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Plant-derived insecticides for pest management

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Abstract

The agricultural sector in developing countries can be the main engine of economic growth and development, but it is always affected by various biotic and abiotic stresses that cause waste of resources. One of the most important of them are pests. Mankind has always been trying to fight against these factors. One of the solutions is the use of chemical and synthetic pesticides, whose negative and destructive effects on human health and the environment are always discussed today. Some plants have secondary metabolites that have pesticidal effects and are very efficient with different effects on insects. Extracts of plant or whole plants have been used for centuries in various cases including pest control, and They are known all over the world. Bioactive plant compounds such as glycosides, alkaloids, flavonoids have pesticidal effects that do not affect natural enemies and provide food products free of toxic residues. In addition, no negative effects of these compounds on human health have been reported so far. Today nearly 2500 plants with insecticidal properties are known, but unfortunately only a few of them have been properly evaluated. Furthermore, commercial biopesticides are not widely used in conventional crop production but are recognized by organic crop producers in industrialized countries.

1-Introduction

Agriculture's extensive links to other economic sectors enable it to drive wealth creation, market development, foreign exchange generation, and industrial growth. However, this profitable process demands careful attention and the implementation of modern, appropriate solutions. Plants face both biotic and abiotic threats, with pests being significant biotic threats that lead to considerable damage and resource waste. Throughout history, humans have sought solutions to mitigate pest damage, employing biological, and chemical methods.

Plant species can synthesize various secondary metabolites that, while not essential for growth and development, effectively protect against

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predators and microbial pathogens and facilitate interactions with other organisms. Many of these metabolites possess insecticidal, repellent, and anti-nutritional properties, delay reproduction, and function as insect growth regulators(Grdiša and Gršić 2013).

Synthetic pesticide development began in 1940, resulting in the decline of biological pesticides in commercial agriculture. Their commercial success stemmed from high efficiency, rapid action, ease of use, and low cost. However, it took 20 years to uncover various negative aspects, including insect resistance, food contamination, environmental pollution, disruption of natural ecosystems, toxicity to non-target organisms, and detrimental effects on human health. These issues prompted the exploration of alternative pest control methods, focusing on the production and use of natural agents for plant protection (Shivkumara 2019). Over 6,000 plant species were screened, resulting in over 2,500 plants from 235 families identified as having biomolecules effective against various pests. Notable families include Apocyanaceae, Asteraceae, Euphorbiaceae, Fabaceae, Meliaceae (the largest), Myrtaceae, Ranunculaceae, and Rosaceae.

Tables 1 to 9 summarize the insecticidal properties of these plant families, detailing the effects of different extract types and the impacted organs.

Table 1. Insecticidal plants from the Apocynaceae family.

plant	insect	Type of extract	Organ used	source
***abernaemontana divaricata*(L.) Rbr.**	*Culex quinquefasciatus, Anopheles stephensi, Aedes aegypti*	petrolm ether	flower	(Sakthivadivel and Daniel 2008)
***Wrightia tinctoria*(Roxb.) R. Br.**	*Culex quinquefasciatus, Anopheles stephensi, Aedes aegypti*	petrolem ether	leaf	(Sakthivadivel and Daniel 2008)
***Neriumoleander* L.**	*Culexquinquefasciatus* Say	Hexane and aqueous extract	flower	(Raveen et al. 2014)
***Ervatamiacoronaria* Stapf.**	*Culex quinquefasciatus, Aedesaegypti* and *Anopheles stephensi* (Diptera: Culicidae)	Methanolic extract	leaf	(Mathivanan et al. 2010)
Parahancornia amapa	*Chrysomya megacephala*(Diptera:Calliphoridae)	latex	latex	(Mendonça et al. 2011)
Calotropis procera	*Acyrthosiphon pisum* (Hemiptera), *Drosophila melanogaster*(Diptera), *Tribolium castaneum* (Coleoptera), *Spodoptera exigua* (Lepidoptera)	Methanolic extract	aerial organs	(Khan et al. 2017)
***Catharanthus roseus* Linn.**	*Anopheles stephensi* Liston.	ethereal extract	leaf	(Panneerselvam et al. 2013)

