Vol. 17(3), pp. 456-462, March, 2021
DOI: 10.5897/AJAR2020.14960
Article Number: A77ACC766334
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Effect of climate variation on the yield of cowpea (*Vigna unguiculata*)

Ibrahim Mohammed[1], David A. Alawa[1], Mshelia J. S. [2], John Adie Betiang[1], Sunday B. Azu[1], and Stephanie S. Bishie-Unung[1]

[1]Department of Vocational Education, University of Calabar, Calabar, Nigeria.
[2]Department of Agronomy, Federal University of Kashere, Gombe State, Nigeria.

Received 7 May, 2020; Accepted 8 December, 2020

This research was conducted to study the effects of climate variables such as rainfall, temperature, and relative humidity on cowpea yield, and evaluated in Gombe State, Nigeria, during the period of 2009 to 2018 (one decade). The ex-post facto research design was adopted for the study, utilizing secondary data obtained from meteorological and agronomic data collected from the Metrological Office and agronomic data from the Ministry of Agriculture, Gombe State. Both data were collected and analysed using analysis of variance (ANOVA), Pearson Product Moment Correlation and Simple Linear regression. The study found that there is a negative relationship between rainfall, relative humidity and area of land/ha, while a positive relationship existed for temperature and cowpea yield over the period under study decade. The study revealed that all the parameters-rainfall temperature, relative humidity contributes 61% to climate variation in the study area. The study among others recommended that cowpea farmers should adopt new measures such as early planting, use of resistant varieties, contour farming to conserve water and supplementary irrigation to cope with the negative effects of climate change on cowpea yield and increases cowpea production in Gombe State, Nigeria.

Key word: Climate variation, yield, cowpea.

INTRODUCTION

The persistent dwindling in the price of oil products have left the Nigerian economy with no other option but to intensify agricultural production as a sharp response to addressing the imbalance created by oil which hitherto was the pivot of the economy. But the success and productivity of any agricultural venture is dependent on climatic conditions. Climate is described by Ajetomobi and Abiodun (2010) as the overall alteration of mean weather condition. It is the long-term average of weather, taken over a long period of time usually 30 to 35 years. Climate is not a static factor in agricultural production hence; it varies over time especially with agricultural intensification as a result of population explosion. Thus, if a climate signal could be detected at local and state level, it would be useful to policy planners, agriculture authority and farmers to prepare for climate variation. Climate variation or change refers to the fluctuations about the mean climate of a particular area over a period. Thus, a changing climate is likely to bring changing patterns of climate variability (Rosenzweig, 2000). Climate variation

*Corresponding author. E-mail: davidalawa007@gmail.com.

is the combined effects of elevated temperatures and drought, with consequential increase in potential evapotranspiration and constitutes the greatest risk to agriculture in many regions (Intergovernmental Panel on Climate Change (IPCC), 2001). The impacts of climate change are reducing the capacity of natural resources (biodiversity, soil and water) to sustain the food demand of the world's increasing population (Murtala and Abaje, 2018). Furthermore, Alawa et al. (2014) stated that climate change occurs as a result of an increase in the concentration of greenhouse gases (GHGs) like CO_2 N_2O and CH4. The authors explained that increased greenhouse gases are associated with economic activities particularly as related to energy, industry, transport and pattern of land use (agricultural production and deforestation). They concluded that climate variation has effects on crop production hence, the need to mitigate these effects on crop production. Among these cultivated crops is cowpea which adversely responds to climate variation in terms of its yield.

Cowpea (*Vigna unguiculata)* is a leguminous crop known as beans or black eye pea that is widely cultivated in the tropics and sub-tropics for human as well as animal feed. Nigeria, Brazil and Niger are among the major producers and account for over 70% of the world population. Oyerinde et al. (2013) stated that cowpea is grown mainly as an alternative crop in association with other staples such as maize, sorghum, millet and cassava. Cowpea 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 (Jayathilake et al., 2018). The fourth assessment by the Intergovernmental Panel on Climate Change IPCC, (2007) reported that global average mean temperature, evaporation, precipitation and rainfall intensity will very likely rise in response to increase concentration of greenhouse gases in the atmosphere. The IPCC reports also predicted that food production in Africa would be halved by 2020. The effort to evaluate climatic effect on crop yield has ranged from complex biophysical simulation models to multiple regression models using many variables (Acock and Acock, 1991). Variability in the average yield of cowpea in the various producing States is a true reflection of the soil and climatic condition required for cowpea production. The crop thrives well in a soil that varies from sandy to clayey, while soil that is easily water logged must be avoided because nitrogen fixation is inhibited in waterlogged soils. This implies that for optimal production; soil must have a depth of at least 1 m to ensure sufficient root development to maintain the plant during drought (Ajetomobi and Abiodun, 2010).

