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Effects of Weather Patterns on the Growth of White Yam *(Dioscoreae rotundata)* in Ardo-Kola LGA, Taraba State

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Abstract This research evaluated the effects of weather patterns on the growth of three selected white yam cultivars 'Yalzo', 'Jajetin' and 'Dan Anacha' in Ardo-kola LGA, Taraba State. The experiment was conducted during the 2016/2017 growing season along Sunkani - Bali highway opposite College of Agriculture Jalingo Taraba State. The experiment was carried out in Randomized Complete Block Designed (RCBD) using 3 replications. The meteorological data were collected from Taraba State University Jalingo, meteorological station throughout the growing season. Based on weather patterns during the cropping season, highest rainfall was recorded in the month of August with the total of 175mm and decreases toward October. There is inverse relationship with rainfall and Maximum temperature, Minimum temperature and sunshine hours, while Relative Humidity showed a direct relationship with rainfall. Correlation result showed that, Relative Humidity and soil temperature correlates positively with all the various developmental stages of yam at 0.01 and 0.05 probability levels respectively. Relative Humidity, rainfall and soil temperature correlates positively with all the growth parameters of the three selected cultivars of yam. Variation in growth of yam revealed that, there is a variation in plant height, number of leaves, number of branches at P=0.05, number of stem node at P=0.01. Knowledge of weather as it relate to yam growth such as onset, cessation and length of rainy season should be pass to local farmers as that will help the farmers in planning and management of their farm. Improve cultivars of yam should also be introduce to the local farmers in the study area.

Keywords Weather, White Yam, Farmers, Taraba State

1. Introduction

Yam is one of the major root crops grown in many parts of the world and serves as a source of food to millions of people and livestock (Amusa, 2003; Demuyakor, 2013). However, climate has remained a major physical and environmental factor influencing agriculture and indeed yam production particularly in the tropics (Ayanlade, Odekunle, & Orimoogunje, 2010; Emaziye, 2015). Yam production is sensitive to weather and climates at all stages of production from land clearing and preparation, through crop growth and management to harvesting, storage, transportation and marketing of agricultural products (Demuyakor, 2013; Law-Ogbomo & S.U. Remison, 2008).

However, knowledge on the major weather variables affecting yam growth/ production and the use of different cultivars is quite limited (Emaziye, 2015; Sadauki & Olanrewaju, 2012). While, such knowledge is fundamental to plants physiologist and agronomists in planning and maintaining crop (yam) production in order to increase its growth from the agro-climate /weather variables and to farmers in choosing suitable crop (yam) variety for a given area.

Yams are annual crops and form one of the most stable and major root crops grown in many part of Nigeria (Bassey & Akpan, 2015). Yam serves as a source of food and as a source of income to the growers to meet other demands of the household and to make investment for the subsequent year (Ayanlade et al., 2010; Denis Cornet, 2014).

The growth cycle of yam plant consists of four phases namely the root, vine, leaf and tuber. Each of these phases is very vital to yam growth and is affected differently by climatic conditions (Adeniyan & Owolade, 2011). Optimal performance of the yam growth is possible when weather patterns such as rain, temperature, relative humidity and sunshine are favorable. Atmospheric variability particularly increasing anomaly in the onset, cessation and duration of the rains and incidence of dry spells during the early growth stages of yam leads to low growth of yam and consequently low yield, low household income, hunger, and food security Orkwor & Ekanayeke (1998).

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However, previous studies including those of Adeniyan and Owolade (2011); Adewuyi, Okojie, Folorunso, and Bada (2014); Amit; Ayanlade, Odekunle, and Orimoogunje (2010); Emaziye (2015); Eruola, Bello, Ufoegbune, and Makinde (2012), carried out on the effects of climate on yam production have not made attempts on the growth of different cultivars of white yam (Dioscoreae rotundata). Similarly, such studies were carried out in the southern and eastern part of the country with different geographical characteristics with the study area. It is on this basis that this research effort is made towards examining the relationship between weather patterns and yam growth, and identifying the best cultivar(s) that is/are suitable to weather conditions of the study area. The findings will open door for further research on weather patterns relate to yam production in Taraba state. Thus, this is predicted on the following specific research objectives:

1. To Analyzing weather patterns during the growing season in the study area.
2. To examine the relationship between weather patterns and yam growth at different developmental stages.
3. To examine the variation in growth of the three cultivars of yam in relation to weather patterns in the study area.

