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EFFECT OF WATER STRESS DURING FLOWERING AND PEGGING ON THE GROWTH AND YIELD OF SIX VARIETIES OF GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT

Groundnut is an important oil seed crop whose growth and pod yield is affected by dry spells especially in drier areas. The availability of drought tolerant varieties is crucial in breeding for drought resistance of the crop. This study was carried out to study the effect of water stress on yield of groundnut and to identify drought tolerant varieties for production and use in breeding. Six groundnut varieties: (SAMNUT 14, SAMNUT 22, SAMNUT 23, SAMNUT 24, SAMNUT 25 and SAMNUT 26) were evaluated in the study. Water stress was imposed by withholding water for 10days at 50% flowering for each variety. The experiment was laid out in a Randomised Complete Block Design (RCBD) and replicated three times. Data were collected on growth and yield parameters and these were subjected to analysis of variance using SAS package (2002). Results obtained in the study showed that water stress significantly ($P<0.05$) decreased all the growth and yield parameters. Among the varieties evaluated, SAMNUT 14 recorded the lowest leaf area ($271cm^2$) while SAMNUT 23 recorded higher chlorophyll a ($79mg/cm^2$), chlorophyll b ($58mg/cm^2$) and total chlorophyll content ($141mg/cm^2$). SAMNUT 14 and SAMNUT 23 also produced higher number of pods, pod weight and number of seeds per plant than the other varieties. The present study revealed that SAMNUT 23 and SAMNUT 14 proved more tolerant to water stress compared to the other varieties. These varieties could be used for genetic enhancement for drought resistance in groundnut.

Keywords: Flowering; Pegging; Groundnut; Water stress; Growth and Yield

INTRODUCTION

Drought stress is one of the most important abiotic stresses affecting world agriculture and is projected to worsen with climate change. With an unabated increase in human population, coupled with climate change there will be a need to improve world agriculture production through better management practices and improved crop breeding strategies. However, this will require a better understanding of crop responses especially with tolerance to drought. During the last 30 years in Nigeria, a declining trend in the annual rainfall duration has been observed, indicating the need for short duration, drought tolerant crop varieties (Shaib *et al.*, 1997). Groundnut (*Arachis hypogaea* L.) is one of the world's most important legumes. It is grown primarily for its high quality edible oil and protein. Total world production of the crop was 45.7 million metric tonnes produced from 25.5 million hectares with an average yield of 1.79 tons/ha in 2013, of which China (37.3%), India (20.8%), Nigeria (6.6%) and the United States (4.2%) are the largest producers (FAOSTAT, 2015). More than half of the production area, which accounts for 70% of the groundnut growing area fall under arid and semi-arid regions, where groundnuts are frequently subjected to drought stresses for different duration and intensities (Reddy *et al.*, 2003). The severity of drought depends on the duration of the stress and various growth stages of the plant. Drought during flowering reduced the yield of groundnut. In Nigeria, major groundnut-producing areas are located in the Sudan and Northern Guinea ecological zones where the soil and agro-climatic conditions are favorable (Misari *et al.*, 1988). Rainfall variability and drought have been identified as the major causes of rain-fed crop failure in the Sudan Savanna of Nigeria (Ajeigbe *et al.,* 2014).Therefore, available genotypes that are tolerant to drought may be necessary for improved production and productivity of groundnut in this agro-ecology. Hence, the need to screen available groundnut lines to identify genotypes that are tolerant to water stress for their use in a planned breeding program.

MATERIALS AND METHODS

Study Area

The study was conducted in 2015 at the screen house of the Institute for Agricultural Research (IAR), Ahmadu Bello University Zaria (11°11´N, 7°38´E 686m above sea level) Nigeria. Samaru lies in the Northern Guinea Savanna zone of Nigeria. It has an annual rainfall of about 1060mm, mostly distributed between the Months of May and October, with mean monthly minimum and maximum temperatures of 20ºC-30ºC respectively during this period.

Experimental Design and Experimentation

Treatments of the experiment comprised of six IAR improved varieties of groundnut (SAMNUT-14 SAMNUT-22 SAMNUT-23 SAMNUT-24 SAMNUT-25 and SAMNUT-26 SAMNUT-14) and water stress treatment compared with a control. Description of the varieties is given in Table 1. Treatments were laid out in a Randomised Complete Block Design (RBCD) and replicated three times. Plastic pots measuring 20.3cm in diameter were filled with well drained sandy loam soil mixed with single super phosphate (SSP) at the rate of 45kg/ha and 5cm was left to the brim to allow for watering. A total of 108 plastic pots were used to allow for destructive sampling. Three seeds were sown per pot, after germination the seedlings were thinned to one stand per pot. The plants were watered at regular intervals from the day of sowing to when the water stress was imposed. Water stress was imposed by withholding water for 10 days at 50% flowering for each variety. All other necessary agronomic practices were observed adequately.

