**International Journal of Chemical and Biomolecular Science**
Vol. 1, No. 3, 2015, pp. 123-128
http://www.aiscience.org/journal/ijcbs

# The Killer Chemicals for Control of Agriculture Insect Pests: The Botanical Insecticides

**Muhammad Sarwar***

Nuclear Institute for Agriculture & Biology (NIAB), Faisalabad, Punjab, Pakistan

## Abstract

This paper is likely to be fruitful by adding a share in the knowledge about use of botanicals and their processing into suitable manner as candidates for inclusion in the insect pests management with special focus on most destructive products. The use of synthetic insecticides for controlling of insect pests globally may have problems such as their persistent toxicity in food, the subsequent development of resistance in insect populations, effects on non-target organisms and other adverse environmental impacts. Of these, for sound management of pests there is an increasing interest in biotic control using plant products, which can prove eco-friendly with highly reduced negative effects on environment. Botanicals pesticides are plant derived materials such as from rotenone, pyrethrum, sabadilla, ryania, etc., used universally from commercial agriculture to institutions, homes and landscapes. Sometimes, nicotine products, although natural, yet are not considered bio-rational due to their high mammalian toxicity. The most potent bioactive compounds responsible for insecticide properties in botanicals are alkaloids, non-proteic amino acids, steroids, phenols, flavonoids, glycosids, glucosinolates, quinones, tanins, terpenoids, salanine, meliantrol, azadiractin, piretrolone, cinerolone and jasmolone acting as contact poisons, ingestion or stomach poisons, feeding deterrences, repellents and confusants, leading to finally death of the insect victims. Some newer botanical insecticides have low mammalian toxicity and these include products made from extract of neem tree seeds, which is labeled for many vegetable crops. Azadirachtin is the active ingredient that works by inhibiting development of immature stages of many insects and by deterring feeding by adults. Garlic and hot pepper-based materials are other low-toxicity botanicals used by some growers, although their efficacy is somewhat certain. Botanical insecticides show significant fatal effects, antifeedant with significantly lower feeding rates and repellent effects against insects when their populations are low to moderate in size. Botanicals pesticides are biodegradable, barely leave residues in the soil and are less likely to harm humans or animals. In addition, these are cheaper and more accessible in less developed countries. Most botanicals are broad spectrum, so along with pest control they may kill beneficial insects too. However, these tend to be moderately toxic to peoples and wildlife, and many are irritating to mucous membranes. Use of powdered and extract forms of test plants is recommended for small scale farmers of developing countries due to the simplicity of application, easy removal and non-toxic effects even if consumed by humans as having medicinal properties.

## Keywords

Botanical Pesticide, Plant Derived Material, Insecticide, Knockdown, Mortality

Received: July 26, 2015 / Accepted: August 6, 2015 / Published online: August 13, 2015



## 1. Introduction

Conventional broad-spectrum insecticides such as carbamate and organophosphate compounds can provide good protection of crops and grains from feeding by insects and other pests. These neurotoxins have activity through contact and ingestion, and cause rapid knockdown and death in the target insects. However, use of plant based pesticides, either in crude form or by processing into different formulations, is

* Corresponding author
E-mail address: drmsarwar64@yahoo.com

one of the many possible avenues explored with regard to biological control (Isaacs et al., 2004). Certain plant families, particularly plant products of Rutaceae and Myrtaceae have shown, in previous observations, repellent, insecticidal, anti-feedant, and growth regulatory properties against insect pests. Most of the plants thrive in rough environmental conditions so they have developed a multitude of defense mechanisms against natural enemies in the course of evolution. Among these are morphological and subtle chemical defense mechanisms against insects and other pests that do not generally cause immediate death but interfere with their vital biochemical and physiological functions (Neoliya et al., 2007; Yankanchi and Gadache, 2010).

