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EFFECT OF WATER STRESS ON THE MORPHOLOGICAL GROWTH OF VERNONIA AMYGDALINA SEEDLINGS

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Abstract— ***Vernonia amygdalina*** **(Bitter-leaf) is a plant whose consumption (leaf and stem) by human races especially Nigeria cannot be underestimated. It is mostly consumed because of its nutritional and medicinal uses in correcting some ailments such as high blood sugar, hypertension, and so on.** ***Vernonia amygdalina*** **growth is hinged on the availability or absence of water in relation to soil. Thus, this study assessed the effect of water stress on the morphological growth of** ***Vernonia amygdalina*** **seedlings. The stem cuttings were obtained from viable growing bitter-leaf plant situated on a small well cultivated garden with only bitter-leaf plants. The experiment was carried out at the Greenhouse of the Botanical Garden of Lagos State University, Ojo. The data were analyzed and result presented in table and bar graph. The result showed that although** ***V. amygdalina*** **can be planted using all types of water treatment as observed in this experiment, the result of the three watering regime shows that the best and favourable growth environment for this plant is normal wet treatment water regime (wetting everyday) followed by water logged treatment water regime (excess water) and the least favourable growth environment which can be manageable in absence of the two first mentioned water treatment is the drought treatment (wetting once a week). The amount of water available to plant will affect the rate of photosynthesis. If the plant does not have enough water, the plant's stomata will shut and the plant will be deprived of carbon dioxide.**

Keywords— **Bitter-leaf, water stress, drought and waterlogged.**

I. INTRODUCTION

The survival of plants and animals relies upon water. It is basically required by plants for photosynthesis, nutrient uptake and transportation, keeping up turgidity and in addition lowering canopy temperature (Farooq *et al.* 2009).Water regime is a primary driver of water flow over a given time and predictability of inundation and drying phases (Rea and Ganf, 1994). A water stress may conceivably arise either due to a deficient or an excess of water (Sena and Kozlowski, 1980). Water potential in higher plants is chiefly controlled by the status of soil moisture. Water stress causes both quantitative and qualitative decrease in plant growth, a decrease in shoot growth expectedly the growth of leaves, which is more sensitive than root growth (Sena and Kozlowski, 1980; Jockson and Drew, 1984). Zingaretti *et al*. (2011) reported that during vegetative stage of growth, water is essentially required by plant to obtain maximum yield, and that inadequate water uptake in this stage may reduce crop productivity. Under stressful condition, plant growth is usually affected due to changes in physiological and biochemical activity caused by reduced photosynthesis which may affect the yield and productivity of agriculture crop in many regions around the world (Jackson, 1985; Justin and Armstrong, 1987; Jackson, 1990b; Rahman *et al.*, 2004; Johnston, 2005, Rashidi and Seyfi, 2006 and Riccardi *et al*., 2016).

Vernonia amygdalina Del. is a species of Vernonia which belongs to the family Asteraceae (compositae). Better leaf as it is popularly called grows under a range of ecological zones in Africa and produces large mass of forage (Hutchinson and Dalziel, 1963 in Bonsi *et al.,* 1995a). They are of the most widely consumed leafy vegetable in West and Central Africa owing to its sweet and bitter taste. They are sold fresh or dried, and it is a typical ingredient in soup and stew. *V. amygdalina* has an astringent taste, which affects its intake (Bonsi *et al.*, 1995a). It is popularly called better leaf due to its multi-nutritional factors such as alkaloids, saponins, tannins and glycosides (Buttler and Bailey, 1973; Ologunde *et al.*, 1992 in Bonsi 1995b). The plant is mainly cultivated by stem cutting and or seedlings. The plant will not grow unless they are supplied with enough water to maintain their leaves, they must be well hydrated in the face of continuing evaporation (Boyer and Westgate, 2004). The amount of water available to the plant will affect the rate of photosynthesis (Steven *et al.*, 1984). Inadequate water supply causes stomata closure depriving the plant of carbon dioxide (Hardwick, 1984).

The objective of the present study is to investigate the morphological and structural changes induced by water deficit or excess water on bitter leaf to determine the capability of the crop to tolerate water stress.

II. MATERIALS AND METHODS

The experiment was carried out in the Greenhouse of the Botanical Garden of the Department of Botany, Lagos State University, Ojo, Lagos, Nigeria.

