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Recent trends
in botanical pesticides

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The ever-increasing environmental burden created by chemical synthetic pesticides gave new life to botanical pesticides in a wider dimension, an evergreen and eco-friendly option for pest management. Several beneficial characteristics like ease of application, unique and versatile mode of action encourage their use. Though botanicals have yet to reach their full market potential due to the lack of formal regulatory approval, they are cheap and easy to produce. Hence, to cope up with the environmental stress and market surge, proper economical extraction of potential botanical active ingredients is the need of hour as an alternate strategy.

Keywords: Botanical pesticides, Eco-friendly, Sustainable agriculture

THE growth of botanical pesticides in India stretches at least two millennia ago whereas in western countries it started around 150 years ago. Exploitation of environment by the deliberately discovered synthetic chemical pesticides (e.g. organophosphates, organochlorines, carbamates, and pyrethroids) is causing the rise of botanical pesticides, which can help the environment to be restored in a natural and safe manner. The exploitation of environment has led to destruction of the food chain. History also shows that overuse of synthetic pesticides has led to numerous unintended consequences, including disruption of pollination, groundwater contamination, subsequently threatening human health. The regulatory bodies responded to these emerging problems due to chemical pesticides by formulating policies for controlling pests by natural resources.

What are Botanical Pesticides?

Products containing different ingredients derived from plant parts (Table 1) containing naturally occurring chemicals are considered as botanical pesticides. The advantages of botanical pesticides are given here.

- Less toxic than chemical pesticides and eco-friendly.
- Target specific pest control.
- Effective at low doses against pests.
- Non-persistent and biodegradable.

The most popular botanical pesticides are azadirachtin or neem based formulations, pyrethrum, rotenone and eucalyptus essential oil based pesticides. Botanical

Table 1. Popular botanical pesticides with sources

Name	Source	Mode of action	Uses
Azadirachtin	Neem seed kernel	Antifeedant	Broad spectrum biopesticide for over 200 insect species including aphids, mealybugs, caterpillars, japanese beetle, whiteflies, mites, root aphids and thrips
Nicotine	Tobacco leaves	Mimics the neurotransmitter acetylcholine	For control of aphids, thrips and bugs
Pyrethrum	Flowers	Interferes with Na & K ion movement in nerve axons	Aerosol bombs for mosquitoes
Sabadilla	Seeds	Interferes with Na & K ion movement in nerve axons	Control of squash bug, citrus thrips
Rotenone	Roots	Disrupts energy metabolism in mitochondria of nerve axons	Beetles, fish poisoning
Ryania	Woody stem	Activates Ca^{++} ion release channels & causes paralysis in muscles	For control of caterpillars and thrips

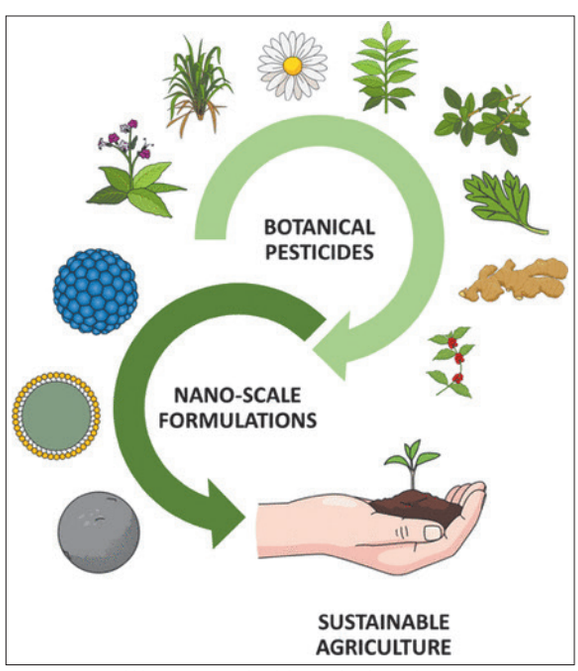
pesticides are introduced in IPM (Integrated Pest Management) strategy due to low persistence, lower bioaccumulation in the environment, no harm to predators, parasitoides and pollinators. The most important plant families explored for biopesticidal properties are Asteraceae, Apocyanaceae, Euphorbiaceae, Meliaceae, Fabaceae, Myrtaceae, Rosaceae and Ranunculaceae.

Scope of botanicals in current indian agriculture

An appreciable number of botanical pesticide formulations have been released and few have captured the market by replacing the conventional pesticide. Almost 6000 plant species have been discovered and screening has been done against the pests globally. A number of botanical formulations isolated from various plant species like tobacco, neem, chrysanthemum, custard apple, citronella, turmeric, karanj etc. have been proved to be safer insecticides or insect growth regulator because they are harmless to environment and non-target species and also have lesser chance of developing insect resistance (Table 2). The majorly responsible secondary metabolites acting as active ingredients are alkaloids, phenolics, terpenoids, lignans and glycosides that carry out the chemical response for defense mechanisms. The Indian farmers are also in the habit of isolating and conserving botanicals as a practice of their indigenous traditional knowledge, as they are easily available but at a commercial point of view there is a need for cost effective mass production which would help make Indian agriculture more sustainable and organic.

