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Assessement of the Relationship Between Increase in Heigth of Cassava Growth Rate and Agro-Climatic Parameters in Ilorin Area of Kwara State, Nigeria

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Abstract
Cassava is primarily produced for food in its various forms and Nigeria has been recognized as the largest producer of the crop in the world. Despite the impacts of various weather parameters on crop production, Cassava can still withstand harsh conditions making it a key crop for protecting small holder farming against climate change. This paper therefore examined the relationship between increase in height of Cassava growth rate and agro climatic parameters. The agro climatic indices appraised were Rainfall, Relative humidity, Temperature and wind speed. Interrelationship between these agro climatic variables and increase in the height of growth rate of Cassava was computed using regression analysis. It was discovered that the four agro climatic variables had relationship with one another at either 95% significant level or 99% level. It was also reveal that there is 75% at 95% significant level in the rate of increase in height and yield of Cassava which was accounted for by relative humidity. It was therefore concluded that increase in the height rate and yield of Cassava due to relative humidity was as a result of combined effects of the three other climatic parameters.

Key words: Cassava; Growth rate; Agro climatic parameters

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INTRODUCTION
Cassava (Manihot Esculenta) is the crop with the highest total production in African, with 115 million MT of productions across the continent in 2010, contributing significant energy input to the population with an average 196 kcal/ capital / day in 2008 (FAO, 2010). It is a major stable for more than 500 million people in Africa, and is renowned for its drought tolerance and hardness in stressful environments (Elsharkawy, 2004).

Cassava is a typical tropical plant. The approximate boundaries for the cultivation may be accepted as from 30°N to 30°S latitude. However, most cassava growing is located between 20°N and 20°S. In general, the crop requires a warm humid climate. The temperature is important, as all growth stops at 10 °C. Typically the crop is grown in areas that are frost free the year round. The highest root production can be expected in the low tropical lands. Below 150 m altitudes, where temperature averages 25-27 °C. But some varieties grow at altitude of up to 1,500.

The plant produces most when rainfall is fairly abundant, but it can be grown where annual rainfall is as low as 500 mm or where it is as high as 500 mm. the plant can stand prolonged periods of drought in which most other food crops would perish. This makes it valuable in regions where rainfall is low or where seasonal distributions are irregular. In tropical climates the dry season has about the same effect on cassava as low temperature has a deciduous perennial in other parts of the world. The period of dormancy lasts few to three months and growth resumes when the rains begin again (Yahaya, 2012).

There are few studies on quantification of impacts and response of Cassava growth and Agro-climatic parameters (rainfall, temperature, relative humidity etc.), it was found out that cassava was least affected crop when compared with other major staple food such as Maize,Sorghum and Millet in term of increase height and rate of production (Elsharkawy, 2004).

Cock, et al. (2008) used the GIS-based Environmental policy Integrated climate (GEPIC) model to evaluate impacts of agro-climatic parameters on cassava production and increase in height growth rate across sub-Saharan Africa. The findings show that there are changes in production and this match with (Howard et al., 2010) who found cassava to moderately benefit from changes in agro-climatic parameters with an average increase of 1.1% in production through the use of statistical models.

Yahaya et al. (2012) worked on determination of seasonal rainfall variability and their agro- climatic implications on crop production, the result indicates that the on-set, cessation and length of rainy season varies from one ecological zone to another and that the variation in distribution of rainfall assist farmers in their farming activities. Studies on quantification of impacts of agro-climatic parameters on Cassava growth height have been carried out from various literatures studied; however, little or no attempt has been made in the literature on the relationship between Cassava growth height and agro-climatic parameters. The present study examined the relationship between increase in Cassava growth height and agro-climatic parameters in Ilorin Areas of Kwara State, Nigeria.

1. THE STUDY AREA

Ilorin is located within longitude 08°9′21″E latitude 04°30′50″E and 08°30′43″E latitude 04°33′01″E. The study area is located within the guinea savanna region of the country, it is characterized by deciduous trees of mixed traits e.g. silk cotton, locust bean tree, tall grasses also found in the area. Ilorin with mean annual rainfall of 1,200 mm (Olaniran, 2002) is characterized by eight months of wetness and four months of dryness. Temperature in the town is uniformly high and evaporation values ranges between 3.1 and 7.8 mm (Oyegun, 1983).

