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Sustainable Management of Insect Pests of Tree Borne Oilseed Species and Pesticide Properties of their Oil Extracted

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ABSTRACT

Seeds of many tree species contain high levels of oil and use for bio-energy generation. *Jatropha curcas* (jatropha or varenda), *Pongamia pinnata* (pongamia or karanj), *Madhuca latifolia* and *M. indica* (mahua), *Calophyllum inophyllum* (Undi.), *Azadirachta indica* (neem) and *Simarouba glauca* (simarouba) are such important trees. These trees are attacked by different insect and non-insect pests which cause reduction of oil production. Among these, leaf-webber, *Pempelia* (*Salebria*) *morosalis* (Saalm Uller), scutellerid bugs, *Chrysocoris purpureus* (Westw.) and *Scutellera nobilis* (Fabricius), thrips, *Retithrips syriacus* (Mayet) and yellow mite, *Polyphagotarsonemus latus* (Banks) are found predominantly. Proper Eco-friendly management should be taken to overcome these pest problems.

Keywords : *Jatropha curcas*, Bio-fuel, IPM, Bio-pesticides, Environmental sustainability, Eco-friendly management.

Introduction

Seeds of many tree species contain high levels of oil and their use for bio-energy generation has been a topic of interest for long (Raina, 1986). Due to exponential rise in petroleum prices and increase in demand for petroleum products around the world, many Governments and researchers are looking for alternate means of fuel. Those trees produce bio-fuel popularly known as Tree-Borne Oilseed TBOs are *Jatropha curcas* (jatropha or varenda), *Pongamia pinnata* (pongamia or karanj), *Madhuca latifolia* and *M. indica* (mahua), *Calophyllum inophyllum* (Undi.), *Azadirachta indica* (neem) and *Simarouba glauca* (simarouba). Mahua oil is also edible and is used by tribal communities. Neem has more recognition for its pesticidal uses than seed oil. There are several reasons for greater interest in jatropha. Seed oil characteristics of jatropha are superior to others for bio-diesel production. Out of various bio-fuel sources, the *Jatropha curcas* (L) is considered to be the best-bet as far as India is considered. Besides its fastest growing attribute when compared to most other TBOS, it also has the ideal size for agroforestry. Thus, jatropha has emerged as the premier TBOS. Another advantage of jatropha is the properties of its oil for bio-diesel production. Rural communities in India are familiar with *Pongamia* because its oil has been used traditionally for lightning lamps in households. It grows well in most parts of the country. Neem is a species that combines two environment- friendly themes of current interest in the form of bio-pesticides and bio-diesel. Its wood is of good quality timber that can be used for making farm implements and construction purposes. Ghosh *et al.* (2012) reported that Jatropha is the important source of bio-fuel and neem is the important source of bio-pesticides.

Pest status on jatropha crop (*Jatropha curcas*)

Among several biotic and abiotic stresses pests and diseases are one of the most important limiting factors in successful cultivation of the aforesaid TBOS. At present, globally 76 species of phytophagous insects in 27 families from five orders have been recorded on *J. curcas*. Apart from this, two species of *Acarine* pests have been recorded on *J. curcas* (Grimm and Fuhrer, 1998; Robinson *et al.*, 2004; Manoharan *et al.*, 2006). Among these, Lepitopteran and Hemipteran constitute majority of insect pest species and these two Orders inflicting damage to leaves and fruiting parts respectively.

In India, seventeen pest species including mites have been reported in jatropha. Among these, leaf-webber, *Pempelia* (*Salebria*) *morosalis* (Saalm Uller), scutellerid bugs, *Chrysocoris purpureus* (Westw.) and *Scutellera nobilis* (Fabricius), thrips, *Retithrips syriacus* (Mayet) and yellow mite, *Polyphagotarsonemus latus* (Banks) are found predominantly. (Manoharan *et al.*, 2006; Chitra shanker and Dhyani, 2006). Except leaf- webber, all other pests are polyphagous in nature.

