



RELATIONSHIP BETWEEN AGRO-CLIMATIC CONDITIONS AND YIELD OF SUGARCANE IN SOUTHERN PARTS OF ADAMAWA STATE, NIGERIA

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Abstract

This study covered eleven Local Government Areas in the southern parts of Adamawa state, with total area of about 20,739.30 Km.² Relationship between the major climatic conditions and the yield of sugarcane in the study area were examined using

Keywords: *Agro-climatic, correlations, dataset, sugarcane, yield*

Pearson's Product Moment Correlation Coefficient (PPMCC) analysis. The conditions considered are rainfall, temperature, relative humidity and

INTRODUCTION

Agro-climatic conditions are indisputably very important in crop production, especially for large scale farming in our country where irrigational farming is a costly venture. Nevertheless, the peasant subsistent farmers always depend on the natural source of all the agro-climatic conditions needed for crop production. Therefore, the outcome of a study on the relationship between these conditions and a crop yield will be good information to the stakeholders. Srivastava & Rai (2012) noted that, climate plays an important role in all the phases of sugarcane crop (and of

solar energy. Climatic data used were obtained from Nigerian Meteorological Agency (NiMet), and Global Weather Data for SWAT. The result indicated that, there is weak positive correlation between the yield of sugarcane and temperature, rainfall and relative humidity (RH) which have PPMCC values of 0.1, 0.2 and 0.1 respectively. While weak negative correlation were observed between the yield of sugarcane and temperature, and solar energy with PPMCC values of -0.3 and -0.1 respectively. This Minimum shows that as the values of Minimum temperature, rainfall and RH increase, the yield of sugarcane increases gradually too. In the other hand, as the values of Maximum temperature and solar energy increase the yield of sugarcane declines gradually in response. Therefore, the trend of these climatic conditions should be considered when investing in sugarcane production.

course any other crop). That, since sugarcane stands in the field for 12-24 months, hence it passes through all possible limits of weather parameters such as rainfall, temperature, sunshine, and humidity. Consequently, all climatic conditions have significant role in the crop's growth, sugar yield, quality and of course juice content. For optimum growth of the crop and high production, specific amount of weather conditions are required. This informs the reason why the authors veered toward the direction of this study with the intention of promoting sugarcane production in the study area.

Sugarcane is a giant grass which belongs to the genus *Saccharum*. There are six species that are included in the classification of sugarcane. Among the species known are *officinatum*, *spontaneum*, *barberi*, *sinense*, *edule* and *robustum*. These species survive in both tropical and sub-tropical regions (Tarimo & Takamura, 1998). According to Republic South Africa (2014), the scientific name for sugarcane is *Saccharum officinarum*. That the crop composed of six species of perennial grasses of the genus *Saccharum* L., in tribe *Andropogoneae* of the *Poaceae*. There are however, two wild species (*S. spontaneum* L. and *S. robustum*) and four cultivated

species, *S. officinarum* L., *S. barberi*, *S. sinense* and *S. edule*. The four cultivated species are complicated hybrids, and all intercross readily. All commercial canes grown today are inter-specific hybrids.

According to Letstalkagric (2017), sugarcane is used as a sweetener in beverages and various foods. It is also used in making confectionaries, example bread, cakes and biscuits. In the production of alcohol example ethanol, sugarcane is useful too. The by-productions of the processing are used in the following ways: cane residue (bagasse) can be used as fuel, manure or fodder.

Every plant has specific climatic condition in which it strives well, same as sugarcane. Mondale (2017) asserted that, sugarcane is a long duration crop and requires 10 to 15 and even 18 months to mature, depending upon the geographical conditions. It requires hot and humid climate with average temperature of 21-27°C and 750-1500 mm rainfall. Letstalkagric (2017) also pointed out some climatic conditions for sugarcane production. That, the temperature should range from 20°C to 27°C throughout the year. Dry sunny conditions are also of great advantage as they promote sugar accumulation. In terms of rainfall, 1200 to 1500 mm will be appropriate.

This study is an effort put to look at how the major climatic parameters in the southern parts of Adamawa state relate with the yield of sugarcane. As the climatic conditions varied over the time covered in this study, the yield of sugarcane also responded to the variations. Thus, this study looks at these variations, to provide useful information to the sugarcane farmers and any other stakeholder in the business of sugarcane cultivation. This will help the farmers in their plans for the cultivation of sugarcane in the southern parts of Adamawa state.

