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PLANT EXTRACTS AS BIOFUNGICIDES: A REVIEW

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Abstract: Use of plant derived bioactive compounds as biopesticides is an emerging trend in today's world. Although, the research on various indigenous plant species is still in its infancy, the plant extracts and the bioactive compounds of many traditionally important plants have tremendous potential to serve as biofungicide in agriculture. This review highlights some of the work that has been performed that validate the high potential and efficacy of many plant extracts in inhibiting various fungal plant pathogens. It also portraits the necessity of further investigation to isolate the active molecules from plants as well as feasibility of application with more field trials.

Key words: Plant extracts, Biofungicides.

INTRODUCTION

The population on our planet has exceeded over 7.04 billion people as of 18th September 2012 as per United States Census Bureau [1]. Food production is increasing due to advancement in science and agriculture but this increment is not sufficient for this population. Therefore, it is a great challenge to fulfill the food requirement for this huge volume of population. Various pests and plant pathogens, natural disaster, progress of desert and war are the few causes of declining food resources. Among the various bacterial, viral and fungal plant pathogens, fungi cause significant losses in many important crops all over the world. According to a recent survey, contribution of fungal diseases towards total yield loss of important crops in India is 18-31% [2]. Fungi are also the major destroyer of food stuffs during storage, rendering them unfit for human consumption by retarding their nutritive value and often by producing mycotoxins.

Why do we need alternatives?: Most commercial fungicides are sold in a liquid form. Among other elements, sulfur is the most common active ingredient [3] present at 0.08% in weaker concentrates, and as high as 0.5% for more potent fungicides. Fungicides in powdered form are extremely toxic and usually contain 90% sulfur as active ingredient. Even evidences have proved their interference in the food chain. Fungicide residues have been found on food for human consumption, mostly from post-harvest treatments [4]. Some fungicides are dangerous to human health, such as vinclozolin, which has been removed from use [5]. In recent years, pressure to reduce the use of chemical pesticides in agriculture has increased. Concerns have been raised about both the environmental impact and

the potential health risk related to the use of these compounds. Literature suggests that over 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target species, including non-target species, air, water and soil [6] Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. Pesticides are one of the causes of water pollution, and some pesticides are persistent organic pollutants and contribute to soil contamination. In addition, pesticide use reduces biodiversity, reduces nitrogen fixation [7] contributes to pollinator decline [8-11] destroys bird's habitat [12] and threatens endangered species [6] due to their residual toxicity. Most of the synthetic pesticides are non biodegradable and thus have the potential to disturb the ecological balance. Development of pesticide resistance in pests is also a major issue in today's agriculture which subsequently leads to an application of greater dose of the pesticide to counteract the resistance. This in turn causes a worsening of the ambient pollution problem. Because of growing concerns about health and environmental safety, the use of toxic, carcinogenic and environmentally damaging chemicals is currently being discouraged. Therefore, there is a need to develop alternative agents for the control of pathogenic fungal diseases in plants.

Why plant extracts?: Historically, many plant oils and extracts have been reported to have antimicrobial properties. Even *'Ayurveda'*, the ancient Indian traditional medicine explains the use of herbal ingredients to cure any kind of disease. It is important to investigate scientifically those plants which have been used in traditional medicines as potential sources of novel antimicrobial compounds. Earlier many pesticides were derived from plants and many plants were exploited widely as sources of chemical fungicides. But synthetic agrochemicals largely replaced plant derived products as the key commercial pesticides. In general, plant-derived natural substances are considered as non-phytotoxic and potentially effective against pests. In recent years, interests have been generated in the development of safer antimicrobial agents such as plant-based essential oils and extracts to control phytopathogens. Also, the resurgence of interest in natural control of plant pathogens and increasing consumer demand for effective, safe, natural products means that quantitative data on plant oils and extracts are required. The research on plant derived natural products for the use in agriculture is now an emerging trend as it becomes evident that plant natural products still have enormous potential to improve modern agrochemical research. There are at least 2.5 million different species of plant in the world [13]. But it was also estimated that only 10% plant species have been examined chemically until 1993, so there is enormous scope for further work. Extracts of many higher plants have been reported to exhibit antibacterial, antifungal and insecticidal properties under laboratory trials. Plant metabolites and plant based pesticides appear to be one of the better alternatives as they are known to have minimal environmental impact and danger to consumers in contrast to synthetic pesticides.

