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Role of botanical plant extracts to control plant pathogens-A review

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ABSTRACT

Agricultural and horticultural crops are spoiled by various fungi causing economic losses, and health risk to the consumers due to mycotoxins produced by fungi. The indiscriminate use of synthetic chemicals led to development of resistance in plants which has necessitated utilization of higher concentrations, with the consequent rise in toxicity in food products. In ecosystem plants are surrounded by various enemies which defend themselves by producing secondary metabolites like terpenes, phenols and nitrogen and sulphur compounds. A new approach to control the pathogens which hampers quality food production has been implemented by the application of plant extract. Various studies have explained that plant extracts contain sundry of bioactive components that can control the fungal growth. The aim of this article is to summarize the results of in vitro experiments from the various literatures regarding the effects of plant-derived compounds for controlling growth of fungi.

Key words: Fungal diseases, Plant pathogens, Plant extract, Synthetic chemical.

There are various types of pests and diseases attack almost all types of crops throughout the world and most are fungal pathogenic diseases. Losses to the post-harvest crops have been estimated around 50% due to fungal and bacterial infections (Magro *et al*., 2006). Moulds are omnipresent biological agents; colonize foods due to their potentiality to synthesize a wide variety of enzymes causing economic losses (Cabral 2013).Vegetable and fruit crops are highly susceptible to fungal spoilage, due to the abiotic factors like pH, water activity (aw), solute concentration, temperature, atmosphere, time, etc. lead to numerous plant diseases and significant economic losses both in the field and prior to harvest. Significant fungal genera like *Aspergillus, Fusarium, Penicillium* and *Alternaria sp*. are also vulnerable to grain crops causing loss in yield of grains and dry matter thus reducing the quality of feed and seed produced (Magan and Aldred, 2007).

Plants produce numerous secondary plant metabolites that are insignificant for growth and developmental processes (Rosenthal *et al*., 1991) act against microbial pathogens on the basis of their toxic nature (Schafer *et al*., 2009).Exploration of plant based pesticides to control post-harvest losses is one of the feasible methods, lead to ecofriendly use of natural products, act as rich source of natural compounds exhibiting many fungicidal and other properties with least side effects. Antifungal activity of plant exerpts may be more effective than some commercial synthetic fungicides natural occurring substances in plants with anti-microbic properties (Tamuli, 2014). Therefore, it has become necessary to adopt ecofriendly management practices for plant health management and better yield. In the present review different *in-vitro* studies are discussed to control plant pathogens.

Drawbacks of using synthetic fungicides: The foremost step to control fungi is the application of fungicides, which can be solicitat post-harvest, does not affect the quality of the produce (Amiri *et al.,* 2008). Antimicrobic chemicals have been used since decades to control of plant diseases, causing development of resistant pathogen populations due to increased concentrations in food products as some of these chemicals are not biodegradable and accumulate in soil, plants and water, affecting living organisms. Although use of chemicals has been considered to be the cheap and most efficient way to prevent diseases. The applied concentrations of fungicides are restricted due to their lethal effects on food and human health. Because of undesirable effects, recent studies resulted in the annulment of new effective fungicides keeping in concern about living beings as an alternative to synthetic fungicides as there is an urgent need to develop alternative these chemicals.

Chemicals alternative to conventional fungicides: The continuous development of fungicide resistance to several pre-harvest and post-harvest pathogens has developed resistance to commonly used fungicides. Hence, a wide range of natural plant fungicides have been evaluated for agricultural use keeping in mind that the natural chemicals should be sensitive at very low dose, should have optimum

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target pathogens and have potential target sites and applicable to the agrochemical industry which can be achieved with proper evaluating the dose respone studies, mode of action and structure activity studies (Wedge and Smith, 2006).

Since early 1970s, agriculture worldwide has struggled with the evolution of pathogen resistance to disease control agents due repeated use of chemical pesticides which brings a desire to public for safer pesticides with less environmental impact. So evaluating a natural products and extracts as a new source of strategy for the discovery of new chemicals that have not previously been created by chemists (Wedge and Smith, 2006). Under this situation new investigated method to plant disease control is an alternative way to chemical fungicide for eliminating these synthetic compounds or meanly controlling their use together with natural fungicide substances is an unique strategy plan called Integrated Pest Management (IPM).

Plants extracts as natural antifungals

Plant extracts and essential oils: To reduce the use of unnatural chemicals in food, several alternative methods such as use of plant extract which produce a wide variety of secondary metabolites in response. In the recent years, increased interest is observed because of their safe status as they can be easily decomposed, nature friendly and non-phytotoxic. It has been proved that plant extracts obtained with different solvents and essential oils are rich in bioactive and antioxidant compounds.

