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GROWTH RESPONSE OF AFRICAN STAR APPLE (*CHRYSOPHYLLUM ALBIDUM G.DON*) SAPLINGS TO PLANTATION ESTABLISHMENT TECHNIQUES

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ABSTRACT

The paucity of research-based findings on the establishment techniques of *Chrysophyllum albidum* saplings has limited its propagation. In this light, three parallel investigations were conducted on the growth responses of *Chrysophyllum albidum* saplings to depths, widths and fertilizer application. The three experiments adopted a completely randomized design with twelve replications to assess the growth responses of *C. albidum* saplings to depths (9cm, 18cm and 27cm), widths (18cm and 36cm) and fertilizer applications (500g cowdung and no cowdung). In all the experiments, well root pruned saplings were established at the espacement of 4mx4m within and between rows on the fields. Growth responses of *C. albidum* saplings to establishment techniques were significantly ($p<0.05$) different. The result revealed that significant height (32.45cm), total fresh weight (21.11g), total dry weight (13.32g), absolute growth rate (0.76gwk^{-1}), chlorophyll a (0.37 mg/g), chlorophyll b(0.47mg/g) and total chlorophyll a+b(0.82mg/g), highest relative turgidity (52.70%) and net assimilation rate (0.06gcm^{-2}wk^{-1}) were recorded from saplings planted at 27 cm depth. Significant height (32.07cm), total fresh weight (20.18g), total dry weight(13.13g), relative turgidity(50.56%), total chlorophyll a+b (0.81mg/g), highest number of leaves (13.38), chlorophyll a (0.37mg/g) and chlorophyll b (0.47mg/g) were recorded from saplings planted at 18cm width. Significant height (33.68cm), girth (3.00cm), number of leaves (14.36), leaf area (72.02cm^2), collar diameter (1.50cm), total fresh weight (21.85g), total dry weight(13.79g), relative turgidity(53.17%), chlorophyll b(0.49mg/g), total chlorophyll a+b (.85mg/g) and higher chlorophyll a(0.39) were recorded from saplings planted in the soil influenced with manure. The *C. albidum* saplings planted at 27cm depth, 18cm width and with fertilizer application gave highest growth variables relative to others. The establishment of *C. albidum* saplings at 27cm depth, 18cm width and with fertilizer enhances its growth and development on the fields.

Keywords: Planting depth, Planting width, Manure, Physiological, Morphological variables

Introduction

The forest, apart from providing a large proportion of the global supply of timber and fuel wood, also provides a wide range of non-wood products and environmental functions. The potentials of forest include provision of bush meat, medicine, watershed protection, stabilization of hydrological regime and carbon sequestration (Aigbe and Oluku, 2012). Chukwuemeka *et al.* (2022) stated that Nigeria

is well endowed with forest resources, but the excessive exploitation of these forest resources is a source of concern and threat to the economic, social and environmental importance.

On the average, Nigeria forest is decreasing at the rate of 0.4 million hectares per year, but the rate of reforestation was put at 0.032% per year (Nweze, 2003). Aruofor (2001) reported that out of the land mass of 997,936km^2 in Nigeria, only 10% is under forest reserve. A report on tropical forest estimated that about 100, 000km^2 area of land are deforested each year, and another 100,000km^2 of forest are degraded globally (University of Michigan, 2010). According to Popoola and Akinwunmi, (2003), available statistics in Nigeria indicated that some 400,000 hectares of forest which comprises of both economic and endangered species is lost annually through shifting cultivation. Nigeria recorded one of the highest rate of deforestation of primary forest, having loss 55.7% of her natural forest between 2000 and 2005, with as many as 58 (10.4%) of the endangeredtree species (Nwajiobi *et al.,* 2022) as *Chrysophyllum albidum. C. albidum* is an endangered species and essential for survival of present generation owing to its potentials (Adelani, 2023).

Adelani and Aduradola (2025) reported that *C. albidum* is recognized in botanical literature as a synonym for *Gambeya albida* and it belongs to the family of Sapotaceae. The high saponin content of *C. albidum* leaves and roots justifies the use of the extracts to control human cardiovascular disease and reduce blood cholesterol as documented by Aletor, (1993). In addition, the bark of *C. albidum* has been used in treatment of yellow fever, fibroids and malaria; while the leaf is used as emollient and for the treatment of skin eruption, stomach ache and diarrhea (Adisa, 2000; Adewoye *et al.,* 2010). Furthermore, Burit and Bucar (2000) and Orijajogun *et al.* (2013) stated that the *C.albidum* contains antioxidants that improve health by protecting the body against harmful radicals, which originate many ailments/diseases such as cancer, cardiovascular diseases, diabetes mellitus, neural disorder and arthritis.