MATERIALS AND METHOD

Preamble

To examine the relationship between the agro-climatic conditions and yield of sugarcane in the southern parts of Adamawa state, the Pearson Product Moment Correlation coefficient in Microsoft Excel is used to achieve this objective. The climatic conditions used in this analysis are rainfall, maximum temperature, minimum temperature, relative humidity

(RH) and solar energy. Each condition is taken and correlation analysis carried out between it and the yield of sugarcane. This shows the impact of variation of the agro-climatic conditions on the yield of sugarcane in the study area.

Study Area

Adamawa state is one of the states in north eastern Nigeria with its capital Yola. It is one of the largest states in the country and occupies about 36,917m². It is located between latitudes 7°N and 11°N and longitudes 11°E and 14°E. The state has common boundaries with Taraba state in the south-west, Gombe state in the north-west and in the north with Borno state. In the eastern part, the state shares an international boundary with the Republic of Cameroon (Adebayo & Tukur, 1999). However, the study area, that is the southern parts of the Adamawa state consists of only eleven (11) Local Government Areas and lies between latitude 7°N and 10°N (Field work, 2019).

According to Adebayo & Tukur (1999), Adamawa state is characterised with varied rainfall ranging from 700mm in the north-western part to 1600mm in the southern part.

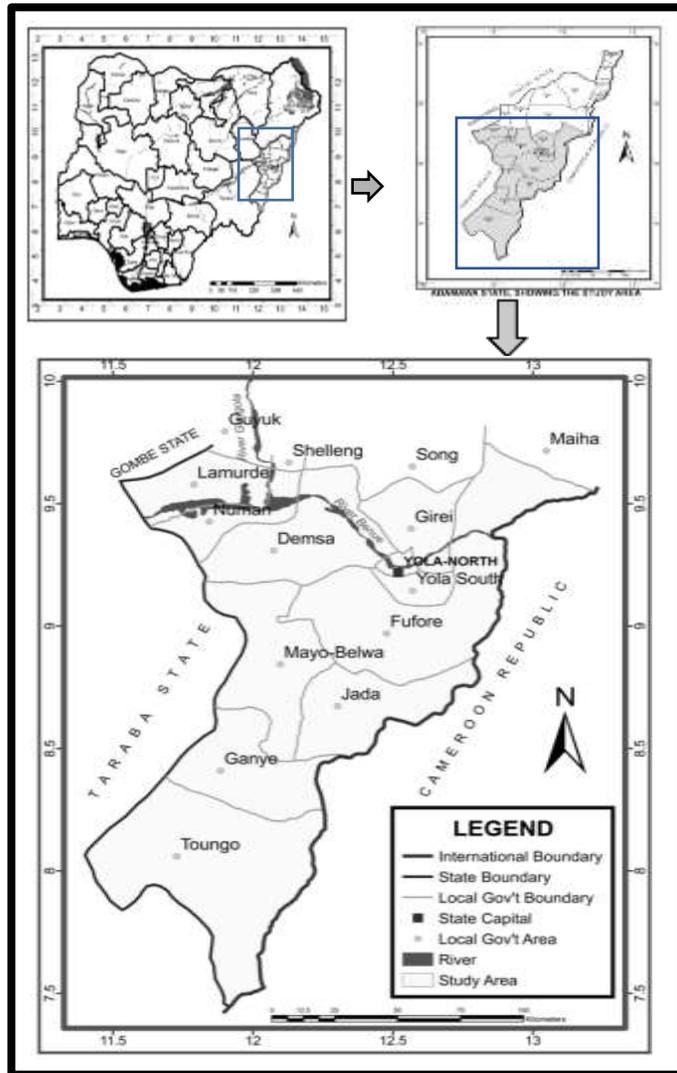


Figure 1 **Location of the Study Area**

Source: GAMERS, 2019

By and large, the mean annual rainfall is less than 1000mm in the central part of the state. This region includes, Song, Gombi, Shelleng, Guyuk, Numan, Demsa, Yola and part of Fufore Local Government Areas (LGAs). Northern strip and southern part have over 1000mm in the other hand. This variation of the annual rainfall amount is as the result of the altitudes of the stations.

The major vegetation formation of the state is divided into three zones: The Southern Guinea Savannah, the Northern Guinea Savannah and the Sudan Savannah. However, each formation is characterised by interspersed thickets trees Savannah, open grass Savannah and fringing forest in the river valleys (Adebayo & Tukur, 1999).

