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Effect of GDD on the Growth and Yield of Groundnut in a Forest-Savanna Transition Zone of Nigeria

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Abstract

Temperature as a limiting factor to groundnut production had affected groundnut economic value in a forest-savannah transition of Nigeria. A field trial was carried out to evaluate the effect Growing Degree Day (GDD) of groundnut intercropped with maize at Abeokuta during the early 2018 cropping season. The experiment was arranged in 6×3 factorial and laid out in a randomized complete block design with three replicates. Experimental factors were the cropping system of sole planting of three groundnut cultivars SAMNUT-24 (GNUT1), SAMNUT-25 (GNUT2), SAMNUT-26 (GNUT3) and their intercrop combinations with maize (SAMMAZ-15), GDD was estimated on emergence, flowering, pod formation, seed formation, and maturity phases. The results of GDD showed that intercrop significantly influence ($p \leq 0.05$) growing degree days (GDD) of groundnut at emergence (2225.50 ºday) and flowering (2700.96 ºday) phases and mulching was significant ($p \leq 0.05$) at seed formation phase, intercrop showed significant influence on GDD and yield of Groundnut.

Key words: GDD, Groundnut, Growth, Yield

Introduction

Growing degree days (GDD), Growing Degree Units (GDU), or Accumulated Heat Units (AHU) are commonly used terms to assign a heat value to each day that has occurred (Spoden, 2015). The values are added together to give an estimate of the amount of seasonal growth and development of a crop to predict crop growth, maturity, or yield (SalazarGutierrez *et al*., 2013).

The concept of heat units can be used to: predict weed growth and insect life stages; identify site suitability for growing crops, predict appropriate timing of fertilizer or pesticide application, estimate abiotic stress (heat and drought) on crops and space planting dates in a crop rotation cycle.

The crop growth response is influenced largely by the microclimate environment in the crop. Microclimate in the crop varies from top of the canopy to the soil surface and affects crop development and yield. Various environmental factors influencing growth are interception of photosynthetically active radiation, air and leaf temperature, relative humidity, prevailing wind speed, Carbon dioxide (CO_2) concentration and soil moisture availability. Temperature and light play a key role in influencing crop production. The occurrence of different phenological events during crop growth period in relation to temperature can be estimated by using accumulated heat units or growing degree-days (GDD) (Gouri *et al*., 2005). Knowledge of accumulated GDD can provide an estimate of harvest date as well as crop development stage.

Groundnut (*Arachis hypogaea L*) is an important annual legume worldwide. it is the 13th worldwide most important food crop, and fourth important oilseed crop known for its oilseed, food and animal feeds (Mangasini *et al*., 2012). The crop is mostly involved in crop rotation in the sub Saharan Africa. Its world production stood at 28.5 million

tons/annum. (Ajeigbe, 2014). About 90 % of the world's groundnut production happens in the tropical and semi-arid tropical areas (Hamidou *et al.,* 2013), in countries including: China, India, Nigeria, Indonesia, Senegal, USA, Argentina, and South America (Mangasini *et al*., 2012). The crop requires about 500mm to 1600mm of annual rainfall on a well-drained light sandy loamy soil. Abundant of the world's groundnut production areas are characterized by high temperature and low or unpredictable rainfall even though it was reported that Groundnut is delicate to temperature. Plant reactions to high temperature differ with plant type and phenological periods.

Groundnut production in Nigeria faces problems that are many and complex. Among which is the drought as a result of weather vagaries coupled with rosette epidemic in 1975, inadequate water supply during the growth period and poor soil fertility. These problems have resulted in the decline of groundnut production in Nigeria especially in savannah ecological zone. Climate change and increase desertification has also led to a southward extension of the suitable climatic zone and soil conditions preferences for groundnut production. The aim of agrometeorological research include the discovery of analogous areas for crop introduction and production, studying the performance of savanna crops in the extended savanna environment becomes imperative. This study aimed to evaluate the response of groundnut growth and yield to Growing Degree Day in a forest-savanna transition one of Nigeria.

1.2 Table 1: Reproductive and Vegetative Growth of Stages of Groundnut

Stage	Stage Title	Description
VE	Emergence	Cotyledons near the soil surface with the seedling showing some part of the plant visible.
R1	Flowering	One open flower at any node
R2	Pegging	One elongated peg (gynophores)
R3	Podding	One peg in soil with swollen ovary at least twice the weight of the peg
R4	Full pod stage	One pod fully expanded to dimensions characteristic for the cultivar
R5	Beginning seed	One fully expanded pod with which seed cotyledon growth is viable when the fruit is cur in cross-section
R6	Full seed	One pod with cavity apparently filled by the seed when fresh
R7	Beginning maturity	One pod showing visible natural colouration or blotching of inner pericarp or testa

Source: Ajeigbe *et al.*, 2014

Materials and Methods

Experimental Site and Location

The field experiment was conducted at the Teaching and Research Farm of the Federal University of Agriculture Abeokuta; Ogun

state Nigeria during the early 2018 cropping season. The research plot was located between latitudes 7°20' and 7 ° 32' N, longitudes 3 ° 35' and 3 ° 47' E, and at an altitude of 141m above the mean sea level. The study area was situated in the forest-savanna transition zone of southwest Nigeria.