In spite of enormous potentials of *C.albidum,* it has been greatly neglected particularly with respect to its regeneration, reforestation and afforestation (Adelani *et al.,* 2017). Yisau (2018) stated that forest regeneration is an act of renewing tree cover, which is achieved by establishing young trees either artificially or naturally. Artifical forest regeneration can be done by plantation establishment. Plantation establishment is the commercial and/ or aesthetic planting of all types of trees on land and it entails tree planting that has some commercial and production intent (Badejo, 2008). Plantation establishment is an essential aspect of forest regeneration.

Hirons and Percival (2011) stated that in the quest for forest regeneration, there are some needful establishment techniques, such as understanding of tree ecophysiology, plant quality, planting and post planting practices, rooting environment, depth of planting, which determine the survival of the transplants. In the same trend, Struve (2009) stated that among transplant survival and regrowth factors such as mulching, backfill amendments, and site quality, planting depth is critical. Tree planting depth that is the location of the root collar relative to soil grade is of particular concern for tree growth, development, and performance in the landscape (Bryan, 2008; Bryan, *et al,* 2010) and forestry.

Georgia Forestry Commission (2017) stated that the correct depth of planting on the fields should be adequate enough to expose the

seedlings to soil and its water content, which significantly improves seedlings survival rates. Proper and deep planting depth gives the plant the ability to anchor itself in the soil, whereby it is able to withstand destruction against wind and to be able to absorb water and nutrients adequately from the soil through the root (Yisau, 2018). Giblin *et al.* (2011) stated that appropriate depth of planting in field can increase stability and tree survival. One of the most common errors in tree planting is to adopt the wrong method such as plants root ball is either planted too deep or too shallow, both of which can cause serious problems (Arnold *et al.,* 2007).

Daniel (2022) stated that when a tree is planted too deep, decay, structural malfunctions, apical dieback, and an increase in abiotic and biotic stress can occur. This result is consistent with arborists' observations that deep planting is a significant source of stress in landscape tree (Wells *et al.,* 2006). MacDonald *et al.* (2004) stated that at greater soil depths, oxygen partial pressures may also fall below those needed to support root respiration, growth, and nutrient uptake. Other mechanisms of deep planting stress such as reduced water infiltration to the root ball or insufficient access to shallow mineral nutrient pools are common (Wells *et al.,* 2006).

Lim *et al.* (2025) stated that trees planted too shallow also tend to exhibit slower growth rates, likely due to shallow surface roots that were more exposed to heat and more likely to experience desiccation. Planting trees with root collars above grade may cause significant reductions in tree growth possibly due to anosmosing effect of moisture and nutrients from the exposed root ball (Bryan *et al*., 2010).

Little information is available on the depth and width of planting as well as fertilizer application of *C. albidum* saplings. There is dearth of scientific information on the appropriate establishment techniques of *C. albidum* saplings. In this light, plantation establishment of this species was investigated with a view to establishment standard depth, width and manure application for *C. albidum* saplings.

Materials and Methods

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 ºN and 7 º55 ' N and longitudes 3 º 20 'E and 3 º 37 ' E. The Federal University of Agriculture, Abeokuta is situated inside the rain forest zone of Southwestern 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 Northeastern end of Abeokuta and lies nearly on latitude 7º 30 ' N and longitude 3º 54 ' E. It positions 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.

Soil collection

Soil samples were collected from six (6) different locations at the forest nursery with the aid of a soil auger. The samples were collected at depth of 0 – 9cm, 0-18cm and 0-27cm prior to transplanting of tree saplings. The

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representatives' samples from each depth were pull together, air dried, ground and sieved using a 2mm sieve. Samples from each depth were replicated three times before subjected to soil analysis. Soil physical and chemical properties were determined according to the standard methods (Amhakhian and Isaac, 2016). The result of replicates of soil chemical analysis was subjected to statistical analysis.

Experimental Treatment and Field Design

The evaluations were structured across three concurrent field layouts.