A. Soil Preparation

Nursery: Each planting bag of diameter 30 cm and depth of 40 cm were filled with 0.5 kg humus soil and poultry manure. Plant Transplanting: Each planting bags of diameter 30 cm and depth of 40 cm were filled with 15 kg humus soil and poultry manure for actual plant experiment.

B. Nursery

The stem cuttings of *V. amygdalina* were collected from viable growing bitter-leaf plant situated on a small well cultivated garden with only bitter- leaf plants. The stem cuttings were planted immediately in 100 bags containing humus soil of 0.5 kg. With one plant to one bag, arranged in a row of ten, watered sufficiently and monitored between constantly.

C. Established Plant

A set of 90 perforated uniform bags of diameter 30 cm and depth of 40 cm filled with 15 kg of humus soil were used for transplanting. The seedlings from the nursery were transplanted into the new planting bag.

D. Application of Treatment

Three watering regimes namely Normal Wet Treatment (Control), Drought Treatment and Water Logged Treatment were used as the treatment for the study. Each water treatment contained 30 plants which were completely randomized. The quantity of water used in each wetting was 75 cl. In Normal Wet Treatment, wetting of the plants in this water treatment was done once every day. Normal Wet Treatment is the control for the experiment. Plants in Drought Treatment were wet only on Monday of every week, that is, once in a week) while the plants in Water Logged Treatment were constantly water logged by watering the plant with excess water more than the plant require. A physical observation of puddles of water always on the rhizospehere of the set of plant for water logged treatment was an indicator of constant waterlogging of these set of plants. The three water regime treated plants were carefully monitored during the time of the experiment which lasted for six months.

E. Data Analysis

Ten seedlings were used from the 100 established plants for the initial measurement of the following morphological data, before the application of treatment; average height of stem cutting established and used for experiment, the average base and oldest leaf length of the established stem cuttings; Leaf breadth; Plant girth; Fresh Weight of Leaf and Petiole. After the application of treatment (water regime), four plants were taken every month end from each water treatment (Normal Wet Treatment (NWT) (control), Drought Treatment (DT) and Water Logged Treatment (WLT)) for destructive measurement of the parameters such as Stem Height (SH), Leaf Length (LL), Leaf Breadth (LB), Plant Girth (PG), Petiole Length (PL), Length of Root (LR), Fresh Weight of Root (FWR) and Fresh Weight of Leaf (FWL) for a period of six months. The average mean of each of the parameters are presented in the table below. At completion of the experiment, 24 Bitter Leaf plants were used from each water regime for destructive experimental measurements.

III. RESULTS AND DISCUSSION

The result for the initial morphological data are presented in Table 1 bellow; average height of stem cutting established and used for experiment was 6.00 cm, the average base and oldest leaf length of these established stem cuttings (LL) was 3.00 cm; Leaf breadth (LB) was 1.80 cm; Plant girth (G) was 1.20 cm; Fresh Weight of Leaf (FWL) was 2.10 g and Petiole was 0.80 cm. The result for each of the measured morphological character was constant for the entire three water regime.

The result of the morphological data after the application of treatment is also presented in Table 1 below. One hundred (100) percent continuous growth without any death was recorded for each water regime, although growth rate was not the same for the three regimes.

Upon analysis of the obtained data, it was determined that the growth of the eight (8) morphological characters varied due to water stress. From the result of the study, differences were recorded on Stem Height (SH), Leaf Length (LL), Plant Leaf Breadth (LB), Plant Girth (PG), Petiole (PL), Length of Root (LR), Fresh Weight of Root (FWR) and Fresh Weight of Leaf (FWL) (Table 1 and Figure 1-8). Restriction of available water content led to decrease of the growth of the eight (8) morphological characters. The performance of the plants under the drought treatment and water logged treatment were below those in the control experiment (normal wet treatment regime).

Adaptation to arid conditions involves increasing root growth despite water deficit (Bauerle *et al.* 2008). In fact, the degree of tolerance of arid conditions shown by *V. amygdalina* is maybe related to their capability to create new roots under stress conditions (Bonsi *et al.* 1955). This capability not only increases the hydraulic absorption of roots, but also guarantees transfer of sufficient water and nutrition to shoots (Lovisolo *et al*. 2010). As the effects of water stress on leaf growth were reviewed (Fig. 2 and 7); it was seen that water stress were significant factors for differences arising in terms of average leaf length and petiole length.