Experimental Materials

Three cultivars of groundnut cultivars SAMNUT-24 SAMNUT-25 and SAMNUT-26, and one maize cultivar SAMMAZ-15 were used for this study. The groundnut and maize cultivars were sourced from the Institute for Agricultural Research Samaru, Zaria Seed Production Unit.

Planting Method and Field Establishment

The field was cleared of all shrubs, stubbles and crop residues from the previous crop, Conventional tillage was employed to plough, harrow and ridge in order to provide a good tilth. Planting of the crops was done during the rainy season of 2018. Three groundnut seeds were sown which were later thinned to two plants per stand at two weeks after sowing (WAS), while two seeds of maize were also sown in intercrop which were also thinned to one plant per stand at two weeks after sowing (WAS).

Data collection and processing

During the experimental period, daily records of maximum and minimum air temperature (T, °C), in decadal basis was collected from the Agrometeorological Weather Station of the Department of Water Resources Management and Agricultural Meteorology, Federal University of Agriculture, Abeokuta. The data was then processed to estimate GDD with the use of equation below:

$$GDD = \frac{\sum_{i=1}^{n}(T_{max} + T_{min})}{2} - T_b$$

..…… (Zalom *et al.,* 1993)

Where:

GDD= Growing degree days,

T_{max}= Maximum temperature

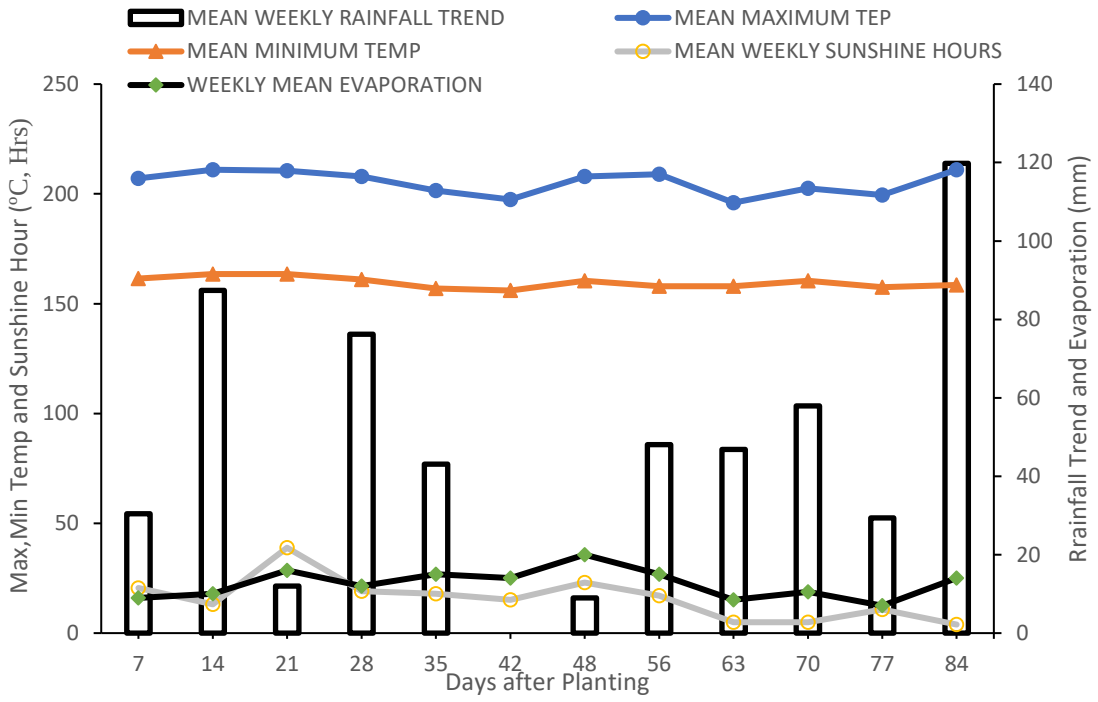
T_{min}=Minimum temperature

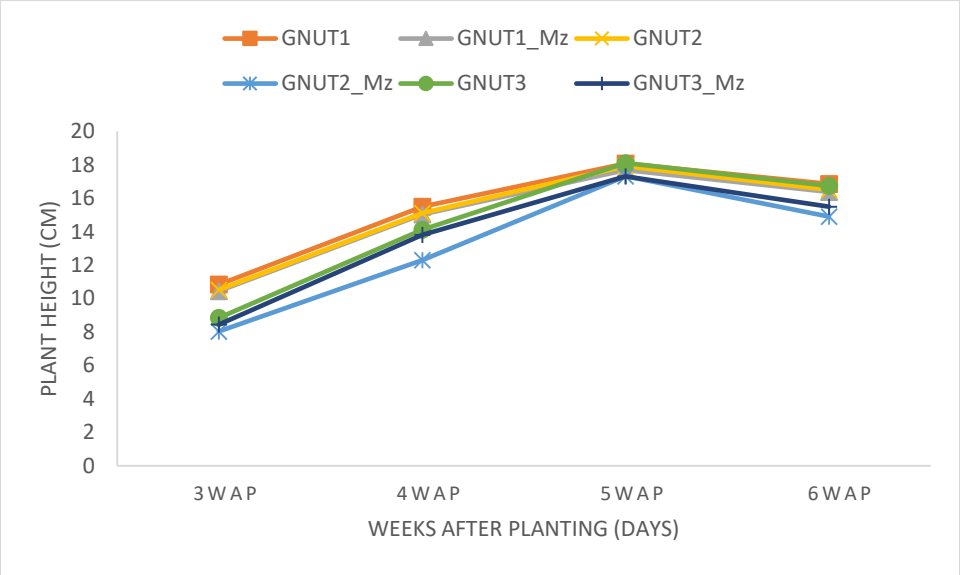
T_b=Base temperature (10 ° C)

Data Analysis

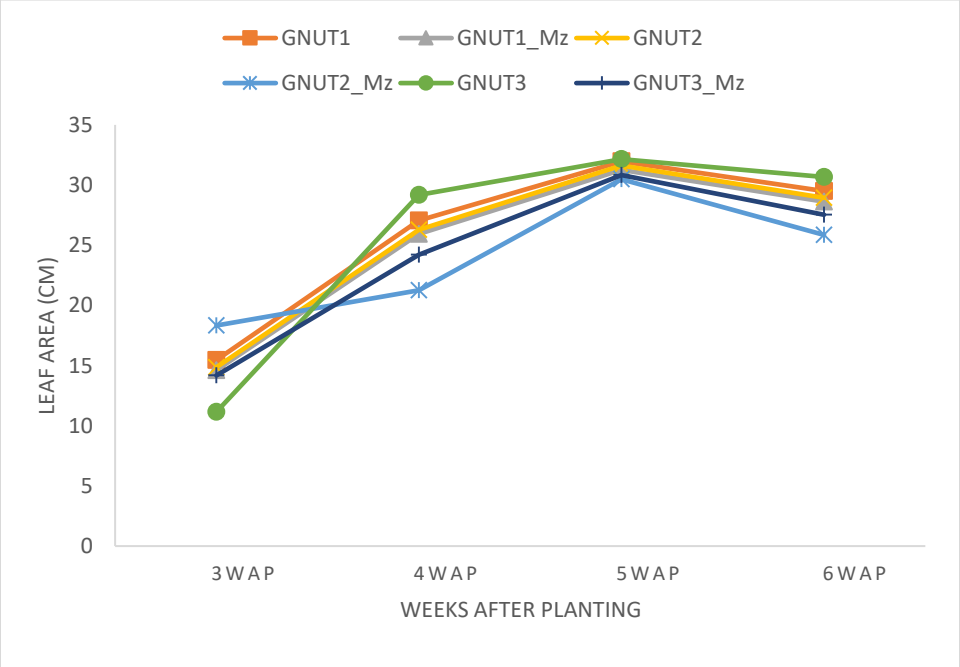
Data collected from the study were analyzed according to the analysis of variance for randomized complete block design experiments using computer package SAS 13th version software while the means were separated using Duncan multiple range test (DMRT).

Results and Discussion





In the figure 2 is the plant height of groundnut cultivars in sole and intercropping combinations with maize at 3,4,5 and 6 (WAP), the figure showed that, there were significant difference ($p \leq 0.05$) at 3 and 4.



In the figure 3 is the leaf area of groundnut cultivars in sole and intercropping combinations with maize at 3,4,5 and 6 (WAS), the figure showed that, there were

significant difference ($p \leq 0.05$) at 3,4,5 and 6 WAS

Plant height of groundnut in the present study differed significantly in sole cropping system, SAMNUT-24 under sole cropping (GNUT1) recorded higher plant heights as compared to their respective mixtures. This could be attributed to competition-free environment, the result was in conformity with the findings of Kassim (2018).

