Volume 7, Number 1
January 2009

ISSN: 2006-7003

JOURNAL of METEOROLOGY and CLIMATE SCIENCE

Published by

Nigeria Meteorological Society (NMetS)
Http://www.nmets.org

Journal of Meteorology and Climate Science

Volume 7 Number 1 January, 2009 ISSN 2006-7003

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JOURNAL OF METEOROLOGY & CLIMATE SCIENCE
J. Met. & Clim. Sci. 7:43-48 (2009)

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CLIMATE AND THE GROWTH CYCLE OF YAM PLANT IN THE GUINEA SAVANNA ECOLOGICAL ZONE OF KWARA STATE, NIGERIA

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Received: March 18, 2008
Accepted: December 27, 2008

Abstract: The study examines the effect of climate on the phenological stages of yam plant. Both the growth cycle and micro climate of yam plant were monitored in the field for two yam growing seasons (2003/2004, 2004/2005). The period of the developmental stages were identified and the data generated were partitioned accordingly. Pearson correlation statistics was employed. The most sensitive and delicate phases of yam phenological cycle are root and vine stages. From the result obtained they exhibit very strong negative relationship (significant at 0.01 confidence level) with all thermal indices but showed very strong positive relationship with all moisture indices. However, the growth of tuber is enhanced by high rainfall frequency but low rainfall amount. Farmers are encouraged to improve on the materials used for mulching to minimize fluctuation in soil temperatures and raise soil moisture reserve.

1. INTRODUCTION

Yams are annual crops and form one of the major root crops grown in Nigeria. The growth cycle of yam plant consists four phases namely the root, vine, leaf, and tuber. Each of these phases is very vital to yam yield and is affected differently by climatic conditions (Okonkwo 1998).

Indira (1998) highlighted the main abotic stress factors affecting root and tuber crops in sub-Saharan Africa to include drought, water logging, temperature and solar radiation extremes. The outcome of these extremes on any crop is low yield. The effects of such extremes on the growth of yam have been noted by Bello (1983), Odjugo (2003), Olanrewaju (2004) and Odugo (2007) respectively.

In Kwara state of Nigeria, yam production is not steady, the yields fluctuate (see table 1 below) and yam market is characterized by inflation (KADP 2005).

Table1: Yam Yield Trend in Kwara State (1995-2004)

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Yield (000) Tonnes/ Hectare	12.8	9.4	10.0	14.7	14.8	10.4	12.96	12.33	10.86	11.70

Source: Kwara State Agriculture Development Project (KADP 2005)

Base on the report of market survey conducted by the PME Department of KADP, a kilogram of yam was sold for #1.00 in 1989 at rural market and #1.55 in the urban market. It skyrocketed to #48.08 and #67.99 in the year 2004 respectively.

Olanrewaju (2003) confirmed a change of climate in Kwara state and traced fluctuation observed in yam production in this area to climate vagaries (Olanrewaju 2004). This present study is an extension of such previous works. It examines the effects of the micro climate on the phenological stages of white yam (D.rotundata) being, the most widely grown in the study area. This exercise becomes necessary to improve yam production in Kwara state.

1.1 *The Study Area*

Production of root crops prevail throughout Kwara state therefore experimental plot could be sited in any part of the state. Base on this and on the fact that National Centre for Agricultural Mechanization (NCAM) is a research institute the centre was chosen. NCAM is located at kilometre 12 Ilorin Idofian Road. Ilorin is located on the latitude 8° 30°N and longitude 4° 35°E.

Olaniran (1986)'s climatic classification put the area under the Guinea Savannah. The tropical maritime air mass prevails on average for only seven months of the year(April to October). Mean annual rainfall varies and the regime shows a south-north gradient over the area. The range decreases from about 1000mm-1500mm in the south to 1200mm in the northwest (Olanrewaju 2007). Temperature is high throughout the year and varies between 25°C to 30°C.

. The soil of the area is ferruginous in nature and made up of sand and clay deposits (Areola 1978). These qualities make the soil of the study area appropriate for yam cultivation.

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J. Met. & Clim. Sci. 7:43-48 (2009)

2. METHODOLOGY

Three main approaches exist in establishing climate-agriculture relationships namely:

(a) The study of the fundamentals of plant-climate relationships,

(b) The study of agricultural data and climatic data for a number of places within a given area for as long a period as consistent records of both agriculture and climate allow deduction of agroclimatological relationship from the analyses of the data.

