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EFFECTS OF WATERING LEVELS AND LIGHT INTENSITIES ON SEEDLING VIGOUR OF AFRICAN STAR APPLE (*Chrysophyllum albidum* G. DON)

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ABSTRACT

A 3x2 factorial experiment was laid down in Completely Randomized Design with three replications to assess the effects of watering levels (30, 80 and 140 mL/seedlings) and light intensities (25 and 50 %) on seedling vigour of C. albidum. Watering levels and light intensities significantly ($P<0.05$) enhanced the seedling growth of C. albidum. Widest leaf area (4.16 cm^2), highest root dry weight (0.14 g), highest leaf dry weight (0.24 g) and highest total dry weight (0.52 g) were recorded for seedlings subjected to 80 mL/seedling watering level. Seedlings planted under 50 % light intensity gave higher value of leaf area (2.71 cm^2), root dry weight (0.13 g), leaf dry weight (0.25 g), total dry weight (0.53 g) and relative turgidity (74.82 %) compared to those subjected to 25 % light intensity. Highest leaf dry weight (0.30 g), shoot dry weight (0.17 g) and total dry weight (0.59 g) were recorded in seedlings subjected to 80 mL/seedling watering level and exposed to 50 % light intensity. Subjection of C. albidum seedlings to a combination of 80 mL/seedling watering level as well as 50 % light intensity enhanced its growth. The study therefore recommends subjection of C. albidum seedlings to 80 mL /seedling watering level and 50 % light intensity for mass production of its seedlings for agro-forestry systems.

Key words: Watering regime, Light intensity, Seedling growth, Propagation, Agro-forestry System

INTRODUCTION

With rapid population growth, forest resources are being depleted owing to increasing demand for forest products without afforestation (Adelani *et al.*, 2014a). Indiscriminate deforestation reduces species diversity and erodes the genetic base of the tropical trees, including those vital for survival of the present generation (Adelani *et al.*, 2014b). One of such species is *Chrysophyllum albidum*. It is one of such indigenous and endangered fruit trees. *C. albidum* is a climax tree species of tropical rainforest that belongs to the family Sapotaceae (Olaoluwa *et al.*, 2012; Wole, 2013) which has up to 800 species and make up almost half of the order (Ehiagbonare *et al.*, 2008). The Yoruba name is "Osan Agbalumo" (Rahaman, 2012) while in Igbo and Hausa languages, it is called "Udara" or "Udala" (Wole, 2013) and Agbaluba or Agbaluma (Adelani *et al.*, 2017).

Chrysophyllum albidum is among the forest tree species which is integrated in the traditional agro-forestry system (Ureigho and Ekeke, 2010; Laurent *et al.*, 2012) that provides Non Timber Forest Products (NTFPs) of immense domestic importance to rural and urban dwellers in West Africa with great export potentials (Nwoboshi, 2000). It is used in the preparation of medicine for treatment of fibroids and female sterility (Egunyomi *et al.*, 2005). Intake of *C. albidum* fruit helps in prevention of mouth gum disease, treatment of toothache and sore throat as well as helping people to lose weight (Adaobi, 2019). Adaobi (2019) stated that the vitamin C content of milky juice of *C. albidum* fruit helps to protect the body against immune system deficiencies, cardiovascular disease, prenatal health problems, eye disease, and even skin wrinkling.

The consumption of *C. albidum* fruits can lower blood cholesterol levels that result in a healthy cardiovascular system and also help to improve the appetite of pregnant women for food as well as help to prevent dehydration and malaria in pregnant women (Agustin, 2018). Agustin (2018) and Adaobi (2019) reported that intake of *C. albidum* fruits neutralize free radicals because it contains antioxidants. Antioxidants help to prevent the damage to the system caused by free radicals. The sweet and sour taste of *C. albidum* fruits acts as a natural remedy for common issues such as constipation, toothache, sore throat, indigestion and help to prevent the urge of vomiting during pregnancy (Agustin, 2018; Adaobi, 2019).

Agustin (2018) stated that the post-birth diagnosed for diabetic disease for pregnant women can be prevented by consuming *C. albidum* fruits because it contains compounds that are hypo glycemic that serves to lower blood sugar levels. Herbal practitioners are also known to use the bark of the tree to treat yellow fever and malaria, while the leaves are useful for treating wounds, stomachache and diarrhoea (Adaobi, 2019). *Chrysophyllum albidum* has been noted to be of great medicinal, nutritional (Adisa, 2000; Onyekwelu and Stimm, 2011), economical (Oboh *et al.*, 2009; Onyekwelu *et al.*, 2011; Olaoluwa *et al.*, 2012) and industrial (Amusa *et al.*, 2003; Olaoluwa *et al*., 2012; Rahaman, 2012) as well as ecological values (Aduradola *et al*., 2005).

