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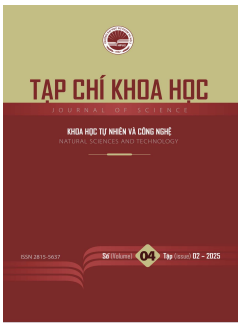

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Morphology and anatomy characterization of *Smilax gaudichaudiana* Kunth in Vietnam

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Abstract

Smilax gaudichaudiana Kunt woody vine, the stem shows a clear distinction between the bark and the column, which is a unique characteristic of Smilacaceae, differing from the common features of Monocotyledoneae. A part of the rhizome of Smilax gaudichaudiana Kunth is transformed into a tuber that has medicinal properties. The leaves are glossy green, oval, egg-shaped or heart-shaped, with parallel veins and undifferentiated palisade tissue, which is suitable for dense forest conditions with low light. The roots develop strongly in the form of fibrous roots, with an anatomical structure featuring a Caspari belt that persists throughout the life of the plant. The diameter of the roots is small and hard, and the soft tissue becomes woody, helping the supporting column to be more solid. The flowers are small, gathered in umbels, unisexual, different from each other, growing in the leaf axils. The fruit is spherical, 0.8–1 cm in diameter, red-black when ripe, with 1–4 seeds.

Keywords: Smilax gaudichaudiana, morphological characteristics, micro-anatomical structure

1. Introduction

Smilax gaudichaudiana Kunth (1850), synonymously known as Heterosmilax gaudichaudiana (Kunth) Maxim. (1872) [1]–[4], is a climbing vine belonging to the Smilacaceae family, primarily distributed in East and Southeast Asia, playing a significant role in forest ecosystems.

Smilax gaudichaudiana has long been recognized as a valuable wild vine, offering various medicinal and practical benefits. The plant exhibits vigorous growth, thriving in diverse habitats from mountainous forests to stream banks, demonstrating adaptability to various climatic conditions [5], [6].

Characterized by its soft yet thorny stems, glossy oval leaves, and robust root system, Smilax gaudichaudiana not only contributes to soil stabilization and erosion control but also serves as a valuable

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medicinal resource in traditional Eastern medicine. Its roots are harvested and processed for medicinal preparations, aiding in detoxification, treating liver and kidney ailments, and addressing bone and joint issues [7]–[10].

Due to its significant medicinal properties, Smilax gaudichaudiana is increasingly being studied and utilized. To provide further biological data for those interested in this species, we conducted a morphological and anatomical study of its stems, roots, and leaves to provide a basis for conservation and medicinal utilization

2. Materials and Methods

2.1. Materials

- Smilax gaudichaudiana Kunth;

- Samples collected at Me Linh Biodiversity Station, Phuc Yen City, Vinh Phuc Province include: 20 samples of fresh stems, branches, leaves, roots, flowers, and fruits for research purposes.

2.2. Experiment design and methods

Observation and documentation of habitat characteristics and vegetative organ morphology (roots, stems, leaves), photography, and sample collection were conducted.

Specimen identification was based on "Vietnamese Flora" by Pham Hoang Ho (2000), with scientific names updated according to the Royal Botanic Gardens Kew [3], [4], [11].

Fresh anatomical sections were prepared using the method described by Klein.R.M and Klein. D.T (1979), and observed under an optical microscope. Microscopic photos were taken using x5, x10 objective lenses. [12]–[14].

3. Results and Discussion

3.1. Stem

Our research revealed that Smilax gaudichaudiana possesses climbing stems, 2–5 m in length, with an average diameter of 2–4 mm. The stems are rigid, cylindrical, with internodes measuring 3–13 cm. Young stems exhibit a green hue, gradually turning light brown with age (Figure 1). A portion of the rhizome undergoes modification, forming tubers with medicinal properties.

According to Nguyen Ba et al. [15]–[18], monocotyledonous stems generally lack distinct cortex and stele regions; beneath the epidermis lies sclerenchyma tissue, providing support and protection for the inner tissues.

However, our study of Smilax gaudichaudiana revealed a distinct difference, with clearly differentiated cortex and stele regions, resembling the general characteristics of dicotyledonous stems. The stem's outermost layer consists of tightly interconnected, non-intercellular, tabular epidermal cells. Some epidermal cells elongate, forming protective trichomes (Figure 1,3).

Beneath the epidermis are 5–10 layers of primarily storage parenchyma cells, interspersed with specialized cells exhibiting lignified walls and calcium oxalate crystal-containing cells. Subsequently, 6-7 layers of sclerenchyma cells with thickened walls, arranged in a beaded chain surrounding the stem, contribute to the plant's rigidity, a distinctive characteristic of this species.

