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Involvement of botanicals in crop diseases management

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Abstract
Chemical fungicides are being used many years ago for the management of crop losses coursed by pathogens. However, these chemicals are hazardous to man and the environment and not all farmers can afford to buy. To mitigate these problems, attention of researchers focused on the identification and characterization of botanicals from many plant species. Currently, several types of researches have been carried out *in vitro* and *in vivo* to evaluate the efficacy of plant extracts and oils against plant pathogens and proved effective. These botanicals exhibit fungicidal potentials in nature, by production of secondary metabolites from their different parts *viz*., leaf, flower, root and stem, widely used in the form of water extracts of leaves or seeds and oil, owing to its effects as pesticide against crop diseases. However, this information on plants antagonistic to crop diseases are revealing to the farmers and entrepreneurs, leaving valuable sources for commercial products undiscovered. Hence, a greater understanding of these alternative fungicides may, therefore, be helpful for practicing sustainable agriculture, particularly considering that they are less hazardous, economically feasible, easily adoptable and could be used to manage pathogens in both fields and stores (postharvest). This review, summarizes previous studies on the efficacy of botanicals from different plant species, for the management of crop diseases with emphasis on insect pests, nematodes, fungal and bacterial diseases.

Keywords: Biofungicides, Plant pathogens, pathogens management, Disease management

Introduction

Plant Pathogens (Nematodes, fungi, viruses bacteria, algae and protozoa) contribute significantly to the total crop losses at global and national level both. The chemical fungicides are inorganic products designed and used as an effective means to control plant pathogens in the fields and storerage. Despite the fact that chemical fungicide is highly effective, however, their repeated and indiscriminate use in agriculture has caused many problems to the environment such as poisoning of farmers; elimination phytopathogens, insensitive to certain active ingredients. It was reported that, hardly 0.1% of the agrochemicals used in crop protection reach the target pathogen, leaving the remaining 99.9% to enter the environment and cause a hazard to non-target organisms, including humans (Pimentel and Levitan, 1986) [55]. Due to the fact that the chemicals can persist in the soil and crops, hence, their use has been discouraged (Isman and Machial 2006; Rajendran and Sriranjini 2008) [29, 59]. Chemicals are hazardous to human health through the intake of pesticide residues in foodstuff, potential poisoning of users during applications. There is a growing movement in many countries to minimize the number of chemicals being released into the environment, this marks the dawn of using alternative methods in the management of crop diseases. This action has been prompted in part by concern over the misuse and overuse of fungicide. Presently, there are many alternatives to chemical fungicide that come from natural plant products and are known to be of low mammalian toxicity and are highly biodegradable (Asawalam and Anaeto, 2014) [11]. The use of botanicals appears the most feasible especially for low-income farmers who constitute about 98% of the farming population. Applications of these botanicals do not constitute a threat to the environment, they are easily affordable, require less skill and above all increase soil fertility (Enyiukwu *et al.,* 2014) [19, 27]. These products are generally assumed to be more acceptable and less hazardous for the ecosystems and could be used as alternative remedies for the treatment of plant diseases (Chuang *et al.*, 2007) [15].

They can easily be adopted by farmers in developing countries in the world, who traditionally use plant extracts for the treatment of human diseases (Nuzhat and Vidyasagar, 2013) [45]. However, It is estimated that there are more than 250,000 higher plant species on earth that can be evaluated for their antimicrobial bioactive chemical compounds. It is also estimated that the plants may contain as many as 4,000,000 secondary metabolites (Mamun, 2011) [38, 39].

These natural products can be used to manage crop pathogens either in the field or in-store (postharvest).

