CLOVE OIL: AS BIOCONTROL AGENT

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Abstract—*India is an agricultural country and ranks second worldwide in farm output. However the economic contribution of agriculture to India's GDP is steadily declining due to loss of standing crop. The major reason for this loss is due to crop diseases caused by fungi, bacteria, viruses and other microorganisms. Limited access to disease-control methods results in annual losses of 30 to 50 percent of the major food crops. The farmers usually rely on chemical insecticides and pesticides for protection of crops from plant pathogens. The excessive usage of these chemicals has resulted in polluting our environment, creating an imbalance in the ecological systems. An alternative method of plant disease management is application of biological controls using herbal compounds extracted from medicinal plants. These compounds are seen to be effective in controlling various plant diseases. Moreover they are environment friendly and have no side effects. Essential oils and their extracts from medicinal plants are able to control various microorganisms causing the diseases in cereal, fruits and vegetables. Essential oils are aromatic, volatile, oily, hydrophobic liquid concentrates that are extracted from plant material, such as flowers, buds, seeds, leaves, twigs, bark, wood, fruits, roots and whole plant. These essential oils contain a variety of volatile molecules such as terpenes, terpenoids and phenol derived aromatic and aliphatic compounds, which have antibacterial, antiviral, and antifungal properties. These essential oils can be therefore used for successful and environment-friendly management of crop diseases, thus increasing the crop yield.*
Clove (Syzygium aromaticum L. Merrill and Perry) is one of the most important spices that have been used from centuries for many medicinal purposes. Active ingredient of clove oil is eugenol, which inhibits the growth of most of the fungal as well as bacterial pathogens. Clove oil has been proved successfully effective in suppressing the growth of Fusarium oxysporum, F. verticillioides, F. avenaceum, F. graminearum, F. moniliforme, Penicillium italicum, P. expansum, P. citrinum, P. viridicatum, Monilinia fructigena, Aspergillus ochraceus, Tricophytonrubrum, and T. mentagrophytes, and Botrytis cinerea as well as many gram positive and gram negative bacteria. Therefore, we can conclude that Clove oil can be used as a source of natural eco-friendly phyto-fungicidal and antibacterial compound.

1. INTRODUCTION

Medicinal plants produce high amount of active principles, which have been used in pharmaceutical industry for their antimicrobial property [1]. These active principles are basically secondary metabolites which are the by-products of primary metabolic pathways. These are viewed as potential source of natural drugs, antibiotics, insecticides and herbicides [2-3]. The medicinal property of most of the plants is associated with the production of essential oil. Essential oils and their extracts have the ability to control various microorganisms (bacteria, fungus, yeast) which cause infection to plants, humans and also spoil the food [4]. These are generally aromatic organic compounds and broadly include phenolics, terpenes, steroids and alkaloids [5]. The active antimicrobial compounds of essential oils are generally terpenes, which are phenolic in nature. These phenolic compounds are responsible for the inhibition of various fungal pathogens [6].

Fungus like *Fusarium* and *Alternaria* have been recognized to be the major plant pathogens all over the world [7]. These fungal plant pathogens results into a great loss to our agriculture every year. Essential oils and their extracts have less toxic side effects than chemical insecticides and pesticides [8]. The pharmacological value of the essential oils is increasing day by day due to their potential role as biocontrol agents, non-phytotoxic compounds and potentially effective against several microorganisms [9-10].

Several experiments have been performed to study the effect of these essential oils on pathogenic fungi. Kurita et al. [11] studied the effect of 40 plant metabolites against seven species of fungal pathogens. Similarly Nosrati et al., [12] have also investigated the antifungal property of spearmint essential oil against *Fusarium oxysporum* f. sp. *radicis-cucumerinum*. Antifungal activity of six essential oils against the *F. oxysporum* f.sp. *radicis-lycopersici* and *F. oxysporum* f.sp. *lycopersici* have also been observed by Arici et al., [13].

