



Field Establishment of *Chrysophyllum albidum* G. Don Seedlings through Planting Depth, Hole Width and Nitrogen Fertilizer Application

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Abstract. The successful establishment of indigenous fruit tree species is fundamental to sustainable forest management, biodiversity conservation, and the domestication of economically important non-timber forest products. *Chrysophyllum albidum* G. Don (African star apple) is a valuable indigenous multipurpose tree species in West Africa whose large-scale cultivation is constrained by inadequate information on appropriate field establishment techniques. This study evaluated the effects of planting depth, planting-hole width and nitrogen fertilization on the early growth, biomass accumulation and physiological performance of *C. albidum* seedlings under field conditions at the Forestry Research Institute of Nigeria (FRIN), Ibadan. A split-split plot experiment arranged in a Randomized Complete Block Design (RCBD) was established using 120 seedlings. Treatments consisted of three planting depths (10, 15 and 20 cm), two planting-hole widths (10 and 15 cm), and two fertilizer levels (0 and 5 g urea seedling⁻¹), resulting in twelve treatment combinations replicated ten times. Morphological parameters were monitored fortnightly for six months, while biomass and physiological growth indices were determined at the end of the experiment. Analysis of variance revealed that fertilizer application and planting depth did not significantly ($P > 0.05$) influence seedling height, collar diameter or leaf production. Planting-hole width significantly affected leaf production ($P < 0.05$), indicating that adequate root-zone preparation enhanced canopy development during the establishment phase. Although biomass accumulation and physiological parameters varied among treatment combinations, interaction effects among the silvicultural treatments were not statistically significant. The findings demonstrate that *C. albidum* seedlings exhibit considerable adaptability to moderate variations in planting depth and fertilizer

application during early establishment, while appropriate planting-hole width improves early canopy development. These results provide valuable silvicultural information for plantation establishment, restoration programmes, and the domestication of African star apple in tropical forest ecosystems.

Keywords: African star apple; indigenous fruit tree; field establishment; planting depth; nitrogen fertilization; silviculture

1. Introduction

Chrysophyllum albidum G. Don (Sapotaceae), commonly known as the African star apple, is one of the most valuable indigenous multipurpose fruit tree species in tropical Africa. The species occurs naturally in the lowland rainforest and derived savanna zones of West and Central Africa, where it contributes significantly to rural livelihoods, biodiversity conservation, food security and environmental sustainability. Its edible fruits are highly appreciated for their pleasant flavour and rich nutritional composition, while different plant parts, including the bark, leaves, seeds and roots, have long been utilised in traditional medicine for the treatment of malaria, yellow fever, diarrhoea, skin infections and several inflammatory disorders (Adebayo *et al.*, 2021; George *et al.*, 2022). Beyond its nutritional and medicinal importance, *C. albidum* provides timber, fuelwood, shade, carbon sequestration and ecological services that support sustainable forest ecosystems and agroforestry production systems.

The increasing commercial demand for African star apple fruits has stimulated renewed interest in its domestication and large-scale cultivation across West Africa. In Nigeria, the fruits constitute an important

source of seasonal income for rural households, particularly women and smallholder farmers involved in fruit harvesting and marketing. Recent studies have further demonstrated that the fruit pulp contains appreciable quantities of vitamins, essential minerals, dietary fibre and antioxidant compounds capable of reducing oxidative stress and improving human health (Obboh *et al.*, 2021; Adepoju *et al.*, 2023). Similarly, phytochemical investigations have identified numerous bioactive constituents including flavonoids, tannins, saponins and phenolic compounds that exhibit antimicrobial, antidiabetic and anti-inflammatory properties, thereby increasing the pharmaceutical and nutraceutical value of the species (George *et al.*, 2022).

Despite its considerable socio-economic importance, *C. albidum* remains largely undomesticated, with production relying predominantly on naturally occurring trees scattered within farmlands and secondary forests. Natural regeneration of the species is generally slow owing to seed recalcitrance, prolonged juvenile growth, poor seedling establishment and increasing anthropogenic disturbances including deforestation, agricultural expansion, bush burning and urbanisation (Kehinde *et al.*, 2021). Consequently, wild populations continue to decline, threatening the long-term availability of valuable genetic resources and limiting opportunities for commercial orchard development.

