Journal of Biodiversity and Ecological Sciences
(JBES©)
Vol. 3, Issue 4
ISSN: 2008-9287
Fall 2013

Original Article

Water use, growth and yields of irrigated plantain in Southwest Nigeria

A. O. Akinro[1,2*], A. A. Olufayo[2], P. G. Oguntunde[2], M. O. Olaniyi[3]

[1]*Department of Civil Engineering, Rufus Giwa Polytechnic, Owo, Nigeria*
[2]*Department of Agricultural Engineering, Federal University of Technology, Akure, Nigeria*
[3]*Department of Crop, Soil and Pest Management, Federal University of Technology, Akure, Nigeria*

***Corresponding Author:**
akinroakinola@yahoo.com

ABSTRACT

Field experiments were carried out for three years to investigate the productivity response of plantain (*musa paradisiaca L.* spp, AAB Subgroup) cultivar Agbagba to water application via low gravity drip irrigation system. There were four treatments and four replicates based on the level of water application as follows: no deficit irrigation, T_{100}, (i.e maintained at near field capacity or 100% available water); 50% deficit irrigation, T_{50}, (i.e maintained at 50% available water); 75% deficit irrigation, T_{25}, (i.e maintained at 25% available water) and the control treatment, T_0, which represented rainfed cropping system. Supplemental irrigation had significant effect ($p<0.05$) on biomass yield. Estimated water consumed ranged from 900 mm to 1700 mm from planting to harvest depending on the level of irrigation treatment. Growth in the T_{100} treatment was enhanced than other treatments. For example, stem height was 256 cm to 202 cm in T_0. Results also showed that plantain biomass and bunch yields were significantly different in irrigated treatments as compared to T_0. Average biomass yields of T_{100} were 23.2 and 24.4 tha^{-1} for 2006-2007 and 2007-2008 seasons respectively and the fresh bunch yield (which is the principal yield component of plantain with commercial value) for T_{100} were 10.2 and 12.9 tha^{-1} in contrast to 3.9 and 4.4 tha^{-1} for T_0 treatment for the two seasons. These results showed that plantain yields respond significantly to irrigation.

KEYWORDS: Supplementary Irrigation; Water Deficit; Available Water; Rainfed Cropping; Growth And Yield**.**

INTRODUCTION

Plantains like the bananas belong to the *Musaceae*. They are giant perennial grasses resulting from intra- and interspecific hybridization of two diploid forest species: *Musa acuminata* (banana) and *M. balbisiana* (plantain). They constitute the fourth most important arable crop. Africa and Latin America produce 74.2% and 22.5% of world production in comparison with 3.3% in Asia (FAO, 1999). Plantains flourish in tropical regions and are the most important carbohydrate source in local economies (Stover and Simmonds, 1987). Plantain cultivation has become very important for food security and job creation in developing countries (Rodríguez Saavedra *et al.* 1999; INFOMUSA, 2001). In West and Central Africa about 70 million people are estimated to depend on *Musa* fruits for a large proportion of their daily carbohydrate intake (Rowe, 1998).

In Nigeria plantains and bananas are both important staples and sources of income for subsistence farmers. There has been increasing trend towards large-scale production of the crop (Obiefuna, 1986) in the traditional humid rainforest production zone and some emergent production zones in the sub-humid areas of southeastern Nigeria (Baiyeri and Mbah, 1994; Baiyeri and Ajayi, 2000). However most of the increases in plantain production have been due to cropland expansion, rather than increases in yield *per* hectare.

Water is probably the most limiting non-biological factor in plantain production (Bassoi *et al.*, 2004). Water requirements of this crop are influenced by the effective rainfall and irrigation, and the proportion of water for plantain derived from these two sources varies widely throughout the world (Robinson, 1995). Plantain has been known as a plant with a rapid growth rate, high consumption of water, shallow and spreading root distribution, roots with weak penetration strength into the soil (Champion, 1968), low resistance to drought and rapid physiological response to soil water deficit (Robinson, 1995). Although much research has been conducted on this crop (Asoegwu and Obiefuna, 1987; Hedge and Srinivas, 1990;1989; Robinson and Alberts, 1989; Geonaga *et al.*, 1995; Bassoi *et al.*, 2004). Little documented evidence exists to indicate the manner in which the plantain plant is able to tolerate long periods of water shortage or respond to irrigation.

Plantain is sensitive to slight variations in soil water content and hence proper irrigation scheduling is critical. Studies have shown that soil water deficits resulted in reduced crop growth and yield. (Turner, *et al*., 1986; Ball *et al*., 1994; Gerik *et al*., 1996). Leaf photosynthesis is also reduced when plants are grown under moisture deficit conditions because of a combination of stomatal and non-stomatal limitations (McMichael and Hesketh, 1982; Ephrath et al., 1990; Faver *et al*., 1996). Photosynthetic activity in plantain decreases with reduction of transpiration and stomata aperture (Robinson and Bower, 1987; Eckstein *et al*., 1995; Eckstein and Robinson, 1996) and hence reduction in yield.

In recognition of its importance, plantain was selected as one of the priority crops in West and Central Africa. However, average plantain yields in this region are below 10 t/ha, considerably lower than yields in Latin America and the Caribbean, where improved technologies have been adopted (INFOMUSA, 2001). For the technology to succeed in West and Central Africa, farmers should be able to irrigate in order to support the high evapotranspiration needs of the high density planting. Thus the need to conduct field trails to render the technology applicable under the bio-physical and socio-economic conditions of West and Central Africa was recommended (INFOMUSA, 2001). However, for precise water application, there is need for data on the effects of variable irrigation on growth, yield and water use of plantain for good water management strategies and improved productivity. The objective of this study, therefore, was to investigate the growth and yield response of plantain to three contrasting irrigation treatments in addition to rainfed condition and also to determine the water yield relationships.