Experiment 1: Planting Depth profile

The first experiment adopted a completely randomized design with twelve replications to assess the effect of depths (9, 18 and 27cm) of planting on the growth of *C. albidum* saplings. Saplings were established at the espacement of 4mx4m within and between rows on the field. The well root pruned 36 saplings were involved in the experiment.

Experiment 2: Hole Geometry width

The second experiment equally employed a completely randomized design with twelve replications to assess widths (18 and 36cm) of planting on the growth of *C. albidum* seedlings. A sapling represented a replicate. Saplings were established at the espacement of 4mx4m within and between rows on the field. The well root pruned 24 saplings were used in the experiment.

Experiment 3: Nutrient amendment

The third experiment similarly adopted a completely randomized design with twelve replications to assess the effect of fertilizer (500g cowdung) and no fertilizer (0 g cowdung) on the growth of transplanted *C. albidum* seedlings. Analysis revealed that cowdung contained nitrogen (6.01%), phosphorus (2.99mg/g) and potassium (4.00mg/g). Saplings were established at the espacement of 4mx4m within and between rows on the field. The well root pruned 24 saplings were involved in the experiment.

After four weeks of seedling establishment of all experiments, growth variables were assessed fortnightly for 36 months. Growth parameters studied include; sapling height with the use of meter rule; girth with the use of venier caliper; collar diameter was determined by meter rule., the number of leaves were counted manually and Leaf area was obtained by using a digital leaf area meter (LI-3000,LI-COR, Lincoln, Nebr.)

The mean of the growth changeable for period of experiment was used for tabulation. Total fresh weight (TFW), total dry weight (TDW), relative turgidity (RT), net assimilation rate (NAR), absolute growth rate (AGR), relative growth rate (RGR), chlorophyll a, b and a+b and nitrogen uptake were determined during and after 3years.

Formula for AGR, RGR

Absolute Growth Rate $= \frac{W2-W1}{T2-T1} gwk^{-1}$ (2)

W_2 and W_1 are plant weight at corresponding time T_1 and T_2.

RGR=LAR xNAR

Relative Growth Rate= $\frac{\log e\, W2-\log e\, W1}{T2-T1} gg^{-1}\, wk^{-1}$ (3)

T1=Initial time (Weeks)

T2= Final or second time (Weeks)

W_2= Total dry weight at T_2

W_1=Total dry weight at T_1

NAR=$\frac{w2-w1}{t2-t1} \times \frac{\log eA2-logeA1}{A2-A1} gcm^{-2}wk^{-1}$ (4)

Where W_2 and W_1 are plant dry weights at times t_1 and t_2, $\log_e A_2$ and $\log_e A_1$ are the natural logs of leaf areas A_1 and A_2 at times t_1 and t_2.

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Relative turgidity also known as relative water content was determined by difference between fresh weight and dry weight, divided by turgid weight minus dry weight multiply by 100. Turgid weight was determined by weight of the plant before and after soaking in water for 24hours. Sapling of high vigour was divided into three parts namely; leaf, stem and root. Each part was weighed (fresh weight, FW), then left saturated in distilled water for twenty four (24hrs) (under normal room light and temperature) (Turgid Weight) and after hydration, the samples were then dried in an oven at 70°C for 48 hours and weighed (Dry Weight) (after being cool down in desiccators).

The RWC/RT is determined as follows:

Relative turgidity= $\frac{Fw-Dw}{Tw-Dw} \times 100$ (5)

FW= Fresh weight
DW= Dry weight
TW= Turgid weight

Estimations of chlorophyll were ascertained by straight forward calculations of the absorbance at different wavelengths, using Model 6405 UV/Vis Spectrophotometer, serial number 1364. The concentrations were worked-out by accumulating 20.2 A645, 8.02 A 663 and fractionated by length of light path in cell (usually 1cm), fresh weight in grams and 1000. The outcome was multiplied by the volume of chlorophyll solution in mL. A645 and A663 is the absorbance at 645 and 663 nm.