2. The Study Area

The study area Ardo-Kola Local Government Area (8° 00' N to 9° 40' N and 11° 00' E to 12° 00' E) is located in the northern zone of Taraba state Fig.1. It has a total landmass of about 2,312Km^2. The study area experience wet and dry climate (Oruonye, 2014). Temperature is high all year round because of its latitudinal location. The study area has two distinct seasons, the rainy and dry season. The rainy season runs from the month of April through October, while the dry season commences in November and in February/March. The onset of rainfall, which is the time a place receives an accumulated amount of rainfall sufficient for growing of crops, commences between March to April. The onset of rainfall is occasionally heralded by dust/sand storm. The mean annual rainfall ranges to 1000mm with the highest occurrence in the month of May and August having 193.67mm to 285.5mm respectively (Yusuf, Firuza. & Khairulmaini, 2015).

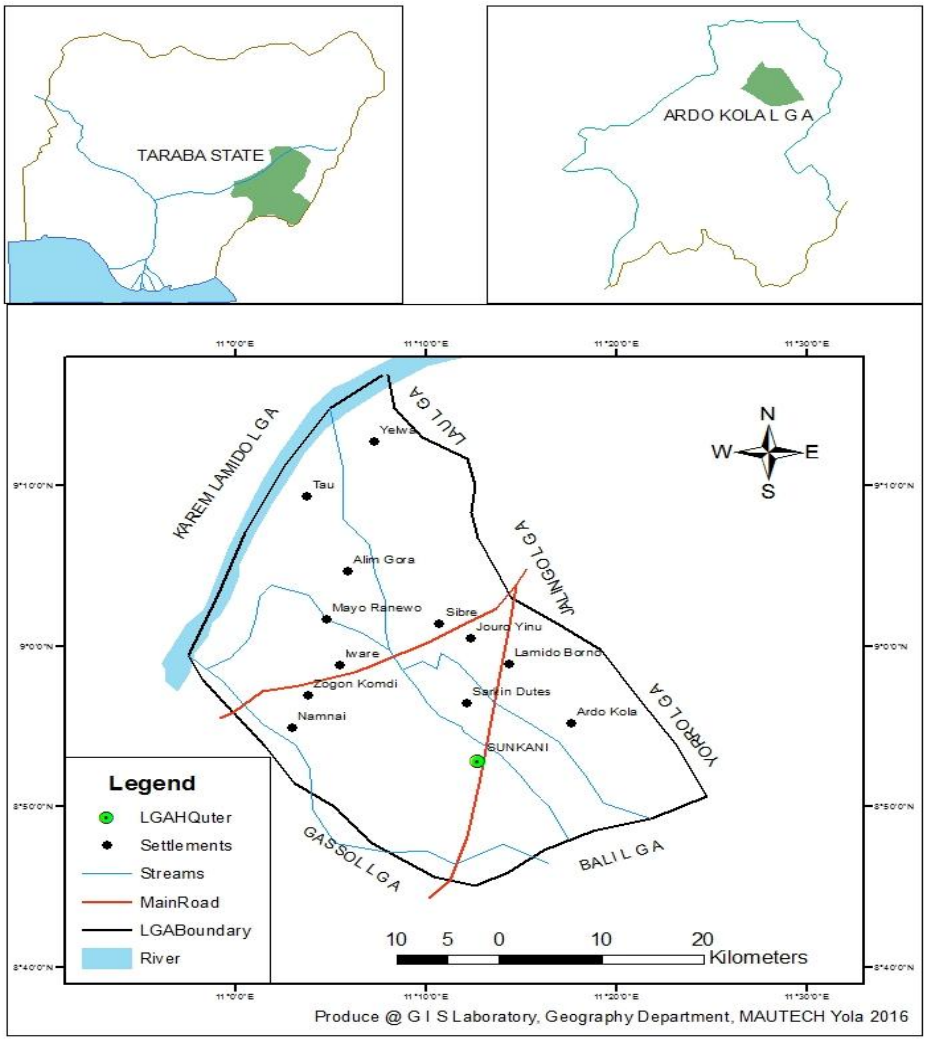

Figure 1. Map of the Study Area

Farming is the major traditional occupation of the people (Ray, & Yusuf, 2011). The farming system and farming practice are characteristically of the subsistence type and involve predominantly mixed or single cropping. Yam, Guinea corns, and maize, are the major crops, cultivated by almost every farm family. Farming operations are generally labour–intensive and largely a reflection of traditional methods, using drudgery- enhancing primitive tools such as hoes, cutlasses, machetes, and axes, which have been passed from generation to generation (Yusuf, M. B., Firuza B.M. & Khairulmaini, O.S. 2017).

