ISSN: 2157-7471
Journal of Plant Pathology & Microbiology

OPEN ACCESS Freely available online

Review Article

A Review of the Efficacy of Medicinal Plants as Good Anti-Infection Agents

Priyanka Singh[1*], Kuleshwar Sahu[2], Anil Kumar[1]

[1]Department of Engineering and Sciences, GD Goenka University, Gurgaon, Haryana, India; [2]Department of Agricultural Sciences, GD Goenka University, Gurgaon, Haryana, India

ABSTRACT

Fungicides should be used to prevent plants against numerous plant-attacking pathogens in order to support the agriculture sector and raise food production, which often results in the ubiquitous usage of synthetic chemicals. Crops are more vulnerable to diseases when they are in the post-harvest stages. However, these compounds have some major drawbacks, such as harm to human health, bad environmental conditions, disease resistance to fungicides, etc. This result in identifying compounds derived from plants that can be used in managing disease control. Plants have a wide variety of compounds that can be isolated and applied in a variety of ways, one of which is treating damaged plants. These substances are collectively referred to as secondary metabolites because, despite playing an equally significant role, they do not play a part in the growth and development of plants. These secondary metabolites cover a wide range, including glycosides, alkaloids, phenols, flavonoids, terpenoids, tannins, and saponins. Several approaches are present to extract the phytochemicals from plants without disrupting their functional groups or qualities that let them target the pathogens. Plant-based fungicides have long highlighted the variety of plant species that shield the flora from pathogens without actually harming the plant system. This review paper focuses on how several medicinal plant families proved to be strong anti-infection agents.

Keywords: Phytochemicals; Fungicides; Secondary metabolites; Anti-microbial; Pathogens

INTRODUCTION

Synthetic fungicides are growing due to pre-harvest and post-harvest illnesses of fruits and vegetables caused by microbial pathogens. Most often during the storage period, fungi infect the seeds, shortening seed germination time and seed viability, and turning them into a seed borne pathogen [1]. The populace uses a variety of anti-microbial chemicals from medicinal plants to rid their crops of all ailments. Chemical pesticides are made up of all compounds capable of inhibiting the growth of weeds, fungi, and insects. Accordingly, these compounds are divided into groups based on the species they are designed to harm. These infections have evolved to become very effective and resistant against these to escape the plant's effectiveness, seriously harming the ecosystem as a whole [2]. Pesticides are extremely important because of their environmental persistence and rising prevalence. Because all pesticides are diverse in nature, their mechanism of action cannot be defined precisely. According to research, organophosphates and carbamates directly target the nervous system by producing intraneuronal stress, blocking neurotransmitters, and eventually causing neurotoxic consequences. Agriculture is an inevitable amenity, and maintaining its protection is crucial to human existence [3].

The two important crops throughout India are rice and wheat, which account for 42.5% and 34.5% of the nation's total food grain output, respectively [4]. The world has been battling with phytopathogen resistance since 1970 and it all has been due to the continuous use of synthetic pesticides. To overcome this critical situation, natural biopesticides need to be given importance [5].

Because of its extensive agricultural output, the state of Andhra Pradesh uses more pesticides than other states in India, contributing to the state's ranking as having the largest number

Correspondence to: Priyanka Singh, Department of Engineering and Sciences, GD Goenka University, Gurgaon, Haryana; E-mail: priyancas961@gmail.com

Received: 03-Apr-2023, Manuscript No. JPPM-23-20564; **Editor assigned:** 06-Apr-2023, PreQC No. JPPM-23-20564 (PQ); **Reviewed:** 20-Apr-2023, QC No. JPPM-23-20564; **Revised:** 02-Jun-2023, Manuscript No. JPPM-23-20564 (R); **Published:** 09-Jun-2023, DOI: 10.35248/2157-7471.23.14.691

Citation: Singh P, Sahu K, Kumar A (2023) A Review of the Efficacy of Medicinal Plants as Good Anti-Infection Agents. J Plant Pathol Microbiol. 14:691.

of pesticide poisoning incidents [6]. Biological pesticides are currently contending for a position in the agricultural market even though synthetic pesticides are undoubtedly more harmful than biological pesticides due to several limitations:

- Expensive preparation.
- Sensitivity to environmental factors.
- Unstabilized storage.
- Some plants compounds are harmful to humans.
- Formulations more effective than single botanical.
- More *in-vitro* effective than *in-vivo*.

