*Plant Archives* Vol. 21, Supplement 1, 2021 pp. 2197-2204 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
doi link : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.S1.362

# ECO-FRIENDLY PLANT BASED ON BOTANICAL PESTICIDES

**Dalavayi Haritha, M. Faiz Ahmed, Suman Bala and Debjani Choudhury***
Department of Plant Pathology, Lovely Professional University, Phagwara, Punjab, India.
*Corresponding author. E-mail: debjani.21697@lpu.co.in

**ABSTRACT**

Botanical pesticides are now a days being used as alternative to synthetic chemical pesticides to control insect and other pests in agriculture. After knowing the adverse effects of synthetic pesticides to the environment and other non-target organisms the researchers have grown interest towards botanical pesticides. In contrast to synthetic chemical pesticides, botanical pesticides are biodegradable and do not leave residues in plant system. The plant extracts are being used in agriculture and other fields for controlling insects and other pests from ancient times especially in India. In the recent year's researchers are working towards identifying and sourcing environmentally friendly plant-based pesticides to lower the usage of synthetic pesticides. These botanical pesticides are being prominently used in organic agriculture for pest management combining with other IPM practices. By lowering the usage of synthetic pesticides there are chances of improving quality of agricultural products and environmental conditions avoiding harm to non-target and beneficial organisms like bees and other pollinators. These botanical pesticides are being used in storage of agricultural products, sustainable agriculture and house gardens in developing countries. In this review paper, many of the recent developments in botanical pesticide discover and use along with some common botanical pesticides in market are discussed. There is a need of further research and development in the field of botanical pesticides to provide an alternative of synthetic pesticides.

***Keywords***: Introduction, Classification, Significance, Mode of action, Some commercially botanical pesticides, information of some known chemicals, role, challenges.

## Introduction

It is recognized that pathogenic microbes such as bacteria, fungi and virus are among the organisms that cause plant diseases and agriculture losses. Plants often suffer from weed competition, and are also harmed by insect attacks. It has been estimated that, pathogenic microbes, pests and weed plant species cause a crop loss of about 30 to 45percent worldwide. Of the estimated35% average losses 12% is caused by insect pests, 12% by weed plants and 11% by pathogenic microorganisms. Oreke and Dehne (2004) recorded that the actual losses for sugar beet, barley, soybean, wheat and cotton were estimated at 26-30 percent, and for maize, potatoes and rice, respectively, 35 percent, 39 percent and 40 percent for the period 1996-1998. The worldwide gross annual crop loss due to plant diseases is about $220 billion (2002 prices) (Agrios, 2005). The important discoveries of agrochemicals after World war II introduced these pesticides for the controlling of losses in crop production so mainly, we will discuss about botanical pesticides in this article.

To replace the pesticides and active ingredients not accepted by the new registration requirements and regulations, there is a need for the discovery of new pesticides such as botanical pesticides is required. For a long time before chemical pesticides were produced many botanical products have been used by farmers as crop protectants and pest repellants from various insect pests. Many phytochemicals and secondary metabolites in plants having pesticidal properties these are discovered and reported as botanical pesticides, such as essential oils, terpenes, alkaloids etc. (Copping and Duke, 2007).

Botanical pesticides or Botanicals are obtained from plants as a whole or from a part of plant. They are derived or extracted from the plant or plant part by using solvents in which the chemically active ingredient dissolves. Most commonly used solvents are water, ethanol, acetone and other organic solvents. They are not simple plant material but are the materials derived from the plants in fresh or dried state. Most of the botanicals are secondary metabolites in the plant or its parts which act as insecticides in other cases they are modified to act as insecticides. These botanicals extracted from dried plants and their parts can be used for dusting, diluted by using certain carriers like clay, diatomaceous earth etc... or can also be used in concentrated pure form based on requirement. Some of the discoveries like the insecticidal property of Parthenium hysterophorus which is actually a weed containing compound Parthenin and other compounds (Datta and Sternberg, 2005), also the antifungal properties of compounds isolated from rhizome of Ginger along with antifeeder effect on insect pest are important in botanical pesticides developed.

Chemical pesticides since their introduction to the farmers and agricultural sector there is a huge dependence on the pesticides for pest control in agriculture that is also harming the environment and humans alike. This dependence will continue as long as there is no alternative and

availability of low cost chemicals pesticides. In agriculture since the ancient Egypt, India, China civilization there is a tradition of using botanical pesticides to counter pest attack for 2 centuries (Thacker, 2002)

In the last 25 years, scientific literature explained and reported hundreds of secondary plant metabolites or phytochemicals that illustrate repellent or toxic effects of feeding of insectpests in laboratory studies and observations, also several recent volumes reported or covered botanical pesticides (Regnault-Roger *et al*. 2005).

Oerke, 2006 reported that In all regions where pest control choices are minimal, crop losses due to insects, diseases, non-insect pests and weeds are estimated at approximately 35 per cent of inmajor crops. Losses may exceed 50 per cent. In certain extreme cases, the insect pest infestation on crops may show higher losses or even overall crop failure (Grzywacz *et al*., 2014; Lingappa *et al*., 2004). In developing and transitional countries, industrial pesticides are used intensively (FAO 2013). Many livelihood or transitional farmers in developing countries have no access to or can not afford them synthetic pesticides (Abateetal, 2000; Nyirendaetal, 2011) Commercial preparations of alternative products are often not available, such as biopesticides (mainly botanicals), and can be costly as well (Amoabeng *et al*., 2014; Dougoud *et al*., 2018).

