EFFECT OF PRECIPITATION EFFECTIVENESS INDICES ON THE YIELD OF MILLET *(PennisetumTyphoideum)* IN THE SUDAN SAVANNA ZONE, JIGAWA STATE, NIGERIA.

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ABSTRACT
Farming in Nigeria is mainly dependent on rainfall which is variable in nature. Therefore, the need to have a full knowledge of rainfall pattern and trend is pertinent in order to achieve food sufficiency. This study examined the effect of some precipitation effectiveness indices: Onset date, cessation date, length of rainy season, seasonality index, amount of rain in the growing season and annual rainfall on the yield of millet in in the Sudan Savanna Zone, Jigawa State, Nigeria between 1995 and 2014. The study used monthly rainfall records (mm) and yield data for millet (kg/ha) sourced from the Jigawa State Agricultural and Rural Development Agency (JARDA). Walter's method was used to derive the selected precipitation effectiveness indices. Millet yield data in (kg/ha) and the selected precipitation effectiveness indices were harmonized using log10 method. All parameters were subjected to time series analysis, trend line and linear trend line equations were fitted to show the direction and magnitude of change. Simple correlation was used to analyze the relationship between crop yield and the selected precipitation indices. Regression analysis was used to determine the extent to which selected precipitation effectiveness indices influence the yield of the selected crop. Consequently the length of rainy season is increasing. Millet yield is increasing, due to early onset date of rains. The regression analysis shows that the selected precipitation effectiveness indices account for only 40.6% of millet yield variation in study area. Pest and diseases, time of cultivation, soil fertility and ability of farmers to obtain incentives and loans could be responsible for the remaining 59.4% variation in millet yield in the study area.The study therefore, recommends planting of crops late in the month of July as long as the onset dates of rains have set in.

Keywords: onset, cessation, variability, Sudan savanna, rainfall

INTRODUCTION

The term "precipitation" is used for any aqueous deposit in liquid or solid form derived from the atmosphere. Consequently the term refers to various liquid and frozen forms of water like rain, snow, hail, dew, hoar frost, fog-drip, and rime. However, only rain and snow make significant contributions to available moisture. In the tropics, the term rainfall is interchangeable with precipitation since snow is generally absent except on some high mountains like the Kilimanjaro in East Africa (Ayoade, 2004). Snowfall is difficult to be measured accurately and most precipitation records are in fact rainfall equivalent records. Hence, rainfall and precipitation are used interchangeably.

The concept of climate and agriculture has been extensively discussed (Ati et al., 2002), Ayoade (2002) and Cicek and Turkogu, (2005) have all confirmed that climatic parameters (i.e rainfall, sunshine, temperature, evaporation, e.t.c) are closely interrelated and influence crops yield. However, of all the climatic parameters affecting crop production and yield, moisture is the most important (Mustapha et al., 2018). Moisture is primarily obtained from rainfall which in the tropics is cyclical and fairly dependable, (Odekunle, 2001). Mubvuma (2013) affirmed that in the tropical environment, temperature is not a limiting factor to plant growth and that the seasonal activities of rainfall coupled with crop husbandry seems to be the issue.According to Ayoade (2004), water in all its forms plays a vital role in the growth of plants and the production of all crops. It provides the medium by which food and nutrients are carried through the plant. Rainfall in the tropics plays a significant role in nearly every stage of agricultural activity, from the time of tilling, planting, crop growth and management, to the time of harvesting, storing, transport and marketing (Hassan and Abdulhamid, 2012).

In Nigeria, distribution of crops is dependent largely on rainfall pattern. For instance, tree crops (like cocoa) are confined to the high rainfall region of the south while grain crops are cultivated predominantly in the low rainfall region of the north, Hence, the type of plants / crops cultivated in any area within the country is related to the rainfall pattern. In fact, in Nigeria climate disrupt efficient practice of agriculture and create significant changes in agricultural production (Efe and Awaritefe, 2003). Apart from the socio-economic problems facing Nigerian farmers, climatic variability constitutes a major limiting factor in crop production. This is so because the bulk of food produced in Nigeria is grown as rain-fed. In spite of its place as the pillar of any agrarian venture, climate, particularly rainfall, has not been accorded the deserved priority in agricultural planning in Nigeria. The general neglect of this natural resource might be based on the impression that tropical climate is variable.

MATERIALS AND METHOD

The study area

The Sudan Savannah Ecological Zone in Jigawa State lies between latitudes $10^0 56'$N and $12^0 2'$N and longitudes $8^0 29'$E and $9^0 8'$E. It shares boundaries with Ringim, Taura and Kaugama local government areas to the north, Kano to the south west, Bauchi at the eastern and southern borders (Ahmed et al., 2019a). See Fig. 1.

The savanna zone is characterized by dry and wet seasons, AW Koppens' climatic classification (Koppens, 1918). The climate is the result of the movement of interaction of two air masses; northeast trade wind and tropical maritime (Ahmed et al., 2018). The northeast trade wind blowing from Sahara desert results in harmattan and tropical maritime which is moisture bearing wind originates from the gulf of Guinea (Ati et al., 2002). The area recorded average rainfall of between 600mm to 1000mm (Ahmed et al., 2019). The hottest months are March and April while coolest is December and January with August being the wettest month (Ahmed et al., 2018). The mean temperature of coolest month is about 21˚C while the temperature in the hottest months is about 31˚C (Ahmed et al., 2019).

Most part of the Sudan Savanna zone is part of the chad formation which is composed largely of unconsolidated sediments, mainly of "tertiary terrestrial origins" (Ahmed et al., 2019a). This zone is dominated by the Chad plains, which are the lowest. Areas around Birnin- Kudu and Gwaramhave the highest elevations, reaching up to 750m above sea level (Ahmed et al., 2018). Two land forms could be identified in this study area: pedi-plain for example the Zalu plains near Gwaram and Clune field such as the Latenwa near Jahun (ahmed et al., 2019c). These are fertile land for the cultivation of variety of grains for food production and millet should be exceptional among commonly grown crops of the study area (Ahmed et al., 2019b).

The soil in the area is mostly sandy (Ahmed et al., 2019a). It developed from unconsolidated sediment of the Chad formation. Aeolian deposit from Sahara desert form substantial part of the soils (Ahmed et al., 2019a). The mixing of subsoil in the deposit has given rise to clayed subsoil, which dominate the zone. The natural vegetation of zone is the Sudan savannah type (Ati et al., 2002). Thorn shrubs dominate the area along with other plant include creepers (Ahmed et al., 2019c). It is also composed of grasses and scattered trees. The canopies are broad while the trees are hardly taller than 20 meters (Ahmed et al., 2018). Therefore, this could be the reason why the soil of the study area is fertile for the cultivation of grains despite the fact that the zone fall within the semi-arid region of northern Nigeria (Ahmed et al., 2019c).

