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Full Length Research Article

IMPACT OF RAINFALL VARIABILITY ON LEGUMINOUS CROPS PRODUCTION IN ZARIA, KADUNA STATE, NIGERIA

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ABSTRACT
Rainfall variability is a significant factor in ensuring food security for every part of the world. Rainfall, especially in tropical regions, is one of the main factors affecting the production of leguminous crops, particularly in Zaria. The aim of this study is to assess the influence of rainfall variability on leguminous crop production in Zaria, Kaduna State, Nigeria, and to determine the trend in leguminous crop yields in the study area. Rainfall data were obtained from the Nigeria Meteorological Agency (NiMet) in Zaria for a period of ten years (2015-2024), and leguminous crop yields were acquired from the National Agricultural Extension Research and Liaison Service (NAERLS) for the same ten-year period (2015-2024). These data were analyzed using correlation and simple linear regression analysis. The results revealed that variability in rainfall during the growing season positively affects leguminous crop yields in the study area, with correlation coefficients of 0.581. There is a general fluctuation in the rainfall pattern from 2015 to 2024. From the data gathered, it is observed that rainfall typically begins in April and ceases in October. The regression analysis showed that the rainfall variability indices account for 40.7 percent of the influence on leguminous crop yield, with r = 0.581 (0.316) during the reference period (2015-2024). This study recommends the judicious use of weather and climate forecasts and further research on other environmental factors such as soil fertility, as this will aid farmers in proper planning during crop production activities.

Keywords: Cessation, Crop; Climate, Legume, Rainfall

INTRODUCTION
Rainfall is one of the most important climatic parameters that has great impact on plants and human systems as it determines plants growth and the livelihood of humans for food production. The understanding of the link between rainfall variability, and crop productivity is very important in ensuring the future of food security in every part of the world (Ray, et. al., 2015). In many poor developing countries, people engage in climate-sensitive activities especially agriculture for their livelihood support (Kyei-Mensah, et. al., 2019). It is reported that, rainfall variability is estimated to control more than 80% of rain-fed agricultural produce in sub-Saharan Africa (Rosegrant, et. al., 2002) and rainfall variability is negatively affecting the agricultural sector. Rainfall, especially in the dry tropical environment is one of the main factors affecting crop productivity (Panda, et. al., 2019), this is because rainfall onset determines planting season and its cessation marks harvesting period. Where rainfall is optimum, crop productivity is usually high and if low, this determines low productivity (Ati, et. al., 2009). Emeghara (2015) revealed that, an in-depth understanding and knowledge of the pattern of rainfall indices is a very important measure in determining crop productivity and also a vital prerequisite to combating food insecurity in many parts of developing countries.
Rainfall availability is the sole factor in the leguminous crop life cycle, in many phonological stages such as germination, growth, flowering and grain development, water deficit can cause damage to its productivity (Heisey and Edmeades, 1999).
Rainfall is considered as the leading climatic factor that has effects on crop productivity (Iornongo and Terser, 2021). However, fluctuations in rainfall will affect yield production.
Variability of rainfall is increasingly becoming a thing of concern in the agricultural rain- fed places of the world, because of its pattern, distribution and seasonality. In areas where rain-fed agriculture is mostly practiced, the erratic nature of water and its irregularities in both the amount received and its spread is a major threat to agricultural production as yields are progressively becoming poorer which indicate that there is high variability in crop production (Agidi, 2014).
The unpredictable pattern of the onset of rainfall, cessation, and length of growing season in a location can affect the farmers negatively in an area that mostly depends on rainfall for their farming activities (Agidi, 2017). Rainfall variability in Nigeria affects the rain-fed agriculture in which people depend. In this region, crop loses their viability, and the farmers lost their income source. Despite the great potentials of Nigeria in crop production, the frequent occurrence of drought occasioned by erratic rainfall distribution or cessation of rain during the growing season is the greatest hindrance to increasing production and this is more serious in the northern part of the country where most of the leguminous crop is produced.
Singh, Ehlers and Sharma (2002) said that leguminous crop is an important grain legume that provides a great companion in most cereal legume cropping systems as it gives benefit from its nitrogen-fixing ability. Leguminous crop plays a significant role in the lives of people due to its nutritional and economic value (Ogunbode et al., 2006). Nigeria, Brazil and Niger are among the major producers and account for about half of the world population and leguminous crop forms part of the cheapest source of dietary protein and energy for most poor people in the tropical world, and is usually consumed because of its high protein and carbohydrate contents with low fat content that complement amino acid (Murtala et al., 2018) .
Despite the importance of leguminous crop its production is affected with constraints such as drought, increase in rainfall, salt –stress and extreme temperatures, all of which worsen as climate changes increases (Adeogun et al., 2009). Productivity of leguminous crop is mainly determined by ecological factors including climate, soil, pests and diseases. Hence, any changes in these factors could lead to changes in productivity and also contribute to inter-annual changes in crop productivity (Adejuwon,

