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Short paper

Impact of climate variability on vegetable crops in Ilorin, Kwara State, Nigeria

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Abstract Climate is one of the key factors in agricultural productivity. Climate variability plays an important role in food production. Vegetable crops are sensitive to climate variability. This paper examines the impacts of climate variability on vegetable crops in Ilorin, Nigeria. Climatic data on temperature, relative humidity, rainfall and sunshine hours were collected for a period of ten years. Agricultural data on the yield of sweat potato, okra, pepper, tomato and *Amaranthus* were also collected for the same period. Multiple regression, trend analysis, correlation statistics and Standardized Anomaly Index (SAI) were employed in the data analysis. The results obtained indicate that the selected climatic elements have weak impact on the yield of okra, sweat potato, pepper, and *Amaranthus*. However, the selected climatic elements have strong impact on the yield of tomato. These results imply that variation in the yield of okra, sweat potato, pepper, and *Amaranthus* could be attributed to non- climatic factors like soil fertility and crop management practices while variation in the yield of tomato could be attributed to climatic factors. The paper thus suggests measures such as breeding new varieties of tomato that are tolerant to climatic stress or variability, application of fertilizer to improve the fertility of the soil and the use of modern agricultural techniques to improve the productivity of vegetable crops in Ilorin.

Keywords: Climate, crops, Ilorin, variability, vegetable.

1 Introduction

According to Ward (2016) the term ‘vegetable’ in its broadest sense refers to any kind of plant life or plant product. In the narrower sense, it refers to the fresh, edible portion of an herbaceous plant consumed in either raw or cooked form. Vegetable crops can be classified as fruit vegetables such as tomato, cucumber, watermelon, peas; root and tuber/root vegetables such as carrot, potato, sweet potato, radish, elephant foot yam; green leafy vegetables such as *Amaranthus*, celery, cabbage, curry leaf and bulb vegetables such as small onion, ballery onion, and garlic. Vegetables are a rich source of vitamins, carbohydrate, salts and protein. They are the best resources for overcoming micronutrient deficiencies and provide small holder farmers with much higher income and more jobs per hectare than staple crops. The worldwide production of vegetables has doubled over the past quarter century and the value of global trade in vegetables now exceeds that of cereals (Bhardwaj 2012). Among vegetable crops, tomato is the most important vegetable crop worldwide and is grown over a four million hectares of land area (Bhardwaj 2012).

Climate is one of the fundamental factors that determine the agricultural productivity of an area. It is so fundamental that it affects virtually all aspects of crop production (Adeniyi 2013). The production and yield of agricultural crops are climate determined. According to Anju *et al*. (2014) climate variability has significant impacts on agricultural sector especially during the last 40 year period. Climatic variability has become an issue today with significant effects on agricultural productivity. Climate determines the quality and quantity of crop productivity. Olanrewaju (2012) declares that many of the problems facing agricultural products are climate related. Climatic variability poses a threat on agriculture especially in an environment where agriculture is rain fed. Ernest (2002) stated that agricultural production depends on climatic variables such as temperature, precipitation and light. Adebayo (2010) observed that high temperature can slow down or completely stop the process of photosynthesis. Yusuf (2012) also reported that excessive heat has desiccating effects on plants and rapid rates of transpiration can cause wilting.

Vegetables crops, like other agricultural crops, are sensitive to climate variability. According to Bhardwaj (2012) vegetables are generally sensitive to environmental extremes, and thus high temperature are the major causes of low yields and will be further magnified by climate change. He also noted that increasing temperature, reduced irrigation water availability, flooding and salinity will be major limiting factors in sustaining and increasing vegetable productivity. Global climatic change, especially erratic rainfall pattern and unpredictable high temperature spells, will reduce the productivity of vegetable crops. High temperature stress disrupts the biochemical reactions fundamental for normal cell function in plants. It primarily affects the photosynthetic function of higher plants (Bhardwaj 2012). High temperature can cause significant loss in tomato productivity due to reduced fruit set, and smaller and lower quality fruits (Bhardwaj 2012). Yusuf (2012) also reported that environmental factors have negative effects on tomato production. Thakur and Jahn (2012) stated that continuous declining weather conditions and changes in climate due to the escalating temperature, erratic rainfall, more demand for water and enhanced incidence of diseases are all set to affect the production of various vegetable crops. Adeniyi (2013) reported that rainfall is one of the most important factors affecting crop production. Bhardwaj (2012) also observed that water greatly influence the yield and quality of vegetables; drought conditions drastically reduced vegetable productivity and tomatoes in particular are considered to be one of the vegetable crops most sensitive to excess water.