Figure 1. Morphology of *Smilax gaudichaudiana* Kunth.

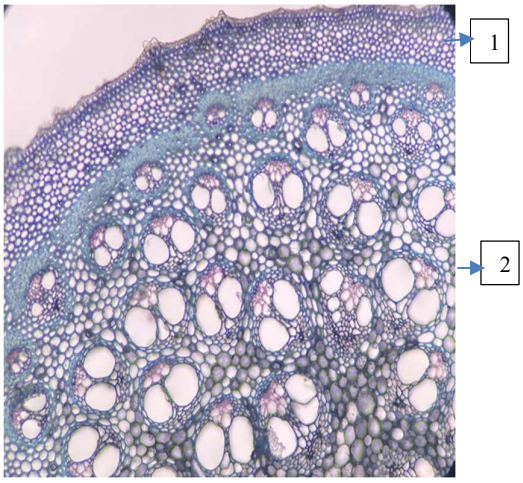

Figure 2. Anatomy of a part of *Smilax gaudichaudiana* Kunth stem; 1. Shell; 2. Stele.

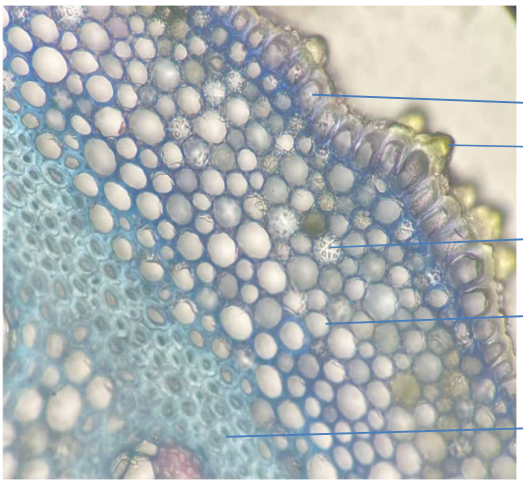

Figure 3. Structural composition of the bark of *Smilax gaudichaudiana* Kunth. 1.Epidermis, 2. Protective trichomes, 3. Calcium oxalate crystals, 4. Parenchyma, 5. Sclerenchyma.

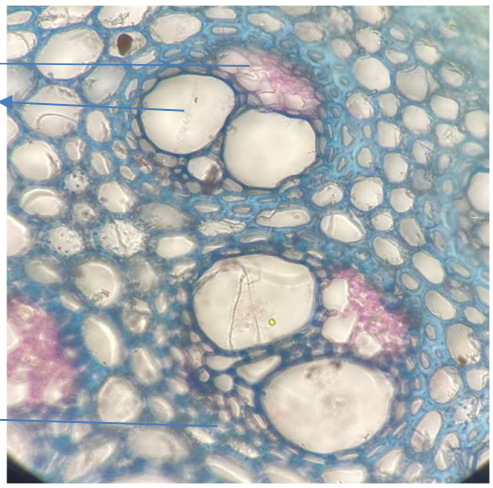

Figure 4. Structure of a closed vascular bundle; 1. Xylem, 2. Phloem, 3. Sclerenchyma.

Smilax gaudichaudiana Kunth., a representative of woody vines, exhibits large vascular bundles with two phloem points. These bundles, interspersed with parenchymal tissue, concentrate centrally within the stele, decreasing in density from the periphery inwards, while their size increases towards the center (Figure 2). A thick (7–10 layers), discontinuous sclerenchyma ring separates the cortex and stele, facilitating twisting around supports, a key adaptation for vines.

Species climbing via tendrils possess numerous small vascular bundles. Their ascent relies on the tendrils' grip (Figure 2). Vascular bundles are arranged in a compact, overlapping pattern, encased by a sclerenchyma ring, comprising xylem and phloem without a vascular cambium (Figure 4).

3.2. Leaves

The leaf blade is ovate or cordate-ovate, 4–15 cm long, 3–13 cm wide, apex acuminate, base rounded or subcordate; 7 main veins, parallel venation; petiole 1–4 cm long, deeply grooved adaxially; the lower

part sheath-like, 3–7 mm long, with a 0.5 mm wide, membranous, reddish-brown wing on the sheath, tendrils 5–15 cm long [19].

Figure 5. Leaf Morphology.

