

## Impact And Variability of Climatic Factors on The Yield of Tomatoes in Nigeria

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**Abstract:** Climatic factor is one of the vital issues facing farming in Nigeria. It is very challenging for the farmer when the climatic condition is not favorable to their product. So, this paper used correlation to show the degree of association between the climatic factors for year 2019 and 2021. For year 2019, the correlation analysis indicates that, the correlation between the climatic factor positively influence the production of tomatoes in Nigeria except the correlation climatic factor RAIN and any other climatic factor, which do not really have influence on the performance (yield) of tomatoes in Nigeria. For year 2021, the correlation analysis indicates that, the correlation between the climatic factor positively influence the production (yield) of tomatoes in Nigeria except the correlation between TMEAN&RH and TMAX&RH, which influence the production of tomatoes negatively. The analysis of variance (ANOVA) shows the variability in the four (4) varieties of tomatoes that, the varieties of tomatoes significantly contribute to the growth of tomatoes which can influence the yield of tomatoes in Nigeria positively.

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**Keywords:** Climate factor, Significantly, Tomatoes, Variability-analysis, Negatively, Association, Correlation.

### 1. Introduction

A momentous change in climate on a universal scale will impact agriculture and accordingly affect the world's food supply. Climate change intrinsically is not necessarily harmful but the problems arise from events that are difficult to predict. The records of inconsistent rainfall patterns and unpredictable high temperature spells consequently reduce crop productivity in the tropics. Latitudinal and altitudinal shifts in ecological and agro-economic zones, land degradation, extreme geophysical events, reduced water availability, the rise in sea level and salinization are suggested, unless prompt decision is undertaken to mitigate the effects of climate change, food security in developing countries will be under threat. In the humid tropics, the rainy (wet) and late (dry) sowing seasons are associated with changes in climatic attributes which to a great extent influence the productivity of agricultural food (vegetable crops). Vegetables are the best means of overcoming micronutrient deficiencies and provide peasant farmers with sustenance income and more jobs per hectare than staple crops. Broadly, vegetable crops are sensitive to environmental condition, high temperatures and excessive soil moisture (rainfall), which are the major causes of low yields in the tropics and this can be further exaggerated by other climatic factors such as radiation and cloud cover. Tomato,

cabbage, onion, hot pepper and eggplant are among few important vegetables consumed and or processed for utilization in Asia and Sub-Saharan Africa region. Tomato (*Lycopersicon esculentum* Mill.), an important horticultural crop grown worldwide is a fruit vegetable belongs to the Solanaceae. Developing countries' agricultural systems are vulnerable to climate change because they tend to be less capital and technology intensive and because they tend to be in climate zones that are already too hot and will probably get hotter (14). Many countries in tropical regions are expected to be more vulnerable to warming because additional warming will affect their marginal water balance. In the southern African regions, the effect of climate change could be exacerbated further due to its high risk cropping environment and the marked intra-seasonal and inter-annual variability of rainfall (6). The aim of this paper is to determine how climate change may influence the production of tomatoes (*Lycopersicon esculentum*) in Nigeria, while the objectives were; to determine the monthly mean weather recorded from the meteorological unit for year 2019 and 2021, to evaluate the correlation between the weather parameters on monthly records for year 2019 and 2021 and to analyze the impact of climate variability based on different varieties of tomatoes with their respective weights on tomatoes production in Nigeria using ANOVA..

Nigeria has a spatial variation of tomato production and climate change or variability. This research used Federal University of Technology, Akure (FUTA) tomato farm climatic change dataset on tomato production. During rainy seasons in Nigeria, flooding may occur in over extensive areas within Akure. The potential for climate change in Akure as induced by global warming is therefore an issue of great importance in Nigeria.