3. Methods

The experimental site was established along Sunkani - Bali highway opposite collage of agriculture Jalingo Taraba state (08°53' N and 011° 18' E). The experimental site lies about 240 meters above sea level (Field Survey 2016 GPS). The block size was 20m x 20m and divided into 9 separate plots with each Cultivar replicated three times (i.e. 3 x 3= 9). That is, each cultivar has three plot.

The number of yam mounds were 90 made manually using Africa hoe on (19th, November, 2016), this 90 mounds were divided into nine (9) separate plots for the three Cultivars. Each plot consists of 10 mounds and the mounds were 90cm wide at the base and 60cm high (i.e. sized of the mound). The mounds were spaced 1m pathway within each plot. Path way of 1.5m was allowed between plots. The outside margin was spaced 1m away from the main plot. The mound tillage system was selected for the study because study has shown that mound tillage system improves the soil aeration and hydrothermal conditions for crops emergence, root development, crop growth and yield (Inyang, 2005).

The three local yam setts Cultivars were obtained from the local farmer in the study area. Whole yam setts weighing between 0.4 to1g for each cultivar were planted with one sett per mound. The three different yam cultivars were planted on 17th, December, 2016 and were mulched immediately after planting while staking was done after sprouting. Weed control was carried out using hand hoe three times throughout the cropping period.

Daily weather data including rainfall, maximum and minimum temperature, soil temperature, relative humidity, and sunshine hours were collected from Taraba State University Jalingo, meteorological station from December, 2016 – October, 2017. The following growth parameters were measured using 3 plants/plot every 2 weeks but after 18 weeks from planting: Plant height (cm), number of leaves, number of branches, number of stems node.

Both descriptive and inferential statistics were used. The descriptive statistics involved the use of tables, percentage simple mean and graphs, while the inferential statistics are; Correlation and Analysis of Variance (ANOVA). The Correlation analysis was used to test the relationship between weather elements and growth of yam at different developmental stages while Analysis of Variance (ANOVA) was used to test the variation in growth of the three selected cultivars of yam. MINITAB statistical package was used for the study.

4. Results and Discussion

4.1. The Weather Pattern of the Study Area During the Growing Season

The weather patterns revealed that the rainy season runs from the month of April through early October. The highest amount of rainfall was recorded in August with the total of 175mm follow by September with 170.5mm while the least was recorded in October with only 9 mm (Table 1). These results concurred with the explanation provided by (Sadauki & Olanrewaju, 2012; Vaillant, 2005; Zakari, 2014) that the Nigerian rainfall distribution pattern has single maxima in the Northern part of the country.

The result also shows an inverse relationship between rainfall and Maximum temperature, Minimum temperature and sunshine hours; probably, because all the parameters normally decrease as rainfall increases due to the cloud produce by rain during the rainy season. The findings further revealed that Maximum and Minimum temperature and Sunshine hour decreases as the month moved toward August to September because of rainfall amount but latter increases as it moves toward October.

Table 1. Monthly meteorological data from Planting to Harvesting Period

	Rainfall	maximum temperature	minimum temperature	sunshine hours	relative humidity
Dec/2016	-	36.5	18.4	7.4	40.9
Jan/2017	-	33.8	18.2	7.7	41.5
Feb.	-	37.39	18.03	8.5	54.04
March	-	36.2	26.9	7.6	69.6
April	19	34.4	26.03	6.4	75.6
May	129	32.4	25.2	5.8	87.6
June	156	31.1	24.5	5.1	80.2
July	133.3	29.29	24.71	6.9	81.9
August	175	29.25	24.4	5.11	89.6
September	170.5	29.31	24.8	7.9	81.9
October	9	33.2	25.7	9.2	74.7

Source: Taraba State University Meteorological Station, 2016/2017

Direct relationship was also noticed in September and October as rainfall decreases relative humidity also decreases. Inverse relationship was noticed with rainfall and relative humidity in June as rainfall increases relative humidity also decreases, while in July as rainfall decreases relative humidity also increases.

4.2. Relationships between Weather Patterns and Growth of Yam at Different Developmental Stages

Correlation between weather patterns and yam at different developmental stages was observed to see the significant of the relationship which is presented in Table 2.

a) Effect of Weather at Planting to Emergence

The differences in the effect of each weather patterns on yam growth at different developmental stages of growth were evaluated. The results showed that at planting to emergence, air relative humidity, sunshine hours and Soil temperature showed positive relationship of 0.745, 0.753 and 0.705 respectively at P=0.05. This positive relationship with yam at this stage suggest the support for germination and emergence of yam.