From the above studies, climatic variables, especially temperature, precipitation and sunshine hours affect the productivity of vegetable crops. This, therefore, suggests that to improve the production and the yield of vegetable crops climate-crop relationship must be taken into consideration. It is against this background that this paper is put forward to ascertain the impact of climatic variability on vegetable crops in Ilorin.

2 Material and Methods

2.1 Study area

Ilorin, the capital of Kwara State is located on latitude 8°24'N and 8°36'N and longitude 4°10'E and 4° 36'E. It is situated at a strategic point between the densely populated South-West and the sparsely populated middle belt of Nigeria. Ilorin is located in the transition zone between the deciduous woodland of the South and dry savannah of North Nigeria (Jimoh 2003). Figure 1 shows the map of Kwara State and the study area.

The climate of Ilorin is characterized by both wet and dry seasons. The rainy season begins towards the end of April and last till October while the dry season begins in November and ends in April. The temperature of Ilorin ranges from 33°C to 35°c from November to January while from February to April; the value ranges between 34°C to 37°C. Days are very hot during the dry season. The diurnal range of temperature and the mean monthly temperatures are characteristically high in the area. The total annual rainfall in the area ranges from 990.3mm to 1318mm. Rainfall in Ilorin city exhibits the double maximal pattern and greater variability both temporarily and spatially. The relative humidity at Ilorin city ranges from 75% to 88% from May to October, while in the dry season it ranges from 35% to 80%. The geology of Ilorin consists of Precambrian basement complex rock. The soils of Ilorin are made up of loamy soil with medium to low fertility. Because of the high seasonal rainfall coupled with the high temperature, there is tendency for lateritic soil to constitute the major soil types in Ilorin due to the leaching of minerals nutrients of the soil (Ajibade and Ojelola 2004). The elevation of the area varies from 273m to 333m in the western side with isolated hill (Sobi

Hill) of about 394m above the sea level while on the eastern side it varies from 273m to 364m (Ajibade and Ojelola, 2004). The lowest level is along the river valley of Asa and Oyun while the highest point is Sobi Hill.

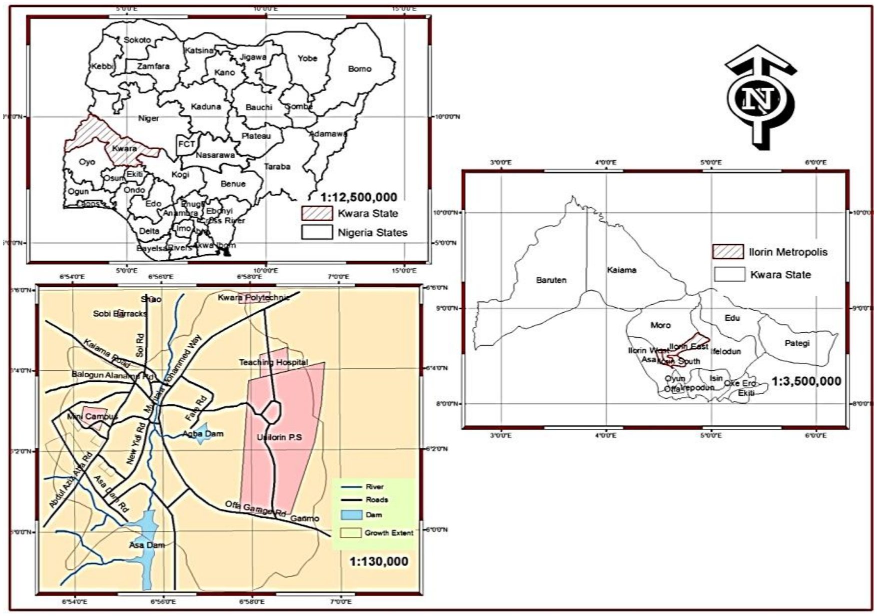

Fig.1: **Map of Nigeria showing Kwara State and the study area** (Source: Ministry of Land and Urban Development)