Table 2. Insecticidal plants from the Asteraceae family

plant	insect	Type of extract	Organ used	source
*Tagetes patula*L.	*Cimex lectularius* L.	Essential oils	Stem, leaf and flower	**(Politi et al. 2017)**
Chromolaena odorata	*Periplaneta americana*	Leaf extract	leaf	**(Udebuani et al. 2015)**
Chromolaena odorata L.	*Anopheles stephensi*, *Culex quinquefasciatus* and *Aedes aegypti*	Methanolic extract	leaf	**(Sukhthankar et al. 2014)**
Ambrosia arborescens	*ControlAedes aegypti* L. (Diptera: Culicidae)	Aqueous extract	leaf	**(Morejón et al. 2018)**
*Artemisia judaica*L.	*Aphis fabae* Scop.	Ethanol extract	aerial organs	**(Acheuk et al. 2017)**
Artemisia annua	*Aedes aegypti*,*Anophelessinensis*, and *Culex quinquefasciatus*(Diptera: Culicidae)	Hexane extract	aerial organs	**(Cheah et al. 2013)**
Acanthospermum australe (Loef.) Kunt., *Achyrocline alata* DC., Baccharis *dracunculifolia* DC., *Baccharis trimera* (L.) DC., *Eupatorium laevigatum* Lam.	*Aedes fluviatilis*(Diptera: Culicidae)	Ethanol extract	aerial organs	**(Macêdo et al. 1997)**
Artemisia scoparia *Waldst. & Kit.* و A. spicigera *C. Koch*	*Tribolium castaneum*	Methanolic extract, dichloromethane extract, n-hexane	aerial organs	**(Afshar et al. 2011)**
Mantisalca duriaei, *Rhaponticum acaule*, *Scorzonera undulata*, *Scorzonera undulata*	*Tribolium confusum*	Methanol extract, ethyl acetate, ether extract	aerial organs, root	**(Boussaada et al. 2008)**

Table 3. Insecticidal plants from the Euphorbiaceae family

plant	insect	Type of extract	Organ used	source
Euphorbia hirta Linn.	*Anopheles stephensi* Liston. (Diptera: Culicidae)	Methanolic extract	leaf	**(Panneerselvam et al. 2013)**
Acalypha alnifolia *Klein ex Willd.*	*Anopheles stephensi* Liston.(Diptera: Culicidae)	Ethanol extract	leaf	**(Murugan et al. 2012)**
Acalypha indica L.	*Anopheles stephensi* Liston (Diptera:Culicidae)	Benzene, chloroform, ethyl acetate and methanol extracts	leaf	**(Govindarajan et al. 2008)**
Croton tetradenius	*Aedes aegypti* and *Mus musculus*	Essential oils	leaf	**(da Silva Carvalho et al. 2016)**
Ricinus communis L.	*Culex quinquefasciatus, Anopheles stephensi* and *Aedes aegypti*	petroleum ether	seed	**(Mendonça et al. 2011)**

Table 4. Insecticidal plants from the Fabaceae family

plant	insect	Type of extract	Organ used	source
Abrus precatorius L., *ndigofera tinctoria* L.	*Culex quinquefasciatus, Anopheles stephensi* and *Aedes aegypti*	petroleum ether	leaf	**(Mendonça et al. 2011)**
Dalbergia horrida(Dennst.) Mabb.	*Culex quinquefasciatus,*	petroleum ether	leaf	**(Mendonça et al. 2011)**
Pongamia glabraVent	*Culex quinquefasciatus, Anopheles stephensi* and *Aedes aegypti*	petroleum ether	seeds	**(Mendonça et al. 2011)**
Senna siamea	*Sitophilus granarius,Tribolium castaneum* and *Acanthoscelides obtectus*	powder	leaf	**(Adarkwah et al. 2018)**
brus pulchellus Wall	*Aedes aegypti*	Methanolic extract	leaf	**(Vinayaka et al. 2009)**
Erythrina indica(Lam.)	*Anopheles stephensi,Aedes aegypti,* و *Culex quinquefasciatus*(Diptera: Culicidae)	Hexane, benzene, chloroform, ethyl acetate and methanol extracts	leaf	**(Govindarajan and Sivakumar 2014)**
Delonix elata(L.) Gamble	*Anopheles stephensi* Liston و *Aedes aegypti* Linn. (Diptera: Culicidae)	Methanolic extract	Leaves and seeds	**(Marimuthu et al. 2012)**
Caesalpinia pulcherrima	*Culex tritaeniorhynchus, Aedes albopictus* و *Anopheles subpictus*(Diptera: Culicidae).	Benzene extract and ethyl acetate	leaf	**(Govindarajan, Rajeswary, and Amsath 2013)**

