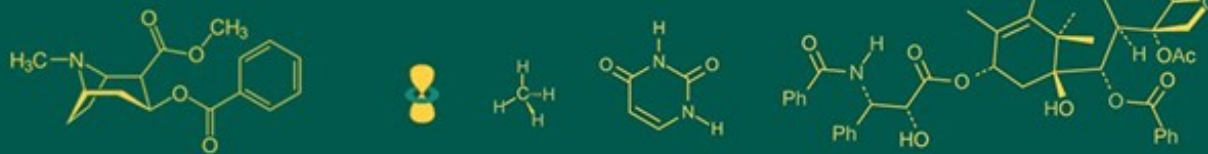


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## *Prosopis cineraria* (L.) Druce: A multifunctional desert tree linking dryland ecology, agroforestry, nutrition, phytochemistry and sustainable development

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**ABSTRACT**

*Prosopis cineraria* (L.) Druce, widely known as Khejri in India and Ghaf in the Arabian Peninsula, is a keystone tree species of arid and semi-arid regions that combines exceptional ecological resilience with major livelihood and medicinal value. This review synthesizes current knowledge on the species' botanical features, geographic distribution, ecological functions, agroforestry importance, nutritional potential, phytochemistry, pharmacological activities, and conservation needs. The tree is highly adapted to extreme dryland conditions through its deep root system, drought tolerance, nitrogen-fixing ability, and capacity to persist under heat, salinity, and poor soil fertility. In natural and managed ecosystems, it improves soil health, stabilizes sand dunes, moderates microclimate, supports biodiversity, and contributes to carbon storage and land restoration. In Indian drylands, especially Rajasthan, *P. cineraria* is central to traditional agroforestry systems, where it supports crop productivity, provides shade and shelter, and supplies fodder, fuelwood, and edible products. The species is also increasingly recognized for its functional food value and medicinal potential, with leaves, pods, bark, and seeds containing flavonoids, phenolics, tannins, alkaloids, sterols, and other bioactive compounds linked to antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and other pharmacological effects. Recent Indian studies have strengthened evidence for its role in soil improvement, habitat suitability, and product development, while also highlighting concerns about regeneration, propagation, and habitat degradation. Overall, *P. cineraria* emerges as a strategically important native desert tree for dryland resilience, sustainable agriculture, and future restoration efforts.

**Keywords:** *Prosopis cineraria*, Agroforestry, Phytochemistry, Pharmacological Restoration, Conservation

**1. Introduction**

Arid and semi-arid ecosystems occupy vast areas of the world and are characterized by low and erratic rainfall, high evapotranspiration, poor soil fertility, and strong climatic stress. In such environments, plant species that can survive prolonged drought, heat, and nutrient limitation are not only ecologically valuable but also central to the livelihoods of rural communities. Among these hardy species, *Prosopis cineraria* (L.) Druce, commonly known as Khejri in India and Ghaf in the United Arab Emirates, stands out as one of the most important multipurpose tree species of the drylands of South Asia and the Arabian Peninsula. Its ecological resilience, cultural significance, and wide range of uses have made it a keystone species in desert landscapes, particularly in the Thar Desert and adjoining arid zones (Chaudhary *et al.*, 2018; Zhong *et al.*, 2022) [1, 2].

*P. cineraria* is a medium-sized, drought-resistant leguminous tree that is remarkably adapted to extreme environmental conditions. It occurs naturally in hot, dry regions and can persist under very limited water availability, making it a prominent component of dryland agroecosystems. The species has a deep and extensive root system that enables access to subsoil moisture and contributes to its survival during long dry periods. This adaptation also supports its role in stabilizing soils and dunes, reducing erosion, and improving the microclimate of surrounding vegetation. Because of these traits, *P. cineraria* is more than a desert tree; it is a structural and functional pillar of fragile arid ecosystems (Orwa, 2009; Sasi *et al.*, 2024;) [3, 4].

Ecologically, the importance of *P. cineraria* extends well beyond simple survival in harsh habitats. As a leguminous and nitrogen-fixing tree, it contributes to nutrient cycling and soil enrichment, thereby improving the fertility of degraded soils and facilitating the growth of associated crops and understory vegetation. This property is particularly valuable in traditional agroforestry systems, where the tree is often retained in farmlands to support crop productivity under rainfed conditions. Recent literature also highlights its contribution to soil organic carbon accumulation in agroforestry settings, reinforcing its relevance in climate-resilient land restoration strategies and sustainable dryland farming. In landscapes increasingly affected by de

sertification, land degradation, and climate variability, such ecosystem services are of exceptional importance (Chaudhary *et al.*, 2018; Zhong *et al.*, 2022) [1, 2].

The species also plays a major role in supporting biodiversity and providing habitat functions in otherwise sparse dryland environments. Its canopy offers shade and shelter for livestock, wildlife, and companion crops, while its litter and root activities improve soil structure and nutrient availability. By creating localized patches of improved environmental conditions, *P. cineraria* acts as a nurse tree and promotes the persistence of plant and animal communities in harsh desert settings. This multifunctionality is one of the main reasons the species has been central to indigenous land-use systems for generations (Orwa, 2009; Zhong *et al.*, 2022) [3, 2].

In addition to its ecological functions, *P. cineraria* is highly valued for its direct contributions to rural livelihoods. Its leaves are an important source of fodder, especially during the dry season when herbaceous feed becomes scarce, and its pods have long been used as traditional food resources in arid communities. Wood from the tree is also used as fuelwood, while other plant parts have practical uses in local economies. In resource-poor areas where alternative feed, fuel, and food sources are limited, these products make the tree economically indispensable. The multiple uses of the species have historically encouraged farmers and pastoralists to protect and conserve it, integrating it into everyday subsistence systems rather than treating it as a purely wild resource (Chaudhary *et al.*, 2018; Zhong *et al.*, 2022; Gupta, 2024) [1, 2, 5].