Chlorophyll a (mg g^{-1}) $[12.7(A663) - 2.69(A645)$ x VC/LLP x FW x 1000]

$= \frac{12.7(A663)-2.69(A645)xVC}{LLPXFWX1000}$ (6)

Chlorophyll b (mg g^{-1}) $[22.9(A645) - 4.86(A663)$ x VC/LLP x FW x1000]

$= \frac{22.9(A645)-4.86(A663)xVC}{LLPXFWX1000}$ (7)

Total Chlorophyll a+b (mg g^{-1}) $[(20.2(A645) + 8.02(A663)$ x VC//LLP x FW x 1000]

$= \frac{20.2\ A645+8.02\ A663xVC}{LLPxFWx1000}$ (8)

Where:

A= absorbance at the given wavelength
C.C= Concentration of chlorophylls
VC = Volume of chlorophyll in mL
LLP = Length of light path usually 1cm
FW = Fresh Weight in grams

Tissue analyses were estimated for the whole plant of *C. albidum* seedlings to establish the nutrient uptake. Tissue analysis was also done for the sample of leaf, stem and root of whole plant of *C. albidum* seedlings, prior to transplanting in the beginning and thereafter transplanting at close of the experiment respectively, to work out nutrient uptake. The nitrogen, phosphorus and potassium content were calculated by Macro Kjeldahl method, Bray-1 method and flame photometry method respectively.

Nutrient Uptake was estimated by Method of Sharma *et al.* (2012) = $\frac{\%N\times\%P\times\%K\times Drymatterkgha-1}{100}$ (7)

Actual nutrient uptake was figured-out differences in nutrient uptake at the onset and the close of the experiment.

Data Analysis

Data were assembled and put through analysis of variance (ANOVA) using SAS (2003). An equivalence of outstanding means was performed using Fishers' Least Difference LSD at 5% level of signification.

Results

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Soil analysis of the experimental site

Significant value of nitrogen (0.57%), potassium (317.67mg/g) and silt (31.67%) were recorded from top soil at 9cm depth. Significant value of phosphorus (27.37mg/g) was recorded from 18 cm depth of soil. Other nutrient content were not significantly ($p<0.05$) at various soil depths (Table 1).

Effect of depths of planting on the establishment of *C. albidum* saplings

Significant girth (3.83cm), number of leaves (14.63), leaf area (70.56cm^2), collar diameter (1.92cm) were recorded from saplings planted at 9cm depth. Significant height (32.45cm), total fresh weight (21.11g), total dry weight (13.32g), absolute growth rate (0.76gwk^{-1}) chlorophyll a (0.37 mg/g), chlorophyll b(0.47mg/g) and total chlorophyll a+b(0.82mg/g), highest relative turgidity (52.70%) and net assimilation rate (0.06gcm^{-2}wk^{-1}) were recorded from seedlings planted at 27 cm depth.

The least values of 30.47cm (height), 1.96 cm (girth), 12.32 (number of leaves), 1.00cm (collar diameter), 19.77g (total fresh weight), 12.47g (total dry weight), 0.44 mg/g (total chlorophyll a+b) were recorded from saplings planted at 18cm depth (Table 2)

Effect of widths of planting on the establishment of *C. albidum* saplings

Significant height (32.07cm), total fresh weight (20.18g), total dry weight(13.13g), relative turgidity (50.56%), total chlorophyll a+b (0.81mg/g), highest number of leaves (13.38), chlorophyll a (0.37mg/g) and chlorophyll b (0.47mg/g) were recorded from saplings planted at 18cm width.

The least values of height(30.70cm), number of leaves (13.01), total fresh weight (19.86g), total dry weight (12.53g), relative turgidity (49.72%), chlorophyll a (0.35mg/g), chlorophyll b (0.45mg/g) and total chlorophyll a+b (0.77mg/g) were recorded from saplings planted in 36cm width of soil (Table 3).

Effect of fertilizer application on the establishment of *C. albidum* saplings

Significant height (33.68cm), girth (3.00cm), number of leaves (14.36), leaf area (72.02cm^2), collar diameter (1.50cm), total fresh weight (21.85g), total dry weight (13.79g), relative turgidity (53.17%), chlorophyll b (0.49mg/g), total chlorophyll a+b (.85mg/g) and higher chlorophyll a(0.39) were recorded from saplings planted in the soil influenced with manure.

The least value of height (29.09cm), girth (2.37cm), number of leaves (12.03), leaf area (53.11cm^2) collar diameter (1.19cm), total fresh weight (18.82g), total dry weight (11.87g), relative turgidity (47.11%), chlorophyll a (0.34mg/g), chlorophyll b (0.42mg/g) and total chlorophyll a +b (0.73mg/g) were recorded from sapling planted in the soil without organic fertilizer (Table 4).

