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BOTANICAL INSECTICIDES - SPECIAL REFERENCE TO HORTICULTURAL INSECT PEST MANAGEMENT: A REVIEW

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ABSTRACT

This paper reviews the botanical pesticidal products and their activity against the horticultural insect pests. About 211 plant species were explained to have different types of pesticidal properties under *in vitro* conditions against the pests. Synthetic insecticides possess inherent toxicities that endanger the health of the farmers, consumers and the environment. Hazardous effects on human health led to a resurgence in interest in botanical insecticides due to their minimal costs and lesser environmental side effects. Botanicals are advantageous over broad-spectrum conventional insecticides. They affect only target pests and closely related organisms, decomposed quickly and leave the food residue free and provide a safe environment to live. As a component in the integrated pest management system, botanical insecticides can greatly reduce the quantity of synthetic insecticides applied and contribute to sustainable crop cultivation.

KEY WORDS: Botanical insecticides, horticultural insect pests, integrated pest management, synthetic insecticides

INTRODUCTION

Botanical insecticides can be recommended as an ecochemical and sustainable strategy in the management of horticultural insect pests. Because of their biodegradable nature, systemicity after application, capacity to alter the behaviour of target pests and favourable safety profile, it is hoped that plant-based pesticides play a significant role in achieving evergreen revolution. According to Joseph *et al*. (2012), about 211 plant species have been shown to have different types of pest management properties in laboratory conditions against defoliator pests. When incorporated into integrated pest management programs, botanical pesticides can greatly decrease the use of conventional pesticides or can be used in rotation or in combination with other insecticides, potentially lessening the overall quantities applied and possibly mitigating or delaying the development of resistance in pest populations and preventing the resurgence of insect pests.

Neem as botanical insecticide

Neem pesticides play a vital role in pest management and hence have been widely used in agriculture. There has been an evident shift all over the world from synthetic pesticides to non-synthetic ones; this is largely because of the wide spread awareness of the side effects of these synthetic pesticides not only on plants and soil but also on other living organisms. 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. One of the most important advantages of neem-based pesticides and neem insecticides is that they do not leave any residue on the plants. Pests generally do not develop a resistance to neem based pesticides (Sreekanth, 2013).

Azadirachtin is the main ingredient used to manufacture bio pesticides. Azadirachtin is a natural antifeedant, insect growth regulator, and sterilant found in the seeds of the neem tree, *Azadirachta indica* (Meliaceae). It exerts a strong negative influence on behavior (feeding and mating activity), postembryonic development (molts), and fecundity of insects resulting in significant reduction of general fitness (Hummel *et al*., 2012). Active ingredient Azadirachtin, acts as an insect repellent and insect feeding inhibitor, thereby protecting the plants. This ingredient belongs to an organic molecule class called tetranortriterpenoids. 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 adult stage (Lokanadhan *et al*., 2012).

War *et al*. (2011) demonstrated the synergistic activity of a neem oil formulation with endosulfan against *Spodoptera litura*. Antifeedant activity was significantly greater (85.34%) in neem oil formulation+endosulfan (endosulfan 0.01% and neem oil formulation 1% at 1:1 ratio) treatment than in individual treatments. Esterase activity was significantly lower and Glutathione-S-Transferase (GST) activity slightly higher in neem oil formulation+endosulfan treatment. A considerable influence of the combined treatment was observed on esterase and GST activities. The study reveals that using little amounts of synthetic insecticides along with neem oil could be effective in controlling insect pests. Therefore, this neem oil formulation could be used as a synergist with endosulfan to reduce the quantity of synthetic insecticides for insect pest control.

