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Role of Green Chemistry Pesticides in IPM

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Introduction

Botanical pesticides or natural insecticides are organic and Botanicals are derived from fresh or dried plants, or plant's isolated or extracted in water, ethanol, or other organic solvents used for flavoring, fragrance, functional health benefits, medicine or other biological and technical activities. These are naturally occurring plant products are extracted from various plant parts *viz*., leaves, stems, seeds, roots, bulbs, rhizomes, unripe fruits, and flower heads etc.) of different plant species. Plant extracts are also called as Green Pesticides, Botanical Pesticides, Plant Pesticides, Botanicals, Ecological pesticides and the method which utilizes botanicals in insect pest management is called as Indigenous Integrated Pest Management or Ethno-Botanical Crop Protection. Hundreds of botanical pesticidal compounds have been discovered from many plants, including wild plants and herbal medicines. These have broad spectrum activity, are less expensive and easily available because of their natural occurrence, have high specificity to target pests, and no or little adverse effect on beneficial insects, resistance development to them is slow or less common, poses least or no health hazards and environmental pollution, have less residual activity and are effective against insecticide resistance species of insects, and have no adverse effect on plant growth parameters. Botanical pesticides are effective in controlling a variety of agricultural pests, affordable, easily biodegradable, have a variety of mechanisms of action, are readily available in their sources, and are not hazardous to non-target organisms.

1649- Rotenone used to paralyse fish in South America.

1690- Tobacco extracts used as contact insecticide.

1825- Quassia used as an insecticide in fly baits.

1848- Derris (Rotenone) being used in insect control in Asia.

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1897- Oil of citronella used as a mosquito repellent.

1949- Synthesis of 1st synthetic pyrethroid "Allethrin".

1962- Antifeedant effect of neem was first reported by Pradhan *et al.*

1973- Development of 1st photo stable synthetic pyrethroid, "Permethrin".

1985- 1st registration of azadirachtin as an insecticide.

2007- Azadirachtin synthesized in the laboratory by Dr. Steven & colleagues, University of Cambridge (UK).

Some botanicals insecticides are:

There are two generations of plant pesticides:

- Among the first-generation botanicals are- Pyrethrum, Nicotine, Rotenone, Ryania
- Second generation botanicals are- Synthetic Pyrethroids and Neem Products

Table 1: Source of plant containing compounds or principles against various target insect pests

Plant Name	Scientific Name	Plant parts use	Compound/ Active Principles	Target Insect Pests
Pyrethrum	*Chrysanthimum cinerarifolium*	Dried flowers	Pyrethrin	Ants, Aphids, Bugs, fleas, Caterpillars, Leaf hoppers, Beetles, flies, ticks, Cabbage worms, Spider mite
Derris	*Derris eliptica*	Roots	Rotenone	Bugs, Potato beetles, Aphids, Carpenter ants, Spider mites
Tobacco	*Nicotiana tobacum*	Whole plants, leaves	Nicotine, Nornicotin, Anabasine	House fly, Aphids, Thrips, Caterpillars
Sabadilla / Cevadilla	*Schoenocaulon officinalea*	Seeds	Cevadine	Leaf hoppers, thrips,

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				caterpillar, Grasshoppers, House fly, Aphids, Moths, Looper, Bugs
Neem	*Azadirachta indica*	Seeds & leaves	Azadirachtin, Nimbin, Nimbidin, Salanin, Meliantriol	Insecticide, rice and wheat weevil
Ryania	*Ryania speciosa*	Roots, leaves & stalks	Ryanodine	Potato aphid, Codling moths, Onion thrips, Silkworm, Corn earworms
Cymbopogon/Lemon grass	*Cymbopogon citratus*	Leaves	Citronellal	Gram pod borer
Bitter melon	*Momordica charantia*	Leaf	Momordin	Mung bean weevil
Turmeric	*Curcuma longa*	Rhizome	ar-turmerone and turmerone	Cabbage looper
Garlic and Onion	*Allium sativum and Allium cepa*	Leaves, Tuberous bulbs	Allicin, Diallyl sulphide, Quarcertin	Red flour beetle, *Tenebrio molitor* (mealworm beetle), Silverleaf whitefly
Custard apple	*Annonna squamosa*	Seeds, leaves & bark	Acetogrns, Anjnonin, Squamocin	Diamondback moth

