A Comprehensive Exploration on Plant Disease Management by Phytochemicals for Sustainable Environment

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Abstract

Plants are rich source of secondary metabolites such as tannins, terpenoids, alkaloids and flavonoids, which have been found as antimicrobial in nature. The growth of plant pathogen can be inhibited by the use of plant extracts from selected indigenous medicinal plants. Botanical extracts would be helpful as an alternative means of chemical pesticides in the disease management. Plants are gaining interest in scientific communities recently due to their valuable pharmacological actions and affordability to local farmer which make them effective in management of various diseases. Bio-pesticides are not harmful as chemical pesticides for human health but very effective in management of crop diseases. Plant extracts are also nature-friendly so they are easily bio-degradable and therefore do not cause any kind of pollution and keep the sustainable environment.

Keywords- Medicinal plants, secondary metabolites, pathogens, disease management, extract.

Introduction

Since thousand years ago of agriculture, plants have been utilized initially in the form of food products. The influences and applications of plants are bigger and more ancient. The autotrophic plants are purified the environment by converting carbon dioxide excreted by living organisms into oxygen through carbon-cycle. The intake of carbon dioxide by plants is also helpful to reduce greenhouse impact and environmental changes. Thus, plants play more significant role to regulate the equilibrium in the environment and to determine more significant biological mechanisms. Plants ameliorate ecosystem by continuously purify existing water, soil and air through removing pollutants like heavy metals, pesticides, solvents etc. Plants also provide a structure to ecological systems by producing native environments in forests and wetlands and mitigate the natural adverse effects like droughts by holding ground water. On the other hands root parts of plants abate erosion of soil by air and raining water through keeping upper soil in its place and regulating water speed. Plants are the main source of staple food for diet of human beings. Several legumes, cereals, young shoots, roots and tubers, leaves, fruits and nuts of plants have vital role in human diets. Besides, numerous plant spp. are broadly used in the forms of condiments and spices that contain more aroma and taste along with nutritional values for example *Zingiber officinale, Piper nigrum, Capsicum frutescens, Prosopis Africana, S. nigrum, P. clappertonia, A. digitate* and *Xylopia aethiopica* (Kayode et al., 2008). Protein, carbohydrates and lipids are essential nutrients for living organisms that obtains from plants. Additionally vitamins, minerals, enzymes and organic acids also acquire from plants that are more

necessary for human health. Almost all plant parts are used as foodstuff. The more significant parts are fruits and seeds that obtain from small grains, nuts, legumes and cereals. They have more nutritional elements and less water amount and their importance increases due to easily preservation and transportation. Other significant food parts are bulbs, roots, tubers and other underground vegetables. Leafy foods have minerals and vitamins, whereas fleshy fruits have numerous organic acids (Fernando, 2012). Currently the use of plant protein is progressively raised in people diets. Various investigations revealed that plant proteins have sufficient amount of essential amino acid that are necessary for human health. Thus, whole plants are very effective to human health.

Plant pathogens and their infection

Several components influence plants by mitigate their vigor index and yield, variety their morphology or even can damage whole plants. Biotic and abiotic both components produce adverse effects on plants. In abiotic components include changes in nutrients, temperature, water etc., and in biotic components include infection of plants with molds, viruses, fungi, nematodes and bacteria. This study focuses on bacterial infection of plants. Bacteria, single cell microscopic pathogens, cause detrimental effects on plants. Approximately 200 bacteria are identified that reduce plants productivity from several years (Leonberger et al., 2016). Commonly pathogenic bacteria belongs to Enterobacteriaceae, Xanthomonadaceae and Pseudomonadaceae families infects all plant species to nutrition and habitat. The main harmful genera of plant bacteria are *Burkholderia, Pantoea, Spiroplasma, Ralstonia, Clavibacter, Phytoplasma, Erwinia, Acidovorax, Pectobacterium, Xylella, Streptomyces, Agrobacterium, Pseudomonasa* and *Xanthomonas*. Pathogenic bacteria are not directly entered into plant tissues. They enter either wound or natural opening site of plant like stomata, nectaroides and hydatodes, through which pathogenic bacteria inject their nucleoproteins/proteins into plants (Buonaurio, 2008) and instantly replicate in it. The significant infectious region found on leaf scares. Pathogenic bacteria have numerous virulent genes, which are responsible to create infection and to spread diseases into other plants. Some phytopathogenic bacteria cause diseases by secrete enzymes or toxins, and thus damage infected plant tissue and obtain nourishment from damage tissue. For example soft-rotting bacteria secrets enzymes to break pectin layer present in between plant cells to hold them. Some type of pathogenic bacteria reproduces into plant vascular systems (xylem and phloem) and blocks water transportation. Bacteria come in the contact of plant surface through insects, water and air. Blights, wilt, leaf spots, soft rots, dieback, cankers and galls are common symptoms of bacterial infection.

