Science World Journal Vol 4 (No 3) 2009
www.sciecnceworldjournal.org
ISSN 1597-6343

Full Length Research Article

EFFECTS OF WATER STRESS ON THE ROOTING, NODULATION POTENTIALS AND GROWTH OF COWPEA (*Vigna unguiculata* (L) WALP)

*ONUH M. O. & DONALD, K. M.

Department of Crop Science & Biotechnology,
Imo State University, Owerri Nigeria
*deracom@yahoo.com

ABSTRACT
Rooting, nodulation and growth ability of cowpea growing under limited water supply was investigated at the Teaching and Research Farm of the Imo State University, Owerri, Nigeria. The experiment was conducted in plastic buckets arranged in a completely Randomized Design with three replications, and treatments represented as 500ml, 1000ml, and 1500ml of water, respectively. Control treatment was represented by cowpea plants that grown with rain-fed water. The 500ml and 1000ml of water were applied two times a week to the receiving cowpea plants while the 1500ml was applied daily to the receiving cowpea. Data were collected on the number of nodules/plant, root length/plant (cm) measured at 2 and 4 wks after planting (WAP) respectively, number of leaves/plant, number of branches/plant and seed yield (kg/ha) collected data were subjected to analysis of variance at the 5% level of significance. Results showed that cowpea plants that received 500ml of water produced mean nodule of 6.0 which was significantly ($p<0.05$) from the mean nodule of 13.2 produced by cowpea plant that grew under rain-fed condition. Cowpea plants that received 500 and 1000ml of water produced mean roots length of 9.8cm and 19.5cm at both 2 weeks and 4 weeks after planting, respectively, which were significantly ($p<0.05$) longer than 5.2cm and 13.4cm mean roots length in the control, at 2 and 4 WAP. Cowpeas that received 500ml of water produced mean plant height of 117cm and number of branches of 1.0 which were significantly different ($p<0.05$) from the mean plants height of 47cm and number of branches of 4.1 in the control plants. Seed yield was significantly ($p<0.05$) higher in the control plants than in the plants that received 500 and 1000ml of water, respectively. It was concluded that root characteristics nodulation potential and seed yield of cowpea were affected by the limiting water supply. Optimal water supply for cowpeas growing in pots should therefore be studied for better irrigation management and optimal performance of cowpea.

Keywords: Nodulation, water stress, cowpea, growth, rooting ability

INTRODUCTION
Cowpea (*Vigna unguiculata* (L.) *Walp*) as the most diverse of the cultivated subspecies and the widest distributed, is an important food legume and versatile crop (Sanginga *et al.,* 2002). It is cultivated within the approximate latitude range of 35^{o}N to 30^{o}S of the equator, covering Asia, and the oceania country, the Middle East, Southern Europe, Africa, Southern USA, and Central and South America (Fall *et al.,* 2003). *V. unguiculata* is a major food legume in the Central and West Africa, where more than 60% of the world's cowpea is cultivated (Daimon & Toshioka, 2001). All the plant parts that are used for food are nutrieitous, providing protein, vitamins and minerals (Abebe *et al.,* 2005).

Cowpea is adapted to high temperatures (20 – 35^{o}C) and grows well in a wide range of soil texture, from heave clays, if well drained, to sandy; it grows best in slightly acid to alkaline soils (pH 5.5 – 6.5). Cowpea grows under wide extreme of moisture condition and once established it is fairly drought tolerant (Gaiser & Graef, 2001). It is often grown in rain-fed agriculture receiving at least 600mm annual rainfall (Valenzuela & Smith, 2002).

Soil water availability is a key factor in the growth, development and species composition of cowpea. The understanding of soil water uptake patterns by cultivars and associated shoot response to water loss during drought will help explain differences among species in productivity, survival and distribution (Raynolds *et al.,* 2004). Information about root distribution and knowledge of the basic mechanisms of soil water extraction and transport by cowpea species provide one basis for assessing differences among species. According to Gomesda *et al.,* (2001), extensive root development allows extraction of water from a large volume of soil or from a deep water table. As water becomes limiting, certain plants show a decrease in cell sap osmotic potential, thus increasing the water potential gradient between soil and roots, thereby allowing water uptake to continue despite declining soil water content (Larcher, 2003).

