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EFFECT OF RAINFALL VARIABILITY ON THE SUSTAINABILITY OF GINGER YIELD IN JABA LOCAL GOVERNMENT AREA OF KADUNA STATE, NIGERIA

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ABSTRACT
This study examined the effects of rainfall variability on the sustainability of ginger yield in Jaba Local Government Area of Kaduna State. Rainfall data for 15 years (2001 to 2015) was analyzed in order to establish the pattern of rainfall anomalies in the area. 274 copies of questionnaires were purposively administered to farmers in order to examine their perception on the effects of rainfall variability on ginger yield in the study area. Linear regression was used to determine the linear trends of rainfall and ginger yield, the Standardized Anomaly Index was then used to determine the dry (-ve values) and wet (+ve values) years in the rainfall series. The relationship between rainfall and ginger yield was determined using Pearson's product moment correlation coefficient, while the perceptions of farmers on the effects of rainfall variation on ginger yield was analyzed using descriptive statistics. The study revealed that as the rainfall is increasing, so also is ginger yield increasing. The Standardized Anomaly Index revealed positive and negative anomalies within the period. The study further observed that fluctuation of rainfall does not have an adverse effect on sustainability of ginger yields. The results of the correlation analysis between the annual rainfall amount and ginger yield showed a strong positive monotonic relationship (r= 0.61) between ginger yield and rainfall amount. The study recommends the need for extension agents to sensitize farmers on adjustments of farming calendar to synchronize planting and growing period. Agricultural Research Institutes in the country should develop drought resistant and early maturing variety of ginger.

***Key words**: Anomalies, climate change, communities, farmers, Onset*

INTRODUCTION
United Sates Environmental Protection Agency (USEPA, 2016) stressed that the Earth's climate is changing and the changing is noticeable in world temperature fluctuations and precipitation variability with a worldwide precipitation increased at an average rate of 2.03 mm per decade over the land Area. Evidence is emerging that climate change according to International Panel on Climate Change (IPCC, 2007) is increasing rainfall variability and the frequency of extreme events such as drought, floods and hurricane. Climate variability is now accepted as a serious environmental issue because it is a threat to sustainable development and food security.

Odjugo (2010) described rainfall variability as variations in the mean state and standard variation of the occurrences of extremes of rainfall on all spatial and temporal scales beyond that of individual precipitation events. In Nigeria, changing rainfall patterns have been observed by many researchers notably, Nnaji (2001), Abaje *et al* (2010) among others. They observed an annual change in the occurrences of wet and dry season regimes in Sub-Saharan Africa, annual decadal and inter decadal variations in rainfall and a general decline in rainfall amount in Nigeria. The variability in rainfall which may result in either a decrease or increase in the rainfall trend in different regions of the world have resulted in reduction of water levels or total dry up of some perennials and seasonal rivers and lakes. The consequences are the effect it has on agricultural production and the sustainability of agricultural lands and crop yields. Ayoade (cited in in Aderibigbe 2016) states that agriculture largely depends on climate to function and that precipitation, solar radiation, wind, temperature, relative humidity and other climatic parameters affect and solely determine the global distribution of crops, livestock as well as the productivity and sustainability of agricultural lands.

Rainfall variability as observed by IPCC (2001) is generally difficult for farmers and scientist to predict precipitation pattern. Furthermore, the fluctuation in rainfall pattern as reported by Adejuwon (2004) has put Nigeria's agricultural production under serious threat, since agriculture in Nigeria is mostly rain-fed. This situation would adversely affect the sustainability of the variety of agricultural crops cultivated in Nigeria and notably in Northern Nigeria. One of such rainfall loving crop is ginger a monocotyledonous herbaceous tropical plant belonging to the family *Zingiberaceae.* 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 (McCarthy *et al*., 2001).

Ginger is a crop that is planted between the months of April to May and needs two (2) to four (4) initial watering at an interval of seven days depending upon the type of soil. After this, the crop receives rain and grows on well till the month of September. Subsequently, the crop has to be given watering commencing from middle of October and end of December at 15 days' intervals. Since ginger is cultivated under rain fed and irrigated conditions in areas that receive less rainfall, the crop needs regular irrigation. In Nigeria, ginger cultivation started in 1927 (Arene *et al*., 1987). It was mostly grown in Southern part of Kaduna State especially in Jaba, Kubacha, Kafanchan and Kagarko and neighbouring parts of Plateau and Nasarawa States. Today, ginger is cultivated in almost all villages in Southern part of Kaduna State because of the economic gains and the sustainability and productivity of agricultural lands.