Variations in the values of leaf area of groundnut and maize were observed in the present study. The higher values of leaf area recorded in sole SAMNUT-24 (GNUT1), SAMNUT-25 (GNUT2), and SAMNUT-26 (GNUT3) over their mixtures was due to competition for soil moisture, nutrient, and thermal indices under mixed cropping condition. The number of component crops increased severity of competition for growth resources, and subsequently led restriction of leaf area growth. Hence higher values of leaf area could as a result of ample space and competition-free environment enjoyed under sole cropping system condition. The results Anil (2007) corroborated the findings of this study.

The results from the Table 3 above indicated that groundnut crop at emergence need high to optimum supply of heat or temperature regime, this is because GDD at emergence was found to be highly significant at ($P \leq 0.01$) (Prasad 2009 and Kassim, 2017). GDD was also found to be highly significant at ($P \leq 0.01$) only at flowering stage of the groundnut crop (Yoldas *et al.*, 2005), also from the findings it was deduced that the groundnut crop require little amount of heat at the commencement of seed formation process which was seen to be significant at ($P \leq 0.05$) level, at maturity stage the groundnut crop showed statistical difference at ($P \leq 0.01$), this further indicated that the crop require much needed amount of heat to attain physiological maturity in the cropping system.

Table 2: Effect of GDD (°days)on the growth stages of groundnut crop at Abeokuta, Nigeria.

Intercrop	E (°days)	FL (°days)	PODFORM (°days)	SDFORM (°days)	MRTY (°days)
GNUT1	135.80±12.83^{a}	969.90±13.90^{a}	284.15±9.19^{a}	253.90±13.66^{a}	575.55±9.35^{a}
GNUT1_Mz	135.80±13.86^{a}	963.40±13.00^{a}	284.15±13.00^{a}	247.28±13.25^{b}	573.68±13.75^{ab}
GNUT2	135.80±12.83^{a}	936.53±11.34^{bc}	285.88±11.74^{a}	254.39±13.51^{a}	569.65±9.48^{b}
GNUT2_Mz	135.60±18.60^{a}	942.66±13.11^{b}	286.01±12.31^{a}	254.58±13.78^{a}	569.40±9.61^{b}
GNUT3	101.13±9.24^{b}	928.50±17.58^{c}	282.08±13.33^{a}	256.05±13.33^{a}	563.03±2.51^{c}
GNUT3_Mz	97.81±0.19^{b}	920.19±13.08^{cd}	282.28±13.26^{a}	256.00±13.26^{a}	563.99±5.18^{c}

Table 3: Effect of cropping system and mulching techniques on yield indices of groundnut crop at Abeokuta, Nigeria.

Cropping system	Number of pods	Biomass (wgt/plt) (Kg)	Total dry matter (wgt/plot) (Kg)	Pod_weight (Kg)	Yield (Kg/ha)
GNUT1	89.63±15.75^{a}	0.48±0.08^{a}	4.32±0.78^{b}	0.31±0.10^{b}	30.0±0.09^{c}
GNUT1_Mz	88.5±12.70^{ab}	0.53±0.11^{a}	4.22±1.10^{b}	0.31±0.08^{b}	10.0±0.02^{c}
GNUT2	77.5±13.56^{bc}	0.64±0.13^{a}	6.24±1.85^{a}	0.34±0.08^{b}	14.0±0.09^{c}
GNUT2_Mz	67.6312.74^{cd}	0.63±0.16^{a}	4.86±1.45^{ab}	0.36±0.04^{b}	70.0±0.05^{a}
GNUT3	55.1316.68^{e}	0.51±0.13^{a}	5.78±1.59^{ab}	0.31±0.10^{b}	12.0±0.02^{ab}
GNUT3_Mz	63.78±18.06^{cd}	2.99±0.46^{a}	7.27±2.91^{a}	2.76±0.22^{a}	34.0±0.06^{b}

Means with the same letter along column are not significantly different (p>0.05)

The table 3 above depicts the effect of GDD on yields of groundnut at Abeokuta, the study found that there was statistical difference (p>0.05) in number of pods, biomass weight, total dry matter, pod weight and grain yield. this could be said that GDD index affected the yields of the crops despite the fact that the study area is a rain fed only region.

Conclusion

The study confirmed that groundnut cultivars accumulate more heat to attain flowering and maturity phases in cropping systems. It was obvious from the study that a detailed knowledge of GDD study of area and crops are very essential for any successful cropping system. The study revealed that partitioning of cropping pattern into growth stages to study the relationship between GDD index and crops gives a better understanding as to what extent GDD factors affect crops. Therefore, such information will assist in designing and developing new cropping systems.

high amount of heat deduced from higher values of minimum and maximum temperatures obtained from the findings greatly affect the process of pod and seed formation, this may account to the lower yield of the crop that was obtained, this is because results from GDD index estimation indicated that the crop do not require much heat at pod and seed formation processes.

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