In spite of enormous potentials of *C. albidum,* it has been greatly neglected particularly with respect to its regeneration (Adelani *et al.*, 2014c, Adelani *et al.*, 2016, Adelani *et al.*, 2017; Adelani and Muhammed, 2019). There is dearth of quantified information on the seedling watering and light requirement for propagation of *C. albidum*. Adelani (2019) stated that of all the factors affecting nutrient uptake, growth and development of the plant, water is most critical. The success of nutrient up take in agro-forestry that leads to growth and development does not depend alone on present of nutrient, species types, age of the plant, soil rhizosphere, but also on soil pH and the availability of water (Adelani, 2019). Water and light intensity are essential factors for healthy plant growth. Also, Adelani *et al.* (2014b) stated that one of the major concerns in forest nurseries in the tropics is the lack of adequate information on light intensity for healthy seedling growth of particular tree species. Liao *et al.* (2006) stated that light is one of the most important environmental factors affecting plant survival, growth, reproduction and distribution. Light intensity affects the central processes of plants such as physiology, biochemistry and cell division (Kong *et al.,* 2016; Wu *et al.,* 2018). In this light, investigation was conducted on watering level and light intensity required by *C. albidum* to ascertain its watering level and light requirement for healthy seedling growth.

MATERIALS AND METHOD

Description of Experimental Site

The experimental site was at the forest nursery of the Federal University of Agriculture, Abeokuta. It is situated along Alabata Road, North-East of Abeokuta. It is located within latitudes 7 ^{o}N and 7 ^{o} 55 ' N and longitudes 3 ^{o} 20 'E and 3 ^{o} 37 ' E. The Federal University of Agriculture, Abeokuta is located within the rain forest zone of South Western Nigeria (Amujoyegbe *et al.*, 2008). It is next to Ogun-Osun River Basin Development Authority (OORBDA), along Osiele-Abeokuta road, off Abeokuta-Ibadan road. It is in the North Eastern end of Abeokuta and lies approximately on latitude 7^{o} 30 ' N and longitude 3^{o} 54 ' E. It lies within the humid lowland rain forest region with two distinctive seasons. The wet season extends from March to October while the dry season extends from November to February (Aiboni, 2001). The rainfall has a characteristic bimodal distribution with peaks in July and September and breaks in August. Generally, the rainfall could be heavy and erosive sometimes accompanied by lightning and thunderstorm at the beginning and end of rainy season.

Determination of watering levels and light intensities on seedling vigour of *Chrysophyllum albidum*

A 3x2 factorial experiment was laid down in Completely Randomized Design with three replications to assess the effects of watering levels (30, 80 and 140 mL/seedlings) and light intensities (25 and 50 %) on seedling vigour of *Chrysophyllum albidum*. A-month old *C. albidum* seedlings were transplanted into top soil filled in the polythene pots of 20 x 10 x 10 cm^3 dimensions at a depth of 15 cm. Seedlings were established by first given 200 mL of water for a week. A rectangular cage of 2.5 x 1.5 x 1 m^3 was constructed and covered with a mosquito net of different layers. The cage was partitioned into two. The first partitioned was covered with two layers of nets, while the second partition was covered with four layers of nets. Digital light meter was used to take the quantity of light intensity under four layers and two layers of nets, respectively. Seedlings placed under two layers of nets were conditioned to 50 % light intensity; while that of four layers of nets was conditioned to 25 % light intensity.

Six seedlings under each watering levels of 30, 80 and 140 mL/seedlings were exposed to 25 and 50 % light intensity. Growth parameters were monitored every two weeks for 12 weeks. Growth parameters assessed include: Seedling height (using meter rule); girth (using venier caliper); the number of leaves were counted manually and Leaf area was obtained by linear measurement of leaf length and leaf width as described by Clifton-Brown and Lewandowski (2000).

LA = 0.74xLxW [1]

Where: LA = leaf Area

LxW = Product of linear dimension of the length and width at the broadest part of the leaf.

The mean of the growth parameters for period of experiment was used for tabulation. Relative turgidity was determined by method of Awodola (1998). Measurements of Chlorophyll were made by direct determinations of the absorbance at different wavelengths, using Model 6405 uv/vis Spectrophotometer, serial number 1364. The concentrations were calculated by adding 20.2 A645, 8.02 A663 and divided by length of light path in cell (usually 1cm), fresh weight in grams and 1000.The result was multiplied by the volume of chlorophyll solution in mL. A645 and A663 is the absorbance at 645 and 663nm.

$$Con. = (20.2\,A645 + 8.02\,A663/(LLP\ x\ FW\ x\ 1000)\ x\ VC$$

Where:

Con. = Concentration

VC = volume of chlorophyll in mL

LLP = Length of light path usually 1 cm

FW = Fresh weight in grams

The dry weights of the *C. albidum* seedlings were determined, by the use of Mettler Top Loading Weighing Balance (Model-Mettler PM 11-K), after oven dried at 70 ^{o}C for 72 hours (Umar and Gwaram, 2006).

Data Analysis

The data collected on watering levels and light intensities of *C. albidum* were subjected to one way analysis of variance (ANOVA). Significant means were separated using Duncans Multiple Range Test (Duncans 1955).

