

Pedalium murex L.: Potential genetic resource for herbal medicine and mucilage

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Abstract

Pedalium murex (Pedaliaceae), commonly known as large caltrops in English and bada gokharu in Hindi is an underutilized mucilaginous medicinal herb having multiple uses in traditional system of medicine. It is mainly used to cure reproductive disorders, like impotency in men, nocturnal emissions, gonorrhoea as well as leucorrhoea in women. It is also useful in the treatment of urinary and gastrointestinal tract disorders. The present paper deals with botanical identity, vernacular names, ecology, environmental requirement and growth conditions, origin and geographical distribution, morphological/botanical description, propagation and cultivation, usages as a source of food, mucilage, medicine and biodiesel, important Ayurvedic formulations, phytochemical and pharmacological profile, future prospect.

Introduction

Genus *Pedalium* belongs to family Pedaliaceae (Sesame family). According to Stapf 1905, there are four species of *Pedalium* viz *P. intermedium*, *P. caillaudii*, *P. filiforme* and *P. busseanum* but according to modern databases (The Plant List and USDA GRIN-Global), it includes a single species with accepted name *Pedalium murex* L. whereas *P. microcarpum* Decne., *P. muricatum* Salisb., and *Rogeria microcarpa* Klotzsch are synonyms of *P. murex*. Other names were unable to establish their status either as an accepted species name or as a synonym of any accepted botanical name in modern database and are in unresolved status till date. It is generally known as large caltrops and land caltrops in English, Bada gokhru in Hindi and Gaja-daunstraka, Gokshura or Titta-gokshura in Sanskrit. Other vernacular names of *P. murex* are Pila gokhru, enugupalleru, pedda paleru, enuga palleru mulla, yenugapalleru (Telugu), annegalu – gida, aneneggilu, doddaneggilu (Kannada), motto ghokru, motherghokharu, hatti charatte, karonathia (Marathi), kadvaghokru, mothaghokru, mothangokharu, mottoghokru, ubbaghokru (Gujarathi), motto ghokru, baraghokhu, mothar ghokru (Bengali), gokshura, gokara (Oriya), gokrukalan (Punjabi), khas ake kabir (Arabic), sulegi (Burmese), Dakhini-gokhru (Rajasthan) Kaxar-marood (Somalia) ati neranchi (Singapore), khasake kalan (Persian) Vilyati gokhru, Dakhini gokhru, Brihat gokhru, Peru neranji, Yanai Nerinji, Peru Nerinji etc.

Ecology, environmental requirement and growth condition

P. murex generally grows as a weed at the edges/ open grassland near seashore, up to 500 m altitude. It is a saline soil indicator, and also occurs on sandy and limestone soils. It grows luxuriously in fertile soils and crop land as a weed at 25-30°C temperature. In Western Uttar Pradesh germination starts during the month of June-July and flowering fruiting occurs during September to December.

Geographical distribution

P. murex is native to Africa and Asia. It is distributed in most of the dry and coastal areas of Africa and Asia. In Africa, it is distributed in nearly all directions of Tropical Africa *i.e.*, Northeast Tropical Africa (Djibouti, Somalia), East Tropical Africa (Kenya, Tanzania), West Tropical Africa (Ghana, Nigeria, Togo), South Tropical Africa (Mozambique) and in western Indian Ocean (Madagascar and Comoros). In Asia

the species is distributed in Arabian Peninsula (Yemen) and Indian Subcontinent (India and Sri Lanka) (Fig. 1). In India, it mainly occurs as a weed of waste places in the southern India especially in Deccan Peninsula and Corommandal coasts, and in saline sandy areas along river belts in the Tamil Nadu, Andhra Pradesh, Haryana, Delhi, Rajasthan, Punjab, Gujarat and Madhy Pradesh, Uttar Pradesh etc.

Morphological description

Morphological study of *P. murex* collected from Bahadurpur site (established in 2017 for rehabilitation of degraded sandy soil and conservation of local phytodiversity) of Botany department, Dayalbagh Educational Institute (Deemed to be University), Dayalbagh, Agra shows that it is an annual, diffuse, succulent, mucilaginous herb of about 60-70 cm height (**Fig. 2**).

