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Review on *Argemone Mexicana*: Multipurpose Role in Management of Human Health.

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Introduction

On this green planet, there are uncountable plants that are considered wild/ weed/ unwanted due to lack of obvious economical value. However, these plants have adapted well to harsh conditions and thrive very well without any special attention. But, every organism created by Mother Nature has its value. Nothing is useless. Hence, these herbaceous weeds also have something valuable in their genomic constitution but they need sharp eyes and great passion to be explored scientifically in sustainable manner. In past many of the plants that were considered useless are now proven very important in terms of their phytochemicals. The wild herbs / shrubs and trees actually are the great reservoirs of novel phytochemicals and hence one aspect of biodiversity research is to conserve these precious gene pools before they become extinct.

Argemone Mexicana is native to Mexico and presently prevalent yearly weed of family Papaveraceae, mainly connected with farming corps and harsh environments. It is a chief weed for numerous cash to crops in the tropical, sub-tropical and humid temperature parts of the world. The Vernacular names of this plant are Mexican prickly poppy, flowering thistly, cardo / cardosantro, etc. In India this plant is variously known as agara / bharband/ bharbhar/ brahamandandi etc. This exacting plant species is considered as a risk to healthiness. If taken with contaminated food because is causes intense itchiness, is an annoyance to the farmers.

History of Introduction and Spread

Meaning of the name Argemone - argemos means white spot, eye cataract, which the plant was believed to cure; mexicana - from Mexico.

A. mexicana has been introduced accidentally (seed contaminant), as an ornamental or for its cultivation mainly for ethnobotanical purposes. Little is known about the history of its introduction and spread around the world. By 1814 it was the commonest weed of St Helena and was first recorded on Ascension in 1828. In New Zealand, it was accidentally introduced with imported wheat in the 1890s. The plant was introduced to Hawaii as an ornamental and was first recorded in 1934. Tye reported that the plant was still relatively uncommon and suspected that it may become problematic in the future. In the Czech Republic, it was first reported occurring in the wild in 1965, but appears to have become extinct.

Plant Profile

Domain: Eukaryota

Kingdom: Plantae

Phylum: Spermatophyta

Subphylum: Angiospermae

Class: Dicotyledonae

Order: Papaverales

Family: Papaveraceae

Genus: Argemone

Species: Argemone mexicana

Vernacular names

The plant is known by different vernacular names in the different areas by the local people mentioned in Table 1.

Sr. No.	Language	Vernacular names
1	Marathi	Phirangi Dhotra
2	Hindi	Satyanashi
3	Bengali	Barashil-kantal
4	Assamese	Kuhum-kata, Sial-kanta
5	English	Mexican Poppy, Prickly poppy, Yellow mexican poppy
6	Kannada	Datturi Gidda
7	Konkani	Phirangi Dhutro
8	Malayalam	Ponnumattu
9	Sanskrit	Kshirini, Swarnakshiri
10	Tamil	Piramathanda
11	Telugu	Brahmadandi
12	Irula	Mulluumathai
13	Other	Bhramadanthi, Mullu Umathai, Pivla dhotra

Table No. 1: Names used worldwide of *Argemone mexicana*

Plant description

A. mexicana is an annual herb, up to 150 cm tall with a slightly branched tap root. The stem is erect, branched, usually prickly, pale bluish-green and exudes an unpleasant-smelling yellow sap when cut. Leaves are alternate, without petioles, more or less sheathing the stem, up to 15 cm long, deeply lobed with irregularly toothed, spiny margins; greyish-white veins are conspicuous on the bluish-green upper surface of the leaves. Flowers are solitary, 2.5-4.5 cm in diameter, subtended by 1-2 leafy bracts; sepals 3, prickly; petals 4-6, yellow to pale orange, glabrous; stamens numerous. Fruit is a capsule, spiny, 2.5-5 cm long and 2 cm wide, with 4-6 valves opening at the tip to release numerous seeds. Seeds are brownish-black, nearly spherical, about 1 mm in diameter, covered in a fine network of veins, oily.

Global description

Argemone mexicana is an erect spiny annual or biennial herb, up to 1 m tall, with a slightly branched taproot. Its stem is branched and very prickly; it exudes a yellow juice when cut. The leaves are thistle-like and alternate, without leaf stalks, toothed and with spiny margins. The grey-white veins stand out against the bluish-green upper leaf surface. Showy solitary flowers of 2.5-5 cm diameter appear at the tips of the branches; their six rounded petals are bright yellow. The fruit is a prickly oblong or egg-shaped capsule that releases numerous small black seeds.

