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Herbal Pesticides, a Natural Weapon to Control the Insect Pests: A Review

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Abstract: Agro inputs are increasing globally day by day by the farmers. However, production, its quality and productivity are not increasing proportionate to incremental expenditure on farming; thus causing agriculture becoming more and more unviable proposition in today's context. Synthetic fertilizers and pesticides are causing unbearable damage to ecology and environment and agriculture cannot sustain on continuous use of such types of fertilizers and pesticides. Synthetic pesticides have been used to control the insects since a long time. This practice gradually affected on the quality and quantity of plants by degrading them. The use of synthetic pesticides on small-scale farms is generally not advocated because the approach lacks sustainability and raises environmental and health concerns. These synthetic pesticides not only affect the negative impact on plants but many farmers simply cannot afford the cost of such pesticides. Therefore, it is high time to screen for safe and effective biodegradable pesticides which is cost-effective with non-toxic effects on non-target organisms. The present review includes the prospects and utilization of plant extracts as natural weapon against various insects.

Keywords: Herbal pesticides, Synthetic pesticides, Natural weapon

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Farmers are generally dependent on using synthetic pesticides to control the plants from damage caused by insects (Rahman *et al.*, 2007). The repeated use of synthetic insecticides for insect pests and vector control has disrupted natural biological control systems. It has also resulted in the development of resistance, undesirable effects on non-target organisms and fostered environmental and human health concerns, which initiated a search for alternative control measures (Adeniyi *et al.*, 2010). Most plant

derived products are presumed to be less toxic to non-target organisms, easily biodegradable and therefore do not persist in the environment as opposed to synthetic products which often end up being pollutants. Plant products are also cheap especially if they are locally available (Isman, 2006). During the search for botanical pesticides, one approach involves the screening of plant extracts for deleterious effects against different organisms (Papachristos and Stamopoulos, 2002; Isman, 2006; Lucia *et al*., 2007; Batish *et al*., 2008). Researches done so far on this aspect generally focused on chemical composition of sap, latex or juices occurring in different plant parts. The Euphorbiaceae family is an example which is known for potent latex available in leaves and barks of most of its species. The latex is particularly rich in diterpene and triterpene esters (Furstenberger and Hecker, 1977) which are known to be pesticidal (Rahuman *et al.*, 2008). Phytolaceae sap on the other hand is rich in triterpenoids (Spengel, 1996) and saponins (Dorsaz and Hostettmann, 1986; Slacanin *et al.*, 1988; Ndamba *et al.*, 1994) possessing molluscicidal properties (Ndamba *et al.*, 1994). This review provides information on some plants which have been used as insecticide against various species of insects.

Zanthoxylum armatum (Tejbal or Timur or Timru)

Zanthoxylum armatum (winged prickly ash) is a species of plant in the Rutaceae family. *Z. armatum* (also known as Tejbal or Timur or Timru) is an evergreen, thorny shrub or small tree; attaining a height up to 6 m. Leaves are 4–20 cm long, imparipinnate, pungent, and aromatic with glabrous, narrowly winged petiole having two stipular prickles at the base. Leaflets are lanceolate, glabrous on the underside, and occur in two to six pairs. The plant can be recognized by its shrubby habit, dense foliage, with pungent aromatic taste, prickled trunk and branches, and small red,

Fig. 1: *Zanthoxylum armatum* (Tejbal or Timru)

subglobose fruits (Fig. 1). The species is found in hot valleys of subtropical Himalayas, from trans- Indus areas to Bhutan, up to an altitude of 2400 m, and between 700 m and 1000 m in the Khasi Hills. It also occurs in the hills of Ganjam and Vishakapatnam at an altitude of about 1500 m. Flowers occur in dense terminal or sparse axillary panicles and are green to yellow in colour. Calyx consists of six to eight sub-acute lobes. Stamens are about six to eight in number. Ripe carpels or follicles are usually solitary, pale red, and tubercled. Seeds are globose, shining, and black. Flowering occurs from March to May, while fruiting occurs from July to August. The plant is adapted to subtropical climates of lower warm valleys of the Himalayas with sufficient rainfall. It grows well in open pastures and secondary scrub forests. Loamy or clayey soil rich in organic content is preferred for its cultivation. Fruits, seeds, and bark of tejbal

are used as aromatic tonic in dyspepsia and fever. Fruits and seeds are beneficial in dental troubles, thus used to prepare dental paste and powder. Tender twigs are used to brush teeth and used as a remedy for toothache. The essential oil from fruits (known as Wartara oil) has deodorant and antiseptic properties. *Z. armatum* is also used to control the insect pests (Kumar *et al.*, 2003; Tiwary *et al.*, 2007; Khan *et al.*, 2008; Singh and Singh, 2011; Mukhija and Kalia, 2014; Wang *et al.*, 2015; Singh *et al.*, 2016).