It was observed that botanical insecticide, azadirachtin and extracts of *Pongamia pinnata* L. at a concentration of 5% gave satisfactory control, recording more than 50% mortality of epilachna beetle. The azadirachtin was found very effective against the beetle, achieving more than 60% mortality at 4 days after spraying (Ghosh and Chakraborty, 2012). Injection of Azadirachtin at 2ml/plant registered 70% reduction in damage caused by pseudostem weevil (*Odoiporuslongicollis* Oliver) in red banana (Irulandi *et al*., 2012). They highlight that stem injection of azadirachtin recorded 84.74% mortality of weevil after 96 hrs of application. According to Prasannath and Mahendran (2013) 5% neem seed extract showed a significant reduction in aphid population and the least damage percentage of leaf miner (1.1%) and pod borer (13.0%) in cowpea crop. Also a significantly higher antifeedant index was recorded for the treatment of the 5% neem seed extract against leaf miner (83.0%) and pod borer (81.8%).

Other plant extracts as insecticides

A. indica is a close relative to *Melia azedarach* and therefore, a similar bioactivity as a biopesticide may be expected. *M. azedarach* aqueous extracts of root cortex did cause a significant increase in mortality of beet armyworm (*Spodoptera exigua*). The root cortex may have a stronger concentration of bioactive compounds or different, more lethal aqueous bioactive compound than fruits. These results are significant in that aqueous extracts are more affordable for the average gardener or small-scale farmer, particularly in developing regions. More interestingly, beet armyworm populations showed significant differences in weight gain. Treated populations did not gain as much weight as untreated populations. This may eventually reduce their ability to molt or reproduce, thus keeping their populations suppressed. The results showed that the *M. azedarach* fruit and root cortex extracts can potentially be used as a botanical insecticide. *M. azedarach* produce a large amount of fruit potentially making it an easily accessed insecticide for home gardeners, small farms or developing regions (Lee and Mix, 2012).

Insecticidal properties of the water extracts of *Jatropha curcas, Vernonia amygdalina, Ageratum conyzoides, Chromolaena odorata* and *Annona squamosa* on two species of flea beetles (*Podagrica uniforma* and *P. sjostedti*) infesting okra was investigated by Onunkun (2012). The results showed that only three of the plant extracts (*Jatropha curcas, Vernonia amygdalina and Annona squamosa*) significantly reduced the population of the two flea beetles at 64%, 55% and 49%, respectively. Though the other two botanicals were not significant in reducing the population of the pests, they were better than the control. Among the tested plants, *J. curcas*, was found to be more effective, hence its use by poor farmers is recommended in the protection of okra against the infestation of *P. uniforma* and *P. sjostedti*.

Pulse beetles *Callosobruchus chinensis* and *Callosobruchus maculatus* are the most serious pests in stored legumes in majority of tropical countries. Various indigenous plant species in different forms such as crude ethanol extracts, vegetable oils, dry powders and combinations of plant materials with insecticides were tested against *Callosobruchus* spp. (Ratnasekera and Rajapakse, 2012). The highest bioactivity (90 – 100% mortality) was manifested by the crude ethanol extracts of *Azadirachta indica* (Neem), *Anona reticulata* (Anona) and *Ocimum sanctum* (Maduruthala) among the crude ethanol extracts tested. Oils of *O.sanctum* and *A.reticulata* completely inhibited oviposition and adult emergence. Clove powder was the most effective among the four powders tested for adult mortality followed by root dust of papaya. Among the plant powders tested, Maduruthala (*O. sanctum*) was the most effective for suppressing oviposition significantly followed by Getathumba (*Leucas zeylanica*). The experiments also revealed enhanced toxicity and persistence of the insecticide in causing significant mortality to *Callosobruchus* spp. when combined with vegetable oils. Further, these results revealed the potential applicability of some indigenous plant materials as stored grain protectants.

Compounds extracted from the leaves of coconut palm, *Cocos nucifera* and the Indian almond, *Terminalia catappa* were assessed as potential grain protectants against four major pests of stored grains, *Sitophilus oryzae*, *Rhyzopertha dominica*, *Tribolium castaneum* Herbst, and *Callosobruchus chinensis*. Results showed that adults of *C. chinensis*, *S. oryzae*, and *T. castaneum* were equally susceptible to the fumigant toxicity of *C. nucifera* and *T. catappa* crude extracts. On the contrary, adults of *R. dominica* showed tolerance to all the extracts tested. These results highlight the potential of *C. nucifera* and *T. catappa* extracts as potent insecticides and consequently are suitable for the control of pests in stored commodities (Usha Rani *et al*., 2011).