The Township plays host to Kwara State as the Capital. It lies along Lagos Kaduna highway, it is approximately 306 km from Lagos, 600 km form Kaduna and about 500 km to the Federal Capital City. The area has been experiencing rapid urbanization since 1967 when it became the capital of Kwara State. The extent of its built-up area between 1935 and 1963 was between 2-5 km^2, while in 1967 the land cover was about 8.37 km^2 (Jimoh, 2004), but it has today increased in multiple folds in the recent years.

Ilorin and its environs is one the fastest growing areas in Nigeria. The Population census (1991) puts the population at 619,310. It had a population of 809,171 in 2001 and 904,102 in 2006 national census. This trend in population growth rate shows a rapid growth in population. The growth rate 1991 and 2006 is at 5.11% which is higher than most other areas in the country (Jimoh, 2004). The study area covered a total land mass of 205,088Ha (2050.88 km^2).

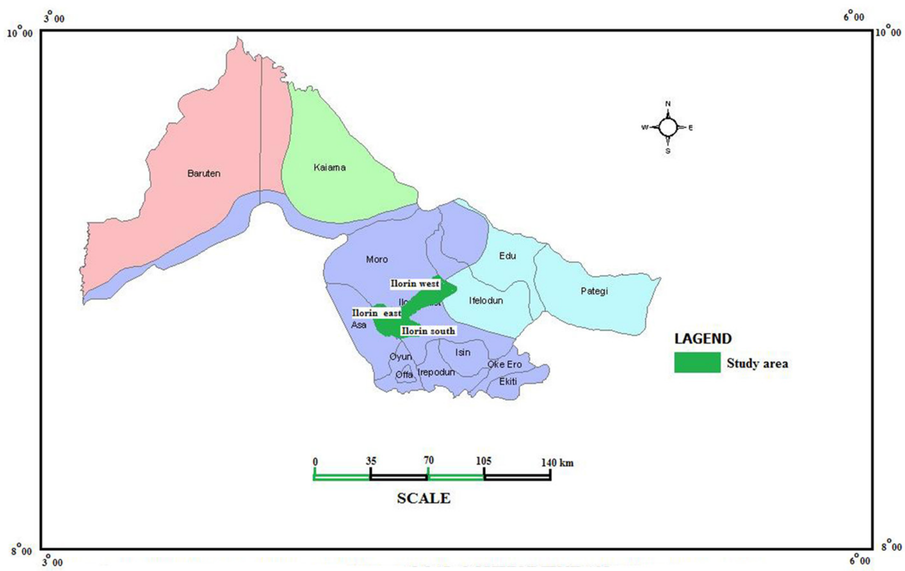

Figure 1
Kwara and the Study Area
Source: Geography Department Futminna

2. MATERIALS AND METHODS

The major data used for this study were collected from field observation from cassava farms for the period of sowing to that of maturity. The agro-climatic indices (rainfall, relative humidity, air, temperature and wind speed) were noted and recorded from period of sowing to maturity. Data on these agro-climatic variables (rainfall, relative humidity, air, temperature and wind speed) were collected for the period under study.

Interrelationship between indices of agro-climatic factors and increase in height of cassava growth rate was computed using regression analysis. Multiple regression was used to shows the relationship between the increase in height of cassava growth rate (Y) and the climatic variables (x), annual rainfall, air, temperature °C, relative humidity % and wind speed using the formula.

$Y = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$.

Where: a_1, b_1, b_2, b_3 & b_4 are the constant of regression.

X_1 = wind speed (annual mean) (WS)

X_2 = Air temperature (AT)

X_3 = Relative humidity (RH)

X_4 = Total monthly rainfall (RR)

Y = Rate of increase in cassava height (RCH)

Pearson product moment correlation was also used to see the various contributions of each of the agro-climatic variables to cassava growth height and given as:

$$\frac{N\sum xy - \sum x \sum y}{\sqrt{N\sum x^2 - (\sum x)^2} \cdot \sqrt{N\sum y^2 - (\sum y)^2}}.$$

Where:

N = Number of years when data is available,

x = independent variable,

y = dependent variable.