The nutritional potential of *P. cineraria* has attracted increasing attention in recent years. Like other *Prosopis* species, it contains diverse bioactive and nutritive compounds, including proteins, carbohydrates, minerals, fatty acids, and phenolic constituents. The edible parts of the plant have been discussed as underutilized resources with potential applications in food and feed systems, particularly in drylands where nutritional insecurity is common. Such interest aligns with broader efforts to identify climate-resilient, locally available plants that can contribute to dietary diversification and food security in arid regions. From this perspective, *P. cineraria* is not only a survival species for ecosystems but also a potentially valuable species for human nutrition and sustainable development (Zhong *et al.*, 2022; Gupta, 2024) [2, 5].

Traditional medicine provides another major dimension of the species' importance. *P. cineraria* has a long history of use in indigenous healing systems across India, Pakistan, the United Arab Emirates, Saudi Arabia, and Iran for the management of a wide range of ailments. Ethnomedicinal uses include treatment for inflammatory conditions, respiratory problems, digestive disorders, metabolic ailments, and skin-related complaints. These traditional claims have motivated phytochemical and pharmacological investigations that have identified flavonoids, tannins, alkaloids, steroids, fatty acids, and other bioactive compounds from different parts of the tree. Recent reviews continue to report antioxidant, antimicrobial, anti-inflammatory, antidiabetic, antitumor, wound-healing, and other biological activities, suggesting that the species has significant pharmacological promise (Sharifi *et al.*, 2019; Zhong *et al.*, 2022; Gupta, 2024) [5, 6, 2]. The growing scientific interest in *P. cineraria* reflects the broader recognition that dryland trees can provide intersecting ecological, nutritional, medicinal, and economic benefits. Recent review literature on the genus *Prosopis* emphasizes the diversity of phytochemicals and bioactivities present in these species and highlights their potential applications in food, feed, and medicine. For *P. cineraria* specifically, newer work has continued to consolidate evidence for its traditional uses and bioactive potential while also pointing to the need for more rigorous studies on compound isolation, mechanism of action, dosage standardization, and safety assessment. In parallel, ecological studies are increasingly examining its role in soil restoration, agroforestry performance, and carbon dynamics, showing that the species has relevance far beyond ethnobotany and pharmacology (Chaudhary *et al.*, 2018; Zhong *et al.*, 2022;) [1, 2].

Despite its importance, several knowledge gaps remain. Propagation and domestication methods are still not fully optimized, which limits large-scale plantation and restoration programs. Similarly, long-term field studies on growth performance, ecosystem service delivery, and climate resilience are still limited, particularly under changing environmental conditions. On the medicinal side, many reported bioactivities are based on extract-level studies, and there is a need for deeper chemical characterization, standardized experimental validation, and translational research to assess real-world applicability. Addressing these gaps will be crucial if the species is to be used more effectively in restoration, agroforestry, nutrition, and product development (Tewari *et al.*, 1998; Sasi *et al.*, 2024) [7, 4].

This review therefore examines *Prosopis cineraria* as a multifunctional desert tree with importance across ecology, agriculture, nutrition, medicine, and sustainable rural development. It synthesizes recent evidence on its ecological roles, soil-improving capacity, phytochemical profile, nutritional value, and pharmacological properties, while also highlighting conservation priorities and future research directions. By bringing together these diverse strands of evidence, the review aims to present *P. cineraria* not simply as a traditional desert species, but as a strategic biological resource for resilient dryland futures (Sharifi *et al.*, 2019; Zhong *et al.*, 2022; Gupta, 2024) [5, 6, 2].

## 2. Botanical description and distribution

*Prosopis cineraria* (L.) Druce is a medium-sized, slow-growing, drought-adapted tree of the Fabaceae family that typically reaches 5–15 m in height, with a spreading canopy that may extend 8–12 m under favorable conditions. It is one of the most characteristic woody species of the hot arid and semi-arid regions of South Asia and the Arabian Peninsula, where it plays a central role in both natural ecosystems and traditional farming landscapes. In India, the species is especially associated with Rajasthan, but it also occurs in Haryana, Gujarat, Punjab, and adjoining dry tracts where native dryland trees remain embedded in agroecosystems. Its broad ecological amplitude and cultural importance have made it a focal species in recent Indian conservation and geospatial studies (Handa *et al.*, 2023; Mathur *et al.*, 2025) [8, 9].

The bark of mature trees is gray to brownish-gray, thick, and deeply fissured, a feature commonly interpreted as an adaptation to intense heat and prolonged water stress. The root system is exceptionally deep and extensive, allowing the tree to access moisture from deep soil layers and groundwater reserves, which is a major reason for its persistence in rainfall-deficient landscapes. Recent Indian modelling work has reinforced the importance of this drought-adapted life history by showing that the species remains dominant in zones where climatic stress is high but suitable arid conditions persist. These structural traits together explain why *P. cineraria* is often described as one of the most resilient native trees of dry India (Orwa, 2009; Mathur *et al.*, 2025) [3, 9].

The leaves are bipinnate and compound, usually small and highly adapted to water conservation. Their reduced size, fine structure, and overall architecture help limit transpiration loss, while also providing palatable and nutritious fodder for livestock during dry months. The flowers are small, creamy-white, and borne in axillary racemes, with flowering generally occurring in the spring to early summer period depending on local climate. These flowers are attractive to pollinators and contribute to the tree's ecological role in supporting dryland biodiversity (Handa *et al.*, 2023; Mathur *et al.*, 2025) [8, 9].