Brent and Hollomon, 1998; Dubey *et al*., 2007; Kumar *et al*., 2007: Now-a-days, in agriculture there is increased constantly of irrigation, more inorganic fertilization and more dosages of pesticides is increasing day by day due to this the crop productivity is damaging and also effects to humans. So organic farming gives best scope to agricultural production by using natural pesticides to diseases and pests. However, repeated usage of chemical fungicides led to increase resistant populations in plant pathogens. In recent years, they reduce the application of chemical fungicides in fields. Moreover, in further, the usage of synthetic chemicals for the managing of post- harvest deterioration has been taken action on their carcinogenicity, hormonal imbalance, effects of environmental pollution and some toxicity compounds that affects humans.

Cutler and cutler, (1999) by usage of synthetic chemicals for the control of plant diseases there is no doubt to increase the production and productivity of crops. But (Sharma and Meshram 2006) discussed that due to some toxic effects on the resistant strains on food grains causes health problems. So, (Okonkwo and Okoye 1996) reported that organic farming and biological methods are the most successful achievements in agriculture and also several methods of using organic methods, in that the most important one is botanical pesticides which can give good health, rich source of plants and became really important in to-days farming.

Elisa GPL *et al.* (2012) reported the existence and usage of botanical pesticides for pest management of crops in ancient civilizations in many parts of the world for centuries (about 1500 BC). Some of the countries using botanical pesticides in ancient times are Asia (Rotenone), India (Neem), Iran (Saabadilla) etc. from these countries these botanical pesticides were later introduced and adapted by the developed countries like Unites States, Europe and others

Anupam *et al*. (2012): Botanical pesticides or Botanicals are basically phytochemicals or secondary plant defence metabolites that help plants resist a constant selection of herbivore predators and other environmental factors. For their insecticidal activities, many classes of plant chemicals, including steroids, alkaloid, terpenoids, phenolics and essential oils, have been previously recorded from over 2000 plant organisms. Phytochemicals were used for mosquito control applications since 1920, but conventional chemical insecticides such as DDT and others were discovered around 1940 which reduced the use of plant chemicals. Chemical insecticides are simple to quickly spread as they win market room as effective, cheaper, reliable to readily available goods. Following infringements of synthetic insecticides and the use in the nature, the focus was on phytochemicals which could be quickly biodegraded and had no harmful effects on non-target species. From the 1990s on there was a renewed interest in the use of biopesticides (botanicals) because of the harmful effects of chemical pesticides on humans and environment. Phytochemicals actually make up 1 % of the global pesticide market.

Prakash and Rao (1996): India being a tropical country is the source of different plants that contain phytochemicals and secondary derivatives that could use in formulation of different botanicals. These botanicals can replace the present-day chemical pesticides as they are environmentally friendly and safe. The botanicals are prepared from whole plant or a part of plant in fresh or dried form containing potential active ingredients with insecticidal and pathogenic properties.

**Classification of pesticides**

The pesticides are classified based on different criteria like mode of of action, based on target pest, based on origin, based on the active ingredient, based on toxicity and others. The commonly followed classification with two broad categories is Synthetic chemical pesticides and Naturel biological pesticides. The Synthetic chemical pesticides are again dividing in to various classes based on the active ingredient present in them and the Naturel biological pesticides are divided into four groups namely Botanical pesticides (Botanicals), Pheromones, Microbial pesticides and Plant integrated proteins. Among these Botanicals are proved effective and efficient.

**Significance of Pesticides**

There is a need to increase the yield and improve quality of the crops which can be done by following proper agricultural practices but the pests mainly insect pests tend to damage the crop and also the stored agricultural products. The insect pests cause significant losses to the agricultural fields and commodities to effectively eradicate these insect pests there is a need for the use of pesticides. The pesticides are needed in the field conditions also in the storage conditions to avoid the attack of storage grain pests which may lower the quality of stored grains and other agricultural commodities. The pests are known to attack the crops at pre-harvest, harvest and post-harvest stages causing significant losses, pesticides play a significant role in avoiding losses by eradicating pests. Even though pesticides have become significant in agriculture these days we should use them judicially and as per need.

**Mode of action**

Basically, to know whether a chemical compound has pesticidal properties or not we consider the biochemical chances it does to the insect pest which refers to the mode of action. The mode of action of many pesticides are by effecting certain enzymes, biochemical processes etc. in the pest, which in turn effects the physiology of the pest. The mode of action is classification of pesticides is bases on the changes in biological processes due to pesticides in the insect pest (Bloomquist *et al.*, 2008).

The knowledge of the mode of action of pesticide is important for the scientists to develop the quality and effects of the product. The scientists investigate and understand all the basic biological processes in normal state of insect then the changes caused by pesticide to these processes are known to formulate and change pesticide. The mode of action is also important to prepare antidotes and other measures to be taken if human accidents occur due to pesticides. Finally understanding the mode of action of pesticide is important to know if target pest has resistance to it or gained resistance so as to change the pesticide (Brown, 2005).