3. RESULT ANALYSIS

Table 2 shows the actual and predicted rate of increase in height of cassava using rainfall as predictor during the years of experimental work. It was observed that rainfall varied from month of March to November and the actual rate of increase also varied within the month.

In June when the rainfall amount was 222.98 mm, the monthly rate of increase (MRI) of cassava height was 43.2 mm as against the previously recorded height of 30.5 cm in the month of May when rainfall was 90.41 mm. However, the month of September witnessed a sharp drop in the actual rate of increase in cassava despite 318.24 mm rainfall recorded, but it must be noted that this time, it had grown to maturity and further growth was not expected.

Table 1
Actual and Predicted Rate of Increase in Height of Cassava Using Rainfall as Predictors

Month	Rainfall (mm)	Actual rate of increase in cassava (cm)	Predicted rate of increase (cm)	Residual
January	-	-	-	-
February	-	-	-	-
March	67.35	23.4	24.87	-1.47
April	50.04	11.6	14.24	-2.64
May	90.41	30.5	28.85	1.65
June	222.98	43.2	38.85	4.35
July	118.72	30.6	26.86	3.74
August	410.72	24.3	28.05	-3.75
September	318.24	13.6	24.5	-10.9
October	126.76	3.3	10.15	-6.85
November	105.00	0.0	16.32	16.32
December	0.0	0.0	0.29	0.29

Source: Field Work Survey (2013).

The graph equally revealed the difference in growth height which indicates that during the vegetative period, the rainfall in the said area was sufficient in providing the necessary soil moisture.

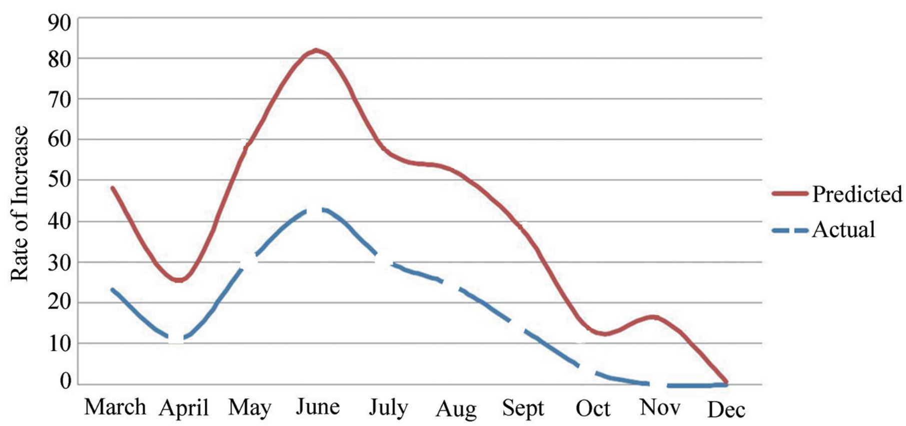

Figure 2
Actual and Predicted Rate of Increase of Cassava Using Rainfall as Predictor
Source: Field Work Survey (2013).

Cassava requires a fair degree of atmospheric humidity for proper growth. During the early stage of growth of cassava plant like many other crops absorb moisture from the unsaturated air layer. Table 2 shows relative humidity varied from one month to another, relative humidity fluctuates and thus affects the rate of cassava growth. Flowering in cassava occurs with the beginning of dry season. When the atmospheric humidity falls below 70%, it was also recorded that the highest rate of increase in cassava plant height was in June when relative humidity was 85%, see Table 2. The harvest ration of increase in cassava height was in October when the recorded relative humidity was 79%. The relationship between actual and predicted rate of increase in cassava height was shown in Figure 3, it fluctuate from one month to another and this implies that relative humidity can be used to estimate the rate of increase in cassava height.