MATERIALS AND METHODS

EXPERIMENTAL SITE

Field experiments were conducted on *musa* during the years 2006-2007 and 2007-2008 at the Experimental Farm of the Department of Agricultural Engineering, Federal University of Technology, Akure, South west Nigeria which lies at latitude 7^o 16’ North and longitude 5^o 13’ East at an altitude of 351 m above mean sea level. The site falls within the tropical humid climate with two major seasons: the wet or rainy season which is often erratic and the dry season which lasts for a period of 4-5 months. The mean annual rainfall is about 1500 mm while the minimum and maximum temperatures are about 20^{o}C and 30^{o}C. Some physical characteristics of the soil and chemical characteristics of irrigation water are shown in Tables 1 and 2. The soils at the research site are light textured, fine sandy loam to fine sandy clay loam.

Table 1. Some physical characteristics of experimental soil

Bulk density (gcm^{-3})	1.50
Field capacity (%)	20.60
Wilting Point (%)	3.43

Table 2. Some chemical characteristics of irrigation water

Conductivity (µmhos)	pH	Cations (ppm)				Anions (ppm)			SAR	CEC	ESP
		Na	K	Ca	Mg	SO_4	NO_3	Cl			
1.2x10^2	5.9	60.1	64	11.3	18	ND*	ND	0.18	15.7	0.05	19.06

*not detected

Table 3. Summary of Irrigation Treatments

Treatment	Code	Definition
High (full)	T_{100}	0% deficit irrigation
Moderate	T_{50}	50% deficit irrigation
Low	T_{25}	75% deficit irrigation
Control	T_0	Control experiment

EXPERIMENTAL DESIGN, TREATMENTS AND MEASUREMENTS

Suckers of plantain, cultivar Agbagba (*musa paradisiaca* spp. AAB) were planted and established between July 2006 - November 2007 and August 2007 – November 2008 in a 4 x 4 Randomized Complete Block Design. The treatments were based on four different levels of water application: no deficit irrigation called T_{100} (maintained at near field capacity i.e. 100% available water), 50% deficit irrigation, T_{50}, (maintained at 50% available water), 75% deficit irrigation, T_{25}, (maintained at 25% available water) and the control treatment, T_0, was not irrigated except during crop establishment. The planting density was 1,921 plants ha^{-1}. Weeds were controlled by spraying 0.5kg ha^{-1} active ingredients of Primextra 660SC (S-2 chloro-N-2-ethyl-6-6-methyl-phenyl) –N (2-methoxy-1-methylethl) -acetamide and R-isomers) 7 days prior to planting. Subsequently the experimental plots were kept weed free by manual weeding. Fertilizer NPK 12-12-17=2% MgO was applied four months after planting at a rate of 300 kg ha^{-1} of 12-12-17 N, P, K respectively. Water stored between the field capacity and the permanent wilting point is the maximum available water (i.e. 100%AW) and it is expressed as:

$$\text{Total Available Water (AW)} = \sum_{d=0}^{d=50} S_{up} - \sum_{d=0}^{d=50} S_{lo} \qquad (1)$$

where S_{up} and S_{lo} are the upper and lower limits of soil storage.

The consumptive use of water by the crop was estimated using the water balance equation

$$\mathbf{ET = I + P \pm \Delta S \pm R \pm D} \qquad (2)$$

where ET = actual evapotranspiration in mm; I = amount of irrigation water (mm); P = effective rainfall (mm); ΔS = change in soil water storage (mm); R = surface runoff, (mm) and D = amount of drainage water (mm).

Water was applied using low gravity bucket irrigation system and emitters were spaced along polyethylene lines with stopcock controls at each end of the line to control the timing and quantity of water applied. Irrigation amount was recorded at every water application. The change of soil water storage, ΔS was estimated from moisture content readings up to a depth of 50 cm which was assumed to be the root zone. Runoff was estimated using runoff meters. The drainage below root zone was estimated using Darcy's equation. A Watermark Soil Moisture Sensor and the Multipurpose Temperature Probe used with the Vantage Pro2 wireless soil moisture /Temperature station was installed on the experimental field to monitor the soil moisture and soil temperature. Soil moisture contents were also determined by gravimetric method. This was measured in each treatment plot to depths of 50 cm at 10 cm interval starting from the soil surface. Rainfall data were collected using standard rain gauges installed at various points of the experimental farm. The rain gauges were regularly raised above crop canopy to avoid errors due to rainfall interception. Reference evapotranspiration (ET_{ref}) was calculated using monthly temperature, humidity, solar radiation and wind speed according to the FAO Penman Monteith Method (Allen *et al*., 1998).

Growth analysis was carried out monthly by harvesting plant material from randomly selected plots of each treatment. Samples were taken in all replicates. Plants were harvested and separated into dry leaves, wet leaves, pseudostem, corm, and fruits. The fresh and dry mass of each sample were determined. Dry matter of plants organs were determined by drying samples in an oven at 65^0C for 48hrs. Weekly measurements of plant height, girth, circumference, fruit size, of *musa* were made beginning from the vegetative stage to the maturity stage. The leaf area index (LAI) was determined weekly from a selected representative plant. Length (L) and the maximum width (W) of each leaf were measured from which the leaf area was computed following the method of Obiefuna and Ndubizu (1979)

$$\text{Leaf Area (LA)} = 0.83LW$$

Leaf area index was then estimated from the relationship below (Gong *et al*., 1995):

$$\text{Leaf Area Index (LAI)} = \frac{\text{Area of leaf per plant}}{\text{Area of soil covered per plant}}$$

Bunch yield and dry matter yield were determined at maturity.