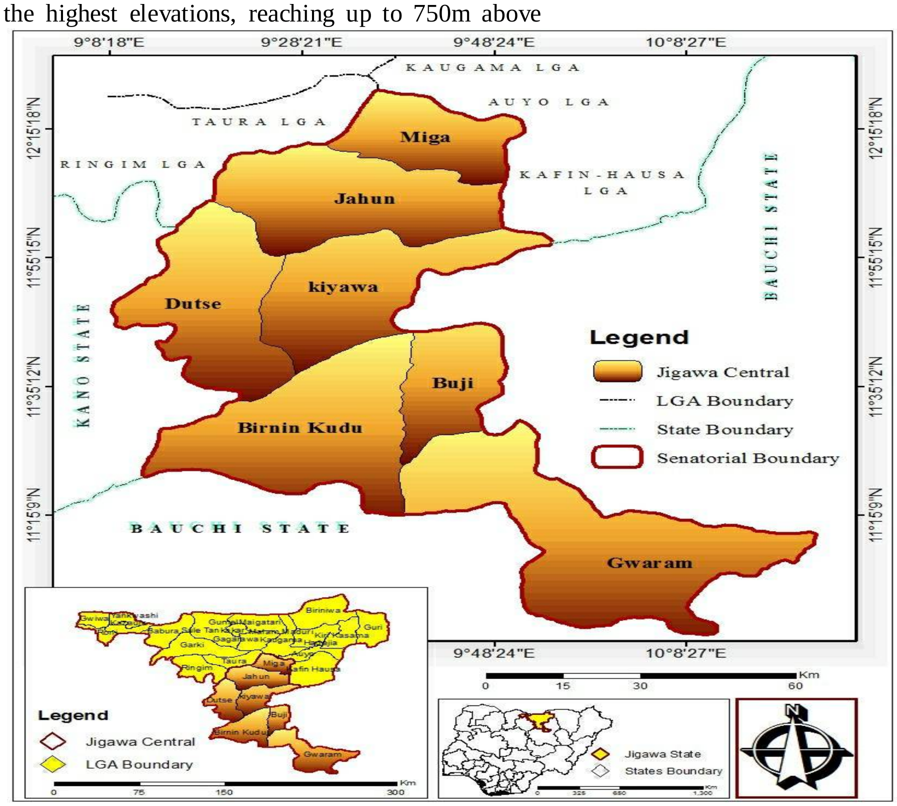

Fig 1. The Study Area

Source: Adapted and modified from the administrative map of Jigawa State, 2015.

Methods

Agro Climatically Derivations

Rainfall data collected for the study area was used to derive the precipitation effectiveness indices: onset, cessation, length of the rainy season, monthly rainfall in the months of growing season of (May, June July, August and September), annual rainfall and seasonality index.

Onset dates of rains

This refers to the time a place receives an accumulated amount of rainfall sufficient for growing of crops. It is not the first day the rain falls, but a time when accumulated rainfall value is up to 51mm (Walter, 1967). Out of different methods proposed: Walter (1967), Adejuwon, (2005), and Anuforom, (2004) to determine the onset date for Nigeria, the Walter's method which utilizes monthly rainfall data was adopted for this study because monthly rainfall data is more widely and readily available across the study area (Ati et al., 2002). Walter (1967) came up with a formula that is used to determine onset date. This relates the soil moisture index to monthly rainfall with the assumption that the soil moisture index required for plants to germinate is 51mm (Ayansina, and Ogunbo, 2009). To compute the onset dates of the rainy season, it is given as the product of the number of days in the month in which cumulative rainfall is greater than or equal to 51mm and the difference between 51 and the total rainfall of the previous month divided by the total rainfall of the month in which cumulative rainfall is greater than or equal to 51mm. Mathematically, is expressed as:

$$\text{Onset Date} = \frac{T(51-x)}{T2}$$

Where:

T= Number of days in the first month in which cumulative monthly rainfall is equal to or greater than 51mm

X= Rainfall total of the previous month

T2= Total rainfall of that first month with cumulative rainfall equal to or greater than 51mm

Cessation dates of rains

Cessation means the termination of effective rainy season. It does not imply the last day rain fell, but when rainfalls can no more be assured or effective thus the amount of water in the soil can no longer support the development of crops. This is computed in the same way as the onset date but the computation is taken in the reverse order from December (Walter, 1967).

Length of the rainy season

The length of the rain season (LRS) is determined by number of days between onset date and cessation date (Walter, 1967). Once the onset, cessation dates are known the length of rainy season can be determined by counting the number of days between onset date and the cessation date of that particular year.

Seasonality index (SI)

It is the exponent of the sum of absolute deviations of mean monthly rainfall from the overall monthly mean rainfall divided by the mean annual rainfall. It was computed by Walsh and Lawler (1981) method as follows:

$$SI = \frac{1}{R}\sum|\bar{X}n - \frac{R}{12}|$$

Where SI= Seasonality index

$\bar{X}$n= Mean rainfall of the month n

R= Mean annual rainfall.

Rain in the months of Growing Season (May, June July, August and September)

Growing season is the period of the year categorized as the rainy or wet season, the length of which varies spatially, temporally, and with crop type. The records of daily rainfall are added monthly to give the monthly rainfall totals for the month of to September (Adebayo, 2000). The same method was also adopted for this study.

Annual rainfall

The records of monthly rainfall are added yearly to give the annual rainfall totals for the year (Adebayo, 2000). Rainfall records of May, June, July, August and September are added together to give annual rainfall for each year.

Data Analysis

Millet yield are measured in tons per hectare while rainfall are measured in centimeter. Therefore, to harmonize the two sets of data, they were both converted into Log10. Firstly, crop yield and the selected precipitation effectiveness indices records were harmonized using the $\log_{10}$ method to a common base (kg) and (mm) as proffered by Sawa and Abdulhamid (2011). Data harmonization is the adjustment of differences and inconsistencies among different measurements to make them uniform or mutually compatible. It creates the possibility to combine data from heterogeneous sources into integrated, consistent and unambiguous information.

