EFFECT OF WEATHER ON CLOVE PRODUCTION IN PEMBA ISLAND, TANZANIA

By

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Declaration

This research project is my original work and has not been presented for a degree in any other University.

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Abstract

This study assesses the effect of weather parameters on clove production in Pemba Island, Tanzania.

The meteorological data in this study were obtained from Tanzania Meteorological Agency (TMA) and the clove yield data were obtained from Zanzibar State Trade Corporation (ZSTC) both for the period from 1992 to 2011.

The estimating of missing data on weather parameters were performed using the arithmetic mean ratio, the single mass curve was used to test for homogeneity and it was observed that all data were homogeneous with time.

The monthly variation of the weather parameters were performed as mean pattern and discussed.

Correlation analysis on a lag arrangement was performed between the clove yield and weather parameters and the results were discussed.

Finally the regression analysis was used for developing regression equation in order to predict the clove yield using the weather parameters and the resulting yield from the equation (model) were discussed.

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List of Acronyms

TMA : Tanzania Meteorological Agency

ZSTC : Zanzibar State Trading Corporation .

MAM : March , April and May

OND : October , November and December.

ITCZ: Inter tropical convergence zone.

ENSO: EL Nino /south oscillation .

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CHAPTER ONE

1.0 Introduction

The clove tree is perennial, originating from the Moluccans Islands (today in Indonesia), was introduced in Zanzibar by the Omani sultans in the first half of the 19th century. Zanzibar, mainly Pemba Island, was once the world's leading clove producer, but annual clove sales have plummeted by 80 percent since the 1970s.

Zanzibar's clove industry has been crippled by a fast-moving global market, international competition, and a hangover from Tanzania's failed experiment with socialism in the 1960s and 1970s, when the government controlled clove prices and exports. Zanzibar now ranks a distant third with Indonesia supplying 75 percent of the world's cloves compared to Zanzibar's 7 percent.

The clove tree is small ever green tree that grow to height of 12-20 meters it increase in a coastal region with the temperature 15^0C and 30^0C ,it is allow altitude plant that grow best at altitude lower than 300m above mean sea level although it will also grow at altitude above 900m. The young leaves of clove trees are bright pink and change to green wish yellow as they mature. Cloves are harvesting when the tree is 6-8years old. The timing harvesting of the clove bud is critical.

The bud should harvest before the purple or before the flower develop in clusters of three to the groups. Cloves are harvested just before they open, and then destalked before being sun-dried. In the course of the drying process, they change color from carmine to dark brown.

Clove trees grow well in a rich loam soils of the humid tropics and can be grown successfully in the red soil of the midlands of Kerala as well as in hilly terrain of Western Ghats at higher elevations in Tamil Nadu and Karnataka. A cooler climate with well distributed rainfall is ideal for flowering, it thrives well in areas receiving annual rainfall of 150-300cm. The site selected for cultivation of clove needs good drainage, since crop cannot withstand water logging.

Clove is a tropical plant and requires warm humid climate. General it is believed that clove require closeness to sea for the proper growth and yield. Clove thrives in all situations ranging from sea level up to an altitude of 1000 meters. Deep loamy soil with high humus content found in the forest region is the best suited for its cultivation. It grows satisfactorily in laterite soil, loamy and rich black soil having good drainage.

Clove tress begins to yield from the seventh year of planting and full bearing stage is attained after 15 to 20 years. The flowering season is September to October in the plains and December to February at high altitudes.

Flower buds are formed on young flush. It takes about five to six months for the buds to become ready for harvest. The optimum stage for picking clove buds is when the buds are full developed and the base of the calyx has turned from green to pink color. The buds after separation from the stalks are spread evenly to dry in the sun on mats or cement floor. The period of drying cloves normally take about four to five days under direct sun. Fully dried buds develop the characteristic dark brown color.

Some stages of the clove include;

i. **Emergency**

This is the appearance of the first green parts of the plant above the soil surface. The phase can be registered only during the first year of the plants life.

ii. **Flowering**

The plant is consider to be flowering even when only one blossom is open. This stage takes about 6years to 8years after planting in fertile soil and good management condition. The flowering season varies from September to October in the plains and December to January at high altitude.

iii. **Ripeness**

This is a mature stage of the flowering bud. The buds take 6months to be ripened.

Clove harvest

There are two harvest season within a year.

1. Start at June until end of August or early September depend on amount of production and start at Southern Pemba followed by Northern Pemba.(associate with long rain season-masika)
2. Start at October until February and start at Southern Pemba followed by Northern Pemba. (associate with short rain – vuli)

These two season are not deviate because soon after harvest then the production start.

Clove Plantation

The clove plantation period is normally during the long rain season because the clove tree need high moisture, also need place which are shading because the open place the trees died.

Figure 1: Clove spices

1.1 The Study area

The Pemba Island is located at 4.87^0 South, 39.68^0 East, and the southernmost point is located at 5.47^0 South, 39.72^0 East. The Island is separated from the Tanzanian mainland by 56 km wide. The Island is about 67 km long and 23 km wide, with an area of 985 km^2.

Figure 2 : Map of Tanzania showing the study area.

Source: https://www.google.com/blank map of Tanzania (2013)

1.2 Statement of the Problem

Over much of the tropics, rainfall is the most important climatic factor influencing agriculture, having the greatest effect in determining the crops which can be grown, the farming system and the sequence and timing of farming operations (Webster and Wilson, 1980). Consequently, it has significant effect on the economies of most tropical countries especially in Africa because agriculture in these countries is rain fed.

Therefore the variation of weather parameters will result the variation of the clove yield.

1.3 Objective.

The main objective of this study is to examine the impact of weather parameters on Clove production in Pemba Island.

Specific Objective.

i. To determine the temporal variation of weather parameters.
ii. To determine the relationship between the weather parameters and the clove yield.
iii. To investigate the predictability of clove yield using weather parameters.

1.4 Justification

The economy of Zanzibar depends significantly on agriculture. Clove is an agricultural crop in Zanzibar, which generate a significant economic value for both the clove farmer and the clove industry.

The weather parameters always influencing the cropping pattern and productivity.

Therefore it is necessary to study the weather parameters characteristics for judging the agricultural production potential.

CHAPTER TWO

2.0 Literature Review

Peter J. Martin (1988), In spite of large year to year variation in clove yield, production in the Island of Unguja and Pemba is often in synchrony and annual harvest of two Islands are correlated with similar variables. Clove harvests are positively correlated with rainfall in October to February two years before the harvest and negatively correlated with the harvest in the previous year and rainfall around July, and October to December of the year before the harvest. It is likely that rainfall in these periods affects vegetative growth of the clove tree and clove bud differentiation.

Over much of the tropics, rainfall is the most important climatic factor influencing agriculture, having the greatest effect in determining the crops which can be grown, the farming system and the sequence and timing of farming operations (Webster and Wilson, 1980). Consequently, it has significant effect on the economies of most tropical countries especially in Africa because agriculture in these countries is rain fed.

Following Omotosho et al. (2000), the definitions of onset and cessation are based on the crop water requirement (CWR). The date of rainfall onset is defined as the first day of any week having a cumulative rainfall of at least 20mm, one of which must be 10 mm or more, followed by two other weeks, each with at least 50% of the weekly CWR.

The first three to four weeks being critical for seed germination and crop establishment need some initial heavy rainfalls (10 mm) to moisten and soften the soil sufficiently for seed germination and ensure crop survival in the following twenty days (Omotosho et al., 2000).

Zanzibar Clove Growers Organizations (ZACPO) in 2010 and the Poverty Reduction Strategy for Zanzibar (MKUZA) in 2007. The variability of the rainfall affects the clove production particularly during planting, harvesting, and drying. Since drying of clove requires no moisture, the cloves tend to be destroyed once they have been harvested.

