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Morphological and anatomical features of Invasive alien weed species *Ageratum conyzoides* L accessions from Tamil Nadu, India

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ABSTRACT

Ageratum conyzoides L. is an invasive alien species, annual herb belongs to Asteraceae family Morphological and anatomical features of A. conyzoides accessions collected from four different regions of Tamil nadu, India to understand the adoptive mechanism and invasiveness of the species in various geographical conditions. Adult plant specimens of A. conyzoides were collected from 1.Coromandel coast (plain and agricultural field); 2.Pachaimalai (moderate altitude); 3.JawaduHills (excessive rainfall), and 4.Gudalur (high altitude),) in Tamil nadu, India. The plant species generally it is erect branching sometimes prostrate and it grows to approximately 2-5 ft. in height in Pachaimalai and 1-3 ft from Coromandel coast. The flowers are small, pretty at the top of its hairy stems. The inflorescence is pale purple and white head, respectively for Jawadhu hills and Coromandel coast and flowers are less than 6 mm across and arrange in close terminal corymbs of 8-15 heads. Anatomical features of node and internode of the stem of A. conyzoides shows following arrangement of the tissue from periphery towards center. Outer most layer, single cell layered thick, compactly arranged, without any intercellular spaces, rectangular outline, thick walled; outer surface cuticularized.

Keywords: *invasive alien species, A. conyzoides, Morphological and anatomical features.*

Introduction

Invasive alien species pose significant threats to biodiversity, ecosystem function, and agricultural productivity worldwide. Among these, *Ageratum conyzoides* L., commonly known as billygoat weed, is a notorious invasive species originating from tropical America [1]. This weed has established itself in various regions across the globe, including India, where it has become particularly problematic. Tamil Nadu, a state in southern India, has witnessed extensive proliferation of *Ageratum conyzoides*, adversely affecting native flora and agricultural practices. The adaptability and aggressive growth of this species enable it to colonize diverse habitats, from roadsides and fallow lands to cultivated fields and forested areas [2]. Understanding the morphological and anatomical characteristics of *Ageratum conyzoides* is crucial for developing effective management strategies to curb its spread and mitigate its impact. Morphological and anatomical studies provide insights into the structural attributes that confer competitive advantages to invasive species. Morphological features such as plant height, leaf shape, and root system architecture can influence a species' ability to compete for resources, while anatomical traits such as leaf epidermal structure and vascular bundle arrangement can affect physiological processes like photosynthesis and water transport. By examining these features in Ageratum conyzoides accessions from different regions of Tamil Nadu, researchers can identify specific traits that contribute to its invasiveness [3-4].

This study aims to investigate the morphological and anatomical characteristics of Ageratum conyzoides L. accessions from Tamil Nadu, India. By conducting a comprehensive analysis of these traits, we seek to enhance our understanding of the factors driving the invasiveness of this weed and to inform management practices aimed at controlling its spread. Through this research, we hope to contribute to the broader field of invasion biology and provide valuable information for the development of effective weed management strategies in Tamil Nadu and beyond. The invasive success of *Ageratum conyzoides* in Tamil Nadu is attributed not only to its robust reproductive strategies and rapid growth rates but also to its allelopathic properties, which allow it to suppress the growth of surrounding plants. This competitive edge enables Ageratum conyzoides to dominate a variety of ecological niches, thereby outcompeting native species and reducing biodiversity [5]. The intricate relationship between the plant's morphological and anatomical features and its invasive capabilities remains a key area of interest for researchers aiming to understand and mitigate the ecological impact of this weed.

In Tamil Nadu, the variability in climatic and soil conditions across different regions presents an opportunity to study the phenotypic plasticity of *Ageratum conyzoides*. By analyzing how this species adapts its morphological and anatomical traits in response to varying environmental pressures, researchers can gain valuable insights into the mechanisms underlying its invasiveness [6]. This study will explore the diversity of traits across multiple accessions of *Ageratum conyzoides* from distinct locales within Tamil Nadu, providing a comprehensive understanding of how local environmental factors influence the plant's growth and spread. The findings will not only enhance our knowledge of *Ageratum conyzoides'* biology but also inform targeted management approaches that consider regional environmental variations.

