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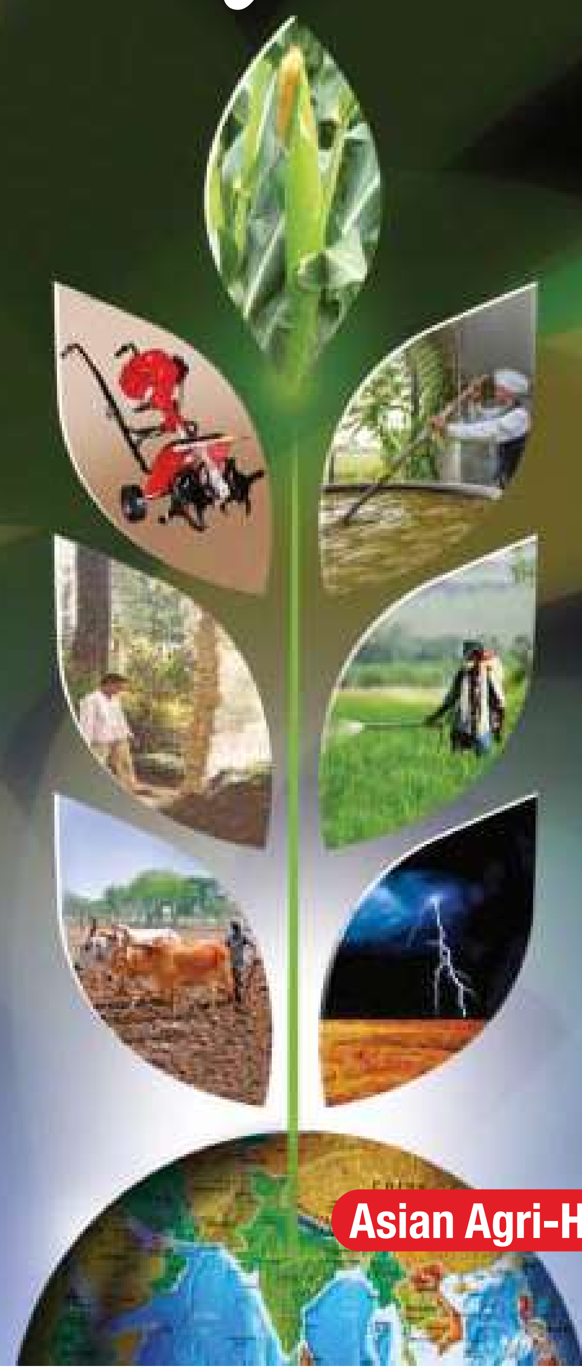

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"Do not believe in traditions because they have been handed down for many generations. But after observation and analysis, when you find that anything is conducive to the good and benefit of one and all, then accept it and live up to it".

– Gautam Buddha

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Abrus precatorius L.: A Review from Ethno to Nano Applications

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Abstract

Folklorists have referred agricultural crops as important beacon of past human civilization. However, medicinal and wild plants have been ignored even though in some cases these plants symbolize some of cultural and social ethnicity of the people who use them. Abrus precatorius *is one of such plants which originated in South Asia and carried from Old World to New World by South Asian dwellers as well as European explorers. The plant has been traditionally used in folk remedies by tribes for centuries throughout tropical and sub-tropical regions of the world. It was also used as adornment in primeval societies and as a unit of measuring mass in old Indian trade system. The plant is valued for its immense medicinal properties and reported to have a wide range of therapeutic effects. The present review provides information on history, ethnomedicinal uses, phytopharmacology and recent advancements that took place in biology and biotechnology of this plant.*

Abrus precatorius L. (common name jequirity bean, rosary pea, and wild licorice) is a pan tropical, slender, herbaceous perennial climber valued for its medicinal, economical and ornamental properties since ancient times. An ancient Indian physician Sushruta [the author of the treatise, The Compendium of Sushruta (Sanskrit: *Susruta-sa Chita*)] and other Sanskrit writers mentioned *Abrus* as venerable Hindu medicine in the literature long before 600 BCE, which indicates its origin in India or Southeast Asia (Pickering, 1879). Cultivation of this plant in Nile Valley was reported by Lindley (1838). Cada-nosto reported that by the end of 1454, this plant had reached to West Coast of Africa (Pickering, 1879). It is supposed that the plant had reached American terrain before arrival of Columbus, and the Carib people had started to cultivate it, immediately after its introduction (Pickering, 1879). Due to early introduction of this plant to the New World, several authors support that the plant must have been carried and dispersed by early ocean-going travelers (Grimr, 1976).