The cultivation can begin early in the season as soon as the minimum temperature remains above 10°C and rain are established. The best vegetative growth is, however, possible with temperatures varying from 21 to 33°C, while higher temperatures can cause earlier flowering and flower abscission, resulting in poor pod set. High night temperatures (above 17°C) can cause flower abscission in some cultivars during flowering. Cowpea is drought tolerant and can be produced in areas where few other crops would not survive well due to low rainfall. Ajetomobi and Abiodun (2010) stated that a well distributed rainfall of 450 mm per year is sufficient to produce between 1 tonne seeds/ha and 4 tonnes/ha. They further explained that the average-rainfall for cowpea production in Nigeria is 1046.33 mm.

Apart from favourable climatic conditions, another factor for better average yield of cowpea in the mid-western and north central part of Nigeria is the significant advances made by the International Institute of Tropical Agriculture (IITA) based in Ibadan, Nigeria, over the last two decades in improving production in the area through release of improved varieties and guidelines on improved agronomic practices. Several drought and pest resistant cowpea varieties are developed and adopted by cowpea farmers in the region to fight against the side effect of climate variation

The response of cowpea yield to climate change varies from one geographical location to the other. This result also showed that as the years went by and climatic factors run contrary to agricultural productivities, Anyanwu and Akintunde (2012) revealed that climate change has adverse effects on cowpea production in the area. This implies that farmers employed varieties of climate adaptation measures in order to cope with the effects of climate change in the area.

The geographical locale of the study (Gombe State) is situated in the Sudan savannah zone of Nigeria, the most northerly regions of the country extending southwards about 250 km from northern border area. The mean annual rainfall is 510 to 1070 mm and the dry season last for 5 to 7 months. Small scale farmers are predominant in the zone, with little capital that may not be able to pursue the new strategies that are required to adopt to change in climate.

Objective of the study

The specific objectives of the study are to determine the relationship between the effect of climatic variables and cowpea yield in Gombe State.

METHODOLOGY

Ex-post facto research design was used in order to enhance better understanding of climate variability on cowpea production in Gombe State. The study was carried out in Gombe State from October 2019 to February 2020. Secondary data (meteorological and agronomic data) collected from the Metrological Office and Ministry of Agriculture, Gombe were utilized for the average annual temperature and rainfall as well as the annual output and hectare of cowpea in Gombe. The data covered 10 years that is 2009 to 2018.

Table 1. Effect of rainfall, temperature and relative humidity on the yield of Cowpea (yield/ha) between 2009 and 2018 at Gombe.

Year	Rainfall	Temperature	Relative humidity	Cowpea
2009	918.9	26.9	50.1	558.8
2010	881.6	27.3	51.8	558.8
2011	1023.2	27.2	50.5	522.7
2012	1005.6	27.5	51.8	480.0
2013	975.5	25.3	46.5	584.6
2014	967.4	27.8	46.9	629.3
2015	881.3	27.5	49.1	574.8
2016	946.4	27.1	46.3	579.7
2017	923.2	27.5	49.2	805.1
2018	658.0	27.5	47.3	580.2

Source: Gombe Meteorological Office and Planning Monitoring and Evaluation Unit, Ministry of Agriculture, Gombe State.

The meteorological and agronomic data include mean annual temperature, rainfall and relative humidity, as well as annual output per hectare of cowpea in Gombe. The dependent variable is yield of cowpea while the explanatory variables are weather data, namely annual mean temperature measured in centigrade, the annual precipitation, measured in millimeter and the relative humidity, measured in percentage.

