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Botanical Pesticides an Upcoming Tool for Plant Protection: A Review

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Abstract: Pest Management plays important role in agriculture. Increasing population and their food demands has led farmers to adopt synthetic pesticides for pest management. Dependency on synthetic pesticides results in detrimental effects on human health, the environment, and development of resistant pest and pathogen strains. Conventional pesticides which is harmful to both for crops and environment should be replaced to botanical pesticides. Botanicals are secondary metabolites which is considered safe as an alternative. Most commonly botanicals used are usually neem based, pyrethrum, rotenone and essential oils of plants which are easily available and environment friendly.
Keywords: Botanical Pesticides, mode of action, pyrethrum, Chrysanthemum

I. INTRODUCTION

The recent industrialization and globalization along with decreasing rate of agricultural land is making an imbalance of the economy of the country. The history shows that the overviews of synthetic pesticides let to numerous problems unforeseen at the time as a destruction of the beneficial insect, natural enemies, and development of resistance of pesticides in pest population. In ancient granth called Vriksh Ayurveda many plant-based extracts believed to possessed insecticidal properties prior to the beginning of agriculture as the means of food production. At present, there are numerous plant species that are used in developing countries for production of pest control formulations and there are several commercial products already available in the market made from them. There are two direct benefits for production of botanical insecticides formerly, the environmental hazards would be prevented. Secondly the farmers who are not able to afford synthetic insecticides could dream for doing agriculture. Definition of botanical pesticides, *"Mode of action refers to the specific biochemical interaction through which a pesticide produces its effect. Usually, the mode of action includes the specific enzyme, protein, or biological step affected."* Essentially, botanical pesticides are organic and natural pesticides that are derived from plants and minerals, that have naturally occurring defensive properties.

II. METHODLOGY

As we all know agriculture sector is one of important growing sector to feed the population of billions. For commercial farming, farmers are using inorganic fertilizers to protect crops from insect pest and disease. Continuous use of inorganic pesticides is harmful for soil as well as for human health. And it is high time to switch to botanical pesticides which have similar effect to inorganic pesticides and is environmentally friendly. This paper is based on the secondary sources of data collected from different journals, research papers, news articles etc. In this paper, we will get to know the basic introduction of botanical pesticides, first to fourth generation botanicals as well as classification of botanicals. We will also be discussing about the commercialized botanical pesticides in the field of agriculture insect pest management and botanical pesticide in agriculture and the advantages and disadvantages of using botanical pesticides.

A. Botanical Pesticides From First To Fourth Generation Pesticides

1) The "botanicals" referred as "first generation" insecticides which incorporate plants secondary metabolites, such as nicotine, pyrethrum, rotenone, derris, quassin and sabadilla and other plants extracts.

2) Some of botanical compounds of first generation form the premise for the synthetic "second generation" pesticides. For example, pyrethrum isolated from Chrysanthemum flowers has become the basic unit for the synthetic pyrethroids and physostigmine from Physostigma venenosa has given rise to the structurally similar synthetic carbamates. These "second generation" pesticides for the most part are nerve poisons which affect target pest as well as the non-target pest. With this same reason in last two decades people moved away from the "second generation" synthetic pesticides.

3) "Third generation" pesticides engrossed on insect growth regulators such as precocenes and phytoecdysones. This generation pesticides are presumed to be more selective and environmentally safe; they usually work slowly and are not able to prevent insects from destroying a bulk amount of crop before dying.

4) The "fourth generation" or "next" of pesticides depend upon the behaviour modifying compounds like antifeedant and deterrents.

Table I. Classification of botanicals which can be used as pesticide.

