Journal of Medicinal Plants Biotechnology
JMPB

Original Article

The important medicinal and industrial properties of *Calotropis procera* (Aiton) W.T.

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ARTICLEINFO

Article history

Submitted: 2020-09-15
Revised: 2020-10-23
Accepted: 2020-11-29

KEYWORDS

Calotropis procera (Aiton) *W. T.* Aiton,
Medicinal composition,
Industrial properties

ABSTRACT

Calotropis (*Calotropis procera* (Aiton) W. T.) is a spreading shrub or medium-sized tree reaching 2.5 to 6 m in height. It has a deep taproot, 3-4 m deep, and a secondary root system with woody lateral roots that may rapidly regenerate adventitious shoots when the plant is injured. The stems are crooked and covered with a fissured corky bark. The grey-green leaves are 15- 30 cm long and 2.5-10 cm broad and have a succulent and waxy appearance, hence the name procera, which means wax in latin. Compounds derived from the plant have been found to have emetic-cathartic and digitalic properties. The principal active compounds are asclepin and mudarin. Other compounds have been found to have bactericidal and vermicidal properties. The root bark is an emetic. An infusion of bark powder is used in the treatment and cure of leprosy and elephantiasis. The extremely poisonous roots are used in the treatment of snakebites. The leaves are used for the treatment of asthma. The milky sap is used as a rubefacient and is also strongly purgative and caustic. The latex is used for treating ringworm, guinea worm blisters, scorpion stings, venereal sores and ophthalmic disorders, it is also used as a laxative. The local effect of the latex on the conjunctiva is congestion, epiphora and local anaesthesia. The latex contains a proteolytic enzyme called caloptropaine. The flower is digestive and tonic. It is used in the treatment of asthma and catarrh. The twigs are applied for the preparation of diuretics, stomach tonic and anti-diarrhoetics and for asthma. Also used in abortion, as an anthelmintic, for colic, cough, whooping cough, dysentery, headache, lice treatment, jaundice, sore gums and mouth, toothache, sterility, swellings and ulcers. Also, stem fibre used for various purposes, such as for making ropes, to form cheap cots, gunny bags, bow strings, fishing nets, and in the manufacture of paper, pulp and duplicating stencils.

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Introduction

Iran is one of the arid and semi-arid regions of the world, located at a latitude of 25 to 38 degrees north. Drought has long been a serious threat to the Iranian plateau. Climate change, mismanagement of water resources, poor agricultural pattern, uncontrolled urban development and declining vegetation are some of the causes of drought. Drought is an ecological, agronomic and social phenomenon that causes great damage to human life and natural ecosystems (Petrasovic, 1995). Predictive models show that the world will experience a critical drought over the next four years (Lau and Kim, 2013). Due to its location in the arid region, Iran is one of the most seriously affected regions (Lau and Kim, 2013). According to the World Resources Institute (WRI), Iran is one of the countries that will be under water stress by the year 2040 (Maddocks et al., 2015). Today, the phenomenon of drought is the most important threat to the survival of rural communities in the southern regions of Iran. One of the ways to deal with the threat of drought is to change the agricultural pattern to plants with little or no irrigation need (Razavi and Masoudifar, 2016). Among these, Calotropis (*Calotropis procera* (Aiton) W.T (Asclepiadaceae)) can be a suitable option due to its special characteristics. This shrub in Bushehr and Hormozgan is called Kharg and in the south of Kerman and Sistan and

Baluchestan is Korg and in Arabic it is called Estabarq.

Geographical distribution and ecology

Calotropis is native to tropical and subtropical Africa, Asia, and is abundant in the Middle East (Parsons and Cuthberston, 2001). *Calotropis* is distributed from West Africa to southern Angola, North and East Africa, Madagascar, the Arabian Peninsula, South Asia, Indo-China to Malaysia. It is also found in Australia and many Atlantic islands, Mexico, South and Central America, and the Caribbean (Rahman and Wilcock, 1991). It grows in arid habitats (150 to 1000 mm rainfall) and sometimes in well-drained soils in areas with more than 2000 mm annual rainfall. *Calotropis* may grow up to 1000 meters above sea level in India (Parrota, 2001). This plant is found in Iran in the tropics and southern coasts of the Oman Sea from Khuzestan to Makran Baluchistan at an altitude of 1100 meters above sea level (Akgul and Tozluoglu, 2009). *Calotropis* also resists in soils composed of sodium-saturated parent rocks. Sea salt spraying on the coast is also not harmful to Calotropis (Little et al., 1974).

