Gombe Journal of Geography and Environmental Studies (GOJGES)

Vol. 1 N0.2 Jun. 2020

e-ISSN: 2714-321X

p-ISSN: 2714-3201

http://www.gojgesjournal.com

Gombe Journal of Geography and Environmental Studies (GOJGES) Vol. 1 N0.2 Jun. 2020, e-ISSN: 2714-321X; p-ISSN: 2714-3201

IMPLICATIONS OF CLIMATIC CHARACTERISTICS ON GINGER YIELD IN JEMA'A LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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Abstract –

Rainfall and temperature characteristics are two determinant elements affecting climate change. Their impacts on crop production for rural, urban and national development cannot be overemphasised. It is therefore paramount to assess the climatic characteristics over a long period in order to ascertain their impact on the yield of ginger in Jema'a local government area of Kaduna State. Rainfall and temperature data for 34 years (1981 to 2014) was used to characterise the climate of the study area. Yield data for ginger tons/ha (1990 – 2016) were sourced and used. The result showed that the long-term mean of rainfall for the period reviewed was 1729.7mm. The mean onset date of rainfall was April 15th, while the mean cessation date was 11th October. The average LRS was about 6 months (178 days). The results further showed that positive trend line equations occurred for TAR, maximum temperature and ginger yield pattern, onset, cessation and LRS were declining to the negative, implying that the study area experienced early onset, early cessation dates and shorter days in LRS. The Pearson's Product Moment Correlation Coefficient (alpha= 0.05) was used to determine the relationship between weather parameters and the yield of ginger and the result showed a positive but imperfect relationship. The findings of this study therefore revealed that increase in rainfall led to subsequent increase in the yield of ginger vice-versa. This means that in cases of declining rainfall, yield in ginger will be poor. The study thus recommended the following: improving climatic data and continuous data monitoring, public enlightenment on the impacts of climate change and the use of viable adaptation strategies in the study area.

Keywords: *Characteristics, Climatic, Implication, Ginger, Yield*

1. Introduction

In Nigeria, certain climatic variables like temperature and rainfall mainly characterize the climate systems and determine the seasons. Rainfall is the single most important meteorological parameter that conditions agriculture as it provides the water necessary for the functioning of the soil-plant-atmosphere-system (FAO, 1986). In to ginger production and can affect the productivity and sustainability of soils to agriculture, some of the most important aspects of rainfall, which are useful in decision-making, are the onset dates and cessation dates of the rains otherwise known as the start and end of the growing season respectively. The combination of these two determines the Length of the Rainy Season (LRS). Rainfall can be a challenging factor ginger yield. According to the National Agricultural Extension Liaison Service, NAERLS (2004) farmers' ability to predict the period of the onset of rain and early cultivation of ginger can meet up with the rainfall requirement of ginger and consequently higher yield depending on the nature of the soil fertility. Ati (2006) investigated the rainfall characteristics in drought prone areas in Nigeria and the result indicates that the annual rainfall totals over Nigeria started decreasing in the 1960s but the last decade especially the late 1990s had been witnessing increasing annual rainfall totals.

The results further reveal that the number of wet days is on the decrease while the number of dry days is on the increase. Increase rainfall with decreasing number of rain days means higher rainfall amount per storm and hence higher intensity. This would result in flooding and soil erosion with its attendant loss of farmland and low yield. Dempewolf, Eastwood, Guarino, Khoury, Müller and Toll (2014) predicted that by the year 2050, much of the world will experience a growing season that will likely have higher temperatures than the hottest growing seasons of recent times and this increase in temperatures will probably be accompanied by more variable rainfall resulting in drought and dry spell. Crops will be impacted in various ways, such as increased sterility at higher temperatures and starting of early senescence under warmer conditions (Lobell, Sibley and Ivan, 2012). Guarino and Lobell (2011) forecasted possible yield losses of 6–10% per 1°C of warming in the average temperature of the growing season. This means the world could see significant production losses in the future.Ginger (*Zingiberofficinale*) is an herbaceous perennial plant belonging to the order *Scitamineae* and the family *Zingiberaceae*. It is also known as '*Chita'* in Hausa language. Ginger is a root crop and a typical herb extensively grown across the world for its pungent aromatic under-ground stem or rhizome, which makes it an important export commodity in world trade (Ajibade and Dauda, 2005). The yellow ginger variety locally called "Tafin Giwa" with a bold yellow rhizome flesh is stout with short internodes. The black ginger variety locally called "Yatsun Biri" with a dull-grey colour rhizome. The yellow variety is more popular than the black variety apparently due to its high yielding capacity and pungency (Kure, 2007). There is successful cultivation of commercial ginger in Nigeria because of its market value. Farmers do not only produce ginger for revenue and income creation, but it is also known for its health advantages/medical value, that is why there is a high demand for ginger nationally and internationally. Nigeria ranked first in terms of the percentage of total hectares of ginger under cultivation. Kaduna State is the highest producer of ginger in the country. Jema'a LGA is well known for its wide spread production of ginger. Ginger is a household crop in Jema'a.

Ginger has wider adaptability for different climatic requirements. It prefers brilliant sunshine, heavy rainfall and high amount of relative humidity for a promising yield. Ginger is cultivated in the tropics with an annual rainfall of 1500 mm or more (Purseglove, 1976). A rainfall, well distributed in 8-10 months is ideal for ginger production. Dry spells during land preparation and before harvesting are required for large-scale cultivation. Ginger prefers warm and humid climate, with moist soils that have proper water holding capacity and aeration. The crop is sensitive to water logging and is also tolerant to wind and drought. The base temperature requirement for ginger is 13^{o}C and the upper limit is 32^{o}C/27^{o}C (day/night), whereas the favorable range is 19-28^{o}C. The optimum soil temperature for germination is between 25-26^{o}C, and for growth it needs 27.5^{o}C. A temperature in excess of 32^{o}C can cause sunburn; on the other hand, low temperatures induce dormancy (McCarthy, Canziani, Leary, Dokken and White, 2001).

The overall objective of this study is to characterize the climate of Jema'a LGA using rainfall and temperature data and how they affect the yield of ginger. The specific objectives of the study are to:

1. Evaluate the long-term changes in rainfalls and air temperatures (maximum, minimum and average) of the study area for 34 years.
2. Assess the impact of rainfall and temperature characteristics on the yield of ginger in the study area.

2. Study Area

The study was carried out in Jema'a Local Government Area of Kaduna State. Kafanchan is the headquarters of Jema'a LGA. The LGA lies between latitudes 9°0'00″ N and 11°0'00″ N from the Equator and longitudes 7°0′0″ and 8°30'E of the Greenwich Meridian. It is located at the southeast part of Kaduna State as shown in Fig. 1 (Kaduna State Ministry of Agriculture, 2007). The climate of the study area is generally characterized by alternating dry and wet seasons. The rainfall usually starts in April and ends early November, while the dry season sets in mid-November and ends in March. Ginger is normally planted in March and harvested in November. Jema'a has an area of 1,661 KM^2 and a population of 278,735 at the 2006 National Population Census. The bulk of agricultural production in the LGA is under-taken by small-scale farmers most of whose labour force, management and capital originate from the household. The main crops grown in the area includes maize, millet, rice, sorghum, yam, cocoa yam and ginger (Kure, 2007).

