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Application of Botanicals in Plant Diseases Management: A Brief Report

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SUMMARY

Attack by various phytopathogens on plants leads to devastating losses in crop yields and quality. In order to tackle problems of plant disease management, there is heavy dependence on agrochemicals. A prevalent misconception present among the modern farmers that chemical pesticide application is the only way out of the problem has led to indiscriminate use of agrochemicals causing numerous deleterious side effects. This incorrect practice has resulted in more damages than amelioration of the problems. Another pressing problem that arises in the larger picture is accumulation of pesticidal residues in environment which affects the food web and the food chain, thereby leading to ecological imbalances as well as polluting the soil and water resources. So, keeping in view the ever increasing demand of food safety and security without harming the environment, a search for alternatives to agrochemicals has shown the pivotal role of the botanicals i.e., the pesticides of plant origin. This article elucidates briefly the importance of botanicals in plant disease management.

INTRODUCTION

Plants are continuously exposed to biotic and abiotic stresses which lead to devastating losses in crop yields and its quality every year. Prevailing scenario has created a global threat to food security and safety. In order to tackle problems of the losses due to plant diseases, there is heavy dependence on agrochemicals. Also it has become a misconception that chemical application is the only effective means to solve the problems of disease management. This belief leads to indiscriminate use of agrochemicals with various side effects rather than the amelioration of the diseases. Another pressing problem that arises in the larger picture is pesticidal residues in environment affects the food web and the food chain, thereby leading to ecological imbalances and also the pollution of soil and water resources. So, keeping in view the ever increasing demand of food safety and security without harming the environment, a look into alternatives for the agrochemicals has become a pivotal part of plant protection. Botanicals are compounds extracted from the plants which, when applied on diseases and pest infested crops are toxic to the diseases and pest without harming the ecosystem and are easily degraded in nature. In organic farming, owing to botanicals being cheaper and safe, they are a natural choice for disease management. Botanical extracts from plants are isolated through various fractionation processes, however their composition varies according to the botanical sample used, the experimental conditions and the physico-chemical properties of the compounds. Plant extracts commonly referred to as botanicals consists of the secondary plant metabolites synthesized by the plant. These botanicals are bioactive in nature and known to target a broad range of pests. Plants synthesize aromatic secondary metabolites, like phenols, phenolic acids, quinones, tannins, coumarin, flavones, flavonoids and flavonols. Often, plant secondary metabolites may be referred to as plant natural products, in which they illicit effects on other organisms. Plant secondary metabolites are recognized as a good source providing lead structures for the development of botanicals. There are three broad categories of plant secondary metabolites as natural products: terpenes and terpenoids (~25,000 types, 55%), alkaloids (~12,000 types, 27%), and phenolic compounds (~8,000 types, 18%) (Gurjar et al., 2012). The different mode of action of phytochemicals is enlisted as given under in Table 1.

Table 1: Mode of action of phytochemicals

Sl.no	Class	Sub - Class	Mechanism
1	Phenolics	Simple phenols	Membrane disruption, substrate deprivation
2	Phenolic acids	Phenolic acids	Bind to adhesins, complex with cell wall, inactivate enzymes
3	Terpenoids, essential oils		Membrane disruption

4	Alkaloids		Intercalate into cell wall
5	Tannins		Bind to proteins, enzyme inhibition, substrate deprivation
6	Flavonoids		Bind to adhesins, complex with cell wall, inactivates enzymes
7	Coumarins		Interaction with eukaryotic DNA
8	Lectins and polypeptides		Form disulfide bridges

Plants release chemical compounds into the environment and when used as cover crops, mulch, smother crops, intercrops or green manures, or grown in rotational sequences, can aid to combat insect pests, pathogens and improve farm yields. Botanicals include crude or semi refined extracts and isolated or purified compounds from various plants species and commercial products. Most of these plants are randomly collected from their habitat areas. Such collected plants are either dried or freshly used for extraction of secondary metabolites. Some commonly used botanicals are enlisted in the table 2.

Table 2: Some commonly used botanicals.

Plant Extracts			**Essential oils**	
1	Neem	*Azaridachta indica*, A. Juss	Nettle oil	*Urtica* spp.
2	Garlic	*Allium sativum*, Linn.	Thyme oil	*Thymus vulgaris*, Linn.
3	Eucalyptus	*Eucalyptus globulus*, Labill.	Eucalyptus oil	*Eucalyptus globulus*, Labill.
4	Turmeric	*Curcuma longa*, Linn.	Rue oil	*Ruta graveolens*, Linn.
5	Tobacco	*Nicotiana tabacum*, Linnn.	Lemon grass oil	*Cymbopogan flexuosus* (stud) Wats
6	Ginger	*Zingiber officinale*, Rosc.	Tea tree oil	*Melaleuca alternifolia*
Gel and Latex: *Aloe vera* (Tourn. Ex Linn)				

In the search for alternative solutions to crop protection problems, the interest in plants and their chemo-biodiversity as a source of bioactive substances has increased. Plants are capable of synthesizing an overwhelming variety of small organic molecules called secondary metabolites, usually with very complex and unique carbon skeleton structures. These substances have been used for the benefit of humankind for many years as crop protection agents. Some instances of utilization of botanicals in plant diseases management are enlisted in the table 3.