This finding agrees report of Paul (1963) that plant water stress depends on the relative rates of water absorption and water loss rather than on soil water supply alone. Water stress like affects the crop growth and development through a progression of complex physio-biochemical and metabolic procedures at genetic and molecular level, for example, photosynthesis, respiration, uptake of water and nutrient elements, enzymatic activities, metabolism of organic materials, and suppressed or over expression of genes encoding stress proteins and transcription factors (Saba *et al*. 2001; Villalobos *et al.* 2004; Farooq *et al.* 2009).

The findings, obtained with respect to the effects of water stress application on shoot and root growth in the *V. amygdalina* tested in this study, are in agreement with literature data (Eriş *et al*. 1998; Bertamini *et al*. 2006; Kliewer *et al*. 1983; Poni *et al*. 1993; Winkel and Rambal, 1993; Paranychianakis *et al.* 2004). According to conducted researches, physiological and biochemical reactions are seen on the plant during an aridity period. The decrease of water in the root area causes abscisic acid (ABA) biosynthesis to increase in roots. Under conditions of inadequate soil moisture, the increase of ABA biosynthesis and accumulation not only leads to the continuation of root growth, but also ensures by both regulating stoma movements and preventing shoot and leaf growth that the loss of water by transpiration decreases (Cramer, 2010; Satisha *et al.* 2006; Lovisolo *et al*. 2010). Thus, root:shoot ratio increases in plants and, therefore, it becomes possible to provide sufficient water and nutrition to the plant (Dry *et al.* 2000).

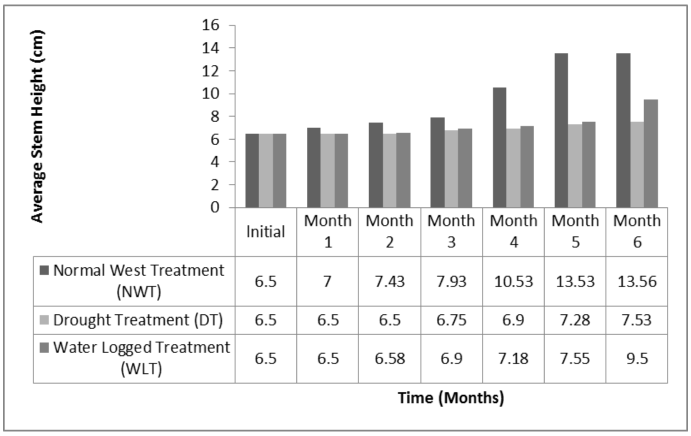


Fig. 1: Effect of Water Regime on the Growth of the Stem Height of *Vernonia amygdalina*.

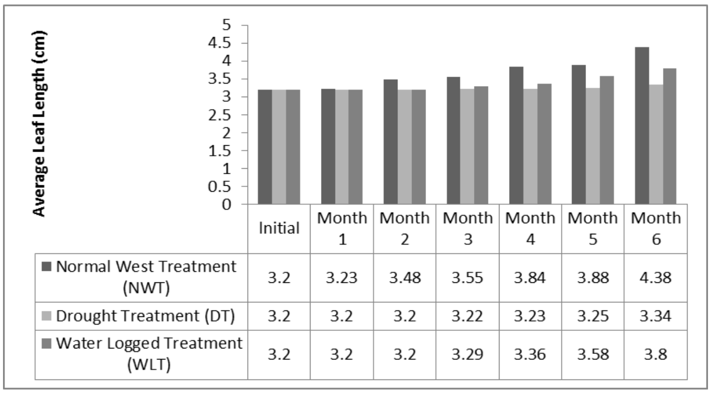


Fig. 2: Effect of Water Regime on the Leaf Length of *Vernonia amygdalina*.

