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Ubiquitous Microbial Disorders of Medicinal Plants and Potential Management of such Phytopathogens

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REVIEW ARTICLE

ABSTRACT

Medicinal plants are known as traditional healers, since ancient times. India has been bestowed with many diversified groups of medicinal plants accounting for approximately 8000 species being used in over 10,000 herbal products. Commercial gardening began as a single way of assessing for the conservation of these valuable plant species, which unknowingly introduced the complexity of many pests and diseases, resulting in crop forfeiture of varying magnitudes. The gravity of medicinal plants has been escalating day by day. Traditional medicine, in the recent years, has made a resurgence for many different reasons together with toxicity and side effects of contemporary synthetic drugs, expansion of multiple drug resistant microbes, and also the inaptitude of modern medicine for locating effective healing procedures for various diseases. Over 70% of the population of developing world currently relies on the traditional medicinal structure, also known as alternative or complementary system of medicine. Medicinal plants are being more widely employed in healthcare organizations, whereas chemical pest management and disease management strategies are becoming obsolete. Among the various microbes, viruses are immensely responsible for causing diseases in medicinal plants. This chapter imparts comprehensive information regarding the family, morphology, pharmacological profile, distribution, active constituents and symptoms of the viral infections among the medicinal plants reported in various parts of India. The analysis of these viral diseases will authorize developing effective mechanisms for safeguarding medicinal plants and maintaining the standard of the fresh materials for pharmaceuticals.

Key words: pests, infection, medicine, microbes, traditional healers, toxicity, pest management.

INTRODUCTION

Plants have been used for medicinal reasons since prehistoric times. Ancient Unani writings, Egyptian papyrus, and Chinese literature all contain descriptions of herbs. Plants have been utilized as medicine by Unani Hakims, Indian Vaids, European and Mediterranean cultures for over 4000 years, according to evidence. Indigenous societies such as Rome, Egypt, Iran, Africa, and America employed herbs in healing rituals, while traditional medical systems such as Unani, Ayurveda, and Chinese Medicine were created by others, in which herbal remedies were used systematically.

Indian traditional healers have long been aware of medicinal herbs. The plants were mostly harvested in the wild and employed in a variety of health product formulations. India is home to a broad range of medicinal plants, totaling about 8000 species that are employed in more than 10,000 herbal treatments. Ninety percent of the raw materials required by the herbal business come from the natural ecosystem - forests – leading in brutal exploitation and destruction of the ecosystem's natural habitats [1]. Commercial cultivation began as one of the strategies to protect the valuable species, but it unwittingly brought with it the problem of pests and diseases, resulting in crop losses of varying magnitudes. Glory lily (*Gloriosa superba*), Noni (*Morinda citrifolia* L.), medicinal coleus (*Coleus forskohlii*), makoi (*Solanum nigrum*), senna (*Cassia angustifolia),* and ashwagandha are some of the most significant medicinal plants discussed in this chapter (*Withania somnifera*). Medicinal plants are being phased out of the health-care system, as are chemical pest and disease management practices. Non-chemical, environmentally friendly, and safer management solutions, which are also covered in this chapter, are required. [1]

Markets and research on medicinal plants are growing at an exponential rate in the pharmaceutical and associated professions across the world. In reality, about fifty to seventy thousand plant species are known to have therapeutic characteristics across the world, with around four to ten thousand of them being endangered [2,3]. Over four lakh tones of medicinal plants are traded globally for over 3000 species. India is one of the major producers and exporters of such medicinal plants [3]. Natural medicines derived from medicinal plants have fewer negative effects on human systems than their synthetic equivalents.

