Effect Of Water Stress On The Leaf Relative Water Content And Yield Of Some Cowpea (Vigna Unguiculata (L) Walp.) Genotype

HAYATU M., Muhammad S.Y., HABIBU U. A.

Abstract: This Experiment was carried out in the screen house of the International Institute of Tropical Agriculture (IITA) Kano station to study the leaf relative water content and yield of nine cowpea (*Vigna unguiculata* (L) Walp.) varieties to water stress. Data were collected on the following criteria, number of leaves, leaf area (LA), leaf relative water content (LRWC), and agronomic traits. The experimental materials were arranged in randomize complete block design with three treatments which include unstressed, vegetative stage and flowering stage of water stress. The results indicate that Leaf Relative Water Content (LRWC) of the water stressed genotypes were lower than the unstressed genotypes. At vegetative stage of water stress only 22.22% had an increase in their leaf water content and 77.78% recorded reduction in their LRWC. The highest reduction was exhibited by IT97K-568-19 with 9.5% and lowest reduction was recorded 0.1% by TVU-7778. 55.55% of the genotypes at flowering stage of water stress had reduction in their pod number. The Fodder yield at vegetative stage of water stress showed that 77.77% of the genotypes recorded reduction in their Fodder yield. IT98K-503-1 had higher dry fodder yield with 4.07% increase. At flowering stage of water stress, 99% of the genotypes recorded reduction in their fodder yield. The present study conclude that, water stress reduced the leaf area, relative water content and grain yield, among the cowpea screen genotypes TVU-7778 and IT98Kk-503-1recorded lower seed number at vegetative and flowering stages

Key words: Cowpea, growth stages, Leaf Relative Water Content and Leaf Area, water stress,

1. INTRODUCTION

Drought is a situation where by moisture become insufficient either due to low precipitation or low soil moisture storage for optimum plant growth. Drought affects the growth of many plants and hence leads to a very poor yield. But nevertheless, some crops try to evade this drought by being tolerant to it. Among crops that are drought tolerant, Cowpea has been found to be one of the most drought tolerant crop[1].Cowpea is widely grown under rainfall conditions in semi-arid regions. In sub-Saharan Africa, where about two thirds of the world's cowpea is produced [2], drought remains one of the major production limitations. The semi-arid areas are characterized by low and unreliable rainfall, and hence are prone to drought. Water deficits are the main constraint on crop production in these areas [3]. Many aspects of plant growth are affected by drought stress [4] including leaf expansion, which is reduced due to sensitivity of cell growth to water stress.

- *Hayatu M. Senior Lecturer, Department of Plant Science, Bayero University Kano, P.M.B. 3011, Kano State, Nigeria E-mail: haymoh2001@yahoo.com*
- *Muhammad S.Y. Lecturer, Department of Biology Federal College of Education (Technical) Bichi, P.M.B 3573, Kano State, Nigeria E-mail: msalisuyunusa@gmail.com*
- *Habibu U.A. Senior Lecturer, Department of Biology, Federal College of Education (Technical) Bichi, P.M.B 3573, Kano State, Nigeria E-mail: habibubichiusman@yahoo.com, alhajhabibu@gmail.com*

Water stress also reduces leaf production and promotes senescence and abscission [5], resulting in decreased total leaf area per plant. Reduction in leaf area reduces crop growth and thus biomass production. Seed production which is positively correlated with leaf area [6] may also be reduced by leaf area reductions induced by drought stress. Most cowpea is produced in arid and semi –arid zones of sub-Saharan Africa where drought is a major production constraint due to low and erratic rainfall [1]. For cowpea to be used as a forage or dual-purpose crop in the semi-arid areas, the effect of drought stress on leaf area, and the relationship between leaf area and seed yield, must be understood to maximize crop production. Changes in plant water status due to drought stress also need to be investigated since the growth of a leaf is intimately linked with its relative water content. Therefore, the aim of this study is to evaluate the effect of water stress on the leaf relative water content of some cowpea genotypes at different growth stages.

