

Table 4.0 Total Annual And Mean Annual Production Of Maize

YEARS	TLC(Ha)	TP(Kg)	MLC(Ha)	MP(Kg)	Yield(Kg/Ha)
1990	478	278140000	39.83	23178333	581882.85
1991	420	265950000	35.00	22162500	633214.29
1992	348	224800000	29.00	18733333	645977.01
1993	276	7820000	23.00	651666.7	28333.33
1994	312	8510000	26.00	709166.7	27275.64
1995	315	183500000	26.25	15291667	582539.68
1996	129	81530000	10.75	6794167	632015.50
1997	356	291850000	29.67	24320833	819803.37
1998	455	351290000	37.92	29274167	772065.93
1999	488	244610000	40.67	20384167	501250.00

MLC= Mean land cultivated, MP= Mean Production.

The table above shows the areas of land cultivated during the study and the quantity of maize (kg) realized from the farm.

The table reveals that the region experience the highest yield in the year 1997 with an average yield of 819,803.37Kg/ha while the least yield value of 27,275.64Kg/ha was recorded in the year 1994

Conclusion

Agro meteorological conditions of maize production in some selected part of the sudano-sahelian region of Nigeria. The study aims at quantifying and analyzing the agro meteorological parameters in some selected part of the country and relates same to maize production. Two sets of data (meteorological and agricultural data) were collected from twelve stations in the sudano-sahelian region of Nigeria. These data were subjected to both agro- meteorological and statistical analysis.

Agro meteorological analysis.

Monthly rainfall amounts in the selected regions have spatial and temporal variations. The trend of precipitation indicates that the mean onset dates of the rain in the selected stations vary on average from 10th April to 25th April. Normal cessation dates range from 10th October to 20th October. The mean length of rainy season ranges from 70 to 250 days as shown in table 1.

Correlation analysis reveals that out of eight observed and derived parameters, onset dates of rains(0.62),cessation dates(0.61), Length of the growing period(0.85),rainfall in May(0.45), and rainfall during the growing period(0.62) have significant relationship with yield. Simple linear regression shows that out of all the parameters observed, Precipitation indices is the most significant parameter to the yield of Maize in the Sudano-sahelian region of Nigeria.

Conclusion.

This study has shown that to achieve better result from improved Agricultural technique in maize production, the beneficial effects of weather related conditions on the growth of maize must be given optimum priority while the negative effects must be reduced as much as possible.

It is glaring from the study that the Precipitation effectiveness plays a very important role in the increasing yield in maize in the Sudano-sahelian part of Nigeria.

Recommendation

From the analysis and the results obtained from the study, it is recommended that:

- Planting of maize should be carried out between 10th and 25th April
- The farmers need to introduce some farming practices to minimize the negative effects which may be poised by the dry spells and also early maturing species should be introduced.
- Areas that are prone to dryness should introduce irrigation practices.

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