The values of the selected precipitation effectiveness indices and crop yield for millet were subjected to time series analysis. Trend lines and linear trend line equations were fitted to show the direction of change. Furthermore, simple correlation analysis was used to examine the relationship between the millet yield and the individual precipitation effectiveness indices and multiple regression technique was employed to determine combined effect of the precipitation effectiveness indices on the yield of millet in the study area. The yield was expressed as dependent variable (y) and precipitation effectiveness indices as independent variables (x). The equation used the regression is:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 \ldots + b_nx_n,$$

Where: Y = Millet yield in Kg/ha

a = Constant

b = is the rise or fall as X changes

X_1 = Total annual rainfall (mm)

X_2 = Onset dates of rains

X_3 = Cessation

X_4 = Length of the raining season

X_5 = Seasonality Index

X_6= Rainfall in May

X_7= Rainfall in June

X_8= Rainfall in July

X_9= Rainfall in August

X_{10}= Rainfall in September

The tests were carried out on 0.05 significant levels.

RESULTS AND DISCUSSION

The Derived Precipitation Effectiveness Indices and Millet Yield

Data Used in the Study

The derived Agro-climatic parameters (Onset and Cessation Dates and Length of rainy season, Seasonality index, rain in the growing season and annual rainfall) and millet yield for the Sudan Savanna Zone, Jigawa State is presented in Table 1. Almost all of the parameters in the table were derived using various methods proffered by different scholars of agro-climate. Each of the parameter was further subjected to time series analysis using the EXCEL computer software to know the direction of change and each parameter are graphically presented and analyzed appropriately.

Furthermore, the parameters were considered for correlation in order to determine the relationship between yield of millet andprecipitation effectiveness indices in the study area. Multiple regression technique was also employed to determine the combined effect of precipitation effectiveness indices on the yield of millet in the area.

Table 1: Data used in the study

Year	Yield (Kg/ha)	Annual Rainfall (mm)	Onset Dates	Julian Day	Cessation Dates	Julian Day	LRS (Days)	SI	May Rainfall (mm)	June Rainfall (mm)	July Rainfall (mm)	Aug Rainfall	Sept Rainfall
1995	788.7	899.7	1st June	153	8th Sept	252	100	1.23	44.6	205.9	232.9	240.6	183.8
1996	849.25	693.15	7th June	159	13th Sept	257	99	1.25	15.25	164.8	62.65	268.5	118
1997	801.35	834	4th June	156	8th Sept	252	97	1.23	35.5	105	237	219.5	192
1998	729.25	751.85	2nd June	154	10th Sept	254	101	1.25	38.1	163	135.4	191.1	146.5
1999	1037.05	764.25	14th June	166	11th Sept	255	90	1.25	3.0	100.6	198.1	200.4	140.8
2000	762.08	722.15	16th June	168	11th Sept	255	88	1.27	4.95	86.3	260.1	223	138.7
2001	790.8	901.95	27th May	148	9th Sept	253	106	1.25	59.1	108.9	193.7	345.4	169.4
2002	854.7	764.25	12th June	164	9th Sept	253	90	1.27	0.6	123.1	152.2	260.5	163.6
2003	962.2	893.5	13th May	133	7th Sept	251	118	1.16	118	126.9	206.9	203.6	215.3
2004	892.13	748.1	14th May	135	23rd Sept	267	133	1.16	107.3	60.8	229.3	254.1	65.9
2005	669.05	672.7	3rd June	155	20th Sept	264	110	1.16	38.6	108.4	165.4	273.6	74.9
2006	679.73	897.7	18th May	139	7th Sept	251	113	1.16	87.75	112.5	230.2	281.1	206.9
2007	882.6	1267.75	28th May	147	15th Sept	259	111	1.22	56.6	262.1	402.4	425.9	99
2008	772.86	1162.2	28th May	147	8th Sept	252	104	1.22	56.9	235.4	280.6	418.6	186.6
2009	904.6	809.25	29th May	148	11th Sept	255	106	1.22	54.85	80.5	273.8	286.5	137
2010	795.25	1280.3	20th May	141	5th Sept	249	109	1.22	76.65	217.3	265.4	322.9	308.6
2011	588.15	1243.8	8thJune	160	7th Sept	251	92	1.31	15.2	139.6	429.3	371.4	216.9
2012	909.65	1192.55	15th May	136	7th Sept	251	116	1.20	107.6	163.4	311.8	673.2	222.7
2013	972.25	1162.5	7th June	159	15th Sept	259	101	1.31	6.0	205.5	241.5	571	101.5
2014	943.2	1070.6	1st June	153	15th Sept	259	107	1.20	47	99	192.1	454.5	102.5

Source: JigawaStateAgricultural and Rural Development Agency (JARDA), (2015)

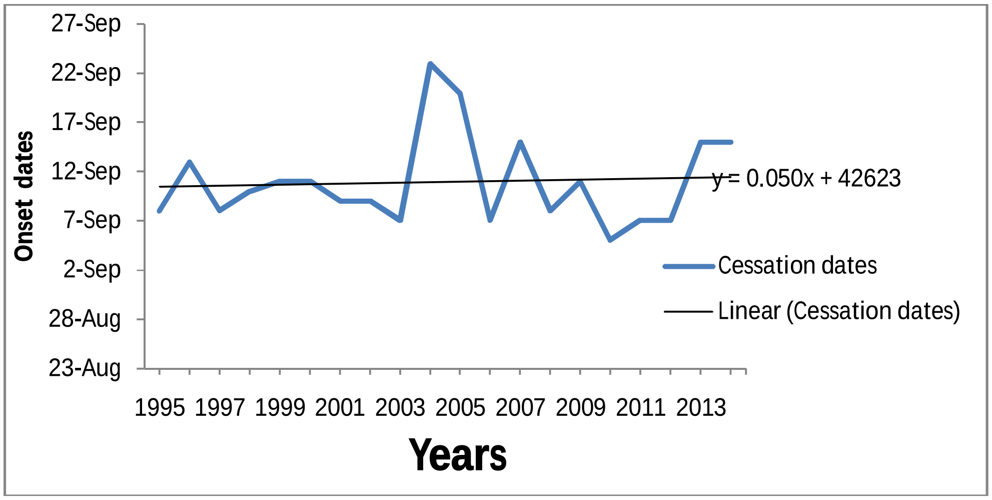

Fig 2: Trends of Rainfall Onset Dates in the Sudan Savanna Zone, Jigawa State
Source: Field Survey, 2016

Fig. 2 shows the linear trend and trend line equation for the onset dates of the rainy season in the study area. The figure clearly shows that the onset of the rainy season is characterized by variability from year to year. This figure indicates a decreasing trend line in the onset dates. The best fit line equation is negative (y = -0.5203x + 42526).This means decreasing Julian days and implies that rainfall progressively starts earlier in recent times in the study area. It therefore implies that millet cultivation will commence earlier in the study area, consequently the earlier harvest. This finding goes contrary to the finding of Sawa and Adebayo (2011), which stated that there is increasing Julian days and rainfall progressively starts later in recent times in northern Nigeria. This variation in result could be as a result of climatic change that affects world ecological zones and difference in length of the data that was used for the various researches. Similar result was presented in Sawa et al. (2014) which showed latter onset dates of the rainy season at Kano.