Rainfall can be a challenging factor to ginger production and can affect the productivity and sustainability of soils to ginger yield. National Agricultural Extension License Service, NAERLS (2004) were of the view that 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 fertility of the soil. An investigation into rainfall variability and it effect on the sustainability of ginger yield by farmers in Duru Ward which is well known for ginger cultivation in Jaba Local Government Area (LGA.) is quite desirable. Therefore, this study aimed to examine the effect of rainfall variability on the sustainability of ginger yield in Jaba LGA of Kaduna State.

Nigeria is one of the climate–vulnerable countries and the impact of climate change is hitting hard on the nation's agricultural sector (IPCC, 2007). The variability in rainfall has therefore put the activities of farmers in the guinea savanna areas of Nigeria in precarious situation. This is because agricultural practice in this zone is largely rain-fed (Ndamani, 2008). Since agricultural practice in this zone is rain-fed, even if there is sufficient rainfall, its irregularity can adversely affect yields especially if it fails to arrive during the crucial growing stage of the crop (Mowa and Lambi, 2006; Rudolf and Herman, 2009). Ginger (*Zingiber offficinale Roscoe*) which is mostly grown in the Southern part of Kaduna State, specifically in Jaba and Kachia LGAs responds to vagaries of rainfall at every stage of its development. This calls for the examination of the effect of rainfall variability on the sustainability of ginger yield in Jaba LGA of Kaduna State.

STUDY AREA

The Headquarter of Jaba LGA is located on Latitude 9° 27'N and Longitude 8° 0'E (Fig. 1). The area is designated as Koppen's Aw climate with two distinct seasons, a wet season in summer and a dry season in winter. Rainfall occurs between the months of April to October with a peak in August, while the dry season extends from ending of October of one calendar year to April of the next (Abaje *et al,* 2016). The mean annual rainfall is about 1733 mm and the mean monthly temperature is 28ºC, while the mean atmospheric relative humidity is about 63% (Abaje *et al,* 2016). The vegetation of the area is the Guinea Savanna type. The main type of soil is the Ferruginous tropical soil which is related to the climate, vegetation, lithology and the topography of the area (Abaje *et al*., 2010). The soils are well drained and shallow, with texture consisting of loamy sand to sandy loam top soils (0-20cm) and supports wide variety of annual, perennial and tree crops respectively (Eroarome, 2005). The relief is relatively flat and undulating and it influences the drainage pattern of the area (Abaje *et al.*, 2009). Ginger is the major cash crop in the area and an important income earner to the farmers as well as foreign exchange earner to the country.