The pods are linear, flat, and become brownish-yellow at maturity, usually containing several seeds that have traditional food and feed value. In Indian rural systems, the pods and leaves are used seasonally, especially when other fodder resources are limited, which increases the practical value of the species in arid livelihoods. This dual importance as both an ecological stabilizer and a livelihood resource makes the species highly significant in dryland India. It is therefore not only a tree of botanical interest but also a species of economic and cultural consequence (Orwa, 2009; Handa *et al.*, 2023) [3, 8].

*Prosopis cineraria* shows remarkable tolerance to drought, heat, and salinity, enabling it to survive in some of the harshest environments of the subcontinent. It grows in sandy loam, clay loam, dune systems, and rocky desert soils, and its occurrence is often associated with low and erratic rainfall regimes. Recent literature continues to highlight its wide environmental tolerance, particularly its ability to persist under strong temperature extremes and poor soil conditions, which supports its use in arid-zone restoration and climate-resilient agroforestry. These adaptive traits are central to the species' persistence in both managed and unmanaged dryland habitats (Orwa, 2009; Mathur et al., 2025) [3, 9].

The species is distributed mainly across South Asia and the Arabian Peninsula, with India representing one of its most important natural and cultural strongholds. In India, it is concentrated in Rajasthan and other western dry regions, while also occurring in Haryana, Gujarat, Punjab, and nearby arid areas. Beyond India, it is present in Pakistan

and several Arabian countries, including the United Arab Emirates, Saudi Arabia, Oman, and Yemen, where it is widely known as Ghaf. The 2025 geospatial study further indicates that its dominance is strongly shaped by climate variables, with major habitat suitability across arid western India (Handa et al., 2023; Mathur et al., 2025) [8, 9].

The species is typically found on sand dunes, plains, and dry rocky terrain, usually at low to moderate elevations in arid landscapes. Although it is naturally associated with very low rainfall regions, it performs best in dry habitats where annual precipitation remains within a range that still supports long-term survival and regeneration. In India, the tree is especially emblematic of the Thar Desert and surrounding dry belts, where it has become embedded in agroforestry, livestock systems, and cultural traditions. This makes *P. cineraria* a key native species for conservation and sustainable dryland management (Orwa, 2009; Handa et al., 2023) [3, 8].

**Table 1.** Taxonomy, common names, distribution, and ecological requirements of *Prosopis cineraria* (L.) Druce

| Category                            | Information                                                                                                                                                                                                                                     |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Scientific name                     | <i>Prosopis cineraria</i> (L.) Druce                                                                                                                                                                                                            |
| Synonym                             | <i>Prosopis spicigera</i> L.                                                                                                                                                                                                                    |
| Family                              | Fabaceae                                                                                                                                                                                                                                        |
| Origin                              | Arid and semi-arid regions of South Asia and the Arabian Peninsula                                                                                                                                                                              |
| Common names                        | India: Khejri, Jandi; Pakistan: Jand; United Arab Emirates, Saudi Arabia, Oman: Ghaf                                                                                                                                                            |
| Major distribution                  | India: Rajasthan, Haryana, Gujarat, Punjab; Pakistan: Punjab, Sindh, Balochistan; United Arab Emirates: arid central and eastern regions; Saudi Arabia: arid central and eastern regions; Oman: arid regions; Sudan and Egypt: dry desert zones |
| Typical rainfall in natural habitat | Very low rainfall conditions, especially arid and semi-arid zones                                                                                                                                                                               |
| Altitude                            | Low to moderate elevations in dry regions                                                                                                                                                                                                       |
| Temperature tolerance               | High heat tolerance and strong drought resilience                                                                                                                                                                                               |
| Preferred soil types                | Sandy loam, clay loam, dunes, and rocky arid soils                                                                                                                                                                                              |
| Adaptation                          | Deep-rooted, nitrogen-fixing, drought-resistant dryland tree                                                                                                                                                                                    |

Sources: (Orwa, 2009; Handa et al., 2023; Gupta, 2024; Mathur et al., 2025) [5, 8, 9, 3]

3. Ecological significance

*Prosopis cineraria* functions as a keystone species in arid and semi-arid ecosystems because it supports soil fertility, stabilizes fragile landscapes, and enhances biological productivity under extreme environmental stress. Its ecological importance in India is especially evident in Rajasthan and adjoining dry regions, where the tree persists in agroforestry and rangeland systems that depend on native drought-hardy vegetation. Recent literature continues to emphasize that the species is not only a useful tree but also a regulator of dryland ecosys-

tem function, linking water, soil, plants, livestock, and human use (Baibout et al., 2022; Mathur et al., 2025) [10, 9].

As a leguminous tree, *P. cineraria* fixes atmospheric nitrogen through symbiosis with rhizobial bacteria in root nodules, thereby enriching soil nitrogen availability for associated plants. This process is central to its role in nutrient cycling and is one reason it is widely retained in traditional farming systems of western India. The tree also contributes organic matter through leaf litter, root turnover, and pruning residues, which improves soil structure and supports microbial activity. In dryland environments where soil fertility is typically low, these processes make the species especially valuable for sustaining long-term productivity (Kaushik et al., 2003; Handa et al., 2023) [11, 8].