Table 5. Insecticidal plants from the Meliaceae family

plant	insect	Type of extract	Organ used	source
Turreae holstii, Azadirachta indica, Lepidotrichilia volkensii, Aphanamixus grandifolia	*Peridroma saucia*. Most	Methanolic extract	leaf	**(Champagne et al. 1993)**
Azadirachta indica(neem),*A. excelsa*(sentang),*Melia volkensii, M. azedarach(China-berry) و Trichilia americana*	*Trichoplusia ni* and *Pseudaletia unipuncta*	Methanolic extract	aerial organs	**(Akhtar, Yeoung, and Isman 2008)**
Melia azedarach	*Liriomyza huidobrensis* (Diptera, Agromyzidae)	Ethanol extract	fruit	**(Banchio et al. 2003)**
Cedrela spp.	*Spodoptera frugiperda*	Dichloromethane extract	aerial organs	**(Céspedes et al. 2000)**
Dysoxylum malabaricum Bedd.	*Anopheles stephensi* Liston (Diptera: Culicidae)	Methanolic extract	leaf	**(Nathan, Kalaivani, and Sehoon 2006)**
Aglaia spectabilis	*Spodoptera littoralis*	rocaglamide	skin	**(Schneider et al. 2000)**
Azadirachta indica, Melia azeda-rach, Toona ciliata and *Trichilia pallida*	*Bemisia tabaci* B.	Dichloromethane and ethanol extracts	leaves and branches	**(Bezerra-Silva et al. 2012)**
Trichilia americana Sessé & Moc., *Trichilia hirta* L., and *Trichilia havanensis* Jacq.	*Copitarsia decolora* Guenée (Lepidoptera: Noctuidae)	Ethyl acetate, hexane, acetone, methanol extracts	skin	**(García-Gómez et al. 2018)**
Annona muricata	*Blatella germanica, decemlineata, Aedes aegypti, Rhodnius pallescens*	Hexane, ethyl acetate, acetone, methanol and aqueous extracts	seed	**(Castillo, Jiménez, and Delgado 2010)**
Annona squamosa	*Drosophila, melanogaster, Tribolium castaneum*	Hexane, ethyl acetate, acetone, methanol and aqueous extracts	seed	**(Castillo, Jiménez, and Delgado 2010)**
Annona montana	*Oncopeltus fasciatus*	Hexane, ethyl acetate, acetone, methanol and aqueous extracts	leaves and branches	**(Castillo, Jiménez, and Delgado 2010)**
Oxandra cf xylopioides	*Spodoptera frugiperda*	Hexane, ethyl acetate, acetone, methanol and aqueous extracts	leaf	**(Castillo, Jiménez, and Delgado 2010)**
Melia azedarach L.	*Sitophylus oryzae*(Linne´), *Pantomorus leucoloma*Boheman, *Epilachna paenulata*(Germ), *Spilosoma virginica*(Fabricius)	Ethanol and hexane extract	fruit	**(Carpinella et al. 2003)**

Table 6. Insecticidal plants from the Myrtaceae family

plant	insect	Type of extract	Organ used	source
Eucalyptus camaldulensis	*Culex pipiens, Tribolium confusum* and Ephestia kuehniella	essential oil	aerial organs	**(Batish et al. 2008)**
Eucalyptus globulus	*Musca domestica, Aedes aegypti, Pediculus humanuscapitis* De	essential oil	aerial organs	**(Batish et al. 2008)**
Eucalyptu ssp.	*Sitophilus oryzae, Thaumetopoea pityocampa*	essential oil	aerial organs	**(Batish et al. 2008)**
Eucalyptus resinifera Sm.	*Rhyzopertha dominica*	essential oil	leaf	**(Filomeno et al. 2020)**
M. microphylla, Eucalyptus camaldulensis و *A. judaica*	*Sitophilus oryzae*(L.) (Coleoptera: Curculionidae) and *Tribolium castaneum*(Herbst) (Coleoptera: Tenebrionidae)	essential oil	leaf	**(Mohamed and Abdelgaleil 2008)**
E. globulus, M. communis	*Mayetiola destructor*(Say)	essential oil	leaf	**(Lamiri et al. 2001)**
Eucalyptus ovata Labill., *Melaleuca fulgens* R.B, *Kunzea* sp., *Melaleuca lanceolate* Otto	*Sitophilus oryzae,Triboliumcastaneum* and *Rhyzopertha dominica*.	essential oil	aerial organs	**(Lee, Annis, and Choi 2004)**
Leptospermum citratum, Leptospermum ericoides, Leptospermum scoparium	*Drosophila suzukii*	essential oil	Flowers and leaves	**(Park et al. 2017)**
Eucalyptus tereticornis Sm.	*Anopheles stephensiListon* (Diptera: Culicidae)	essential oil	leaf	**(Nathan 2007)**
Callistemon citrinus	*Callosobruchus maculatus*(F.)(Coleoptera: Bruchidae)	essential oil	leaf	**(Zandi-Sohani, Hojjati, and Carbonell-Barrachina 2013)**

