CLIMATIC VARIABILITY AND ITS EFFECTS ON SORGHUM PRODUCTION IN NIGERIA, 1980-2021 (A REVIEW).

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Abstract

The study examined the relationship between Climatic variability and sorghum yield in Nigeria.The analysis was done on the data of sorghum yield and Climatic variability from1980 to 2021. The trends were shown during the rainfall season with the effect of climatic variability on sorghum production. It was revealed that sorghum production suffered significant yield reduction when the rains were high. Tests (unit and diagnostic) were conducted at the preliminary stage, with the usage of a time series variables. The adjusted R^2 value of 86.62% suggested that rainfall, temperature and relative humidity jointly explain a significant part of the variation in Sorghum yield. The findings further showed that sorghum is a drought resistant crop in the study area; despite the decline in annual rainfall, sorghum yield was increasing as a result of other factors(-4.181885 temperature, and -177.8620 relative humidity). The study thus, recommended the provision of early warning weather information to farmers; use of climate-resilient varieties, high and early maturing cultivars and fertilizer management to improving the productivity of sorghum in the study area.

Key words: **Sorghum, production,** limatic variability

INTRODUCTION:

Rainfall is considered the primary input for crop yield in Sub-Saharan Africa, any significant variability in the amount of annual rainfall could have an equally significant impact on agricultural production (Ati et al.,2009). Rainfall shows a more complex structure over time and space. The rainfall is highly variable both in amount and distribution across regions and seasons. The Intergovernmental Panel on Climate Change License 4.0 International License (IPCC, 2001) pointed out that rainfall in Sub-Saharan Africa exhibits high inter-decadal variability, a pattern of continuous aridity since the late 1960s. The degree to which rainfall amounts vary across an area or through time is an important characteristic of the climate of an area. This subject area in meteorology/climatology is called rainfall variability (Nouaceur and Murarescu, 2016). Impacts of rainfall variability are felt among farmers in many regions and developing countries including Nigeria. Rainfall variability constitutes a serious adverse socio-economic and environmental problem in Nigeria. It has resulted into seasonal drought, flood, soil erosion, climate change, biodiversity loss among others (Adejuwon and Odekunle, 2006). The natural resources base on which farmers depend on are altered, traditional socio-economic livelihoods stressed and the potential for future agricultural development are affected by rainfall variability. Moreover, over the past years concerns have grown on increased rainfall variability across seasons resulting in large yield variability and thus becoming an apparent determinant on the performance andadaptation of sorghum varieties (Traore et al., 2016). Meteorological data have shown that rainfall pattern in Nigeria has changed in the past decades. Oladipo (1995) reported that decline in the rainfall in Nigeria started in the beginning of the 1960s when a decade of relatively wet years ended. Fluctuations in rainfall and other manifestations of the impacts of climate change are direct threats to the livelihoods of Nigerians, and indeed a direct threat to farmers. As rainfall variability increases, its impact on livelihoods of indigenous farmers bites harder. Some of the consequences of this are that farmers are forced to cultivate more lands to marginally increase yield to make up for the shortfall (Agwu and Okhimamhe, 2009). Total annual rainfall at a location is influenced by several variables including the frequency of rainfall events, the duration of the rainy period and the intensity of rainfall of individual events. Inhomogeneities in the annual rainfall therefore reflect changes in these contributory variables. Adejuwon et al. (1990) fitted linear trends to the annual rainfall series of several locations in Nigeria for the entire period of available data which, in some cases, began in 1922. Olaniran (1991) analyzed the fluctuations in the series of rain days of three rainfall categories (low, moderate and heavy intensity). On the other hand, Dammo et al. (2015) examined quantitative analysis of rainfall variations in north- eastern region of Nigeria based on the standard climatic normal periods. Apart from this, assessment of the trends and changes in different categories of rainfall variability and its effects on the yield of sorghum in Potiskum Local Government Area (LGA), Yobe State, Nigeria appears in the literature.