Root

Tap root system, 4 to 5 inch long, reddish brown in colour and bear a sweet aroma.

Stem

Stem is of about one cm diameter, much branched, succulent, glandular green in colour having branches spread up to 30 X 30 to 60 X 60 cm east-west and north-south diameter. The main shoot may be prostrate or erect. Phyllotaxy is opposite decussate.

Leaves

Leaves are simple, opposite, ovate, glabrous, alternate, fleshy, estipulate, petiolate and irregular in shape. Leaf length and width varies from 4.0-6.5 cm, and 4.0-5.0 cm respectively. Petiole length varies from 2.7-3.0 cm. Leaf contain prominent midrib, slightly thicker lateral veins, uniformly thick lamina with smooth surface, flat petiole and glandular trichomes are also found on both abaxial and adaxial sides of leaf. Venation is reticulate type with thick and straight veins.

Flowers

Flowers arise on leaf axis, pentamerous, gamopetalus, 2.5-3.0 cm long and 1.0-1.5 cm width and are yellow in colour with short pedicel. Calyx five, parietal with gamopetalous corolla, five lobes, round, tetradynamous stamens, bicarpellary stigma, ovules four celled

Fruits

Fruits are 1.5-2.0 cm long, 0.8-1.5 cm diameter in size with pale yellowish to brown colour, indehiscent hard drupe, pyramidal glabrous surface and ovoid, globular in shape with four-ridges, having four spreading spines of 2.0-4.0 mm long at the base; attached with a short curved pedicle and having a terminal apex. Fruit possess 5-12 compartments having single seed in each compartment.

Seeds

Seeds are oblong, black in colour and covered with pappus. Seeds are mucilaginous, odourless and sweet in taste. Average weight of 1000 seeds was estimated to 151.69 grams.

Propagation And Cultivation

Plant is propagated by seeds in nature, but the germination requirement of seed and information regarding dormancy and viability period of the seeds are not known. There is no information regarding cultivation practices, requirement of nutrients and irrigation. Germination of seed without any seed treatment from the seeds collected from Bahadurpur site before one year was unsuccessful in soil as well as by filter paper method; however plant was propagated successfully by stem cuttings.

An experiment was carried out in the month of October, 2019 in the Department of Botany, Dayalbagh Educational Institute, Agra (27°13'45.57"N and 78°0'9.45"E). About 4-5 inches long and one cm thick stem cuttings were collected from natural vegetation with the help of a sharp sterilized knife. Leaves from the cutting were trimmed, and 6 cuttings were planted in four replicate in pots containing a potting mixture farm yard manure and sandy soil in a ratio of 1:3. The average environmental condition at that time in the month of October (post monsoon month) with temperature ranges of average high was 29.4°C (85°F) in day time and an average low of 20°C (68°F) during night and average relative humidity was near to about 40%. Sprouting started in 4th day after transplantation (DAT) and all the cuttings were sprouted in seven days. The number of sprouts' increases with time (Fig. 3 and 4)

Usages As A Source Of Food, Mucilage, Medicine And Biodiesel

P. murex is a very important source of food, mucilage and medicine. Leaves are used as vegetable (Kirtikar and Basu, 1935). Various parts of the plant are used for the maintenance of general health and vitality, prevention and treatment of various disease and ailments of human being and domestic animals. The leaves and stems when agitated in cold water turn into tasteless, colourless thick mucilage, which is of high medicinal importance. It is a cheap and effective natural excipient that can be used as an effective alternative for the formulation of pharmaceutical suspensions. It have low rate of sedimentation, high viscosity, slightly basic pH and is easily redispersible (Yeole et al. 2010). An infusion of the stem and leaves is also used in gonorrhoea and dysuria (Kirtikar and Basu, 1935). It is a medicinal plant used in Ayurveda for the treatment of calculi, spermatorrhoea, amenorrhoea, dysmenorrhoea, inflammation, ulcers, fevers and other disorders. In Ayurveda, it is used as a tonic, aphrodisiac, appetizer, strangury, bladder stone, cough, asthma, pain, heart trouble, piles, leprosy, blood purifier and to cure skin diseases (Chopra et al. 1956). It is a major constituent of Ayurvedic formulations such as Gokhuradiguggul, Gokhurkwath, Gokhuradiawalaha, and Deshnularishta (Sivarajan and Balchandra 1994). According to Unani system of medicine, it helps to cure gleet, lumbago, stomachache, emmenagogue etc. (Shukla and Khanuja 2004). Beside Ayurveda and Unani system of medicine various parts of the plant are used as ethno medicine by the indigenous communities for treatment and prevention from various diseases and ailments in various parts of the world (Table 1).