RESULTS

Effect of watering levels on seedling vigour of *C.albidum*

Widest leaf area (4.16 cm^2)., highest root dry weight (0.14 g)., highest leaf dry weight (0.24 g) and highest total dry weight (0.52 g) were recorded for seedlings subjected to 80 mL/ seedling watering level. Shortest height (11.87 cm) and lowest leaf area (3.97 cm^2)., root dry weight (0.09 g)., leaf dry weight(0.21 g)., shoot dry weight (0.12 g)., total dry weight (0.40 g) and relative turgidity (63.89 %) were recorded from seedlings subjected to 30 mL/seedling watering levels (Table 1).

Effect of light intensities on the seedling vigour of *C. albidum*

Seedlings planted under 50 % light intensity gave higher values of leaf area (2.71 cm^2), root dry weight (0.13 g), leaf dry weight (0.25 g), total dry weight (0.53 g) and relative turgidity (74.82 %) compared to those subjected to 25 % light intensity. Lower number of leaves (2.59), root dry weight (0.24 g)., leaf dry weight (0.24 g)., shoot dry weight (0.10 g), total dry weight (0.45 g) and relative turgidity were recorded from seedlings placed under 25 % light intensity (Table 2).

Table 1: Effect of watering levels on seedling vigour of *C. albidum*

Parameters	Watering levels		
	30 mL	**80 mL**	**140 mL/seedlings**
Height(cm)	11.87[a]	11.80[a]	12.13[a]
Number of Leaves	2.70[a]	2.58[b]	2.67[a]
Leaf area (cm^2)	3.97[a]	4.16[a]	3.80[a]
Collar girth (cm)	0.97[a]	0.94[b]	0.95[ab]
Root dry weight (g)	0.09[b]	0.14[a]	0.13[a]
Leaf dry weight (g)	0.21[a]	0.24[a]	0.23[a]
Shoot dry weight (g)	0.12[a]	0.13[a]	0.13[a]
Total dry weight (g)	0.40[b]	0.52[a]	0.48[ab]
Chlorophyll content (Mg/g)	3.86[a]	3.73[a]	3.42[a]
Relative turgidity (%)	63.89[a]	64.13[a]	69.22[a]
SE±	0.43	0.43	0.43

ab Means on the same row having different superscripts are significantly different (P<0.05).

Table 2: Effect of light intensities on seedling vigour of *C. albidum* seedlings

Parameters	Light intensities	
	25 %	**50 %**
Height (cm)	12.26[a]	11.61[b]
Number of leaves	2.59[b]	2.71[a]
Leaf area (cm^2)	3.98[a]	3.98[a]
Collar girth (cm)	0.99[a]	0.91[b]
Root dry weight(g)	0.11[a]	0.13[a]
Leaf dry weight(g)	0.24[a]	0.25[a]
Shoot dry weight(g)	0.10[b]	0.15[a]
Total dry weight(g)	0.45[b]	0.53[a]
Chlorophyll content (Mg/g)	4.14[a]	3.19[b]
Relative turgidity (%)	56.66[a]	74.82[a]
SE ±	0.35	0.35

ab means on the same row having different superscripts are significantly different (P<0.05).

Interactive effect of watering levels and light intensities on seedling vigour of *C. albidum*

Tallest plant (12.51 cm) was recorded from seedlings administered to 140 mL/seedling watering level and subjected to 25 % light intensity. Highest number of leaves (2.75) and highest root dry weight (1.10 g) were recorded in seedlings subjected to 30 mL/ seedling watering level and exposed to 50% light intensity. Widest leaf area (4.38 cm^2) was recorded in seedlings watered at 80 ml/seedling and subjected to 25 % light intensity. Widest girth (1.04 cm) and highest chlorophyll content (4.46 Mg/g) were recorded in seedlings subjected to 30 mL/seedling watering level and exposed to 25 % light intensity. Highest leaf dry weight (0.30 g), shoot dry weight (0.17 g) and total dry weight (0.59 g) were recorded in seedlings subjected to 80 ml/seedling watering level and exposed to 50 % light intensity. Highest relative turgidity was recorded in seedlings subjected to 140 mL/seedling watering level and exposed to 50 % light intensity. Irrespective of watering levels, seedlings conditioned to 25 % light intensity gave lowest growth parameters (Table 3).

Table 3: Interactive effect of watering levels and light intensities on seedling vigour of *C. albidum*