**Botanical pesticides**

These are a subgroup of biopesticides produced from plants used as alternatives of synthetic pesticides in integrated pest management (IPM). Also known as Botanicals. Botanical pesticides are naturally present in plants as secondary metabolites (phytochemicals) which are used as repellants, anti-feeders, in pest management. These can be extracted from various plant species and different parts of plant. The feature of botanicals like less bioaccumulation and lack of residues in plant and environment, selective to pests, and low toxicity to humans and other organisms (Grdisa and Grsic, 2013) led to the discovery and study of different botanical pesticides from different plant species and parts. They are safer than conventional chemical pesticides to environment, humans and other organisms (Dimetry, 2014). Thus, botanical pesticides gained a greater importance in research of integrated pest management and Organic agriculture.

Botanical pesticides are naturally occurring chemical compounds present in the plants of different species. These chemicals are extracted and used for the preparation of botanical pesticides. They are known to be less harmful to humans and other organisms than synthetic pesticides. But some are known to be poisonous to humans and may act as fast acting poisons (Regnault- Roger *et al.*; 2005; Regnault-Roger and Philogene, 2008).

**Some commercially available botanical pesticides**

**Neem based Pesticides**

These are the chemicals obtained from the extracts of Azardirachta indica (neem tree), a member of the Meliaceae family (Campos *et al*., 2016). Neem tree extract contains a number of potent active ingredients like azadirachtin, nimbin, meliantriol, desacetylnimbin, nimbidin, salannin and desacetylsalannin. Azadirachtin is proved to be the most potent active compounds among other compounds in the neem tree extract, which is chemically a tetranortriterpenoid limonoid, [Mordue (Luntz) and Blackwell, 1993]. Azadirachtin is high in seeds of the neem tree (0.2 – 0.6%) compared to leaves, stem of the neem tree (Govindchari, 1992).

Sola *et al*. (2014), reported that Azadirachtin A form has higher insecticidal activity compared to other analogs or forms of azadirachtin. The most effective insecticide against 550 species of insects is Azadirachtin, primarily related to Dictyoptera, Orthoptera, Isoptera, Lepidoptera, Hemiptera etc.

Bramhachari (2004) reported that Azadirachtin shows a broad range of actions or effects on insect pests such as repellant, insect growth suppressor, antifeedant etc...

Recently, it has been reported that extraction of neem compounds by ethanol is highly effective against the pest species, Aleurodicus disperses(spiraling white fly) which is a pest of various vegetable plants. The mixture of acetone extract of crown flower and ethanolic extract of neem seed in the ratio 3:1 shows higher insecticidal effect against spiraling white fly compared to other combinations formulated in their study (Alim *et al*., 2017). Ali *et al*. (2017) reported neem seed extract is the most effective insecticide against sucking insect pests, compared to other plant extracts used in their research work.

**Rotenone:**

Rotenone is a broad-spectrum botanical, which is extracted from the stems and roots of different tropical legume species like *Tephrosia virginiana, Lonchocarpus* species (*L utilis, L urucu*) and Derris species (*D elliptica, D involuta*) (Isman, 2006). Rotenone is chemically a bioflavonoid present in roots and stems of the above legume species. The dried root powder is directly used or sprayed by making spray solution. Rotenone, can act as a contact poison, food poison, stomach poison, cellular respiratory enzyme inhibitor.

Isman, 2006; El-Wakeil (2013) reported that pure form of rotenone has the toxicity similar to DDT (synthetic chemical pesticide) in terms of toxicity to mammals like rat. LD50 of rotenone is 132 mg/ kg of rat orally.

**Pyrethrum:**

Pyrethrum is a botanical pesticide used globally which is extracted from Chrysanthemum flowers (El-Wakeil, 2013). The pyrethrum is chemically present in all parts of the plant but higher concentration in flowers (Sola *et al*., 2014).

Grdisa and Grsic (2013) Pyrethrum has been reported to be a blend of six potent active ingredients consisting of pyrethrin I and II, jasmolin I and II, cinerin I and II. There are two types of active ingredients dependent on the formation of esters. The Chrysanthemic acid esters are Pyrethrin I, Jasmolin I and Cinerin I, while the Pyrethric acid esters are Pyrethrin II, Jasmolin II, and Cinerin II. The typical pyrethrum extract includes jasmolins, cinerins andpyrethrins, in the ratio of 1: 3: 10. Pyrethrins are thus the primary type of possible active ingredients in terms of concentrations relative to cinerins and jasmolins.

**Eucalyptus Essential oil:**

A complex blend of different phytochemicals such as monoterpenes, sesquiterpenes, aromatic phenols, oxides, ethers, alcohols, aldehydes, and ketones is eucalyptus oil. The structure of the chemical components and the percentage of them varies with the genus. 1, 8-cineole (eucalyptol),

citronellal, citronellol, citronellyl acetate, p-cymene, eucamalol, limonene, linalool, and alpha-pinene are responsible for the pesticide activity of eucalyptus oil (Batish *et al*., 2006; Su *et al*., 2006; Batish *et al*., 2008). Among the different components of essential oil, 1, 8 – cineole is the most important characteristic compound for the pesticidal activity (Batish *et al*., 2008). In addition to the Eucalyptus essential oil, Eucalyptus leaf extracts often have insecticidal efficacy against different pests. Uh, Koul *et al*. (2008) showed that Eucalyptus globulus Labill essential oil, consisting of eucalyptol, alpha-pinene, and alpha-cymene, was an effective repellent against target pests. The leaf powder of Eucalyptus globulus L. was found to have shown insecticidal action against *Prostephanus trunatus* (Mukanga *et al*., 2010 and Singh *et al*. (2012) found that insecticidal action against test insects, namely *Aphisgossypi Glover* (aphids) and *Phenacoccus solenopsis* Tinsley (mealy bugs) in vitro, was substantially demonstrated by the leaf extracts of three plants, namely *Azadirachta indica, Ocimum sanctum* L., and *Eucalyptus globulus*.