Sustainable Management of jatropha pest

The leaf-webber larvae are parasitized by *Trathala flavo-orbitalis* (Cameron), *Bracon hebetor* (Say) *Brachymeria nephantidis* (Gahan) and *Podagrion hayati* (Narendran). The *T. flavo-orbitalis* and *B.hebetor* are the potential parasitoids of leaf webber parasitizing 60 and 70 per sent respectively under natural conditions. The eggs of scutellerid bug is parasitized by *Anastatus bengalorensis, Trissolcus sp, Pteromalid sp* and *Eurytoma sp. Tachinid sp* a larval pupal parasitoid is found on tussock caterpillar. A total of seven predatory spiders are found feeding on leaf webber (*Peucetia viridans, Vicaria monostriata*, *Argiope pulchella* (Thorell), *Oxyopes* sp. *Thomisus* sp. and (*Plexippus paykulli*). (Manoharan *et al.*,2006). For controlling the Lepidopteran pests spraying of plant extract like neem oil 1500 ppm @ 2.5ml/L is very effective. Among the microbial pesticides *Bacillus thuringiensis*, *Beauveria bassiana* should be used. For controlling sucking pests, neem oil (Ghosh, 2020), Imidacloprid 17.8 SL @ 1 ml/ 7 L (Priyadarshini *et al.*, 2017), Acetamaprid 20SP @L g/5 L or Acephate 75 SP 0.75g/L may be effectively used. For termite control soil drenching with Chloropyriphos 20 EC @ 5ml/L should be practiced. For mite control microbial toxin, Abamectin 1.9 EC @ 0.5 ml/L is advocated.

Important pests of Karanj (*Pongamia pinnata*)

***Leaf-miner* (*Acrocercops anthrauris*) *and foliage feeder* (*Eucosma balanoptycha*) :**

The larvae of the insects feed on the soft tissues eating away on shallow depression during August to September causing stunted growth (considerable % of leaves is damaged).

***Bark eating caterlillar* (*Indarbela quadrinotata*) :**

The larvae feed on the bark and bore into the shoots of the plant and feed the inner content.

***Gray weevil* (*Myllocerus* sp) :**

The weevil feed on the leaves and make circular holes.

Management

Metallic wires are to be inserted into the hole of the affected shoots /trunk to kill the larvae of bark eating caterpillar. Poring kerosene / petroleum oil or DDVP (Dichlorvos or 2,2-dichlorovinyl dimethyl phosphate) or carbon-disulphide inside the hole and plastering with mud is also effective against the pest. Spraying DDVP 76 SL @ 0 .75ml/L or any systemic insecticides for leaf miner control may efficiently be used.

Important pests of neem *(Azadirachta indica)*

Laspeyresia koenigana :

Infestation was recorded in almost all the neem plantation and nurseries. The moths lay eggs on the tender superimposed shoot and the larvae after hatching bores in the shoot and continue this habit throughout the process of its development. The apical growing shoot develops a callus structure due to excessive gum exudation and secondary fungal infection. As a result of which the plant exhibits a forked appearance.

Helopeltis antonii :

Both adult and nymph of the bug suck plant sap from the tender shoots and leaves and inject a phytotoxin into the plant system. Within a short period of time after sucking, the surrounding tissues became necrotic and brown to black patches are formed due to action of phytotoxin. In severely infested plant, the entire flush dries up and the whole plant presents a scorched appearance.

***Aonidiella orientalis* :**

It is a polyphagous armoured scale insect. After hatching of eggs, the crawlers move freely and find succulent spot and insert their needle like mouth parts into the plant tissues and stars feeding. Simultaneously, they also secrete a waxy covering over dorsal surface. In severe infestations the leaves of the young plant are shed resulting die-back of the plant.

***Boarmia varigata* :**

The looper larvae feed on the neem leaves and defoliate them completely resulting of loss green matter.

***Pulvinaria maxima* :**

Nymphs and adults suck the sap of tender shoots and leaves cause considerable damage to the young plants.

***Heliothrips haemorrhoidalis* :**

The nymphs and adults attack leaves and shoots. Lacerating on leaves and puncturing of tissues by several individuals result in bleaching of green parts. Besides, nymphs also leaves behinds faecal globules that appear like black specks all over the leaves. Due to heavy infestation, the leaves get distorted, crinkled and mottled.

***Holotrichia consanguinea* :**

The chaffer beetle is widely spread throughout western India. The pest mainly attacks in the root system of the tree.

***Termite* :**

Damage occurs underground by hollowing or partly removing of the bark of the roots.

Management of neem pest

Control of tip borer**,** *Laspeyresia koenigana* can be achieved by spraying dimethoate 30E.C. @0.05 % in combination with blitox @0.05% and vipul @ 2.0 ml/L. Spraying of a mixture of rogor and blitox is a successful control method of tea mosquito bug. Spraying of monocrotophos is very effective against scale insect and thrips. Chloropyrephos is used @5.0 ml/L for controlling soil insect pests like white grub and termite.