Parameters	Watering level levels					
	30mL		80mL		140mL	
	25	50	25	50	25	50%
Height (cm)	12.11^{ab}	11.62^{b}	12.15^{ab}	11.46^{b}	12.51^{a}	11.76^{ab}
Number of Leaves	2.65^{ab}	2.75^{a}	2.50^{b}	2.67^{ab}	2.61^{b}	2.72^{a}
Leaf area (cm^2)	4.25^{a}	3.70^{a}	4.38^{a}	3.95^{a}	3.31^{a}	4.29^{a}
Collar girth (cm)	1.04^{a}	0.91^{b}	0.99^{b}	0.88^{c}	0.95^{b}	0.96^{b}
Root dry weight (g)	0.08^{c}	1.10^{a}	0.17^{b}	0.12^{b}	0.07^{c}	0.18^{b}
Leaf dry weight (g)	0.18^{b}	0.23^{ab}	0.18^{b}	0.30^{a}	0.25^{ab}	0.22^{ab}
Shoot dry weight (g)	0.10^{b}	0.13^{ab}	0.10^{b}	0.17^{a}	0.10^{b}	0.15^{ab}
Total dry weight (g)	0.36^{b}	0.46^{ab}	0.45^{ab}	0.59^{a}	0.42^{ab}	0.55^{a}
Chlorophyll content (Mg/g)	4.46^{a}	3.25^{ab}	4.28^{a}	3.17^{b}	3.69^{ab}	3.15^{b}
Relative turgidity (%)	51.37^{b}	76.38a	57.29^{b}	70.96^{a}	61.31^{ab}	77.13^{a}
SE±	0.61	0.61	0.61	0.61	0.61	0.61

ab Means on the same row having different superscripts are significantly different (P<0.05).

DISCUSSION

The improvement in growth parameters recorded from seedlings subjected to 80 mL/ seedlings was connected to an adequate supply of water. Similar observation has been recorded by Mukhtar *et al.* (2016a) on *Balanites aegyptiaca* seedlings. Adequate supply of water prevents water logging or water stress. In order to avoid water stress or water logging, it is important to establish adequate water requirements for tree seedlings which will help in reducing the cost of planting stock production in commercial nurseries. Similar observation has been reported by Simon *et al.* (2011). Since growth is proportional to water supply and its usage. Growth and biomass production is directly proportional to the supply and use of water (Mukhtar, 2016b). Water requirement of any tree depends on the botanical characteristics of the plant, its stage of growth and weather conditions (Mukhtar, 2016b; Olaoye and Oyun, 2019) and must be ascertained.

It could be traced that lowest growth parameters recorded for seedlings subjected to 30 mL/seedling was as a result of water stress experience. Mukhtar *et al.* (2016a) stated that water stress has a strong influence on the physiological functions of tree crops which adversely affects the growth and yield of tree plants. Water stress is said to affect the physiological functions of a tree crop, thereby influencing growth and yield (Alves and Setter, 2000; Hsiao and Xu, 2000; Ky-Dembele *et al.*, 2010; Simon *et al.*, 2011; Abdelbasit *et al*. 2012; Vandoorne *et al.*, 2012; Sale, 2015). Gonzales *et al.* (2009) made the similar observation for *Chenopodium quinoa*. This is in agreement with the finding of Vandoorne *et al.* (2012) that water stress drastically decreased fresh and dry root weight, leaf number, total leaf area and stomatal conductance in *Cichorium intybus* (var: sativum).

One of the crucial environmental factors that affect plant growth and development is light intensity. The light intensity is vital for plant physiological and morphological growth. Higher morphological and physiological parameters recorded for seedlings planted in the 50 % sunlight intensity showed that average sunlight intensity enhanced the growth of *C. albidum* seedlings. Similar observation has been reported by Onyekwelu *et al.* (2012), Ologundudu *et al.* (2013) and Nguyen *et al.* (2019). Seedlings planted under higher light intensity in this experiment gave highest number of growth parameters. It can be deduced that increasing light intensity increased the growth parameters of *C. albidum* seedlings during photosynthesis.

Sun-light stimulates the plant growth and development; by photosynthesis process, plants use sun-light to convert H_2O and CO_2 into carbohydrate, photosynthetic pigments (Chl a, Chl b, and Chl a+b) play an important role in changing the solar energy to chemical energy (Liang 2000; Yuncong *et al.*, 2007). This is in consonance with the reports of Michalska *et al.* (2009). Increased photosynthetic rate is one of the main factors for plant biomass production (Raza *et al.*, 2018). Previously, researchers have found that biomass accumulation is directly associated with the availability of light intensity (Kiniry *et al.*, 2004) and reductions in light decreased the biomass production (Maddonni and Otegui, 2004).

The growth of *C. albidum* seedling was correlated to the light intensity since higher light intensity gave higher growth parameters. This is consonance with the reports of Liao *et al.* (2006) and Zervoudakis *et al.* (2012). The excellent performance in term of growth parameters recorded for seedlings planted in higher light intensity in this experiment was also due to ability of seedlings to adjust to different light regimes by developing mechanism of morphological and physiological changes at various levels. This inference is in consonance with that of Zhang *et al.* (2003) and Fan *et al.* (2013).

The reduction in growth parameters recorded for seedlings subjected to 25 % light intensity could be traceable to inadequate light intensity for photosynthesis to take place and thereby growth was affected. The numerous plant processes impair with decreasing light intensity which bring dramatic developmental and physiological changes, leading to a rapid decrease of these processes (Yang *et al.*, 2015; Wu *et al.*, 2016). Yang *et al.* (2018a) stated that shading conditions could affect carbon balance of plant because the carbohydrate (sugars) demand increases under low light intensity while its production decreases: rates of physiological processes rise while the photosynthetic yield reduces. Plant growth as dry matter production is largely dependent on current photosynthesis and, therefore, one of the main important changes by shade stress in plant growth is ascribed to its huge reduction of net photosynthesis (Yang *et al.*, 2018b).