Table 2. Different plant species with pesticidal properties

Plant	Active compound	Activity
Abies balsamea	Juvabione	Juvenile Hormone Agonist (JHA)
Acorus calamus	Asarone	Antifeedant
Ageratum houstonianum	Precocene, Anacylin	Anti JH
Ajuga remota	Ajugarin	Feeding deterrent
Allium sativum	Diallyl sulfide	Repellent
Atalantia racemosa	Luvangetin	Antifeetant
Citrullus colocynthis	Cucurbitacin-B	Antifeedant
Citrus paradisi	Isolimonic acid	Oviposition deterrent
Clerodendron infortunatum	Clerodin	Antifeedant
Curcuma longa	Termeron	Growth inhibitor
Glycine max	Glyceollin	Antifeedant
Tagetes minuta	E-Ocimenone	Repellent
Ricinus communis	Ricinine	Oviposition deterrent
Medicago sativa	Butyric acid	Repellant
Ocimum basillicum	Juvocimene	JHA
Parthenium hysterophorus	Parthenin	Growth inhibitor
Piper nigrum	Piperin	Oviposition deterrent
Quassia amara	Quassin	JHA
Pongamia pinnata	Karanjin	Antifeedant, JHA



Way to sustainable agriculture by using botanical pesticides

Recent Advances in Botanical Pesticides

One of the major agricultural pests affecting a variety of crops such as cotton, corn, sunflower, soybeans, and potatoes is *Helicoverpa armigera*. Application of 5% *Nigella sativa* seed extract gave 73% mortality against *H. armigera* (fruit borer). Moreover, 5% *Jatropha curcas* extract also showed potential to control it with 62.64% mortality. The important and major pests in cabbage and other economical crops are Diamondback moth (*Plutella xylostella*) and cabbage butterfly (*Pieris brassicae*) in India. Using 5% Neem seed kernel extract, 0.5% *Alpinia galanga* and *Gomphrena globosa* extracts exhibited better effectiveness in controlling the larval density of Diamondback moths. Moreover, plant extracts of *Artemisia brevifolia*, neem and *Melia azedarach* proved to be highly effective in reducing larval density of *Pieris brassicae*. Besides, botanical pesticides derived from *Azadirachta indica, Chrysanthemum cinerariifolium, Datura metel, Tagetes minuta, Mirabilis jalapa, Tagetes erecta, Hyptis suaveolens,* and *Allium sativum* have been successfully experimented against aphids, pink stalk borer, bruchid beetle, bollworm, armyworms, grasshoppers, cabbage loppers, thrips, potato aphids and leaf spot of common bean. Nevertheless these studies also demonstrated that the plant extracts of *Daphne mucronata* and *Isodon rugosus* can act as an effective pesticide against pea aphid. The recently developed bioactive ingredients in controlling pests are enlisted below.

Menthone: Menthone is the most biologically active ingredient of essential oil extracted from medicinal plants like *Carangana sinica, Adenophora remotiflora,* and *Artemisia princeps*. It is highly active against stored grain pests like rice weevil due to its volatile or fumigant properties.

Anethole: It is extracted from the fruit of *Illicium verum* and is effective against *Musca domestica* and *Blattella germanica*. It has ovicidal effect on *Acanthoscelides obtectus*.

Astilbin: Astilbin is isolated from *Wulffia baccata* and *Lonchuphorus speciosus vitis*. Due to its radical scavenging properties, astilbin can control *Spodoptera frugiperda* and *Anticarsia gemmatalis*. Moreover, castor oil derived flavonoids showed antimicrobial activity against *Pseudomonas putida* and *Bacillus firmus*, and also insecticidal properties against *Callosobruchus chinensis*.

Mesotrione: Mesotrione is specially used in controlling weeds in maize. The compound is isolated from *Callistemon citrinus*. It disrupts 4-hydroxyphenyl pyruvate dioxygenase (HPPD) in weed but as maize can metabolize this compound it is selective to maize.

Limonene: The monoterpenes such as limonene and trans-anethole are the responsible factors of aromatic character *Foeniculum vulgare* which are effective against controlling stored-product pests like bee weevil, rice weevil and cigarette beetle.

Parthenin: Eleven analogues of parthenin have herbicidal activity which acts as insect growth regulator against *S. litura, Tribolium castaneum*. It also shows nematicidal activity against *Meloidogyne incognita*.

Zingiberene: A terpenoid isolated from *Zingiber officinale* showed moderate IGR activity and antifeedant activity against *Spilosoma obliqua*.

Foliar extracts of *Anona squamosa* containing acetogenin annonin showed activity against *Callosobruchus* spp.

Moringa seed extracts containing behenic acid have potential activity as biofungicide.

The flower extract from *Tagetes* sp. containing polythienyls especially α-terthienyl shows nematicidal activity.

Menthol extract from herb *Mentha pulegium* exhibits acaricidal activity against *Dermatophagoides farinae*.

Present status of Botanical Pesticides in India

The chemical pesticide market is showing a declining trend at the rate of 1.5% annually. In the present context, biopesticides capture 2.5% of the total pesticide market. It is also expected to grow to about 4.2% in next ten years. Till date Azadirachtin (Neem based product), citronella (from *Cymbopogon* sp.), eucalyptus leaf extract, pyrethrin (from *Chrysanthemum* sp.) are the only registered botanical pesticide in the India under Insecticides Act, 1968.

Limitation in commercialization of Botanical Pesticides in India

Among the number of factors in de-escalating the commercialization of botanical pesticides, high cost, low stability, difficulty in formulation, product standardization, slow acting in field conditions are the main barriers. Their synergism or antagonism studies are also unexplored. Farmers have to invest ₹200 per acre for neem based product compared to ₹140 per acre for synthetic pesticide. The lack of minimum regulatory guidelines for standardization of formulations is also an additional drawback for commercialization of botanicals.

SUMMARY

Botanical pesticides are the unexplored wealth of nature. It is essential to overcome the barriers in commercialization of the botanical pesticides on their way to be a registered product. The nuisance created by the synthetic pesticides will be neutralized by use of botanicals. Research such as modifying the stability, prevention of pest resistance by formulating different novel formulations and alternative application is need of the hour. The thorough direction given by policymakers to the regulatory bodies will certainly pave the way for easy production and better commercialization of botanical pesticides in building sustainable agriculture in near future.

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