(c) By studying plant – climate relationship under controlled environment (Olaniran 1981).

The first method is adopted in this study. Experimental yam plot of 100 heaps was set up at NCAM located at kilometre 12 Ilorin-Idofian road. The heaps were prepared manually with hoe and mulched. The plot is sited in an upland farm area. This is because the above method of bed preparation and location of farm land are the common methods farmers adopted in the study area and study confirmed that this method of yam bed preparation is the best in the guinea Savanna ecological zone of Nigeria (Olarewaju 2007).

The research farm span two yam growing seasons of 2003/2004 and 2004/2005. Yam seeds were planted on 7/10/03 and 10/10/04 for both first and second seasons while harvesting of tubers occurred on 26/10/04 and 17/10/05 respectively.

All weather instruments used were manual and installed the date yam seeds were planted. They include rainguage, thermometer, soil thermometers, hygrometer and evaporimeter. Measurement of all weather variables was commenced immediately by a field assistant who works in the weather station of the institution (NCAM). Hand screw soil sampler was used to take soil sample at various depths. Climatic parameter measured include ;

(a) Mean annual and monthly air temperature (°C)

(b) Mean annual and monthly rainfall (mm)

(c) Number of rain days.

(d) Mean annual and monthly relative humidity (%)

(e) Soil temperatures at different depth intervals of 5cm, 10cm, 20cm and 30cm.

(f) Soil moisture at different depth intervals of 0-15cm and 15-30cm.

These soil depths represent the major zones of root and tuber development. Since our focus is on the identification of the period of each developmental stage, the physiological parameter measured is the total plant biomass. Two yam stand crops were randomly sampled once every four weeks starting from when sprouting of yam seed was noticed at 22WAP(Weeks After Planting) and run through 50WAP when yam tuber was harvested. Each growth organ is carefully separated and oven dried at a temperature of 110°c to a constant weight.

The data generated were tabulated and then partitioned based on the four phases of yam development and analysed using Pearson correlation to determine the strength of association between climatic variables and each phenological stage of yam plant.

3. RESULTS AND DISCUSSION

Yam Phenological Cycles in the Guinea Savanna Ecological Zone of Kwara state:

The results confirmed the overlaps of developmental stages as noted by Okonkwo (1998). The period for each of the four stages as identified are stated below.

(a) Root stage: Mid February-May (22WAP-30WAP)

(b) Vine stage: Mid February-June (22WAP-34WAP)

(c) Leaf stage: April-July (26WAP-42WAP)

(d) Tuber stage: June- September (34WAP-50WAP) (see table 2 and figure 1 below)

Table 2: the Dry Weights (g) of each organ of yam plant during its phenological cycle

Stages of development	22 WAP	26 WAP	30 WAP	34 WAP	38 WAP	42 WAP	46 WAP	50 WAP
Root	0.53	1.14	4.55	4.56	-	-	-	-
Vine	4.18	13.33	32.88	44.45	44.27	-	-	-
Leaf	-	3.03	12.95	71.57	89.41	87.54	82.02	
Tuber	-	-	-	1.07	228.58	440.90	2980.82	3055.49

Source: Olanrewaju, 2005. KEY: WAP=WEEK AFTER PLANTING.