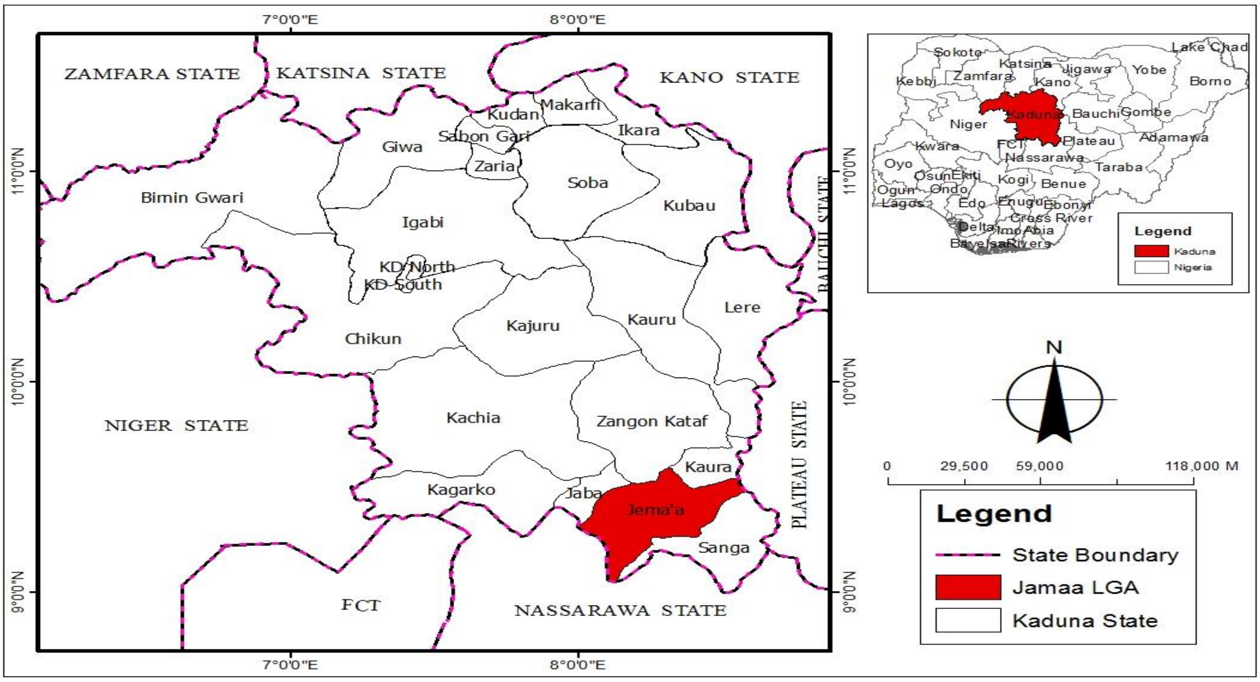

Figure 1: Map of Nigeria showing the study area

3. Materials and Methods

3.1 Source and Type of Data

The study design involved the collection and analyses of rainfall and temperature data (1981 -2014) for Kafanchan metrological station, Jema'a LGA of Kaduna State and yield data for Ginger (1990 – 2016). Yield data for ginger tons/ha (1990 – 2016) were also sourced and used. Available literature such as journals, textbooks, conference proceedings, seminar papers, thesis, reports and web references were consulted for the literature and properly referenced.

3.2 Test for Normality

The standardized coefficient of Skewness (Z_1) and Kurtosis (Z_2) statistics as defined by Brazel and Balling (1986) were calculated for testing the normality of the annual rainfall series (1981-2014). These statistics were used to test the null hypothesis that the individual temporal samples came from a population with a normal (Gaussian) distribution. If the absolute value, Z_1 or Z_2 is greater than 1.96, a significant deviation from the normal curve is indicated at 95% confidence level or at 0.05 significance level. Any value outside the normal curve is judged to be abnormal. The Microsoft Excel package was used to accomplish this.

3.3 Climatic Characteristics

The rainfall data obtained from the meteorological station for 34 years (1981–2014) was added for each of the years beginning from January to December to give the TAR received in Jema'a LGA. The long-term mean was determined by summing all annual rainfall records and dividing by the number of years. The Standard deviation explains the measure of dispersion of rainfall values from the mean. The mean was subtracted from each of these rainfall values and the sum of their squared differences divided by number of rainfall years. The square root of the result gives the Standard deviation. The Coefficient of Variation equals the standard deviation divided by long-tern mean multiplied by 100. The annual mean temperature was obtained by summing up all the monthly temperatures for each of minimum and maximum temperatures and dividing by the number of months in a year. The monthly mean temperature was derived from the addition of each month from 1981–2014 and dividing it by the number of years (34 years).

3.4 Determination of Onset, Cessation and Length of Rainy Season

Various methods abound for characterizing the climate of an area (determination of onset dates, cessation dates and length of the rainy season), for example, Walter (1967), Ilesanmi (1972), Kowal and Knabe (1972), Stern, Dennett and Dale (1982); Stern and Coe (1982); Olaniran (1984 and 1988), Sivakumar (1988) and Adefolalu (1993). Walter's (1967) method remains the best method for determining the onset and cessation dates of rains and LRS and adopted for this study because according to Ati (1996) and Sawa and Adebayo (2011), it has better coverage, it is more scientific and reliable in the semi-arid regions in determining the onset dates, cessation dates and LRS.

Several approaches have been developed over the years for characterizing the climate of an area, but this research adopted Walter's (1967) method. According to Walter (1967), onset date of rain is the product of the number of days in the month from January whose cumulative rainfall is greater than or equal to 51mm and the difference between 51 and the total amount of rainfall in the preceding month divided by the total amount of rainfall in the month with cumulative rainfall greater than or equal to 51mm, mathematically expressed as:

$$\text{Onset date} = Ndx\left(\frac{51\text{mm}-\text{TRA}}{\text{TRx}}\right)$$

Where;

Ndx = number of days in the month from January whose cumulative rainfall is ≥51 mm.

TRA= total rainfall in the month preceding the month with cumulative rainfall ≥51mm.

TRx = total rainfall in the month with cumulative rainfall ≥51mm.

Fifty – one millimetres of rainfall are used as the threshold because it is the required amount of the available moisture necessary for effective germination, growth and development of crops.

According to Walter (1967), cessation date of rain is determined in a similar way with the onset but in a reverse order. It is the product of the number of days in the month from December whose cumulative rainfall is greater than or equal to 51mm and the difference between 51 and total rainfall of the month before the month whose number is greater or equal to 51 mm divided by the total amount of rainfall in the month whose cumulative rainfall ≥51 mm. This value is subtracted from the total number of days in the month whose cumulative rainfall ≥51 mm.

Cessation date = $Ndx\left(\frac{51\text{mm}-\text{TRA}}{\text{TRx}}\right)$

Where;

Ndx = number of days in the month from December whose cumulative rainfall is greater than or equal to 51 mm

TRA = total rainfall in the month before the month with greater than or equal to 51 mm from December

TRx = total rainfall of the first month with cumulative rainfall greater than or equal to 51 mm.

At the end, the answer obtained is subtracted from the number of days in the month with the cessation date. Walter (1967) further explained the LRS as the number of days between the onset date of the rains and the cessation date of the rains.

3.5 Relationship between climate and ginger yield

The Pearson's Product Moment Correlation coefficient (***r***) was computed to see if there was any significant relationship between climate using Total Annual Rainfall (TAR) and Annual mean temperature data (independent variables, **X**) on ginger yields (dependent variable, **Y**) from 1990 – 2014. It is a form of linear regression analysis used to ascertain the strength or index of crop-climate relationship. Pearson was employed because the distribution is bivariate, continuous and normal. Both ginger yield and climatic data were harmonized by dividing by 100 to avoid bogus figures. The value ***r*** must fall within the ranges of -1≤ 0 ≤ +1. If the values tend towards +1, it indicates a perfect positive relationship but if it tends to -1, a perfect negative relationship has been established. If it is 0, there is no relationship established. All the data were analysed using trend line equations. The results of the analyses are presented in tables, charts and bar graph.

4. Results and Discussions

4.1 General statistics of annual rainfall characteristics for Kafanchan station

Rainfall analysis including amount, intensity and spatial coherence is relevant to agriculture; the dependency of wet sequence or days has become an interesting starting point for agronomically relevant analysis (Ojo and Ilunga, 2018). The annual rainfall series for Kafanchan station from 1981 to 2014 (34 years) were subjected to descriptive statistical analysis and presented in Table 1.

