Journal of Medicinal Plants Studies
Year: **2014**, Volume: **2**, Issue: **3**
Pages: (**44-50**)
ISSN: **2320-3862**
Online Available at **www.plantsjournal.com**

Journal of Medicinal Plants Studies

Cryptic but some potential Insecticidal Plants of India

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Plants have evolved a wide variety of chemical compounds which are known as secondary metabolites for protecting themselves against insect herbivory. These chemicals have evolved as a result of long period of coevolution which has taken place between the plants and the insect over a period of centuries. Plant based insecticides are safe for use and hence have been researched to develop insecticides for commercial utilization. The paper gives detailed information of sevenless known insecticidal plants of India.

Keyword: Insecticidal Plants, Potential, Insects

1. Introduction

Plant defense mechanisms against insect herbivory are diverse. These could be mechanical or biochemical. Mechanical defense mechanisms include the presence of trichomes, glands, thick cuticle, presence of wax, presence of spines on the leaves, etc. Some plants have evolved defensive symbioses with microbes or myrmecophily where they harbour protective ants or recruit parasitoids and predators that attack the herbivores (Schardl. & Chen, 2010) [1]. Some plants have interesting defence strategy wherein they attract predatory insect to protect themselves from insect attacks, for example plants attract wasp, *Opius dissitus*, by releasing a compound, (Z)-3-hexenol, and the wasps protect the plant frompredatory attack of pea leafminer pest, *Liriomyza huidobrensis* (Wei *et al*, 2007) [2].

The biochemical defense mechanisms include the diverse chemicals which are synthesized by plants and stored in tissues. These organic chemicals include alkaloids, glycosides, proteinaceous compounds, organic acids, alcohols, resins and resinoids (including phenolics), nitrate-nitrites, steroids, phenylpropanoids and compounds that act as precursor which on damage of the plant tissue release cyanide (Schardl & Chen, 2010) [1]. The biochemicals have evolved as a result of long period of coevolution which has taken place between the plants and the insect over centuries. The secondary metabolites protect the plants from herbivore attacks. The better the plants are equipped with defensive chemicals, the more is the success of the plants to grow successfully and produce offsprings.

The secondary metabolite also varies with the organs of the plant. The tissues such as stem and branches which are generally tougher for the insect to feed have lesser quantity of secondary metabolite; the leaves on the other hand have higher quantity of secondary metabolites. Interestingly the reproductive organs such as seeds and vegetative reproductive organs such as rhizomes and other root stocks which are essential for the survival of species are richer in secondary metabolite. For example, the seeds of *Datura*, rhizomes of aconite, have higher level of protection due to presence of higher dosages of the toxic constituents (Subramaniam, 1993) [3].

Some insects have a remarkable ability to feed on plants having secondary metabolites and use the secondary metabolites to their advantage. The

insects sequester the toxic constituents and store it in their body which protects them from their predators. For example, the monarch butterfly, *Danaus plexippus*larva feed on milkweeds (Ackery *et al*., 1984; Harborne 1986; 1989) [4, 5, 6] and *Cycnia tenera* is a common feeder on *Apocynum cannabinum* (dogbane, Indian hemp) which also produces a milky latex containing cardenolides, toxic cardiac glycoside that defend against herbivores. It also feeds on milkweeds (Cohen & Brower 1983) [7].

The insecticidal properties of the plants which they have evolved over a period of time can be used to advantage by utilizing these against insect pests. For example the insecticidal plants can be used for protecting the stored grains against insect pests, protecting human beings against the insect vector borne diseases, protecting crop plants against insect damage, protecting pets against insect attack, etc. Thus, observing the immense value and economic importance of these insecticidal plants an effort to divulge and document the morphology and functional properties of some of the important yet less known plant species have been taken into account.Information on scientific name, common name, family, morphology, distribution and the insecticidal properties known till date have been compiled and presented.

2. Materials and methods

Available literature on insecticidal plants were collected and analysed thoroughly in order to gain information on the extensively studied insecticidal plants. Based on the current knowledge on the potential insecticidal plants, seven plants were indentified as having enormous potential for their applicability as insecticides, but unexploited. This review presents literature collected for the little known potential insecticidal species and details about their scientific name, family, distribution, chemical constituents and their morphology.

