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IMPACT AND VARIABILITY OF CLIMATIC FACTOR SON 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 conditionisnotfavorabletotheirproduct. So, this paper used correlation to shows 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. Foryear2021, 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.

INTRODUCTION

Amomentouschangeinclimateonauniversalscalewillimpactagricultureandaccordinglyaffecttheworld’sfoodsupply.Climatechangeintrinsicallyisnotnecessarilyharmfulbuttheproblemsarisefromeventsthataredifficulttopredict.Therecordsofinconsistentrainfallpatternsandunpredictablehightemperaturespellsconsequentlyreducecropproductivityinthetropics.Latitudinalandaltitudinalshiftsinecologicalandagro-economiczones, land degradation, extreme geophysicalevents,reducedwateravailability,theriseinsealevelandsalinizationaresuggested,unlesspromptdecisionareundertakentomitigatetheeffectsofclimatechange,foodsecurityindevelopingcountrieswillbeunderthreat.Inthe humidtropics,therainy(wet)andlate(dry)sowingseasonsareassociatedwithchangesinclimaticattributeswhichtoagreatextentinfluencetheproductivityofagriculturalfood(vegetablecrops).Vegetablesarethebestmeansofovercoming micronutrientdeficienciesandprovidepeasantfarmerswithsustenanceincomeandmorejobsperhectarethanstaplecrops.Broadly,vegetablecropsaresensitivetoenvironmentalcondition,hightemperaturesandexcessivesoilmoisture(rainfall),whicharethemajorcausesoflowyieldsinthetropicsandthiscanbefurtherexaggeratedbyotherclimaticfactors suchasradiationandcloudcover.Tomato,cabbage,onion,hotpepperandeggplantareamongfewimportantvegetables consumedandorprocessedforutilizationinAsiaandSub-SaharanAfricaregion.Tomato(Lycopersiconesculentum Mill.),animportanthorticulturalcropgrownworldwideisa fruitvegetablebelongstotheSolanaceae.Developingcountries’agriculturalsystemsarevulnerabletoclimatechangebecausetheytendtobelesscapitalandtechnologyintensiveandbecausetheytendtobeinclimatezonesthatarealreadytoo hotandwillprobablygethotter(14).Manycountriesintropicalregionsareexpectedtobemorevulnerabletowarmingbecauseadditionalwarmingwillaffecttheirmarginalwaterbalance..InthesouthernAfricanregions,theeffectofclimatechangecouldbeexacerbatedfurtherduetoitshighriskcroppingenvironmentandthemarkedintra-seasonalandinter-annualvariabilityofrainfall(6).Theaimofthispaperistodeterminehowclimatechangemayinfluencetheproductionof tomatoes(Lycopersiconesculentum)inNigeria,whiletheobjectiveswere;todeterminethemonthlymeanweatherrecordedfromthemeteorologicalunitforyear2019and2021,toevaluatethecorrelationbetweentheweatherparametersonmonthlyrecordsforyear2019and2021andtoanalyzetheimpactofclimatevariabilitybasedondifferentvarietiesoftomatoeswiththeirrespectiveweightsontomatoesproductioninNigeriausingANOVA..Nigeriahasaspatialvariationoftomatoproductionandclimatechangeorvariability.ThisresearchusedFederalUniversityofTechnology,Akure(FUTA)tomatofarmclimaticchangedatasetontomatoproduction.DuringrainyseasonsinNigeria,floodingmayoccurinoverextensiveareaswithinAkure.Thepotentialforclimatechangein

AkureasinducedbyglobalwarmingisthereforeanissueofgreatimportanceinNigeria.

2.1RELATEDSTUDY

Anincrementofthismagnitudeisexpectedtoaffectglobalagriculturesignificantly(4).Inaddition,suchchangesinclimaticconditionscouldprofoundlyaffectthepopulationdynamicsandthedistributionofcroppestsasreportedin(24).Theseeffectscouldeitherbedirect,throughtheinfluencethatweathermayhaveontheinsects'physiologyandbehavior(9);(10);(2);(21);(19);(15),ormaybemediatedbyhostplants,competitorsornaturalenemies(9);(2).Intemperateregions,mostinsectshavetheirgrowthperiodduringthewarmerpartoftheyear(2).Inthefirstcase,thegeneralpredictionisthatifglobaltemperaturesincrease,thespecieswillshifttheirgeographicalrangesclosertothepolesortohigherelevations,andincreasetheirpopulationsize(23;9;2;21).Inagreementwiththisprediction,manyexamplesmaybefoundintheliterature(8;18;16).

