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Plant Extracts as Biological Control Agents

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Abstract

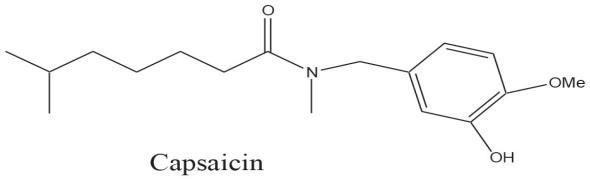
Over the years, synthetic pesticides have been used by farmers to control and eradicate pests, with a view to increase crop production and productivity. However, scientists have found that synthetic pesticides are detrimental to the environment, are expensive, non-biodegradable and can increase pest resistivity. To continue to mitigate pest control in crops, there has been the use of organic pesticides as biological controllable agents against pests in crops. Such a practice is easier, less costly, eco and environmentally friendly and eliminate pesticide residues etc and make agriculture, agricultural products and market sustainable, and increase food security around the globe. The use of plant extracts as bio-controlling agents or "green agrochemicals" should be intensified, so that there is a gradual phasing out of synthetic organic pesticides. This article, gives a mini review of the use of plant extracts as natural pesticides or biological control agents against disease inducing pests that destroy agricultural crops.

Keywords: synthetic pesticides; crop production and productivity; organic pesticides; biological control.

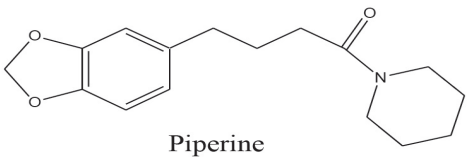
Introduction

Biological controls or biocontrols are agents, usually plant extracts, plant products, microorganisms such as bacteria, viruses, fungi, fungal and bacterial enzymes, enzyme inhibitors, antibiotics that play an important role in control of plant pathogenic fungi and insects or another living organism that inhibit the activity of a living pathogens. They have found widespread use, worldwide to control various plant diseases in the field of agriculture [1,2]. Plant diseases need to be controlled, so as to maintain the quality and abundance of food, feed and fiber produced by growers around the world. About 35% of crops in the field, fourteen, 14% in storage are lost annually via attacked by insect and pests [3]. Different approaches may be used to prevent, mitigate or control plant diseases. One usual approach, is the use of synthetic chemical fungicides/pesticides. The use of synthetic chemical fungicides/pesticides is a common practice around the globe. However, their toxicity and pollution to the environment, and non-biodegradable nature, limit their usuage [4,5]. Plant extracts as biological control in pest management, have been reported to be eco-friendly, less costly, safer and more compatible with environmental components, compared to synthetic pesticides and fungicides and are now classed as "green agrochemicals" and their increasing use is noted [6]. Thus, plant extracts as biological control has more advantages than synthetic versions. These include: Biological control is less costly and cheaper than any other methods; Biological agents give protection to the crop throughout the crop period; They are highly effective against specific plant diseases; They don't cause toxicity to the plants; Application of biocontrol agents is safer to the environment and to the person who applies them; They multiply easily in the soil and leave no residual problem; Biocontrol agents can eliminate pathogens from the site of infection; Biocontrol agents, not only control the disease, but also enhance the root and plant growth by way of encouraging the beneficial soil microflora; It increases the crop yield also. It helps in the volatilization and sequestration of certain inorganic nutrients. As an example, Bacillus subtilis solubilizes the element phosphorus and makes it available to the plants; Biocontrol agents are very easy to handle and apply to the target; Biocontrol agents can be combined with biofertilizers and are easy to manufacture.