A. mexicana forma leiocarpa is a form found in West Africa which has few or no prickles on the stem, leaves and capsule.

Habitat

Argemone mexicana tends to grow along roadsides, in fallow and cultivated lands, riverbanks, disturbed areas, and on floodplains. It competes with and replaces native species in some cases and is also a significant crop weed.

Morphological Characteristics

Similar_species

Argemone mexicana differs from A. ochroleuca in that it has bright yellow flowers as opposed to cream or pale-yellow flowers, and globular flower buds as opposed to the egg-shaped buds of Argemone ochroleuca. The leaves of A. mexicana are green as opposed to bluish glaucous for A. ochroleuca.

Cotyledons

Cotyledons are linear and pale green, fleshy to acute apex, 6 cm long.

First_leaves

First leaves are simple, alternate, arranged in a rosette, green ribbed white, sessile.The blade is spatulate, attenuate at base, 6 to 8 cm long and 1 cm wide with 4 strong teeth, terminating in a short spine.

Stem

Stem is cylindrical to oblong, smooth and pale greenish. The entire stem is covered with very short hairs and few long yellowish spines.

Leaves

Leaves are simple, alternate, sessile, blue-green, thick and leathery. Blade is lobed, pinnate shape obovate, base slightly clasping, 6 to 20 cm long and 3 to 8 cm wide. Lobes oblong, convoluted, teeth ending in spines. Pinnate veins, whitish spines on smaller and less frequent, especially on the underside. Both leaf surfaces are hairless.

Inflorescence

Inflorescence is solitary sessile, in terminal or axillary, bright yellow.

Flowers

The flowers are large, 4 to 7 cm in diameter. There are 6 round petals, bright yellow.

Fruits

Fruits are ovoid capsules, 5cm long and 2cm in diameter. It is covered by stout, yellowish spines. When ripe it opens from the apex. It is divided into five chambers, contain numerous seeds.

Seeds

Seeds are produced in large quantity, small and black, 1.7-2 mm x 1.6 mm.

Chemical Constituents.

Whole plant: berberine, protopine, sanguinarine, chelerytherine, pancorine, (+)-argenaxine, angoline, aronttianamide, dihydrocheilantifoline, allocryptopine, coptisine, jatrorrhizine, columbamine, oxyberberine, N-demethyloxysanguinarine **Seed oil**: myristic, palmitic, oleic, linoleic acids. **Yellow juice**: berberine. Leaves: mexicanol, mexicanic acid. **Seeds**: dihydropalmitine hydroxide; berberine, protopine, ferulic acid, tannic acid,

caffeic acid, benzoic acid, cinnamic acid (Singh et al., 2010; Rajvaidhya et al., 2012). **Leaves**: protomexicine, mexitin, 8-methoxydihydrosanguinarine, 13-oxoprotopine, rutin, quercitrin, eriodictyol (Singh et al., 2012; Koumari et al., 2013)

