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Vegetative Regeneration Potential of *Trichoscypha arborea* A.Chev., 1912 (Anacardiaceae), a Key and Understudied Forest Fruit Tree Species Undergoing Decline: A Practical Alternative for Its Conservation

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Abstract

Trichoscypha arborea is a forest tree species of high socio-economic value in West Africa. Although currently assessed as "Least Concern" on the IUCN Red List, field surveys across several regions of Côte d'Ivoire reveal a significant population decline and near disappearance of the species outside protected forests. This decline is primarily due to overexploitation (destructive harvesting practices) and limited natural regeneration. This study evaluates the vegetative regeneration potential of stem cuttings, as a practical strategy to support their reintroduction into community agroforestry systems. Stem segments from multiple mother trees across six locations were pooled to assess the overall feasibility of propagation and classified into three types of cuttings (hardwood "basal lignified part", semi-hardwood "intermediate semi-lignified part", and softwood or herbaceous "apical green part"). These were assessed in a nursery without hormonal treatment to determine their potential for domestication, regeneration, and conservation by rural communities. Results showed budding rates of 46% for herbaceous cuttings, 34% for semi-hardwood, and 30% for hardwood. However, three months after budding, mortality rates reached 100% for herbaceous cuttings, 76.47% for semi-hardwood, and only 13.33% for hardwood. These findings highlight the relevance of vegetative propagation of *T. arborea* using hardwood and semi-hardwood cuttings, a simple and low-cost method to support the conservation and domestication of this increasingly rare forest species in Côte d'Ivoire. Further improvements, such as the use of enriched organic substrates, rooting hormones, or propagation under tunnel systems to prevent desiccation, should be explored to optimize this technique in community nurseries.

Keywords

Trichoscypha arborea, Cutting Propagation, Agroforestry, Conservation, Côte d'Ivoire

1. Introduction

Trichoscypha arborea is a little-studied forest fruit tree belonging to the Anacardiaceae family, widely distributed in the humid tropical forests of West and Central Africa [1]-[4]. Its edible fruits, with a sweet and tangy taste, are highly appreciated by local populations and are consumed fresh or sold in local markets [5]-[7]. The species also plays a significant cultural role, with key traditional medicinal uses and important ecological functions within forest ecosystems, particularly through its contribution to biodiversity and local agroforestry practices [8]-[10]. However, recent field surveys conducted in several areas of Côte d'Ivoire (Man, Daloa, Oumé, Agboville, Adzopé, and Alépé) reveal an alarming trend: *T. arborea* is gradually disappearing from agricultural landscapes, forested areas, and rural territories outside classified forests and protected areas, mainly due to unsustainable harvesting practices [6] [11]. Rural communities report that tree felling to access ripe fruits, often located high in the canopy and difficult to reach, is a major driver of this decline, along with deforestation. In addition to forest clearing, most accounts point to the widespread practice of cutting down mature trees in order to more easily harvest the highly valued and marketable ripe fruits. This is attributed to the large size of the tree, the scarcity of fruit-bearing branches near the base of the trunk, and the exhaustive harvesting of mature fruits throughout the canopy. As a result, natural regeneration has become nearly nonexistent in many surveyed areas, and only older members of the community still recall the importance of the species and strongly advocate for its preservation. These factors severely hinder participatory reforestation initiatives. Given the threats facing the species particularly the limited availability of seeds, their low budding rates under natural conditions (reflecting poor sexual regeneration), and the absence of structured propagation programs, there is an urgent need to develop effective, simple, and locally adapted vegetative propagation techniques to support ex situ conservation and reintroduction into agroforestry systems. In this context, cutting propagation emerges as a promising and practical alternative [12] [13]. Yet, no previous scientific study has assessed the ability of *T. arborea* to propagate vegetatively. The objectives of this study are therefore to (i) evaluate for the first time the vegetative regeneration potential of *T. arborea* through stem cuttings by comparing the performance of different types of cuttings (hardwood, semi-hardwood, and herbaceous) to test the overall feasibility of the technique, and (ii) identify the cutting category that offers the highest rooting rate, survival rate, and best morphological quality of the resulting plantlets under low-input conditions. We hypothesize that semi-hardwood cuttings, taken from the median (semi-lignified) parts of the branches, will offer the best balance between vigor and physiological maturity, thereby promoting optimal rooting and growth of young plants compared to herbaceous cuttings, which are too tender, or hardwood cuttings, which are overly lignified.

