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Department of Geography and Meteorology
Nnamdi Azikiwe University, Awka

Assessment of the Effects of Dry Spell on the Yield of Maize During the Growing Season in Sokoto State, Nigeria (2010-2019)

Ozoemene, M.L.[1*], Nwosu, A, C.[2], Obikwelu, M.C.[3] andDuru C.P.[4]

[1,2,3,4]Department of Geography and Meteorology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

[*]Corresponding Author Email: ml.ozoemene@unizik.edu.ng

Abstract

This work examined the effects of dry spells on the yield of maize in Sokoto State in Nigeria using the daily rainfall data obtained from Nigeria Metrological Agency (NIMET) Abuja for a period of 10 years (2010-2019); used to determine the trends in the dates of onset and cessation of dry spells using MAKESENS while the data on the yield of maize was collected from Agricultural Development Program (ADP) office in Sokoto state for a period of 10 years (2010-2019), used together with the frequency of dry spells to determine the perceived effects of dry spells on the yield of maize. Trends on the occurrence and frequency of dry spell were also determined focusing only on the raining months (May to October).LinearRegression analysis and correlation analysis was done to determine the effects of dry spell on maize yield. The results showed that the onset of dry spells ranged from 9th April, in 2015 to 1st June in 2012; showing fluctuations in three months (April, May & June) as well as in date in the months. The cessation dates of dry spells occurred in two months (September & October) but was stable in October, it fluctuated within the month, having the maximum cessation dates to be 25th October and the minimum date to be 22th September. It was concluded that there are changes in the onset and cessation of dry spells of rainfall due to the changes in rainfall characteristics which also affected the variability of the onset and cessation of dry spells. The studyalso shows recent changes in the trends of dry spells from year to year. The perceived effects of dry spells of rainfall showed negativecorrelation with maize yield,implying a significant relationship between dry spells and the yield of maize.

Keywords: Climate Change, Dry spell, Maize yield, Markov Chain and Rainfall

Introduction

Rainfall is an important climatic variable that varies with locations, leading to alteration of wet and dry seasons in most areas. The important characteristics of rainfall are the amount, the frequency, the intensity. These values vary from place to place, day to day, month to month and from year to year (Adigun, Ufoegbune, Makinde, Ahmad, Oyelakin& Dada, 2020). These characteristics affect agriculture significantly. For instance, all crops need at least some water to survive.Rainfall is important in crop output analysis because it helps to determine the rate of growth of crop from seed level to its harvest period. Plants cannot do without the presence of water during its entire life cycle.At shorter time scales, the day-to-day variability of rainfall is characterized by wet and dry episodes, namely, spells of continuous rain or no rain. These spells of rain are usually a manifestation of synoptic scale events, which in themselves might be part of larger-scale organization of convection such as lows and depressions during the rainy season. A regular rainfall pattern is usually vital for crop development but too much or too little rainfall can be harmful, even devastating to crops (Ibitoye and Shaibu, 2014).Insufficient rainfall caused by prolonged dry spells has devastating impacts on the economy and leads to low agricultural yield.

Dry spell can be defined as a sequence of dry days including days with less than a threshold value of rainfall. It is a drawn-out period where the weather has been dry, for an abnormally long time; it is one form of drought that interrupts the rainy season. Sivakumar (1998) analysed the long-term daily rainfall data in 58 locations in West Africa and showed the significant relationship between date of onset and the length of growing season. A dry spell is a period of 3 or more days of lack of rainfall during the wet season.A dry spell according to Usman & Reason (2004) can be defined as a pentad which receives 5 mm rainfall, and a wet spell as a pentad receiving 20 mm rainfall. Consecutive dry pentads were counted as a single dry spell and thus the duration of dry spells was variable. While the dry spells affect soil water retention which would negatively impact on the crop germination and establishment, the wet spells effects are more pronounced in the maturing stage of a crop (Ibitoye and Shuaibu, 2014).

Growing season can be defined as the period of the year during which rainfall distribution characteristics are suitable for crop germination, establishment and full development. It is the period of the year categorised as the rainy season or wet season, the length of which varies, spatially, temporally, and with crop type.Ezeh (2014) compared the sequences of daily rainfall over coastal southern and semi-arid northern Nigeria. Daily rainfall occurrences for 41 years (1971–2011) over two meteorological stations in Lagos and Katsina were analysed using frequency analysis and Markov chain model. His findings indicate that the coastal area had a dry spell of 1 to 4 days spell predominance while the semi- arid region showed a predominance of higher dry spells.