Since ancient times, there have been efforts to protect harvest production against pests. The Egyptian and Indian farmers used to mix the stored with fire ashes. The ancient Romans used false hellebore (*Veratrum album*) as a rodenticide, the Chinese are credited with discovering the insecticidal properties of *Derris species*, whereas pyrethrum was used as an insecticide in Persia and China (Ahmed and Grainge, 1986) [8]. Botanicals contained compounds that are natural in origin, have minimum adverse effects on the physiological processes of plants and are easily convertible into common eco-friendly organic materials (Gnanamanickam, 2002) [24]. Moreover, botanical fungicide is extracted from various plant parts (leaves, stems, seeds, roots, bulbs, rhizomes, unripe fruits, and flower heads, etc.) of different plant species. Botanicals derived from plants such as Neem, Ghora-neem, Mahogany, karanja, Adathoda, Sweet flag, Tobacco, Derris, Annona, Smartweed, Bar weed, Datura, Calotropis, Bidens, Lantana, Chrysanthemum, Artemisia, Marigold, Clerodendrum, Wild sunflower and many others may be grown with minimum expense and extracted by indigenous methods (Mamun and Ahmed, 2011) [38, 39]. Some of the botanical fungicide that have primarily been used and are commercially available include Ryania, Rotenone, Pyrethrin, Nicotine, Azadirachtin, and Sabadilla (Rajashekar *et al.*, 2012) [58]. Previous researches carried out in proved that compounds from botanicals extracts successfully managed different crop diseases. Examples, allicin (diallyl thio sulphinate) a volatile antimicrobial substance is synthesized in Garlic. Slusarenko *et al*., (2008) reported that allicin effectively controlled seed- borne *Alternaria* spp. in carrot, *Phytophthora* leaf blight of tomato and of potato as well as *Magnaporthe* on Paddy and Downy mildew of *Arabidopsis thaliana*. However, the essential oil extracted from lemongrass (*Cymbopogon* spp.) was successfully managed postharvest Anthracnose of Mango fruits. In addition, Lavanya *et al*., (2009) [35] reported that anti-viral protein (AVP) extracts from *Bougainvillea spectabilis* and *Prosopis chilinesis* were found to be effective in reducing the Sunflower Necrosis Virus (SFNV) infection both in cowpea and sunflower plants. Several successful tests of *Azadirachta indica* against insect vectors of plant virus has been performed. Neem leaf extracts reduced the transmission of tobacco mosaic, a virus that seriously affects several vegetable crops (Sivakumar and Gunassekaran, 2011) [68]. All parts of *Azadirachta indica* has been used as seed-coating and bare-root-dip treatments against nematodes (Akhtar *et al.,* 2008) [9]. Also, water extracts of *Azadirachta indica* have been identified to have nematicidal properties and have proven to better control soil pests, especially soil parasitic nematodes and also provides soil nutrients (Agbenin *et al*., 2005) [7].

The mechanism of actions of plant botanicals has not yet been fully explained. Hence there is a need for the advances in the study of the formulation and possible beneficial mechanism to prevent or control diseases attack. A better understanding of how they will fit into integrated strategies of disease management is therefore required. However, previous researches reported that botanicals contain compounds that mostly affect pests in their growth by inhibiting metamorphosis. The compound would either prevent metamorphosis from taking place at the right time or force pests to go through early stages of metamorphosis so that development takes place at a time not favourable for pests (Carolyn, 2000) [14]. It was reported that, essential oils possess acute contact and fumigant toxicity to insects (Abdelgaleil *et al*., 2009) [2], due to high volatility and lipophilic properties can penetrate into insects rapidly and interfere in physiological functions (Negahban *et al*., 2007) [43]. Essentials oils also have a repellent activity (Nerio *et al*., 2009) [44]. The repellent activity has been linked to the presence of essential oils that cause the death of insects by inhibiting AChE activity in the nervous system. However, essentials oils were reported to have antifeedant activity as well as development and growth inhibitory activity. An example, *Azadirachta indica* contains essential compounds that have been proven to have biological activity on insect pest behaviour, feeding, fumigant toxicity, knockdown activity and lethal toxicity via contact (Isman, 2000) [28]. Moreover, previous researches showed that, *Azadirachta indica* extract contains compounds that stimulate the production of oxygen radicals which block the metabolic pathways of the nematodes (Gommers *et al*., 1982) [25]. Some of these compounds are synthetic metabolites and are more lethal to plant pathogens. It was also reported that, botanical fungicide inhibits fungi by affecting its physiological processes and consequently lowering its growth (Kator *et al*., 2015) [31].