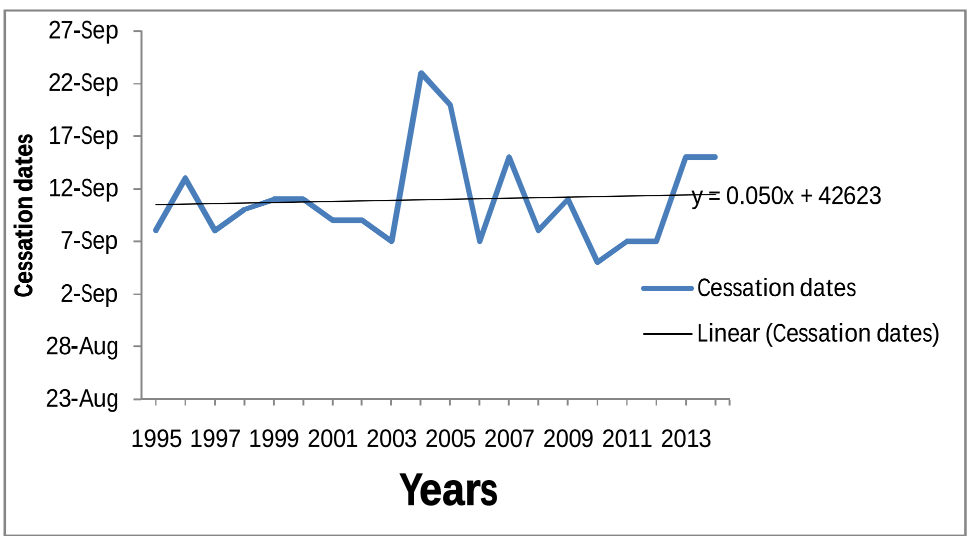

Figure 3: Trends of Rainfall Cessation Dates in the Sudan Savanna Zone, Jigawa State
Source: Field Survey, 2016

Trend in the cessation dates of the rainy season in the Sudan Savanna zone, Jigawa Stateis presented in Fig.3. From Fig.3, it is observed that the trend in cessation dates of the rains is on the increase. The linear trend line equation is positive (y = 0.0504x + 42623). This further indicates that in the study area, there is increase in Julian days and rains progressively stop later in recent times unlike onset date. Since, there is delay in the cessation of rain; it is therefore expected to provide adequate moisture for later stage of crop development in the study area. This finding is against the finding of Sawa and Adebayo (2011) which concluded that rains stop earlier in recent times in northern Nigeria. This difference in result could be as result of climatic change that is affecting climatic regions of the world. Similar finding was presented in Sawa et al. (2014) for trend in cessation dates of the rainy season at Kano, which stated that rainfall stop earlier in recent time.

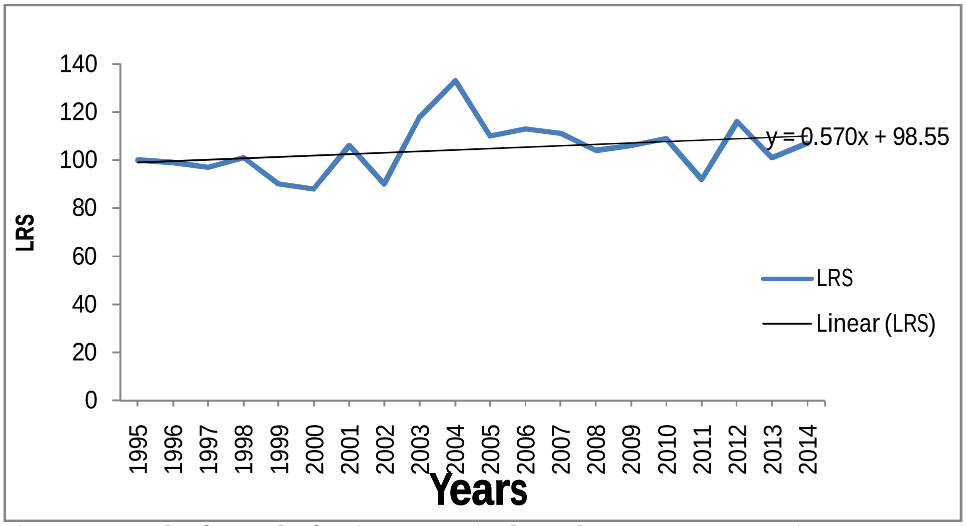

Figure 4: Trends of Length of Rainy Season in the Sudan Savanna Zone, Jigawa State
Source: Field Survey, 2016

The pattern of progressive length of the rainy season inthe study areaindicates an upward trend in length of the rainy season. A positive trend line equation of y = 0.5707x + 98.558 implies that the length of the rainy season is progressively increasing in the area. This figure (4) shows that the variability (noise) in duration of the rainy season is not as marked as the variability in onset and cessation of the rains. This signifies that the duration of the rainy season in the study area is gradually widening over the years. The general increase in the length of rainy season in the study area will give rise to a boost of millet cultivation by farmers during the growing season, consequently increasing the millet yield. This finding is not in concordance with the finding of Akinsanola and Ogunjobi (2014), which revealed that there is gradual decline in the duration of rainy season in northern Nigeria. Climatic change makes some ecological zones to receive much rainfall while others with deficit amount; this could be the reason for the variation in result. Similar results were presented in Ojo (2003) and Sawa et al., (2014) for length of the Hydrological Growing Season (HGS) at Kano which stated that there was decline.