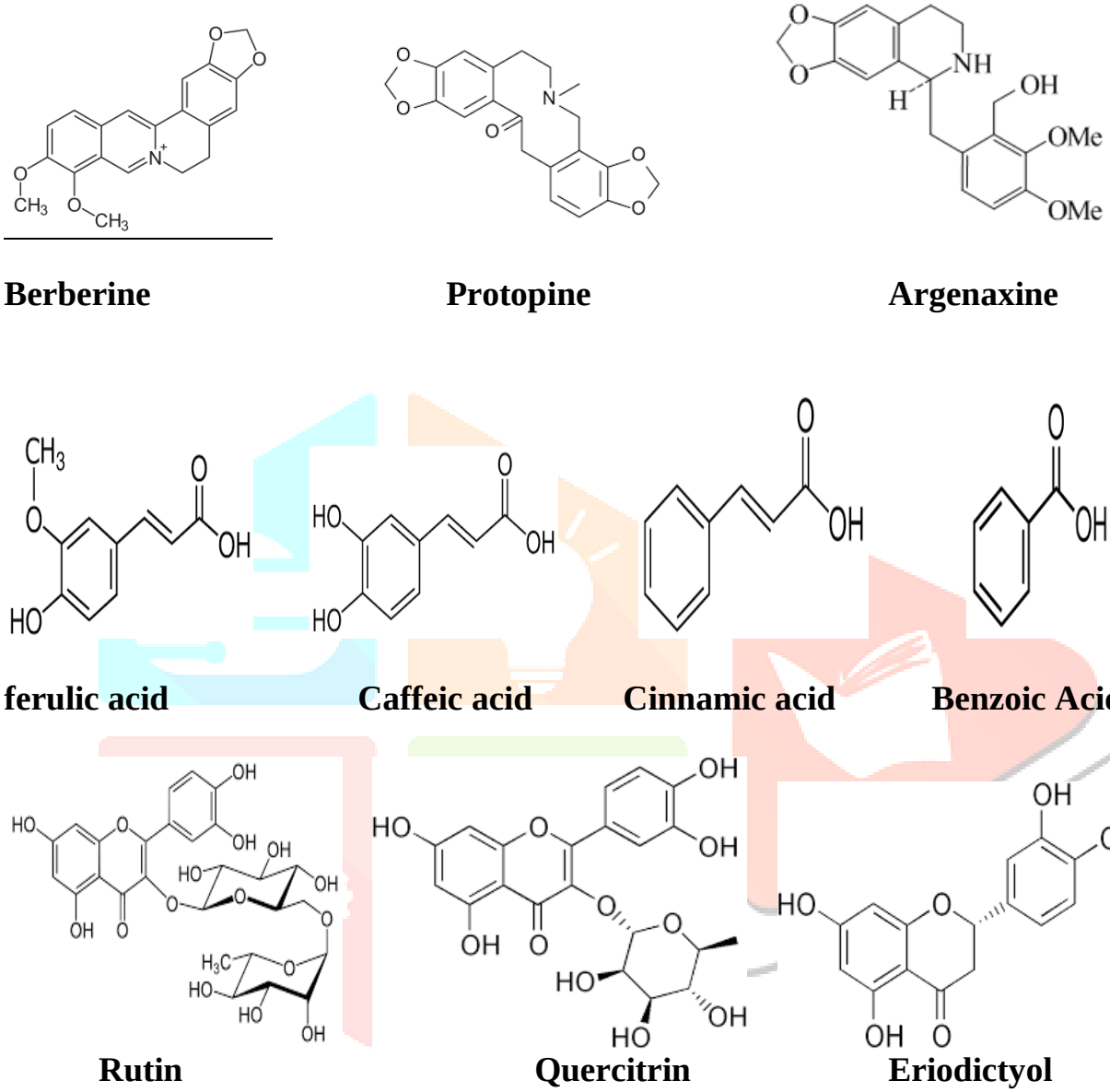

Figure No.1: Structure of some identified compounds from *Argemone Mexicana*

MATERIAL AND METHODS for Identification

Flavonoids identification through the Shinoda test

Argemone mexicana and Ricinus communis leaves were dried and macerated. Subsequently, 300 mL of reagent grade ethanol were added to the organic material. Ethanolic extracts were filtered and cooled. Later, 10 mL of magnesium chips were added jointly with concentrated hydrochloric acid.

Flavonoids identification through gaseous ammonia

Argemone Mexicana leaves were dried and 100 g were macerated for the further addition of 400 mL of distilled water to form an aqueous extract. Later, 400 mL of ethanol were incorporated. Mixtures were filtered for their placement in a vessel containing 300 mL of ammonia.

Flavonoids identification through base action

100 g of Argemone mexicana leaves were dried, and then macerated in a porcelain mortar. Subsequently, 500 mL of distilled water was used to prepare the aqueous extracts. The mixture was filtered. Then 150 mL were used to add 20 mL of 0.1 N sodium hydroxide to each sample. Four replications were carried out.

Sterols identification through the Liebermann-Burchard test

100 mL of chloroform were added to 10 g of Argemone mexicana material. Subsequently, extracts were filtered and added 3 drops of Liebermann reagent to the sample.

Saponins identification test

Fresh Ricinus communis leaves were used in the test. 50 g were placed in a beaker and added 300 mL of ethanol. The extract was filtered through a gauze. Subsequently, 40 mL of the extract were placed in a test tube and vigorously stirred. Foam presence indicates the existence of saponins. The compound represents a water-soluble, foam-producing group of oily glycosides.

Leucoanthocyanidins identification

50 g of dry Ricinus communis material was weighed for a later addition of 100 mL of ethanol. Subsequently, the mixture was filtered and added 50 drops of concentrated hydrochloric acid for a later water bath.

Ricinus communis acidity identification

100 mL of Ricinus communis aqueous, ethanolic and chloroform extracts were prepared. Subsequently, 50 mL of each extract were measured in a 500 mL volumetric flask with distilled water and the addition of 0.1 N sodium hydroxide.