**Table 2.** Ecological functions of *Prosopis cineraria* in arid agroforestry systems

| Category               | Parameter                        | Observation                                                             | Comparative Effect                              |
|------------------------|----------------------------------|-------------------------------------------------------------------------|-------------------------------------------------|
| Nitrogen fixation      | Symbiosis with rhizobia          | Root nodules fix atmospheric nitrogen                                   | Improves soil nitrogen availability             |
| Soil fertility         | Organic matter input             | Leaf litter and fine-root turnover                                      | Raises soil organic carbon and nutrient cycling |
| Soil biological health | Microbial activity               | Higher under tree canopy than open field                                | Supports richer soil biota                      |
| Crop support           | Shade and microclimate buffering | Canopy reduces heat and moisture stress                                 | Improves understorey crop performance           |
| Erosion control        | Sand binding                     | Extensive roots stabilize soil and dunes                                | Reduces wind erosion and desertification        |
| Biodiversity support   | Habitat and food supply          | Flowers, pods, canopy, and litter support insects, birds, and livestock | Enhances dryland biodiversity                   |

(continued on next page)

| Category           | Parameter                | Observation                                                    | Comparative Effect             |
|--------------------|--------------------------|----------------------------------------------------------------|--------------------------------|
| Agroforestry value | Compatibility with crops | Deep roots reduce direct competition with shallow-rooted crops | Supports mixed farming systems |

**Sources:** (Kaushik *et al.*, 2003; Kumar *et al.*, 2018; Baibout *et al.*, 2022; Mathur *et al.*, 2025) [10, 11, 12, 9]

The ecological value of *P. cineraria* extends strongly into soil restoration and carbon storage. Recent Indian literature and ecosystem-service reviews note that the tree improves soil organic carbon, supports nutrient retention, and contributes to long-term land rehabilitation in degraded drylands. A study from western Rajasthan reported that canopy effects can significantly moderate soil temperature and light interception, creating better conditions for understorey growth in arid agroforestry systems. Such microclimatic buffering helps crops and grasses survive high heat and moisture stress, which is especially important in desert agriculture (Kumar *et al.*, 2018; Pareek *et al.*, 2024) [12, 13].

The tree also plays a major role in desertification control. Its deep and widespread root system stabilizes sandy substrates, while the canopy reduces wind velocity and surface evaporation, thereby limiting aeolian soil loss. These functions are particularly relevant in Rajasthan, where *P. cineraria* is widely regarded as a protective tree against dune movement and land degradation. The species is therefore not only a component of dryland vegetation but also a natural infrastructure for maintaining landscape stability in highly vulnerable environments (Kaushik *et al.*, 2003; Pareek *et al.*, 2024) [11, 13].

**Table 3.** Crop productivity and microclimate benefits associated with *Prosopis cineraria*

| Category           | Parameter                                  | Observation                                  | Comparative Effect                    |
|--------------------|--------------------------------------------|----------------------------------------------|---------------------------------------|
| Microclimate       | Soil temperature under canopy              | About 5–8 °C lower than open field           | Reduces heat stress on crops          |
| Microclimate       | Light interception                         | Higher near canopy, moderates radiation load | Improves understorey conditions       |
| Crop yield         | Rainfed fodder and grain crops             | Yield increases reported under tree cover    | Better performance than sole cropping |
| Crop compatibility | Deep-rooted tree with shallow-rooted crops | Minimal below-ground competition             | Enables agroforestry integration      |
| Rangeland support  | Grass production under canopy              | Improved grass growth under tree cover       | Enhances forage availability          |

**Sources:** (Nagarajan, 2000 [14]; Kaushik *et al.*, 2003 [11]; Kumar *et al.*, 2018; Baibout *et al.*, 2022 [10]; Pareek *et al.*, 2024)

Biodiversity support is another major dimension of the species' ecological role. The creamy-white flowers are attractive to bees and other pollinators, making the tree important for honey production and pollinator conservation in dry regions. Its pods and canopy also provide food and shelter for birds, insects, reptiles, and small mammals, creating microhabitats in otherwise resource-poor landscapes. In this way, *P. cineraria* helps maintain dryland food webs and supports ecological interactions that would otherwise be limited by extreme aridity (Nagarajan, 2000; Pareek *et al.*, 2024) [14, 13].

The species is also strongly linked to agroforestry productivity in India. Older field studies from arid Haryana showed that crops grown in association with Khejri often performed better than sole crops, with improved fodder and grain yields under tree-based systems. More recent Indian studies continue to show that microclimate modification under *P. cineraria* can benefit understorey crops such as cactus pear by reducing temperature stress and improving moisture retention. This makes the tree highly relevant to climate-resilient agriculture, particularly where farming must continue under hot and water-limited conditions (Baibout *et al.*, 2022; Mathur *et al.*, 2025) [10, 9].

The presence of *P. cineraria* is also culturally and practically associated with underground water in desert areas. Because the species can develop exceptionally deep roots, its growth is often linked to access to subsurface moisture and groundwater. This trait has historically made it useful as a field indicator of water availability and as a dependable perennial element in arid farming landscapes. Its survival during prolonged drought therefore reflects both its physiological re-

silience and its ecological importance in water-limited ecosystems (Kumar *et al.*, 2018; Pareek *et al.*, 2024) [12, 13].

#### 4. Nutritional, ethnobotanical, and livelihood importance

*Prosopis cineraria* is more than a drought-tolerant desert tree; it is also an important food and livelihood species in arid and semi-arid regions of India and the Arabian Peninsula. Recent reviews describe the species as a promising functional food because its pods, leaves, and other edible parts contain proteins, dietary fiber, minerals, fatty acids, and diverse phytochemicals with potential health benefits. In dryland communities, this nutritional value matters because the tree provides food and feed during periods when crops fail and other forage sources become scarce (Chaudhary *et al.*, 2018; Singh *et al.*, 2024) [1, 15].

The pods of *P. cineraria* are the most widely discussed edible part in recent literature. A 2022 biochemical study identified the edible pods as a novel source of antioxidant flavonoids and isoflavonoids, strengthening the argument that the species has value beyond traditional use and should be considered in future food-development research. Earlier and recent review papers also highlight the use of pods in local diets and their possible role in functional foods, especially in communities that depend on native dryland plants for seasonal nutrition. Because the species grows in harsh environments where conventional crops are less reliable, its food value is particularly relevant for nutritional security in arid India (Asati *et al.*, 2022; Singh *et al.*, 2024) [16, 15].

