IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

ANALYSIS OF THE CONTRIBUTION OF BOTANICALS TO PEST MANAGEMENT STRATEGIES.

Anuja Dnyaneshwar Bokharepatil
Research Scholars,Department of Botany,
Yeshwant Mahavidyalaya, Nanded, Maharashtra, India

Madhuri Mukund Maindargikar
Research Scholars,Department of Botany,
Yeshwant Mahavidyalaya, Nanded, Maharashtra, India

Chandrakant Dnyaneshwar Ghorband
Research Scholar,Department of Botany,
Yeshwant Mahavidyalaya, Nanded,
Maharashtra, India.

Saheb L. Shinde
Professor, Department of Botany,
Yeshwant Mahavidyalaya, Nanded,
Maharashtra, India.
Corresponding author: Saheb L. Shinde

Abstract
Among the most important characteristics of farming is pest management. Traditional pesticides have caused many environmental issues, such as ecological imbalance, reduction in soil fertility, and degradation of Ocean life. Traditional pesticides have caused many dangerous and major concerns to animal and human health affecting serious malignancies, nervous system diseases, the hormones disruptions as well as reproductive problems. Increasing interest in environmentally helpful, biological agriculture chemicals with reduced Health hazards and enhanced control of pests is driving the manufacturing and use of plant-derived materials. Natural compounds taken from plants are showing great potential as a replacement for standard synthetic pest control. Botanicals are valuable components of pest management that spans traditional methods, environmentally conscious practices, and holistic strategies. Despite a long-standing history of using plants for pest control, botanical pesticides were less popular than other biological methods during the 20th century. However, our increasing understanding of the mechanisms behind plant allelochemical activity is creating new opportunities to use these compounds in crop protection.
This review includes information about botanical pesticides that are currently in use. Botanical insecticides are compounds that come from plants. Derived from nature, these substances effectively manage pests such as insects, fungi, and weeds, and have been a long-standing and crucial pest control tool.

Keywords: Botanicals, Eco-friendly, Allelochemicals, Pesticides, Nanded.

Highlights

- Importance of botanical pesticides.
- Plant diseases and pest management by using botanical pesticides.

- Currently used botanicals in pest management.
- Future scope of botanical pesticides.

Introduction

A significant increase in crop production is required to supply the world's expanding population with food over the next two decades. Crucially, this growth must be achieved sustainably, preserving the environmental and social benefits of agriculture. A single solution to this complex challenge is unrealistic. As farmers operate in diverse geographical conditions, development and implementation of technologies adapted to specific needs and environments is essential (Bastiaans L *et al*., 2008).

Pests are a major threat to agriculture and various methods exist to manage them. Commercial synthetic pesticides, these substances, including halogenated hydrocarbons and organophosphates, persist in the environment for extended periods and are believed to be toxic. This has led to a, Rising need for alternative solutions. The increasing need for environmentally friendly, safe, and selective pesticides is driving the search for alternatives. Plant-based solutions, rich in natural pest-fighting compounds, provide a valuable option for reducing the use of harmful chemicals (McLaren, 1986). Plant-derived pesticides provide a sustainable approach to reducing pesticide contamination in agriculture and the environment, thanks to their efficient pest control, natural decomposition, multiple mechanisms of action, and minimal toxicity (Neeraj, G. S. *et al*., 2017). Plant-based pesticides offer the advantage of short pre-harvest and re-entry intervals, and are frequently utilized in organic agriculture, which leads to higher prices for organic produce (Datta, S. 2015). Botanical pesticides are gaining popularity due to safety for human consumption and increasing demand for organic food (Misra, H. P. 2014). Plant-based crop protection treatments are used by farmers for post-harvest pest management and grain protection. These treatments are isolated or extracted from plants, plant parts or organic solvents. They are used for flavor, aroma, functional health benefits, medicine and other biological and technological applications. Botanicals can be ground into a dust or powder, used whole, or diluted with a carrier (Kumbar C.R., 2020).