In Iran, this plant grows in the southern and southeastern regions (Fars, Hormozgan, Bushehr, Khuzestan, Kerman, Baluchistan provinces). Mozaffarian (1991) also reported that Calotropis grows in the southern provinces including Hormozgan, Baluchistan and Khuzestan in these areas, there are relatively dense and widely distributed communities of this plant. In

Iran there are 2 species of the genus Calotropis including C. *Procera* and C. *gigantean*. The first species is growing in all areas and southern coasts and the second species in Baluchistan.

Propagation and growth of *Calotropis procera*

The plant is propagated by seeds, but although it produces a lot of seeds, it has little distribution. It seems that the establishment of this plant is naturally problematic. This plant produces bolls in which the seeds are located (Fig. 1). These bolls open naturally after ripening and the seeds come out (Katembe et al., 1998). *Calotropis* seeds lack initial dormancy, and the longer the seed is stored, the lower the germination rate and germination percent (Al-Sobhi et al., 2006). Germination determines the onset of plant growth, followed by seedling establishment is the most important stage in the plant life cycle (Delesalle and Blum, 1994). The seeds are dispersed by the wind. Seedlings may emerge from a rainy season, but only a few survive (Parsons and Cuthberston, 2001). Using the main root nutrient reserve, *Calotropis* can germinate again each year after a fire or cut (Hassan et al., 2015). The height of the stalk is usually up to about 2 m, but it can sometimes reach up to 5 m in height and 25 cm in diameter of the stem (Little et al., 1974). The root of this tree is 3-4 meters long, if the plant is damaged, the secondary root system, which is made of wood, can quickly reproduce the roots (Orwa et al., 2009).

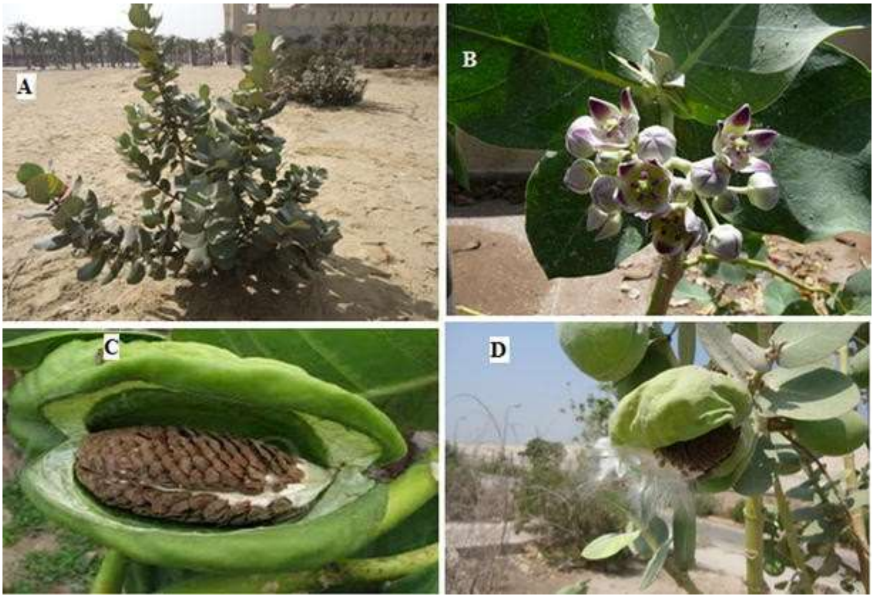

Fig. 1. *Calotropis procera* grows in monospecific stand, b open flowers, c dehiscent fruit showing *dark brown* seeds and d dispersal of seeds with *white silky* pappus

Salinity and drought resistance

Salinity is a limiting factor for the growth and production of various plants. In recent years, the trend of salinization of soils has increased and a large area of arable land has become uncultivable due to excessive accumulation of salt.

Lands with different salinity soils cover an area of about 55.6 million hectares, most of which are located in the central plateau of the southern coastal plains of the country and the plain of Khuzestan (Momeni, 2009). *Calotropis* is reported as a resistant plant to relatively high levels of drought (Alcazar et al., 2011) and salinity, which typically grows in known environments with severe drought characteristics, high temperatures and salinity stress (Khan et al., 2007). It is a drought-resistant desert shrub that can grow widely in desert, tropical, subtropical, arid and semi-arid regions and all desert areas of western India (Boutra, 2010).