2006).

In this sense, rainfall variability affects leguminous crop productivity as it affects the number of rainy days, length of rainy season and the length of leguminous crop growing season (Ammani, et. al., 2012). Previous researches in the country have discussed the influence of climatic change on farming activities, yet much attention has not been given to a rainfall variability and its effect on a leguminous crop productivity. It is based on this facts that this article aimed at impact of rainfall variability on leguminous crops production in Zaria, Kaduna State, Nigeria.

MATERIALS AND METHODS

Study Area.

Zaria Local Government Area (LGA) is located in Kaduna State, Nigeria. It is located in the northwestern part of Nigeria. It is situated approximately 78 kilometers north of Kaduna, the state capital, and about 206 kilometers north of Nigeria's capital, Abuja. It covers an area of approximately 3,080 square kilometers. The LGA is at latitude $11^0$3'31.39"N, longitude $7^0$42'25.37"E (Fig 1). The study area which include Kufena at latitude $11^0$5'53.37"N and longitude $7^0$39'56.39"E), Tudun wada at latitude $11^0$5'5.88"N and longitude $7^0$43'5.64"E) and Dambo (located at northeastern part of Zaria at latitude $11^0$4'22.50"N and longitude $7^0$46'27.37"E). (Odunze, 2012). Figure 1.

The study area lies in the tropical wet and dry climate zone (Aw) characterized by strong seasonality in rainfall and temperature distributions. The wet season lasts from April through October with a peak in August, while the dry season extends from November of one calendar- year to April (Murtala, et. al., 2021)

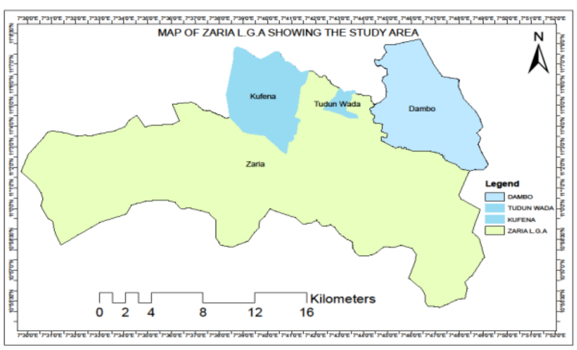

Figure 1: Map of Zaria Local Government Area

Data Collection

The Daily rainfall data (mm) from 2015-2024 was retrieved from the database of the Nigerian Meteorological Agency (Nimet) and leguminous crop yield data was collected from National Agricultural Extension Research and Liason Service (NAERLS) in Zaria also for the period of ten (10) from 2015 to 2024. The daily rainfall data (mm) collected for the study was used to derive rainfall onset date, cessation date, length of the rainy season and annual rainfall.