## 2. Related Study

An increment of this magnitude is expected to affect global agriculture significantly (4). In addition, such changes in climatic conditions could profoundly affect the population dynamics and the distribution of crop pests as reported in (24). These effects could either be direct, through the influence that weather may have on the insects' physiology and behavior (9); (10); (2); (21); (19); (15), or may be mediated by host plants, competitors or natural enemies (9); (2). In temperate regions, most insects have their growth period during the warmer part of the year (2). In the first case, the general prediction is that if global temperatures increase, the species will shift their geographical ranges closer to the poles or to higher elevations, and increase their population size (23; 9; 2; 21). In agreement with this prediction, many examples may be found in the literature (8; 18; 16).

Species distributions are expected to change dramatically in response to future rapid climate warming (1), and generally climate change modelling predicts that the risks of species loss will increase (17). Therefore, improving our understanding of the factors controlling potential species distributions under future global warming scenarios has become a central goal in ecology today (7). Prediction of known occurrences of global warming constitutes an important technique in analytical biology, with applications in conservation modeling of species' geographic distributions based on the environmental conditions of sites and reserve planning, ecology, evolution, epidemiology, invasive species management and other fields (20; 22). Global warming poses a significant threat to future economic activities and the wellbeing of a significant number of human beings (11). Among all economic sectors, the agricultural sector appears to be the most sensitive and vulnerable (3). Plant production is influenced by climate factors such as temperature and rainfall. Each crop has optimal conditions for growth. Therefore, any change in the climate can have a serious impact on the crop production sector. It has been shown that at global level, the impacts will be small since production reduction in some areas is balanced by gains in others (12).

Overall, climatic changes will affect agriculture either negatively or positively depending on the location. There is wide concern that the agricultural sector in Africa will be especially sensitive to future climate change and variability (14). In this paper, the tomato crop was used. The tomato (*Lycopersicon esculentum*) belongs to the family of Solanaceae. It is commercially important globally, for both the fresh fruit market and the processed food industries. The Tomato originated in the dry west coast of tropical South America. The growing season in this region has temperatures that are moderate with an average minimum night temperature of 15°C and average maximum day temperature of 19°C (5). The plant thrives in temperatures between 10°C and 30°C and is tolerant of neither frost nor waterlogged conditions (13).

## 3. Methodology

This paper was carried out at the Research Farm of the Federal University of Technology, Akure, (lat 7.17°N, long 5.8°E), a tropical rainforest zone of southern Nigeria. The climate of the area was characterized by heavy rainfall during the months from April to July and August to November. The sandy loam soil at the site of study is an alfisol classified as clayey skeletal oxic-paleustalf (USDA Soil Survey Staff, 2009). The nutrient status of surface soil for 0-15cm at the experimental site before planting are: pH 6.8; N (0.19 mg/kg); P (7.69mg/kg); K, Ca and Mg (1.75, 0.84, 4.39 cmol/kg soil respectively); organic matter (2.42 g/kg), bulk density (1.28 mg/m<sup>3</sup>). The field site was manually cleared. Seeds of four tomato varieties: Ibadan local (Ib. local), UC, Roma VF and Beske were nursed on 5th of March, 2019 for early/rainy season planting and transplanted to the field on 2<sup>nd</sup> of April, 2019. The late season planting was on 4<sup>th</sup> of September and transplanted to the field on 1<sup>st</sup> of October. The experiment was repeated in the cropping seasons of year 2020. The experimental design was a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 2mx2m. The tomato variety seeds were nursed in a well pulverized rich loamy soil and was transplanted into the field after 5 weeks at a planting distance of 90cm by 30 cm. Two weeks interval records of plant height (cm), number of leaves per plant, leaf area per plant (cm<sup>2</sup>), dry weight of leaves and fruits per plant (g), number of flower clusters per plant, number of fruits per plant, weight of individual fruit (g), weight of fruits per plant (kg), weight of fruits per plot (kg) and fruit yield (t/ha) were taken up to maturity and tomato yield was assessed at the final harvest. Weather data includes rainfall (RR), maximum temperature (T<sub>max</sub>), minimum temperature (T<sub>min</sub>) and relative humidity (R/H) was taken simultaneously on weekly basis in two planting seasons. Data were analyzed to establish the

relationship between various growth stages and weather elements considered using multiple correlation method and ANOVA.