As per studies, there is an emphasis on using underground parts of plants (root, tuber, rhizome, bulb, etc.) compared with other above-ground parts due to bioactive compounds possessing antimicrobial properties [7].

After the completion of the extraction, the residue contains an amount of solvent. It mustn't be toxic and non-interfering with the bioassay [8]. A good solvent is necessary for the determination of the biologically active compound of the plant during extraction having certain properties like easy evaporating at low heat, harmless to extract prepared, preservative, etc. Many medical plants contain lethal plant chemicals, and when these chemicals are isolated and applied to diseased plants, they are referred to as botanical pesticides or botanicals [9].

Table 1: Some common botanicals used in pesticide formulations.

S. no.	Common name	Botanical name	Major constituent	Parts used	References
1	Neem	*Azadirachta indica* A. Juss	Azadirachtin	Seeds, leaves, bark	Campos EVR, et al.
2	*Eucalyptus*	*Eucalyptus globulus*	Citronellal	Leaves	Naga Parameswari Mangalagiri, et al.
3	Tobacco	*Nicotiana tabacum*, Linn.	Nicotine, pyridine, indole, d-limonene	Leaves	Tyas Soemarah Kurnia Dewi, et al.; Potera, et al.
4	Lemon grass	*Cymbopogon flexuosus*	Citral	Leaves	Naga Parameswari Mangalagiri, et al.
5	Thyme	*Thymus vulgaris* Linn.	Thymol	Leaves	Weria Weisany, et al.; Isman, et al.
6	Clove	*Syzigium aromaticum* Linn.	Eugenol	Buds, leaves	Bao-Liang Tian, et al.
7	Tea tree	*Melaleuca alternifolia*	Eucalyptol, terpineol	Branches, leaves	Thanh Khang LE, et al.

The neem tree (*Azadirachta indica* A. juss) and its other forms, such as neem extract, neem oil, and neem cake, are one example of medicinal plants that have been used as sources of biopesticides. They have been used for many different purposes, in the forms of fertilizers, pesticides, or to protect crops after harvest [10]. Clove essential oil is one of many plant oils that are used to prevent illnesses that appear after harvest. Due to its primary component eugenol, which seems to have potent activity against fungi like *Botrytis cinerea*, *Penicillin expansum*, *Aspergillus* spp., etc., it can lower pathogenicity. Eugenol is highly volatile and only weakly water-soluble hence its application is confined [11]. Different odors in essential oils have the ability to draw pollinators. By evaporating in the air, it also shields the plants from the heat of the sun [12].

LITERATURE REVIEW

Microbes are one of the essential aspects that can devastate crops, which are a necessary component of human life that cannot be avoided. Because plants are susceptible to major physiological and anatomical ailments that shorten their lifespan, they have a limited shelf life [13]. They have a standard system that aids their survival and shields them from unfavorable and harsh environmental conditions. Numerous life forms rely on plants to survive, mostly for their sustenance because they are thought of as possible food sources. According to current statistics, around 175 biopesticides have been registered internationally, while only 12 have been registered in India [14].

Nature is full of exceptions. Some bacteria rely on plants for a living, while others are extremely beneficial because they function as plant protectors. *Bacillus thuringenesis* (BT) is a kind of gram positive bacteria that makes poisonous proteins known as BT-toxins, which are activated once swallowed by the target pathogen and kill it. It has long been utilized in agricultural systems due to its capacity to synthesize various insecticidal proteins, making it a useful eco-friendly biopesticide. *Trichoderma* spp., which is free-living soil fungi, is another often employed organic agent. They are a powerful fungicide against other soil-

borne diseases that cause root rot. Three Indian companies manufacture this sort of biopesticide [15].

Phytopathogens are among the other life forms that rely on plants as their host in order to fulfill their needs [16]. As a result, plants become adversely affected and are regarded as sick as a result. Numerous phytochemicals are utilized to treat these symptomatic disorders because of their diverse capabilities, such as anti-microbial, anti-inflammatory, etc., resulting from their complex ingredients.