**Table 4.** Nutritional, ethnobotanical, and livelihood importance of *Prosopis cineraria*

| Category            | Parameter                   | Observation                                                 | Comparative Effect                           |
|---------------------|-----------------------------|-------------------------------------------------------------|----------------------------------------------|
| Nutritional value   | Pods                        | Rich in flavonoids and isoflavonoids                        | Functional food potential                    |
| Nutritional value   | Leaves and pods             | Contain protein, fiber, minerals, and fatty acids           | Supports human and livestock nutrition       |
| Health value        | Bioactive compounds         | Antioxidant and health-promoting phytochemicals             | Potential nutraceutical use                  |
| Ethnobotanical use  | Food resource               | Used traditionally as seasonal food in dry regions          | Supports food security                       |
| Ethnobotanical use  | Fodder resource             | Leaves used as livestock feed during dry months             | Reduces fodder shortage                      |
| Livelihood value    | Rural survival              | Supports households in arid and semi-arid areas             | Improves resilience under drought            |
| Medicinal relevance | Traditional medicine        | Used in folk remedies for several ailments                  | Links indigenous knowledge with pharmacology |
| Product potential   | Functional food development | Underutilized desert legume with food application potential | Scope for value-added products               |

**Sources:** (Chaudhary *et al.*, 2018; Asati *et al.*, 2022; Singh *et al.*, 2024; Mathur *et al.*, 2025) [16, 1, 9, 15]

Ethnobotanical records show that *P. cineraria* has been used in local medicine and household food systems for a long time. In Indian drylands, leaves are commonly used as fodder, while pods and other plant parts are incorporated into traditional diets and folk remedies. This multifunctional use pattern explains why the species has been conserved in many rural landscapes despite increasing pressure from changing land use and declining natural regeneration. It also shows that the tree serves as a practical biological resource rather than a purely symbolic one (Chaudhary *et al.*, 2018; Mathur *et al.*, 2025) [1, 9].

Recent pharmacological reviews add another layer to the species' importance by linking its traditional uses to measurable biological activity. A 2024 review summarized antioxidant, antimicrobial, anti-inflammatory, and other health-related properties of *P. cineraria*, and emphasized that many of these effects may be associated with C-glycosyl flavones and related compounds. Broader *Prosopis* literature similarly notes that the genus contains many compounds with biological activity, including flavonoids, tannins, and phenolic constituents that support medicinal and nutritional applications. These findings suggest that the species deserves further investigation as a source of food ingredients and natural health products, especially in India where local knowledge and biodiversity provide a strong foundation for applied research (Baibout *et al.*, 2022; Singh *et al.*, 2024) [10, 15].

From a livelihood perspective, the species is valuable because it supports both household resilience and livestock systems. During dry months, when cultivated fodder and wild forage are limited, *P. cineraria* leaves and pods help bridge feed shortages and reduce pressure on other vegetation. This is one reason the species has remained central to traditional agro-pastoral systems in Rajasthan and neighboring dry regions. Its nutritional and ethnobotanical importance therefore connects directly with sustainable rural development, food security, and conservation (Asati *et al.*, 2022; Mathur *et al.*, 2025) [16, 9].

## 5. Phytochemistry and pharmacological relevance

Recent studies have shown that *Prosopis cineraria* is a chemically rich medicinal tree whose different parts contain a broad range of bioactive compounds with potential nutritional and therapeutic value. Phytochemical investigations have consistently reported the presence of flavonoids, tannins, alkaloids, steroids, phenolics, saponins, glycosides, and related secondary metabolites in leaves, bark, pods, and seeds. In particular, recent Indian work has highlighted that the leaves and pods are among the richest sources of metabolites, followed by flowers, seeds, and stem tissues. This chemical diversity explains why

the species continues to attract attention in both traditional medicine and modern natural-product research (Garg *et al.*, 2013; Kalim *et al.*, 2024) [17, 18].

A major focus of recent literature has been the flavonoid-rich nature of the plant, especially in edible pods. A 2022 study identified the edible pods as a novel source of antioxidant flavonoids and isoflavonoids, supporting their potential use in functional foods and nutraceutical development. Broader genus-level reviews also report phenolic acids and flavonoids such as gallic acid, rutin, luteolin, quercetin derivatives, protocatechuic acid, chlorogenic acid, caffeic acid, and ferulic acid in *P. cineraria* and related *Prosopis* species. These compounds are important because they are strongly associated with antioxidant, anti-inflammatory, antidiabetic, and antimicrobial effects in plant-based bioactive research (Asati *et al.*, 2022; Zhong *et al.*, 2022) [16, 2].

## 6. Propagation, conservation, and future prospects

*Prosopis cineraria* remains an important species for dryland restoration and agroforestry, but its large-scale multiplication is still constrained by propagation challenges and uneven regeneration in the field. Recent review literature notes that conventional propagation is often slow or inconsistent, which is a major limitation for reforestation, farm tree planting, and conservation programs. For this reason, recent studies increasingly emphasize both seed-based methods and tissue-culture approaches as practical routes for mass multiplication. These approaches are especially important in India, where demand for native drought-hardy trees is rising under climate and land-degradation pressures (Shekhawat *et al.*, 1993; Kumar *et al.*, 2024) [23, 22].

Seed propagation is the most common and practical method, but it is affected by hard seed coat dormancy, which reduces germination unless pre-treatments such as scarification or soaking are applied. Recent propagation guidance also states that seed is generally preferred over cuttings because cuttings are difficult to root consistently, although air layering, root suckers, and hormonal treatment can improve success. In vitro studies have further shown that *P. cineraria* can be cloned successfully under controlled conditions, with shoot induction and rooting influenced by explant type, genotype, season, and growth regulators. A 2024 review of tissue-culture methods concluded that micropropagation is a promising tool for rapid mass multiplication and conservation of the species (Sandison *et al.*, 1991; Kumar *et al.*, 2024) [24, 22].