RESULTS AND DISCUSSIONS

ENVIRONMENTAL CONDITIONS AND SOIL MOISTURE CONTENT

The mean monthly relative humidity (Fig.1) was least in January (47%) and peaked up to 88% in the month of August. There was a reduction in the relative humidity from the month of September through November coinciding with the vegetative period of the plantain crops. It then remained constant at about 68% at the onset of the harmattan in November. Rainfall showed a bimodal distribution pattern with peaks around June and September of the respective seasons. Monthly total value was higher for 2008. The reference ET for the month of July, 2007 (when the first season cropping began) was 2.11 mm/day. This is expected as the period coincides with the rainy season with relatively high humidity. Planting was done during this period to enable the crops to be well established.

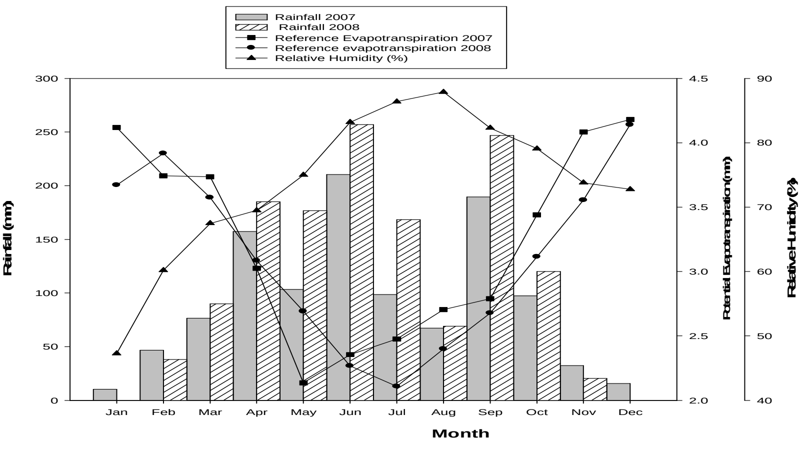

Fig. 1. Rainfall, relative Humidity and Potential Evapotranspiration at the experimental site

The variation in the volumetric soil moisture content up to a depth of 50 cm is shown in Fig. 2. It was observed that moisture content values were dynamic i.e. varied with depths of the root zone, days after planting, seasons of the year and irrigation treatments. In most cases, moisture content values increased gradually up to a depth of 20 cm but rose sharply from depth 30 cm to 50 cm. Frequent irrigation resulted in a significant ($p<0.05$) higher water content in the soil profile. The moisture contents under T_{100} were remarkably higher than those under the control treatments (T_0). Values under the other treatments (T_{50} and T_{25}) were between the two extremes. Although difference in moisture content under low irrigation treatment (T_{25}) and the control experiment was not significant ($p>0.05$) during the wet season of the year, the difference became significant during the dry season of the year when water was completely excluded from the control plots. The soil moisture contents at depths 40 cm to 50 cm were not significantly different.