Hassan *et al*. (1992) reported that rust pustules on the wheat leaves can be reduced with leaf extracts of *Datura stramoniu*. According to Khan *et al*. (1998) of *Allium cepa* aqueous extract exhibited antifungal activity against *Helminthosporium turcicum* and *Ascochyta rabiei* and that of *Calotropis procera* against *Alternaria redicina*. Rai *et al*. (2000) found that pure extract of *Adenocallima alliaceum* can completely inhibit the spore germination of *Alternaria alternata* and *Fusarium oxysporum*. Bajwa*et al*. 2001 evaluated aqueous extracts of three Asteraceous allelopathic species on growth of *Aspergillus niger* which shows effective result. Khallil (2001) tested evaluated that extract of *Eugenia aromatica* to completely inhibit the spore germination of *A. solani* and also reported that extracts of garlic and onion bulbs, eucalyptus leaves and pepper fruits shows remarkable inhibitory effects against these *Alternaria solani* and *Saprolegnia parasitica*.

Paul (2003) carried out *in vitro* tests against *Phytophthora cryptogea, Trichoderma virens, Aspergillus niger, Phoma sp., Fusarium oxysporium, Pythium ultimum, Cochliobolus heterostrophus, Rhizoctonia solani, Sclerotium rolfsii* and *Pyrenophora teres*using extracts of *Maesalan ceolata var. goulun gensis* showed effective results against all the pathogens tested.

Harish *et al*. (2004) working on rice brown spot (*Helminthosporium oryzae*) control with 15 seed extracts under laboratory condition found that 10% rhizome extract of turmeric (*Curcuma longa*), seed extracts of sundavathal (*Solanum indicum*) and vedpalai (*Wrightia tinctoria*) exerted maximum mycelial growth and spore germination inhibition. Choi *et al*., (2004) reported the extract of *Rumex acetosella* roots reduced development of powdery mildew of barley. Velluti *et al*. (2004) evaluated 37 essential oils of which lemongrass, cinnamon, clove, palmarosa and oregano showed antifungal activity against *Fusarium* sp. showing no interspecific difference which suggests that EOs can be safe alternative

Rodriguez *et al*., (2005) reported the antifungal activity of *Aloe Vera* (syn: *A. barbadensis*) on mycellium growth of *Rhizoctonia solani*, *Fusarium oxysporum*, and *C. coccodes* showed an inhibitory against fungi.

Antifungal activity of volatile components extracted from flowers of *Lantana camara, Malvaviscus arboreus* and *Hibiscus rosa-sinensis* showed stronger antifungal activity against *Alternaria solani, Botrytis cinerea, Pythium ultimum, Rhizoctonia solani* and *Verticillium dahlia* than extracts from stems or leaves (Boughalleb *et al*., 2005).

Doltsinis *et al*. (2006) evaluated the efficacy of Milsanato induce resistance to powdery mildew on cucumbers, against *Leveillula taurica* on greenhouse tomato which demonstrate that Milsana could play an supreme role in of powdery mildew management in organic and low resource tomato production.

Kumar *et al*., (2007) reported *Chenopodium ambrosioides* can inhibit two aflatoxigenic strains of *Aspergillus flavus* along with *A. fumigatus, Botryodiplodia theobromae, F.oxysporum, P. debaryanum* and *S. rolfsii*) and essential oil of *Peumusboldus*was effective against *A. niger, A. flavus* and *Fusarium* spp. (Souza *et al*., 2005). Magro *et al*., 2006 evaluated that inhibition *of Aspergilluscandidus, A. niger, Penicillium sp.*, and *F. culmorum* with Chamomile and malva aqueous extracts. Viuda-Martos *et al*. (2008) used cold-pressing the peel of lemon and orange, against *Penicillium chrysogenum, Penicillium verrucosum, A.*niger and *A. flavus* gives effective result.

Shirzadian *et al*. (2009) evaluated twenty one moss species and two leafy liverwort species obtained by ethanol, water and petroleum ether solvents against *Alternaria alternata* showing broadest spectrum antifungal activity by the ethanolic extracts of six moss species.

Fawzi (2009) carried out in vitro studies of different plant extracts against *Fusarium oxysporum* showed radial growth inhibition of the fungi. Lakhdar (2010) evaluated antifungal activity of powdered extracts and essential oils of some local medicinal plants on *F.oxysporum f. sp. lentil* population in soil showed 10% and 5% powdered extracts of *I.viscosa* and *M.pepirita* and all the essential oil formulations of all the plant extract reduced the soil population densities of fungi and disease incidence in lentil.