Botanicals	Source	Mode of action	Use against
Nicotine	Simple form of allaloid procure from tobacco leaves, *Nictiana tabacum* (Solanaceae family) and other tobacco species.	Acute fast acting nerve toxin. Action of nicotine is reasonably selective in insects and only certain types of insects are affected.	Thrips, Aphids, and caterpillars
Anabasine	Liquid form alkaloid obtained from *Nicotiana glauca* (Solanaceae family)	Nerve toxin	*Aphis fabae,* guinea pigs, codling moth larvae, rabbits etc
Nornicotine	Liquid form alkaloid taken from *Nicotiana sylvestris* (Solanaceae family)	Also, a nerve toxin causes uncontrolled nerve firing.	*Myzus persicae, Aphis fabae*
Pyrethrum & Pyrethrins	Organic compound isolated from dried flower head of *Chrysanthemum cinerariaefolium* (Asteraceae family)	Interferes with Na+ and K+ exchange process in insect nerve fibres and disturbs the normal transmission of their nerve impulses.	Aphids, beetles, leaf hoppers, mealy bugs, loppers, cabbage worms etc.
Azadirachtin	Isolated from Neem tree, *Azadirachta indica* (Meliaceae family) and belongs to limonoids group	Feeding deterrent, repellent, reproduction suppressant and growth regulator.	Insects belong to order Diptera, Hymenoptera, Lepidoptera, Coleoptera and Orthoptera.
Rotenone	Ketonic organic compound procure from roots of Lonchocarpus species. (Fabaceae family)	Robust inhibitor of cellular respiration. Extremely toxic to fish(piscicidal) and spiders(acricidal)	*Aphis fabae, Bombyx mori, Apis mellifera*
Limonene	A terpene isolated from citrus fruits. (Rutaceae family)	It affects the peripheral nervous system.	Mites, ticks, fleas, lice
Sabadilla alkaloids	Vetarine alkaloid derived from the ripe seeds of *Schoenocaulon officinale*, a tropical lily plant. (Melanthiaceae family)	It affects the nervous system which results in paralysis of body and even lead to death.	Thrips, stink bugs, aphids, moths, cabbage loopers, caterpillars of leaf hoppers, blister beetles, codling moths, harlequin bugs.
Ryanodine	An alkaloid isolated from woody stems of *Ryania speciosa* (Salicaceae family)	It causes muscular contractions and paralysis.	Codling moths, potato aphids, corn earworms, onion thrips, Japanese beetles, squash bugs and silkworms

B. Commercialized Botanical Pesticides

Major commercially used botanicals in fields of agriculture pest management are shown in the figure:

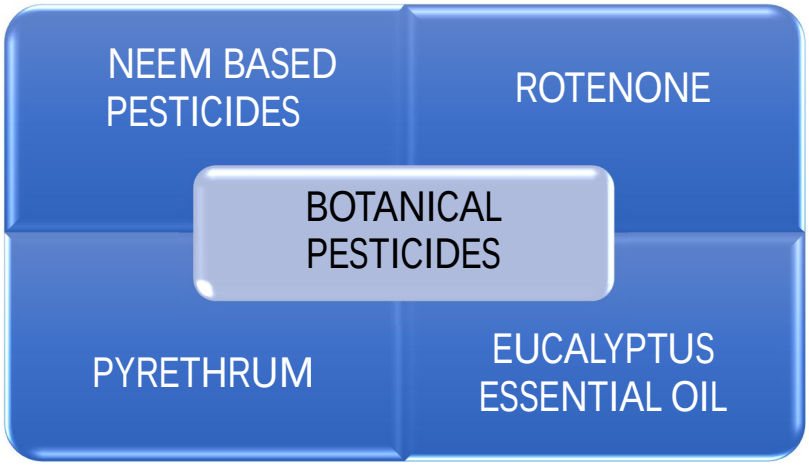

Fig I. Major botanical pesticides

1) *Neem Based Pesticides:* They are extracted from the neem tree, *Azadirachta indica*, Meliaceae family. Azadirachtin, meliantriol, salannin, desacetyl salannin, nimbin, desacetyl nimbin, and nimbidin are the formidable ingredients of neem plant. Azadirachtin, a tetranortriterpenoid limonoid, is one of the most potent active compounds which is present in higher concentration (0.2 – 0.6%) in the seeds of the neem compared to other parts of the neem tree. It has a wide spectrum of actions on insects such as repellents, antifeedant, insect growth regulatory, and anti – ovipositional properties. It is most effective against 550 insect species, mostly relating to orders Dictyoptera, Orthoptera, Heteroptera, Isoptera, Lepidoptera, Diptera, Coleoptera, Homoptera, Siphonaptera and Hemiptera. The spiralling whitefly, *Aleurodicus disperses* (Hemiptera: Aleyrodidae) is one of the major pests affecting a variety of agricultural crops in the tropical and subtropical regions of the world. Recently, it was found that ethanolic extract of neem was highly effective against test pest, *Aleurodicus dispersus*. The combination of ethanolic extract of neem and acetone extract of crown flower in the ratio 1: 3 showed highest synergistic insecticidal effect against *Aleurodicus dispersus* compared to other combinations formulated.
2) *Rotenone:* It is one of the broad-spectrum botanical pesticide that is extracted from the roots and stems of tropical legumes Derris (*Derris elliptica*, *Derris involuta*), Lonchocarpus (*Lonchocarpus utilis*, *Lonchocarpus urucu*) and *Tephrosia virginiana*. Chemically, rotenone is the isoflavonoid. The dried root powder is used or sprayed. The active ingredient is Rotenone, which acts as a contact and food poison, cellular respiratory enzyme inhibitor, stomach poison.
3) *Pyrethrum:* It is one of the most important botanical pesticides used in India, which is extracted from the flowers of *Chrysanthemum cinerariaefolium*. The higher concentration of pyrethrum is found mainly in the flowers of the plant compared to other parts of the plant. Pyrethrum is the mixture of six active ingredients, namely, pyrethrin I, pyrethrin II, cinerin I, cinerin II, jasmolin I, and jasmolin II. Pyrethrin I, cinerin I, and jasmolin I are the esters of chrysanthemic acid, whereas pyrethrin II, cinerin II, and jasmolin II are the esters of pyrethric acid. The typical pyrethrum extract contains pyrethrins, cinerins, and jasmolins in the ratio 10: 3: 1. Thus, pyrethrins are the most dominant form of active ingredients compared to cinerins and jasmolins in terms of concentrations.
4) *Eucalyptus Essential Oil:* The eucalyptus oil is a complex mixture of various phytochemicals such as monoterpenes, sesquiterpenes, aromatic phenols, oxides, ethers, alcohols, aldehydes, and ketones. The composition and proportion of the chemical constituents vary with the species. The pesticidal activity of eucalyptus oil is due to 1, 8 – cineole (eucalyptol), citronellal, citronellol, citronellyl acetate, p – cymene, eucamalol, limonene, linalool, and α – pinene. Among the various components of essential oil, 1, 8 – cineole is the most important characteristic compound for the pesticidal activity. In addition to the essential oil of Eucalyptus, leaf extracts of Eucalyptus also have insecticidal activity against various pests. It is showed that essential oil of Eucalyptus globulus Labill, consisting of eucalyptol, α – pinene, and α – cymene was effective repellent against target pests. It was found that the leaf powder of Eucalyptus globulus L., showed insecticidal activity against *Prostephanus trunatus*.

C. Botanical Pesticides In Agriculture Production

Various plants are the prime sources of botanical pesticides which are easily available in the environment. They are easily available which makes them inexpensive and easily mixed with agriculture production. Commercialized pesticides from plants such as pyrethrum, neem and sabadilla are some of the least toxic especially to non-targets organisms such as pollinators and fish. This one feature of botanical pesticide makes it effective, reliable, and acceptable in sustainable crop production. Other than that, they do not leave any residue behind and ensure environmental conservation and safety to consumers. Botanical pesticides and pest have naturally biochemical interaction so pests cannot develop resistance. Plants based chemical compounds and essential oils are target specific which make certain the safety of non-target organisms like beneficial insects like pollinators and predators and have zero or minimal effect on crops. Usually, their efficacy depended on the species of source plant and the concentrations used, whether dry or fresh, solvents used for extraction and extraction method.

Botanical Pesticides have different modes of action on the target pests. They obstruct with insect behaviour, their physiological activities, biochemical process, morphology, and their metabolic pathways. The activity of the metabolites is specific in their effect on the pest, for example terpenes block glucose on chemosensory receptor cells in the mouth of lepidopteran larvae.

The incorporation of botanicals in agriculture production system makes sure that farmer gets considerable benefit including reduced past levels, food safety, improved quality of produce which provide maximum benefit and guaranteed market access. Consumer is willing to pay higher prices for organically produce goods, thereby create market opportunities for botanical pesticides.

Fig 2. Differences between synthetic pesticides and botanical pesticides with respect to use, mode of action, persistence, and effect on ecosystem.

