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Review

Role of Botanicals in Pest Management - A Review

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Abstract: Pest management is one of the most aspects of agriculture. Conventional pesticides led to a number of environmental problems, including loss of soil fertility, ecological imbalances, and declines in marine life. Conventional pesticides have been linked to a number of detrimental and dangerous health problems in humans and animals, including serious cancers, neurological diseases, hormone imbalances, and problems with reproduction. With a view to over view these demerits, nowadays more emphasis is being laid on IPM by using botanicals. Botanical pesticides derived naturally from compounds found in plants, and are useful substitute for conventional pesticides The use of botanical pesticides is now emerging as one of the effective ways to safeguard crops, their products, and the environment against chemical pollution. Botanicals breakdown more quickly than majority of chemical pesticides, and are therefore considered as eco-friendly and less likely to kill beneficial pests than synthetic pesticides. One of the most significant botanical insecticides used extensively in India for agricultural pest control is neem-based pesticide; it is followed by pyrethrum and pesticides based on eucalyptus oil. The conventional, sustainable, and integrated approaches to pest management all make use of different botanical pesticides.

Keywords: Botanicals, Chemical pesticides, Integrated Pest Management, Eco-friendly, Neem, Pyrethrum and Environmental pollution.

Introduction:

Pest management in agriculture is challenging task in the context of increasing agricultural productivity without upsetting the ecological balance and deteriorating the environment. Agrochemicals in agriculture of course are useful for protecting crops against insect pests and diseases and have played a significant role to boost the agricultural production. However, these chemicals are posing enormous problems like environmental pollution, pesticide resistance, pest resurgence, toxicity hazards, secondary pest out breaks, residues in feeds, foods, soil and water, destruction of biodiversity of useful natural enemies and some social economic

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problems (Damalas and Koutroubas 2014). To obviate these ill effects, there has been increased demand for alternative and selective pest control agents, particularly Integrated Pest Management (IPM) due to the ecological advantages such as eco-safety, no development of resistance, higher acceptability and value of produce for exports.

With a view to over view these demerits, nowadays more emphasis is being laid on IPM by using botanicals. Botanicals are naturally occurring chemicals (Insect toxins) extracted from plants. They are also called as Natural insecticides. The use of plant and plant derived products (Botanicals) to control insect pests in developing world is well known and prior to the discovery of synthetic pesticides, botanicals were the only pest managing agents available to farmers around the world (Misra, 2014). These have been classified into herbicides, insecticides, fungicides, nematicides, molluscides and rodenticides and have variable mode of actions. Botanicals have long been touted as attractive alternatives to synthetic chemical insecticides for pest management as they possess an array of properties including toxicity to the pest, repellency, antifeedance, insect growth regulatory activities against pests and eco-friendly, economic, target specific and biodegradable (Hikal *et al.*, 2017). These degrade more rapidly than most chemical pesticides and are therefore considered relatively environment friendly and less likely to kill beneficial pests than synthetic pesticides with longer environmental retention. Most of the botanicals generally degrade within few days and sometimes within few hours. Their greatest strength is their specificity, as most of them are essentially non-toxic and non-pathogenic to animals and humans besides being ecofriendly.

Botanicals are becoming an efficient part of Integrated Pest Management (IPM) strategies for all types of crops due to their:

- Effectiveness in controlling pest
- Environmental and public health safety
- Eco-friendly nature and cost effective
- Abundant supply of substances with biological activity
- Excellent tools for organic farming system

Generic Name	Oral LD 50	Dermal LD50	Signal Word
Neem	13,000	3,578-8,374	Caution
Pyrethrin	1,200-1,500	>1,800	Caution
Rotenone	60-1,500	940-3,000	Caution
Sabadilla	4,000	-	Caution
Ryania	750-1,200	4,000	Caution
Nicotine	50-60	50	Danger
d-limonene	>5,000	-	Caution
Linalool	2,440-3,180	3,578-8,374	Caution

