International Scholars Journals

African Journal of Crop Science ISSN 2375-1231 Vol. 7 (12), pp. 001-005, December, 2019. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Growth and evapotranspiration of groundnut (*Arachis hypogaea*) in a transitional humid zone of Nigeria

M. E. Idinoba[1*], P. A Idinoba[2], A. Gbadegesin[3] and S. S. Jagtap[4]

[1]06 BP 9478, Ouagadougou, Burkina Faso.
[2]Africa Rice Centre, Cotonou, Benin.
[3]Department of Geography, University of Ibadan, Nigeria.
[4]Department of Agiricultural and Biological Engineering, University of Florida.

Accepted 11 September, 2019

This experiment was conducted in the transitional humid zone of Nigeria to examine crop evapotranspiration and growth characteristics of groundnut (*Arachis hypogaea L.*) for that ecological zone . The crop was grown in and outside a drainage lysimeter for two years. Mean total water used (Evapotranspiration) by the crop during the 105 days from sowing to harvest was 302.5 mm. More water was used between the vegetative and reproductive growth stages of the crop, that is, between 20 and 60 days after planting DAP. The highest mean leaf area (LAI) obtained was 7 at 75 DAP. Lysimeter mean grain yield was 940 kg/ha while mean yields in rainfed plots was 1511 kg/ha. Yield from the rainfed plot was significantly different (p = 0.01) from yields from the lysimeter plot. There was high positive correlation (p = 0.01) between growth parameters and water use. Dry matter accumulation was highest between 75 and 90 DAP when canopy radiation interception was between 70 and 80 percent.

Key words: Drainage lysimeter, crop evapotranspiration, leaf area index, dry-matter accumulation, yield, Canopy radiation interception.

INTRODUCTION

Groundnut (*Arachis hypogaea*) is a major crop grown in the arid and semi arid zone of Nigeria. It is either grown for its nut, oil or its vegetative residue (haulms). Recently, the use of groundnut meal is becoming more recognized not only as a dietary supplement for children on protein poor cereals-based diets but also as effective treatment for children with protein related malnutrition. Groundnut production is influenced by several environmental factors, especially by moisture stress and temperature as reportted by several authors (Simmonds and Williams, 1989; Ravindra et al., 1990; Ntare et al., 2001 and Karim, 1990).

Before the 70s, production was concentrated around the arid and semi arid zone of Nigeria. However, from late 70s production began to suffer from yield uncer-tainties due to several factors including the vagaries of changing climate, particularly changing rainfall pattern, droughts of the late sixties (leading to Aflatoxin contamination), changes in ecological boundaries, increases in temperature coupled with the discovering of mineral resources which lead to less emphasis on cash crop. This is evidenced in the collapse of the popular ground-nut pyramids of the arid and semi arid zone before the 70s, and decline in exportation from about 26% before 1970 to 0% today. The IPCC (2001) report on changing climate in some tropical locations whereby minimal increase in temperature of some crops will reduce yields further highlights the importance of environmental factors on tropical crops, most crops are already near their temperature tolerance and the dry land/rainfed agriculture predominates. The optimum temperature for groundnut growth is between 27 and 30 ºC (De beer, 1963). Today, temperatures in the arid and semi arid zones of Nigeria often do exceed this optimum, resulting to yield losses (Prasad Vara et al., 1999). Though there are varieties to withstand high temperatures in the Sahel, it is hoped that with changes in ecological boundaries resulting from changing land use and climate pattern, exploitation of the

*Corresponding author. E-mail: m.idinoba@cgiar.org.

transitional humid zone may offer options for increase production in Nigeria. At the moment such studies in this zone are scanty. Hence the objective of this study is to determine crop evapotranspiration (water use) and growth potentials of groundnut in the transitional humid zone of Nigeria.