Table 1- Summarized Rainfall Statistics for Kafanchan station (1981-2014).

TAR	Long term Mean	SD (mm)	CV (%)	Max (Year)	Min (Year)	Range (Years)	Z_1	Z_2	Mean Onset Date	Mean Cessation Date	Mean LRS
58810 (mm)	1729.7 (mm)	320.38	18.52	2333.4 mm (1994)	1151.3 mm (1983)	1182.1 mm (11 yrs)	0.294	-0.435	15th April	11th October	178 days

Source: NIMET, *Lagos office and Author's Field work analysis (2020)*

4.1.1 Rainfall normality test

The annual rainfall series for Kafanchan station was subjected to the normality test using the coefficients of Skewness (**Z_1**) and Kurtosis (**Z_2**) as illustrated in Table 1. The results showed that the series was positively skewed (0.294) and had no significant deviation from the normal curve (1.96) at 95% confidence level showing normal distribution of data since the results were below 1.96. However, that of Kurtosis (-0.435) was to the negative

4.1.2 Annual rainfall statistics

The annual rainfall series (1981-2014) for the station for the 34 years was 58810 mm as presented in Table 1. The Standard Deviation (SD) decreased greatly below the Mean. Maximum rainfall within the period reviewed was recorded in 1994 while minimum rainfall was recorded in 1983. The Mean onset and cessation dates occurred in mid-April and early-October respectively. The Mean LRS lasted for almost 6 months (178 days) which appears to be a good omen for farmers. The availability of adequate information on rainfall characteristics of an area is very important to farmers in making vital decision relevant to agricultural practices (Ojo and Ilunga, 2018).

4.1.3 Trends in total annual rainfall (TAR)

The trends in the TAR are presented in Figure 2. The TAR data for the study area was used to describe the pattern of rainfall during the period reviewed and to show the trend in TAR within the period reviewed (1981 – 2014).

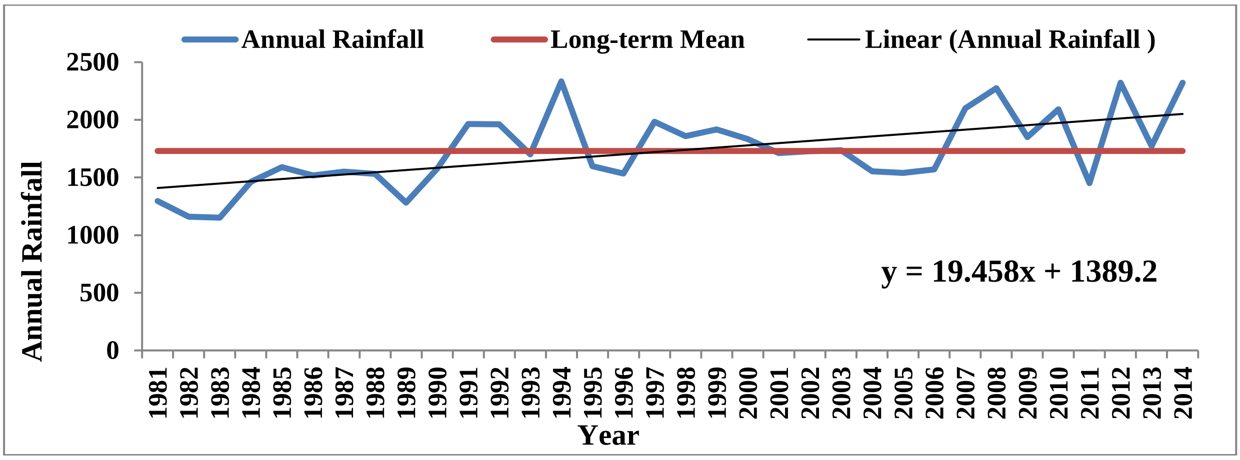

Figure 2 – Trends in Annual Rainfall for Kafanchan Station, Kaduna State (1981-2014)
Source: *Author's fieldwork analysis (2020)*

The trend in annual rainfall series from 1981 to 2014 presented in Figure 2 shows that from 1981-1991, TAR was below the mean but began to steadily rise above normal from 1992 until 1995 when there was a short decline. The TAR rose again and maintained its rise above the mean till 2003 to 2006 and in 2011 to 2012 when it dropped. Generally, this trend explains that the Kafanchan station had suffered rainfall decrease in the 80s but rose above normal in the 90s and fluctuated in the millennium period when the rainfall experienced became appreciable. The linear equation for the TAR is y= 19.458x + 1389.2 showing a positive trend line which signifies an above normal scenario, which is favourable for crop production. According to McCarthy, Canziani, Leary, Dokken and White (2001), ginger requires an annual rainfall of 1500mm or more and a rainfall duration well distributed between 8 to 10 months for sustainable and higher yield of ginger, and that any rainfall short of this value will have adverse effect on the yield of ginger.

That there is a positive increase in the trend of TAR coincided with the findings of Sawa

(2010) and Nnachi (2014) which reported that most parts of northern Nigeria experienced increase in rainfall between 1990 and 2000. This result further corroborated with the findings of Ogunrayi, Akinseye, Goldberg and Bernhofer (2016) which reported that rainfall in Akure, Nigeria is characterized by alternating wet and dry periods with a tendency towards a wetter condition, which implies an increase in the TAR and LRS. According to Olaniran (2001), Nigeria is characterized by alternating wet and dry conditions with rainfall anomaly showing wetter than normal rainfall conditions. More so, that the TAR of the study area is increasing is in agreement with the observation made by Building Nigeria's Response to Climate Change (BNRCC, 2011) which reported that Nigeria is now experiencing wetter conditions in recent years. These results agree with the work of (Ojo and Ilunga 2018) that rainy period in a tropical location can fluctuate in length, time of occurrence, and severity. Ati, Stiger, Iguisi and Afolayan (2009) who stated that evidence from nine stations in northern Nigeria, shows that there is a significant increase in annual rainfall amount in the last decade support this result.

4.1.4 Trend in annual temperature

Trend in annual temperature is presented in Figure 3. To describe the pattern of temperature during the period reviewed, the minimum and maximum temperature data for the study area was used to show the trend of annual temperature within the period reviewed (1981 – 2014).

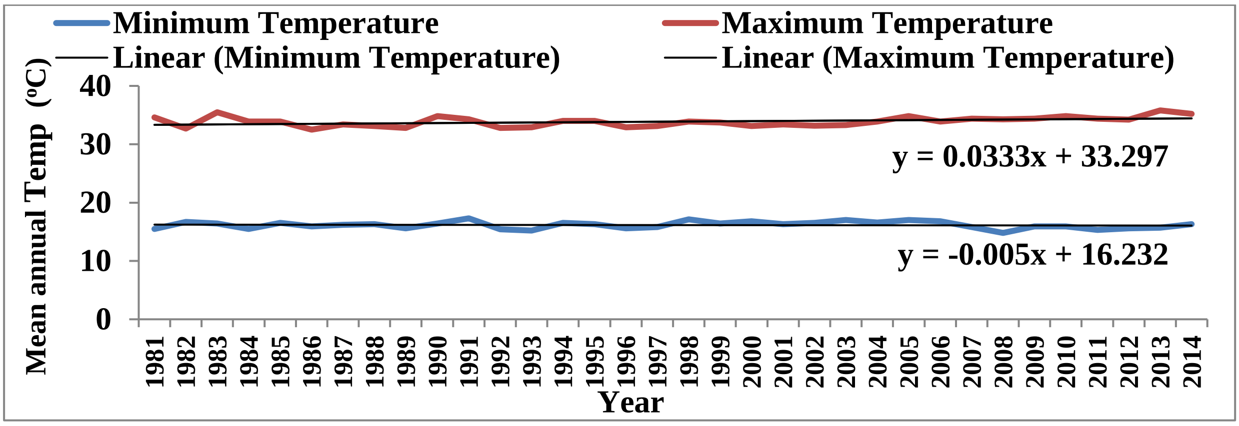

Figure 3 – Trends in Mean Annual Temperature for Kafanchan Station (1981-2014)
Source: *Author's fieldwork analysis (2020)*