It has been reported by Gomesda *et al.,* (2001), that water stress has a significant effect on the growth and biological nitrogen fixation of the crop. The effect of drought on biological nitrogen fixation has been widely reported and is considered to be by far, the most important environmental factor resulting in crop yield losses (Marino *et al.,* 2007). Hsiao & Xu (2000) reported that a decrease in soil water potential can markedly affect root hair and retard nodule growth and nitrogen fixation. In their own study, Ramos *et al.,* (1999 and Ramos *et al.* (2003) stated that once

nodules are formed, water stress can also lead to morphological and physiological alteration, including nodule structure. This present study was aimed at investigating the impact of water stress on the rooting ability of cowpea and to determine its effects on the nodulation capacity of the cowpea roots as a legume crop.

MATERIALS AND METHODS

A pot experiment was conducted during the cropping season (April-August) of 2008, at the Teaching and Research Farm of the Faculty of Agriculture and Veterinary Medicine, Imo State University, Owerri Nigeria using a Completely Randomized Design with four replications. Treatments consisted of different water volumes (500ml, 1000ml and 1500ml), including a control represented by cowpea plants that grew under rain-fed condition. Sixteen plastic buckets of 30cm^3 capacity were perforated around the base and at the bottom to make for easy drainage, and were dilled with top-soil collected from the University's farm site to $^2/_3$ of their capacity. The top soil was first air-dried for 48 hrs to reduce the water content of the soil so as to initiate a water deficit condition. Seeds of cowpea (Vita 7 variety) collected from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria were planted at the rate of five seeds per bucket at the dept of 2-3cm; germination of the seeds took place between 4 and 5 days after planting. The water treatments were applied in the following schedule: 1500ml (T_1) and 1000ml (T_2) were applied to the receiving crops twice in 7 days; 1500ml (T_3) was applied to the receiving crops on a daily basis, while the control (T_4) was placed in the open space where it received rain water throughout the duration of the experiment.

The experiment was monitored, while the following parameters were recorded; number of root nodules per plant, root length (cm) per plant measured at 2 and 4 wks after planting, and at flowering, through destructive sampling method, number of leaves per plant, number of branches per plant. Data collected on these parameters were subjected to Analysis of Variance (ANOVA). Separation of treatment means was carried out by the Least Significance Difference (LSD) method using 5% level of significance (Onuh & Igwemma, 2001).

RESULTS

Nodulation of cowpea: The least mean number of nodules (6.0) was obtained from cowpea plants that received 500ml of water treatment and this was significantly different from the 13.2 mean number of nodules recorded from the cowpea plants that grew under rain-fed condition (control) at 2 wks after planting (Table 1). At 4 wks after planting, the highest (53.2) mean number of nodules was obtained from cowpea plants under rain-fed condition which was significantly different from the 17.5 mean number of nodules recorded in the plants that received 500ml, 1000ml and 1500ml of water, respectively. There was also significant difference in the mean number of nodules recorded in the plants that received 1500ml of water and the plants that received 500 and 100ml of water, respectively (Table 1). The trend was almost maintained at maturity, when the cowpea plants that grew under rain-fed condition recorded significantly higher number of nodules than the plants that received 500, 1000 and 1500ml of water, respectively.

Root length of cowpea: The highest mean root length (9.8) at two wks after planting was observed from plants that received 500ml of water treatment, while the least mean root length (5.2cm) was observed from plants that were grown under rain-fed condition (control) (Table 1). Also at 4 wks after planting, plants that received 500ml of water treatment gave the highest root length of 18.5cm, while 13.4cm, the least mean root length, was observed from plants in the control experiment (Table 1).

Height of cowpea plant: From the Fig. 1, the highest mean plant height (117cm) was observed from the cowpea plants that received 500ml of water treatment, which was significantly different from the 47.0cm mean plant height observed from plants grown under rain-fed condition.

Branching of cowpea

Cowpea plants in the pots that served as the control showed significant difference in the seed yield with a value of 62.9kg/ha as the highest observed mean seed yield which was significantly different from the 11.1kg/ha obtained from plots that received 1500ml.