**Information of some of the known phytochemicals with pesticidal properties along with their mode of action and use on different pests species.**

| Name | Sources | Mode of action | Uses |
|---|---|---|---|
| Sabadilla | Seeds | Toxic alkaloids influence the activity of cell membrane, and also the loss the functions of nerve cell membrane, paralysis and death. (Isman 2006)<br>Affect with Na & k ions in nerve cells. | Control of caterpillars, leaf hoppers, squash bugs, stink bugs, thrips.<br>Act as contact and stomach poisons. |
| Ryania | Woody stems | Active compound: ryanodine. Itdoes not cause paralysis or knock down the insect pest. After ryanodine is ingested by the insect, it stops feeding and die.<br>An alkaloid inhibits the release of calcium in muscle tissues (Weinzierl 2000; Isman 2006). | It is a slow stomach poison for larval stage. |
| Nicotine | Tobacco plants | Alkaloids present in the leaves(nornicotine and anabasine) mimic the neurotransmitter acetylcholine and causes symptoms of poisoning same as that of insecticides of organophosphates and carbamates group (Regnault Roger and Philogene 2008). In addition, Alkaloids are known to be potent against nicotinic acetylcholine receptors in Haloxylon salicornicum and Stemona japonica (El-Shazly *et al*., 2005). | It is fast – acting nerve nerve toxin. |
| Synthetic pyrethroids | Flowers | In sensory organs and in myelinated nerve fibres, these compounds cause extreme repetitive activity (Henk *et al*., 1982). Pyrethroids are also known to induce sodium current prolongation along with repeated activity in invertebrate nerve fibres. Narahashi, 1976). | |

**Mechanisms of botanical pesticides**

| Name | Crop | Mechanism of action | Source |
|---|---|---|---|
| Mesotrine | Maize | Prevents 4-hydroxyphenyl pyruvate deoxygenase | *Callistemon citrinus* |
| Essential oil | Rice weevil | Prevents acetylcholinesterase | *Adenophora remotflora* |
| Astilbin | Lonchuphorus speciosus | Disturbance the integration of cell membrane (Abdelglaeil *et al*., 2002). | *Dimorphandra controls Spodoptera frugiperda* |
| Flavonoids | Castor oil | Agents of antimicrobial activities (Liu 2006). | *Bacillus firmus* |
| Limonoids | Stem bark | It reported first on antifungal compounds | *Khaya ivorensis* |

**Role of botanical pesticides in future:**

**Which role in crop defense and other uses will botanical pesticides play in the near future?**

It is difficult to conceive in developed countries that botanicals are more essential than today, even in the processing of organic food. According to National Research Council 2000in Europe and North Americaorganic crop production is expected to rise by 8 to 15 per cent per annum and in those markets the fewest competitors are botanical products. However, even there have been effective and cost-effective microbial insecticides and spinosads. The use of botanicals in crop defensive rotations, in accordance to recorded resistanceto bacillus thuringienesis and spinosad by diamondback moth due to overuse, may be best stated rather than as stand-alone products (Zhao *et al*., 2002). The traditional farming industry is facing immense competition for synthetic Insecticides such as neonicotinoids from the current wave of "reduced risk."

The benefits of the botanical pesticides over conventional chemical pesticides can be observed in developed countries due to high costs of conventional chemical pesticides. The botanical pesticides can be used in storage and warehouses also to avoid storage pests. In fact, when conventional pesticides are cost-effective to farmers (e.g., government subsidies), there are still thousands of incidental contaminants every year (Isman, 2006), owing to low alertness and lack of protective equipment.

Morse *et al*. 2002, discussed about the review on botanical pesticides is developing day by day all over the world as they produce more efficacies to the plants to reduce the crop productivity of causing with the diseases and pests and factors affecting in the environment in the research community of bioactive substances.