Role of plant extracts as antifungal agents: Plants like *Psidium guajava, Azadirachta indica* and *Clitoria ternatea* are known to possess antimicrobial properties [14-16]. Several plant extracts were also tested for their bio-efficacy in the management of various fungal diseases in plants [17,19-24,26-34]. Alcohol and water extracts of *Ocimum sanctum* were reported to be effective against *Colletotrichum lindemuthianum* infecting cowpea causing anthracnose [17]. Leaf extracts of *Azadirachta indica, Datura stramonium, Ocimum sanctum, Vinca rosea, Withania somnifera, Polyalthia longifolia, Tagetes erecta, Allium cepa, Allium sativum, Calotropis procera, Hordeum vulgare, Phaseolus vulgaris, Cicer arietinum, Solanum melongena, Triticum aestivum, Brassica juncea* and *Capsicum annum* were tested against *Sclerotinia sclerotiorum* that causes white rot disease in 361 plant species [18] and found that leaf extract of *A. indica, D. stramonium, O. sanctum, V. rosea, W. somnifera, P. longifolia* and *T. erecta* were more fungitoxic than others. Similarly *A. cepa, D.*

stramonium, O. sanctum, V. rosea, W. somnifera, P. longifolia, T. erecta and *A. sativa* were found to inhibit the sclerotial production almost completely [19]. Chloroform extracts of *Silene multifida* (Adams) Rohrb. was reported to have antifungal activity at various concentrations (1-10 mg/ml) against *Candida albicans* which is an opportunistic human pathogen [20].

Ocimum sanctum, Azadirachta indica, Rheum emodi, Eucalyptus globulus, Artemessia annua were tested to control other fungal disease like Brinjal wilt caused by *Fusarium Solani* and 20% *A. indica* was found to be the most effective [21]. Aqueous extract of eight plants were screened for antifungal activity against *Fusarium solani* and *Aspergillus flavus* at 10% concentration by dry mycelial weight, spore germination and poisoned food techniques. The results revealed that *Decalepis hamiltonii* Wight & Arn (Asclepiadaceae) showed significant antifungal activity. The antifungal activity of aqueous extract of *D. hamiltonii*, an edible plant, was further evaluated at different concentrations by poisoned food technique against eight species of *Fusarium*, ten species of *Aspergillus*, three species of *Penicillium*, two species of *Drechslera* and *Alternaria alternata*. It was observed that aqueous extract showed significant antifungal activity against all the test pathogens. *P. chrysogenum* was completely inhibited at 10% concentration. *D. halodes* and *A. fumigatus* were inhibited at 20% concentration, whereas *F. lateritium* and *F. moniliforme* were inhibited at a higher concentration of 50%. *D. hamiltonii* was further subjected to different solvent extraction using petroleum ether, benzene, chloroform, methanol and ethanol to identify the solvent extract having high activity. It was observed that petroleum ether extract showed highly significant antifungal activity followed by benzene and chloroform extracts, whereas no activity was observed in methanol and ethanol extracts at 2000 µg/ml [22].

Anogeissus leiocarpus and *Terminalia avicennioides* were also reported to possess antifungal properties against *Aspergillus niger, Aspergillus fumigatus, Penicillium species, Microsporum audouinii* and *Trichophyton rubrum*. Chloroform, ethanol, methanol, ethyl acetate and aqueous root extracts of the two plants were used in the investigation and found out that the ethanol extracts were more effective that the others. *A. leiocarpus* appeared to be more effective against the test pathogen than *T. avicennioides*. The MIC of the extracts ranged between 0.03 µg/ml and 0.07 µg/ml while the minimum fungicidal concentration ranged between 0.04 µg/ml and 0.08 µg/ml [23].

The methanol leaf extracts of *Acacia nilotica, Sida cordifolia, Tinospora cordifolia, Withania somnifera* and *Ziziphus mauritiana* possessed antifungal activity against *Aspergillus flavus, Dreschlera turcica and Fusarium verticillioides* in comparison to root/ bark extracts. *F. verticillioides* recorded susceptibility for all the five plant leaf and bark /root extracts. [24].

Mimosa pudica L. is a creeping herb, identified as Lajjalu in *Ayurveda* that has been found to have antiasthmatic, aphrodisiac, analgesic and antidepressant [25]. In the previous study, the active phytocomponents of *M. pudica* were determined using phyto-chemical analysis. The antimicrobial activity of *Mimosa* was studied. The activity was tested against *Aspergillus fumigates* and bacterial pathogens like *Citrobacter divergens* and *Klebsiella pneumonia* at different concentrations of 50, 100 and 200 µg/disc and the results have been illustrated [26]. The leaf extract and essential oils derived from *Piper betle* leaf possess both antifungal and antibacterial properties. This plant could be trapped for generating effective antifungal drugs in India because North East India is one of the two centers of species diversity of Indian piper, besides the Southern Deccan [27]. Again it was found that *Ocimum sanctum* worked against *Fusarium wilt* by 60% in Mulberry [28]. Methanol extracts of fresh materials of fifty seven plants were screened for *in vivo* antifungal activity against *Magnaporthe grisea, Corticium sasaki, Botrytis cinerea, Phytophthora infestans, Puccinia recondita* and *Blumeria graminis* f. sp. *hordei*. Among them, seven plant extracts