Materials and Methods

Adult plant specimens of *Ageratum conyzoides* L., were collected from different eco-type regions such as 1. Coromandel coast

(plain and agricultural field); 2.Pachaimalai (moderate altitude); 3. Jawadu Hills (excessive rainfall), and 4. Gudalur (high altitude),) in Tamil Nadu, India (Fig.1) for assessing the morphology and anatomy of the species.

Transverse sections of fresh leaf, petiole, stem, root, and nodal region of stem were cut into small pieces for taking free hand sectioning then soaked in distilled water for a day and warming subsequently to expel air bubbles. For the epidermal studies the peels of fresh as well as preserved leaves were used and the sections were applied with withsafranin, fast green, double staining procedures, and permanent mounts prepared using Canada balsam and studied under a microscope. All the sections were photomicrographed.

The sections were transferred to safranin stain till it attains dark red colour*i.e*. 10-15 minutes. They were then passed successively through 30%, 50%, 70%, 90% and absolute alcohol. In each dilutions were kept for one minute. Just when still visibly over-stained, the sections were transferred to fast green in clove oil. Here the section loses the red stain rapidly. At the critical moment it was shifted to absolute alcohol and xylol (1:1) solution. In this solution detaining is arrested and the colour of the safranin would be fixed over the section. Then the section was treated with pure xylol twice. Finally the sections were transferred to mountant Canada balsam on a slide and cover slip was placed over it and set aside to dry [12]. Anatomical observations and photographic documentation were conducted using a light microscope (model AX70TRF, Olympus Optical) equipped with a U-Photo system. The descriptive terms for the anatomical features were based on standard anatomical reference books.

Foliar epidermal morphology was investigated across all four accessions of A. conyzoides, focusing on the shape, size, type, and nature of the stomata, as well as epidermal appendages such as hairs and trichomes, and the structure of epidermal cells. Epidermal peels of both the upper and lower leaf surfaces were prepared mechanically. These peels were stained with 2% aqueous safranin solution, mounted in 5% glycerin solution, and observed under a compound microscope (15x40x). The collection process and slide preparation followed the standard method described by relevant literature.

The study included an examination of the shape, size, type, and nature of the stomata, along with their subsidiary cells and the epidermal cells. The number of stomata and epidermal cells was counted, and the stomatal frequency and stomatal index were calculated using the following formulas:

- *Stomatal frequency (S.F.) = (S / E) x 100*
- *Stomatal index (S.I.) = (S / (E + S)) x 100*

where S represents the average number of stomata, and E represents the average number of epidermal cells in the same unit area.

The length and breadth of stomata were measured with an ocular micrometer under high-power magnification (15x40x). Thirty readings for each parameter per species were taken, and the mean values were calculated, statistically analyzed, and tabulated. Microphotographs of both the upper and lower epidermal peels were taken using an Olympus Camedia C5060 model microphotographic camera. The terminologies for different epidermal structures followed those proposed by relevant authorities. The stomatal index and frequency were calculated using the formulas proposed by established methods.

Results and Discussion

Morphological Variations

The study of Ageratum conyzoides L. accessions from Tamil Nadu revealed significant morphological variations between populations from the Jawadhu Hills and the Coromandel Coast. Plants from the Jawadhu Hills, growing to heights of approximately 2-5 feet, exhibited a more erect and branching habit compared to the 1-3 feet tall, sometimes prostrate individuals from the Coromandel Coast. This height disparity suggests that the environmental conditions of the Jawadhu Hills, which are likely cooler and less saline compared to the coastal areas, may promote more robust vertical growth. The stems of both populations were characterized by their red and pubescent nature, with young stems showing a higher density of fine white hairs, contributing to the plant's distinctive appearance [7-8]. The leaves of A. conyzoides displayed variation in size, ranging from 2-10 cm in length and 1-6 cm in width, with an ovate to rhombic-ovate shape. Despite these size variations, the leaves consistently exhibited a crenate margin and were covered with glandular hairs dorsally, producing an aromatic or unpleasant smell [9-10]. The differences in leaf size between the two populations could be attributed to differing moisture availability and soil fertility, with the Jawadhu Hills likely providing more favorable conditions for larger leaf development.