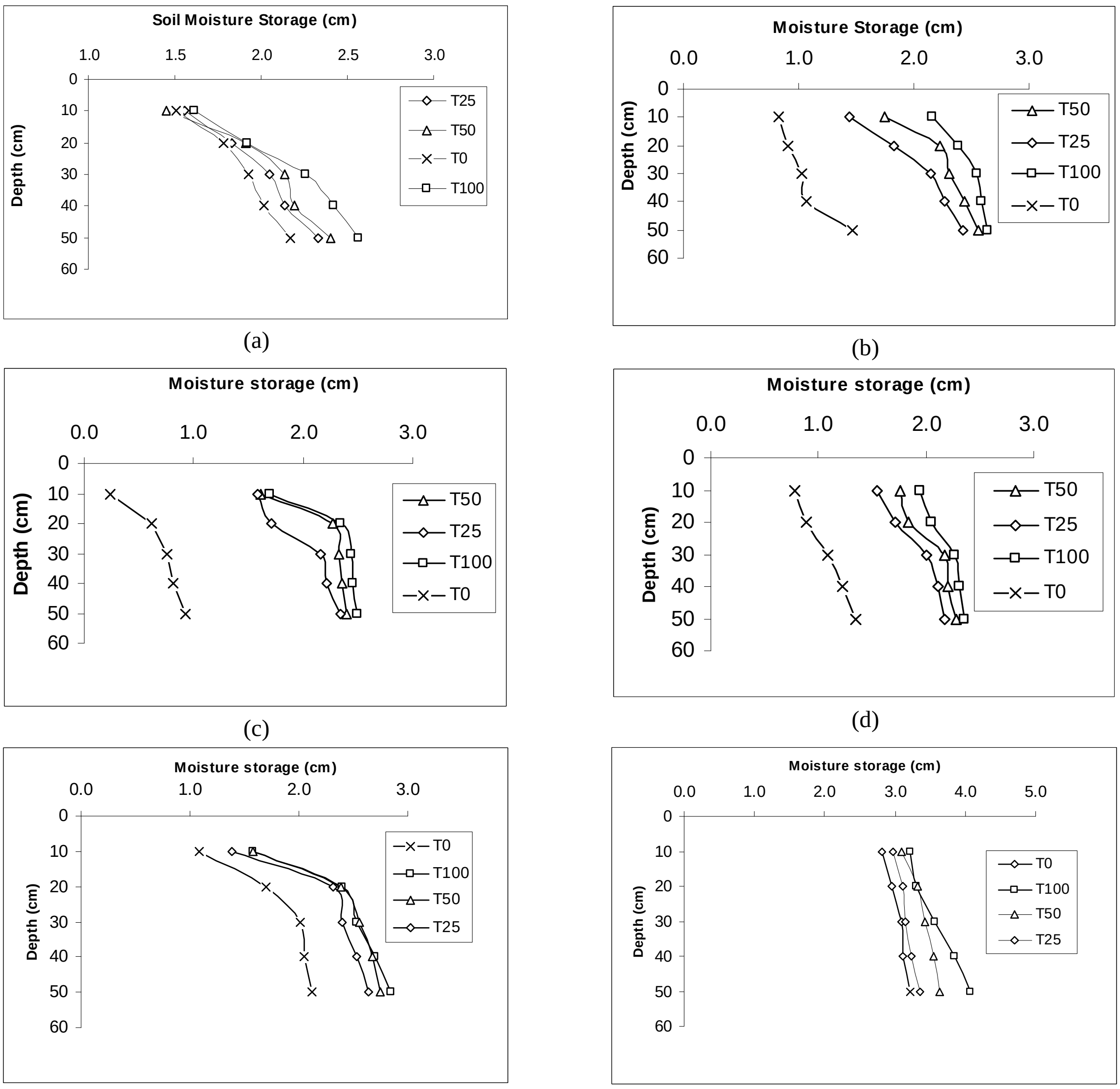

Fig. 2. Soil moisture storage within the root zone on (a) 12th July, 2006 (b) 20th Nov. 2006, (c) 28th Jan. 2007 (d) 22nd Feb. 2007 (e) 5th April, 2007 (f) 17th July 2007

The variations in soil moisture accumulation at different crop phonological stages are shown in Figure 3. Stored water was lowest under the control (T_0) experiment throughout the crop growth stages. The total storage values under the medium (T_{50}) and full (T_{100}) irrigation treatments during the growth period were significantly different at 5% level; their values being 216.8 and 234.4 cm respectively. The total storage values of the other two treatments (T_{25} and T_0) lie between the two extremes. It was also observed that the lowest soil moisture storage under the control experiment was 3.47 cm at 219 DAP. This period fell within the vegetative period and dry season period (month of February). The highest value of 14.96 cm was observed in the T_0 treatment at 400 DAP which fell into the fruit bulking stages of the crop. Depletion in soil moisture was highest between 7th December - 27th March (141-260 DAP) and the difference in soil moisture storage was only a reflection of the amount of water used during irrigation on each plot. Plot that received full irrigation stored more moisture than other treatments. The soil moisture storage value increased sharply between April and August 2007 (271-400 DAP) and this coincides with the raining season of the study location.

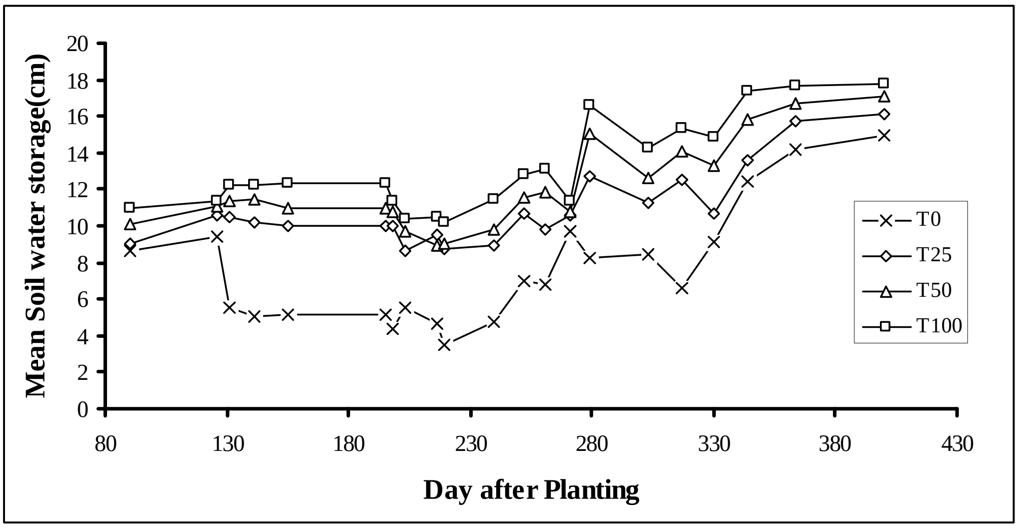

Fig. 3. Water held (cm) in the 50cm crop root zone for treatments T_0, T_{25}, T_{50} and T_{100} during the period of the experiment.

YIELD AND YIELD COMPONENTS

Plantain yield distribution analysis was carried out by considering the fresh and dry weights of the crop separately following Goenaga *et al.* (1989). The fresh weight enables the marketable components of the crop to be evaluated. Tables 4-7 show the effects of irrigation on fresh and dry weight of plantain crop components during the 2006-2007 and 2007-2008 field experiments. The fresh and dry above ground weight of plantain produced in the two seasons (Table 4) are highest in T_{100} treatment and lowest in T_0 treatment. The values of the other two treatments lied between these two extremes. In the first season, the highest value of 32.38 (±4.98) tha^{-1} was obtained in T_{100} with the T_0 treatment having the least yield of 15.57 (±2.43) tha^{-1} for fresh below ground biomass (Table 5). The result for 2007-2008 experiment showed that T_{100} had the highest value of 34.94 (±4.27) tha^{-1}. The trend was not different for the below ground dry weight. In the case of fresh and dry plantain biomass weight (Table 6) yield values of T_{100} treatment were highest with 207.05 (±19.98) and 245.97 (±14.7) tha^{-1} for 2006-2007 and 2007-2008 (Table 8) respectively. The yield value of the T_{50} treatment was 156.19 (±12.42) tha^{-1} which is about 75% of T_{100} in 2006-2007. The control treatment T_0 had the lowest fresh weight of 53.88 (±10.72) tha^{-1} which is about 26% of T_{100} in 2006-2007. The trend was the same under the 2007-2008 experiment. In respect of the dry biomass weight of the plantain crop during the experimental periods, in the first season, the highest mean yield value of 23.22 (±2.17) tha^{-1} was obtained in the T_{100} treatment. Values of 15.2 (±0.69), 12.63 (±0.33) and 8.25 (±2.17) tha^{-1} were obtained for T_{50}, T_{25} and T_0 treatments. During the 2007/2008 experiment, the highest value of 24.44 (±1.78) tha^{-1} was obtained in the T_{100}. The least dry biomass weight was obtained in T_0 with a value of 8.80 ((±0.59) tha^{-1}.

