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# A Comprehensive Review Of Eleusine Indica (Goosegrass): Phytochemical Composition, Morphology, And Anatomy

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***Abstract***
*Eleusine indica (goosegrass) is a fast-spreading weed known for its exceptional ecological adaptability, economic importance, and pharmacological potential. This review comprehensively explores the anatomical, phytochemical, ecological, and economic dimensions of E. indica. Emphasis is placed on its weed management strategies, pharmacological applications, and sustainable utilization. The plant's anatomical adaptations, such as Kranz leaf anatomy and aerenchyma formation in roots, contribute to its resilience in diverse environments. Rich in bioactive phytochemicals, E. indica has demonstrated antioxidant, antimicrobial, and anti-inflammatory properties, positioning it as a valuable resource in traditional medicine and phytoremediation. However, its herbicide resistance poses challenges to crop management. A dual approach, balancing conservation and control, is vital for harnessing the plant's benefits while mitigating its invasive tendencies.*
***Keywords:*** *Eleusine indica, goosegrass, phytochemistry, weed management, ecological adaptability, anatomical adaptation, herbicide resistance, traditional medicine.*

## INTRODUCTION

Eleusine indica (L.) Gaertn., commonly known as goosegrass, is an annual grass species belonging to the family Poaceae. While often classified as a tenacious and troublesome weed in agricultural settings, it also holds ethnopharmacological value and plays notable roles in agroecological systems. Its dual identity—as both a nuisance in crop production and a resource in traditional medicine—makes it a species of significant ecological and scientific interest.
Globally distributed across tropical and subtropical regions, E. indica has demonstrated remarkable ecological plasticity, particularly in disturbed or human-modified landscapes (Holm, 1977). Its ability to colonize such environments is a testament to its physiological resilience and adaptive traits.
Historically, various parts of the plant have been used in traditional healing practices for the treatment of fever, urinary tract infections, asthma, and gastrointestinal disorders, underscoring its widespread ethnobotanical relevance (Adekunle, 2013). With the advent of modern phytochemical investigations, E. indica has been shown to possess a diverse array of bioactive compounds, many of which are associated with therapeutic potential (Chukwuma, 2019).

**Distribution and Habitat**

**Global Distribution**

Eleusine indica is recognized as one of the most widespread and persistent weed species in tropical and subtropical regions across the globe. Although its exact origin is debated, with some evidence pointing to tropical Africa or Southeast Asia, it has now been reported in over 60 countries, showcasing its exceptional ability to thrive in a wide range of habitats (Holm, 1977).

The species is especially prevalent in South and Southeast Asia (e.g., India, Indonesia, the Philippines), much of sub-Saharan Africa (notably Nigeria and Ghana), as well as in parts of the Americas, including Brazil and the southern United States. It also occupies numerous Pacific islands (GBIF, 2023). E. indica frequently colonizes disturbed environments such as roadsides, construction sites, industrial zones, and agricultural lands—areas where competition is low and soil disturbance is high, favouring its establishment and spread.

Fig. 1 Morphological Structure of Goose Grass

**Environmental Plasticity and Edaphic Tolerance**

A key factor in the ecological success of E. indica (Fig-1) is its extraordinary environmental adaptability. It can thrive in both nutrient-rich and nutrient-poor soils, and germination can occur over a broad temperature range (15°C to 35°C), making it suited to diverse climatic zones (Chauhan & Johnson, 2008). The species shows resilience to compacted soils and periodic drought conditions, supported by a suite of morphological and physiological traits adapted for stress tolerance. Moreover, E. indica has a short life cycle—completing growth and reproduction within 6 to 8 weeks under optimal conditions, which allows for multiple generations within a single growing season and rapid population turnover (Steckel, 2007).

**Invasive Potential and Seed Ecology**

The invasive nature of E. indica (Fig-1) is closely linked to its prolific seed production and efficient dispersal mechanisms. A single plant can produce over 140,000 seeds, many of which enter dormancy and persist in the soil seed bank for several years (Steckel, 2007). These seeds are dispersed by wind, surface water runoff, animal fur, footwear, farm equipment, and other human-mediated activities, allowing the species to invade new territories with ease.

In regions where glyphosate is widely used for weed control, E. indica has quickly developed herbicide resistance, complicating management strategies and posing significant challenges for agriculture (Goh, 2019). This combination of biological resilience and human-assisted dispersal underscores its high invasive potential.