2. Materials and Methods

2.1. Study Site

The study was conducted from September to December 2024 in the experimental nursery of Jean Lorougnon Guédé University in Daloa (6˚909'6363"N; 6˚438'1157"W). The site is located in a humid forest zone with an annual rainfall ranging from 1300 to 1700 mm and average temperatures between 24˚C and 28˚C. The soils are ferrallitic, deep, acidic, and low in exchangeable bases, but generally rich in organic matter [14]. **Figure 1** shows the geographical locations of the areas surveyed for the collection of categorized stem cuttings.

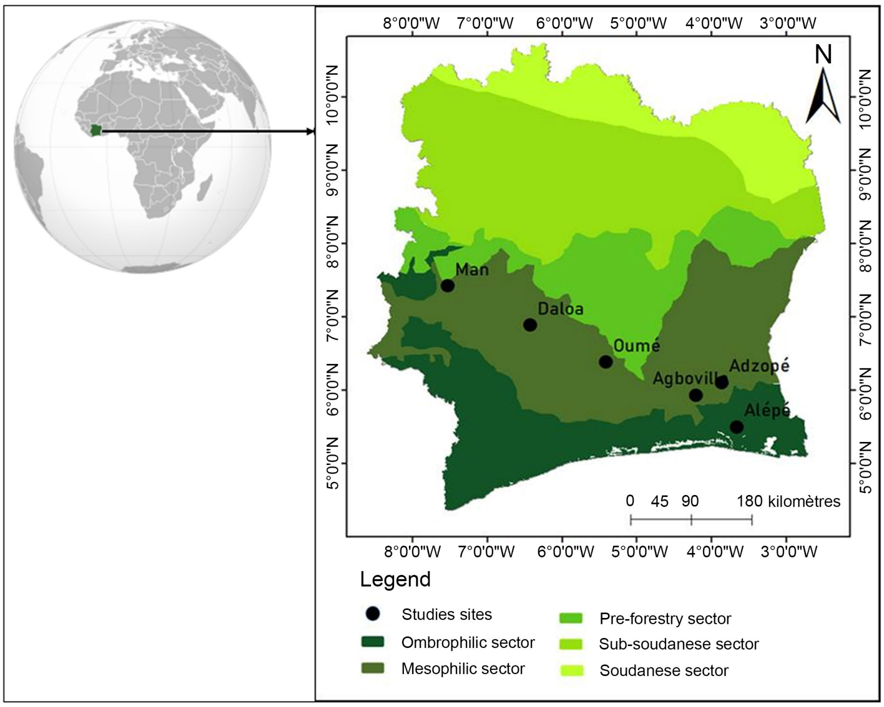

Figure 1. Geographical distribution map of the surveyed localities. (Source: the authors)

2.2. Sampling and Categorization of Cuttings

Two to four branches (generally branches of order A2 to A3), depending on their accessibility in the canopy, were selected arbitrarily and randomly from the crown architecture of two to seven visibly and physiologically healthy trees per site, from residual forests and/or fields spread across six locations surveyed in Côte d'Ivoire

(**Figure 1**). The residual or classified forests were surveyed with the permission of the state agency responsible for managing Côte d'Ivoire's forest heritage (SODEFOR), and the fields were surveyed with the verbal agreement of the owners of the agroforestry plots harbouring the target species. The geographical coordinates of the sites and trees sampled, their dendrometric measurements and the collection period were deposited in the Zenodo data warehouse repository (https://doi.org/10.5281/zenodo.17096404), in accordance with the FAIR principle.