Sorghum *(Sorghum bicolor L. Moench)* is a local grain cultivated predominantly in the semiarid savannah and grassland areas of Northern Nigeria and other parts Ejeh and Ikpe 11 of the world. Sorghum is viewed as a possible replacement crop for corn cultivated for grain and silage, in part due to sorghum's lower input requirements and costs, and its drought tolerance. It is nutritionally rich and serves as a staple food in most parts of Nigeria.The grain has assumed commercial relevance lately, especially in the food and beverage industry. It has been found to be a valuable ingredient next to malted barley used in the beverage industry. Sorghum is an annual grass, 5–7 feet tall, similar in appearance to maize (corn). Through breeding efforts, newer varieties now have 2-3 dwarf genes, resulting in a plant 2-4 feet tall and easier to harvest. The most extensively grown and best-known sorghum species in Nigeria is vulgare and S. bicolor (L.) Moench., locally called guineacorn,. Both varieties can be white or yellow (Food and Agriculture Organization, 2012). Sorghum requires rainfall of about 600-1,000 mm for a duration of at least five months spread over eighty rainy days (Odjugo, 2009). That means where rainfall totals fall below 600 mm, effective sorghum production will be affected. It also implies that sorghum production will also be affected where the amount of rainfall exceeds the required maximum. The development of the crop takes 110 to 170 days, and is frequently considered to have 3 stages: emergence, floral initiation to flowering, and flowering to physiological maturity. The crop thrives better under dry and cool conditions. Sorghum is a thermophilic (26ºC-40ºC), drought-resistant plant, which grows slowly at 16-20ºC, and stops growing under 14ºC. Its productivity is dependent on quantity of rains during pre-sowing season and water holding capacity of soil (Iren, 2004). Sorghum is widely grown both for food and as a feed grain. It plays a significant role in food security in northern Nigeria. The stems are used for fuel and building fences and local huts, hence, the reason for its wide cultivation in northern Nigeria. Nigeria must double its production capacity and equally address the challenges facing the agricultural sector,particularly those associated with rainfall variability in order to meet the high demand of sorghum. According to Schaefer (2001), crop yields are affected by climatic variables, uneven rainfall distribution and prolonged arid period which lead to further development of soil erosion and loss of fertile soil.

Result and conclusion

Table 1: contains ARDL co-integration test results and critical values for F-Statistic are presented in Pesaran (2001).

Note: k shows the number of explanatory variables. On the bases of F-test at 5%, levels of probability with the critical values stated below which are less than the F-calculated of 27.61707, we accept the null hypothesis and conclude that the regression line for crop yield is statistically insignificant.

As seen in Table 1, the calculated F statistic values are above the critical values. This implies that there is a long-run relationship between the mentioned variables in the period covered. Long term coefficients calculated according to the estimation results of ARDL model are shown in Table 2. The results of long run estimates are presented in Table 2. The results show that the rainfall has a negative and significant impact on the sorghum yield, in the long run. The bottom part of Table 2: contains diagnostic test results of the selected ARDL model. The adjusted R2 value of 86.62% suggests that rainfall, temperature and relative humidity jointly explain a significant part of the variation in Sorghum yield. Next are the results of the short run ARDL estimate are presented in Table 3: The coefficient of temperature implies that increase in temperature, will cause a decrease of 418.18% in yields of Sorghum in the long run in Nigeria. However, the results show that the rainfall has a negative and significant impact on the yield of Sorghum, in the long run. The coefficient of rainfall implies that an increase of 1% in rainfallleads to a decrease of 5.83% on Sorghum yield, in the long run in North Central. The coefficient of relative humidity implies that an increase of 1% in relative humidity leads to an increase of 177.86% on Sorghum yield.