Speciesdistributionsareexpectedtochangedramaticallyinresponsetofuture rapidclimatewarming(1),andgenerallyclimatechangemodellingpredictsthattherisksofspecieslosswillincrease(17).Therefore,improvingourunderstandingofthefactorscontrollingpotentialspeciesdistributionsunderfutureglobalwarmingscenarioshasbecomeacentralgoalinecologytoday(7).Predictionofknownoccurrencesofglobalwarmingconstitutesanimportanttechniqueinanalyticalbiology,withapplicationsinconservationmodelingofspecies'geographicdistributionsbasedontheenvironmentalconditionsofsitesandreserveplanning,ecology,evolution,epidemiology,invasivespeciesmanagementandotherfields(20;22).Globalwarmingposesasignificantthreattofutureeconomicactivitiesandthewellbeingofasignificantnumberofhumanbeings(11).Amongalleconomicsectors,theagriculturalsectorappearstobethemostsensitiveandvulnerable(3).Plantproductionisinfluencedbyclimatefactorssuchastemperatureandrainfall.Eachcrophasoptimalconditionsforgrowth.Therefore,anychangeintheclimatecanhaveaseriousimpactonthecropproductionsector.Ithasbeenshownthatatgloballevel,theimpactswillbesmallsinceproductionreductioninsomeareasisbalancedbygainsinothers(12).

Overall,climaticchangeswillaffectagricultureeithernegativelyorpositivelydependingonthelocation.ThereiswideconcernthattheagriculturalsectorinAfricawillbeespeciallysensitivetofutureclimatechangeandvariability(14).Inthispaper,thetomatocropwasused.Thetomato(Lycopersiconesculentum)belongstothefamilyofSolanaceae.Itiscommerciallyimportantglobally,forboththefreshfruitmarketandtheprocessedfoodindustriesTheTomatooriginatedinthedrywestcoastoftropicalSouthAmerica.Thegrowingseasoninthisregionhastemperaturesthataremoderatewithanaverageminimumnighttemperatureof15°Candaveragemaximumdaytemperatureof19°C(5).Theplantthrivesintemperaturesbetween10°Cand30°Candistolerantofneitherfrostnorwaterloggedconditions(13).

3.METHODOLOGY

ThispaperwascarriedoutattheResearchFarmoftheFederalUniversityofTechnology,Akure,(lat7.17°N,long5.8°E),atropicalrainforestzoneofsouthernNigeriaTheclimateoftheareawascharacterizedbyheavyrainfallduringthemonthsfromApriltoJulyandAugusttoNovember.Thesandyloamsoilatthesiteofstudyisanalfisolclassifiedasclayeyskeletaloxic-paleustalf(USDASoilSurveyStaff,2009). The nutrient statusofsurfacesoilfor0-15 cm at the experimental site before planting are: pH6.8;N (0.19mg/kg); P(7.69mg/kg); K, Ca and Mg (1.75, 0.84,4.39cmol/kgsoilrespectively);organicmatter(2.42g/kg),bulkdensity(1.28mg/m3).Thefieldsitewasmanuallycleared.Seedsoffourtomatovarieties:Ibadanlocal(Ib.local),UC,RomaVFandBeskewerenursedon5thofMarch,2019forearly/rainingseasonplantingandtransplantedtothefieldon2ndofApril,2019.Thelateseasonplantingwason4thofSeptemberandtransplantedtothefieldon1stofOctober.Theexperimentwasrepeatedinthecroppingseasonsofyear2020.TheexperimentaldesignwasaRandomizedCompleteBlockDesign(RCBD)withthreereplications.Theunitplotsizewas2mx2m.Thetomatovarietyseedswerenursedinawellpulverizedrichloamysoilandwastransplantedintothefieldafter5weeksataplantingdistanceof90cmby30cm.Twoweeksintervalrecordsofplantheight(cm),numberofleavesperplant,leafareaperplant(cm^2),dryweightofleavesandfruitsperplant(g),numberofflowerclustersperplant,numberoffruitsperplant,weightofindividualfruit(g),weightoffruitsperplant(kg),weightoffruitsperplot(kg)andfruityield(t/ha)weretakenuptomaturityandtomatoyieldwasassessedatthefinalharvest.Weatherdataincludesrainfall(RR),maximumtemperature(T_max),minimumtemperature(Tmin)andrelativehumidity(R/H)wastakensimultaneouslyonweeklybasisintwoplantingseasons.Datawereanalyzedtoestablishtherelationshipbetweenvariousgrowthstagesandweatherelementsconsideredusingmultiplecorrelationmethodaand ANOVA.

