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Volume IV
Nanoinsecticides

Edited By

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Preface

Insect pests have been established as one of the critical factors contributing to the higher rate of loss of agricultural crops worldwide.

The application of synthetic insecticides is effective for the prevention of agricultural insect pests, but they can pose serious threats to human health and the maintenance of a healthy environment.

These synthetic pesticides also affect humanity due to drifting, and whenever they are ingested in contaminated foods and water.

Insecticide pollution is a global challenge whenever synthetic insecticides are applied for insect pest regulation.

This has led to a higher level of pest resistance to these synthetic pesticides, instabilities of the environment, lethal influence to non-target organisms, secondary-pest resurgence, and direct toxicity to the people who applied these synthetic insecticides.

Globally, large sums of money are spent on preventing the destructive action of agricultural pests by using synthetic insecticides, but there are several challenges.

This includes their non-biodegradable attributes, higher cost, and higher level of toxicity, as well as greater amount of insecticides that reside in the water, soil, and crops, all of which affect public health.

Hence, there is a need to search for biologically compatible, naturally available materials that can be used for effective management of agricultural pests. One solution is to use plant-based repellents, which is a sustainable technique and can result in an increased yield of agricultural crops. Their success is due to their effectiveness, biocompatibility, availability, sustainability, high repellency, biodegradability, environmental friendliness, and good consumer safety.

This book provides detailed information about the application of repellent products that contain plant-based ingredients known as nanobioinsecticides. It includes the pesticide evaluation scheme guidelines for repellent testing; relevant information about the procedures to evaluate several repellent compounds and develop new products that offer high repellency; and guidelines for good consumer safety.

The chapters herein focus on a wide range of related topics. The book chronicles many traditionally repellent plants that could be used in ethnobotanical studies and provides valuable insight into the development of new natural products. It outlines the standardization and numerous investigations used to affirm the level of repellent compounds from various plants. Furthermore, it details the safety, efficacy, and facts about plant-based repellent testing, and reviews new developments in the field.

Finally, the book explores the sustainable techniques involved in the structural elucidation and characterization of active constituents found in nanobioinsecticides, and gives relevant information on the use of essential oils, derived from plants, in the preparation of nanobioinsecticides.

This book is a useful resource for a diverse audience, including global leaders, industrialists, food industry professionals, agriculturists, agricultural microbiologists, plant pathologists, botanists, agricultural experts, microbiologists, biotechnologists, nanotechnologists, environmental microbiologists and microbial biotechnologists, investors, innovators, farmers, policy makers, extension workers, educators, researchers, and many in other interdisciplinary fields of science. It also serves as an educational resource manual and a project guide for undergraduate and postgraduate students, as well as for educational institutions that seek to carry out research in the field of agriculture and nanotechnology.

I offer my deepest appreciation to all the contributors who dedicated their time and efforts to make this book a success. Furthermore, I want thank my co-editors for their effort and dedication during this project. Moreover, I wish to gratefully acknowledge the suggestions, help, and support of Martin Scrivener and the Scrivener Publishing team.

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December, 2023

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The Contribution of Ethnobotany to the Discovery of New Plant-Based Repellents

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Abstract
Bug, mosquito, mite, tick, and lice are insects that pose a variety of issues for people. There is an ongoing want to produce novel deterrent and insecticide, especially in light of report of insect resistance and necessities to better eco-friendly societies. Traditional plant-based repellant ethnobotanical surveys give direct approach to identify plant for possible usage. A repellent is a chemical or plant-based agent that renders the insect's surroundings uninhabitable, preventing it from contacting the host. Repellents are chemicals that are applied to treated surfaces to prevent arthropods from settling or crawling. They are safe to use on exposed skin, clothing, and other surfaces. Repellents can be thought of as a specific tool for keeping humans safe from insect-borne illnesses because they aid in the prevention, reduction, and control of disease outbreaks.

Keywords: Ethnobotany, phytomedicine, secondary products, bioinsecticides, plant-based repellents

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1.1 Introduction

Bug, mosquito, mite, tick, and lice are hematophagous insects that pose a variety of issues for people. When they sting, they can result in necrosis, blister, or allergy in people [1]. Furthermore, hematophagous invertebrates can transmit infectious pathogens to humans, resulting in the spread of ailment. Humans have tried a variety of tactics to combat hematophagous insects. Native herbs have traditionally been applied in protection of people against bite. Oil derived from plant parts apply to the body, for example [2]. Traditional plant-based insect repellents are no longer practical in urban environments, but are exploited as source for recent pesticides and repellent. Pyrethrum and neem are two instances of actual current product derived through traditional botanicals [3]. Plant items, such as wood and leaves, are also commonly burned to deter insects.