Antifeedant effect in insect is one of the major parameters to assess the efficacy of crop protections. The antifeedant activity of different solvent extracts (0.625, 1.25, 2.5 and 5%) of *Calotropis procera* leaves against third instar larvae of *Spodoptera litura* was determined by Bakavathiappan *et al*. (2012). The maximum activity was recorded in chloroform extract followed by hexane, ethanol, acetone, ethyl acetate and methanol. Chloroform extract exhibited the best larvicidal activity against the *S. litura.* The antifeedant activity was directly proportional to the concentration of the extract. The results clearly indicate that the chloroform extract of *C. procera* possesses many useful properties to control insect pests. Leaf extracts of *Acacia arabica* and *Annona squamosa* were found most promising causing 76.6% and 83.3% larval mortality of *Spodoptera litura* respectively at 25% concentration within 3 days of treatment. Leaf extract of *Datura stramonium* inflicted 93.3% larval mortality at 50% concentration within 4 days (Rajguru and Sharma, 2012).

Efficacy of three botanical insecticides based on pongam oil (from *Pongamia pinnata*) and neem oil (from *Azadirachta indica*) against *Plutella xylostella* larvae was studied (Pavela, 2012). Application of the botanical insecticides caused high larval mortality and significantly lower feeding damage to the plants compared to the control. The differences between individual botanical insecticide formulations were determined using estimated lethal concentrations. LC_{50} of the insecticide based on *P. pinnata* oil alone were found to be significantly higher compared to LC_{50} of insecticides designed as combinations of pongam oil and *Thymus vulgaris* or *Foenicum vulgare* essential oil, where LD_{50} was estimated as 0.58% and 0.73%, respectively. Based on the results, product formulation based on the combination of *Pongamia pinnata* and *Thymus vulgaris* or *Foenicum* *vulgare* essential oils can be recommended for protection of cabbage crops against *Plutella xylostella* larvae.

Efficacy of plant products *viz.*, neem oil (2%), iluppai oil (2%), pungam oil (2%), combination of iluppai and pungam (1:1) and microbial formulations *viz.*, entomopathogenic fungi, *Beauveria bassiana* and *Verticillium lecanii* against the brinjal shoot and fruit borer (BSFB) was evaluated by Mathur *et al*. (2012). The results revealed that newer plant products *i.e*. oils of iluppai and pungam were at par with standard check endosulfan and were found to be significantly superior than microbial formulations and also showed better efficiency than neem oil in the suppression of BSFB infestation with significant insecticidal property. The results thus suggest that newer plant products such as oils of iluppai and pungum are promising botanicals in the integrated pest management strategy against BSFB.

Pongamia pinnata seeds (both mature as well as immature) methanolic extracts (2.5, 5.0, 7.5 and 10.0%) were assessed for their insecticidal activities against *Helicoverpa armigera* (Hubner). The mature seed extract 5.0% exhibited more than 50% first instar larval mortality and more than 65% third instar larval feeding deterrence. Besides, a pronounced decrease in food consumption and utilization indices was noticed when fourth instar larvae were fed on extract treated chickpea pods. Adults when fed on the extract treated sucrose diet exhibited a marked reduction in oviposition and egg hatching. Extracts also deterred the adult females from egg laying when applied on to the oviposition substrate at 5.0% concentration. Mature seed extracts gave better results than the immature one, though both were effective. Repeated application of mature *Pongamia pinnata* seed methanolic extract 5.0% may be incorporated in integrated pest management programmes to take care of *H. armigera* menace on crop plants (Reena and Ram, 2012).

CONCLUSION
Efforts should be made scientifically to document the pesticidal plants and to investigate the biocontrol efficacy of plant diseases of the plant products. Field trials are required to assess the practical applicability of the botanical insecticides. Biosafety studies should be conducted to ascertain their toxicity to humans, animals and crop plants.

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