Volume 8, Number 2
November 2010

ISSN: 2006-7003

JOURNAL of METEOROLOGY and CLIMATE SCIENCE

Published by

Nigerian Meteorological Society (NMetS)
http://www.nmets.org/

Journal of Meteorology and Climate Science

Volume 8, Number 2 November 2010 ISSN 2006-7003

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D'ENVIRONS

0803-224-7974, 0803-562-8239

JOURNAL OF METEOROLOGY & CLIMATE SCIENCE
J. Met. & Clim. Sci. 8(2):102-110 (2010)

N.Met.S
Nigerian Meteorological Society

CLIMATE AND RICE PRODUCTION IN A PART OF THE NIGER RIVER BASIN DEVELOPMENT AUTHORITY AREA (NRBDA). A CASE STUDY OF EDU AND LAFIAGI LOCAL GOVERNMENT AREAS OF KWARA STATE, NIGERIA.

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Abstract: The study examined the impact of climate on rice production in the lower Niger River Basin of Edu/Lafiagi Local Government Area of Kwara State . Data on rice production, hectare put into production and yield were correlated and regressed on climatic parameters of rainfall amount, number of rain days, relative humidity, evaporation, maximum and minimum temperatures. Also onset and cessation of rain were computed. The result revealed a downward trend in rainfall amount and number of rain days but air temperature was constantly high throughout the period of study. Annual changes in percentage yield fall with increase changes in hectares put into rice cultivation. The critical climatic parameters for the optimum production of rice as identified are number of rain days and minimum temperature. Number of rain day exhibited a strong positive relationship of 0.53 while a strong negative relationship of -0.50 is established between minimum temperature and rice yield. Suggestions were made on different coping strategies that can be adopted to improve yield.

Key words: Production, raindays, climatic parameters and annual changes.

INTRODUCTION

The Federal government of Nigeria took a decision against importation of some agricultural products to protect and encourage local production of such crops among other reasons. However, that decision does not affect rice as free flow of imported rice is encouraged. This is because local supply of rice is not keeping pace with the demand. Currently Nigeria spends more of its export earnings on food importation. For instance, the food importation bill of Nigeria which was #102,185.1 million in 1993 shoot up to #176,670.31 million in the year 2007 (CBN,2008).

Rice by status is a major staple food in Nigeria. The shortage in the supply of rice is reflected in the increase in its price over years. The market survey conducted by the Planning, Monitoring and Evaluation (PME) department of Kwara State Agricultural Project(KWADP) between the year 1989-2007 showed that a kilogram of rice sold at #7.90 in 1989 at urban market and #5.70 in rural market soared to #109.80 and #93.51 in urban and rural markets respectively in year 2007.

Although Olaniran (1988) described both topography and the soil condition of the study area suitable for the growth of rice, yield has not improved over years even with involvement of the Zimbabwean farmers. The above findings suggest climate as the most critical environmental factor for rice production in the study area. Thus, this present study attempt isolating the most crucial climatic parameters responsible for the growth of rice in the study area. This will help in identifying the best coping strategies that can be adopted for optimum yield of rice in the study area.

RICE PRODUCTION AND CLIMATE

The most weather sensitive among all man's activities is agriculture (Ayoade 2004).Each crop has its own environmental requirement. The Daily Star (2007) reported that study conducted in Bangladesh showed that a rise in temperature of 1-2^{0}C in combination with lower radiation causes sterility in rice spikelets. According to Yoshida and Parao (1976), such sterility becomes very severe near 40^{0}C resulting in complete loss of crop production. Similarly Cruz (2009) linked the decline experienced in rice yield in Philippine with an increase in nighttime temperature. The U.S, DOE (1989) examined the effect of carbon dioxide and temperature on rice yield and found out that increase in temperature results in large reduction in rice yield which was not compensated for by increase in carbon dioxide. The grain yield decreases above a critical temperature greater than 30^{0}C.

Contrary to the above findings, the International Rice Research Institute (IRRI) found out that the combination of increased carbon dioxide and temperature resulted in a small increase in biomass and yield in the dry season and a small decrease during the wet season. However in the same vein, they agreed that higher maximum and minimum temperatures can decrease rice yield due to spikelet sterility and higher respiration loss.