Clove is the most important spice of the world, being next only to black pepper. The clove is the air-dried unopened flower-bud obtained from an evergreen, straight-trunked tree. The cultivation of clove is largely confined to south India.

Agricultural and Environmental Education, the long pre-bearing age, lack of scientific knowledge of clove crop, and the need of reliable planting material seem to come in the way of its large scale cultivation and economic utilization. This provides valuable information regarding all these aspects of clove cultivation. (Dr. K.T. Chandy),Spices are non-leafy parts of plants used as a flavoring or seasoning. They are used to add flavor to foods and beverages, and as herbal medicines.

Asia is known as the 'Land of Spices' as it is the place of origin, production, consumption and export of most spices. Out of the world's 70 plant species grown as spices, 13 are considered major spices produced in Asia. They are briefly described below: Black pepper (Piper nigrum) is the whole dried fruit of a perennial climber. India and Indonesia together produce about half of the world's total production of 180,000 tone. Cardamom is a group of herbaceous plants of the ginger family whose fruits are used as spices. Small cardamom (Elettaria cardamomum) grown in India and Sri Lanka is by far the best quality of all (Narong Chomchalow 1996).
All oil extracts possessed antimicrobial activity against all bacteria and yeast tested. Their water extracts exhibited lower antimicrobial activity, though thyme aqueous extract was active only against *S. aureus.* The lowest concentration of antimicrobial activity (0.1% i.e., 1:1024) was obtained with thyme oil extract using *Candida albicans*. There was no significant difference in antimicrobial activity between clove obtained from Sri Lanka or Zanzibar or thyme obtained from Iran or Oman by B C Nzeako,Zahra S N Alkharous and Zahra S Mahrouq in 2006

Climate of East Africa including Zanzibar has an equatorial climate of two seasons of rain. These are short season rain from October to December (OND) and long rain from March to May (MAM). The short rain (OND) are highly variable in space and time as compared to relatively less variable long rain (MAM) over the bimodal and the October to May rain over the bimodal which generated by ITCZ , Monsoon ,Sea breeze due to the moisture from the Indian Ocean (Nyenzi el at 1998).

The weather and climate change in Zanzibar influence by monsoon , ITCZ ,easterly and westerly were EL Nino / south oscillation (ENSO) , the Arabian and mascarene high pressure cell of the Northern and southern India ocean .(Ogallo 1987).

The economy of Zanzibar depends significantly on rain fed agriculture, which is highly vulnerable to the amount and distribution of rainfall. Both spatial rainfall anomalies over the region and temporal variability within the wet season itself can be prominent and lead to significantly deficiencies. In some areas of Zanzibar, agriculture is limited by the length of the rain season while in others it is amount limited (Mhita, 1989).

Rainfall is one of the important climatic parameter influencing the cropping pattern, productivity, flooding and drought hazards, erosion and sedimentation.

It is therefore necessary to study the rainfall characteristics for judging the agricultural production potential and sustainability of agricultural production system. Planning suitable measures for mitigating the problems requires through knowledge of the rainfall pattern.

Ambenje (2001) had noted a decreasing tendency in the frequency of days with precipitation above 1mm, 12.5mm and 25.4mm over equatorial eastern Africa. However a significant decreasing trends at 95% confidence levels was noted in the frequency of day with precipitation exceed 50.8mm during the March to May rainfall season over the same region.

CHAPTER THREE

3.0 Data and Methodology

3.1 Data collection

- The meteorological data which were used in this study are;
  - rainfall
  - relative humidity (taken at 0600z and 1200z)
  - temperature (maximum and minimum)

were obtained from Tanzania Meteorological Agency (TMA) for the period of 20 years from 1992 to 2011.

- Clove yield data were obtained from the Zanzibar State Trading Corporation (ZSTC) for the period of 20 years from 1992 to 2011.

3.2 Methodology

Various statistical methods were used in this study to achieve the above objectives. These include - estimation of missing data and quality control, time series plots, correlation analysis linear and multiple regression analysis.

3.3 Estimating of missing data

Meteorological records that were missed due to various reasons were estimating using the arithmetic mean ratio as shown below.

$$X_m = \left(\frac{\overline{X}}{\overline{Y}}\right)Y_m \quad \text{..........(1)}$$

Where

X_m - missing records at station X.

$\overline{X}$ - long term mean for the station with missing data in certain year and month.

$\overline{Y}$ - long term mean for station with complete data.

Y_m - corresponding records at station Y having complete data.

3.4 Test for data homogeneity.

The quality of the estimated data examined using cumulative mass curve. This involved the plotting of the cumulative meteorological variables against time.

3.5 Time series Analysis

The available meteorological variables were plotted as time series in order to identify the months of high and low occurrences. The mean patterns of occurrence were observed for each meteorological variables to detect cycles, trends and persistence of the variables.

3.6 Correlation Analysis

Correlation analysis was used to examine the relationship between the clove yield and the weather elements which used in this study. The following formula was used to determine the correlation coefficient (r).

$$r = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2 (y_i - \bar{y})^2}} \text{..(2)}$$

where r is the correlation coefficient.

The significance of the correlation coefficient values were tested using the t-test statistic.

$$t_{n-2} = r\sqrt{\frac{n-2}{1-r^2}} \text{...(3)}$$

where

t_{n-2} - t-test computed

r - correlation coefficient.

3.7 Simple Linear Regression

This used to describe the relationship between the independent variable (x) and dependent variable (y) as a straight line.

In this study simple linear regression analysis was used to determine the degree of relationship between clove yield outbreaks(y) and weather parameters(x).

$$y = a + bx + \varepsilon \quad (4)$$

y - dependent variable

x - independent variable

a - Intercept

b - slope of regression line

ε - Error term

3.8 Multiple Regression analysis

Regression analysis is used to predict the value of a dependent variable based on the value of at least one independent variable.

The weather parameters such as rainfall, relative humidity, maximum and minimum temperature were combined and analyzed together to assess how they affect the clove yield in Pemba Island.

The multiple regression formula that involves more than one independent variable was given below.

$$y = b_o + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + \varepsilon \quad (5)$$

where

y - Clove yield

x_1 - Rainfall

x_2 - Maximum temperature

x_3 - Minimum temperature

x_4 - Relative humidity

The regression coefficients represent:

b_o - Intercept

b_1 - Contribution of rainfall to clove yield

b_2 - Contribution of maximum temperature to clove yield

b_3 - Contribution of minimum temperature to clove yield

b_4 - Contribution of relative humidity to clove yield

ε - Error term

In developing the model, the estimation of the expected value of y i.e E(y) was introduced below.

$$E(y) = \hat{y} = \hat{b}_0 + \hat{b}_1 x_1 + \hat{b}_2 x_2 + \hat{b}_3 x_3 + \hat{b}_4 x_4 \text{..}(6)$$

Then we determined the sum of square of error.

$$SSE = \sum (y - \hat{y})^2$$

$$SSE = \sum (y - \hat{b}_0 - \hat{b}_1 x_1 - \hat{b}_2 x_2 - \hat{b}_3 x_3 - \hat{b}_4 x_4)^2$$

We then solved for unknown parameters $\hat{b}_0, \hat{b}_1, \hat{b}_2, \hat{b}_3, \hat{b}_4$ by partially sum of the square of errors with respect to $\hat{b}_0, \hat{b}_1, \hat{b}_2, \hat{b}_3, \hat{b}_4$ then equating to zero that gives sets of equations which when solved give the values of unknowns. We can solve the coefficients using the matrices methods.

i. Determination of the variance of the error term

The variance of the error term was given by

$$S^2 = \frac{SSE}{n - (k+)} \text{...}(7)$$

The standard deviation of error term was given by

$$S = \sqrt{\frac{SSE}{n - (k+1)}} \text{...}(8)$$

The mean of error term was zero.