Maize, a monocotyledonous crop, grown for grain and forage, is the most important cereal crop in sub-Saharan Africa. Among several cereal crop varieties, maize is cultivated globally, being one of the most important cereal crops worldwide. It occupies more than 33 million ha each year and is an important staple food for more than 1.2 billion people in Sub-Saharan Africa (SSA) and Latin America (IITA, 2009; FAOSTAT, 2015). More than 300 million people in SSA depend on maize as a source of livelihood. The world ranking of maize production shows Nigeria as the 12^{th}largest producer of maize in 2012 with 8,694,900tonnes, 14th largest producer in 2013 with 8,422,670tonnes (FAOSTAT, 2015) and 14th largest producer in 2014 with 10,790,600 tonnes (Knoema, 2016). Across Nigeria, maizeis mostly planted on dry lands in most parts and is sensitive to water stress. The maize growing season experiences different rainfall characteristics such as dry spells which may impact phenology and lead to reduced crop yields (Tadross et al., 2009). World Atlas (2016); Kowal and Kassam (1973); Akintola (1983), Oguntoyinbo (1967); Olaniran and Babatolu (1987) examined the relationship between climate and crop yields in Nigeria. The yield and quality of maize depend on the distribution of rainfall during the different phenological stages in addition to other factors (Tadross et al., 2009, Mupangwa et al., 2011). Most studies show that maize plants are more sensitive to water stress during silking and pollination compared to the vegetative stage (Du Plessis, 2003; Masupha et al., 2016).In Nigeria, rain falls in different months of the year at different places; it begins in February over southern Nigeria and June over the northern parts, as the rain belt appears to follow the relative northward and southward movements of the sun. A delay of 1 or 2 weeks in the onset is sufficient to destroy the hopes of normal harvest (Olaniran, 1983; Jackson 1989). A false start planting, encouraged by a false start rainfall, may be followed by prolonged dry spells whose duration of two weeks or more may be critical to plant germination and growth (Olaniran, 1983). The mean annual rainfall and anomalies over Nigeria from 1986 to 2015 according to the Nigeria climate reviewed bulletin shows that rainfall have been increasing, though not at a steady rate (NIMET, 2016). The agency envisaged total rainfall amount to be 400mm in the north and about 3000mm in the south. The Agency also reveals that dry spell may last between 2 to 3 weeks after the onset and urged farmers to adopt soil moisture conservation techniques to avoid crop losses during the period.

Sokoto falls under the likelihood of increasing dry spell as a result of climate change up to 10 -21 days after the onset of rain thereby affecting plant growth. This study therefore sought to examine the effect of dry spell on the yield of maize across Nigeria using Sokoto state due to its known dry spell.

Materials and Methods

Study Area

Sokoto state is located between latitude 13°03’ and 44° N and Longitude 5°- 14° E (Figure 1). It is located in the extreme northwest of the country on the national border with and shares common borders with Niger Republic to the North, Kebbi State to the southwest and Zamfara State to the east. Its capital and largest city is the city of Sokoto. It is located near to the confluence of the Sokoto River and the Rima River. As of 2005 it has an estimated population of more than 4.2 million with a total land area is about 32,000 square kilometres. The state falls on the boundary between semi-arid region and the Sahel savannah.

Fig.1.1 Map of Nigeria showing Sokoto state (Source:https://africaprimenews.com)

Sokoto State climate is in the dry Sahel, with an annual average temperature of 28.3 °C, Sokoto is, on the whole, a very hot area. However, maximum daytime temperatures are for most of the year generally under 40 °C and the dryness makes the heat unbearable. The warmest months are February to April when daytime temperatures can exceed 45 °C (113.0 °F). There are two major seasons in Sokoto, namely wet and dry. The wet season on the other hand, rain starts late and ends early with mean annual rainfall ranging between 500mm and 1,300mm. It begins in most parts of the state in May and lasts up to September or October during which showers are a daily occurrence. The showers rarely last long and are a far cry from the regular torrential rain known in wet tropical regions. The dry season starts from October and lasts up to April in some parts and may extend to May or June in other parts. From late October to February, during the cold season, the climate is dominated by the Harmattan wind blowing Sahara dust over the land. The dust dims the sunlight thereby lowering temperatures significantly and also leading to the inconvenience of dust everywhere in houses.The region's lifeline for growing crops is the floodplains of the Sokoto-Rima River system, which are covered with rich alluvial soil fit for a variety of crop cultivation in the state. For the rest, the general dryness of the region allows for few crops, millet, guinea corn, beans perhaps being the most abundant, followed by maize, rice, sesame and vegetables such as: onions, tomatoes, pepper, garden egg, lettuce, and cabbage. The topography of the state is dominated by the famous Hausa plain of northern Nigeria. The vast FADAMA land of Sokoto – Rima River systems dissects the plain and provides the rich alluvial soil. There are also isolated hills and mountain ranges scattered all over the state.Over eighty percent (80 percent) of the inhabitants of Sokoto practice one form of agriculture or the other such as animal husbandry, farming and fishing.