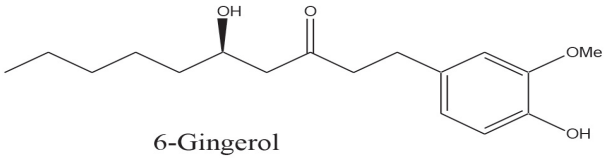
The over use of chemical pesticides causes environmental and health problem have been the matter of concern, so plant extracts which known as biocide or green pesticides



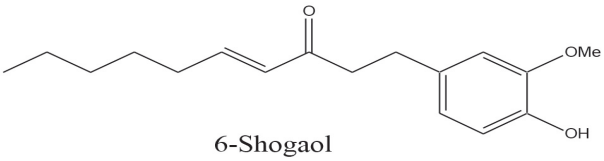
Capsaicin



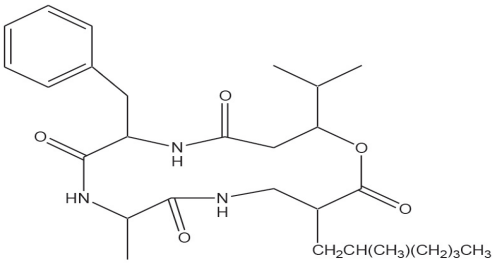
Piperine



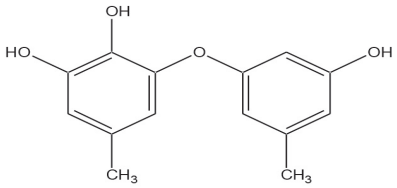
6-Gingerol



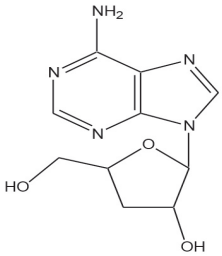
6-Shogaol



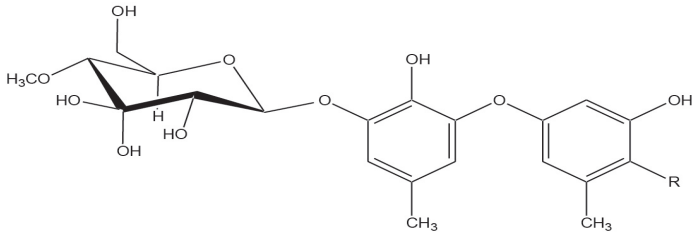
Cordycepeptide



Cordyol

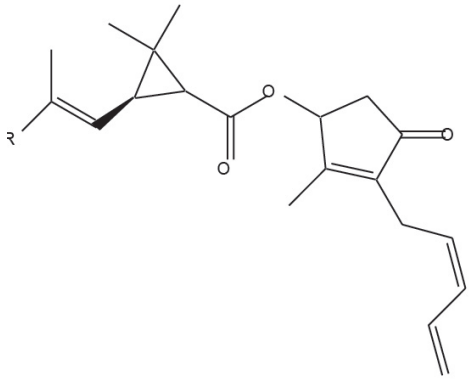


Cordycepin

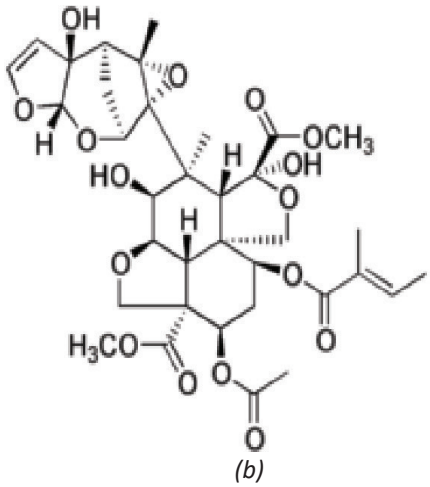


Cordyol A; R =H

Cordyal B, R = CO_2CH_3



(a)



(b)

Figures 1 & 2: Biological controlling agents (a) Pyrethrins, R = CH3 and Pyrethrin II (R = CO2CH3) and (b) Azadirachtin

can be an alternative good source of chemical pesticide due to their safe, eco-friendly and more compatible properties. This paper survey the use of plant extracts as biological agents/control

