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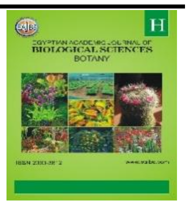

Effects of Sources of Phosphorus and Watering Regimes on the Growth of African Star Apple (*Chrysophyllum albidum* G. Don) Seedlings

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ABSTRACT

There is an insufficiency of examined and corroborated findings on the outcome of phosphorus-based enrichers on the improvement of *Chrysophyllum albidum*. To advance the time-consuming development of *Chrysophyllum albidum,* studied was accomplished. A 2 x 3 split-plot experimental arrangement following three imitations was approved to establish the influences of fountains of phosphorus and watering periods on the advancement of *Chrysophyllum albidum* plantlets. Two origins of nutrient specifically; poultry manure (25g) and single superphosphate (10g) accomplished the main plot investigation. The daily watering (200ml), 3-day interval (200ml) and 5 days interval (200ml) established sub plot investigation. The investigation encompassed two bases of phosphorus and three moisture application intervals reciprocated thrice. Twelve (12) plantlets denoted a copy. Two hundred and sixteen (216) plantlets were explored. A month-old *C. albidum* plantlets were transferred into pots with enhancers and exposed to 200ml at different day's meantime. The assembled data were subjected to two-way Analysis of Variance (ANOVA) at a 5% significance level. The outcomes disclosed that bases of phosphorus and watering stretch tremendously ($p<0.05$) improved the growth of *C. albidum* plantlets. A distinguished height (41.41cm), girth (4.03cm)., leaf number (16.18), collar diameter (2.02cm)., chlorophyll a (0.6092 mg/g)., total chlorophyll a+b (0.3753mg/g) and phosphorus uptake (2.02%) were obtained from plantlets developed in the soil modified with single super phosphate and watered (200ml) at 3 days interval relative to control experiment. Improvement of soil accompanying single super phosphate and application of 3 days watering intervening time enriches the growth of *C. albidum* plantlets.

INTRODUCTION

The tropical forests are sources of useful timber and non-timber species essential to the well-being of the local people (Areo, 2018; Iroko *et al.,* 2020). Nadrowski *et al.* (2010) stated that forests perform critical roles in maintaining and providing ecosystem services and functions. Africa is privileged to have forests and forest resources of ecological and socio-economic potentials. Unfortunately, the reality of the situation is that these resources are being milked in an unsustainable manner and consequently vanish at appalling rates, mostly due to human activities (Adeyoju, 2001). Lamb *et al.* (2005) stated that the great direct and indirect benefits of forest assets are threatened owing to combined influences of clear felling, forest fragmentation and degradation.

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The yearly clear cutting in Nigeria is 3.5%, which is nearly 350,000-400,000 hectares per year (FAO, 2005; Lapido, 2010). In a report by IITA (2011), Nigeria was established as the country accompanying the worst deforestation rate in the world, which can be accredited to her escalating population and associated leading poverty rate. Rotowa *et al.* (2020) disclosed that the high rate of deforestation and a fall in afforestation of the species has led to yearly decline in formation and successful management of forest. Thus, result to incessant erosion and decrease of natural gene pool of significant forest tree species that are critical for the survival of the current and forthcoming generation (Iroko *et al.,* 2020) as African star apple in Nigeria (Adelani *et al.,* 2023).

African star apple or White star apple, *Chrysophyllum albidum* synonymns of *Gambeya albida* (Adelani *et al.,* 2022) is a climax tree species of tropical rainforest that is a member of the family Sapotaceae (Olaoluwa *et al.,* 2012; Wole, 2013) that produces accurately half of the order accompanying 800 species (Ehiagbonare *et al.,* 2008). It is named "Osan Agbalumo," "Udara" or "Udala" and "Agwaluma or Agwaluba" in Yoruba, Igbo and Hausa accents individually (Rahaman, 2012; Wole, 2013; Adelani *et al.,* 2018). It is in the company of forest tree species incorporated in the long-established agroforestry systems (Ureigho and Ekeke, 2010; Laurent *et al.,* 2012), that furnishes NTFPs of enormous household significance to rural and urban dwellers in West Africa accompanying excellent export prospects (Nwoboshi, 2000). The *C. albidum* has been recognized as having considerable economic (Onyekwelu *et al.,* 2011), nutritional and medicinal (Onyekwelu and Stimm, 2011) and industrial (Olaoluwa *et al.,* 2012) values.

Comprehensive human activities exhaust the populace of unregenerated *C. albidum* (Onyekwelu *et al.*, 2011) during the permanent transformation of forest regions to other uses (Adelani *et al.,* 2020). Adelani *et al.* (2014) mentioned that despite the significance of *C. albidum,* it has been considerably ignored specifically regarding its regeneration. This requires intentional measures to save the genetic erosion of this significant species. It is appropriately comprehended that the disappearance of diversification possibly reduced in a maintainable approach, by multiplying the quantity of varieties adopted in productive forestry through breeding of native timber varieties (Hoque *et al.,* 2004a) and fruit tree types as *C. albidum.*

Adelani *et al.* (2023) published that the time-consuming growth of *C. albidum* and low soil fertility that connect to clear felling as well as degeneration are difficulties to its reproduction and planned management. Fertilizer applications are fundamental to address these challenges. Upgraded soil fertility through the administration of fertilizers is an indispensable determinant in plant growth (Brady and Weil, 2004). Fertilizer employment is widely established in nurseries to boost plant vigor and productivity (Shen *et al.,* 2010). Moreover, fertilizer enrichment can upgrade plant growth (King *et al.,* 2006) by either intensifying soil resources or by embellishing the ability of seedlings to accumulate materials (Lincoln *et al.,* 2007) and by improving soil pH (Jose *et al.,* 2003).