TABLE 1. EFFECTS OF WATER STRESS ON ROOT DEPTH AND NODULE FORMATION

	Mean Root length (cm)			Mean No of nodules per plant		
	2 wks	1 month	At flowering	2 wks	1 month	At flowering
Rain-feed (control)	5.2^c	13.4^c	13.3^c	13.2^a	53.2^a	35.1^a
500ml	9.8^a	18.5^a	20.3^a	6.0^c	17.5^c	11.2^d
1000ml	7.6^b	18.5^a	19.6^b	7.5^b	19.8^c	14.6^c
1500ml	5.6^c	15.3^b	14.11^c	8.2^b	25.6^b	18.3^b

Means in the same column with the same letter superscript are not significantly different at $p \leq 0.05$, according to LSD test.

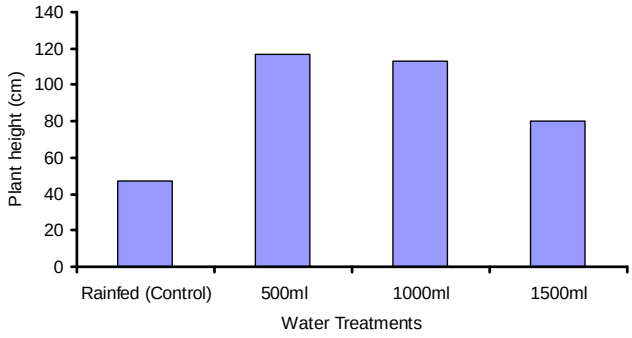

FIG 1. EFFECT OF WATER STRESS ON THE HEIGHT OF COWPEA PLANTS

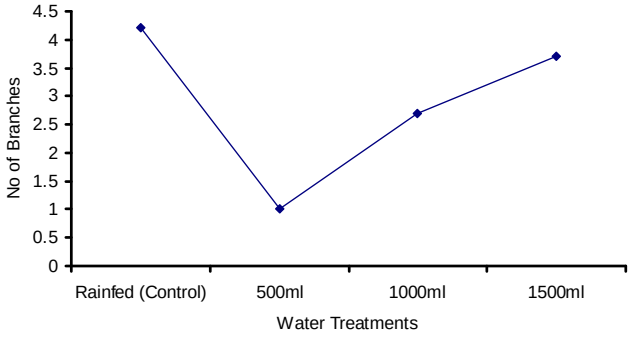

FIG 2. EFFECT OF WATER STRESS ON COWPEA BRANCHING

Discussion

Results of this study revealed that water was a limiting factor for proper agronomic growth and development of cowpea plant. Effects of water stress on the nodulation of cowpea plant roots indicated that the cowpea plants that received higher volumes of water produced more number of root nodules. Cowpea pants that received 500ml water produced the lowest root nodules, while the control plants, represented by rain-fed plants, produced the highest number of root nodules, followed by the plants that received 1500ml of water during the growth period. This is an indication that water is an essential component of root nodulation in plants, and shortage of it results in reduced formation of nodules in the cowpea roots. This is in conformity with the observation of Serraj (2003), who reported that root nodulation in legumes synchronize with the availability of necessary soil components, including soil moisture.

It was observed that cowpea plant decreased in height in relation to the progression in the volume of water supplied for the growth of the plant. Cowpea plant that received 500ml of water grew taller followed by those that received 1000ml, next with those that received 1500ml of water while the rain-fed plants were the shortest. This is attributed to the physiological stress occasioned by the limiting water supply. According to the annual report of the Science Daily (2008), plants growing under water limiting condition tend to grow taller in an effort to scramble for nutrients around the growth environment. This observation was similar to the observation made in the length of cowpea plant roots, where higher root lengths were recorded in the cowpea plants that grew with an average of 500ml of water supply, while the rain-fed cowpea plants produced shorter root lengths. This observation is attributed to the fact that plants growing in a water stress condition will tend to elongate their roots around the growth environment in the bid to capture moisture from the atmosphere and absorb water from the rhisosphere, the stem and roots become elongated and hence longer than normal. This consequently resulted in the longer root-length observed in the cowpea plants that received average of 500ml of water during their growth period, while those that were rainfed had the shortest root length. This observation is in agreement with the finding of Scholz *et al.,* (2002) who reported that roots of plants growing in water stress condition tend to be excessive and longer than their counterpart that grew with the natural rainfall condition.

REFERENCES

Abebe, G., Hattar, B. & Al-Tawaha, A. R. M. (2005). Nutrient availability as affected by manure application to cowpea (*Vigna unguiculata* L. Walp) on calacarious soils. *Journal of Agriculture and Social Sciences* 1(1):1- 6.