Members of family of aromatic plants such as Eucalyptus species are usually highly aromatic and have monoterpenoids as bioactive principles with insecticidal properties. Due to their volatile and lipophilic nature, monoterpenoids can rapidly penetrate into insect's cuticle and cause their mortality by interfering with their vital physiological functions (Isman, 2000). It is possible to create effective and natural insecticides from these substances to protect crops to cope with pests that unlike to wild plants may have lost their capability through cultivation. Botanical pesticides have many advantages over synthetic ones and may be more cost-effective as a whole, considering the environmental cost of chemical alternatives. Most botanicals are broad spectrum, so along with pest control they may kill beneficial insects, too. Many plant products could be expected to break down naturally outdoors and not cause any long-term toxic effects. Botanicals are generally short-lived in the environment, as these are broken down rapidly in the presence of light and air, thus they do not provide pest control for very long time or perhaps several days (Ahmad et al., 2011; Sarwar, 2012 a).

The botanicals insecticide can work by ingestion, through contact, as a deterrent and by disrupting developmental processes. Ingestion is when the moth larvae consume the pesticide and are poisoned. Contact poisoning is when the solution kills the moth larvae through their skin or other tissue. A deterrent is when the insecticide prevents the moth larvae from feeding and they starve. Finally, certain pesticides, notably oil from the neem tree, disrupt the hormones that control molting and other processes. Aphids, spider mites, and other pests can cause serious damage to flowers, fruits, and vegetables. These creatures attack garden and farm in swarms, literally draining the life from crops and often inviting disease in the process. Many chemical pesticides can prove unsafe for the environment or may make fruits and vegetables unsafe for consumption, however, there are many homemade, organic options to turn to war against pests (Sarwar, 2010; 2013 a).

## 2. Considering Botanical Insecticides

For botanical insecticides, sometimes also referred to as 'botanicals', the earlier scientists have reported the development of inhibitory action and reproductive sterility effects against insects on agricultural crops that are under constant assault by pests, making use of insecticides essential to reduce losses. Synthetic insecticides such as organophosphates are important and effective tools in modern crop management. However, these pose serious threats to the environment and to peoples. Humans come in contact with dangerous pesticides on food, in water and in the air near farms. This 'pesticide drift' occurs when pesticide dust and spray travel by wind to places unexposed to pesticides. Almost ninety eight percent of sprayed pesticides do not reach to their target pests. They penetrate to groundwater, pollute streams and harm wildlife, including natural predators of the targeted pests. In short, global ecology is facing severe threat from the use of pesticides so the search for ecologically safe methods to control insect pests of crops and stored food products is an awe inspiring field of research (Sarwar and Sattar, 2012; Hina et al., 2015).

Botanical pesticides are naturally occurring insecticides derived from plants that have been formulated specifically for their ability to control insects. Botanical insecticides degrade readily in the sunlight, air, and moisture, breaking down into less toxic or nontoxic compounds and posing less risk to non-target organisms. But this requires precisely time of application and may also need to make more frequent applications if someone observes additional damage. Botanicals may not kill an insect for hours or days, but they act very quickly to stop its feeding. It must be noted that data on effectiveness and long-term toxicity are unavailable for certain botanicals. Botanicals tend to be less expensive than synthetic pesticides, and some are not as widely available. Also, the potency of some botanicals may differ from one source or batch to the next. Most botanicals do not damage plants and many botanicals are low to moderate in toxicity to mammals, but there are exceptions. For example, both inhalation and skin exposure to nicotine preparations can cause death. Also, rotenone is similar in toxicity to the common synthetic insecticides carbaryl and diazinon (Rajput et al., 2003; Khan et al., 2010). Plants produce numerous chemicals, many of which have medicinal and pesticidal properties. More than 2000 plant species have been known to produce chemical factors and metabolites having value in pest control programs. 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 (National Academy of Sciences 1992).

