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ARTICLE

Precipitation Effectiveness and Yam Production in Kwara State, Nigeria

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ABSTRACT

Insufficiency in the production of food crops in Nigeria has been linked with variation in rainfall features. This paper examined the impacts of variation in rainfall onsets, cessations and length of growing season on yam yield in Kwara State, Nigeria to proffer a solution to the problem of food insecurity in the state. Rainfall data were collected monthly for six stations in Kwara State between 1961-2017 (57 years). Yam yield data were also collected for the same period. Since no separate record of yam is kept for each climatic station, mean climatic data were calculated to match the yam yield record obtained from the above stations. Rainfall onset, cessation and Length of Growing Season (LGS) were calculated from monthly values. Decadal partitioning of both the crop and rainfall features was made to show variations. Time series analysis was employed to study trends. The strength of the relationship between the length of the growing season and yam yield was also conducted using correlation analysis. The result showed an upward trend of onset of rain coupled with a downward trend in late cessation of rain and a decline in the length of the growing season. On a decadal basis, increasing frequency of delayed onset of rain and late cessation was observed. Length of growing season exhibits a positive (r = 0.455**) relationship with yam yield. Suggestions were made on how to attain sustainable efficient yam cropping in the study area.

1. Introduction

Nigerian agriculture is rain-fed, and hence its characteristics are highly varied. Agriculture has been Nigeria's largest sector, providing an average of 24% of the country's GDP over the last seven years (2013-2019) [1]. Furthermore, the sector employs more than 36% of the country's workforce, making it the country's largest employer of labour. Previous studies have observed dwindling agricultural production, shrinkages in the belts of food crops as a result of shrinkage in the length of the rainy season, which is synonymous with the length of the growing season (LGS) in the tropics, and insufficiency in the production of food crops in Nigeria [2-5]. Nigeria's agricultural production followed population increase, and the country

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struggles to feed its constantly expanding population [4].

The onset of rain and the length of the rainy season is linked to efficient agricultural production in the tropics [6]. The onset of rain does not only determine when to plant a crop but also decides whether the crop will survive and perform well in the field [4]. Studies have highlighted rainfall onsets, cessation, and the length of the rainy season as major rainfall aspects critical for agricultural activities in the tropics [7]. The time gaps between the start and end of the growing season are represented by the length of the growing season. As a result, the amount of rainfall received is less essential than its distribution in terms of crop performance in the field.

Yams are rain-fed crops which grow for 6-12 months depending on the cultivars, ecology and soil properties of the production area [8]. Nigeria has been recognized as one of the largest producers of yam worldwide. Out of the annual global output of 28 million tonnes and 33 million metric tonnes, 95% comes from Africa of which 96% comes from West Africa and 80% is produced by Nigeria alone.

Although Nigeria is witnessing a sporadic rise in yam production the present yield per hectare computed, as a percentage of the potential yield for yam crop is still very low. Besides, not all yam-producing areas in Nigeria can boast of the upward trend in yam production. An example of such an area is Kwara State [9].

Climate has been identified as the number one natural factor affecting crop production in the tropics [10-12]. Climate change and variability can bring about changes in the length of the growing period. For instance, a loss in crop yield occurs when the growing period is either shorter or longer than the growth cycle [13]. Based on this, it has been predicted that a 50% reduction in crop yield for some African countries by 2020 [14].

2. Yam Production and Rainfall Effectiveness Indices

The most important component of moisture resources status for the determination of the production potential of any crop including yam is moisture indices of onset, cessation and length of the rainy season [6]. Similarly, the importance of the amount and the distribution of rainfall during the length of the growing season and the reliability of rainfall after planting had been emphasized [15,16]. The amount and the distribution of rainfall during these periods is a determinant factor in water availability for crops in the field [16]. Thus, knowledge of the pattern of these indices during the length of the growing season can help farmers make reasonable decisions relating to the choice of suitable cultivars for a particular Eco zone.

The variability of moisture-based agro-meteorological indices is the most important element for yam production in the humid tropics [17]. For instance, late onset of rain, dry spells after planting, sprouting and the emergence of yam crop limit leaf development hence, leaf area index (LAI) and the affect tuber bulking period which largely determines tuber yield in yam [17]. Studies have been conducted on the effect of climate on yam tuberization in an experimental farm in Kwara State and found out that an increase in rainfall resulted in leaf development and hence LAI which increased with yam yield [18]. This increase in LAI brought an increase in yam yield in Kwara State, Nigeria.