Allium sativum (Garlic)

Garlic, *Allium sativum* L. (Liliaceae family) has been widely recognized as a valuable spice and a popular remedy for various ailments and physiological disorders (Fig. 2). Garlic is one of the important bulb crops grown and used as a spice or a condiment throughout India. It is a perennial herb with a tall, erect flowering stem that grows up to 3 feet. The garlic plant's bulb is the most commonly used part of the plant. With the exception of the single clove types, the bulb is divided into numerous fleshy sections called cloves. The cloves are used for consumption (raw or cooked) or for medicinal purposes. Garlic has been used throughout history for both culinary and medicinal purposes (Coppi *et al.*, 2006).

Fig. 2: *Allium sativum* (Garlic)

The bulbs of the plant have been used in many parts of the world as a stimulant, antiseptic, anthelminthic, antihypertensive, carminative, diaphoretic, expectorant, diuretic, anti-scorbutic, aphrodisiac and anti-asthmatic and for the relief of rheumatic pains (Mikail, 1995). Recent research revealed that garlic is not only beneficial as medicinal plant but it can be used as repellent to some plant pests and diseases (Ramasasa, 2009). *A. sativum* is a versatile herb that contains numerous vitamins, minerals and trace elements. The presence of two trace elements, germanium and selenium has been postulated to play a role in the herb's antitumor effect (Ariga *et al.*, 1980). The volatile oils present in garlic possess sulfur containing compounds such as diallyldisulphide, diallyltrisulphide and methylallyltrisulphate. Allicin, derived from amino acid allin gives the pungent characteristic odour to crushed garlic and is believed to be responsible for some of the pharmacologic activity of the plant (Coppi *et al.*, 2006).

A. sativum has demonstrated numerous insecticidal activities on a wide range of insect species; its juice had insecticidal activity against *Delia radicum* and *Musca domestica* (Prowse *et al.*, 2006). Garlic extract has shown larvicidal effects against *Anopheles stephensi* and *Culex quinquefasciatus* mosquitoes (Singha and Chandra, 2011), and acaricidal activity against *Tetranychus cinnabarinus* (Mansour *et al.*, 2004). In addition, the extract of garlic cloves has shown larvicidal activity against the eggs, larvae, and adult of *Callosobruchus maculates* (Denloye, 2010).

Essential oil bulbs exhibited larvicidal activity against *Culex pipiens* (Kimbaris *et al.*, 2009), fumigant toxicity against *Camptomyia corticalis* (Kim *et al.*, 1997), insecticidal and

larvicidal potential against *Lycoriella ingenue* (Park *et al.*, 2006), and acaricidal properties against all stages of *Boophilus annulatus* (Aboelhadid *et al.*, 2013). Moreover, the leaf (ASAI) and bulb (ASAII) agglutinins from *A. sativum* exhibited insecticidal activity against the cotton leaf worm, *Spodoptera littoralis* (Sadeghi *et al.*, 2008). The garlic lectins, ASAI and ASAII, have also revealed insecticidal properties against *Acyrthosiphon pisum* (pea aphids) (Fitches *et al.*, 2008).

Mentha piperita (Peppermint)

Peppermint (*Mentha piperita*) are used for their flowering and medicinal properties widely throughout different countries of the world. *M. piperita* is currently one of the most economically important aromatic and medicinal crops (Fig. 3). It is also known as candy mint, balm mint, pudina or paparaminta and belongs to the family Lamiacea. The world production of peppermint oil is about 8000 tons per year (Eccles, 1994). *M. piperita* is a triple hybrid (Fleming, 1998). The plant is strongly scented, perennial, glabrous, herbs 30 – 90 cm in height, the square stems is usually reddish, purple and smooth. The leaves are short 2.5 – 5 cm long, oblong-ovate and serrate. The flowers are purples, pinkish and appear in summer months. It is originally native of Europe and Canada and US and has been naturalized in many parts of India. It is cultivated in India, China, Europe, America, Australia, South America and some other countries. The leaves and flower tops are collected as soon as flowers begin to open and dried as crude drug for its oil and peppermint (Fleming, 1998).

Peppermint is currently used to treat irritable bowel syndrome, Crohn's disease, ulcerative colitis gall bladder and biliary tract disorders and liver complaints (Tyler, 1992; Fleming, 1998; Robbers and Tyler, 1999). Repellent and insecticidal activities of *M. piperita* leaves tested against cabbage aphid using petroleum ether, acetone, ethanol and aqueous extracts. Repellent activity of *M. piperita* extract was tested by leaf disc bioassay method (Mersha *et al.*, 2014). Repellent activity of the plant extract clearly demonstrated that at high concentration and exposure period percent repellent activity was increased. This is due to the odour of aromatic plant *M. piperita* which repelled the insects (Mersha *et al.*, 2014).