The branches were harvested using forks equipped with metal blades and sterilized pruning shears. These branch segments were kept shaded in cotton cloths and moist plastic bags. To minimize provenance effects and focus the study on the influence of cutting type on regeneration success, the collected branches were pooled and then segmented into three categories based on their position on the main shoot: hardwood cuttings (woody basal segments near the insertion point on the main axis, exhibiting highly lignified tissues); semi-hardwood cuttings (intermediate middle segments of the shoot, semi-lignified with moderate lignification); and herbaceous or softwood cuttings (green segments closer to the apex, characterized by young, tender, poorly lignified tissues with high meristematic activity) (**Figure 2**).

x: basal lignified cuttings (hardwood); y: median semi-lignified cuttings (semi-hardwood); z: apical green cuttings (softwood or herbaceous).

Figure 2. Images related to branch sampling (a) and cutting categorization (b).

Each cutting segment was trimmed to obtain standardized cuttings measuring 12 to 15 cm in length and 0.6 to 2 cm in diameter, each containing 3 to 6 nodes (buds). Lower leaves were partially removed, leaving one to two pairs of basal leaves. For each category, 100 cuttings were prepared for planting without the use of hormonal treatments or rooting stimulators (such as IBA, NAA, or ANA) or enriched compost. Only local soil substrate (a mixture of clayey soil and sieved sand without added compost, vermiculite, or chemical fertilizers) was used, filled into polyester pots measuring 30 × 15 cm. After cutting, the cuttings were immediately transported to the nursery for planting. Regarding placement, cuttings were inserted vertically or slightly inclined into the pots previously filled with the substrate described above.

2.3. Experimental Design and Monitoring

Cuttings were soaked in water for two hours and individually planted in pots under light shade, watered daily with well water. The pots were arranged in a comparative trial consisting of three elementary plots. Each elementary plot, containing 100 pots with one cutting each, corresponded to one of the three cutting categories described above. The pots were randomly distributed on three budding tables equipped with 50% shade nets to minimize microclimatic variations and promote air circulation. Thus, the experiment included a total of 300 pots, with the following scheme: plot 1 contained 100 hardwood cuttings, plot 2 contained 100 semi-hardwood cuttings, and plot 3 contained 100 softwood (herbaceous) cuttings. Observations (budding or bud break, mortality, growth) were recorded daily for 114 days. Mortality was noted as it occurred. Watering was performed by light sprinkling each morning to keep the substrate just moist, avoiding saturation to prevent root asphyxiation. No additional mulching was applied. For cuttings that had emerged, measured variables included the daily dynamics of budding and mortality, budding rate (%), mortality rate (%), number of buds emerged per cutting, length and collar diameter of sprouted seedlings, number of phytomers per sprouted seedling, and rooting rate per cutting. The rooting rate was determined at the end of the experiment by carefully removing each surviving cutting from its pot and counting the number of cuttings that had successfully developed a root system.

Figure 3 shows the test of the three treatment groups (the three types of cuttings), indicating overall feasibility with all provenances combined. This was done to intentionally eliminate the effects of provenance and test the species' vegetative reproduction capacity with readily available material.

Figure 3. Arrangement of pots and planting of cuttings in elementary plots.

2.4. Statistical Analyses

Data were subjected to Analysis Of Variance (ANOVA) followed by Tukey's post-hoc test to compare parameters and determine significant differences between treatments. Statistical analyses were performed using R software (version 4.1.0) after verifying normality assumptions. Differences were considered statistically significant at an alpha level of $p < 0.05$.