It therefore expected that 95% of the observations were lie within 2S for E(y)

ii. Test for model adequacy

In this case we used the coefficient of determination (R^2) to measure how well the model fits a given set of data. The coefficient of determination is the portion of the total variation in the dependent variable that is explained by variation in the independent variable.

The coefficient of determination is also called R-squared and is denoted as R^2 and may given as,

$$R^2 = 1 - \frac{\sum (y - \hat{y})^2}{\sum (y - \bar{y})^2} \text{...}(9)$$

It can also be written as

$$R^2 = 1 - \frac{SSE}{SSyy} \text{...(10)}$$

If $R^2 = 0$ then there is lack of fit of the model to the data

$R^2 = 1$ then there is perfect fit of the model and the model is good.

In reality $0 \le R^2 \le 1$ thus the closer R^2 to 1 the better the model is said to fit the data

iii. Error Analysis

Percentage difference was used to assess the performance of clove production model as shown by the equation below.

$$\text{Percentage difference} = \frac{Predicted - Observed}{Observed} \times 100 \text{..(11)}$$

A positive value of the percentage difference implies an overestimation and the negative values of the percentage difference implies underestimation.

CHAPTER FOUR

4.0 Results and Discussion

4.1.0 Test for homogeneity

The resultant single mass curve for Rainfall, Clove yield, Relative humidity, maximum and minimum temperature were given in the figure 3 to 8