Reductions in photosynthesis could occur thanks to two main principle mechanisms (Yang *et al.*, 2017): (i) decrease CO_2 diffusion into leaves, since the decrease internal and stomatal conductance (gi and gs, respectively), and (ii) metabolic potential inhibition for photosynthesis by inhibiting the leaf growth and enlargement by controlling the cell proliferation (Wu *et al.*, 2017; Wu *et al.*, 2018). However, the higher chlorophyll content and height were recorded for *C. albidum* seedlings under 25 % light intensity. Similar observations have been made by Li *et al.* (2014) and Ipor *et al.* (2017) respectively.

Subjecting the *C. albidum* seedlings to 80 mL/seedling watering level and exposing it to 50 % light intensity enhanced its growth. It can be concluded that there was appropriate compatibility of watering regime and light intensity which enhanced the performance of seedlings. Since water and light intensity are considered to be main environmental factors limiting plant growth and photosynthetic capacity. Low number of growth parameters recorded for seedlings subjected to 140 mL and exposed to 50 % intensity could be attributed to the effect of excess water that resulted to low dissolved oxygen availability which affected the photosynthetic capacity, nutrient uptake as well as growth of *C. albidum* seedlings. This observation is in line with the reports of Sakio (2005); Xiao *et al.* (2007), Predick *et al.* (2009); Huber *et al.* (2014); Gbadamosi (2014),Wang *et al.* (2016) and Olaoye and Oyun (2019).

CONCLUSION

Investigation conducted into watering levels and light intensities of *C. albidum* revealed that seedlings subjected to 80 mL/seedling watering level and exposed to 50 % light intensity gave higher morphological and physiological parameters. Subjecting the *C. albidum* seedlings to 80 mL/seedling watering level and exposing it to 50 % light intensity enhanced its growth.

REFERENCES

Abdelbasit, H. E., Sadya, M and Ahamed, E. (2012). Variation in drought tolerance and survival among three provenances of *Acacia tortilis* Subspecies *Raddiana* and Subspecies *Spirocarpa* seedlings. *Asian Journal of Agricultural Sciences* 4(2): 134–139.

Adaobi, O. (2019). Five interesting health benefits of Agbalumo (African star apple). *Pulse Nigeria,* 1:1-5, Accessed on 28/08/ 2019.

Adelani, D.O., Aduradola, M.A., Aiyelaagbe, I.O.O., Akinyemi, O and Agbaje, C.I. (2014a). Growth promoters of tropical forest tree seedlings: A Review. *Biological and Environmental Sciences Journal for the Tropics* 11(1): 92-100.

Adelani, D.O., Adedire, M.O., Aduradola, M. A and Suleiman, R. A. (2014b). Enhancing seed and seedling growth of forest trees. *Biological and Environmental Sciences Journal for the Tropics 11*(1): 50-56.

Adelani, D. O., Suleiman, R. A., Akesode, H. A and Akande, M. T. (2014c). Effect of sources and rates of organic fertilizer on the growth of *Chrysophyllum albidum* seedlings. *Organic Agriculture Research: A Catalyst for Sustainable National Agricultural Transformation Agenda. In:* Olabiyi, T.I and Bolarinwa, I.F (*Eds*). *Proceedings of the 10th National Conference on Organic Agriculture,* pp65-73.

Adelani, D. O., Aduradola, M. A and Maisamari, I. J. (2016). Storability and pre-sowing treatments of *Chrysophyllum albidum* seeds: A step towards biodiversity conservation. *In*: Borokini, I.T and Babalola, F.D. (Eds); *MDG$_S$ to SDG$_S$: Towards Sustainable Biodiversity Conservation in Nigeria. Proceedings of Joint Biodiversity Conservation Conference of Nigeria Tropical Biology Association (NTBA) and Nigeria Chapter of Society for Conservation Biology (NSCB) Conference,* Pp 80-86.

Adelani, D.O., Aduradola, M. A and Aiyelaagbe, I.O.O. (2017). Storability and pre-sowing treat ments of African star apple (*Chrysophyllum albidum* G. Don) seeds. *Journal of Agricultural Science and Environment* 17(1): 91-102

Adelani, D.O and Muhammed, R. (2019). Effect of sowing and growth media on the seed germination and early seedling growth of African star apple (*Chrysophyllum albidum* G.Don). *Journal of Sustainable Environmental Management* 11:127-143.

Adelani, D.O. (2019). Effect of watering regimes on the growth and nutrient uptake of *Citrus tangelo* J. W. seedlings grown in a mixture of sand and pulverized *Jacaranda mimosifolia* D. don leaves. *Journal of Research in Forestry, Wildlife and Environment* 11(3): 172-179.

Aduradola, A. M., Adeola, B. F and Adedire, M. O. (2005). Enhancing germination in seeds of African Star Apple, *Chrysophyllum albidum* (G. Don). *Journal of Food, Agriculture and Environment 3* (2): 292-294.