**List of important botanical pesticides to control plant disease management:**

| Plant | Parts used | Form of use | Disease controlled | Reference |
|---|---|---|---|---|
| Neem (*Azardirachta indica*) | On the leaf | Ash method | When crop in pre emergence seed stage | Enikuomehin *et al*. (1998) |
| | On the leaf part | Dust method | Cauliflower crop, the disease observes in collar root. | Enikuomehin *et al*. (1998) |
| | On leaves | Extraction method | In groundnut crop like rust disease, chili like leaf spot, etc. | Lokhande *et al*. (1998) |
| | | Oil and cake method | Many diseases controlled like leafspot, leaf curl, leaf blight of tomato, chili, groundnut etc. | Prasad *et al.* (1998) |
| Garlic (*Allium sativum*) | On leaves | Extract method | Diseases like chili stem rot, arecanut stem rot, wilt of gladiolus | Lyer *et al.* (2004)<br>Mathur and Gurjar (2002)<br>Jha *et al*. (2004)<br>Tomar and chandel (2006) |
| Onion (*Allium cepa*) | On seeds | Extraction method | Diseases like Early and late blight of potato, maize leaf blight | Abd – El – Khair and Wafaa (2007)<br>Jha*et al*, ( 2004) |
| Chilli (*Capsicum frutescens*) | On fruits | Extract method | Disease of muskmelon like fusarium wilt. | Browers and Locke (2000) |
| Eucalyptus (*Eucalyptus globosus*) | On leaves | Extract method | Diseases of potato Early and Late blight | Abd – El – Khair and Wafaa (2007) |
| Lemon grass (*Cymbopogon citratus*) | On leaf | Extract method | Diseases of cabbage and mustard like bacterial soft rot and Alternaria blight | Aced *et al*. (1999)<br>Patni *et al*. (2005a) |
| Peppermint (*Mentha piperata*) | On leaf | Extract method | Disease of potato | Abd – El – Khair and Wafaa (2007) |
| *Mentha arvensis* | Oil method | - | Diseases of citrus rot | Tripathi *et al*. (2004) |
| Tulsi (*Ocimum sanctum*) | On leaf | Extract method | Diseases of rice, cowpea like sheath rot and wilt and charcoal rot | Pramanick and phookan (1998)<br>Ushamalini*et al*. (1997) |
| Basil (*Ocimum baccillium*) | On leaf | Extract method | Diseases of rubber | Ogbebor and Adekunle (2005) |
| Calotropis procera | - | Extract method | Diseases of mustard, chickpea like Alternaria blight, root knot | Patni *et al*. (2005 b)<br>Jain and Trivedi (1997) |
| Cotton | On seeds | Cake method | Diseases of sunflower, sorghum like root, stalk rot | Ehteshamal Haque *et al*. (1998) |
| Datura (*Datura fastuosa*) | On leaf | Extract method | Diseases of sunflower root | Ehteshamal Haque *et al*. (1998) |
| Safflower | On seed | Cake method | Disease of sorghum stalk rot | Hundekar*et al*. (1998) |
| *Ipomoea carnea* | On leaf | Extract method | Disease ofleaf spot of faba bean | Mahmoud *et al*. (2004) |
| Rosemary & lavender | On leaf | Extract method | Diseases of cocao black pod | Widmer and Laurent(2006) |
| Tobacco | | Decoction method | Disease of potato Early blight | Patil *et al* (2003) |
| Ashoka | On leaf | Extract method | Disease of mango blight | Bhende and Deshmukh (2003) |

**Challenges of commercializing botanical pesticides:**

Manas Sarkar (2014) reported that There has been extensive study in the world in a attempt to find remedies by botanicals for pervasive harmful insects. However, very few research ventures contribute to independent releases of products. For saving cost, time and resources, all people want fast results. Much scholarly study is, however, perhaps inadequate due to its short-term design objectives. These results in badly performed research, insufficient data, weak examination, disabled data and simplistic tests aimed solely at publishing. Funding agencies should also seriously examine how science hits the end through the comprehensive research and teamwork of multiple stakeholders. Once bioactivity is detected in the plants, it becomes a major obstacle in the introduction and selling of the plant-based commodity. First and foremost, proof of concept data should be produced by the collection of the particular species from differentPhyto- geographic locations, the collection of the species at different seasons of the year, the collection of different species at different times, the collection of different plant sections / parts of the same species, the processing up to extraction and, finally, the systematic biological assessment of the insect pest concerned. The potential environmental sources of bioactivity must also be ruled out side by side (e.g., whether or not the leftover pesticide is effective that may have been sprayed on crops or on agricultural land).

Rajendra Kshirsagar (2014) discussed about the Herbal /Ayurveda medicine consumption is widespread and growing. Harvesting herbs from the wild is the main source of raw material, causing depletion of genetic diversity and disruption to plant habitat. Domestic cultivation is therefore a viable alternative that offers the opportunity to overcome difficulties of inconsistency in plant materials and extracts due to factors such as incorrect identification, phenotypic and genetic variability, variability of extracts and unstable nature for longer periods, toxic components and contaminants. Raw material procurement is a real problem for the selling of any plant-based commodity. The propagation cultivation of every wild species is not possible. If they are to be seed propagated, then germination, followed by domestication tests, understanding the species and formulating cultivation and management practices, determining the fertilizer requirement and other agrochemicals if required, re-establishment of the bioactivity profile of species obtained from ex-situ cultivation, considering factors such as climate change, soil profile, precipitation, cultivation temperature of crop rotations.

## Conclusion

Currently bio pesticides and other biological control measures are playing a vital role in integrated agriculture in India and all over the world. For completing the needs of the growing population there is a need to the development of sustainable agriculture so there should be an alternative to the chemical fertilizers, fungicides and pesticides. Bio pesticides are considered the suitable and better alternative to the chemical pesticides and others. Many naturally occurring products are being used as bio pesticides among them botanical pesticides are regarded as environmentally friendly and nontoxic to other non-target organisms. The properties of botanical pesticides such as low bioaccumulation in environment and less hazardous nature then synthetic pesticides make them favorable to environment and humans. Additionally, it is accepted that complex chemical nature of the botanical pesticides makes it difficult for the pest to gain resistance compared to chemical pesticides. But there is a long way to go in the identification, development and commercialization of the botanical pesticides because of the following reasons; the botanical pesticides are specific to pest the discovery of the active compound in plants to be used as pesticides and its extraction are costly. The process of identification and extraction of botanical pesticides takes longer time period than synthetic chemical pesticides. Following the production of botanical pesticides there are many problems in commercialization and acceptance by the farmers. Botanical pesticides are not easily accepted by the farmers as they are costly over the chemical pesticides and their effectiveness can vary in the field conditions and laboratory. Finally, there is a need of development and commercialization of the botanical pesticides for a sustainable and healthy supply of food to the World.