Important Medicinal Plants

India has long been known as a rich source of medicinal herbs among ancient civilizations. The Indian Forest is home to a diverse range of medicinal and fragrant plants, which are usually exploited as raw materials for medicines and perfumery products. Approximately 8,000 herbal therapies have been defined in India's AYUSH systems. Unani, Ayurveda, Folk (tribal), Siddha, medicine are the main stems of indigenous medicine. In India, Ayurveda and Unani Medicine are the most advanced and widely practiced of these systems.[4]

As per the World Health Organization (WHO), herbal medicines are used by 80% of people throughout the world for some aspect of their primary health care. According to the WHO, there are around 21,000 plant species that have the potential to be implemented as medicinal plants.

Thus, as per to published data, approximately three-quarters of the world's population gets their health care mostly from plants and plant extracts. At one point or another, more than 30% of all plant species have been used for medicinal purposes. Plant treatments are predicted to account for up to 25% of total drugs in developed countries such as the United States, but up to 80% in fast-developing countries such as India and China. As a result, the economic relevance of medicinal plants is significantly greater in India than in the rest of the globe. These nations offer two-thirds of the plants used in modern medicine, while the rural population's health care system is based on indigenous medicine. [5,6]

The usage of medicinal plants is seen to be relatively risk-free, as there are no or only minor side effects. The most significant benefit is that these treatments are in sync with nature. Herbal medicines may be utilized by individuals of all ages and genders, according to the golden truth.[7]

Herbs are only answers to a number of health-related concerns and diseases, according to ancient doctors. They conducted significant investigation and testing in order to arrive at trustworthy conclusions about the efficacy of numerous medicinal herbs. The vast majority of drugs developed this way have no significant side effects or reactions. This is why herbal medicine is gaining popularity all over the world. These medicinal plants provide a practical method to treating a wide range of internal problems that are traditionally thought to be difficult to cure. [6, 7]

As per Floral Statistics of India 2017, which was held by the Botanical Survey of India in Kolkata, West Bengal, there were a total of 2,68,600 blooming plants globally, with 18,386 (6.84%) of them being in India. In India, over 3000 plant species are known to have therapeutic characteristics [8], and according to another study, 2500 plants are employed in traditional medicine, with 100 plants being used on a daily basis [9]. Traditional plant medicinal knowledge is helpful not just for biodiversity conservation, but also for healthcare and medicine development. The Himalaya is a global biodiversity hotspot with a diverse variety of topographical, ecological, and evolutionary traits that support 18,440 plant species, 25.3 percent of which are indigenous to the region. [10,11]. Indian state of Uttarakhand is situated in the Himalayan hotspot, and it covers 17.3 percent of India's total land area, with 92.57 percent of it covered by hills and 7.43 percent by plains. It is situated between the latitudes of 28˚43'–31˚27'N and the longitudes of 77˚34'–81˚02'E. River Tons divides it from the state of Himachal Pradesh, river Kali from the country of Nepal, and the broader Himalaya forms the state's northern boundary as well as with China (international border). In the Himalaya, there are around 1748 commercially significant plants. The Tharus, Bokshas, Bhotias, Marchchas, Van-gujjars, Jaunsaris, Tolchas, Koltas, Banw-rauat, Gangwal, and other people communities rely on wild flora for their traditional medicine [11]. Joshi et al. found 102 plant species from 48 families that have ethno-medicinal applications in the state's four districts: Almora, Champawat, Bageshwar, and Pithoragarh [9,12]. Adhikari et al. At the Wildlife Institute of Dehradun in Uttarakhand, researchers looked at the condition and distribution pattern of medicinal plants, discovering 605 species from 94 families. This essay is based on earlier research on Uttarakhand medicinal herbs [13,14]. Authors concentrated on several key features of local medicinal plants that require protection and cultivation since they are naturally abundant and rapidly disappearing, and they may assist indigenous make a living to some extent. This work will be useful to pharmacologists, phytochemists, and researchers in this subject in the future. As a result, the purpose of this study is to write a manuscript that emphasizes the value of traditional knowledge in the Himalayan state of Uttarakhand, India, for the treatment of various ailments.