Lower crop biomass and grain yield are also caused by continuous cloudiness and rainfall as well as low irradiance in Calapan (Cruz, 2009). For the Niger River Basin Authority Area of Nigeria, Olaniran (1988) put the consumptive use of water during the growing season of early maturing variety at 597mm and 1016mm for late maturing cultivar. Dent and Young (1984) put the growing period of rice between 90 – 150days based on the water requirement of each variety.

THE STUDY AREA

The study area form some part of the Niger flood plain in Edu/ Lafiagi Local Government Areas of Kwara State, Nigeria (Figure1). The area lies mainly between latitude 8^0 10'- 9^0 5' and longitude 4^0 50' – 6^0 15'. The flood plain is about the height of 310 meters above sea level. The soil is alluvial in nature. The climate is controlled by two opposing surface winds, the maritime air mass from the Atlantic Ocean and the dry continental wind from the Sahara desert. This gives the area its characteristic wet and dry seasons. The wet season starts around April and prevails till October. The dry season commences in November through May. The above attributes make for the prospect of a good yield of rice in this area.

METHOD OF STUDY

The study was conducted with the aim of knowing the impact climate has on the production of rice in the study area. Thus, information on the climatic factors and rice production for the period of ten years spanning between 1998-2007 were compiled. Data on rice production, hectares put into production and yield were calculated. Climatic parameters of rainfall amount, number of rain days, relative humidity, evaporation, maximum and minimum temperatures were collected from Jebba Hydro –Electric Power Station, the closet weather

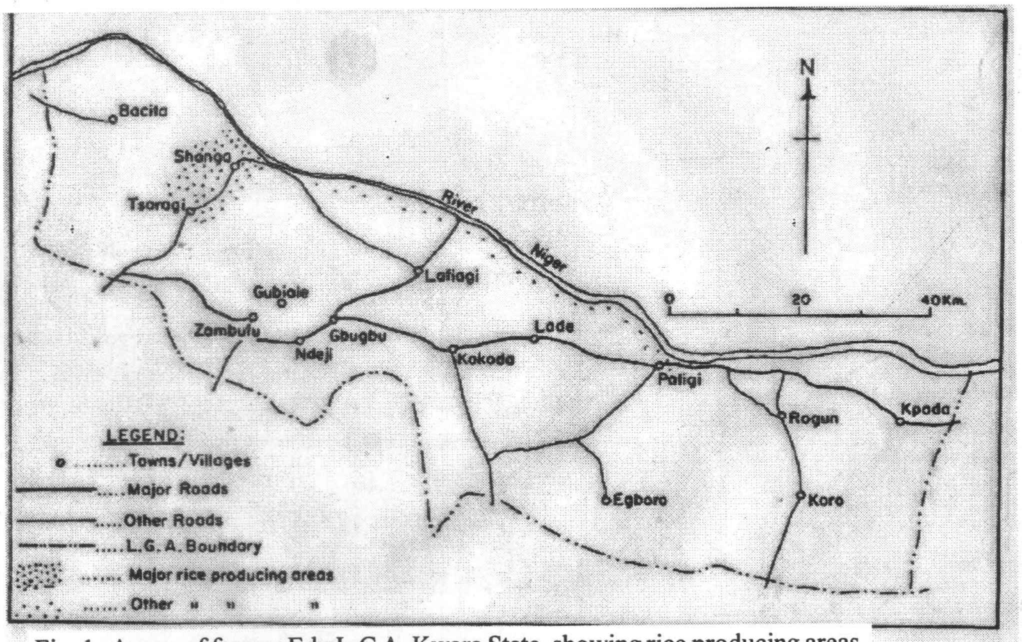

Fig. 1: A map of former Edu L.G.A, Kwara State, showing rice producing areas

station to the study area. Mean annual climatic data, the annual percentage difference in hectares put into rice cultivation, in production and yield were calculated. The onset and cessation of rain were also computed using Walter's (1967) method as modified by Olaniran (1988) as follows.

$$\text{Days in the Month} \times \frac{51 - \text{accumulated rainfall total of previous month}}{\text{Total rainfall for the Month}}$$

Where, the month under reference is that month in which the accumulated total of rainfall is in excess of 51mm. The formula is applied in reverse order from December to calculate the end of the rain. However Olaniran (1988) noticed that planting date arrived at by Walter's method, may be followed by a prolong dry spell in the tropics. To take care of such lapses, such dates are disregarded and Walter's method reapplied.