Ethnobotany is the study of plants in a particular place, as well as their practical application based on local culture and expertise. Taxonomy, cultivation, and the usage of indigenous plants as food, medicine, and shelter are all covered. The use of ethnobotany to choose plants demands detailed documenting of indigenous communities' relationships with plants. Ethnobotanic knowledge is based on observation, relationships, requirements, and traditional ways of knowing and can be applied to both wild and domesticated species. New discoveries, ingenuity, and techniques are constantly added to the mix as knowledge advances. Ethnobotany is now acknowledged as an important subject dedicated to the study of all sorts of human–plant interactions.

1.2 Ethnobotany in the Discovery of New Plant-Based Repellents

Botanical knowledge of a specific ethnic group can be useful in a variety of situations. Plants used for fiber, color agent, poison, manure, construction material, watercraft, and plant-based repellents are among the natural products studied by ethnobotany. Plant-based repellents were use as private defense technique against mosquito for ages. Ethnobotanical research yields relevant information of traditional deterrent plant use in development of novel products [4]. In order to generate new plant-based repellents, ethnobotany is required.

Phytochemicals are produced by many plants to deter insects that feed on plant fluids. Mosquito repellents are required to protect humans from mosquito stings [5]. Depending on their activity, phytochemicals can be extracted from whole plants or specific parts of plants. Photo-activated toxins found in certain phytochemicals have been shown to be effective against mosquitos [5]. Human-friendly plant-based insect repellents should be less harmful and have fewer adverse effects. As a result, using plant derivatives rather than chemicals in mosquito repellents could result in lower manufacturing costs and reduced environmental impact. The development of novel and more effective plant-based repellents has been aided by ethnobotanical research with indigenous peoples and their use of plants as repellents.

1.2.1 Ethnobotany and Its Role in Plant-Based Repellents

For decades, plant-based repellents have been used as a personal defense against mosquitoes looking for a place to lay their eggs [4]. Ethnobotanical research can be used to develop new natural goods based on traditional repellant plants [4]. In comparison to long-established synthetic repellents, consumers are becoming interested on repellent made from plant compound since they are observed to be safe [4]. With a few exceptions, the majority of newly emerging infectious illnesses are arthropod via tick or mosquito which are not vaccine-preventable. Plants are frequently used in the creation of effective plant-based repellents. Tobacco, corymbia, neem, and citronella are some examples.

1.2.2 Problems in Ethnobotanical Studies in Relation to Plant-Based Repellent

Traditional plant-based insect repellents are no longer practical in urban environments, but exploited as means for current pesticides and deterrent. Researchers have screened plants that may operate as natural repellents and characterized their activities and toxicities over numerous generations. Due to their low cost, few individuals in distant regions still employ old ways in control of insects [6, 7].

Also, traditional pest management knowledge is fast being lost because of increases in standard of living and lack of information [18]. Ethnobotany has yielded a harvest of unique, laboratory-proven therapeutic plants and chemicals in recent decades, but it has fallen short of its promise of producing a cornucopia of new and taxonomically focused plant-based repellant discoveries. Individual or group interviews are frequently used to obtain information about how different plant species are used in a community, and range of information varies depending on method applied. Finally, a lack of funding for ethnobotanical research and studies is a barrier. When financing for ethnobotanical research is scarce, progress is stifled, providing a problem for the field's future growth.

1.3 Plant-Based Repellent

A plant-based repellent is an organic repellent that is created from plant extracts and concentrates or comes in the shape of a plant. Plants were used to deter and eradicate insects since prehistoric times, and many people continue to do so today in the world [8]. Traditional repellent plant knowledge can be applied to produce current natural repellents that can be used instead of synthetic repellents. Plant-based repellents provide a high concentration of bioactive phytochemicals that are both innocuous and non-toxic biodegradable byproducts that might be studied for insecticidal efficiency [2].