Surender (2012) evaluated aqueous extract of 20 plants for antifungal activity against *F.solani* (dry rot of potato) showed differential activities of different plant extracts against the mycelial growth inhibition.

Cheng *et al.* (2008) investigated the antifungal activity of essential oil from *Calocedrus macrolepis* var. *formosana* and its constituents T-murolol and a-cadinol on the growth of plant pathogenic fungi which also inhibited the growth of *Rhizoctonia solani*and *Fusariumoxysporum* and mycelial growths of *Colletotrichum gloeosporioides*, *Pestalotiopsis funerea*, *Ganoderma australe* and *F. solani.*

Razzaghi-Abyaneh *et al.* (2008) investigated the inhibitory effect of carvacrol and thymol as aflatoxins producer obtained from essential oil of *Satureja hortensis* against *Aspergillu sparasiticus* inhibit the growth of fungal.

Feng and Zheng (2007) studied the antifungal activity of essential oils of five plants (thyme, sage, nutmeg, eucalyptus and cassia) against *Alternaria alternata* at different concentrations and found that the cassia oil can completely inhibit *A. alternata* growth. Faria *et al*. (2006) reported that essential oil of aerial parts of *Ocimum gratissimum* obtained can inhibite growth of several fungi including *Botryosphaeria rhodina*, *Rhizoctonia* and *Alternaria*sp.

Abo El-Seoud *et al*. (2005) evaluated essential oils of fennel, peppermint, caraway, eucalyptus, geranium and lemongrass for their antimicrobial activities against some plant pathogens *(F oxysporum, A alternata*, *P italicum* and *B cinerea*) and found that essential oils of fennel, peppermint and caraway can be used as active ingredients for formulating biocides. Hassane *et al*. (2008) tested ethanol, ethyl acetate and water extracts leaf of *Azadiracta indica* and *Melia azedarach* against two tomato fungal pathogens at different concentrations and found that both ethanol and ethyl acetate extracts of neem leaves assayed, completely suppressed the growth of *F. oxysporum* and *A. solani.*

Hadizadeh *et al*. (2009) working on antifungal effect of essential oils from some medicinal plants of Iran: neetle (*Urticadioica*), thyme (*Thymus vulgaris),* eucalyptus (*Eucalyptus* sp.), rute (*Ruta graveolens*) and common yarrow (*Achillea millefolium*) on *A. alternata* of potato as a model pathosystem. Zabka *et al*. (2009) reported use of EOs obtained from *Carum carvi, Cymbopogon nardus, Pelargonium roseum, Pimentadioica* and *Thymus vulgaris* against growth *F. oxysporum, Fusarium verticillioides, Penicilliumexpansum, Penicilliumbrevicompactum, A. flavus and A. fumigatus*.Vilela *et al*. (2009) showed the EO of *Eucalyptus globulus* showed inhibitory effect against fungal species, *A. flavus*and *Aspergillus parasiticus*. Ravikumar *et al*. (2007) reported the use of crude ethanolic *Thevetia peruviana* extracts against 50% radial growth reduction of A. niger and *Penicillium spp***.** Singh *et al* (2007) reported 100% effect of Cinnamon leaf oil against *A. niger, A. flavus, Fusarium moniliforme, Fusarium graminearum, Penicillium citrinum*and *Penicillium viridicatum.* Deba *et al*. (2008) tested the fungitoxic activities of the flower essential oils of *Bidens pilosa* against *Fusarium spp., Fusarium solani* the most suppressed species, followed by *F. oxysporum.* Naeini *et al*. (2010) observed anti-Fusarium properties of five EO of *Cuminum cyminum* and *Zataria multiflora*. A preliminary study was conducted by Matchima and Ampai (2009) to investigate efficacy of crude dichloromethane extracts of pomelo albedo on radial growth and spore germination of *Colletotrichum gloeosporioides* at different concentrations which showed that crude extracts did not affect radial but reduced spore germination at 25% and 100% concentration. Yasmin (2008) evaluated 55 angiospermic plants the *in vitro* vegetative growth of *Fusarium moniliforme* Sheldon where leaf extract of *Lawsonia inermis* showed maximum inhibition followed by roots extract of *Asparagus racemosus*. Yusuf (2011) evaluated Antifungal activities of *Xanthium strumarium, Laurisnobilis, Salvia officinalis* and *Styrax officinalis* which were the most active against mycelial growth of *P. infestans*.