Data Collection and Analysis

The data required for this analysis is the daily rainfall data andMaize crop yield in Sokoto from 2010-2019).The secondary data forSokoto state was obtained from Nigerian Meteorological Agency (NIMET) Abuja while the yearly maize crop yield for a period of 10 years (from 2010 - 2019) collected from Agricultural Development Project office (ADP) in Sokoto state.

Methods of Data Analysis

The non-parametric Mann–Kendall rank test identifies monotonic trends, over time, for given variables, and establishes whether the trend is upwards or downwards. A positive correlation indicates that the ranks of both variables are increasing, and a negative correlation indicates that the rank of one variable increase while that of the other variable decreases. The Mann-Kendall test statistic S is calculated using the formula that follows:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1} \text{sign}(xj - xk) \quad (1)$$

Where xj and xk are the annual values (years) j and k, j > k, respectively, and sign (x_j-x_k) is given by:

$$\text{Sign}(x_j-x_k) = \begin{cases} 1 \; if \; xj - xk > 0 \\ 0 \; if \; xj - xk = 0 \\ -1 \; if \; xj - xk < 0 \end{cases} \quad (2)$$

If n is 9 or less, the absolute value of S is compared directly to the theoretical distribution of S derived by Mann and Kendall (Gilbert, 1987). In MAKESENS the two-tailed test is used for four different significance levels α: 0.1, 0.05, 0.01 and 0.001. At certain probability level H_0 is rejected in favour of H_1 if the absolute value of S equals or exceeds a specified value S α /2, where S α /2 is the smallest S which has the probability less than α /2 to appear in case of no trend. A high positive value of S is an indicator of an increasing trend, while a low negative value indicates a decreasing trend. However, it is necessary to compute the probability associated with S and the sample size, n, to statistically quantify the significance of the trend. The variance of S is computed as:

$$\text{VAR (S)} = \frac{1}{18}\left\{n(n-1)(2n+5) - \sum_{p=t}^{q} t_p(t_p-1)(2t_p+5)\right\} \ldots\ldots (3)$$

Here q is the number of tied groups and t_p is the number of data values in the p^{th} group. If n is at least 10 the normal approximation test is used. For n > 10, the test statistic Z approximately follows a standard normal distribution. The values of S and VAR(S) are used to compute the test statistic Z as follows:

$$Z = \begin{cases} \frac{S-1}{\sqrt{\text{VAR (S)}}}, & S > 0 \\ 0, & S = 0 \\ \frac{S+1}{\sqrt{\text{VAR (S)}}}, & S < 0 \end{cases} \ldots\ldots (4)$$

The Z values will be tested at the 95% ($Z_{0.025}$=1.96) and 99% ($Z_{0.001}$=2.58) level of significance. The trend is said to be decreasing if Z is negative and the absolute value is greater than the level of significance, while it is increasing if Z is positive and greater than the level of significance. If the absolute value of Z is less than the level of significance, there is no trend. Sen's estimator of slope, which is a non-parametric method, is used to determine the magnitude of the trends. The Sen's method is given as:

$$f(t) = Qt + B \ldots\ldots (5)$$

Sen's non-parametric method was used to estimate the magnitude of trends in the time series data:

$$Tt = \frac{\text{xj} - \text{xk}}{j-k} \ldots\ldots (6)$$

Where xj and xk represent data values at time j and k respectively. A positive Qi value represents an increasing trend; a negative Qi value represents a decreasing trend over time. The magnitude of the trend over time Qi is given by:

$$Qi = \begin{cases} \frac{T(N+1)}{2} & N \text{ is odd} \\ \frac{1}{2}\left(T\frac{N}{2} + T\frac{N+2}{2}\right) & N \text{ is even} \end{cases} \ldots\ldots (7)$$

Determining the Event (Onset and Cessation) of Dry Spells of Rainfall in the Study Area.