Coumarins identification through UV light

50 mL of ethanolic extract were transferred to a beaker on which a filter paper was placed. Later, 5 drops of ethanolic extract were added on the paper. Subsequently, the beaker was heated on an electric grill until boiling. Finally, observation of the paper through UV light was carried out.

Pharmacological properties

ln Vitro Experiments

Antimalarial activity

Some compounds isolated from the active fraction of *Argemone mexicana* decoction were considered to be highly active against *Plasmodium falciparum*. These compounds are protopine (IC_{50} 0.32 µg/mL), allocryptopine (IC_{50} 1.46 µg/mL), sanguinarine (IC_{50} 7.02 µg/mL).

Antibacterial activity

The leaves aqueous extracts exhibited moderate antibacterial effects against *Enterococcus fecalis* and *Staphylococcus aureus* with inhibition zone of 20 and 10 mm respectively at 250 µg/disc concentration. With *Proteus mirabilis* and *Klebsiella pneumoniae* the inhibition zone was 16 mm at 250 µg/disc concentration. The aqueous extract of the leaves exhibited antifungal activity at 500 µg/disc concentration only against *Cryptococcus neoformans* and did not show any antifungal activity on *Aspergillus fumigatus*. The methanolic extract of the leaves exhibited significant antimicrobial activity at 125, 250 and 500µg /disc (zone of inhibition, 10-20mm) against *Proteus mirabilis, Klebsiella pneumoniae, Staphylococcus aureus, Enterococcus faecalis, Aspergillus fumigatus, Cryptococcus neoformans* (Kumari et al., 2013). Acetone extract of seeds inhibited the growth of *Klebsiella oxytoca* (MIC 0.02 mg/disc), *Vibrio damselle* (0.01 mg/disc), *Enterobacter aerogenes* (MIC 0.01 mg/disc), *Escherichia coli* (MIC 0.005 mg/disc) (Kempraj & Bhat, 2010). The chloroform fraction (CH3) of seeds was significantly active at 4 to 64 mg/mL against *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumoniae* and *Pseudomonas aeruginosa.*

Antioxidant activity

The flower methanolic extract showed a dose dependent scavenging activity and free radical inhibition of total antioxidant (IC_{50} 280 µg/mL), hydrogen peroxide (IC_{50} 290 µg/mL), reducing power assay (IC_{50} 250 µg/mL), nitric oxide (IC_{50} 280 µg/mL) comparable to free radical scavenging activity of ascorbic acid (Kasthuri & Chitra, 2014). The ethyl acetate and methanol extracts of the leaves exhibited an interesting DPPH free radicals scavenging with IC_{50} values of 39.31 µg/mL and 65.56 µg/mL, respectively.

ln Vivo Experiments

Hepatoprotective activity

The protective effects of the aqueous extract of *Argemone mexicana* whole plant, against CCl_4 induced hepatic failure in male albino rats (wistar strain) was investigated. The administration of aqueous extracts (250mg/kg and 150mg/kg of body weight) for 7 days, elicited protective action since the elevated levels of marker enzymes (AST, ALT, ALP) of liver functions were found to be decreasing progressively in a dose dependent manner with net weight gain. In the aqueous extract 250mg/kg treated rat group all the marker enzymes were analyzed to be decreasing significantly ($p<0.001$), (AST, 272.77±24.08; ALT, 189.15±7.16; ALP, 97.15±6.54) and the

final body weight wasalso significantly ($p<0.001$) increased (6.16±1.01) when compared with the toxic control group (Willcox et al., 2007).

Das et al. (2009) showed promising antihepatotoxic activity of aqueous extract of *A. mexicana* stem in carbon tetrachloride-induced hepatotoxic male Albino Wistar rats; oral administration of 150 and 250 mg/kg body weight of the extract decreased serum asparate transaminase, alanine aminotransferase and alkaline phosphatase levels. Another research group (Sourabie et al., 2012) also investigated the anti-icterus activity of crude leaf powder of the plant against CCl_4-induced hepatotoxicity in Wistar rats; the investigators observed significant increase in the levels of ASAT/GOT (aspartate aminotransferase), ALAT/GPT (alanine aminotransferase) and ALP (alkaline phosphate) while decrease in total bilirubin (TBIL) and direct bilirubin (DBIL) level tested at different doses of 125, 250 and 500 mg/kg b.w.