3. Plants of less known potential insecticidal properties.

The morphology, distribution, insecticidal properties and chemical constuituents are hereby discussed and documented in this paper.

A. *Abelmoschus moschatus* Medic.

Syn.: Hibiscus abelmoschus L.
Common Name: Ambrette plant, Musk mallow
Family: Malvaceae
Morphology: Erect annual or biennial hirsute herb 0.6-1.8 m and grows at a fast rate.Leaves polymorphous: the lower, ovate and acute; the upper, palmately 3-7 lobed; flowers large bright yellow, usually solitary and axillary, sometimes in few-flowered racemes; capsules ovate; the seeds are sub-reniform, black and musk-scented.
Distribution: All over Deccan and Karnataka in hilly regions and at foothills of Himalayas.
Insecticidal Properties: Seeds used for making less expensive sachet powders for placing among clothes as an insect repellent. Upper part of plant and fruits mildly insecticidal property (Watt & Breyer-Brandwijk 1962, Cravo *et al*., 1992, Bown 1995) [8, 9, 10].
Chemical Constituents: Steam distilled crushed seeds yield a volatile oil, known as musk seed oil or ambrette seed oil (Bown 1995) [10]. The oil contains 18.9% linoleic acid and contains a-cephalin, phosphatidylserine, its plasmalogen and phosphatidylcholine plasmalogen. The characteristic musk-like odor of the seed oil is mainly due to the presence of a ketone, ambrettelide, a lactone of ambrettolic acid (Guenther, 1948; Krishna & Badhwar, 1966) [11, 12]. The essential oil also contains trans-2-trans-6-farnesyl acetate and ambrettolide, cis-2-cis-6-farnesyl acetate, cis-2-trans-6-farnesyl acetate, ethyl hexadecanate, ethyl laurate and trans-2-trans-6-farnesol (Hort Abstr, 1993) [13]. Seeds contain gossypetine, hibiscine and a quercitine.

B. *Aconitum ferox* Wall. ex Ser.

Common Name: Aconite, monkshood
Family: Ranunculaceae

Morphology: A deciduous perennial herb, up to 1 m high, erect stem bear racemes of large bluish purple flowers having numerous stamens, sepals are petaloid, petals have nectarines, upper two petals large.
Distribution: Alpine Himalayas of Kashmir at altitude of 3,600 m.
Insecticidal property: The roots are effective insecticide (IUCN, 2000) [14].
Chemical constituents: Roots contain aconite alkaloid such as pseuaconitine, chasmaconitine, indaconitine, bikhaconitine and diacetylpseuaconitine which is responsible for insecticidal properties (WOI, 1985) [15].

C. *Acorus calamus* L.
Common Name: Calamus, Sweet Flag
Family: Araceae
Morphology: The plant is a semi-aquatic perennial aromatic herb with creeping rhizome. Leaves erect, sword-shaped, up to 2 m long and come from branched, underground rhizome. Rhizome cylindrical, 1-2 cm thick and up to 1m long. Flowers many yellow and green present on a spike-like spadix, having a spathe.
Distribution: Found wild and also cultivated.
Insecticidal Property: Fragrant leaves deter insects. Powdered rhizome used for killing fleas, bedbugs, moths, lice and ant. Effective in killing insect pests in stored rice without any residual effect. Ether extract of rhizome shows ovicidal properties (Jacobson 1983; Risha *et al*, 1990; Schmidt *et al*, 1991; Su, 1995) [16, 17, 18, 19].
Chemical constituents: The rhizome yields oil (1.5-3.5% dry weight) containing asarone (up to 82%) and its *β*-isomer. Sweet flag oil contains phenylpropanes, monoterpenes, and sesquiterpenoids (Todorova *et al*., 1995) [20].