3. Results

3.1. Cutting Regeneration

Bud break on the cuttings began around the 8th day after planting (**Figure 4(a)**). Among the different cutting types, herbaceous and semi-hardwood cuttings initiated bud break at day 7, while hardwood cuttings started at day 8. Bud break accumulated until the 54th day and stabilized around the 69th day for herbaceous and semi-hardwood cuttings. For hardwood cuttings, bud break accumulation extended until the 98th day and stabilized from the 100th day onwards. Bud swelling generally began around the 13th day (**Figure 4(b)**). The first leaves appeared on young shoots at day 19 for herbaceous cuttings, day 22 for semi-hardwood cuttings, and day 27 for hardwood cuttings (**Figure 4(c)** and **Figure 4(d)**).

However, from day 40 onward, the burst buds of herbaceous and semi-hardwood cuttings began to wither and die. Only buds from hardwood cuttings remained alive and continued to develop. All herbaceous cuttings that sprouted eventually dried up and died by day 84. More than 76% of sprouted semi-hardwood cuttings dried and died by day 85, after which mortality stabilized. Only buds from hardwood cuttings persisted, with just 13.33% mortality, and this percentage remained stable until the end of the experiment (day 114).

Figure 4. Bud break and bud development.

3.2. Daily Dynamics of Budding

Figure 5 shows the cumulative proportion of budded cuttings recorded on each observation date (days 1, 3, 7, 9, 24, 39, 54, 69, 84, 99, 114) for each of the three cutting categories (hardwood, semi-hardwood, and herbaceous or softwood). For hardwood cuttings, budding began on day 9 (4%) and gradually reached a stable rate of 30% by day 99. In semi-hardwood cuttings, budding started on day 7 (9%), peaked at 32% on day 39, and stabilized at 34% from day 54 until the end of the experiment (day 114). As for herbaceous or softwood cuttings, budding was observed as early as day 6 (14%), reached a maximum rate of 46% on day 54, and no further budding was observed thereafter until the final observation on day 114.

3.3. Daily Mortality Dynamics

Figure 6 summarizes the cumulative mortality recorded on the same dates following the sprouting of the cuttings. Mortality remained low for hardwood (mature) cuttings, reaching only 13.33% by day 114. In contrast, semi-hardwood cuttings experienced 76.47% mortality by day 114, while herbaceous (softwood) cuttings showed 100% mortality by the end of the experiment (day 114). For the latter, no bud survived beyond day 84. Mortality peaks mainly occurred between days 54 and 84, a period characterized by increased water stress and competition for root-zone oxygen in the unamended substrate.

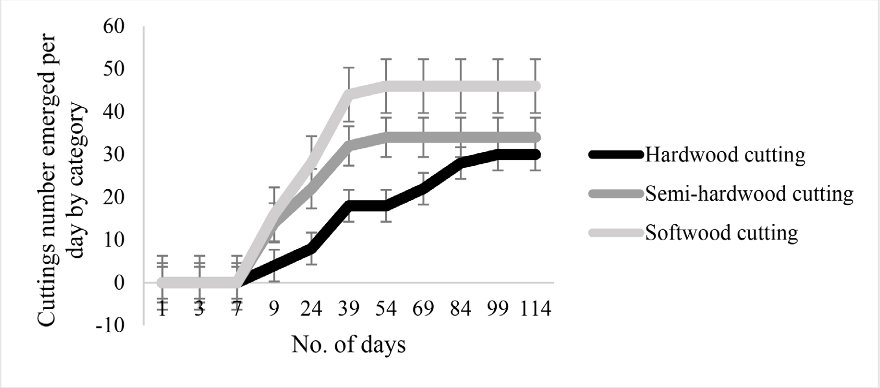

Figure 5. Bud development dynamics by cutting category in *Trichoscypha arborea*.