**Morphology, Growth Form, and Habit**

Eleusine indica is a mat-forming, tufted annual grass that utilizes the C4 photosynthetic pathway, contributing to its efficiency in hot, dry environments. Typically, it grows to a height of 15–90 cm, depending on moisture levels and soil fertility. Its extensive fibrous root system helps it anchor firmly in the soil and endure mechanical stress, while also enhancing water uptake during periods of drought (Hasan, 2021).

The plant's stems, known as culms, are generally flattened at the base and display a decumbent-to-ascending growth pattern. Under high sunlight, the culms often turn purplish due to anthocyanin accumulation—an adaptive pigmentation that likely protects against UV radiation (Chauhan & Johnson, 2009).

**Leaf Structure**

Leaves of E. indica are narrow and elongated, measuring 4–30 cm in length and 2–8 mm in width. The leaf blades are usually flat and may range from glabrous to sparsely hairy. Each leaf emerges from a sheath that wraps around the culm, and a distinctive membranous ligule is found at the junction of blade and sheath—a characteristic feature used in Poaceae identification (Hasan, 2021).

The sheaths are prominently keeled and often display reddish or purplish discoloration in older tissues. This pigmentation is believed to serve a photoprotective role, particularly in high-light environments where oxidative stress may otherwise damage plant tissues.

**Morphological Leave of Goose grass**

**Anatomy**

The internal anatomical organization of Eleusine indica reflects its adaptation to a wide range of environmental conditions and contributes to its competitive advantage in disturbed and cultivated ecosystems. Its anatomical structures have been studied with emphasis on the root, stem( Fig-2) leaf, and reproductive organs to understand its physiological functions and ecological role

**Fig. 2. Anatomical Structure of Stem**

**Root Anatomy**

The root system of E. indica is fibrous and extensive, enabling efficient water and nutrient uptake. Cross-sections of mature roots reveal a typical monocotyledonous anatomy comprising an epiblema, cortex, endodermis, pericycle, and a central vascular bundle. The cortex is multilayered with thin-walled parenchymatous cells facilitating aeration and storage. The endodermis features prominent Casparian strips, while the pericycle gives rise to lateral roots (Santos et al., 2013). Xylem elements are arranged radially in a polyarch condition, allowing efficient water conduction.

**Stem Anatomy**

The stem anatomy of E. indica (Fig-2) shows adaptive xeromorphic features. It is characterized by a circular outline with a single-layered epidermis covered by a thick cuticle. Beneath the epidermis lies a hypodermis of sclerenchymatous cells providing mechanical strength. The ground tissue is parenchymatous with large intercellular spaces. Vascular bundles are scattered and are conjoint, collateral, and closed, typical of monocot stems (Gill & Nyawuame, 2011). Bundle sheaths of sclerenchymatous cells surround each vascular bundle, enhancing structural rigidity.

**Leaf Anatomy**

The leaves of E. indica exhibit adaptations conducive to high transpiration and sunlight exposure. They are isobilateral, with both surfaces possessing similar anatomical structures. The epidermis is single-layered and covered by a thick cuticle. Stomata are paracytic and more abundant on the abaxial surface, facilitating gas exchange. Bulliform cells are present in the upper epidermis and aid in leaf folding during water stress. Mesophyll cells are undifferentiated, forming a uniform palisade-like tissue, which is typical of C4 grasses. Vascular bundles are surrounded by large bundle sheath cells rich in chloroplasts, indicative of Kranz anatomy associated with C4 photosynthesis (Khoshravesh et al., 2017).

**Reproductive Anatomy**

The inflorescence of E. indica is composed of racemose spikes with spikelets arranged in a digit-like fashion at the apex. Each spikelet consists of two glumes and several florets, each protected by a lemma and palea. The ovary is superior, bicarpellary, and unilocular with a single ovule. Stamens are three in number with versatile anthers, and the pollen grains are spheroidal, smooth, and tricolpate. These features are consistent with wind pollination (anemophily) and self-compatibility, promoting reproductive success in open habitats (Chepkoech et al., 2021).

**Phytochemical Composition**

Plants can synthesize an almost unlimited number of substances. In many cases, these chemicals serve in plant defense mechanisms against microorganisms, insects, and herbivores. All parts of the plants contain various active ingredients (Cheema,et.al. (2018).The phytochemical profile of Eleusine indica is rich and diverse, contributing significantly to its ecological adaptability and ethnomedicinal applications. Secondary metabolites found in this species include flavonoids, alkaloids, phenolics, terpenoids, saponins, and glycosides, each playing crucial roles in plant defense, allelopathy, and potential therapeutic properties (Fig-3).