Adisa, S. A. (2000). Vitamin C, Protein and Mineral Contents of African Apple (*Chyrsophyllum albidum). In*: *Proceedings of the 18th Annual Conference of NIST* (Eds), S. A. Garba; I. F, Ijagbone; A.O. Iyagba; A. O. Iyanu; A. S. U. Kilani; N. Faruna, PP 141-146.

Agustin, W. I. (2018). 10 Best Health Benefits of African Star Apple during Pregnancy. *www.dr.heath.benefits.com* Accessed 22/12/ 2019. Pp4.

Aiboni, V.U. (2001). Characteristics and classification of soil of a representative topographical location in University of Agriculture, Abeokuta. *Asset Series A,* 1(1): 51- 61.

Alves, A. A. C and Setter, T. L. (2000). Response of cassava to water deficit: Leaf area growth and Abscisic acid. *Crop Science* 40: 131–137.

Amujoyegbe, B. J., Bamire, A. S and Elemo, K. O. (2008). Agronomic analysis of fertilizer effect on maize/ cowpea intercrop in Ile-Ife and Abeokuta, South-Western Nigeria. *Asset Series A,* 8(1): 62-72.

Amusa, N. A., Ashaye, O. A and Oladapo, M.O. (2003). Biodeterioration of African star apple (*Chrysophyllum albidum*) in storage and the effect of its food value. *African Journal of Bio technology* 2:56-59.

Awodola, A. M. (1998). The effect of nitrogenous growth in seedlings of *Zizyphus spinachustii and Zizyphus mauritiana* (Linn). *Journal of Tropical Forest Resources* 14: 24-31.

Clifton-Brown, J.C and Lewandowski, I. (2000). Water use efficiency and biomass partitioning of three different *Miscanthus* genotypes with limited and unlimited water supply. *Annals of Botany* 86:191-200.

Duncan, D. B. (1955). *"Multiple range and multiple F tests"*. *Biometrics* 11: 1–42.

Egunyomi, A., Fasola, T. R and Oladunjoye, O. (2005). Charring medicinal plant: A traditional method of preparing phytomedicines in South Western Nigeria. *Ethnobotany Research and Applications* 3: 261-265.

Ehiagbonare, J. E., Onyibe, H. I and Okoegwale, E. E. (2008). Studies on the isolation of normal and abnormal seedlings of *Chrysophyllum albidum:* A step towards sustainable management of the taxon in the 21st Century. *Scientific Research and Essay 3* (12): 567-570.

Fan, X. X., Xu, Z. G., Liu, X. Y., Tang, C. M., Wang, L. W and Han, X. (2013). Effects of light intensity on the growth and leaf development of young tomato plants grown under a combination of red and blue light. *Scientia Horticulturae,* 153:50-55.

Fan, Y., Chen, J., Cheng, Y., Raza, M. A., Wu, X., Wang, Z., Liu, Q., Wang, R., Wang, X and Yong, T. (2018). Effect of shading and light recovery on the growth, leaf structure, and photo synthetic performance of soybean in a maize-soybean relay-strip intercropping system. *Plos One* 13(5):1-15. e0198159.

Gbadamosi, A. E. (2014). Effect of watering regimes and water quantity on the early seedling growth of *Picralima nitida* (Stapf). *Sustainable Agriculture Research* 3(2): 35-43.

Gonzales, J. A., Gallardo, M., Hilal, M., Rosa, M and Prade, F. E. (2009). Physiological responses of quinoa (*Chenopodium quinoa* Willd.) to drought and water logging stresses: dry matter partitioning. *Botanical Studies, 50*: 35-42.

Hsiao, T. C and Xu, L. (2000). Sensitivity of growth of roots versus leaves to water stress: biophy sical analysis and relation to water transport. *Journal of Experimental Botany*, 51(350): 1595-1616. http://dx.doi.org/10.1093/jexbot/51.350.1595

Huber, H., Visser, E. J.W., Clements, G and Peters J. L. (2014). Flooding and fragment size interact to determine survival and regrowth after fragmentation in two stoloniferous *Trifolium* species. *Annals of Botany Plants*, 6:1–14.

Ipor, I. B., Djzamanni Yahya, M. D and Tawan. C. S. (2017). Response of *Cryptocoryne pallidnervia* Engler (Araceae) on light intensity and water depth. *Journal of Tropical Biology and Conservation* 14:1–19.

Kiniry, J. R., Bean, B., Xie, Y and Chen, P. Y. (2004). Maize yield potential: Critical processes and simulation modeling in a high-yielding environment. *Agricultural System* 82: 45-56.

Kong, D. X., Li, Y. Q., Wang, M. L., Bai, M., Zou, R., Tang, H and Wu, H. (2016). Effects of light intensity on leaf photosynthetic characteristics, chloroplast structure, and alkaloid content of *Mahonia bodinieri* (gagnep.) laferr. *Acta Physiologiae Plantarum* 38(5): 120-135.

Ky-Dembele, C., Bayala, J., Savadogo, P., Tigabu, M., Odén, P. C and Boussim, I. J. (2010). Comparison of growth responses of *Khaya senegalensis* seedlings and stecklings to four irrigation regimes. *Silva Fennica,* 44(5): 787-798.