Table 3: Utilization of botanicals in plant diseases management

Sl. no.	**Plants**	**Parts used**	**Preparations**	**Diseases/pathogen**	**References**
1	Datura (*D.stamonium*) *Calotropis procera* (Ait.) R. Br. *Oscimum* spp.	Root, stem, Leaf, flowers	Crude extract	*Curvularia lunata*	Manoharachary et al., 1988
2	Turmeric (*Curcuma longa* Linn.), Ginger (*Zingiber officinale* Rosc.)	Rhizome	Crude extract	*Phytopthora infestans Pyricularia oryzae* , *Fusarium solani*,	Bandara et al., 1989
3	Perslane (*Portulaca olaracea* Linn.)	Leaf	Crude extract	*Helminthosporium maydis*	Noriel et al., 1990
4	Hena (*Lowsonia inermis* Linn.)	Leaf	Crude extract	*Dreshslera oryzae*	Natarajan et al., 1987
5	Neem (*Azadirachta indica* A.Juss.), Sugar apple (*Annona squamosa* Linn.),	Leaf, Stem Bark, root	Crude extract	Anthracnose of pepper	Nduagu et al., 2008

	Holy basil (*Oscimum sanctum* Linn.)				
6	Neem (*A indica* A.Juss.),	Seed kernel	Oil	*A. alternata*	Dharam et al., 1985
7	Oscimum *spp.*	Leaf	Essential oils	*Aspergillus flavus*	Mishra et al., 1989
8	*Garlic (*Allium sativum *Linn.), Datura (*D. stramonium *Linn.)*	Bulb, Leaf	Ethanol extracts	*Curvularia lunata*	Upadhyaya et al., 1990
9	*Spearmint (*Mentha spicata *Linn.),* Greek Sage *(Salvia fruticosa* Mill.*), Thymbra spp.*	Leaf	Essential oils	*Rhizoctonia solaniSclerotiorum, Sclerotium*	Yegen et al., 1992
10	Spanish flag *(Lantana camara* Linn.*)*	Leaf	Crude Extracts	Castor grey rot *(Botrytis ricini)*	Bhattiprolu et al., 2006
11	Neem *(A indica A.Juss.)*	Seed, Leaf	Crude Extracts	Early blight of tomato	Patilet al., 2001
12	Madar *(Calotropis procera(Ait.) R.Br.*	Leaf	Crude Extracts	Tikka leaf spot disease of groundnut	Srinivas et al., 1997
13	Neem (*A indica* A.Juss.)	Seed	Neem Seed Kernel Extract	Powdery mildew of pea	Surwase et al., 2009
14	Spanish flag (*L.camara* Linn.), Pongam (*Pongamia pinnata* L.Pierre.)	Leaf	Crude extracts	Leaf blight of onion	Bhosale et al., 2008
15	Holy basil (*Oscimum sanctum*Linn.), peach (*Prunus persica* Linn.) Stokes.	Leaf	Essential oil	Grey mould (*Botrytis cinerea*) of grapes	Tripathi,et al., 2008
16	Neem *(A indica A.Juss.)*	Leaf	Achook formulations (azadirachtina)	Sheath blight of rice	Kandhari et al., 2007
17	Neem *(A indica A.Juss.)*	Seed kernel	Neem oil	Rice tungro virus	Muthamilan et al., 2007
18	Neem *(A indica A.Juss.)*	Leaf, Seed	Achook, Neemazal,	Bacterial blight of rice	Sunder et al., 2005
19	Oregano (*Origanum hercleoticum*	Leaf	Essential oils	*Fusarium oxysporum, Phoma tracheiphila*	Salomone et al., 2008
20	Neem *(A indica A.Juss.)* Black cumin (*Nigelia sativa* Linn. Asoefetida (*Ferula asafoetida* Linn.)	Seeds	Essential oils	*Fusarium oxysporum, A.niger, A.flavus*	Sitara,et al., 2008
21	Strawberry (*Fragaria* spp.)	Fruit	Volatile compounds	Anthracnose of strawberry	Arroyo et al., 2007
22	Raspberry (*Rubus* spp.) and Strawberry (*Fragaria* spp.)	Fruit	Volatile compounds	Post-harvest decay fungi	Vaughan et al., 1993