2. MATERIALS AND METHODS

The experiment was conducted in a screen house at the International Institute of Tropical Agriculture (IITA) Kano station, Nigeria. The experiment was carried out in pots. Eighty one pots (81) were used, and each pot measured 25cm in length; the top diameter is 25cm while the bottom is 19cm in diameter. The pots were filled with a mixture of top soil, river sand and animal manure in the ratio of 1:2:1 respectively. These were thoroughly mixed and watered for two days. Two holes were made in each pot one opposite the other in which 4 clean seeds of each variety was planted. The pots were arranged in complete randomized design with three replications. Following one week after germination, the plants were thinned to two plants per pots. Watering was done once daily and weeds were manually removed when observed.

Imposition of water stress

The experiment comprised of three treatment regime which include unstressed, water stress at vegetative and flowering stages. Imposition of water stress was done by complete withdrawal of water at vegetative i.e. when the plant had attained full vegetative stage at 28 days after planting and flowering stages,, when the plants had 70% of fully opened flower (37 days after planting). The following data were collected. Water stress was imposed at vegetative and flowering stages by withholding irrigation. The unstressed plants received irrigation up to the harvest as they reached physiological maturity.

Leaf Relative Water Content

This was determined at vegetative and reproductive stages of water stress, by cutting top-most fully expanded leaves; leaves were immediately weighed to obtain the fresh weight. The leaves were kept in small sealed plastic bags and kept in ice box. The leaves were then soaked in water for 4hr and blotted with tissue paper to remove moisture on the leaves. The leaves were weighed to obtain the turgid weight. The turgid leaves were oven-dried at 80^0c for 24hr. in a ventilated oven. The dried leaves were weighed and were reported in gram per leaves [7]. The relative water content (RLWC) was calculated according to the following formula proposed by [8]

$$RWC (\%) = [(FW-DW) / (TW-DW)] \times 100$$

Where, FW is the sample fresh weight, TW is the sample turgid weight and DW is the sample dry weight. Leaf areas were estimated as suggested by [9]. Agronomic components were estimated such as pod number, pod weight, seed number and seed weight. After harvest, the plant parts were estimated as Fodder yield and were reported in dry weight in gram per plant.

Data Analysis

Data collected were subjected to analysis of variance using Genstat 3 edition and means were separated using least significant difference at 5%.

3. RESULTS

Mean leaf area and relative water content are presented in Table 1; the results indicated that there is significant reduction in leaf area at vegetative and flowering stages of water stress. The reduction was more at vegetative stage with mean value of 46.1cm, flowering stage exhibit a mean value of 62.8cm. The reduction in leaf area at vegetative stress ranged from 17.6 to 51.6%. IT84S-2246-4 recorded the highest reduction in leaf area with 51.6%, the lowest reduction was recorded in IT98K-205-8 with 17.6%. However, IT90K-277-2 had an increase in their leaf area by 26.9%. Leaf relative water content of the stressed genotypes, were lower than the unstressed genotypes, at vegetative stage of water stress only 22.22% had an increase in their leaf water content, 77.78% recorded reduction in LRWC. The highest reduction was exhibited by IT97K-568-19 with 9.5% and lowest reduction was recorded 0.1% by TVU-7778. At flowering stage of water stress, 33.33% of the varieties had increase in LRWC; the highest reduction was recorded in IT84-2246-4 with 14.09%. The lowest reduction in LRWC was exhibited by TVU-7778 with 0.49%. The reduction in LRWC is not significant as water stress genotypes exhibited a minimal reduction. Water stress significant reduced numbers of leaves at vegetative and flowering stages, genotypes with lower reduction in number of leaves were recorded in IT84S-2246-4 and IT90K-277-1. Genotype TVU-7778 recorded the highest reduction in number of leaves at vegetative and flowering stress respectively (Fig. 1).

Table 1: Mean leaf area (cm) and leaf relative water (%) content of cowpea genotype under different moisture stress condition.