In the last few decades, the implementation of enrichers in forest nurseries has enticed accelerating awareness all over the globe on the account of escalated request for fiber, wood (Kauter *et al.,* 2003), CO_2 offsets as well as foods. Excellent growth of the plants through application of fertilizer assists to surmount food insecurity of teeming populace growth. Sarfraz, *et al.* (2023) established that the estimated universal population of 9.9 billion by 2050 warrants an over 70% surge in food creation. Consequently, the effective employment of fertilizers to embellish cultivation of *Chrysophyllum albidum* to meet population demand of its abundant potentiality is extremely crucial. The types of fertilizer to use are also vital.

Farmers employ synthetic fertilizers independently for adequating or providing nutrients that are low in supply (Jafer and Gebresilasie, 2018). Purbajanti *et al.* (2019) announced that farmers use synthetic fertilizers due to the fact that they are more reasonable, economical, accessible, users friendly and swift in reciprocation; while natural enricher accomplishes gradual reaction on plant yield, even though they are capable of sustaining soil attributes. It is well established that administration of synthetic plant foods strengthened the seedling and substantial growth in biomass of many tree categories (Bungard *et al.*, 2000; Ong *et al.,* 2004; Hoque *et al.,* 2004b; Uddin *et al.,* 2007); while the natural soil amendment advances the material and synthetic attributes of the soils (Ojelabi *et al.,* 2018); enhancing soil water holding capacity and operations of soil organism (Mbah and Mbagwu, 2003); promising long time remaining effects of nutrient (Makinde and Ayoola, 2008; Ogunade *et al.,* 2020) and as well as entices low cost (Bayu *et al.,* 2006).

Assessment of the effect of natural and synthetic origins of phosphorus on plants is crucial because phosphorus is restricted in availability in tropical soil. Thompson *et al.* (2019) stated that tropical forest productivity is limited by soil phosphorus (P) accessibility. Richardson and Simpson (2011) expressed that its obtainability for plants is primarily controlled by mineral weathering, organic matter decomposition, microbial activity, and interactions accompanying soil particles. In highly weathered tropical soils, P is frequently bound to iron and aluminium oxides, making it less approachable to forests (Dalia *et al.,* 2024). The inefficiency and unavailability of phosphorus can be traced to their properties accompanying only 15–25% being taken up by plants; while the remaining amount is leached, causing soil deterioration and water pollution directly (Conley *et al.,* 2009; Johnston *et al.,* 2014). Paz-Ares *et al.* (2022) substantiated that phosphorus is detected in abundance in the lithosphere, but the form used by plants, inorganic orthophosphate (Pi), is indissoluble and distributes gradually in soils. This leads to P inadequacy in farming land, other ecological communities (Fahad *et al.,* 2023) and marginal land pushed to forestry practices in tropics.

Tropical forestlands are always identified by small soil phosphorus (P) obtainability, indicating that P limits plant achievement (Laura *et al.,* 2023). Nutritional studies entailing phosphorus accessibility principally disclosed it limits plant advancement (Epstein and Bloom, 2004; Campo and Vazquez-Yanes, 2004; Sardans *et al.,* 2004; Villar-Salvador *et al.,* 2004; Condit *et al.,* 2013). Various bioassay investigations on seedling growth have corroborated that phosphorus is the chief limiting nutrient in tropical forest soils (Hinsinger, 2001; Lawrence, 2001; Sardans *et al.,* 2004; Villar-salvador *et al.,* 2004; Dean *et al.,* 2009; Wan Juliana *et al.,* 2009; Nilus *et al.,* 2011; Thompson *et al.,* 2019).

Phosphorus (P) is a vital macronutrient that engages in a pivotal role in the growth and development of plants (Fahad *et al.,* 2023). However, Fahad *et al.* (2023) asserted that the insufficient accessibility of phosphorus in soil presents a meaningful difficulty for crop yield. Khan *et al.* (2023) affirmed that phosphorus is pivotal for the growth of plants. Nevertheless, the difficult attainability of P in soil forms the foremost problem to challenge for crop output, especially after plants suffer from drought. A significant section of soils universal shorts of phosphorus (P), leading to a serious restriction of crop yields and give rise to a monumental threat to universal food guarantee (Heuer *et al.,* 2017). Forest crops also need rudimental soil nutrients to furnish food security. The productivity and stability of forest ecosystems are fundamentally governed by nutrient obtainability particularly phosphorus (P) (Shi *et al.,* 2016; Wang *et al.,* 2022). Dalia *et al.* (2024) emphasized that, while P is a limiting nutrient in forest ecosystems, its fertilization upgrades biomass productivity, thereby donating to higher carbon sequestration in international forests.

Low P availability in forest soils is necessitating plants to acquire extra P from diverse origins for the plant community to function (Olander and Vitousek, 2004; Condit *et al.,* 2013). Lambers *et al.* (2018) avowed that when P is incorporated into forest soils, plants often demonstrate various responses, such as modifications in morphology, phosphatase enzyme production, and embellished interactions accompanying mycorrhizal fungi. Reciprocations of plants to phosphorus nutrient availability in the soil result in vigorous growth. P is vital for ATP synthesis, nucleic acid formation, and membrane function straight forwardly modifying plant growth, photosynthesis (Ewuketu and Wenxing, 2005), carbon assimilation, and ribulose-1,5-biphosphate regeneration in the Calvin cycle (Vance *et al.,* 2003; Vitousek *et al.,* 2010). Phosphorus is vital nourishment for plant growth and productivity (Dalia *et al.,* 2024).

