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# Use of neem extracts as bio-pesticides: Scoping review

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**Abstract-** Consequently, with the geometrically rising world population and the increasing pressure on food items, it has become increasingly necessary to increase food production from the present level. The possibility of achieving this is not only to increase production but also to protect the crops cultivated. Crop protection can be achieved through several means. One of such is the use of pesticides. This paper, therefore, reviews the use of neem extracts as bio-pesticides among other plant species with inherent pesticidal activities. It is no doubt that the chemical pesticides or insecticides possess inherent toxic substances that endangers the ecological environment, operators of application equipment, and consumers of agricultural products. It is therefore important that we encourage the use of biological pesticides as they affect only target pests, are easily biodegradable, increase farmland fertility, are environmentally friendly, cost-effective, and simple to availability. It is also important that because of the low cost of production of biopesticides it should be encouraged as an option in India in agricultural practices.

**Key words: Neem, bio- pesticides, *Azadirachta indica*, herbal-pesticide**

## INTRODUCTION

Pesticides are substances or a mixture of substances used to prevent, destroy, repel, attract, sterilize, or mitigate pests. Biopesticides are a type of pesticide derived from natural materials such as animals, plants, bacteria, and certain minerals.[1] Although chemical pest control agents are extensively used in all countries of the world they are regarded as ecologically unacceptable. Therefore, there is an increased social pressure to replace them gradually with biopesticides that are safe for humans and non-target organisms.[2]

The neem tree (*Azadirachta indica*) is indigenous to India, it belongs to the family maliceae and all the parts of the neem tree are medicinal.[3]

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**Taxonomical Classification**

The neem plant is taxonomically classified as[4,5]:-

| | | |
|---|---|---|
| Kingdom | : | Plantae |
| Division | : | Tracheophyta |
| Class | : | Magnoliopsida |
| Order | : | Sapindales |
| Family | : | Meliaceae |
| Subfamily | : | Melioideae |
| Tribe | : | Melieae |
| Genus | : | *Azadirachta* |
| Species | : | *indica* |

*Indica* is synonymous with *Melia azadirachta* L. and *Antelaea azadirachta* (L.) Model.

*Azadirachta indica* belongs to Meliaceae, a family of dicots mostly represented by trees and shrubs. According

to National Research Council (US) Panel on Neem[6] the family includes about 51 genera and 550 species, with many of them prized for their wood, edible fruits, and medicinal and ornamental qualities.[7] It is small to the medium-sized evergreen tree with a height of 15 m (30 m maximum), having a large rounded crown (10-20 m) with spreading branches and a branchless bole (7.5 m, diameter 90 cm). The bark of the tree is thick, fissured, dark gray to red (inside) in color, and it possesses a gummy colorless span.[8] The leaves are long (20-40 cm), alternate, pinnate, exstipulate, and glabrous with a light green hue. The leaves have two pairs of basal glands with a subglabrous petiole (2-7 cm) and above, channeled rachis. Each leaf comprises 8-19 serrated, proximally alternate, ovate to lanceolate leaflets. The inflorescence is axillary clustered multiflowered thyrsus (150-250 flowers) with a length of 15-30 cm and minutes caducous bracts. The flowers of the tree are small (1 cm in diameter), white or pale yellow, and sweet-smelling.[9] They are actinomorphic, pentamerous, and bisexual or unisexual males on the same plant. The calyx of the flowers is imbricate, ovate, thin, and puberulous from the inside, while petals are free, spreading, imbricate, spathulate, and ciliolate from the inside. Fruits are single (maximum of two) and small (1-2 cm) in size.[10] They are greenish to yellow and an ellipsoidal seeded drupe. The tree has a thin exocarp, pulpy mesocarp, and cartilaginous endocarp. Seeds are unwinged, oval, or spherical structures with thin testa.