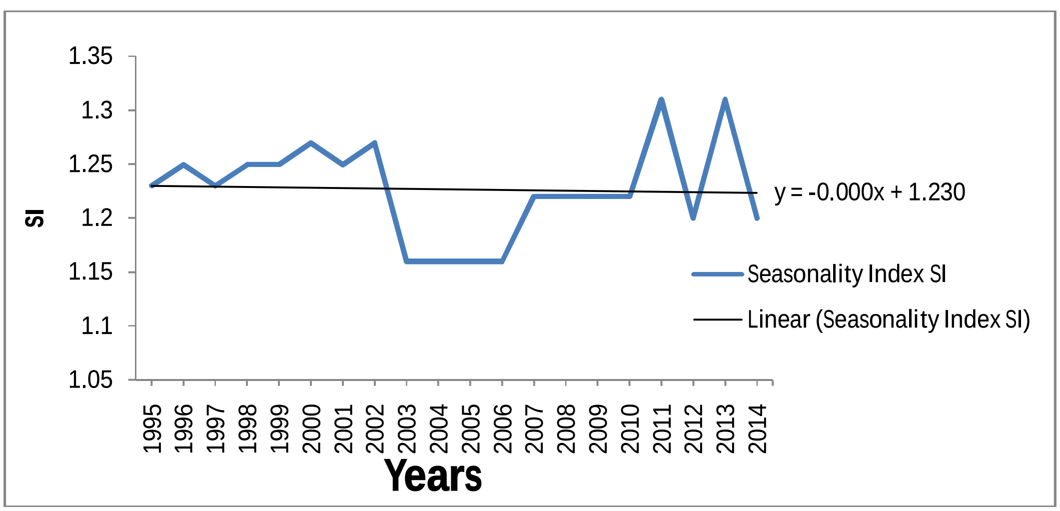

Figure 5: Trends of Seasonality Index in the Sudan Savanna Zone, Jigawa State
Source: Field Survey, 2016

The negative (y = -0.0003x + 1.2306) best fit line equation means that there is shorting spread of the rainy season in the zone.This therefore means that most of the rains fall within some few months. The other months experience few rainy days only. This may not affect the performance of millet growth since is a type of crop that still thrive well when there is deficit rainfall and consequently higher yield in the study area. This finding correspond with the finding of Mustapha et al. (2018) in their study of Analysis of rainfall variation over northern parts of Nigeria which concluded that there is shorting spread of rainy season in northern Nigeria.

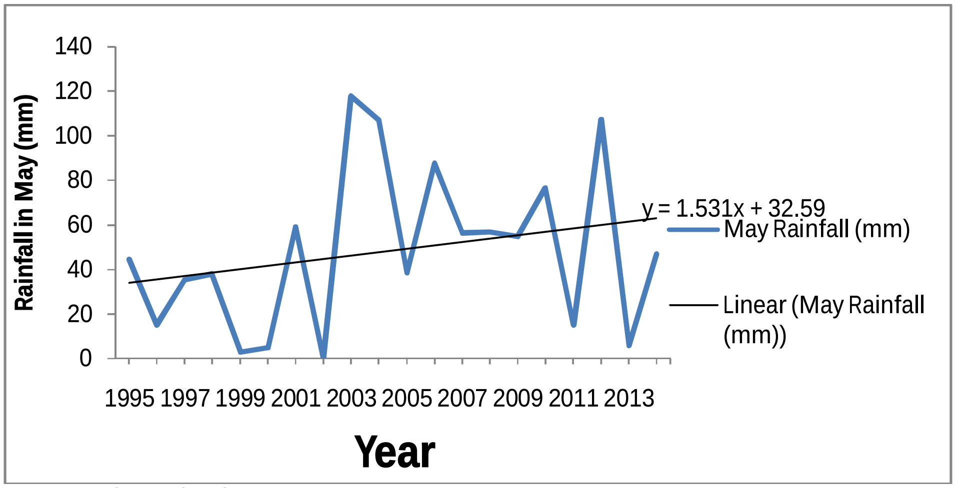

Figure 6: Trends of Rainfall for May in the Sudan Savanna Zone, Jigawa State
Source: Field Survey, 2016

The result shows an increasing trend in amount of rainfall in May. The positive best fit line equation (y = 1.5312x + 32.599) means that there is progressive increase in May rainfallin the rainy season in the zone. It therefore means adequate soil moisture will be provided for millet growth in the study area. The finding is contrary with Ayansina (2009) in his study of Seasonal rainfall variability in Savanna part of Nigeria: a GIS approach which stated that rainfall variability is very high in most of Northern Guinea Savanna (e.g. Yola, Minna, and Ilorin) with values of coefficient of variation (CV) between 26 and 49 percent while in Southern Guinea Savanna, the CV is very low especially, in Enugu (9 percent), and Shaki (8 percent). These anomalies (such as decline in annual rainfall, change in the peak and retreat of rainfall and false start of rainfall) are detrimental to crop germination and yield, resulting in little or no harvest at the end of the season.

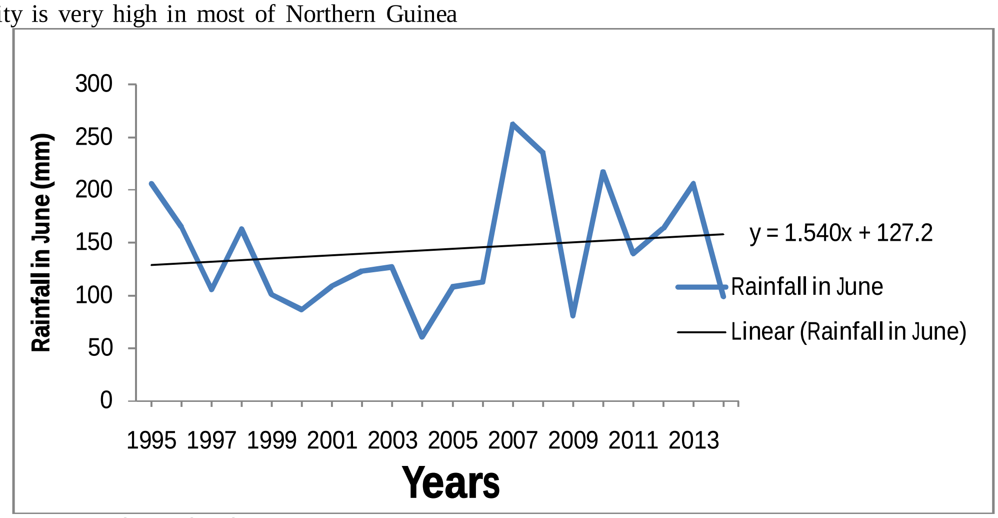

Figure 7: Trends of Rainfall for June in the Sudan Savanna Zone, Jigawa State
Source: Field Survey, 2016

Figure 7 shows an increasing trend in amount of rainfall in June. The positive best fit line equation (y = 1.5312x + 32.599) confirms that there is increase in amount of rain in Junein the area.This finding therefore means adequate soil moisture will be provided for millet growth in the study area.Akinsanola and Ogunjobi (2014) in their study on the Analysis of Rainfall and Temperature Variability over Nigeria observed thatthere is an increase in the rainfall amount in cities like Jos, Enugu, Kaduna, Minna, Nguru and Katsina. A decline in rain amount was noted in larger part of south West and North eastern Nigeria. In the second decade only few stations in south west Nigeria (e.g. Osogbo, Ikeja and Ondo) were having wet years while the whole country exhibits dryness throughout the entire during of analysis. In the third decade, Jos and Katsina were the only stations with dry tendencies while most part of the country is having abundant rainfall amount. This gradual reduction in rainfall amount may be attributed to variation in local factors such as orography; boundary layer forcing and moisture build up. .