Data Source

As stated earlier, the climatic data used include: Rainfall, Maximum Temperature, Minimum Temperature, Solar energy, and Relative Humidity (RH). These datasets were obtained from Nigerian Meteorological Agency (NiMet), Global Weather Data for SWAT (GWDS) and NASA Prediction of Worldwide Energy Resources (POWER). The data covered a period of 35 years, which is from 1982 to 2017. All the climatic data were in numeric form.

Data Preparation

The daily amount and mean values of all the climatic data of the study area were computed in the Excel environment to come up with annual amount and mean for used in achieving the aim of this study. This was done to prepare the data for correlation analysis and examination of their relationship with the yield of sugarcane in the southern parts of Adamawa state.

For the rainfall, simple arithmetic of addition was used. The daily values were summed up to come up with the monthly amounts, which were further added to get the total annual value for a given year. This computation was carried out using the summation tool in Microsoft Excel 2010. The computation was carried out as follows:

1. **Monthly Total Amount**= Day 1 (Value) + Day 2(Value) + Day 3 (Value).....Last Day of the Month (Value)
2. **Annual Total Amount**= January (Value) + February (Value) +March (Value).....December

For the other climatic datasets that is temperature, relative humidity and solar energy, their annual means were computed and used in the analysis. This was done by first, computing the monthly means from the daily values, which in turn were used to get the annual means used for the study. Here too, Microsoft Excel 2010 Average tool played a great role. The arithmetic mean formula used is as follows:

$$X = \frac{X_1+X_2+X_3\dots X_N}{N} \quad \text{---}$$

Where:

X = the mean ---

X1 = the first value

X2 = the second value

X3 = the third value

XN = the last value

N = the number of value

The computation was carried as follows:

1. **Monthly Means** = $\frac{\text{Sum of Daily Values for the Month}}{\text{Number of Days in the Month}}$

2. **Annual Means** = $\frac{\text{Sum of Monthly Mean Values}}{12}$

Pearson's Product Moment Correlation Analysis

Pearson r correlation is used to measure the degree of relationship between two variables. The point-biserial correlation is conducted with the Pearson correlation formula except that one of the variables is dichotomous. The following formula is used to calculate the Pearson r correlation:

$$r = \frac{N \sum xy - \sum(x)(y)}{\sqrt{[N \sum x^2 - \sum(x)^2]} \sqrt{[N \sum y^2 - \sum(y)^2]}}$$

r = Pearson r correlation coefficient

N = number of observations

$\sum xy$ = sum of the products of paired scores

$\sum x$ = sum of x scores

$\sum y$ = sum of y scores

$\sum x^2$ = sum of squared x scores

$\sum y^2$ = sum of squared y scores

If the value of r is close to +1, it indicates a strong positive correlation, and if r is close to -1, it denotes a strong negative correlation.

RESULTS AND DISCUSSION

Results

Relationship between Maximum Temperature and Yield of Sugarcane

From figure 2 and table 1 the correlation test carried out for maximum temperature and yield of sugarcane indicates that, there is weak negative correlation between the yield of cane and maximum temperature.