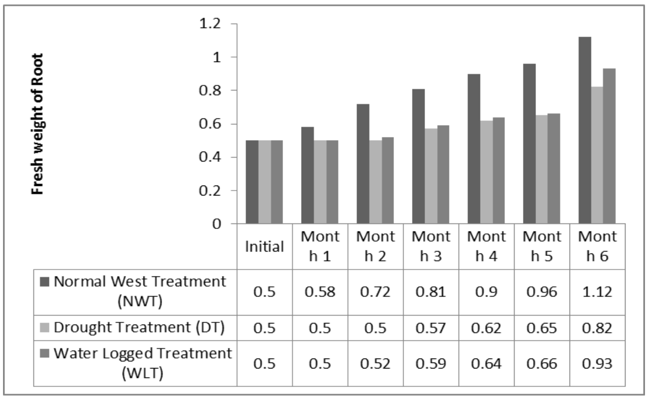
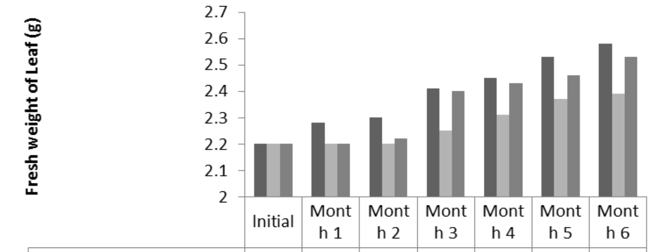
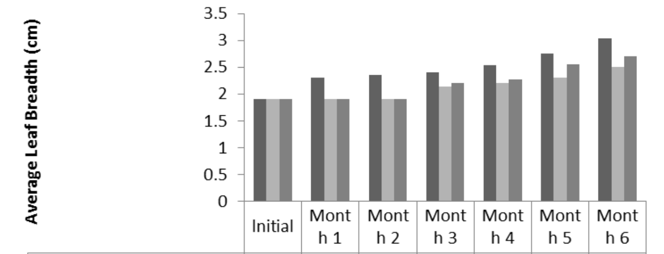


Fig. 3: Effect of Water Regime on the Fresh Weight of Root of *Vernonia amygdalina*



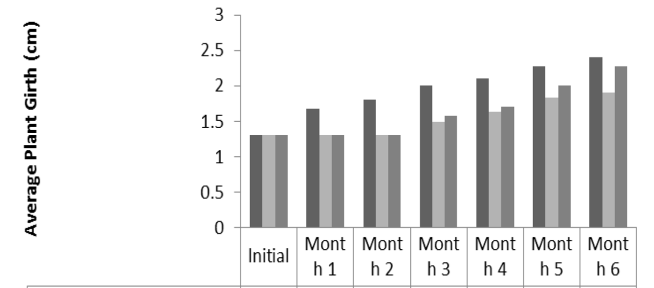
	Initial	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Normal West Treatment (NWT)	2.2	2.28	2.3	2.41	2.45	2.53	2.58
Drought Treatment (DT)	2.2	2.2	2.2	2.25	2.31	2.37	2.39
Water Logged Treatment (WLT)	2.2	2.2	2.22	2.4	2.43	2.46	2.53

Fig. 4: Effect of Water Regime on the Fresh Weight of Leaf of *Vernonia amygdalina.*



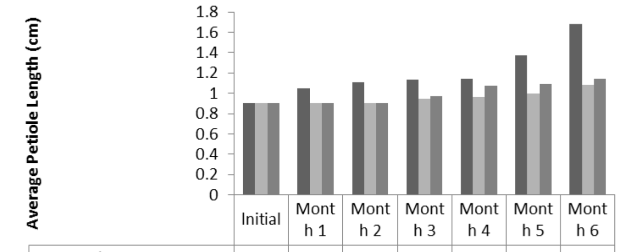
	Initial	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Normal West Treatment (NWT)	1.9	2.3	2.35	2.4	2.53	2.75	3.03
Drought Treatment (DT)	1.9	1.9	1.9	2.14	2.2	2.31	2.5
Water Logged Treatment (WLT)	1.9	1.9	1.9	2.21	2.27	2.55	2.7

Fig. 5: Effect of Water Regime on the Growth of the Leaf Breadth of *Vernonia amygdalina.*



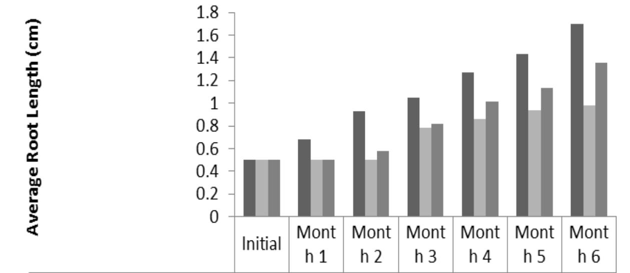
	Initial	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Normal West Treatment (NWT)	1.3	1.68	1.8	2	2.1	2.27	2.41
Drought Treatment (DT)	1.3	1.3	1.3	1.49	1.63	1.83	1.91
Water Logged Treatment (WLT)	1.3	1.3	1.3	1.57	1.7	2	2.27

Fig. 6: Effect of Water Regime on the Growth of the Plant Girth of *Vernonia amygdalina.*