An ancient Indian physician Sushruta and other Sanskrit writers mentioned* Abrus *as venerable Hindu medicine in the literature long before 600 BCE, which indicates its origin in India or Southeast Asia.

However, there is no significant proof for pre-Columbian trans-Atlantic journeys. Many botanists hypothesized that the Phoenicians might have introduced *A. precatorius* to the New World. They were renowned for their fleets of wooden ships used for travel around the Mediterranean. The possibility of a natural dispersal of *A. precatorius* through birds is speculative. The shortest distance from West Africa to the Caribbean is ca 2,700 km. Furthermore, no bird species except cattle egrets has been reported in that geographical location that normally flies this voyage route and might have carried the seed of this plant (Ridley, 1930). However, possibilities of seed dispersion by cattle egrets are less because this migratory bird apparently did not establish itself in the New World until the mid-1930s (Crosby, 1972). Moreover, the diet of cattle egret is entirely small animals (insect, earthworm and small vertebrate) and do not support this hypothesis (Palmer, 1962).

Since its inception, *Abrus* was valued not only in Asian but also in African and Caribbean culture. An ethnomedicinal use of this plant, popular in different areas of the world has been summarized in table 1. Apart from medicinal uses, its seeds due to their attractive colours are also utilized by tribes for decorative purposes. The red shiny seed is a Chinese symbol of love. The seeds are very consistent in weight and therefore, in ancient India Abrus seed was used to weigh gold as measure called *Ratti* (Chopra *et al*., 1956). The ceremonial garb of West African tribes remained incomplete unless it was not decorated with *Abrus* beads and hence many markets dedicated for exclusive weekly sale of beads had been developed (Poole, 1850). Similarly, the tribes on the island of Fiji and in India, coat their sacred objects with seeds of *Abrus*. *A. precatorius* is also linked to witchcraft in the Obeah religion of West Africa. It has been suggested that this association is due to the black spot on the red seed which resembles an eye. *Abrus* was used in divination where "the pattern of a number of thrown seeds indicated favourable or unfavourable circumstances for a project or journey (Weiss, 1979).

Considering multiple uses of this plant, particularly in various medicinal systems of India, the present review attempts to compile updated information regarding its ethnobotanical uses and recent advances made in the field of biotechnology and agricultural use, primarily focusing on the medicinal properties, which have been exploited extensively in India and tropical parts of the world from ancient times.

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Plant description

Abrus precatorius L. belongs to the family Fabaceae and is commonly known as Jequirity bean, Crab's Eye, Rosary Pea, Akar Saga, John Crow Bead, Precatory bean, Indian Licorice, and Jumbie Bead in various countries (Fig. 1). The plant is also known as *Gunja* in Sanskrit, *kundu mani* in Tamil, *Kunni kuru* in Malayalam, and *Guruvinda ginja* in Telugu.

The plant is native to India, widespread in tropical and subtropical areas, up to an altitude of 1200 m on the outer Himalayas of India and also grows wild in the dry regions at low elevation. It is a deciduous woody climbing, perennial herb, which can be easily recognized by its shiny scarlet coloured seeds with a black spot at one end.

Young stems are usually smooth and greenish whereas older stems covered with wrinkled brown bark. Leaves are alternate and pinnate with 5-15 pairs of leaflets. These leaflets (5-25 mm long and 2-8 mm wide) are glabrous and oblong having rounded tips. Flowers are small whitish, pink or purplish, papilionaceous (about 10 mm long) usually borne in clusters. Individual flowers have five green sepals, which are fused together at the base into a short tube. Fruit is a flat and broad pod of 20-35 mm length with a sharp point having rough and hairy texture.