Methodology

The material for this review paper has been collected from various electronic sources like Google, Google Scholar, PubMed and INFLIBNET. Highly reliable and up-to-date material has been collected. The search terms used were: Botanicals, Eco-friendly, Allelochemicals, Pesticides etc.

Botanicals

Botanical pesticides are compounds produced naturally from plants. Although natural pesticides are alternatives to industrial chemicals, they may not be as safe for humans. Natural toxins and carcinogens can be deadly and have rapid effects (Regnault-Roger *et al.,* 2005). Nowadays, the use of botanicals is gaining traction as a practical and effective strategy within Management of Integrated Pests (IPM).

Techniques to grow different kinds of crops due to their:

- Effective on insects' control
- Safe for the environment and public health safety.
- Eco-friendly and affordable.
- Ideal for organic farming systems.
- Rich in biologically active substances.

Current Botanicals in use

Neem

Azadirachta indica, commonly known as neem, is indeed a tropical evergreen tree. It's known for its various medicinal and agricultural uses. It is used as a biological pesticide for managing plant diseases and pests. It offers long-term pest control, low toxicity, and cost-effectiveness. Neem tree exhibits antifungal, antibacterial, and antiviral activities, with its active chemical concentration highest in the seeds. Neem seeds contain insecticidal components like Nimbine, Meliantriol, Nimbidine, and Azadirachtin (Sonkar. S. Y. and Chauhan N. K., 2023). Nowadays, commercial formulations of neem, including Neem Gold, Neemzal, Econeem, Neemmark, Neemcure and Azatin, are available in many countries. The neem tree is considered to be the very beneficial & traditional plant. The characteristics of the neem include insecticidal, anti-food, hormonal, antifungal, anti-allergic, anti-dermatitis, anti-inflammatory, anti-scabies, larvicidal and spermicidal activities (Acharya, P. *et al.,* 2017). Neem trees develop chemical defenses against insects, including repellents, anti-food, ovipositional deterrents, growth inhibitors and toxins (Saxena, *et al.,* 1989).

Tobacco

Tobacco (*Nicotiana tabacum*) A tall, leafy plant from the Solanaceae (nightshade) family reproduces through blooms and seeds. It is used as a biological insecticide due to the presence of nicotine, a naturally occurring insecticide. At least 15 Nicotiana species contain nicotine, with Nicotiana tabacum and Nicotiana rustica being the most commercially important (Sonkar. S. Y. and Chauhan N. K., 2023). Nicotine, a compound found in plants, was first recognized as an insecticide in the 16th century. It mimics acetylcholine by binding to its receptor in muscle synapses' post-synaptic membrane, causing nerve impulses that can lead to convulsions and death. Neo-nicotinoids, synthetic derivatives of nicotine, include imidacloprid, thiacloprid, nitempyram, acetamiprid, and thiamethoxa (Kumbhar C.R., 2020). Tobacco can be used as a dust, liquid extract, or smoked.

Pyrethrum

Pyrethrum, derived from chrysanthemum flowers, has been used as an insecticide since around 1800 in Asia. The insecticidal activity comes from six distinct compounds called pyrethrins, found in the dried flower heads of *Chrysanthemum cinerarifolium* and *Chrysanthemum coccinea* belongs to the family, Asteraceae (Sonkar. S. Y. and Chauhan N. K., 2023). Pyrethrins disrupt sodium ion flow, affect ion channel conductance, and cause a "knockdown" effect that prevents insects from feeding. These natural compounds inspired the development of synthetic pyrethroid insecticides (Kumbar C. R., 2020).

Lantana

Lantana camara, a member of the Verbenaceae family, is a widespread shrub found in tropical, subtropical and temperate regions around the world. Known for its adaptability and rapid spread, it is considered an invasive species in many areas (Rajashekar Y. *et al.,* 2014). This product with various compounds is effective against insects. It is made from dried lantana twigs, leaves and fruits, ground into a powder, mixed with water and sprayed (Sonkar. S. Y. and Chauhan N. K., 2023).