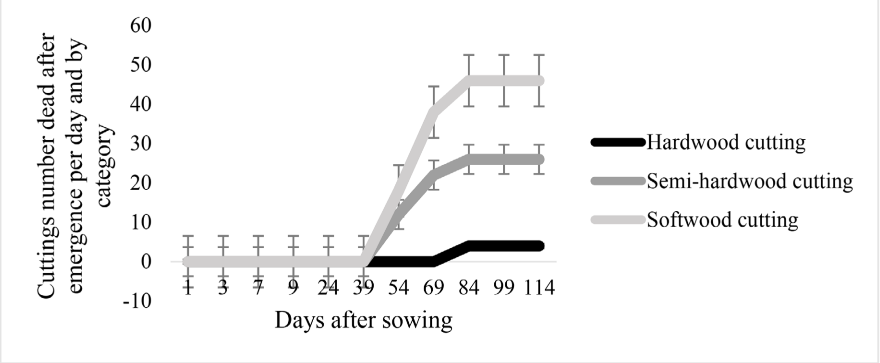

Figure 6. Cumulative mortality dynamics (%) of the three cutting categories from day 39 after planting in *Trichoscypha arborea*.

3.4. Budding and Mortality Rates after Bud Emergence

The budding rate was 30% for hardwood cuttings, with a mortality rate of 13.33%. For semi-hardwood cuttings, the budding rate was 34%, with a mortality rate of 76.47%. In contrast, herbaceous (softwood) cuttings exhibited the fastest and highest budding rate (46%) among the three categories. However, none of the cuttings in this category survived, resulting in 100% mortality by the end of the observation period (Figure 7).

3.5. Characteristics of Seedling Growth from Rooted Cuttings

Analysis of variance revealed significant differences among cutting categories (Table 1, $p < 0.05$). Only successfully rooted cuttings were evaluated for aerial development (Number of buds emerged per cutting stem, shoot length, collar diameter and phytomer number of seedling) and rooting rate. The rooting rate was defined as the percentage of initial cuttings in each category that successfully developed roots by the end of the experiment. The mean values ± standard deviation are presented in **Table 1**. Hardwood (woody) cuttings exhibited the highest survival rate (76.67%, *i.e.*, 26 surviving cuttings out of 30 that had sprouted). However, the resulting seedlings displayed less vigorous growth compared to those from semi-hardwood cuttings. Although the rooting and survival rate of semi-hardwood cuttings was 23.53%, they produced higher-quality seedlings, with an average of approximately two buds per cutting, a mean shoot length of 16.8 cm, a mean collar diameter of 0.46 cm, and an average of six phytomers per plantlet (**Table 1**). In contrast, herbaceous or softwood cuttings exhibited the highest budding rate (46%) but a survival rate of 0% (**Table 1**).

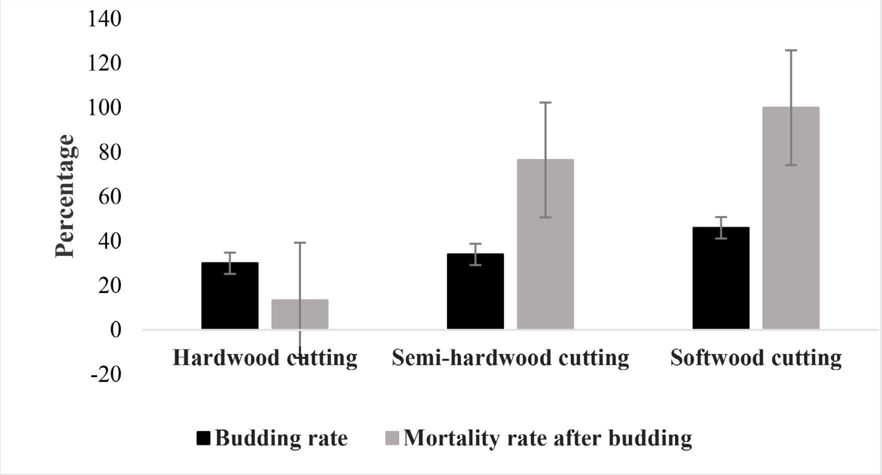

Figure 7. Budding and mortality rates of cuttings by category.