b) Effect of Weather patterns at Vegetative Stage of Yam

Vegetative stage is one of the most important stages in yam production. Result in Table 2 showed that, all the weather patterns shows positive relationship with vegetative stage of yam. Rainfall and relative humidity showed a highly positive relationship at p= 0.01 while sunshine hours also showed positive relationship at 0.05 probability level. This signifies the importance of rainfall and humid environment during the vegetative growth stage. This finding agrees with the report of (Adewuyi, Okojie, Folorunso, & Bada, 2014; Ayanlade et al., 2010) that, low rainfall and prolonged dry spells during the crop growth period are the main reasons for low average yields in several parts of Africa. This implies that, all the weather variables supply is sufficient for growth of yam at vegetative stage.

c) Effect of Weather at Flowering Stage of Yam

The correlation coefficients result displayed in Table 2 showed that, Rainfall, minimum temperature and sunshine hours correlated positively with yam growth at p= 0.01, while relative humidity and soil temperature displayed positive relationship with yam at p= 0.05. Maximum temperature shows weak positive relationship of 0.281 with yam at flowering stage. This result implies that, flowering stage is significantly influence by all the weather patterns consequently leading to high yield.

d) Effect of Weather at Tuber Bulking Stages of Yam

At this stage almost all the weather patterns has a positive relationship with yam growth Table 2. Rainfall, maximum temperature and minimum temperature showed positive correlation of 0.608, 0.641 and 0.108 respectively. Relative humidity and soil temperature displayed positive relationship with yam growth at 0.01 probability level. Generally, it has been observed in Table 2 that only relative humidity and soil temperature that showed highly positive significant relationship with yam at all the developmental stages. This implies that, relative humidity and soil temperature are very vital in all the developmental stages of yam growth in the study area.

4.3. Variations in the Growth Parameters of the Three Yam Cultivars

These section examined the differences between the growth parameters of the selected cultivars of yam.

a) Numbers of Leaves per Plant

Results on the mean performance of the number of leaves per plant in Table 3, showed significant differences at P=0.05 in all the weeks. The mean performance of the selected Cultivars also indicated that C1 has the highest performance in number of leaves follow by C2 and C3 which clearly indicated that C1 responded positively to weather conditions of the study area then C2 and C3.

b) Number of Branches per Plant

Table 4 showed significant differences in number of branches per plant in weeks 20, 24, 26, 28, 30, 32, and 38 at P=0.01 while weeks 22, 34, 36 and 40 showed at P=0.05. From the mean performance, it shows that C1 has the highest number of branches than C2 and C3. The genetic differences between the cultivars is instrumental to the significant differences in the number of branches per plant. This disagree with the earlier finding of (Amusa, 2003; Awoniji & Omonona, 2007) that, there is no significant differences among the genotypes for number of branches per plant.

Table 2. Correlations between weather patterns and Yam Growth at Different Developmental Stages

	Rainfall	Maximum temperature	minimum temperature	relative humidity	sunshine hours	Soil temperature
Planting- emergence	-0.524	-0.524	-0.524	0.745*	0.753*	0.705*
Vegetative	0.957**	0.506	0.532	0.877**	0.741*	0.647
Flowering	0.802**	0.281	0.999**	0.704*	0.967**	0.724*
Tuber bulking	0.608	0.641	0.108	0.982**	-0.189	0.912**

*correlation is significant at 0.05 **correlation is significant at 0.01

Table 3. Mean Performances for the Number of Leaves during the Sampling Period (ANOVA)

TRT	18WAP	20WAP	22WAP	24WAP	26WAP	28WAP	30WAP	32WAP	34WAP	36WAP	38WAP	40WAP
C1	24.67	128.3	225	323.7	418.7	509	593.3	692.3	775.7	843.7	858	860
C2	22	118.3	206.7	299.3	386.3	482.7	579	679	770.3	819	834.33	836
C3	11	61.7	155	244	310	368.7	429.7	489.3	540	580.7	590	595.65
MEAN	19.22	102.77	195.57	289	371.67	453.47	534	620.2	695.33	747.8	760.78	763.88
LSD	0.026	0.012	0.032	0.059	0.029	0.023	0.036	0.031	0.028	0.027	0.025	0.026
	*	*	*	NS	*	*	*	*	*	*	*	*

TRT = Treatment, C1, C2 and C3 = Cultivar 1, 2 and 3. WAP = Week After Planting, LSD = Least Significant Difference NS = Not Significant, * = Significant at P = 0.05.