The precipitation used in the analysis is the annual precipitation rather than monthly precipitation for only the cropping month. This is because a significant part of the research falling outside the cropping month will be retained inside the soil as moisture content and hence contributing to crop growth and the onset of the cropping season.

Data on three climatic parameters rainfall, temperature and relative humidity were correlated and regressed on cowpea yields. These data were subjected to regression and Analysis of Variance (ANOVA) and mean comparisons were done using F-test with the aid of SPSS version 20.

RESULTS

The data of climate variability, annual yield output of cowpea (Yield/ha) presented in table includes the followings.

Rainfall

The annual rainfall pattern ranges from 918.9 mm in 2009 to 1023.2 mm in 2011. Table 1 and Figure 2 revealed that there was a drop in 2018 that is 658 mm of rainfall with an increase of cowpea yield of 580.2 yield/ha; the mean annual rainfall is 918.2 mm. There was an increase of yield as a result of increase in rainfall that is 918.9 mm in 2009 to 975.5 mm in 2013 with 1.47% increase in cowpea yield from 2009 to 2013. However, more drop of rainfall occurs in 2014 to 2018 with an increase of 6.21% cowpea yield with the same period. This agreed with Olanrewaju and Tunde (2010) who suggested that two much rainfall may inhibit good performance of cowpea yield.

Temperature

Mean temperature as presented in Figure 3 rose from 25.3°C in 2013 to 27.8°C in 2014 while the yield of cowpea was 477.9 yield/ha in 2012 to 804.11 yield/ha in 2017. There was a drop in the yield of cowpea in 2012 and the mean temperature was 27.2°C over ten years. There was also a drop of temperature from 26.9°C in 2009 to 25.3°C in 2013 with an increase of 1.47% of cowpea yield from same 2009 to 2013. There is a slide drop of temperature from 27.8°C in 2018 with an increase of 6.21% of cowpea yield within 2014 to 2018.

Relative humidity

Table 1 and Figure 4 revealed that relative humidity drop from 51.8% in 2010/2012 respectively to 46.3% in 2016, with the yield of cowpea rose from 477.9 (yield/ha) to 805.11 (yield/ha) in 2017. The mean relative humidity was 48.9 over ten years (decade). There was an increase of yield output as a result of drop in relative humidity that is from 50.1% in 2009 to 46.50% in 2013 with an increase of 1.47% of cowpea yield from 2009 to 2013. There was also more increase of relative humidity in 2018 of 142.24 within an increase of 6.21% of cowpea yield within the last five years.

The result in the Table 2 and Figure 1 showed that climatic factors affecting cowpea production output over the period of study exhibit gradual increase. The maximum rainfall experienced in- the State was 1023.20 mm while the minimum was 658.00 with a mean of 913.11 mm and a standard deviation of 103.06 mm over the years showing mark changes in the quantity of rainfall witnessed over the period of the study. The maximum of temperature experience in the State was 27.80°C while