Table 7. Insecticidal plants from the Ranunculaceae family

plant	insect	Type of extract	Organ used	source
Allium sativum, Zingiber officinale و *Nigella sativa*	*Trogoderma granarium* (E.)	Aqueous extract	Total plant	**(Ahmad et al. 2013)**
Clematis vitalba L.	*Spodoptera littoralis*	Methanolic extract	stem	**(Pavela 2011)**
Hepatica nobilis Schreb.	*Spodoptera littoralis*	Methanolic extract	stem	**(Pavela 2011)**
Aconitum episcopale	Tribolium casteneum(Herbst.)	Ethanol extract	root	**(Liu et al. 2011)**
Aconitum	*Tribolium casteneum*(Herbst.)	Acetone extract	aerial organs	**(Ulubelen et al. 2001)**

Table 8. Insecticidal plants from the Rosaceae family

plant	insect	Type of extract	Organ used	source
Prunus Domestica	*Culex Pipiens* L. (Diptera: Culicidae)	Chloroform, methanol, ether extracts	Aerial organs	**(Spochacz et al. 2018)**
Potentila argentea L., *Potentilla anserina* L., *Potentilla fruticosa* L., *Potentilla hirta* L., *Potentilla reptans* L.	*Spodoptera littoralis*	Methanolic extract	stem	**(Pavela 2011)**
Fragaria virginiana Duchesne, *Heteromeles arbutifolia*, *Potentialla fruticoseauct.* non L. , *Prunusilicifolia* Nutt. ex Hook. & Arn.,	Coleoptera	Ethanol extract	Aerial organs	**(Totland 1996)**
Quillaja saponaria Molina	Diptera	Ethanol extract	Aerial organs	**(Totland 1996)**

Table 9. Insecticidal plants from the Asclepiadaceae family

plant	insect	Type of extract	Organ used	source
Pergularia tomentosa L.	fifth instar larvae *Locusta migratoria*		Total plant	**(Acheuk and Doumandji-Mitiche 2013)**
Pergularia tomentosa L.	Larvae *Locusta migratoria*		latex	**(Miladi et al. 2018)**
Pergularia tomentosa L.	*Plutella xylostella*		Total plant	**(Ferreira et al. 2020)**

Biological pest control compounds, including essential oils, flavonoids, alkaloids, glycosides, esters, and fatty acids, possess varied chemical properties and modes of action, impacting insects in diverse ways Biopesticides offer several advantages: they are environmentally transient, pose minimal risk to non-target organisms (beneficial predators and parasites), and are relatively non-toxic to mammals (Grdiša and Gršić 2013). The following are types of bioactive compounds derived from plants that exhibit pesticidal effects:

2.Essential oils

Essential oils are aromatic oils derived from steam distillation of various plants. Approximately 3,000 essential oils exist, with over 10% having commercial significance in the cosmetic, food, and pharmaceutical industries. They function effectively as individual compounds or in combinations. Aromatic plants produce compounds that repel insects, deter feeding, inhibit growth, and disrupt mating and oviposition. Being lipophilic, essential oils interfere with the metabolic, biochemical, physiological, and behavioral functions of insects, and can be inhaled, ingested, or absorbed through their skin (Khater 2012).

3.Alkaloids

Alkaloids are a crucial group of natural substances used in biological insecticides. For instance, furocoumarin and quinolone alkaloids derived from *Ruta chalepensis* leaves exhibit larvicidal and anti-nutritional effects on Spodoptera littoralis larvae (Emam, Swelam, and Megally 2009). Plant alkaloids are important and widely used components in many biological insecticides (Hikal, Baeshen, and Said-Al Ahl 2017).