MATERIALS AND METHODS

Location, experimental design and crop management

This study was conducted in two years (1998 and 1999) at the experimental field of the International Institute of Tropical Agriculture, (IITA) Ibadan (7^0 30' N, 3^0 54' E). This zone is under going transition from deciduous tree canopy, secondary bushes and grassland vegetation where average annual rainfall is 1300 mm and its distribution is bimodal, April to July and August to November. The soils belong to plinthic luvisols (FAO classification), and are essentially heterogeneous.

The field was disc- ploughed. The experiment was designed as Randomised Complete Block (RCB) in three replicates; each replicate was divided into two plots of 900 m^2, giving a total land area of 0.81 ha. The plots (30 x 30 m) were made large enough to take care of periodic destructive sampling. The trial was carried out on same location for two cropping years (four growing seasons) April to December. A popular local ‘Fugar’ variety of groundnut (spreading and bushy, 100 - 120 days to maturity) was planted at optimal density of 80,000 stands per hectare. The crop was planted at the start of the first cropping seasons (April) and harvested in August. The plot received 100kg/ha of single super phosphate (SSP) fertilizer at planting, manual weeding was done as required.

Plants for growth analysis were harvested at 10 days interval from 21 days after planting until maturity. Four plants were randomly selected from each plot and above ground dry weight taken. Leaf area was measured on field with a LAI 2000 canopy analyser, while number of leaves per plant at every sampling day. was counted Solar radiation transmitted through the canopy was recorded with tube solarimeters. The tubes were place horizontally beneath and above the crop canopy and connected to a data logger (model CR 21x, Campbell scientific Inc. logan, Utah, USA). Intercepted photosynthetically active radiation (IPAR) was calculated from the global short wave radiation using the expression given by Monteith (1993): $Tq = Tt^{1.35}$ Where: Tq is fractional transmission of PAR, Tt is fractional transmission of short wave energy measured by the solarimeter.

Crop evapotranspiration (water use)

Crop water use was determined from a drainage lysimeter using a simple water balance equation expressed as: $ET_0 = R + I - S – D$ where: R is rainfall, I is the amount of irrigation water added, S is change in soil moisture storage. D is drainage water. Rainfall data was collected from an automatic weather station located 30m from the experimental plots. Soil moisture content from 0.10 to 1.7 m depth was determined by the use of a 503 DR neutron probe. Daily irrigation was determined as the product of the previous day evaporation reading from the class A pan and the lysimeter surface area, this amount was increased as plant grew. Drainage was measured every morning before irrigation. Correlation and least significance difference (LSD) procedures in Statiscal analysis system (SAS Inst, 1996) were used to determine relationships and treatment means.

RESULTS AND DISCUSSION

Crop evapotranspiration

Total mean crop evapotranspiration (water used) from sowing to harvest was 302.5 mm. More water was used up between the formative grand stage of the crop (Figure 1), that is between 20 and 60 days after planting. The period of maturity recorded the period of less water use because it is the period when almost all the leaves are dried up and leaf area is at its minimum. This confirms Kassam et al., 1975 observation that water use of a groundnut crop decreased as a result of maturation and that value for a fully developed canopy were higher than those observed at time of flowering.

Higher daily water use of between 4 and 5 mm is used up at between 20 and 50 days after planting, thereafter, the daily water use decreased to between 1.5 and 2 mm. Water use of groundnut obtained in this study for the humid transitional zone is lower than values (438 mm) obtained by Kassam et al. (1975) for the semi arid zone of northern Nigeria. This is as a result of several reasons, amongst varietal differences, changing evaporative demands of the atmosphere especially with respect to the controlling factor of insolation, and differences in soil characteristics. The arid and semi arid zone of Northern is characterized by a clear sky and more than 10 h of bright sunshine, the clear sky allows a high radiation incidence, leading to higher evapotranspiration rate. The mean daily totals of solar radiation in the semi arid zone is between 15 and 20 Mj/m^2/day during the growing season, in contrast to 10 and 17 Mj/m^2/day in the humid zone depending on the season. In addition higher wind speed often experienced in the arid and semi arid zone causes the stomata aperture to decrease, this is probably not a direct effect, but may result from stomata response to an increase in transpiration causing a reduction in leaf water potentials and a reduction in boundary layer thickness.