Table 1. Mean growth parameters for each category of rooted cuttings.

Category	No. of buds per cutting	Plant length	Plant diameter	Phytomere number	Rooting rate (%)
Hardwood cutting	1.63 ± 0.74a	9.38 ± 4.47b	0.43 ± 0.10a	5.75 ± 1.49a	76.67
Semi-hardwood cutting	1.4 ± 0.55a	16.8 ± 2.17a	0.46 ± 0.13a	6 ± 2.24a	23.53
Softwood cutting	0 ± 0b	0 ± 0c	0 ± 0b	0 ± 0b	0
Pr* > *F	**0.022**	**0.013**	**0.041**	**0.033**	-

Means followed by different letters differ significantly at the 5% level according to the Tukey HSD post-ANOVA test ($p < 0.05$).

4. Discussion

4.1. Vegetative Propagation Potential of *Trichoscypha arborea*

This study represents the first experimental demonstration of the vegetative regeneration potential of *Trichoscypha arborea* by cutting propagation in Côte d'Ivoire. In the context of a marked decline of this species in village agroecosystems, our results confirm that vegetative reproduction can be a practical and cost-effective alternative to support its domestication and ex situ conservation, although further optimization of protocols is necessary to improve survival rates and the morphological quality of young plants. Observations from the six surveyed localities thus provide essential data on the budding capacity and survival of cuttings according to their tissue maturity.

4.2. Influence of Physiological Maturity on Bud Break and Survival

The significant differences observed among the three types of explants clearly illustrate the effect of physiological maturity on cutting performance [13]. Our results show that herbaceous cuttings (green parts) exhibit the highest budding rate (46%) and a rapid onset (from the 7th day), supporting the hypothesis of a high endogenous auxin content that promotes the initiation of rhizogenesis, as observed in other plant species [13] [15]-[19]. However, the total mortality recorded from the 84th day (100%) reflects their inability to sustain growth, likely due to a failure to develop a sufficient root system (0% rooting rate in **Table 1**) and low carbohydrate reserves, rendering these young tissues vulnerable to water stress and root hypoxia.

In contrast, the hardwood (woody) cuttings showed the highest post-budding survival rate (76.67%) with limited mortality (13.33%), indicating a better physiological tolerance to stress in the unenriched substrate. Similar results were observed by Akaffou and collaborators in *Myrianthus arboreus* [13]. However, the aerial growth of these types of explants remains lower than that of the semi-hardwood cuttings (middle section), which aligns with observations in other species where advanced lignification confers increased resistance at the expense of growth vigor [17] [20]-[22].

The semi-hardwood cuttings (semi-ligneous) confirm our initial hypothesis: they offer the best compromise between budding (34%), morphological quality (average length of 16.8 cm, 6 phytomers), and initial vigor, even though their post-budding mortality remains high (76.47%). This profile reflects an optimal hormonal and structural balance to initiate and sustain both root and shoot development [13] [23]-[26].

4.3. Technical Constraints and Optimization Prospects

The increased mortality observed between the 54th and 84th days, particularly in herbaceous and semi-hardwood cuttings, suggests an accumulation of stresses related to the substrate structure (poor, non-amended sandy-clay soil) and competition for oxygen [12] [13] [27] [28]. The absence of exogenous hormones (IBA or ANA) likely limited root emission, particularly for the semi-hardwood segments [24] [26] [29]. Moreover, the prolonged duration until shoot stabilization (nearly 100 days for the hardwood cuttings) highlights the importance of optimizing cultural conditions: enriched organic substrates, mulching, intermittent watering to prevent asphyxiation, cultivation under tunnels or greenhouses to maintain relative humidity and avoid desiccation, followed by fungicidal treatments to combat rot [13] [15] [30] [31].