P. murex is also used for the biological synthesis nanoparticles. Biosynthesis of gold nanoparticle using cold and hot extract of *P. murex* showed that both the extracts produced nanoparticles in the range of 180-200nm. The biosynthesized AgNPs were found to have a potent antibacterial activity against *E. coli*, *K. pneumonia*, *B. subtilis*, *S. aureus*, etc. Ceramic SrO/CeO₂ mixed oxide NPs biosynthesised from leaves of *P. murex* shows high antibacterial activity against *S. aureus* (G+) and *E. coli* (G-) bacteria and high antioxidant activity (Peter et al. 2014; Anandalakshmi et al. 2015; Pandiyan et al. 2019). Due to presence of high lipid content in areal parts *P. murex* can be used for biodiesel production (Shivprakash et al. 2019)

Phytochemical And Pharmacological Profile

Phytochemical and pharmacological profile of the plant is studied well and documented in scientific literatures. *P. murex* is a rich source of various triterpenoids, fatty acids, steroids, flavonoids, tannins, saponins, vitamins, proteins, sugars, vanillin, ursolic acid. It contains higher concentrations of steroids and sterols, and moderate concentrations of flavanoids, phenols, glycosides, alkaloids, proteins, terpenes, carbohydrates, gums and mucilage. It has been reported that steroidal components found in the plants possess fertility potentiating properties, and they have been found to be useful in the treatment of impotence (Das et al. 1966; Subramanian and Nair 1972; Rastogi et al.1982; Zafar et al.1989; Bhakuni et al. 1992; Vedavathy et al. 1997; Srinivasrao et al. 1999; Suganthy 2000; Venkatarathina et al. 2005; Kapoor et al. 2006; Rajashekar et al. 2012; Ananth 2018).

Pharmacological profile of the *P. murex* is also well explored and documented. Various parts of the plant exhibit antimicrobial activity (moderate activity), anti-inflammatory, anti-nephrolithic, anti-hyperlipidemia, antioxidant, antiulcer, anti-pyretic; aphrodisiac, hepatoprotective, nephroprotective, increases testosterone properties (Balamurugan et al., 2010; Srinivas et al., 2011; Siva et al. 2012; Ananth 2018; Rathur 2019; Madhvan et al. 2020; Ramadevi et al. 2020; Abirami et al. 2021)

Conclusion And Future Perspectives

On the basis of multidimensional potential of *P. murex* it is concluded that the species is underutilized and used for the healthcare management only by the practicers of Ayurveda, Unani, and folklore system of medicines. The plant has industrial value and hard and prickly fruits are traded as raw medicine in Indian herbal mandies and used by Aurvedic medicines manufacturers for the medicinal preparations. Due to edible nature of leaves as green vegetable and high mucilage and lipid content (to be used for industrial production) the plant may have high demand in near future. As the plant is collected from natural resources and seeds are collected for selling in local market/venders the species should be properly conserved and domesticated. Studies for the development of suitable agro-technology for commercial cultivation of *P. murex* should be conducted to utilize full potential of this species for human welfare.

Declarations

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Conflicts of interest/Competing interests

Authors have no competing interests

Availability of data and material

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Code availability

Not applicable

Ethics approval

Not applicable

Consent to participate

Not applicable

Consent for publication

All the authors have given their full consent for the publication of the Manuscript in Genetic Resources and Crop Evolution

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Table

Table 1: Ethno medicinal uses of *Pedaliium murex* L. in different parts of the world