Successful domestication of indigenous tree species depends not only on efficient propagation techniques but also on appropriate silvicultural practices that enhance seedling survival and early field establishment. The establishment phase represents one of the most critical stages in plantation development because seedlings are particularly susceptible to environmental stress, nutrient deficiency, moisture fluctuations and transplant shock. Poor establishment frequently results in high mortality rates, uneven stand development and increased plantation management costs (Grossnickle & MacDonald, 2018). Therefore, identifying suitable field establishment practices is essential for improving plantation success and accelerating the domestication of economically important indigenous species.

Among the various silvicultural interventions employed during plantation establishment, planting depth plays a crucial role in regulating root development, water availability, aeration and seedling stability. Planting seedlings too shallow may expose roots to desiccation and mechanical instability, whereas excessively deep planting can reduce soil aeration, restrict root respiration and impair subsequent growth (Davis *et al.*, 2019). Similarly,

planting hole dimensions influence root expansion, soil loosening, water infiltration and nutrient accessibility during the initial stages of seedling establishment. Larger planting holes generally improve root penetration in compact soils by reducing mechanical resistance, thereby facilitating greater exploration of soil resources (Haase *et al.*, 2021).

Nutrient availability represents another major determinant of seedling establishment and productivity in tropical forest plantations. Nitrogen, being the most limiting macronutrient in many tropical soils, is directly involved in chlorophyll synthesis, photosynthetic efficiency, protein formation and vegetative growth. Appropriate nitrogen fertilization during early establishment has been reported to enhance leaf production, biomass accumulation, stem development and physiological performance of numerous tropical tree species (Lambers & Oliveira, 2019; Crous *et al.*, 2022). However, the response of seedlings to nitrogen application is strongly influenced by soil conditions and interactions with other silvicultural practices, particularly planting depth and rooting environment. Consequently, fertilizer recommendations developed for exotic plantation species may not necessarily be applicable to indigenous fruit trees such as *C. albidum*.

Although considerable attention has been devoted to the propagation, seed germination, vegetative multiplication and nutritional composition of *Chrysophyllum albidum*, relatively little information exists regarding optimum field establishment practices following nursery production. In particular, there is a paucity of empirical data on the combined effects of planting depth, planting hole width and nitrogen fertilization on the early growth and physiological performance of transplanted seedlings under tropical field conditions. This knowledge gap has constrained the development of evidence-based silvicultural recommendations for large-scale plantation establishment and conservation programmes.

The present study was therefore designed to evaluate the effects of planting depth, planting hole width and nitrogen fertilization on the early field establishment of *Chrysophyllum albidum* seedlings at the Forestry Research Institute of Nigeria, Ibadan. Specifically, the study assessed their influence on morphological growth attributes, biomass accumulation and physiological growth indices with the aim of identifying appropriate silvicultural practices that can improve seedling establishment, promote plantation productivity and support the conservation and sustainable utilization of this important indigenous fruit tree species.

2. Materials and Methods

2.1 Study Area

The study was conducted at the Arboretum of the Forestry Research Institute of Nigeria (FRIN), Jericho Hill, Ibadan, Oyo State, Nigeria. The experimental site is located within the Ibadan North-West Local Government Area between latitude 7°23'18"N and 7°23'43"N and longitude 3°51'20"E and 3°51'43"E. The area is characterized by a humid tropical climate with distinct wet and dry seasons. The rainy season extends from April to October, while the dry season occurs between November and March. Annual rainfall ranges from approximately 1,400 to 1,500 mm, with an average relative humidity of about 85%. Mean annual temperature is approximately 31.2°C. The predominant soil type is a well-drained lateritic alluvial soil, which supports the growth of a wide range of indigenous tropical tree species. Climatic data were obtained from the Forestry Research Institute of Nigeria Meteorological Station (FRIN Meteorological Report, 2015).