Crop development

The growth of the groundnut maintained a steady increase with age (Figure 2). The highest dry matter production was reached at about 75 days after planting. The rate of leaf production between 50 and 70 days after emergence was extremely high but a proportional decline followed after this period. Highest period of leaf area index, was observed between 65 and 85 DAP. The groundnut crop maintained a comparatively high LAI all through the crop age, mean leaf area index obtained was as high as 7. The high LAI reported in this study could be related to adequate rainfall distribution during the season in the transitional humid zone.

The sharp rise in LAI between the 55 and 75 DAP indicated a period of rapid physiological development. This agrees with results by Babiker (1989) and Chavula

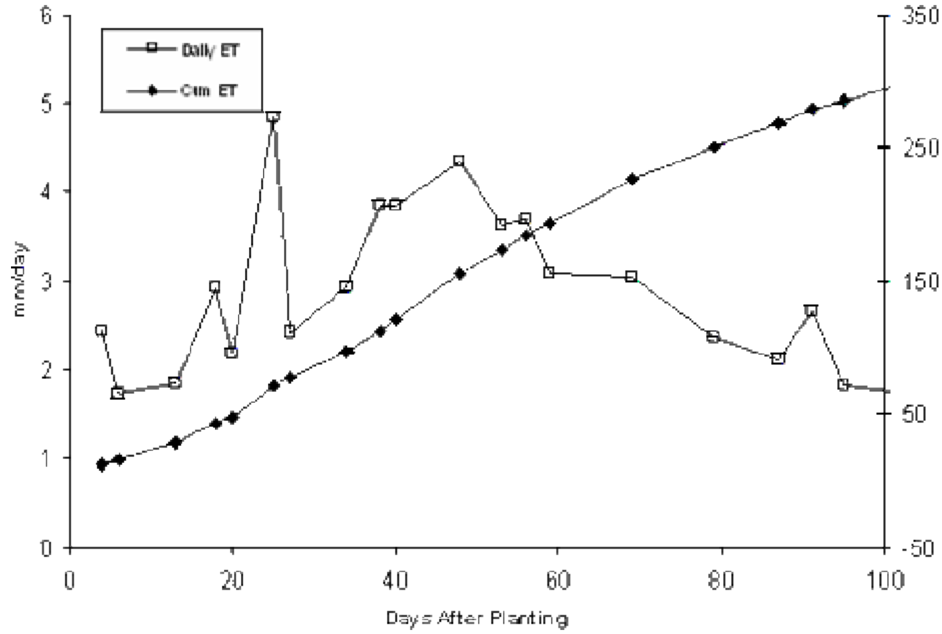

Figure 1. Groundnut water use pattern in a Transitional Humid zone.