Table 2
Actual and Predicted Rate of Increase in Height of Cassava Using Relative Humidity as Predictor

Month	Relative humidity (%)	Rate of increase in cassava (cm)	Predicted rate of increase (cm)	Residual
March	74	23.3	14.879	8.424
April	73	11.6	12.984	-1.384
May	84	30.5	24.340	6.160
June	88	43.2	27.179	16.021
July	89	30.6	28.125	2.475
August	90	24.3	29.072	-4.472
September	86	13.6	25.256	11.656
Octocber	79	3.3	8.662	5.362
November	65	0.0	5.413	5.413
December	54	0.0	-4.997	-4.997

Source: Field Work Survey (2013).

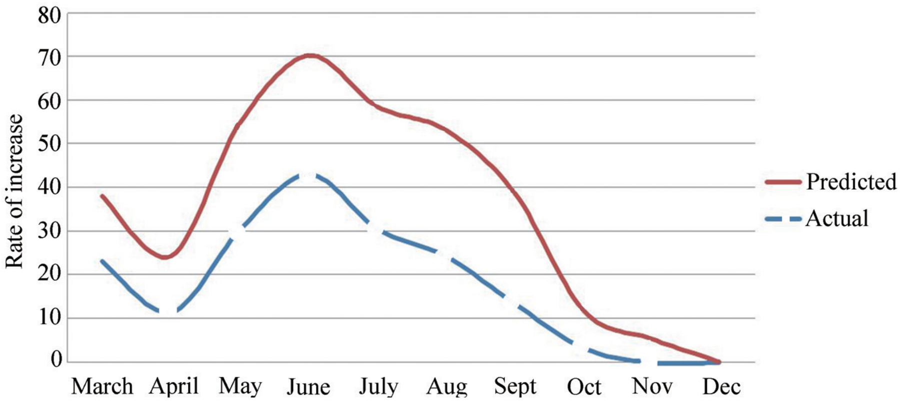

Figure 3
Actual and Predicted Rate of Increase in Cassava Using Relative Humidity as a Predictor
Source: Field Work Survey (2013)

Table 3
Actual and Predicted Rate of Increase in Growth of Cassava Height Using Air Temperature as Predictor

Month	Mean air temp (^oC)	Rate of increase of cassava (cm)	Predicted rate of increase (cm)	Residual
March	29.2	23.4	15.13	8.27
April	31.6	11.6	26.77	-15.17
May	30.4	30.5	33.15	-2.65
June	30.2	43.2	26.79	16.41
July	30.6	30.6	28.91	1.69
August	24.2	24.3	20.43	3.87
September	28.4	13.6	18.31	-4.71
Octocber	29.6	3.3	11.95	-8.65
November	30.2	0.0	2.94	2.94
December	30.4	0.0	-3.42	-3.42

Source: Field Work Survey (2013).

Air temperature affects sprouting, leaf formation, root formation and the general growth of cassava. The growth is favorable under annual mean temperature ranging from 25 to 29 ^oC , but it can tolerate from 16-30 ^oC. Table 3 shows the variation of mean air temperature. The highest temperature of 31.6 ^oC is in April while the lowest temperature of 24.2 ^oC is in August. The range of temperature was 71.4 ^oC, slight changes in temperature results in to great fluctuation in the rate of increase in temperature to 31.6 ^oC in April. Resulted into a decrease in the rate of increase in cassava growth to 11.6 cm, of 30.2 ^oC in June and 30.6 ^oC in July had growth rate of 43.4 cm and 30.6 cm respectively see Table 3. It had been confirmed by El-Sharkawy et al, 1992 and Abafu, 1992 that the growth and yield of cassava is optimum when temperature are 25-27^oC. Since the average temperature of the study area falls between these ranges, it implies that cassava will not only thrive well, but will also have sufficient yield. See Figure 4.

