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Climate change and its effect on grain crops yields in the middle belt in Nigeria

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Crop yield data were obtained from Kwara State Agricultural Development Project (KWADP), Ilorin and National Bureau of Statistics (NBS), Lagos on the crops considered in this study, while climate data were sourced from the Nigeria Meteorological Agency (NIMET), Oshodi, Lagos and National Bureau of Statistics (NBS), Lagos for a decade (2002 - 2011). These data were analyzed using SPSS 16.0 and Microsft Excel in order to evaluate the impact of climate on the yield on reference crops in Kwara State, Nigeria. Multiple regression, trend analysis, correlation analytical and ANOVA techniques were used to analyze the data. This study was necessitated by the decline observed in the production of cash crops in the state. The result obtained from the analysis carried out on the output per hectare showed that the impact of climate on crop yield was significant for maize and rice yield at 95% probability level while the impact of climate on the yield of millet, sorghum and cowpea was insignificant. As a result, it is recommended that investment should be made to intensify the cultivation of crops on which climate had no significant impact on their yield.

Key words: Agriculture, climate, grain-crops, yield, decade.

INTRODUCTION

Agriculture is the practice of crop cultivation and livestock keeping within boundaries. The choice of what to produce, where to produce and how to produce it is determined by the culture, traditions, market, water supply, climate, soil condition, plot size and distance from home (Abdul-Aziz, 2002; Wiebe, 2003).

Climate is a long-term average weather conditions that directly or indirectly affects agricultural production. Climate determines the choice of what plant to cultivate, how to cultivate it, the yields of crops and nature of livestock to keep. Ajadi (2011) reported that solar radiation, temperature, moisture and other climatic parameters determine the global distribution of crops and livestock as well as crop yield and livestock productivity. Reuben and Barau (2012) observed that rainfall distribution and the occurrence of moisture stress condition during the vegetative period are critical for the yield formation of the cassava crop.

In view of the foregoing, Odjugo (2010) opined that climate change is unequivocal and its impacts are here with us.

Available pieces of evidence show that each day brings

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Figure 1. Map of Kwara State. **Source:** http://goo.gl/plXIfL.

fresh proofs of climate change effects and these effects include increasing temperatures, decreasing rainfall in the continental interiors, drought, desert encroachment, melting ice, extreme weather, floods, sea level rise, sinking of Islands, water scarcity, health and agricultural problems. Excessive increases in temperature results in low agricultural productivity and this may lead to depletion of soil nutrients and destruction of soil structure and organisms which contribute to the fertility of the soil. Ordinarily, rainfall can be considered to have positive effect on agricultural productivity except where it leads to flooding, erosion and leaching.

Rainfall amount and high temperatures are the most important elements of climate change in Nigeria as a result the northeast region of Nigeria is increasingly becoming an arid environment at a very fast rate occasioned by the fast reduction in the amount of surface water, flora and fauna resources on land. Consistent reduction in rainfall leads to a reduction in the regeneration rate of land resources. The northern zone therefore faces the threat of desert encroachment. The southern area of Nigeria, which was largely known for high rainfall, is currently confronted by irregular rainfall and high temperatures (Adejumo, 2004; Obioha, 2008; FME, 2004).

The impact of climate change on agricultural production in Nigeria has received limited attention despite the fact that over 60% of the active populations of Nigerians are farmers. Studies on climate change globally and in Nigeria have revealed that the potential impacts of climate change will include every aspect of the four dimensions of food security; food availability (production and trade), food accessibility, food stable supplies, and food utilization (Nwafor, 2007).

Olarenwaju (2012) reported that many of the problems facing agricultural production are climate related. It is against this background that this paper is put forward to ascertain the impact of climate on grain crop yield in Kwara State. The objectives are to: examine the relationship between selected climatic elements and the yield of the three major grain crops in the state and examine the contribution of climatic element to the trends and variability of grain crop yield over the decade under review.

MATERIALS AND METHODS

Study area

The study area is Ilorin, Kwara State. Ilorin lies on latitude 8°29'20.9"N and longitude 4°33'11.1"E and at an altitude of 290 m above sea level. The state has an elongated shape covering an area of about 32,500 sq. km. The state is bounded by River Niger along its northern and eastern boundaries and shares a common boundary with Niger State in the north, Kogi State in the east, Oyo, Ekiti and Osun States in the south and an international boundary with the Republic of Benin in the west (Figure 1). The soils of Ilorin are loamy and clay.

Kwara State is located in the West-central area of Nigeria andlies in the region termed the Middle Belt of Nigeria. It is located in the forested savannah and enjoys moderate dry and wet seasons. The derived guinea savannah grasslands dominate the Northern parts of the state while the Southern part falls within the rain forest.