Table 4. Fresh and dry above ground biomass weight of plantain produced during the 2006/07 and 2007/08 Experiments

	Fresh above ground weight (tha^{-1})		Dry above ground weight (tha^{-1})	
Treatment	2006-2007	2007-2008	2006-2007	2007-2008
T_{100}	174.66 (±20.3)*a	211.03 (±13.8)a	15.93 (±0.9)a	16.08 (±1.4)a
T_{50}	133.19 (±15.2)b	153.66 (±12.7)b	13.29 (±1.2)b	13.75 (±0.8)b
T_{25}	95.81 (±14.9)c	106.64 (±10.4)c	9.92 (±0.6)c	10.64 (±0.7)c
T_0	38.31 (±8.4)d	39.32 (±3.8)d	6.17 (±0.6)d	7.44 (±0.7)d
LSD (0.05)	22.93	16.32	1.26	1.37

*Numbers in parenthesis show the standard deviations. Mean Values in the same column followed by different letters indicate significant differences according to Duncan's comparison of means at 5% level

Table 5. Fresh and dry below ground biomass weight of plantain (tha^{-1}) produced during the 2006/07 and 2007/08 Experiments

	Fresh below ground weight		Dry below ground weight	
Treatment	2006-2007	2007-2008	2006-2007	2007-2008
T_{100}	32.38 (±4.9)*a	34.94 (±4.3) a	6.03 (±0.3)a	7.45 (±1.3)a
T_{50}	23.01 (±3.2)b	25.33 (±2.3)b	4.43 (±0.9)ab	5.41 (±0.9)b
T_{25}	19.66 (±2.3)bc	21.26 (±2.0)b	3.81 (±1.5)b	4.40 (±0.3)bc
T_0	15.57 (±2.4)c	16.09 (±1.1)c	3.59 (±1.6)b	3.62 (±0.5)c
LSD (0.05)	7.80	4.00	1.86	1.30

*Numbers in parenthesis show the standard deviations. Mean Values in the same column followed by different letters indicate significant differences according to Duncan's comparison of means at 5% level

Table 6. Total fresh and dry biomass weight of plantain (tha^{-1}) produced during the 2006/07 and 2007/08 Experiments

	Fresh biomass yield		Dry biomass yield	
Treatment	2006-2007	2007-2008	2006-2007	2007-2008
T_{100}	207.05 (±20.0)*a	245.97 (±14.7)a	23.22 (±2.2)a	24.44 (±1.8)a
T_{50}	156.19 (±12.4)b	178.99 (±11.2)b	15.24 (±0.7)b	16.45 (±0.7)b
T_{25}	115.47 (±16.3)c	127.90 (±11.2)c	12.63 (±0.4)c	14.16 (±1.1)c
T_0	53.88 (±10.7)d	55.41 (±4.9)d	8.25 (±2.1)d	8.80 (±0.6)d
LSD(0.05)	22.92	16.58	1.75	1.72

*Numbers in parenthesis show the standard deviations. Mean Values in the same column followed by different letters indicate significant differences according to Duncan's comparison of means at 5% level

Table 7. Fresh and dry plantain bunch weight (tha^{-1}) produced during the 2006/07 and 2007/08 Experiments

	Fresh plantain bunch weight		Dry plantain bunch weight	
Treatment	2006-2007	2007-2008	2006-2007	2007-2008
T_{100}	64.63 (±8.7)*a	69.66 (±7.3) a	10.18 (±0.2)a	12.89 (±2.3)a
T_{50}	45.86 (±14.1)b	53.12 (±7.4)b	6.96 (±0.8)b	7.52 (±0.7)b
T_{25}	29.61 (±7.7)c	36.55 (±3.7)c	5.52 (±0.6)c	6.41 (±0.8)bc
T_0	11.28 (±3.7)d	12.91 (±2.5)d	3.85 (±0.4)d	4.37 (±0.9)c
LSD (0.05)	14.00	4.00	0.83	2.04

*Numbers in parenthesis show the standard deviations. Mean Values in the same column followed by different letters indicate significant differences according to Duncan's comparison of means at 5% level

Table 8. Summary of plant growth characteristics

Treatment	Stem height (cm)	Stem girth (cm)	Number of leaves		
			Emerged	Functional at flowering	Functional at harvesting
T_{100}	256a	14.9a	35a	13a	4a
T_{50}	245a	14.2a	32ab	9b	3ab
T_{25}	217b	12.8b	28b	8b	3b
T_0	202c	8.0c	15c	6c	1c

Mean Values in the same column followed by different letters indicate significant differences according to Duncan's comparison of means at 5% level

The fresh weight of plantain bunch produced for both seasons are shown in Table 7. In the first season, the highest yield of 64.63 (±8.70) tha^{-1} was obtained in the T_{100} treatment. T_0 had 11.28 (±3.71) tha^{-1} during the growth period. The yield was also higher in the T_{100} treatment for the second season with value of 69.66 (±7.38) tha^{-1}. The T_{100} yields represent an increase of about 6 times over the rainfed (control) for 2006/07 and 2007/08 seasons, respectively. Goenaga and Irizarry (1998) reported the highest yield of 76.20 tha^{-1} in a similar field experiment under drip irrigation system in Puerto Rico. In another experiment, a value of 58.20 tha^{-1} have been reported (Irizarry and Goenaga 1995). Bassoi *et al.*, (2004) reported a range of 10.8-15.5 tha^{-1} in a similar experiment in Brazil. Dry weight of plantain bunch produced during the first season was highest in T_{100} with a value of 10.18 (±0.23) tha^{-1} and least in T_0 with a value of 3.85 (±0.41) tha^{-1} similarly for the second season experiment.