Table 1: Origin and description of the groundnut varieties used in the study

Varieties	Characteristic
SAMNUT-14	Developed at IAR; Potential pod yield 2000kg/ha; Late maturing (135-150 days); Rosette resistant; Seed colour-variegated (tan and white); High oil content 55-52% (Dry matter basis); Adaptation-Guinea savannah and forest
SAMNUT-22	Developed at IAR & ILRI-ICRISAT; Potential pod yield 2400kg/ha; Potential haulm yield 4000kg/ha; Medium maturing (110-120 days); Seed mass- 45-50g; Seed colour- tan; Oil content: 45%; Adaptation-Sudan and guinea savannah.
SAMNUT-23	Developed at ICRISAT& IAR; Potential pod yield 2000kg/ha; Early maturing (90-100 days); Rosette resistant; Seed mass- 35-38%; Seed colour-red; Oil content- 53%; Adaptation-Sudan and Sahel savannah.
SAMNUT-24	Developed at ICRISAT& IAR; Extra-early maturing; High oil content; Seed colour-red; Adaptation-Sudan and Sahel savannah
SAMNUT-25	Developed at ICRISAT& IAR; Extra-early maturing; Rosette resistant; Seed colour-red; Adaptation-Sudan and Sahel savannah
SAMNUT-26	Developed at ICRISAT& IAR, Extra-early maturing Rosette resistant, High oil content, Seed colour-red, Adaptation-Sudan and Sahel savannah

Source: NACGRAB (2014)

Data Collection and Analysis

Assessment of plant characters started at 50% flowering for each genotype; three plants were selected and tagged for observation and data collection. Data were collected on Plant height per plant, Number of branches per plant, pod weight per plant, Number of pods per plant and Number of seeds per plant. Leaf area (cm^2) per plant was measured using a portable leaf area meter (model LI-3100 C Biosciences) and leaf Chlorophyll content was estimated according to the method of Arnon (1949) for each variety as follows: Destructive leaves samples were obtained in the morning and leaves were separated from, stems and roots. A cork borer of 1cm in diameter was used to cut 4 discs from the leaves. Samples were macerated with pestle and mortar and poured into test tubes, which were wrapped with aluminum foil paper. Ten (10) mls of 80% ethanol: water (v/v) solution was poured into each test tube to extract the chlorophyll. The test tubes plugged with cotton wool and stored for 48 hours. Thereafter, 5ml of the sample filtrate was used to determine absorbance at 663nm and 645nm using spectrophotometer and also 80% ethanol was used as blank. Two readings were taken at each wavelength and an average was estimated for data analysis.

Chlorophyll a and chlorophyll b and total chlorophyll content was determined as follows:

Chl a (mg/cm^2) = (12.7 A663-2.7 A645)5

Chl a (mg/cm^2) = (22.9 A645-4.7 A663)5

Total Chl (mg/cm^2) = (8.5A663 +20.2A645)5

Where A is the absorbance of the acetone extract at 663 and 645nm and 5 is the 5ml of 80% ethanol extract used for taking readings.

The data collected were subjected to analysis of variance (ANOVA) using the general linear model (GLM) procedure of the statistical analysis system (SAS). Where means are significant, Least Significance Difference (LSD) was used to separate the means ($P<0.05$).

RESULTS AND DISCUSSION

Effect of Water Stress and Variety on Plant Height in Groundnut

Results from this study showed that plant height significantly ($P<0.05$) decreased under water stress (Table 2). The reduction in plant height could be attributed to decline in rapid cell division, elongation and enlargement due to low turgor pressure in the plant under water stress. Decrease in plant height of groundnut under water stress was reported by several authors (**Arunachalam and Kannan, 2013;** Madhusudhan and Sudhakar, 2014). Remarkable differences were observed among the varieties in response to water stress (Table 2). SAMNUT 22 produced statistically similar plant height with SAMNUT 23 but taller plants than SAMNUT 14, SAMNUT 24, SAMNUT 25 and SAMNUT 26. This observed variation could be attributed to genotypic influence. Madhusudhan and Sudhakar (2014) also observed significant variation in plant height among groundnut genotypes under water stress.