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Quassia	*Q. amara*	Wood and bark	Quassin, Isoquassin, Neoquassin & Quassmarin	Aphids, moths, potato beetles, apple blossom weevils and fruit flies
Eucalyptus	*Eucalyptus globulus*	Leaves &Oil	Camphene, Linalool, Limonene, α-terpinol	Housefly (*Musca domestica*)
Lantana	*Lantana camara, Lantana trifoli*	Whole plant & leaves	Lantic acid, Lantalonic acid, Urosolic acid stearoylgluside	Aphids, Beetles, leaf minor
Calotropis/Ekka leaf extract	*Calotropis procera*	Leaf	Calotropin, Calotoxin	Termites,
Datura	*Datura stramonium*	Roots, leaves, flower and seeds	Hyoscyamine, Atropine, and Scopolamine	Tea mosquito bug, Aphids, Thrips, Jassids

Pyrethrum-

Pyrethrum ($C_{21}H_{30}0_3$) is a botanical pesticide used globally which is extracted from Chrysanthemum flowers (El-Wakeil, 2013), family Compositae, commercially grown in Kenya. The pyrethrum is chemically present in all parts of the plant but higher concentration in flowers (Sola et al., 2014). Pyrethrum is a potent insecticide acts as neurotoxin. It is very toxic to cold blooded animals and mainly used in domestic or green pests. Pyrethrum is also used in combination with other insecticides as synergists for the control of household pests. The substances that are active are: 1. Pyrethrin I, a chrysanthemum monocarboxylic acid and pyrethrolone ester 2. an ester of cinerolone and chrysanthemum monocarboxylic acid known as cinerin. 3. Pyrethrin II, a chrysanthemum dicarboxylic acid and pyrethrolone ester methyl monoester. 4. Cinerin II, a monomethyl ester of chrysanthemum dicarboxylic acid and cinerolone.

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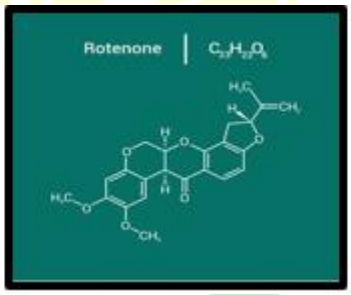
Rotenone

Rotenone ($C_{23}H_{22}0_6$) is an isoflavonoid, considered as one of the broad-spectrum botanical pesticides obtained from stems and roots of *Derris elliptica*, *D. involuta* and *Lonchocorpus sp.* (contain 8-11%). The dried root powder is directly used or sprayed by making spray solution. Rotenone, can act as a contact poison, food poison, stomach poison, cellular respiratory enzyme inhibitor. In insects' rotenone exerts its toxic effects primarily on nerve and muscle cells, causing rapid cessation of feeding. Death occurs several hours to a few days after exposure. Rotenone is extremely toxic to fish, and is often used as a fish poison (piscicide) in water management programs.



Tobacco

Nicotine ($C_{10}H_{14}N_2$) is the principle alkaloid in tobacco which is very poisonous and pure alkaloid is isolated by Posselt and Reimann. LD_{50} is 50-60 mg/kg. Two formulations i.e. nicotine 40% solution and 10% DP are registered in India for export only. Nicotine is a contact and nerve poison. Main effect is on aphid (aphidicide).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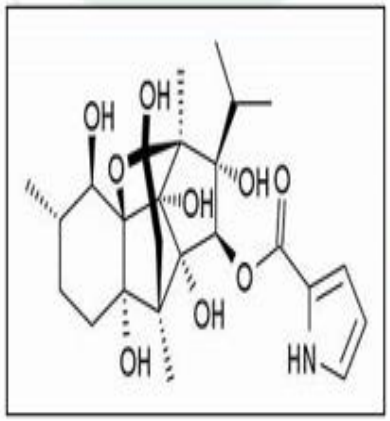
Neem- The active principle of neem, Azadirachtin ($C_{35}H_{44}O_{16}$) was discovered by Rambold. These are the chemicals obtained from the extracts of *Azardirachta indica* (neem tree), a member of the Meliaceae family (Campos *et al*., 2016). Neem binding to acetylcholine receptors thereby disrupting the nervous system, Repellence Feeding deterrence, Inhibition of oviposition, egg hatching and moulting in pest Neem controls leaf miners, sweet potato whiteflies, gypsy moths, loopers, caterpillars, western flower thrips and mealybugs as well as some of the plant diseases, including certain mildews and rusts (Dubey *et al.*, 2011).