2.2 Experimental Materials

Healthy, vigorous and uniform seedlings of *Chrysophyllum albidum* G. Don (Syn. *Gambeya albida*), raised under nursery conditions, were selected for field establishment. Prior to transplanting, seedlings were inspected to ensure uniformity in height, stem diameter and overall vigour in order to minimize experimental variability.

2.3 Experimental Design and Field Establishment

The field experiment was conducted in the Arboretum of FRIN using a split-split plot arrangement within a Randomized Complete Block Design (RCBD). A total of 120 seedlings were used for the experiment.

The experiment consisted of three factors:

Main plot factor: Planting depth

D₁ = 10 cm

D₂ = 15 cm

D₃ = 20 cm

Sub-plot factor: Planting hole width

W₁ = 10 cm

W₂ = 15 cm

Sub-sub plot factor: Fertilizer application

F₀ = No fertilizer application

F₁ = Application of 5 g urea per seedling

The factorial combination of the three planting depths, two planting-hole widths and two fertilizer levels resulted in twelve treatment combinations (3 × 2 × 2 =

12). Each treatment was replicated ten times, giving a total of 120 experimental units.

Seedlings were transplanted into prepared planting holes according to the designated treatment combinations. Urea fertilizer was applied four weeks after transplanting by ring placement around the base of each seedling at the prescribed rate. Routine field maintenance, including manual weeding and protection against pests and mechanical damage, was carried out uniformly throughout the experimental period.

2.4 Growth Measurements

Growth assessments were carried out at two-week intervals for six months following transplanting.

The following morphological parameters were measured:

- Seedling height (cm), measured from the collar region to the terminal bud using a graduated metre rule.
- Collar diameter (mm), measured at the stem base using a digital Vernier caliper.
- Number of leaves, determined by direct counting of fully expanded leaves.

At the end of the six-month experimental period, destructive sampling was undertaken to determine biomass accumulation. Harvested seedlings were carefully uprooted and separated into roots, stems and leaves. Each plant component was oven-dried at 70 ± 2°C to constant weight before dry biomass determination.

2.5 Physiological Growth Analysis

Physiological growth indices were calculated to evaluate the growth performance of *Chrysophyllum albidum* seedlings under the different silvicultural treatments.

Relative Growth Rate (RGR)

$$RGR = \frac{\log_e H_2 - \log_e H_1}{T_2 - T_1} \text{ (gg}^{-1} \text{ day}^{-1}\text{)}$$

where

H₁ = Initial plant height

H₂ = Final plant height

T₁ = Initial sampling time

T₂ = Final sampling time

Absolute Growth Rate (AGR)

$$AGR = \frac{H_2 - H_1}{T_2 - T_1} \text{ (cm day}^{-1}\text{)}$$

Leaf Area Ratio (LAR)

$$LAR \text{ (m}^2\text{Kg}^{-1}\text{)} = \frac{A}{W}$$

where

A = Leaf area (m²)

W = Total plant dry weight (kg)

Net Assimilation Rate (NAR)

$NAR = \frac{RGR}{LAR} \text{ (gcm}^{-2} \text{ day}^{-1}\text{)}$

Leaf Turgidity

Leaf turgidity was estimated according to the expression:

$$\frac{\text{Leaf turgidity}}{\text{Leaf weight in water} - \text{Initial fresh weight}} \times 100 = \frac{\text{Initial Fresh Weight}}{\text{Initial Fresh Weight}}$$

where

TW = Turgid weight after soaking in distilled water

FW = Initial fresh weight

2.6 Statistical Analysis

Data obtained from the experiment were subjected to analysis of variance (ANOVA) appropriate for a split-split plot arrangement in a Randomized Complete Block Design using the Statistical Package for the Social Sciences (SPSS). Treatment means were separated using Fisher's Least Significant Difference (LSD) test at the 5% probability level ($P \leq 0.05$). Descriptive statistics were computed for all measured variables, and treatment effects were considered statistically significant when probability values were less than 0.05.