Antidiabetic activity

Aqueous extract of aerial parts of *A. mexicana* at a dose of 200 and 400 mg/kg body weight was reported to have hypoglycemic efficacy in alloxaninduced diabetic rats; significant reduction in blood glucose levels, plasma urea, creatinine, triacylglyceride, cholesterol values and recovery in body weight compared to diabetic control rats and the standard drug treated rats are found when treated with the aqueous extract at a dose of 400 mg/kg body weight. The hydro-alcoholic extract of aerial parts of *A. mexicana* also reduces fasting blood glucose levels in Streptozotocininduced hyperglycemic Wistar albino rats at a dose of 200 and 400 mg/kg body weight.

Wound healing activity

The wound healing effects of the leaf extract (50% ethanol) and latex were investigated on albino rats using both excision and incision wound models. Topical application of the extract and latex, respectively, gave 67.08 and 57.86% healing after 12 days in the excision model and increased tensile strength to 188.50 and 154.61 gm in the incision model.

Clinical Studies

A prospective, dose-escalating, quasi-experimental clinical trial was conducted with a traditional healer using a decoction of *Argemone mexicana* for the treatment of malaria. The remedy was prescribed in three regimens: once daily for 3 days to group A; twice daily for 7 days to group B; and four times daily for the first 4 days followed by twice daily for 3 days to group C. Thus, 80 patients were included, of whom 80% were aged < 5 years and 25% were aged < 1 year. All presented to the traditional healer with symptoms of malaria and had a *Plasmodium falciparum* parasitaemia > 2000/µl but no signs of severe malaria. The proportions of adequate clinical response (ACR) at day 14 were 35%, 73% and 65% in Groups A, B and C, respectively ($P = 0.011$). At day 14, overall proportions of ACR were lower in children aged < 1 year (45%) and higher in patients aged > 5

years (81%) (P = 0.027). Very few patients had complete parasite clearance, but at day 14, 67% of patients with ACR had a parasitaemia < 2000/µl.

Biological activities exhibited by the plant and plant constituents

Anti-HIV activity

The benzo[c]phenanthridine alkaloid, (±)-6-acetonyl dihydrochelerythrine isolated from the methanolic extract of air-dried whole plants of A. mexicana was found to exhibit potent anti-HIV activity in H9 lymphocyte assay with EC50 value of 1.77 µg/mL (Therapeutic Index: 14.6).

Anti-inflammatory activity

The ethanolic extract of leaves of A. mexicana is reported to have significant anti-inflammatory and analgesic activity at a dose of 200 mg/kg in mice. It is also reported that leaf extract of A. mexicana is able to show significant anti-inflammatory activity in rats; the investigators are in opinion that the chemical constituents of the leaf extract such as isorhamnetin-3-O-β-D-glucopyanoside, β-amyrin, cysteine and phenylalanine might be responsible for such activity.

Anti-stress and antiallergic activity

Both the polar extracts (i.e. aqueous and methanolic) of A. mexicana stems were evaluated to exert antiallergic as well as antistress efficacy in asthma developed by milk-induced leucocytosis and milk-induced eosinophilia at a dose of 50 mg/kg i.p. in albino mice model; both of the test extracts showed significant ($p<0.05$) decrease in leucocytes and eosinophils in vivo.

Vasoconstrictor and vasorelaxant effects

Paez-Sanchez and his group (2006) evaluated the vascular effects of methanolic extract of the aerial parts A. mexicana in rat aortic rings; the test extract was found to produce relaxation from contraction induced by noprepinephrine in a concentration-dependent manner. The overall experimental results demonstrated that the plant extract is able to induce a direct and dual specific effect upon the vascular smooth muscle, mediated, at least in part, by adrenergic receptors.

Anti-fertility activity

Three isoquinoline alkaloids, dihydropalmatine hydroxide (44), berberine (2) and protopine (9), isolated from the seeds of Argemone mexicana were evaluated to have inhibitory activity against spermatogenesis in dogs at the stage XII of late spermatids on administration at a dose of 30 mg/kg for 70 days; the numbers of spermatids were found to decrease by 46.5, 58.0 and 97.7% with compounds 44, 2 and 9, respectively (Gupta et al., 1990).

In addition, the total numbers of mature Leydig cells were also decreased by compounds 2 and 9. The relative antispermatogenic activity was reported to be: 9 > 2 > 44.