Ilorin is mainly drained by Asa river which flows in a South-North direction (Ajibade and Ojelola 2004). The pattern of the drainage system of Ilorin is dendritic. Asa River occupies a fairly wide valley and goes a long way to divide Ilorin into two parts; namely the eastern and the western part. The eastern part covers those areas where the GRA is located while the core indigenous area of Ilorin falls under the western part. Other rivers in Ilorin that drain into Asa river are river Agba, river Alalubosa, river Okun, river Osere, river Aluko, river Yalu, river Odota and river Loma. The soils of Ilorin are easy to farm. They are loamy soil with low sodium and low fertility. Because of the high seasonal rainfall coupled with the high temperature, there is tendency for lateritic soil to constitute the major soil types due to the leaching of mineral nutrients of the soil (Ajibade and Ojeola 2004).

The socio-economic activities in Ilorin have increased tremendously from agricultural practices of growing food crops to local craft of cloth weaving, leather works, pottery, embroidery, tie and dye, mat making, etc., to modern commerce with viable trading industry and administrative activities (Olorunfemi 2001). Agricultural activities in Ilorin are limited to small garden plots of maize, beans, and vegetables which are cultivated mainly for domestic consumption. Cultivation of tuber crops like yam and cassava are mainly done at the outskirts of the city. Both climate and soil of Ilorin support the growth of vegetable crops.

2.2 Climatic data

There are many ways of estimating the impact of climatic variability on agricultural productivity. These include the study of radiation and moisture balance of various crops under different climatic environment and the study of the relationship between plant and climate in a controlled environment (Olaniran 1981). However, this study employs the method of analyzing agricultural and climatic data in Ilorin over a period of ten years (2002-2011) to determine if there are strong correlations between climate factors and crop production. Climatic data on temperature, rainfall, relative humidity and sunshine hours were collected from Ilorin International Airport, Ilorin for the period of ten years. These climatic variables were selected based on the important role they play in the production and yield of vegetable crops. Agricultural data on sweet potato, tomato, pepper and *Amaranthus* were also collected from Kwara State Agricultural Development Project Office, Ilorin. The selected vegetable crops are the common and major vegetable crops grown in the area. Descriptive and inferential statistics were employed in data analysis. Simple correlation and Multiple Regression were used in showing the relationship between climatic parameters and vegetable yield, Mann-Kendull statistics was used in showing the trend and variations in vegetable yield while Standardize Anomaly Index was used in the analysis of fluctuations in climatic parameters over ten years in the study area. Statistical Package for Social Science (SPSS) was used in the analysis.

3 Results and Discussion

3.1 Patterns of agricultural data in Ilorin (2002-2011)

Table 1 shows the descriptive analysis of the agricultural data on vegetable crops in Ilorin. Out of the five selected vegetable crops, sweat potato has the highest mean value (8.43 Tons). This was followed by *Amaranthus* (4.43) while pepper has the lowest mean value (2.62). This implies that within the years under review, sweat potato has the highest yield value. The highest deviation was obtained in tomato production (1.70). The dispersion characteristics of sweat potato, okra, and *Amaranthus* are low. The co-efficient of variation which shows the relative deviation between crop yields indicated that tomato and pepper are heterogeneous with values greater than 33% while that of sweat potato, okra and *Amaranthus* are homogeneous with values less than 33%. This suggests that the values of tomato and pepper produced in the area differ significantly. The relative deviation in the yield of the crops could be a result of climate, soil fertility or crop management techniques.

Table 1: Descriptive analysis of agricultural data (2002-2011).

Crop	Mean (Yield) (Tons)	Standard Deviation	Co-efficient of Variation
Sweet Potato	8.43	0.72	8.49
Okra	4.06	0.49	12.09
Tomato	3.58	1.70	47.52
Pepper	2.62	1.10	41.91
Amaranthus	4.43	0.30	6.68

Source: Own data computation

3.2 Patterns of climatic data in Ilorin (2003-2013)

Figures 2-5 show the fluctuations of the selected climatic variables in Ilorin. From Figure 2, the annual temperature fall below the long term average in 2004 to 2006 and 2011. However, it falls above the long term average in 2003 to 2008 to 2010. This suggests a decline in temperature in 2004 to 2006 and 2011. The result also shows that temperature fluctuate around the long term average. From Figure 3, the annual rainfall fall above the long term average in 2003 to 2009 while the annual relative humidity falls above the long term average in 2004, 2006 and 2009 to 2011 (Figure 4). Similarly, from figure 5, the annual sunshine hours fall above the long term average in 2006, 2008, and 2010 to 2011. These suggest that there is an increase in Rainfall, relative humidity and sunshine hours in those years. From Figure 3, rainfall has the longest consecutive years of annual rainfall above the long term average. The above results indicate that the selected climatic variables fluctuate around the long term mean.