#### Variability Analysis

The data were analyzed by the use of IBM SPSS Statistics version 17 and R packages. While the descriptive statistics were represented in the form of tables and graphs, the inferential statistics involved the use of multiple correlation and analysis of variance (ANOVA). The multiple correlations was used to establish the degree of association between different climatic conditions while the ANOVA test for means analysis was employed to further test the significance of the relationships between different weather variability on tomato production at 5 percent significance level and 95 percent confidence level for year 2019 and 2021.

The multiple coefficients denoting a correlation of one variable with other variables denoted as  $R_{ABCD...K}$  which denote that A is correlated with B, C, and D up to K. For example, if you want to compute multiple correlations between A, B, and C, it can be express as

$$R_{A\cdot BC} = \sqrt{\frac{\Gamma_{AB}^2 + \Gamma_{AC}^2 - 2\Gamma_{AB}\Gamma_{AC}\Gamma_{BC}}{1 - \Gamma_{BC}^2}}$$

Where  $R_{A\cdot BC}$  is the multiple correlations between A and linear combination between B and C,  $\Gamma_{AB}$  is the correlation between A and B,  $\Gamma_{AC}$  is the correlation between A and C and  $\Gamma_{BC}$  is the correlation between B and C.

Significance testing of  $R^2$

$H_0: p^2 = 0$

Against

$H_1: p^2 \neq 0$

The population value of  $R^2$  is  $p^2$ . Hence,  $R^2$  is an estimator of  $p^2$

Test statistic: The F statistic is used for testing the significance of  $R^2$  and is given as

$$F_{cal} = \frac{(n-k-1)R^2}{k(1-R^2)} \text{ and } F_{tab} = F_{k,n-k,\alpha}$$

Where  $R^2 = 1 - \frac{(1-R^2)(n-1)}{n-k-1}$  which is the percentage of variance in the constant variable explained by linear combination of the regression model.

#### 4. Analysis of Data

Monthly Data Record for Year 2019 and 2021 at The Research Farm of The Federal University Of Technology, Akure (FUTA)

**Table 4.1: Monthly data record for year 2019 at FUTA research farm**

2019	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean	25.9	26.5	26.7	26.6	26.0	25.2	24.3	24.6	24.8	25.1	25.4	25.2
T min	21.9	22.9	23.8	23.5	23.3	22.8	22.0	21.8	22.4	22.6	22.8	21.6
T max	30.4	31.0	30.7	30.6	29.6	28.5	27.5	28.4	28.0	28.6	28.6	29.2
R H	89.1	83.4	84.7	84.4	87.0	89.4	90.4	88.2	90.5	89.4	89.9	83.7
Rain	51.6	99.1	120.0	439.2	281.4	466.6	119.6	83.6	343.6	247.5	411.5	101.6
Wind speed	1.9	2.2	2.4	2.1	2.0	2.2	2.5	2.6	2.2	1.9	1.8	1.9

**Table 4.2: Monthly data record for year 2021 at FUTA research farm**

2021	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean	25.9	26.5	26.5	26.2	26.2	25.6	24.8	24.5	25.1	25.7	25.1	25.9
T min	22.1	22.8	23.6	23.4	23.3	23.3	22.2	22.2	22.6	22.8	22.6	21.9
T max	30.3	31.1	30.3	29.9	29.8	28.8	27.8	27.8	28.3	29.2	28.3	30.3
R H	79.1	81.2	85.5	86.2	86.2	89.8	90.5	90.5	90.0	88.1	90.0	77.8
Rain	36.3	80.6	224.8	433.0	489.5	339.0	154.6	452.5	223.9	419.6	223.9	20.7
Wind speed	1.8	1.9	2.3	2.1	1.8	2.2	2.6	2.2	1.9	1.7	1.9	1.6