Garlic produces allicin, which gives to garlic its smell and healthful properties. Garlic does not contain allicin itself, but when the cloves are crushed, two chemicals inside react to form allicin. This is why garlic does not smell until anyone crushes it. Allicin has been shown to have antifungal, antibiotic and antiviral properties, and researchers believe that it may help to prevent cancer. Garlic oil has been used as an insect repellent, and may be toxic to certain insect eggs. It is possible that in high concentrations, the antibiotic effects of garlic become lethal to the moth larvae. Garlic-based insecticide is highly concentrated and somewhat slower to cause 50% mortality but it has the second highest eventual lethality. It may have acted as a repellent to the worms, making them not to eat their food, but it may also have contact-based effects. Green chilies and other hot peppers contain a natural substance called capsaicin that creates the hot, spicy effect. Capsaicin at 10 parts per million causes a persistent burning sensation. The intense flavor comes from the large hydrocarbon 'tail' of the molecule. Capsaicin works by opening doors in the cell membranes that enable calcium ions to flood into the cell, making it trigger a pain signal that is transmitted to the next cell, and onward and so on. Extremely high concentrations of capsaicin are toxic and destroy cells by stopping the production of certain neurotransmitters that enable cellular communication. By boiling the chilies, it is possible to isolate and concentrate the capsaicin and other chemicals. Because greater wax moth larvae are small, soft-bodied insects, sufficiently high concentrations might contain enough capsaicin to destroy cells and kill them. Another possibility is the acidity of hot peppers and the soft skin of a wax moth might be damaged by the pepper's chemicals (Liener, 1986). Limonoids, are extremely bitter chemicals present in citrus seeds, act as antifeedants or antagonize ecdysone action in many species of coleopteran (Schultz, 1994). A variety of these plants contain secondary metabolites that show insecticidal activity against several coleopteran and dipterans species (Salvatore et al., 2004).

Botanicals are basically secondary metabolites that serve as a means of defense mechanism of the plants to withstand the continuous selection pressure from herbivore predators and other environmental factors. Several groups of phytochemicals such as alkaloids, steroids, terpenoids, essential oils, and phenolics from different plants have been reported previously for their insecticidal activities (Canyonb et al., 2005). Research studies have been carried out to evaluate insecticidal action of two plant products on a major stored-product insect *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). The plant species studied included, *Psidium guajava* (L.) (Guava, leaves: Myrtaceae) and *Citrus reticulata* (Kinnow, peel and leaves: Rutaceae). Two formulations viz., powder and ethanol extract of each plant have been prepared. Repellency has been tested using the filter paper test whereas mortality, weight loss protection and anti-feedant potential of all treatments evaluated by using whole wheat grains. The results reported that all tested treatments have significant effects pertaining to all variables analyzed and ethanol extract has been found to be remarkably more potent than powder form of same plant. Furthermore, leaves and peel of *C. reticulata* do not differ significantly pertaining to their toxicity against adult *T. castaneum* but proved stronger than *P. guajava* (Iram et al., 2013).

## 3. Common Botanicals

Common botanical insecticides include pyrethrum or pyrethrin that is a dust or extract derived from the pyrethrum daisy. These products are registered for use on animals to control fleas, flies and mosquitoes. They are also used as indoor household sprays, aerosols and 'bombs'. Pyrethrins are sometimes combined with rotenone and ryania or copper for general use in gardens. Sabadilla is effective against certain true bug insects such as harlequin bugs and squash bugs, which are difficult to control with most other insecticides. Sabadilla is highly toxic to honey bees, so avoid spraying it when bees are present. Ryania may be used on citrus, corn, walnuts, apples and pears for the control of such pests as citrus thrips, corn borer and codling moth. Nicotine is used in greenhouses and gardens to control soft-bodied sucking pests such as aphids, thrips and mites. Because it can be toxic to humans, nicotine teas are not recommended as a way to control garden or household pests. Limonene and linalool are especially common in flea dips and pet shampoos. And the compound azadirachtin, derived from the neem tree, is sold under various names, and it may be used on several food crops and ornamental plants to control white flies, thrips, mealybugs, and other pests (Sarwar et al., 2005: 2012; 2013). The most prominent active constituents from plants which are responsible for the botanical insecticides properties are alkaloids, non-proteic amino acids, steroids, phenols, flavonoids, glycosids, glucosinolates, quinones, tanins, terpenoids, salanine, meliantrol, azadiractin, piretrolone, cinerolone and jasmolone. Mode of action for plant derivatives used for insect pests management is as contact poisons, ingestion or stomach poisons, feeding deterrences, repellents and confusants, which paralyze nerve activity, respiratory arrest, and act on the central and peripheral nervous system leading to convulsions and finally death of the insect victims (Rahuman et al., 2008; Silva-Aguayo, 2013).