The climate of Ilorin is tropical with annual rainfall of about 1500 mm, average maximum temperature of 38°C, average relative humidity of 77.50% and 7.1 h of sunshine daily (Olanrewaju, 2009). The rainy season begins at about the end of March and lasts until early September, while the dry season begins in early October and ends in early March. This attribute predisposes the people to make farming their major occupation. Food crops produced in the state include white yam, cassava, water yam, sweet potato, groundnut, sorghum, millet, maize and cowpea (Ajadi et al., 2011).

There are three methods of establishing agriculture - climate relationships and these methods include: plant growth and development - climate relationship, agricultural products yield data - climate parameters relationship and plant - climate relationship under controlled environment (Olarenwaju, 2012). However, the method of studying the relationship of agricultural product yields data and climatic parameters were employed in this research.

A decade climatic data (rainfall, maximum temperature, minimum temperature, evaporation, relative humidity, sunshine hours, soil temperature) were obtained from the Nigeria Meteorological Agency, Oshodi, Lagos and National Bureau of Statistics (NBS), Lagos while, crop yield data were obtained from National Bureau of Statistics (NBS), Lagos and Kwara State Agricultural Development Project (KWADP), Ilorin on maize (*Zea mays*), sorghum (*Sorghum bicolor*), rice (*Oryza sativa*), millet (*Pennisetum americanum*) and cowpea (*Vigna unguiculata*). The choice of the aforementioned climatic parameters was based on their vital role to the selected crop yield and the evaluation of a decade data is based on statistical theories.

Data obtained from the experiments were analysed using Statistical Package for Social Sciences (SPSS). Mean separation was done using Duncan's new multiple range tests. Both descriptive and inferential statistical techniques were employed in data analysis while simple correlation, stepwise multiple regressions and analysis of variance (ANOVA) were used in showing the relationship between climatic parameters and crop yield and showing the trend and variation in crop yield. These statistical techniques were employed in the analysis of both crop yield data and climatic parameters because of their peculiarity in revealing the relationship and variation among variables.

Table 1. Pattern of meteorological Data (2002 - 2011).

Year Rainfall (Mean)	Rainfall (mm)	Sunshine hour (h)	Evaporation	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)	Soil temperature (°C)
2002	1028.5	5.6	3.6	36.44	20.30	77.00	29.6
2003	811.75	5.7	5.9	31.17	17.50	83.00	29.3
2004	1597.4	6.4	5.4	33.33	20.15	82.00	29.2
2005	1144.5	6.3	5.7	35.90	23.90	82.50	29.9
2006	1236.99	6.2	5.7	36.47	22.79	81.40	28.8
2007	1481.63	6.7	6.0	37.08	22.50	78.60	29.9
2008	1381.9	6.0	6.2	36.00	22.00	84.00	29.1
2009	1526.57	6.3	6.2	38.00	23.40	87.10	29.7
2010	1165.7	5.5	6.7	36.00	23.30	87.40	29.0
2011	1253.4	6.8	7.1	36.10	22.91	84.42	29.4

Source: NBS, 2012.

Table 2. Grain crops yield (Tons), area cultivated (Ha) and yield (Tons/Ha).

Crop	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Maize ton ha yield (tons/ha)	70.91 57.66 1.30	100.40 57.66 1.47	86.74 64.05 1.25	113.40 82.9 1.35	150.38 110.42 1.58	149.89 109.20 1.37	164.53 114.66 1.43	189.78 126.22 1.50	196.56 133.27 1.47	210.70 141.16 1.49
Sorghum ton ha yield (tons/ha)	73.27 40.32 1.70	42.65 33.47 1.27	47.47 30.67 1.42	60.30 47.6 1.27	75.33 57.12 1.32	102.97 67.30 1.53	112.70 80.50 1.4	131.05 84.93 1.54	137.96 87.32 1.58	146.00 96.26 1.52
Rice ton ha yield (tons/ha)	22.72 8.19 2.77	18.71 8.20 2.28	47.47 20.85 2.30	71.90 31.3 2.36	118.31 50.01 2.37	234.21 97.18 2.41	345.69 135.04 2.56	440.43 142.81 3.08	480.80 147.13 3.27	384.44 128.75 2.986
Millet ton ha yield (tons/ha)	12.20 11.87 1.03	13.00 12.00 1.04	8.74 5.02 2.30	11.30 6.5 .75	14.66 8.06 1.82	25.39 13.43 1.89	28.44 15.05 1.89	19.54 16.64 1.17	20.50 17.09 1.20	26.01 19.26 1.35
Cowpea ton ha yield (tons/ha)	4.95 7.04 0.69	5.56 7.74 0.72	0.67 1.47 0.46	0.721 1.5 0.47	0.70 1.39 0.50	0.968 4.34 0.22	1.08 5.12 0.21	3.12 5.42 0.57	3.27 5.54 0.59	3.58 5.91 0.60

Source: KWADP, 2012.