Anatomical Features

Anatomical examination revealed distinct differences in stem, petiole, and root structures between the two accessions. The transverse sections of the stem in both populations showed a single-layered outermost epidermis, compact and cuticularized, providing protection against desiccation and herbivory. The hypodermis was more pronounced in the Jawadhu Hills population, indicating a possible adaptation to retain moisture in the relatively drier hill environment.

The petiole anatomy revealed an arc shape, with an adaxial concave and abaxial convex surface. The epidermis was uniseriate in both accessions, but the cortex varied slightly. The Jawadhu Hills population showed more layers of polygonal collenchyma cells, suggesting a structural adaptation to support taller growth. The vascular bundles, 3-5 in number and bicollateral, were more robust in the hill population, supporting efficient transport of water and nutrients necessary for their larger size.

Root anatomy also varied between the populations. The epidermis of the roots, like the stems, was a single cell layer thick and compactly arranged. The cortex was prominent in both accessions, but the Jawadhu Hills plants had a more developed cortical layer, possibly an adaptation to enhance nutrient storage and absorption. The vascular bundles in the roots were conjoint, collateral, and closed, with the xylem located towards the upper epidermis and phloem towards the lower epidermis. The more robust development of xylem in the hill population could be an adaptation to facilitate efficient water transport in response to potential water stress conditions.

Ecological Implications

The morphological and anatomical differences observed between A. conyzoides populations from the Jawadhu Hills and the Coromandel Coast highlight the species' phenotypic plasticity and its ability to adapt to varying environmental conditions. The larger size and more robust anatomical features of the Jawadhu Hills population suggest that this environment

supports greater vegetative growth, possibly due to more favorable climatic and edaphic factors.

The study's findings underscore the importance of considering local environmental conditions when developing management strategies for invasive species like A. conyzoides. Understanding the specific traits that enhance the invasiveness of this weed in different habitats can inform targeted control measures. For instance, management practices in the Jawadhu Hills might focus on reducing moisture availability or altering soil conditions to inhibit the growth of larger, more competitive individuals. Overall, this research contributes to a deeper understanding of the adaptive strategies of *A. conyzoides* and emphasizes the need for region-specific approaches to effectively manage its spread and mitigate its impact on native ecosystems and agricultural productivity [11-15].

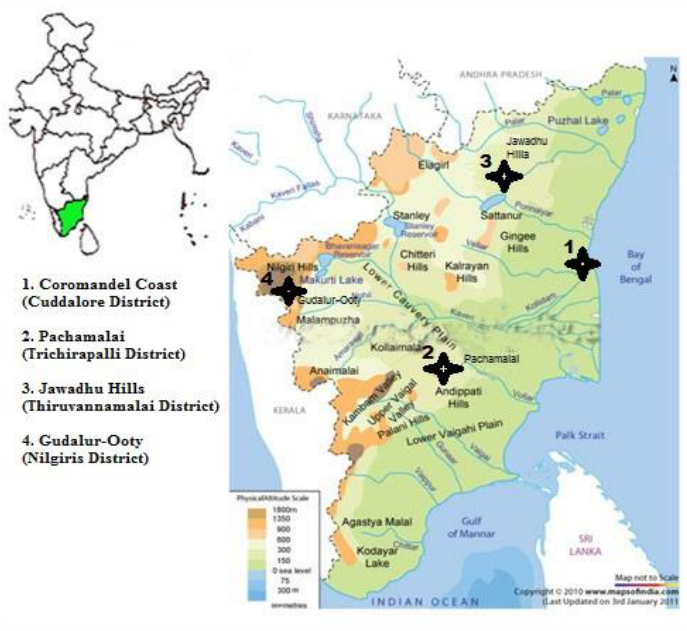

Fig.1: A. conyzoides Accession Collection Sites in Tamil Nadu, India

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Table-1: Morphological variations of A.conyzoides accession from Coromandel Coast (A1), Pachaimalai (A2), Jawadhu hills (3) and Gudalur-Ooty (A4).