Table 1: A list of selected medicinal plants with their ethno-medicinal uses from Uttarakhand, India

Botanical Name (Family)	**Local name**	**Parts used**	**Ethno-medicinal Uses**

Abelmoschus moschatus Medik. Malvaceae	Jangali bhindi	Root, Seed	Fresh roots from a young Bombax ceiba plant are used to treat female leucorrhea and male sexual impotency [9]. Seeds have aphrodisiac, diuretic, cardiotonic, ophthalmic, digestive, stomachic, constipating, carminative, stimulant, antispasmodic properties and are used to treat cardiac debility, asthma, hyperdipsia, burning sensation, dyspepsia, flatulent colic, diarrhoea, gonorrhoea, spermatorrhea, [15,16]
Acorus calamus L. (Acoraceae)	Baj	Root	Fever [17], asthma, bronchitis, cough, digestive issues; anti-bacterial [18], anti-helmintic; (gas, bloating, colic) [19].
Adenostemma lavenia (L.) Kuntze Asteraceae	Jangli-jira	Flower, Leaf	Flowers are used to increase saliva production, which is beneficial in the treatment of mouth dryness.[9] Wound healing using leaves paste.[20]
Aegle marmelos (L.) Corrêa (Rutaceae)	Bel	Fruit, Root	Antidiarrheal, demulcent, antipyretic, prevents dysentery, laxative, [17,21,22] astringent.
Aesculus indica (Wall. ex Cambess.) Hook. (Sapindaceae)	Panker	Fruit	Rheumatism is an inflammatory disease that affects the joints (warm paste applies on affected part).[17,23]
Ageratum conyzoides L. Asteraceae	Goatweed	Leaf	The paste made from the leaves is beneficial for wound healing, leprosy therapy [9], diarrhoea, dysentery, intestinal colic, rheumatism, and fever.[24]
Allium cepa L. (Amaryllidaceae)	Pyaj	Bulb	The antibacterial and antioxidant qualities of the roasted heated bulb make it useful in the treatment of stomach discomfort [17] and skin illnesses, as well as malaria, diarrhoea, and wounds.[25]
Amelanchier canadensis (L.) Medik. Rosaceae	Indian wild pear	Fruit	Diarrhea can be treated using the juice of the ripe fruit.[26,27]
Anaphalis triplinervis Sims ex C.B. Clarke (Asteracese)	Bakal	Leaf	Used to treat wounds and skin conditions [17], as well as illness, fever, nausea, and eye infections.[28]
Anisomeles indica (L.) Kuntze Lamiaceae	Catmint	Leaf	The volatile oil found in the fresh leaves and greenish sections of the plant [9] is used to cure coughs and colds, chronic rheumatism, psoriasis, and snake bites.[29]

Asparagus curillus Buch. -Ham. ex Roxb. (Asparagaceae)	Safed Musli	Root	In addition to dysuria, diabetes,[17] and dysentery, root powder is used as a sexual tonic.[30]

Diseases And Their Manifestations Caused by Microbes in Medicinal Plants

The Most Significant Phytopathogens

Viruses And Viroids

Viruses are non-cellular creatures that can only replicate in live cells and are thus infectious. All living things, including plants, animals, bacteria, and archaea, are infected by viruses. [34] They can be integrated into the host's genome and remain inactive as a provirus, or they can multiply and influence the metabolic processes of the host. Inhibition of viral gene transcription can result in a latent infection. Viruses that infect plant include single-stranded (ss) as well as double-stranded (ds) RNA containing viruses, and also, ss DNA retroviruses. [35] Because of diversity in genetic material, viruses have a broad range of life behaviors and reproductive cycles. A virus is made up of nucleic acid and a protein coat (capsid) which provides protection. [34] A lipoprotein membrane is formed by a mixture of proteins and lipids found in capsids. A plant virus is typically 30 nm in size.[36]