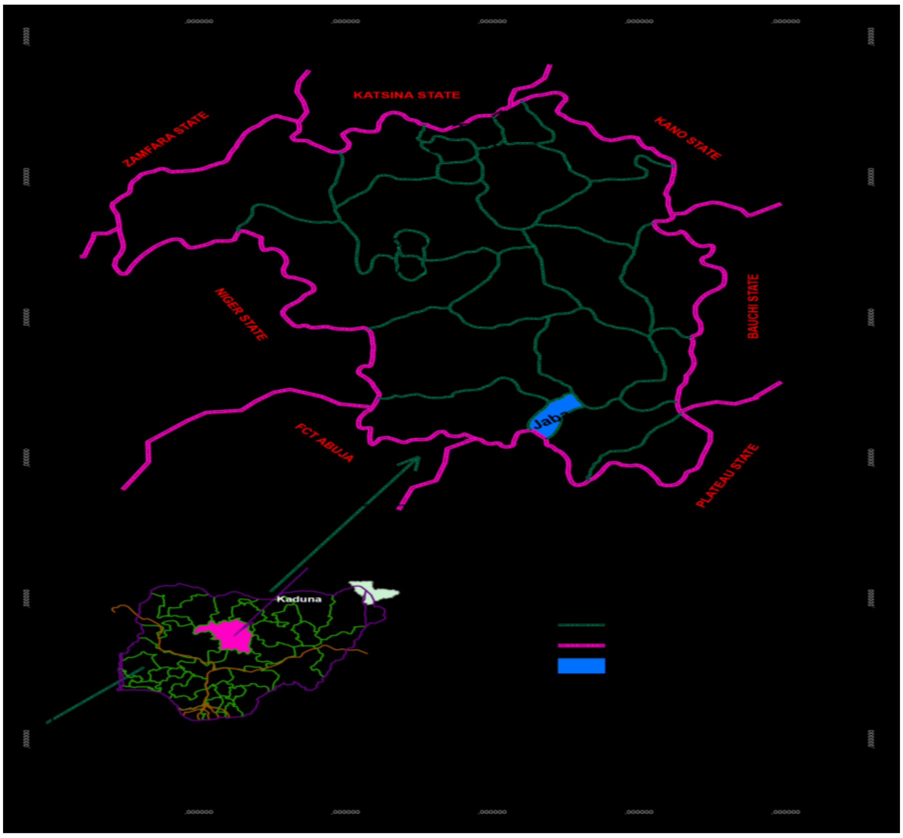

Figure 1: Kaduna State Showing the Study Area
Source: *Ministry of Land and Survey, Kaduna (2014)*

MATERIALS AND METHODS

Data Collection

Data and information for this research work were obtained between November and December, 2016 from a direct field study and the used of secondary sources. The secondary data were obtained from two sources; climatic data on rainfall for a period of 15 years (2001-2015) and ginger yield for the same period were obtained from the Department of Hydrology (Meteorological Unit), Kaduna State Water Board and Kaduna State Agricultural Development Project (KADP) respectively.

The 1991 census population of the area (66,119 people) was used to determine the sample size of the population. The study area with 68 communities and an annual growth rate of 2.8% (NPC, 1991), was projected to the year 2016 for the purpose of this study using the method of Mehta (2004). The projected population of the study area for the year 2016 is 131,874 people. The basis for using the 1991 census instead of 2006 was due to the fact that this study is focused on localities and the 2006 population census' document has no locality population. Cohen *et al.* (2011) Table of sample size determination was adopted. Based on this method, the sample size used with anticipated response rate of 95% was 274. However, only five communities were purposively selected based on ginger production from the 68 communities for this study (Table 1).

Table 1: Sampled Communities and Number of Respondents

Selected Communities	Population (1991)	Projected Pop. (2016)	No. of Respondents
Nok	1,024	2,042	13
Fai	1,705	3,401	22
Sabon-Gari, Chori	1,819	3,628	24
Kwoi/ Ung. Haruna	13,598	27,121	177
Kurmin-Jatau	2,882	5,748	38
Total	**21,028**	**41,940**	**274**

Source: *Field Survey (2016)*

The questionnaires were purposively administered to ginger farmers who must have been residing in the community for at least 20 years. The basis for this was to gather information from farmers who have had experiences in farming of ginger and on rainfall variability over the years, and are also more concerned and conscious about the impacts and vulnerability of rainfall variability on their livelihoods and the environment. Using the Table of random numbers, 274 farmers engaged in ginger farming were selected and administered the questionnaire. The areas the questionnaire asked include: socio-economic characteristics of the respondents, the perception of farmers on the effects and influence of rainfall variation on ginger yield.

Data Analysis

Linear regression was used to determine the linear trends of rainfall and ginger yield in order to compare people's perception of climate change and the observed change. The formula for the linear regression is given as:

$$y = a + bx \quad \text{…………………..……… eq. 1}$$

where a the intercept of the regression line on the y-axis; b is the slope of the regression line. The values of a *and* b can be obtained from the following equations:

$$a = \frac{\sum y - b(\sum x)}{n} \quad \text{…………………….….. eq. 2}$$

$$b = \frac{n(\sum xy) - (\sum x)(\sum y)}{n(\sum x^2) - (\sum x)^2} \quad \text{…………………..… eq. 3}$$

To further examine the nature of the rainfall trends, the Standardized Anomaly Index (*SAI*) is then used. It provides an area-average index of relative rainfall yield based on the standardization of rainfall totals. It was calculated as:

$$z = \frac{x - \bar{x}}{S} \quad \text{------------------------------------ eq. 4}$$

Where: z is the Standardized Anomaly Index, $\bar{x}$ and *S* are the mean and standard deviation of the entire series respectively. This statistic will enable us to determine the dry (-ve values) and wet (+ve values) years in the record.

Similarly, the relationship between rainfall and ginger yield in the study area was tested using Pearson's product moment correlation coefficient. This is computed as:

$$r = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2}\sqrt{\sum (y - \bar{y})^2}} \quad \text{------------------------ eq. 5}$$

Where: r = correlation coefficient

x and *y* = individual observations of dependent and independent variables respectively

$\bar{x}$ and $\bar{y}$ = mean of dependent *(x)* and independent *(y)* variables respectively.