Plant part	Method of medicine preparation and administration	Region and Local Name	References
Whole Plant	Water boiled with whole plant is fed to animals to help in expel out the placenta after delivery.	Gujarat (Sach gokhru)	Mistry <i>et al.</i> (2003)
	Whole plant extract is used as a tonic for health and vigour.	Rajasthan (Dakhini gokhru)	Katewa <i>et al.</i> (2005)
	Plant mucilage is administered to livestock for every delivery of young ones.	Tamil Nadu (Anai nerunji)	Ganesan <i>et al.</i> (2006)
	The entire plant is macerated and is given for ephemeral fever in cattle for 4 days.	Andhra Pradesh (Yenugu Palleru)	Reddy <i>et al.</i> (1989)
	Whole plant is fed to the animal for its cooling effect during summer.	Rajasthan (Dakhini-gokhru)	Galav <i>et al.</i> (2013)
	Fresh whole herb is soaked overnight in water. The sticky infusion mixed with cane sugar is taken daily once to cure painful urination, excess urination, haematuria, etc. An infusion is a remedy for dysuria.	Gujarat (Ubbu-gokhru)	Punjani B.L (2010)
	Plant infusion is given for common fever	Uttar Pradesh (Bara gokhru)	Ali Z.A (1998)
	Fine powder or paste is mixed with butter milk and given to drunk to reduce body heat in animals and plants are given as a fodder or soaked in water and this medicated water is given to drink to reduce the exposure to diseases in animals.	Rajasthan (Gokhru Bada)	Upadhyay <i>et al.</i> (2011)
Aerial Part	The plant twig is dipped in water seven to ten times and this water is taken orally to cure dysentery.	Rajasthan (Bada gokhru)	Upadhyay <i>et al.</i> (2010)
	Crushed plant is soaked in water, filtered in next morning, mixed with sugar candy and seed powder of black pepper and taken as refrigerant as well as skin diseases.		
	Plant is used to cure male fertility disorders.	Haryana (Vilyati gokhru)	Panghal <i>et al.</i> (2010)

	Aerial part of the plant is stirred in cup of water, to make oil appearance preparation; taken orally once a day up to one week for the treatment of hyperacidity.	Tamil Nadu (Anaineringi)	Nazar <i>et al.</i> (2008)
	Stem and leaves are soaked and stirred in milk for few minutes until the milk becomes thick and is taken internally to treat diabetes, urinary irritations, uterine and puerperal diseases and local ulcers.	Tamil Nadu (Yanai nerunjil)	Vimalanathan <i>et al.</i> (2009)
Leaves	Leaves mixed with garlic are made into paste & administered orally for leucorrhoea.	Andhra Pradesh (Yenugu Palleru)	Reddy <i>et al.</i> (1989)
	Decoction prepared from the plant with leaves of <i>Azadirachta indica</i> is taken internally to treat fever.	Tamil Nadu (Anai Nerunji)	Bose <i>et al.</i> (2014)
	Paste prepared from the leaves, ginger and common salt is used to cure tympany.	Tamil Nadu (Peru nerunji)	Jeeva <i>et al.</i> (2006)
	Leaf decoction is used to cure diabetes.	Tamil Nadu (Yanai Nerinji or Peru Nerinji)	Bose <i>et al.</i> (2014)
	8-10 fresh leaves are boiled in half litre of water, the water becomes mucilaginous. Half cup of this water is taken once a day for seven days to cure gonorrhoea by the tribals.	Rajasthan (Gokhru, Halvi gokhru)	Jain <i>et al.</i> (2004)
	Leaves and stem are soaked & stirred in milk for few minutes until the milk becomes thick and is taken internally to treat diabetes, urinary irritations, uterine and puerperal diseases and local ulcers.	Tamil Nadu (Peru Nerunji)	Vimalanathan <i>et al.</i> (2004)
	Leaves soaked in water for twelve hours are crushed with sugar candy and cardamon, given to women suffering from leucorrhoea.	Rajasthan (Bada Gokhru)	Upadhyay <i>et al.</i> (2010)
	Leaf maceration is drunk for aspermatogonia.	Andhra Pradesh (Yenugu Palleru)	Reddy <i>et al.</i> (1988)
Leaves			
Fruits	Decoction of fruits is used for continuance of urine & other complaints of urinary system.	Rajasthan (Dakhini-gokhru)	Katewa <i>et al.</i> (2005)
	Fruit powder is mixed with powdered sugar and ghee is	Haryana	Yadav <i>et al.</i>

