A Medicinal Plant, *Ardisia gigantifolia* Grown under Canopy of Natural Forest for Sustainable Management

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Abstract

Medicinal plants play a vital role in biodiversity conservation and sustainable development, with species like Ardisia gigantifolia offering significant ecological and socio-economic benefits. This study was conducted in Central Vietnam, where A. gigantifolia was cultivated under a natural forest canopy with a canopy cover of 0.45. The plant's survival rate exceeded 90% after one year, demonstrating its adaptability to shaded environments. Stems reached an average height of 1.35 m, and crown diameters averaged 0.93 m after three years, with consistent leaf thickness and uniform leaf production across growth layers. Sustainable cultivation techniques, including minimal fertilizer use and manual weeding, resulted in stable growth and leaf yield. The leaves exhibited significant medicinal properties, including antioxidant and antimicrobial activities, making A. gigantifolia a promising candidate for local and global herbal product markets. On average, 5 kilograms of fresh leaves were required to yield 1 kilogram of dry product. Consequently, a total of 80 kilograms of dry leaves was produced per hectare. Frequent harvesting cycles every six months further enhanced its economic viability for rural communities, aligning with sustainable forest management objectives. The findings highlight the potential of A. gigantifolia to contribute to biodiversity conservation, poverty alleviation, and income diversification while maintaining ecosystem services. Challenges such as market access and value chain development must be addressed to optimize its cultivation and ensure equitable socio-economic impacts. This study underscores the role of A. gigantifolia as a model for integrating medicinal plant cultivation with sustainable forest management frameworks, supporting both ecological integrity and socio-economic growth.

Keywords: *Ethnic people, Forest canopy, Forest management, Medicinal plant, Sustainable harvest*

1. INTRODUCTION

Medicinal plants have long been recognized for their therapeutic properties and play a crucial role in healthcare systems worldwide (Sofowora, Ogunbodede & Onayade, 2013). These plants, often found under forest canopies, contribute significantly to biodiversity and ecosystem services (Zubair et al., 2021; Hamilton, 2004). Forests provide a unique microenvironment that supports the growth of a diverse range of medicinal species, offering shade, moisture, and nutrient-rich soil that are essential for their development (Fahim et al., 2024; Schippmann, Leaman , & Cunningham, 2002). The sustainable management of these resources is vital, as overharvesting and habitat destruction pose significant threats to their survival (Margaret & Timothy, 2012; Ticktin, 2004). Integrating medicinal plant cultivation with forest conservation efforts can enhance biodiversity while providing economic benefits to local communities (Michael et al., 2023; Shanley & Luz, 2003). This approach not only supports the preservation of traditional knowledge but also promotes the sustainable use of forest resources, aligning with global conservation goals (Prakas, et al., 2016; WHO, 2002).

Ardisia gigantifolia Stapf is a notable medicinal plant with a wide range of applications. Morphologically, it is characterized by its evergreen leaves, small white flowers, and red berries, which are often used in traditional medicine (Le & Tran, 2020; Phung et al., 2020). Ecologically, *A. gigantifolia* thrives in the understory of tropical and subtropical forests, where it benefits from the

humid and shaded conditions (Le & Tran, 2020; Phung et al., 2020). This species is distributed across Southeast Asia, particularly in Vietnam, where it is commonly found in natural production forests (Le & Tran, 2020; Phung et al., 2020). The medicinal value of *A. gigantifolia* is well-documented, with its roots and leaves being used to treat various ailments, including inflammation, fever, and digestive disorders (Phung et al., 2020). Recent studies have also highlighted its potential antioxidant and antimicrobial properties, further underscoring its importance in traditional and modern medicine (Phung et al., 2020).

Cultivating *A. gigantifolia* involves specific techniques that ensure optimal growth and yield. These include selecting appropriate sites with suitable soil conditions, implementing shade management practices, and employing organic fertilization to enhance soil fertility (Phung et al., 2020; Landicho & Ramirez, 2023). Propagation is typically achieved through seed germination or vegetative cuttings, with careful attention to spacing and planting depth to promote healthy development (Phung et al., 2020; Duc, Quynh & Thanh, 2021). The production of *A. gigantifolia* has seen a steady increase, driven by rising demand in both local and international markets for herbal products (Phung et al., 2020). This demand has spurred interest in developing sustainable cultivation practices that can meet market needs while preserving natural populations Phung et al., 2020; Landicho & Ramirez, 2023). The economic potential of *A. gigantifolia* is significant, offering opportunities for income generation and employment in rural areas (Phung et al., 2020). The cultivation and utilization of *A. gigantifolia* contribute to poverty reduction and sustainable forest management by providing alternative livelihoods for forest-dependent communities (Phung et al., 2020; Cory et al., 2016). By integrating this species into agroforestry systems, communities can diversify their income sources while maintaining forest cover and ecosystem services (Castle, Miller & Merten, 2022). This approach aligns with sustainable development goals, promoting environmental conservation and socio-economic development (Markus, 2022). The objective of this study is to explore the potential of *A. gigantifolia* as a sustainable resource for medicinal plant production, with a focus on its role in enhancing forest management practices and improving the livelihoods of local communities.