The ginger yields value was used as dependent variables and rainfall value as the independent variable.

The perceptions of farmers on the effects of rainfall variation on ginger yield were analyzed using descriptive statistics such as frequencies and percentages using Microsoft Excel 2013 and SPSS version 23.

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

The result of the findings (Table 2) shows that the majority of the respondents were males (66.4%) while only 36.6% were females. Out of the 274 respondents, 47.1% attended primary school, 9.1% have tertiary education, and 28.8% have secondary education, while 15.0% have no formal education. The average age of the respondents is 40 years, and majority of them (63.9%) are married. The respondents have been living in the area for an average of 45 years and their major occupation is farming which represent 27%, while 9.5% are pensioners, civil servants represent 20.2% and others (traders/artisans) 23%. Based on this result, it is a clear that most of the respondents depend heavily on farming for their livelihood.

The highest percentage of males' respondents in the study area may not be unconnected with the culture and religion of the people where women are restricted from some certain social activities. Age and level of education are important factors in terms of climate variability perception and farming in the study area. This is because the younger ones that did not attend any formal education but very active and agile commit more of their energy in crop (ginger) production, whereas the older and uneducated ones have had experiences in rainfall variability and ginger production over the years and some of the traditional/local coping and adaptation strategies to be adopted in combating the impacts of rainfall variability in the area. The educated ones on the other hand are more aware of the modern coping/adaptation strategies to rainfall variability in order to increase ginger yield in the area. The assumption herein is that an educated person is more able to process information and use it to inform decisions, in addition to enabling the individual to perform tasks more efficiently, whereas lower education constrains the ability to understand warning information and access to recovery information (Cutter *et al*, 2003).

Table 2: Socio-economic Characteristics of Respondents

Variables	Categories	Frequency (N=274)	Percentage
Years of Residency	≤ 20	2	0.7
	21-30	26	9.5
	31-40	127	46.3
	41 and above	119	43.4
Sex	Male	182	66.4
	Female	92	33.6
Age	20-29	11	4.0
	30-39	89	32.5
	40-49	133	48.5
	50 and above	41	15.0
Marital Status	Married	175	63.9
	Separated/Divorced	43	15.7
	Single	56	20.4
Educational Level	Primary	129	47.1
	Secondary	79	28.8
	Tertiary	25	9.1
	Non formal	41	15.0
Occupation	Farming	151	55.1
	Civil servant	74	27
	Pensioner	26	9.5
	Others	23	8.4

Source: *Field survey, 2016*

Observed Annual Trends of Rainfall Amount and Ginger Yield in the Study Area

The observed annual trends of rainfall amount and ginger yield of the study area are represented in Figure 2. The highest annual rainfall amount (2321.9mm) was recorded in the year 2014, while the lowest rainfall amount of 1451.2 mm was recorded in the year 2011. Also, the highest annual ginger yield was recorded in the year 2015, while the lowest yield was recorded in the year 2011. A closer examination of Figure 2 shows that as the rainfall is increasing from 2001 to the 2015, so also is ginger yield increasing from 2001 to the recent years.