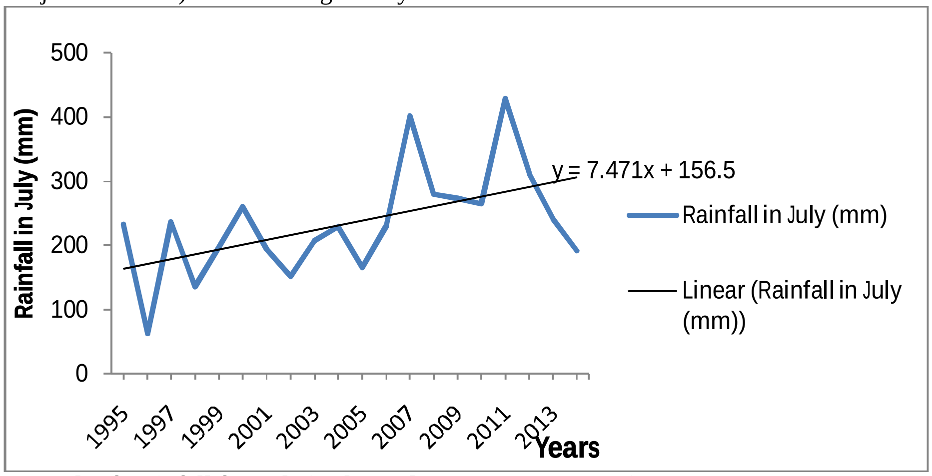

Figure 8: Trends of Rainfall for July in the Sudan Savanna Zone, Jigawa State
Source: Field Survey, 2016

The result in Fig 8 shows an increasing trend in amount of rainfall in July. The positive best fit line equation(y = 7.4713x + 156.59) corroborates that there is increase in amount of rain in Julyin the study area. The increasing trend in amount of rainfall in July will establish the importance of soil moisture on millet, consequently the readily available the soil moisture, the higher the yield of millet in the study area. This finding is in line with the findings of Adenodi (2018) in his study of centurial analysis of rainfall variability in Nigeria, whichindicate an upward trend and positive slope respectivelywith maximum rainfall occurred in July and August over northern Nigeria. . Farther north, it is usually June or July before rains really commence. The peak of rainy season occurs through most of northern Nigeria in August, when air from the Atlantic covers the entire country. In the southern regions, this period marks the August dip in precipitation. Although rarely completely dry, this dip in rainfall, which is especially marked in the southwest, can be useful agriculturally, because it allows a brief period for grain harvesting, (Ryan, 2005 and Osang et al., 2013).

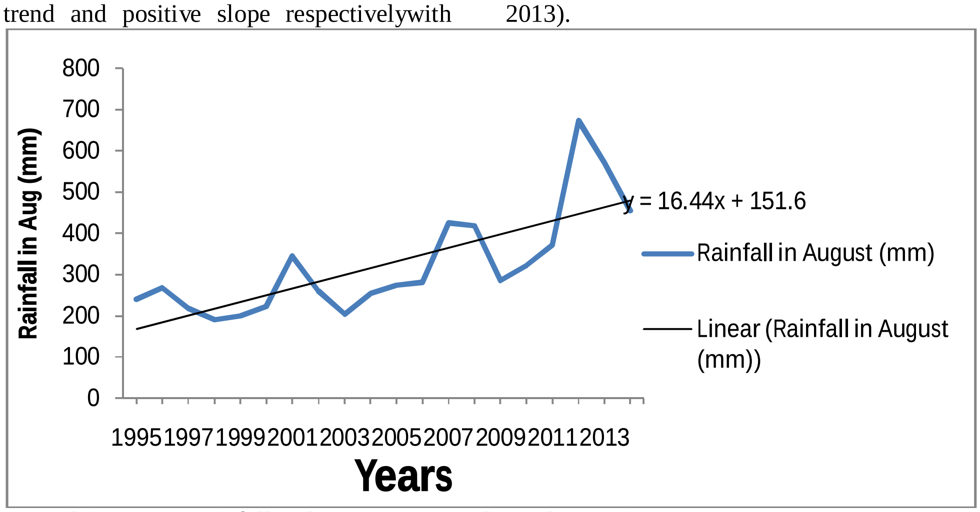

Figure 9:TrendsinAugustRainfallSudan Savanna EcologicalZone,Jigawa State
Source: Field Survey, May 2016

The result in Fig 9 shows an increasing trend in amount of rainfall in August. The best fit line equation(y = 16.441x + 151.64)means that there is increase in amount of rain in August. The upward trend in rainfall in the month of August at the study area anticipated to go in long way in providing moisture needed by millet for growth consequently higher yield in the study area. The least values were recorded at Nguru, Katsina and Maiduguri which are all in the Northern part of the study area. These are the areas in the heart of the Sahel. Kano located in the central part of the study area recorded the maximum highest total annual rainfall and the minimum again at Nguru. However, Kano recorded the largest range that is the difference between the minimum and the maximum. Potiskum exhibits the most evenly spread distribution followed by Yola (Peter, 2012)

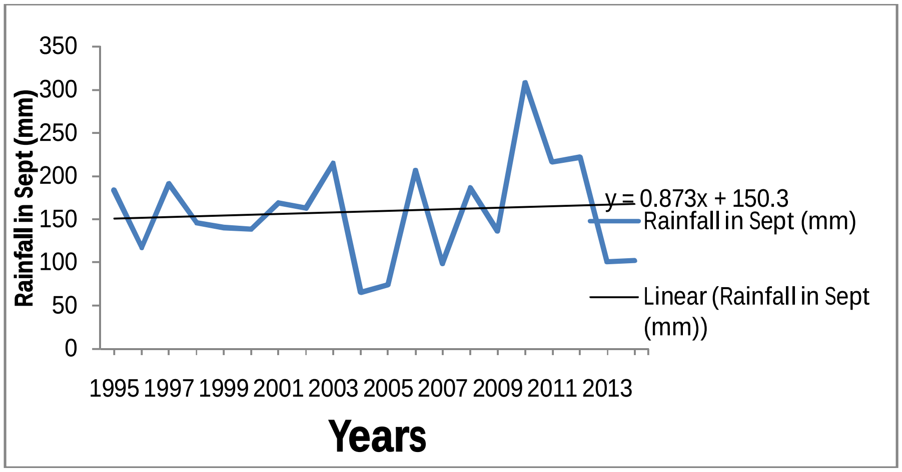

Figure 10: Trends of Rainfall for September in the Sudan Savanna Zone, Jigawa Sate
Source: Field Survey, 2016