Rotenone

Rotenone, a flavonoid insecticide, is produced from the roots of plants belonging to *Derris spp.* (Fabaceae) and *Loncocarpus spp*. (Fabaceae). Acting as a contact, ingestion, and repulsive compound, rotenone disrupts insect metabolism by inhibiting mitochondrial electron transport, thereby inhibiting ATP production. Derris species from the eastern tropics may contain 13% rotenone, while Loncocarpus species, native to the Western Hemisphere, typically contain 5% (Kumbhar C.R., 2020). Rotenone is a contact toxin used to efficiently control aphids, thrips, flea beetles, and caterpillars in vegetable crops. It decomposes upon exposure to air and light, turning colorless to yellow to dark red, producing a non-pesticide-free end product. However, it cannot be used with alkaline dusts or wetting agents due to its ease of oxidation when exposed to alkali (Sonkar. S. Y. and Chauhan N. K., 2023).

Sabadilla

Schoenocaulon officinale, also known as sabadilla, is a plant whose seeds contain potent compounds. It is a toxic alkaloid found in the Liliaceae family. It is photosensitive and can damage nerve cells in insects, causing loss of function, paralysis and death (Ulfat Jan *et al*, 2024). Despite their structural differences, Sabadilla alkaloids are similar to pyrethrins. Organic growers in California use approximately 100 kg of citrus and avocado crops each year. (Isman, 2006). Veratridine, a highly toxic alkaloid, is used worldwide in insecticides and diluents. Found in South America to Peru, this plant is classified as a member of the Melanthiaceae family. Its flowers are spiky and have short stems. The seeds contain 13% civadin, 10% veratradin and small amounts of civadiline, sobitin and sabidin. While veratridine and civadin are effective against insects, veratridine is highly toxic and should be kept in a dark, closed place (Sonkar. S. Y. and Chauhan N. K., 2023).

Ryania

Ryania, a chemical derived from the South American plant *Ryania speciosa*, is a slow-acting gastrointestinal toxin that prevents insects from eating after being eaten. Ryanodine, an alkaloid, constitutes a very small fraction, specifically 0.2%, of the dried stem wood. Although it does not immediately paralyze the insect, it is enhanced in warmer temperatures (Kumbhar C. R., 2020). The alkaloid ryanodine is present in the root and stem tissues of a plant originating in South America, it is an effective insecticide beneficial for muscle spasms, paralysis, and stomach poisoning. It Soluble in water and most organic solvents, and less harmful to animals than rotenone. Ryanodine is stable to light and air and is used as a spray and dust for pest control. A similar plant, Ryania, is rarely found in India because of its import costs and high price (Sonkar. S. Y. and Chauhan N. K., 2023).

Eucalyptus

Eucalyptus (Eucalyptus camaldulensis) is a tree in the Myrtaceae family, which has more than 900 species. Cultivated worldwide from its Australian origins, eucalyptus yields an oil with a diverse chemical composition, including terpenes, phenols, and various oxygen-containing compounds (Batish, *et al.,* 2008). Ethnobotanical practices often utilize eucalyptus species to manage tick and mosquito populations, thereby reducing the risk of parasitic and viral infections such as malaria and Lyme disease, which pose a threat to public health and require control measures (Benelli *et al.,* 2016). The oil is Derived from the leaves, buds, fruits and bark of the Eucalyptus plant. Eucalyptus oil contains insecticidal components such as 1, 8-cineol, citronellal and p-cymene, which

provide anti-feedant properties and potential natural insecticide against herbivores and mosquitoes (Ayed *et al.,* 2024). It is also detrimental to various microorganisms, Bacteria and fungi are responsible for soil-borne and post-harvest diseases. Eucalyptus oil is acaricidal and can efficiently eradicate parasitic and free-living ticks and mites (Noaman and Bahreninejad, 2024), as well as nematodes.