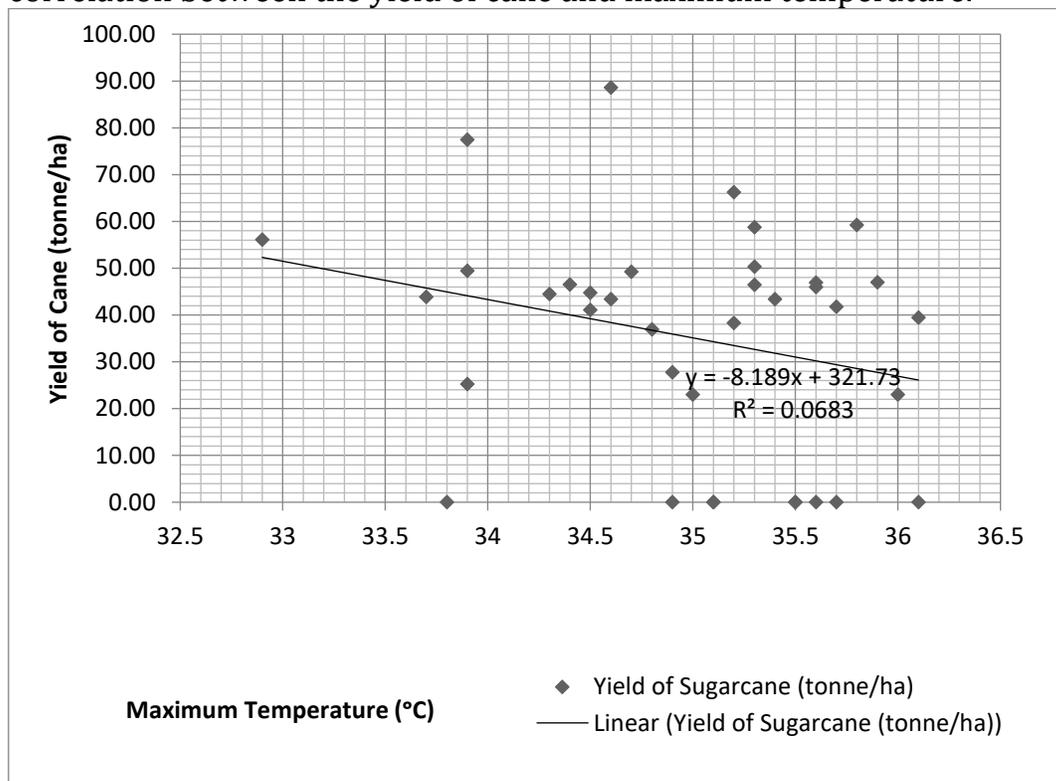


Figure 2 Relationship between Maximum Temperature and Yield of Sugarcane

Source: Author's Processed Data via Microsoft Excel

Relationship between Minimum Temperature and Yield of Cane

From figure 3 and table 1 the relationship between minimum temperature and yield of cane indicates a positive correlations.

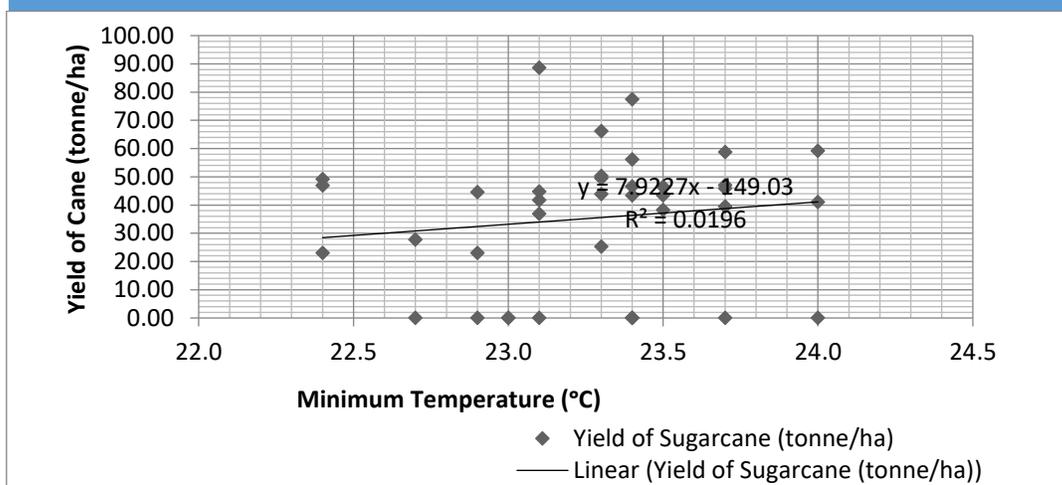


Figure 3 Relationship between Minimum Temperature and Yield of Sugarcane

Source: Author's Processed Data via Microsoft Excel

Relationship between Rainfall and Yield of Cane

Rainfall is one of the most important climatic elements a crop requires for growth and yield. The correlation test result in figure 4 and table 1 shows that, there is a positive correlation between the total annual rainfall and the yield of cane.