This study adopted dry spell to be a sequence of at least two (2) days with rainfall below 3mm, the onset and cessation of and dry spells of rainfall in the study area was obtained using the Markov chain. Many studies (Ray et al, 2018; Idris, Mudiare, Igbadun and Ramalan, 2021; Fischer, Mul and Savange, 2012; Mengistu, Olivier, Botai, Adeola and Daniel, 2021) using the Markov chain model were conducted by assuming a fixed threshold value to characterize a rainy period as being wet or dry. Reddy (1990) stated that 3mm of rainfall per day can satisfy the average crop water requirement, and a decade. Mersha (2003) used the same threshold value to assess the moisture availability over the arid and semiarid zone of Ethiopia using a Markov chain model. Similarly, Yemenuand Chemeda (2010) considered a fixed threshold value of 30mm per decade to categorize a decade as a wet or dry spell.Trend analysis was done to compare the trends in dry spells within the study period (2010-2019) in the study area. The trends of all the occurrences, yearly was done by MAKESENS in Excel to show the trends in the research. Correlation analysis was done to obtain the nature of relationship between dry spell and maize yield. Regression analysis was used to determine the relationship between the yield of maize and dry spell over Sokoto for a duration of 10 years (from 2010—2019).A pentad with less than 15 mm rainfall was considered as a dry pentad and a pentad with 15 mm or more rainfall as a wet pentad (Ray, Biswasi, Sahoo and Patro, 2018). The Markov chain model calculates the initial probabilities of getting a dry spell or wet spell for a given pentad. The calculation of conditional probabilities provides the information on the dry spell followed by dry or wet spell and vice-versa. The calculations of initial and conditional probabilities are given below.

Initial probability:

$P_D = F_D / N$ ………………………………………………………………………….… (8)

$P_W = F_W / N$…………………………………………………………………………..…. (9)

Conditional probabilities: $P_{DD} = F_{DD}/F_D$……………………………………………………. (10)

$P_{WW} = F_{WW} / FW$………………………………………………………………………… (11)

$P_{DW} = 1 - P_{WW}$.. (12)

Consecutive dry and wet pentad probabilities

$2D = P_{Dp1}\ P_{DDp2}$…………………….……………………………………………...……. (13)

$2W = P_{Wp1}P_{WWp2}$…………………………………………………………...……….(14)

$3D = P_{Dp1}\ P_{DDp2}\ P_{DDp3}$…………………………………………………………………(15)

$3W = P_{Wp1}\ P_{WWp2}\ P_{WWp3}$………………………………………………………………(16)

Where, P_D is the probability of the pentad being dry, P_W is the probability of the pentad being wet, N is the number of years of data, F_D is the number of dry pentads, F_W is the number of wet pentads, P_{DD} is the probability of a dry pentad preceded by a dry pentad, P_{WW} is the probability of a wet pentad preceded by wet pentad, P_{DW} is the probability of a dry pentad preceded by a wet pentad, F_{DD} is the number of dry pentads preceded by another dry pentad, F_{WW} is the number of wet pentads preceded by another wet pentad, 2D is the probability of 2 consecutive dry pentads starting with a particular pentad, 2W is the probability of 2 consecutive wet pentads starting with the pentad, 3D is the probability of 3 consecutive dry pentads starting with the pentad, 3W is the probability of 3 consecutive wet pentads starting with the pentad, PDp1 is the probability of the pentad being dry (first pentad), P_{DDp2} is the probability of the second pentad being dry, given the preceding pentad dry, P_{DDp3} is the probability of the third pentad being dry, given the preceding pentad dry, P_{Wp1} is the probability of the pentad being wet (first pentad), P_{WWp2} is the probability of the second pentad being wet, given the preceding pentad wet, and P_{WWp3} is the probability of the third pentad being wet, given the preceding pentad wet.

Results

Determination of Onset, Cessation and Duration of the Rainy Season

To determine the onset date of the rainy season for a given year, the daily rainfall data were observed from the beginning of the year to identify a wet day, then the next four consecutive wet days were also identified, ensuring that no dry spell of duration longer than 12 days occurred between them. The first wet day, after which no dry spell longer than 12 days occurred before the next four consecutive wet days were counted, marked the onset of the rainy season. On the other hand, cessation of the rainy season was determined by observing the daily rainfall data backward from the end of the year to identify the wet day after which a dry spell longer than 12 days occurred during the last four wet days of the year.