**Table 4.3: Growth and yield early rain fed and late rain fed season of tomatoes.**

Seasons of sowing	Root weights (g)	Shoot weights (g)	No. of branches	Plant height (cm)	50% flowering days	Fruit weights (g)	Fruit yield (kg/ha)
Early (rain fed) (March-June)	14.7	33.1	22	122	56	15720	4.37
Late (rain fed) (August-December)	13.4	31.2	19	109	54	12847	3.12

**Table 4.4: Varietal effects (across the seasons) on the performance of tomatoes**

Varieties	Root weights (kg)	Shoot weight (g)	No. of branches	Plant height (cm)	50% flowering days	Fruit weight (g)	Fruit yield (kg/ha)	Harvest index
Beske	11.24	1210.3	17.5	104.7	54.3	346.9	19354.7	0.31
Ibadan local	11.43	1950	21.0	123.4	53.3	369.5	20447.3	0.22
Roma vf	7.82	415.3	11.3	80	55.7	134.8	9320.5	0.33
VC	9.9	330.5	9.7	76	56	120.2	6348.2	0.33

### Correlation Between the Different Climatic Factors

Table 4.5: Degree of relationship between the climatic factors for the months in the year 2019

	RH	RAIN	WD	TMEAN	TMIN	TMAX
RH	1.0000					
RAIN	0.4219	1.0000				
WD	0.9190	0.2627	1.0000			
TMEAN	0.9802	0.3997	0.9083	1.0000		
TMIN	0.9735	0.3682	0.9046	0.9989	1.0000	
TMAX	0.9847	0.4415	0.9174	0.9970	0.9924	1.000

Table 4.5 shows the correlations between the climatic factors are positive and statistically significant at 5% level. However, the degree of association between RAIN and WD, TMEAN, TMIN and TMAX is weak positive while the rest associations are strong positive. These indicates that, the combinations of climatic factor RAIN and any other factors do not really have effect on

the production of tomatoes in Nigeria while the combinations of other factors are very important factors to influence the yield of tomatoes in Nigeria positively. That is, the yield of tomatoes in Nigeria for year 2019 with reference to the combinations of climatic factors WD, TMAX, TMIN, RH and TMEAN will give much quantity of quality tomatoes.

Table 4.6: Degree of relationship between the climatic factors for the months in the year 2021

	TMEAN	TMIN	TMAX	RH	RAIN	WD
TMEAN	1.0000					
TMIN	0.5543	1.0000				
TMAX	0.9380	0.2563	1.0000			
RH	-0.6497	0.2500	-0.8549	1.0000		
RAIN	-0.1354	0.5402	-0.3510	0.6226	1.0000	
WD	-0.3311	0.2015	-0.4544	0.5504	0.1328	1.0000

Table 4.6 shows the correlations between the climatic factors TMEAN&TMIN, TMEAN&TMAX, RAIN&TMIN, RH&RAIN and WD&RH are strong positive, which indicates the relationship between those combinations would have positive influence (quality and quantity) on the yield of tomatoes in Nigeria.

The correlation between the climatic factors TMEAN&RH and TMAX&RH is a strong negative relationship which indicates that, the combination of the factors has a very strong negative influence on the yield of tomatoes in Nigeria.

The correlations between the climatic factors TMIN&TMAX, TMIN&RH, TMIN&WD and RAIN and WD is a weak positive relationship which indicates that, the combination of the factors may or may not really have any positive influence on the yield (quality and quantity) of tomatoes in Nigeria.

The correlations between the climatic factors TMEAN&RAIN, TMEAN&WD and TMAX&RAIN is a weak negative relationship which indicates that, the combination of the factors may or may not really have any negative influence on the yield (quality and quantity) of tomatoes in Nigeria.