Table 2: Effect of water stress and variety on plant height, number of branches plant^{-1} and leaf area of groundnut

Treatment	Plant height (cm)	No. branches plant^{-1}	Leaf area (cm^2)
Control	16.9^{a}	3.3^{a}	539^{a}
Drought	13.8^{b}	2.3^{b}	351^{b}
SE±	0.19	0.05	28.65
Variety			
SAMNUT 14	11.9^{c}	3.4^{a}	271^{f}
SAMNUT 22	21.4^{a}	3.5^{a}	296^{d}
SAMNUT 23	18.5^{ab}	2.5^{bc}	295^{e}
SAMNUT 24	11.7^{c}	3.0^{ab}	681^{a}
SAMNUT 25	17.3^{b}	2.2^{c}	454^{c}
SAMNUT 26	11.5^{c}	2.4^{bc}	673^{b}
SE±	0.59	0.15	85.97
CV%	16.50	23.5	0

Means followed by the same letter(s) within a column are not significantly different ($P<0.05$) using LSD

Effect of Water Stress and Variety on Number of Branches per Plant in Groundnut

Branching is an important yield determinant as it carries the leaves which are the major photosynthetic organs in plant. Several authors indicated that adequate water is necessary for branching in groundnut (Pervin *et al*., 2014; Zagade and Chavan, 2006). Results obtained in this study showed that water stress significantly ($P<0.05$) decreased the number of branches per plant of groundnut (Table 1). The decrease in number of branches under the water stress condition could be due to reduced rate of nitrogen metabolism. According to Lisar_*et al*. (2012) nitrogen metabolism is the most important factor that influences plant growth. Under water deficit nitrate uptake is impaired and this disrupts nitrogen metabolism. Among the varieties evaluated SAMNUT 14, SAMNUT 22 and SAMNUT 24 produced statistically taller plants with 3.4, 3.5 and 3.0, respectively. This could be attributed to genotypic make-up of the varieties.

Effect of Water Stress and Variety on Leaf Area of Groundnut

Water stress treatment produced a marked decrease in total leaf area per plant of groundnut (Table 2). This result confirms previous findings in groundnut plants (Fazeli *et al*., 2007; Madhusudhan and Sudhakar, 2014). The decline in leaf area under water stress could be due to low photosynthesis and leaf senescence during the stress condition. Significant ($P<0.05$) difference was also observed among the varieties evaluated with SAMNUT 14 recording the lowest leaf area followed by leaf area value observed in SAMNUT 23 (Table 2). This confirms earlier reports by Madhusudhan and Sudhakar (2014) in groundnut, where significant variation in leaf area among groundnut genotypes was observed under water stress.

Effect of Water Stress and Variety on Leaf Chlorophyll Content in Groundnut

Results obtained from this study showed that chlorophyll *a* and chlorophyll *b* content of groundnut varieties significantly ($P<0.05$) decreased under water stress condition as compared with the control (Figure 1). Silva *et al.* (2015) observed that total chlorophyll content of groundnut decreased significantly with increasing water deficit levels that the cultivar having the highest total chlorophyll content also had the highest drought tolerance and yield stability. In this study, SAMNUT 23 recorded significantly ($P<0.05$) higher chlorophyll *a*, chlorophyll *b* and total chlorophyll than all the other varieties with the least value observed in SAMNUT 14(Figure 2). The result suggested that SAMNUT 23 is more tolerant to water stress. According to Arunyanark *et al.* (2008), the ability to maintain stability of chlorophyll content under water deficit conditions is a good measure of the groundnut genotype capability to cope with drought stress. It was shown that chlorophyll contents are closely associated with drought tolerance and suggested these parameters as biochemical markers for the identification of drought tolerant genotype in cluster bean (Vyas *et al*., 2001).