	taken for the treatment of leucorrhoea.	(Bara gokhru)	(2006)
	Fruits are used to cure spermatorrhoea, urinary problems, nocturnal emission, impotency and tonic.	Rajasthan (Bara gokhru)	Mohammed <i>et al.</i> (2004)
	A pinch of shade dried fruit powder is taken regularly for two weeks with honey for impotence.	Tamil Nadu (Anai Nerunji)	Bose <i>et al.</i> (2014)
	Fruits are used to cure fertility problems by taking two spoonful of fruit powder mixed with the leaf juice of <i>Cleome viscosa</i> is administered from the fifth day of menstrual cycles before going to sleep daily once for 7 days.	Andhra Pradesh (Enugu palleru)	Panduranga <i>et al.</i> (2011)
	Two spoons of fruit powder mixed with <i>Cleome viscosa</i> L. leaf juice from the fifth day of menses before bed for seven days for fertility.	Tamil Nadu (Yanai Nerinji, Peru Nerinji)	Bose <i>et al.</i> (2014)
	An extract of three fruits of gokhru and approx. 25 g of babool (<i>Acacia nilotica</i> L.) leaves mixed with sugar are given twice a day for a week in case of venereal diseases.	Madhya Pradesh (Gokhru)	Anis <i>et al.</i> (2000)
	Powder of fruits with roots of <i>Capparis seiparia</i> , <i>Bombax ceiba</i> and <i>Chlorophyton</i> are taken orally with water as a cooling agent and also used as a tonic.	Rajasthan (Bada Gokhru)	Upadhyay <i>et al.</i> (2010)
Roots	The roots are powdered and mixed with cold water; the patient is bathed in the mixture once a day for 3 days to cure allergic infections.	Somalia (Kaxar-marood)	Anis <i>et al.</i> (1992)
	Root paste made into small pellets and 2-3 pellets given daily with boiled cow milk for increasing vigour in men	Tamil Nadu (Yanai Nerinji or Peru Nerinji)	Bose <i>et al.</i> (2014)
Seeds	Laddus (a type of sweet) is prepared from the seeds are given to patients suffering from joint pain, lumbago and for better health.	Rajasthan (Dakhini-gokhru)	Katewa <i>et al.</i> (2005)