## References


Agrios, G. N. 2005. Plant Pathology. 5th ed. Elsevier Academic Press, Burlington, Mass., USA.

Agarwal *et al*., 2001. Insect growth inhibition, antifeedant and antifungal activity of compounds isolated/derived from Zingiber officinale Rosae (Ginger) rhizomes. Pest Management Science 57:289-300.

Abate T, Ampofo JK, Van Huris A, (2000) Pest management strategies in traditional agriculture: an African perspective. Annu Rev Entomol 45: 631-659.

AmoabengBW, Gurr GM, Gitau CW, Stevenson PC (2014); Cost: benefits analysis of botanical insecticide uses in cabbage: implications for smallholder farmers in developing countries. Crop Prot 57:71.

Anupam G, Nandita C, Goutam C (2012) Plant extracts as potential mosquito larvicides. Indian J Med Res 135: 581-598.

Ali SS, Ahmed SS, Rizwana H, Bhatti F, Khoso AG, Mengal MI, Jatoi JH, Bugti A, Rind MA and Shahwani SA (2017) Efficacy of different biopesticides against major sucking pests on brinjal under field conditions. J. Basic Appl. Sci., 13: 133 – 138

Alim MA, Song J, Lim UT, Choi JJ and Hossain MA (2017) Bioassay of plant extracts against Aleurodicus dispersus (Hemiptera: Aleyrodidae). Florida Entomologist, 100 (2): 350 – 357.

Abdelglaeil SAM, Hashinga F and Nakatani M. 2002. Isolation of diterpenes from Euphorbia paralias. Pest Management Science 58: 123-127

Abd – El – Khair, H. and Wafaa, M.H. (2007). Application of some Egyptian Medicinal Plant Extracts Against Potato Late and Early Blights. Research J. Agric. Biological Sci, 3(3): 166-175.

Aced, A. L. Jr; Acedo, J.Z. and Evangelio, M.F.N. (1999). Post -harvest biocontrol of bacterial soft rot of cabbage using botanicals. Phillipines J. Crop Sci.. 24(1):12.

Brent, K.J. and Hollomon, D.W. (1998): Fungicide resistance: the assessment of risk. FRAC, Global Crop Protection. Federation, Brussels, Monograph. 2: 1-48.

BloomquistJR, Chow E, Renia M, Carlier PR, Gonzalez-Coloma A, Boina DR (2008): Mode of action of the Plant-derived silphinenes on insect and mammalian GABAA receptor/chloride channel complex. PesticiBiochem&physiol 91: 17-23

Brown AE (2005): Mode of action of insecticides and related pest control chemicals for production agriculture, ornamentals and turf, Pesticide Info Leaflet Nr 43: 1-13.

Brahmachari G (2004) Neem – an omnipotent plant: a retrospection. Chembiochem., 5: 408 – 421.

Batish DR, Singh HP, Setia N. Kaur S and Kohli RK (2006) Chemical composition and phytotoxicity of volatile essential oils from intact and fallen leaves of Eucalyptus citriodora. Z. Naturforsch. c61: 465 – 471.

Batish DR, Singh HP, Kohli RK and Kaur S (2008) Eucalyptus essential oil as a natural pesticide. For. Ecol. Manag., 256: 2166 – 2174.

Bowers, J. H., and Locke, J. C. (2000). Effect of botanical extracts on the population density of Fusarium oxysporum in soil and control of Fusarium wilt in the greenhouse. Plant Dis. 84:300-305.

Bhende, P.B. and Deshmukh, V.V. (2003). Efficacy of fungicides and plant extracts against Alternaria alternata in vitro of mango. Research on Crops. 4(1): 148-149.

(Cutler, H. G. and cutler, S. J. (1999): Biological Active Natural Products: Agrochemicals, CRS Press, Boca Raton, USA. 299 P.

ChengalaLaxmishree and Singh Nandita (2017); Botanical pesticides- a major alternative to chemical pesticides: Int. J. of Life Sciences, 2017, Vol. 5 (4); 722-729.

Campos EVR, de OliveiraJL, Pascoli M, de Lima R, Fraceto LF (2016) Neem oil and crop protection: From now to the future, Front Plant Sci., 7:1494

Dehne, H.-W and Oerke, E. C. 2004. Safeguarding production losses in major crops and the role of crop protection. Crop Prot. 23: 275–285.

Duke, S. O. and Copping, L. G. 2007. Natural products that have been used commercially as crop protection agents. Pest Manag. Sci. 63: 524–554.

(Dev S and Koul O(1997); Insecticides of natural origin. Harwood Acad, Amsterdam, p 365

Dhaliwal GS, Koul O (2001); Phytochemical biopesticides. Harwood AcadAmster, p 223

Dougoud J. Edgington S, Cock MJW, Kuhlmann U (2018). A baseline study using plantwise information to access the contribution of extension services to the uptake of augmentative biological control in selected low- to lower-middle-income countries. BioControl 63(1):117.

Dubey, R. K; Raiesh, K. Jaya, and Dubey, N. K. (2007); Evaluation of Eupatorium cannabinum Linn. Oil in enhancement of shelf life of mango fruits from fungal rotting. World Journal of Microbiology and Biotechnology, 23: 467-473.