Analysis of Data

Relationships between the rainfall variability and leguminous crop yield was analyzed through the use of the Pearson product-moment correlation method. The Pearson product-moment correlation was used to test the to achieve rainfall variability, assessment of the trend of leguminous crop yield, and identification of the onset and cessation of rainfall in order to achieve the relationship between rainfall variability and leguminous crop yield in the study area within the research reference period. This is calculated using the Pearson product moment correlation equation below.

$$r = \frac{\frac{1}{n}\Sigma(x_1-x)(y_1-y)}{\sigma x \sigma y} \quad (1)$$

$$\sigma x = \frac{\sqrt{\Sigma}(x_1-x)^2}{n} \quad (2)$$

$$\sigma_y = \frac{\sqrt{\Sigma}(y_1-y)^2}{n} \quad (3)$$

Where: r is the coefficient of correlation, σx is the standard deviation of x, σy is the standard deviation of y, x1 is the score of the first variable, y1 is score of the second variable and n is the number of variables.

For testing for significance of 'r' (two-tailed at 0.05 significant levels) the equation is given below as:

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}} \quad (4)$$

Where: $n - 2$ = degree of freedom, n = sample size of paired scores, r = coefficient of correlation, t = testing for the significance of 'r'.

Also, multiple linear regression analyses was used in predicting crop yields. The yield was expressed as dependent variable (y) and rainfall indices as independent variables (x). The general form of multiple linear regression equation is presented below:

$$y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 \quad (5)$$

Where: y = Maize yield in tons, a = Constant, b = is the rise or fall as x changes, x1 = Total annual rainfall (mm), x2 = Onset dates of rain, x3 = Cessation dates of rain, x4 = Length of the raining season.

RESULT AND DISCUSSION

Analysis of Rainfall Data

The monthly rainfall distribution of the years under study was analyzed. The analysis revealed that the highest rainfall in 2015 is 313.9 millimeter (mm) and least of 0 millimeter (mm). It was observed that the highest monthly rainfall in 2016 is 374.3mm and the least of 0mm (Fig 2). Also, highest monthly rainfall was recorded to be 347.1mm and the least of 0mm in 2017. It was also recorded in 2018 that the highest monthly rainfall in the study area is 263.7mm with the least of 0mm. Likewise in 2019 (Fig 2), it was observed that the highest monthly rainfall of the year is 271.0mm with the least of 0mm. 303.4mm was recorded to be the highest monthly rainfall with the least of 0mm in 2020 (Fig 2). Observation also indicates that in 2021, the highest monthly rainfall in the year is 274.6mm and the least is 0mm. In 2022, it was recorded that 338.7mm is the highest monthly rainfall in the year and with less of 0mm. subsequently, in 2023 the highest monthly rainfall is observed to be 332.4mm and less of 0mm. 350.7mm was recorded to be the highest monthly rainfall in 2024 with the least of 0mm (Fig

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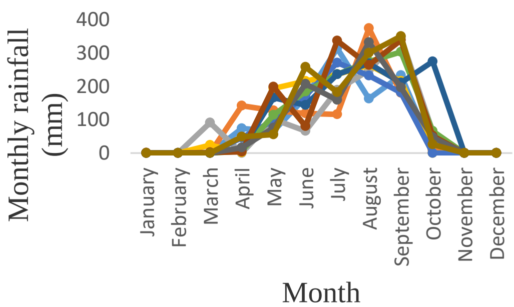

Figure 2: Monthly rainfall in (mm) from the year (2015 – 2024).

Over the period of study, 2024 is observed to be with the highest average annual rainfall of 116 (mm) and the least average annual rainfall of 83.3mm (Fig 3), which shows the average annual rainfall graph in (mm).