Table 1

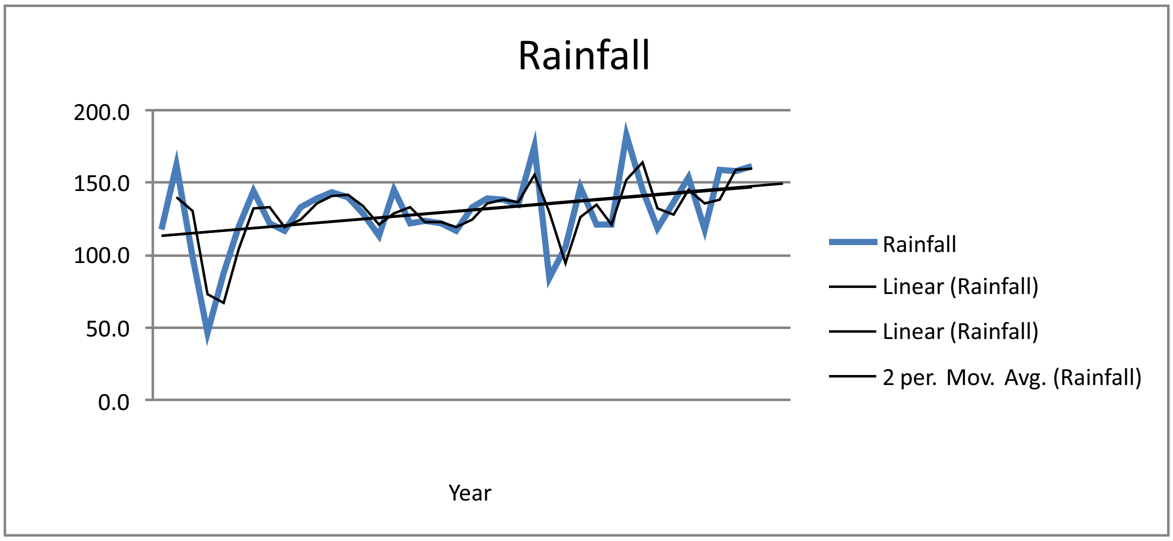
ARDL Co-integration Test Results Test statistic	Value	k
F Statistics	27.61707	3
Critical Value Bounds (Peseran 2001)		
Significance	I0 Bound	I1 Bound
10 %	3.38	4.02
5%	3.88	4.61
1%	4.99	5.85