3.1 VARIABILITYANALYSIS

ThedatawereanalyzedbytheuseofIBMSPSSStatisticsversion17andRpackages.Whilethedescriptivestatisticswererepresentedintheformoftablesandgraphs,theinferentialstatisticsinvolvedtheuseofmultiplecorrectionandanalysisofvariance(ANOVA).Themultiplecorrelationswasusedtoestablishthedegreeofassociationbetweendifferentclimaticconditionswhilethe ANOVAtestformeansanalysiswasemployedtofurthertestthesignificanceoftherelationshipsbetweendifferentweathervariabilityontomatoproductionat5percentsignificanceleveland95percentconfidencelevelforyear2019and2021.

Themultiplecoefficientsdenotingacorrelationofonevariablewithothervariablesdenotedas$R_{ABCD\ldots K}$whichdenotethatAiscorrelatedwithB, C, and Dupto K. For example, ifyouwanttocomputemultiplecorrelationsbetweenA,B,and C, it can be express as

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

Where$R_{A.BC}$isthemultiplecorrelationsbetweenAandlinearcombinationbetweenBandC,Γ_{AB}isthecorrelationbetweenAandB, Γ_{AC}isthecorrelationbetweenA and Cand$\Gamma_{BC}$is the correlationbetweenBandC.

Signific ancetesting ofR^2

H_o:p^2=0

Against

H_1:$p^2\neq0$

-

ThepopulationvalueofR^2isp^2.Hence,R^2isanestimatorof p^2

Teststatistic:TheFstatisticisusedfortestingthesignificanceofR^2 andisgivenas

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

Where$R^2 = 1-\frac{(1-R^2)(n-1)}{n-k-1}$ which is the percentage of varianceintheconstantvariableexplainedbylinearcombinationoftheregressionmodel.

4.0ANALYSISOFDATA

MONTHLY DATA RECORD FOR YEAR 2019 AND 2021 AT THERE SEARCH FARM OF THE FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE(FUTA)

Table4.1:Monthlydatarecordforyear2019atFUTAresearchfarm

2019	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tmean	25.9	26.5	26.7	26.6	26.0	25.2	24.3	24.6	24.8	25.1	25.4	25.2
Tmin	21.9	22.9	23.8	23.5	23.3	22.8	22.0	21.8	22.4	22.6	22.8	21.6
Tmax	30.4	31.0	30.7	30.6	29.6	28.5	27.5	28.4	28.0	28.6	28.6	29.2
RH	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

Table4.2:Monthlydatarecordforyear2021atFUTAresearchfarm

2021	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tmean	25.9	26.5	26.5	26.2	26.2	25.6	24.8	24.5	25.1	25.7	25.1	25.9
Tmin	22.1	22.8	23.6	23.4	23.3	23.3	22.2	22.2	22.6	22.8	22.6	21.9
Tmax	30.3	31.1	30.3	29.9	29.8	28.8	27.8	27.8	28.3	29.2	28.3	30.3
RH	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

Table4.3:Growthandyieldearlyrainfedandlaterainfedseasonoftomatoes.

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

Table4.4:Varietaleffects(acrosstheseasons)ontheperformanceoftomatoes

Varieties	Root weights(kg)	Shoot weight(g)	No.ofbranches	Plant height (cm)	50%floweringdays	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
Romavf	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

4.2CORRELATIONBETWEENTHEDIFFERENTCLIMATICFACTORS

Table4.5:Degreeofrelationshipbetweentheclimaticfactorsforthemonthsintheyear2019

	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

Table4.5showsthecorrelationsbetweentheclimaticfactorsarepositiveandstatisticallysignificantat5%level.However,thedegreeofassociationbetweenRAINandWD,TMEAN,TMINandTMAXisweakpositivewhiletherestassociationsarestrongpositive.Theseindicatesthat,thecombinationsofclimaticfactorRAINandanyotherfactorsdonotreally haveeffectontheproductionoftomatoesinNigeriawhilethecombinationsofotherfactorsareveryimportantfactorstoinfluencetheyieldoftomatoesinNigeriapositively.Thatis,theyieldoftomatoesinNigeriaforyear2019withreferencetothecombinationsofclimaticfactorsWD,TMAX,TMIN,RHandTMEANwillgivemuchquantityofqualitytomatoes.