Salami *et al.* (2020) expressed that application of phosphorus fertilizers is more important practice in nursery formation. The utilization of P-fertilizer remarkably magnified the seedling enhancement of chosen agroforestry tree species in nursery (Mohammad *et al.,* 2007). Siddhuraju (2007) opined that throughout the primary stages of maturation, trees are very well dependent on soil nutrients provide. Negligence to handle nursery soil adequately by way of not furnishing it with the essential nutrient can lead to exhaustion of site attribute and a decline of seedling growth (Hoque *et al.*, 2004b). Soil nutrient (P) is significant for a healthy seedling growth in the nursery. Not only to supply *C. albidum* seedlings with essential nutrient (P) through fertilizer application is vital, but also to expose it suitable watering interval that embellishes its maturation for standard planting stock (Adelani *et al.,* 2023).

Inadequacy of soil moisture can result in nutritional shortages, even within the soil provided with fertilizer (da Silva *et al.,* 2011). Homyak *et al.,* (2017) opined that water shortage has an effect on the movement and disappearance of both nitrogen and phosphorus nutrients. Water is indispensable for germination, dividing cells and expansion, metabolic activities, and other functions (da Silva *et al.,* 2013). Adelani (2019) established that of all the determinants influencing nutrient uptake, growth and development of the plant, water is most crucial. Regardless of the quality and quantity of nutrients existing in the soil, only water helps the nutrient to dissolve and form ions for the assimilation of the root for plant growth and development. The significance of water cannot be over overstated as it facilitates in biochemical, physiological and hormonal process in the plants (Adelani, 2019).

Growth and biomass productivity is straightway commensurate to furnish and use water in plants (Cao, 2000; Olajuyigbe *et al.,* 2013). Water is an influential determinant in the growth, development and productivity of plants (Gbadamosi, 2014; Ogidan *et al.,* 2018). Yisau *et al.* (2020) observed that productivity of vigorous seedlings within good time frame is of essentials in silviculture as well as forestry in general. Standstill in seedling growth or subsequent mortality as a result of lack of water converts into financial forfeiture to a nursery operator (Mhango *et al.,* 2008). Aderounmu *et al.* (2017) cited that water has major impacts on growth of plants, whereas watering needs of different species vary. Even with variations in species watering preference, fertilizer and water complement each other for plant growth and productivity.

Adequate fertilizer utilization and watering interval-gap are paramount determinants and outstanding components that regulate production and growth of quality young plants (Adelani *et al.,* 2023). Dalia *et al.* (2024) noted that both nutrients and water are two of the most critical components influencing tree growth, and they collaborate with each other. The production of healthy seedlings necessitates the proper recognition of specific limiting factors (Fox, 2000). There is a scarcity of assessed findings on the moisture and nutrient specification (Okafor, 2003; Adelani *et al.,* 2014) for majority of tree species as *Chrysophyllum albidum*. Little work is obtainable on the effect of sources of phosphorus and moistening regimes on the growth of *C. albidum* seedlings. In this light, the fact finding was channelled on the effect of sources of phosphorus and moisture application regimes on the enhancement of *C. albidum* seedlings.

MATERIALS AND METHODS

Description of Experimental Site:

The observational trial location was at the forest nursery of the Federal University of Agriculture Abeokuta. It is sited along Alabata Road, North-East of Abeokuta. It is positioned within latitudes 7º N and 7º 55 ' N and longitudes 3º 20 'E and 3º 37 ' E. The Federal University of Agriculture Abeokuta is established 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 almost on latitude7º 30 ' N and longitude 3º 54 ' E. It lies within the humid lowland rain forest region accompanying 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 accompanying 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.

Seedling Growth:

Chrysophyllum albidum seedlings were raised from seeds for the study. Established seedlings of *C. albidum* of regular measurement at 2-4 leaf periods after two weeks of watering were introduced into 0.75 litre polypot that accommodated sand washed accompanying acid.

Effects of Sources of Phosphorus and Watering Regimes on the Growth of *C. albidum* Seedlings:

The effect of origins of phosphorus and watering intervals on the growth of *Chrysophyllum albidum* plantlets was studied. A 2x3 split-plot experimental representation along with three duplications was selected to evaluate the influences of beginnings of phosphorus and watering interval gaps on the growth of *C. albidum* plantlets. Two sources of nutrient particularly; poultry manure (25g) and single superphosphate (10g) formed the main plot investigation. The daily watering (200ml), 3 days interval (200ml) and 5 days interval (200ml) made up sub plot investigation. The investigation incorporated two inceptions of phosphorus and three watering breaks repeated thrice. Twelve (12) plantlets expressed a clone. Two hundred and sixteen seedlings were engaged. Seedling under each base of phosphorus was split into 3 groups and exposed to different regimes of moisture application. A month-old *C. albidum* plantlets were moved into pots with boosters and exposed to 200ml at varying day's interval.

Growth constants were taken fortnightly for 6 months. Growth variants studied include seedling height accompanying the use of meter rule., girth accompanying the use of veneer caliper., collar diameter was calculated by meter rule., the number of leaves were enumerated manually, and Leaf area was attained by linear measurement of leaf length and leaf width as presented by **Clifton-Brown and Lewandowski (2000).**

$$LA = 0.74 \times L \times W \quad (1)$$

Where LA, Leaf area= Product of linear dimension of the length and width at the broadest part of the leaf.