Application in agriculture and environment

Establishment of *Calotropis* to protect the environment and as a nurse species is suitable for most valuable species, which is easily possible by planting potted seedlings or dividing the roots (Campolucci and Paolini, 1990; Fig. 2). In competition with tall weeds, shrubs, especially graminea, *Calotropis* weaken and overcome existing plants, but will remove the shade of their trees. This plant is sometimes cultivated in arid or coastal areas due to its beauty and suitable size, ease of reproduction and management. This plant is a useful biomarker for monitoring pollution in urban and suburban areas. *Calotropis* has the property of bioaccumulation of heavy metals in its leaves and since this plant is able to live in most contaminated soils, it can be used as a strong bioremediation agent in contaminated areas, industrial wastewater or contaminated groundwater (D 'Souzza et al., 2010). Tree sap is used as an indicator of eroding soil in tropical West Africa (Leeuwenberg, 1987).

The valuable medicinal plant *Calotropis* has a high capacity to absorb heavy metals in its tissues; without serious physiological damage (Al-Yemni et al., 2011). *Calotropis* is mentioned as copper, cadmium and zinc fixing plant and the accumulation of these elements in the roots of the plant is more than the leaves, based on which it can be considered a useful plant for decontamination of soil pollution (Al-Qahtani, 2012).

The observed differences in concentrations of barium, manganese, chromium and zinc between sediment samples in urban and suburban areas indicate that this plant has the necessary potential to absorb these elements (Altaf, 2006). The plant has also been reported to be used to removal of heavy metals such as cadmium and lead from soil, industrial wastewater or contaminated groundwater (D'Souza et al., 1987).

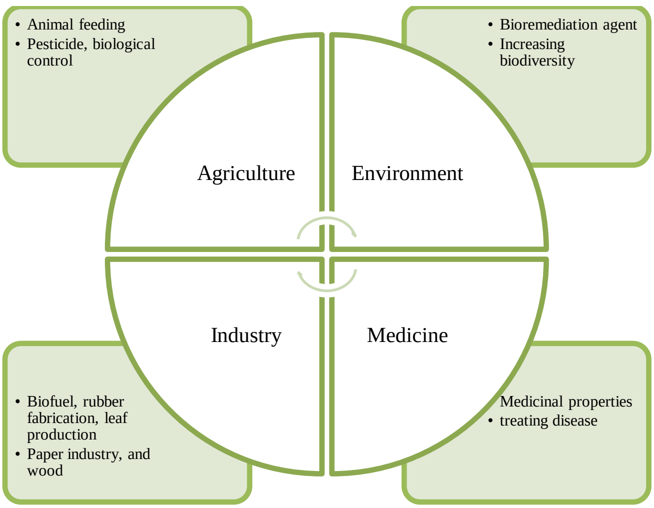

Fig.2. different application of *Calotropis procera*

Pesticide properties

Since the extract of *Calotropis* has high amounts of secondary plant compounds, its extract is a pesticide with a low line slope and has several points of action (Mirzaei et al., 2015; Fig. 2). Considering the harmful environmental effects of chemical pesticides and the low risk of plant compounds for humans and the environment, it seems that such secondary compounds can be used in the short term as a suitable alternative to pest control. *Calotropis* extract is an antioxidant and anti-inflammatory property that has been used to treat farmed catfish (Sayed et al., 2016). The effect of *Calotropis* extract on three pathogenic bacteria of farmed fish has been proven (Sancholi and Rigi, 2016). *Calotropis* has an allopathic effect on germination and rooting of other plants. The allochemical compounds in the leaves and roots of *Calotropis* have shown a strong barrier to germination, the growth of millet seeds. Therefore, due to its allopathic potential, *Calotropis* can be used as a biological control of weeds and insects (Samreen et al., 2009) and, of course, as a weed, it is considered a threat to agricultural fields (Yasin et al., 2012). This plant has antifungal properties and is used for fungal diseases of mango (Usha et al., 2009). Asparagus inhibits the growth of plants in the desert by producing toxins (Russell et al., 2011). The leaf extract of *Calotropis* has been used for biological control of the leaf-eating pest *Spodoptera litur* (Bakavathiappan et al., 2012).