Daimon, H. & Yoshioka, M. (2001). Responses of root nodules formation and nitrogen fixation activity to nitrate in a split-root system in peanut (*Arachis hypogia* L.) *Journal of Agronomy Crop Science.* 187**:**89-95.

Eugene, M. & Spent, J. I. (2006). Effects of water stress on growth and nitrogen fixing activity of Tripoliumrepens. *New Phytologist* 72(1)**:**117-126.

Fall, L. D., Fall-Ndiaye, M. A., Badiane F. A. & Crueye M. (2003). Genetic diversity in cowpea (*Vigna unguiculata* (L Walp) varieties determined by ARA & RAPD techniques. *African Journal of Biotechnology* 2(2):48- 50.

Gaiser, T. & Graef, F. (2001). Optimization of a parametric land evaluation method for cowpea and mearl millet production in semiarid regions. *Agronomic* 21: 705-712.

Gomesda, S. J. A., Ja Costa R. C. & Oliveira, J. T. A. (2001). Drought – induced effects and recovery of nitrate assimilation and nodule activity in cowpea plants inoculated with bradyrhizobium spp. under moderate nitrate level, *Brazilian Journal of microbiology* 32 (3).

Hsiao, T.C. & Xu L. K. (2000). Sensitivity of growth of roots versus leaves to water stress: Biophysical analysis and relation to water transport. *Journal of Experimental Botany* 51**:**1595-1616.

Larcher, W. (2003). *Physiological plant ecology. Ecophysiology and Stress physiology of functional groups* 4th Edn. Springer Verlay Berlin

Marino, D., Frendo, P., Gonzalez, E. M., Puppo, A., & Arrese, C. (2007). NADPA recycling systems in oxidative stressed nodules: a key role for the NADP ± dependent isocitrate dehydrogenase. *Planta* 225**:**413-421.

Martins, M. N., Xavier, G. R., Rangel, F.W., Ribeiro, L. R. A., Neves, M. C. P., Morajado L. B. & Ram J. N. G. (2003). Contribution of biological Nitrogen fixation to cowpea: a strategy for improving gram yield on the semi arid region of Brazil. *Biology of Fertile soil.* 38:333-339.

Onuh, M. O. & Igwemma, A. A. (2001). *Statistical Techniques for Business and Basic Science*. 2nd edition CRC publication Owerri , Nigeria.

Ramos, M. L. G., Gordon, A. J., Minchin, F. R., Sprent, J. I. & Parsons, R. (1999). Effect of water stress on nodule physiology and biochemistry of a drought tolerant cultivar of common bean (*Phasioous vulgans* L.). *Annals of Botany, London* 83:57-63.

Ramos, M. L. G., Parsns R., Sprent, J. I. & James, E. K. (2003). Effect of water stress on nitrogen fixation and nodule structure of common bean. *Pesquisa Agropecuiria Brasileira.* 38 (3):339-347.

Reynolds, J. F., Kemp, P. R., Ogbe, K. & Fernandez, R. J. (2004). Modifying the pulse presence paradigm for derserts of North America. Precipitation pulses, soil water and plant response. *Oecologia* 141:194-210.

Sanging, N. G., Tholta, P. & Dashiell, K. (2002). Effectiveness of rhizobra nodulating recent promiscuous soybean selections in the moist savannah of Nigeria. *Soil Biology and Biochemistry* 32:127-133.

Scholz, F. G., Bucci, S. J. Goldsteem, G. Meinzer, F. C. & Tranco, A. C. (2002). Hydraulic redistribution of soil water by neotrpical savanna tress. *Tree Physiology* 22**:**603- 612.

Science Daily (2008). Nitrogen fixation process in plants to combat drought in various species of legumes. *Science Daily* (Jan. 25, 2008). http://www.scienedaily.com/releases/2008/01/080123085302.htm. Accessed 31/07/2009.

Serraj, R. (2003). Effects of drought stress on legume symbiotic nitrogen fixation: physiological mechanisms, *Indian Journal of Experimental Biology* 41(10):1136-1141.

Volenzuela, H. & Smith, J. (2002). Green manure crops: Cowpea. *Cooperative Extension Service.* College of Tropical Agriculture and Human Resources University of Hawai at Manoa ASPGM-6.