Laurent, G. H., Toussaint, O. L., Francois, G. G., Lisette, E. A and Brice, S. (2012). Ethno-botanical study of the African star apple (*Chrysophyllum albidum* G. Don) in the Southern Benin (West Africa). *Journal of Ethnobiology and Ethnomedicine* 8: 40-48.

Li, T., Liu, L. N., Jiang, C. D., Liu, Y. J and Shi, L. (2014). Effects of mutual shading on the regulate on of photosynthesis in field-grown sorghum. *Journal of Photochemistry and Photobiology B*. 137: 31-38.

Liang, Z. (2000). Studies on variation and difference of characters of stem and leaf between shade-enduring and shade-non-enduring soybeans. *Soybean Science,* 19: 35-41.

Liao, J., Zou, X., Ge, Y and Chang, J. (2006). Effect of light intensity on growth of four Mosla species. *Botanical Studies*, 47: 403-408.

Maddonni, G and Otegui, M. (2004). Intra-specific competition in maize: Early establishment of hierarchies among plants affects final kernel set. *Field Crops Research*, 85: 1-13.

Michalska, J., Zauber, H., Buchanan, B. B., Cejudo, F. J and Geigenberger, P. (2009). Ntrclinks built-in thioredoxin to light and sucrose in regulating starch synthesis in chloroplasts and amyloplasts. *Proceedings of the National Academy of Sciences*, 106(24): 9908-9913.

Mukhtar, R.B., Mansur, M.A., Abdullahi, S and Bunza, M.S. (2016a).The growth of *Balanites aegyptiaca* (l.) seedlings under varied watering intervals in the nursery. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension* 15 (3): 30 – 33.

Mukhtar, R.B. (2016b). Effect of drought stress on early growth of *Adansonia digitata* (L.) in semi-arid region of Nigeria. *Journal of Research in Forestry, Wildlife and Environment*, 8(4): 109-115.

Nguyen, T. P. D, Tran, T. T. H and Nguyen, Q. T. (2019). Effects of light intensity on the growth, photosynthesis and leaf microstructure of hydroponic cultivated spinach (*Spinacia oleracea* L.) under a combination of red and blue LEDs in house. *International Journal of Agricultural Technology*, 15(1): 75-90.

Nwoboshi, L.C. (2000). *The Nutrient Factor in Sustainable Forestry*. Ibadan University Press, Nigeria, 303pp.

Oboh, I.O., Aluyor, E.O and Audu, T. O. K. (2009). Uses of *Chrysophyllum albidum* for the removal of metal ions from aqueous solution. *Scientific Research and Essay 4*(6):632-635.

Olaoluwa, T. A., Muhammad, N.O and Oladiji, A. T. (2012). Biochemical assessment of the mineral and some antinutritional constituents of *Aspergillus niger* fermented *Chrysophyllum albidum* seed meal. *African Journal of Food Science* 6(1): 20-28.

Olaoye, B. A and Oyun, M.B. (2019). Early growth of selected indigenous tree species in response to watering regime. *Tropical Plant Research* 6(2): 192–198.

Ologundudu, A. F., Adelusi, A. A and Adekoya, K. P. (2013). Effect of light stress on germination and growth parameters of *Corchorus olitorius, Celosia argentea, Amaranthus cruentus, Abelmoschus esculentus* and *Delonix regia. Notulae Scientia Biologica* 5(4):468-475.

Onyekwelu, J. C and Stimm, B. (2011). *Chrysophyllum albidum In*: A, Roloff; H, Weisgerber; U, Lang; B, Stimm (Eds): Enzyklopadia der Holzgewachse, Wiley-VCH, Weinheim, 59.Erg. Lfg. 10/11, 12PP.

Onyekwelu, J. C., Stimm, B., Mosandi, R and Olusola, J.A. (2011). Domestication of *Chrysophyllum albidum* from rainforest and derived savannah ecosystem – Phenotype variation and selection of elite trees. *Conference on International Research on Food Security, Natural Resource Management and Rural Development*. Tropentage, pp. 7.

Onyekwelu, J.C., Stimm, B., Mosandi, R. M and Olusola, J. A. (2012). Effects of light intensities on seed germination and early growth of *Chrysophyllum albidum* and *Irvingia gabonensis* seedlings. *Nigeria Journal of Forestry* 42 (2):58-67.

Predick, K. I., Gergel, S. E and Turner, M. G. (2009). Effect of flood regime on tree growth in the flood plain and surrounding uplands of Wisconsin River. *River Research and Application*, 25: 283-296.

Rahaman, O. (2012). Review of medicinal values of *Chrysophyllum albidum* (African Star apple) http:// search warp.com/swa 857453-A-Review-of-medicinal-value-of *Chrysophyllum albidum. Traditional Medicine* 1(1):1-2.

