AN ASSESSMENT OF CLIMATE CHANGE IMPACTS ON MAIZE (*Zea Mays*) YIELD IN SOUTH-WESTERN NIGERIA

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Abstract

Maize is the most important cereal crop in sub-Saharan Africa (SSA) and an important staple food in Nigeria. Africa produces 6.5% of maize worldwide. Nigeria with nearly 8 million tons, emerged the largest producer in Africa. However, most maize production in Africa is rain-fed. Given the current trends in climate change at its uncertain specific effects on the crop yields in general and maize yield in particular, formulating practical, affordable and acceptable response strategies for maize production in Nigeria required a study that evaluates the impacts of climate change on maize under varying climatic conditions over a period of eleven years in the South-western Nigeria. Yield data of maize for eleven years (1999-2009) and a corresponding climatic data (minimum and maximum temperature, solar radiation and rainfall) for the period were used. The data set was smoothened and adjusted for appropriate statistical analysis to generate model that could be adopted for seasonal planning and future yield optimization of Zea mays in the region. A linear regression model expressed as : Yield = 55.503SRAD + 2.054Tmax + 29.501Tmin-0.052RAIN-1459.373was generated where SRAD = Solar Radiation, Tmax = Maximum Temperature, Tmin = Minimum Temperature and RAIN = rainfall. Model performance was measured normalized root mean square error otherwise called percentage error (PE).

Introduction

Maize is grown widely throughout the world in different agro-ecological environments and is the most important cereal crop in sub-Saharan Africa (SSA) and an important staple food in Nigeria. Africa produces 6.5% of maize worldwide. Nigeria, with nearly 8 million tons, emerged as the largest producer in Africa. Africa imports 28% of the required maize from countries outside the continent. Most African agricultural productions in general and maize production in particular are rain-fed. Irregular rainfall can trigger famines during occasional droughts (IITA, 2015).

Agriculture and climate change take place on a global and regional scale. They are both interrelated processes. In spite of the uncertainties about the precise magnitude of climate change on regional scales, an assessment of the possible impacts of climate change on agricultural resources under varying conditions is important for formulating response strategies, which should be practical, affordable and acceptable to farmers. Several studies have shown that assessment of potential yield by evaluation of the previous performance, help in identifying the yield limiting factors and in developing suitable strategies to improve the productivity of a crop (Aggarwal and Kalra, 1994; Lansigan et al., 1996; Evenson et al., 1997; Naab et al., 2004). This assessment on agriculture might help to properly anticipate and adapt farming to maximize agricultural production under variable and changing climatic conditions.

Climate change is projected to have significant impacts on conditions affecting agriculture. The critical elements in this regard are: temperature, solar radiation, precipitation and the interaction among them. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. The overall effect of climate change on agriculture will depend on the balance of these effects (Fraser, 2008).The study aimed at assessing the impact of climatic change on maize yield in south-western Nigeria.

Results

Relationship between yield and the evaluated climatic variables was determined using Pearson's correlation (Table 1). Effect of SRAD and T_{min} on yield of maize are found significant at α = 0.01 level. The maximum temperature and rainfall however have negative correlation with the yield

Analysis of variation observed in the yield as affected by the four climatic factors considered revealed a significant dependent of the yield on the four parameters with P value = 0.003 at for degree freedom = 65 at 0.01level of significance. The regression model for this dependence is represented as:

$$\text{Yield} = 55.503\text{SRAD} + 2.054\text{Tmax} + 29.501\text{Tmin} - 0.052\text{RAIN} - 1459.373$$

Table 2 shows the performance of the regression model using the described RMSE/PE method. Since PE calculated (31.16%) is more than 30%, the simulation is said to be fair. It must be used for maize yield prediction in the observed region considering the fact that the yield can be 31.16% more or lesser than the predicted yield value.

Table1: Correlation between maize yield and weather variables in South-western Nigeria between 1999 and 2009

.	SRAD	T_{Max}	T_{Min}	RAIN
Yield	0.326**	-0.185	0.345**	-0.15
P-level (α = 0.01)	0.008	.137	.005	.720

**Correlation is significant at the 0.01 level

Conclusion

Proper understanding of impacts of these variables will go a long way in attaining good yield and as such good economic return. From this experiment, a model was simulated and validated which could be used for maize yield prediction if predicted climatic variables are substituted into the equation. The simulated model does not put other production factors like fertilizer, soil, seed quality, insect and pest management into consideration. But could be used to manage and manoeuvre the unconsidered factors expecially ss regards timing of all farm operations, thereby enhancing productivity. There is need for good weather prediction and the percentage error should be considered when making yield prediction.

Methods

Study Area

The study area is the south-western of Nigeria (Figure 1located between longitude 30° and 7°E and latitude 4° and 9°N. The region comprises of six states; Oyo, Osun, Ogun, Ondo, Ekiti and Lagos state (Figure 1). The total land area is about 191,843 square kilomaters (Iloeje, 1981). The weather conditions vary between two distinct seasons; the rainy season (March - November) and the dry season (November - February). The dry season is characterized by harmattan dust and cold dry winds from Sahara deserts.

Data for yield and growth parameters of maize for eleven years (1989-2009) were obtained from the Agricultural Production Survey (APS, 2009) under the National Programme for Agriculture and Food Security (NPAFS) of the Federal Ministry of Agriculture and Rural Development, Nigeria. Daily climatic data (minimum and maximum temperature, solar radiation and rainfall) for the same period were obtained from the Nigeria Meteorological Agency (NIMET), Oshodi, Nigeria.

Figure 1: Map of Nigeria showing the States in the south-western Nigeria

Data Analyses

Relationship between the climatic variables and maize yield were determined with the aid of Pearson's correlation. Regression Analysis was used to generate linear regression model expressed as $y = c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + k$ (y is the dependent variable which is the yield, k is a constant value, and x_1, x_2, x_3 and x_4 are independent variables where x_1 = Solar Radiation (SRAD), x_2 = Maximum Temperature (Tmax), x_3 = Minimum Temperature (Tmin) and $x4$ = RAIN). The c_1, c_2, c_3 and c_4 are the respective coefficients of the independent variables.

The model generated was validated with climatic data and maize yield from 2004 to 2007. The model was analyzed to test the reliability of data using normalized root mean square error otherwise called percentage error (PE) calculated following Loague and Green (1991).

Table2: Correlation between maize yield and weather variables in South-western Nigeria between 1999 and 2009

Year	Observed	Simulated	RMSE	%PE
2004	158.00	215.23	12.4644	31.16
2005	189.08	209.37		
2006	211.05	233.87		
2007	224.10	261.32		

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