Table 5. Major phytochemicals and pharmacological activities reported in *Prosopis cineraria*

| Plant part              | Major phytochemicals reported                                             | Main pharmacological activities reported                                                      | Notes / relevance                                                                             |
|-------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Leaves                  | Flavonoids, tannins, phenolics, alkaloids, steroids, glycosides, saponins | Antioxidant, antimicrobial, <i>anti</i> -inflammatory, antidiabetic                           | Leaves are one of the most studied parts and are important for standardization and herbal use |
| Pods                    | Flavonoids, isoflavonoids, phenolic acids, dietary fiber                  | Antioxidant, nutraceutical, health-promoting, possible antidiabetic effects                   | Pods have strong potential as a functional food source                                        |
| Bark                    | Phenolics, tannins, flavonoids, sterols, alkaloids                        | Antioxidant, <i>anti</i> -inflammatory, spasmolytic, bronchodilator, vasodilator              | Bark has long been used in experimental pharmacology and ethnomedicine                        |
| Seeds                   | Proteins, fatty acids, phenolics, sterols                                 | Antioxidant, nutritional support, possible metabolic benefits                                 | Seeds add nutritional value, though they are less studied than leaves and pods                |
| Whole plant extracts    | Flavonoids, tannins, alkaloids, phenolic compounds                        | Antioxidant, antimicrobial, antihyperglycemic, antitumor, anticancer                          | Extract-level studies support the medicinal potential of the species                          |
| Traditional use context | Mixed bioactive secondary metabolites                                     | Folk use for inflammation, digestive issues, respiratory problems, and general health support | Traditional uses provide the basis for modern pharmacological exploration                     |

Sources: (Janbaz *et al.*, 2012; Garg *et al.*, 2013; Yamini *et al.*, 2023; Kalim *et al.*, 2024) [17, 19, 18, 20]

Table 6. Propagation methods and conservation relevance of *Prosopis cineraria*

| Category               | Parameter                   | Observation                                                      | Comparative Effect                        |
|------------------------|-----------------------------|------------------------------------------------------------------|-------------------------------------------|
| Seed propagation       | Dormancy                    | Hard seed coat limits germination                                | Requires scarification or soaking         |
| Vegetative propagation | Cuttings                    | Rooting is difficult without hormonal support                    | Lower success than seed or tissue culture |
| Vegetative propagation | Air layering / root suckers | Better success than stem cuttings                                | Useful for clonal multiplication          |
| Micropropagation       | In vitro culture            | Shoots can be induced from nodal and root/stump explants         | Suitable for rapid mass production        |
| Conservation           | Natural regeneration        | Limited in some dryland regions due to grazing and land pressure | Requires active protection                |
| Restoration            | Plantation use              | Appropriate for dryland rehabilitation and agroforestry          | Supports native tree restoration          |

Sources: (Shekhawat *et al.*, 1993; Kumar *et al.*, 2024; Mathur *et al.*, 2025) [22, 9, 23]

Conservation is increasingly important because the species is under pressure from overgrazing, fuelwood collection, reduced regeneration, and habitat fragmentation. Although global plant databases do not classify it as highly threatened at the species level, regional genetic erosion and local decline remain concerns, especially in heavily used drylands. This means that conservation must be understood not only as species preservation but also as protection of local populations and genetic diversity adapted to extreme arid conditions. Indian dryland landscapes are particularly important in this respect because they contain some of the strongest remaining farm-based populations of *Khejri* (Handa *et al.*, 2023; Mathur *et al.*, 2025) [8, 9].

Recent geospatial work has made conservation planning more precise by identifying suitable habitats and dominance zones across arid India. This kind of modelling can help prioritize areas for planting, regeneration, and protection, particularly in Rajasthan where the species remains ecologically and culturally central. At the same time, ecosystem-service studies show that the tree delivers measurable benefits in terms of microclimate regulation, soil improvement, and carbon storage, strengthening the case for its inclusion in climate adaptation and land restoration projects. The combination of ecological value and livelihood support makes conservation of *P. cineraria* a practical necessity rather than a purely botanical concern (Pareek *et al.*, 2024; Mathur *et al.*, 2025) [13, 9].

From a future-perspective standpoint, the species has strong potential in climate-resilient agroforestry, carbon farming, and desert restoration programs. Its deep root system, nitrogen fixation, and compatibility with dryland crops make it a highly strategic native tree for sustainable farming systems in western India. New research on microclimate moderation and soil carbon shows that retaining *P. cineraria* in agricultural landscapes can enhance both productivity and resilience. This positions the species as a model for nature-based solutions in hot, water-limited regions (Handa *et al.*, 2023; Kumar *et al.*, 2024) [8, 22].

Future work should focus on standardizing propagation protocols, assessing genetic variability across populations, and linking conservation with farmer-led management. There is also a clear need for long-term trials that compare seedling performance, tissue-culture plantlets, and field survival under different arid-zone conditions. If these gaps are addressed, *P. cineraria* could play an even larger role in ecological restoration, rural livelihoods, and sustainable dryland development in India and beyond (Kumar *et al.*, 2024; Mathur *et al.*, 2025) [22, 9].

## 7. Research gaps and future directions

Although *Prosopis cineraria* has received growing attention for its ecological, nutritional, and medicinal value, the literature still shows clear gaps that limit broader scientific and practical use. Recent reviews continue to note that the evidence base is fragmented across ecology, agroforestry, phytochemistry, and pharmacology, with many studies relying on short-term observations or laboratory screening rather than long-term field validation. This is especially evident in India, where research is concentrated mainly in Rajasthan and a few neighboring dry regions, while many other native populations across the Thar landscape remain under-documented (Manisha *et al.*, 2020; Nemade *et al.*, 2026) [25, 26].