### 3.1. Neem

Neem (*Azadirachta indica*) is a fast-growing broad-leaved evergreen tree that has many uses for centuries and one of those is as insecticide action. It can work in several ways, as a sterilant, a deterrent, an anti-feedant and as an insect growth regulator. However, it is relatively recent as a commercially available product and its effectiveness is not yet at the level of the other botanical discussed herein. It works best when insect populations are low to moderate in size. The product needs to be applied as soon as the pest appears and then re-applied, as often as every week, as long as the pest is active. This may become time-consuming (at the commercial level) and not necessarily cost effective. It is expected that more effective neem products can appear eventually. The *A. indica* tree contains an unusually high number of potent compounds, notably the chemical azadirachtin has strong resistance to termites that makes it a useful construction material. Azadirachtin harvested from the seeds, commonly offers broad range insect control and it is known not highly toxic to mammals. The bright red adult lily leaf beetle (Liliocerislilii) and its larvae are voracious feeders of all true lilies and it is a devastating pest. Neem has been effective against this pest when utilized as described in the above line.

### 3.2. Nicotine Sulfate

Nicotine sulfate is toxic to most warm-blooded mammals and requires extreme caution when handling and applying. It kills insects by disrupting their nervous systems, causing vital functions to cease and finally the death. The tobacco is steeped in water to manufacture it, and it is then sprayed onto plants and sometimes livestock to ward off insects.

### 3.3. Pyrethrum or Pyrethrins

Pyrethrum or Pyrethrins are widely-used botanical insecticides made from the chrysanthemum plant. Pyrethrins can incapacitate most insects immediately; however, many insects can recover from its effects unless pyrethrins are combined with other insecticides.

### 3.4. Rotenone Insecticides

Rotenone insecticides are made from the roots of the Leguminoceae or Fabaceae plant family like from roots of Derris plant species. Rotenone is an odourless and colorless, crystalline ketonic chemical compound used as a broad-spectrum insecticide and pesticide. Rotenone insecticides are mildly toxic to humans and many animals, fish in particular. It stops insects from feeding, leading to their demise via starvation and interference with respiration at the cellular level.

### 3.5. Ryania

It comes from the stems and roots of the shrub Ryaniaspeciosa. It acts as a stomach poison and keeps insects from feeding leading to death. The Ryania is moderately toxic to mammals, if ingested.

### 3.6. Sabadilla

The botanical pesticide manufactured from the seeds of sabadilla lily, is possibly the least toxic of all organic insecticides. It is sold as a powder and is a contact poison, but unfortunately due to its low toxicity, sabadilla may not stop density of all insects. It is effective against leafhoppers, stink bugs, thrips, most caterpillars and squash bugs. It repels slugs, snails and many crawling pests. It is toxic to honeybees and degrades rapidly on exposure to sunlight and leaves very minimal trace toxicity.

## 4. Preparing of Botanical Pesticide

All of botanical pesticides are made from common plants that grow in many parts of the world and can be purchased quite cheaply. It is easy for anyone to produce them in kitchen and method is same that is already used with other plants such as neem tree leaves, and could be expanded to industrial capacities.

i. To prepare botanical pesticide, cut off 200 g of plant parts to be tested, wash thoroughly, chop them up in a food processor and add one liter of distilled water. It is important that there is nothing in the water that might affect the pesticide and then concentrate it by boiling to extract the substances from the plant parts, and strain out the sediment.

ii. The same could also try with 400 g of peeled garlic cloves and 250 g of green chilies by weighing out a cup of each, and calculate the concentration of plant substances per liter of solution. All the vegetables should be washed and chopped prior to use.

iii. Blend the vegetables together in an electric blender, and a thick, chunky paste should form.

iv. Add the vegetable paste to 2 cups (500 milliliters) of warm water and thoroughly mix the ingredients together.

v. For neem seed extract, powder obtained by crushing 400 g of seeds is dissolved in 2 litres of water and stirring well. Then allow the solution to soak for about 12 hrs. The resulting solution is filtered through a thin cotton cloth, and diluted with water to bring the solution to 10:1, for the control of pest attack.