Researches have been carried out to evaluate the efficacy of plant extracts and oils against insect plant pathogens. The results proved effective and some commercially botanical formulations have been prepared and marketed, but their applications have not been popularized yet. However, mechanisms of action of these natural products are still in its infancy and yet to be fully explored. Thus, there is a need to explore more effective botanicals, their formulations, preparation of crude extracts, storage and quality verification, application methods, mechanisms of action and synthesis and commercial formulations of botanical fungicide. Moreover, water extracts are easily washed off due to heavy rains. Hence, research is needed to extend residuals by adding stickers. This review, summarized some reported work on botanicals befitting the management practices of plant diseases, not only because of its ease of availability but also economical feasibility for the growers/f armers entrepreneurship.

The table below summarized the previous studies on botanical fungicide, with emphasis on the parts used, concentrations/dosages, targeted insect pests/pathogens and the tested crops. Hence, for detailed information refer to the appropriate literature cited.

Table 1: Show Nematocidal potentials of some plant products

				Nematocidal potentials of some plant products			
1	**Neem**	***Azadirachta indica***	**Leaf powder**	**20% w/v**	***Meloidogyne incognita***	**Tomato**	**Agbenin *et al.*, 2005 [7]**
	Garlic	*Allium sativum*	Rhizome	20% w/v	*M. incognita*		
2	Citrus	*Citrus aurantifolia*	Leaf	390 ppm	*M. incognita*	Chickpea	Singh, 2015 [66]
3	Neem	*Azadirachta indica*	Leaf	2g/plant	*Heterodera zeae*	Maize	Baheti *et al.*, 2017 [12]
4	Neem	*Azadirachta. indica*	Leaf	30g/ kg of soil	*M. javnica*	Okra	Sidhu *et al.*, 2017 [64]
	Jimson weed	*Datura stramonium*	Leaf	20% w/v			
5	Moringa	*Moringa oleifera*	Leaf	20,000 mg/kg	*M. incognita*	Cowpea	Claudius-Cole *et al.*, 2010 [16]
	Neem	*Azadirachta. indica*	Leaf	20,000 mg/kg			
	Bitter leaf	*Vernonia amygdalina*	Leaf	20,000 mg/kg			
6	Rape seed	*Brassica napus* L.	Leaf	10%	*M. incognita*	Tomato	Feyisa *et al.*, 2015 [21]
	Lantana	*Lantana camara* L.	Leaf	10%			
	Marigold	*Tagetes erecta* L.	Leaf	10%			
	Neem	*Azadirachta indica*	Leaf & seed	10%			
7	Wormwood	*Artemisia absinthium*	Leaf	3% & 5%	*M. incognita*	Tomato	Ozdemir and Gozel 2018 [52]
	Lavander	*Lavandula officinalis*	Leaf	3% & 5%			
	Field mint	*Mentha arvensis*	Leaf	3% & 5%			
	Wild thyme	*Wild thyme*	Leaf	3% & 5%			
8	Hindi-Aak	*Calotropis gigantea*	Leaf	5.00%	*M. incognita*	Tomato	Saravanapriya and Sivakumar 2005 [62]
	Watermelon	*Citrullus lanatus*	seed				
9	Abeere	*Hunteria umbellata*	Leaf	100%	*M. incognita*	Cashew (*Anacardium occidentale* L)	Okeniyi *et al*., 2013 [48]
	Ukpo	*Mallotus oppositifolius*	Leaf	100%			
	Ironwood	*Bridelia micrantha*	Leaf	100%			
	Citron	*Citrus medica*	Leaf	100%			
10	Ajowan	*Trachyspermum ammi*	Seeds	1.0 mg/ml	*Bursaphelenchus Xylophilus*	*Pinus densiflora*	Park *et al*., 2007 [23, 53]