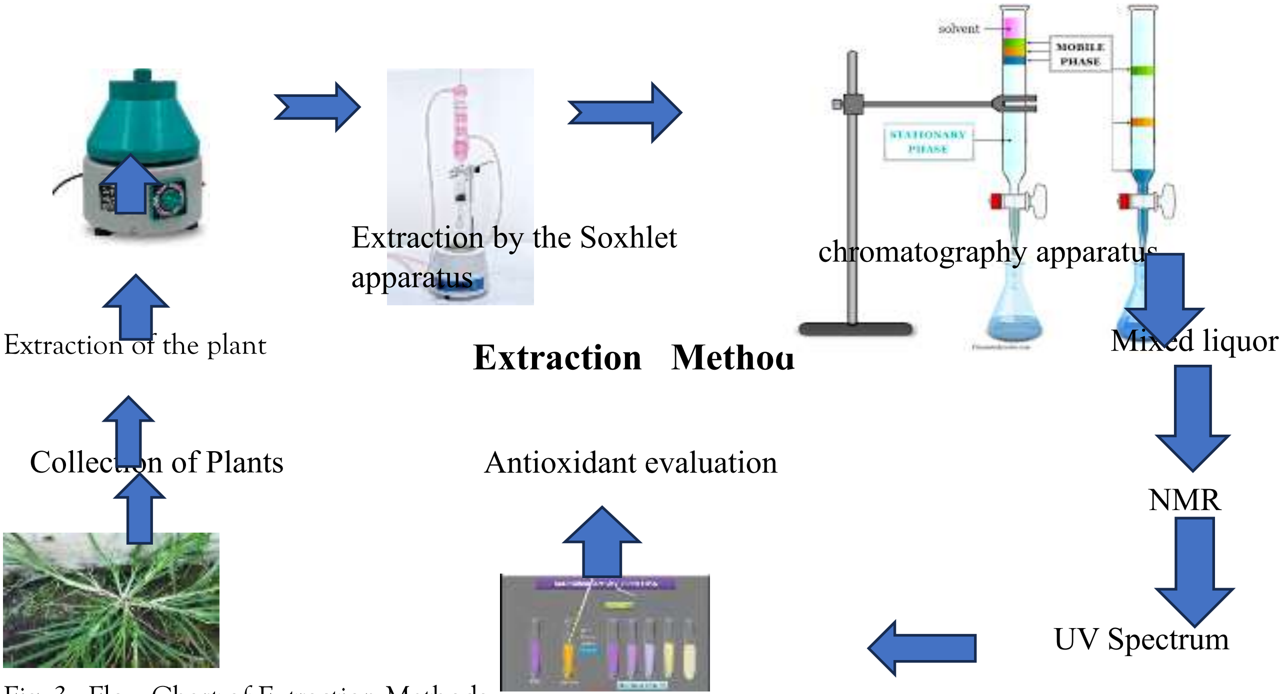


Fig. 3 - Flow Chart of Extraction Methods

**CHEMICAL CONSTITUENT**

Flavonoids Quercetin:

A flavonoid with antioxidant properties. Kaempferol: A common structure feature associated with antioxidant activity is the presence of a 3',4'-dihydroxy (catechol) group in the B-ring A flavonoid that may have anti-inflammatory, antioxidant, and anticancer effects. Rutin: A flavonoid glycoside that can have antioxidant and anti-inflammatory. Flavonoids can directly neutralize free radicals, preventing oxidative damage to cells and tissues. Quercetin 3-O-glucuronide is a naturally occurring compound formed when the body metabolizes quercetin, a flavonoid found in various foods. It's known for its antioxidant and anti-inflammatory properties. (Panche 2016, Rice-Evans C.A et al. (1996,95) Fig; 3