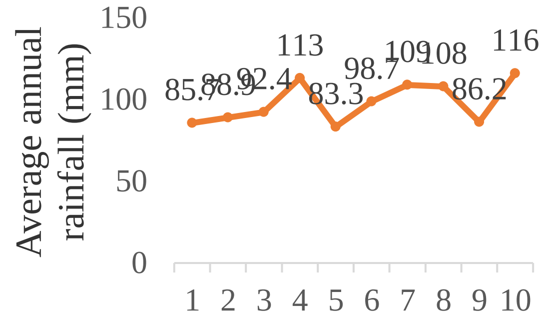

Figure 3: *Average annual rainfall (mm) from the year 2015-2024.*

The research observed that 2016 is recorded to be with the highest leguminous crop yield production of 3.27 (t/ha) and the least leguminous crop yield production of 2.56 (t/ha) (fig 4). Figure 4 shows the performance of leguminous crop yield production.

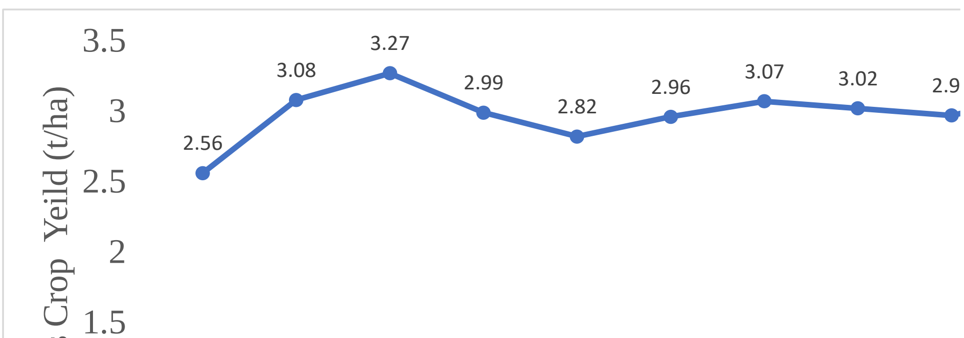

Figure 4: *leguminous crop yield (t/ha) from the year (2015 – 2024).*

Relationship between Rainfall and leguminous Crop Yield

The correlation of annual rainfall and leguminous crop yield (r = 0.581) shows a moderate positive correlation and accounts for 38.777 percent variation in leguminous crop yield (Table 1). The computed 't' value is 2.525 which is greater than the critical 't' value of 2.4225 at 0.05 two tailed level of significance (Table 1). Therefore, it can be concluded that there is significant relationship between annual rainfall variation and leguminous crop yield in the study area. The implication is that increase in average annual rainfall in the study area contributes slightly significantly to influence leguminous crop yield in Zaria, Kaduna State. This finding is in concordance with the study of (Shugaba, 2017) which also revealed a weak positive correlation of annual rainfall with millet in Katsina state and also agreed with Murtala and Abaje (2018) that the correlation analysis indicates a positive relationship between rainfall values and leguminous crop yield, which also revealed positive relationship between temperature and leguminous crop yield. But contrary to the findings of Egbutah and Odiaka (2011) that the effect of rainfall and temperature on yield of tomato was not significant.

Rainfall onset date and cessation date show a weak relationship with (r = -0.572) and (r = 0.432) Table 1. These indicate an early rainfall onset date and late cessation date and short spread of rainy season (with most rain in three or less than three months) in the study area. These findings is in line with the research of Shugaba and Ahmed, (2020) which revealed a weak relationship between rainfall onset date and cessation date with millet yield in Katsina state

Length of rainy season has the strongest effects on leguminous crop yield in the study area with correlation coefficients of 0.524 and it account for 25.111 percent variation in leguminous crop yield (Table 1). The computed 't' value is 2.546 which is greater than the critical 't' value of 2.4225 at 0.05 two tailed level of significance (Table 1). Therefore, there is a significant relationship between length of rainy season and leguminous crop yield in the study area.