showed disease-control efficacy of more than 90% against at least one of the six plant diseases. The methanol extracts of *Chloranthus japonicas* (roots) (CjR) and *Paulownia coreana* (stems) (PcS) displayed the highest antifungal activity; the extract of PcS also had a curative activity against rice sheath blight and that of CjR had a little curative activity. On the other hand, the extract of *Rumex acetocella* roots reduced specifically the development of barley powdery mildew [29]. Anti-mycotic activity of the ethanol extracts from *Urtica dioica* L., *Citrullus colocynthis* L. Schrad, *Ziziphus spina-christi* L. and *Nerium oleander* L. floral parts were screened *in vitro* against four important plant pathogenic fungi viz., *Alternaria alternate, Fusarium oxysporum, Fusarium solani* and *Rhizoctonia solani* using agar dilution bioassay. Extracts showed antifungal activity against all the tested fungi. Among the plants, *U. dioica* and *C. colocynthis* were the most effective against *A. alternate* and *R. solani* while *N. oleander* possesses the best inhibition on *F. oxysporum* and *F. solani*. *Z. spina-christi* was the most effective extract in reducing the growth of *R. solani* than other fungi [30].

Forty nine plant extracts that are vastly used in Indian traditional medicine were evaluated for their antifungal activity against *Aspergillus niger* and found out that forty three out of forty nine plant extracts possessed antifungal activity. Four plants *Grewia arborea, Melia azedarach, Peltophorum pterophorus, Terminalia chebula* showed exceptionally prominent activity. Methanol extract of *G. arborea* showed maximum activity even at very low concentration of 50 mg/ml [31]. Aqueous extract of *Allium sativum (*cloves of garlic) showed antifungal activity against *Candida parapsilosis* isolate with 30 mm of Inhibition zone [32].

n-butanol, methanol and aqueous extracts of *Lawsonia inermis L, Mimosa pudica L, Phyllanthus niruri L., Tephrosia purpurea Pens., Vinca rosea L.* were evaluated against plant pathogenic fungus *Pythium debaryanum* that causes damping off disease in plants. n-butanol and methanol extract of *L. inermis* exhibited maximum antifungal activity followed by *P. niruri* and *T. purpurea*. Methanol extract of *M. pudica* also showed significant activity against the test pathogen with 20 mm inhibition zone [33].

Plant extracts of *Gongronema latifolium* and *Vernonia amygdalina* were found to possess very high antifungal properties in field conditions at different plant densities of Cowpea (*Vigna unguiculata* (L) Walp) against *Aspergillus* species, *Penicillium* species, and *Rhizoctonia solani* [34].

CONCLUSION

The use of crude plant extracts to control plant diseases is an old practice in many parts of the world. The Indigenous Technical Knowledge (ITK) would be helpful in exploring indigenous flora for management of fungal diseases in systematic and scientific way. The plant products or their active principles, thus require a systematic study in order to search for better fungicides for management of fungal diseases. Despite the stunning success of the agrochemical industries in creating new chemical fungicides, finding new wide spectrum biological antifungal agents is still a priority because of many adverse effects of these synthetic chemicals, like resurgence of resistant pathogens and disturbance of ecological balance etc.

The plant world, the rich storehouse of natural chemicals could be exploited for the use as pesticides. Although the body of literature identifying the antimicrobial potential of many traditional plants is growing, many species of higher plants have not been yet explored, much less surveyed for biologically active constituent and new sources of commercially valuable pesticides. This is mainly due to lack of information on the screening and evaluation of diverse plants for their antimicrobial potential. Systematic and scientific evaluation of plant derived bio-active molecules for using their potential for the effective management of fungal plant diseases to maintain high level of bio-safety and non-adverse effects on the environment will

open up many revenues for the betterment of environment and mankind. This approach would contribute positively to global scenario of food crisis and environmental pollution by effectively controlling many major fungal diseases of plants without creating potential threats to the ecological balance.

It is evident from the previous reports that plant extracts and essential oils are effective antimicrobial agents for soil borne fungi, food spoilage fungi, foliar pathogens and nematodes and do not produce any residual effects. The botanicals are cost effective, non hazardous, easily available and do not pollute the environment. Also, biologically active plant derived pesticides are expected to play a significant role in crop protection strategies. Exploitation of naturally available chemicals from plants, which retards the growth of disease causing pathogens, would be a more realistic and ecologically sound method for development of future commercial pesticides for crop protection strategies, with special reference to the management of plant diseases.

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