A major gap is the lack of standardized propagation and plantation protocols for large-scale restoration. Seed dormancy, uneven germination, and poor seedling establishment remain practical constraints, and although tissue-culture methods have shown promise, they are still not widely translated into field-scale planting programs. Recent review discussions also point to the need for more reliable clonal systems and nursery practices that can produce uniform planting stock for dryland forestry and agroforestry. Future work should therefore compare seed-based and clonal propagation under different arid-zone conditions and identify the most effective pretreatments, substrates, and nursery management approaches (Rai *et al.*, 2020; Nemade *et al.*, 2026) [26].

Another limitation is the incomplete understanding of genetic and ecological variation across populations. Trees from different regions may differ in drought tolerance, growth rate, biomass accumulation, fodder quality, and phytochemical composition, yet this variation is still poorly mapped. Genomic and biotechnological work suggests that more molecular research would improve the use of *P. cineraria* in stress-tolerance breeding and conservation planning. For future restoration and product-development efforts, it will be important to identify superior genotypes and conserve locally adapted genetic resources before they are lost through land-use pressure and habitat fragmentation (Rai *et al.*, 2020; Mathur *et al.*, 2025) [9].

The ecosystem-service literature also needs stronger quantitative support. Although *P. cineraria* is widely recognized as a soil-improving, microclimate-buffering, and carbon-contributing tree, comparative measurements across soil types, plantation densities, rainfall gradients, and cropping systems remain limited. Recent studies show positive effects on soil carbon, canopy microclimate, and arid agroforestry performance, but more standardized long-term trials are still needed to separate tree effects from site-specific variation. Such data would help refine recommendations for dryland farming, rangeland improvement, and desert restoration (Kumar *et al.*, 2018; Eschen *et al.*, 2023) [12, 27].

The pharmacological literature likewise remains at an early stage. Most studies focus on crude extracts, in vitro bioassays, and preliminary screening of antioxidant or antimicrobial activity, while detailed mechanism-based studies and clinical validation are still scarce. Recent reviews emphasize the need for comprehensive phytochemical profiling, standardized extraction, toxicological assessment, and molecular target identification before therapeutic claims can be translated into products or medicine. This is particularly important because chemical composition can vary with geography, season, and plant part, which affects reproducibility and bioactivity (Awasthi *et al.*, 2024; Nemade *et al.*, 2026) [28, 26].

From a conservation perspective, future work should connect scientific research with local livelihoods and farmer participation. The species remains deeply embedded in traditional agro-pastoral systems, and conservation efforts will be more effective if they support community use rather than treating the tree only as a protected wild resource. Integrating *P. cineraria* into agroforestry policy, carbon farming, and dryland restoration programs could strengthen both ecological resilience and rural income security. In this sense, the tree should be viewed as a long-term ecological and socio-economic asset for arid landscapes rather than a single-purpose species (Rai *et al.*, 2020; Mathur *et al.*, 2025) [9].

## Conclusion

This review shows that *Prosopis cineraria* is one of the most important native trees of the arid and semi-arid regions of India and the wider drylands of South Asia and the Arabian Peninsula. Across the literature, the species is consistently described as a keystone desert tree because it survives under severe drought, improves soil fertility through nitrogen fixation, stabilizes sandy soils, supports biodiversity, and contributes to microclimatic buffering in fragile dryland landscapes. The reviewed studies also confirm that the tree has major value in Indian agroforestry systems, especially in Rajasthan and adjoining dry regions, where it is retained in farmland for shade, fodder, soil improvement, and crop support. Recent work further shows that the species contributes to soil organic carbon, microbial activity, and crop productivity, reinforcing its role in climate-resilient land-use systems. These ecosystem services make *P. cineraria* highly relevant for dryland restoration and sustainable agriculture.

In addition to its ecological value, *P. cineraria* is important for rural livelihoods and traditional knowledge systems. Its leaves and pods are used as fodder and seasonal food resources, while its bark, leaves, and pods have long been used in ethnomedicine. Recent Indian and international studies also report the presence of flavonoids, phenolics, tannins, alkaloids, sterols, and other bioactive compounds, along with antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and other

pharmacological activities. However, the literature also makes clear that important gaps remain. Propagation is still limited by seed dormancy and inconsistent regeneration, while conservation is challenged by grazing pressure, habitat loss, and reduced natural recruitment. Similarly, medicinal studies are often based on crude extracts and require stronger standardization, toxicity testing, and clinical validation before practical application. Future research should therefore focus on improved propagation methods, long-term field studies, habitat modelling, genetic conservation, and rigorous phytochemical and pharmacological validation.

Overall, the evidence in this review supports the view that *Prosopis cineraria* is not only a desert tree but a multifunctional resource species with ecological, agricultural, nutritional, medicinal, and cultural importance. Its conservation and promotion should be treated as a priority in dryland India, where native trees are essential for resilience, productivity, and sustainable development.