Previous studies on the effect of temporal variation of rainfall occurrence on tuber crop production in Niger Delta, South-South, Nigeria has been examined, and the result revealed that any shift in onset and cessation of rain tends to affect tuber crops including yam [19]. Delay onset of rain means a delay in the planting of tuber crops. A long duration of rain will result in a delay in the harvest which can lead to the rottenness of tuber in the field. The above facts call for the need for an in-depth knowledge of the agro meteorological information about the behaviour of the rainy season on yam crop.

The length of the growing season must tally with the growth cycle of a plant crop for efficient and optimal production of such crop. However, increasing anomalies in the onset, cessation, and length of the growing season, as well as the occurrence of dry spells during the early stages of yam growth, have resulted in low yam production in many yam-growing areas of Nigeria, as farmers have shifted to other crops for economic reasons [20].

3. Research Methodology

3.1 The Study Area

The study area is Kwara State of Nigeria. It is bordered on the northeast by the River Niger, on the north by Niger State, on the east by Kogi State, on the south by Oyo, Ekiti, and the Osun States, and on the west by the Republic of Benin. It is located between latitudes 8^{o} and 10^{o} 15’ of the equator, and longitudes latitude and 2^{o} 45’ and 6^{o} 15’east of the Greenwich Meridian (Figure 1). The main crop grown in Kwara State is yam [9,21]. In response to the pressure pattern resulting in seasonal shifts of pressure belts associated with the apparent movement of the overhead sun, and also in response to the Inter-Tropical Discontinuity between the moist South-West monsoon wind and the dry North-East continental wind, the climate of the study area exhibits a distinct wet season and a distinct dry season.

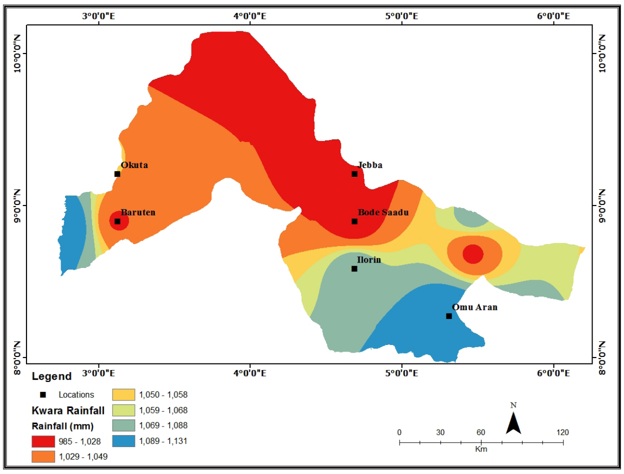

Figure 1. The Meteorological Stations and Average Annual Rainfall of Kwara State, Nigeria

3.2 Method of Study

Rainfall data were collected on monthly basis from six stations in Kwara State namely Okuta, Baruteen, Jebba, Bode Saadu, Ilorin and Omu-Aran from Satellite records while yam data for Kwara State were collected from Kwara State Agricultural Development Project (KADP) Ilorin, CBN Statistical Bulletins and Federal Office of Statistics, Abuja for the period of fifty-seven years which spanned between 1961 and 2017. Since no separate record of yam is kept for each climatic station, mean climatic data was calculated to match the yam yield record obtained from the above stations. In 1967, the Walter's approach [22], as modified by Olaniran in 1988 [23], was used to determine rainfall onset, cessation, and LGS from monthly values. The formula is as follows.

$$\text{Days in the month} \times \left[\frac{51 - \text{Accumulated Rainfall Total}}{\text{Total Rainfall for the Month}}\right]$$

When an area has received 51 mm of rain in total, the growing season begins [22]. If the planting data are followed by a prolonged dry spell, the previous planting data are ignored, and new planting data were calculated. Rainfall cessation is determined using a similar procedure, except the monthly rainfall value is calculated backwards from December. The rainy season ends in the month in which the total rainfall surpasses 51 mm. The length of the growing season was determined by the period between onset and cessation (LGS).

Several onsets and cessations for the guinea savanna environment were identified [2]. For rainfall onset, normal onset is defined as the time between early and mid-April, early-onset as the period from March to April, and late-onset as the period from April to May [2]. The last week of October is considered typical rainfall cessation, September to the third week of October is considered early cessation, and November to December is considered late cessation. Decadal partitioning of both the crop and rainfall features was made to show variations. Time series analysis was employed to study trends. The strength of the relationship between the length of the growing season and yam yield was also conducted using correlation analysis.

4. Results and Discussion

4.1 Trend of Onsets of Rain 1961-2017

From an agricultural viewpoint, onset of rain has been defined as the date when rainfall can provide sufficient water to compensate for water losses through evapotranspiration from the plant environment [20]. Figure 2 shows an upward trend of onset of rainfall within the period of study. The implication of the finding is that onset of rain is becoming delayed.