D. *Adhatoda zeylanica* Medic.
Syn.: *A. vasica* Nees
Commion Names: Malabar nut, Malabar chestnut, White vasa, Yellow vasa, Vasaka
Family: Acanthaceae
Morphology: Evergreen gregarious, stiff perennial shrub 1.2-6.0 m in height. Leaves elliptic-lanceolate, entire, 10-25 cm long, hairy, light green above, dark below; flowers large, white with red- or yellow-barred throats, in spikes with large bracts; fruit a capsule.
Distribution: The plant is distributed throughout India and in the lower Himalayan ranges, up to 1500 m.
Insecticidal Property: The plant has insecticidal property (Rathi *et al*., 2008) [21]. An infusion of leaves used against white ants and red spiders of tea (Singh *et al*, 1965) [22]. The plant has feeding deterrence activity against *Spodoptera litura* (Fab.) (Anuradha *et al*., 2010) [23] and *Spodoptera littoralis* (Sadek, 2003) [24].
Chemical composition: Leaves contain an essential oil (0.075%) chiefly containing limonene and an alkaloid vasicine. Quinazoline alkaloids- vasicoline, adhatodine, vasicolinone and anisotine have been isolated from leaves.

E. *Agave americana* L.
Common Name: Century plant century plant, maguey or American aloe
Family: Agavaceae
Morphology: The plant is a stiff upright shrub, up to 1.3 m tall. Leaves are simple basally arranged, leathery, prickly and succulent, lanceolate, flowers are in corymb like panicles, corolla rotate, showy green or yellow, fruit a capsule, brown or black. The plant is monocarpic.
Distribution: Native to America introduced and naturalized throughout India.
The plant has insecticidal property (Bown, 1995) [10]. The volatile oil from leaves renders the wall paper and plasters white-ant proof (Watt & Breyer-Brandwijk 1962) [8].
Chemical constituents: The plant possesses acrid and non-volatile oil.

F. *Albizia lebbeck* (L.) Benth.
Common Name: Siris tree, Lebbek Tree, Flea Tree, Woman's Tongue Tree
Family: Mimosaceae
Morphology: A deciduous tree grows up to 25 m tall. Leaves bipinnate, alternate, stipulate, up to 15 cm long, with one to four pairs of pinnae, each pinna with 6–18 leaflets; flowers greenish- white, bisexual in subglobose heads, with numerous long stamens, and very fragrant; fruit a pod up to

30 cm long contains six to twelveseeds.seeds about 10, ovate, dull dark brown, flattened.
Distribution: Common all over India
Insecticidal Properties: Seeds, leaflets, petiole and pods are toxic to cotton stainer adults. Bark roots and seeds are toxic to melon worm larvae. Seeds contain proteins which caused mortality and suppressed larval growth of *Pieris brassicae* larvae. It was also found to be effective against gut trypsin extracted from *Spodoptera littoralis* (Sharma *et al*, 2012) [25].
Chemical composition: Leaves contain caffeic acid, alkaloids, kaempferol and quercitin. Bark yields tannins. Seeds contain toxic protein (Sharma *et al*., 2012) [25].