The average of the growth criterion for duration of examination was used for categorization. Total fresh weight, total dry weight, relative turgidity, net assimilation rate, absolute growth rate, relative growth rate, chlorophyll a, b and a+b and phosphorus uptake were investigated during and after 24 weeks.

Formula for AGR, RGR

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

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

RGR=LAR*NAR

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= $\frac{w2 - w1}{t2 - t1} \times \frac{\log e\ A2 - \log eA1}{A2 - A1} gcm^{-2} wk^{-1}$ (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.

Relative turgidity, which is synonymous to relative water content was detected by interval between fresh weight and dry weight divided by turgid weight subtracting dry weight multiply by 100. Turgid weight was found out by weight of the plant before and after soaking in water for 24hours. Plantlet of high vigour was detached into three parts particularly: leaf, stem and root. Each part was weighed (fresh weight, FW), then left soaked in distilled water for twenty-four (24hrs) (under normal room light and temperature) (Turgid Weight) and after hydration, the samples were then dehydrated in an oven at 70°C for 48 hours and weighed (DW) (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

Evaluations of Chlorophyll were established by straight forward calculations of the absorbance at different wavelengths, using Model 6405 uv/vis Spectrophotometer, serial number 1364. The concentrations were computed by accumulating 20.2 A645, 8.02 A 663 and divided by length of light path in cell (usually 1cm), fresh weight in grams and is 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 (mgg^{-1}) =12.7(A663) - 2.69(A645) x VC/LLP x FW x 1000 =

$\frac{12.7(A663) - 2.69(A645) x\ VC}{LLPXFWX1000}$ (6)

Chlorophyll b (mgg^{-1}) =22.9(A645)-4.86(A663) x VC/ LLP x FW x1000 =

$\frac{22.9(A645) - 4.86(A663) x\ VC}{LLPXFWX1000}$ (7)

Total Chlorophyll a+b (mgg^{-1}) = (20.2(A645) + 8.02(A663) x VC/LLP x FW x 1000

$= \frac{20.2\ A645 + 8.02\ A663 x\ VC}{LLPxFWx1000}$ (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 assessed for the whole plant of *C. albidum* seedlings to calculate the nutrient uptake. Membrane analysis was also carried out for the specimen of entire plant of *C. albidum* plantlets prior to establishing in the beginning and after establishing at end of the investigation respectively to ascertain nutrient uptake. Phosphorus content was detected by Bray-1 method.

Nutrient Uptake was evaluated by Method of

Sharma *et al.* (2012) = $\frac{\%N \times \%P \times \%K \times Dry\ mtter\ kg\ ha{-}1}{100}$ (9)

Actual nutrient uptake was ascertained by variations in nutrient uptake at the beginning and the end of the experiment

Data Analysis

Data were amassed and put through analysis of variance (ANOVA) using SAS (2003). An analyzing of outstanding means was achieved using Fishers' Least Difference LSD at 5% level of significance.

RESULTS

Prominent height (29.83cm), leaf area (145.3cm^2), total fresh weight (8.01g), total dry weight (3.65g), relative turgidity (58.58%) and higher absolute growth rate (0.397gwk^{-1}) were gotten from seedlings sown in the soil modified following poultry manure. Notable girth (3.11cm), leaf number (14.60), collar diameter (1.56cm) and relative growth rate (0.465gg^{-1}wk^{-1}) were traced from seedlings established in the soil improved accompanying single superphosphate. The lower values of height (29.45cm), leaf area (107.1cm^2); total fresh weight (5.90g), total dry weight (2.85g), relative turgidity (56.73%) and absolute growth rate (0.366gwk^{-1}) were reported from seedlings put up in the soil fertilized with single superphosphate fertilizer. The smaller value of 1.04cm (girth), 12.10 (leaf number), 0.52cm (collar girth) and 0.405gg^{-1}wk^{-1}(relative growth rate) were gotten from seedlings established in poultry manure.

Remarkable height (39.97cm), girth (2.48cm), collar diameter (1.24cm) and total dry weight (3.32g) were reported from seedlings implanted in the soil watered at 3days interval. Outstanding leaf number (14.53) and relative growth rate (0.494gg^{-1}wk^{-1}) were produced from seedlings watered daily. Meaningful leaf area (156.7cm^2), total dry weight (3.46g) and relative turgidity (58.61%) were derived from seedlings watered at 5 days interval. A prominent height (39.97cm), girth (2.48cm), collar diameter (1.24cm) and total dry weight (3.32g) were written from seedlings watered (200ml) at 3 day's interval.

The least value of height (18.41cm), leaf number (11.67), relative growth rate (0.403gg^{-1}wk^{-1}) were put down from seedlings watered at 5days interval. The least value of 1.69cm (girth), 0.85cm (collar diameter), 6.51g (total fresh weight), 2.56g (total dry weight), 56.76% (relative turgidity) and 0.336gwk^{-1} (absolute growth rate) were documented in seedlings watered daily (Table 1).