2. MATERIAL AND METHOD

2.1. Study Site

This study was conducted in Yen Hoa Commune, Tuong Duong District, Nghe An Province, Central Vietnam, at 19°17′34″N and 104°39′51″E, with an elevation of 182 m above sea level. In 2021, *A. gigantifolia* was planted by local ethnic communities under the canopy of natural forests predominantly composed of *Lagerstroemia tomentosa*. The forest features a canopy cover of 0.45 and a density of 350–450 stems/ha (stems with a diameter at breast height ≥ 6 cm). The soil is thick, moist, well-drained, and rich in organic matter. Leaves of *A. gigantifolia* were first harvested in December 2023, two years after planting.

The planting was conducted at a spacing of 0.8 m × 0.8 m, achieving a survival rate of over 90% one year after planting. At the time of planting, NPK fertilizer (16:16:8) was applied at a rate of 50 g per planting hole. No additional fertilization was applied in subsequent years. Weeding and tending were performed twice annually, in June/July and December/January, under an extensive cultivation approach. Approximately 8,000–9,000 seedlings per hectare were planted, accounting for areas excluded due to tree stumps, exposed rocks, and similar obstacles. Seedlings were propagated from cuttings sourced from high-quality mother plants. Forestry technicians provided support for seedling preparation, planting, and tending techniques. For the first harvest, guidance on leaf harvesting and drying techniques was also provided. During sunny weather, leaves were air-dried under direct sunlight, requiring 1–2 days to produce commercial products. In cloudy conditions, leaves were oven-dried using fuel, taking 4–6 hours to achieve commercial readiness.

Leaf harvesting was performed by hand-picking the lower leaf layer of each stem, leaving one leaf layer intact after each harvest. The stems continued to grow, forming new leaf layers. Once the new leaves matured sufficiently (approximately six months), the lower leaf layer was ready for the next harvest.

2.2. Data Collection

Data collection was conducted on 50 randomly selected stems of *A. gigantifolia* (Fig. 1a). For each stem, the stump diameter (cm), stem height (cm), and crown diameter (cm) were measured.

Additionally, the number of leaves on each leaf layer (Fig. 1b) was recorded. Most stems had two leaf layers, while a few exhibited three leaf layers, as they were not harvested during the previous harvesting season. Fifty leaves were randomly selected from the measured stems, representing all three leaf layers. These leaves were measured for petiole diameter, leaf thickness, width, and length (Fig. 1c).

Figure 1. *A 3-year old plantation of A. gigantifolia (a) a 2-leaf layer plant (b) leaves of different sizes (c)*

2.3. Data Analysis

Means and standard errors were calculated for all measured parameters. ANOVA, followed by a post-hoc test, was performed to analyze differences in the number of leaves across leaf layers (Fig. 1b). All statistical analyses were conducted using SAS 9.2 software (SAS Institute Inc., Cary, NC, USA) with a significance level of $p = 0.05$.

3. RESULTS

After three years of growth (Fig. 2), *A. gigantifolia* stems attained a mean height of 1.35 m, with the tallest stem measuring 1.85 m and the shortest measuring 0.75 m. The mean crown diameter was 0.93 m, ranging from 0.65 m to 1.66 m. The mean stump diameter was 1.9 cm, with the largest stump measuring 2.6 cm and the smallest measuring 1.4 cm.
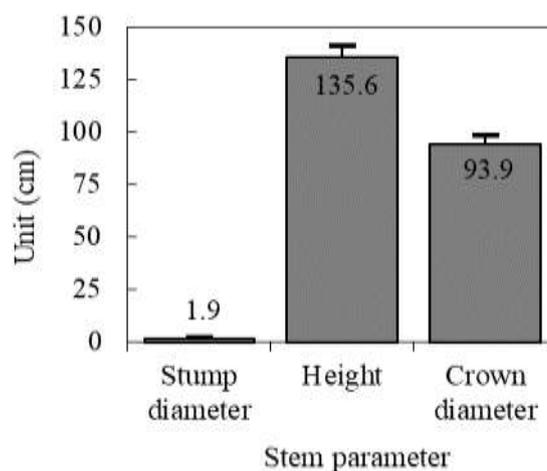

Figure 2. *Growth parameters of A. gigantifolia after planting 3 years. Bars indicate +SE (standard error)*