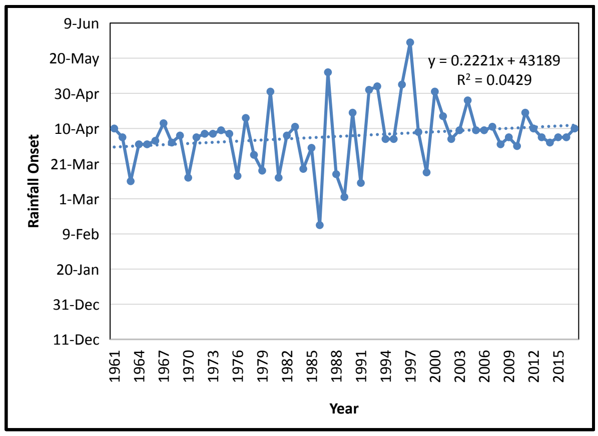

Figure 2. Trend Analysis of Rainfall Onset 1961-2017

For instance, in some years, the onset of rain was delayed till the end of April and the month of May. Examples of such years were 1980, 1987, 1992 and 1997. The trend of rainfall cessation for the study period is shown in Figure 3. The trend is downward. It implies rain stops earlier than normal.

The upward trend of increasing late-onset and early cessation as displayed means short LGS (Figure 4). Figure 4 shows a downward trend in LGS for the period of study.

Yam yield trend is presented in Figure 5. Yield fluctuated but on an upward trend. Most years that witnessed short LGS of less than 200 days observed lower yam yield. The exceptions to this were 1996, 2000, 2005-2007 and 2011-2015. This may have resulted from reasons that have to do with the annual increase in the total hectare of land devoted to yam production. To increase yield more land is being put under yam cultivation [9]. This action tends to mask the effect of climate and gives the wrong impression of a rise in yam production. The consequence of this as emphasized by a study conducted in 2012, is mal-adapted agriculture as the farming of such crops might be done beyond its ecological tolerance range [9]. The decadal implication of these scenarios (late-onset, early cessation and short LGS) is investigated on yam yield in Kwara State.

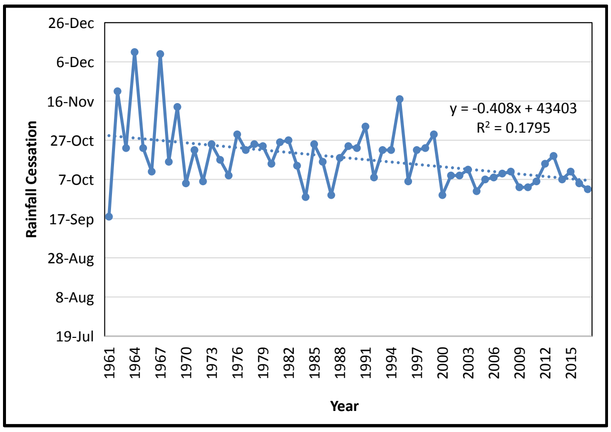

Figure 3. Trend Analysis of Rainfall Cessation, 1961-2017

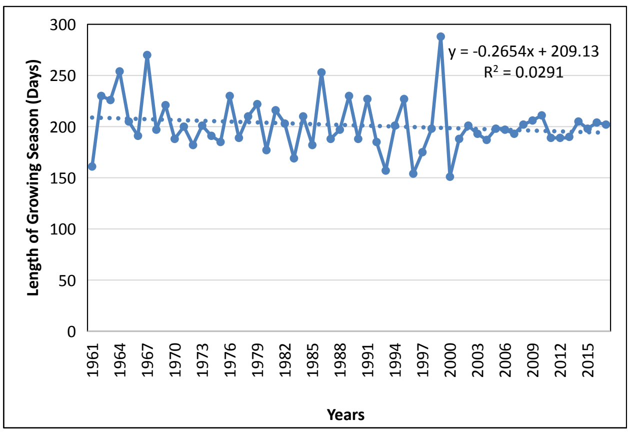

Figure 4. Trend Analysis of Length of Growing Season, 1961-2017

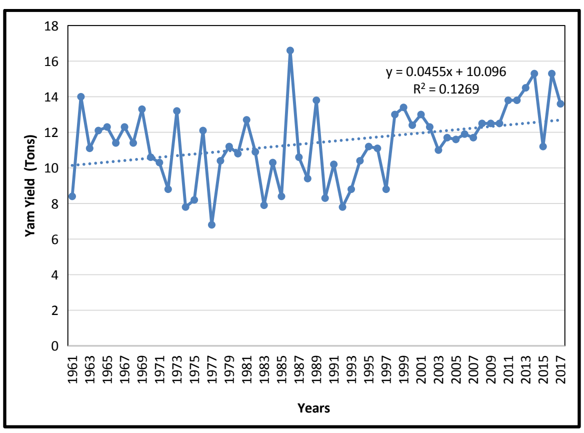

Figure 5. Trend Analysis of Yam Yield, 1961-2017

4.2 Onsets of Rain and Yam Yield in Kwara State

The onset of rain can be described as normal, early and late. The period of the year designated normal, early and late is a function of the location of such area. For Kwara State, the period of early April-mid April is the normal onset of rain, March downward is early-onset while delay onset begins from late April upward [2].