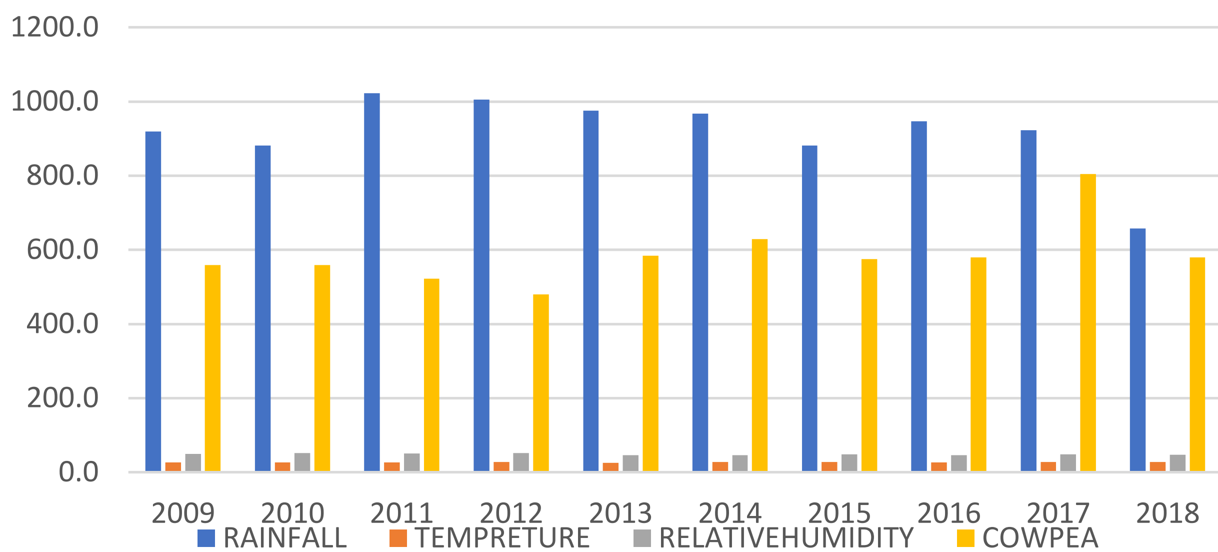

Figure 1. Effect of rainfall, temperature and relative humidity on cowpea yield.

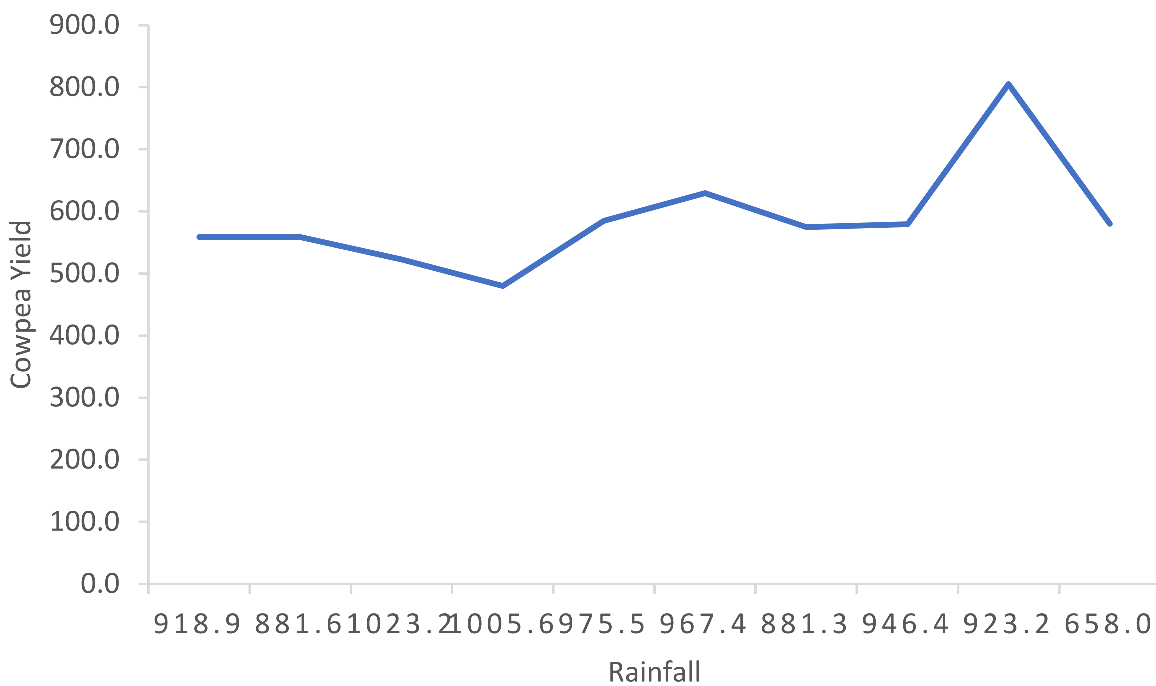

Figure 2. Effect of rainfall on cowpea yield.

the minimum was 25.30°C with a mean of 27.17°C and a standard deviation of 0.71 over the years showing slight increase in the temperature' with more increased of cowpea output or yield over the years. Similarly, the maximum relative humidity was 51.75% and the minimum was 46.33% with a mean of 48.92% and a standard deviation of 2.09% over the years showing marked changes in relative humidity over a decade.