The result shows an increasing trend in amount of rainfall in September. The best fit line equation(y = 0.8738x + 150.35)corroborates theincreasing amount of rain in Septemberin the study area. This finding implies that millet during the month of September will not thrive well; as it has minimum water demand which can lead to lose of pollen due to progressive increase in the amount of rainfall in September. Therefore, this could cause low yield of millet in the study area. This finding is not in support of result presented in Hassan and Abdulhamid (2012) which indicated that the monthly rainfall of September show decreasing trend in Katsina. This difference may be as a result of climate change or difference in the numbers of years considered for the research.

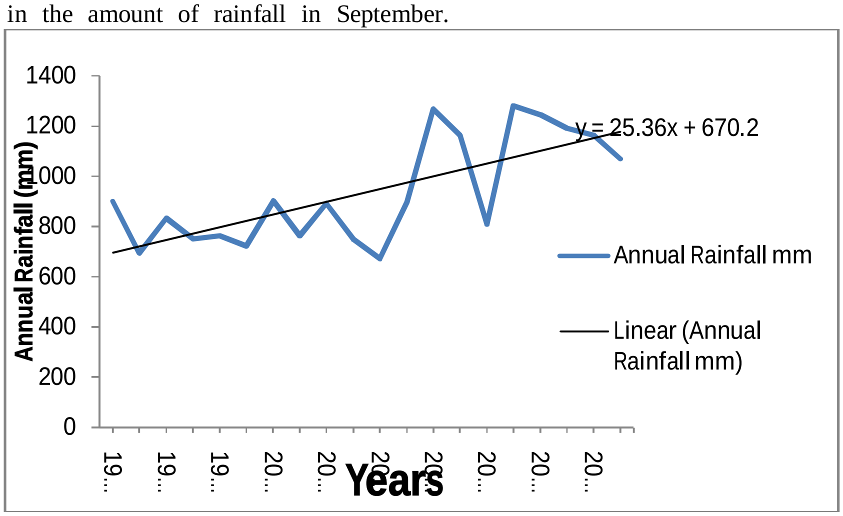

Figure 11: Trends in annual rainfall in the Sudan Savanna Zone, Jigawa Sate
Source: Field Survey, 2016

Fig 11 shows variability in annual rainfall. The rainfall in the study area shows high variability throughout the study period. There is increasing trend in annual rainfall. The best fit line equation is positive (y = 25.366x + 670.27). This means that there is increase in amount of annual rainfall in the area. This is a welcome development to farmers in the study area, as there will be sufficient moisture for cultivation of millet consequently higher yield. The annual cumulative rainfall amounts of 300 – 1000mm were recorded in the northeast, parts of Katsina and Kano in the northwest and Ilorin in the central region. The entire southeast and parts of Akure, Benin, Ijebu Ode and Oshogbo in the southwest had 2000 – 3000mm of rainfall in the year. The rest of the country experienced rainfall between 3000 – 4500mm. The highest cumulative rainfall amount of 4224.0mm recorded at Eket is about 269.3mm less than the 2009 record high at the same station.

Nguru, like in the year past, recorded the lowest rainfall of 447.8mm.Obot et al, (2005), Studied rainfall trends over west Africa from 1991 – 2004, they showed average rainfall interms of the 1950 – 1990 mean event through the years 1999 and 2000 were exceptionally wet.

For instance, the wettest city in Nigeria, receives more than 4000mm of rainfall annually, (Ewona and Udo, 2009). Obot et al, (2010) found that the total amount of rainfall across Nigeria in selected locations in each of the six zones within a 30 years period (1978-2007) from the Mann Kendall test reveals an increasing trend in only one out of the six locations. Maiduguri (North East) where formally the trend was decreasing, (Hess et al. 1995) is now witnessing an increasing trend of 9.46 mm of rainfall per year. This trend was non-existing in a sub 20 year period of (1978-1997) but came out when another sub period of (1988-2007) was examined.

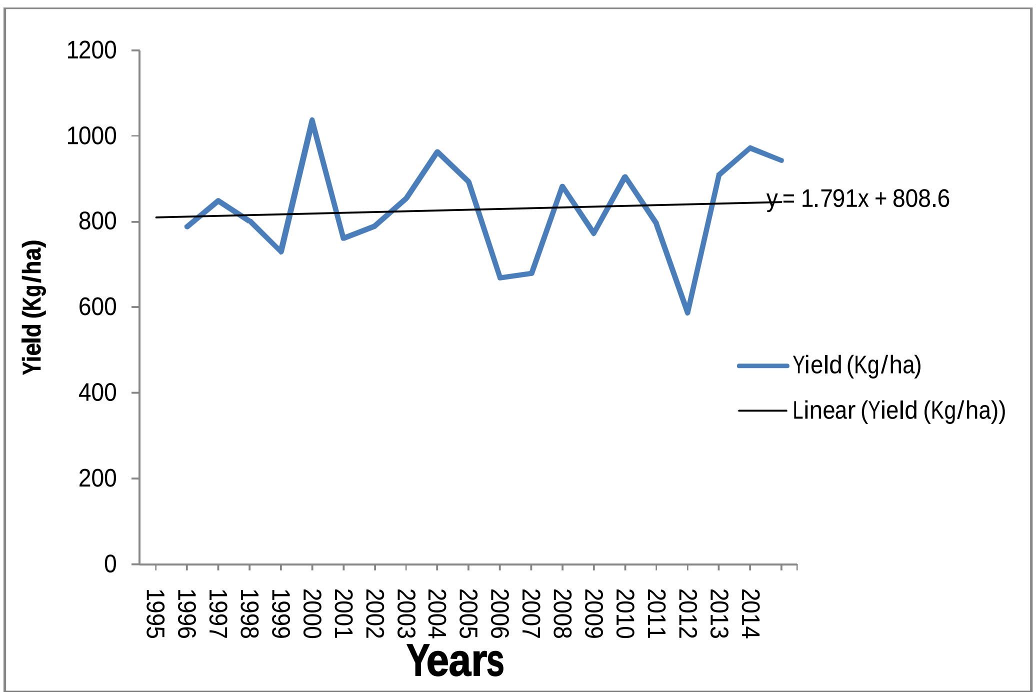

Figure 12: Trends in Millet Yield in the Sudan Savanna Zone, Jigawa State
Source: Field Survey, 2016