Trends in Mean annual minimum and maximum temperature for the station from 1981-2014 are presented in Figure 3. The graph showed a near normal data for both minimum and maximum temperature, although the trend line for minimum temperature was to the negative (y = -0.005x + 16.232) while that of maximum was to the positive (y = 0.0333x + 33.297). This implies that there is an increase in temperature of the study area within the period reviewed. Trenberth, Jones, Ambenja, Bojariu, Easterling and Zhai (2007) reported that there is a general concern that global temperatures and sea level are rising and will continue to rise throughout 21st century and that temperatures at the surface have risen globally, with regional variations. Ogunrayi, Akinseye, Goldberg and Bernhofer (2016) in their study "Descriptive Analysis of Rainfall and Temperature Trends over Akure, Nigeria reported that temperature rises during the dry periods (November – March) and gradually cools at the approach of the wet season. The result is further supported by the findings of Odjugo (2010) which reported an increase by

1°C in the temperature of Nigeria from 1940 to 2010.

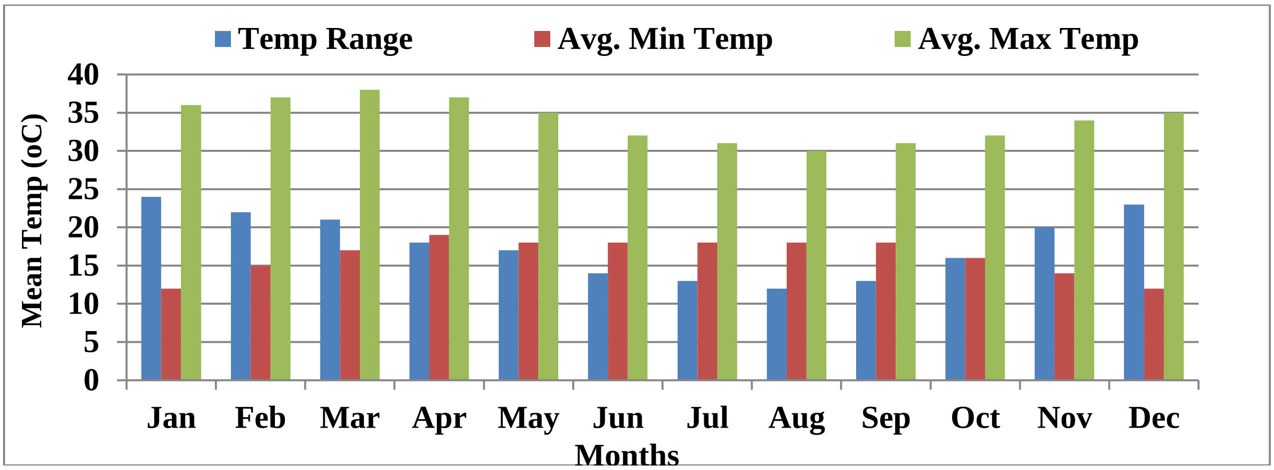

Figure 4 – Monthly Mean Temperature (˚C) for Kafanchan Station (1981-2014)
Source: *Author's field work analysis (2020)*

Figure 4 shows the monthly mean temperatures for Kafanchan station from 1981 to 2014. The highest mean maximum temperature was recorded in the month of March while the lowest mean minimum temperature was in the months of January and December. This corresponds with Ayoade's (1982) report which stated that the climate of the tropics is characterized by two distinct seasons, hot and rainy season between April and October and the cold, dry harmattan season between November and March. Based on the monthly temperature range between maximum and minimum, it shows that the average temperatures appeared to be higher at the beginning and end of the year but dropped at the middle of the year in the study area.

4.1.5 Relationship between Rainfall and Temperature

Figure 5 shows the relationship between two climatic variables, rainfall and temperature of Kafanchan station from 1981-2014. As the rainfall bar graph increased in the months of July, August and September, the line graphs for mean maximum and minimum temperature reduced in the same months and vice versa. Average maximum temperatures ranging from 30-33^{0}C induced high rainfall of 320-350 mm in the months of July, August and September. This coincides with the rainy season condition in most northern parts of Nigeria according to Ayoade (1982).

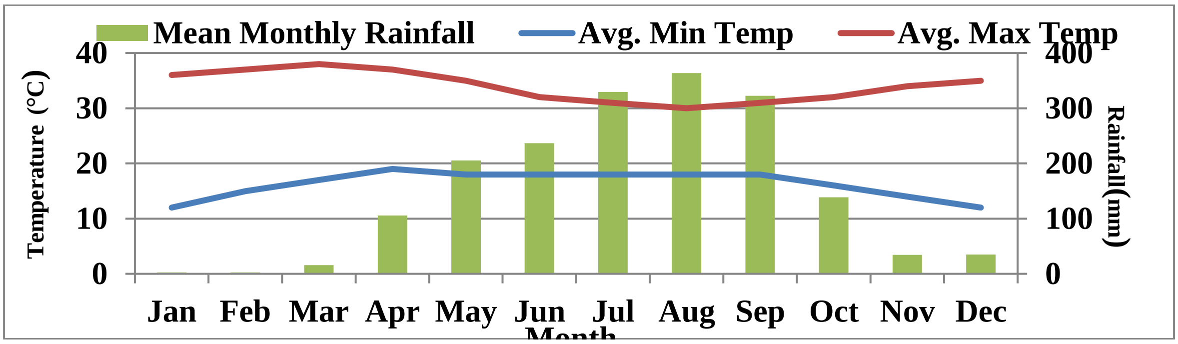

Figure5: Relationship between Rainfall and Temperature for Kafanchan Station
Source: *Author's Fieldwork analysis (2020)*

4.1.6 Determination of Onset Dates, Cessation Dates and Length of Growing Season

The precise onset and cessation dates as well as the amount and the distribution of rainfall each year are usually some of the needs of agriculturists to ensure that they realize a bumper harvest of crops. The information is strongly dependent on the unique characteristics of high seasonal, monthly, and daily variability in its moisture content and the vertical depth. Therefore, the onset, cessation dates, and Length of Rainy Season (LRS) as well as the amount and the distribution of rainfall each year could show high variability in subsequent years (Ojo and Ilunga, 2018). The Onset dates, Cessation dates and LRS for Kafanchan LGA are presented in Table 2.

Table 2: Derived Precipitation Characteristics for Kafanchan Station (1981 - 2014)

Year	Onset Dates	Julian Days	Cessation Dates	Julian Days	LRS
1981	Apr-08	98	Oct-02	275	117 days
1982	Apr-16	106	Sep-07	250	144 days
1983	May-04	124	Oct-25	298	174 days
1984	May-02	123	Oct-10	283	160 days
1985	Apr-02	92	Oct-22	295	203 days
1986	Apr-23	113	Nov-27	331	218 days
1987	May-21	141	Nov-27	331	190 days
1988	Apr-02	93	Sep-02	275	182 days
1989	Apr-04	94	Oct-15	288	194 days
1990	Apr-12	102	Oct-12	285	183 days
1991	Apr-06	96	Oct-15	288	192 days
1992	May-10	131	Oct-04	277	146 days
1993	May-01	121	Oct-09	282	161 days
1994	Apr-04	94	Oct-04	277	183 days
1995	Apr-15	105	Oct-10	283	178 days
1996	May-01	122	Oct-07	280	158 days
1997	Apr-07	97	Oct-08	281	184 days
1998	Apr-29	119	Oct-13	286	167 days
1999	Mar-16	75	Oct-12	285	210 days
2000	Apr-07	98	Oct-12	285	187 days
2001	Apr-13	103	Oct-02	275	172 days
2002	Apr-09	99	Oct-10	283	184 days
2003	Apr-09	99	Oct-05	278	179 days
2004	Apr-11	102	Sep-08	251	149 days
2005	Apr-17	107	Oct-12	285	178 days
2006	Apr-16	106	Oct-10	283	177 days
2007	Apr-05	95	Oct-14	287	192 days
2008	Apr-04	95	Oct-12	285	190 days
2009	Apr-10	100	Oct-05	278	178 days
2010	Apr-01	91	Oct-06	279	188 days
2011	May-03	123	Oct-23	296	173 days
2012	Apr-19	110	Oct-06	279	169 days
2013	Apr-08	98	Oct-18	291	193 days
2014	Apr-09	99	Oct-07	280	181 days