The onset and cessation dates of dry spell of rainfall for the study period (2010 – 20019) were calculated to observe the onset date and cessation of dry spells. The result is presented in figure 1. The result shows that the onset of dry spells occurred in three months, 3 times in April(9th, 10th& 28th), 6 times in May (4th, 7th, 13th, 16th, 20th& 31st) and once on the 1st of June; showing that the onset fluctuates in the date and month. In the same vein, the cessation date of dry spells in the study area within the study period of (2010 – 2019) occurred in two months, 2 times in September (22nd& 39th) it was fairly stabled in the month of October occurring 8 times (4th, 7th, 13th, 15th, 16th, 19th& 25th) but fluctuates in date of the month having the maximum date to be 25st October in2010 and occurring on the 4th of October consecutively in 2011 & 2017.

In general, the onset of dry spell in the study period of (2010 – 2019) fluctuates in month and the day in each month, which makes the onset of dry spell difficult to predict while, the cessation of dry spell was stable in October and occurred close to the end of September but fluctuates in the day of the month which makes it easier to predict with a range in the study area. The result is presented in figure 2.

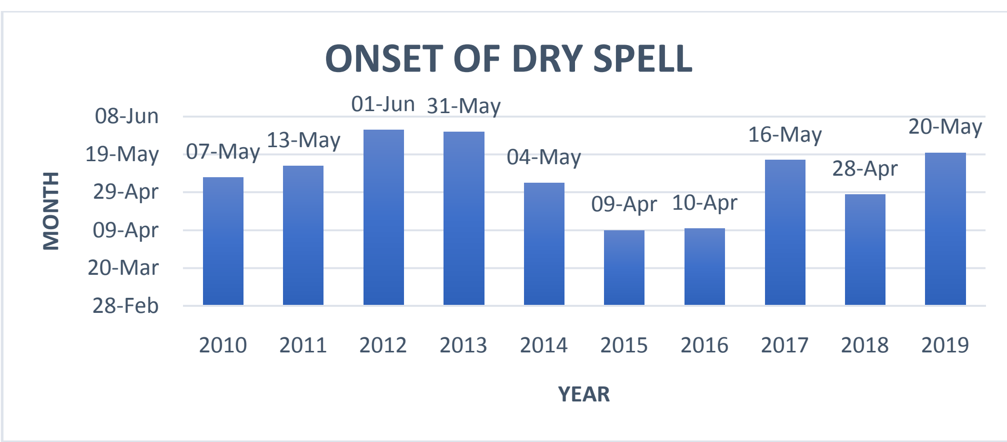

Fig 2: Trends in the Onset of Dry Spells Dates of Rainfall in SokotoState (2010-2019).Source: Authors Analysis, 2022

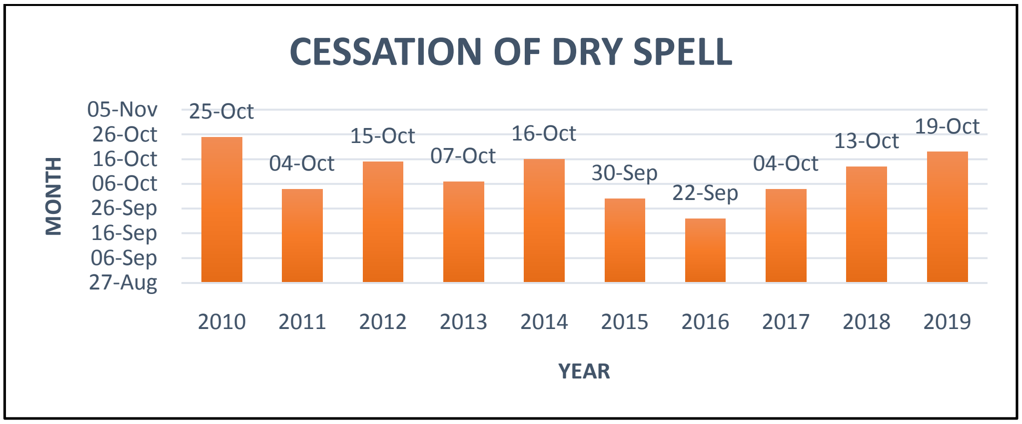

Fig 3: Trends in the Cessation of Dry Spells Dates of Rainfall in Sokoto (2010-2019).Source: Authors Analysis, 2022

Trends in occurrence and frequency of Dry Spells of rainfall.

