Review Article

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# *Ziziphus nummularia* (Burm. f.) Wight & Arn.: A versatile array of fruits from the Indian Thar Desert-A review

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## ABSTRACT

The recognition of diversity among plant species highlights the importance of utilizing neglected and underutilized plants, which play a crucial role in ensuring food security, providing livestock feed, generating income, and meeting the energy requirements of rural communities. This approach promotes sustainable food security by diversifying our food sources, rather than depending solely on staple crops, which can create a limited food supply and increase vulnerability. Although dietary diversification and the supply of essential micronutrients like vitamins and minerals hold significant promise for reducing risks in agricultural production systems, they remain underexplored in research and development. This neglect may result in genetic erosion. *Ziziphus nummularia* is a plant species whose entire structure-fruits, leaves, branches, and roots-holds considerable economic value in rural communities. For instance, ripe fruits are consumed fresh, leaves serve as fodder, thorny branches are used for fencing farm boundaries, and wood is utilized for fuel and the creation of local agricultural tools, in addition to its applications in traditional medicine. In addition, this plant is capable of thriving under environmental pressures such as high temperatures, significant wind speeds, and low moisture availability, making it appropriate for cultivation in regions with adverse natural conditions, such as deteriorating land and limited water supplies. The limited research conducted on *Z. nummularia* has further complicated efforts to develop superior varieties within this species. In the future, it is crucial to conduct studies that fully leverage the potential of this species. This article is designed to provide a comprehensive overview of *Z. nummularia*, with the intention of inspiring researchers to explore this crop, which is vital in India and other arid and semi-arid areas around the world.

## Introduction

The total number of cultivated species worldwide that could be beneficial to humans is estimated to be about 7,000 (Rehm and Espig, 1991, Hammer and Khoshbakht, 2005; Raman, 2006). Kunkel (1984) suggests a higher figure of 12,650, and when ornamental plants are included, Khoshbakht and Hammer (2008) raise this number to 35,000. Nonetheless,

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there is a considerable discrepancy between the available diversity and the diversity that is actually utilized (Prescott and Prescott, 1990). Globally, the commercial cultivation of crops is limited to approximately 150 to 200 significant species, with just 30 of these providing 95% of the food energy needed worldwide (FAO, 1998). Among these, key crops like rice, wheat, maize, and potatoes together make up 45% of the daily food supply across the globe (FAOSTAT, 2012). The FAO (1999) also noted that approximately 18,000 to 25,000 species collected from the wild are used for food. Indigenous fruit trees are especially vital, as they provide essential resources for nutrition, medicinal purposes, cosmetics, fodder, fibers, and fuel. These trees play a critical role in supporting the livelihoods of rural populations, particularly in arid areas where the failure of crops often results in inadequate nutrition for the local communities (Maxwell, 1991).

Over the past decade, the rising interest in neglected and underutilized species has emerged as a constructive reaction to the increasing worries regarding the heavy reliance on a small selection of crops to secure global food supply and stimulate economic growth in the face of global changes (Padulosi *et al*., 1999 and Stamp *et al*., 2012). There is a growing acknowledgment of the significant contributions that these species can make towards agricultural diversity and alleviating poverty (Padulosi *et al*., 1999 and Frison *et al*., 2006,) While these indigenous plants may be perceived as overlooked or underused worldwide, they are recognized for their significant contributions at local, national, and international levels (Hammer *et al*., 2001). They are integral to local and regional agricultural practices for food sourcing and are essential genetic resources in the global endeavor to sustain biodiversity (Grivetti and Ogle, 2000). Indigenous plant species play a vital role in the rural economy of arid regions in India, where natural scrublands are still abundant (Mann and Saxena, 1981). There is a marked interest among local populations in these plants, which serve multiple functions, including providing food, generating additional income, feeding livestock, offering folk remedies, supplying energy, and contributing to soil conservation, particularly in stabilizing sand dunes (Gebauer *et al.*, 2007).