23	Garden croton (*Codiaeum variegatum* Linn.)	Leaf	Phenolic compounds	*Alternaria alternate, Fusarium oxysporum*	Naidu et al., 1988
24	Oleander (*Neriumoleander* Linn.)	Leaf	Crude extracts	Brown spot of rice (*Bipolaris oryzae*)	Harish et al.,2008
25	Indian aloe (*Aloe barbadensis* Mill.) Neem *(A indica A.Juss.)*Tobacco (*Nicotiana tabacum* Linn.)	Leaf	Crude extracts	Dry rot of yam *F. oxysporum, A.nizer*	Taiga et al.,2009
26	Black pepper (*Piper nigrum* Linn. Clove (*Syzygium aromaticum* (Linn.) Merr. & Perry, Geranium (*Pelargonium graveolens* L'Herit), Nutmeg (*Myristica fragrans* Houtt.), (*Origanum vulgare* spp. *hirtum* (Link) Letsw. and thyme (*Thymus vulgaris)* Linn.	Leaf	Volatile oil	Anti-bacterial (gram positive and gram negative)	Dorman et al., 2000
27	*Metasequoia glyptostroboides*	Leaf	Essential oil	*Fusarium oxysporum, Fusarium solani, Phytophthora capsici, Colletotrichum capsici, Sclerotinia sclerotiorum, Botrytis cinereaand Rhizoctonia solani*	Bajpai et al., 2010
28	Clove *(Syzigium aromaticum*Linn.*)*, Turmeric *(Curcuma longa*Linn.*)*, garlic *(Allium sativum* Linn.) and Holy Basil *(Ocimum Sanctum* Linn.)	Leaf, Fruit and Seed	Crude extract	*Aspergillus flavus*	Reddy et al.,2009
29	*Aspilia africana, Chromolaena odorata, Musa paradisiaca* and *Tithonia diversifolia*	Leaf	Aqueous extract	*Cercospora indicum* L. *(*Sesamum leaf spot of Sesame *)*	Enikuomehin et al.,2005
30	Lemon grass (*Cymbopogonspp.)*, Thyme (*Thymus vulgaris* Linn.*)*	Leaf, root	Volatile compound	Black Mould Disease on Onion Bulbs (*Aspergillus niger)*	Abd-Alla et al.,2006
31	*Brassica napus and* Tomato *(Lycopersicon esculentum*Mill.*)*	Leaf, stem	Water extract	Bacterial disease on Onions	Kowalska et al.,2008
32	Ginger *(Zingiber officinaleRosc.)*, aloe *(Aloe vera)*,bitter kola (*Garcinia*	Leaf, Fruit and Seed	Crude	Root rot disease of cow pea (*Vigna unguiculataL.)*	Suleiman et al.,2009

	cola) Neem *(A indica A.Juss.)*				
33	*Chloranthus japonicas*, *Paulownia coreana*	Roots, stem	Crude extract	rice blast, rice sheath blight, and wheat leaf rust	Choi et al., 2004
34	*Urtica dioicaL., thyme Thymus vulgaris* L.,*Eucalyptus* spp., *Ruta graveolens* L. and *Achillea millefoliumL.*	Leaf	Volatile oil	*Alternaria alternata*	Hadizadeh et al., 2009
35	*Acacia nilotica, Achras zapota, Datura stramonium, Emblica officinalis, Eucalyptus globules, Lawsonia inermis, Mimusops elengi, Peltophorum pterocarpum, Polyalthia longifolia, Prosopis juliflora, Punica granatum* and *Sygigium cumini*	Leaf, Fruit and Seed	Aqueous extract	*Aspergillus spp.*	Satish et al., 1999
36	*Eugenia aromatica* , *Piper betle*), *Alpinia galanga* and *Sphaeranthus indicus*	Leaf	Crude	Stem rot disease of Vanilla	Suprapta et al., 2009
37	*Ocimum gratissimum, Aframomum melegueta*	Leaf	Crude	Post-harvest yam *(Diascorea spp.) rot*	Okigbo et al., 2006
38	Neem *(A indica A.Juss.)*	Leaf	Crude	Protozoan, Bacteria, Antifertility	Atawodi et al., 2009

CONCLUSION

Overzealous and indiscriminate use of chemical pesticide will only lead to harmful outcomes for human and the environment. Thousands of phytochemicals with potentials for inhibition of phytopathogens are yet to be extracted for utilization and application in large scale as plant protection measures. The ethno-botanical study of plants is a crucial topic applicable in modern day plant disease management, but its usefulness cannot be overemphasized without proper methods of extraction and standardization of botanicals. Some handful of botanicals have been evaluated and applied in plant diseases management and thereby have paved a way for microbiologist, plant pathologist , pharmacologist to find a lead compound, a botanical to an exploitable product.

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