Table 4. Mean Performances of Number of Branches (ANOVA) during the Sampling Period

TRT	18WAP	20WAP	22WAP	24WAP	26WAP	28WAP	30WAP	32WAP	34WAP	36WAP	38WAP	40WAP
C1	2.67	7.3	15.3	23	30	35.7	41.7	47.3	51.7	55.3	60	61.67
C2	3.33	9	14	19.7	24.3	30.3	35.3	40	46	50.3	53	54.33
C3	1.33	6.7	12.3	18	23.3	29	34.7	39.7	44	46.7	49	51.33
MEAN	2.44	7.67	13.87	20.23	25.87	31.67	37.23	42.33	47.23	50.77	54	55.78
LSD	0.174	0.005	0.013	0.005	0.008	0.008	0.006	0.007	0.011	0.018	0.004	0.011
	NS	**	*	**	**	**	**	**	*	*	**	*

TRT = Treatment, C1, C2 and C3 = Cultivar 1, 2 and 3. WAP = Week After Planting, LSD = Least Significant Difference NS = Not Significant, * = Significant at P = 0.05, ** = Significant at P = 0.01.

Table 5. Mean Performances of Plant Height (cm) during the Sampling Period (ANOVA)

TRT	18WAP	20WAP	22WAP	24WAP	26WAP	28WAP	30WAP	32WAP	34WAP	36WAP	38WAP	40WAP
C1	45.53	95.2	147.3	210.7	283.5	379.7	452.2	494.1	527.7	545.2	549.37	550.9
C2	36.83	77.83	118.03	181.97	230.03	296.53	380.7	443.8	505.8	522.3	529.1	526.97
C3	32.07	74.23	122.7	175.6	225.6	291.53	344.3	396.8	427.2	439	442.93	446.03
MEAN	38.14	82.42	129.34	189.42	246.38	322.59	392.4	444.9	486.9	502.17	507.13	507.97
LSD	0.018	0.041	0.017	0.014	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000
	*	*	*	*	**	**	**	**	**	**	**	**

TRT = Treatment, C1, C2 and C3 = Cultivar 1, 2 and 3. WAP = Week After Planting, LSD = Least Significant Difference,* = Significant at P = 0.05, ** = Significant at P = 0.01.

Table 6. Mean Performances of Number of Stems Nodes (ANOVA) during the Sampling Period

TRT	18WAP	20WAP	22WAP	24WAP	26WAP	28WAP	30WAP	32WAP	34WAP	36WAP	38WAP	40WAP
C1	7	12.3	16.7	21.3	24.7	28.7	33.7	37.7	41	43.3	46	47.33
C2	4.67	9	13	17	20.3	24.3	28.3	31.3	34	37	40.67	41.33
C3	3	7.3	11.7	14.7	18	21.3	24	26.7	29.3	31.7	33.67	35
MEAN	4.89	9.53	13.8	17.67	21	24.77	28.67	31.9	34.77	37.33	40.11	41.22
LSD	0.002	0.001	0.023	0.046	0.054	0.026	0.012	0.011	0.006	0.01	0.007	0.005
	**	**	*	*	NS	*	*	*	**	**	**	**

TRT = Treatment, C1, C2 and C3 = Cultivar 1, 2 and 3. WAP = Week After Planting, NS = Not Significant,
LSD = Least Significant Difference, * = Significant at P =0.05, ** = Significant at P = 0.01.

c) Plant Height (cm) per Plant

Variation in plant height of the three selected cultivars of yam was taking at 2 week interval after plant establishment. The result as presented in Table 5, indicates highly significant differences between the three cultivars at 0.01 and 0.05 probability levels. Highly significant differences for the three cultivars at P=0.01 was recorded in weeks 26, 28, 30, 32, 34, 36, 38, and 40 while weeks 18, 20, 22, and 24 showed significant differences at P=0.05. The mean performance of plant height showed that, C1 performed higher than C2 and C3. Genetic factor could be the reason for the differences in height.

d) Number of Stem Nodes per Plant

Results on the number of Stem Nodes per plant are shown in Table 6. The result showed highly significant differences at P=0.01 in weeks 18, 20, 34, 38 and 40 while, significant differences at P=0.05 were recorded at weeks 22, 24, 28, 30, 32, 36. From the mean square values, C1 performed higher than C2 and C3 in relation to weather patterns of the study area.

5. Conclusions

Based on weather patterns of the study area during the growing period, rainfall increase as the month move toward August but letter drops in September and October. Month of August record highest amount of rainfall. Maximum temperature, Minimum temperature and sunshine hours shows an inverse relationship with rainfall as a result of increase in rainfall. while Relative Humidity showed a direct relationship with rainfall. Relative humidity and soil temperature correlates positively with all the various developmental stages of yam growth. The three cultivars of white yam vary significantly in plant height, number of leaves, number of branches and number of stems node.

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