PLANT GROWTH CHARACTERISTICS

Table 8 shows the summary of the pseudostem height and girth, emerged leaf, functional leaf at flowering and at harvest. The pseudostem girths vary from 8.0 cm to 14.9 cm from T_0 to T_{100}. Similarly, T_{100} showed the highest number of emerged leaf during the experimental period of 2006-2007 and 2007-2008. Their values were not significantly different to T_{50}. T_0 had the least number of emerged leaves. This can be attributed to low water uptake during the vegetative cycle. T_{100} had the highest number of functional leaves at flowering. T_0 had the least mean number of functional leaves at harvest. The number of functional leaves over time is a function of the relationship between the rates of leaf emergence and abscission, which in turn determine the number of leaves that the plant has at the time of flowering (Aristizábal *et al.*, 1988) provided plants do not suffer from lack of water, disease, or nutrient deficiency.

Functional leaves after flowering does not differ significantly ($p<0.5$) for irrigated treatments. The number of functional leaves at harvest is a good indicator of resistance or susceptibility to black leaf streak disease, and there is a positive correlation between the number of functional leaves at harvest and bunch weight (Álvarez, 1997)and can used as fire softened plantain leaves for the agrifood industry (InfoMusa, 2001.

The seasonal trends and patterns of leaf area index (LAI) evolution during crop growth and development is shown in Fig. 4. The rainfed treatment, T_0 showed the lowest values of LAI whereas T_{100} has the highest LAI. At the peak period which corresponds to the flowering stage of the crops the value of LAI varied between 3.02 m^2m^{-2} and 5.63 m^2m^{-2} at 240 DAP. There were increase in the LAI from the development stage and reached the peak at flowering /fruit filling stage. There was a reduction in the LAI from the fruit filling stage down the harvest stage when bud differentiation occurs and leaf emergence decreases (Turner, 1998). The observed seasonal pattern in plantain LAI was similar to other crops. Others have reported similar pattern of LAI in different species (Oguntunde and van de Giesen, 2004; Oguntunde et al., 2007). The observed lowest values of LAI in T_o at different growth stages confirms previous studies that water stress imposed at any stage of crop growth reduces leaf area expansion and leaf area duration (Kagabo, 2006).

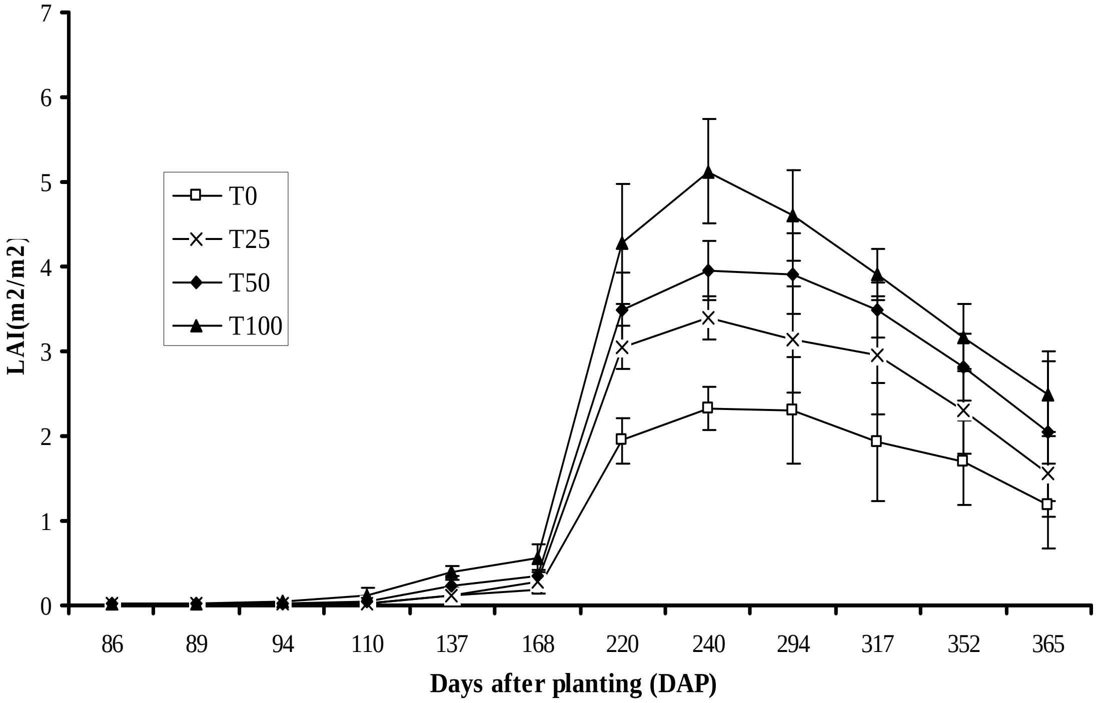

Fig. 4. The seasonal pattern of leaf area index (LAI) for plantain exposed to different irrigations.