Nutrient uptake from saplings subjected to establishment techniques

Significant nutrient uptake of nitrogen (5.20%), Phosphorus (2.86mg/g) and potassium (3.85mg/g) were recorded from saplings planted with organic fertilizer. The least values of 0.29% (N), 0.08mg/g (P) and 1.15mg/g (K) were recorded from saplings planted without organic fertilizer (Table 5)

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Table 1 : Soil analysis of the experimental site

D (cm)	% N	pH	% O.M	P (mg/kg)	K(mg/kg)	Na(mg/kg)	Ca(mg/kg)	Mg(kg/g)	Ex (mg/kg)	% sand	% clay	% silt
D1	0.57^{a}	6.90^{a}	1.67^{a}	25.02^{b}	317.67^{a}	203.33^{a}	40.62^{a}	31.44^{a}	0.43^{a}	47.90^{b}	20.50^{b}	31.61^{a}
D2	0.52^{ab}	6.90^{a}	1.54^{a}	27.37^{a}	298.67^{b}	205.00^{a}	42.60^{a}	32.07^{a}	0.35^{a}	52.09^{a}	23.25^{a}	24.65^{b}
D3	0.49^{b}	6.77^{a}	1.45^{a}	25.91^{b}	313.33^{a}	213.33^{a}	42.25^{a}	32.37^{a}	0.39^{a}	49.19^{ab}	15.55^{c}	32.26^{a}
SE±	0.02	0.58	0.52	0.52	3.57	6.67	1.08	0.62	0.39	1.01	0.39	1.75

Means on the same column having different superscripts are significantly different ($p<0.05$)
Key: D1=9cm, D2=18cm, D3=27cm

Table 2: Effect of depths of planting on the establishment of *C.albidum* saplings

Depths(cm)	H (cm)	G (cm)	NL	LA (cm^2)	CD (cm)	TFW (g)	TDW(g)	NAR($gcm^{-2}wk^{-1}$)	AGR(gwk^{-1})	RGR$gg^{-1}wk^{-1}$	RT (%)	Cla (mg/g)	CLb (mg/g)	CL a+b (mg/g)
D1	31.15^{a}	3.83^{a}	14.63^{a}	70.56^{a}	1.92^{a}	20.13^{a}	12.69^{b}	0.04^{a}	0.60^{b}	0.04^{a}	48.37^{a}	0.36^{b}	0.45^{ab}	0.78^{b}
D2	30.47^{a}	1.96^{c}	12.32^{b}	70.04^{a}	1.00^{c}	19.77^{c}	12.47^{c}	0.05^{a}	0.73^{a}	0.04^{a}	49.36^{a}	0.45^{a}	0.44^{b}	0.77^{b}
D3	32.54^{a}	2.27^{b}	12.65^{b}	47.10^{b}	1.13^{b}	21.11^{b}	13.32^{a}	0.06^{a}	0.76^{a}	0.04^{a}	52.70^{a}	0.37^{b}	0.47^{a}	0.82^{a}
SE±	1.04	0.08	0.63	7.73	0.04	0.09	0.06	0.01	0.02	0.01	2.1	0.01	0.01	0.01

Means on the same column having different superscripts are significantly different ($p<0.05$)
Key: D1=9cm, D2=18cm, D3=27cm, H=Height, G=Girth, NL=Number of leaves, LA=Leaf area, CD=Collar diameter, TFW=Total fresh weight, TDW=Total dry weight, NAR=Net assimilation rate, AGR=Absolute growth rate, RGR=Relative growth rate, RT=Relative turgidity, CLa= Chlorophyll a, CL b=Clorophyll b, CLa+b= Total chlorophylla+b

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Table 3: Effect of widths of planting on the establishment of *C.albidum* saplings