	Allspice	*Pimenta dioica*	Berries	1.0 mg/ml		*P. thunbergii*	
	Litsea	*Litsea cubeba*	Fruits	1.0 mg/ml			
11	Cinnamon	*Cinnamomum verum*	Bark	5000 ppm	*Bursaphelenchus Xylophilus*	*Bursaphelenchus xylophilus*	Park *et al*., 2005 [54]
12	Marigold	*Tithonia diversifolia*	Leaf and Tender stem	1% v/v	*M. incognita*	Cowpea	Odeyemi *et al*., 2014 [47]
	Siam weed	*Chromolaena odorata*		1% v/v			
13	Garlic	*Allium sativum*	Cloves	0.63%	*M. incognita*	Eggplant	El-Nagdi *et al*., 2014 [18]
14	castor bean	*Ricinus communis*	Seeds	10 g/100 ml	*M. incognita*	Tomato	El-Nagdi and Youssef 2013 [17]
15	Liquorice	Glycyrrhiza glabra	Leaf	4000 ppm	M. incognita		Haroon *et al*., 2018 [26]
	Lantana	Lantana camara	Roots	4000 ppm			
16	Brown mustard	Brassica juncea	Aerial parts	2% W/V	Xiphinema index	Grapevine	Aballay *et al*., 2004 [1]
	Thyme	**Hymus vulgaris**					
				Fungicidal potentials of some plant products			
1	MalabarNut	*Adhatoda vasica*	Leaf	4-5%	*Rhizoctonia solani* (stem rot)	Carnation *Dianthus caryophyllus*	(Sunita and sushma, 2014)
2	Tobacco	*Nicotiana tabacum*	Leaf	60%	*Aspergillus viridae* (fruit rot)	Tomato *Lycopersicon esculentum*	(Suleiman, 2011)
3	Tobacco	*Nicotiana tabacum*	Leaf	100mg/ml	*Colletotrichum coccode*	Tomato *Lycopersicon esculentum*	(Bankole *et al*., 2018) [13]
	Neem	*Azadirachtha indica*	Leaf	100mg/ml	(Tomato anthracnose)		
4	Snakeroot	*Rauvolfia serpentine*	Leaf	10%	*Cochliobolus heterostrophus* (Maydis Leaf Blight)	Maize (Zea mays)	(Vinod *et al*., 2018)
5	Camphor	*Artemisia camphorata*	Aqueous extract	10%	*Bipolaris sorokiniana* (*wheat black point disease)*	Wheat (*Triticum aestivum*)	(Franzener *et al.*, 2003) [22]
6	Mehandi	*Lawsonia inermis*	Leaf extract	40%	*Drechslera bicolor* (sweet pepper blight)	Sweet pepper (*Capsicum annuum)*	(Kuldeep *et al*., 2016) [33]
7	liquorice plant	*Glycyrrhizaglabra*	Whole plant	46%	*Fusarium guttiforme* pineapple fusariosis	Pineapple (*Ananas comosus*)	(Maria *et al*., 2015) [4]
8	Garlic	*Allium sativum*	Bulbs	20%	*Fusarium oxysporum* vascular wilt of coffee	Coffee (*Coffea arabica* L.)	(Silva*et al*., 2014) [65]
	Clove	Syzygium aromaticum	Flower buds	20%	*Cercospora coffeicola Cercospora coffeicola*		
9	Early- flowering borage	*Trachystemonorientalis*	Leaf, flower &root	400 mg/ml	*Alternaria solani* Early blight of tomato	Tomato *Lycopersicum esculentum*	(Abdurrahman, and Hayriye, 2016) [3]
10	Cherry laurel	*Prunus laurocerasu*	Leaf &fruit	400 mg/ml	*Botrytis cinerea* Graymold of Strewberry	Strawberry *Fragaria × ananassa*	(Abdurrahman, and Hayriye, 2016) [3]
11	Devil's trumpet	*Datura metel*	Leaf	30 µ l	*Pestalotiopsis theae* Tea gray blight	Tea plant (*Camellia sinensis*	(Saha *et al*., 2005) [60]
12	Ajowan	*Trachyspermumammi*	Seeds essential oil	25 µl	Banana wilt(*Fusarium Oxysporum* F. sp. *cubense*	Banana *Musa* spp	(Sirirat, 2010) [67]
				Bactericidal potentials of some of plant products			
1	Ginger	*Zingiber officinale*	Rhizomes	5 g L^{-1}	*Xanthomonas campestris* pv.	Solanum	(Opara and Obani,