	Leaf Area (cm)			Leaf Relative Water Content (%)		
Variety	Unstr	vgt	flw	unstr	vgt	flw
IT84S-2246-4	91.4	44.2	64.7	92.2	82.5	79.2
IT90K-277-2	61.6	78.2	64.5	60.7	74.2	80.69
IT97K-499-35	72.8	53.1	53.7	90.6	86.7	88.12
IT97K-568-19	80.1	48.5	68.7	90.2	81.6	83.42
IT98K-205-8	38.5	31.7	41.9	81.7	84.7	86.31
IT98K-503-1	49.3	43.4	67.8	93.6	87.8	83.08
IT99K-1060	76.8	38.4	79.9	92	87.4	84.41
IT99K-494-6	43	37.8	49.1	80.8	78.7	86.95
TVU-7778	67	39.5	74.8	82.9	82.8	83.31
Mean	64.5	46.1	62.8	85	82.9	83.94
Lsd (5%)	21.58	18.84	32.36	25.87	9.85	7.36

Key: Lsd (5%), least significant difference at 5%; unstressed; vgt, vegetative stage of water stress; flw, flowering stage of water stress

Mean agronomic yield component of cowpea genotypes grown under different moisture stress are presented in Table 2.The present study indicates that 77.77% of the genotypes had reduction in their pod number at vegetative stage of water stress. 55.55% of the genotypes at reproductive stage of water stress had reduction in their pod number. At reproductive stage of water stress variety IT90K-277-2 exhibited an increase in the pod number by 62.2%, IT98K-503-1 by 54.9% and TVU-7778 by 33.5%.

Table 2: Mean Agronomic traits of cowpea genotype at different moisture stress condition.

	pod number			Pod weight (g)			seed number			seed weight (g)		
Variety	unstr	vgt	Flw	unstr	vgt	flw	unstr	vgt	flw	unstr	flw	vgt
IT84S-2246-4	3.33	2.33	1.67	2.4	1.79	3.74	15	16	26	1.66	2.69	1.34
IT90K-277-2	2.67	1	4.33	9.06	1.43	4.08	47.3	8.7	21.67	7.59	3.44	1.23
IT97K-499-35	3.33	3.33	3	3.19	2.94	4.06	21	21.3	21	2.47	3.35	2.5
IT97K-568-19	5.67	2.33	3	4.4	4.1	5.97	21	24	28.33	3.69	4.74	3.57
IT98K-205-8	4	4	1.33	2.63	4.2	3.96	15	29.3	23.33	2.14	3.58	3.34
IT98K-503-1	2.33	2	3.67	3.61	2.23	1.96	25.7	11	16.67	2.88	1.88	1.77
IT99K-1060	4	3	2.33	3.91	4.23	4.59	21	27.3	30	3.12	3.64	3.44
IT99K-494-6	4	4	6	4.88	2.79	2.72	37.3	28	21.33	3.88	2.16	2.37
TVU-7778	2	1.33	2.67	3.62	1.78	3.33	30.3	18	22.33	2.72	2.77	1.45
mean	3.48	2.59	3.11	4.19	2.83	3.83	26	20.4	23.41	3.35	3.14	2.33
Lsd (5%)	2.23	2.20	3.56	4.03	3.09	1.56	18.69	22.4	8.83	3.32	1.48	2.73

Key: lsd (5%) least significant difference at 5%; unstr, unstressed; vgt, vegetative stage of water stress; flw, flowering stage of water stress