YIELD AND CONSUMPTIVE USE OF WATER

The relationship observed between the measured consumptive use, biomass and bunch yields for each treatment are presented in Tables 9 and 10. Estimated water consumed ranged from 900 mm to 1700 mm from planting to harvest depending on the level of irrigation treatment. In the fully irrigated treatment (T_{100}), crop at harvest i.e 413 DAP consumptive use was 1691.5 mm while crop consumptive use was 910.7 mm at same period for treatment T_0. Correspondingly, highest biomass yield was 23.2 tha^{-1} at harvest for T_{100} treatment while lowest value of biomass yield was 8.3 tha^{-1} in T_0 treatment. The trend was the same during the 2007-2008 season. The consumptive water use was significantly different in all the treatments. Plantain yield increased in all the treatments in 2008 in response to increased water availability through both rainfall and supplemental irrigation. This showed that supplemental irrigation had significant effect ($p<0.05$) on biomass and bunch yields.

Table 9. Biomass yield and consumptive use under different irrigation regimes for plantain during the growth seasons in 2006-2007 and 2007-2008

Treatment	Biomass yield (tha^{-1})	Water applied (mm)	Rainfall (mm)	**CU (mm)
2006-2007 Experimental season				
T_{100}	23.15 (±2.1)	581.7	850	1691.5
T_{50}	15.21(±1.8)	467.2	850	1254.3
T_{25}	12.63(±1.3)	447.5	850	1157.1
T_0	8.25(±1.2)	-	850	910.7
2007-2008 Experimental season				
T_{100}	24.44 (±1.8)	605.3	927	1734.4
T_{50}	16.45 (±0.7)	517.2	927	1328.6
T_{25}	14.16 (±1.1)	489.6	927	1197.3
T_0	8.80 (±0.6)	-	927	975.8

*Numbers in parenthesis show the standard deviations
******CU = consumptive use

Table 10. Bunch yield and consumptive use under different irrigation regimes for plantain during the growth seasons in 2006-2007 and 2007-2008

Treatment	Bunch yield (tha^{-1})	Water applied (mm)	Rainfall (mm)	**CU (mm)
2006-2007 Experimental season				
T_{100}	10.21 (±2.6)	581.7	850	1691.5
T_{50}	6.96 (±0.8)	467.2	850	1254.3
T_{25}	5.47 (±1.3)	447.5	850	1157.1
T_0	3.85 (±1.2)	-	850	910.7
2007-2008 Experimental season				
T_{100}	12.89 (±2.3)	605.3	927	1734.4
T_{50}	7.52 (±0.7)*	517.2	927	1328.6
T_{25}	6.41 (±0.8)	489.6	927	1197.3
T_0	4.37 (±0.9)	-	927	975.8

*Numbers in parenthesis show the standard deviations
**CU = consumptive use

CONCLUSION

The responses of plantain to water application via low gravity drip irrigation were observed in the biomass and bunch yields, growth and water use. Significant increases in yield and its components were obtained with increases in water application up to about three times. Although, increases in yields were due to increase in supplemental irrigation amounts, higher amount of rainfall regime in 2007/2008 resulted in higher yields in 2006/2007 irrespective of the irrigation treatment. It was also observed that the reference evapotranspiration was generally lower in 2007/2008 than in the previous season. Plantain water use and growth also influenced by the soil moisture regimes. These results confirmed the fact that plantain crop is sensitive to water application and hence require supplemental irrigation in order to produce higher yields.

ACKNOWLEDGEMENTS

Authors acknowledge the assistance of the management of Rufus Giwa Polytechnic, Owo, Nigeria and the Federal University of Technology, Akure, Nigeria for financial assistance and the use of the research farm and facilities.

REFERENCES

Allen, R.G., Pereira, L.S., Raes, D., Smith, M., 1998. *Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements.* FAO Irrigation and Drainage Paper. No 56. FAO, Rome. 300p.

Álvarez, J., 1997. Introduction, evaluation, multiplication and dissemination of FHIA hybrids in Cuba. Infomusa 6, 10-14.

Aristizábal, L.M., Rodriguez, L.R., Tabrda. M.I., 1988. Análisis del crecimiento producción del plátano (Musa AAB cv. Dominico) en diferentes densidades de siembra. Cenicafé, pp16-23. In: Herrera, J.W.M., Aristizábal, L.M; 2003. Characterization of the growth and production of some plantain hybrids and cultivars in Colombia. Infomusa, Vol. 12 No.2. pp 22-24.

Atteya, A.M., 2003. Alteration of water relations and yield of corn genotypes in response to drought. Bulg. J. Plant Physiol. 2961-2, 63-76.

Asoegwu, S.N., Obiefuna, J.C., 1987. Effect of irrigation on late season plantains. tropical agriculture 64(2):139-143.

Ball, R.A., Oosterhuis, D.M., Mauromoustakos, A., 1994. Growth dynamics of the cotton plant during water deficit stress. Agron. J. 86:788-795.

Bassoi, L.H., Teixeira, A.H., Eilho, J.M.P., Silva, J.A.M., Silva, E.E.G., Ramos, C.M.C., Sediyama, G.C., 2004. Guidelines for Irrigation Scheduling of Banana Crop in Sảo Fransisco valley, Brazil. II – Water consumption, Crop Coefficient and Physiolgical Behaviour. Rev. Bras. Frutic, Jaboticabal – SP. 26, 464-467.

Baiyeri, K.P., Ajayi, A.R., 2000. Status and constraints of *musa* spp. production in a subhumid zone of Nigeria. Proceedings of International Conference on banana and plantain, Kampala, Uganda, July, 2000. Available at http//www.actahort.orq./books/540.