Figure 1a: The Dry Weight of Yam Root during the Phenological Circle

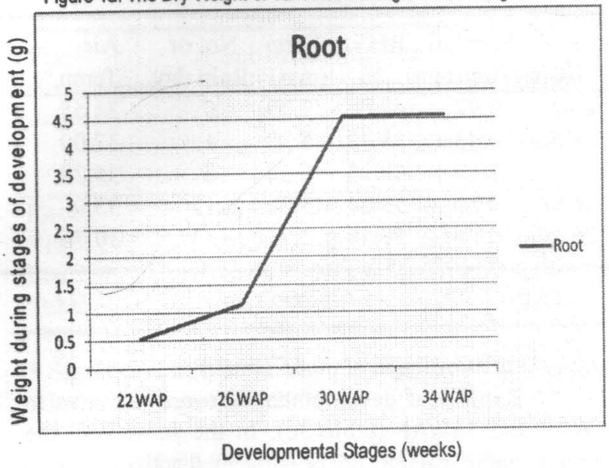


Figure 1c: The Dry Weight of Yam Leaf during the Phenological Circle

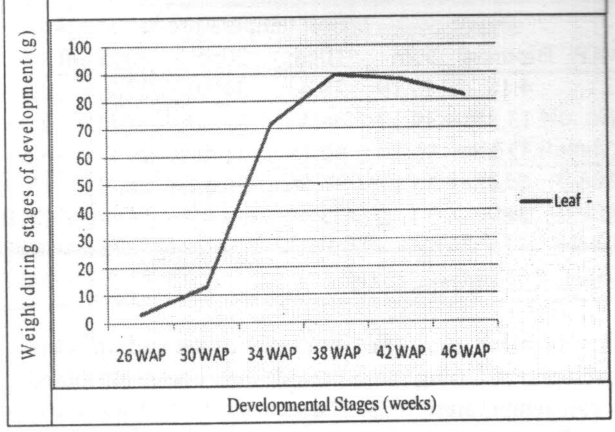


Figure 1b: The Dry Weight of Yam Vine during the Phenological Circle

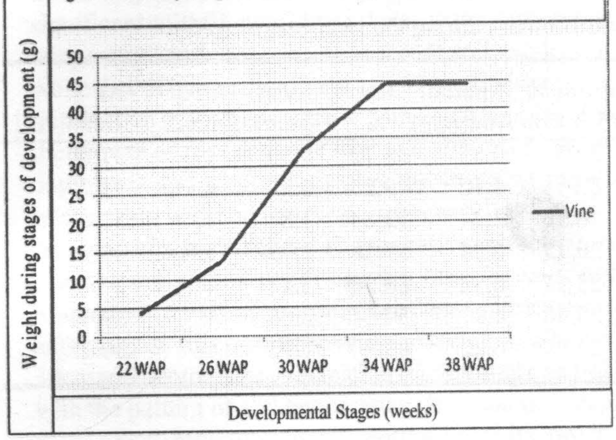
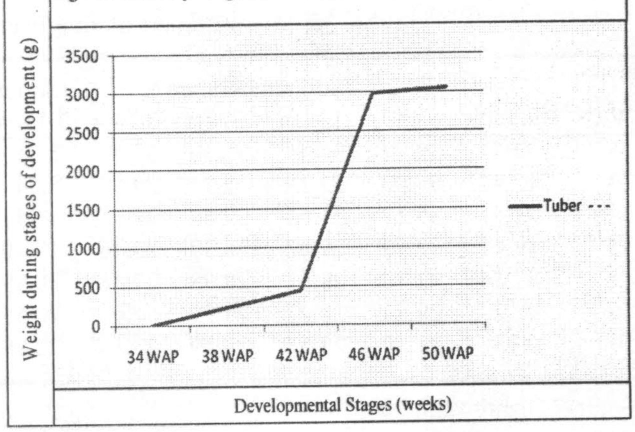


Figure 1d: The Dry Weight of Yam Tuber during the Phenological Circle



3.1 Microclimate of Yam Plant during Various Phenological Phases

The effects of the sub aerial and the aerial climate on each of the yam developmental stage are discussed in this section.

3.1.1 Root Development and the Microclimate

The dry weight increases from 0.53g observed at 22WAP to 4.56g at 34WAP. Soil temperatures at all depths fell but a rise in soil moisture and the moisture indices of the aerial climate of yam were observed. Yam root developed with greatest vigour between 26 WAP and 30 WAP when drastic temperature decline occurred at 5cm soil depth. Air temperature was high without displaying any specific pattern. It appears root development in yam is enhanced by high moisture and low thermal indices.

3.1.2 Vine Development and Climate

Soil temperature falls with depth over time. As soil temperature decreases vine dry weight increases. However between 30WAP and 34WAP soil temperature at 5cm depth witnessed almost similar values.

Table 3a: Shows the climatic patterns during the root stage of yam plant.