There is currently considerable agreement that plant-based products are safer and that phytochemicals degrade swiftly, piquing researchers' and the general public's curiosity [8]. One advantage of using a plant-based botanical is user acceptance. The majority of individuals prefer natural things to synthetics. Plant-based repellents are economical, widely accessible, well-known, and culturally suitable [8]. Ethnobotany plays an important role in the development of new plant-based repellents. It's a strategy of conducting in-depth interviews with key people knowledgeable about culture and traditional medicine in order to conduct a concentrated search for therapeutic plants. Plant by ethnic group is commonly studied using ethnobotanical research that combines scheduled discussions with plant voucher species collection. Plants that have been wounded or harmed release volatile odors into the environment, providing insect defense from afar. When these chemicals are used in repellents that are applied to the skin, their volatility becomes a concern.

1.3.1 Plant Products Used as Repellents

Plant repellents including citronella oil from *Cymbopogon nardus*, PMD from Eucalyptus *Maculata citriodora*, and fennel oil from *Foeniculum vulgare* do little to no harm in societies or human life, and might be a good alternative to artificial repellent like DEET [19, 20]. Some of these plants-derived repellents are discussed below:

1.3.1.1 Citronella

Citronella is a natural oil obtained from stem and leaf of many lemongrass specie (*Cymbopogon* sp) [9]. It's made of lemongrass and has a repellent effect on Anopheles culicifacies for 11 hours [10]. Mosquito coils with citronella oil or the citronellal component are also used to keep mosquitos out of outdoor spaces [11]. Citronella was first distilled for perfume use in 1858, and comes from French term Citronelle.

It is widely use natural repellent, with concentrations ranging from 5% to 10%. Although the concentration is low compare to that of most repellent, larger concentration could cause skin irritation. It's frequently used as an insect repellant in the outdoors. Citronella is available at 0.5–20% concentrations in lotions, oils, and hard wax infused candles and blazing pots. Due to its high volatility, citronella duration of effect is short, yet it can repel mosquito bites for up to 2 hours.

1.3.1.2 Neem

Neem oil, made from cold-pressed seeds, is efficient against a variety of insects and mites, as well as phytopathogens [11]. Despite the presence of over a dozen azadirachtin analogs in neem seeds, azadirachtin is the major form, and the other minor chemicals are unlikely to have a substantial impact on the extract's overall efficacy. Nimbin, salannin, and triterpene derivatives are among the other triterpenoids found in seed extracts. Other natural chemicals' functions are questionable, but azadirachtin appears to be the main functional principle.

1.3.1.3 Oil of Lemon Eucalyptus

P-menthane-3, 8-diol (PMD), sometimes known as lemon eucalyptus oil, is an organic or inorganic extract of the leaves of Corymbiacitriodora. PMD has similar insect repellent efficiency and length like DEET, *Andas picaridin* may provide superior tick guard than DEET. Centers for Disease Control (CDC) has recommended PMD as the only plant-based deterrent for use in disease zones [12]. It was discovered to be just as effective and long-lasting as DEET.

1.3.1.4 Essential Oils

They are one-of-a-kind combination of unstable organic chemicals produce as secondary metabolite by plant. Hydrocarbon (Sesquiterpenes and

Terpene) and oxygenated compounds (ethers, esters, ketones, aldehydes, alcohols, phenols, lactones, and phenol ethers) make up essential oils [12]. Several plant essential oils and concentrates, particularly for Anopheles species, could be utilized to make long-lasting and environmentally friendly repellents [13, 21–24].

Essential oils obtain through distilling aromatic plant have long been employed in the manufacture of colognes and aromatics in cologne and food products, and are now used for therapeutic and medicinal herbs [4, 5, 13–15]. Commercially available extracts of cinnamon, thyme, garlic, cedar, pine, fennel, peppermints, geranium, verbena oils, and lavender have been shown to repel numerous mosquito species, including *Aedesalbopictus* [3] [13, 16, 23]. Prior to the discovery of efficient synthetic repellents, the military used aromatic oils as repellents. A lotion containing citronella, paraffin, and camphor was issued to the British Indian troops, but it barely lasted 2 hours [13, 17, 18, 21, 24].