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Figure 1. Morphology of leaf, flower, seed pod and seeds of *A. precatorius* (Source: https://en.wikipedia.org/wiki/Abrus_precatorius#/media/File:Abrus_precatorius).

Mature pods have 3-7 oval-shaped seeds (5-7 mm long and 4-5 mm wide) which are usually scarlet red in colour with a large black spot at one end or white in colour. Different genotypes based on flowers and seed coat colours have been reported.

Ethnomedicinal and other uses

Plant-based traditional knowledge has become a recognized tool in search for new sources of drugs and nutraceuticals. Being a plant with medicinal potential, *A. precatorius* has been well explored for its ethnobotanical and pharmacological properties. Every part

Table 1. Ethnomedicinal properties of *A. precatorius* reported from various geographical regions of world.

Plant part	Used for	Geographical region	Reference
Seeds	Treatment for tetanus, rabies and intestinal worms	Central Africa	Obeta *et al.* (2014)
	Anti-ophthalmic, aphrodisiac, treatment of conjunctivitis, ulcer and anemia	Nigeria and West Africa	Olowokudejo *et al*. (2008)
	Anti-fertility agent and abortifacient	South Asia	Mali *et al*. (2006)
	Anti-intestinal worm, chronic eye diseases and against trachoma	India	Acharya *et al.* (2004)
	Anti-plasmodial agent	Africa	Menan *et al*. (2006)
	Aphrodisiac	Afghanistan and Egypt	Raamachandran (2008)
	Oral contraceptives	India and Africa	Dwivedi *et al*. (2018)
	Treatment for typhoid, respiratory tract infections	Nigeria and West Africa	Saganuwan and Onyeyili (2010)
Leaves	Oral candidiasis	Namibia and West Africa	Kayode (2006)
	Anti-diabetic	Lagos, Nigeria and West Africa	Gbolade (2009)
	Treatment for coughs and colds	Africa and Peru	Jiofack *et al*. (2010)
Root	Treatment for diuresis, fever, sore throat, bronchitis	South Asia	Sankaranarayanan *et al*. (2010)
	Treatment for sore throat and rheumatism	India	Chaudhari *et al*. (2012)
	Treatment for jaundice and liver problems	South India	Xavier *et al*. (2014)
	Treatment for whooping cough	India	Ahirwar (2015)

of the plant is equally important and has been used as folk/herbal medicines to treat various ailments in different parts of the world as listed in table 1.

Apart from medicinal significance, bright coloured seeds were also utilized by tribes for decorative purposes as well as for making beautiful jewelry. The red shiny seed is a Chinese symbol of love. It is referred as *ratti* (Sanskrit: *raktika*) in customary Indian unit of measurement of mass. Seeds were used for weighing gold in historic times, when modern weights/measures were not

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accessible at micro level. It was due to the consistency in its seed weight. A *Satamana* (hundred measures) was interpreted as hundred *rattis* and used as a standard weight of silver coins of olden India (Chopra *et al*., 1956).

Chemical composition of bioactive compounds and their therapeutic uses

Tremendous medicinal properties of the plant are attributed mainly to the glycoproteins known as lectins/agglutinins. Various plant parts of this species are known to contain alkaloids such as precol, abrol, abrasine, abrin A and B, glucoside, abrusic acid and haemagglutinin (poisonous proteins). Bioactive compounds present in different plant parts and their pharmacological effects are given in table 2.

Tremendous medicinal properties of the plant are attributed mainly to the glycoproteins known as lectins/ agglutinins.

Studies of different extracts and their pharmacological effects

The diverse pharmaceutical activities of *A. precatorius* are due to the presence of a wide array of bioactive compounds. A range of biological effects of different extracts has been reported in rodents or other animal systems, but are yet to be demonstrated clinically in human (Table 3).

Recent advances

Biotechnological approaches for *in vitro* studies. Natural propagation by seeds is

Table 2. Chemical constituents of different plant parts with pharmacological effects.