Rynia

This compound is obtained from the roots and stems of a plant native to South America known as *Ryania speciosa* (Salicaceae) contains 0.16 to 0.2% insecticidal substances, the most significant of which is the alkaloid ryanodine. This alkaloid is effective as a contact or stomach poison and directly prevents muscles from contraction, causing paralysis. LD 50 equals 750 mg/kg.



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Sabadilla (veratrine alkaloids)-

Cevadine:$C_{32}H_{49}NO_9$

Veratridine: $C_{36}H_{51}NO_{11}$

Sabadilla also known as cevadilla or caustic barley. It is derived from the ripe seeds of *Schoenocaulon officinale*, a tropical lily plant which grows in Central and South Amerika. In insects sabadilla's toxic alkaloids affect nerve cell membrane action, causing loss of nerve cell membrane action, causing loss of nerve function, paralysis and death. Sabadilla degrades rapidly in air and sunlight and has little residual toxicity. It is a broad-spectrum contact poison, but has some activity as a stomach poison. It is very toxic to honey bees and most effective against true bugs such as harelequin bugs and squash bug.


Calotropis

The plant calotropis is poisonous. Calotropin and calotoxin are the active principles present in calotropis, which show anti-feedant, repellent, oviposition deterrent and insect growth regulator activity against insect pests (Baby joseph *et al*., 2013; Suresh *et al*., 2013; Rohit Sharma et al., 20120). Ekka leaves were sun-dried, ground into a powder by pounding, and then steeped in 50L of water for 24 hours before being filtered through muslin fabric and sprayed.


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Datura- The active ingredients in datura, hyoscyamine, atropine, and scopolamine, have insect pest-repelling and oviposition-deterrent properties. Datura leaves and pods were pounded into a fine powder and dried. This powder is filtered through a muslin cloth and sprayed after being steeped in 40L of water for 24 hours.



Benefits/Importance of botanical pesticides

Typically, the range of activity for biopesticides is limited; they are less expensive, less hazardous to consumers or workers, safer for the environment, and effective for insect pests.

Most botanical insecticide compounds are non-phytotoxic. Since most botanically derived insecticidal compounds have ingestion or stomach-based modes of action, they tend to be more selective to insect pests and less aggressive to beneficial natural enemies, people, pests, or livestock. Botanical pesticides are efficacious in managing different crop pests, inexpensive, easily biodegradable, have varied modes of action, their source are easily available and have low toxicity to non-target organisms. Their varied modes of action are attributed to the phytochemical composition in different plants. The increasing concern on environmental safety and global demand for pesticide residue-free food has evoked interest in pest control through use of biopesticides botanicals, and natural enemies which offers a good alternative to manage the insect pests and diseases in an ecofriendly way.

Role of botanicals in integrated pests' management

Natural pesticides are pesticides made by organisms usually for their own defense or are derived from a natural source as plant, animal, bacteria and certain minerals use to control pest naturally with less effect or no effect. Pyrethrum, Sabadilla, Neem, Nicotin, Ryania, and other botanical pesticides have a broad range of chemical characteristics, modes of action, and effects on insects in different ways, including growth retardants, repellents, feeding deterrents/antifeedants, toxicants, chemosterilants, and attractants. Botanicals insecticides are natural chemicals extracted from plant with insecticidal properties and used as an excellent

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alternative to synthetic or chemical pesticides for crop protection to avoid negative or side effects of synthetic insecticides. Insect pests, viruses, nematodes, bacteria, and fungi can all be effectively controlled with botanical pesticides. They are easily found in the environment, highly biodegradable, have a variety of modes of action, are less hazardous to humans, and are not pollutants.

Conclusion

In present review aimed at to gathering information on, present status of botanicals in India, mode of action of different botanicals and barriers in commercialization of botanical pesticides in brief. A variety of tactics are combined in integrated pest management in order to achieve sustainable pest management. Botanicals help in preventing the dumping of thousands of tons of pesticides on the earth, they are safer to the user and the environment because they are biodegradable and break down into harmless compounds within hours or days in the presence of sunlight. They are easy to formulate, manufacture, readily available, have longer shelf life and simple to apply. Natural products called botanical pesticides are efficient against bacteria, virus, fungi, nematode and insect pests. They are abundantly available in the environment, extremely biodegradable, have a variety of mechanisms of action, are less harmful to human, and have no negative environmental effects**.**

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