Datura

Datura stramonium, a toxic flowering plant belonging to the Solanaceae family, is also known as thorn apple, jimsonweed, devil's snare, or devil's trumpet. This invasive weed spreads rapidly globally in temperate climates. Datura leaves and pods are processed into a powder, containing potentially toxic tropane alkaloids, responsible for its psychedelic effects. This powder is then soaked in water and filtered before being sprayed as an insecticide. The active compounds in Datura, which include hyoscyamine, atropine and scopolamine, not only repel insects but also interfere with their ability to locate oviposition sites (Sonkar. S. Y. and Chauhan N. K., 2023). Datura is a widespread, well-known folk medicinal plant. The leaves can be given orally to treat infections of the sinus and asthma, while the bark can be extracted and applied externally to treat swelling, inflammation, ulcers. Growing plants keep insects away, protecting neighboring plants (Das S. *et al.,* 2012). A variety of plant compounds, including phenols, flavonoids, tannins, saponins, alkaloids, steroids, and glycosides, were found through phytochemical analysis. While toxicity is present in all plant sections, the highest alkaloid concentration is in the mature seeds (Shagal M.H. *et al.,* 2012). Tropical regions are renowned for their rich diversity of plants with insecticidal and therapeutic properties. Datura plays an important role in controlling such pests, offering a safer alternative to chemical treatments for preserving stored grains such as wheat (Jhalkar N. *et al.,* 2016).

Calotropis

Calotropis gigantea, also known as giant milkweed, is a member of the Apocynaceae family. While poisonous, it has a history of traditional medicinal uses. Calotropis has also shown promise for improving nitrogen utilization in ruminants, suggesting its potential in sustainable agriculture. Extensive research has explored the Calotropis's chemical analysis, the extraction process, and biological pesticides potential, showing that different parts of the plant yield different bioactive compounds depending on the solvent used for extraction (Ullah R. and Widmer S. K., 2024). Its latex contains cardiac glycosides, fatty acids and calcium oxalate. Calotropin is also found in the roots. Historically, various plant and animal substances have been used as arrow poisons to capture animals (Sonkar. S. Y. and Chauhan N. K., 2023). The leaf extract has biological insecticidal properties and can effectively combat pests in agricultural crops. Previous investigations have shown that aqueous leaf extracts have high biological insecticidal efficacy on several crops. Calotropis is used as a biological control agent in agriculture due to its medicinal value. Studies have found that an aqueous crude extract of its leaves has a high mortality rate and its mode of action against plant pathogens is unknown (Ullah R. and Widmer S. K., 2024).

Photographs of currently used Botanicals


Fig. 1 Neem


Fig. 2 Tobacco


Fig. 3 Pyrethrum


Fig. 4 Lantana

Fig. 5 Rotenone

Fig. 6 Sabadilla

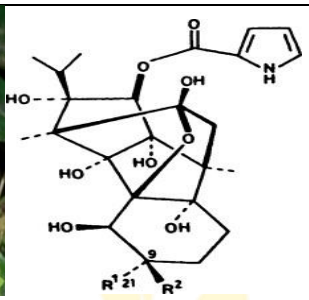

Fig. 7 Ryania

Fig. 8 Eucalyptus

Fig. 9 Datura

Fig 10. Calotropis

Table 1: List of currently used Botanicals.

Sr. No.	Name of Botanicals	Part Used	Botanical Name	Family
1	Neem	Leaf, Bark & Fruit	*Azadirachta indica*	Meliaceae
2	Tobacco	Leaf	*Nicotiana tabacum*	Solanaceae
3	Pyrethrum	Flower	*Chrysanthemum cinerariifolium* & *Chrysanthemum coccineum*	Asteraceae
4	Lantana	Leaf	*Lantana camara*	Verbenaceae
5	Rotenone	Root	*Derris spp., Lonchocarpus spp.*	Fabaceae
6	Sabadilla	Seed	*Schoenocaulon officinale*	Liliaceae
7	Ryania	Root, stem	*Ryania speciosa*	Flacourtiaceae
8	Eucalyptus	Leaf, Buds, Fruits & Bark	*Eucalyptus camaldulensis*	Myrtaceae
9	Datura	Leaf, Pod	*Datura stramonium*	Solanaceae
10	Calotropis	Leaf	*Calotropis gigantean*	Apocynaceae

Advantages of Botanicals

- The plants that provide the chemicals are native to the area, so farmers are already familiar with them.
- Eco-friendly, safe for users/applicators, and effective when used properly.
- Rapid breakdown of the active component can lessen the risk of residues on food.