Bacteria And Phytoplasmas

Bacteria may be harmful to animals, plants, and fungus and can be found practically anywhere.[37] Genetic information in bacteria is encoded inside DNA in form of chromosome; a cell might have several chromosomes. Extrachromosomal mobile genetic elements such as plasmids, which can carry essential virulence factors or, on the other hand, biological control factors, can be found in bacterial cells. DNA of bacteriophage that is incorporated already into the genome of bacteria is known as a prophage. [38] Binary fission is a kind of bacterial division that involves the duplication of both chromosomal DNA and extrachromosomal components at the same time.[39] The existence of the membrane potential is required for bacterial cell division. Because some plasmids are lost during division, bacteria can have several plasmids. *Pantoea stewartii*, for example, might have up to 13 distinct plasmids. Although bacteria frequently transmit plasmids within their population, horizontal genetic information transfer in prokaryotes world is still relatively prevalent.[40]

Phytoplasmas and spiroplasmas are two kinds of bacteria with no cell wall that are very tiny (approximate diameter of 1μm) and are kept away from external environment by cytoplasmic membrane).[41] Phytoplasmosis and growth retardation are caused by them.[42] Phytoplasmas, like mycoplasmas, a similar genus of bacteria, appear to be among the most basic and self-replicating biological entities.[43] Phytoplasmas have genomes of 0.5–1.3 million base pairs, while *Mycoplasma genitalium*, a model organism for investigating the minimum genome, has a genome of 0.58 million base pairs.[44] Gliding motility is found in Phytoplasmas, while spiroplasmas have a spiral form and move in a twisting manner.[45] Phytoplasmas are difficult to grow in axenic cultures, indicating that they are more reliant on the host metabolism.[46]

Pests And Disease Scenario of Medicinal Plants

Noni (Morinda Citrifolia L.)

Noni, *Morinda citrifolia L*., is a highly prized medicinal tree whose therapeutic virtues have been known to Indians since ancient times. The therapeutic benefits of all parts of the plants — leaves, flowers, fruits, roots, and stems – are being explored [47]. Various insect and non-insect pests are said to be wreaking havoc on the crop [48,49,50].

Pests of Noni: -

***Dulinius conchatus*- a lacewing bug (Tingidae, Hemiptera)**

The lacewing insect is a significant noni pest, especially in nurseries. Lacewing insect nymphs and adults feed on the sap, causing brown stains on the top surface of the leaves. Spots turn dark, and the leaves shrink and dry out in extreme cases. Adults have a heavily reticulate body and 5–8 mm long wings that they use to live on the underside of leaves.

Black Fly: *Aleurocanthus terminaliae* (Aleyrodidae, Hemiptera)

Due to the desapping of leaves from the lower surface of the leaves, they turn blackish and often coiled upside down. On the sticky material released by the insect pest, sooty mould grows. In a spiral pattern, the adult female lays 15–20 eggs. In her lifetime, a female can lay one to three spirals.

***Coccus viridis* (Green) (Coccidae, Hemiptera)**

The adult green coffee scale has an oval to elongate body that is dorsoventrally flattened. Insects eat the plant's phloem and can be found on the stems, leaves, fruits, and young twigs. The sap feeding by green scales causes yellowing of the leaves, which can lead to defoliation and a reduction in fruit set, as well as a general decrease in plant growth and vitality. [49,51]

Diseases of Noni

Anthracnose: *Colletotrichum gloeosporioides*

On the leaves, little brown shaped patches of varied sizes (0.5–2.5 cm) emerge, expand, and combine. The centre of the consolidated lesion becomes greyish white, causing a shot hole symptom. Acervuli with pink masses of spores appeared on the lesions under humid settings. Anthracnose has been reported for the first time in India [52,53].