Raza, M., Feng, L., Iqbal, N., Manaf, A., Khalid, M., Wasaya, A., Ansar, M., Billah, M., Yang, F and Yang, W. (2018). Effect of sulphur application on photosynthesis and biomass accumulation of sesame varieties under rainfed conditions. *Agronomy* 8(149): 1-16.

Sale F. A. (2015). Evaluation of watering regime and different pot sizes on the growth of *Parkia biglobosa* seedlings under nursery condition. *European Scientific Journal*, 11 (12): 313-325

Sakio, H. (2005). Effects of flooding on growth of seedlings of woody riparian species. *Journal Forest Research,* 10(4): 341-346. http://dx.doi.org/10.1007/s10310-005-0156-9

Simon, A.M., Festus, K.A., Gudeta, S., Oluyede, C.A., Betserai, I.N and Ranmi, J. (2011).Water application rate and frequency affect seedling growth of *Vangueria infusta* and *Persea americana*. *African Journal of Biotechnology*, 10(9): 1593-1599.

Umar, T and Gwaram, A. B. (2006). Foliar nutrient contents of four indigenous trees of the sudan savanna. *In:* Popoola, L. (Eds). *Proceedings of 31st Annual Conference of Forestry Association of Nigeria. pp* 131-139.

Ureigho, V.N. and Ekeke, B.A. (2010). Nutrient values of *Chrysophyllum albidum* Linn African star apple as a domestic income plantation species. *An International Multi-disciplinary Journal,* Ethiopia 4(2):50-56.

Vandoorne, B., Mathieu, A. S., Van den Ende, W.,Vergauwen, R., Perilleux, C., Javaux, M and Lutt, S. (2012). Water stress drastically reduces root growth and inulin yield in *Cichorium intybus* (var. sativum) independently of photosynthesis. *Journal of Experimental Botany,* 63(12): 4359-4373. http://dx.doi.org/10.1093/jxb/ers095

Wang, P., Zhang, Q., Xu, Y.S and Yu, F.H. (2016). Effects of water level fluctuation on the growth of submerged macrophyte communities. *Flora–Morphology Distribution Functional Ecology of Plants*, 223:83–89.

Wole, O. (2013). Unlimited nutritional benefits of African star apple. *Journal of Natural Health* 1(1):1-4.

Wu, Y., Gong, W., Yang, F., Wang, X., Yong, T and Yang, W. (2016). Responses to shade and subsequent recovery of soya bean in maize-soya bean relay strip intercropping. *Plant Production Science*, 19: 206-214.

Wu, Y., Gong, W and Yang, W. (2017). Shade inhibits leaf size by controlling cell proliferation and enlargement in soybean. *Scientific Reports*, 7(9259):1-10.

Wu, Y., Gong, W., Wang, Y., Yong, T., Yang, F., Liu, W., Wu, X., Du, J., Shu, K and Liu, J. (2018). Leaf area and photosynthesis of newly emerged trifoliolate leaves are regulated by mature leaves in soybean. *Journal of Plant Research*, 131(4): 671-680.

Xiao, K., Yu, D and Wu, Z. (2007). Differential effects of water depth and sediment type on clonal growth of the submersed macrophyte *Vallisneria natans*. *Hydrobiologia*. 589:265 – 272.

Yang, F., Lou, Y., Liao, D., Gao, R., Yong, T., Wang, X., Liu, W and Yang, W. (2015). Effects of row spacing on crop biomass, root morphology and yield in maize-soybean relay strip inter cropping system. *Acta Agronomica Sinica* 41: 642-650.

Yang, F., Liao, D., Wu, X., Gao, R., Fan, Y., Raza, M. A., Wang, X., Yong, T., Liu, W and Liu, J. (2017). Effect of aboveground and belowground interactions on the intercrop yields in maize-soybean relay intercropping systems. *Field Crops Research* 203: 16-23.

Yang, F., Feng, L., Liu, Q., Wu, X., Fan, Y., Raza, M. A., Cheng, Y., Chen, J., Wang, X and Yong, T. (2018a). Effect of interactions between light intensity and red-to-far-red ratio on the photosynthesis of soybean leaves under shade condition. *Environmental and Experimental Botany* 150: 79-87.

Yang, F., Fan, Y., Wu, X., Cheng, Y., Liu, Q., Feng, L., Chen, J., Wang, Z., Wang, X and Yong, T. (2018b). Auxin-to-gibberellin ratio as a signal for light intensity and quality in regulating soybean growth and matter partitioning. *Frontiers in Plant Science* 9: 56-87.

Yuncong, Y., Shaohui, W and Yun, K. (2007). Characteristics of photosynthesis machinism in different peach species under low light intensity. *Scientia Agricultura Sinica* 40(4): 853-863.

Zervoudakis, G., Salahas, G., Kaspiris, G and Konstantopoulou, E. (2012). Influence of light intensity on growth and physiological characteristics of common sage (*Salvia officinalis* L.) *Brazilian Archives of Biology and Technology*, 55(1): 89-95.

Zhang, S., Ma, K and Chen, L. (2003). Response of photosynthetic plasticity of *Paeonia suffruticosa* to changed light environments. *Environmental and Experimental Botany*, 49:121-133.