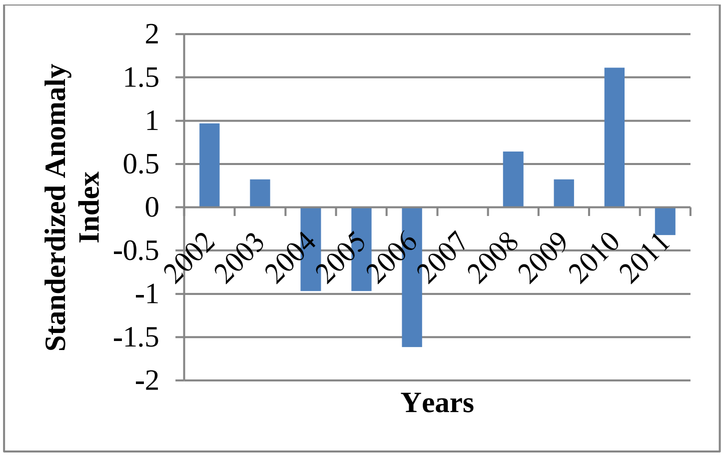

Fig 2. Annual Temperature Fluctuation for Ilorin (2002- 2011).

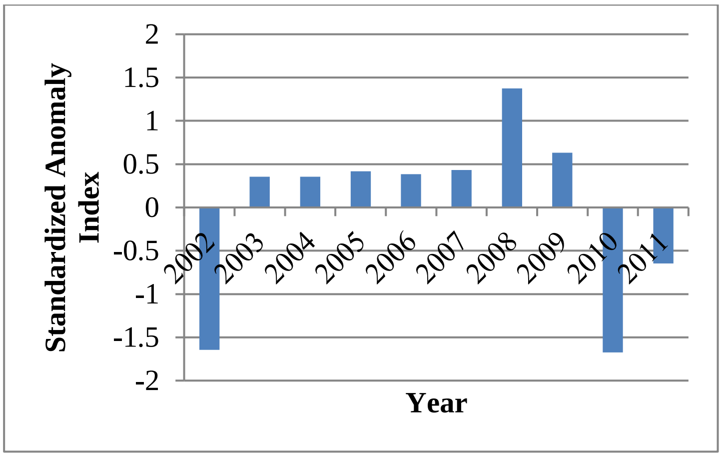

Fig 3. Annual Rainfall Fluctuation for Ilorin (2002- 2011).

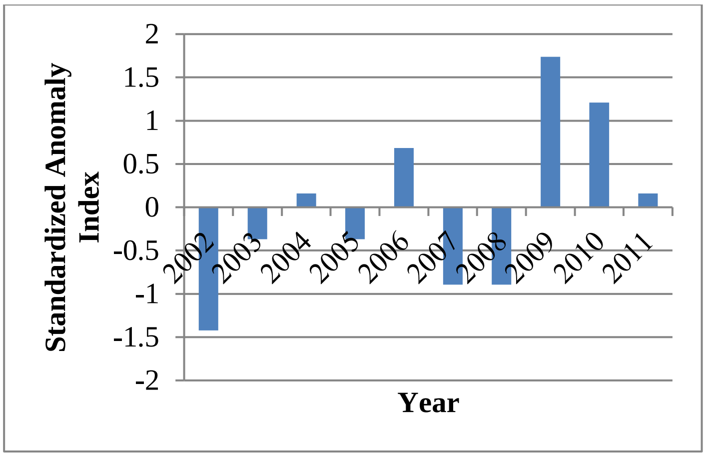

Fig 4. Annual Relative Humidity Fluctuation for Ilorin (2002- 2011).