Widths (cm)	H(cm)	G(cm)	NL	LA (cm^2)	CD (cm)	TFW (g)	TDW (g)	NAR($gcm^{-2}wk^{-1}$)	AGR (gwk^{-1})	RGR($gg^{-1}wk^{-1}$)	RT (%)	CLa (mg/g)	CLb (mg/g)	CL a+b (mg/g)
W1	32.07^a	2.50^b	13.38^a	59.26^a	1.26^b	20.18^a	13.13^a	0.05^a	0.69^a	0.04^a	50.56^a	0.37^a	0.47^a	0.81^a
W2	30.70^b	2.87^a	13.01^a	65.87^a	1.43^a	19.86^b	12.53^b	0.05^a	0.70^a	0.04^a	49.72^b	0.35^a	0.45^a	0.77^b
SE±	0.85	0.06	0.51	3.31	0.03	0.08	0.05	0.01	0.02	0.01	2.0	0.01	0.01	0.01

Means on the same column having different superscripts are significantly different ($p<0.05$)
Key: W1=18cm, W2=36cm, H=Height, G=Girth, NL=Number of leaves, LA=Leaf area, CD=Collar diameter, TFW=Total fresh weight, TDW=Total dry weight, NAR=Net assimilation rate, AGR=Absolute growth rate, RGR=Relative growth rate, RT=Relative turgidity, CLa= Chlorophyll a, CL b=Clorophyll b, CLa+b= Total chlorophylla+b

Table 4: Effect of fertilizer application on the establishment of *C. albidum* saplings

Fertilizer (organic)	H(cm)	Girth (cm)	NL	LA (cm^2)	CD (cm)	TFW (g)	TDW (g)	NAR ($gcm^{-2}wk^{-1)}$	AGR(gwk^{-1})	RGR ($gg^{-1}wk^{-1}$)	RT (%)	Cla (mg/g)	Cl b (mg/g)	CL a+b (mg/g)
F1	33.68^a	3.00^a	14.36^a	72.02^a	1.50^a	21.85^a	13.79^a	0.05^a	0.69^a	0.04^a	53.17^a	0.39^a	0.49^a	0.85^a
F2	29.09^b	2.37^b	12.03^b	53.11^b	1.19^b	18.82^b	11.87^b	0.05^a	0.70^a	0.04^a	47.11^b	0.34^a	0.42^b	0.73^b
SE±	0.85	0.06	0.51	3.31	0.03	0.08	0.05	0.01	0.02	0.01	2.04	0.36	0.01	0.01

Means on the same column having different superscripts are significantly different ($p<0.05$)
Key: F1= 500g cow dung fertilizer F2=No 500g cow dung fertilizer, H=Height, G=Girth, NL=Number of leaves, LA=Leaf area, CD=Collar diameter, TFW=Total fresh weight, TDW=Total dry weight, NAR=Net assimilation rate, AGR=Absolute growth rate, RGR=Relative growth rate, RT=Relative turgidity, CLa= Chlorophyll a, CL b=Clorophyll b, CL a+b= Total chlorophyll a+b

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Table 5: Nutrient uptake from saplings subjected to establishment techniques

Depth (cm)	N%	P (mg/g)	K(mg/g)
D1	3.02^{ab}	2.10^{a}	3.00^{a}
D2	2.99^{b}	1.00^{b}	2.00^{ab}
D3	2.50^{bc}	0.60^{b}	1.50^{b}
W1	1.50^{bc}	0.40^{b}	1.20^{b}
W2	1.30^{bc}	0.37^{b}	1.00^{b}
F1	5.20^{a}	2.86^{a}	3.85^{a}
F0	0.29^{c}	0.08^{b}	1.15b
SE±	0.81	0.37	0.38

Means on the same column having different superscripts are significantly different ($p<0.05$)
Key: D1=9cm, D2=18cm, D3=27cm, W1=18cm, W2=36cm F1= 500g cow dung fertilizer F2=No 500g cow dung fertilizer.

Discussion

Highest growth constants recorded from *C. albidum* saplings planted at 27cm depth of soil could be attributed to ability of its seedlings to get enough water and nutrients from that depth. Similar observation has been made by Yisau (2018) who attributed the highest physiological and morphological growth parameters of *Sysepalum dulcificum* planted at 27cm to its accessibility to water and nutrient from that depth and ability of its leaves to photosynthesize for food that leads to growth. This result is in consonance with the reports of Aduradola and Okoro (2001) who observed that deeper planting depth of 30cm enhanced collar diameter and root length of *Parkia biglobosa* and *Prosopis cineriara* seedlings owing to their ability to get water and nutrients there. However, Ash tree stem diameter and root volume of birch tree were influenced by shallow depth of 5cm (Giblin *et al.,* 2011).