Table4.6:Degreeofrelationshipbetweentheclimaticfactorsforthemonthsintheyear2021

	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

Table4.6showsthecorrelationsbetweentheclimaticfactorsTMEAN&TMIN, TMEAN&TMAX, RAIN&TMIN, RH&RAINandWD&RHarestrongpositive, which indicates therelationshipbetweenthosecombinations would havepositiveinfluence(qualityandquantity) on the yieldoftomatoesinNigeria.

ThecorrelationbetweentheclimaticfactorsTMEAN&RHandTMAX&RHisastrongnegativerelationshipwhichindicatesthat,thecombinationofthefactorshasaverystrongnegativeinfluenceontheyieldoftomatoesinNigeria.

ThecorrelationsbetweentheclimaticfactorsTMIN&TMAX, TMIN&RH, TMIN & WD and RAIN and WD is aweak positiverelationshipwhichindicatesthat, the combination of thefactorsmayormaynotreallyhaveany positive influenceontheyield(qualityandquantity)of tomatoes in Nigeria.

ThecorrelationsbetweentheclimaticfactorsTMEAN&RAIN, TMEAN&WDand TMAX&RAIN is a weak negativerelationshipwhichindicatesthat,thecombinationofthefactorsmayormaynotreallyhaveanynegativeinfluenceontheyield(qualityandquantity)oftomatoesinNigeria.

4.2.1ASSUMPTIONOFNORMALITY

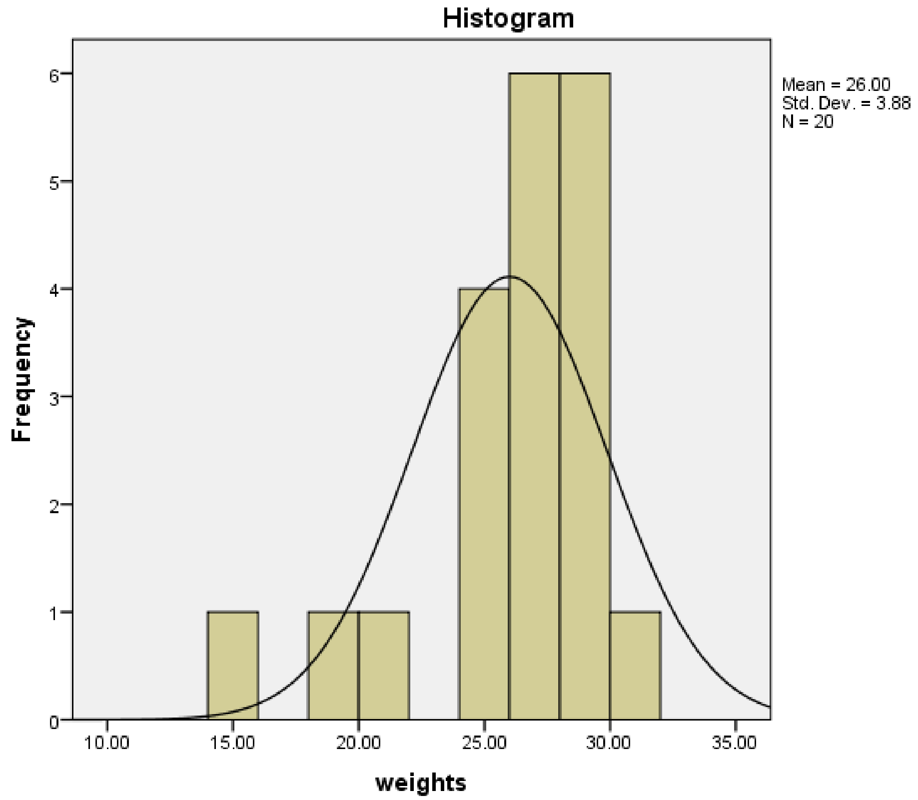

Figure4.1plotofweightsoftomatoeswithanormalitycurve

4.2.2ANALYSISOFVARIANCEONTHEWEIGHTSOFTOMATOES

Table4.7:analysisofvarianceonvarietaleffects(acrossseason)oftheperformanceoftomatoes

Sourceofvariation	Degreeoffreedom	Sumofsquares	Meansumofsquares	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			

-

Table4.7showstheresultoftheanalysisofvarianceonvarietaleffectsoftheperformanceoftomatoesandtheinterpretationisasfollows:

Comparisonsoftreatmenteffects

H_o: thetreatmentmeansarenotsignificantlydifferent

H_1:thetreatmentmeansaresignificantlydifferent

α=0.05

P–value=0.130

Decision rule: rejectHoifP–valueissignificantlylessthanthelevelofsignificanceα, otherwise accept.