- These plants have a variety of functions, including insect repellant and therapeutic purposes.
- These chemicals are effective when eaten by pests and decompose quickly, resulting in a more targeted effect on insects and reduced harm to natural enemies.

Disadvantages of Botanicals

- Many of these products are not true pesticides, but rather slow-acting pesticides.
- Plant pesticides are quickly broken down by UV radiation, leaving short-term residual effects.
- Plant pesticides are not always safer for animals than synthetic pesticides.
- Most of them do not have a specific residue tolerance.
- They may not be available for the entire season.

Scope of Botanical Pesticide

Biopesticides, classified into biochemical and microbial agents, differ from conventional pesticides. Efforts are underway to develop new, non-cross-resistance biopesticides, as harmful biopesticides are harmful and require environmentally acceptable, biodegradable, and cost-effective pest management solutions. (Oguh C.E. *et al*., 2019). Integrated pest management (IPM) programs use botanical insecticides to prevent resistance, for different effects on pests. Rural cooperatives develop locally available plants, saving farmers money on synthetic agrochemicals. High demand for fruits, vegetables, snacks and residue-free cotton is significant. (Kumbhar C.R., 2020). Plant-based pesticides are beneficial Farmers in poorer countries lack access to artificial pesticides and have a history of using plants for crop protection despite government funding and inadequate protective equipment. (El-Wakil N. E. 2013).

Conclusion

Plant-based pesticides, or botanicals, offer a natural and safer alternative to synthetic pesticides for protecting crops. They minimize the harmful side effects associated with chemical pesticides. Botanicals work in diverse ways, repelling pests, disrupting their feeding, poisoning them, inhibiting their growth, affecting their reproduction, or attracting them. Using botanical pesticides is preferred over synthetic options, especially in organic farming. They are environmentally friendly, breaking down quickly in sunlight, which prevents the release of harmful chemicals into the environment. This rapid degradation also makes them safer for biodiversity and human health. Botanicals are crucial for integrated pest management (IPM) programs, contributing to long-term pest control. Their effectiveness against various pests across different climates and crops helps increase yields while safeguarding the environment.

Acknowledgement

The authors are appreciative to the management and principal of Yeshwant Mahavidyalaya in Nanded for supplying the laboratory and other facilities required to finish the work effectively.

Author Contribution

Anuja Dnyaneshwar Bokhrepatil designed the experiment, methodology and data collection. Madhuri Mukund Maindargikar and Chandrakant Dnyaneshwar Ghorband Strictly closed. Data analysis and MS writing. Saheb L. Shinde direction and revision and compilation in MS. The final manuscript was approved by all of the authors.

Conflict of Interest.

The authors have declared that they have no conflicts of interest.

References

[1] Acharya, P., Mir, S. A., & Nayak, B. (2017). Competence of biopesticide and neem in agriculture. *International Journal of Environment, Agriculture and Biotechnology*, *2*(6), 238987.

[2] Ayed, A., Caputo, L., De Feo, V., Elshafie, H. S., Fratianni, F., Nazzaro, F., Hamrouni, L., Amri, I., Mabrouk, Y., Camele, I and Polito, F. (2024) Antimicrobial, anti-enzymatic and antioxidant activities of essential oils from some Tunisian Eucalyptus species. Heliyon. 10, 14.

[3] Bastiaans, L., Paolini, R., & Baumann, D. T. (2008). Focus on ecological weed management: what is hindering adoption?. *Weed Research*, *48*(6), 481-491.

[4] Batish, D. R., Singh, H. P., Kohli, R. K. and Kaur, S. (2008) Eucalyptus essential oil as a natural pesticide. Forestry Ecology and Management. 256(12), 2166-2174.