4.Flavonoids

Flavonoids are commonly found in medicinal plants with insecticidal properties and serve multiple functions, including as feeding deterrents in pest management. They significantly protect plants from herbivores by influencing their growth and development (Shivkumara 2019). Reports indicate that flavonoids can inhibit feeding. Additionally, a study highlighted the larvicidal effects of flavonoids from *A. hypogaea* extract against Chikungunya (*Aedes aegypti*) and malaria (*Anopheles*) vectors (Khater 2012; Velu et al. 2015).

5.Glycosides

Glycosides are vital in biological insecticides, with cyanogenic glucosides in plants serving as a defense against herbivores. Glycosides of *A. hypogaea* extract exhibit larvicidal effects against chikungunya (Aedes aegypti) and malaria (Anopheles)(Shivkumara 2019). In some instances, esters and fatty acids from plants can control pests.(Shivkumara 2019). For example, a study found that methyl ester fatty acids from *Solanum lycocarpum* exhibit larvicidal effects on *C. quinquefasciatus* (Silva et al. 2015).

6.Impact of bioactive compounds on insects

Bioactive compounds with insecticidal properties impact pests differently based on the insect species' physiology and the specific plant involved. The effects of these compounds can be categorized into six groups: repellents, food inhibitors/anti-nutritional substances, toxic substances, growth inhibitors, chemicals, and adsorbents (Khater 2012). Table 10 summarizes various plants with pesticidal effects and their mechanisms of action.

Table 10. insecticidal plants list and their modes of action.

plant	insect	ingredient obtained	Activity	Source
Zanthoxylum rhoifolium	*Bemisia tabaci*	Nano encapsulated essential oils	Resulted in a 95% reduction in the number of eggs and nymphs compared to the control	**(Christofoli et al. 2015)**
Lamiaceae	*Tetranychus urticaeKoch* *Bemisia tabaci Genn*	Essential oils	Reduces female fertility, increases larval and adult insect mortality due to increased dose and duration	**(Çalmaşur, Aslan, and Şahin 2006)**
Arnicamontana, Apis mellifica, Uva ursi, Urtica urens, Digitalis purpurea, Cicuta virosa, Sambucus nigra and *Thuja occidentalis*	*Tribolium castaneum*	Methanolic extract	All crude extracts showed time- and concentration-dependent insecticidal activity	**(Plants 2013)**
rtemisia herbaalba Asso, Eucalyptus camaldulensis Dehnh and *Rosmarinus officinalis* L.	*Myzus persicae*	terpenes	The ether extract of the leaves has good insecticidal properties.	**(Billal, Naama, and AZOUI 2015)**
Centaurium erythraea,Peganum harmala	*Tribolium castaneum*	Methanolic extract	By inhibiting the growth of larvae, these plant extracts can be useful in reducing seed damage caused by this pest.	**(Jbilou et al. 2008)**
Peganum harmala (Zygophyllaceae), Ajuga iva *(Labiateae),* Aristolochia baetica *(Aristolochiaceae)* and Raphanus raphanistrum *(Brassicaceae)*	*Tribolium castaneum*	Methanolic extract	Inhibition of larval growth, insecticidal effect on adult insects, inhibition of F1 offspring production, *T. castaneum* 7population management	**(Jbilou, Ennabili, and Sayah 2006)**
*Vepris heterophylla (*Rutaceae*), Ocimum canum*, and *Hyptis spicigera (*bothLamiaceae)	*Sitophilus oryzae* L.	Essential Oils	The highest repellent effect was achieved with a combination of H. spicigera and O. canum essential	**(Ngassoum et al. 2007)**