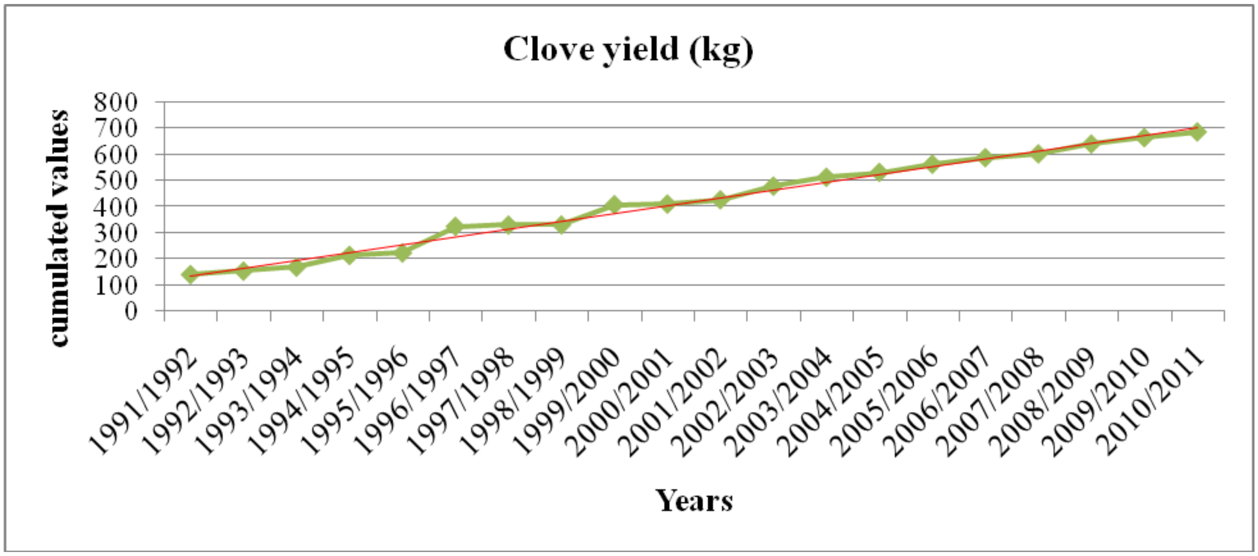

Figure 3: Single mass curve of clove yield for the period of 20 years

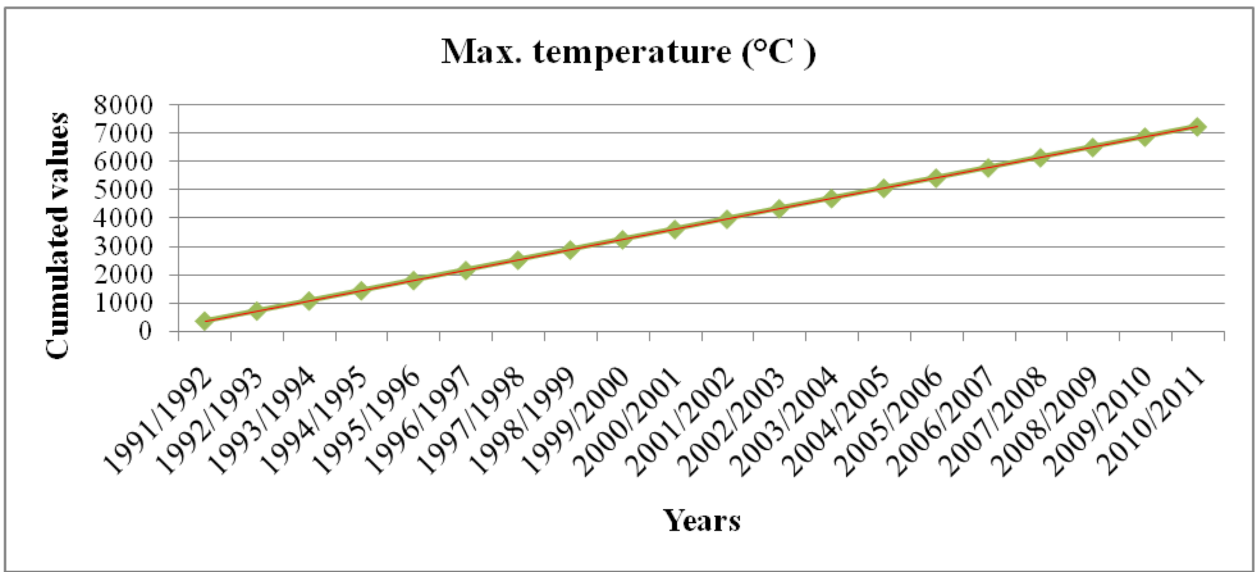

Figure 4: Single mass curve for maximum temperature for the period of 20 years

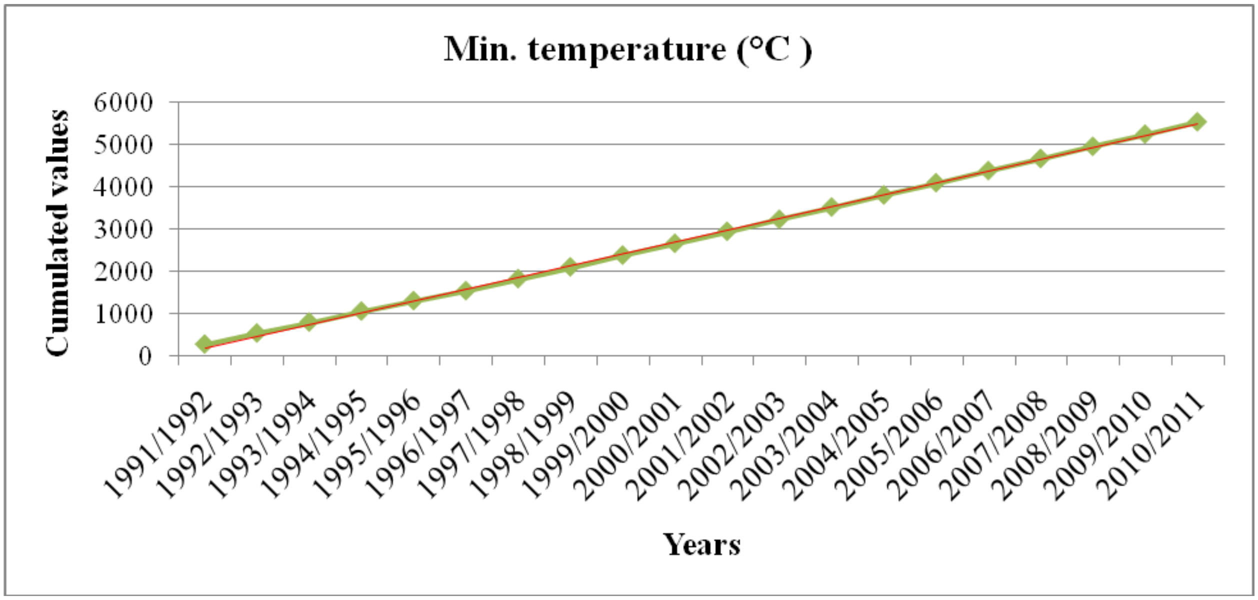

Figure 5: Single mass curve for minimum temperature for period of 20 years

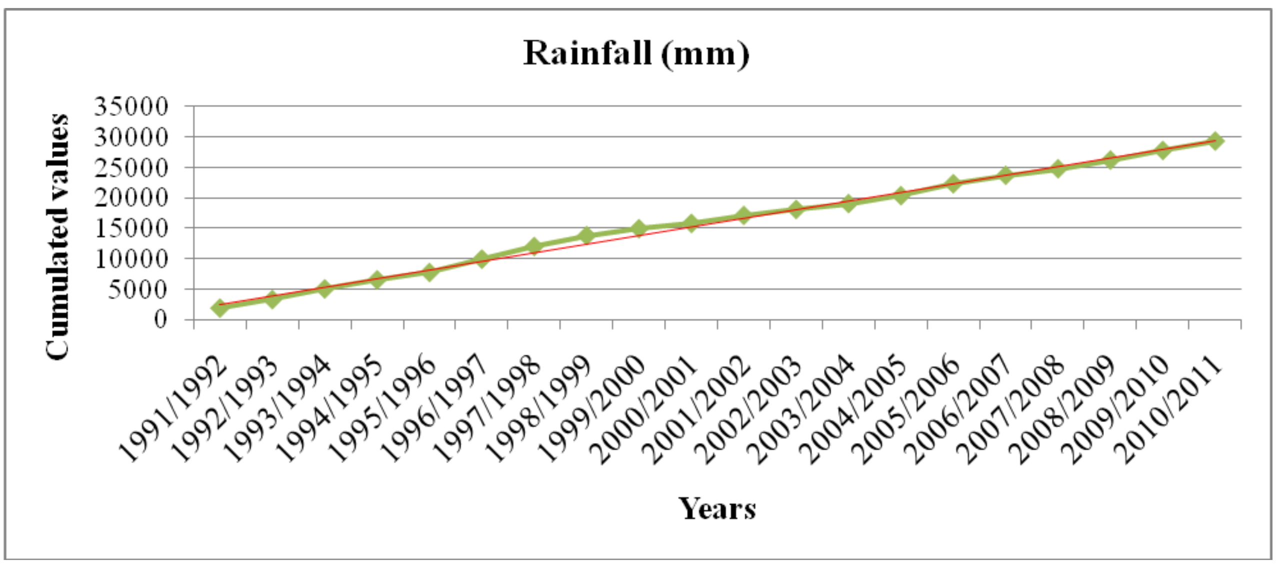

Figure 6: Single mass curve for rainfall for the period of 20 years

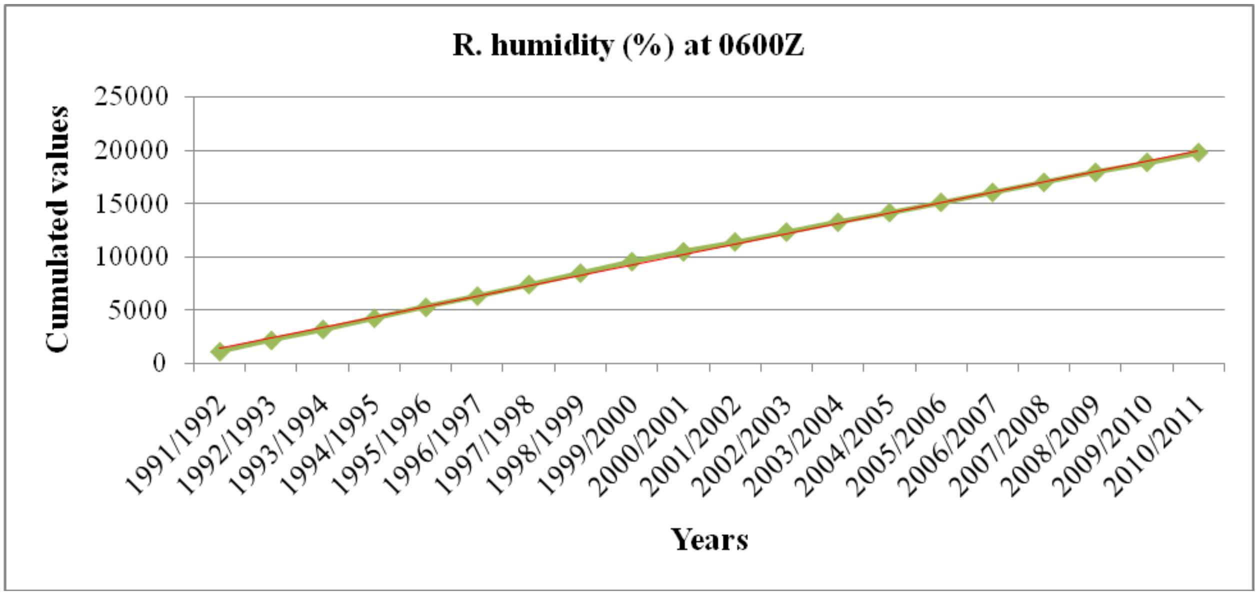

Figure 7: Single mass curve for relative humidity at 0600Z for the period of 20 years

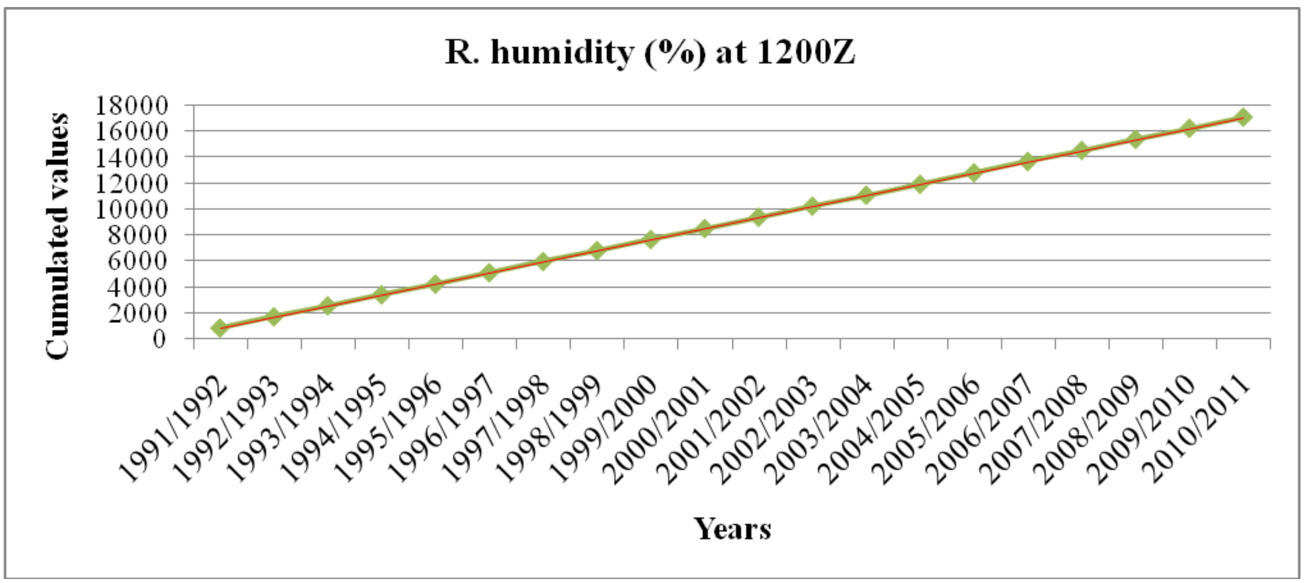

Figure 8: Single mass curve for relative humidity at 1200Z for the period of 20 years