The number of leaves varied significantly among the three leaf layers (Fig. 3). However, no significant difference was observed between the top and middle layers, which had an average of 7.1 and 7.3 leaves, respectively (Fig. 1b). In contrast, the lowest layer contained significantly fewer leaves, with an average of only 1.2 leaves. The comparable leaf counts between the top and middle layers suggest stable leaf production for subsequent harvests. Leaf parameters of *A. gigantifolia* are presented in Figure 4. The petioles had a mean diameter of 4.9 mm. The leaves exhibited mean dimensions of 43.9 cm in length, 15.1 cm in width, and 0.3 mm in thickness. The largest leaf measured 68.5 cm in length, 22 cm in width, and 0.4 mm in thickness, while the smallest leaf measured 33 cm in length, 12 cm in width, and 0.3 mm in thickness. Leaf thickness showed minimal variation, consistently ranging between 0.2 mm and 0.4 mm.
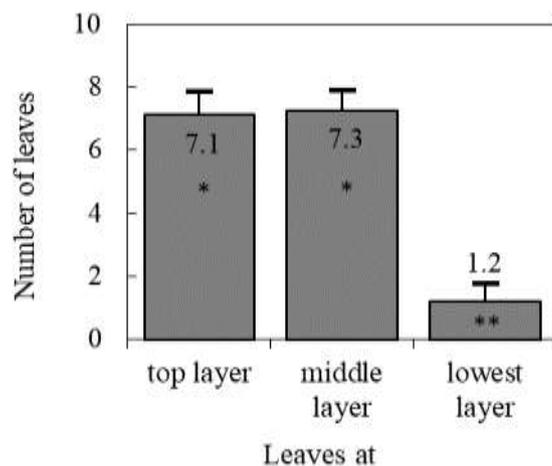
Figure 3. *Number of leaves on each leaf layer for A. gigantifolia. ** indicate significant difference of means at p = 0.05*
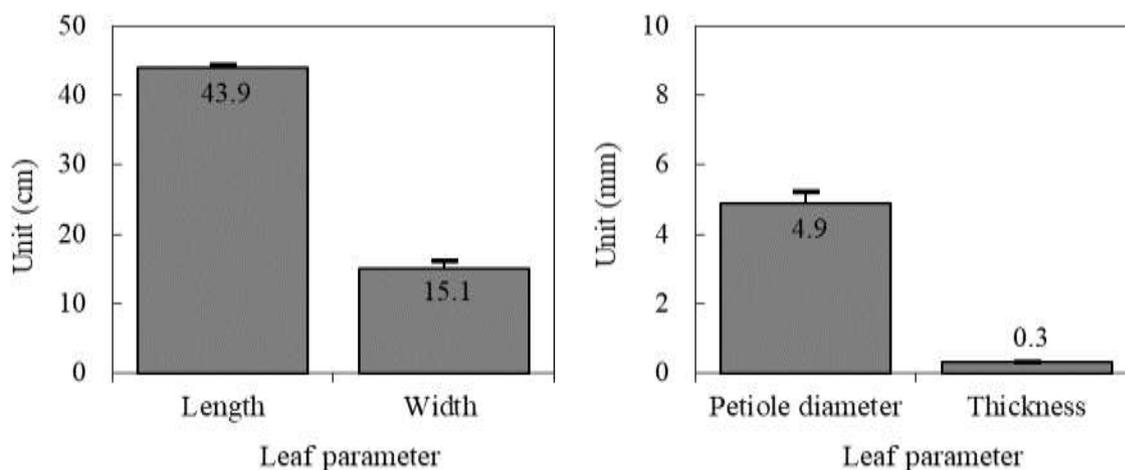

Figure 4. *Leaf parameters for A. gigantifolia*

In 2024, a single hectare of *A. gigantifolia* plantation was harvested twice, once in June and again in December. Data collected from these harvests indicated that each harvest yielded approximately 200 kilograms of fresh leaves. The fresh leaves were air-dried over 1 to 2 days to produce commercially viable dry products. On average, 5 kilograms of fresh leaves were required to produce 1 kilogram of dry product. As a result, the total dry leaf yield per hectare was 80 kilograms.

4. DISCUSSION

The successful cultivation of *A. gigantifolia* in Yen Hoa Commune, Tuong Duong District, highlights its adaptability to local environmental conditions, such as high canopy cover, nutrient-rich soils, and a humid microclimate. These findings corroborate earlier studies emphasizing the importance of site-specific conditions for medicinal plant growth under forest canopies (Zubair et al., 2021; Schippmann, Leaman & Cunningham, 2002; Rahman et al., 2011). The high survival rate (>90%) within the first year of planting demonstrates the resilience of *A. gigantifolia* to initial transplantation stress, likely aided by its inherent adaptability to shaded and moist environments (Le & Tran, 2020; Phung et al., 2020). This underscores the potential of integrating *A. gigantifolia* into agroforestry systems, especially in areas with similar ecological profiles.