The reports on the bioactivity of extracts from both species are numerous, where the extracts have been utilized as herbicide, fungicide, insecticide, nematicide, acaricide, and as molluscicide. Traditionally, extracts from *C. procera* have been used alone or in combination with that of other plants, such as in a combination of the extract of *C. procera* flowers, *Azadirachta indica* and *Nicotiana tabacum* leaves, and *Trachyspermum ammi* seeds used against the common cattle tick *Rhipicephalus microplus* (Boophilus) (Al-Sulaibi et al., 2020).

Medicinal application

Calotropis tissues, especially the root bark, are used to treat various diseases such as leprosy, fever, malaria and snakebite (Parrota, 2001). *Calotropis* sap is toxic and can cause blistering, itching and skin irritation in sensitive individuals (Little et al., 1974). *Calotropis* has antioxidant, antimicrobial and anti-cellulite properties. In traditional medicine, its leaves, stems and roots are used to treat wounds and skin diseases, diarrhea, fistula and hair sinus disease (Moronkola et al., 2011). In coastal areas of Africa, the plant is used for dermatitis, dysentery and varicose veins (Von Maydell, 1986). In traditional Indian medicine, dried root powder is used effectively to treat bronchitis, asthma, liver and spleen diseases, and its sap is used to treat hair loss, toothache, fever, swelling and tremors (Vohra, 2004). *Calotropis* leaves are used as a remedy for rheumatism, mumps and burns in India (Murti et al., 2010). *Calotropis* flowers are used to treat gastrointestinal complications, acne, in the West Coast and Central Africa (Von Maydell, 1986).

All parts of *Calotropis procera*, especially seeds and leachate, are often toxic and contain a variety of alkaloids and glycosides, many of which are used in pharmacy and as insecticides. The plant leachate has analgesic and wound healing properties and the plant root has contraceptive and anti-ulcer properties. The hepatoprotective and antioxidant properties of the plant have been attributed to flavonoids in flowers (Qureshi et al., 2007).

Calotropis plant leachate is an important source of new compounds such as quercetin flavonoids, flavonoid glycosides, anthocyanins, resins, protein-digesting enzymes in leachate, tannins, sterols, saponins and triterpenoids (Khasawneh et al., 2011; Sharma et al., 2011). Chemical analysis of leaf extracts of the plant revealed the presence of compounds such as glycosides, proteins, triterpenoids, steroids and flavonoids, which indicates the importance and medicinal properties of the plant (Tiwari et al., 2014).

Phytochemical studies have shown that a variety of compounds such as triterpenes, triterpenoids (Tiwari et al., 2014), phytosterols, saponins, alkaloids, cardinolides (Sommer and Saedler, 1986) are present in the plant. The presence of alkanes, alkenes, ketones and esters has also been reported in different parts of the plant (Feinbaum and Ausubel, 1988).

Industrial application

Research has shown that all components of the *Calotropis* shrub can be used in different applications (Fig. 2) (Hassan et al., 2015). All parts of this shrub, when cut down, are able to produce large amounts of white sap (Latex) (Mohamed et al., 2016). After separation by centrifugation, this juice contains rubber, serum and oil (Mohamed et al., 2016). *Calotropis* is a source of bioenergy and biofuels in semi-arid regions (Rathore and Menna, 2010). This plant contains valuable hydrocarbons that can replace diesel fuels (Choudhury and Singh 1993; 2007). The chemical composition of white sap is very complex, with 25 to 35% of it being made of natural rubber (cis-1,4-isopropane) (Rifaat et al., 2004). This natural sap is used as a raw material for making tires, gloves, seals, balloons, sports balls, etc. (Bode et al., 2000). The trunk of *Calotropis* can be comprehensively studied for use in lignocellulose industries such as paper making (Dehghani Firoozabadi et al., 2017). The fibers produced from this plant, unlike other natural cellulose fibers, have a low density (0.9 g/cubic centimeter) and an attempt has been made to use the raw inflorescence of this plant as a filler in the jacket (Kamrani et al., 2010).

