Print : ISSN 0970-7662

Journal of Tree Sciences

online available at www.ists.in

Volume 33 No.1 June, 2014

Effect of Water Stress on Growth Peformance of *Synsepalum dulcificum* (Schum. & Thonn.) Daniell Seedlings

OO Fawibe[1], AA Ajiboye[2] and DA Agboola[1*]

[1]Department of Biological Sciences, Federal University of Agriculture; P.M.B 2240, Abeokuta, Ogun State, Nigeria [2]Department of Biological Sciences, Osun State University, Osogbo, Osun State, Nigeria.

** E- mail: jareagbo@yahoo.com Phone: +2348063024517*

ABSTRACT

Miracle plant (*Synsepalum dulcificum*) is an important protein sweetener with potential for use in a food industry. There is however the problem of its susceptibility to drought. The study was conducted to determine the effect of water stress on the growth performance of the seedlings. Seedlings were raised from seeds extracted from matured berries in a 30 cm × 19 cm polythene bags. Four months after planting, seedlings were subjected to three moisture regimes of 25%, 50%, 75% and compared with the control 100% (field capacity). Treatments were replicated five times and arranged in a Completely Randomized Design (CRD). The growth parameters measured were plant height, primary root length, number of leaves per plant, leaf area per plant, root and shoot dry weights at 7 days interval for 42 days. Dry weight and leaf area taken at 7, 21, 42 days (t1, t2 and t3) after application of treatments were used to calculate the Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Leaf Area Ratio (LAR). Data obtained were analysed using one-way analysis of variance (ANOVA). The RGR (0.0172 ± 0.0100 $g^{-1}week^{-1}$), NAR (0.0013 ± 0.0200 $gcm^{2-1}week^{-1}$) and LAR (197.80 ± 0.01 cm^2g^{-1}) obtained at 75% field capacity showed the fastest growth rate while the slowest growth rate was obtained at 25% field capacity with RGR (0.0077 ± 0.0100 $g^{-1}week^{-1}$), NAR (0.0005 ± 0.0300 $gcm^{2-1}week^{-1}$) and LAR (269.70 ± 0.01 cm^2g^{-1}). Moisture regime of 25% field capacity significantly ($P<0.05$) reduced leaf area, number of leaves and total dry weight per plant. The study showed that *S. dulcificum* seedlings could be cultivated productively at 75% moisture regime.

Keywords:

Field capacity, growth, moisture regime, seedlings, *Synsepalum dulcificum*

INTRODUCTION

Synsepalum dulcificum (Schum. & Thonn.) Daniell. - Sapotaceae, also known as the miracle fruit is an evergreen shrub native of tropical West Africa. It is a valuable plant of the rain forest due to its potential in nutrition and medicare. The fruits have the property of remarkably altering the sour taste into sweet taste (Kurihara 1997). This small, evergreen shrub grows very slowly to a height of 1.2 - 1.8 m in container, and 3.1 – 4.6 m in natural habitat. The mature bushes usually have a few fruits hanging around all year. The stages of seed germination and fruiting take about 3 to 4 years; however, flowering to fruiting takes 30 to 45 days (James and Judith 1993). The sweet taste of the fruits of this plant is as a result of a glycoprotein (miraculin) extracted from the fruit (Theerasilp and Kurihara 1988). The sweet sensation lasts from half an hour to a few hours (Slater 2007).

Current estimates indicate that 25% of the world's agricultural lands are now affected by water stress, identified as one of the most devastating environmental stresses (Jim 2003). Hsiao (1973) explained that loss of turgor affects the rate of cell division and cell expansion as the first effect of stress and later results in decrease in growth rate, stem elongation, leaf expansion and stomata aperture. When water content of plant decreases, its cell shrinks and the cell wall relaxes. This decrease in cell volume results in lower turgor pressure. The water uptake and its loss in guard cells change their turgor and modulate stomata opening and closing. This study was aimed at investigating the effect of water stress on the growth performance of *Synsepalum dulcificum*.