* Toxicity varies greatly depending on type of solvent used as carrier

Different Botanical Insecticides and their mode of action are as follows:

1. Neem

The Neem tree, *Azadirachta indica* (Meliaceae) is a native to south-east Asia and grows in many countries throughout the world (Roshan and Verma, 2015). This amazing tree is used to make a wide variety of agricultural products. Products made from neem include fertilizers,

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manures, compost, soil conditioners, insecticides, pesticides, and fumigants (Kumari *et al*., 2020). Neem oil is made of many components. "Azadirachtin" is most active. Azadirachta is a mixture of seven isometric compounds being Azadirachta-A to G with Azadirachta-A as dominant and Azadirachta-E as most effective growth regulator (Rosell *et al*., 2008). It serves as a repellent, reduces insect feeding and oviposition, sterilant, suppressant and growth regulator (Figure 1). As a repellant, neem prevents insects from initiating feeding. It acts as a feeding deterrent, making insects quit feeding. As a growth regulator, it disrupt normal development and interfering with the manufacture of chitin. Additionally, it disrupts the hormone systems of insects, making it more difficult for them to develop and lay eggs. Azadirachtin can repel and deter nematodes from feeding.

Neem tree products can help to control nematodes and fungus in addition to being useful insect growth regulators (IGRs) (Lokanadhan *et al.*, 2012). Neem compositions derived from kernels are effective against over 105 insect pests across 10 orders in gardens and crops. Azadirachtin repel and kills a variety of caterpillar, thrips, and whitefly species (Egwu *et al*., 2019). Neem oil is useful in controlling various pests, such as *Cnaphalocrocis medinalis*, *Ceraeochrysa claveri*, *Diaphorina citri*, *Helicoverpa armigera*, *Mamestra brassicae*, *Pieris brassicae* and *Spodoptera frugiperda* (Senthil-Nethan *et al*., 2009 and Tavares *et al*., 2010).

Figure 1. a) Neem oil b) Azadirachtin Structure

2. Eucalyptus

Eucalyptus tree, *Euclayptus camaldulensis* (Myrtaceae), is native to Australia and grown all over the world. The eucalyptus oil is a complex mixture of various monoterpenes and sesquiterpenes, as well as aromatic phenols, oxides, ethers, alcohols, esters, aldehydes, and ketones (Batish *et al*., 2008). The pesticidal activity of eucalyptus oils is due to the components including 1,8-cineole, citronellal, citronellol, citronellyl acetate, p-cymene, cucamalol, limonene, linalool, α-pinene, γ-terpinene and α-terpinelol.

Eucalyptus oil has antifeedant properties that protect against herbivores and can function as a natural insect repellent to protect against mosquitoes and other harmful arthropods (Ayed *et al*., 2024). It also possesses toxicity against a wide range of microbes including bacteria and fungi, both soil borne and post harvest pathogens (Figure 2). Eucalyptus oil has acaricidal activity and can be effectively used to dispel ticks and mites (Noaman and Bahreininejad, 2024), both parasitic and free living and is also a good Nematicide.

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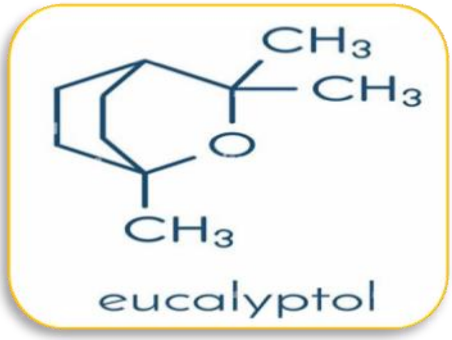

Figure 2. Eucalyptus oil and Its Structure

3. Nicotine

Nicotine is a basic alkaloid derived from tobacco, *Nicotiana tabacum* (Solanaceae) and other Nicotiana species. Nicotine constitutes 2-8% of dried tobacco leaves. Currently, tiny amounts of insecticidal formulations are imported from India and typically include 40% nicotine sulfate. Nicotine has insecticidal qualities and is effective against several insect orders, including hemiptera, (Aphids, whiteflies), thysanoptera (Thrips) and coleoptera (Beetles) (Dewi *et al*., 2018).