The tree has a profound taproot system with widespread lateral roots. It may form suckers if roots encounter some damage in different parts of the neem plant. Of its biological constituents, the most active and well-studied compound is Azadirachtin.[1] However, in most traditional preparations of neem as pesticide or medicine, a mixture of neem chemicals is present and provides the active principles. Several kinds of azadirachtins have been isolated, the most abundant of which is Azadirachtin.[11] The neem terpenoids are present in all parts of the plant, in the living tissues. Recently, the site of synthesis and accumulation of the neem chemicals have been identified as secretory cells. Secretory cells are the most abundant in the seed kernels.[12] The secretory cells can be seen with iodine solution. Besides the terpenoids, neem also contains more than 20 sulfurous compounds responsible for the characteristic smell of crushed seeds and neem oil.[13]

## MATERIALS & METHODS

Scoping review method was used to find the results related to the research question. The literature was searched from different electronic and online free asses data based. Only the English language and the refereed journal were included in the study.

## RESULT & DISCUSSION

According to National Research Council (US) Panel on Neem (1992)[14] Neem oil is recognized as a powerful biopesticide and may offer a solution to global agricultural, environmental, and public health problems. The neem seed oil allelochemicals are reported to have feeding and oviposition deterrence, repellency, growth disruption, reduced fitness, and sterility activities, and hence have been widely used in agricultural pest control. In neem seed oil, high concentrations of bioinsecticide limonoids are reported.

The most potent limonoid in neem seed oil, azadirachtin, primarily acts as an insect repellent and insect growth regulator. Its structure is similar to that of insect hormones, "ecdysones," responsible for metamorphosis in insects. It is active at minute concentrations (1-10 ppm) and responsible for hindering the action of ecdysones, thus preventing the larvae from shedding their exoskeletons. Thus, azadirachtin alters their life cycle and inhibits the development of immature insects.[15] Neem seed oil exhibits antifeedant and oviposition deterrent activity.[16]

Antifeedent activity, credited to azadirachtin, Nimbin, Salannin, epoxyazadiradione, and melandriol, causes antiperistaltic movement in the alimentary canal and initiates a vomiting sensation in the insect.[17] The nauseated feeling and inability to swallow do not allow insects to feed on NSO-treated surfaces. It checks to feed in approximately 200 types of insects at concentrations of 10-100 ppm. Similarly, NSO sprayed during storage does not allow female insects to lay eggs.[18] The broad-spectrum activity coupled with non-toxicity to mammals brands NSO as a perfect candidate for biopesticide treatment. The use of biopesticides is assumed to be a significant component of integrated pest management for the realization of sustainable agriculture, due to their economic viability and eco-friendly nature. Recent research has been conducted to exploit neem pesticide potential in agriculture has been described in table 1.

Neem pesticides play a vital role in pest management and hence have been widely used in agriculture.[19] There has been an evident shift all over the world from synthetic pesticides to non-synthetic ones. This is largely because of the widespread awareness of the side effects of these synthetic pesticides not only on plants and soil but also on other living organisms.[20] This is a great opportunity for neem pesticides manufacturers to cash in on the growing popularity of natural or herbal pesticides. Neem pesticides are being manufactured and exported to various countries as a lot of research has been conducted to test the safety and efficacy of neem for use as a pesticide.[19]

Azadirachtin is the main ingredient used to manufacture bio-pesticides. Neem oil and seed extracts are known to possess germicidal and anti-bacterial properties which are useful to protect the plants from different kinds of pests. One of the most important advantages of neem-based pesticides and neem insecticides is that they do not leave any residue on the plants. It also helps to nourish and condition the soil, it is environmentally friendly, it is non-toxic and it can be used in combination with other pesticides and oil for more effectiveness. Instead of killing the pests, it affects the life cycle of the pests. Anti-feedant properties found in neem compounds help to protect the plants.[21] Pests generally do not develop a resistance to neem-based pesticides.

Neem pesticides are generally water-soluble and help in the growth of plants. It acts as a pest repellent and pest reproduction controller. The transition from the use of synthetic products to natural ones is evident in the agricultural industry also.[22] Excessive use of synthetic insecticides has resulted in a series of problems like the development of insect resistance to insecticides, harm to other natural enemies of insects, toxic effects on plants and soil, etc. Neem is being used to manufacture what is known as natural or bioinsecticide, which is environmentally friendly and does not have any toxic effects on plants and soil.[23]