			oils with a repellent percentage of 77.5%, a suitable strategy for pest management of stored products.	
ginger *(Zingiber afficinale)*, hail *(Elettaria cardam-omum)* and shammar *(Foeniculum vulgare)*	*Oryzaephilus surinamensis*	PAGE bioassays	All tested plants showed insecticidal activity against *O. surinamens*is, altering the protein structure of *O. surinamens*is	**(Al Qahtani, Al-Dhafar, and Rady 2012)**
Lamiaceae	*Tribolium castaneum* Herbst	Dichlorometh ane extract	Dose-dependent inhibition of larval growth, increased mortality of larvae and adult insects	**(Clemente et al. 2003)**
Cinnamomum camphora,Ocimumbasilicum,Chenopodium ambrosioides, and seeds of Pimpinella anisum	*Trogoderma granarium* And *Tribolium castaneum*	powders and essential oils	All tested plants showed dose-dependent insecticidal activity against laboratory insects with T, which can be integrated into integrated pest management (IPM) strategies.	**(Nenaah and Ibrahim 2011)**
Mentha pulegium and *Mentha spicata*	*Drosophila melanogaster*	*essential oils*	Two aromatic plants showed strong insecticidal activity	**(Franzios et al. 1997)**
Lamiaceae	*Drosophila auraria*	*essentialoils*	Death of larvae, pupae, and adult insects, anti-nutrition, growth inhibition, and pupal abnormalities	**(Konstantopoulou et al. 1992)**
fenugreek (*Trigonella foenum-graecum*), celery (*Apium graveolens*), radish (*Raphanus sativus*), and mustard (*Brassica compestris*)	*Lucilia sericata*	Essential oils	All plants Larvicidal effects, anti-feeding, reduction in the number of females, morphological abnormalities of larvae, pupae and adult insects	**(Khater and Khater 2009)**
P *brutia* Ten,*Laurus nobilis* L,*Liquidambar orientalis* Miller,*Juniperus communis* subsp *nana* Willd, *Cupres sussempervirens* L,*Lavandula stoechas* L,*Lavandula angustifolia* Miller, *Eucalyptus*	*Thaumetopoa pityocampa* Schiff	essential oils	The results showed that essential oils from *ninespecies* and *sulfate turpentine* had effective insecticidal effects, the most effective essential oil in controlling	**(Kanat and Alma 2004)**

camaldulensis Dehnh and *Thymus vulgaris* L.			larvae was *P. brutia Ten*.	
Syzygium aromaticum, Piper nigrum, Cinnamomum zeylanicum, Amomum subulatum, Myristica fragnans, Nigella sativa, Curcuma longa, Capsicum frutescens, Cuminum cyminum, Elettaria cardamomum and *Cinnamomum tamala*	*Callosobruchus maculatus* (Fabricius)	This experiment was conducted in a randomized complete block design and was used as a dry powder.	All plants caused adult insect death and weight loss, with *Piper nigrum* and *Syzygium aromaticum* having the greatest effect.	**(Mahdi and Rahman 2008)**
Angelica acutiloba	Drosophila melanogaster	chloroform extract	Acetylcholinesterase (AChE) inhibitory activity, effective in controlling larvae and adult insects	**(Miyazawa et al. 2004)**
Cyrabopogon eitratus Stapf., *Momordiea ebarantia* L., *Zingiber officinMe, Xylopia ae~iopiea* A. Rich., *Ocimum gmtissimum* L. and *Afmmomum melegueta*	*Aphis craccivora* Koch	acetone extracts	*Z. officinale* and *A.* melegueta extracts had the greatest effect on pest mortality, *M. cbamntia* caused high mortality of nymphs, and *C. eitmtus* extract also caused significant mortality in nymphs and reduced the lifespan of adult insects and inhibited reproduction.	**(Ofuya and Okuku 1994)**
Eucalyptus spp.	*Lutzomyia longipalpis*	essential oils	Death of adult insects and larvae	**(Maciel et al. 2010)**
Eucalyptus spp. And *Citrus* spp.	*Rhyzopertha dominica*(F.) and *Triboliumcastaneum*(Herbst)	essential oils. (eucalyptol and limonene)	Both species are fatal when ingested or come into contact with adult insects.	**(Prates et al. 1998)**
Acalypha gaumeri, Annona squamosa, Carlowrightia myriantha, Petiveria alliaceae and *Trichilia arborea*	*Bemisia tabaci* Genn.	Aqueous and ethanolic extracts	Both extracts showed high insecticidal effects on *B. tabaci* eggs, ethanolic extracts of *P. alliaceae* and *T. arborea* plants showed the highest insecticidal effects on *B. tabaci* eggs and nymphs.	**(Cruz-Estrada et al. 2013)**
Ailanthus altissima L.	*Aedes aegypti*	Plant extract	killing larvae	**(Tsao et al. 2002)**

7.Types of commercial botanical pesticides in agriculture

7-1.Pyrethrum

Pyrethrum, derived from the dried flowers of *Tanacetum cinerariaefolium*, is one of the oldest and safest insecticides, historically used to control body lice during the Napoleonic Wars in the early 19th century [68].

it is crucial in India's herbal pesticide use and extracted from the flowers of *Chrysanthemum cinerariaefolium*. Pyrethrum acts quickly, paralyzing flying insects within seconds by blocking voltage-gated sodium channels in their nerve axons. However, its outdoor application is limited due to instability, particularly under UV light. Pyrethrum constitutes 80% of all plant insecticides globally and is favored by organic producers for its low toxicity to mammals and minimal environmental impact, making it one of the safest available insecticides(Acheuk et al. 2017; Isman 2006).