Source: *Author's Fieldwork analysis (2020)*

Table 2 shows that the onset of the rainy season for the 34 years' period fell between March 16th (1999) and May 21st (1987) while the cessation dates were between September 2nd (1988) and November 27th (1986 and 1987). The LRS lasted between four to seven months with the highest LRS recorded in 1986 (218 days) followed by 1999 (210 days) while the shortest duration was recorded in 1981 (117 days).

4.1.7 Trends in Onset Dates at Kafanchan Station

Trends in onset dates of rainy season for Kafanchan station are presented in Figure 6.

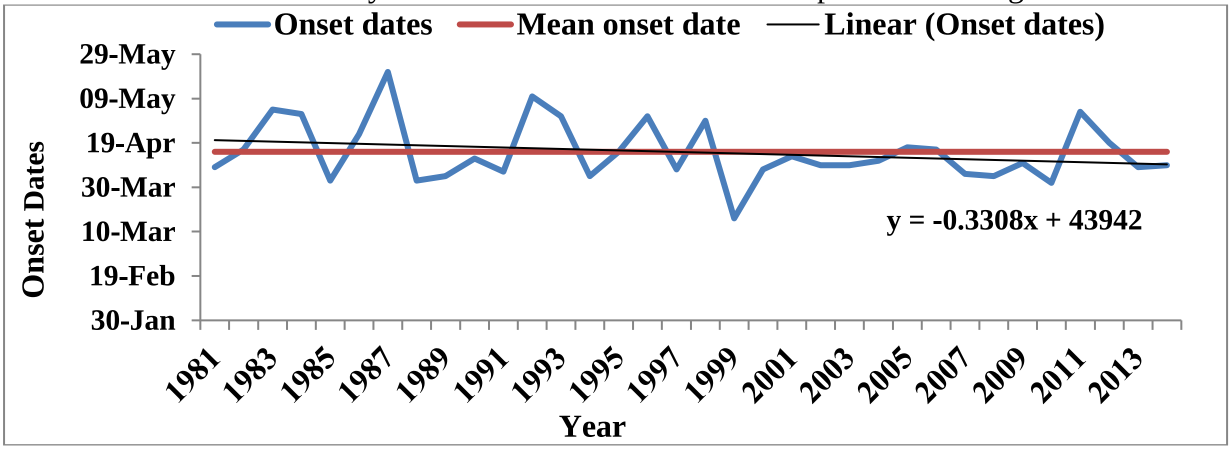

Figure 6 – Trends in Rainfall Onset Dates in Kafanchan station (1981-2014)
Source: Author's fieldwork analysis (2020)

Figure 6 showed noisy fluctuations in the onset dates between 1981 and 2014. It also showed early onset of the rainy season in the study area which means that the rain is now coming early as indicated by the trend line equation y = -0.3308x + 43942. The mean onset date is 15th April, which is early enough for farmers to start planting especially farmers who depend on the early rains for plant germination, growth and optimal yield. Figure 6 further indicates that the rains started with early onset dates below the mean, which continued in a fluctuating pattern above and below normal until the end of the data towards the same early onsets. That the rain is now coming early is in agreement with the findings of Ekoh (2020) which stated that rainfall is now coming early (early onset dates) in Sokoto State, Nigeria. The result of early onset disagrees with the study of Ikpe, Sawa and Ejeh (2017) which reported late onset dates and frequent agricultural drought in Sokoto State, Nigeria.

4.1.8 Trends in Cessation Dates at Kafanchan Station

The linear trend and trend line equation for the cessation dates of rainfall is shown in Figure 7 for Kafanchan station. The Cessation dates were plotted against years.

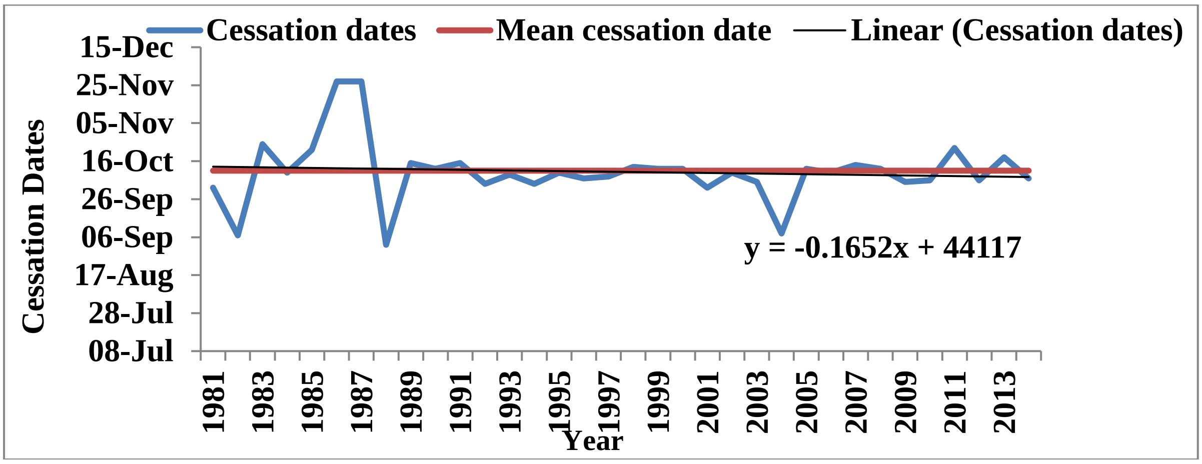

Figure 7 – Trends in Cessation dates of Daily Rainfall in Kafanchan Station (1981-2014)
Source: *Author's Fieldwork analysis (2020)*

Figure 7 shows that the cessation dates of rainfall are characterized by marked 'noise' (variability) from 1981 to 1989 but showed almost normal condition until 2014. The mean cessation date is early on October 11th. Figure 5 clearly indicates an increasing trend in cessation dates as the trend line equation (y = -0.1652x + 44117) is negative. This means that rainfall cessation date comes relatively early. The implication of this result is that early cessation of rainfall may affect the yield of ginger especially when it is in its fruiting stage. This is not good for farmers in the study area, as some crops may not have adequate moisture for later stage development. That there is an early cessation of rainfall in Kafanchan station agrees with the findings of Ikpe, Sawa and Ejeh (2017) which reported early cessation of rainfall in Sokoto State, Nigeria. This result disagrees with the study of Ekoh (2020) which reported that cessation date of rainy season in Sokoto is significantly increasing.

4.1.9 Trends in Length of Rainy Season (LRS)

Figure 8 depicts the linear trend and trend line equation for the LRS.