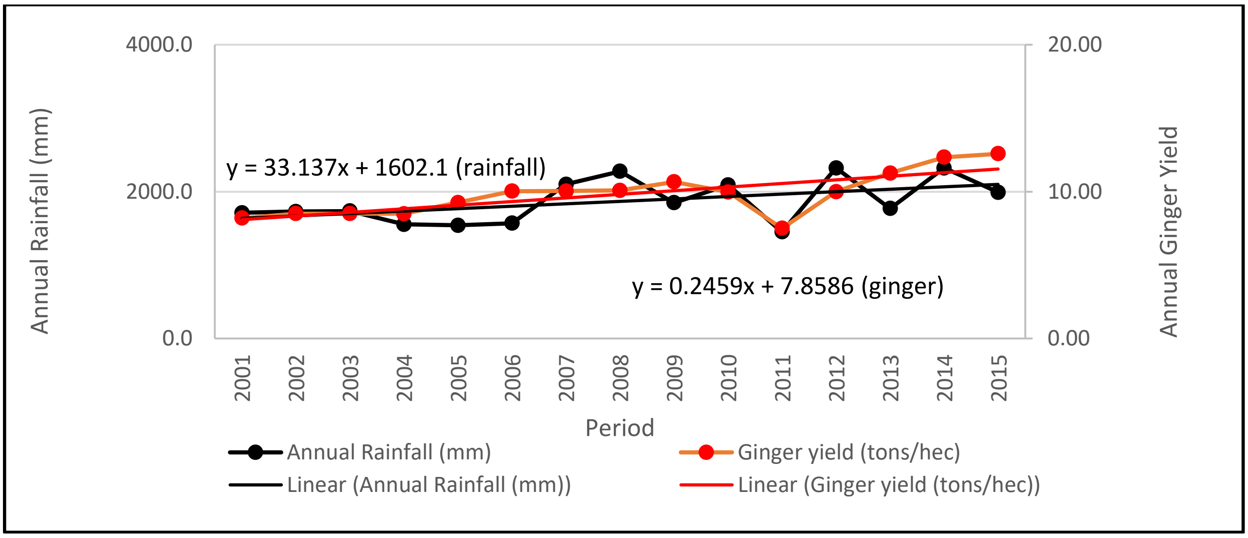

Figure 2: Annual Trends of Rainfall Amount and Ginger Yield in the Study Area

The Pattern of Rainfall Anomalies in the Study Area from 2001 to 2015

The rainfall anomalies as depicted in Figure 3 shows a drop in rainfall amount from the 2006 to 2008 and a two-year positive variability of rainfall experienced in 2009 to 2010 and subsequent rise from 2012 to the end of the study period (2015). NIMET (2015) described rainfall in Kaduna State as being unstable, unpredictable and dynamic.

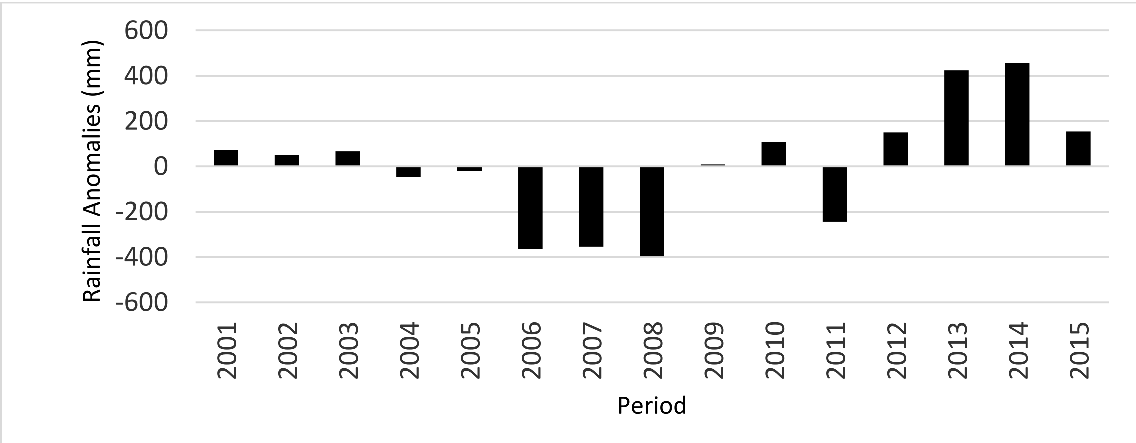

Figure 3: Annual Rainfall Anomalies, 2001-2015

Relationship between Annual Rainfall Amount and Ginger Yield

The result of Pearson moment correlation shows that there existed a strong positive relationship (r= 0.606) between ginger yield and rainfall amount which is statistically significant at 95% confidence level (Table 3). This is an indication that as annual rainfall amount increases, the annual ginger yields also increases. Thus, any change in the rainfall amount received in the study area will have a significant effect on the annual ginger yield. McCarthy *et al.*, 2001 observed that ginger requires an annual rainfall of 1500mm or more and a rainfall duration well distributed to 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. The model has an R^2 of 0.367, standard error of 0.001 which indicates that the model has a very low margin of error and is statistically significant at 95% confidence level. The R^2 of 0.367 shows that annual rainfall amount contributed 36.70% to the variability in ginger yield in the study area. This result means that rainfall amount is not the sole determinant of ginger yield. Invariably, the variability in rainfall does not have much adverse effect on sustainability of ginger yield.

Table 3: Impact of Rainfall Amount on Ginger Yield

Variables	Parameter Estimates	Standard Error	R	R^2	Coefficient of determination	% of Contribution
Intercepts	4.195	2.074				
Rainfall Amount	0.003	0.001	0.606	0.367	36.70	36.70

From Table 3, the relationship between annual rainfall amount and annual ginger yield indicates that for every 1% increase in rainfall amount, there is 0.03% increase in annual ginger yield in the study area.