Debjani *et al* (2017) observed three plant extracts Ginger, Polyalthi and Clerodendrum shows good inhibitory effect on *Rhizoctonia solani* under *in vivo* condition and also observed dose response effect against growth of *Colletotrichum capsici* at three different concentrations**.** Rupert *et al* (2016) observed the methanol extracts of *Polyalthia longifolia* and *Terminalia chebula* and chloroform extract of *Zingiber officinale* were found to be most effective against the *Xanthomonas campestris pv. campestris* in *in vitro* condition. *Zingiber officinale, Polyalthia longifolia* and *Clerodendrum inerme* leaf extracts exhibited more than 80 per cent inhibition of against mycelial growth of *colletotrichum musae* (Bhutia *et al* 2015). Jantasorn (2016) investigated the efficacy of *Hydnocarpus*, *Caesalpinia* and *Carallia* against five plant pathogenic fungi in *in vitro* conditions at various concentrations among which Hydnocarpus fruit extracts exhibited potential to growth inhibition, and recorded 100 % growth inhibition against *P. oryzae*, *P. palmivora* and *R. solani* followed by *S. rolfsii* (96.33 %). Monika (2016) evaluated antifungal activity of dill seed oil and its fractions against *Alternaria triticina, Bipolaris sorokiniana* and *Ustilago segetum* var. *tritici* and it was observed that Carvone, camphor and polar fraction showed effective against *A. triticina, B. sorokiniana* and *U. segetum.*

Combined application of plant extracts: In the foregoing section bioactivity of plant extracts against different plant pathogens and diseases caused by them were presented. Majority of the researches on bio-active plant extract emphasized on effect of sole plant extract against plant pathogens or diseases. Though few in number some research group tried to formulate and test different combined or mixture of plant extracts. Suprapta and Khalimi (2009) evaluated methanol extract of *Eugenia aromatica, Piper*

betle, Alpiniaga langa, Sphaeranthus indicus as sole and also in combination against stem rot disease of Vanila caused by *Fusarium oxysporum f.sp. vanille*. A formulation containing mixture of aromatica flower bud extract and Piper betle leaf extract significantly inhibited the fungal growth in-vitro by more than 90% and stem rot disease incidence by more than 92% over control. This combination was reported to be significantly better than the sole extract formulation to suppress the population growth of *Fusarium oxysporumf.sp. vanillae* in soil.

Similarly Bhardwaj (2012), tested aqueous extract of twenty plants as sole and also in combination against *Fusarium solani* causal agent of dry root rot of potato. The mixtures of *Lawsonia alba* leaf extracts and Acacia catechu stem extracts showed an enhancement in activities over the individual extracts by 54.69 % and 62.07 % respectively. Nguefack *et. al.* (2012) observed synergistic effect against *Penicillium expansum* by mixing fractions of essential oil from *Cymbopogon citrates, T. vulgaris and O. gratissimum*.

Another strategy to improve bio activity of plant extracts to combine with bio control agents as demonstrated by Bowers and Locke, (2000). Similarly in India, Akila *et. al*., (2011) clearly found that combined application of botanical extracts and biocontrol agents effectively reduced *Fusarium* wilt of banana.

Botanicals are also been tried in the field of food borne microorganisms. The combined extracts of *Corni fructus,* cinnamon and Chinese chive were used to evaluate its antimicrobial activity on common foodborne micro-organisms by Hsieh *et al*. (2001). The combined extract was not only found very stable under heat treatment and also showed an outstanding inhibitory effect against entire antimicrobial spectrum. They concluded that combined extract is suitable application where a naturally antimicrobial additive is desired. Burtram *et al.* (2015) observed both synergistic and antagonistic interactions between the plant extracts and the kresoxim-methyl fungicide which showed both Synergistic and additive effects against one strain of *B. cinerea*

Some researchers also reported enhanced antifungal activity of cassia oil, essential oils when applied in combination with salt like KCl or NaCl (Feng and Zheng, 2006), polysaccharide like chitosan (dos Santos *et al*., 2012).Most of researches related to combination have been done against human pathogens where synergistic effect of two plant extracts (Tahany *et.al*., 2010), plants extracts and antibiotics (Adwan, 2008; Rakholiya and Chanda, 2012) were studied in different ways.

CONCLUSION

The search of alternative chemicals now a days is of great concern for food industry, mainly due to fungal contamination in post-harvest crops. There are many nature protection agencies, who express concern about the widespread use of unnatural chemicals that contaminate soil and water, and leave toxic residues that might affect the environment. The mycotoxins produced by fungi can be controlled by plant extracts and has been extensively studied as reviewed in this article. These botanicals can be used as antifungals in combinations to human and animals and have greater number of opportunities to explore. So a systematic research has to be done to broaden the knowledge in this area. For future studies the plant species which are tested has to be described thoroughly including their location and season where they grow.

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