1.3.1.5 Catnip

Catmint is a common name for a perennial mint plant in the Labiatae family called Catmint. This herb grows from central Europe through central Asia, as well as on the Iranian plateaus [17]. Catnip has long been known for its cat-stimulating properties. The active ingredient in catnip has been identified as nepetalactone, which is found in two isomers in the essential oil of the plant: E,Z (trans, cis) and Z,E (cis, trans), with Z,E-nepetalactone the most common. Catnip has a lengthy history of insect repellent use, with the majority of it being scientifically proven.

1.3.1.6 Vanillin

Asynthetic version of a natural occurring molecule present in vanilla seed pods. Vanillin (10%) has been found to enhance the repellent qualities of different volatile oils against *Aedesaegypti*. Addition of vanillin to an oil-based repellent reduces volatility and increases the natural repellent's lifespan. The increase in protection time with varied ratios of vanillin to repellents was not substantial, with the exception of diethyl toluamide (deet [diethyltoluamide]). In most cases, the length of protection was increased by more than 100%. According to studies, some mosquito repellents containing vanillin can provide protection from mosquito stings for up to a day [16].

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2

Nanobioinsecticide Derived from Essential Oils of *Cymbopogon nardus*

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Abstract
Generally, for a long period of time chemically synthesized insecticides has played a major part in integrated pest management program. But recently eco-friendly bio pesticides based on essential oil has strongly replaced them. These nano-pesticides and insecticide are human and environment friendly and simultaneously increase the yield crop productivity. Essential oils derived exhibit toxic repellent and anti-feeding effect on different species of insects. Air, light, moisture and high temperature have special influence on the nano-bio-pesticides. But this problem can be solved by incorporating the plant derived oils into controlled and released nano-formulations.

Keywords: Nanobioinsecticide, cymbopogon nardus nano-formulant, essential oil, insect pest control

2.1 Introduction

There are many developments of novel technique of protection against urban pest agriculture storage and due to their increase of plant derived substance and nontoxic material. Food industries generally relies on authorized pesticides and these scientific community increases to use the eco-friendly formulation and novel application techniques [1].

There has been un controlled uses of synthetic pesticides which contributed to several hazards to environment and change the ecosystem.

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Rebellion of resistance in some pest and their consequent drop of efficiency of the fungicide synthetic germicide can contaminate the environment there by polluting the whole food chain.

Likewise, there is a drop environmental diversity including non-targeting organism. Pest, parasites, insect pollinators, predators which may be linked to the application of artificial pesticide [2]. Generally methyl bromide and phosphene are used against the stored products, insects, pest hence they are highly reactive against non-entities. But the restriction of methyl bromide and the growing resistance to phosphene have determined the critical development of indispensable pesticide and insecticide for stored product in pest operations [3, 4].

Nanotechnology is an important exploration field which can be used for crop protection and to make new active constituents at nanoscale dimensions. Generally selected nanofungicide should retain certain characteristic features to overcome the limitations and also improve the bio activity of synthetic germicide [5, 6], hence promoting stability and continuity in the environment perfecting the toxic action towards the targeted pest but avoiding secondary effect on the non-target organism [7]. Generally, the majority of the commercial pesticides are neurotoxic and interfere directly or indirectly with the neurological system of the insect. Mammals and unintended insects may be at risk from this type of insecticide. Thus, the expression of nano-biopesticide with different modes of action increases the sustainability and safety pest control method [8].

Many biopesticides are plant based secondary metabolites that are thought to play a key role in plant protection against biotic and abiotic stress [9, 10]. Composites are the most prevalent secondary metabolites among alkaloids, phenols, and terpenoids [11]. The plant tissues solvent or heated distillation can uproot this substance, which contains a complex admixture of colorful compounds known as essential oils. Numerous essential oils are bioactive substances that have insecticidal, poisonous, and repellant properties against the target pest species sterility-infertility and developmental and behavioral differences [12]. Essential oils are a type of pest control that has been used for centuries. Botanicals were utilized to manage stored grain pests several million years ago, circa 2000 BC, across Asia, the Middle East, and Northern Africa [13]. The low toxicity of essential oils toward animals has sparked interest in their usage as a pest control tool [14, 15]. As a result, these compounds are utilized as food protection as well as insect control. Essential oils are predominantly made up of volatile lipophilic substances with fire breakdown property and poor water solubility [16–18]. Despite their potential and well-known insecticidal action, there are only few commercial essential oil-based bio pesticides are available due to some characteristic features.