Perceptions of Farmers on Climate Variability and its Sustainability to Ginger Yield

From the listed responses in Table 4 on climate variability and its sustainability to ginger yield in the study area, 88.7% of respondents strongly agreed that rainfall vary with every passing year. This suggests that farmers have a clear perception of the nature and pattern of rainfall experience within their locality on yearly bases. This is in agreement with the assertion made by Federal Republic of Nigeria (FRN, 2000) that the pattern of rainfall in northern Nigeria (Jaba LGA inclusive) is highly variable in spatial and temporal dimensions with inter-annual variability of between 15 and 20%.

Table 4: Farmers' perceptions of rainfall variability and sustainability to ginger yield in the study area

S/N	Variables	SA	A	UD	D	SD	Total
1	Rainfall vary every year	88.7	9.5	1.8	00	00	100
2	Seasonal delay in the onset of rainfall	97.2	12.7	00	00	00	100
3	Delay in rainfall affect the yield of ginger	61.7	22.6	00	15.7	00	100
4	Shortage of rainfall lead to low output	72.3	18.2	2.9	6.6	00	100
5	Shortage of rainfall lead to high output	00	00	00	12.0	88.0	100
6	Ginger requires low rainfall for its sustainability	00	00	7.3	24.1	68.6	100
7	Ginger requires moderate to high rainfall	73.4	26.6	00	00	00	100
8	Variation in rainfall delay ginger growth	71.2	28.8	00	00	00	100
9	Variation in rainfall affect ginger quality	67.9	22.6	1.5	7.7	3.3	100

Source: Field Survey, 2016

On whether there is seasonal delay in the onset of rainfall, 97.2 % of respondents strongly agreed that onset of rain comes with a lot of expectation and anxiety because there is mostly delay in starting of rainfall. 61.7% of respondents strongly agreed that delay in rainfall affects the yield of ginger except for the farmers who use irrigation method to supplement water to the farm lands and 22.7% agreed that although there is delay in rainfall, it does not actually affect much of the yield of ginger. This is in accordance with the statement of Stewart (cited in Edward *et al.* 2008) that reliable prediction of rainfall characteristics, especially the onset, is needed to determine a less risky planting date or planting method, or sowing of less risky types/varieties of crops in responsive farming. This statement also confirmed the response of farmers that delay in rainfall affect ginger yield. From the response on whether shortage of rainfall leads to low or high output in ginger yield, 72.3% respondents strongly agreed that shortage of rainfall lead to low output while 88.0% strongly disagreed that delay in rainfall lead to high output in the yield of ginger. Response of farmers on the requirement of ginger to rainfall for its sustainability, 68.6% respondents strongly disagreed that ginger requires low rainfall to sustain it growth to maturity while 73.4% strongly agreed that ginger requires moderate to high rainfall of between 6 to 7 months for the sustainability of ginger growth and higher yield. On variation in rainfall and ginger yield, 71.2% and 67.9% of the respondents strongly agreed that variation in rainfall delay ginger growth and equally affect the quality of yield depending on whether the rainfall is high or low respectively. Julius *et al*. (2012) asserted that seasonal rainfall has been marked by delayed onsets, declining number of rain days and increased intensities altering farming calendars with negative effects on the yields.

CONCLUSION AND RECOMMENDATIONS

The perception of respondents from the study reveals that rainfall varies with every passing year. Onset of rainfall comes with a lot of expectation and anxiety because there is mostly delay in starting of rainfall, and the delay in the onset of rainfall affects ginger yield. Ginger requires moderate to high rainfall of between 6 to 7 months for its growth and higher yield. The variation in rainfall delay ginger growth and equally affect the quality of yield depending on whether the rainfall is high or low respectively. The results of the correlation and regression analysis between annual rainfall amount and ginger yield from 2001 – 2015 showed a strong positive relationship (r= 0.606) between ginger yield and rainfall amount. This is because as annual rainfall amount increases, the annual ginger yields also increases. Annual rainfall amount contributed 36.70% to the variability in ginger yield. The result showed that rainfall amount is not the sole determinant of ginger yield.

The study recommends that farmers need to adopt other strategies including the art of supplementing rainfall with irrigated water when the need arises. The needs for extension agents to consistently advice the farmers in the area to adjust the ginger cropping calendar to synchronize planting and growing period with soil moisture availability based on rainfall forecast. The Cereal Research Institute should develop drought resistant varieties of ginger, early maturing variety and the use of genetically modified ginger.

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