Table 1: Effects of Sources of Phosphorus and Watering Regimes on the Growth of *C. albidum* Seedlings

S.O.P	H(cm)	G(cm)	LN	LA(cm^2)	CD(cm)	TFW(g)	TDW(g)	RT(%)	NARgcm^{-2}wk^{-1})	AGR(gwk^{-1})	RGR(gg^{-1}wk$^{-1)}$
POM	29.83^a	1.04^b	12.10^b	145.1^a	0.52^b	8.01^a	3.65^a	58.58^a	0.003^a	0.397^a	0.405^b
SSP	29.45^a	3.11^a	14.60^a	107.1^b	1.56^a	5.90^b	2.85^a	56.73^a	0.003^a	0.366^a	0.465^a
SE±	0.52	0.07	0.70	4.85	0.05	0.54	0.38	4.93	0.001	0.07	0.02
WR											
1	30.55^b	1.69^c	14.53^a	126.69^b	0.85^c	6.51^a	2.56^b	56.76^a	0.003^a	0.336^a	0.494^a
3	39.97^a	2.48^a	13.86^a	95.07^c	1.24^a	6.96^a	3.32^a	57.59^a	0.003^a	0.336^a	0.408^b
5	18.41^c	2.06^a	11.67^b	156.7^a	1.03^b	7.39^a	3.46^a	58.61^a	0.002^a	0.449^a	0.403^b
SE±	0.64	0.11	0.86	5.94	0.06	0.35	0.27	6.04	0.001	0.09	0.03

Means on the same column having different superscript are significantly different ($p<0.05$).
S.O.P= Source of phosphorus, WR= Watering regime, H= Height, G=Girth, LN= Leaf Number, LA= Leaf area, CD=Collar diameter, TFW=Total Fresh Weight, TDW=Total Dry Weight, R.T= Relative Turgidity, NAR= Net Assimilation Rate, Absolute Growth Rate = AGR, RGR= Relative Growth Rate.

Significant height (41.41cm), girth (4.03cm), leaf number (16.18) and collar diameter (2.02cm) were entered from plantlets sown in the soil corrected accompanying single super phosphate and watered at 3 days interval. Superior leaf area (210.76cm^2) was acquired from seedlings established in the soil enriched with poultry manure and watered at 5days interval. Excellent absolute growth rate (0.584gwk^{-1}) and relative growth rate (0.540gg^{-1}wk^{-1}) were obtained from seedlings placed in the soil upgraded with single super phosphate and watered at 5 and 1 days interval respectively.

The lowest values of height (15.07cm), girth (0.71cm), leaf number (10.50), collar diameter (0.36cm), net assimilation rate (0.002gcm^{-2}wk^{-1}) and relative growth rate (0.337gg^{-1}wk^{-1}) were noted for seedlings cultivated in poultry manure and watered at 5 days interval. The minimum value of 85.34cm^{2} (leaf area) was traced from seedlings put in soil helped accompanying poultry manure and watered at 3 days interval. The meanest values of 5.13g (total fresh weight) and 2.15g (total dry weight) were produced from seedlings transplanted in the soil boosted accompanying single superphosphate and watered daily. The minimal value of 48.92% (relative turgidity); 0.002gcm^{-2}wk^{-1} (net assimilation rate) and 0.214gwk^{-1} (absolute growth rate) were recounted from seedlings introduced into the soil amended with single superphosphate and watered at 3 days interval (Table 2).

Table 2: Interactive Effect of Sources of Phosphorus and Watering Regimes on the Growth of *C. albidum* Seedlings

S.O.P	WR	H(cm)	G(cm)	LN	LA(cm^{2})	CD(cm)	TFW(g)	TDW(g)	RT (%)	NAR (gcm^{-2}wk^{-1})	AGR(gwk^{-1})	RGR(gg^{-1}wk^{-1})
P.O.M	1	35.89^{b}	1.48^{d}	14.26^{ab}	139.37^{b}	0.74^{d}	7.90^{ab}	2.98^{ab}	56.82^{a}	0.003^{b}	0.418^{ab}	0.448^{ab}
	3	38.52^{ab}	0.94^{e}	11.54^{b}	85.34^{d}	0.47^{e}	8.18^{a}	3.60^{ab}	66.26^{a}	0.005^{a}	0.459^{ab}	0.431^{ab}
	5	15.07^{e}	0.71^{e}	10.50^{c}	210.76^{a}	0.36^{e}	7.95^{ab}	4.38^{a}	52.67^{a}	0.002^{b}	0.314^{ab}	0.337^{b}
SSP	1	25.20^{c}	1.90^{c}	14.80^{ab}	114.01^{c}	0.95^{c}	5.13^{b}	2.15^{b}	56.71^{a}	0.003^{b}	0.300^{ab}	0.540^{a}
	3	41.41^{a}	4.03^{a}	16.18^{a}	104.79^{cd}	2.02^{a}	5.75^{b}	3.85^{ab}	48.92^{a}	0.002^{b}	0.214^{b}	0.386^{b}
	5	21.75^{d}	3.41^{b}	12.8^{b}	102.71^{b}	1.71^{b}	6.83^{ab}	2.55^{ab}	64.56^{a}	0.003^{b}	0.584^{a}	0.469^{ab}
SE±		1.20	0.15	0.86	8.40	0.06	0.94	0.82	8.55	0.001	0.12	0.05

Means on the same column having different superscript are significantly different ($p<0.05$)
S.O.P= Source of phosphorus, WR= Watering regime, H= Height, G=Girth, LN= Leaf Number, LA= Leaf area, CD=Collar diameter, TFW=Total Fresh Weight, TDW=Total Dry Weight, R.T= Relative Turgidity, NAR= Net Assimilation Rate, Absolute Growth Rate = AGR, RGR= Relative Growth Rate.

Significant values of 0.6092 mg/g (chlorophyll a), 0.3753mg/g (total chlorophyll a+b) and 2.02% (phosphorus uptake) were written from stems and leaves of seedlings initiated in the soil developed with single superphosphate and watered (200ml) at 3 days interval. Substantial values of 0.2386mg/g (chlorophyll b) and 2.02% (phosphorus uptake) were entered from leaves of plantlets instituted in the soil controlled with poultry manure and watered at 5days interval.