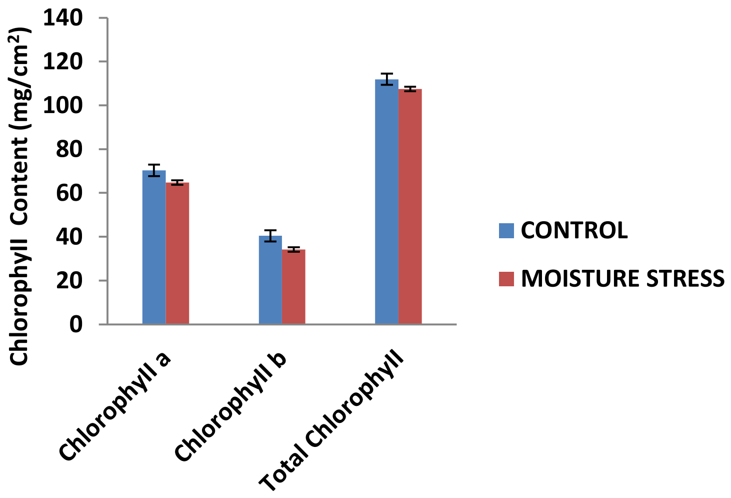

Figure 1: Effect of water stress on Leaf chlorophyll content of groundnut

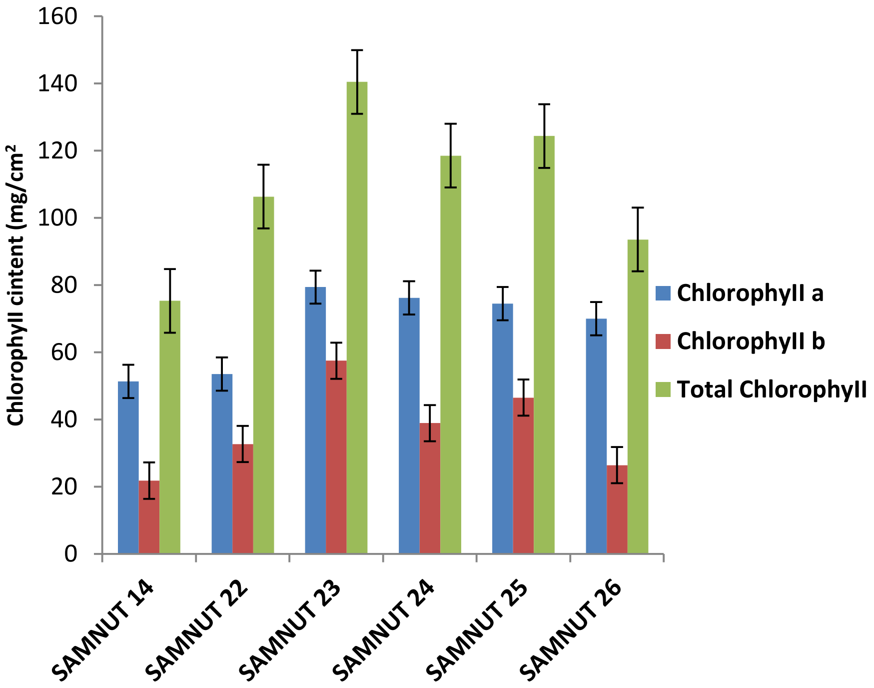

Figure 2: Leaf chlorophyll content of six groundnut varieties as affected by water stress

Effect of water stress and variety on number of pods per plant in groundnut

This study indicated that water stress significantly (P<0.05) decreased the number of pods per plant in groundnut (Table 3). The reduction in number of pods per plant could be due to reduced pollen fertility and increased pod abortion. Among the varieties evaluated it was observed that SAMNUT 14, SAMNUT 23, SAMNUT 24 and SAMNUT 25 produced statistically similar values and SAMNUT 26 yielding the lowest value (Table 3). Arunachalam and Kannan (2013) reported a reduction in number of matured pods and pod yield per plant in groundnut under drought.

Table 3: Effect of water stress and variety yield parameters of groundnut

Treatment	Number of pods plant^{-1}	Pod weight	Number of Seed plant^{-1}
Stress Treatment			
Control	9.17^{a}	6.4^{a}	15.0^{a}
Water stress	4.83^{b}	2.9^{b}	7.05^{b}
SE±	0.24	0.13	0.39
Variety			
SAMNUT 14	10.3^{a}	4.8^{b}	15.7^{a}
SAMNUT 22	4.2b^{c}	3.8^{bc}	7.2^{bc}
SAMNUT 23	8.5^{a}	7.3^{a}	14.3^{a}
SAMNUT 24	7.5^{ab}	4.3^{bc}	12.6^{ab}
SAMNUT 25	8.0^{ab}	5.3^{ab}	12.3^{ab}
SAMNUT 26	3.0^{c}	2.3^{c}	4.0^{c}
SE±	0.72	0.40	1.19
CV%	43.7	37.5	45.8

Means followed by the same letter(s) within a column are not significantly different (P<0.05) using LSD

Effect of water stress and variety on pod weight in groundnut

Pod weight per plant of groundnut was significantly (P<0.05) influenced by water stress (Table 3). The control recorded higher pod weight compared to the water stress treatment. Silva *et al*. (2015) observed decrease in pods weight per plant in groundnut with increasing water deficit level. Among the varieties evaluated, SAMNUT 14 and SAMNUT 23 recorded higher pod weight compared to the other varieties while the lowest value was observed in SAMNUT 26 (Table 3). Silva *et al.* (2015) also observed variation among groundnut genotypes for pod weight under water stress.

Effect of water stress and variety on number of seeds per plant in groundnut

The present study revealed a decrease in number of seeds per plant under water stress condition in comparison to control (Table 3). The findings are in agreement with Arruda *et al*. (2015) who reported that water stress caused reduction in number of seeds per plant of groundnut. Among the varieties evaluated SAMNUT 14 and SAMNUT 23 recorded higher number of seeds than the other varieties (Table 3). The observed variation could be attributed to genotypic influence.

CONCLUSION

The study revealed that water stress at flowering and pegging significantly decreased growth and pod yield of groundnut. Among the varieties evaluated SAMNUT 23 and SAMNUT 14 proved more tolerant to water stress compared to the other varieties, as the highest pod yield was observed in these varieties. These varieties can be useful genetic material for genetic improvement of groundnut to drought tolerance.

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