Regressing the four parameters on yield, (Table 3), the result showed a non-significant effect on yield at Fe = .05. The regression statistics of the four parameters on yield showed a correlation coefficient of 0.782 as strength of relationship and R^2 as 0.612. The study showed that rainfall, temperature, relative humidity and area of land/ha jointly accounted for 61% variability in cowpea yield. This means that rainfall, temperature, relative

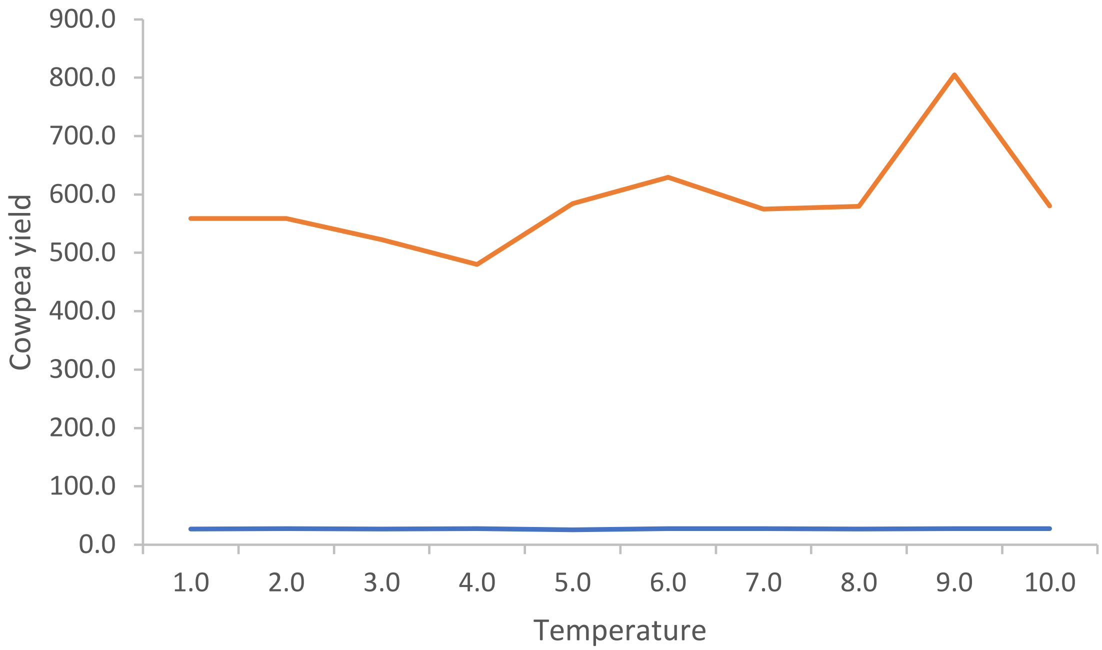

Figure 3. Effect of temperature on cowpea yield.

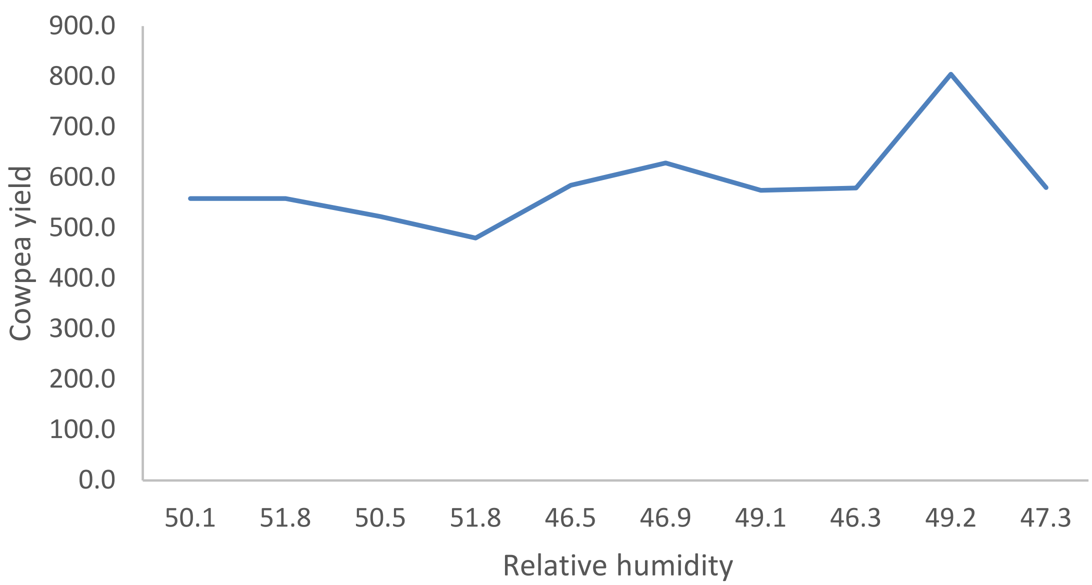

Figure 4. Effect of relative humidity on cowpea yield.