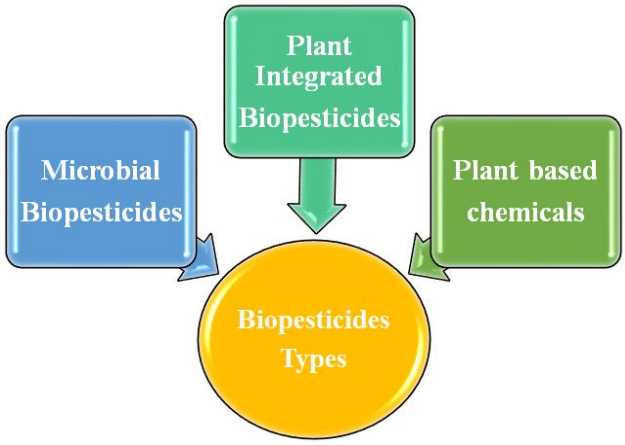

Figure 1: Types of biopesticides adapted from Asghar, et al.

What are the benefits of botanicals?

- Sustainable agricultural solutions.
- Reduce crop losses.
- Eco-friendly.
- Easily biodegradable.
- Organic farming.
- Less expensive.
- Integrated disease management.

How did it all start?

Since India has a wealth of traditional knowledge, it has been using plant based medicines for centuries. Because it is described in the "Rig Veda," which is regarded as the first collection of ancient knowledge and is thought to have been composed between 4500 and 1600 B.C., Hindu culture may trace the use of medicinal herbs for healing back to the dawn of human civilization. However, the overuse of medicinal plants in the contemporary era has led to occurrences of drug resistance [17]. As earlier as 350 BC, Aristotle recorded the first instance of plant disease. However, it used to be a misconception that plant diseases were caused by crimes committed by humans, bad spirits, or the wrath of the gods. All of this was brought to an end after Anton Leeuwenhoek developed a lens that could magnify the affected tissue and came to the conclusion that plant pathogens are to blame for the degeneration. Duhamel de Monceau noted *Rhizoctonia's* "saffron infection of the *Crocus*" in 1728, but it received no attention.

The earlier era saw the introduction of chemical pesticides, and at that time salt, sulfur, and heavy metals were used to create the pesticides. Sulfur has been used as a pesticide for a long time because it prevents mold growth, whether administered as a liquid, powder, or acidic solution [18]. Lead, mercury, and arsenic III oxides were also used because they disrupt biological processes including the generation of ATP, and are still popular today. Finally, they contaminated the ecosystem and wreaked havoc on both people and animals.

In many communities, chemical pesticide usage in agricultural areas is still a contentious issue. Rachel Carson wrote her book "Silent Spring" in which she revealed the negative consequences of DDT, which resulted in the cessation of DDT usage in agriculture [19].

When active and harmless elements were coupled, insecticides were manufactured. A chemical pesticide is often administered in its formulated form, which is created by combining an inert element that enhances storage, safety, and handling applications, while the active component has cidal ability and is primarily responsible for pathogen destruction.

Table 2: Types and harmful effects of the chemical pesticides adapted from Chandra Shekara, et al.

S. no.	Pesticide category	Types	Harmful effects
1	Organochlorines	DDT, dieldrin, chlordane, furan, toxaphene, dioxin, imidacloprid	Act as teratogens, neuroendocrine disruptors, tumor causing, dysregulate lipids and metabolism.
2	Organophosphates	Parathion, malathion, diaznon, glyphosate	Neurotoxin, coma, bronchospasm, change in heart rate, OP induced delayed polyneuropathy.
3	Carbamates	Carbofuran, carbaryl, propoxur, aminocarb	Neuronal damage.
4	Synthetic pyrethroids	Cypermethrin, permethrin	Endocrine disruption in humans, leukaemia, alteration of the nervous system.

Excellent soil and climatic conditions that are suited for a variety of aromatic and medicinal plants that can also be used as raw materials for the food, agrochemical, and pharmaceutical industries are just two examples of the many distinct factors that divide India.

How about worse conditions?

According to the reports by the directorate of plant protection, quarantine and storage, there are 307 pesticides registered in India and among them, many pesticides are still in use after being banned or prohibited by government officials.

Several findings demonstrate a probable harmful relationship between pesticide residues and human and animal health. When experimental animals were subjected to organophosphates and synthetic pyrethroids, there were detrimental consequences such as cancer. Exposure to pesticide contaminated environments causes' pesticide ingestion, which results in the generation of reactive oxygen species and a decrease in anti-oxidant levels and action against oxidative damage. Many health problems have arisen as a result of oxidative stress and ROS [20].