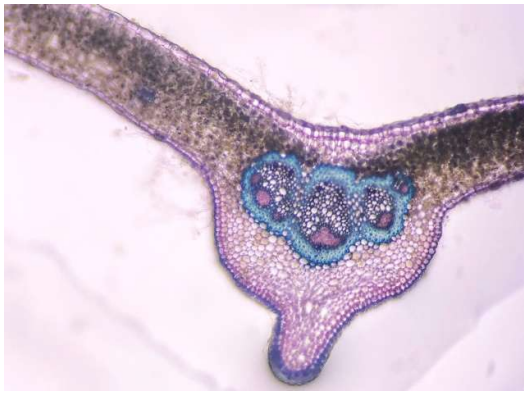

Figure 6: Anatomy of leaf vein.

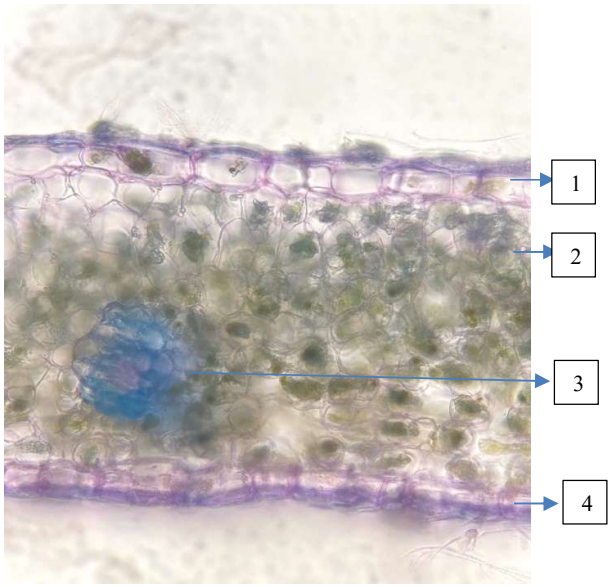

Figure 7. Anatomy of the leaf; 1. Upper epidermis, 2. Mesophyll, 3. Vascular bundle, 4. Lower epidermis.

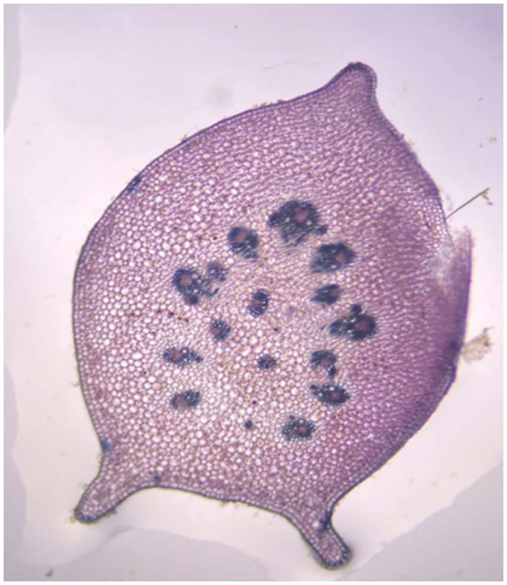

Figure 8. Anatomy of the petiole.

Anatomically, the outermost layer of the petiole is composed of lamellar epidermal cells. The number and arrangement of vascular bundles in the petiole and midrib vary. The vascular bundles in the petiole typically have a structure similar to the stem. The vascular bundles are arranged in an elliptical shape, connected by a soft tissue system (Figure 8).

The vascular bundles in the main vein are surrounded by a ring of sclerenchyma cells with thick walls, providing greater strength to the leaf vein (Figure 6). Further from the main vein, this sclerenchyma ring disappears, and the number of fiber cells significantly decreases, leaving mainly conductive elements (Figure 7).

The mesophyll lacks differentiation into palisade and spongy parenchyma, a characteristic adaptation of shade-tolerant species.

3.3. Roots

The root system is well-developed, branching to form a fibrous root system with numerous root hairs to ensure adequate water and mineral nutrient supply to the plant (Figure 9). Lateral roots are formed endogenously. Young roots are typically located further from the root base.

The root anatomy exhibits distinct cortex and stele regions.

Figure 9. Root morphology.

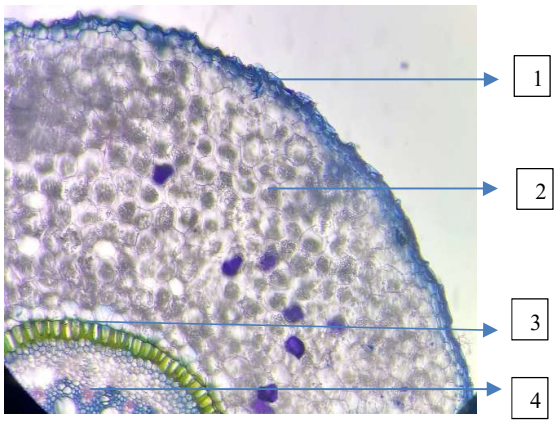

Figure 10. Anatomy of *Smilax gaudichaudiana* Kunth root 1. Epidermis; 2. Soft tissue; 3. Caspari belt; 4. Phloem.