#### Assumption of Normality

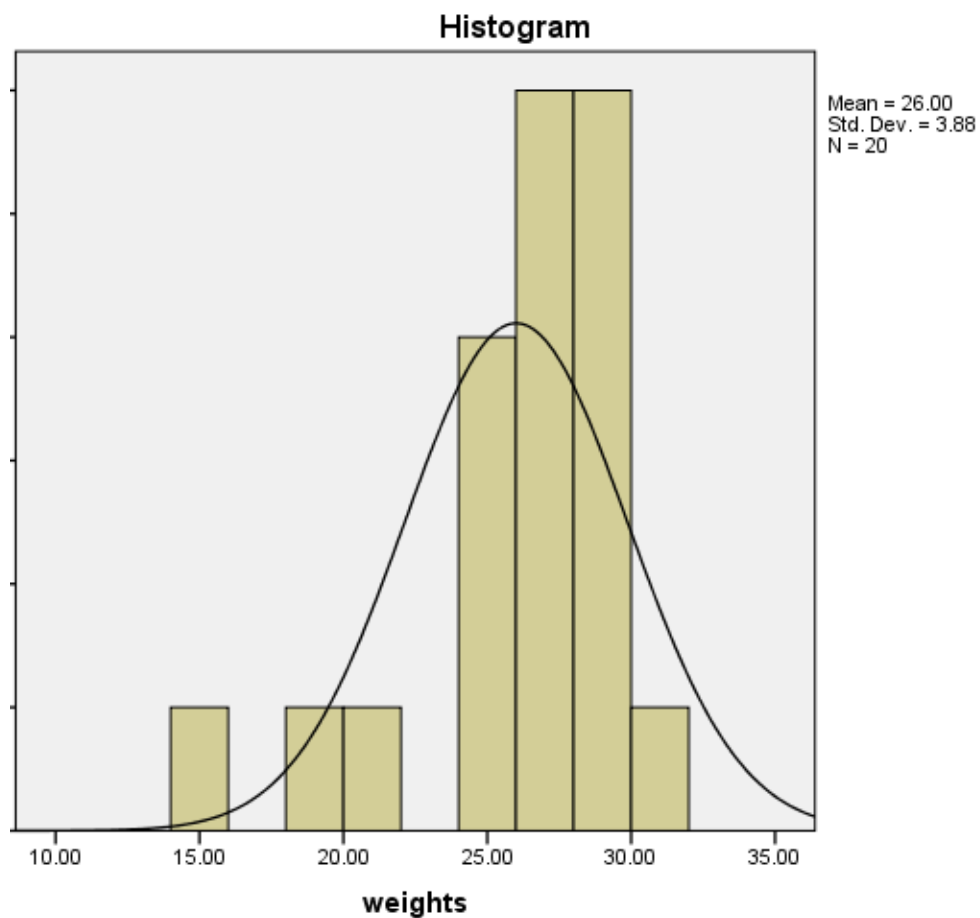


Figure 4.1 plot of weights of tomatoes with a normality curve

#### Analysis of Variance on the Weights of Tomatoes

Table 4.7: analysis of variance on varietal effects (across season) of the performance of tomatoes

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F – ratio	Pr(>F)
Treatment	3	5.902	1.967	2.819	0.130
Blocks	2	241.075	120.538	172.704	0.000
Error	6	4.188	0.698		
Total	11	421.990			

Table 4.7 shows the result of the analysis of variance on varietal effects of the performance of tomatoes and the interpretation is as follows:

Comparisons of treatment effects

H<sub>0</sub>: the treatment means are not significantly different

H<sub>1</sub>: the treatment means are significantly different

$\alpha = 0.05$

P – value = 0.130

Decision rule: reject H<sub>0</sub> if P – value is significantly less than the level of significance  $\alpha$ , otherwise accept.