The morphological characteristics of *A. gigantifolia*, including its moderate height (1.35 m on average), substantial crown diameter (0.93 m), and consistent leaf thickness (0.3 mm), indicate a stable growth trajectory under natural forest conditions. These parameters align with earlier reports on its ecological preferences for shaded understory environments (Fahim et al., 2024; Le & Tran, 2020; Valladares et al., 2016). Notably, the uniformity of leaf production across the top and middle layers supports sustainable harvesting practices that allow for continuous regrowth and minimal impact on plant health

(Duc, Quynh & Thanh, 2021; Srirama et al., 2017). These characteristics make *A. gigantifolia* a promising candidate for cultivation in degraded or secondary forests, where ecological restoration and economic viability are critical.

The cultivation of *A. gigantifolia* under natural forest canopies aligns with sustainable forest management goals by promoting biodiversity conservation and reducing deforestation pressures. Integrating non-timber forest product (NTFP) species like *A. gigantifolia* into forest management plans has been shown to enhance ecosystem services and contribute to carbon sequestration (Michael et al., 2023; Castle, Miller & Merten, 2022). The use of minimal inputs, such as organic fertilization and manual weeding, further supports environmentally friendly practices that align with global sustainability standards (Landicho & Ramirez, 2023; Miller & Merten, 2022). By maintaining forest cover and promoting species diversity, this approach can serve as a model for balancing ecological integrity with socio-economic needs.

The economic viability of *A. gigantifolia* is underscored by its high demand in local and international markets for herbal products. The efficient propagation techniques employed in this study, coupled with the plant's significant medicinal value, enhance its marketability. Its leaves, known for antioxidant and antimicrobial properties, cater to the growing global demand for natural and sustainable health products (Phung, et al., 2020; WHO, 2019). Furthermore, the relatively short growth-to-harvest cycle of six months per leaf layer provides frequent harvest opportunities, boosting income for local communities. This aligns with findings that NTFPs can significantly contribute to rural livelihoods (Shanley & Luz, 2003; Cory, 2016; Katja et al., 2011).

Beyond its medicinal applications, *A. gigantifolia* presents potential for diversification into cosmetic and nutraceutical industries due to its bioactive compounds. Recent phytochemical studies have identified compounds in *A. gigantifolia* that could be further explored for skincare and dietary supplements (Phung et al., 2020). Diversifying its applications could enhance its value chain and open new economic opportunities for producers. Additionally, its role in traditional medicine underscores the importance of preserving indigenous knowledge systems while integrating scientific advancements (Sofowora, Ogunbodede & Onayade, 2013; Prakash, 2016).

While the results are promising, challenges such as market access, value chain development, and climate variability must be addressed. Developing infrastructure for processing and quality control can enhance the competitiveness of *A. gigantifolia*-based products in global markets. Moreover, research into genetic improvement and pest management could further optimize its cultivation and resilience (Margaret & Timothy, 2012). Future studies should also explore the socio-economic impacts of *A. gigantifolia* cultivation on local communities to ensure equitable benefits.

5. CONCLUSION

This study underscores the significant potential of *A. gigantifolia* as a medicinal plant cultivated under natural forest canopies for sustainable management. The findings demonstrate the species' adaptability to local ecological conditions, characterized by high survival rates and consistent growth under shaded environments. The stable production of leaves across growth layers, coupled with minimal inputs such as organic fertilization and weeding, highlights its suitability for integration into agroforestry systems. The medicinal value of *A. gigantifolia*, evidenced by its antioxidant and antimicrobial properties, further enhances its market potential. Additionally, the relatively short harvest cycles and efficient propagation techniques present economic opportunities for rural communities, supporting income diversification and poverty alleviation. Importantly, the cultivation of *A. gigantifolia* aligns with sustainable forest management practices, promoting biodiversity conservation, maintaining ecosystem services, and reducing deforestation pressures. The study also identifies potential avenues for diversification into cosmetics and nutraceutical industries, emphasizing the importance of value chain development and infrastructure for processing. However, addressing challenges related to market access, climate variability, and pest management remains crucial for optimizing its cultivation and utilization. Future research should focus on genetic improvement, quality control measures, and the socio-economic impacts of *A. gigantifolia* to maximize its benefits and ensure equitable growth within forest-dependent communities. Overall, the integration of *A. gigantifolia* into sustainable forest management frameworks offers a promising model for balancing ecological integrity with socio-economic development, aligning with global conservation and development goals.

6. ACKNOWLEDGEMENTS

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