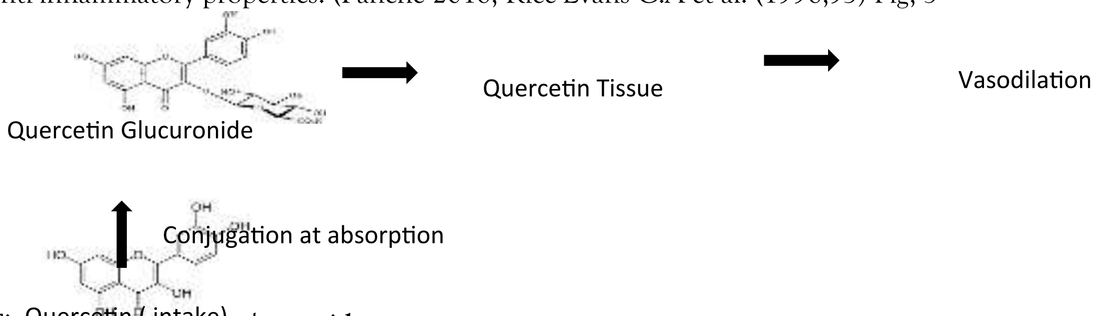


**Fig. 4 Flow Chart of Flavonoid**

Vasodilation is the widening of blood vessels due to the relaxation of the blood vessel's muscular walls(Fig-4)

2. **Triterpenoids Betulinic Acid**: A pentacyclic triterpene that has been studied for its anti-inflammatory, anticancer, and antiviral activities. 30-carbon structure formed by six isoprene units. It features a double bond at position 20(29) and substituents at positions 3β-hydroxy and 28-carboxy. (Mahavir , Jamkhande , 2019) (Fig-5)

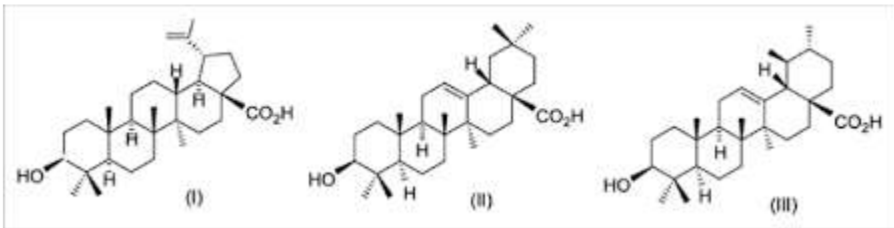


Fig 5. Structure of Terpenoid

3. **Alkaloids:** Alkaloids like indole derivatives have been detected, which are known for their bioactive properties, including antimicrobial and anti-inflammatory effects. Many plants avoid insect herbivory by producing secondary metabolites that repel insects or have toxic effects. Some noxious compounds are both unpalatable and toxic for insects, whereas others are merely unpalatable or toxic. Alkaloids are a huge group of naturally occurring organic compounds that contain nitrogen atom or atoms (amino or amido in some cases) in their structures. These nitrogen atoms cause the alkalinity of these compounds. These nitrogen atoms are usually situated in some ring (cyclic) system (Joanna Kurek (2019).

4. **Saponins:** These glycosides can have antifungal, antibacterial, and anti-inflammatory properties. Saponins in Eleusine indica are thought to contribute to its medicinal properties. The name saponin comes from the Latin word Sapo, which means soap, as saponins show the unique properties of foam in emulsifying agents. Steroidal and triterpenoid saponins can be used in many industrial applications, from the preparation of steroid hormones in the pharmaceutical industry to their utilization as food additives that exploit theirnon-ionic surfactant properties. Saponins also exhibit various biological activities (Dorota Kregiel 2017)

5. **Phenolic**: Compounds Gallic acid and its derivatives are present, with antioxidant, anti-inflammatory, and potential anticancer properties. Saad Bakrim et.al. (2022)

6. **Fatty Acids:** Linoleic acid (an essential omega-6 fatty acid), Palmitic acid, and Stearic acid have been identified, which are important for their role in the regulation of various metabolic functions.(Norris et. al. (2013).

7. **Amino Acids:** Essential amino acids, including glutamic acid and aspartic acid, have been found in the plant.( Kumar Vinod 2019)(Fig-3)

8. **Steroids**: Sitosterol and other phytosterols, which are beneficial for reducing cholesterol and supporting heart health. Fotios Barkas et.al.(2023)

**Quantitative Phytochemical Analyses**

Quantitative analysis using spectrophotometric and chromatographic methods (e.g., HPLC, GC-MS) has revealed significant concentrations of polyphenols and flavonoids. In one study by (Nwachukwu et al. 2014), the total phenolic content of E. indica methanolic extract was reported as 145.32 mg GAE/g extract, while the total flavonoid content was 89.17 mg QE/g extract.