Table 1: Relationship between Rainfall Variability and leguminous crop Yield

Variables	*R*	r^2	r^2x100	100-r^2	Computed *'t'*	Critical *'t'*
Rainfall Variation & leguminous crop	0.581	0.216	38.777	65.258	2.525	2.4225
Onset of rain & leguminous crop yield	-0.572	0.322	22.112	78.258	-2.112	2.4225
Cessation of rain & leguminous crop	0.423	0.211	12.214	87.855		2.4225
Length of raining season & leguminous crop yield	0.524	0.321	25.111	74.523	1.678	2.4225
					2.526	

Regression Analysis for Rainfall Variation and Leguminous crop Yield

The multiple regression analysis was used in predicting annual leguminous crop yield based on the studied rainfall variation effectiveness parameters.

The result indicates that the rainfall variation, accounts for 72.7 percent influence in leguminous crop yield in the study area (Table 2). Rainfall amount in July has the highest influence on leguminous crop yield with the regression coefficient of 0.543. This finding is related to the findings of Emeghara (2015) whose work revealed that onset date of rainfall, cessation date of rainfall, length of rainy season and dry spell account for 52.1 percent variation in leguminous crop yield in Sokoto state.

Table 2: Regression for Rainfall Indices and Maize Yield

Variables	Coefficient	t-value	Sig. of t	R^2
Leguminous crop yield		658	0.58	72.
Annual rainfall	-055	428	0.87	7
Onset date of rain	287	-		
Cessation date of rain	0.474	0.58	0.62	
Length of raining season	0.247	8	7	
		0.32		
		4	0.88	
		0.14	7	
		4	0.78	
			7	

DISCUSSION OF FINDINGS

Base on rainfall distribution trends, the analysis of the monthly rainfall data from 2015 to 2024 reveals significant variations in monthly rainfall amounts. The highest monthly rainfall occurred in July 2015, with 313.9 mm, while some months in various years experienced no rainfall. This highlights the variability in rainfall patterns over the study period. It was observed that the average annual rainfall over the 10-year period, 2024 was recorded to have the highest average annual rainfall of 116 mm, whereas 2017 had the least with 83.3 mm. This indicates fluctuations in annual rainfall, with implications for agricultural activities that depend on consistent and adequate water supply. The analysis of leguminous crop yield production from 2015 to 2024 indicates variations in leguminous crop output. In 2016, the highest yield of 3.27 t/ha was recorded, while 2017 had the lowest yield of 2.56 t/ha. These variations could be attributed to rainfall variation with other several factors, including agricultural practices, and pest/disease management. The current study aligns with Murtala and Abaje (2018), indicating a positive relationship between rainfall and leguminous crop yield.

Conclusions

The study concludes that, there is no doubt that rainfall is one of the most important factors that determine leguminous crop productivity in Zaria during the study reference period (2015-2024). While there is a positive relationship, the low coefficient and the modest R-squared value indicate that other factors, not included in the model, play a substantial role in determining leguminous crop yields. In essence, the study revealed how significant rainfall is in determining leguminous crop yield, even though, other factors play a vital role in that purpose. This means rainfall variation at a local scale in this area may risk people lives to food insecurity through hunger and diseases.

The study concludes that the importance of conducting comprehensive agricultural studies that consider a range of variables influencing crop production. While rainfall is a crucial factor, such as soil quality, crop management practices, pest and disease control, and technological interventions also contribute to agricultural outcomes. Future research should explore the interplay of these factors to provide a more nuanced understanding of leguminous crop -yield dynamics.

Recommendations

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

1. Given the observed impact of climate variability on agriculture, it is recommended to promote and adopt climate-smart agricultural practices. This includes the integration of resilient crop varieties, water management strategies, and soil conservation techniques.
2. Farmers should be educated and supported in implementing practices that enhance their adaptive capacity to changing climatic conditions.
3. To mitigate the risk associated with fluctuations in rainfall and other climatic factors, farmers should consider diversifying their crop portfolio. This diversification can include the cultivation of different crop varieties with varying water requirements, helping to ensure a more stable agricultural output despite varying climate conditions.

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