Correlation and multiple regression analyses were employed to find out the strength of relationships and to identify the most crucial climatic parameters for rice production in the study area.

RESULTS AND DISCUSSION.

Rice Production, Hectares and Yield: Table 1 and figure 2 reflect the pattern of rice production; hectares put into production and yield between 1989 and 2007. In most years under consideration, production level increased with increasing hectares under cultivation. On the other hand, increase in hectares did not bring about increase in yield except in year 2001.

Table 1; Rice Production Hectares and Yield (000Ton).

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
HA	19.18	12.54	10.02	15.96	8.19	8.20	20.85	31.3	50.01	97.18
Production	35.23	44.83	35.58	42.29	22.72	18.17	47.96	71.1	118.31	34.21
Yield	1.84	2.70	2.60	3.43	2.77	2.28	2.30	2.36	2.37	2.41

Source: KWADP, Ilorin 2008.

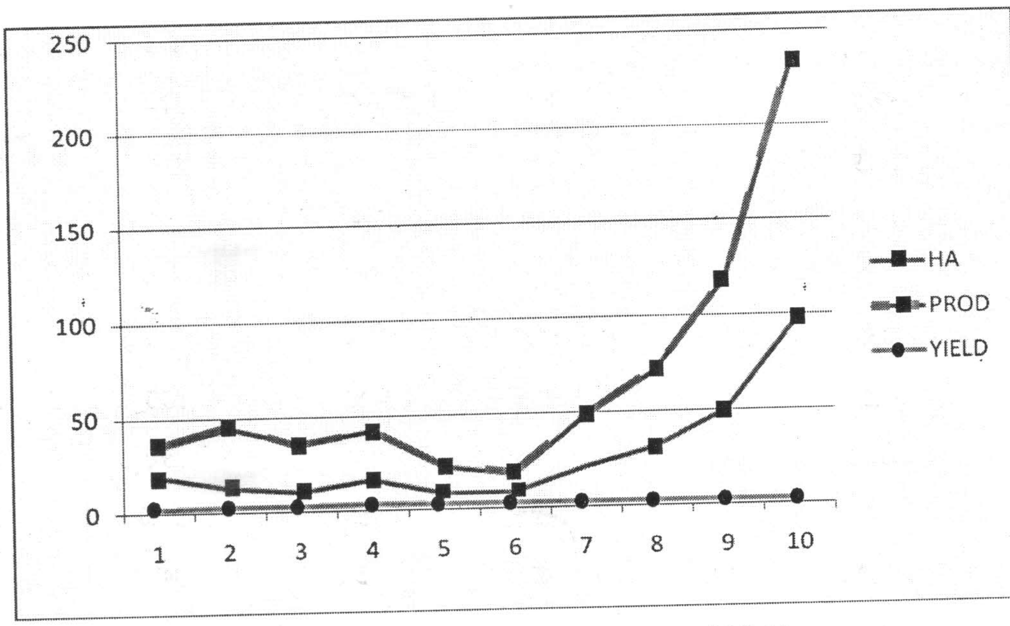

Figure 2; Rice Production, Hectare and Yield. , The condition became deteriorated between year 2004 and 2007 when hectares put into rice cultivation yearly almost doubled the previous year with yield remaining almost constant.

The result of the percentage change calculated in hectares, production and yield showed a decline in yield with an increase in land devoted to rice production (see table 2).