Plant part	Name of the chemical constituents reported	Pharmacological effects	Reference
Leaves	Abrusosides A–E (cycloartane-type triterpene glycosides) and glycyrrhizin	Sweetener with low caloric value	Karwasara *et al*. (2010)
	Lupenone, 24- methylenecycloartenone and luteolin	Porcine pancreatic α-amylase inhibitors	Yonemoto *et al*. (2014)
	Abrusogenin, saturated monoglyceride and unsaturated triglyceride	Antimicrobial	Ragasa *et al*. (2013)
Roots	Saponins and C-glycosyl flavones	Potent HIV-1 PR inhibitor	Ma *et al*. (2003)
Seeds	Abruquinone A to G	Anti- tubercular, anti-viral, cytotoxic, anti-platelet, anti-plasmodial	Limmatvapirat *et al*. (2004)
	Toxins abrin I, II and III and agglutinin APA-I and II	Immunomodulatory and anti-tumor	Ghosh and Maiti (2007)
	Trigonelline	Anti-diabetic	Monago and Nwodo (2003)

Table 3. Pharmacological effect of *A. precatorius* reported in literature.

Extract of plant part	Pharmacological effect	Reference
Ethanolic extract of seeds	Antifertility effect on sperm	Ahan *et al*. (2009)
	Anticancerous	Ramaswami *et al*. (2010)
	Antioxidant, anti-inflammatory	Arora *et al*. (2011)
	Contraceptive	Arora (2013)
	Anthelmintic	Rajani *et al*. (2013)
	Contraceptive	Bhatt *et al*. (2007)
	Anti-ovulatory	Okoko *et al*. (2010)
Methanolic extract of seeds	Anti-diabetic	Monago and Alumanah (2005)
	Anti-protozoal	Hata *et al*. (2013)
	Anti-bacterial	Mistry *et al*. (2010)
	Immunomodulatory	Tilwari *et al*. (2011)
Chloroform/ methanol extract of seeds	Antioxidant and free radical scavenger	Okoh *et al*. (2014)
Crude extract of seeds	Anti-bacterial	Jain and Gautam (2011)
Aqueous extract of seeds	Neuromuscular blocking agent	Premanand and Ganesh (2010)
Essential oils extracted from seed and shell	Anti-asthmatic	Taur and Patil (2012)
	Anticancerous	Manoharan *et al*. (2011)
Ethanolic extract of leaves	Antioxidant and anti-proliferative	Gul *et al*. (2013)
	Anti-bacterial	Adelowotan *et al*. (2008)
	Anti-tuberculosis	Ibekwe *et al*. (2014)
	Improved liver functioning	Ikechukwu *et al*. (2015)
	Fertility enhancement	Ogbuehi *et al*. (2015)
	Anti-microbial	Roy *et al*. (2012)
Methanolic/ chloroform extracts of leaves	Antimicrobial	Saganuwan and Gulumbe (2005)
	Nephroprotective	Sohn *et al*. (2009)
	Anti-plasmodial	Saganuwan *et al*. (2011)
	Haematonic and plasma expander	Saganuwan and Onyeli (2012)
	Protect liver damage	Wakawa and Frankline (2015)
Aqueous extracts of leaf	Anti-diabetic	Wakawa *et al*. (2015)
Ethyl acetate extract of leaves	Anti-serotonergic	Choudhari *et al*. (2011)
	Antioxidant and antiproliferative	Gul *et al*. (2013)
	Anti-carcinogenic	Anbu *et al*. (2011)
	Anti-bacterial	Mistry *et al*. (2010)
	Anti-microbial	Shourie and Kalra (2013)

Natural propagation by seeds is tough in* A. precatorius *due to hard seed coat. To cater the increasing demand and to save this medicinal plant from depletion, it becomes important to develop alternative methods of quality propagation.

tough in *A. precatorius* due to hard seed coat. To cater the increasing demand and to save this medicinal plant from depletion, it becomes important to develop alternative methods of quality propagation. Recently several protocols have been developed for the rapid *in vitro* shoot multiplication, rooting and callus organogenesis of *A. precatorius* (Table 4).