The straight line plots in the figure 3 to 8 indicates that the data for rainfall, Clove yield. relative humidity, maximum and minimum temperature used for this study were homogeneous.

4.2.0 Monthly variation

The monthly variation for rainfall, relative humidity, maximum and minimum temperature were given in figure 9 to 13

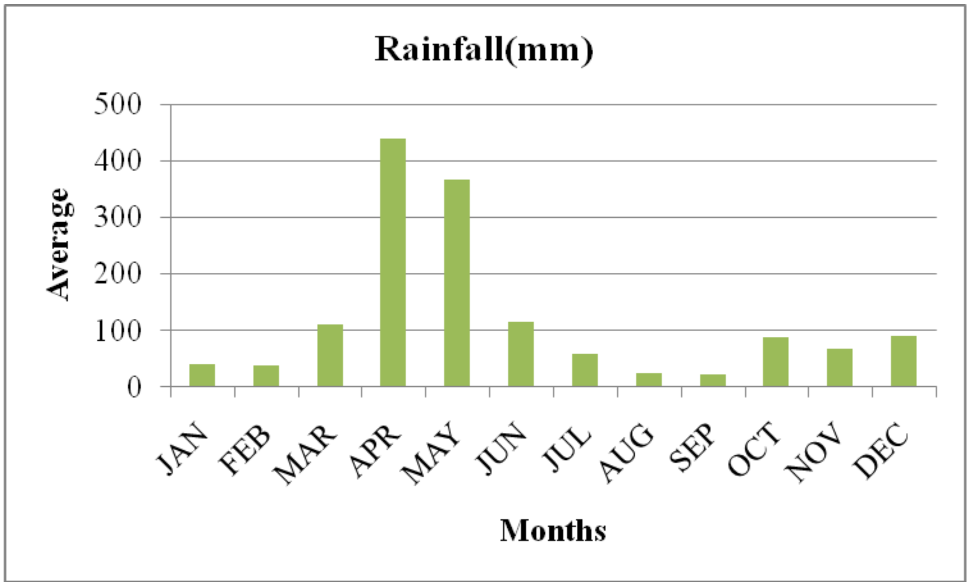

Figure 9: A plot of rainfall against months

It was observed from figure 8 that there are two distinct high rainfall during the months of April and May however March, April and May is a long rain season. The lowest rainfall was observed during the months of August and September while the October, November and December depict the short rain season, although the season changes due to global climate change.

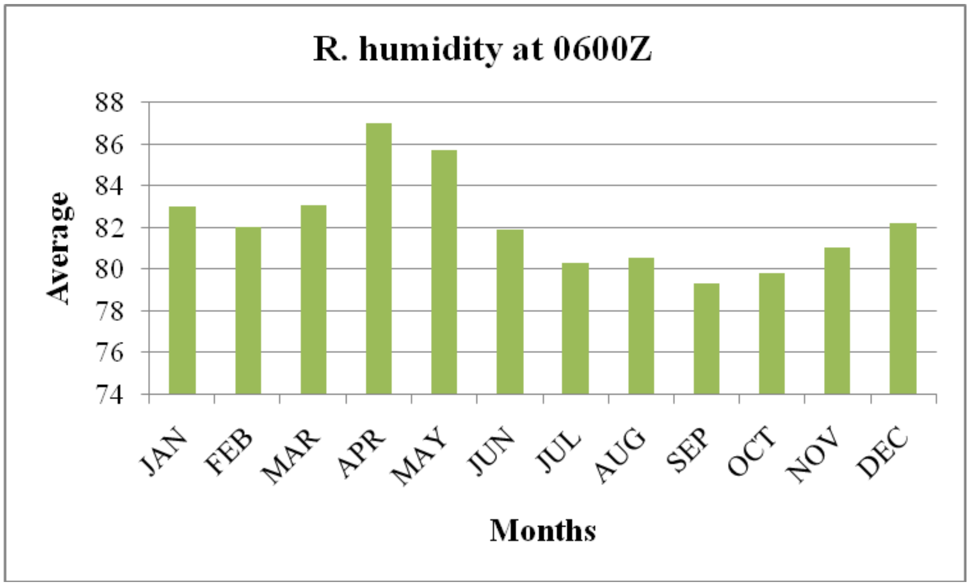

Figure 10: A plot of Relative humidity at 0600Z against months

The relative humidity taken in the morning shows its peak value was during the month of April and May due to long rain experienced from March to May and the lowest Relative humidity was observed during the month of September.

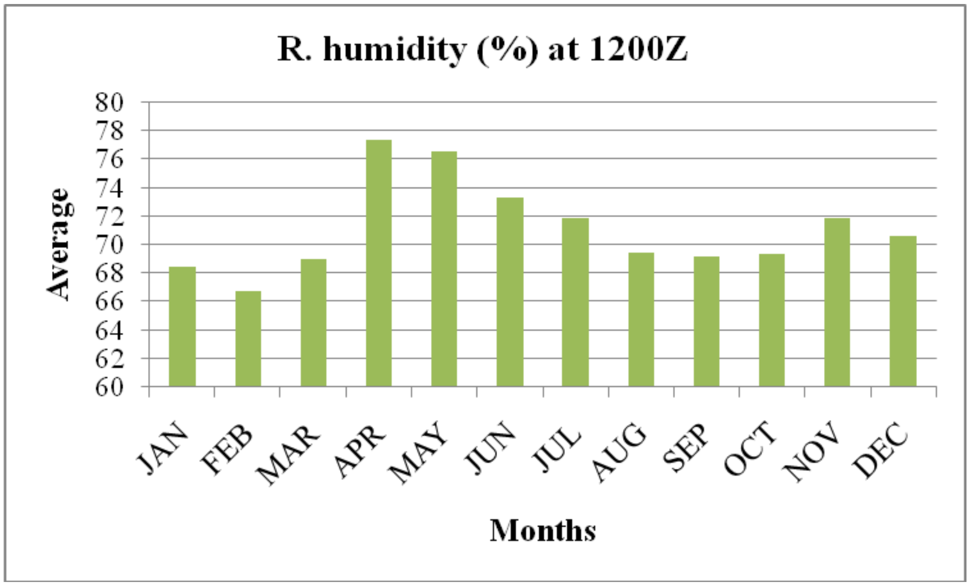

Figure 11: A plot of Relative humidity at 1200Z against months

The relative humidity taken in the afternoon shows its peak value was during the month of April due to long rain experienced from March to May and the lowest Relative humidity was observed during the month of February as a result of dry period which observed during December to February.