Cytotoxic activity

Methanolic extract of A. mexicana leaves was found to exhibit cytotoxic activity against healthy mouse fibroblasts (NIH3T3) and three human cancer-cell lines (AGS, HT-29 and MDA-MB-435S) using the MTT [3-(4,5-dimethylthiazole-2-yl)-2,5-diphenyltetrazolium bromide] assay as reported by Uddin and his group (2011). The result showed that the extract is much active against MDA-MB-435S cancer cell line (IC50 1.82 mg/mL). Chang and his group (2003a) isolated a number of alkaloids from A. mexicana and evaluated cytotoxic activity of some of the isolated alkaloids viz.N-demethyloxysanguinarine (33), pancorine (34), (+)-argenaxine (27), (+)-higenamine (28), (+)-reticuline (8), angoline (41) and chelerythrine (22) to human nasopharyngeal carcinoma (HONE-1) and human gastric cancer (NUGC) cell lines. Chelerythrine (22) was found to be the most active among the series against NUGC cell lines, whereas (+)-argenaxine (27) showed only a moderate activity. On the other hand, angoline (41) inhibited both HONE-1 and NUGC cancer cell lines.

Nematicidal activity

It was reported that the seed oil of A. mexicana is found to kill Meloidogyne incognita larvae in 17 min (Das & Sukul, 1998). The investigators found reduction of nematode infection in terms of root galling, root protein content and nematode population in soil and roots after application of aqueous mixture (0.2%) to soil and leaves of Hibiscus esculentus inoculated with M. incognita. Nath et al. (1982) investigated nematicidal properties of plant extracts of different parts of A. mexicana against M. juvanica in experimental test tubes of microplots. They reported that plant extracts are capable of lowering nematode population in the field while larvae were found to be immobile in 24 h. Another research group (Shaukat et al., 2002) reported that juvenile mortality of M. juvanica is caused by different extracts of A. mexicana leaf material, out of which polar solvent extract found to be more effective. Again, seed soaking in aqueous extract of A. mexicana is found to reduce penetration of the nematodes juvenile in chick pea, thereby supporting nematicidal efficacy of the plant.

Antifeedant activity

It is reported that petroleum ether and aqueous leaf extracts of A. mexicana were found to exhibit significant antifeedant activity against second stage larvae of Henosephilachna vigintiocto puncata Fabricius.

Lousicidal activity

Kumar and his group investigated lousicidal efficacy of aqueous leaf extract of A. mexicana by conducting mortality and repellency tests on tropicalis peters and found lousicidal activity with 73% mortality.

Mollucicidal activity

Two alkaloids, protopine and sanguinarine, isolated from the plant are found to exhibit mollucicidal activity by decreasing significantly in the levels of protein, free amino acid, DNA and RNA in the nervous tissue of Lymnaea acuminata and also to cause a significant reduction in phospholipids levels and a simultaneous increase in the rate of lipid peroxidation in the nervous tissue of treated snails.

Effect on ileum organ

Capasso and his group studied the effect of the methanolic extract, its partially purified fraction, and the isolated pure compounds such as protopine and allocryptopine from A. mexicana on the morphine withdrawal effect in guinea pig isolated ileum; all the tested materials were observed to reduce the effect significantly and in a concentration-dependent manner, thereby suggesting the possible application of isoquinoline alkaloids as potential agents in the treatment of drug abuse. Further investigation in this direction also indicated that that CHCl3/MeOH and MeOH extracts reduced the contractions of isolated guinea-pig ileum in a dose-dependent manner (Piacente et al., 1998); the effects were attributed to the active compounds identified as protopine , allocryptopine and berberine .

Fungitoxic activity

A. mexicana seed extract is found to be fungitoxic against a number of fungal strains. The latex of the plant was found to exhibit toxicity against Trichophytan mentagrophytes. The leaf extract of A. mexicana is found to exhibit significant fungitoxic activity against few fruit pathogens like Alternaria alternata, Dreschlera halodes, and Helminthosporium speciferum and also against Curvularia tuberculata , responsible for die-back diseases.

Antihelmintic activity

The aqueous plant extracts of A. mexicana find useful as significant antihelmintic against Indian earthworm Pheritima posthuma also investigated antihelmintic activity of alcohol and aqueous extracts of leaves against P. posthuma and Ascardia galli in a dose dependent manner (6.25, 12.5, 25, 50, 100 mg/mL) and found that both the extracts show significant antihelmintic activity at a concentration of 100 mg/mL.