WAP	Biomass	Soil temperature °c 5cm	10cm	20cm	30cm	Soil moisture % 0-15cm	15-30cm	Rainfall Amt(mm)	RH %	Evap (mm)	No. of Rain day	Air Temp.°c
22	0.53	40.9	38.43	34.80	32.21	0.89	2.81	0.92	42.0	7.09	0	34.55
26	1.14	39.71	36.44	35.30	33.81	2.35	2.95	0.82	38.72	8.30	1	37.09
30	4.55	35.30	33.19	31.71	29.83	6.54	8.95	1.12	49.25	6.30	6	35.29
34	4.56	35.12	31.56	29.84	28.31	13.51	16.96	2.24	53.64	3.84	12	33.0

Source: Olanrewaju, 2005 key: WAP= Weeks After Planting.

Table 3b: Micro climate of yam plant and Biomass during the vine stage

WAP	Biomass	Soil temperature °c 5cm	10cm	20cm	30cm	Soil moisture % 0-15cm	15-30cm	Rainfall Amt(mm)	RH %	Evap (mm)	No. of Rain day	Air Temp.°c
22	4.18	40.19	38.43	34.80	32.21	0.89	2.81	0.92	42.0	7.09	0	34.55
26	13.33	39.17	36.44	35.30	33.81	2.35	2.95	0.82	38.72	8.30	1	37.09
30	32.88	35.30	33.19	31.71	29.83	6.54	8.95	1.12	49.25	6.30	6	35.29
34	44.45	35.12	31.56	29.84	28.31	13.51	16.96	2.24	53.64	3.84	12	33.0
38	44.27	32.12	29.42	29.37	26.66	17.10	20.17	6.94	57.58	2.75	13	30.76

Source: Olanrewaju, 2005 Key: WAP= Weeks After Planting

This implies that the increase observed in vine development during these periods may not be attributed to soil temperature at 5cm depth but to soil moisture, rainfall amount, relative humidity and number of raindays which were on the increase through the vine's phenological period.

3.1.3 Leaf Development and Climate

Rapid leaf development also occurs between 30WAP and 34WAP (table 3c). In the same vein the development of leaf may not be connected with the pattern of soil warming at 5cm depth during the period but rather on the soil moisture indices.

Table 3c: Micro Climate of Yam Plant and Biomass during the Leaf Stage

WAP	Biomass	Soil temperature °c 5 cm	10 cm	20 cm	30 cm	Soil moisture % 0-15cm	15-30cm	Rainfall Amt(mm)	RH %	Evap (mm)	No. of Rain day	Air Temp. °c
26	3.03	39.71	36.44	35.30	33.81	2.35	2.95	0.83	38.72	8.30	1	37.09
30	12.95	35.30	33.19	31.71	29.83	6.54	8.95	1.12	49.25	6.30	6	35.29
34	71.57	35.12	31.56	29.84	28.31	13.51	10.96	2.24	53.84	3.84	12	33.0
38	89.41	32.12	29.42	28.37	26.66	17.10	20.17	6.94	57.58	2.75	13	30.76
42	87.54	32.10	29.61	28.98	27.46	20.99	23.97	6.32	60.36	2.57	11	29.75
46	82.2	29.84	28.27	27.99	26.0	20.55	23.43	4.27	59.54	2.06	10	29.41
50	9.95	31.19	29.51	29.19	27.10	22.99	25.99	6.22	63.90	1.93	16	30.15

Source: Olanrewaju, 2005. key: WAP= Weeks After Planting

3.1.4 Tuber Development and climate

The tuber development and the micro climate of yam plant is displayed on table 3d below.

Table 3d: Micro Climate of Yam Plant and Biomass during the Tuber Stage

WAP	Biomass	Soil temperature °c 5cm	10cm	20cm	30cm	Soil moisture % 0-15cm	15-30cm	Rainfall Amt(mm)	RH %	Evap (mm)	No. of Rain day	Air Temp.°c
34	1.07	35.12	31.56	29.84	28.31	13.51	16.96	2.24	53.64	3.84	12	33.0
38	228.58	32.12	29.42	28.37	26.66	17.10	20.17	6.94	57.58.	2.75	13	30.76
42	440.9	32.10	26.61	28.98	27.46	20.99	23.97	6.32	60.36	2.57	11	29.75
46	2980.82	29.84	28.27	26.0	26.0	20.55	23.45	4.27	59.54	2.06	10	29.41.
50	3055.49	31.19	29.51	27.10	27.10	22.91	25.39	6.22	63.60	1.93	16	30.15

Source: Olanrewaju (2005) key: WAP= Weeks After Planting

Yam tuber developed with greatest strength between 42WAP and 46WAP (July and August). Thereafter the rate of tuber development slowed down. Soil temperatures at all depths fell while soil moisture rose throughout the tuber stage. Rainfall amount and frequency decline, air temperature also dropped to almost similar values during these months.