Within limits, the wood of *C. procera* is utilized as cooking fuel in some areas. Also, the plant is being studied extensively as a source of biofuel with the gross heat content of the plant estimated at 6.1 kcal/g. Erdman et al. (1981) give a heat value of the whole plant of 4.2 kcal/g, Radhaboy et al. (2019) put it at 5.2 kcal/g. The heat values of whole plant fractions extracted with benzene, with petroleum ether and with ethyl acetate have been given as 9.6 kcal/g, 13.7 kcal/g, and 7.4 kcal/g, respectively. Both the seeds of *C. procera* and *C. gigantea* are judged as having the potential of providing biodiesel conforming to European and ASTM standards and have a relatively high oil-content (*C. gigantea*: 31%; *C. procera*: 26%). In all published seed oil analyses of both *C. procera* and *C. gigantea*, oleic acid, palmitic acid, linoleic acid and stearic acid were the main constituents (Al-Sulaibi et al., 2020).

Decan hydrocarbon is an alkan with the chemical formula of $C_{10}H_{22}$. There are 75 structural isomers for the decan with almost similar properties. These isomers of decan are flammable liquids. The decan is part of diesel (gasoline) and white petrolreum. Like other alkanes, these compounds are non-polar solvents, do not dissolve in water, and are easily flammable (Alam and Ali 2009). Therefore, it can be used as fuel. The decan compounds are also used as solvents in the paint, rubber and paper industries. The presence of decan compounds including pentadecan, hexadacan, pentadecan in leaf, docazenamide, isobutyl nonan, chromium methyl dodecan has been reported in the essential oil of *Calotropis* (Alam and Ali 2009). Doshi et al., (2012) reported the composition of decan and its derivatives including tetradcan, penta decan and trimethyl decatrin by examining the latex compositions of the plant. Dhivya and Manimegalai (2013) also detected the presence of pentadecanoic acid and octadecanoic acid methyl ester compounds by chromatogram analysis of GC/MS extract of *Calotropis* extract. Verma et al., (2013) also identified the presence of octadecanoic acid methyl and ethyl ester compounds in the ethanolic and chloroform extracts of *Calotropis* leaf.

Natural fibers are considered by researchers and craftsmen due to their properties such as low density, availability, suitable length, renewability and high strength in composite fabrication, especially as a reinforcing material in thermoplastic composites (Cristaldi et al., 2010). *Calotropis* has two types of fibers, including the fibers inside the fruit (short fibers) and the fibers in the stem bark (long fibers) (Figure 2) and has the potential to be used in the manufacture of wood composites and textiles (Reddy & Yang 2009). Also, *Calotropis* shrub with advantages such as low density and high percentage of cellulose, can provide suitable composites and insulation boards (Tarbi et al., 2016).

The production of yarn from the fibers of the *Calotropis* shrub as a mixture has existed since ancient times; Due to the smooth, brittle and slippery surface of the fiber, it is possible to produce yarn in the form of 100% fiber with a special method and with new devices and equipment. To produce yarn, 100% starch is needed to first turn these fibers into an arranged form called wick, so that it can be turned into yarn in a spinning machine. Silk pitchers can be obtained from the *Calotropis* plant. Water vapor permeability is one of the most important properties of the fabric that has a direct impact on the comfort of clothing.

Conclusion

Calotropis procera and *Calotropis gigantea* are undemanding plants that, while being undesirable weeds in some regions, have economic potential as a source of fuel and chemical feedstock. The review showed their use in providing construction materials and, in limitations, their utilization as animal feed. Extracts of *C. procera* and *C. gigantea* are employed widely as natural pesticides. The application of the two plants in bioremediation efforts, including in the monitoring of environmental pollutants in the soil was discussed, also. Given the importance of this plant in rehabilitating arid and desert areas and turning them into economic areas, the study of how to preserve and rehabilitate vegetation in natural resources is of particular importance and needs to be given special attention. Due to its great adaptation to environmental dehydration conditions and pharmaceutical and industrial applications, it can be a very economical alternative to low-yield and high-consumption irrigated crops.

On the other hand, this plant can be cultivated and developed well in lands and waters unsuitable for agriculture. Principled planning for the development of planting, rehabilitation, exploitation and protection of this plant in natural and agricultural fields can be an effective aid in job creation and sustainability of the rural community economy exposed to water stress.

Sponsor: This research has not received any financial support from funding organizations.
Conflict of interest: According to the author's statement, this article has no conflict of interest.
Derived from thesis/dissertation: This article is not derived from thesis/dissertation.

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