The observed occurrence and frequency of dry spells with different length of days, two (2) days and above, were automatically counted from the data spread sheet (May to October 2010 – 2019) through the use of the Markov Chain probability model. The yearly observations of dry spells occurrences, having the maximum dry spells occurred 132 times in the year 2014 and the minimum dry spells occurred 72 times in 2013.It was also observed that the years that dry spell stated early (9th April – 16th May) in 2010, 2011, 2014, 2015, 2016, 2017 & 2018 had an average of 100 days of dry spells, with dry spell of more than 7 days occurring immediately at intervals after the rains begin (false start of rainy season) showing that April – May is not an ideal time to start planting as the rains is yet to fully set. In the same vein, dry spells that begin from the ending of May to the beginning of June (20thMay– 1st June) in 2012, 2013 & 2019 had an average of 72 days of dry spell. The rains start to stabilize July - September with shorter intervals of dry spell of 2-4 days. Indicating that this is an ideal time for planting, also the dry spell occurs more frequently from the ending of September to the beginning of October right about the time that it ends. This means that dry spell occurs at the beginning, middle and at the end of the rainy season but it is more severe at the beginning and at the end of the rainy season. The result is presented in Table 1

Table 1: Frequency, Onset & Cessation of Dry spells

YEAR	FREQUENCY	ONSET	CESSATION
2010	105	07-May	25-Oct
2011	108	13-May	04-Oct
2012	95	01-Jun	15-Oct
2013	72	31-May	07-Oct
2014	132	04-May	16-Oct
2015	107	09-Apr	30-Sep
2016	123	10-Apr	22-Sep
2017	102	16-May	04-Oct
2018	103	28-Apr	13-Oct
2019	90	20-May	19-Oct

Source: Authors Analysis, 2022

The result of the trend in frequency of annual dry spell series is presented in figure 3

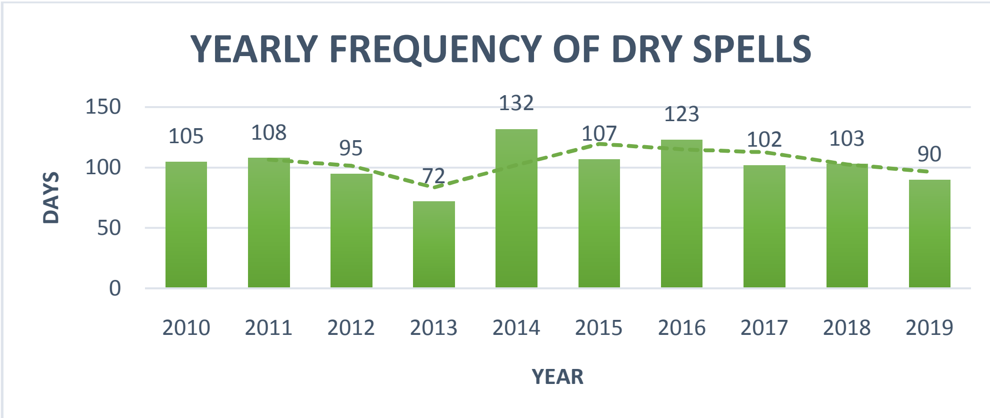

Figure 3: Trends in the Frequency of Dry Spells Yearly in Sokoto state (May to October, 2010 -2019)
Source: Authors Analysis, 2022.

Analysingthe Perceived Effects of Dry Spells on the Yield of Maize in Study Area.

Regression analysis was used to determine the relationship between the yield of maize and Dry spell over Sokoto for a duration of 10 years (from 2010—2019). The result is presented in table 2.

Table 2: Regression Analysis: DRY SPELLS (mm) versus YIELD OF MAIZE (Mt/ha)
The regression equation isDRY SPELLS (mm) = 106 - 0.0185 YIELD OF MAIZE (Mt/ha)
9 cases used, 1 case contain missing values

Predictor	Coef	SECoef	T	P
Constant	105.634	6.384	16.55	0.000
YIELD OF MAIZE (Mt/ha)	-0.01849	0.09974	-0.19	0.858

S = 17.9542 R-Sq = 0.5% R-Sq(adj) = 0.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	11.1	11.1	0.03	0.858
Residual Error	7	2256.5	322.4		
Total	8 2267.6				

After the linear regression was calculated, it gave results with the Significance F to be (0.858169) which is significantly greater than the critical value (0.05). This implies that there is a relationship between dry spells and the yield of maize in Sokoto state, and further calculated the predict the yield of maize as seen below in the (Fig 4) which rightly explains that a decrease in dry spell will result in an increase in the yield of maize and vice versa. The correlation of frequency of dry spell and maize yield showed that there is a negative relationship between the increases in duration of dry spell with maize yield. This meant that as the frequency of dry spell increases, the yield decreases as shown in the result below.