Nicotine represents the class of nicotenoids with a unique mode of action. It functions as a contact toxin, and fast acting nerve toxin which kill the insects rapidly within hours, and resulting in tremors, loss of coordination, and finally death (Vij, 2014). It competes with acetylcholine, the major neurotransmitter, by biding to acetylcholine receptors at neuron synapses and inducing uncontrollable nerve firing (Figure 3). This disturbance of normal nerve impulse activity results in rapid failure of those body systems that rely on nervous input for proper functioning. Action of nicotine is selective and affects only a certain types of insects.

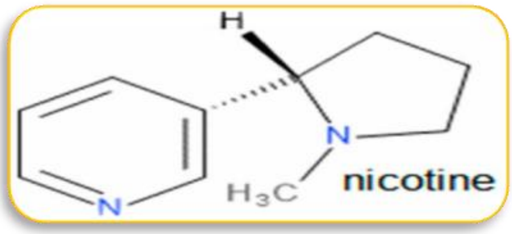

Figure 3. Nicotine oil and Its Structure

4. Lemon grass

Lemon grass oil is obtained from three different species, *Cymmbopogan flexuosus*, known widely as East Indian lemon-grass, but also referred to as Cochin, Native, or British Indian lemon-grass; *C. citratus*, mainly known as West Indian lemon-grass, but also called Madagascar or Guatemala lemongrass. A third species *C. pendulus*, also known as North Indian lemon-grass, is a minor source of commercial production.

The three species of lemon grass are cultivated in humid tropical climates.

Lemon grass oil has been reported to have insecticidal effects against diverse insect species and also has anti-fungal properties and as an insect repellent. The main active component of Lemon grass oil is "Citral", a terpenoid, which are mixture double bound isomers. The E-isomer, or citral A, is also known as "Geranyl" (CAS 141-27-5). The Z isomer is known as citral B or "Neral" (CAS-106-26-3). Lemon

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grass oil tends to produce a racemic mixture of two isomers (CAS5392-40-5) at a 2:1 ratio of geranial and neral (Merck, 2015). The citral content is more in *C. flexuosus* than *C. citratus* (Khan and Abourashed, 2010) (Figure 4).

Lemon grass essential oil and its constituents, such as "Citral" and "Geranyl acetate", are found effective against *Sitophilus granarius* (Plata-Rueda *et al*., 2020). Lemon oil derived from Citrus lemon was effective was effective in controlling *Culex pipiens* mosquito larva, and their reproduction and fertility were effectively suppressed and their integument layers underwent histological alterations (Dabour *et al*., 2023). Lemon grass oil is toxic to *Drosophila melanogaster* (Alijedani, 2021), *Agrotis ipsilon* larvae by affecting their peroxidase and detoxification activity (Moustafa *et al*., 2021). It has also insecticidal effects against aphids, while it doesn't affect non-target predators (Gupta *et al*., 2017).