humidity contributes significantly to influence cowpea yield in Gombe. This is contrary to the findings of Egbutah and Odiaka (2011) that the effect of rainfall and temperature on yield of tomato was not significant. However this finding agreed with Murtala and Abaje (2018) that the correlation analysis indicates a positive (weak) relationship between rainfall values and cowpea yield, it also revealed positive relationship between temperature and cowpea yield.

Correlation value of coefficients

The correlation matrix of coefficients is presented in Table 4. Table 4 presents the correlation matrix; it revealed that cowpea yield is negatively related (-0.492)

Table 2. Descriptive statistics of factors affecting cowpea yield (2009-2018).

Variable	Minimum	Maximum	Mean	Sd
Rainfall (mm)	658.00	1023.20	913.11	103.03
Temperature (°C)	25.30	27.80	27.17	0.71
Relatively humidity (%)	46.33	51.75	48.92	2.09
Area cultivated (ha)	105.78	142.24	132.07	10.04
Yield (ha)	60.91	85.97	76.44	6.64

Source: Result of data analysis (2019).

Table 3. Regression ANOVA Statistic of rainfall, temperature, relative humidity and area/ha on yield of cowpea.

Predictor constant			Coefficients		
Multiple R			0.782		
R. square			0.612		
Standard error			5.55		
Observation			10		
Sov	**DF**	**SS**	**MS**	**F**	**Fe .05**
Regression	4	243.53.	60.88	1.973	0.237
Residual	5	154.25·	.30.85		
Total	9	397.78			
		Standard coefficient	**Standard error**	**F-test**	**p-Value**
Constant		194.921	88.571	2.20	0.079
Rainfall		-0.028	0.020	-1.41	0.218
Temperature		1.003	2.914	0.344	0.745
Relative humidity		-1.806	0.976	-1.851	·0.123
Yield/ha		-0.239	0.192	-1.242	0.269

Sov = source of variation; Fe= level of significance.

and statistically significant at (P<0.10) in relation to rainfall. This suggested that the more rainfall experienced in the year, the less quantity or yield of cowpea obtainable. Temperature was found to be positively related to cowpea yield though non-statistically significant. This implied that the higher the temperature, the more yield of cowpea obtainable in the year. Cowpea yield was found to be negatively related (-0.582) to relative humidity and statistically significant at (P≤0.05) level. This implied that invariably the decrease in relative humidity leads to increase in cowpea yield obtainable which actually concord with Ajetomobi and Abiodun (2010) whose findings revealed that temperature is significant at 5% level in some of the northern States of Nigeria.

Summary

The research was conducted to find the effect of climate variability on cowpea (Vigna *unguiculata*) production in Gombe State of Nigeria. At the beginning of the research, the secondary data were collected on climatic parameters such as rainfall, temperature and relative humidity, from Gombe State meteorological office and the secondary data on cowpea yield (mt) and area of land (1,000 ha) were also collected at Ministry of Agriculture Gombe State. Both data were collected for ten years (one decade) that was from 2009 to 2018 and analyzed using analysis of Variance (ANOVA), Pearson product moment correlation and simple linear regression.

The dependent variable was yield in thousand metric tones' (000mt) while the independent variable is rainfall, temperature, relative humidity and area of land used-in thousand hectares (000 ha). The R^2 value revealed that annual rainfall, R. H., temperature and area of land has contributed 61% on cowpea yield/hectare while the coefficient correlation F-test revealed that at P≥0.05, rainfall was negatively correlated at -0.393, temperature was significant at 0.96, relative humidity is negatively significant at -0.516, as well as area of land/ in hectare was also negatively insignificant at -0.346.