MATERIALS AND METHODS

Healthy, disease-free and ripened fruits of *Synsepalum dulcificum* (Schum. & Thonn.) Daniell. were collected from mother trees in the undisturbed forests of Fiditi in Afijio LGA of Oyo State, Nigeria (7° 42' 49" North, 3° 55' 2" East) and Ilobu in Egbedore-Irepodun LGA of Osun State, Nigeria (7° 52' 0" North, 4° 23' 0" East). Collections were made at different cardinal points of the collection site. Identification and authentication were done at Forestry Herbarium of Federal University of Agriculture Abeokuta where voucher specimens were deposited.

Sandy-loamy soil collected at 20 cm depth was sieved to remove stones and pebbles and 7 kg of the soil type was dispensed into each of the 30cm × 9cm dark polythene bags. 20 ml of distilled water was added to 20 g of sieved air-dried soil in a 50ml beaker. It was allowed to stand for 30 minutes and stirred occasionally with a glass rod. The pH value of the soil (6.52) was determined by dipping the electrode of the standardized pH meter into the partly settled suspension (Bates 1954).

The experiment was conducted at the Department of Biological Sciences screen house, Federal University of Agriculture Abeokuta (latitude 7° 15' N, longitude 3° 25' E), Ogun State, Nigeria from September 2012 through March 2013. Scanty rainfall, low humidity and clear sunny days were the features of these periods. The bags were perforated at the bottom to enhance drainage without depleting the soil quantity. Each bag filled with soil was wetted with water to field capacity. The epicarp and orange-coloured fruit pulp were peeled off to obtain the seeds. Three seeds were sowed to a depth of 5mm in each bag. Two weeks after emergence, the seedlings were thinned to one per pot. The seedlings were nurtured for 4 months before they were subjected to these varying moisture regimes: (i) 100% (field capacity): non water stress (1litre) (ii) 25 % (1/4 of field capacity): severe water stress (25 centilitre) (iii) 50% (1/2 of field capacity): moderate water stress (50 centilitre) (iv) 75% (3/4 of field capacity): mild water stress (75 centilitre). The seedlings were watered once per week, arranged in a Completely Randomized Design (CRD) with 5 replicates per treatment (Siddique et al. 2000).

Plant height (PH) was measured using metre rule (cm) from the base of the plant (above the ground level) to the apical region of the stem. The compacted soils around the primary root length (PRL) were washed away under running water to expose the primary root which was measured with metre rule (cm). The numbers of leaf (NL) were obtained by counting the leaves of each plant in the bag. Leaf area (LA) was measured at seven days interval by graphical method.

Total dry weight (TDW) was obtained by uprooting the seedling, washing its root to remove attached soils and oven-dried to a constant weight at 60 C for 72 hours in a Gallen camp electric oven. The temperature was further increased to 105 C for 1 hr to remove bond water. The oven-dried samples were weighed with an electric weighing balance (Mettler PM11-K). They were further divided into shoot and root at a point of demarcation. The shoot and root were weighed using the electric weighing balance (Agboola et al.

2004).

The seedlings were harvested at 1, 3, 6 weeks for dry weight measurement and growth analysis. The components of growth analysis calculated were relative growth rate (RGR), net assimilation rate (NAR) and leaf area ratio (LAR), according to the methods of Beadle (1982).

Data were subjected to analysis of variance, ANOVA (one way) and treatment means were compared with Duncan multiple range test (DMRT) at 0.05 probability level

RESULTS

The results of the different water stress regimes on growth parameters of *Synsepalum dulcificum* (Schum. & Thonn.) Daniell. seedlings showed that Optimum height was attained at the mild water stress level (75% field capacity) having the mean height of 21.6cm while the least mean height of 19.6cm was observed at the severe water stress level (25% field capacity) (Figure 1). Seedling with the severe water stress level had the longest mean PRL of 24.3cm while the moderate water stress level had the shortest mean length of 17.9cm.