Studies on natural populations. Genetic diversity refers to the morphological variation conferred by genes within species that is heritable within and between populations. In *A. precatorius* many varieties based on seed coat colours have been reported. Also, each variety of seeds has its unique medicinal properties. Evaluation of genotypic variation among natural populations of *A. precatorius* has been carried out using different genetic markers (Table 5). A novel method of DNA isolation from *A. precatorius* has also been reported by Ghadia *et al.* (2016).

Development of botanicals. Higher plants are proficient in producing many secondary metabolites for self-protection against pests, diseases and weeds. Agricultural researchers have done extensive research for identification of plant extract referred as botanicals for control of pest and diseases of crop plants. In case of *Abrus*, Dimetry *et al*. (1990) tested coumarin, â-amyrin and sterols isolated from petroleum ether seed extract of *A. precatorius* for their activity against two-spotted spider mite, *Tetranychus urticae*, and found these compounds as most toxic for them. Larvicidal activity of the leaf and seed extracts against *Culex quinquefasciatus* has been observed by Manimegalai *et al*. (2011). Thangarasu *et al*. (2015) assessed pesticidal activities (antifeedant, ovicidal, larvicidal, and oviposition deterrent) using various extracts of *A. precatorius* against agricultural polyphagous field pest, *Spodoptera litura*. Prasad *et al*. (2015) reviewed literature on the toxic effects of *A. precatorius* derivatives against invertebrate pest species and indicated that many insect pests in the Pacific region (e.g. mosquitoes, termites, and aphids) are susceptible to the extract of this plant species.

Genetic transformation. Genetic transformation proved to be an effective way to enhance secondary metabolites production through plant cell cultures under controlled aseptic conditions facilitating production of high-quality products. *Agrobacterium rhizogenes* induced hairy root development and its effect on the production of glycyrrhizin in *A. precatorius* has been reported (Dixit and Vaidya, 2010). Karwasara and Dixit (2009) reported *A.*

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Table 4. Reports of *In vitro* propagation in *A. precatorius* from different explants.

Explant	Optimized Media	Response	References
Epicotyl segments	MS + NAA (0.1mg/l) + BAP (0.5mg/l)	Plantlets	Narula *et al*. (2001)
	MS + NAA (0.1 mg/l) + Kn (0.5 mg/l)	Plantlets	
Nodal segment	MS + 5.0 mg/l BAP and 0.5 mg/l NAA	Callus	Biswas *et al*. (2007)
	MS + 3.0 mg/l BAP + 0.5 mg/l Kn + 0.5 mg/l NAA.	Adventitious shoots formation from callus	
	½ MS containing 1.0 mg/l IBA	*In vitro* rooting in adventitious shoots	
Leaves and internodal segments	MS+ 1.5 mg/l 2, 4-D + 0.5 mg/l BAP	Maximum 80% callus from leaf explants	Hassan *et al*. (2009)
Internodal and leaf segments from *in vitro* grown seedlings	MS + 1.0 mg/l BAP + 0.1 mg/l NAA	Callus induction	Rahman *et al*. (2012)
	MS+0.5 mg/l BAP	Cell suspension culture established from callus	
	MS+0.5 mg/l BAP+ 0.1 mg/l NAA	Single cell suspension culture	
	MS+ 2.0 mg/l BAP + 0.2 mg/l NAA	Somatic embryos from single cells of suspension culture	
	2.0 mg/l BAP and 0.1 mg/l NAA	*In vitro* shoot induction from somatic embryos	
	1.0 mg/l IBA.	*In vitro* rooting	
Mature nodal explants (5-year-old field grown plant)	MS + 2.5 µM TDZ, 120 mg/l PVP, and 0.5 µM NAA	Direct shoot organogenesis	Perveen *et al*. (2013)
	½ MS+1.5 µM IBA	*In vitro* rooting of induced shoots	

MS: Murashige and Skoog's nutrient medium; **NAA**: 1-naphthaleneacetic acid; **2, 4-D**: 2,4-dichlorophenoxyacetic acid; **IAA**: Indole-3-acetic acid; **BAP**: 6-benzyl amino purine; **Kn**: kinetin; **IBA**: Indole-3-butyric acid; **TDZ**: Thidiazuron; **PVP**: Polyvinylpyrrolidone.