Phytochemical Compounds

The phytochemicals were flavonoids, phenols, steroids, cardiac glycosides, resins, phlobatannins, volatile oils, fixed oils, phenolic compounds, coumarins, glycosides, saponins, steroids, anthraquinones, and terpenoids, with flavonoids, alkaloids, and phenols being the most abundant. A large number of such phytochemical compounds have been isolated from plants and used for the

development of bio-pesticides to control the growth of bacterial and fungal pathogens The methanolic and ethanolic extracts showed an activity against the pathogens like bacteria, fungi, virus strains. They play a important role in disease control. Antimicrobial extract of plants damage the cell wall and enzymes of microbial pthogens. They inhibit lipid bio-synthesis in microbes also.

Antimicrobial properties of plant extracts

In addition, plant extracts have been found to induce a defense response in infected plants. Geetha and Shetty, 2002 mentioned that the mode of action of plant extracts against bacterial pathogens may enhance natural host defense mechanisms by increasing the activity of some antioxidant enzymes. This may directly affect the survival of the pathogens or act indirectly on plant metabolism. Akhtar *et al*., (1997) evaluated 208 diffusates from various plants such as forest trees, herbs, fruit trees, spices, vegetables, food legumes, fodder, oil seed, fiber crops, cereals and ornamentals through agar diffusion assay to determine their inhibitory activity against *Xanthomonas campestris* pv. *citri.* Kagale *et al*., (2004) investigated that leaf extract of *Datura metal* plant showed significant inhibitory activity against in vitro growth of *Rhizoctonia solani* and *Xanthomonas oryzae* pv*. Oryzae..* Mahesh and Satish (2008) studied that the methanol leaf extracts of *Acacia nilotica*, *Withania somnifera, Tinospora cordifolia, Sida cordifolia* and *Ziziphus mauritiana* exhibited the strongest antibacterial activity against *Bacillus subtilis, Escherichia coli, Pseudomonas florescens*, *Staphylococcus aureus* and *Xanthomonas axonopodis* pv. *malvacearum* and antifungal activity against *Aspergillus flavus* and *Fusarium verticillioides.* Sukanya *et al*., (2009) reported the ethnobotanical efficacy of some medicinal plants viz*, Azadirachta indica, Achyranthes aspera, Calotropis gigantea, Ixora coccinea, Parthenium hysterophorus, Lawsonia inermis, Mimosa pudica. Chromolaena odorata* and *Artemisia parviflora* by agar diffusion method against human (*Escherichia coli and Staphylococcus aureus*) and phytopathogenic bacteria (*Xanthomonas vesictoria* and *Ralstonia solanacearum)*. Aman *et al.,* (2010) reported the antimicrobial activity of the methanolic extracts of *Boswellia serrata* and *Rhus mysorensis* plant parts against *Xanthomonas axonopodis* pv. *malvacearum*, *X. oryzae* pv*. oryzae, Pseudomonas aeruginosa* by paper disc diffusion method. The methanolic extract of *Rhus mysorensis* (leaves, fruits) and *Boswellia serrata* (leaves and flowers) have showed significant antimicrobial activity. Shankar *et al.,* (2010) reported that the methanolic leaf extract of *Wrightia tinctoria* showed antibacterial activity against the growth of all tested gram negative bacteria such as *Erwinia* sp., *X. campestris, X. citri* and *X. oryzae.* Jabeen (2011) investigated the potentiality of 25 indigenous medicinal plants against *Xanthomonas oryzae* pv. *oryzae* by the disc diffusion method. Out of 25 plants *Thuja orientalis* (cone, leaves), *Azadirachta indica* (fruits), *Terminalia chebula* (fruits), *Terminalia bellerica* (fruits) and *Amomum subulatum* (fruits) decoctions showed significant antibacterial activity. Govindappa *et al.,* (2011) reported that leaf extract of *Adhatoda vasica* can be used for the seed treatment of rice. It was found to significantly reduce the bacterial infection of leaf blight pathogen, *X. oryzae* pv. *oryza*e in vitro. Verma and Agrawal, (2015) investigated the bioefficacy of aqueous extracts of six medicinal plants namely *Withania somnifera* (leaves), *Azadirachta indica*