The rapid increase of hectares put into rice production witnessed since year 2004 reflected the initiative of the Government of Kwara state by inviting fifteen Zimbabwean farmers to establish rice farm in Shonga,Edu LGA in year 2004. For instance, the percentage change in hectares between the periods of 2003/2004, 2004/2005, 2005/2006, 2006/2007 were 60.7%, 50.1%, 59.7% and 48.5% with corresponding percentage changes in yield of 6.6%, 2.6%, 0.4% and 1.6% respectively. These values are too low compared with the values of the hectares put into cultivation.

THE CLIMATIC PATTERN OF THE STUDY AREA

The mean climatic pattern during the period of study is shown in table 3. Rainfall fluctuates and on the downward trend. Year 2003 observed the highest rainfall while the least occurred in the year 2005.

Table 2: Percentage Change in Hectares, Production and Yield

Years	98/99	99/2000	2000/01	01/02	02/03	03/04	04/05	05/06	06/07
Ha. (%)	34.6	-20.1	58.2	-46.2	0.31	60.7	50.1	59.7	48.5
Prod. (%)	-27.2	-26.0	18.8	-20.0	-21.5	62.0	48.2	66.9	98
Yield (%)	46.7	-3.7	31.9	-19.2	-17.3	6.6	2.6	0.4	1.6

Table 3: The Mean Climatic Pattern of the Study Area (1998 – 2007)

Year	Rainfall Amount(mm)	No. of Rain days	Evap.(mm).	R.H(%)	Maxi.Temp.$^{(oC)}$	Mini.Temp.$^{(oC)}$
1998	1206.6	74	6.7	68	34.3	24.0
1999	1139.4	72	6.5	57	34.3	23.8
2000	1008.7	82	6.8	62	34.4	23.1
2001	1240.9	84	6.7	78	35.0	23.0
2002	1038.9	70	7.0	56	35.2	25.2
2003	1339.1	65	7.1	52	35.5	24.0
2004	984.8	71	7.0	68	35.4	23.6
2005	937.2	60	7.0	55	35.3	25.0
2006	1007.2	69	6.2	56	35.0	25.4
2007	939.6	63	6.0	56	35..0	23.1
Total	10842.4	710	67	598	349.4	240.2
Average	*1084.2*	*71*	*6.7*	*59.8*	*34.9*	24.0

Source; Jebba Hydro Power Station.

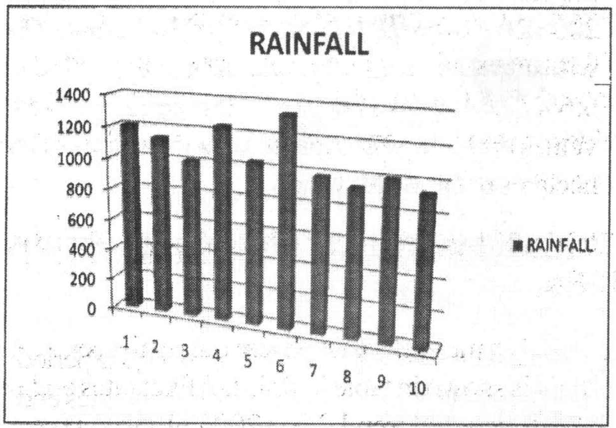

Figure 3: Rainfall (mm).
Source: Author's Computation (2009)

Number of rain days fluctuates between the years 1998 through 2005 while it declined from year 2006 through year 2007

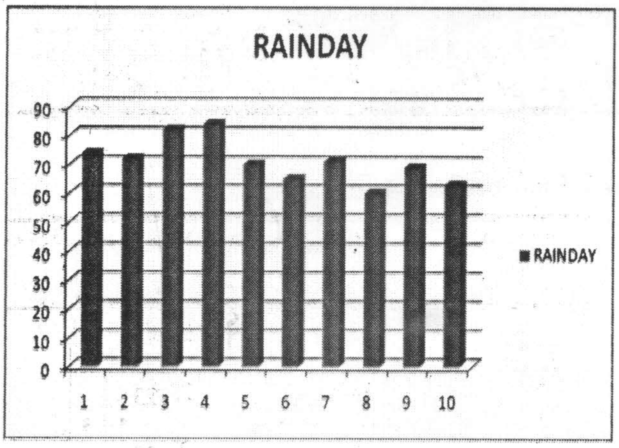

Figure 4: Number of Rain days.
Source: Author's Computation (2009)

Relative humidity varied and the year 2005 that witnessed the least rainfall also observed the lowest relative humidity. The highest occurred in the year 2001 that observed the highest number of rain days. Air temperature and evaporation were constantly high with air temperature on the upward side.