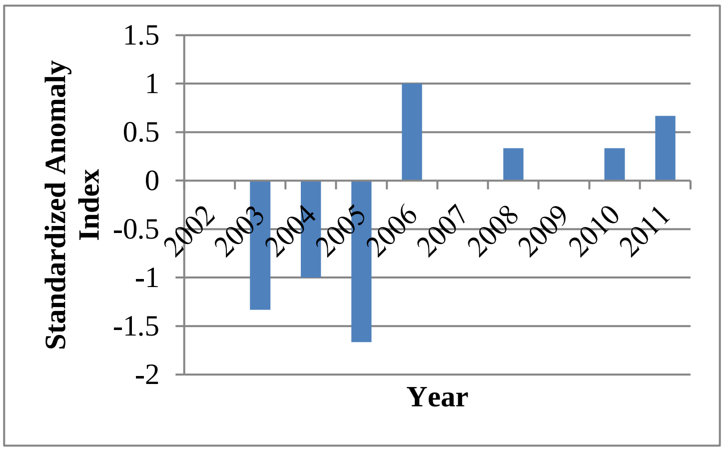

Fig 5. Annual Sunshine Hour Fluctuation for Ilorin (2002- 2011).

3.3 Relationship between climatic variables and crop yield

The result of the regression analysis shows that 46.5%, 32.9%, 44.7%, 26.7% and 79.7% of the variance in sweat potato, okra, pepper, *Amaranthus* and tomato yields can be respectively explained by the climatic parameters (Table 2). This implies that the impact of climate variability on variation of vegetable crops in Ilorin over the years under review is low except that of tomato. This also implies that variation in the yield of sweat potato, okra, pepper and *Amaranthus* could be attributed to non-climatic factors like soil fertility while variation in tomato yield could be attributed to climate variability.

Table 2. Statistical relationship between climate and crop yield.

Crop	R	R^2	Regression coefficient	Standard Error	F	Significant
Sweat potato	0.682	0.465	-10.525	31.901	1.08	0.453
Okra	0.574	0.329	9.550	24.513	0.613	0.672
Pepper	0.669	0.447	-65.781	49.794	1.01	0.481
Amaranthus	0.516	0.267	-2470.779	8103.555	0.454	0.768
Tomato	0.893	0.797	-117.355	45.147	4.899	0.056

Source: Own data computation

3.4 Crop - climate correlation

The simple correlation coefficient (r^2) between the selected climatic variables and the selected vegetable crops were computed (Table 3). The result shows that the correlation values of temperature and sweet potato, okra, pepper and tomato. This implies that temperature has weak correlation with the selected crops. Rainfall also has a weak correlation with all the crops. Relative humidity and sunshine hour have a weak correlation with pepper and *Amaranthus*. However, relative humidity and sunshine hours have a strong correlation with tomato. The result also shows that rainfall has a negative correlation with all the crops except *Amaranthus*. The implication is that as rainfall increases, the values of the crop yield reduce except that of *Amaranthus*.

Table 3. Climate – Crop Correlation

Crop	Temperature	Rainfall (mm)	Relative humidity	Sunshine hours
Sweet potato	0.181	-0.296	0.365	0.618
Okra	-0.185	-0.118	0.512	0.085
Pepper	0.885	-0.384	0.388	0.314
Amaranthus	0.115	0.125	-0.129	-0.467
Tomato	0.449	-0.328	0.561	0.684

Source: Own data computation

3.5 Trend in crop yield

Table 4 shows the result of the trend analysis using Mann-Kendull method. The result shows that there is no significant difference or decline in the values of the crop yield at 95% or 99% probability levels. This implies that no differential pattern of variation exists in yield of selected vegetable crops in each successive year under study.

Table 4: Trend analysis of crop yield

Crop	$(r)_t$
Sweet potato	0.73
Okra	0.42
Tomato	0.78
Pepper	0.47
Amaranthus	0.24

Source: Own data computation

4 Conclusion and Recommendations

The study examines the impact of climatic variability on vegetable crops in Ilorin. The results of the regression analysis show that climate has little impact on the selected vegetable crops except tomato. This implies that variation in the climatic variables have little effect on sweet potato, pepper, okra, and *Amaranthus*. The results, therefore, suggest that variation in vegetable yield could be as a result of other non-climatic factors. Such factors could be soil fertility, disease and insect pests or farm management techniques.

Based on the above findings, we recommend additional research to determine if the application of fertilizer can improve soil fertility resulting in higher crop production, if the use of insecticides to control crop pest and diseases will impact crop yield, and if practicing modern agricultural techniques can improve the yield of vegetable crops.

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