(leaves), *Emblica officinalis* (fruits), *Terminalia chebula* (fruits), *Allium sativum* (bulbs) and *Zingiber officinalis* (rhizomes) against *P. syringae* pv. *pisi* causing bacterial blight of pea. The plant extracts exhibited significant antibacterial activity against tested bacterium by filter paper disc assay and seed treatment method *in vitro*. Usman *et al.,* 2014 reported that plants have well organized structures. They phytoremediate and cool the environment. They provide oxygen, medicines, fuel, timber, recreation, industrial products; preservatives, pesticides in addition to all the three necessities of life: food, clothing and shelter. Pereira *et al.,* 2020 reported that Wild edible plants (WEPs) are gaining importance increasingly as they are potential sources of food due to their nutritional value, besides showing health positive effects and offering innovative applications in haute cuisine. In addition, they are considered as promising sources of essential compounds as phenolic compounds, vitamins or carotenoids that have shown numerous beneficial bioactivities such as antioxidant, anti-inflammatory or anti-tumor activity. Punchay *et al.,* 2020 studied that wild food plants are commonly used in the traditional diets of indigenous people in many parts of the world. The importance of the wild vegetables was mainly related to taste, availability, and multi-functionality of the species. The wild leafy vegetables, therefore, are good sources of minerals and can recommend their continued usage by people. Banik *et al.,* 2018 determined the nutritional values as various parameters such as fats, carbohydrate, protein, and lipid and to detect the presence of heavy metals in four selected medicinal plants that was *Centella asiatica* (L), *Pogostemon benghalensis*, and *Cinnamomum tamala*. Jnanesha and Kumar, 2018 reported that plants that possess therapeutic properties or exert beneficial pharmacological effects on the human body are generally designated as medicinal plants. These plants naturally synthesize and accumulates secondary metabolites like alkaloids, sterols, terpenes, flavonoids, saponins, glycosides, cyanogenics, tannins, resins, lactones; quinines and volatile oil etc. in addition to secondary metabolite these plants also contain minerals, vitamins, carbohydrates and proteins etc. play important role overcoming deficiency problems in human beings. Some of the important nutritionally rich and medicinal crops in India are *Moringa oleifera, Aegle marmelos, Mucuna pruriens. Spilanthes acmella, Withana somnifera, Zingiber officinale, Asparagus racemosus, Annona muricata, Phyllantlius emblica, Chlorophytum borivilianum, Commiphora wightii* and *Morns alba*. Thus they suggested that the phytochemical properties of medicinal plants possess numerous pharmaceutical potential that are responsible to cure various ailments. Thakur *et al.,* 2017 investigated amino acid composition in selected hybrid varieties of legume seeds viz *Glycine max*, *Vigna radiata*, *Phaseolus mungo*, *Cicer arietinum* and *Lens esculenta* by HPLC technique. All the varieties were found rich source of some essential and non-essential amino acids (glycine, arginine, cystine, tyrosine & aspartic acid) and presenting high nutritive value. Accordingly the quality of a seed depends on the total amount of amino acids present in protein, and these amino acids in legume seeds enhance nutritional benefits. Venkata *et al.,* 2017 investigated the chemical composition and pharmacological actions in *Trigonella foenum-graecum* belong to *leguminosae* family.