Outstanding morphological and physiological variables recorded from saplings established at 27cm depth could also be connected to its preference for deep planting depth, where the environment around the root is favourable and conductive for growth and development. It can be deduced that the root environment and planting depth among other factors are essential for survival and growth of transplants. This inference is corroborated by submissions of Hirons and Pervical (2011) who opined that the survival and establishment of transplant seedlings is dependent on root environment and planting depth among other factors.

The lower growth variables recorded from saplings planted at 9cm and 18cm could be adduced to shallow planting in comparison to that of 27cm planting. Shallow planting depth affects the growth and development of some forest species. This statement is in consonance with the reports of Arnold *et al*. (2007) who stated that planting with the root collar 7.6 cm below grade unfavourably and differently affected the growth of crapemyrtle (*Lagerstroemia indica* L. × *Lagerstroemia fauriei* Koehne. 'Basham's Party Pink'), green ash (*Fraxinus pennsylvanica* Marsh.), oleander (*Nerium oleander* L. 'Cranberry Cooler'), sycamore (*Platanus occidentalis*), and vitex (*Vitex agnus-castus* L. 'LeCompte'). In the same trend, Bryan *et al.* (2005) found that Green Ash (*Fraxinus pennsylvanica*), American Sycamore (*Platanus occidentalis*), Crape Myrtle (*Lagerstroemia indica* ×

L. *fauriei* 'Basham's Party'), Oleander (*Nerium oleander* 'Cranberry Cooler'), and Chaste Tree (*Vitex agnus-castus* L. 'LeCompte') were critically impacted the vertical growth, trunk diameter, and cross-sectional area when planted 7.6 cm (3 in) below grade.

The excellent performance of *C.albidum* saplings planted at 18cm width could be traced to presence of adequate space for root growth and development. Adequate width of planting trees enhances root growth and inadequate width of planting trees may restrict root growth and development. This observation can be corroborated by submission of Kendall (2020) who stated that limited space or width for root growth of plant can be detrimental to the growth and development. The small planting space or width limits root expansion capacity of trees (Koeser *et al.,* 2013). Kendall (2020) stated that root growth of plant may be limited by small width of planting.

The highest growth variables recorded from sapling planted at 18cm width could also be linked to permission of oxygen and water by the uncompacted soil around the root. Compaction of soil prevents oxygen and water availability in the soil. Similar observation has been reported by Kendall (2020) who stated that with compaction of soil around trees, the pore spaces are eliminated; oxygen and water become unavailable to the transplants. Schroder (2008) also confirmed that the absence of oxygen and water in the soil limits root growth beneath the plants.

The outstanding growth performance of *C. albidum* saplings planted with organic manure (500g cow dung) is connected to the ability of manure to supply nutrients, nourish beneficial soil organisms and increases the physical and chemical properties of soil for plant growth. Similar potentials organic manure on soil has been reported by Musa *et al.* (2018) and (Erin, 2007).

It could be deduced that organic manure, owing to its potentials enhances the growth of forest tree species. This observation is corroborated by the reports of Rafiu *et al*. (2016) (*Kigelia africana*), Agera *et al*. (2019) (*Eucalyptus camaldulensis*) and Falana *et al.* (2016) (*Khaya senegalensis*) who concluded that organic manure enhances the growth of forest tree species. On the other hand, Yisau (2018) stated that effect of fertilizer application was not significant ($p>0.05$) in seedlings physiological variables measured on *Sysepalum dulcificum.*

The prominent growth parameters recorded from *C.albidum* saplings supplied with 500g cowdung could be traced to sufficient nutrient from organic manure. Rufai *et al.* (2020) stated that *Hibiscus physaloides* seedlings raised with 25g of poultry manure performed best in terms of the variables measured while the control recorded least growth values.

Conclusion

The influence of field establishment techniques on physiological and morphological development as well as survival of transplanted saplings is a critical factor in successful forest plantation establishment. This investigation into field establishment for *Chrysophyllum albidum* saplings demonstrated that individuals planted at a 27 cm depth, utilising an 18 cm width and supplemented with 500 g organic manure yield the highest morphological and physiological variables relative to all other treatments, therefore adopting these specific planting dimensions and nutritional amendments is highly recommended to optimize the field growth and development of this valuable

indigenous fruit tree species in plantation systems.

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