**Antioxidant and Antimicrobial Properties**

The phytochemicals of E. indica are directly linked to its strong antioxidant capacity. DPPH radical scavenging assays have shown that leaf and root extracts exhibit over 70% inhibition at concentrations of 100 μg/mL (Akinmoladun et al., 2007). Moreover, antimicrobial testing against Staphylococcus aureus, Escherichia coli, and Candida albicans has demonstrated significant zones of inhibition, especially in ethanolic extracts (Oladimeji et al., 2016).

**Allelopathic Interactions**

The presence of phenolic acids and flavonoids in E. indica contributes to its allelopathic potential. Leachates and decomposing residues have been observed to inhibit germination and root elongation of neighboring species like Amaranthus hybridus and Capsicum annuum (Cheema et al., 2018), affirming its competitive edge in agroecosystems.

**Economic and Ecological Significance**

Eleusine indica exhibits a dual role in both economic and ecological contexts—serving as a valuable resource in traditional medicine and soil stabilization, while simultaneously acting as a resilient agricultural weed. Its widespread adaptability across ecological gradients and its phytochemical richness underscore its importance in both anthropogenic and natural systems.

**Economic Importance**

Though generally regarded as a weed in commercial agriculture, E. indica has notable ethnobotanical and economic uses:

i. **Traditional Medicine:** In several tropical and subtropical regions, especially in parts of Africa and Southeast Asia, E. indica is used for the treatment of fever, wounds, diarrhea, and respiratory conditions (Burkill, 1985). Decoctions from the root and leaf are commonly prepared to treat urinary infections and to reduce inflammation (Akinmoladun et al., 2007).

ii. **Veterinary Use:** The whole plant is sometimes employed in ethnoveterinary practices, including treating livestock wounds and digestive ailments. Bula Kere Oda et. al. (2024)

**Agricultural and Ecological Impacts**

Despite its beneficial uses, E. indica is more commonly perceived as a highly competitive weed, particularly in tropical agricultural systems:

i. **Weediness and Crop Competition:** It competes effectively for water, light, and nutrients, particularly in maize, rice, and sugarcane fields. Its rapid vegetative growth and C4 photosynthetic pathway make it particularly efficient in warm climates (Zimdahl, 2007).

ii. **Herbicide Resistance:** One of the most alarming features is its capacity to develop resistance to commonly used herbicides, including glyphosate and ACCase inhibitors (Heap, 2024). This resistance has led to significant economic losses, particularly in Southeast Asian and South American cropping system.

iii. **Soil Stabilization and Erosion Control:** On the positive side, the plant's fibrous root system helps in binding the soil, reducing erosion on degraded lands, roadsides, and construction zones. ( Hao-Xin et. al. 2021)

iv. **Habitat for Microfauna:** The dense basal rosette of leaves and spreading growth form provides microhabitats for insects and soil organisms, contributing to biodiversity in disturbed ecosystems. (Duane 2007).

v. **Climate Resilience and Adaptive Plasticity:** E. indica thrives under diverse conditions, showing tolerance to drought, compacted soils, and variable light conditions. Its phenotypic plasticity, including early flowering under stress and prolific seed output, enhances its invasiveness and ecological success (Zhang et al., 2012).

vi. **Role in Phytoremediation:** Recent studies suggest the potential of E. indica in the phytoremediation of heavy metals. It has demonstrated the ability to accumulate and tolerate elevated levels of lead (Pb), cadmium (Cd), and zinc (Zn) in contaminated soils, indicating promise for use in ecological restoration and reclamation efforts (Olabode et al., 2020).

## CONCLUSION

Eleusine indica (goosegrass) is a plant of remarkable ecological adaptability, anatomical specialization, and economic versatility. Although often classified as a nuisance weed due to its invasiveness and competitive ability in agroecosystems, a closer examination reveals a species that is physiologically efficient, morphologically diverse, and chemically endowed. The anatomy of E. indica, particularly its C4 photosynthetic adaptation, dense fibrous roots, and epidermal features, supports its survival in stressed environments and contributes to its rapid proliferation across continents.

The species has demonstrated significance in traditional medicinal systems, providing therapeutic remedies against a range of ailments. Furthermore, its potential use in phytoremediation and erosion control reveals its underexplored utility in sustainable environmental management. However, its expanding herbicide resistance and aggressive colonization necessitate a dual management-conservation strategy. Future research should focus on unraveling the full scope of its phytochemical constituents, ecological interactions, and molecular mechanisms governing its resilience. A balanced perspective on E. indica is essential—not only to mitigate its threats in cropping systems but also to harness its potential in ecological and pharmaceutical domains.

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