Despite the acknowledged importance of this indigenous species, it continues to be underexploited and insufficiently appreciated, with its contributions to farmers' livelihoods not adequately incorporated into poverty reduction initiatives (Schreckenberg *et al*., 2006). The world population is estimated to climb to 9 billion people by 2050 (UN Population Division, 2011), requiring an additional increase in food production of 70 per cent to 100 per cent (Godfray *et al*., 2010). In demand of this future foods to meet the needs of an increasing world population the development of alternative crops to improve the range of produce available is needed (El-Siddig *et al*., 1999). The significance of this is especially evident in species capable of adapting to severe environmental conditions such as drought, heat, and salinity stress. One notable example is *Ziziphus nummularia* (Burm.f.) Wight & Arn. This fruit crop is referred to by several local names, including *Jharber* in Hindi, *Aja-priya, Balakapriya*, and *Bhu-kartaka* in Sanskrit, as well as *Chanyabor* in Gujarati, Zariab, and Poast jharberi in Urdu, and Parpalligidda in Pali (Madhya Pradesh) and Karnataka (Verma, 2016). Rural communities in the arid regions of India place significant reliance on this species, which is noted for its importance and has historical references regarding its uses (Pareek, 1978).

There has been minimal research conducted under Indian conditions, and no internationally recognized germplasm collection exists in the country. While efforts have been made to explore its nutritional and pharmacological properties, research on other critical aspects remains insufficient. The seeds are categorized as orthodox, and there is a lack of information concerning their genetic variability and agronomic requirements. This paper seeks to summarize the available information on *Z. nummularia* to foster interest in this crop and to present indigenous knowledge related to its various uses and genetic diversity.

# Botany

*Ziziphus,* a genus within the Rhamnaceae family, comprises around 100 species of deciduous and evergreen trees and shrubs that are distributed across tropical and subtropical regions worldwide (Johnston, 1963). Of these, twelve species are known to be cultivated (Hammer *et al.,* 2001). In the desert regions of India, five or six species are represented, including *Z. glabra*, *Z. mauritiana, Z. rugasus, Z. truncate, Z. nummularia,* and *Ziziphus xylopyrus* (Bhandari, 1978). Among the six species identified, *Z. nummularia* and *Z. mauritiana* are the most commonly dominant in Indian conditions. *Z. mauritiana* is commercially cultivated, while *Z. nummularia* is not and is predominantly found thriving in the wild of the Indian Thar Desert. Although *Z. nummularia* generally grows as a tree, it has adapted to a shrubby form due to significant grazing pressure from both domestic and wild animals during its growth and fruiting stages, as well as the use of its thorny branches for agricultural fencing and wood for tool production, resembling other related species such as *Z. spina-christi* (Obeid and Mahmoud, 1971).

The root system of these plants is extensive and reaches considerable depths. They are classified as thorny shrubs, averaging between 1 and 2 meters in height, with the potential to grow as tall as 6 to 8 meters. The plants are multi-stemmed at the base, with stems and branches that are widely divergent and flexible. Their coloration ranges from purplish to ashy, featuring velvety stipular prickles arranged in pairs. The branches typically exhibit a zigzag formation and are coated in white, complemented by light brown bark. Leaves of this shrub are alternately arranged on short stalks, measuring between 12-18 mm in length and 8-10 mm in width. The upper surface is a deep green and glossy, while the underside is more or less tomentose and white, with a rounded shape at both the apex and base.

The leaves are serrated and feature 3 to 5 veins that extend from the base. Stipular spines are present in pairs, with one spine being slender and straight, and the other being shorter and recurved. The flowering period typically coincides with the onset of the southwestern monsoons, occurring from July to August, while the fruits reach full ripeness in November and December. The flowers are cream in color and are arranged in short, compact cymes in the axillary position. The calyx exhibits a pubescent texture on its outer surface and has a fissure located roughly halfway down. The lobes are triangular-ovate, and the petals are either cuneate or rounded at the apex. The filaments are deflexed, while the disc comprises ten lobes, each with a pit situated opposite. The style is bifurcated, and the ovary consists of two cells.

The fruits are fleshy drupes that can be either red or black, globose in shape, and less than one centimeter in diameter. They contain limited edible pulp, which is often characterized by an astringent or tart taste. The seeds are smooth, shiny, and brownish, typically found in pairs within the hard stones of the fruit (Orwa *et al*., 2009).

## Ecology and distribution

Reports indicate that this species possesses a deep-root system and is capable of storing larger quantities of carbohydrates. The *Ziziphus* genus is well-regarded for its hardiness as a shrub, exhibiting strong resistance to abiotic stresses such as drought, frost, and heat, as well as to various biotic threats like pests and diseases (Paroda and Mal, 1989). Its extensive root zone allows for regeneration even after suffering injuries or damage from, setting it apart from other species such as *Ziziphus mauritiana* and *Z. jujuba* Mill., according to the findings of Kirkbride *et al.* (2006).