Baiyeri, K.P., Mbah, B.N., 1994. Growth and yield correlation in Falsehorn plantain (*Musa* AAB cv. Agbagba) in a sub-humid zone of Nigeria. MusAfrica 5:3-4

Calvache, M., Reichardt, K., 1997. Effects of water stress imposed at different plant growth stages of common bean (*pahaseolus vulgaris*) on yield and Nitrogen fixation. In: Kirda, C; Mountonnet, P; Hera, C., Nielson, D.R., (eds.). Crop yield response to deficit irrigation. Dordrecht, The Netherlands. Kluwer Academic Publishers.

Eckstein, K., Robinson, J.C., 1996. Physiological responses of Banana (*Musa* AAA:Cavendish Subgroup) in the Subtropics VI: Seasonal Responses of leaf gas exchange to Short term water stress. J. Horticultural Science. 71: 145-155

Ephrath, J.E., Marani, A., Bravdo, B.A., 1990. Effects of moisture stress on stomatal resistance and photosynthetic rate in cotton (*Gossypium hirsutum*) 1. Controlled levels of stress. Field Crops Res. 23:117-131.

Faver, K.L., Gerik, T.J., Gerik, Thaxton, P.M., El-Zik, K.M., 1996. Late season water stress in cotton: 11. Leaf gas exchange and assimilation capacity. Crop Sci.36:922-928

FAO., 1999. http://www.fao.org

Gerik, T.J., Faver, K.L., Thaxton, P.M., El-Zik, K.M., 1996. Late season water stress in cotton. 1. Plant growth, water use, and yield. Crop Sci. 36:914-921.

Goenaga, R., Irizarry, H., 1995. Yield Performance of banana irrigated with fraction of Class A Pan evaporation in a semi arid environment. Agron. J. 87, 172-176.

Goenga, R., Irizarry, H., Gonzalez, E., 1989. Water requirement of plantains (*musa accuminata x Musa balbisians* AAB grown under semi-arid conditions. Tropical Agriculture 70, 3-7.

Goenaga, R., Irizarry, H., 1998. Yield of Banana grown with supplemental drip irrigation on an Ultisol. Expl. Agric. 34, 439-448.

Gong, P., Ruiliang, Pu., Miller, J.R., 1995. Coniferous Forest Leaf Area Index Estimation along the Oregon Transect Using Compact Airborne Spectrographic Imager Data, PE & RS, 61 – 9: 1107 – 1117.

Hedge, D. M., Srinivas, K., 1990. Growth, Productivity and water use of banana under drip and basin irrigation in relation to evaporation replenishment. Indian J. Agron.35:106-112.

Hedge, D.M., Srinivas, K., 1989. Irrigation and nitrogen fertility influences on plant water relation, biomass, and nutrient accumulation and distribution in banana cv. Robusta. J. Hort. Sci. 64(1): 91-98.

Irizarry, H., Goenaga, R., 1995. Yield and quality of Superplátano (Musa, AAB) grown with drip irrigation in the semiarid region of Puerto Rico. J. Agric. Univ. P. R. 79, 1-11.

Kagabo, D.M., 2006. Modelling the Soil Balance of Potatoes for Improved Irrigation Management. M.Sc. Dissertation. University of Pretoria. Unpubl.

McMichael, B.L., Hesketh, J.D., 1982. Field investigation of the response of cotton to water deficits. Field crops Res. 5:319-333.

Obiefuna J. C. 1986. The effects of monthly planting on yield, yield patterns and yield decline of plantains (*Musa* AAB). Scientia Horticulturae 29: 47 – 54

Obiefuna, J. C., Ndubizu, T.O.C., 1979. Estimating leaf area of Plantain. Scientia Horticulturae 11, 31-36.

Oguntunde P.G. and van de Giesen N. 2004. Crop growth and development effects on surface albedo for maize and cowpea fields in Ghana, West Africa. International Journal of Biometeorology 49(2): 106 - 112

Oguntunde P. G. Olukunle O. J. Itatuyi, O. A. and Olufayo A. A. 2007. A semi-empirical Model for Estimating Surface Albedo of Wetted Rice Field. CIGR Electronic Journal.

Robinson, J. C., 1995. System of cultivation and management. In: GOWEN, S. (ed.), Bananas and Plantains. Chapman and Hall, London. pp15-65.

Robinson, J. C., Alberts, A. J., 1989. Growth and yield responses of banana (“cultivar Williams”) to drip irrigation under drought and normal rainfall conditions in the subtropics. Scientia Horticulturae 30, 187-202.

Rodríguez, S A., Rodríguez M.J.L., 1999. Aspectos Socioeconómicos del Cultivo del Plátano en Colombia. Oficina Regional de Planeación - Corpoica, Regional Nueve. Manizales, abril. In: Rodríguez M.J.L., Rodríguez S.A., 2001. Socioeconomic aspects of plantain cultivation in Colombia. INFOMUSA 10: 4-9

Rowe, P.R., 1998. A banana breeder’s response to “the global program for *Musa* improvement” INFOMUSA 7(1):PROMUSA.

Stover, R.H., Simmonds, N.W., 1987. Bananas. 3rd. Edition, John Wiley & Sons, Inc. New York. 468pp

Turner, N.C., Hearn, A.B., Begg, J.E., Constable, G.A., 1986. Cotton (Gossypium hirsutum L.): Physilogical and morphological responses to water deficits and their relationship to yield. Field Crops Res. 14:153-170.

Turner, D. W., 1998. Ecophysiology of Bananas: the generation and functioning of the leaf canopy. Acta Horticulturae, Leuven. 490: 211-221.