Fig. 3: *Mentha piperita* (Peppermint)

The insecticidal activity of the plant may be associated with various phytochemical present in the plant extract. According to Sujana *et al.* (2013), *M. piperita* leaves extract contains alkaloids, flavonoid, steroids, tannin and phenols. In general, phenolic compound may be interfering with the feeding of insect (Stevenson *et al.*, 1993).

Azadirachta indica (Neem)

Neem or Neem tree (*Azadirachta indica*) belongs to mahogany family Meliaceae (Fig. 4). It is native to India and the Indian subcontinent including Nepal, Pakistan, Bangladesh and Sri Lanka. It is typically

grown in tropical and semi-tropical regions. Its fruits and seeds are the source of neem oil (Mersha *et al.*, 2014). The neem tree is noted for its drought resistance. Normally it thrives in areas with sub-arid to sub-humid conditions, with a moderate annual rainfall. It can grow in regions with an annual rainfall below 400 mm with availability of ground water levels. Neem can grow in many different types of soil, but it thrives best on well drained deep and sandy soils. It is a typical tropical to subtropical tree and exists at annual mean temperatures of 21–32 C. It can tolerate high or very high temperatures but does not tolerate temperature below 4 C. Neem is one of a very few shade-giving trees that thrive in drought-prone areas. The trees are not at all delicate about water quality and thrive on the merest trickle of water, whatever the quality. In India and tropical countries where the Indian diaspora has reached, it is very common to see neem trees used for shade lining streets, around temples, schools and other such public buildings or in most people's back yards. In very dry areas the trees are planted on large tracts of land (Siddig, 1987; Mohamed, 2002; Satti and Nasr, 2006).

Fig. 4: Azadirachta indica (Neem Tree)

Chandra and Shri (2012) explained the effect of different dose level of neem seed acetone extract which exerted a depressive effect on the life cycle stages of *Corcyra cephalonica.* Abdelouaheb *et al.* (2009) examined the larvicidal activity of a neem tree extract (Azadirachtin) against mosquito larvae. Neem foliage extract has been shown to have toxic effect on diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera, Plutellidae) (Sharma *et al.*, 2014). Neem extract holds a very good promise for the control of mosquito both at larval stage and adult stage of the insect. Its potentiality have been widely researched by many authors whether as lotion cream on the body or combination with coconut oil or on the larva form alone (Umar *et al.*, 2007).

Polar and non-polar extractions of neem yield 24 compounds other than azadirachtin that are of biological importance (Jacobson, 1999; Egho, 2012). These include anthraquinones, saponins, tannins, alkaloid, limonoids and meliantriol among others. Some active ingredients in neem plant includes azadiractin and Limonoids which are toxic to over 500 species of insects including *Myzus persicae* (aphids) (Khalid *et al.*, 2002; Martinez and Machado-Neo, 2007; Qadri and Narsaiah, 2005), *Culex pipiens* (Abdelouaheb *et al.*, 2009). Quadri and Narsaiah (2005) reported 24 h LD_{50} value of azadirachtin against *Periplaneta americana* as 1.5 mg/g.

Melia azedarach (Indian lilac or pride of India or bead tree or bakain)

Melia azedarach (Indian lilac or bead tree or pride of India) is a perennial tree and belongs to the family Meliaceae. It is one of the medicinal plants which grows wild throughout the Sub-Himalayan belt (Fig. 5). It

is cultivated in India and Pakistan for both ornamental and medicinal purposes (Watt *et al.*, 1962). Various preparations of *M. azedarach* are being used for the treatment of several diseases and reports are also available on the analgesic, anticancer, antiviral, anti-malarial, antibacterial, antifungal and antifertility activities of this plant (Watt *et al.*, 1962; Baquar, 2008; Muhammed *et al.*, 2015).

Fig. 5: *Melia azedarach* (Indian lilac)

The insecticidal activity of *M. azadarach* is found in leaves, fruits and seed, and it is due to a group of biologically active triterpenoid that have antifeeding effect (Valladares *et al.*, 1997; Isman, 2006). Generally extracts from green fruits and leaves have been found most efficacious because of their anti-feeding effects, mainly on beetles and lepidopteran (Carpinella *et al.*, 2003; Nathan and Schoon, 2006; Defagó *et al.*, 2006). However, *M. azadarch* had a modest development as a commercial insecticide compound as it is toxic to mammals (Defagó *et al.*, 2006). In any event, the chemical composition of *M. azadarach* varies enormously from its wild form to the cultivated one.