A Survey of Plant Extracts Used as Biological Control

In this mini-review, ten articles were reviewed between the years, 2000 and 2007, using the Google search engine. Higher plants are considered as the reservoir of useful natural products that can be used as biopesticides. These act singly or in combination to produce the natural pesticidal effect (Figures 1&2). gives the structure of some plant active natural products that may be responsible for the natural pesticidal effect. Extracts of onion, garlic, eucalyptus and tobacco are known to control many plant-pathogenic fungi and insects. Finely ground, dried flowers of chrysanthemum, marketed as insecticides, contains an active ingredient, pyrethrin. Pyrethrum is one of the oldest insecticides known. Pyrethrins, have a rapid paralytic action on insects. Certain essential oils, which are used as fragrances and flavors in the perfume and food industries, have shown insectidal activities. The importance of essential plant oils, in the management of tobacco cutworm, Spodoptera litura and the green peach aphid, Myzus persicae have been reported [7].

It's the natural products or active metabolites produce by plants, that seem to bestowed on them, insecticidal properties. The neem plant, Azadirachta indica, seem to have a range of natural products with insecticidal properties. For centuries, neem leaves and seeds have been used as a biological control against insect pests. Some of neem insect repellant natural products include a number of triterpenoids, flavonoids, amino acids and sulphur containing compounds. One of these is Azadirachtin, found predominantly in the seeds and leaves of the plant. This compound is said to have a disruptive effect on the feeding and growth of insects. Thioremone, a non-toxic insect repellent is produced in the seed kernels. The seed extracts are highly effective against more than 100 species of crop pests such as the gypsy moth, Mexican bean bettle, confused flour bettle, citrus mealy bug, aphids, tobacco budworm etc. Biological formulations, using neem are mostly non-toxic and biodegradable. Neem extracts have been used in vitro and in vivo in the control of rice-blast fungus Pyricularia oryzae [8].

Alcoholic extracts of Fresh leaves of Dhatura (Datura metal), Morning glory (Ipomoea carnea), Congress grass (Parthenium hysterophorus), Creeping launea (Launea procumben), Swallow wart (Calotropis procera) were prepared and sprayed on experimental fruits such as ladies finger, pomegranate, brinjal and guava fruits. Out of these botanicals, Creeping launea leaves extract showed best performance against the pest attack, compared to other extracts. Swallow wart extract also showed good performance in the protection of fruit from pest. The efficacy of Morning glory leaf extracts was nearly same on fruit against the pest attack. Congress grass extract showed lowest efficacy on fruit pest [9].

The efficiency of the biopesticides: matrine (extract from Sophora flavescens), spintoram (derived from soil bacterium Saccharopolyspora spinosa), azadirachtin (neem extract), and Annona squamosa (custard apple extract) against the cotton aphid (Aphis gossypii Glov.) and the two-spotted spider mite, (Tetranychus urticae Koch) was investigated. A drip-irrigation hydroponics system (DIHS) was designed and used for this study. Results revealed that the custard apple extract showed the highest efficiency (80 and 76%) reduction against the aphid and the mite, respectively, followed by matrine and neem extract (73%), and spintoram (69%) in case of the aphid and was followed by matrine (75%), spintoram (radiant), (66%), and neem extract (56%) in the case of the mite. There is an expanding interest in hydroponics, because they can produce fresh food closer to urban areas [10].

Several plant species and their compounds are well-known to have pesticidal properties against a wide range of insect pests and thus can be classed as biological control. To this end, the aqueous extracts of two plants, Azadirachta indica A. and Melia azedarach L., in comparison with the synthetic pyrethroid bifenthrin against sucking insect pests and their associated predators, as well on the yield in Bt cotton, were evaluated. Bt cotton contains the Bacillus thuringiensis genes. The population of the sucking insect pests was found to be lowest in the positive control which uses bifenthrin alone. The A. indica extract reduced the pest population equivalent to the positive control, but the highest populations were observed in both negative controls which consisted of only water and 0.1% soap with water application. The M. azedarach did not show any harmful effect on the insect population. The predators' abundance was higher in the plots where botanicals were applied, while the lowest population was observed in the bifenthrin treatment. In comparison to the negative control (only water application), (63.4%) cotton yield was increased by the application of A. indica and (58.8%) by the application of the synthetic insecticide. Using plant extracts of A. indica to control sucking insect pests of cotton can be as effective as synthetic insecticides and to make agriculture sustainable in terms of crop yield beside they are environmentally safe [11].