S. No.	Morphological Parameters	A. *conyzoides* accession			
		A1	**A2**	**A3**	**A4**
1.	**Plant Height (cm)**	**43.2 (±3.5)**	**193.5 (±7.6)**	**113.1 (±5.4)**	**69.6 (±3.2)**
2.	**Leaf number/Plant**	**71 (±3.0)**	**69.0 (±3.1)**	**193 (±8.2)**	**56.5 (±2.6)**
3.	**Leaf area index**	**0.212 (±0.013)**	**0.269 (±0.022)**	**0.365 (±0.023)**	**0.192 (±0.014)**
4.	**Number of branches/Plant**	**12.3 (±0.2)**	**8.0 (±0.25)**	**19.4 (±1.1)**	**11.3 (±0.5)**
5.	**Number of flowers/Plant**	**89.6 (±3.5)**	**34.2 (±2.2)**	**41.2 (±2.2)**	**68.6 (±2.6)**
6.	**Fresh weight(g)/Plant**	**72.6 (±3.0)**	**224.6 (±11.0)**	**155.4 (±6.3)**	**82.6 (±3.2)**
7.	**Dry weight(g)/Plant**	**19.45 (±0.52)**	**93.1 (±3.5)**	**62.8 (±2.6)**	**35.9 (±1.6)**
8.	**Number of seed production/ flowers**	**248.24 (±7.5)**	**141.6 (±3.2)**	**186.2 (±8.7)**	**212.5 (±8.5)**
9.	**Number of seed production/ Plant**	**22242.30 (±88.6)**	**4815.0 (±36.2)**	**7671.44 (±51.4)**	**17528.0 (±80.4)**

Mean Data of five replicates

Fig.2. Morphological variations of A.conyzoides accession from Coromandel Coast (A1), Pachaimalai (A2), Jawadhu hills (3) and Gudalur-Ooty (A4).