2. CLOVE AS ANTIFUNGAL AGENT

Clove (*Syzygium aromaticum* L. Merrill and Perry) is one of the most valuable spices, which belongs to the family Myrtaceae. The dried flower buds have been used traditionally as food preservative and for many medicinal properties like antimicrobial, antifungal and general stimulating, carminative and anesthetic [14-17]. Clove plant is the native of Indonesia but nowadays it has been cultivated in many parts of the world [18].

Eugenol (80-95%), acetyl eugenol (1-5%), and β-caryophyllene (4-12%) are main chemical components of

clove oil [19-21]. Besides this, it has Gallotannic acid, Oleanolic acid, Vannilin, and Eugenin also. Antimicrobial activity (antibacterial and antifungal) of clove oil is directly related to the presence of a high concentration (85.3%) of Eugenol [22-25].

Eugenol inhibits the activity of various enzymes such as ATPase, histidine decarboxylase, amylase, and protease enzymes. High concentration of eugenol is responsible for inhibition of the ATPase enzyme which kills the cell [26]. The antimicrobial activity of compound is associated with their lipophilic nature. It leads to their accumulation in membranes and also causes the reduction of the energy. Phenolic components of essential oils increase the permeability of the cell membrane. It results into the leakage of vital intracellular constituents or destruction of microbial enzyme systems [27].

Fusarium sp. causes crown and root rot disease, it is one of the most destructive soil borne fungal diseases on various plants. Clove oil is able to inhibit the mycelial growth of various species of *Fusarium* genera such as *F. oxysproum, F. solani, F. monliformi* [28]), *F. oxysporum*, *F. verticillioides* and *F. avenaceum* [29]. Similarly, antifungal activity of clove essential oil against was also observed in *F. oxysporum*, *F. redolens* and *F. commune*. Inhibition started at the 0.1µL/mL of essential oil and this inhibition successively increased with the increasing of oil concentration [30].

Eugenol extracted from powdered cloves inhibited the growth of *Aspergillus flavus, A. fumigates, A. acculeatus* and *A. versicolor* [31]). Clove oil rich in eugenol (apprx. 90%) was also reported to inhibit the growth of *Aspergillus niger* [4, 32]). *Aspergillus* species are basically responsible for diseases caused by food contamination as well as opportunistic infections of humans [33]. Clove oil exhibits the complete inhibition of mycelial growth of *Botrytis cinerea* also, which cause a great loss to our wine industry [34-35]. It has also been observed that if clove oil and cinnamon oil are mixed in a proper ratio, grapes can be protected against the postharvest decaying fungi such as *Aspergillus niger, Alternaria alternata, Colletotrichum gloeosporioides, Lasiodiplodia theobromae, Phomopsis viticola* and *Rhizopus stolonifer* [36]. Similarly, the combination of clove oil and cinnamon oils at 3.0% was capable of providing complete protection in rubberwood particle boards against growth of *Aspergillus* sp. and *Trichothecium* sp. for 9 weeks at 25 °C and 100% RH [37]. In a recent study it was reported that anthracnose caused by *Colletotrichum gloeosporioides* could also be controlled by clove oil [38].

The antifungal activity of the clove oil was also investigated against *Candida, Aspergillus* and dermatophyte. Dermatophytes cause infection of skin, hair, nails which obtain nutrients from keratinized material [39]. Clove oil showed inhibitory activity against all the tested strains. It was also concluded that clove oil emerged as a strong antifungal agent than the standard antifungal drug amphotericin-B [40].

3. CONCLUSION

Fungal plant pathogens are commonly controlled by the application of synthetic fungicides in the field, either in soil or as foliar sprays. As these synthetic chemical pesticides harm humans directly by affecting their health, so there is a significant desire to find "natural" substitutes for fungicide. In this regards, clove oil can be used as a natural antifungal against various fungal plant pathogens. Application of clove essential oil will be eco-friendly disease management. The only hindrance for our farmers is that clove oil is very costly and probably not that cost effective for a poor farmer. Therefore, there is an urgent need to find out the cost effective fungicide as clove.

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