Harmful effect of chemical insecticides

Since the discovery of DDT as an insecticide in 1939 by Dr. Paul Muller, there has been a great expansion in the use of chemicals for pest control. Pesticides during manufacturing, transportation, storage and actual use, enter in the abiotic and biotic components of the environment through air, water and soil and disturb the ecosystem, causing great disaster sometimes. Miss Rachel Carson published an epoch-making book "Silent Spring" in the year 1962 awakened the people referring the forceful account of the danger of pesticides. These days the pollution of the environment is a problem of great importance and is about everybody's concern. The pesticides may accumulate in the environment and contaminate all the systems i.e. air, water, soil, plants, animals etc. by being transported from one system to another. Although they are protecting the crops from pests for boosting up the agricultural productivity but bring out ecological disturbance and environmental pollution. A variety of insecticides like BHC, aldrin, dieldrin, heptachlor, chlordane, toxaphene, methyl parathion, phorate etc. are being used in our country for the control of termite, white grub, cutworm, root borer etc. It is found that the pesticides disturb the microbial activity of the soil, adverse effect on the earthworm and may harm the predatory mites and carabid beetles. They may have an adverse effect on some invertebrates that were responsible soil fertility. The uptake of insecticide residues by some crops adversely affects our health. The people around vicinity of pesticide factories even upto 5-7 km area badly feel off flavor and such suffocated environment ultimately results in different kind of diseases among the residents. The contamination of air during application of pesticides may also take place which could pose serious health hazards, if the concentration in air raised above the thresh hold values. Different doses of pesticides at different dose levels are being used in the different types of crops against noxious pest all over the country for the last four decades. Saxena *et al.* 1990 reported that the residue of malathion was found more than the permissible limits in tomato, okra, cauliflower, brinjal and beans. Gupta *et al.* (1987-88) reported that above 60% samples of potato, brinjal, cabbage, cauliflower okra and cucurbits were containing the residues of organophosphate insecticides more than the permissible level. Water has been found contaminated with pesticides by different ways. Many great rivers of the world have been found to contain large amounts of insecticide residues which killed the fishes and other aquatic animals living there (Srivastava and Saxena, 1989). In order to destroy unwanted plants, insects and fishes etc. the deliberate use of pesticide is being done due to which water is contaminated. Water has also been found to be contaminated with pesticides through runoff from fields, through sewage disposal, through the effluents of industries using pesticides, through dead and decayed plants treated with pesticides. In UK the presence of insecticides was reported in rain water. Fresh rain water on the mountain top of the Himalaya was found possessing pesticide residues. Commonly cultivated crops, vegetables and fruit plants have been found to be affected with injudicious use of pesticides right from germination through growth to harvest. The application of pesticides may bring the resurgence of the target pests against which the chemicals are applied, the outbreak of some unimportant pests. The pesticides are also harmful to beneficial fauna such as honey bees and natural enemies like parasites, predators and pathogens of the pests, etc. As a result of pesticide pollution several diseases may develop in human beings and domestic animals.

Importance of bio-pesticides for pest control

In view of the harmful effects of chemical pest control, several alternatives have been explored to control the insect pests. In more recent times, there is a renewed interest in eco-friendly approaches to pest management and the rationale for biological approaches is irrefutable. In a broader sense, bio-pesticides include pesticides of biological origin.

Botanical extracts :

Botanical pesticides are either naturally occurring plant materials or products derived rather simply from such plant materials. They are water extracts or organic solvent extracts of insecticide components of plants. Plant substances are produced as byproducts of major biochemical pathways and chemically, they include alkaloids, terpenoids and phenols as well as a number of other compounds.