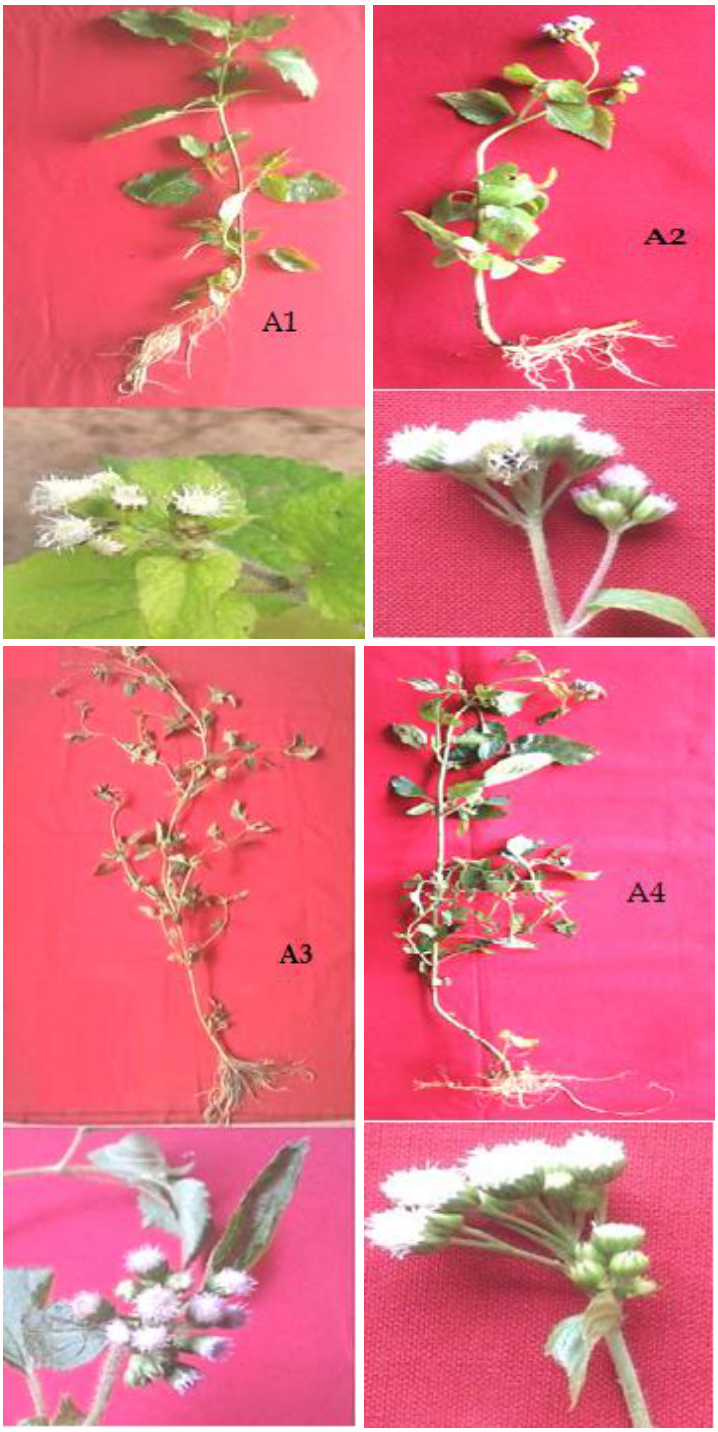
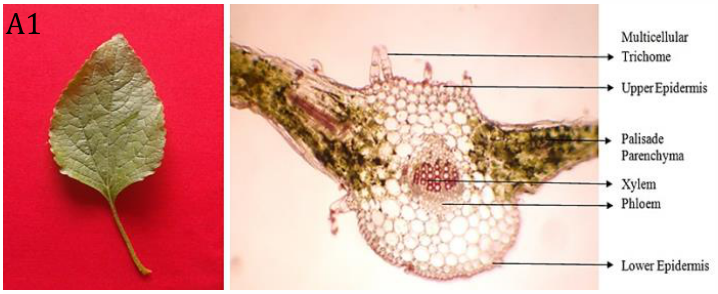
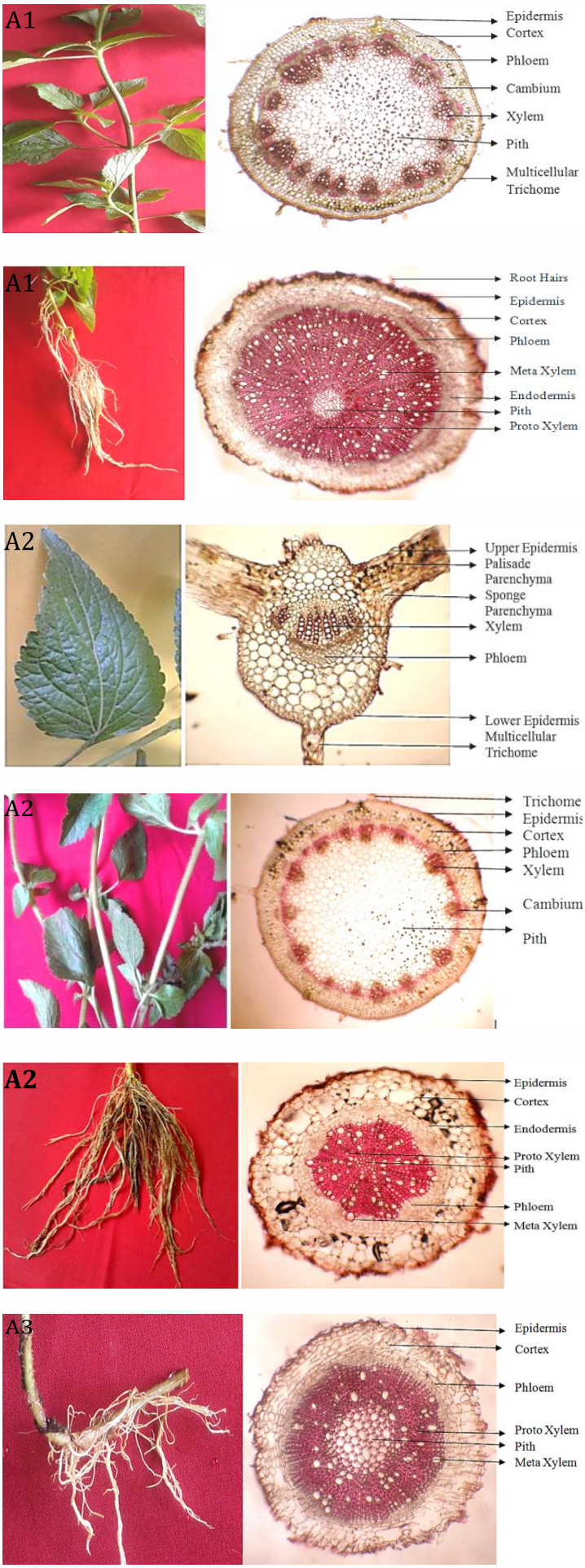
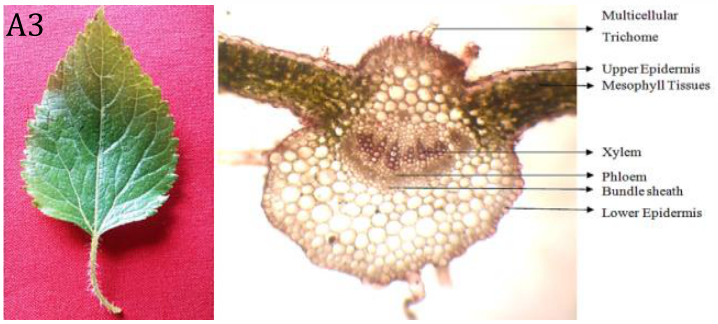
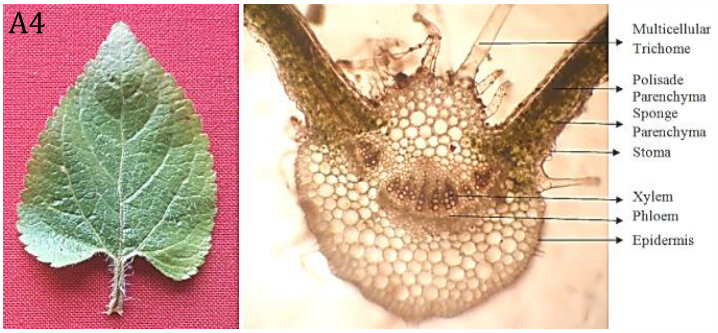