Neem insecticides are used to protect both foods as well as cash crops like rice, pulses, cotton, oils seeds, etc. Great for use on all crops, trees, plants, flowers, fruits, and vegetables around the home as well as organic and commercial growers. Active ingredient Azadirachtin, found in neem trees, acts as an insect repellent and insect feeding inhibitor, thereby protecting the plants.[24] This ingredient belongs to an organic molecule class called tetranortri terpenoids. It is similar in structure to insect hormones called "ecdysones," which control the process of metamorphosis as the insects pass from larva to pupa to the adult stage. It is interesting to note that neem doesn't kill insects, but alters their life process. The major parts/ extracts of neem seed that are used for making neem insecticides.[25]

**Table 1- Neem pesticide potential in agriculture**

| Crop | Pathogen/Disease | Treatment | Reference |
|---|---|---|---|
| Mango | Powdery Mildew and Mango Malformation | Neem oil (1%) | Chaudhary *et al.,* 2017[1] |
| Cowpea (Brazil) | *Spodoptera eridania* (southern armyworm) | Neem oil (0.35% and 0.7%) | Campos *et al.,* 2016[2] |
| Brinjal | Shoot and fruit borer | Neem oil | Thakore *et al.,* 2017[3] |
| Cowpea | *Maruka vitrata* | Multinucleopolyhedro virus + neem oil | Acheuk *et al.,* 2022[7] |
| Kinnow mandarin | *Penicillium digitatum* and *P. italicum* | Neem essential oil | Ali *et al.,* 2021[9] |
| Cultivated crops | *Helicoverpa armigere* | Neem oil | Chaudhary *et al*., 2017[1] |
| Cotton | Cotton pest | *Beauveria bassiana* + neem oil | Mossa *et al.,* 2018[29] |
| Cabbage | Cabbage aphid | Neem oil (1%) | Siegwart *et al.,* 2015[12] |
| Okra | Whitefly | Mineral oil + Neem oil | Braga *et al*., 2021[13] |
| Western white pine | *Zootermopsis augusticollis* (Dampwood termite) | Neem oil | Winkaler *et al*., 2017[19] |
| Cashew trees | *Toxoptera odinae* | Neem oil | Mantzoukas *et al.,* 2020[25] |
| Stone fruit | *Monilinia fructicola* | Neem oil | Senthil *et al.,* 2013[26] |
| Watermelon | *Aphis gossypii* | Neem oil | Benelli *et al.,* 2017[27] |
| Coconut | *Aceria guerreronis* | Neem oil (3%) | Shah *et al.,* 2019[28] |

According to recent studies conducted on parts of neem, it was found that neem seed extracts contain azadirachtin, which in turn works by inhibiting the development of immature insects.[29,30] Neem oil or neem seed oil is extensively used to manufacture insecticides used for different crops. Neem oil enters the system of the pests and obstructs their proper working. Insects do not eat, mate and lay eggs resulting in the breaking of their life cycle.[31] Another interesting function of neem oil pesticides is that they do not harm beneficial insects. The neem oil insecticides only target chewing and sucking insects.[32]

Regulation of the insects' growth is a very interesting property of neem products which is unique since the products work on juvenile hormones. The insect larva feeds and as it grows, it sheds its old skin. This particular shedding of old skin is the phenomenon of ecdysis or molting and is governed by an enzyme, ecdysone.[33] When the neem components, especially azadirachtin, enter the body of the larva, the activity of ecdysone is suppressed and the larva fails to molt, remains in the larval stage and ultimately dies.[34] If the concentration of azadirachtin is not high enough, the larva will die only after it has entered the pupal stage. If the concentration is lower still, the adult emerging from the pupa will be 100% malformed, and sterile.

## CONCLUSION

There are a need for cost-effective, biodegradable, potential, ecofriendly and safe sustainable agricultural products alternating with chemical fertilizers and pesticides. As neem act as the most reliable source of pro-pesticide having no adverse effect on humans and animals. Thus neem-based products play a crucial role in organic agriculture. The practice of farmers making their neem-based products for pest control would reduce their dependence on external inputs for agriculture. It would also reduce their cost of pest control to almost zero, leaving only labor as a potential expenditure item. Pests can also be controlled without the use of toxic chemical pesticides, which will reduce the harm posed to humans and the environment alike. There is wide scope for innovation in developing neem as an efficient bio-pesticide.

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