A decline in the normal onset of rain was established. The frequency of early-onset fluctuated while late-onset was on the increase. For instance, no year recorded the late onset of rain during the first decade of 1961-1970 and only two years each experienced late-onset during the second (1971-1980) and in the third decade (1981-1990). However, between 1991 and 2000 which represents the 4th decade, a sharp increase of five years was reported and the frequency escalated to six during the fifth decade (Table 1).

The yield of yam fluctuated most with the late onset of rain. For instance, yield declined with a drop in the frequency of normal and late onsets during the first two decades however, the decline continued through the rest decades with a decline in late onset of rain (Table 1).

Table 1. Yam Yield and Frequency of Different Rainfall Onsets

DECADES	RAINFALL ONSETS			YAM YIELD ('000'TONNES)
	Normal	Early	Late	
1961-1970	8	2	0	11.64
1971-1980	6	2	2	9.91
1981-1990	2	6	2	10.89
1991-2000	3	2	5	10.65
2001-2010	3	1	6	10.20

Source: Author's Computation 2018

4.3 Cessations of Rain and Yam Yield in Kwara State

The pattern of different rainfall cessations and yam yield is displayed in Table 2. The rainfall feature of the study area is characterized by an increase in the frequency of early cessation of rain. The period between 2001 and 2010 witnessed neither normal nor late cessation of rain. The late cessation of rain the area used to enjoy during the first decade has been displaced by early cessation by the 2001-2010 decade. An increase in early cessation brought about a decline in yam yield during these decades (Table 2).

Table 2. Yam Yield and Frequency of Different Rainfall Cessations

DECADES	RAINFALL CESSATIONS			YAM YIELD ('000'TONNES)
	Normal	Early	Late	
1961-1970	3	3	4	11.64
1971-1980	6	4	0	9.91
1981-1990	5	5	0	10.89
1991-2000	5	3	2	10.65
2001-2010	0	10	0	10.20

Source: Author's Computation 2018

4.4 Length of Growing Season and Yam Production in Kwara State

The compilation of climatic requirements of crops can be done with particular reference to the length of the growing season and moisture requirements of the crop during the growing season [23]. Another rainfall feature crucial for agricultural activities in the tropics is the length of the growing season, which is synonymous with the length of the rainy season (LRS). The time lag between the start and the end of the growing season marks the length of the growing season. When compared with yam yield, the two fluctuated together i.e. increase in the length of the growing season brings about an increase in yield during most of the decades under study (Table 3).

Table 3. Yam Yield and Frequency of Different LGS

Decade	Mean LGS	Mean Yield('000' H)
1961-1970	214	11.64
1971-1980	199	9.91
1981-1990	204	10.89
1991-2000	196	10.65
2001-2010	197	10.20

Source: Author's Computation 2018

Increase in LGS brought about increase in yam yield and vice-versa. To further confirm these findings, the data were subjected to correlation analysis.

Length of the growing season exhibited a positive (r = 0.455**) relationship with yam yield, indicating that the longer the length of the growing season, the higher yam yield, and vice versa (Table 4).

Table 4. Result of Correlation Analysis

Variables	Maize Yield
Length of Growing Season	0.455**

**. Significant at 0.01 level

Source: Author's Computation 2018

Reduction in these precipitation features accounted majorly for the fluctuation and reduction in yam yield experienced during the five decades of the study period. These findings corroborated the previous studies conducted in Nigeria [24,25]. It was observed that a considerable fall in LGS, which caused a decline in crop production in Southern Nigeria [25], while poor agricultural productivity and low income experienced by Nigerian farmers is associated with fluctuations in moisture pattern [24].

5. Conclusions

The results of this study concluded a change from a normal LGS to a shorter LGS in Kwara State and this confirmed further the findings of the previous study which revealed that the climate of Kwara State has changed towards aridity [2]. The implications of this change on the life cycles of various crops are of utmost importance to food security in the state. Attaining sustainable food security in the state will require curtailing the growing of crops to within the length of the rainy season (growing season) since the type of agriculture practiced is rain-fed. Research efforts should be directed towards this and finding out the new climatic requirements for optimal performance of each crop as climate change unfolds changes in these various rainfall indices.

Conflict of Interest

There is no conflict of interest.

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