3. Results

Effects of Planting Depth, Planting Hole Width and Fertilizer Application on Morphological Growth of *Chrysophyllum albidum* Seedlings

The analysis of variance (Table 1) revealed that fertilizer application had no significant ($P > 0.05$) effect on seedling height, collar diameter or leaf production of *Chrysophyllum albidum* seedlings during the six-month field establishment period. Likewise, planting depth did not significantly influence any of the measured morphological growth parameters. Planting hole width also had no significant effect on seedling height or collar diameter ($P > 0.05$). However, planting hole width significantly affected leaf production ($P = 0.033$), indicating that leaf development was influenced by the size of the planting hole.

The interaction effects among fertilizer application, planting depth and planting hole width were not statistically significant ($P > 0.05$) for seedling height, collar diameter or number of leaves, suggesting that the combined application of the three silvicultural treatments did not produce additional growth responses beyond their individual effects during the establishment period.

Table 1: Effects of Planting Depth, Planting Hole Width and Fertilizer Application on Morphological Growth of *Chrysophyllum albidum* Seedlings

Experimental treatment	Seedling height (cm)	Collar diameter (mm)	Number of leaf	Leaf area estimate	Total folial weight	Dry weights			R/S ratio
						Leaf	stem	Root	
F0W1D1	60.0	6.61	17.38	1663.2	18.33	8.07	6.36	7.59	0.24
F0W1D2	70.05	8.12	20.13	878.85	5.91	2.09	1.91	3.26	0.50
F0W1D3	63.03	6.96	16.00	1265.99	17.24	8.50	7.87	4.78	0.27
F0W2D1	59.99	6.36	13.38	1062.72	16.17	7.99	7.89	3.48	0.33
F0W2D2	51.30	7.18	15.13	1396.68	17.56	9.02	6.80	6.88	0.30
F0W2D3	66.24	7.65	19.13	845.3	12.26	5.75	5.27	5.38	0.37
F1W1D1	62.33	7.06	15.50	2593.01	24.60	11.55	10.92	9.77	0.58
F1W1D2	65.25	7.13	18.88	1386.48	22.98	10.67	10.62	5.45	0.35
F1W1D3	49.51	6.09	16.00	708.56	6.28	0.09	0.30	0.28	0.33
F1W2D1	70.41	6.73	12.88	648.32	19.62	8.89	7.28	4.71	0.27
F1W2D2	61.44	6.83	13.63	2964.06	33.28	15.68	10.53	8.83	0.31
F1W2D3	62.90	6.49	14.50	777.36	8.44	2.71	3.37	16.0	0.25
S.E	1.994	0.173	0.585						

The treatment means presented in Table 2 demonstrated considerable variation in growth performance among the twelve treatment combinations. Seedling height ranged from 49.51 cm under treatment F₁W₁D₃ to 70.41 cm under treatment F₁W₂D₁. Collar diameter varied from 6.09 to 8.12 mm, while the number of leaves ranged between 12.88 and 20.13 leaves per seedling.

Substantial differences were also observed in biomass accumulation. Leaf dry weight ranged from 0.09 to 15.68 g, stem dry weight from 0.30 to 10.92 g, and root dry weight from 0.28 to 16.00 g among the treatment combinations. Root-to-shoot ratio varied between 0.24 and 0.58, reflecting differences in biomass partitioning among seedlings subjected to different establishment treatments.

Although numerical differences existed among treatments, these variations generally did not translate into statistically significant differences for most measured growth variables during the six-month assessment period.

Table 2: Analysis of Variance for the Effects of Planting Depth, Planting Hole Width and Fertilizer Application on Morphological Growth of *Chrysophyllum albidum* Seedlings