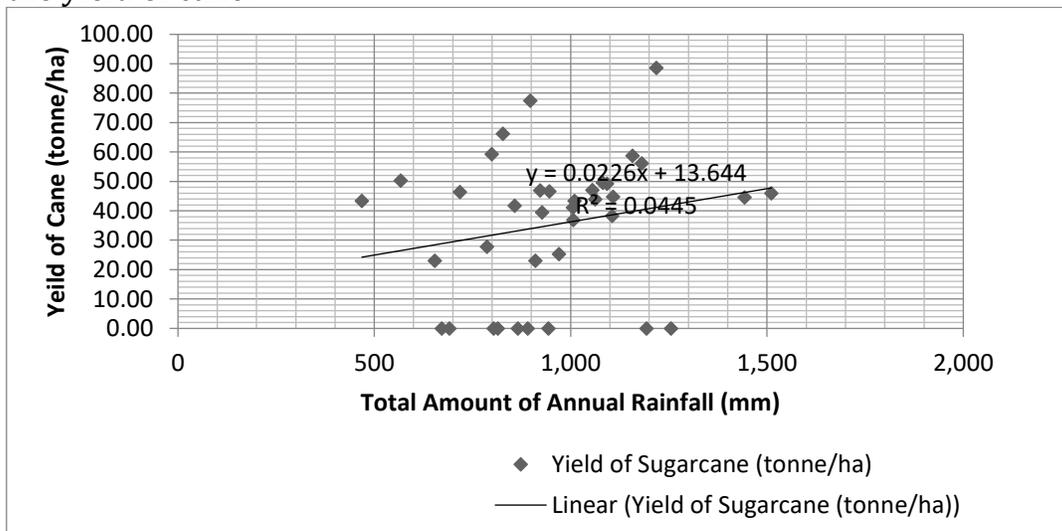


Figure 4 Relationship between Rainfall and Yield of Sugarcane

Source: Author's Processed Data via Microsoft Excel

Relationship between Relative Humidity (RH) and Yield of Cane

Relative Humidity plays an important role in the cultivation of sugarcane also. The correlation test carried out in this study on yield of cane and RH is shown in figure 5 and table 1.

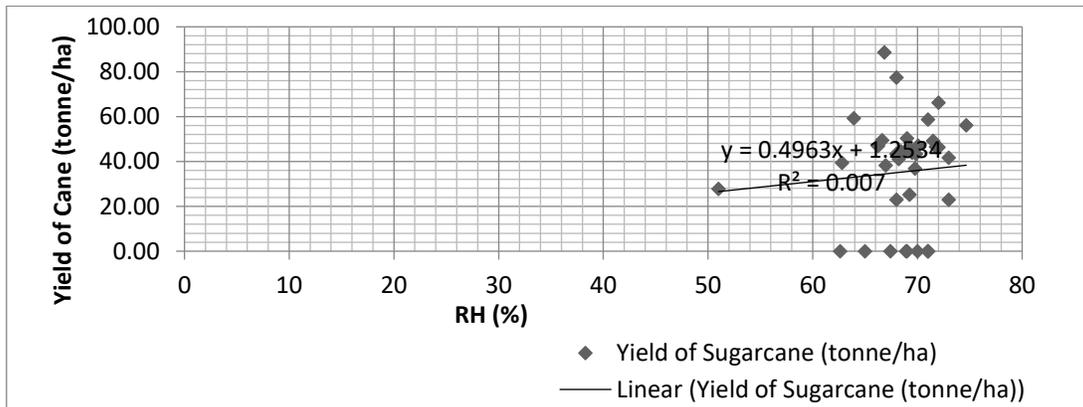


Figure 5 Relationship between Relative Humidity and Yield of Sugarcane
 Source: Author's Processed Data via Microsoft Excel

Relationship between Solar Energy and Yield of Cane

Solar energy is also one of the requirements for any crop growth and yield. Sugarcane also requires certain intensity of solar radiation to undergo the process of photosynthesis like any other crop. Therefore, to examine the relationship between solar energy and sugarcane, correlations test were carried out. The results are shown in figure 6 and table 1.

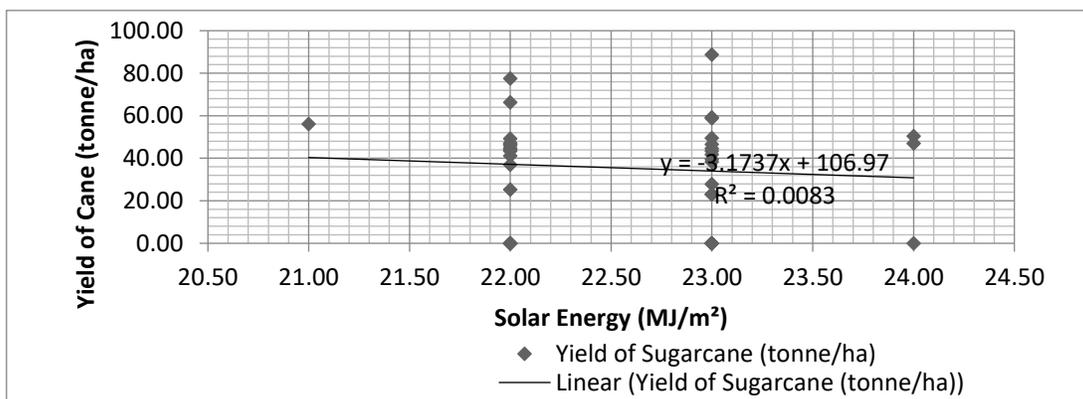


Figure 6 Relationship between Solar Energy and Yield of Sugarcane
 Source: Author's Processed Data via Microsoft Excel