It appears the climatic variables that favour development in the first three stages of yam development inhibit it during the last stage. For instance, high moisture indices which encourage root, vine and leaf development hinder yam tuberization.

Table 4 below reflects the result of correlation between climatic variables and the biomass of various parts of yam plant that constitutes its phenological phases.

Table 4: correlation between climatic Variables and Biomass of Various Yam Organs.

Yam phenological stages	Sub aerial microclimate Soil temperature at various depth (°C)				Soil moisture at various depth (%)		Aerial microclimate			
	5cm	10cm	20cm	30cm	0-15cm	15-30cm	Rain (mm)	RH E (%)	vap (mm)	No. of Raindays
Root	-0.99**	-0.96**	-0.93**	-0.89**	+0.86**	+0.86**	+0.70**	+0.91**	-0.77**	+0.80**
Vine	-0.94**	-0.81**	-0.95**	-0.90**	+0.93**	+0.94**	+0.64**	+0.92**	-0.80**	+0.90**
Leaf	-0.56*	-0.64**	-0.73**	-0.68**	+0.55*	+0.59*	+0.56*	+0.50*	-0.63**	+0.40
Tuber	-0.78**	-0.18	-0.39	-0.31	+0.74**	+0.72**	+0.26	+0.72**	-0.82**	+0.80**

* Significant at 0.05 level. ** Significant at 0.01 level.
Source: Olanrewaju, 2005

The type and strength of relationships displayed by variables confirmed the previous findings. Each phase of yam plant is affected negatively by soil temperatures at all depths. A very strong negative relationship significant at 0.01 confidence level exists between soil temperature and root, vine and tuber at soil depth of 5cm while that of leaf is significant at 0.05 confidence level. It implies that soil temperature at 5cm depth suppress more the growth of root and vine than leaf and tuber. At 10cm depth root and vine still display the strongest negative relationship with soil temperature but very weak negative relationship with tuber. The negative effect of soil temperature at this depth on yam tuber is very mild. Similar pattern of relationship between soil temperature and biomass discussed above is sustained at 20cm and 30cm soil depths. The explanation for this might be linked with the pattern of soil temperature decrease with depth.

Soil moisture at all depths exhibits positive relationships with all phases of yam growth that is, as soil moisture rises, the growth of yam plant increases in the study area.

Rainfall amount displayed a very strong positive relationship, which is significant at 0.01 level of confidence with root and vine development. While positive relationship established with leaf is significant at 0.05 confidence level. Weak positive relationship exists between rainfall amount and tuber growth. But rainfall frequency (No of rain day) displayed a strong positive relationship with root, vine and tuber stages. These findings support the assertion of Bello (1986), that for yam to reach its optimum yield the amount of rainfall received is not as important as its distribution. Okuewu (2002) noted that rainfall must be well distributed throughout the year for yam to perform optimally.

High evaporation rate and high air temperature retarded the growth of yam plant. Vine and tuber stages showed the strongest negative relationship with evaporation rate. This is followed by root and leaf stages. Every other stages of yam development showed a strong negative relationship with air temperature but Root stage is least affected.

4. CONCLUSION

High air and soil temperature suppress yam growth. Indira (1998) discovered that yam requires air temperature range of 25-30°c for its optimum performance in field. Similarly high evaporation rate inhibits growth. High soil moisture at all depths considered enhanced development of all yam stages. Increase in rainfall amount results in rapid growth of root, vine and leaf but tuber development showed a weak positive relationship. Increase in rain frequency enhanced tuber development.

From this study, it is evident that the most delicate and sensitive phases of the yam phenological cycle is root and vine. They displayed the strongest relationships with the micro climatic variables. They exhibit negative relationships with all thermal indices and positive relationship with moisture indices. Farmers in the study area are encouraged to improve on the materials used in mulching since mulching minimises fluctuations in soil temperature, improve infiltration and raises soil moisture reserve.

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