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
F	Collar Diameter	4.378	1	4.378	1.532	0.219
	Seedling Height	1.021	1	1.021	.003	0.959
	Number of Leaf	63.375	1	63.375	1.932	0.168
W	Collar Diameter	0.363	1	0.363	0.127	0.723
	Seedling Height	2.975	1	2.975	0.008	0.930
	Number of Leaf	155.042	1	155.042	4.726	0.033
D	Collar Diameter	7.108	2	3.554	1.244	0.293
	Seedling Height	123.038	2	61.519	0.161	0.851
	Number of Leaf	80.771	2	40.385	1.231	0.297
F * W	Collar Diameter	.050	1	0.050	0.017	0.896
	Seedling Height	735.380	1	735.380	1.926	0.169
	Number of Leaf	8.167	1	8.167	0.249	0.619
F * D	Collar Diameter	8.871	2	4.435	1.553	0.218
	Seedling Height	948.927	2	474.463	1.243	0.294
	Number of Leaf	5.812	2	2.906	0.089	0.915
W * D	Collar Diameter	5.767	2	2.884	1.009	0.369
	Seedling Height	1696.689	2	848.344	2.222	0.115
	Number of Leaf	148.146	2	74.073	2.258	0.111
F * W * D	Collar Diameter	0.943	2	0.472	0.165	0.848
	Seedling Height	49.159	2	24.579	0.064	0.938
	Number of Leaf	38.521	2	19.260	0.587	0.558
Error	Collar Diameter	239.975	84	2.857		
	Seedling Height	32071.854	84	381.808		
	Number of Leaf	2756.000	84	32.810		
Corrected Total	Collar Diameter	267.455	95			
	Seedling Height	35629.042	95			
	Number of Leaf	3255.833	95			

Effects of Silvicultural Treatments on Physiological Performance

The physiological responses of *Chrysophyllum albidum* seedlings under different silvicultural treatments are presented in Table 3. Relative water content (RWC) ranged from 36.95% to 53.93%, with the highest value observed under treatment F₀W₂D₂ and the lowest under F₁W₂D₂. Leaf turgidity varied considerably among treatments, ranging from 0.28 to 3.35.

Net assimilation rate (NAR) ranged from 0.0007 to 0.0051 g cm⁻² day⁻¹, whereas relative growth rate (RGR) varied from 0.220 to 0.871 g g⁻¹ day⁻¹. Absolute growth rate (AGR) ranged from 0.67 to 1.69 cm day⁻¹, indicating appreciable variation in growth efficiency among the treatment combinations. Despite these numerical differences, the generally non-significant treatment effects observed in the morphological parameters suggest that variations in physiological performance did not produce corresponding statistically detectable differences in overall seedling growth during the experimental period.

Table 3: Effects of Silvicultural Treatments on Physiological Performance

Experimental treatment	RWC (%)	Leaf Turgidity	NAR (gcm ⁻² /day)	RGR (gg ⁻¹ day ⁻¹)	AGR (cm day ⁻¹)
F0W1D1	43.01	1.94	0.0015	0.508	1.005
F0W1D2	41.46	1.87	0.003	0.220	1.23
F0W1D3	49.63	0.93	0.0015	0.482	0.67
F0W2D1	44.52	1.013	0.0030	0.342	1.225
F0W2D2	53.93	1.54	0.0024	0.258	1.075
F0W2D3	46.61	3.35	0.005	0.871	0.935
F1W1D1	47.92	0.49	0.0016	0.362	1.275
F1W1D2	48.05	1.74	0.0007	0.244	1.685
F1W1D3	52.03	1.05	0.0012	0.236	0.95
F1W2D1	47.37	0.98	0.0009	0.288	1.235
F1W2D2	36.95	2.04	0.0010	0.421	1.2
F1W2D3	37.01	0.28	0.0051	0.379	0.73

4. Discussion

The establishment phase represents one of the most critical stages in the successful cultivation of indigenous tropical tree species because seedling survival and subsequent productivity largely depend on the interaction between planting techniques, soil conditions and nutrient availability (Grossnickle & MacDonald, 2018). This study evaluated the influence of planting depth, planting-hole width and nitrogen fertilization on the early field performance of *Chrysophyllum albidum* seedlings. The results showed that these silvicultural factors had limited influence on seedling height and collar diameter during the six-month establishment period, whereas planting-hole width significantly affected leaf production. These findings suggest that the early growth of *C. albidum* is governed more by its inherent physiological adaptation and establishment strategy than by moderate variations in field planting practices.