Table 3: Interactive Effect of Sources of Phosphorus and Watering Regimes on the Chlorophyll and Phosphorus Uptake

S.O.P	WR	P.P	Cl (a)mg/g	Cl (b)mg/g	Cl (a+b) (mg/g)	P Uptake (%)
POM	1	Leaf	0.2147^{bc}	0.1468^{c}	0.3616^{ab}	1.18^{de}
	1	Stem	0.0948^{d}	0.0769^{d}	0.1717^{b}	0.16^{de}
	1	Root	0.0283^{ef}	0.021^{ef}	0.0493^{d}	0.62^{cd}
POM	3	Leaf	0.1707^{c}	0.1653^{b}	0.3334^{b}	1.47^{b}
	3	Stem	0.0849^{d}	0.0808^{d}	0.1657^{cd}	0.21^{de}
	3	Root	0.274^{b}	0.0216^{ef}	0.049^{d}	0.53^{d}
POM	5	Leaf	0.1249^{cd}	0.2386^{a}	0.3635^{ab}	2.02^{a}
	5	Stem	0.0877^{d}	0.0942^{d}	0.1819^{bc}	0.20^{de}
	5	Root	0.0245^{f}	0.0241^{e}	0.0486^{d}	0.74^{cd}
SSP	1	Leaf	0.2355^{b}	0.1288^{c}	0.3642^{ab}	0.78^{cd}
	1	Stem	0.101^{d}	0.0742^{d}	0.1752^{c}	0.09^{e}
	1	Root	0.0314^{e}	0.0183^{f}	0.0497^{d}	0.32^{de}
SSP	3	Leaf	0.2486^{b}	0.1268^{c}	0.3753^{a}	2.02^{a}
	3	Stem	0.6092^{a}	0.0751^{d}	0.1771^{c}	0.13^{e}
	3	Root	0.0301^{e}	0.0183^{f}	0.0484^{d}	0.76^{cd}
SSP	5	Leaf	0.1565^{c}	0.1847^{b}	0.3411^{b}	0.96^{c}
	5	Stem	0.0908^{d}	0.0861^{d}	0.1768^{c}	0.18^{c}
	5	Root	0.0302^{e}	0.0221^{ef}	0.0523^{d}	0.32^{b}
SE±			0.02	0.01	0.01	0.16

Means on the same column having different superscript are significantly different ($p<0.05$).
S.O.P= Source of phosphorus, WR= Watering regime, P.P= Plant part, Cl(a) = Chlorophyll a, Cl(b)= Chlorophyll b, Cl(a+b)= Total chlorophyll, P uptake= Phosphorus uptake.

The least value of 0.0245mg/g (chlorophyll a) and 0.0484 (total chlorophyll a+b) were noted down from roots of plantlets originating in poultry manure amended soil and watered at 5days interval and root of those developed in soil modified accompanying single superphosphate and water at 3 days interval respectively. The least value of 0.0183mg/g (Chlorophyll b) was established from root of seedlings set up in soil reinforced with single superphosphate and watered at day 1 and 3 intervals. The least value of 0.09% (P uptake) was reported from stem of seedlings produced in the soil advanced accompanying single superphosphate and watered daily (Table 3).

DISCUSSION

Significant growth constants recorded from *C. albidum* seedlings cultivated in poultry manure revealed its better source of phosphorus. A source of phosphorus motivates the growth of plants. Several investigators have recounted the superior performance of origins of phosphorus in improving the growth of trees (Rickard, 2000; Abedin *et al.,* 2002; Khatik *et al.,* 2004; Liu *et al,* 2005; Broschat, 2006; Ogunwole *et al.,* 2006; Suthiphasilp, 2009; Balal *et al.,* 2011; Pereira *et al.,* 2014; Larwanou *et al.,* 2014; Anamayi *et al.,* 2016). Dalia *et al.* (2024) discovered that sources of phosphorus (H_3PO_4) meaningfully improved the growth of *Swietenia mahagoni*. Some of agroforestry trees increased appreciably with the application of P fertilizer (Triple Super Phosphate TSP) (Mohammad *et al.,* 2008). Administration of triple superphosphate (77kg P ha-1) on the topsoil of Chittagong University Campus is mandatory to boost the diameter and total dry matter production of *Michelia champaca* seedlings (Hoque *et al.,* 2004b).

Source of phosphorus, Organic manure furnished *C. albidum* seedlings with better phosphorus. Phosphorus is a rudimentary element grouped as a macronutrient because of the approximately large amounts of phosphorus mandatory for plants. The greatest role of phosphorus inside a plant is energy store and transport in adenosine di and tri phosphate as well as engages in a principal responsibility in the establishment of DNA and proteins (Abod and Siddiqui, 2002; Taiz and Zeiger, 2002; Epstein and Bloom, 2004; Havlin *et al.,* 2005; Nathan, 2009; Busman *et al.,* 2009; CFF, 2011; Anderson, 2015; Malhotra *et al.*, 2018; Sezer and Seda, 2019; Isidra-Arellano *et al.,* 2021; Dalia *et al.,* 2024). Phosphorus is a paramount component of nucleic acids, phospholipids, high-energy phosphate bond complexes, and many coenzymes (Wyngaard *et al.,* 2016; Fahad *et al.,* 2023; Dalia *et al.,* 2024). Yao *et al.* (2012) observed that phosphorus is inevitable for glucose and nitrogen metabolism, and the mutual conversion of protein and carbohydrate metabolism. It is a supreme constituent of ATP, the chemical that accords energy to the plant for nutrition translocation, nutrient uptake, and respiration (Dalia *et al.,* 2024).