vi. Pour the solution into a plastic or glass container and allow it to sit for 24 hours, if possible keep it in a sunny location, or if not, at least keep the mixture in a warm spot.

vii. Strain the mixture, pour the solution through a strainer removing the vegetables and collecting the vegetable-infused water into another container that is the desired pesticide.

viii. Pour the pesticide into a squirt bottle and make sure that the spray bottle has first been cleaned with warm water and soap to rid it of any potential contaminants.

ix. Spray the plants with pesticide and treat the infected plants every four to five days. After three or four treatments, the pests may scatter. If the area is thoroughly covered, this pesticide should keep bugs away for the rest of the season.

x. The solutions prepared here should be mixed well with soap solution at the rate of 10 g/ 1 litre of extract before spraying to facilitate uniform spread of the neem solution. It is recommended that the application or spraying of the all botanical pesticide should be carried out only in the late afternoon of the day.

## 5. Testing Procedure of Botanical Pesticide

Botanical insecticides can be tested each at three concentrations, on populations of adults or larvae of insect. The medium and lowest concentrations are diluted 3:1 and 5:1 from the fully concentrated solution. After creating test insect populations, allow the adults or larvae to get time used to their environment and eliminate natural deaths, then spray the known numbers with natural insecticide and thereafter track their survival rates. The highest concentrations of all of the insecticides can cause mortality within one to three days of spraying. Every day try to track the numbers of dead and live adults or larvae of insect population for each concentration of the insecticide. It can be analyzed, 1) the mortality rate (how many died on each day), 2) how many days are needed to achieve lethality to 50% of the population, or LD 50, which is the standard used when testing products, and 3) total mortality after 15 days.

## 6. Switch Over to Integrated Pest Management (IPM)

In order to minimize the use of hazardous chemical pesticides and to manage the insects, pests and diseases attack as well as to increase the crop productivity, it is necessary to implement a scheme to strengthen and modernization of pest management approach by adopting Integrated Pest Management (IPM) as cardinal principle and main plank of plant protection strategy in overall crop production program. Under this program, it should have a mandate to popularize adoption of integrated pest management through training and demonstration in crops inter-alia promotion of biological control approaches in plant protection technology. Settlement of the laboratory to land gap can be narrowed down through proper training and education to the farmers by way of expert and regular extension services. The managed pest management system eliminates or mitigates economic and health damage caused by pests; minimizes the use of pesticides, and the risk to human health and the environment associated with pesticide applications; and uses integrated methods, site or pest inspections, pest population monitoring, an evaluation of the need for pest control; and one or more pest control methods including sanitation, structural repairs, mechanical and biological controls, other non-chemical methods, and if nontoxic options are unreasonable and have been exhausted, use least toxic pesticides (Sarwar, 2012 b; 2013 b; 2013 c).

## 7. Conclusion

In the light of the findings of present study, it could be stated that botanicals pose reasonable insecticidal properties against insects and have shown promising effects for plants and seeds protection, so these might be used in pests population managing in crops and stored grains. Other potential experiments could include trying of different concentrations and varying the spraying frequency of the botanicals, as well as spraying the larvae and their food separately to see if the botanical is effective through ingestion or as a deterrent, as opposed to killing by contact. It could be tried different species of pests to see which botanicals are most broadly effective. There could also try to test different parts or ingredients of the plants, or mixing of solutions together to create more potent botanicals. It could be tested other botanicals to see if these have similar effects or could also try testing relatives of botanicals such as different types of plant families and such experiment could lead to derive many more pesticides that could improve the farming processes used today. Members of family of aromatic plants like Eucalyptus, and members of the families such as Solanaceae, Asteraceae, Cladophoraceae, Labiatae, Miliaceae, Oocystaceae and Rutaceae are available for maximum months in a year. So, use of their body parts (leaves, stems, barks, flowers, fruits, roots, seeds) as alternative to conventional insecticides is recommended due to their relative abundance and accessibility throughout the year. Further investigation for the isolation of individual components of plant prats to determine the exact mode of action of the active components, and their effect on target and non-target organisms is advocated for their possible incorporation in botanical insecticides on commercial scale.

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