Dry Fruit Rot: *Colletotrichum gloeosporioides*

Colletotrichum gloeosporioides infects all areas of the noni plant, regardless of crop stage. On twigs, flowers, and fruits, the symptoms were noticed. The infection induced by *C. gloeosporioides* on flowers manifests itself as dull brown lesions. Within 48 hours of infection, the diseased blossoms were dried. Brown necrotic patches on the corolla tube sticking to the noni fruit were discovered when the blooms were examined with a stereo zoom microscope. The occurrence of necrotic brown lesions with a yellow halo was characteristic of *C. gloeosporioides*-infected twigs. The lesions grew in size over time and had a grey centre. The number of minute pinhead-shaped acervuli fructifications was counted on the grey centre. The necrotic lesions spread slowly along the peduncle to the fruits, infecting the flowers and fruits. Later, the infected fruits shrink, dry off and got mummified. Post mummification, saprophytic moulds like Aspergillus and Penicillium colonized the fruits that got infected. [53].

Leaf Blight and Dry Fruit Rot: *Alternaria alternata*

Tamil Nadu and Karnataka states witnessed a severe outbreak of leaf blight, for the first time during 2008–2009. The causal agent was identified as *Alternaria alternate* [54]. The same disease causes dry fruit rot, which is marked by the formation of a black necrotic sunken region on green unripe fruits with a diameter of 2–3 mm. The spot becomes a dark black lesion that coalesces when the environment is favorable. The centre of the lesions is black in color with alternate concentric regions. Drying and splitting of fruits along with saprophytic infection of some other moulds, occurs, as the fruit expands [53].

Diseases of Glory Lily

Root Rot: *Macrophomina phaseolina*

Symptoms of *M. phaseolina*-caused root rot include yellowing of leaves, the formation of dark lesions on the stems with black sclerotial bodies, and the rotting of roots. The pathogen might live for several years in the soil. According to Meena and Rajamani, the yield loss ranged from 50 to 60 percent [56].

Leaf Blight: *Alternaria alternata*

Leaf blight begins as little reddish spots on leaves that expand into concentric rings; many of these spot's merge, causing the entire leaf to be blighted [57].

Conventional Methods of Plant Disease Control

Generations of farmers have been developing techniques to battle the different pests that afflict our crops since the dawn of agriculture. Since our discovery of the causes of plant diseases in the early 1800s, we have been able to devise a wide range of strategies for the management of specific plant diseases as our understanding of the interplay between pathogen and host has improved.

We can derive some fundamental principles of plant disease control from this cumulative knowledge base to aid in the treatment of emerging issues on every crop in any environment. H. H. Whetzel's concepts, initially defined in 1929 and somewhat amended by other writers over the years, have been extensively embraced and taught to generations of plant pathology students all over the world. A committee of the National Academy of Sciences in the United States articulated these "traditional principles" in 1968.

Traditional Principles of Plant Disease Control

1. Avoidance—avoid illness by going at a time of year or visiting a location where there is no inoculum or the environment is not conducive to infection.

2. Exclusion—prevent inoculum from being introduced.

3. Eradication—the inoculum must be eliminated, destroyed, or rendered inactive.

4. Protection—use a toxin or another barrier to infection to avoid infection.

5. Tolerance or resistance to infection—Use cultivars that are resistant or tolerable to infection.

6. Treatment—Plants that have been infected can be healed.

While these beliefs are still true now as they were in 1929, they have a slew of issues when it comes to plant disease prevention. To begin with, these principles are stated in absolute terms (e.g., "exclude," "prevent," and "eliminate"), implying that the objective is to remove all sickness. "Plant disease management" in this sense is usually impractical, if not impossible. Indeed, we do not need to eradicate a disease; rather, we just need to slow down its spread and protect the condition from progressing too far. We should think about plant disease management rather than plant disease control. Traditional plant disease control ideas, on the other hand, ignore the dynamics of plant disease, that is, fluctuations in the frequency and severity of sickness across time and space. Furthermore, because different diseases have different dynamics, it is impossible to assess the relative efficacy of different disease-control techniques. They also don't show how different disease control measures interact with one another in terms of disease dynamics. We need a technique to quantify the effects of various control measures on disease development, both individually and in combination. Finally, traditional plant disease control strategies place a greater emphasis on tactics than on integrating them into a workable overall strategy. [58]