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The use of different types of plant extracts such as neem, garlic, tobacco, kappettiya, syringe, ginger and many others as biocides or natural pesticides to control and manage the pest or disease of different plants, with a view to minimize yield loss, have been reported. The petroleum ether extract of periwinkle, can be used to control the pest Uzi fly during sericulture. The neem extract of different concentrations show significant effect to control pest of rice, betel leaf and vegetable. Garlic bulb extract, tobacco and kappettiya leaf extract, Eve's apple latex/ fruit/ seeds extract, lilac flower extract, neem leaf/ seeds or it oil act as potential insecticide to tea, rice, betel leaf and vegetables pests [12] .

With the aim of intensifying botanical insecticides, seven plant extracts: Daphne mucronata (Thymelaeaceae), Tagetes minuta (Asteraceae), Calotropis procera (Apocynaceae), Boenninghausenia albiflora (Rutaceae), Eucalyptus sideroxylon (Myrtaceae), Cinnamomum camphora (Lauraceae) and Isodon rugosus (Lamiaceae)) were screened for their toxic effects against four important agricultural pest insects: pea aphids of Acyrthosiphon pisum (Hemiptera), fruit flies of Drosophila melanogaster (Diptera), red flour beetles of Tribolium castaneum (Coleoptera), and armyworms of Spodoptera exigua (Lepidoptera). Aphids were the most susceptible insect with 100% mortality observed after 24 h for all the plant extracts tested. Further bioassays with lower concentrations of the plant extracts against aphids, revealed the extracts from I. rugosus (LC50 36 ppm and LC90 102 ppm) and D. mucronata (LC50 126 ppm and LC90 198 ppm) to be the most toxic to aphids. These most active plant extracts, against pests, were further fractionated into different solvent fractions on polarity basis and their insecticidal activity evaluated. While all the fractions showed considerable mortality in aphids, the most active was the butanol fraction from I. rugosus with an LC50 of 18 ppm and LC90 of 48 ppm. Considering that high mortality was observed in aphids within 24 hours of exposure to a very low concentration of the butanol fraction from I. rugosus [13].

Fifty plant extracts, four oil cakes and eight antagonistic organisms were tested against Bipolaris oryzae (Cochliobolus miyabeanus), the causal agent of brown spot disease of rice. In vitro studies indicated that two leaf extracts, Nerium oleander and Pithecolobium dulce exerted the higher percent inhibition to mycelial growth (77.4, 75.1%) and spore germination (80.3, 80.0%) of B. oryzae. Amongst the four oil cake extracts tested in vitro against B. oryzae, neem cake extract showed the maximum inhibition percent to mycelial growth (80.18%) and spore germination (81.13%) of the pathogen followed by mahua cake extract, castor and gingelly cake extract. Trichoderma viride (Tv) was significantly effective in inhibiting the mycelial growth (62.92%) and spore germination (77.03%) of the pathogen followed by Trichoderma harzianum (Th) and Trichoderma reesei (Tr). The promising leaf extracts, oil cake extracts and antagonistic microorganisms were further evaluated for their efficacies in disease management under glasshouse and field conditions. In glasshouse studies, post-infectional spraying of rice plants with neem cake extract, N. oleander leaf extract and T. viride (Tv) were significantly effective in reducing the incidence of brown spot of rice by 66, 52 and 45 percent respectively. Two rounds of spraying of rice plants with neem cake extract, N. oleander leaf extract and T. viride (Tv) in the field at initial appearance of disease and 15 days later reduced the incidence of brown spot (70, 53 and 48% disease reduction respectively) and increased the yield by 23, 18 and 15 percent respectively [14].