The distribution of *Zyzyphus nummularia* is limited to certain regions, specifically Afghanistan, India, Iran, Lebanon, Pakistan, and Zimbabwe, with an exotic presence in Mauritania, Nigeria, and Uganda (Orwa *et al*., 2009). Thanks to its high adaptability, this shrub can occupy large arid expanses in the Indian desert, even in regions that receive only 150-250 mm of rainfall, covering multiple districts in northwestern India (Jawanda and Bal 1978). This species, *Z. nummularia*, is capable of growing in nearly all soil types, including skeletal soils, gravelly plains, sand dunes, alluvial regions, and rocky landscapes, but it does not thrive in saline patches or certain sand dunes. Large populations of *Z. nummularia* are prevalent in Punjab, Rajasthan, Gujarat, Uttar Pradesh, and Madhya Pradesh (Saxena and Mann, 1981).

In the northwestern regions of India, especially in the arid western Rajasthan, many “Orans” and “Bir” (common village grazing lands) are largely dominated by this shrub. It plays a significant role as a co-dominant species alongside Kair (*Capparis decidua*) in communities found on eroded rocky surfaces, piedmont plains, and pediment plains. Furthermore, *Z. nummularia* can be found in scattered distributions across sandy, undulating hummocky plains, where the predominant vegetation is psammophytic. The arid landscapes of Rajasthan, characterized by their rolling terrain, host a community of *Calligonum polygonoides* and *Ziziphus nummularia*. This combination of species serves as an effective soil binder, exhibiting a moderate to high density ranging from 60 to 302 plants per hectare.

In protected forest areas located on low hills and piedmonts, this species is often found in association with *Acacia senegal*, where plant density varies between 80 and 350 plants per hectare, accompanied by a modest crown cover of 5 to 7 percent. Conversely, in unprotected hilly regions facing significant exploitation, the shrub density is minimal, contributing only 10 to 50 plants per hectare, often in association with other species such as Thor and Euphorbia (Saxena and Mann, 1981).

Notably, some larger orans exhibit a relative dominance of 75 to 90 percent of this species, with the remaining 10 to 25 percent typically occupied by other plants like *Khejri* (*Prosopis cineraria*), Hingota (*Balanites aegyptiaca*), and Kair (*Capparis deciduas*). *Ziziphus nummularia* is commonly found at elevations up to 1700 meters and can endure temperatures reaching 50°C (Kumawat *et al.*, 2018).

## Perpetuations

*Z. nummularia* is capable of reproduction through both sexual and asexual means. In natural settings, it propagates using seeds and root suckers (Kumawat *et al.*, 2018). The cross-pollination of this shrub, primarily conducted by insects and bees, contributes to a high level of genetic variability due to segregation. The process of propagation via seeds reveals considerable genetic variation. This trait of having broad genetic diversity could offer this species a distinct advantage in adapting to challenging and severe environmental conditions.

*Z. nummularia* seeds feature resilient seed coats that hinder germination. In a controlled environment, seeds generally require 1 to 3 months for germination. To mitigate this challenge in commercial propagation, the seed coats can be gently broken using a hammer or stones, allowing the shelled seeds to be planted thereafter. Seed treatments, particularly scarification, can significantly enhance the germination of these seeds (Moustafa *et al.*, 1998). In a study involving *Z. spina-christi*, it was found that seeds exposed to 97% sulfuric acid for 120 minutes achieved a germination rate of 91%, compared to just 41% for those that were not treated (Saied *et al.*, 2007). Emerging young plants are at risk from browsing animals and require protection, while well-established plants have a significant capacity for regeneration and can withstand considerable levels of browsing. The exploration of biotechnological approaches for large-scale propagation is still in its early stages, with no commercial cultivars developed or released for these fruit crops.