Figures

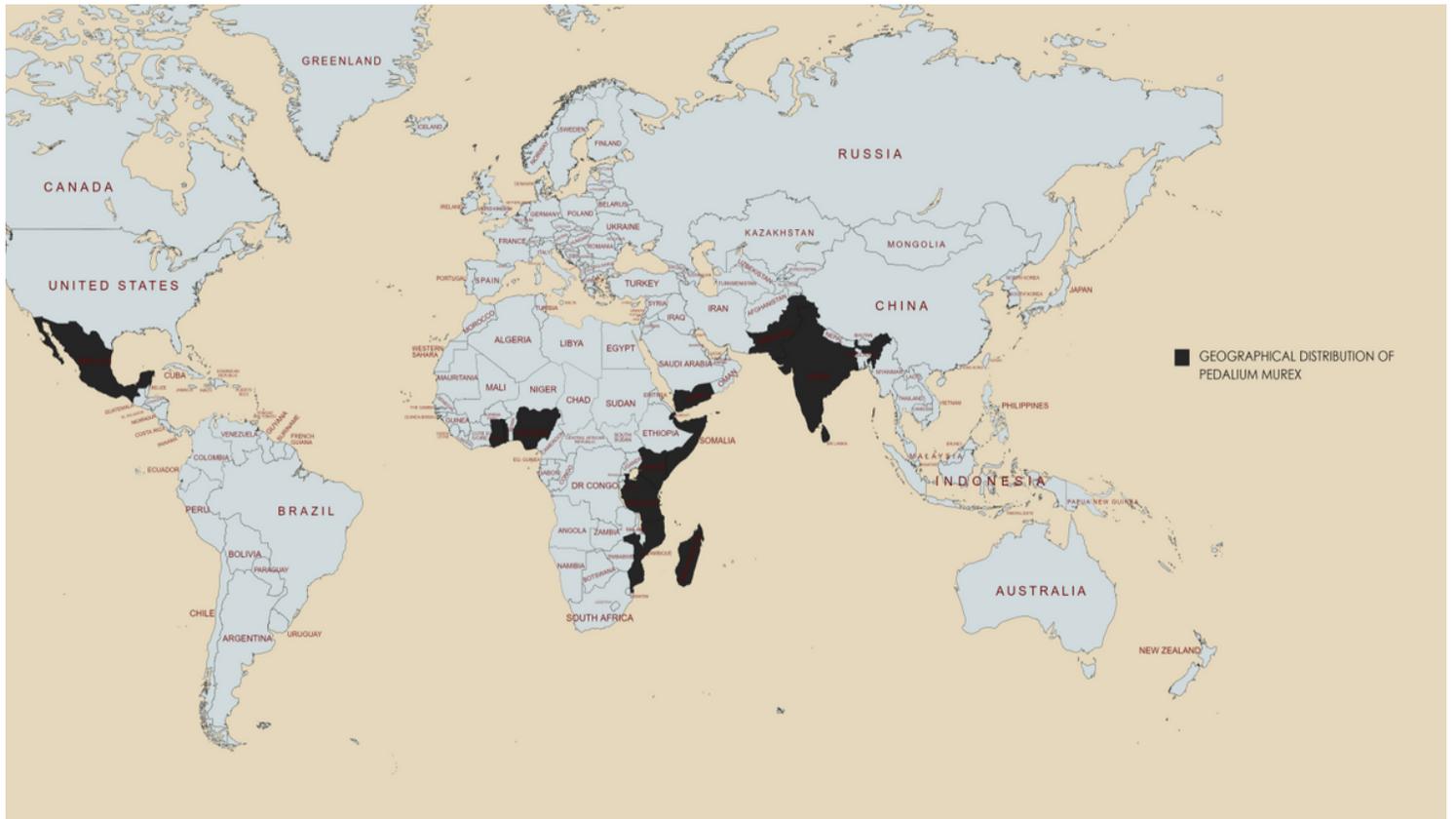


Figure 1

Map showing the geographical distribution of *P. murex* throughout the world

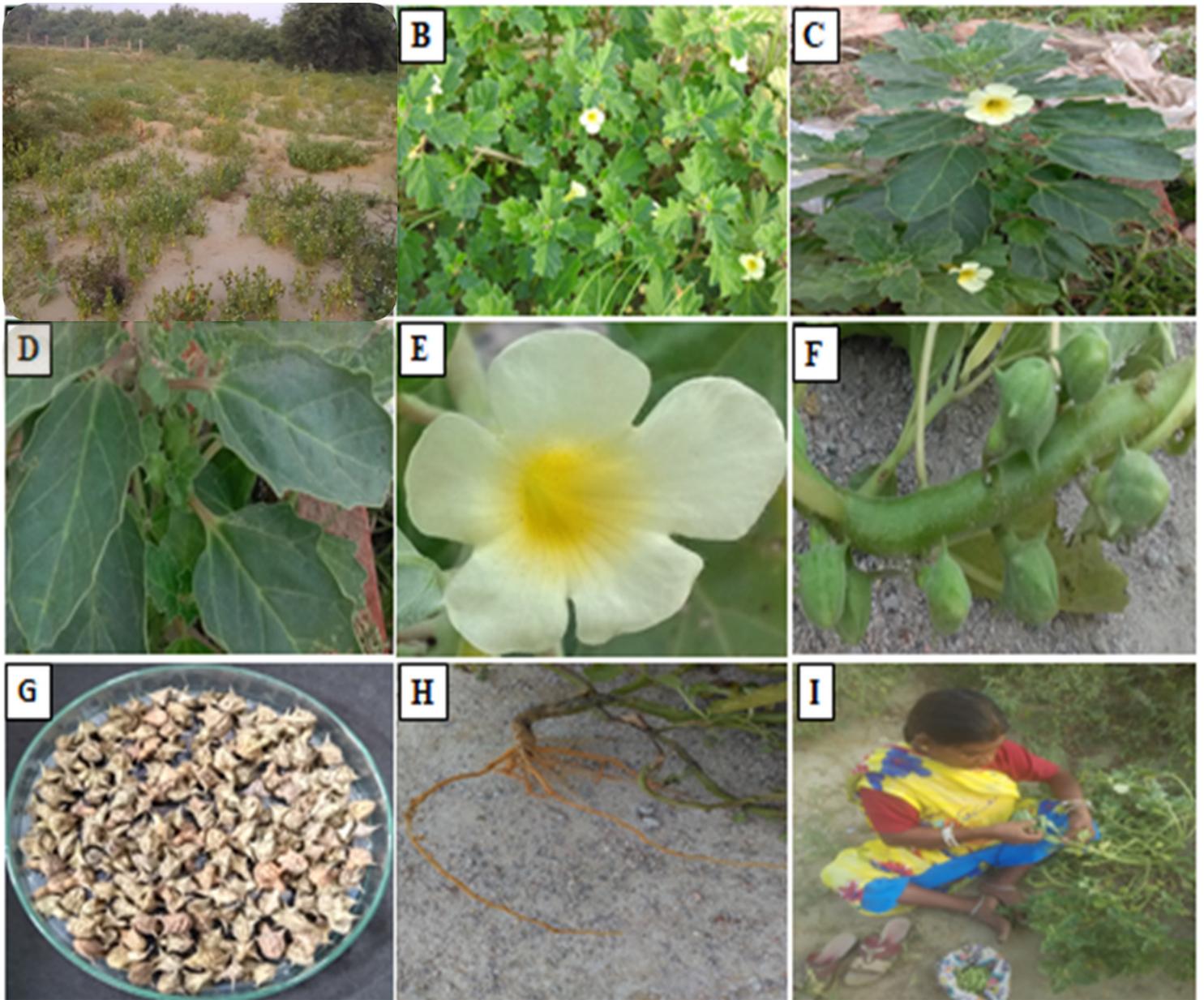


Figure 2

Habit and Morphology of *P. murex* L. (A) Naturally growing plant in field (B) A plant with flowers (C) A flowering twig (D) Leaves with petiole (E) Flower (F) Stem bearing fruits (G) Dried fruits (H) Roots (I) A local women collecting the seeds for medicinal purposes.



Figure 3

Vegetative propagation through cuttings in *P. murex* L. (A) After 7 days (B) After 14 days (C) After 21 days (D) After 28 days

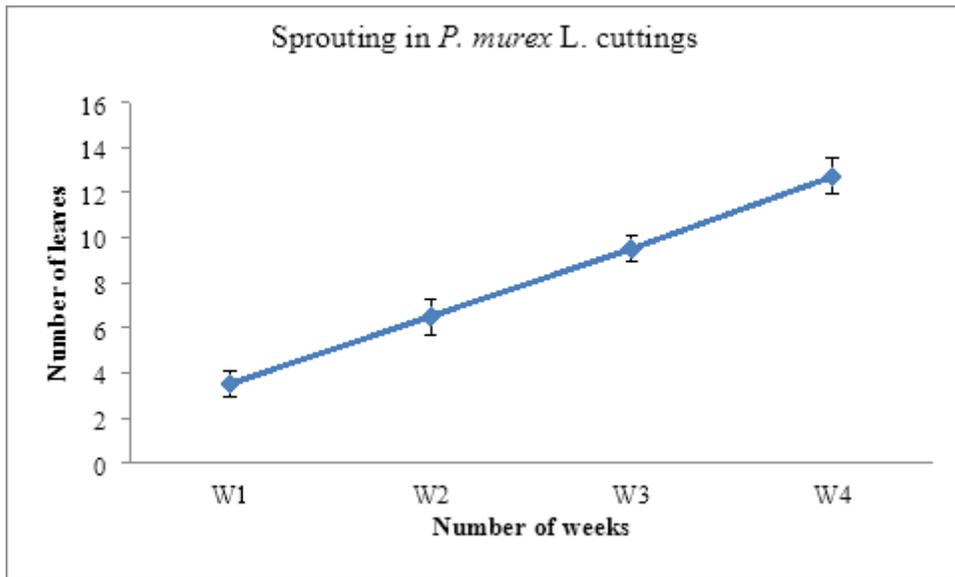


Figure 4

Sprouting in *P. murex* L cuttings