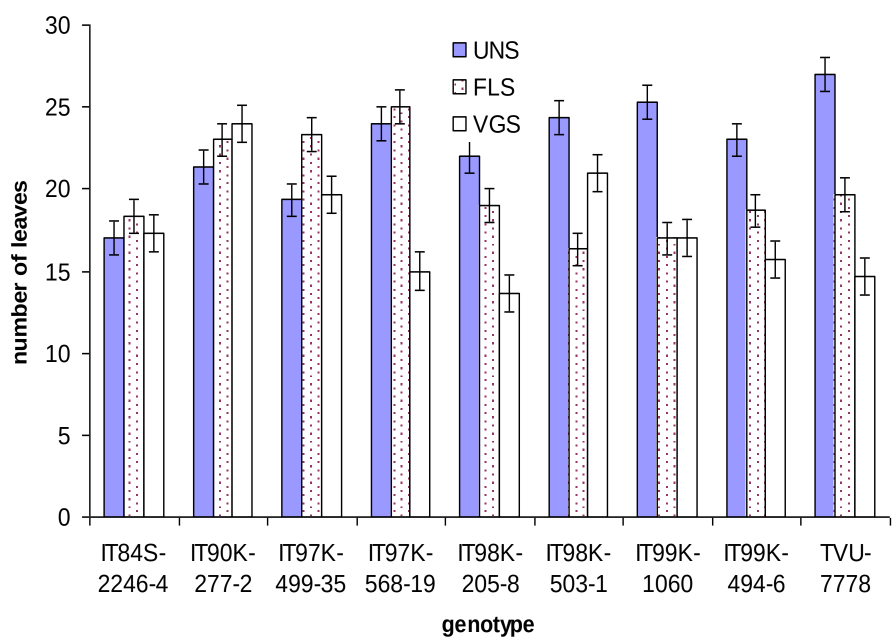

Figure 1: Effect of water stress on the number of leaves of cowpea genotypes at different growth stages of water stress, Vertical bar show ± SE of three replications

Table 3: Mean Fodder dry matter g plant-1 of cowpea grown under different moisture stress condition

	Fodder dry weight (g)		
Variety	unstr	vgt	flw
IT84S-2246-4	3.72	2.75	3.85
IT90K-277-2	6	2.59	3.08
IT97K-499-35	5.43	3.32	1.75
IT97K-568-19	4.55	3.88	3.42
IT98K-205-8	4.62	5.08	2.79
IT98K-503-1	1.29	4.07	3.82
IT99K-1060	3.02	2.82	4.71
IT99K-494-6	3.31	2.69	2.77
TVU-7778	6.41	2.59	4.72
Mean	4.26	3.31	3.43
s.e.d.	2.362	1.594	2.101

Key: SED, standard error of differences of means; unstr, unstressed; vgt, vegetative stage of water stress; flw, flowering stage of water stress

The mean for fodder yield at vegetative stage of water stress indicates that 77.77% of the genotypes recorded reduction in fodder yield. IT98K-503-1 had higher dry fodder yield with 4.07% increase. Lowest fodder dry matter was recorded in TVU-7778 with 2.59g plant^{-1}. At reproductive stage of water stress, 99% of the genotypes had reduction in their fodder yield. IT98K-503-1 had higher fodder dry matter with 3.82g plant^{-1}. The lowest fodder yield was recorded in IT97K-499-35 with 1.75g plant^{-1} (Table 3)

4. DISCUSSION

In this study, water stress significantly reduced leaf area, leaf relative water content and grain yield of cowpea. Results from this study are similar to those found by [10] where reduction in leaf relative water content was reported. The study also recorded reduced vegetative growth due to water stress. This finding agrees with that of [11].Similar results on decrease in growth and yield were reported by [11], which can be attributed to the effects water has on the physiology of the crop. The finding also agrees with that of [12] on cowpea that reduction in LA were observed in water stress cowpea. The reduction in leaf area in cowpea genotypes is a mechanism adapted to avoid higher rate of transpiration and reduced surfaces for radiation due to water deficit The ability of cowpea to maintain high tissue water potential despite a shortage of soil moisture content is drought avoidance mechanism. Plants develop strategies for maintaining turgor through increasing root depth or having an efficient rooting system to maximize water uptake, and by reducing water loss through reduced stomatal conductance, reduced absorption of radiation by leaf rolling and reduced evapo-transpiration [13]. Reduction in leaves production and or increase in leaf senescence and abscission due to water stress have been reported by [14]. The decrease in leaf production and or increased leaf senescence results in reduced leaf area which might be a drought avoidance mechanism [15]. Reduction in number of pods was reported in cowpea by [15]. They observed that with increasing reduction in soil moisture, the numbers of seeds are reduced and which may contribute to low yield in water stressed cowpea.