The non-significant response of seedling height and collar diameter to fertilizer application indicates that nitrogen was probably not the primary limiting factor under the prevailing field conditions. Many indigenous tropical tree species characteristically exhibit slow juvenile growth and initially allocate assimilated carbon towards root establishment rather than rapid shoot development following transplanting (Lambers, Chapin, & Pons, 2008). Such conservative growth strategies enhance water and nutrient acquisition and improve the ability of seedlings to withstand environmental stress during establishment (Poorter & Bongers, 2006). Consequently, immediate responses to fertilizer application may not always be reflected in above-ground growth, particularly during the first growing season. Similar observations have been reported in *Chrysophyllum albidum*, where nutrient addition produced only moderate improvements in seedling vigour under nursery conditions (Adelani & Amos, 2021).

Although fertilizer application did not significantly increase plant height or stem diameter, numerical differences in biomass production among treatments indicate that nitrogen may have enhanced assimilate production and partitioning without producing statistically detectable differences in external morphology. Nitrogen is a structural component of chlorophyll molecules, proteins and nucleic acids, and therefore plays an indispensable role in photosynthesis, enzyme synthesis and vegetative growth (Marschner, 2012). Several studies have demonstrated that appropriate nutrient management improves biomass accumulation and physiological performance in tropical tree seedlings even when

height growth remains relatively unchanged during the early establishment stage (Lawrence, 2003; Cárate Tandalla *et al.*, 2025). The present findings therefore suggest that the influence of nitrogen fertilization on *C. albidum* may become more evident over a longer monitoring period as seedlings transition from establishment to active vegetative growth.

Planting depth also had no significant influence on the measured morphological characteristics. This result indicates that the three planting depths evaluated (10, 15 and 20 cm) were all within the range tolerated by *C. albidum* seedlings under the environmental conditions of the study area. Proper planting depth is recognised as a key silvicultural practice because excessively shallow planting may expose roots to moisture stress, while excessively deep planting can reduce soil aeration and restrict root respiration (Grossnickle & MacDonald, 2018). However, when planting depths remain within an acceptable range and soil moisture is adequate, seedlings often maintain satisfactory physiological function and root growth. The findings therefore demonstrate that *C. albidum* seedlings possess sufficient ecological plasticity to establish successfully across moderate variations in planting depth, an attribute that is advantageous for plantation establishment under variable field conditions.

Among the silvicultural factors investigated, planting-hole width exerted the only significant influence on leaf production. Leaf number is an important determinant of photosynthetic capacity because it directly affects canopy development and carbon assimilation. Larger planting holes generally provide a less compact rooting environment, thereby facilitating root elongation, improving water infiltration and enhancing nutrient uptake during early establishment. Improved root development subsequently supports increased leaf initiation and expansion through enhanced water and mineral acquisition (Haase & Davis, 2017). Similar relationships between improved rooting conditions and increased canopy development have been reported in several indigenous tropical tree species, where soil preparation significantly enhanced seedling vigour and early plantation performance (Adelani & Amos, 2021).

The absence of significant interaction effects among fertilizer application, planting depth and planting-hole width suggests that the individual silvicultural treatments acted independently during the six-month establishment period. Nevertheless, the observed variation among treatment means indicates that *C. albidum* responds to the cumulative influence of several environmental factors rather than to a single management practice. Similar observations have been reported in tropical forest restoration studies, where

genetic variability, microsite conditions and seasonal climatic fluctuations often contribute more to seedling performance than individual silvicultural treatments during the juvenile growth stage (Ashton & Kelty, 2018).

Variation in biomass accumulation among treatments further illustrates differences in resource allocation strategies. Seedlings exhibited considerable differences in leaf, stem and root dry matter production as well as root-to-shoot ratio, suggesting that assimilates were partitioned differently according to the prevailing establishment conditions. Biomass allocation is a fundamental adaptive mechanism through which plants optimise the acquisition of limiting resources while maintaining structural balance (Poorter *et al.*, 2012). Increased root biomass enhances soil exploration and nutrient uptake, whereas greater investment in leaf biomass improves photosynthetic capacity and dry matter production. The observed variation in root-to-shoot ratio therefore reflects adaptive growth responses rather than evidence of physiological impairment.