RESULTS AND DISCUSSION

Pattern of Agro-climatic Variables in Ilorin City (2002-2011) is as shown in Table 1 while Table 2 shows the descriptive analysis of the agricultural products yield data in Kwara State between 2002 - 2011. Out of the five selected crops, Cowpea has the least mean value (2.5). This is followed by Millet (17.98) while Rice has the highest mean value (216.45). This shows that within the years under study, Rice had the highest yield value.

Multiple regression analysis

The result obtained from the multiple regression analysis is shown in Table 3. The result shows that 97.9, 96, 95.2, and 80% of total variability in yield of maize, sorghum, rice and millet respectively can be explained to be as a result of the effect of the climatic parameters. Also, the P-value (significance) obtained from the analysis of variance (ANOVA) show that the influence of climate on the yield of maize, sorghum, rice and millet are statistically

Table 3. Descriptive Statistics of Grain Yield Data (2002-2011).

Crop	Mean	Std. deviation	Median	Variance
Maize	143.33	48.60	150.135	2.362E3
Sorghum	92.97	38.22	89.15	1.461E3
Rice	216.47	182.88	176.26	3.344E4
Millet	17.98	6.97	17.1	48.535
Cowpea	2.46	1.874	2.1	3.512

Table 4. Regression analysis.

Crop	R	R2	Adjusted R	F	Significance
Maize	0.998	0.995	0.979	59.83	0.017
Sorghum	0.996	0.991	0.960	31.72	0.031
Rice	0.995	0.989	0.952	26.53	0.037
Millet	0.978	0.956	0.800	6.14	0.147
Cowpea	0.851	0.725	-0.237	0.75	0.675

Table 5. Prediction model.

Parameter	Maize	Sorghum	Rice	Millet	Cowpea
	B	B	B	B	B
(Constant)	-2515.47	-2771.38	-9678.39	-342.48	-28.90
Rainfall	-0.369	-.663	-0.798	-.191	-0.04
Maximum Temperature	26.967	23.447	51.12	3.479	0.99
Mininimum Temperature	-4.310	4.413	22.94	.572	0.58
Evaporation	61.277	49.704	197.34	12.726	0.98
Relative Humidity	-8.710	-12.796	-27.65	-4.554	-0.66
Sunshine Hours	-47.897	-48.828	-204.33	-7.619	-2.51
Soil Temp.	78.419	93.968	319.32	15.867	1.214

significant except for cowpea, where most of the climate parameters are redundant (Table 4).

From Table 5, the model of the multiple regression analysis predicts that an increase in rainfall, evaporation and soil temperature will cause a decrease in yield of all the grain crops. However, an increase in maximum temperature, minimum temperature, relative humidity and sunshine hours will result in an increase in yield of all crops except for maize, where an increase in maximum temperature will cause a decrease in yield.

Correlation analysis

The pearson correlation coefficient (r) between the climatic parameters and the selected grain crop yields were computed and result is as presented in Table 6. This result shows that the correlation values of rainfall, maximum temperature and evaporation against maize, sorghum and rice yields are greater than 0.5 and this shows positive correlation relationships exist between these particular grain and the climate parameters. That is an increase in these climate parameters will result in an increase in yield. However, a weak correlation relationship exist between maize, sorghum and rice yields and minimum temperature, relative humidity, sunshine hours and soil temperature except for rice which has a value greater than 0.5 for soil temperature. For millet and cowpea, a strong relation exits for rainfall and minimum temperature respectively while a weak and negative relationship exists for the other climatic parameter under consideration. The analyses imply that the effect of climate on grain yield in the study area is not significant.

Table 6. Correlation (r) analysis.

Crop	Rainfall	Maximum temperature	Minimum temperature	Evaporation	Relative humidity	Sunshine hours	Soil temperature
Maize	0.544	0.546	0.268	0.841**	0.386	0.295	0.372
Sorghuim	0.539	0.613	0.443	0.610	0.266	0.195	0.509
Rice	0.668*	0.612	0.491	0.715*	0.290	0.120	0.399
Millet	0.545	0.324	0.199	0.613	-0.133	0.296	0.278
Cowpea	-0.120	0.360	0.564	-0.159	-0.064	-0.516	-0.375

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

Conclusion

From the result of the analysis, it was concluded that the Ho held for the yield of millet, sorghum and cowpea, while the opposite held for rice nd maize. In other words, the analytical results show that the variations in climatic parameters within the decade under consideration had little and no impact on the selected grain crops.

Recommendations

Based on the above findings, the study thus recommends that: the current climate change effect can be minimized if policies towards climate change mitigation are put in place; agricultural productivity can also be increased and sustained by developing agricultural technologies that are environmentally sensitive, and agricultural innovations that aid soil nutrient conservation and do not contribute to change in climate should be encouraged.

Conflict of Interest

The authors did not declare any conflict of interest.

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