Owing to its role in proteins and nucleotides, adequate phosphorus is connected to improve root growth, strong stem development and appropriate development of reproductive parts (Williamson *et al.,* 2001; Zapata and Zaharah, 2002 ; Haggai *et al.,* 2003, Lopez-Bucio *et al.,* 2003; Epstein and Bloom, 2004; Anghinoni and Bissani, 2004; Jin *et al.*, 2005; Havlin *et al.,* 2005; Hill *et al.,* 2006; Pandey *et al.,* 2006; Alabi, 2006; Huda *et al.,* 2007; Mohammad *et al.,* 2007; Xu *et al.,* 2012; Wu *et al.,* 2015; Waraich *et al.,* 2015; Muhammad *et al.,* 2017; Wen *et al.,* 2017; Lai *et al.,* 2018; Sezer and Seda, 2019 ; Thompson *et al.,* 2019; Dalia *et al.,* 2024). Moreover, various investigators (Ramos *et al.,* 2000; Nicoloso *et al.,* 2001; Schumacher *et al.,* 2004; Gomes *et al.,* 2004; Melo *et al.,* 2005) relate the P effect on the primary growth of forest species. Ramos *et al.* (2000) pronounced a general positive effect of phosphorus from nitrogen, phosphorus and potassium employment in the improvement of *Bauhinia forficate* seedlings. Gomes *et al.* (2004) noticed that *Anadenantheta colubrine* offered favourable reaction to the phosphorus administration. Nicoloso *et al.* (2001) noted that from 60 to 120 days subsequently, *Apuleia leiocarpa* seedlings emergence, phosphorus fertilization escalated sequentially to seedling height in conditions of nitrogen and potassium inadequacy. Bhuiyan *et al.* (2000) has reported the speed up of growth factors on the administration of P-fertilizer, specifically on *Casuarina* spp. The responsibilities of phosphorus in plants are very basic and indispensable. It assists a plant to convert other nutrients into useful building blocks with which to grow (Heather, 2021). Graciano *et al.* (2006) registered that P addition is accelerating soil N absorption in *Eucalyptus grandis* seedlings.

Phosphorus is vital to flowering, fruiting and to transfer of hereditary (Vance *et al.,* 2003; Epstein and Bloom, 2004; Nathan, 2009; Haque and Khan, 2012; Anderson, 2015; Sezer and Seda, 2019). It also intensifies disease resistance in plants (Anderson, 2015; Dalia *et al.,* 2024). It alleviates the toxic effects of arsenite in the soils (Soriano and Fereres, 2003; Quaghebeur and Rengel 2003; Liu *et al.*, 2005; Tao *et al.,* 2006; William *et al.*, 2007; Pigna *et al.,* 2010). Fahad *et al.* (2023) established that phosphorus comes up as a key player in bolstering plant resilience against unfavourable atmospheric situations. Phosphorus increased reduced soil pH by 0.06 (P+) and 0.14(P++) units equated accompanying the control ($P < 0.01$) (Laura *et al.,* 2023). Fahad *et al.* (2023) observed that phosphorus is imperative for the synthesis and activation of enzymes concern with the nutrient obtaining and transfer and its dearth give rise to nutrient instability and poisonousness signs.

For tree cultivated in soil without phosphorus addition, there was a reduction in biomass production equated to the plants that obtained phosphorus fertilization on Padula, Vertricella and La Bolte soils of Italy respectively (Pigna *et al.,* 2010). Tariq *et al.* (2023) noticed that lacking of P affects the uptake of other nutrients like nitrogen (N), potassium (K) and calcium (Ca) by plants, changing their architecture contributing to things such as diminished stem elongation and the production of shorter and thicker stems. P insufficiency also influences biomass allocation, with a drop in above-ground biomass and a rise in root biomass (Fahad *et al.,* 2023). Overall, P inadequacy not only affects nutrient acquisition and transport, but also stimulates variations in plant morphology, biomass allocation, leaf morphology and photosynthesis, underscoring its significance in diverse physiological processes and overall plant growth and development (Fahad *et al.,* 2023). Jose (2003) also announced that high deprivation of phosphorus and mineral uptake may lead to poor cell differentiation and multiplication of plant. Nevertheless, some species, such as *Arabidopsis thaliana* establishes larger roots in P-deficient conditions (Ma *et al.,* 2001).

Outstanding growth parameters produced from seedlings planted in poultry manure relative to single superphosphate could also be traced to potentials of natural manure in embellishing the growth of seedlings. Organic manures are fundamental in the growth and development of plant because they serve as soil modification (Abou El-Magd *et al.,* 2005; Ojelabi *et al.,* 2018; Adedokun *et al.,* 2020c)., binding nutrients vulnerable to leaching (Abou El –Magd *et al.,* 2006)., balance of soil pH flunctuation (Eifediyi and Remison, 2010) and reduction of soil pH (Laura *et al.,* 2023). Poultry manure is natural by characteristics. Poultry manure comprises nutrients and essential elements (nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, copper, zinc) that can boost plant productivity and strengthen the physical and chemical attributes of the soil (Telkamp, 2015; Usman *et al.,* 2022). Alabi (2006) declared that poultry manure accommodates enormous contents of all the mineral nutrients essential to the plant. Poultry manure utilization upgrades soil retention and uptake of plant nourishments. This intensifies plant health by increasing water and nutritious accessibility as well as overpowering harmful levels of plant parasitic nematodes, fungi and bacteria (Agbede *et al.,* 2008). Salami *et al.* (2020) announced that P in poultry manure is swiftly hydrolyzed and chemically accelerated or assimilated for plant growth.