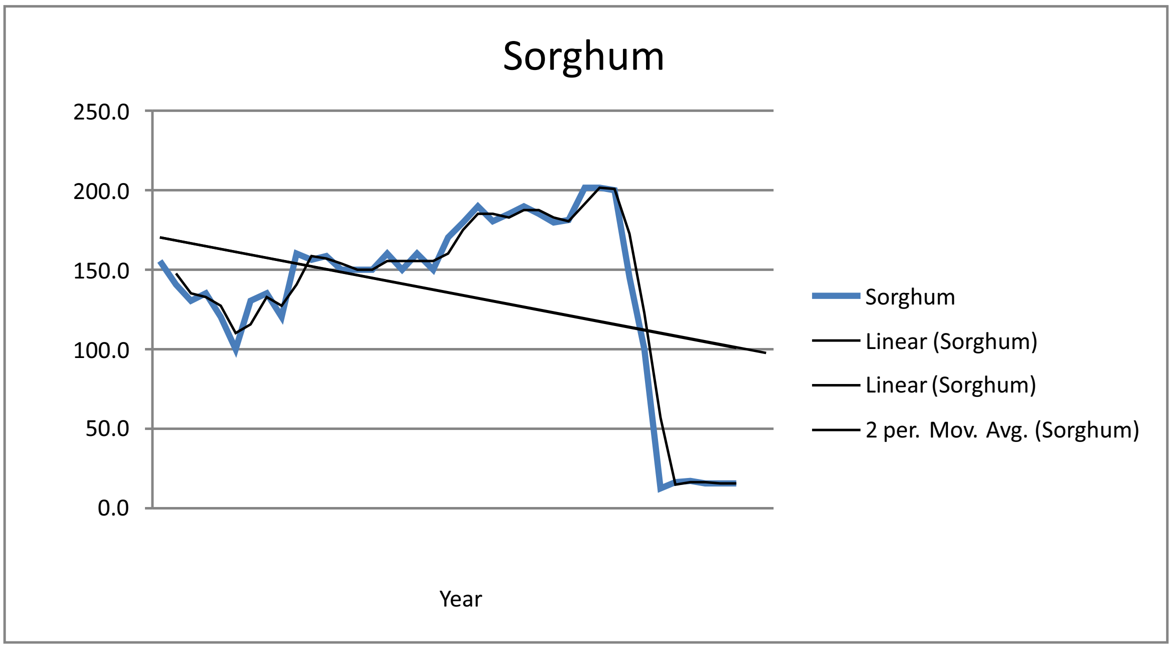
Table 2

Long-Run ARDL Estimates Dependent variable is Sorghum		
Regressor	Coefficient	T-statistics (Probability)
RAF	-0.058346	-0.302553 (0.7645)*
TEMP	-4.181885	-0.834327 (0.4112)**
REH	-177.8620	-1.741109(0.0926)*
Diagnostic test statistics		
R2	0.898754	
Adj.R2	0.866210	
F-statistic	27.61707 (0.000000)	

Table 3

Short-run ARDL Estimate Dependent variable is Sorghum		
Variable	Coefficient	T-statistics (Probability)
(SORG(-1))	0.978678	15.48792(0.0000)
(SORG(-2))	0.960916	14.51000(0.0000)
(RAF)	-0.058346	-0.302553 (0.7645)
(RAF(-1))	-0.090284	(0.6454)
(TEMP)	-4.181885	-0.834327 (0.4112)
(TEMP(-1))	0.440821	0.082931(0.9345)
(REH)	-177.8620	-1.741109(0.0926)
(REH(-1)	-123.6337	-1.210265 (0.2363)
C	-26.71921	-0.182976(0.8561)





SORGHUM'S YIELD (1980-2021)

Recommendations and conclusion

It is important for the Ministries of Agriculture and other relevant agencies to ensure the propagation of early warning weather information to farmers. This, in conjunction with the availability sorghum varieties that show resilience during climate adversity must be encouraged for planting. It is also necessary to boost the enhancement of high and early maturing cultivars while taking into cognizance the practice of fertilizer management to improving the productivity of sorghum in the study area.

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APPE
NDIX

Null Hypothesis: LNS has a unit root
Exogenous: Constant, Linear Trend
~~Lag Length: 0~~ (Automatic - based on SIC, maxlag=0)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.055432	0.9234
Test critical values:	1% level	-4.219126	
	5% level	-3.533083	
	10% level	-3.198312	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNS)
Method: Least Squares
Date: 01/21/23 Time: 13:45
Sample (adjusted): 1981 2023
~~Included observations~~: 38 after adjustments

~~Variable~~	Coefficient	Std. Error	t-Statistic	Prob.
LNS(-1)	-0.087432	0.082840	-1.055432	0.2985
C	0.551587	0.464897	1.186470	0.2434
@TREND("1980")	-0.010175	0.006110	-1.665237	0.1048

R-squared	0.075498	Mean dependent var	-0.060526
Adjusted R-squared	0.022669	S.D. dependent var	0.366532
S.E. of regression	0.362354	Akaike info criterion	0.883264
Sum squared resid	4.595506	Schwarz criterion	1.012548
Log likelihood	-13.78203	Hannan-Quinn criter.	0.929262
F-statistic	1.429105	Durbin-Watson stat	1.964692
Prob(F-statistic)	0.253157		

2[ND]

Null Hypothesis: D(LNS) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic	-6.104549	0.0001

Test critical values:	1% level	-4.226815
	5% level	-3.536601
	10% level	-3.200320

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNS,2)
Method: Least Squares
Date: 01/21/20 Time: 13:46
Sample (adjusted): 1982 2023
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNS(-1))	-1.046723	0.171466	-6.104549	0.0000
C	0.102004	0.130832	0.779657	0.4410
@TREND("1980")	-0.008218	0.005884	-1.396736	0.1715

R-squared	0.522913	Mean dependent var	0.002703
Adjusted R-squared	0.494849	S.D. dependent var	0.523071
S.E. of regression	0.371768	Akaike info criterion	0.936509
Sum squared resid	4.699181	Schwarz criterion	1.067124
Log likelihood	-14.32543	Hannan-Quinn criter.	0.982557
F-statistic	18.63289	Durbin-Watson stat	1.995091
Prob(F-statistic)	0.000003		