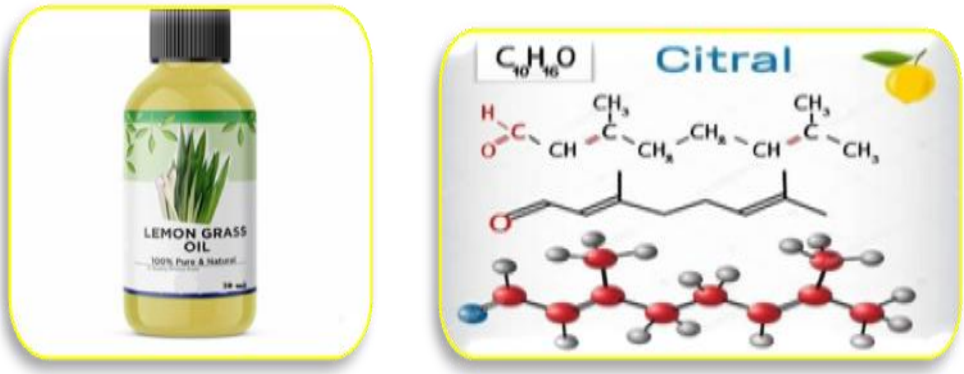

Figure 4. Lemon grass oil and its Structure

5. Pyrethrum and Pyrethrins

Pyrethrum is the powdered, dried flower head of the pyrethrum is daisy, *Chrysanthemum cinerariafolium*. The crude flower dust itself is known as Pyrethrum and the six related insecticidal substances that are naturally present in the material the "pyrethrum" flowers are referred to as "pyrethrins". They are produced as a resin from crude pyrethrum dust and are used to make a variety of insecticidal products.

Pyrethrins cause poisoning by interfering with the sodium and potassium ion exchange process in insect nerve fibers and preventing normal nerve impulse transmission. The insecticides pyrethrins work very quickly, and cause instant "knockdown" paralysis in insects (Figure 5). Despite their rapid poisonous impact, however, many insects metabolize (breakdown) pyrethrins rapidly. After a temporary paralysis, these insects regain their ability to move. Most pyrethrins containing treatments also contain piperonyl butoxide (PBO), a synergist, to stop insects from metabolizing pyrethrins and recovering from poisoning. Without PBO the effectiveness of pyrethrins is greatly reduced. Pyrethrins are used as commercial and household insecticides. Pyrethrins are toxic to insects such as honey bees, dragonflies, mayflies, gadflies, and some other invertebrates, including those that constitute the base of aquatic and terrestrial food webs (Zaveri and Mihir 2012). About more than 1,000 pyrethroids have been made, only a few are used in the United States. These include permethrin (Biomist^{R}), sumithrin (Anvil^{R}) and resmethrin (Scourage^{R}).

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Figure 5. Pyrethrum and Its Structure

6. Rotenone

Rotenone is one of the earliest naturally occurring substances found in different plants. Rotenone is the trivial name of the main chemical component of certain plants of the *Derris*, *Lonchocarpus*, *Tephrosiaand Mundulea* species. It naturally exists in the roots of numerous different Fabaceae species as well as in the seeds and stems of a number of plants, including the Jicama vine. It has a molecular formula of $C_{23}H_{22}O_6$ and a molecular weight of 394.42 (Figure 6).

Rotenone is a crystalline isoflavone with no smell or color that is used as a broad-spectrum pesticide, and insecticide. It was the first described member of the family of chemical compounds known as rotenoids. It is formulated, along with other pesticides, such as carbaryl, pyrethrins, piperonyl butoxide, and lindane, in products to control insects, mites, ticks, lice and spiders. Rotenone is potential inhibitor of cellular respiration, the method by which nutrients are converted into energy. Rotenone mostly damages nerve and muscle cells of insects, which results in abrupt stoppage of feeding. Death occurs few hours to few days after exposure. Additionally, rotenone dust is used to suppress aphids and insects on fruits, vegetables and berries. Rotenone is both contact and systemic insecticide (Gupta, 2018).