## References

- Chaudhary KK, Kumar G, Varshney A, Meghvansi MK, Ali SF, Karthik K, Kaul RK. Ethnopharmacological and phytopharmaceutical evaluation of *Prosopis cineraria*: An overview and future prospects. *Current drug metabolism*. 2018;19(3):192-214.
- Zhong J, Lu P, Wu H, Liu Z, Sharifi-Rad J, Setzer WN, Suleria HA. Current insights into phytochemistry, nutritional, and pharmacological properties of *Prosopis* plants. *Evidence-Based Complementary and Alternative Medicine*. 2022;2022(1):2218029.
- Orwa C. Agroforestry Database: a tree reference and selection guide, version 4.0. <http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp>. 2009.
- Sasi S, Krishnan S, Kodackattumannil P, Kottackal M, Amiri KM. Learning from the desert legume tree, *Prosopis cineraria* to develop stress-tolerant crops. *Environmental and Experimental Botany*. 2024;228:106003.
- Gupta A. *Prosopis cineraria* pharmacological properties and health benefits: A review study of a potential herb of the Thar Desert. *Int J Pharmacogn Life Sci*. 2024;5(2B):91-103.
- Sharifi-Rad J, Kobarfard F, Ata A, Ayatollahi SA, Khosravi-Dehaghi N, Jugran AK, Martins N. *Prosopis* plant chemical composition and pharmacological attributes: Targeting clinical studies from preclinical evidence. *Biomolecules*. 2019;9(12):777.
- Tewari JC, Pasiecznik NM, Harsh LN, Harris PJC, editors. *Prosopis* species in the arid and semi-arid zones of India. Proceedings of a conference held at the Central Arid Zone Research Institute, Jodhpur, Rajasthan, India, November 21-23, 1993. 1998:iv+127.
- Handa AK, Rizvi RH, Arunachalam A, Singh RK, Dhyani SK, Rizvi J, Yadav M. *Azadirachta indica* and *Prosopis cineraria* species contribution to agroforestry/tree cover in arid region of Rajasthan. *Indian Journal of Agroforestry*. 2023;25(1):133-136.
- Mathur M, Mathur P. Geospatial modelling of *Prosopis cineraria* (L.) Druce dominance using interpolation and machine learning techniques in arid landscapes of India. *Environmental Monitoring and Assessment*. 2025;197(12):1-32.
- Baibout M, Corcket E, Kothari SL, Fievet V. Ecosystem services provided by *Prosopis cineraria* (L.) Druce in the drylands of Southern and Western Asia. *Botany Letters*. 2022;169(1):30-42.
- Kaushik N, Kumar V. Khejri (*Prosopis cineraria*)-based agroforestry system for arid Haryana, India. *Journal of Arid Environments*. 2003;55(3):433-440.
- Kumar M, Kumar S, Uthappa AR, Kalappurakkal S. Influence of *Prosopis cineraria* L. on microclimate conditions under agroforestry system in arid region of India. *Indian Journal of Agroforestry*. 2018;20(1):35-39.
- Pareek L, Yadav VS, Tripathi SL, Yadav S. Impact of *Prosopis cineraria* on soil organic carbon: Implication for arid agroforestry with a case study of Sardarshahar, Rajasthan. *International Journal of Environment, Agriculture and Biotechnology*. 2024.
- Nagarajan M. Role of agroforestry in controlling desertification with special reference to *Prosopis cineraria* (Linn) Druce in arid farming of western Rajasthan. *LEISA Newsletter*. 2000;2(1):8-10.
- Singh N, Pareek A. *Prosopis cineraria*: a potential functional food for improving sports performance. *Vegetos*. 2024;37(1):1-5.
- Asati V, Deepa PR, Sharma PK. Desert legume *Prosopis cineraria* as a novel source of antioxidant flavonoids/isoflavonoids: Biochemical characterization of edible pods for potential functional food development. *Biochemistry and Biophysics Reports*. 2022;29:101210.
- Garg A, Mittal SK. Review on *Prosopis cineraria*: A potential herb of Thar desert. *Drug invention today*. 2013;5(1):60-65.
- Kalim S, Kumar M, Khare A. Phytochemical and chromatographic analysis of *Prosopis cineraria* in different polar solvents. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*. 2024;15(3):167-173.
- Janbaz KH, Haider S, Imran I, Zia-Ul-Haq M, De Martino L, De Feo V. Pharmacological evaluation of *Prosopis cineraria* (L.) Druce in gastrointestinal, respiratory, and vascular disorders. *Evidence-Based Complementary and Alternative Medicine*. 2012;2012(1):735653.
- Yamini SSS. Extraction of *Prosopis cineraria* from Bikaner, Rajasthan of India-detection of compounds via GCMS, calibration via HPLC, UV, FTIR, FESEM EDAX-an anti-cancer agent for blood cancer with validated IC<sub>50</sub> via testing over country eggs. *Ayushdhara*. 2023:34-50.
- Malik A, Kalidhar S. Phytochemical examination of *Prosopis cineraria* L. (Druce) leaves. *Indian Journal of Pharmaceutical Sciences*. 2007;69(4):576-576.
- Kumar R, Bhandari S, Sarita. Plant tissue culture techniques for in vitro mass multiplication of *Prosopis cineraria* (L.) in Thar Desert of Rajasthan. 2024.
- Shekhawat NS, Rathore TS, Singh RP, Deora NS, Rao SR. Factors affecting in vitro clonal propagation of *Prosopis cineraria*. *Plant Growth Regulation*. 1993;12(3):273-280.
- Sandison MS, Harris PJC, Hussain I. *Prosopis cineraria*: A multi-purpose tree for arid areas (NFTA 91-04). Nitrogen Fixing Tree Association. 1991.
- Manisha, Garg NK. Therapeutic uses of Khejri (*Prosopis cineraria*): A review article. *World Journal of Pharmaceutical and Medical Research*. 2020;6(6):135-138.
- Nemade CT, Baste NS, Bihani MM, Surse S, Gawali SR. Update on phytochemistry and pharmacology of Shami (*Prosopis cineraria* (L.) Druce): A review. *Journal of Pharmacognosy and Phytochemistry*. 2026;15(3):414-424.
- Eschen R, Bekele K, Jumanne Y, Kibet S, Makale F, Mbwambo JR, Schaffner U. Experimental *Prosopis* management practices and grassland restoration in three Eastern African countries. *CABI Agriculture and Bioscience*. 2023;4(1):21.
- Awasthi S, Arya KY, Tripathy P, Shahi S. *Prosopis cineraria*: A multifaceted tree: From cultural significance to medicinal potential. *Afr J Biomed Res*. 2024;27(4s):9848-54.

29. Rai MK, Shekhawat JK, Vinod K, Mahendra P, Shekhawat NS. Genomic and biotechnological interventions in *Prosopis cineraria*: current status, challenges and opportunities. *Trees*. 2021;35(4):1109-1121.

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