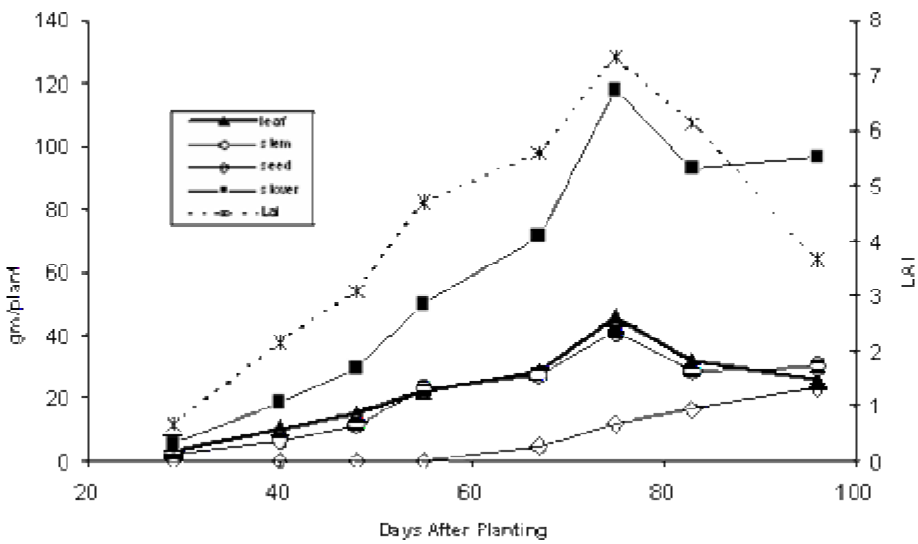

Figure 2. Groundnut Biomass Yield and Leaf Area Index

(1991), they observed a close relationship between leaf area index and dry matter. This is because large leaf area allows for an increase rate of transpiration and also facilitate more carbon dioxide assimilation and intercept-tion of solar radiation which are processes directly related to dry matter syntheses (Squire, 1990). The stage of maximum net assimilation started 65 DAP which coincided with pod filling, although pod formation started at about 48 DAP.

Groundnut lysimeter average yield at harvest was 940 kg/ha while the rain fed yield was 1511 kg/ha. Yield was higher under rain fed condition by 60% and significantly different ($p = 0.01$) from the lysimeter plot, which had rainfall and supplementary irrigation as water input. This is because once growth reaches it maximum - peg forma-tion and pod development becomes the major physiolo-gical function of the crop while additional water supply above rainfall becomes less important. Kramer 1983) (observed that excessive as well as deficient water input during the later half of the growing period of groundnut

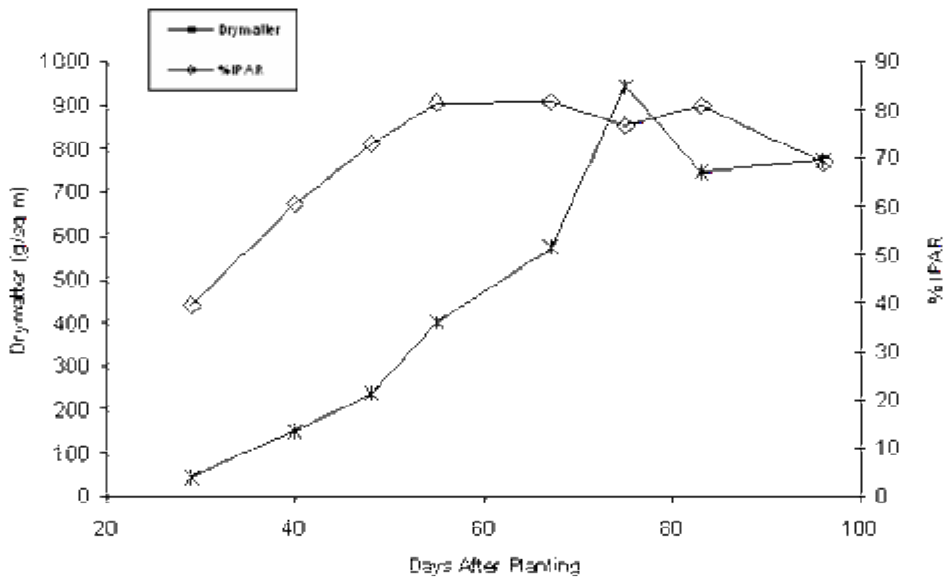

Figure 3. Cumulative dry matter and % IPAR.

Table 1. Correlation coefficient of Groundnut growth parameters with water use

	DAP	LAI	Leaf	Stem	Root	Petiole	LEAFCT	ET	Grain Yield
DAP	1	0.96*	0.94*	0.93*	0.82**	0.94*	0.95*	0.99*	0.77**
LAI		1	0.92*	0.96*	0.76**	0.92*	0.78**	0.94*	0.87*
LEAF WT				0.95*	0.82**	0.98*	0.91*	0.93*	0.74**
STEM WT				1	0.80**	0.96*	0.96*	0.92*	0.88*
ROOT WT					1	0.85*	0.74**	0.83*	0.43
PETIOLE WT						1	0.91*	0.93*	0.67**
LEAFCOUNT							1	0.94*	0.85*
ET								1	0.70**
GRAIN YIELD									1

* $P < 0.01$; ** $P < 0.05$ Where: DAP = Days after planting, Leafct = Number of leaves per plant, ET = Water use, LAI = Leaf area index.

tends to depress yields. Ameyam and Doku (1983) also demonstrated a similar reduction in yield in response to high levels of soil moisture for legumes. They found that legumes are susceptible to water logging due to the sensitivity of rhzobia within root nodules to anaerobic condition.