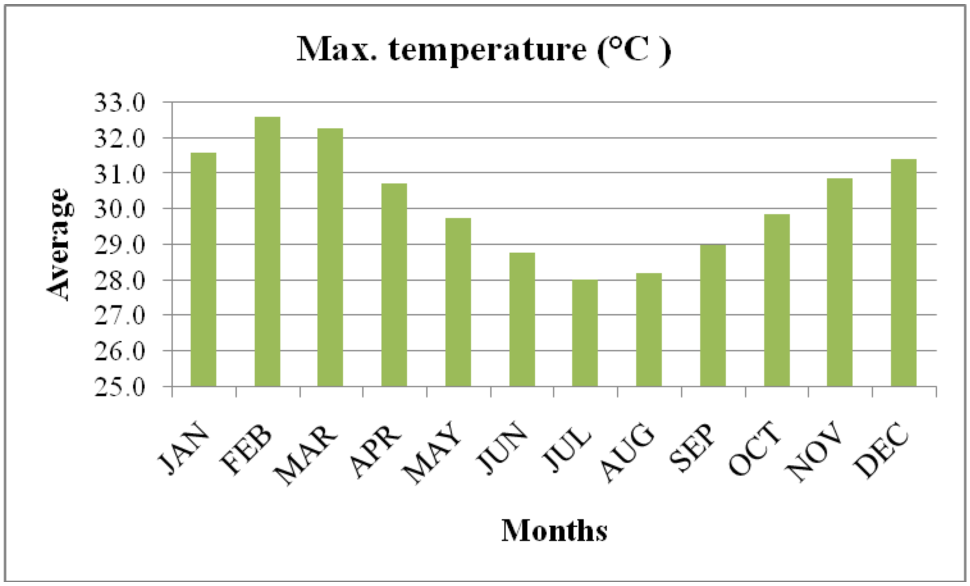

Figure 12: A plot of Maximum temperature against months

The maximum temperature has its peak value during the month of February while the lowest value was observed during the of July, this is because more insulation during December that influence the maximum temperature.

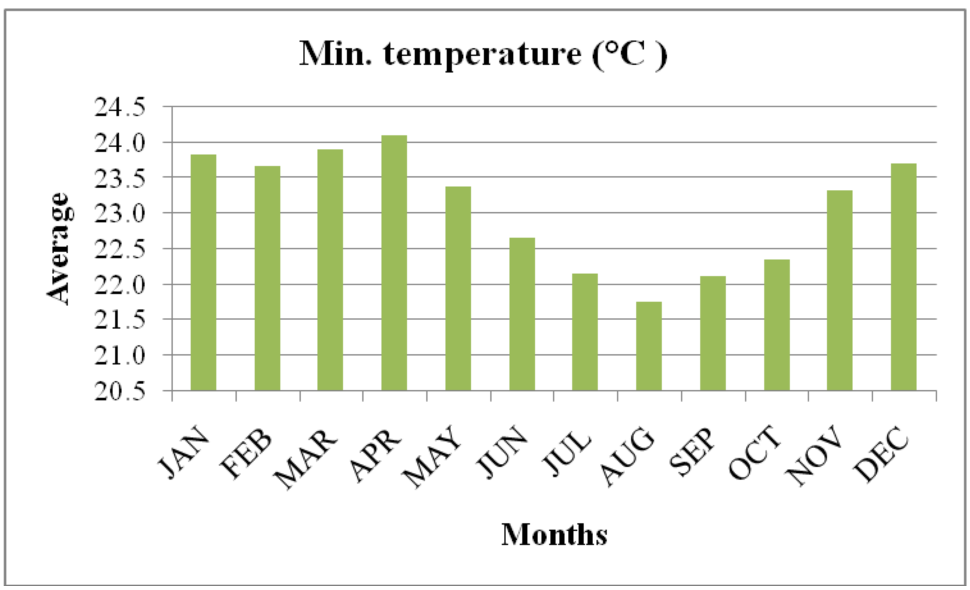

Figure 13: A plot of Minimum temperature against the months

The minimum temperature has its peak value during the month of April due to association of long rain during March , April and May.

4.3.0. Relationship between the clove yield and weather parameters

The values of rainfall, relative humidity, maximum and minimum temperature were plotted against Clove yield at 95% confidence level for Pemba Island, the observed relationship was shown in the figure 20 to 24 below.

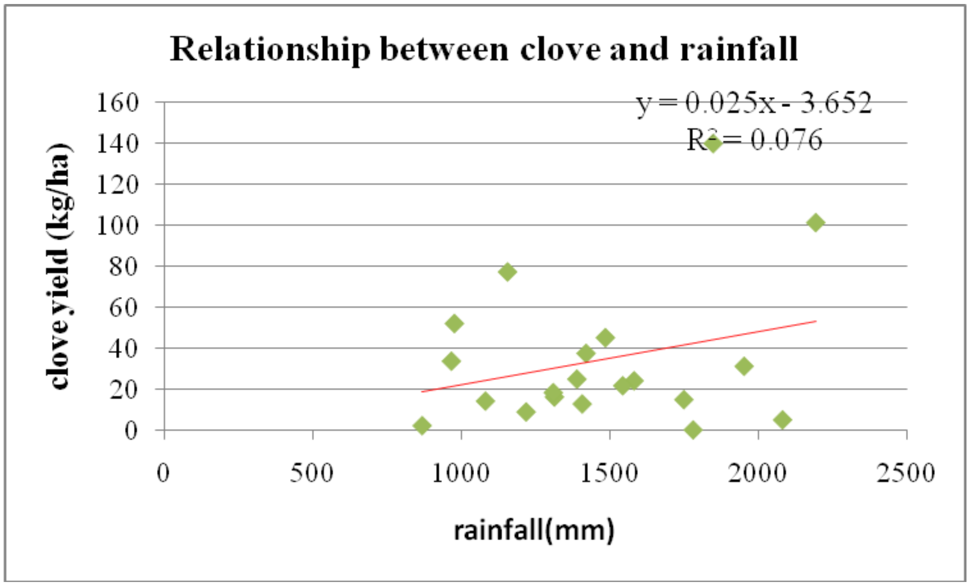

Figure 14: A plot of rainfall and clove yield

The scatter diagram showed that the clove and rainfall were positive correlated. Therefore increasing in rainfall there was increasing in clove yield.

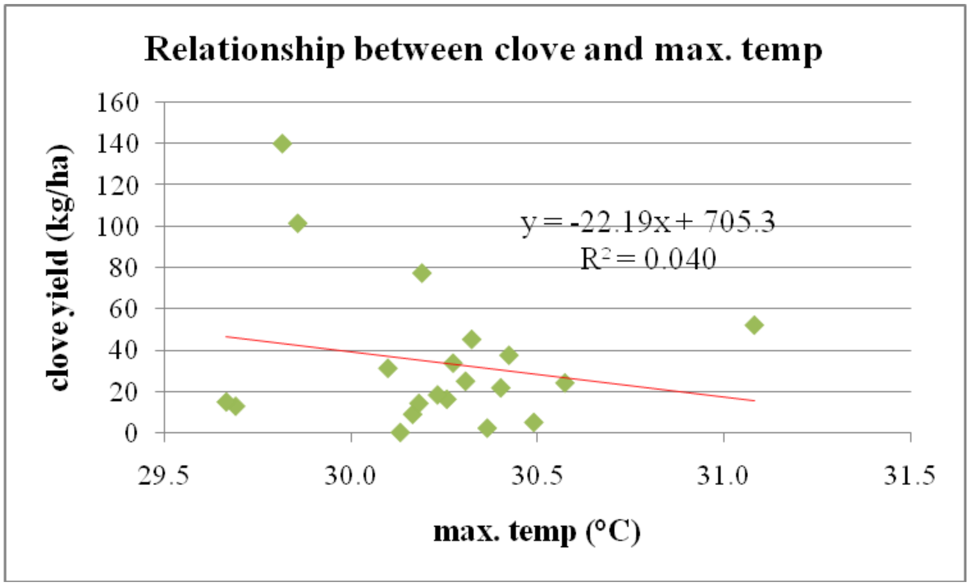

Figure 15: A plot of maximum temperature and clove yield

The scatter diagram showed that the clove yield and the maximum temperature were negative correlated. Therefore increasing in maximum temperature result in decreasing the clove yield.