Table 1 Results of Pearson's Product Moment Correlation Coefficient

Variable	Value
Maximum Temperature and Yield	-0.26137
Minimum Temperature and Yield	0.139888
Rainfall and Yield	0.210854
RH and Yield	0.083491
Solar Energy and Yield	-0.09106

Source: Author's Processed Data via Microsoft Excel

Discussion

The Pearson's Product Moment Correlation Coefficient (PPMCC) computation was used to examine the relationship between each agro-climatic conditions and the yield of sugarcane in the study area. The result of each test is explained in the following sections in topical order.

Rainfall and Sugarcane Yield

Rainfall is one of the most important climatic elements a crop requires for growth, development and yield. The correlation test result shows that, the PPMCC value is 0.21 (table 1). This is an indication that, there is a weak positive correlation between the two variables. Therefore, it is not out of place to conclude that, over the period covered in this study, yield of sugarcane showed a gradual increase as the amount of annual rainfall increased too (figure 4).

Maximum Temperature and Sugarcane Yield

The result of the relationship test is shown in table 2 and figure 1. From the result, the PPMCC value for the relationship is -0.26. This is an indication that there is a weak negative correlation between the yield of cane and the maximum temperature in the study area. This means that, as the temperature increases the yield of cane decreases gradually over the time.

Minimum Temperature Sugarcane Yield

In examining the relationship between the yield of cane and minimum temperature, table 1 and figure 3 are the result of the analysis. From the result, the PPMCC is 0.14, which indicates a weak positive correlation. This in other words means that as the minimum temperature increases over

time the yield of sugarcane also increase gradually through the period of the study.

Relative Humidity (RH) and Sugarcane Yield and

From the result of the test shown in table 1 and figure 5, it is indicated that there is a correlation between the two variables. However, from the value of PPMCC (0.08), one could deduct that; the correlation is a weak positive one. This means that, over the period covered by this analysis, the yield of sugarcane increased gradually as the RH value increased.

Solar Energy and Sugarcane Yield

Solar energy is also one of the requirements for any crop's growth and yield. Sugarcane also requires certain intensity and duration of solar radiation to undergo the process of photosynthesis like any other crop. Therefore to examine the relationship between the solar energy and yield of cane, correlation test was carried out. The result shows that there is a weak negative correlation between the two variables (table 1). Therefore, increase in the amount of solar radiation induces a gradual decrease in the yield of sugarcane (figure 6).

CONCLUSION AND RECOMMENDATIONS

This study indicates that, there is weak relationship between the yield of sugarcane and the agro-climatic conditions. However, the correlation between them is weak as noted from the Pearson's Product Moment Correlation Coefficient values. Nevertheless, one has to appreciate the fact that, all these climatic factors have impact in the production of sugarcane in the study area.

In as much as all the climatic factors are essential in the production of sugarcane, there is also a required amount needed as ideal. The study therefore, shows that, increase in some of these factors result in increase in the yield of sugarcane, increase in others leads to decrease in the yield of the crop. From the study, it is clear that, even though maximum temperature and solar energy are needed for the crop to grow, yield and product sugar, increase in their amount will always lead to decrease in the yield of the crop. In the other hand rainfall, relative humidity and minimum

temperature show a positive influence on sugarcane production. This means that, increase in the amount or quantity of these factors will always induce increase in the yield of sugarcane.

To many peasant farmers this fact may not be clear to them, but if ministry of Agriculture in the state could take the pain of enlightening them on this fact, their approach to sugarcane cultivation would be improve for good yield. Climatic authorities such as NiMet usually give seasonal rainfall prediction and early warning on the expected prevailing seasons. Therefore, stakeholders in the business of sugarcane cultivation should always adhere to their pieces of advice when planning to cultivate the crop. Since, increase in the amount of rainfall will lead to increase in the yield of sugarcane; irrigation should be encouraged and incentive provided by the government to the prospective farmers to enable them supplement shortage of rainfall should it occur in a given year.

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