G. *Allium sativum* L.
Common Names: Garlic
Family: Alliaceae
Morphology: Erect herb, propagated as an annual from cloves, up to 150 cm tall; stem short, formed at the base of the plant in the form of a disk, with adventitious roots at base; bulb solitary, depressed globose to ovoid, consisting several sessile cloves. Leaves 4–10, distichously alternate, glabrous, with tubular sheath; blade linear-oblong; inflorescence a spherical umbel, on a solid scape up to 150 cm long; flowers greenish white or pale pink; stamens 6; fruit seedless.
Distribution: Cultivated for bulbs.
Insecticidal property: Aqueous and methanol extracts showed highest insecticidal activity against the larvae of *Spodoptera litura* and *Plutella xylostella* (L.) (Meriga *et al* 2012; Samarasinghe *et al*. 2007) [26, 27]. Powder, extract, and essential oil were toxic to adults, eggs, and larvae of *Callosobruchus maculatus* F. (Coleoptera: Bruchidae) and to serious grain storage pest *Trogoderma granarium* (E.). The essential oil of *A. sativum* possessed contact toxicity against overwintering *Cacopsylla chinensis* Yang et Li (Hemiptera: Psyllidae), with an LC_{50} value of 1.42 µg per adult. The two main constituent compounds, diallyl trisulfide and diallyl disulfide, exhibited strong acute toxicity against the overwintering *C. chinensis*, with LC_{50} values of 0.64 and 11.04 µg per adult, respectively. Alcoholic extract of the bulbs has lousicidal activity on the adult goat louse, Damalinia caprae (Denloye, 2010; Douiri *et al*, 2013; Ahmad *et al*, 2013; Zhao *et al*., 2013; Lakshmanan, *et al*., 2013) [28, 29, 30, 31].
Garlic juice has effective insecticidal efficacy on two target dipteran pests, *Delia radicum* (L.) and *Musca domestica* L. and mosquitoes. Garlic preparations showed also an interesting and significant insecticidal activity against larvae of *Aedes albopictus* (Skuse), Methanolic extracts were obtained from minced dehydrated garlic had larvicidal property against 3rd-stage larvae of *Culex peus* Speiser, *C. tarsalis* Coquillett, *Aedes aegypti* (L.), *A. triseriatus* (Say), *A. sierrensis* (Ludlow), and 3rd- and 4th-stage larvae of highly insecticide-resistant strains of *A. nigromaculis* (Ludlow). The active principle has present in the oil of garlic (Prowse *et al*., 2006; Amonkar and Reeves, 1970) [33, 34]
Chemical constituents: Garlic contains sulphur-containing compounds collectively referred as S-alkyl-cysteine sulphoxides which is responsible for the flavour of garlic. Garlic chiefly contains alliin (S-allyl-L-(+)-cysteine sulphoxide), which is odourless, but on crushing gets converted to allicin (diallyldisulphide-mono-S-oxide), the principal element of the taste of raw garlic. Allicin gets converted to diallyldisulphide, the principal taste component of cooked garlic (Holland *et al*., 1991; Le Bon & Siess 2000) [35, 36].

4. Discussion
Plants are subjected to severe biotic stress factors, of which herbivory. Herbivory is especially intense in the tropics, where insects reach their highest biodiversity. Tropical plants that are exposed to a diverse range of herbivorous insects and can thus be expected to have evolved effective defense strategies enabling them to survive and thrive in spite of a heavy load of herbivores as highlighted by the well known natural insecticide azadirachtin isolated from the tropical neem tree *Azadirachta indica*. Plant

derived insecticides have been used commercially for about 50 years and have contributed significantly to improve the efficacy of insecticides, particularly when problems of resistance have arisen. The mode of action of the majority of insecticides is to block the metabolic systems that would otherwise break down insecticide molecules. The search for and the need of new molecules capable of synergizing existing or new pesticides has reactivated the identification and characterization of secondary plant compounds possessing such activity. Insecticides produced form plant sources are among the materials longest known to be valuable in offsetting the attcks of insects upon man, food and fibre crops. The insecticides possess a value considerably greater than is indicated by figures, for they are often effective in much lower concentrations than are the arsenicals. The property of relative safety to man is of much importance in maintaining the position of plant insecticides. There are several natural (plant) insecticides that have been widely used, although compared with modern synthetics the plant substances are relatively weak. One benefit of a plant insecticide is that many of them are biodegradable. More than 1500 species of plants have been reported to have insecticidal value, and many more exist, undiscovered. Many plant species produce substances that protect them by killing or repelling the insects that feed on them. For example, the Douglas fir has a special sap that wards off beetles if it is attacked. Neem trees produce oil that alters the hormones of bugs so that they cannot fly, breed or eat. Much more plants in the tropics and sub-tropics are unexploited and await for theeir utilization in plant derived insecticidal properties.

5. Conclusion

Knowledge of the toxic plants, and the toxic principles and their biological activity is of paramount importance not only to utilize them as natural insect control agents and replace the toxic commercialchemical insecticides but also to understand the nature of their toxicity in less known species. Over 2,000 plant species have been reported to possess insecticidal activity and only a fraction of them analysed. Many more insecticidal plants still await discovery. An attempt has been made in this paper to compile preliminary literature on some of the less known and potential insecticidal plants of India. All these plants are used locally and their use at wider scale is yet to be explored. Intense surveys along with scientific research in unravelling and understanding the potential of plants having insecticidal properties need to be carried out at a larger scale.

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