Use of Phytochemicals in Pest Management

Nature is a vital source of a vast range of phytochemicals which were used as bio-pesticide in pest management and restore natural ecosystem. Chemical pesticides, still causes a harmful effect to the environment. Due to synthetic pesticides use in farming, it fails to conserve biodiversity, environmental resources and health of humans. There are vast varieties of medicinally valuable plants in our circumstance from which we can isolate various phytochemical compounds and used as fertilizer, pesticide in agriculture (Table 1). Some medicinal Plants have been utilized as a safe source of insecticides.

Table 1: Shows plants Botanical name, family, common name, Phytochemical Compounds and target Plant pathogens.

Sr No.	Botanical name	Family	Common name	Phytochemical Compounds	Uses of Plants against target phyto-pathogen
1	Abutilon indicum	Malvaceae	Kanghi	abutilin A, phenylethyl-4-hydroxybenzamide	Aphids,
2	Aloe barbad ensis	Asphodelaceae	Gheekwar	enzymes, minerals, lignin, saponins, salicylic acids and It contains vitamins A and E and choline	Sitotroga cerealella
3	Annona squamosa	Annonaceae	Sitaphal	sesquiterpene, α-muurolene, α-cadinol, isoquinoline	Lymnaea acuminate
4	Aristolochia indica	Aristolochiacea e	Kiramar	aristolochic acid , sesquiterpene hydrocarbons, aristolochene	Diptera: Culicidae
5	Azadirachta indica	Meliaceae	Neem	Azadirachtin, nimbin, nimbanene, 6-desacetylnimbinene, nimbandiol, nimbolide, ascorbic acid, n-hexacosanol	whitefly, Japanese beetles, moth and *spider*
6	Calotropis gigantea	Asclepediaceae	Madar	steroids, tannins, , flavonoids, alkaloids, saponins	mustard aphid Lipaphis
7	Carica papaya	Caricaceae	Papita	Carpaine, pseudocarpaine, rutinoside quercetin, kaempferol	S. litura larvae
8	Chrysanthe mums indicum	Asteraceae	Guldaudi	Pyrethrins, quercetin,resveratrol	Tribolium, moth larva
9	Cissus quadrangula ris	Vitaceae	Hadjod	aliphatic acid hexadecanoic acid, d-amyrin, β-sitosterol,	Spider, Diptera
10	Datura stramonium	Solanaceae	Datura	cleomiscosin,fraxetin ,scopolamine,7-hydroxy-β-carboline1-propionic acid	Sitophilus oryzae
11	Eucalyptus globulus	Myrtaceae	Nilgiri	ρ-cadinol, and α-pinene	Coleoptera: Tenebrionidae
12	Ocimum sanctum	Lamiaceae	Basil	ursolic acid, eugenol, Rosmarinic acid,	mites and whiteflies
13	Justicia adhatoda	Acanthaceae	Vasaka	salicylic acid, salicylic acid, campesterol, stigmasterol, triterpenoids	Spodoptera litura
14	Leucas aspera	Lamiaceae	Thumbai	Leucasperons A and B, eudesmol	E. coli, P. aeruginosa, and
15	Ricinus communis	Euphorbiaceae	Castor	Ricinine, Ricinoleic acid, α-Thujone	B. cereus, A. niger
16	Tagetes erecta	Asteraceae	Genda	a terpene , kaempferol,	Whiteflies
17	Vitex negundo	Lamiaceae	Nochi	4-terpineol, linalool, globulol, elemol , aromadendrene	red flour beetle,

Conclusions

Use of synthetic pesticides has increase various problems due to their negative effects on the human health, natural ecosystem balance and environmental conditions. Some of the main components of synthetic pesticides found to be very carcinogenic thus causing cacer problems in humans. Phytochemicals used as bio-pesticides offer better choice to chemical pesticides. Due to low toxicity, biodegradability of biopesticides they helps to keep sustainable environment. Most of the evaluated medicinal plants showed remarkable antimicrobial activity against tested fungal, bacterial and viral strains and nematodes, which can be attributed due to the presence of phytochemicals of different classes of secondary metabolites compounds. Uses of botanical plant extracts have induced disease resistance in plants against many causal microbial pathogens including bacteria, fungi, viruses and nematodes. In future these biopesticides are efficiently use for disease control for sustainable environment.

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