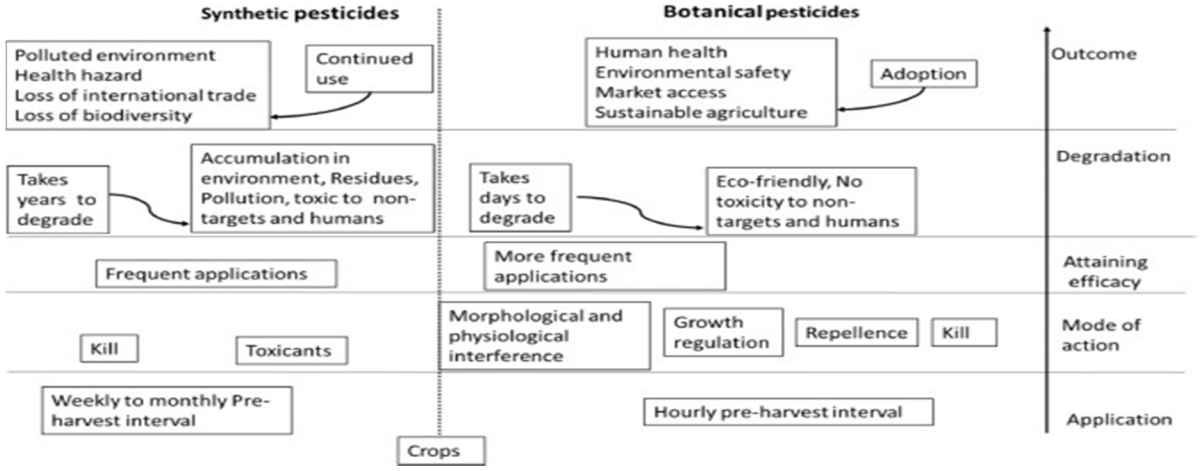

Table 2. Advantages and disadvantages of biopesticides.

S.N	Advantages	Disadvantages
i)	Produce little toxic residue and are minimal risk to human health.	Lower efficiency, slower rate of control and shorter persistence compared to conventional pesticides.
ii)	Have zero or little re-entry and handling intervals.	Require a considerable level of knowledge.
iii)	Few microbial biopesticides can reproduce on or near to the target pest / disease and develop self-perpetuating control.	Majority of products are not exactly insecticides since many are insect deterrents and their effect is slow.
iv)	Reduce the selection pressure for the evolution of pesticide resistance in pest populations.	Not all recommendations are scientifically verified.
v)	Useful as a second line of defence or supplementary treatment.	Do not have any established residue tolerances.
vi)	Environment friendly and do not cause pollution.	Not certainly available for a long season.

D. Some Major Plants Use For Botanical Pesticides

There are many crops which is used for botanical pesticides. Some of the crops which is widely practice for making of pesticides along with their target pests are as follows:

1) Aloe vera plant which targets *Pseudomonas aeruginosa, Staphylococcus aureus, Bacillus cereus, Streptococcus pyogenes.*
2) *Origanum spp.* plant which targets *Bacillus* spp, *Staphylococcus saprophyticus, Micrococcus luteus, Serratia marcescens.*
3) *Jatropha* spp plants targets *Alternaria alternata, Aspergillus* spp, *Fusarium oxysporum, Rhizoctonia solani, Trichoderma viride.*
4) *Cinnamon* spp targets *Staphylococcus aereus, Escherichia coli.*
5) *Lantana camara* targets *Klebsiella pneumoniae, Escherichia coli.*
6) *Thymus vulgaris* targets *Erwinia amylovora, Eschrichia coli, Staphylococcus aureus, Bacillus cereus.*
7) *Citrus* spp targets *Escherichia coli, Salmonella enterica, Pseudomonas putida, Staphylococcus aureus.*
8) *Artemisia* spp targets *Bacillus* spp , *Staphylococcus aureus, Pseudomonas aerogenosa, Candida albicans, Rhizopus japonicum*
9) *Mentha piperita* targets *Enterococcus faecium, Salmonella choleraesuis, Staphylococcus aureus, Bacillus subtilis.*
10) *Piper nigrum* targets *Escherichia coli, Salmonella typhi, Proteus* spp, *Staphylococcus aureus, Fusarium oxysporum.*
11) *Rosmarinus officinalis* targets *Listeria monocytogenes, Staphylococcus aureus, Escherichia coli.*
12) *Azadirachta indica* targets *Aspergillus niger, Microsporum gypseum, Aspergillus flavus.*

III. CONCLUSION

Use of synthetic or convectional form of pesticides are no more of trend. It is high time to switch to alternative pesticides which have zero or minimal effect to crops as well as environment. Botanical pesticides are those which is user friendly to both environment as well as guarantees consumer safety. It is saving environment form pesticides pollution as well emerging the solution of synthetic fertilizer-based produce which may be fatal to human life. More emphasis should be given to botanicals to make it trend of new and sustainable form of agriculture as pest management will always the part of agriculture practices.