The Bhopal gas tragedy, which is acknowledged as among the biggest economic historical disasters is among the most well-known incidents of pesticide poisoning that have been reported. The Union Carbide pesticide manufacturing facility in India happened in 1984. This disaster happened as a result of the methyl isocyanate and water mixture, which caused a hazardous chemical to be released into the atmosphere from the processing plant and resulted in the development of gas-filled clouds. Approximately 2000 people perished right away, and 5000 more perished within two days of the disaster.

The Endosulfan poisoning case, often known as the pesticide catastrophe in India, attracted attention. Around 100 people perished in 1958 as a result of eating tainted flour that contained the organophosphate insecticide parathion. The government sector plantation corporation of Kerala sprayed the chemical aerially on the 12,000 acre cashew estates between 1975 and 2000, intoxicating the crops and the air that residents of the 20 gram panchayat in Kasaragod district were exposed to nearly 1000 people died and 6,000 people were poisoned as a result. After then, congenital disorders, CNS problems, mental disabilities, etc. were transmitted to newborn babies at birth. Neurotoxicity is the main side effect of endosulfan (CNS hyperstimulation). Although its usage was discontinued in 2001, its effects persisted since more newborns continued to be born with genetic diseases and physical abnormalities. Since there is no known cure for the endosulfan tragedy, prompt and intensive therapy is required. Finally, it was outlawed in Kerala in 2005, but it was discontinued in India around 2011.

It is commonly recognized that an infected pregnant mother can readily infect her unborn child due to their intimate relationship. There has been researching on pesticide exposure and brain cancer in young children as a result of their mother being exposed during, before, or after pregnancy, causing the kid to suffer as well because their immune system is weak and inactive at the time. These occurrences almost often end in brain malignancy.

Remedies of how plants extract are acting as saviors

Since ancient times, traditional medicines are used to treat diseases and compared with modern medicine, they are very cheaper and easily available to use. The early Romans created a procedure by using smashed olive pits to create oil termed "Amurea" that could kill pests. Because of their high toxicity, heavy metals have also been once used. Following the introduction of biopesticide, North America (44%) has the largest biopesticide market, followed by the European Union, Latin and South America, and Asia and India (6% each).

Jantasorn, et al. investigated the anti-microbial efficacy of *Hydnocarpus*, *Caesalpinia*, and *Carallia* against five plant pathogenic fungi *in vitro* conditions at various concentrations among which *Hydnocarpus* fruit extracts exhibited potential for growth inhibition, and recorded 100% growth inhibition against *P. oryzae*, *P. palmivora*, and *R. solani* followed by *S. rolfsii* (96.33 %).

In their study, Choudhury, et al. reported that three plant extracts, namely ginger, *Polyalthi*, and *Clerodendrum* showed a good inhibitory effect on *Rhizoctonia solani* under *in vivo* conditions among all the eleven plant extracts used. All the plant extracts were prepared using different plant parts and each with three different solvents methanol, chloroform, and hexane and it was observed that extracts with hexane showed less activity. It was concluded that *Clerodendrum*-chloroform extract was most effective compared to other extracts in controlling sheath blight disease of rice in pot culture and field experiment caused by *R. solani*.

Hasheminejad, et al. compared the activity of free and encapsulated clove essential oil and the results showed that the mycelial growth of *Aspergillus niger* could not be completely inhibited by free CEO, even at concentrations as high as 3 mg/ml while, after loading of oil into chitosan nanoparticles, the encapsulated CEO could completely inhibit the fungal growth at 1.5 mg/ml. He suggested that nanoparticles can be a better way of exposing plants and controlling diseases by slowly releasing plant extracts with antimicrobial properties.

Perczak, et al. their study examined the antifungal activity of ten essential oil against *Fusarium* species namely *Fusarium graminearum* and *F. culmorum*. They stated that the antifungal activity depends on the kind of EO and its concentration. Out of the ten examined essential oils-clove, thyme, and lemongrass demonstrated the highest anti-fungal activity (approximately 90-99%), completely inhibiting the growth of the tested *Fusarium* species at a concentration of 1000 µl/l. They concluded in their study that essential oils strongly reduce the mycotoxins level but the reduction depends on the type of EO and the concentration used.