Dimetry NZ (2014) Different Plant Families as Bioresources for Pesticides. In: Advances in Plant Biopesticides, D. Singh (Ed.), Springer India. DOI: 10.1007/978-81-3222006-0_1

Elisa GPL, Laura P, Graciela BZ, Víctor M, VelázquezH (2012) In: Current Status: Mexican Medicinal Plants with Insecticidal Potential, Bioactive Compounds in Phytomedicine, Prof. IrajRasooli (Ed.), Mexico.

El-Wakeil NE (2013) Botanical Pesticides and Their Mode of Action. GesundePflanzen , 65, 125-149.

El-Shazly AM, Dora G, Wink M (2005) Alkaloids of Haloxylon salicornicum (Moq.) Bunge ex Bioss. (Chenopodiacea). Pharamize 60:949-952

Enikuomehin, O.A.; Ikotum, T. and Ekpo, E.J.A. (1998). Evaluation of ash from some tropical plants of Nigeria for the control of Sclerotium rolfsiisacc. On wheat (Triticum aestivum L.) Mycopathologia.142(2): 81-87.

Ehteshamal Haque; Zaki, M.J.; Vahidy, A.A. and AbaulGraffars. (1998). Effect of organic amendments on the efficacy of Pseudomonas aeruginosa in the control of root rot diseases of sunflower. Pakistan J. Botany, 30(1):45-50

Forget G, Goodman T, de Villiers A (eds) (1993) Impact of pesticide use on health in developing countries. IntDev Res Centre, Ottawa p 335

Grzywacz D. Mushobozi WL, Stevenson PC, Wilson K, BelmainS, (2014) The use of indigenous ecological resources for pest control in Africa. Food Sec 6(1):71.

Grdisa M and Grsic K (2013) Botanical Insecticides in Plant Protection. Agriculturae Conspectus Scientificus, 78 (2): 85 – 93.

Govindchari TR (1992) Chemistry and biological investigation on Azadirachta indica (the neem tree). Curr. Sci., 63: 117 – 122

Haynes KF (1998) Sublethal effects of neurotoxic insecticides on insect behavior. Ann Rev Entomol 33: 149-168

Hollingworth RM, Hedin PA, Miyamoto J, Thompson DGMasler EP, (eds) (1997) Phytochemicals for pest control. American Chemical Society, Washigton DC, p 372.

Isman MB (2006) Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu. Rev. Entomol., 51: 45 – 66

Iyer, R.; Meera, P. Lekha, G. Hedge, V, and Gunasekharam, M. (2004). Management of basal stem rot of Areca catechu L. in India. Journal of Plantation Crops. 32(1): 25-27

Kumar, R; Dubey, N. K. Mishra, A. k. and Tripathi, Y. B. (2007): Evaluation of Chenopodium ambrosoides oil as a potential source of antifungal, ant aflatoxigenic and antioxidant activity. International Journal of Food Microbiology, 115: 159-164

Khambay BP, Jewess PJ, Batty D, Bateman GL., Hollomon DW (2003); Mode of action and pesticidal activity of the natural product dunnione and of some annalogues. Pest Manag Sci 59: 174-182

Koul O, Singh G, Singh R, Singh J, Daniewski WM and Berlozecki S (2004) Bio efficacy and mode of action of some limonoids of salannin group from Azadirachta indica A. Juss and their role in a multicomponent system against lepidopteran larvae. J. Biosci., 29: 409 – 416

Koul O, Waliai S and Dhaliwal GS (2008) Essential oils as green pesticides: potential and constraints. Biopest. Int., 4 (1): 63 – 84.

Lingappa S, Kulkami KA, Basavanagoud K, Kambrekar DN, K Patil RS, (2004) Threat to vegetable production by diamondback moth and its management strategies. In Fruit and vegetable diseases. Kluwer Academic, Dordrecht, pp 357-396

Liu A, Ou X, Huang M, Wang X, Liu X and Yao J. 2006. Mesotrine: a New Selective Herbicide for use in Maize Pest Management Science 57: 112-117.

Lokhande, N, M.; Lanjewar, R. D. and Newaskar. V.B. (1998) Effect of different fungicides and neem products for control of leaf spot of groundnut. J. Soils and Crops.8(1); 44-49

Menn, J. J. andCopping, L. G. 2000. Biopesticides: a review of their action, applications and efficacy. Pest Manag. Sci. 56: 651–676.

Mordue (Luntz) AJ and Blackwell A (1993) Azadirachtin: An Update. J. of Insect Physiology,39, 903-924

Mukanga M, Deedat Y and Mwangala FS (2010) Toxic effect of five plant extract against larger grain borer, Prostephanus truncates. Afr. J. Agricul. Res., 5 (24): 3369 – 3378

Mathur, K.; and Gurjar, R.B.S. (2002). Evaluation of different fungal antagonists, plant extracts and oil cakes against Rhizoctonia solani, causing stem rot of chilli. Ann. PI. Protec. Sci. 10(2): 319-322.

Mahmoud, Y.A.G; Ebrahim, M.K.H. and Aly, M.M. (2004). Influence of Some Plant Extracts and Micro bioagents on Some Physiological Traits of Faba Bean Infected with Botrytis fabae. Turk. J. Bot.28:519-528.