Plant origin insecticides offer a great advantage of being compatible with other low risk options such as pheromones, biopesticides and bioagents such as entomopathogenic fungi and nematodes, predators and parasitoids, etc. which can be integrated in IPM programmes. These chemicals repel approaching insects, deter feeding and oviposition on the plants, disrupt behaviour and physiology of insects in various ways and even prove toxic to different developmental stages of many insects (Dhaliwal and Arora, 2001). The use of plants as pesticides has been practiced since times immemorial. The Hindu book, the 'Rig Veda' written in India in 2000 BC, makes a mention of the use of poisonous plants for pest control. Crude botanical pesticides have been used in several countries and were known in tribal or traditional indigenous technologies around the world before been introduced to Europe. Those with long histories of traditional use include neem in India, rotenone in East Asia and South America, pyrethrum in Persia, and sabadilla in Central and South America. Neem (*Azadirachta indica)* tree is indigenous to India and is a storehouse of large number of pesticidally active tetranortriterpenes, commonly called limonoids, among which azadirachtin, salanin and nimbin are the most active. Although neem seeds and leaves have been used as traditional insecticides for centuries, modern interest in neem as an insecticide dates back to the work of Pradhan *et al.* (1962) who reported that dilute aqueous kernel extracts prevented feeding by the desert locust, *Schistocerca gregaria*. The most abundant neem constituent, azadirachtin is considered an excellent botanical pesticide because of its biodegradability, demonstrated low toxicity to vertebrates, environmental safety, and safety to non-target organisms (Jacobson, 1989; Rembold, 1989). *Polygonum* and *Pongamia* are such type of plants having insecticidal properties needed to be conserved. *Polygonum hydropiper*, a well known weed in northeast India especially in the foot hill of the Himalaya, locally known as "biskanthali" is widely used indigenously in different tribal areas for pest control in vegetable field (Mandal *et al.*, 2016; Subba and Ghosh, 2016; Ghosh, 2017; Ghosh,2020). *Pongamia pinnata*, a medium sized tree is well known in Tterai region of West Bengal having humid and subtropical climate. It is one of the few nitrogen fixing trees often planted as an ornamental and shade tree. *Pongamia* oil and leaf extract is useful for pest control in vegetable field (Ghosh *et al.*, 2016; Ghosh and Chakraborty, 2012; Mandal and Ghosh, 2021). *Spilanthes paniculata* is an important weed and its floral parts are useful for controlling sucking pest and mite pests (Subba *et al.*, 2014; Subba *et al.*, 2017; Ghosh, 2023; Ghosh, 2019).

More than 1000 species of plants have been reported to have chemicals in leaves, stems, flowers, seeds and roots which have insecticidal properties. Among the estimated over five lakh species of plants in existence today, nearly 2500 species belonging to 235 plant families have exhibited measurable anti- pest properties. A large part of the plant biodiversity still remained unexplored. A comprehensive account of phytochemical biopesticides (Parmar and Walia, 2001; Walia *et al.,* 2001; Parmar and Walia, 2006) and antifeedant allelochemicals (Koul, 2005) have recently been published. Various scientists direct their attention to discover such type of plant toxicant which is eco-friendly and play a better role in the control of pest. Their limited persistence in the environment helps to minimize their adverse effects (Weinzierl, 2000). It is an important component of IPM. Plant origin insecticides offer a great advantage of being compatible with other low risk options such as pheromones, biopesticides and bioagents such as entomopathogenic fungi and nematodes, predators and parasitoids, etc. which can be integrated in IPM programmes.

Neem tree as a source of bio-pesticide :

Among the various pesticide plants, neem (*Azadirachta indica*) has been exploited for pest management at global level. During the last three decades, neem has been established as a multipurpose tree, but its recognition as a source of valuable plant allelochemicals, specifically for insecticidal, insect repellent, antifeedant and growth regulatory properties of neem seed kernel extracts, has attracted worldwide attention. The most important components identified in neem are the tetranortriterpinoids, the azadirachtins.

These occur in the concentrations of 0.1-0.9 per cent in the seed core and it has been established that 30-60 g azadiractin per ha is sufficient to combat and repel key pest of various crops. In spite of high selectivity, neem derivatives affect more than 500 species of insects belonging Coleoptera, Diptera, Hemiptera, Isoptera, Lepidoptera and Thysanoptera (Koul and Wahab, 2004). Its multi-pronged effects against insects including repellent, antifeedant, oviposition deterrent, molting or growth disruption, sterilant, ovicidal and oviposition deterrent, etc. are helpful to an effective control of a variety of farm and household insect pests and pathogens infesting agricultural plantation and cash crops. Several commercial formulations of neem like Neem Gold, Neemazal, Econeem, Neemark, Neemcure and Azatin among now available in many countries including the United States, India, Germany and several Latin American countries. Besides azadirachtin, other two major constituents namely salanin and nimbin also exhibit significant biological activity. While azadirachtin A is present in the extract to the extent of 85 %, azadirachtin B and H are present only at concentration up to 15 %. Other azadirachtin congeners occurred as minor constituents in neem seed extracts. Most of the commercial neem products are standardized based on azadirachtin-A.