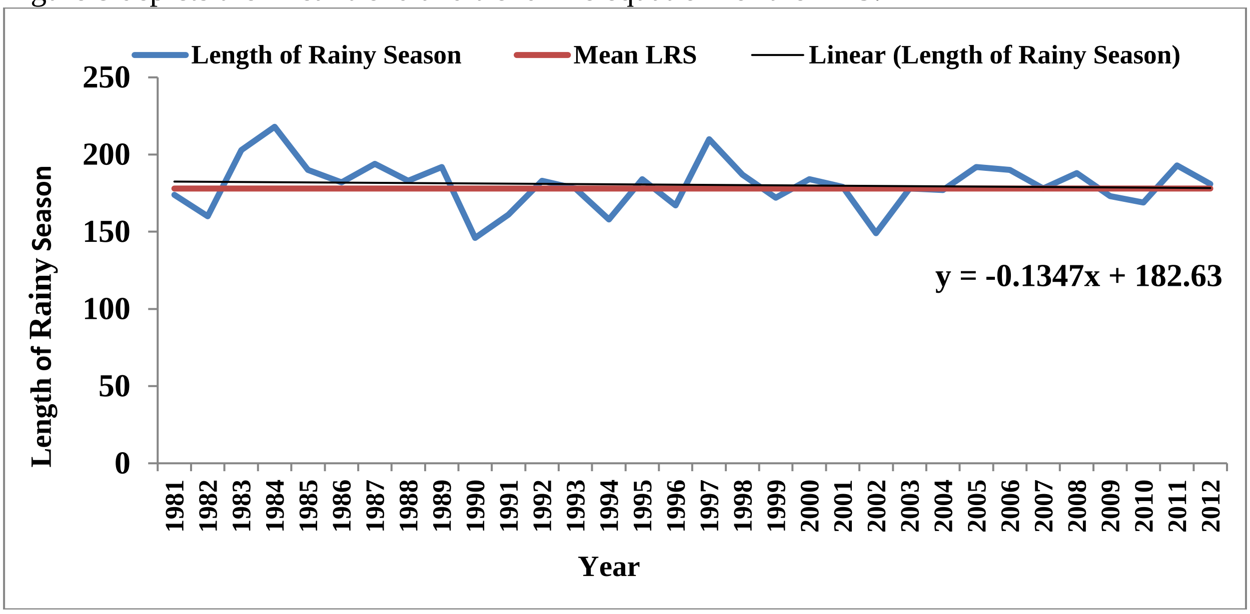

Figure 8 – Trends in Length of Rainy Season in Kafanchan, Kaduna State (1981-2014)
Source: *Author's Fieldwork analysis (2020)*

Figure 8 shows a downward negative trend line equation of y= -0.1347x + 182.63, which indicates shortening of the growing season. The mean LRS was 178 days or about 6 months. However, this confirms to the marked yearly 'noises' on the trend line. The decreasing LRS is owing to the fact that the mean onset date is early (15th April) and the mean cessation date is early (October 11th). Hence, the early onset and early cessation dates imply that there are shorter days in LRS. That the LRS in Kafanchan station is decreasing agrees with the result of Sawa, Adebayo and Bwala (2014) which indicated that the hydrological growing season of Kano State is progressively shortening.

4.2 Trends in Ginger Yield Pattern

So far, the climate of Jema'a LGA, using Kafanchan meteorological station has been characterised to have early onset and early cessation, hence, a shortening growing season which may not be favourable to agricultural activities and by extension ginger production in the study area without viable adaptation strategies. According to Odjugo (2010) shift and frequent changes in the onset and cessation dates of the rainy season has significant implications for agriculture in the savannah region of Nigeria. Figure 9 depicts the linear trend and trend line equation for the yield of ginger (tons/hectare) from 1990 to 2016.

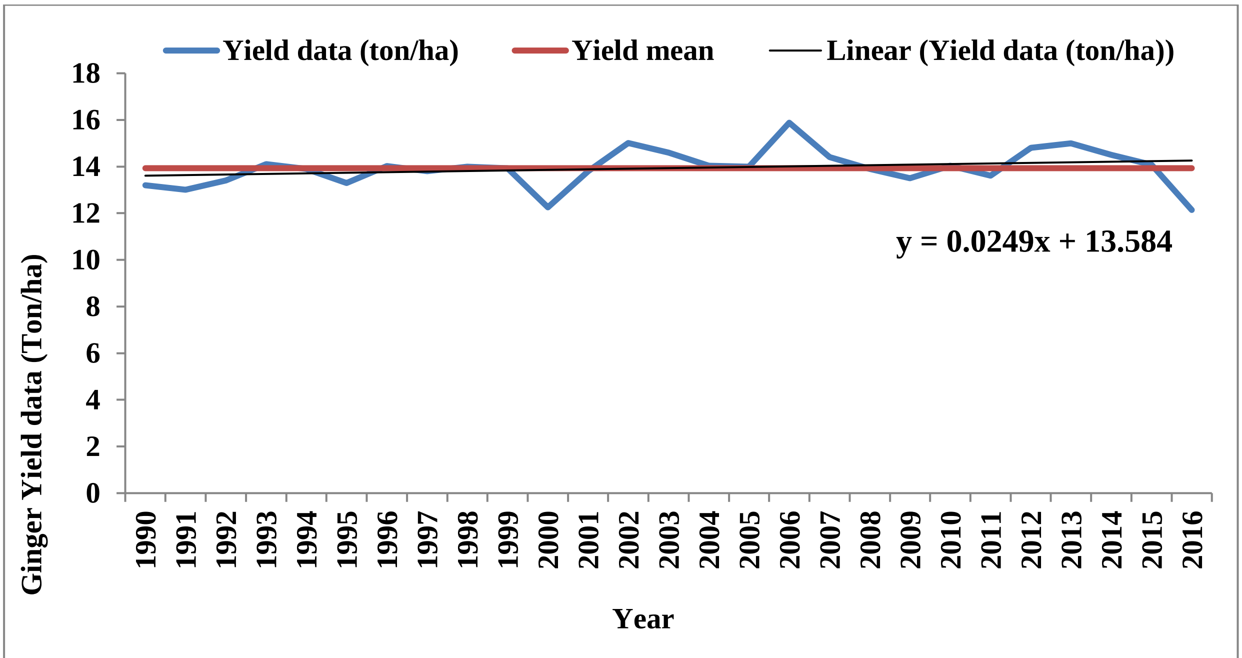

Figure 9– Trends in Ginger yield pattern for Kafanchan Station (1990-2016)
Source: *Author's Fieldwork analysis (2020)*

Figure 9 indicates an increasing trend in ginger yield (ton/ha) in the study area with the trend line equation y = 0.0249x + 13.584. The graph shows a near normal trend in the yield of ginger. The highest yield (tons/hectre) was recorded in 2006 and the lowest yield was recorded in 2016. That there is an increase in the yield of ginger in the study area agrees with the findings of Atiyong, Abaje and Abdulkarim (2018) who reported increase in the yield of ginger at Jaba LGA of Kaduna State, Nigeria.

4.3 Relationship between TAR and the yield of Ginger:

The Pearson's moment correlation coefficient (r) was used to show the relationship between TAR and annual mean temperature on the yield of ginger in Kafanchan. The relationship between climate and ginger yield from 1990 to 2014 are presented in Table 3. The independent variable (X_1- values) is for TAR, (X_2- values) is for Annual mean temperature while Ginger Yield is the dependent variable (Y-values), since climatic variables affect yield.