7-2.Neem

Neem is a large, hardy evergreen tree native to South and Southeast Asia and the tropics. Known as the "Botanical Marvel," it serves as both an ancient and modern insecticide. Indians have utilized Neem since prehistoric times to combat household and warehouse pests, as well as some crop pests. Additionally, they traditionally burn Neem leaves in the evening to repel mosquitoes.

The main active ingredients of Neem are: azadirachtin, meliantriol, salannin, desacetyl salannin, nimbin, desacetylnimbin, and nimbidin. Chewing insects are generally more impacted than sucking insects, and those that undergo complete metamorphosis are more affected than those that do not (Acheuk et al. 2017).

7-3.Rotenone

Rotenone is a broad-spectrum plant pesticide typically extracted from the roots and stems of the tropical legume Derris (Derris elliptica), Lonchocarpus (Lonchocarpus utilis, Lonchocarpus urucu) and Tephrosia virginiana. The active ingredient is Rotenone, which acts as a contact and dietary toxin, a cellular respiratory enzyme inhibitor, a stomach poison(Grdiša and Gršić 2013).

Rotenone is a natural plant toxin, isoflavonoid, which occurs naturally in more than 65 plant species. However, most commercial crops are isolated from the roots and rhizomes of tropical species of the Fabaceae family. Rotenone has been used for centuries by indigenous tribes of Southeast Asia and South America as a fish poison to catch fish and obtain food.

7-4.quassinoids

Quassia amara L. is a tropical shrub, occasionally a small tree, from the Simaroubaceae family. Native to northern Brazil and Guyana, it also grows in Venezuela, Colombia, Argentina, Panama, and Mexico. Traditionally in Guyana, Suriname, and Brazil, insecticidal sprays are made by boiling Quassia wood in water. It was widely used as an effective insecticide before the advent of synthetic alternatives. The wood contains 0.14-0.28% of compounds (mainly quassin and neoquassin) that exhibit insecticidal properties, depending on its age (Acheuk et al. 2017).

7-5.Sabadilla

Sabadilla is derived from the seeds of the sabadilla lily (*Schoenocaulon officinale* Schltdl. & Cham.), a tropical plant found in Central and South America. Native Americans have utilized sabadilla for pest control for centuries, creating an insecticidal powder by grinding the seeds, which was also used by Spanish explorers and colonists. The alkaloids in sabadilla are collectively referred to as veratrine.

Ripe sabadilla seeds contain about 0.3% alkaloids, which can disrupt nerve cell

membranes, leading to nerve dysfunction, paralysis, and death. Highly toxic to honey bees, sabadilla degrades rapidly in air and sunlight, resulting in minimal residual toxicity. It is one of the least toxic plant insecticides, with an oral LD50 of 4000-5000 mg/kg(Acheuk et al. 2017).

7-6.Ryania

Ryania speciosa Vahl. (Flacourtiaceae) is a South American plant whose woody stems contain insecticidal alkaloids known as ryanoids, primarily ryanodine and 9,21-dehydroryanodine. Milled stem wood has less than 1% ryanoid content. These compounds disrupt calcium release in muscle tissue, blocking neuromuscular junctions. As a slow-acting stomach poison, insects quickly cease feeding after ingestion. Ryania has relatively low toxicity to mammals, with effects lasting longer than most plant insecticides (Acheuk et al. 2017; Dayan, Cantrell, and Duke 2009).

8.conclusion

Biological pesticides, derived from various plants, offer an effective alternative to chemical pesticides, minimizing the adverse effects associated with synthetic insecticides. These biological pest control agents—such as essential oils, flavonoids, alkaloids, glycosides, esters, and fatty acids—exhibit diverse chemical properties and modes of action that target insects differently. The advantages of biological insecticides include their lack of environmental persistence, low toxicity to beneficial insects and mammals, and reduced risks. Given the harmful impacts of chemical insecticides on human health and the environment, the adoption of biological insecticides in integrated pest management is essential. Additionally, prioritizing the search for new sources of these low-risk insecticides should be a key focus for research.

9.References

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