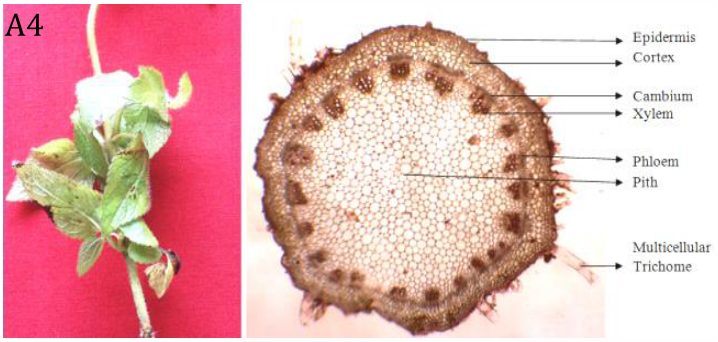
Fig.3. Leaf and Stem anatomy off A.conyzoides accession from Coromandel Coast (A1), Pachaimalai (A2), Jawadhu hills (3) and Gudalur-Ooty (A4).

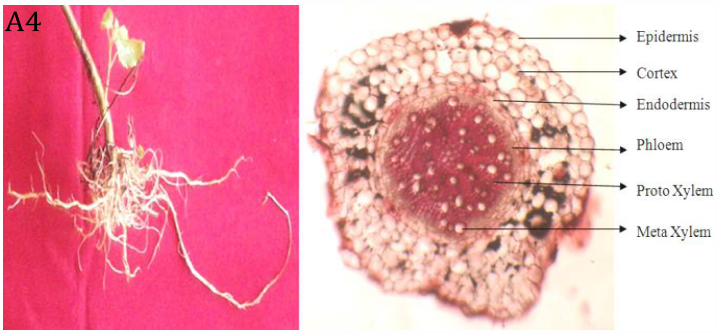












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