Fig 12 shows that there is increasing trend in millet yield. Highest yield was observed in 1999, while the lowest was yield was recorded in 2011. The trend line equation is positive, (y=1.7917x + 808.64) which confirms increase in yield. The implication of this finding is that it could leadto reduction in hunger as farmers may tend to have more food in the study area. This finding is in agreement with the findings of Emeghara (2015) which shows an increasing trend in millet yield at Sokoto. This result is not surprising because is in line with the observed earlier onset of rains, latter cessation of rain, increasing length in length of the rainy season, increase in rainfall in May, June, July August, and September and increase in total annual rainfall. This could bring higher yield which reduce the problem of food shortage, boast the economy and provide raw materials for agro industries in the study area.

Relationship Between The Derived Precipitation Effectiveness Indices and Millet Yield

The relationship between the selected precipitation effectiveness indices, namely: onset date, cessation date, the length of the rainy season, seasonality index, rainfall in May, June, July, August and September and annual rainfall with millet yield in the study area.

Table 2: Precipitation Effectiveness Indices

Precipitation effectiveness indices	(r value)	p
Annual rainfall	0.015	0.951
Onset	0.134	0.573
Cessation	0.257	0.274
LRS	0.171	0.472
SI	-0.033	0.890
Rainfall in May	-0.110	0.645
Rainfall in Jun	-0.053	0.825
Rainfall in July	-0.116	0.625
Rainfall in August	0.134	0.573
Rainfall in Sept	-0.235	0.318

r = > 0.380 is significant at 0.05 (2-tailed).

Table 2 shows that annual rainfall has weak relationship with millet yield (r = 0.015). This indicates that deficit or inadequacy of rains could not reduce the yield of millet in the study area. Millet is one of the crops that adapt to drought, low fertility and high temperature inrainfed agriculture. Bello (2012) was able to show an insignificant relationship between annual rainfall and rice productivity in Kano.

Onset, Cessation dates and Length of the rainy season of rain have weak correlation with millet yield; (r= 0.134), (r= 0.257), and (r= 0.171) respectively. This indicates that late onset, earlier cessation and short length of rainy season of rains may not drastically reduce the yield of millet in the study area. Similar results was presented in Adejuwon (2005) which indicates positive insignificant relationship between cessation dates and length of the rainy season and rice productivity, and negative insignificant relationship between onset dates and rice productivity in Kano. Abdulhamid and Giade (2007) were also able to observed high positive relationships between the onset dates of sorghum and their total yield and negative relationships between sorghum yield and cessation dates.

There is insignificant and negative correlation between millet yield and seasonality index during the growing season (-0.033).. Bello (2012) was able to present positive insignificant relationship between derived precipitation effectiveness indices and millet yield in Kura Local Government Area.

Rainfall in May, June, July and September also have insignificant negative relationship with millet yield with the exception of August which has positive correlation with millet yield. This signifies that without much rainfall during the pre-sowing period which is a measure, to some extent, of the soil moisture available at germination, millet could still thrive well in the zone consequently higher yield. In fact high rainfall in September destroys pollen from the millet and causes low yield. Bello (2012) show high positive significant relationship between June rainfall and millet yield and positive insignificant relationship between July and September rainfall and millet yield in Kura.

Table 3: Effect of Derived Precipitation Effectiveness Indices on Millet Yield

Dependent Variable	Independent Variable	Coefficient	T-Value	Sig. of T	R^2	Equation
Millet Yield	Annual rainfall	-0.0706	-0.11	0.917	40.6%	$Y=-9.59 -0.071X_1$
	Onset	-0.00421	-0.09	0.929		$-0.0042X_2+3.24X_3$
	Cessation	3.239	1.44	0.184		$+1.29X_4 + 0.01X_5$

LRS	1.294	1.09	0.304	$-0.0930X+0.096X_7$
SI	0.013	0.01	0.995	$- 0.009X_8 -0.090X_9$
Rain in May	-0.09302	-1.46	0.179	$+ 3.23X_{10}$
Rain in June	0.0956	0.52	0.618	
Rain in July	-0.0085	-0.05	0.964	
Rain in August	-0.0905	-0.44	0.671	
Rain in Sept	3.231	1.42	0.190	

*Regression is significant at the 0.05 level (2-tailed).

All the ten derived agro-climatic variables used for correlation were included in the regression analysis. The results indicate that the selected precipitation effectiveness indices, accounts for 40.6 percent variation in millet yield in the study area while the cessation has the highest influence on millet yield with the regression coefficient of 3.239.

The remaining 59.4 percent variation in millet yield could be due to soil fertility, pest and diseases, time of planting, ability of farmers to obtain soft loans and fertilizer from Local, State or Federal Governments. These are may also be critical to millet growth in the study area.

CONCLUSION

Based on the findings of the research, it was concluded that there is early onset of rains and late cessation of rains in the study area. Furthermore, millet yield are increasing due to early onset of rains. This is a welcome development to farmers, agricultural industries and policy makers in the zone as this will increase output, generate employment, diversify in the area and raise the level of foreign exchange earnings and provide input for manufacturing and processing on a sustainable basis.

RECOMMENDATIONS

Following the findings and conclusion made in the study between 1995 and 2014, the following recommendations are made:

Since the characteristics of rainfall onset and cessation dates, length of rainy season, seasonality index, annual rainfall and rainfall in May, June, July, August and September are inconsistent and variable in the study area; Farmers should acquaint themselves with information from Nigeria Meteorological Agency (NiMET) in order to have an idea of the predicted rainy season so as to know the likely onset dates of rains, cessation dates, rainfall , length of the raining season, seasonality index, amount of rain in the growing season and annual rainfall as they affect the performance and yield of millet and other crops.

Planting of crops in the month of July should be encouraged as long as the onset dates of rains have set in. This is to allow the crop mature within the rainy season to avert the danger of high rainfall which characterized the month of May, June, July, August and September. This is because this high rainfall is unhealthy to the pollen gains of the crops.

This study only considered the derived rainfall parameters. Research works need to be conducted in other areas like cultural practices on the farms, soil factor so as to understand the contribution of each of these factors on the yield of millet in the study area.

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