Table 3: Computation of Relationship between TAR and yield in Ginger

Year	Total Annual Rainfall (X_1) (cm)	Annual Mean Temp (X_2) (ºC)	Ginger Yield (Y) (Tons/ ha)	$X_1 - x_1$	$X_2 - x_2$	Y - y	$(X_1-x_1)(Y-y)$	$(X_2-x_2)(Y-y)$	$(X_1-x_1)^2$	$(X_2-x_2)^2$	$(Y-y)^2$
1990	15.76	18.4	13.2	-2.75	0.59	-0.8	2.2	-0.47	7.56	0.35	0.64
1991	19.63	17	13.01	1.12	-0.81	-0.99	-1.11	0.80	1.25	0.66	0.98
1992	19.62	17.4	13.4	1.11	-0.41	-0.6	-0.67	0.25	1.23	0.17	0.36
1993	17	17.7	14.1	-1.51	-0.11	0.1	-0.15	-0.01	2.28	0.01	0.01
1994	23.33	17.5	13.9	4.82	-0.31	-0.1	-0.48	0.03	23.23	0.10	0.01
1995	15.99	17.7	13.3	-2.52	-0.11	-0.7	1.76	0.08	6.35	0.01	0.49
1996	15.35	17.3	14.02	-3.18	-0.51	0.02	-0.06	-0.01	10.11	0.26	0.0004
1997	19.84	17.3	13.8	1.33	-0.51	-0.2	-0.27	0.10	1.77	0.26	0.04
1998	18.57	16.8	14	0.06	-1.01	0	0	0	0.0036	1.02	0
1999	19.16	17.3	13.92	0.65	-0.51	-0.08	-0.05	0.04	0.42	0.26	0.0064
2000	18.32	16.3	12.25	-0.19	-1.51	-1.75	0.33	2.64	0.036	2.28	3.06
2001	17.11	17.1	13.8	-1.4	-0.71	-0.2	0.28	0.14	1.96	0.50	0.04
2002	17.29	16.7	15.01	-1.22	-1.11	1.01	-1.23	-1.12	1.49	1.23	1.02
2003	17.35	16.3	14.6	-1.16	-1.51	0.6	-0.7	-0.91	1.35	2.28	0.36
2004	15.54	17.3	14.03	-2.97	-0.51	0.03	-0.09	-0.02	8.82	0.26	0.0009
2005	15.41	17.8	14	-3.1	-0.01	0	0	0	9.61	0	0
2006	15.7	17.1	15.88	-2.81	-0.71	1.88	-5.28	-1.34	7.9	0.50	3.53
2007	20.99	18.6	14.41	2.48	0.79	0.41	1.02	0.32	6.15	0.62	0.17
2008	22.75	19.5	13.9	4.24	1.69	-0.1	-0.42	-0.17	17.98	2.86	0.01
2009	18.49	18.5	13.5	-0.02	0.69	-0.5	0.01	-0.35	0.0004	0.48	0.25
2010	20.91	18.9	14.04	2.4	1.09	0.04	0.1	0.04	5.76	1.19	0.0016
2011	14.51	19.1	13.61	-4	1.29	-0.39	1.56	-0.50	16	1.66	0.15
2012	23.21	18.6	14.8	4.7	0.79	0.8	3.76	0.63	22.09	0.62	0.64
2013	17.71	20.1	15	-0.8	2.29	1	-0.8	2.29	0.64	5.24	1
2014	23.22	18.9	14.5	4.71	1.09	0.5	2.36	0.55	22.18	1.19	0.25
Total	**462.76**	**445.2**	**349.98**				**2.07**	**3.01**	**176.17**	**24.01**	**13.02**

Source: *Author's fieldwork analysis (2020)* *Significant at alpha = 95% confidence level*

$\sum \mathbf{X_1} = 462.76$

$\sum \mathbf{X_2} = 445.2$

$\sum \mathbf{Y} = 349.98$

$x_1 = {}^{\Sigma X_1}/_{n} = {}^{462.76}/_{25} = 18.51$

$x_2 = {}^{\Sigma X_2}/_{n} = {}^{445.2}/_{25} = 17.81$

$y = {}^{\Sigma Y}/_{n} = {}^{349.98}/_{25} = 14.00$

$\sum (\mathbf{X_1} - x_1)(Y - y) = 2.07$

$\sum (\mathbf{X_2} - x_2)(Y - y) = 3.01$

$\sum (\mathbf{X_1} - x_1)^2 = 176.17$

$\sum (\mathbf{X_2} - x_2)^2 = 24.01$

$\sum (\mathbf{Y} - y)^2 = 13.02$

$r_1 = {}^{2.07}/_{\sqrt{176.17 \times 13.02}}$

$r_1 = {}^{2.07}/_{47.89}$

$\boldsymbol{r_1 = 0.043}$ **(for rainfall)**

$r = {}^{3.01}/_{\sqrt{24.01 \times 13.02}}$

$r = {}^{3.01}/_{17.68}$

$\boldsymbol{r = 0.17}$ **(for temperature)**

Table 3 displays the computation of the Pearson's Product Moment Correlation coefficient (***r***) calculated for both TAR and average temperature on ginger yield. The result shows that there existed a positive relationship of the both climatic elements on the yield of ginger. The results (r_1=0.043 and r_2=0.17) indicated that there was a positive though imperfect relationship between ginger yield and climatic elements records from 1990 to 2014. The trend line equation for TAR (Fig.2), maximum temperature (Fig.3) and Ginger yield (Fig.9) were all positive. This shows that an increase in climate also increased the outcome of ginger yield and production within the study area. According to Dammo, Abubakar and Sangodoyin (2015), declining rainfall has adverse effect on water resources and agricultural output. Availability or non-availability of rainfall, which determines the level of wetness or dryness during the growing season, makes rainfall the single most important element of climate affecting agriculture and water management in any region (Olatunde, 2012). This result agrees with the findings of Atiyong, Abaje and Abdulkarim (2018) which reported a strong positive relationship (r=0.606) between ginger yield and rainfall amount in Jaba LGA of Kaduna State, Nigeria. The implication of this result means that, any change in the rainfall amount received in the study area will have a significant effect on the yield of ginger in the study area.

5. Conclusion

The importance of adequate analysis of climatological data cannot be overemphasized as it helps in making vital decision relevant to agricultural practices. This study has examined the climatic characteristics of Jema'a LGA and its implication on the yield of ginger. The study has established that the TAR made meaningful increases in the study area from the 1990s to the end of the data but the 1980s were characterised by drought years. The trend line equation was positive for TAR. For Annual temperatures, the maximum temperature graph recorded positive trend lines than the minimum. The onset dates, cessation date and LRS all showed negative trend line equations which means early onset dates, early cessation dates and shorter days of LRS which can affect the yield of ginger in the study area. There was a positive but imperfect correlation between TAR and ginger yield pattern and their trend line equations were positive meaning, higher TAR leads to higher yields in ginger production within the study area. Increase in the yield of ginger within the period reviewed was also recorded. However, the implication is that declining rainfall due to early onset and cessation dates will lead to poor yield in ginger production. This may not be a good omen for commercial ginger farmers in the study area owing to the economical and medicinal importance of the crop.

6. Recommendations

Based on the findings of the study, the following recommendations were made;

i. Continuous updating of climatic and yield data and monitoring of climatic trends in the study area will boost the production of ginger in the study area.
ii. The fluctuating and unpredictable nature of the climatic season characterized by early onset, cessation dates and short LRS coupled with temperatures irregularities explains why ginger must be planted early enough.
iii. Adoption of viable adaptation strategies such as crop rotation, shifting cultivation, application of organic and inorganic fertilizer, terracing, improved ginger seedlings etc. will help to retain soil fertility for bumper ginger harvest
iv. Largescale irrigation development schemes should be developed by the government and NGOs to intensify

agriculture especially for ginger. Water for irrigation should be supplied from dams, boreholes and reservoirs.

v. Public enlightenment of the farmers especially ginger farmers by agricultural extension workers on the impact of climate change in the study area for better planning and land preparation before the planting season.

References

Adefolalu, D. O. (1993). World Meteorological Organization. Lecture Series 1: 1-4.

Ajibade, L., Kand, Y. (2005). Ginger Plant; Ginger Extension Pamphlet. Bennard Ginger Company, Kafanchan, Nigeria.

Ati, O. F. (1996). A comparison of Methods to Detect the onset of Growing Season and its Trends for some Stations in the Sudan Savanna in Northern Nigeria. M.Sc, Thesis, Department of Geography, Ahmadu Bello University, Zaria. http//doi/abs/10.1002/joc.712

Ati, O. F. (2006). Rainfall Characteristic in Drought-Prone Sudano-Sahelian Zone of Nigeria. Unpublished Ph.D Dissertation. Department of Geography, Ahmadu Bello University, Zaria, Nigeria.