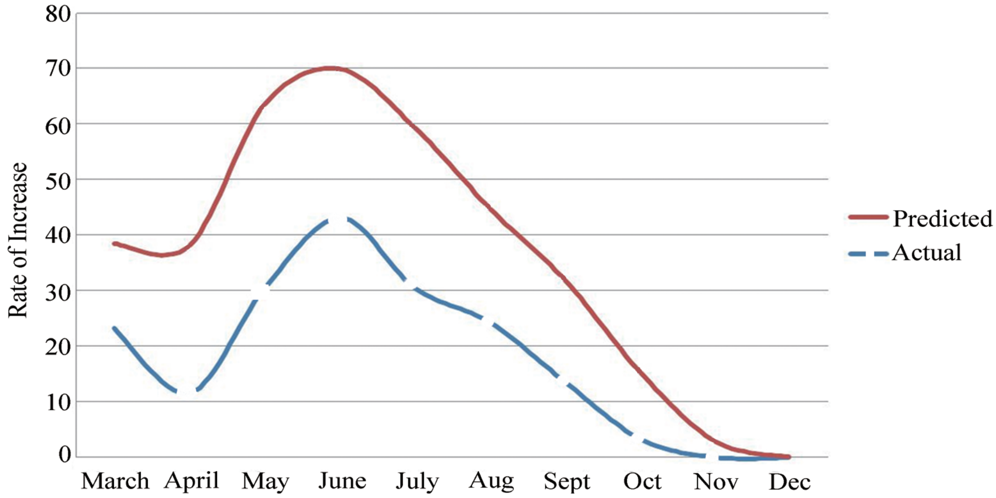

Figure 4
Actual and Predicted Rate of Growth Using Temperature as a Predictor
Source: Field Work Survey (2013)

Table 4
Actual and Predicted Rate of Increase in Cassava Growth Height Using Wind Speed as Predictor

Month	Wind speed (cm. 5^{-2})	Rate of Increase (cm)	Predicted rateof increase	Residual
March	12.3	24.4	15.12	9.28
April	20.7	11.6	26.79	-15.19
May	17.5	30.5	33.15	-2.65
June	20.7	43.2	26.79	16.41
July	29.8	30.6	28.91	1.69
August	33.8	24.3	20.43	3.87
September	26.7	13.6	18.31	-4.71
Octocber	19.7	3.3	11.95	-8.65
November	8.4	0.0	2.94	2.94
December	9.7	0.0	-3.43	-3.43

Source: Field Work Survey (2013).

Wind play a significant seasonal role in global scale as it is associated with the movement of cloud and rainfall and thus affects the growth of crops. Mean monthly wind speed varied from month to month. The highest wind velocity was recorded in August when the wind speed was 33.8 cm^2. Wind at this period moves with relative ease. The wind speed recorded during the study period was moderate and contributed greatly to the rate of increase in growth height of cassava.

The actual and predicted rate of increase in cassava growth height is shown in Figure 5. The differences are small and fluctuate from the month of March to December.

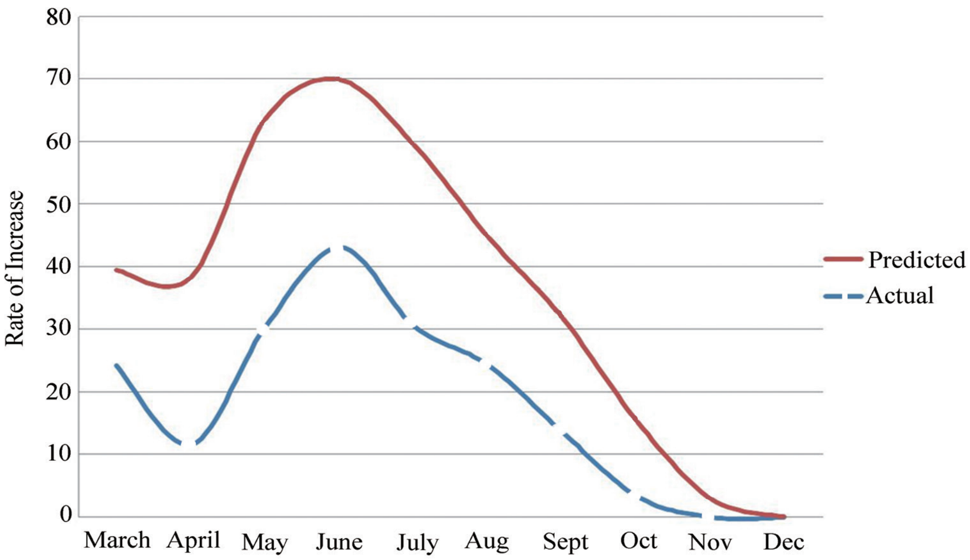

Figure 5
Actual and Predicted Rate of Growth Using Wind Speed as a Predictor
Source: Field Work Survey (2013).