5. CONCLUSION

The study revealed that water stress reduced leaf area leaf relative water content and grain yield of cowpea. Among the genotypes studied, IT84S-2246-4, IT98K-205-8, and IT97K-568-19 recorded increase in grain yield under flowering stage of water stress, higher reduction were recorded under vegetative stage of water stress. TVU-7778 recorded higher reduction in grain yield under flowering and vegetative stages of water stress. To maximize crop production in arid and semi –arid zones of sub-Saharan Africa where drought is a major production constraint due to low and erratic rainfall, this study revealed genotypes, IT84S-2246-4, IT98K-205-8, and IT97K-568-19 to be suitable.

Acknowledgments

The authors wish to thank Bayero University Kano; Federal College of Education (Technical), Bichi, Kano and International Institute of Tropical Agriculture, Kano station for supporting this work.

6. REFERENCES

[1]. Singh B.B, Chambliss, O.L; and Sharina, B. (1997). *Recent advances in cowpea breeding. in: Advances in cowpea research*. B.B. Singh, B.R Mohan Raji, K.E Dasiell and L.E.N. Jackiat (eds) co-pub. Of IITA and JIRCAS IITA Ibadan, Nigeria.

[2]. Ehlers-JD. Hall-A.E (1997). *Heat tolerance of contrasting cowpea varieties in short and long days*. Field-Crops-Research 55:1-2.

[3]. Begg, J.E. and Turner, N.C., 1976. Crop water deficits.Adv. Agron. 28:161-217

[4]. Hsiao TC (1973). *Plant responses to water stress. Ann. Rev. Plant physiology* 24:519-570.

[5]. Karamanos A.S. (1980). Water stress and leaf growth of field beans (Vicia faba) in the field. Leaf number and total leaf area. Ann. Bot. 42:1393-1402

[6]. Rawson H.M and N.C Turner, (1982). *Recovery from water stress in five sunflower (Helain thus annus!) cultivars 1*

[7]. Painawadee, M., S. Jogloy, T. Kesmala, C. Akkasaeng and A. Patanothai, (2009). Identification of Traits Related to Drought Resistance in Peanut (Arachis hypogaea L.). Asian Journal of Plant Sci. 8(2) pp:120-128.

[8]. Slavick,B.,1979. Methods of studying plant water relation. Springer-Verlang. New York.

[9]. O'Neal M; Douglas AL; and Rufus I. (2002**)**. An inexpensive, Accurate Method for Measuring Leaf Area and Defoliation through Digital Image Analysis, *J.Entomol*.95 (6): 1190-1194

[10]. Lobato, A.K., Costa, R.C.,2011.ABA-mediated proline synthesis in Cowpea leaves exposed to water deficiency and rehydration. Turk J. Agric. (35): 309-317

[11]. Aguyoh, J.N., Sibomana, I.C, Opiyo, A.M., 2013.Water stress affects growth and yield of container grown tomato plants.Global Journal of Bio-Science and Biotechnology. Vol2(4): 461-466

[12]. Samson H., Helmut H. (2007). Drought effect on yield, leaf parameters and evapotranspiration efficiency of cowpea.

Conference on International Agricultural Research for Development.

[13]. Mitra J (2001). Genetics and genetics improvement of drought resistance of crop plants. Curr Sci 80:758-763

[14]. Abidoye T.O. (2004). Effects of soil moisture content on growth and yield of cowpea (Vigna unguiculata L.Walp). B. Agric. Dissertation, University of Ilorin, Nigeria.

[15]. Abayomi, Y.A., T.O. Abidoye (2009). Evaluation of cowpea genotypes for soil moisture stress tolerance under screen house conditions. *African Journal of Plant Science* Vol. 3. (10) pp. 229-239