Correlations: DRY SPELLS (mm), YIELD OF MAIZE (Mt/ha)

Pearson correlation of DRY SPELLS (mm) and YIELD OF MAIZE (Mt/ha) = -0.070

P-Value = 0.858

The result of the dry spells, production of maize, area cultivated and the yield of maize in the study area is presented in table 4.

Table 3: Dry spells Production of Maize, Area Cultivated & the Yield of Maize in the Study Area.

Year	Dry Spells (mm)	Production of Maize (Mt)	Area Cultivated (ha)	Yield of Maize (Mt/ha)
2010	105	35	44.90.	0.78
2011	108	33	45.00.	0.73
2012	95	33.5	46	0.73
2013	72	33.8	45.50.	0.74
2014	132	50	46.5	1.08
2015	107	60.7	47	1.29
2016	123	60.9	47.5	1.28
2017	102	91.5	47.7	192
2018	103	93	47.7	1.95
2019	90	-	-	-

Source: Authors Analysis, 2022.

Also, an empirical trend analysis graph of dry spells against maize production was plotted in (Fig 5) and from practical observation following the trend lines it shows on an average that higher occurrences of dry spells have led to a decrease in the yield of maize. Trend analysis of the frequency of dry spell and maize yield over the time period is shown in Table 4. The result shows that there is a positive increase in the incidence of dry spell over the time period with z-score of 1.22 and a B-score of 1.881 which indicates that the frequency of dry spell increased by 2 days over the decade while the maize yield showed a negative trend with z-score of -1.81 and a B-score of 0.103.The trend of the dry spell analysis of maize yield is shown on figure 5 and 6.

Table 4: Mann-Kendall Trend analysis of dry spell.

Time series	*First year*	*Last Year*	*n*	*Test S*	Test Z	Significance.	Q
Dry Spell	*2010*	*2019*	*10*		1.22		1.881
YIELD OF MAIZE (Mt/ha)	*2010*	*2019*	*10*		-1.81	+	-0.103

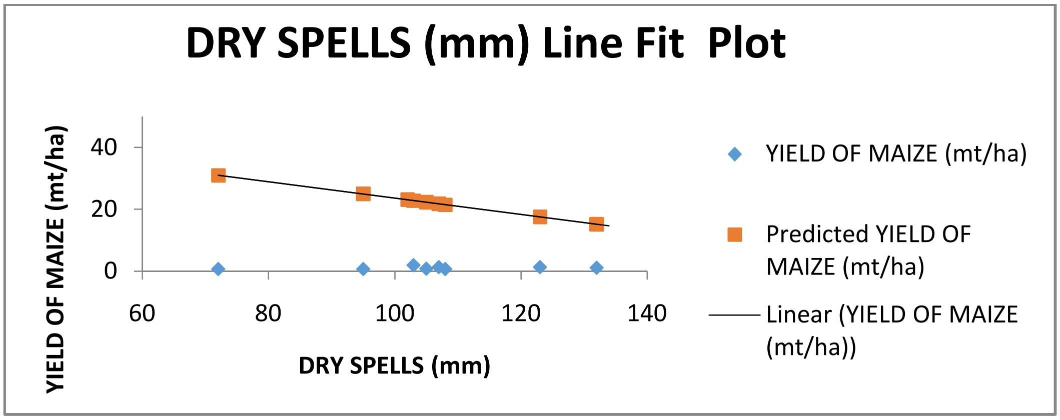

Fig 5: Trend Analysis line fit plot (Source: Authors Analysis, 2022)