[5] Benelli, G., Pavela, R., Canale, A., Mehlhorn, H., 2016. Tick repellents and acaricides of botanical origin: a green roadmap to control tick-borne diseases? Parasito Res. 115, 2545–2560.
[6] Das, S., Kumar, P., & Basu, S. P. (2012). Phytoconstituent and therapeutic potentials of Datura stramoni Linn. *Journal of Drug Delivery and Therapeutics*, *2*(3).
[7] El-Wakeil, N. E. (2013). Botanical pesticides and their mode of action. *Gesunde Pflanzen*, *65*(4).
[8] Dutta, S. (2015). Biopesticides: an ecofriendly approach for pest control. *World Journal of Pharmacy and Pharmaceutical Sciences*, *4*(6), 250-265.
[9] Misra, H. P. (2014). Role of botanicals, biopesticides and bioagents in integrated pest management.
[10] Isman, M. B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annual review of entomology*, *51(*1), 45-66.
[11] Jawalkar, N., Zambare, S., & Zanke, S. (2016). Insecticidal property of Datura stramonium L. seed extracts against Sitophilus oryzae L.(Coleoptera: Curculionidae) in stored wheat grains. *J. Entomol. Zool. Stud*, *4*(6), 92-96.
[12] Kumbhar, C. R. (2020). Role and mechanism of botanicals in pest management. *Just Agric. Multidiscip. e-Newsl.*, *1*, 226-232.
[13] McLaren, J. S. (1986). Biologically active substances from higher plants: Status and future potential. *Pesticide Science*, *17*(5), 559-578.
[14] Neeraj, G. S., Kumar, A., Ram, S., & Kumar, V. (2017). Evaluation of nematicidal activity of ethanolic extracts of medicinal plants to Meloidogyne incognita (kofoid and white) chitwood under lab conditions. *Int. J. Pure Appl. Biosci*, *1*, 827-831.
[15] Noaman, V and Bahreininejad, B. (2024) Evaluation of the acaricide activity of extracts from eight species of medicinal plants on larvae of *Hyalomma anatolicum* (Acari: Ixodidae) ticks. Journal of Asia-Pacific Entomology. 27, 2.
[16] Oguh, C. E., Okpaka, C. O., Ubani, C. S., Okekeaji, U., Joseph, P. S., & Amadi, E. U. (2019). Natural pesticides (biopesticides) and uses in pest management-a critical review. *Asian Journal of Biotechnology and Genetic Engineering*, *2*(3), 1-18.
[17] Rajashekar, Y., Ravindra, K. V., & Bakthavatsalam, N. (2014). Leaves of Lantana camara insect pests. *Journal of food science and technology*, *51*, 3494-3499.
[18] Regnault-Roger, C., Philogène, B. J., & Vincent, C. (2005). *Biopesticides of Plant Origin* (pp. xxi+-313).
[19] Saxena, R.C., Jilani, G. & Abdul Kareem, A. (1989). Effects of neem on stored grain insects, In Jacobson, M. [Ed.]. Focus on phytochemical pesticides. The neem tree. CRC press, Boca Raton, FL., 1: 97-111.
[20] Shagal, M. H., Modibbo, U. U., & Liman, A. B. (2012). Pharmacological justification for the ethnomedical use of Datura stramonium stem-bark extract in treatment of diseases caused by some pathogenic bacteria.
[21] Sharma, B. D., & Lakshminarasimhan, P. (1996). *Flora of Maharashtra state* (Vol. 1). Kolkata: Botanical Survey of India.
[22] Singh, N. P., & Karthikeyan, S. (2001). *Flora of Maharashtra state* (Vol. 1, p. 898). Calcutta: Botanical survey of India.
[23] Sonkar, K. S. Y., & Chouhan, N. K. (2023). Role of Botanicals in Pest Management. *Emerging Trends in Entomology*, 43.
[24] Ulfat Jan, Tariqe Hassan Askary and Heena Jan (2024). Role of Botanicals in Pest Management - A Review. *International Journal of Global Science Research,* 11(2), 2429-2437.
[25] Ullah, R., & Wiedmer, S. K. (2024). Potential biopesticides from Datura alba and Calotropis gigantea: Extraction, analysis, and reported compounds. *Crop Protection*, 107009.