The excellent performance of poultry manure in improving the growth of tree seedling have been reported by Olajiire-Ajayi *et al.* (2018) (*Mansonia altissima*) and

Adedokun *et al*. (2020a) (*Tamarindus indica*). Contrary to this finding, Adedokun *et al.* (2020b) recommended 1g of urea fertilizer for upbringing *Blighia sapida* seedlings. Iroko *et al.* (2020) approved 0.09g/pot (141kg/ha) urea plant food employment for successful nurturing of *Pterocarpus erinaceous* seedlings. Salami (2015) discovered that application of 15g urea to soil embellished the healthy growth of *Enterolobium cyclocarpum* seedlings.

Significant growth criterion written from seedlings moistened at 3 days revealed that modest and adequate supply of water is basic. Moderate supply of water that prevents the excesses and insufficiencies varies from one species to another. Quantity of water is adequate when it can successfully improve the growth of tree seedlings better than others. Various researchers such as Isah *et al.* (2012) (*Acacia senegalensis*), Olajuyigbe *et al.* (2013) (*Diospyros mespiliformis*) and Usman *et al.* (2013) (*Moringa oleifera*) published the efficacy of adequate provision of water in upgrading the growth of tree seedlings. Mukhtar (2012) disclosed that plant water level has a powerful impact on plant growth and biomass productivity through its influence on leaf and root expansion. This also authenticates the announcements of earlier investigators who have published highest growth variables in seedlings subjected to adequate watering (Akinyele, 2007; Dauda *et al.,* 2009; Gbadamosi, 2014; Oboho and Igharo, 2017; Ogidan *et al.,* 2018). This consequently implies that growth and biomass output is straight-forwardly proportional to the present and utilize of water (Sale, 2015; Mukhtar, 2016) and it also stresses the importance of instituting maximum water specifications for tree seedlings to enhance growth (Mukhtar *et al.,* 2016).

Only the moderate and adequate supply of water advances the plant growth. Lesser growth variables written from seedlings treated with 5days watering intervals compared to that of 3 days is an indication of low availability of water to seedlings. Inferior water availability damages seedlings and sapling growth and survival (Cao, 2000; Engelbrecht and Kursar, 2003). Insufficient water supply is dangerous to the growth of plants. A decrease in water consumption negatively influences plant production (Kang *et al.,* 2024). Scarcity can have a negative effect not only on the morphological features of plant, but also on the physiological, biochemical, and molecular features (Fathi and Tari, 2016). The menace of inadequacy of water accounts for morphological and physiological alterations in higher plants (Ghorbani *et al.,* 2019). On the other hand, reduced growth constant recorded from seedlings watered daily relative to that of 3 days interval revealed the effect of unrestrained supply of water on plant growth. Superabundance supply of water is harmful. In an unrestricted water supply condition, available oxygen in the soil is usually low, thus restricting nutrient assimilation for species not acclimatized to this condition. This is in conformity with the discoveries of Predick *et al.* (2009) who established that growth of flood-uncompromising varieties is often depressed in overabundance of water. Similar observation has been reported by Gbadamosi (2014) who stated that extravagant supply of water had adverse influence on the growth and biomass production of the *Picralima nitida* seedlings. Gonzales *et al.* (2009) reported the unfavorable consequence of surplus watering on the enhancement of *Chenopodium quinoa.*

A significant morphological and physiological growth specifications entered from seedlings embedded in the soil amended with single superphosphate and watered (200ml) at 3 days interval revealed the appropriate collaboration of sources of phosphorus and watering regimes. Appropriate association of fountains of phosphorus and watering stretches enriches the enlargement of tree seedlings. The excellent performance of seedlings implanted in the soil modified following single superphosphate in the presence of adequate watering regime of three days interval could also be attributed to ability of 3 days watering regime to dissolve the sources of phosphorus correctly for plant uptake for growth to take place. This is in consonance with the report of John (2013) who disclosed that when the water is sufficiently supplied to sources of phosphorus; it is effective in supplying the nutrients to the plant for growth. Similar pronouncement has been registered by Adelani (2019) who noticed that daily watering considerably (P<0.05 embellishes plantlet growth and nutritional uptake (P) of *Citrus tangelo* planted in the combination of sand and pulverized *Jacaranda mimosifolia* leaf litters as source of nitrogen, phosphorus and potassium.

CONCLUSION

Some of our indigenous priority trees species of ample potentials are slow to meet the population request of their benefits. Inadequate water and nutrient supply is also a threat to propagation as well as biodiversity preservation of our native fruit tree types. Investigation on the effects of fountains of phosphorus and watering seasons exposed that the improvement of soil with single super phosphate and application of 3 days watering periods enriches the increase of *C. albidum* seedlings. The essential roles of adequate combinations of fertilizer and watering application to seedlings of agroforestry species as *C. albidum* for afforestation, reforestation, agroforestry systems as well as for biodiversity conservation programmes cannot be over emphasized.

Declarations:

Ethical Approval: This study did not involve any live animals. It was based solely on experimental laboratory and analysis of plant extracts

Conflict of interest: The authors declare no conflict of interest.

Author's Contributions: I hereby verify that the authors mentioned on the title page has Contributed significantly to the idea and planning of the research, has carefully read the work, attested to the veracity and correctness of the data and its interpretation, and has given their approval for submission.

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