Table 5. Reports of Analysis of genetic variation/diversity among natural population of *A. precatorius* using different genetic markers.

Varieties/genotypes	Markers used	References
Eight wild accessions of *A. precatorius* L. from different areas of Maharashtra, Orissa and West Bengal	RAPD and ISSR markers	Randhawa *et al*. (2007)
Natural populations of *A. precatorius* (White, Red, Black and Pink seed coat color)	Protein and isozyme polymorphism using SDS-PAGE	Gupta (2008)
Seven varieties (White, Red, Sandal, Violet, Red with black, green, and Black color seeds)	SDS-PAGE analysis	John De Britto *et al*. (2011)
Three genotypes having red, white and black seed coat color	RAPD and ISSR markers	Mathur *et al*. (2013)
Three varieties of *Abrus* (Red and black, Black and white seeds)	Isoelectric focusing, MS analysis, binding assay and toxicity studies.	Chaturvedi and Kumar (2015)

rhizogenes mediated genetic transformation of *A. precatorius*. Roots and leaves of *A. precatorius* contain glycyrrhizin, which is commonly used in the pharmaceuticals and food industries. Further, Karwasara *et al*. (2010) studied the effect of different elicitors prepared from the fungi (*Aspergillus niger* and *Rhizopus stolonifer*), yeast extract, salicylic acid, ascorbic acid and eugenol on production of glycyrrhizin with a positive result of enhanced production of glycyrrhizin in *in-vitro* cultures using *A. niger* and ascorbic acid as elicitors. Ghosh *et al*. (2015) stated that gamma proteobacteria found in root nodule of *A. precatorius* possess the ability to produce ascorbic acid with some other plant growth-promoting rhizobacteria (PGPR) beneficial for nodule function and plant growth promotion.

Antibacterial potential of silver nanoparticles prepared from leaf extract of* A. precatorius *was demonstrated.

Nanotechnology

Nanotechnology is an emerging field with an ever-increasing impact, potential and applications in almost every field of science especially medical science. Biosynthesis of silver nanoparticles has been performed using number of plants (Ashok Kumar *et al*., 2015; Deepa *et al*., 2016) and reported to be more promising in applications such as biosensing, catalysis drug delivery, antimicrobial, therapeutic, imaging and in medicine (Yugandhar and Savithramma, 2016). Bhumi and Savithramma (2015) developed a fast, eco-friendly and convenient method for the synthesis of silver nanoparticles from *A. precatorius* leaf extracts. Ajitha *et al*. (2014) demonstrated antibacterial potential of silver nanoparticles prepared from leaf extract of *A. precatorius*.

Unconventional uses

Abrin and ricin are plant toxins derived from *A. precatorius*. They are relatively easy to acquire and produce, therefore considered as potential terrorists' biological weapon or chemical warfare agents. Ricin has been incorporated in schedule 1 of Chemical Weapons Convention (CWC). *A. precatorius* is also used for fertility enhancement in fish seed production (Nwude and Ibrahim, 1980). Bio-based absorbent has been developed by blending chitosan with *A. precatorius*. The resulting chitosan blended beads (CS/Ab) were effective in removal of phenolic compounds from aqueous medium (Kumar *et al*., 2009). The potential of non-edible *Abrus* seed oil is also investigated to produce biodiesel (Obeta *et al*., 2014).

Conclusion

The present review not only focuses on the ethnomedicinal significance, bioactive constituents and therapeutic properties of a much-valued medicinal plant *A. precatorius*, but also is a first attempt in consolidating various biotechnological advances as well as listing the various unconventional uses, such as in agriculture, biological warfare, genetic engineering, and nanotechnology. The extensive literature search concludes that although *A. precatorius* has immense medicinal importance, but biotechnological advances are still limited and more need to be done. All the information provided in the review was verified with the available literature.

> ***Abrin and ricin are plant toxins derived from* A. precatorius*. They are relatively easy to acquire and produce, therefore considered as potential terrorists' biological weapon or chemical warfare agents.***

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