Nanoparticles In Detection and Control of Phytopathogens

It is critical to get an assessment of the incidence and severity of illness on the plants in order to regulate phytopathogens. Because illnesses are linked to yield losses, this knowledge is critical for making decisions that lead to successful disease control methods. Previously, visual indicators such as leaf yellowing, curling, and wilting were employed to determine the severity of disease/infection, followed by quick testing to establish the pathogen's identification. Disease diagnoses based on symptom observations are very subjective and reliant on the observer's competence. Furthermore, to identify unknown infections, Koch’s postulates have to be confirmed. Making the difference between pathogen and saprophytic bacteria in a traditional microbiological investigation of diseased tissue is particularly important since the latter are common in the environment.[59]

Rapid detection and identification of the pathogen has been aided by the development of molecular methods and immunodiagnostic techniques for characterization of microorganisms. PCR for specific detection of *Clavibacter michiganesis* subsp. michiganesis in tomato [60], *Xanthomonas axonopodis* pv. punicae in pomegranate [61], and enzyme-linked immunosorbent assay (ELISA) for detection of *Xylella fastidiosa* in landscape trees [62] are just for pathogen confirmation, advanced technologies such as real-time PCR (qPCR) are also useful.

Silica nanoparticles

Fluorescent dye-doped silica nanoparticles have shown great promise in enhanced bioanalysis, allowing for a more detailed understanding of biology and medicine at the molecular level[63]. The fluorescent dye is protected from photobleaching and leaking by being incorporated into the silica nanoparticles. Using antibody-conjugated Rubpy-doped silica nanoparticles as a detection probe,[64] effectively identified *Xanthomonas axonopodis* pv. vesicatoria, a plant pathogen responsible for bacterial spot disease in Solanaceae. The findings show that fluorescent silica nanoprobes may be used to diagnose plant diseases quickly.

Gold nanoparticles

In the detection of harmful bacteria, DNA-gold nanoparticle probes offer promise as a new generation of biosensors. Hereby, probes of gold nanoparticle-oligonucleotides are getting hybridized with complementary DNA, which there by stabilizes these gold nanoparticles against aggregation by pertaining to the native pink hue of gold) (retaining the native pink colour of the colloidal gold). The solution becomes purple in the absence of complementary DNA because the agglomeration of gold nanoparticles causes the absorbance peak to shift toward a longer wavelength [65,66].

Gold nanoparticle-bound probes were utilized in a recent work to colorimetrically detect *P. syringae* pathovars. PCR was used to amplify the hrcV gene from pathogen DNA, and thiol-functionalized DNA coupled to gold nanoparticles was used to detect it. The test was able to identify genomic template concentrations as low as 15 ng/L. As a result, the test was sensitive and proven to be highly specific, having the ability to detect *P. syringae* early. [67].

CONCLUSION

The study of the causes and effects of phytopathogens on plants has developed to a multidisciplinary level with the introduction of modern diagnostic procedures, genome sequencing and editing tools, as well as technologies for microbiome and proteome investigation. In this article, we have put in an attempt to present a comprehensive image of the current scenario of pest management. However, many other aspects of the interaction between plants and phytopathogens need to be considered, like damage by the ice nucleation proteins, which leads to ice crystal formation in the plant cells [68] or the sequences of effector molecules having conserved nature in bacteria: the pathogens of animals, humans and plants [69]. Control and management of plant diseases needs agents which can reduce the suspected pathogen to minimal levels, means of early-stage pathogen detection, and chemical compounds that effectively trigger immune response among the host plants. Nanomaterials have been assessed by scientists and researchers for their considerable utility in all such approaches for control of disease. This present review article also focuses on nanomaterials for control of the known phytopathogens, role of nanomaterials as mediators of the plant immune response. Hence, nanomaterials can be referred as novel weapons in this war against these phytopathogens and subsequently, can be a potential component in agro-ecosystem.

CONFLICT OF INTEREST

None Declare

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None Declare

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