Additionally, tissue culture protocols represent another promising biotechnological method for propagation. Rathore *et al.* (1992) conducted research on the cloning of *Zizyphus nummularia* from nodal stem explants, achieving the proliferation of five to seven shoots on Murashige and Skoog's (MS) medium that contained 5.0 mg l–1 of 6-benzylaminopurine (BAP) and 0.05 mg l–1 of indole-3-acetic acid (IAA). The shoots produced in vitro were able to be further multiplied on new medium. The study also indicated the feasibility of mass multiplication of *Ziziphus nummularia*, a drought-resistant shrub found in the Indian Desert, through this in vitro technique. Explants derived from shoot tips demonstrate significant potential for multiple shoot proliferation, producing approximately 15 to 20 shoots. This is followed by cotyledonary nodes, which yield around 10 to 15 shoots, nodal regions with 8 to 10 shoots, and hypocotyls that generate 6 to 8 shoots. These observations were made using Murashige and Skoog's (MS) medium enriched with 2.5 mg L-1 kinetin (kn).

Furthermore, rooting can be facilitated in both the original explants and the newly formed shoots by placing them on a filter paper bridge for 12 hours in White's liquid medium containing 8.0 mg per litre Indole Butyric Acid (Mathur *et al.*, 1993).

# Pharmocological evidences and ethnomedicinal uses

*Z. nummularia* is recognized as an underutilized plant that warrants additional research. It is a valuable source of nutrition and serves multiple purposes (Oudhia, 2003). The bark is effective in treating boils and is beneficial for dysentery and diarrhea. In the context of Ayurveda, the root of *Z. nummularia* is noted for its bitter and cooling properties, which help alleviate coughs, biliousness, and headaches (Kirthikar and Basu, 1994).

The fruits of *Z. nummularia* are also rich in sugars, vitamin C, and various important minerals. Alkaloids are present in dried fruits, while the bark contains a unique 13-membered N-formylcyclopeptide alkaloid referred to as nummularine-T (Singh and Pandey, 1995). Additionally, the dried leaves of *Z. nummularia* are recognized for a novel dammarane saponin named Zizinummin (Sharma and Kumar, 1983) and various glycosides (Srivastava, 1984). These substances are associated with several beneficial properties, including anticancer, anodyne, pectoral, refrigerant, sedative, styptic, stomachic, and tonic effects. The local populace believes that these fruits can purify the blood and enhance digestion. These substances are also employed for the internal treatment of various conditions such as loss of appetite, anemia, bronchitis, burns, chronic fatigue, diarrhea, hysteria, irritability, and pharyngitis (Chopra *et al.*, 1956 and Singh *et al.*, 2002).

The fruits are utilized to relieve abdominal pain during pregnancy, act as an antidote for aconite poisoning, and facilitate wound healing. Notably, during the 1869 famine in the Thar desert, these fruits served as a vital food source for thousands of inhabitants. Furthermore, the plants have been reported to exhibit pharmacological effects, including anthelmintic, antitumor, antibacterial, antifertility, abortifacient, sedative, hypnotic, hypoglycemic, and hypolipidemic properties (Bachaya *et al.*, 2009; Kumar *et al.*, 2002; De Boer *et al.*, 2005; Shah *et al.*, 2009; Rauf *et al.*, 2016 and Rajsekharan, 2013).

# Major uses

This species is a shrub that holds considerable economic significance and is highly valued by local villagers. It provides essential nutritious feed even during famine conditions when other vegetation has dried up (Purohit and Khan, 1981). In the rural areas of western India, where this species grows naturally, all parts of this species-roots, stems, branches, leaves, fruits, and seeds—are economically beneficial. The mature fruits of *Z. nummularia* consist of 81 to 97% pulp, which includes 12-23% total soluble solids (TSS), 0.13-1.42% acidity, 3.1-14.5% total sugars, 1.4-9.7% reducing sugars, 5.6% sucrose, 1.5% glucose, 2.1% fructose, and 1.0% starch (Jawanda and Bal, 1978).

Roots are extracted for medicinal applications and can also be fashioned into toothbrushes or dried for use as fuel. The stems are transformed into durable furniture and local agricultural implements, such as *Bhai* and *Chokni*, and are also used as firewood. Thorny branches hold significant value, serving as fencing to safeguard agricultural crops from domestic and wild animals. Furthermore, these branches are employed in constructing roofs for shelters, with the dried versions also used for firewood. The leaves provide a nutritious local fodder known as Pala and can be utilized as manure. The species is frequently browsed by animals, which contributes to its bushy growth form. The ripe fruits are particularly enjoyed by local women and children, who consume them directly (Kumar, 2016).