Manas Sarkar 2014Botanical Pesticides: Current Challenges and Reverse Pharmacological Approach for Future Discoveries J Biofertil Biopestici 5:2

Nyirenda SP, Sileshi GW, Belmain SR, Kamanula JF, Mvumi BM, Sola P, Nyirenda GKC, Stevenson PC (2011) Farmers ethno-ecological knowledge of vegetable pests and pesticidal plant use in Northern Malawi and Eastern Zambia. Afr J Agric Res 6(2): 41-49

Narahashi T (1976) Effects of insecticides on nervous conduction and synaptic transmission Editor(s): Wilkinson, Christopher Foster. InsecticBiochemPhysiol pp 327-352 nPublisher: Plenum, New York, NY CODEN: 34LXAP; English

Oreke EC (2006) Crop losses to pests. J Agri Sci 144(01):31

(Okonkwo, E. U. and Okoye, W. L. (1996). The efficacy of four seed powders and the essential oils as protectants of cowpea and maize grains against infestation by Callosobruchus maculate (Fabricius) (Coleoptera: Bruchidae) and Sitophuszeamais (Motschulsky) (Coleoptera; Curculionidae) in Nigeria. International Journal of pest management, 42; 143-146

Prakash, A. and Rao, J. 1996. Botanical Pesticides in Agriculture. CRC Press New Delhi, Indian.

Prasad, M.S.; Lakshmi, B.S. and Shaik Mohiddin (1998). Survival of sclerotia of Rhizoctonia solani in rice soils amended with oil cakes and green leaf manures. Ann. Agric. Res. 19 (1):44-48.

Pramanick, T.C. and phookan, A.K. (1998). Effect of plant extracts in the management of sheath rot of rice. J. Agric. Sci. Soc. North East India. 11 (1): 85-87.

Rao J, Prakash A, 1997 Botanical pesticides in agriculture. CRC Press, Boca Raton, p 461.

Regnault-Roger C, Vincent C, Philogene BJR, (eds) (2005) Biopesticides of plant origin. Lavoisier, Paris, p 313.

Regnault-Roger C, Philogene BJR (2008): Past and current prospects for the use of botanicals and plant allelochemicals in integrated pest management. Pharmac Biol 46: 41-52

Rhoda B, Freyer B and Macharia J (2006) Towards reducing synthetic pesticide imports in favour of locally available botanicals in Kenya. Conference on International Agricultural Research for Development. October 11 – 13, 2006, Tropentag, Bonn.

(Rajendra Kshirsagar (2014). Botanical Pesticides: Current Challenges and Reverse Pharmacological Approach for Future Discoveries J Biofertil Biopestici 5:2.

Sternberg and Datta 2005. Famoxadone: the discovery and optimization of new agricultural fungicide. Pest Management Science 62: 1228-1234

Sharma, K. andMeshram, N. M. (2006). Bioactivity of essential oils from Acorus calamus Linn. And Syzygiumaromaticum Linn. Against Sitophilus oryzae Linn. In stored wheat. Biopesticide International, 2: 144-152.

Sola P, Mvumi M, Ogendo JO, Mponda O, Kamanula JF, Nyirenda SP, Belmain SR and Stevenson PC (2014) Botanical pesticide production, trade and regulatory mechanisms in sub – Saharan Africa: making a case for plant based pesticidal products. Food Sec. DOI: 10.1007/s12571-014-0343-7

Su YC, Ho CL, Wang IC, Chang ST (2006) Antifungal activities and chemical compositions of essential oils from leaves of four eucalypts. Taiwan J. For. Sci., 21: 49 – 61.

Singh A, Kataria R and Kumar D (2012) Repellence property of traditional plant leaf extracts against Aphis gossypii Glover and Phenacoccussolenopsis Tinsley. Afr. J. Agricul. Res., 7 (11): 1623 – 1628.

Shaon Kumar Das2014Recent Development and Future of Botanical Pesticides in IndiaISSN: 2321-0001

Thacker JMR (2002) An introduction to arthropod pest control. Cambridge University Press, Cambridge, p, 343.

Tomar, M. and chandel, S. (2006). Use of phhytoextracts in the management of Gladiolus wilt. J. Mycol. PI. Pathol. 36(2): 142-144.

Tripathi, P.; Dubey, N.K.; Banerji, R. and Chansouria, J.P.N. (2004). Evaluation of some essential oils as botanical fungitoxicants in management of post-harvest rotting of citrus fruits. World J. Microbial. Biotech. 20 (3): 317-321.

Tang JD, Gilboa S, Roush RT, Shelton AM (1997) Inheritance, Stability and lack-of-fitness cross of field-selected resistance to Bacillus thuringensis in diamondback moth (Lepidoptera: Plutellidae) from Florida. J Econ Entomol 90:732-741

Ushamalini, C.; Rajappan, K. and Gangadharan, K, (1997). Supression of charcoal rot and wilt pathogens of cowpea by botanicals. Plant Disease Research. 12(2): 113-117

Ware GW (1983) Pesticides. Theory and application. Freeman, San Francisco, p 308.

Weinzierl RA (2000) Botanical insecticides, soaps, and oils. In: Biological and Biotechnological Control of Insect Pests, Ed. J. E. Rechcigl, N. A. Rechcigl, pp 101 – 121. Boca Raton, FL: CRC Press.

Weinzierl RA (2000) Botanical insecticides, soaps, and oils. In: Rech-cigl JE, Rechcigl NA (eds) Biological and biotechnological control of insect pests. Lewis Publishers, Boca Raton, pp 101-121;

Zhao JZ, Li YX, Collins HL, Gusukuma-Minuto L, Mau RFL rt al (2002) Monitoring and characterization of diamondback moth resistance to spinosad. J Econ Ent 95:430-436