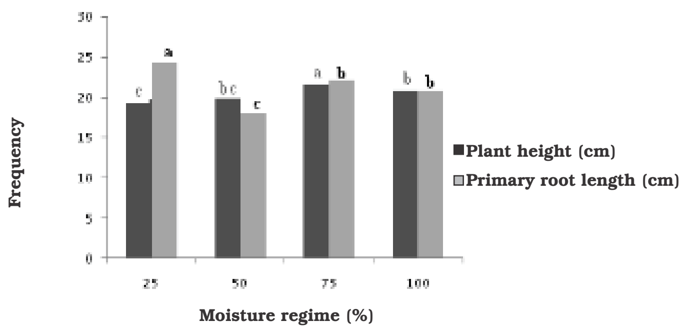

Figure 1: Effect of water stress on plant height (cm) and primary root length (cm) of *Synsepalum dulcificum* seedlings.

PRL further decreases as the water field capacity increases with mild water stressed seedlings and the control having 22.1cm and 20.8cm respectively.

There was decrease in mean NL of the seedlings as water stress level increases. The control seedlings had the highest mean LN of 10.5 with the lowest recorded from the severe water stressed seedlings with mean value of 8.1. LA decreased gradually from 13.7cm^2 to 11.1cm^2 with the control and severe water stress seedling having the highest and lowest mean value respectively (Figure 2).

There was significant difference ($P < 0.05$) between the mean RGR at different moisture regimes. The highest mean RGR was recorded at the 75% moisture regime with the value of $1.72 \times 10^{-2}g^{-1}week^{-1}$ while the lowest mean RGR was recorded at the 25% moisture regime ($0.77 \times 10^{-2}g^{-1}week^{-1}$). Moisture regimes of 50% and 100% had mean RGR values of $1.20 \times 10^{-2}g^{-1}week^{-1}$ and $1.39 \times 10^{-2}g^{-1}week^{-1}$ respectively. The highest mean NAR was also recorded at the 75% moisture regime seedlings ($1.30 \times 10^{-3}gcm^{2-1}week^{-1}$) while lowest mean NAR was observed at the 25% moisture regime ($0.50 \times 10^{-3}gcm^{2-1}week^{-1}$). Both 50% and 100% moisture regime had mean NAR of $0.80 \times 10^{-3}gcm^{2-1}week^{-1}$. The 100% moisture regime had the highest mean LAR of 321.00cm^{2}g^{-1} while the lowest mean LAR was recorded at the 75% moisture regime with a value of 197.80cm^{2}g^{-1}. 25% and 50% moisture regime had mean LAR of 269.70cm^{2}g^{-1} and 217.60cm^{2}g^{-1} respectively (Table 1).

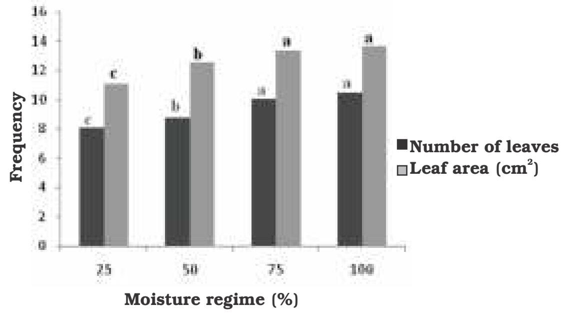

Figure 2: Effect of water stress on number of leaves and leaf area (cm^2) of *Synsepalum dulcificum* seedlings

DISCUSSION

The results revealed that many cellular activities and physiological processes within a plant depend on water as a solvent. Indeed, a cell enlargement could not take place without the influx of water stretching its wall. The decrease in plant height agreed with the result of Gore (2010) who reported that reduction of plant height could be due to reduction in plant photosynthetic efficiency. This was also supported by Randy et al. (1998) who further explained that lack of water is the single most limiting factor in the regulation of photosynthesis.

Severe water stressed seedlings showed the longest mean value of primary root length which could be as a result of high matric potential. The primary roots of the seedlings have high energy which searched for available water in the soil. Jim (2003) reported that during the early stages of water stress, root growth increases to access water deeper in the soil profile. Nevertheless, the mean primary root length of the mild and non water stressed seedlings which are not significantly different could be as a result of the amount of food transported to the root cells after photosynthesis for the development of root.