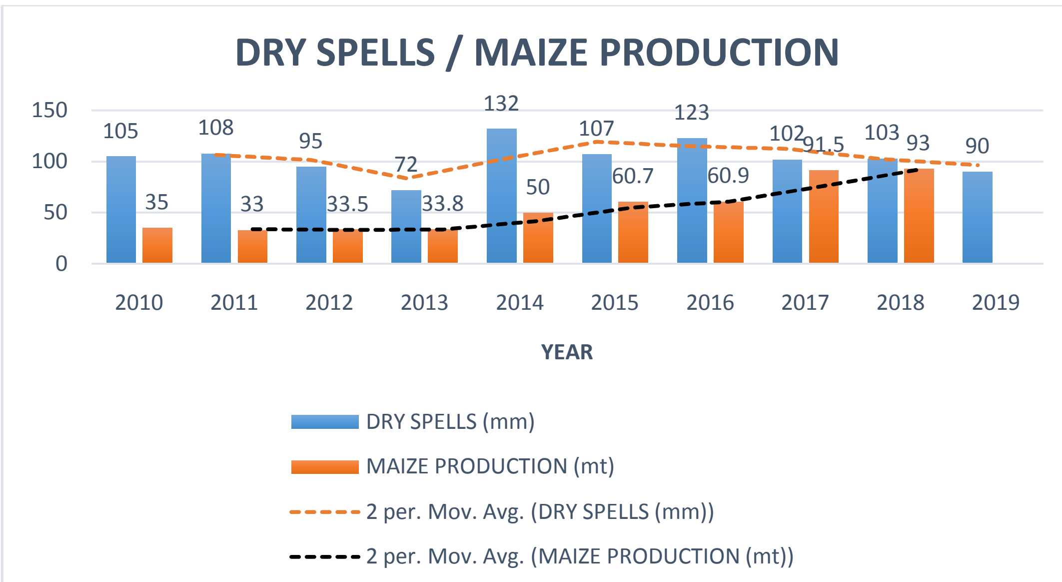

Fig 6: Trend analysis of the relationship between Dry spells and the production of maize inSokoto state (May to October, 2010 -2019). Source: Authors Analysis, 2022.

Discussion

The study made use of daily dataset of rainfall for Sokoto state obtained from Nigeria Metrological Agency (NIMET) Abuja for a period of 10 years (2010-2019) to determine the trends in the dates of onset and cessation of dry spells of the study area using direct observation (empirically) with the help of excel spreadsheet. Trends on the occurrence and frequency of dry spell were also determined yearly by direct observation in Excel spreadsheet within the study period (2010-2019) focusing only on the raining months in the study area (May to October). Also, data on the yield of maize was collected from ADP office in Sokoto state for a period of 10 years (2010-2019) was used together with the frequency of dry spells to determine the perceived effects of dry spells on the yield of maize in the study area using linear regression analysis.

The results show that the onset of dry spells in the study area within the study period ranges from 9th April, in 2015 to 1st June in 2012 showing fluctuations in three months (April, May & June) as well as in date in the months. While, the cessation dates of dry spells occurred in two months

(September & October) but was stable in October, it fluctuates in dates in the month, having the maximum cessation dates to be 25thOctober and the minimum date to be 22th September. In general, the research work indicated that the onset dates of dry spells are difficult to predict as it fluctuates between three months but having the maximum month to be May. In the same vein, cessation date of wet spells can be predicted on the study area.

These changes on the onset and cessation of wet and dry spells of rainfall indicates that there have been recent changes in rainfall characteristics which affect the inconsistency and variability on the onset and cessation of dry spell in the study area within the study period. All these changes in dry spell have a negative effect on crop production when they become usual.

Meanwhile, the occurrence and frequency of dry spells was also determined in the study area within the study period, to compare the trends, if there have been changes in the year of the study periods. The analysis show that there have been changes in trends and most of the changes occur of recent and need to be checked in other for the country not to be at risk in years to come due to the relationship and the importance of rainfall in agricultural production.

Additionally, linear regression analysis was used to determine if a relationship exists between dry spells and the yield of maize in the study area. The results showed a significant F value of (0.858169) which is greater than the critical value of (0.05) indicates that a relationship exist between dry spells and the yield of maize. Therefore, having a significant F value that is greater than the critical value (0.05) rejects the null hypothesis (H_0) which states that “there is no significant relationship between dry spells and the yield of maize” and accepts the alternative hypothesis H_1: that “there is a significant relationship between dry spells and the yield of maize. The knowledge of dry spells of rainfall will enable farmers in Sokoto state to take advantage on how to plan for their farming activities each season. A graph was used to empirically analyse the perceived effects of dry spells of rainfall and the production of maize. The result shows that the perceived effect of dry spells of rainfall has negative effects on the yield of maize crop.

Conclusion

The research finding observedthat there are changes in the onset and cessation of dry spells of rainfall due to the changes in rainfall characteristics which also affect the variability of the onset and cessation of dry spells in the study area. It observed an increase in trend of dry.Finally, the perceived effects of dry spells of rainfall showed negative impacts on maize yield in the study area. The increase in dry spells beyond normal is unfavourable to production of maize because crops require at least 1mm per day to grow well. There is need to employ irrigation agriculture to boost maize production and improve economic fortunes of the residence.Given by the above discussed results of the study, the following are therefore recommended:The occurrence of dry spells, the onset and cessation are highly variable in the study area, this fluctuation in the onset and cessation of dry spells requires the need for irrigation agriculture. The perceived effect of dry spells on crop production is negative and it is recommended that farmers should use drought resistant varieties of crops to improve yield.Government should bring policies that will be favourable and helpful to the young farmers in the study area.

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