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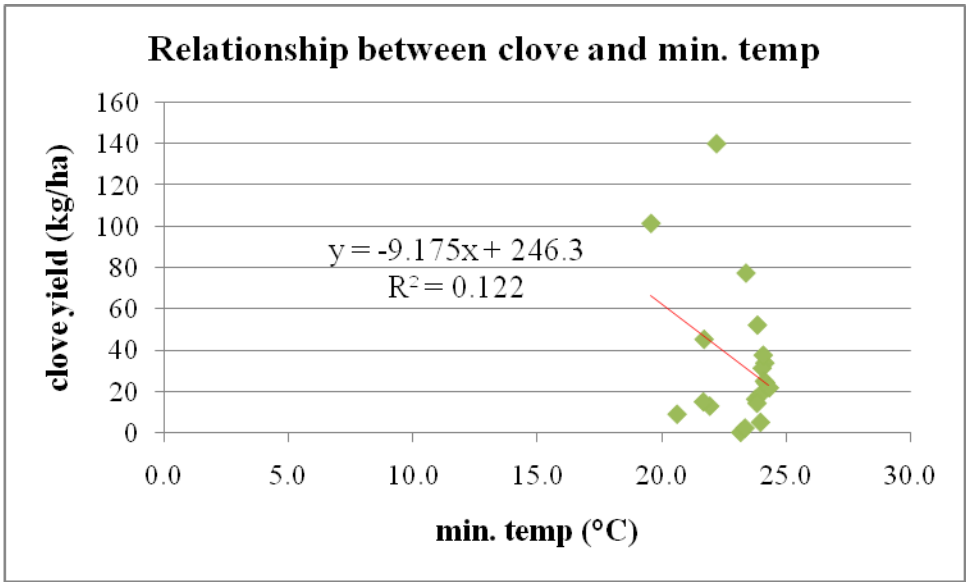

Figure 16: A plot of minimum temperature and clove yield

The scatter diagram showed that the clove yield and the minimum temperature were negative correlated. Therefore increasing in minimum temperature result in decreasing the clove yield.

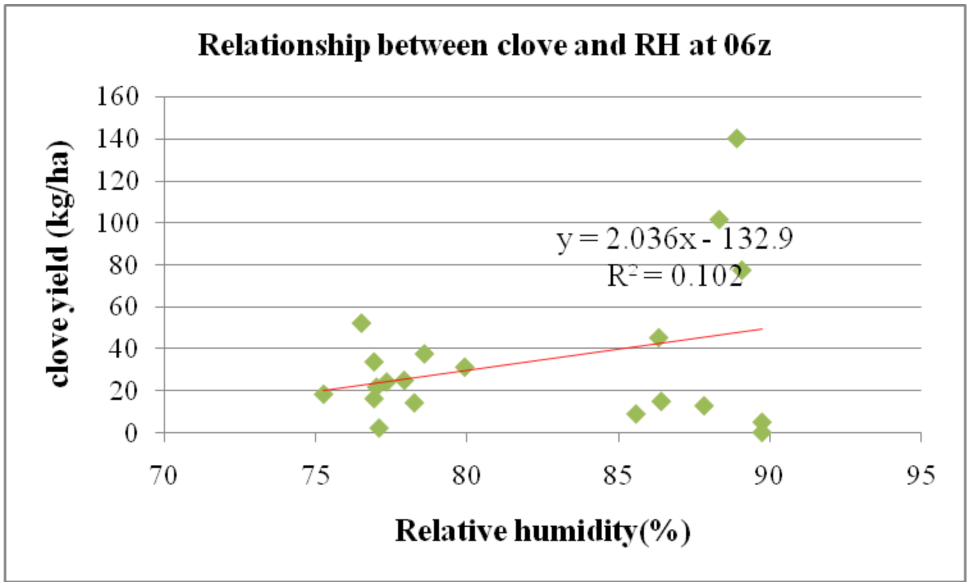

Figure 17: A plot of relative humidity at 0600Z and clove yield

The scatter diagram showed that the clove yield and the relative humidity taken at 0600z were positive correlated. Therefore increasing in relative humidity at 0600z result increasing the clove yield.

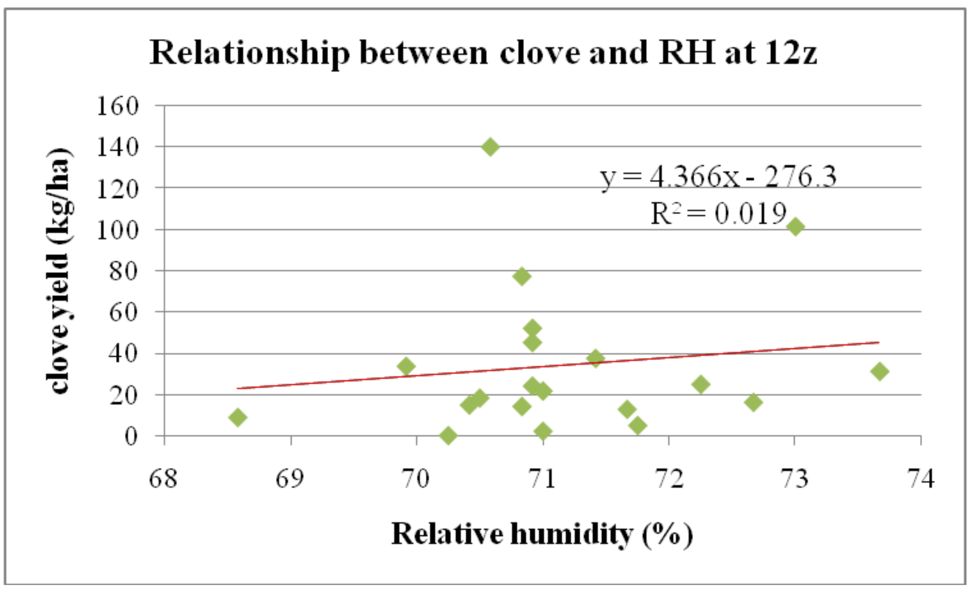

Figure 18: A plot of relative humidity at 1200Z and clove yield

The scatter diagram showed that the clove yield and the relative humidity taken at 1200z were positive correlated. Therefore increasing in relative humidity at 1200z result increasing the clove yield.

4.3.1 Correlation Analysis

The correlation analysis was performed between clove yield and weather parameters with three different lag arrangements which are lag zero, lag one and lag two. The 95% confidence level interval was used to test the significant of the correlation coefficient. The correlation coefficient values were taken as significant if the t-test (t-calculated) were greater than the t-tabulated. At the degree of freedom $v = n - 2$.

Table 1: Correlation coefficients for lag zero

Parameters	correl. Coefficient	t-calculated	t-tabulated
Rainfall	0.409	1.902	2.101
Maximum temperature	-0.246	-1.077	2.101
Minimum temperature	-0.342	-1.544	2.101
Relative humidity 06z	0.370	1.689	2.101
Relative humidity 12z	0.319	1.423	2.101

The table above showed the output correlation coefficient values for the weather parameters and the clove yield at zero lag arrangement. It was found that non of the parameters were significant correlated with the clove yield.