Number of leaves decreased with increasing water stress. This agreed with the suggestion of Theodore (1973) and Hopkin and Huner (2004) that when water stress develops gradually in plant, it brings about slowing down of leaf growth which is as a result of reduced water potential. The mean leaf area was high in both 75% and 100% moisture regime seedlings with no significant difference between the two. This indicated that they are fastest growing type.

This research showed that though the leaf area of the non water stress seedlings was slightly larger than that of the mild water stressed seedlings; the leaf area of the mild water stressed seedlings are more effective than that of non water stressed seedlings. This was further proven from the LAR which is the ratio of leaf area to the dry weight gained. The smaller the LAR the more effective the leaf area (Hopkin and Huner 2004). In addition, the effectiveness in leaf area might be attributed to the wide variation in number and distribution of stomata in the seedlings of each moisture regime as suggested by Randy et al. (1998). The mean NAR, RGR are high in the mild water stress seedling of *S. dulcificum*. This shows that the mild water stress seedlings show the fastest rate of growth. The growth rate of plants has been found to be dependent on the effectiveness of the leaf area. This is not far-fetched as the leaf is the major assimilatory surface (Agboola et al. 2004).

CONCLUSION

There is decrease in growth rate, plant height; primary root length, leaf number and leaf area of *S. dulcificum* seedlings with increasing water stress regimes which is due to change in physical characteristics of the structural system of cells and alteration in the metabolic reactions that eventually affect physiological processes. The result of this research has shown that the optimum field capacity of the seedling is at 75%, showing that increase in water stress level can bring the life of the seedling gradually to a halt. Excessive administration of water can also deteriorate growth when persisted.

REFERENCES

Agboola DA, Idowu WF and Kadiri M 2004 Seed germination and seedling growth of *Tithonia diversifolia* (Hemsl) A. Gray, the Mexican sunflower. *International Journal of the Tropical Environment* 62- 72

Bates RG 1954 *Electrometric pH Determinations* John Wiley and Sons.Inc. New York pp 13

Beadle CL 1982 Plant growth analysis. Coombs S.J. & Hall D.O. (Eds). *Techniques in Bioproductivity and photosynthesis*. Pergamon Press, Oxford. Pp 19-25

Gore J 2010 Effect of Water Stress on Plants. www.ehow.co.uk

Hopkins GW and Huner PN 2004 Introduction to plant physiology 3rd Edition. John Wiley & Sons Inc. Pp. 459-467

Hsiao TC 1973 Plant Response to water stress. *Annual Review of Plant Physiology*, 24: 519-570.

James AD and Judith LD 1993 *CRC handbook of alternative cash crops*. CRC press. P.433-434

Jim B 2003 “How and when does water stress impact plant growth and development” Presentation at the American society of Agronomy, Crop Science Society of America and Soil Science Society of America, 2003 Annual meetings held in Denver, Colorado.

Kurihara Y 1997 "Characteristics of antisweet substances, sweet proteins, and sweetnessinducing proteins". *Crit Rev Food Science Nutrition* **32 (3):** 231–234.

Randy M, Dennis C and Darrell V 1998 Botany. Boston, Mass: WCB/ McGraw-Hill. ISBN: 0697286312. Edition: (student study guide) pp 136.

Siddique MRB, Hamid A and Islam MS 2000 Drought stress effect on water relation of wheat. *Bot.Bull.Acad.Sin* **41**:35-39

Slater J 2007 To make lemon into Lemonade, try "Miracle Fruit". *Wall Street Journal* **42(3)**: 179-182.

Theerasilp S and Kurihara Y 1988 "Complete purification and characterization of the taste-modifying protein, miraculin, from miracle fruit". *Journal.of Biology Chemistry.* **263 (23)**: 11–19.

Theodore CH 1973 Plant Responses to Water Stress. *Annual Rev. Plant Physiology*, **24(5):** 19-21