Table 4. Correlation Matrix of coefficients of the estimated variables.

Variable	Cowpea	Rainfall	Temperature	R.H.	Yield/ha
Rainfall	-0.492*	1.000			
Temperature	0.042**	-0.220	1.000		
R.H.	-0.582**	0.219	0.307	1.000	
Yield/ha	-0.171	-0.258	0.040	-0.143	1,000

* ≤ 0.05, level of significant, ** < 0.01 level of significant.

Conclusion

The impacts of climatic change were highly variable in cowpea production in Gombe State due to the variability in rainfall, temperature and relative humidity throughout Sudan Savannah region. This result also showed that as the years went by, climatic factors can be contrary to agricultural productivities, cowpea production was also affected both positively and negatively.

This was because the research result revealed that the more rainfall and relative humidity the less the quantity of cowpea output. On the other hand, the reverse was the case with temperature because a little increase in temperature brought about increase in the yield of cowpea. However, the climatic parameters, rainfall, temperature, relative humidity, and area of land have contributed about 61% to the production of cowpea yield in Gombe State between 2009 and 2018.

Recommendations

For better performance on yield of cowpea, this study suggests the following recommendations:

1. Famers should understand the climatic variability and other environmental factors and manner in which they affect cowpea production in Sudan savannah (Gombe) area that would greatly enhance the benefits accruable from new food production technologies.
2. Government should ensure the release of information regarding the daily climatic data through the media and extension agents to the rural communities or cowpea farmers.
3. Cowpea farmers should adopt new measures such as introduction of drought or heat resistant varieties, early sowing and mixed cropping to cope with the negative effects of climate change on cowpea yield.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Acock B, Acock MC (1991). Potentials for using long-term field research data to develop and validate crop simulation. Agronomy Journal 83:56-61.

Ajetomobi, J, Abiodun A (2010). Climate change Impacts on Cowpea Productivity in Nigeria. African Journal of Food Agriculture Nutrition and Development 10(3):2258-2270.

Alawa DA, Asogwa VC, Ikelusi CO (2014). Measures for mitigating the effects of climate change on crop production in Nigeria, American Journal of Climate Change 3:161-168.

Anyanwu E, Akintunde JO (2012). Effect of climate change on cowpea production in Kuje Area council, Abuja, Nigeria. International Journal of Advanced Research in Management and Social Sciences 1(2):273-283.

Egbutah EU, Odiaka NI (2011). Effects of climate variability on tomato (*Lycopersicum esculentum*) Proceedings of the 29th Annual Conference of the Horticultural Society of Nigeria. University of Agriculture, Makurdi, Benue State. 24th-29th July.

Intergovernmental Panel on Climate Change (IPCC) (2007). Climate change (2007): Synthesis report. In: Pachauri K, Reisinger A (Eds.). Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland: Intergovernmental Panel on Climate Change.

Intergovernmental Panel on Climate Change (IPCC) (2001) Climate change: Impacts, vulnerability and adaptation. Working group II, WMO, Geneva.

Jayathilake C, Visvanathan R, Deen A, Bangamuwage R, Barana C, Jayawardana SN, Ruvini L (2018) Cowpea: An overview on its nutritional facts and health benefits. Journal of the Science of food and Agriculture 98:4793-4806.

Murtala M, Abaje IB (2018) Effects of climate change on cowpea yield in Kaduna State, Nigeria: Evidence from rainfall and temperature parameters. Dutse Journal of Pure and Applied Sciences 4(2):565-574.

Olanrewaju RM, Tunde AM (2010). Climate Effects on Production in the Derived Savannah Ecological Zone of Nigeria: A Comparative Study of Two Agricultural Zone in Kwara State. National Conference of the Nigerian Meteorological Society 2010, Ilorin.

Oyerinde AA, Chuwang PZ, Oyerinde GT (2013). Evaluation of the effects of climate change on increased incidence of cowpea pests in Nigeria. The Journal of Plant Protection Science 5(1):10-16.

Rosenzweig C (2000). Potential impacts of climate change on agriculture. In A Spectrum of Achievement in Agronomy: Women Fellows of the Tri-Societies, ASA Special Publication, 62 American Society of Agronomy, Crop Science Society of America and Soil Science Society of America pp. 73-88.