The physiological indices measured in this study further support the observed morphological responses. Relative water content remained comparatively stable across treatments, indicating that transplanted seedlings successfully maintained cellular hydration and water balance despite differences in planting depth and fertilizer application. Maintenance of adequate tissue water status is essential for stomata regulation, photosynthetic activity and cell expansion, particularly during the establishment phase when root systems are still developing (Taiz *et al.*, 2018). Likewise, differences in leaf turgidity among treatments suggest varying capacities for osmotic adjustment and water retention, both of which contribute to transplant success under field conditions.

Variation in net assimilation rate (NAR), relative growth rate (RGR) and absolute growth rate (AGR) indicates that physiological performance differed among treatment combinations even though these differences were not reflected in statistically significant changes in plant height or stem diameter. Net assimilation rate represents the efficiency with which leaf area converts assimilated carbon into plant biomass, while relative growth rate integrates biomass production with plant size over time (Hunt, 1990). The variation observed among treatments therefore suggests that seedlings differed in physiological efficiency and carbon utilisation despite exhibiting similar external morphology. Such temporal differences between physiological activity and morphological expression have been widely reported

in slow-growing woody perennials during the early stages of plantation establishment (Lambers *et al.*, 2008).

From a silvicultural perspective, the findings demonstrate that *Chrysophyllum albidum* is capable of establishing successfully under a range of practical field planting conditions. The absence of adverse effects associated with planting depths between 10 and 20 cm provides operational flexibility during plantation establishment, while the significant improvement in leaf production associated with planting-hole width emphasises the importance of adequate site preparation. Although nitrogen fertilization did not significantly improve morphological growth within the study period, its influence on biomass production and physiological performance suggests that nutrient management should remain an integral component of plantation establishment, particularly on nutrient-deficient tropical soils.

The present study contributes to the limited body of knowledge on the field silviculture of *Chrysophyllum albidum*, a species of considerable ecological, nutritional and economic importance in West Africa. As increasing attention is directed towards the domestication, conservation and commercial cultivation of indigenous fruit tree species, evidence-based silvicultural recommendations become essential for improving plantation establishment and long-term productivity. Future studies should extend the monitoring period beyond the juvenile stage, evaluate additional fertilizer regimes and planting configurations, and examine the influence of soil physicochemical properties on seedling growth and survival to develop comprehensive management guidelines for large-scale cultivation.

5. Conclusion

The present study evaluated the influence of planting depth, planting-hole width and nitrogen fertilization on the field establishment of *Chrysophyllum albidum* seedlings under tropical conditions. The findings demonstrated that the species established successfully across all planting depths investigated, indicating considerable adaptability during the juvenile stage. Fertilizer application and planting depth had no significant influence on seedling height, collar diameter or leaf production during the six-month experimental period, whereas planting-hole width significantly improved leaf production, emphasizing the importance of adequate site preparation for enhancing early canopy development. Although treatment effects on most morphological variables

were not statistically significant, appreciable differences were observed in biomass accumulation and physiological growth indices among treatment combinations. These responses suggest that *C. albidum* modifies biomass allocation and physiological processes during establishment to optimize resource acquisition and adaptation to field conditions. The relatively stable physiological performance across treatments further confirms the species' resilience under moderate variations in planting practices.

From a silvicultural standpoint, the results indicate that moderate planting depths (10–20 cm) can be adopted without adversely affecting early field performance, while careful preparation of planting holes should receive greater attention during plantation establishment. Although nitrogen fertilization did not produce immediate improvements in morphological growth, its influence on biomass production suggests that longer-term evaluation may be required to fully assess fertilizer responses in this characteristically slow-growing indigenous hardwood. This study contributes valuable baseline information for the domestication, plantation establishment and conservation of *Chrysophyllum albidum*. The findings provide practical guidance for foresters, nursery managers and restoration practitioners seeking to improve the establishment success of this economically and ecologically important indigenous fruit tree. Future research should investigate longer-term growth responses, different fertilizer sources and rates, soil physicochemical interactions and multi-location field trials to develop comprehensive silvicultural recommendations for large-scale cultivation.

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