Cortex: The outermost layer is the epidermis, composed of tightly packed lamellar cells. The innermost layer of the cortex is the endodermis with U-shaped (Casparian strip) Casparian thickenings on three sides of its cells [15]–[18], (Figure 10). The U-shaped belt is a characteristic of species belonging to the Monocotyledon class, the belt is thick, impermeable in the radial wall and transverse wall of the endodermal cells, so water from the environment still moves into the root through the intercellular path to the endodermal layer considered to be finished, the water flow and mineral nutrients must pass through the suction cells to enter the inside of the conductive column (A Fahn, 1982) [19].

The stele: occupies 50% of the root's thickness. The pericycle is meristematic, giving rise to lateral roots. Xylem and phloem are arranged adjacently, forming alternating vascular bundles (Figure 10). There are 13–15 vascular bundles, with metaxylem larger than protoxylem. The metaxylem is well-developed, early lignified, and thick-walled.

As the primary root persists throughout the plant's life, the root's diameter remains small and rigid, with lignified pith parenchyma contributing to the vascular cylinder's strength.

3.4. Flowers and Fruits

The flowers are small, arranged in axillary, unisexual, dioecious umbels. Male umbels have 15–20 flowers, without bracts at the base; the receptacle is swollen, and the pedicels are 1–2 cm long. Female umbels have 5–25 flowers, with a swollen receptacle and 1–2 cm long pedicels [1], [2].

Male flowers: perianth with 6 tepals, reddish-brown, oblong-ovate or oblong, 4-4.5 mm long, 2-3 mm in diameter, base constricted, with 3 triangular teeth, 0.3 mm long, at the apex. Stamens 3, filaments completely fused into a 2.5–3 mm long column; anthers 1–2 locules, ovoid, 1 mm long, 0.7 mm wide, introrse, dehiscing longitudinally [1], [2].

Female flowers: perianth with 6 tepals, fused into an urn-shape, oblong-ovate or oblong, 3.75–4 mm long, 2.2–2.5 mm in diameter, base rounded, with 3 triangular teeth, 0.3 mm long, at the apex. Ovary

ovoid, 3 mm long, style 0.3 mm long, stigma 3-lobed. Staminodes 6, needle-like, 1.5–1.75 mm long. Berry globose, 0.8–1 cm in diameter, reddish-black when ripe, with 1–4 seeds (Figure 11).

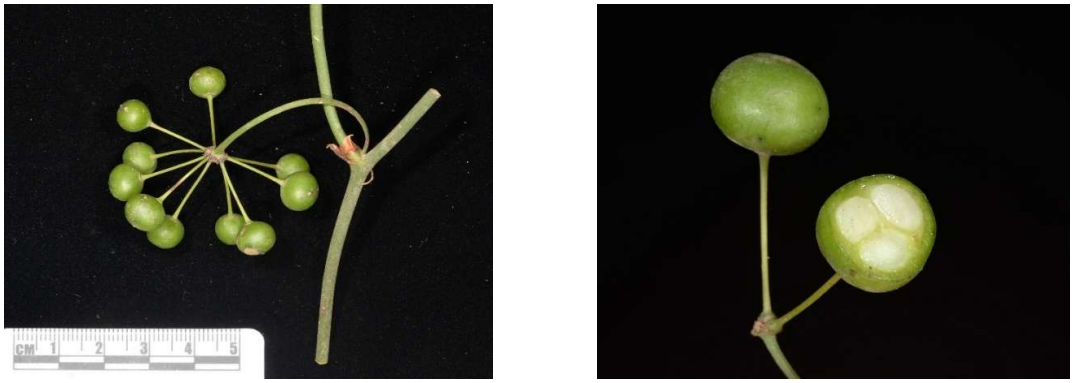

Figure 11. Fruit Morphology of *Smilax gaudichaudiana* Kunth.

4. Conclusion

Through morphological and anatomical studies of *Smilax gaudichaudiana*, numerous adaptive characteristics specific to its habitat are observed. There is a clear distinction between the cortex and the stele in woody vines. The vascular bundles are scattered within the stele. Leaves with parallel venation, and undifferentiated mesophyll demonstrate adaptation to low-light rainforest conditions. The root system exhibits vigorous development as an adventitious root system, with the primary root persisting throughout the plant's lifespan. The U-shaped suberization of the Casparian strip is observed in endodermal cells. Unisexual flowers, dioecious, occur in clusters. These results contribute to the anatomical database of Smilacaceae and support future conservation or pharmacognostic studies.

Acknowledgements

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