Conclusion: looking at the above analysis, P – value which is 0.130 is greater than the level of significance  $\alpha = 0.05$ , we do not reject H<sub>0</sub> and conclude that the means of the treatment effects are not significantly difference. Simply put, the varieties of the tomatoes (across seasons) significantly contribute to the performance (yield) of tomatoes.

Comparisons of block effects

H<sub>0</sub>: the means of the block effect are not significantly different.

H<sub>1</sub>: the means of the block effect are significantly different.

$\alpha = 0.05$

P – value = 0.000

Decision rule: reject H<sub>0</sub> if P – value is less than the level of significance  $\alpha$ , otherwise accept.

Conclusion: : looking at the above analysis, P – value which is 0.000 is less than the level of significance  $\alpha = 0.05$ , we do not accept H<sub>0</sub> and conclude that the means of the block effects are significantly difference. That is, the block effect of the means do not have any significance contribution on the performance (yield) of tomatoes.

#### Post HOC Test for Block Effects Using Tukey HSD

Table 4.8: Multiple Comparisons of the means on block effect Dependent Variable: the weights of the yield of tomatoes.

Tukey HSD

(I) WEIGHTKINDS	(J) WEIGHTKINDS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ROOTWEIGHT	SHOOTWEIGHT	9.1197*	.59074	.000	7.3071	10.9322
	FRUITWEIGHT	9.8539*	.59074	.000	8.0413	11.6664
SHOOTWEIGHT	ROOTWEIGHT	-9.1197*	.59074	.000	-10.9322	-7.3071
	FRUITWEIGHT	.7342	.59074	.474	-1.0783	2.5467
FRUITWEIGHT	ROOTWEIGHT	-9.8539*	.59074	.000	-11.6664	-8.0413
	SHOOTWEIGHT	-.7342	.59074	.474	-2.5467	1.0783

Table 4.8 shows the post hoc analysis of the means of block effect to know which of the mean weight makes the analysis significantly different. Looking at the above analysis, the P – value (shoot weights – fruit weights) which is 0.474 is greater than the level of significance  $\alpha = 0.05$ , then, the mean effect of shoot weights – fruit weights are not significantly different while the other mean weights (root weights – shoot weights and root weights – fruit weights) are significantly different.

#### Summary

This project work examined the impact and variability of climatic effect on the yield of tomatoes in Nigeria. The specific objectives are to determine the monthly mean weather recorded from the meteorological unit, FUTA for 2019 and 2021. Also, to evaluate the multiple correlation between the weather parameters with respect to the tomatoes varieties and lastly, analyzed the impact and variability of varieties of tomatoes on tomatoes yield in Nigeria.

## Conclusion

This research study was undertaken with prior motive of knowing the impact and variability of climatic effect on the performance of tomatoes in Nigeria. Multiple correlation was carried out on monthly data between the climatic factors considered in this research work to know their impact on tomatoes yield. For year 2019, it can be deduced that, the correlations between the climatic factors are positive and statistically significant at 5% level. The combinations of RAIN any other climatic factors do not really have effect on the production of tomatoes in Nigeria while other factors combination influences the production of tomatoes in Nigeria positively. Also in year 2021, based on the climatic factors combinations TMEAN&TMIN, TMEAN&TMAX, RAIN&TMIN, RH&RAIN and WD&RH are strong positive, which indicates positive influence on the yield of tomatoes in Nigeria while the correlation between the climatic factors TMEAN&RH and TMAX&RH has a negative influence on the production of tomatoes in Nigeria. Analysis of variance was conducted on foot weight, root weight and shoot weight against with respect to the four (4) varieties of tomatoes in this research study. It was deduced that, the treatment means are not significantly different, which simply means, the varieties of the tomatoes (across season) positively contribute to the growth of the tomatoes which helps in production of tomatoes in Nigeria.

## Recommendation

This paper recommends that, the farmer should take the weather factors very important as it is an important influence on the growth (yield) of tomatoes in Nigeria.

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