	Initial	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Normal West Treatment (NWT)	0.9	1.05	1.11	1.13	1.14	1.37	1.68
Drought Treatment (DT)	0.9	0.9	0.9	0.95	0.96	1	1.08
Water Logged Treatment (WLT)	0.9	0.9	0.9	0.97	1.07	1.09	1.14

Fig. 7: Effect of Water Regime on the Growth of the Petiole Length of *Vernonia amygdalina.*



	Initial	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
Normal West Treatment (NWT)	0.5	0.68	0.93	1.05	1.27	1.43	1.7
Drought Treatment (DT)	0.5	0.5	0.5	0.78	0.86	0.94	0.98
Water Logged Treatment (WLT)	0.5	0.5	0.58	0.82	1.01	1.13	1.36

Fig. 8: Effect of Water Regime on the Growth of the Root Length of *Vernonia amygdalina.*

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Table 1: Average (mean) values of all the morphological growth characters at the Initial and next six months after the application of treatment.

	0 initial month (May)			1st month (June)			2nd month (July)			3rd month (August)			4th month (September)			5th month (October)			6th month (November)		
	NWT	DT	WLT	NWT	DT	WLT	NWT	DT	WLT	NWT	DT	WLT	NWT	DT	WLT	NWT	DT	WLT	NWT	DT	WLT
SH (cm)	6.50	6.50	6.50	7.00	6.50	6.50	7.43	6.50	6.58	7.93	6.75	6.90	10.53	6.90	7.18	13.53	7.28	7.55	13.56	7.53	9.50
LL (cm)	3.20	3.20	3.20	3.23	3.20	3.20	3.48	3.20	3.20	3.55	3.22	3.29	3.84	3.23	3.36	3.88	3.25	3.58	4.38	3.34	3.80
LB (cm)	1.90	1.90	1.90	2.30	1.90	1.90	2.35	1.90	1.90	2.40	2.14	2.21	2.53	2.20	2.27	2.75	2.31	2.55	3.03	2.50	2.70
PG (cm)	1.30	1.30	1.30	1.68	1.30	1.30	1.80	1.30	1.30	2.00	1.49	1.57	2.10	1.63	1.70	2.27	1.83	2.00	2.41	1.91	2.27
PL (cm)	0.90	0.90	0.90	1.05	0.90	0.90	1.11	0.90	0.90	1.13	0.95	0.97	1.14	0.96	1.07	1.37	1.00	1.09	1.68	1.08	1.14
LR (cm)	0.50	0.50	0.50	0.68	0.50	0.50	0.93	0.50	0.58	1.05	0.78	0.82	1.27	0.86	1.01	1.43	0.94	1.13	1.70	0.98	1.36
FWR (g)	0.50	0.50	0.50	0.58	0.50	0.50	0.72	0.50	0.52	0.81	0.57	0.59	0.90	0.62	0.64	0.96	0.65	0.66	1.12	0.82	0.93
FWL (g)	2.20	2.20	2.20	2.28	2.20	2.20	2.30	2.20	2.22	2.41	2.25	2.40	2.45	2.31	2.43	2.53	2.37	2.46	2.58	2.39	2.53

Stem Height (SH), Leaf Length (LL), Leaf Breadth (LB), Plant Girth (PG), Petiole Length (PL), Length of Root (LR), Fresh Weight of Root (FWR) and Fresh Weight of Leaf (FWL).

IV. CONCLUSION AND RECOMMENDATION

A. Conclusion

Although *V. amygdalina* can be planted using all types of water treatment as observed in this experiment, the result of the three watering regime shows that the best and favourable growth environment for this plant is normal wet treatment water regime (wetting everyday) followed by water logged treatment water regime (excess water) and the least favourable growth environment which can be manageable in absence of the two first mentioned water treatment is the drought treatment (wetting once a week). The amount of water available to plant will affect the rate of photosynthesis. If the plant does not have enough water, the plant's stomata will shut and the plant will be deprived of carbon dioxide and if there is excess of water, the photosynthetic activities is also affected.

B. Recommendation

In case of water logged or riverside cultivation, it is advisable that farmers prepare a nursery growth for the plant to establish before transplanting into the water logged soil and the plant should be carefully monitored as it will not show any meaningful differences at the first month. The plant will try to adapt to the new environment. Since the plant already have established roots, it is easier to germinate than introducing directly into the water logged area without any nursery establishment, this will lead to the death of the plant since it has no root that will help to adapt to the new environment.

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