Larvicidal activity

Acetone fraction of the petroleum ether extract of seeds from A. mexicana exhibited larvicidal and growth inhibiting activity against the 2nd instar larvae of Aedes aegypti at concentrations from 25 to 200 ppm having IC50 values of 13.58 ppm and 17.43 ppm at field condition and laboratory condition, respectively (Sakthivadivel & Thilagavathy, 2003). Willcox et al. (2007) also reported significant larvicidal activity of acetone fraction of petroleum ether extract of A. mexicana seeds against 2nd instar larvae of A. aegypti. The leaf extract (in petroleum ether) of the plant also exhibits high larvicidal potential with LC50 value of 48.89 ppm against 3rd -4th instar larvae of Culex quinquefasciatus (Sakthivadivel et al., 2012). A synergistic action of

this plant was also reported in their findings; larvicidal potential of leaf extract of A. mexicana increases (LC50 value of 28.60 ppm) when mixed (1:1) with that of Clausena dentate.

Anticancer activity

The ethanol extract of A. mexicana was reported to exhibit inhibitory activity against human cancer cell lines such as HeLa-B75 (48%), HL-60 (20.15%) and PN-15 (58.11%) (Gacche et al., 2011). Gali et al. (2011) also reported anticancer activity of methanolic extract of A. mexicana leaves against HeLa and MCF-7 cancer cell lines with IC50 values ranging from 1.35 to 1.2 µg/µL based on MTT assay results. The investigators also proved that the nature of this cytotoxic activity is apoptotic rather than necrosis and this activity may be due to the presence of flavonoid constituents in leaf.

Antihepatotoxic activity

Das et al. (2009) showed promising antihepatotoxic activity of aqueous extract of A. mexicana stem in carbon tetrachloride-induced hepatotoxic male Albino Wistar rats; oral administration of 150 and 250 mg/kg body weight of the extract decreased serum asparate transaminase, alanine aminotransferase and alkaline phosphatase levels. Another research group (Sourabie et al., 2012) also investigated the anti-icterus activity of crude leaf powder of the plant against CCl4-induced hepatotoxicity in Wistar rats; the investigators observed significant increase in the levels of ASAT/GOT (aspartate aminotransferase), ALAT/GPT (alanine aminotransferase) and ALP (alkaline phosphate) while decrease in total bilirubin (TBIL) and direct bilirubin (DBIL) level tested at different doses of 125, 250 and 500 mg/kg b.w.

Miscellaneous activities

The Department of Traditional Medicine in Mali has recognized A. mexicana as a standardized phytomedicine for home-based management of malaria (Willcox, 2011; Schrader et al., 2012). Aqueous extract of the aerial parts of the plant was found to exhibit anti-parasite activity against the chloroquine-resistant K1 strain of Plasmodium falciparum with an IC50 value 5.89 µg/mL; in a randomized, controlled clinical trial, 89% of patients recovered clinically (95% with artemisinin based combination therapy), although parasite clearance was only achieved in 9% of patients (Schrader et al., 2012). No deterioration of severe malaria in patients >5 years and 1.9% deterioration in children <5 years were observed in the clinical trials (Willcox et al., 2011). As far as phytochemical constituents are concerned, A. mexicana contains the alkaloids berberine (2), protopine (9) and allocryptopine (10); although these compounds showed in vitro antimalarial activity (IC50 of protopine against the W2-strain 0.91 µM) (Avello Simoes Pires, 2009), berberine is purely absorbed, and the aqueous decoction of the plant was not active against Plasmodium berghei in the mouse model.

Recently, Amartha & Chaudhari (2011) reported on neuropharmacological applications of A. mexicana; the ethyl acetate and methanol extract of the whole plant of A. mexicana exhibited analgesic, locomotor and muscle relaxant activity in Wistar albino mice at an oral dosage of 100, 200 and 400 mg/kg b.w. Both extracts showed

significant activities but methanol extract at a dosage of 200 mg/kg body weight was found to be more potent for central nervous system activities such as analgesic, anxiolytic and sedative effects (Amartha & Chaudhari, 2011). In addition, acetone leaf extract of the plant showed significant anti-termitic activity against the Formosan subterranean termite pest, Coptotermes formosanus Shiraki, in a dose-dependent manner; after 48 h of exposure, the plant extract exhibited LD50 and LD90 values of 253 and 1511 ppm.

Uses

Economic worth

A. mexicana has revealed significant antimicobial action against the bacteria strains, viz., Staphylococcus agalectiaei, S. aureus an Escherichia coli, with impending in the pharmaceutical production (Alemayehu and Desalegn, 2016). This weed has been cultivated for its seed oil, which is specifically used at industrial scale for soap manufacture and also for fuel production.