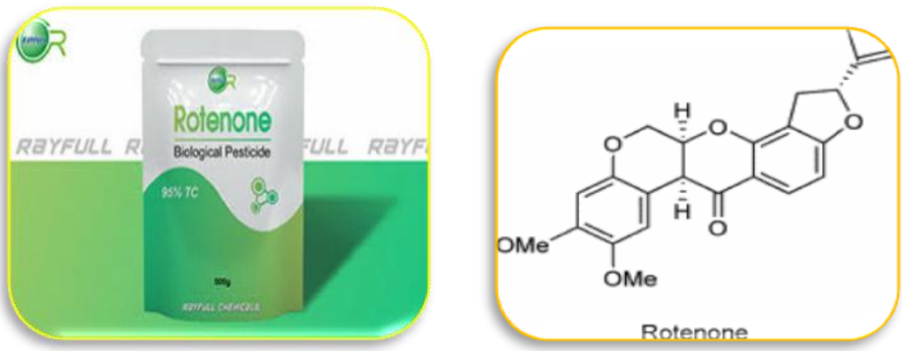

Figure 6. Rotenone and its Structure

7. Sabadilla

Sabadilla (Family: Liliaceae) is derived from the ripe seeds of *Schoenocaulon officinale*, a tropical lily plant which grows in Central and South America. Sabadilla is also known as cevadilla or caustic barley. Sabadilla is light-sensitive and breaks down rapidly in sunlight (Figure 7).

In insects, sabadillas toxic alkaloids affect nerve cell membrane action, resulting in loss of nerve function, paralysis, and death. Some insects are instantly killed by sabadilla, while others may live for a few days in a paralyzed state for several days before dying.

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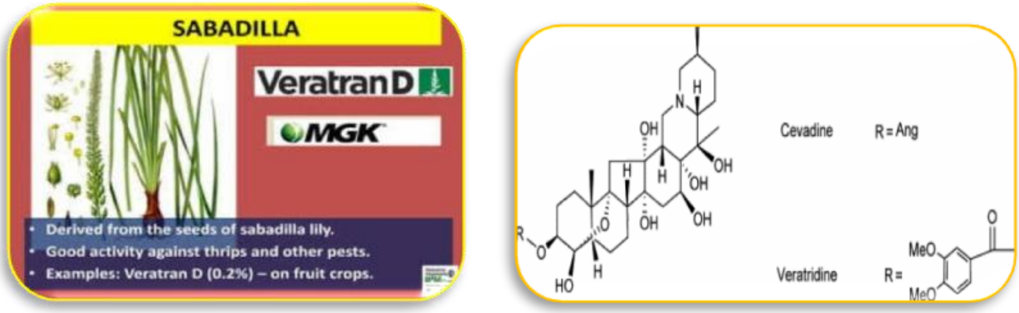

Figure 7. Sabadilla and Its Structure

8. Ryania

Ryania comes from the woody stems of South American shrub *Ryania speciosa*. Powdered Ryania stem wood is combined with carriers to produce a dust or is extracted to produce a liquid concentrate. The main active ingredient in Ryania is the alkaloid "ryanodine", which makes up 0.2% of the dry weight of stem wood.

Ryania is a stomach toxin that acts slowly. It doesn't cause instantaneous knockdown paralysis, but it does insects stop feeding shortly after ingesting it. Regarding its mode of action more information is not present. Ryania is said to work best in hot weather and is synergized efficiently by BPO (Figure 8).

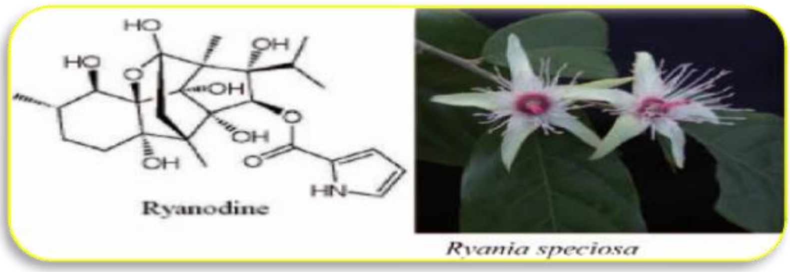

Figure 8. Ryania and Its Structure

Conclusion:

Botanicals help in preventing the dumping of thousands of tons of pesticides on the earth, they are safe compounds because botanicals are biodegradable and transform into harmless compounds in matter of hours and days when exposed to sunlight.

The application of plant based insecticides in the control of insect pests is quite broad. Production of botanical insecticides would remove the high cost of importation in developing countries. These botanicals are eco-friendly and can play very important role in development of sustainable crops and offer a steady insect management program. Therefore, the search of new botanicals insecticides with greater efficacy, persistence and desirable host specificity should continue using molecular tools and recent novel techniques.

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