Considering the result of diverse studies of the insecticidal effectiveness of diverse parts of *M. azadarach* and that this plant is grown as an urban tree may be used to prepare natural extracts for use against diverse pest. Different results have been observed in the antifeeding and insecticidal properties of immature (green) fruit of *M. azadarach* when different solvents are used for extraction. Other studies of antifeeding effects of ethanol extracts of *M. azadarach* with other insects found close to 100% anti-feeding effect with ethanol extract from matured fruit when similar concentration 2, 5 and 10% applied to *Spodoptera eridania* (Cramer) (Lepidoptera , noctuidae) (Rossetti *et al.*, 2008). Other authors have studied the insecticidal effect of 5% aqueous fruit extracts of *M. azadarach* by applying of the fruits at to the spider mite. Castiglioni *et al.* (2002) found 63% mortality. Other studies have evaluated the insecticidal effect of extracts obtained with other solvents such as methanol, hexane, petroleum ether and acetone (Nunes *et al.*, 2004).

Solanum incanum L. (Bitter Brinjal)

Bitter brinjal or bitter tomato *(Solanum incanum)* is a perennial, wild shrub like herb that belongs to family Solanaceae, which grows in many regions of Africa, Middle East, East Asia and India. It is an erect or spreading perennial shrub-like with leaves and stem occasionally having small prickles (Fig. 6). The fruits are small berries of 2-3 cm in diameter and yellowish orange or brown in color when ripe (Umar *et al.*, 2015). It is common as a weed around houses, in overgrazed grass land and on road sides. It is also found at forest edges and in bush land and grasslands, from sea-level up to 2500 m altitude (Habtamu *et al.*, 2014).

The plant is used in the treatment of various illnesses such as sore throat, angina, stomach pain, colic, headache, painful menstruation and liver pain. For these

purposes leafs, roots and fruit decoctions are taken, roots are chewed and sap swallowed. Leaf sap is used for washing painful areas, and ash of burnt plants is mixed with fat and applied externally (Habtamu *et al.*, 2014). Leaves are added to soup to improve the flavor. The fruits and the seeds are used in milk to make cheese. Further, the plant is employed in some parts of Africa and India for the treatment of skin diseases, general infections, abdominal pains, fever, stomachache and indigestion (Mwonjoria *et al.*, 2014).

Fig. 6: *Solanum incanum* L. (Bitter Brinjal)

In addition, the fruit of *S. incanum* is also used for the treatment of dandruff, skin diseases, sores and wounds. Another widespread use of bitter brinjal is in the treatment of venereal diseases. In Senegal, Kenya, Uganda and Zimbabwe different plant parts are used to treat snake bites: a decoction of the roots is drunk, roots are chewed and sap is swallowed, and young chewed leaves or pulped fresh roots are applied to the bite wound. In Niger, Sudan, Rwanda, Mozambique and Namibia the fruits are used as an ingredient of arrow and fish poison (Mwonjoria *et al.*, 2014). In Ethiopia, the fruit juice is used by peasant farmers to control ticks (Regassa, 2000). Umar *et al.* (2015) reported the insecticidal and deterrent activity of crude fruits sap extract of *S. incanum* against green peach aphid (*Myzus persicae*).

Peganum harmala (aspand or wild rue)

Peganum harmala (Aspand or wild rue) is a perennial glabrous herb that grows in semi-arid conditions, steppe areas, and sandy soils (Fig. 7). It has frequently been used in traditional medicine and as an abortive agent (Lamchouri *et al.*, 2002). Dried capsules mixed with other ingredients are burnt to produce scented smoke that is used to purify the air and the mind, but it is mostly used as a charm against "the evil eye" (Frison *et al.*, 2008). *P. harmala* is a rich source of b-carboline and quinazoline alkaloids (Kartal *et al.*, 2003). The possible use of aspand in modern phyto-indole entheogen preparations is correlated to its b-carboline content: harmine, harmaline, and tetrahydroharmine (THH), collectively known as harmala alkaloids, which are mostly found in the seeds and roots. Harmine and harmaline are competitive and reversible inhibitors of monoamine oxidase type-A (MAO-A) enzymes, whereas THH is believed to inhibit serotonin uptake (Buckholtz *et al.*, 1977; Kim *et al.*, 1997).

Fig. 7: *Peganum harmala* (Aspand or Wild Rue)

Regarding its efficacy against different insects, Abbassi *et al.* (2003) found the toxic effect of *P. harmala* on the survival, feeding, behavior, and reproduction of the desert locust, *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae), under laboratory conditions. Jbilou *et al.* (2006) found that methanol extracts from different medicinal plants, including *P. harmala* seeds, have insecticidal effects on the larvae and adults of the stored grain pest *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae) after a period of time.

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