Table 2: Correlation coefficients for lag one

Parameters	correl. Coefficient	t-calculated	t-tabulated
Rainfall	-0.143	-0.596	2.110
Maximum temperature	-0.256	-1.092	2.110
Minimum temperature	-0.167	-0.698	2.110
Relative humidity 06z	-0.087	-0.360	2.110
Relative humidity 12z	-0.302	-1.306	2.110

The table above showed the output correlation coefficient values for the weather parameters and the clove yield at one lag arrangement. It was found that non of the parameters were significant correlated with the clove yield and these coefficients were negative correlated with clove yield.

These correlation coefficients above were related to the same statement as from the Peter J. Martin (1988), but not significant correlated.

Table 3: Correlation coefficients for lag two

Parameters	**correl. Coefficient**	**t-calculated**	**t-tabulated**
Rainfall	-0.467	**-2.121**	2.120
Maximum temperature	0.565	**2.739**	2.120
Minimum temperature	0.136	0.549	2.120
Relative humidity 06z	0.022	0.088	2.120
Relative humidity 12z	-0.294	-1.230	2.120

The table above showed the output correlation coefficient values for the weather parameters and the clove yield at two lag arrangement. It was found that rainfall and maximum temperature were significant correlated with the clove yield and the remaining parameters which are minimum temperature, relative humidity at 0600z and relative humidity at 1200z were not significant correlated with clove yield.

These correlation coefficients above were related to the same statement as from the Peter J. Martin (1988), and were significant correlated.

4.4.0 Multiple Regression analysis

The regression analysis was performed between clove yield and weather parameters. The lag correlation analysis that had significant correlation coefficient was selected and used to perform regression. The weather parameters were the predictors and the clove yield was the predictant. The following output were obtained as shown below.

Table 4: Regression out put

```
------------------------------------------------------------------------------
Dependent Variable YIELD
Minimum tolerance for entry into model = 0.000000
Backward stepwise with Alpha-to-Enter=0.150 and Alpha-to-Remove=0.150

Step # 1 R =  0.735 R-Square =  0.540
Term removed: MIN

Effect              Coefficient   Std Error  Std Coef    Tol.  df       F     'P'

In
___
1 Constant
2 RAINFALL             -0.011       0.042    -0.095 0.31873   1   0.068   0.799
3 MAX                  56.083      21.102     0.680 0.63943   1   7.063   0.022
5 RH06                  1.118       1.047     0.229 0.90835   1   1.141   0.308
6 RH12                 -1.758       3.945    -0.144 0.40314   1   0.199   0.665

Out                 Part. Corr.
___
4 MIN                  -0.092        .          .    0.53919   1   0.086   0.775
----------------------------------------------------------------------------
```

From the above results the model equation was developed that can be used to predict the clove production, putting in mind that the weather parameters are the function of the clove yield.

The coefficient of determination $R^2 = 0.540$

The model equation look as;

y = -1589.543 - 0.011RF + 56.083MAX + 1.118RHm – 1.758RHa……………(11)

In the above equation we have;

y - the clove yield (predictant)

RF - the rainfall

MAX - the maximum temperature

RHm - the relative humidity in the morning (0600Z)

RHa - the relative humidity in the afternoon (1200Z)

4.4.1 Testing Model Performance

In the regression analysis, four (4) years from 2008 to 2011 were excluded to be used for prediction of the yield for these years. The resulting yield values and the observed values were used to compute the error. If the error between the two values was small than the model was reliable and can be applied with confidence for prediction. This can be shown in the table below.

Table 5: The model Performance

Years	Observed value	Predicted value	% difference
2008	14.5	16.5	13.8
2009	37.8	44.6	17.9
2010	24.4	30.7	25.8
2011	22	35.7	62.3

The **difference** (over-estimation) in 2011 was probably due to:-

1. Too much wetness resulting to increase cases of pests and diseases.
2. Soil clogging leading to unfavorable soil pH.
3. Rainfall dislodged the berries prematurely from the tree.

4.4.2 Graphical Representation between Predicted and Observed value

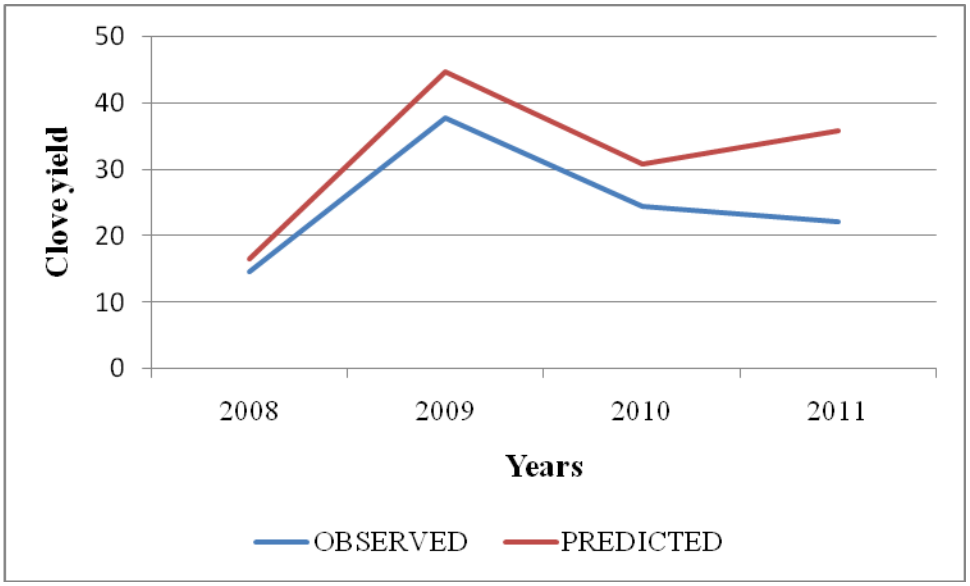

Figure 19: A plot of Observed and Predicted values against time

The figure above showed the variation of the observed values and predicted values. The two graphs were fluctuated nearly in similar position , therefore the regression model used for the prediction of the yield was reliable.

These results were similar related to the same statement Zanzibar Clove Growers Organizations (ZACPO) in 2010 and the Poverty Reduction Strategy for Zanzibar (MKUZA) in 2007.

Also the results were under-estimation since there are more numbers of the percentage differences which are smaller than those which are large.

CHAPTER FIVE

5.0 Conclusion and Recommendation

5.1 Conclusion

Various objectives of the study have been adequately achieved. The temporal variability of the five climatic parameters namely the total monthly rainfall, the mean monthly relative humidity taken at 0600z, mean monthly relative humidity taken at 1200z and mean monthly maximum and minimum temperature have been carried out. The results from the temporal variation show that rainfall in this region is bimodal (MAM and OND), the minimum temperature is high during MAM seasonal, maximum temperature and both relative humidity taken in the morning and afternoon have high value in long rain season.

From the correlation analysis, the result show that all the five climatic parameters were non significant correlated at both zero lag and lag one. On the other hand the rainfall and the maximum temperature were significant correlated at lag two, the other three remaining parameters namely minimum temperature, relative humidity taken at 0600z and relative humidity taken at 1200z were not significant correlated at this lag.

Finally the results of multiple regressions show that the model was reliable to predict clove yields in this region . Hence information on climatic parameters, which can be obtained from the local clove factories can help farmers and the management of various clove factories in making informed decisions well in advance in order to achieve maximum returns from the produce.

5.2 Recommendation

- More study should be done on other clove factors such as diseases, soils nature and others.

- More meteorological parameters should be used to develop a regression model to predict clove production. This could increase reliability of the model.

- Education must be provided to farmers from meteorological sector and agricultural sector.

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