Inadequate stability, problems in large-scale production, lack of effective delivery system, poor self life, and diminished residual toxicity under field condition, non-availability of reliable standards and inadequate availability of the raw material are some impediments in successful commercialization of neem pesticides.

Neem volatiles :

Volatiles compounds from neem are also effective pest control agents. Neem seed volatiles are toxic to *Trogoderma granarium* (Khapra beetle) adults and larvae if applied as fumigants (Arivudainambi and Singh, 2003). At 50 to 200 µl doses of neem seed volatiles, 100% mortality of adults and grubs has been achieved under laboratory conditions. These volatiles have been found effective as insect fumigants against the stored grain pests, *Callosobruchus maculates* and *T. castaneum*. It is believed that the cocktail of organosulphur and other constituents present in neem leaf and seed volatiles are responsible for causing adults mortality of the stored grain pests. Several sulphurous constituents like di-n-propyl and propyl propenyl di-, tri-, and tetrasulphides among others have been reported from headspace volatiles of neem seeds. Head space volatiles, including 73% di-n-propyl disulphide from freshly crushed neem seeds are toxic when applied topically or as a fumigant to *Tribolium castaneum* adults and larvae, and sitophilus oryzae adults. Di-n-propyl disulphide significantly decreases the growth rate and dietary utilization with moderate inhibition of food consumption in insects (Koul, 2004). The composition of the neem leaf and seed volatiles obtained after steam distillation has been determined by capillary gas chromatography, mass spectroscopy (GCMS) as well as electrospray ionization mass spectroscopy (ESI-MS) in direct infusion mode (Devakumar and Dev, 1993; khatavkar and Walia, 2005). Some of the major constituents identified by ESI-MS include tetracosane, triacontane, triacosanol,hexacosanol, heptacosanol and dotriacontanoic acid along with trace quantities of dipropyl trisulphide and propyl propenyl tetrasulphides. Other constituents identified by GC, MS include cyclic/acyclic alkyl alkenyl sulphides, trithiacyclodecanone, trithiocyclohexane, tetrathiacyclodecaneand longifolene.

Karanja tree as a source of bio-pesticide :

Pongamia pinnata Lin. Indigenous plant of India is variously known as karanja, puna oil tree, Indian beech or pangram. The active component of this plant is karanjin, a furaflavone. The oil of karanja repelled brown plant hopper in rice and significantly reduced its ingestion and assimilation of food. Both brown plant hopper and white backed plant hopper suffered heavy mortality, but green leafhopper was less susceptible (Lim and Bottrell, 1994). Karanja oil applied as a surface protectant effectively checked the infestation of pulse beetles, *Callosobruchus maculates* (Fabr.) and *C. chinensis* (Lin.) and other storage pests like *Rhyzopertha dominica* (Fabr.) and *sitotroga cerealella* (Oliv.). It was found to reduce the fecundity of these pests. *Pongamia* cake is found effective in controlling the attack of ground beetles on tobacco. It also does not leave any harmful residues in the soil. Pongamia cake water extract was found to act as an antifeedant against *Spodoptera litura* in tobacco nurseries and in groundnut crop. Other pest which have been reported to be susceptible to powders or extracts of pongamia are *Papilio demoleus* (Lin.) *Epilachna vigintioctopunctata* (Fabr.), *Amsacta moorei* (Butl.), *Chilo partellus* (Swin.), *Leucopholis lepidophora* (Blanc.), *Tetranychus* sp., *Maconellicoccus hirsutus (Green)* etc. (Dhaliwal and Arora, 2006; Mandal and Ghosh, 2020; Mandal and Ghosh, 2020).

Conclusion

From the overall discussion it is found that a number of pests cause damage the oil-borne seed trees. Proper Eco-friendly management should be taken to overcome these pests problems. For controlling the Lepidopteran pests spraying of plant extract like neem oil 1500 ppm @ 2.5ml/L is very effective. Among the microbial pesticides *Bacillus thuringiensis*, *Beauveria bassiana* should be used. For controlling sucking pests, neem oil, Imidacloprid 17.8 SL @ 1 ml/ 7 L, Acetamaprid 20SP @1 g/5 L or Acephate 75 SP 0.75g/L may be effectively used. For termite control soil drenching with Chloropyriphos 20 EC @ 5ml/L should be practiced. For mite control microbial toxin, Abamectin 1.9 EC @ 0.5 ml/L are advocated. Integrated Pest Management (IPM) is the best way to control these pests which are eco-friendly and environmentally sound process.

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