Ati, O. F., Stiger, C. J., Iguisi, E. O. and Afolayan, J. O. (2009). Profile of Rainfall Changes and variability in the Northern Nigeria, 1953 - 2002. Journal of Environmental and Earth Sciences, 1(2), 58 -63.

Atiyong, B. R., Abaje, I. B. and Abdulkarim, B. (2018). Effect of Rainfall Variability on the Sustainability of Ginger Yield in Jaba Local Government Area of Kaduna State, Nigeria, FUDMA Journal of Sciences (FJS) 2(1) 171-177.

Ayoade, J. O. (1983). Introduction to Climatology for the Tropics, Wiley Chichester Publishers, 258.

Brazel, S. W. and Balling, R. C. (1986). Tropical Analysis of Long-term atmospheric moisture levels in Phoenix and Arizona. Journal of Climate and Applied Meteorology. Vol. 25. pp. 112-117.

Building Nigeria's Response to Climate Change, BNRCC. (2011). National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN). Climate Adaptation Strategy Technical Reports, Ibadan, Nigeria.

Dammo, M. N, Ibn Abubakar, B. S. U and Sangodoyin, A. Y. (2015). Quantitative Analysis of Rainfall Variations in North- Eastern Region of Nigeria. *Journal of Agricultural and Crop Research* 3(5), pp. 67-72.

Dempewolf, H., Eastwood, J. R., Guarino, R., Khoury, C. K., Müller, J. V. and Toll, J. (2014). Adapting Agriculture to Climate Change: A Global Initiative to Collect, Conserve and use of crop Wild Relatives.

Ekoh, H. C. (2020). Analysis of Rainfall Trend in Sokoto State, Nigeria (1987-2016), Journal of World News of Natural Sciences, 28: 171-186.

Food and Agricultural Organization (FAO) (1986). Early Agrometeorological Crop Yield Assessment. *Plant Production and Protection*. Paper 73. FAO, Rome, 1986, pp. 114–123.

Guarino, L. and Lobell, D. B. (2011). A Walk on the Wild Side. *Nature Climate Change*, 1:374-375.

Ikpe, E., Sawa, B. A. and Udeh, E. L (2017). Evidence of Climate Change and Adaptation Strategies in Sokoto State, Nigeria. IORS Journal of Environment, 2(1) 17-23.

Ilesanmi, O. O. (1972). An Empirical Formulation of the Onset, Advance and Retreat of Rainfall in *Nigerian Journal Tropical Geography*, 34: 17-24.

Kaduna State Ministry of Agriculture (2007). A Survey Report on Ginger

Production. Kaduna State Agricultural Development Project, Zone IV, MOA, Kaduna 110.

Kowal, J. M. and Knabe, D. T. (1972). An Agro-climatic Atlas of Northern States of Nigeria. Ahmadu Bello University Press, Zaria, pp: 111.

Kure, S. T. (2007). The Prospects of Ginger Production in Jaba Local Government Area Kaduna State, Nigeria. Unpublished HND Project, College of Agriculture, DAC/ABU Zaria.

Lobell, D. B., Sibley, A. and Ivan Ortiz-Monasterio, J. (2012). Extreme Heat Effects on Wheat Senescence in India. *Nature Climate Change*, 2:186–189.

McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J., and White, K. S. (2001). Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change

National Population Commission, NPC. (2009). National Population Commission Census Report, Federal Republic of Nigeria.

National Agricultural Extension Research and Liaison Services (NEARLS) (2004). Prospects and Problems of the 1996 Cropping Season. A report of a study conducted by the National Agricultural Extension Research and Liaison Services (NEARLS) and Agricultural Planning Monitoring and Evaluation Unit (APMEU), 2-3 Oct. (NEARLS), Ahmadu Bello University, Zaria: 62.

Nnachi, S. U. (2014). *Vulnerability Assessment and Adaptive Strategies of grain Farmers to Climate change in Shinkafi Local Government Area, Zamfara State, Nigeria.* A Published M.Sc. Thesis, Geography Department, ABU, Zaria.

Odjugo, P. A. (2010). Regional Evidence of Climate Change in Nigeria. Journal of Geography and Regional Planning. 3(6):142-150.

Ogunrayi, O. A., Akinseye, F. M. Goldberg, V. and Bernhofer, C. (2016). Descriptive Analysis of Rainfall and Temperature Trends over Akure, Nigeria. Journal of Geography and Regional Planning, 9(11): 195-202.

Ojo, O. I. and Ilunga, M. F. (2018). Application of Nonparametric Trend Technique for Estimation of Onset and Cessation of Rainfall. Journal of Air, Soil and Water Research, 11: 1-4.

Olaniran, O. (2001). Rainfall Anomalies in Nigeria: The Contemporary Understanding. Ilorin, Nigeria: Department of Geography, University of Ilorin.

Olaniran, O. J. (1984). The Onset of Rains and the Start of the Growing Season in Nigeria. *Nigerian `Geographical Journal*, 34: 17-24.

Olaniran, O. J. (1988). The Distribution in Space of Rain Days of Rainfall of Different Amounts in the Tropics; Nigeria as a case study. *Geoforum*, 19(4): 507-520.

Olatunde, A. F. (2012). The Intensity of Wet Years in the Sudano-Sahelian Region of Nigeria between 1941 and 2008. *Cont. Journal of Environmental Science*, 6(2):44-53.

Purseglove, J. W. (1976). Tropical Crops, Dicotyledons (pp. 1-719). Longman Group Limited, London.

Sawa, B. A. (2010). Climate Change and Spatio-temporal Variability in Occurrence of Dry Spells in Northern Nigeria. IN: - *The Zaria Geographer*. Geography Dept. ABU-Zaria. Vol.18, No. 1, 2010. pp 23.

Sawa, B. A. and Adebayo, A. A. (2011). The Impact of Climate Change on Precipitation Effectiveness Indices in Northern Nigeria. *Research Journal* *of Environmental and Earth Sciences* 3(5): 481-486, 2011.

Sawa, B. A., Adebayo, A. A. and Bwala, A. A. (2014). Dynamics of Hydrological Growing Season at Kano as Evidence of Climate Change. *Asian Journal of Agricultural Sciences 6(2): 75-78.*

Sivakumar, M. V. K. (1988). Predicting Rainy Season Potential from the Onset of the Rains in Southern Sahelian and Sudanian Climate Zones of West Africa. Agric. *Forest Meteorology* 42: 295-305.

Stern, R. D. and Dale, I. C. (1982). Statistical Methods for Tropical Drought Analysis based on Rainfall Data. Project AZ1: A Report on data requirements for estimating the likelihood of droughts. WMO Programme Res. *Tropical Meteorology*, (PRTM), 35.

Stern, R. D., Dennett, M. D. and Dale, I. C. (1982). Analysing Daily Rainfall Measurements to give Agronomically Useful Results II: A modelling Approach: *Experimental Agriculture*, 18: 237-253.

Trenberth, K. E, Jones, P. D, Ambenje, P, Bojariu, R, Easterling, D, Klein Tank, A, Parker, D, Rahimzaden, F., Renwick, J.A. Rusticucci, M., Soden, B., and Zhai, P. (2007) Observation: Surface and Atmospheric Climate Change. In: Solomon, S., Quin, Manning, M, Chen, Z., Marquis, M, Averyt, K.B, Tignor M., and Miller, H.L (Eds). United Kindom and New York, N Y: Cambridge University Press. Retrieved February, 5 2009 from http://www.ipcc.ch/pdf/assessment-report/ar4/wg l/ar4-wg l-chapter2.pdf

Walter, M. W. (1967). Length of the Rainy Season in Nigeria. *Nigerian Geography. J.*, 10:123128.