Table 5
Pearson Product Moment Correlation for Rate of Increase in Cassava Growth Model Correlations

		Rate of increase in cassava yield	Rainfall	Air temperature	Wind speed	Relative humidity
Rate of increase in cassava yield	Pearson correlation	1	.332	-.115	.465	.748*
	Sig. (2-tailed)		.349	.751	.176	.013
	N	10	10	10	10	10
Rainfall	Pearson correlation	.332	1	-.830**	.747*	.697*
	Sig. (2-tailed)	.349		.003	.013	.025
	N	10	10	10	10	10
Air temperature	Pearson correlation	-.115	-.830**	1	-.549	-.404
	Sig. (2-tailed)	.751	.003		.100	.246
	N	10	10	10	10	10
Wind speed	Pearson correlation	.465	.747*	-.549	1	.832**
	Sig. (2-tailed)	.176	.013	.100		.003
	N	10	10	10	10	10
Relative humidity	Pearson correlation	.748*	.697*	-.404	.832**	1
	Sig. (2-tailed)	.013	.025	.246	.003	
	N	10	10	10	10	10

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

Table 5 above reveals the cross correlation between the climatic variables (rainfall, relative humidity, air temperature and wind speed) and the rate of increase in cassava yield over the period under consideration. It reveals that all the four climatic variables have relationship with one another the either 95% significant level or 99% significant level. The pearson product moment correlation statistics reveal that there is a 75% rate increase in yield of cassava that could be explained by relative humidity for significant level of 95%. The table also reveals that other weather variables considered though are not directly significant with the rate of increase in cassava yield but all are significant with the relative humidity.

Rainfall shows a correlation of 0.83, 0.75 and 0.70 with air temperature, wind speed and relative humidity respectively. It was also revealed that there was a correlation of 0.83 between wind speed and relative humidity (Table 5). All these point to the fact that the increase in the rate of yield experienced by cassava due to relative humidity is due to the combined effect of three other climatic variables, which implies that temperature, rainfall and wind speeds are indirectly factors that could be used to explain the growth rate experienced in cassava yield.

DISCUSSIONS

The paper investigated the relationship between the increase in height of cassava growth rate and agro climatic parameters in Ilorin Area of Kwara State, Nigeria. It was discovered that all the agro climatic parameters appraised varied from month of March to November and the actual rate of increase in the growth rate in height of cassava also varied within the months. For instance, In June when the amount of rainfall was 222.98 mm, the monthly rate of increase of cassava height was 43.2 cm as against the previously observed height of 30.5 cm in the month of May when rainfall was 90.4 1mm.

It was also showed that the highest rate of increase in Cassava growth height was in June when the relative humidity was 85%. This implies that relative humidity can be used to estimate the rate of increase in Cassava growth height. It was also observed that slight changes in temperature result in fluctuation in the growth rate on the height of Cassava. The wind speed recorded during the study period was moderate and contributed greatly to the rate of increase growth rate in height of Cassava. Pearson product movement correlation regression analysis for rate of increase in Cassava growth height also indicated that the four climatic variables used have relationship with one another for significant level of 95% and that 75% rate increase in yield of cassava was accounted for by relative humidity. This mean that increase in the height rate and yield of cassava by relative humidity was as a result of combined effects of other three climatic variables (Rainfall, Temperature and wind speed).

CONCLUSION

The results of the study reveal that all the agro-climatic parameters appraised have relationship with one another the significant level of 95%, however 75% of relative humidity accounted for the increase in the growth height and yield of cassava. This mean that increase in the height rate of cassava growth accounted for by 75% was as a result of combined effects of other climatic parameters. It is therefore concluded that all the climatic parameters analyzed can be used to estimate the rate of increase in cassava growth height.

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