An investigation was carried out to evaluate the efficacy of some selected plant extracts for seed treatment of hybrid rice, according to the rules of International Seed Testing Association (ISTA) and following Completely Randomized Design with four replications. Nine plants extracts: onion bulb, kalijira seed, allamonda leaf, garlic clove, neem leaf, datura leaf, turmeric rhizome, biskatali leaf and shimul leaf extract were evaluated against seed borne pathogens of hybrid rice. All of the plant extracts were used as per 1:1 (w/b) ratio. These pathogens include two strains of a single bacterium and seven seed borne fungi. Xanthomonas oryzae pv. oryzae (two strains), Rhizopus stolonifer, Aspergillus spp., Fusarium moniliforme were predominant. Amongst the plant extracts, datura leaf extract, turmeric rhizome extract; allamonda leaf extract and garlic clove extract showed best performance against the seed borne pathogens. Kalijira seed extract, bishkatali and shimul leaf extract also showed promising effect against seed borne fungi only. Datura leaf extract and turmeric rhizome extract have the highest bactericidal and anti fungal efficacy amongst the plant extracts used in this experiment. Considering the overall performance of plant extracts, datura leaf extract (1:1 w/b) and turmeric rhizome extract (1:1 w/b) could be used for seed treatment of hybrid rice as an eco friendly biological approach [15].

The severity of leaf blight of wheat of local and exotic origin was studied under field conditions. None of the 333 wheat materials were highly resistant to this disease, 76 were graded to be resistant and 89 materials were moderately resistant. The remaining 90, 99 and 179 materials were moderately susceptible, susceptible and highly susceptible, respectively. Diseased leaves of wheat plants from different locations were collected and isolation of Helminthosporium sativum was carried out. In the following year, the wheat

materials that showed resistance under field conditions, were screened by artificial inoculation against nine H. sativum isolates at the seedling and the flag leaf stage. Seedling inoculation revealed that some materials were resistant to some isolates, but were susceptible to others. In case of flag leaf inoculation, six materials were recorded resistant to all isolates. Moreover, 16 and 31 materials were graded to be moderately resistant at the seedling stage and at the flag leaf stage, respectively [16].

India is the second largest producer of black tea in the world. However, the biggest challenge for tea growers to combat pests and diseases. Tea crop is infested by not less than 720 insects and mite species. At least four sucking pests and six chewing pests have well established themselves as regular pests causing substantial damage to this foliage crop. Various synthetic pesticides are widely used for the management of tea pests . Applications of synthetic pesticides are discouraged due to various problems such as development of resistance, deleterious effects on non-target organisms, such as insect predators and parasitoids, upsetting the ecological balance, and accumulation of pesticide residues on tea leaves. There is a growing demand for organic tea or at least pesticide residue free tea in the international market which affects the export price. There is also a higher emphasis of implementation of new regulations on internationally traded foods and implementation of Plant Protection Code (PPC) for tea. This has led to the application of plant extracts with insecticidal properties as an alternative to the synthetic pesticides. Botanical products, especially neem-based products, have made a relatively moderate impact in tea pest control. Research has also demonstrated the potential of 67 plant species as botanical insecticides or biological control against tea pests, making tea production sustainable [17].

Conclusion

A wide range of pests (insects, pathogens) affect food crops around the world. Over the years, synthetic chemicals have found widespread use to kill pests and increase agricultural production and productivity in the fields. However, because of environmental and health risks associated with synthetic pesticides, to continue to mitigate pest control in crops, there has been the use of organic pesticides as biological controllable agents against pests in crops. Such a practice is easier, less costly, eco and environmentally friendly and eliminate pesticide residues etc and make agriculture, agricultural products and market sustainable and increase food security around the globe.

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