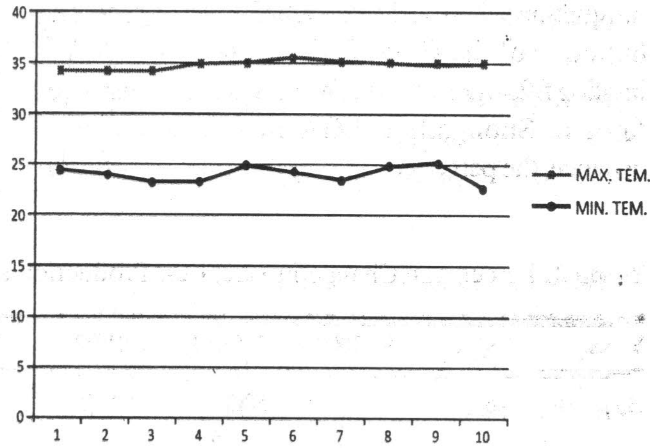

Figure 5: Maximum and Minimum Temperature (^{o}C).
Source: Author's Computation (2009)

From these findings, it is obvious that the climatic condition of the area tends towards aridity. The implication of this on rice production cannot be over emphasized.

The result of the rainfall onset and cessation dates computed for the study area is presented in table 4.

Table 4: Rainfall Onset, Cessation Dates and Rice Yield over the Study Area.

Year	Onset Date.	Cessation Date.	Yield(000ton)
1998	21st, April	13th, October.	1.84
1999	30th, April.	17th, October	2.70
2000	15th, May.	23rd, October.	2.60
2001	7th, June.	26th, October.	3.43
2002	4th, June.	10th, October.	2.77
2003	21st, April.	9th, October.	2.28
2004	10th, April	8th, September.	2.30
2005	13th, April,	20th. October.	2.36
2006	14th, May.	25th, October	2.37
2007	12th, May.	22nd, October.	2.41

Table 5: Model Summary of Regression Analysis on Hectares put into Rice Cultivation and Production.

Model	R	R-Square	Adjusted R-Square	Standard Error of the Estimate
1	.922	.850	.800	17.71394

Source: Authors Computation (2009)

There are three types of rainfall onsets as recognized by Bello (1996) and confirmed by Olanrewaju (2003) for Guinea ecological zone of Nigeria. These are early, normal, and late onsets of rain. Based on the conclusion reached by Olanrewaju (2003) for this zone, six out of the ten years understudied (1999-2002 and 2006-2007) experienced late onset of rain while one year (2004) observed early cessation.

When rice yield and climatic pattern were compared, it appeared more hectares were put into cultivation of rice to compensate for the late onset experienced. For instance, 58.2% change in hectares occurred between year 2000 and 2001 (see table 2). This change might have responsible for the increase in yield observed in 2001. However, it appeared rice plant performance defiled the above compensation during the subsequent years as increase in hectares put into rice cultivation has no remedy for the option (decline in yield) the climate presented.

RESULTS OF CORRELATION AND REGRESSION ANALYSIS BETWEEN YIELD, PRODUCTION AND HECTARES.

To further confirm with precision the findings that increase in hectare and production does not necessarily result in increase in yield, percentage year to year changes in hectares put into rice cultivation was correlated and regressed with percentage changes observed in production and yield. The result is reflected in table 5.

Changes in hectare put into rice cultivation explained 85% changes observed in production in the study area. R is 0.92 and is significant at 0.003 confidence level. The result of correlation analysis reflects a strong positive relationship of 0.73 between changes in hectares put into rice cultivation and changes in rice production while a milder positive relationship of 0.55 is exhibited between changes in hectares and yield (see table 6). The implication of this is that changes in hectares keep a closer pace with changes in production than changes in yield thus confirming the earlier finding.