According to Muthana and Shankarnarayan (1978), *Z. nummularia* fodder is the fourth most preferred choice for sheep, following the leaves of Acacia nilotica (Babool), Prosopis cineraria (Khejri), and *Salvadora oleoides* (*Jal*), which occupy the first three positions. Under open grazing conditions, the leaves are a significant source of forage and fodder for animals (Verinumbe, 1993). This becomes especially vital in the dry season when grazing options are limited. Small branches are commonly lopped to serve as fodder for camels and goats during this time and are later repurposed for building thorn fences (Bunderson *et al.*, 1990). Furthermore, a blend of ripe fruits and buttermilk is beneficial in mitigating the effects of opium intoxication.

Various vigor tonics can be formulated by mixing these with additional components. Bark serves as an effective ointment for treating foul sores, while its decoction is commonly utilized for gargling in cases of sore throat and ulcerated gums. The cotyledons are beneficial for addressing eye issues. Additionally, the leaves are employed in the treatment of scabies and various skin conditions. Dried leaves can be burned and inhaled to alleviate symptoms of cough and cold (Saxena and Mann, 1981).

## Species conservation and future genetic improvement

Among the various species of Ziziphus, *Z. nummularia* and *Z. rotundifolia* stand out as the most crucial, predominantly located in the arid areas of India. While both are valued for their horticultural qualities, they differ in their morphological traits. This species shows considerable variability across the country. To evaluate the genetic diversity and relationships of Jharber cultivars, modern morphological and molecular markers can be employed, facilitating advancements in breeding initiatives (Yashmin *et al*., 2017). Over the years, both species have been used in studies related to rootstock for cultivated ber (*Z. mauritiana*).

*Z. rotundifolia* is often preferred over *Z. nummularia* due to its advantageous traits. India is home to a rich genetic diversity of Ziziphus, with around 20 species primarily found in the latitudinal range of 8.5-32.5°N and longitudinal range of 69-84°E. This genetic variation leads to a heterozygous population, which contributes to a wide adaptability to different soil types and climatic conditions, as well as various morphological, physiological, and phenological characteristics, chromosome counts, and resistance to both biotic and abiotic challenges (Awasthi and More, 2008). But however, full exploitation of this potential is still negligible.

Furthermore, the increase in agricultural land to meet food requirements has led to heightened browsing pressure, as well as rampant lopping and collection practices (Anonymous, 2000). To advance conservation efforts, it is crucial to assess and document these plant genetic resources and establish a collaborative research strategy. An effective strategy must be formulated to facilitate successful conservation and promotion through enhanced usage. The conservation of germplasm for this species will act as a genetic reservoir, providing breeders with the opportunity to select new traits aimed at developing cultivars that exhibit desired qualities, such as resilience to biotic and abiotic challenges. The enhancement of diversity within this species will support the crop's adaptive potential and mitigate the effects of unpredictable changes in the environment (Peroni and Hanazaki, 2002; Jackson *et al*., 2007; Hajjar *et al*., 2008 and Frison *et al*., 2011).

## Prospective applications

In the dry regions of India, the vegetation primarily consists of short-lived and annual plant species. These plants emerge with the onset of the monsoon rains and complete their life cycle before the season concludes. For grazing communities, perennial species are vital as they offer nourishment once the annual plants have died off. *Ziziphus nummularia* is a key perennial species, demonstrating remarkable adaptation to the harsh dry and hot conditions prevalent in the arid and semi-arid regions of North Western India.

This species maintains its foliage for an extended period and is essential to the desert economy. Currently, there is a lack of effective management strategies for *Z. nummularia*. These plants grow naturally through seed dispersal facilitated by natural agents such as wind, animals, and humans. To enhance the systematic propagation of this tree, thorough research is necessary, including the collection and analysis of plant materials, identification of superior genotypes, development of effective cultivation techniques, and the multiplication and distribution of seedlings to farmers. Establishing large-scale plantations of this species near rural communities would significantly help combat environmental degradation by serving as a barrier against shifting sand dunes and storms.

Additionally, this strategy not only has the potential to provide food, fodder, and fuel but also increases the availability of arable land for growing local populations who currently face challenges due to limited productive land. Integrating this species into agroforestry systems can enhance the productivity of various agricultural activities while protecting soil, water, and livestock resources.

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