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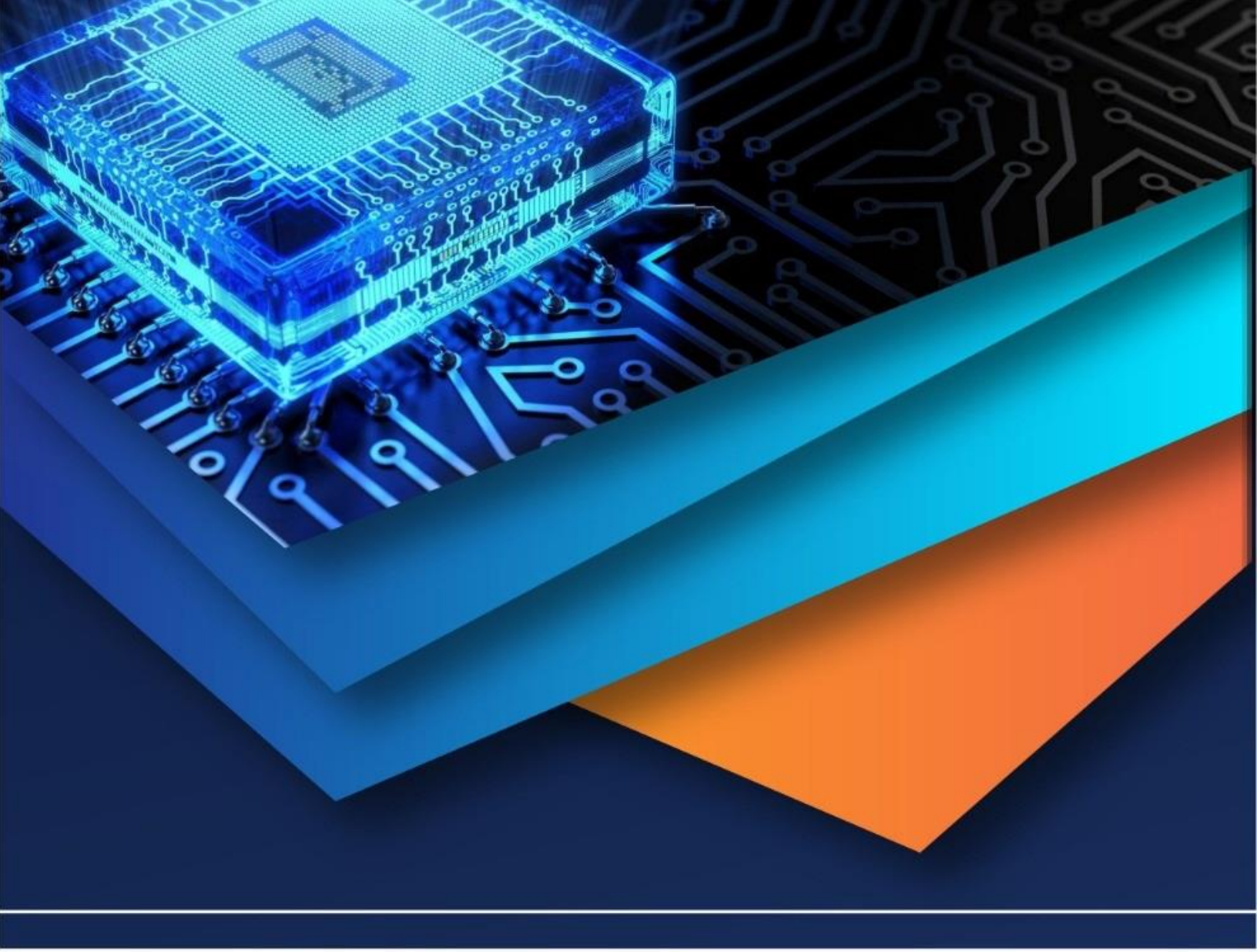

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