DISCUSSION

Weria Weisany, et al. in their research encapsulated the thyme and dill essential oil with copper nanoparticles and evaluated

their anti-fungal activity against the phytopathogen *Colletotrichum nymphaeae*. Encapsulation of thyme and dill EOs with copper NPs resulted effective in reducing the mycelium growth even by 90% after 9 days of treatment. Furthermore, a strong inhibitory effect on conidia germination of *C. nymphaeae* was observed.

Kota Chakrapani, et al. their study suggested that garlic exhibits more antimicrobial activity followed by ginger, marigold, *Eucalyptus*, turmeric, onion, and tulsi. They grew the pathogen on potato dextrose agar amended with various extracts with different concentrations. The study revealed that phytoextracts have the ability and they deliberately control mycelial growth.

Chinche, et al. worked on *Ocimum sanctum* and *Aloe barbadensis* mill to check their antifungal activity against *Aspergillus niger* and *Sclerotium rolfsii* and concluded that at 60 mg/ml highest growth inhibition was observed and lowest at 20 mg/ml of the test fungus. The extracts isolation method was cold percolation and soxhlet extraction method with methanol and stated that methanol is a good extraction solvent.

Kitherian Sahayaraj, et al. their study produced the silver nanoparticles of the dry leaf aqueous extract of *Pongamia glabra* and tested its activity against *Rhizopus nigricans in vivo* and suggested that it's a good eco-friendly plant having antimicrobial activity useful in post-harvest against seeds infecting pathogenic bacteria. It was found that the increased quantity of agNPs decreases the spore count.

Perumal, et al. their study revealed the antimicrobial activity of green tea essential oil against *Magnoporthae oryzae* when it was used in the form of nanoemulsions. It suggested that prepared nanoemulsions can be a good substitute for synthetic fungicides.

Naga Parameswari Mangalagiri, et al. showed a study was done by using lemon grass, palm rosa, *Eucalyptus*, *Tagetus*, *Pelargonium*, *C. winteranus*, and *Mentha arvensis* chemical compounds were effective against rice plant infection and found that lemon grass, palm rosa, and *Eucalyptus* showed a significant reduction in microbial biomass production.

Seema, et al. suggested that to treat the post-harvest crown rot disease of bananas the extract of holy basil and *Cassia* can be used. They evaluated the efficacy of both extracts by disc volatilization method against *Colletotrichum musae* and *Lasiodiplodia theobromae*. They observed that cassia was completely able to inhibit both the fungal causative agents at 6 µL per plate whereas holy basil was active at different concentrations for both agents. The lipophilic content of essential oils forms micelles and hinders their attachment to the fungi when it is in the liquid phase. They also stated that essential oils should be used in the vapor state as they do not change the sensory properties of food and are required in very small amounts whereas while using in the liquid phase higher concentration is needed. Hence, in this study, essential oils were used in the vapor state.

Androutsopoulou, et al. demonstrated that plants with antimicrobial activity have different effects at different concentrations. They showed the activity of *Pelargonium* grave lens and rose petals and suggested that *Pelargonium* grave lens has the greatest effect on fungal strains. It was also effective at low concentrations whereas the extract of rose petals was maintaining its activity only at higher concentrations.

CONCLUSION

There have been many cases of pesticide poisoning reported, but endosulfan in Kerala and the Bhopal gas catastrophe in Bhopal are the greatest examples of the grave effects of prolonged usage of extremely strong pesticides. Due to their great efficacy and low cost, the 165 chemicals listed in the pesticides manufacturers and formulators association of India are frequently utilized; nevertheless, these advantages are usually balanced by the hazards they carry. Due to their slow rate of degradation, high environmental stability, and lengthy half-life, these pose major risks to ecosystems. Additionally, if they are used for a very long time, they can have catastrophic consequences that last for many years. Even though these chemical pesticides have been outlawed, they are still being used illegally in nations like China, India, and others. There is a tremendous desire to promote bio-degradable, environmentally benign bio-pesticides to win this conflict with the chemical sector. Numerous plant species have a variety of traits that can be utilized to treat plant diseases brought on by dangerous plant pathogens. Additionally, they offer significant risks when used for an extended period.

Additionally, it's critical to raise awareness among farmers and the general public about the dangers of toxic pesticides so that their usage can be reduced and the value of biopesticides they can be used in place of chemical pesticides.

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