The result of correlation analysis between rice yield and various climatic parameters measured is reflected in table 7 below.

Both thermal and moisture conditions have serious implications on rice yield. Minimum temperature appeared to be the most critical thermal index for the cultivation of rice in the study area. For instance, the strength of relationship between maximum temperature and rice yield though positive but very weak and non significant (0.05). Minimum temperature exhibited a stronger negative relationship of -0.50. The implication is that increase in minimum temperature will result in drastic reduction in rice yield. This finding is in broad agreement with Cruz (2004) for rice production in Philippine. However, increase in maximum temperature will cause a slight and non significant increase in rice yield.

Similarly, the strength of relationship between rice yield and moisture indices showed number of rain days to be more significant than rainfall amount in the study area. A strong positive relationship of 0.53 is established between number of rain days and rice yield while rainfall amount displayed a weak positive relationship of 0.12. This implies that the amount of rainfall received is not as crucial as its spread over time for optimal yield of rice to occur. These findings hold for yam crop in this ecological zone (Olanrewaju, 2004) and for other crops in the tropics in general (Adefolalu, 1999).

Model summary of regression analysis showed R to be 0.87% while R^2 is 75.8% (Table 8). This implies that climate alone explained 75.8% of variation observed in rice yield in the study area. The remaining 24.2% could be attributed to other factors such as edaphic, farm management techniques etc.

Table 6: Result of correlation Analysis between Hectares put into Rice Cultivation, Rice Production and Rice Yield.

Parameter	Correlation Coefficient	Remark
Production	0.73	Strong
Yield	0.55	Mild

Source: Authors Computation (2009)

Table 7: Result of Correlation between Rice Yield and Climatic Variables.

Climatic Variables	Correlation Coefficient	Remarks
Rainfall (mm)	0.12	Weak positive
No. of Rain day	0.53	Strong positive
Evaporation (mm)	-0.02	Weak negative
Relative Humidity (%)	0.40	Mild positive
Max. Temp (°C)	0.05	Weak positive
Mini. Temp (°C)	-0.50	Strong negative

Source: Authors Computation (2009)

Table 8: Model Summary of Climatic Variables and Rice Yield.

Model	R	R-Square	Adjusted R- Square	Standard Error of the Estimate
1	.8719	.758	.089	.43387

SUMMARY AND CONCLUSION

The strength of climate on rice production was examined. Percentage change in hectares put into production and percentage change in production and yield were calculated. Correlation and regression analyses were conducted between various climatic variables, production and yield to isolate the most critical climatic parameters for rice production in the study area. The results revealed a decline in the rainfall amount, number of rainfall rain days and increase in temperature through years of study. To compensate for the climatic hazards, farmers result into expansion of hectares put under rice cultivation. However, this step taken by farmers failed to produce the desired corresponding increase in rice yield. Annual changes in percentage yield fall with increase changes in hectares put into rice cultivation. The critical climatic parameters for optimal yield of rice in the study area identified are number of rain days and minimum temperature. Increase in number of rain days brings about increase in rice yield while high minimum temperature retards yield.

In conclusion the above findings are caution to all rice farmers in this area and in particular to the Zimbabwean farmers using this area for a large scale cultivation of rice. The need to be cognizance of the roles climate play on rice production will help to plan ahead hence, averting the unnecessary risks that climate could introduce to their farming activities. The impact of climate on agriculture, method of mitigation and adaptation should be implemented in the Kwara State policy. The following coping strategies are suggested for optimal production of rice in the study area.

1. Farmers should focus more on the cultivation of early maturing variety (that can mature within 90days) as advocated by Olaniran 1988. Even while adopting this coping method, arrangement to suppress the dry spell of August break must be put in place. This can be in form of irrigation.

2 Rice farmers in this area should be enlightened by the state government on various measures of adaptation and mitigation they can adopt to reduce the risks climate introduce to their farming activities and farm inputs in form of fertilizer and pesticides need be encouraged.

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