Social benefit

A. mexicana is used for spiritual reasons by many tribes (Hanelt and IPK, 2016). The extracts of the leaves, floral buds and seeds of this weed have been evaluated in laboratory conditions for their insectidal potential (Chitra et al., 1997), common crop pathogens (Singh et al., 1993) and also against nematodes (Das and Sukul, 1988; Saxena and Tabassum, 2000; Shaukat et al., 2002). Aqueous extracts were successfully assessed against, Lipeurus lawrensis tropicalis (Kumar et al., 2002). Few researches recommended that the root extracts can be utilized to avert oviposition and work as ovicidal in opposition to Aedes aegypti (Warikoo and Kumar, 2014).Von Weizsäckerl (1995) stated that this weed is used in India to set up an antifeedant spray similar as the foliage of Azadirachta indica (Neem). Plant extracts of A. mexicana eagerly kill the Biomphalaria glabrata (snail) and thus regarded as molluscide for the fairly economical management of schistosomiasis in humans.

Medicinal value

Medicinal possessions have been recognized to the seed sap and its oil (Holm et al., 1977). Ethnobotanically the entire plant is used as a blend to cure asthma. The root is mixed with alcohol (rum) to cure stomach pain. The sap of the stem (cut ends) is useful for the cure for toothache. Kids having obscure urination are given mixtures of petals (DeFilipps et al., 2004). In Madhya Pradesh (India) it is designated as a homeopathic preparation (Oudhia et al., 1998). In African nations, leaves of the plant are used as a cosmetic (Rukangira, 2001). The seeds are ground and mixed with beer/tea to augment their strength (Verdcourt and Trump, 1969). In India, the minute quantity of seeds of this plant is mixed with mustard oil to increase its pungency, however, above that minute quantity the mixing of its seeds to mustard is considered as an adulteration.

Environmental services

Although this herb species has been stated as toxic to animals, however, this plant is palatable by lemurs, which were seen consuming the stems of this weed when other resources were insufficient after a destructive cyclone in Madagascar. Those lemurs were then observed and no harmful concerns related to normal healthiness were reported by the researchers (LaFleur and Gould,2009). Hence it can be concluded that the shoots are risk free and only seeds have toxic substances.

Ethnobotanical uses

Among many tribes this plant has certain ritual uses which are evident by their folklores (Hanelt and IPK, 2016). The different parts of this weed posses strong emetic, sedative actions and conventionally been used to take care of syphilis and various skin-diseases (Krishnamurthy, 1969; Savithramma et al., 2007). In cough and asthma seeds are given as a remedy. Seeds are also found laxative in nature with emetic, expectorant and demulcent properties. The root is an anti-helmintic (Nadkarni, 1982). Chemical characterization of this plant has discovered the existence of certain alkaloids, amino acids, phenolics and fatty acids (Hussain et al., 1983; Harborne and Williams, 1983). The plant contains several alkaloids, viz., protopine, berberine, sarguinarine, optisine, chelerytherine etc. While, the seed oil has fatty acids, viz., palmitic, myristic, oleic, linoleic acids, etc. The sap of the plant is yellow and contains minute quantities of berberine, also potassium nitrate was identified among the salts naturally existing in the plant.

Ethnobotanical Importance

Argemone species have been used in traditional medicine from ancient cultures. A. mexicana was described in the “De la Cruz Badiano” Codex, a compilation about the traditional use of the medicinal plants by Aztecs . According to the ethnobotanical interpretation of archaeobotanical and iconographic records, A. ochroleuca subsp. stenopetala was identified as a medicinal plant potentially used by Teotihuacan culture. In Mexico, infusions of aerial parts of the plant are still used in the treatment of eye such as conjunctivitis, respiratory, dermatological, and oral infections, as well as for wounds. Some communities such as Tepotzotlán (State of Mexico), Ahuacatlán (Nayarit), among others also use these infusions because of their stimulant and hallucinogenic effects. Other medicinal properties of Argemone species have been reported in different Latin American countries, such as analgesic use of A. subfusiformis in Argentina, or in Bolivia, against cough and cold. Moreover, Argemone species are also part of the traditional medicine of Saudi Arabia, and India (Tribe in Myeong area, Assam); where they have been used against diseases such as dropsy, jaundice, as well as eye and skin infections such as scabies and leprosy.

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