Correlation between growth parameters and water use was high and positive (Table 1). This implies that as growth increases, water use tends to increase. The least correlation coefficient between growth parameters and water use were statistically significant ($P = 0.01$).

Canopy PAR interception of groundnut increased with increased crop development (Figure 3). As ground cover by leaf canopy increased, plant grew to cover the inter-row spaces leading to higher rate of light intercept-ion, transpiration and therefore higher rate of dry matter accumulation. After reaching a close canopy, almost all solar radiation was intercepted and plants increased in dry matter weight at a nearly constant rate until fruit development began at 75 DAP. Dry matter accumulation was highest between 75 and 90 DAP when canopy PAR interception was between 70 and 80%.

In summary, we may conclude that the humid transition zone of Nigeria has great potentials for the production of groundnut. The region can provide suitable environment for the production of groundnut if the seasons are well managed. Though, the present rainfall pattern and distribution is adequate for growth, excess rainfall could lead to yield losses at harvest as a result of breakage of pegs and pods left in the soil.

REFERENCES

Ameyam CE, Doku E V (1983). Effects of soil moisture stress on the reproductive efficiency and yield of the bambara groundnut. T ropical Grain Legume Bulletin 28: 23-29

Babiker AM (1989). Growth, dry matter and yield of bambara groundnut and groundnut under irrigated and droughted conditions. Msc Thesis, University of Nottingham, U.K

Chavula KM (1991). Growth, light interception and yield of groundnut in response to soil moisture. Msc Thesis, University of Nottingham, U.K De beer (1963). Influence of temperature on Arachis hypogaea L. with reference to its pollen viability. Doctoral dissertation, Wageningen Agricultural University, the Netherlands.

IPCC (2001). Climate change: Impacts, Adaptation and Vulnerability. Summary for policy makers and Technical summary of working group 11 report.

Karim M F (1990). Growth, development and light interception of bambara groundnut (Vigna Substaranea L Verdc.) and groundnut (Arachis hypogaea) in relation to soil moisture. Msc Thesis, University of Nottingham.

Kassam A A, Kowal JM, Harkness C (1975). Water use and growth of groundnut at Samaru, Northern Nigeria. Tropical Agriculture 52: 105-112

Kramer PJ (1983). Water relations of plant. Academic press p. 489.

Monteith JL (1993). Using tube solarimeters to measure radiation interception by crop canopies and to analyse stand growth. Pub. Delta-T Devies, document code TSL – AW-4-1 11pp.

Ravindra V, Nautyal PC, Joshi YC (1990). Physiological analysis of drought resistance and yield in groundnut. Tropical Agriculture 67:290-296

Ntare BR, Williams JH, Dougbedji F (2001). Evaluation of groundnut genotypes for heat tolerance under yield conditions in a Sahelian environment using a simple physiological model for yield. The J. of Agric. Sci. 136(1) : 81-88

Prasad PV Vara, Craufurd PQ, Summerfield RJ (1999). Sensitivity of peanut to timing of heat stress during reproductive development. Crop Science 39: 1352-1357.

SAS Intitute (1996). SAA User's guide. SAS Inst Cary, NC

Simmonds L P, Williams JH (1989). population, water use and growth of groundnut maintained on stored water 11. Transpiration and evaporation from soil. Experimental Agriculture 25: 63-75

Squire GR (1990). The physiology of tropical crop production. Wallingford: CAB Internationa 236pp.