Conclusion: lookingattheaboveanalysis, P–valuewhichis0.130isgreaterthanthelevelofsignificanceα =0.05, wedonotrejectHoandconcludethatthemeansofthetreatmenteffectsarenotsignificantlydifference.Simplyput,thevarietiesofthetomatoes(acrossseasons)significantlycontributetotheperformance(yield)oftomatoes.

Comparisonsofblockeffects

H_o: themeansoftheblockeffectarenotsignificantlydifferent.

H_1:themeansoftheblockeffectaresignificantlydifferent.

α=0.05

P–value=0.000

Decision rule: rejectHoifP–value is less than the level of significanceα, otherwise accept.

Conclusion: lookingattheaboveanalysis, P–value which is 0.000islessthanthelevelofsignificanceα=0.05, wedonotacceptHoandconcludethatthemeansoftheblockeffectsaresignificantlydifference.Thatis,theblockeffectoft hemeansdonothaveanysignificancecontributionontheperformance(yield)oftomatoes.

4.2.3POSTHOCTESTFORBLOCKEFFECTSUSINGTUKEYHSD

Table4.8: MultipleComparisonsofthemeansonblockeffect Dependent Variable: theweightsoftheyieldoftomatoes. TukeyHSD

(I)WEIGHTKINDS	(J)WEIGHTKINDS	Mean Difference (I-J)	Std.Error	Sig.	95%ConfidenceInterval	
					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

Table4.8showstheposthocanalysisofthemeansofblockeffecttoknowwhichofthemeanweightmakestheanalysissignificantlydifferent.Lookingattheaboveanalysis,theP–value(shootweights–fruitweights) which is 0.474 is greaterthanthelevel ofsignificanceα=0.05, then, the mean effectofshootweights–fruitweightsarenot significantly differentwhilethe othermeanweights (rootweights–shootweightsandrootweights–fruitweights) aresignificantlydifferent.

5.1SUMMARY

ThisprojectworkexaminedtheimpactandvariabilityofclimaticeffectontheyieldoftomatoesinNigeria.Thespecificobjectivesaretodeterminethemonthlymeanweatherrecordedfromthemeteorologicalunit,FUTAfor2019and2021. Also,toevaluatethemultiplecorrelationbetweentheweatherparameterswithrespecttothetomatoesvarietiesandlastly,analyzedtheimpactandvariabilityofvarietiesoftomatoesontomatoesyieldinNigeria.

5.2CONCLUSION

ThisresearchstudywasundertakenwithpriormotiveofknowingtheimpactandvariabilityofclimaticeffectontheperformanceoftomatoesinNigeria.MultiplecorrelationwascarriedoutonmonthlydatabetweentheclimaticfactorsconsideredinthisresearchworktoknowtheirimpactontomatoesyieId.Foryear2019,itcanbededucedthat,thecorrelationsbetweentheclimaticfactorsarepositiveandstatisticallysignificantat5%level.ThecombinationsofRAINanyotherclimaticfactorsdonotreallyhaveeffectontheproductionoftomatoesinNigeriawhileotherfactorscombinationinfluencestheproductionoftomatoesinNigeriapositively.Alsoinyear2021,basedontheclimaticfactorscombinationsTMEAN&TMIN,TMEAN&TMAX,RAIN&TMIN,RH&RAINand WD&RHarestrongpositive,whichindicatespositiveinfluenceontheyieldoftomatoesinNigeriawhilethecorrelationbetweentheclimaticfactorsTMEAN&RHandTMAX&RHhasanegativeinfluenceontheproductionoftomatoesinNigeria.Analysisofvariancewasconductedonfootweight,rootweightandshootweightagainstwithrespecttothefour(4)varietiesoftomatoesinthisresearchstudy.Itwasdeducedthat,thetreatmentmeansarenotsignificantlydifferent,whichsimplymeans,thevarietiesofthetomatoes(acrossseason)positivelycontributetothegrowthofthetomatoeswhichhelpsinproductionoftomatoesinNigeria.

5.3RECOMMENDATION

Thispaperrecommendsthat, thefarmershouldtaketheweatherfactorsveryimportantasitisanimportantinfluenceonthegrowth(yield)oftomatoesinNigeria.

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