					Vesicatoria (Bacterial leaf spot)	*S.gilo* *S.torvum*	2010) [49]
2	Jute	*Corchorus capsularis* L.	Dry leaves	90%	Erwinia carotovora (Bacterial soft rot)	Potato *Solanum tuberosum*	(Rahman *et al*., 2012) [57]
3	Turmeric	*Curcuma longa*	Rhizomes	20%	*Xanthomonas axonopodis* pv. *manihotis* (cassava bacterial wilt)	Cassava (*Manihot esculenta*)	(Kuhn *et al*., 2006) [32]
4	Chickweed or whiteweed	*Ageratum conyzoides*	Whole plant parts	15%	bacterial wilt and canker of tomato (*Clavibacteria michigenesis)*	Tomato *Lycopersicum esculentum*	(Mitali *et al*., 2012) [42]
5	Indian sorrel	*Oxalis corniculata*	Leaf extract	1:10 w/v	Angular leaf spot of cotton (*Xanthomonas axonopodis* pv. *Malvacearum*)	Cotton (Gossypium spp	(Raghavendra *et al*., 2006) [56]
6	Milk weed	*Euphorbia hirta*	Leaf extract	1:1 dilution	Bacterial soft rot of Cabbage (*Erwinia carotovora* pv. *Carotovora)*	Cabbage *Brassica oleracea* var. *capitata*	(Acedo *et al*., 1999)
7	Achiote	*Bixa orellana*	Extract	2000ppm extract	Bacterial Leaf Spot of capsicum *Xanthomonas euvesicatoria*	*Peppers Capsicum annuum*	(Sree and Sreeramulu, 2002)
8	Malabar nut	*Justicia adhatoda*	Leaf extract	15%	Bacterial blight of rice (*Xanthomonas oryzae pv. Oryzae*)	Rice *Oryza sativa* or *Oryza glaberrima*	(Madhiazhagan *et al*., 2002) [37]
9	Aloe	*Aloe vera*	Stem	100%	Bacterial leaf spot (BLS) of tomato (*Xanthomonas euvesicatoria, X. vesicatoria, X. perforans and X. gardneri*	Tomato *Lycopersicum*	(Ernest *et al*., 2012) [20]
	Silver birch	*Betula pendula*	Leaf	100%			
	Coffee	*Coffea arabica*	Seeds	100%			
10	Turmeric	*Curcuma longa*	Seed	30%	Bacterial soft rot	Tomato	Adamu *et al*., 2017 [5]

Conclusion

The findings of the studies we have outlined here showed that botanicals could conceivably be exploited for effective management of crop diseases. Application of botanicals or botanicals based byproducts to the soil leaves no residues in the field and are economically viable to the farmers. This information will be essential to develop a durable, cost-effective and sustainable strategy for the management of crop diseases. Concerning the environmental safety, now-a-days botanicals are gaining much importance in the integrated pest management (IPM) practices. Efficient use of the botanicals will reduce insect pathogens damage which inturn increase crop productivity and improve the economic status of the farmers. Moreover, the studies showed that application of botanicals to the crops will yield healthy crops without chemical contamination which results in healthier human generations.

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