4.4. Implications for Domestication Programs and Participatory Conservation

These results highlight the potential of vegetative propagation by cuttings, particularly from the semi-woody middle portions of shoots, as a simple and appropriate method for multiplication in rural Ivorian contexts. This technique could overcome the limitations of natural regeneration (deforestation, destructive fruit harvesting, and low availability of viable seeds) and promote the reintroduction of *T. arborea* in village agroforests. Furthermore, this approach aligns fully with participatory strategies for sustainable management and restoration of forest resources by mobilizing local knowledge and reducing costs for communities [4] [14] [22] [32]-[34].

4.5. Research Perspectives to Secure and Expand the Approach

To consolidate these findings and enhance the effectiveness of cutting propagation, further research is necessary. Future studies should explore: 1) the combined effect of enriched organic substrates and low doses of rooting hormones (IBA, ANA) on increasing rooting rates; 2) the physiological and biochemical characterization of tissues at the time of cutting collection (carbohydrate reserves, hormonal profiles) to better identify optimal harvesting windows; and 3) the monitoring of plant performance under both field and greenhouse conditions to assess survival, long-term growth, and fruit production capacity across different agroforestry systems. These investigations will not only refine protocols for *T. arborea* but also facilitate their transfer to other fruit-bearing forest species facing similar scarcity challenges in West Africa.

4.6. Limitations of the Study and Research Prospects

It is important to acknowledge the limitations of this study, which constrain the generalization of its findings. The experiment was conducted over a single season (September-December), used pooled genetic material from six locations, and was carried out under ambient conditions without humidity control, using a basic, unenriched substrate and no hormonal treatments. These factors represent key areas for future research. Based on the high mortality of semi-hardwood cuttings due to withering after budding, we hypothesize that improving humidity control (e.g., through the use of simple polyethylene tunnels) would be the most critical factor to test to significantly enhance their survival and rooting rates, thus unlocking their potential for vigorous growth.

4.7. Key Highlights and Practical Implications

This pioneering study highlights the practical value of vegetative propagation by cuttings, particularly using semi-woody stem segments taken from the middle portions of branches, for low-cost multiplication of *T. arborea*. This species is a key fruit tree but increasingly rare in West African agroforestry systems. The study proposes a simple and accessible technique that rural communities can directly apply to establish village nurseries, thereby contributing to the restoration of degraded landscapes and the conservation of culturally important forest species. Further technical improvements, such as the use of organic substrates, moderate application of rooting hormones, and greenhouse cultivation, could enhance success rates even more, making this approach a critical lever for participatory agroforestry and biodiversity conservation strategies in the sub-region.

5. Conclusion

This study provides the first experimental evidence of the vegetative regeneration potential of *Trichoscypha arborea* via cutting propagation. The results reveal a clear trade-off based on the physiological maturity of the cuttings. While herbaceous cuttings failed to survive, both hardwood and semi-hardwood cuttings show promise. Under the low-input conditions tested, hardwood cuttings are recommended for practitioners in community nurseries, as they offer the highest final survival rate (76.67% of sprouted cuttings), providing the most robust and reliable option. However, semi-hardwood cuttings should not be dismissed, as the few surviving plants showed the most vigorous growth. This makes them a prime candidate for future optimization efforts. We recommend that future research focus on improving the survival of semi-hardwood cuttings, likely through better humidity control and substrate aeration, to harness their superior growth potential. For now, the use of hardwood cuttings offers a practical and accessible solution for the conservation, domestication, and reintroduction of this overexploited species.

Author Contributions

B. I. A. designed the methodology, took the experimental measurements, analysed the data and wrote the paper. D. S. A. corrected the manuscript J. D. supervised the work. All authors have read and agreed to the published version of the manuscript.

Data Availability

ADJI, B. I. (2025). Supporting Dataset for Document “Vegetative Regeneration Potential of *Trichoscypha arborea* A.Chev., 1912 (Anacardiaceae), a Key and Understudied Forest Fruit Tree Species Undergoing Decline: A Practical Alternative for Its Domestication and Conservation” [35].
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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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