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PROTECTION OF FOOD FROM FUNGAL PATHOGENS A REVIEW

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ABSTRACT

The profitability, quality, and output volume of plant production is significantly influenced by plant fungal diseases. These phytopathogens are persistent in getting past plant defences, which leads to diseases and quality losses that cost the US economy billions of dollars every year. Farmers have employed fungicides to manage the damage caused by plant pathogenic fungus in order to combat the epidemic of fungal plant diseases. Researchers and growers are looking for alternate solutions because of drawbacks including resistance development and environmental damage linked to these drugs. Materials and Procedures Using the search terms "plant fungal pathogen," "plant extracts," and "phytopathogens," several databases were consulted to learn more about research on protecting plants against plant fungal diseases. The best extractants and bioassay methods are suggested for use. Results: Plant fungal diseases have previously been treated with biological agents in addition to conventional fungicides. There are numerous instances when plant extracts or chemicals derived from plants have been employed on a broad scale as commercial fungus deterrents in agricultural and horticultural settings. The fact that plant extracts typically include many antifungal compounds is a benefit of this strategy. Consequently, if various substances have an impact on various metabolic processes, the development of pathogen resistance may be reduced. Plants grown with the use of plant extracts may also be marketed as organic. Numerous studies on potent antibacterial substances found in plant extracts with a focus on applications in human health have been released. To create acceptable, affordable, efficient, and sustainable botanical solutions that can be utilised to combat the epidemic of plant fungal infections, more study is necessary. Conclusions: The benefits of concentrating on plant fungal infections should be considered by scientists who have solely concentrated on using plants to control human and animal fungal illnesses. This strategy is considerably simpler to assess the efficacy in greenhouse or field studies, which could boost the food security for farmers in rural areas and result in financial incentives. Extracts may still be valuable in the floriculture sector even if they are hazardous..

INTRODUCTION

The majority of infections that occur in horticultural and agricultural settings are caused by plant fungal pathogens (Agrios, 2009). Fungal diseases are effecting both creature animal and Humans some fungal diseases like aspergillus infection are similar to viral diseases but fungal diseases have treatment while viral disease don't have any treatment (Samad, Hamza, Muazzam, Ahmer, Tariq, Javaid, et al., 2022; Samad, Hamza, Muazzam, Ahmer, Tariq, Javaid, et al., 2022; Samad et al, 2021; Samad, Hamza, Muazzam, Ahmad, Ahmer, Tariq, et al., 2022a, 2022b;F. M. S. Muthanna & Samad, 2022, Ibrahim et al., 2022; Mohammed et al., 2022) while bacterial disease also have treatment. (Mohammed et al., 2022b; F. M. Muthanna et al., 2022).

To target any plant, the phytopathogens have collectively developed strategies and methods (Knogge, 1996) that allow them to forcefully access nutrients for growth and development (Horbach et al., 2011). These infections are sexually and/or asexually reproducing (Gould, 2009), and they are capable of defeating plant immune defences (Thomma et al., 2011; Zvereva and Pooggin, 2012). This harms the health, homeostasis, physiology, and in some situations, the systemic health of the plant (Agrios, 2005). Plant fungal pathogens must be able to grow on the surface of an appropriate host for plant fungal diseases to manifest. The right circumstances are necessary for the plant fungal pathogen's spores to germinate. This includes a suitable host, low molecular mass nutrients, and adequate humidity from rain or dew (Osherov and May, 2001). By utilising self-inhibitors to delay germination until favourable conditions are present, fungal spores can survive for many years (Chitarra et al., 2004). For the hyphae to enter the host when the conditions are right, plant fungal diseases create infection structures such the appressorium and the infection peg (Schafer, 1994). Waxy hosts can serve as a vehicle for pathogens like Colletotrichum gloeosporioides to infect their hosts and cause illnesses in avocados (Podila et al., 1993). Different tactics can be employed by plant fungal infections to attack and infect their host. Others enter their host through wounds and the stomata, while certain germs enter by mechanical pressure and chemical activity (Knogge, 1998). Plants have evolved defences against fungus-related infections. This is an excellent reason to look into if plants contain antifungal chemicals (Eloff and McGaw, 2014). The pathogen associated molecular patterns (PAMP), PAMP-triggered immunity (PTI) inducible defence, and effector triggered immunity (ETI) defence are plant host defence systems that the plant fungal pathogens need to avoid (Thomma et al., 2011; Zvereva and Pooggin, 2012). Successful pathogens that are able to circumvent plant PTI and ETI, particularly those that have developed their avirulent genes to circumvent plant host R-resistance genes (Stergiopoulos and de Wit, 2009), produce catastrophic plant illnesses that can spark epidemics (Dean et al., 2012). Not all plant fungal infections can infect a single host with illness. Some have a restricted range of hosts, while others have a wide range. A variety of plant fungal diseases may be able to live on some plants (Agrios, 2005). Plant fungi can spread to new areas where they have never existed through the wind, birds, people, insects, water, and contaminated plant parts (Agrios, 2005; Rossman, 2009). Although not all fungi infect plants, plant fungi diseases attack all types of plants (Knogge, 1996). Collectively, these fungi are to blame for 80% of plant illnesses (El Hussein et al., 2014). Nearly 100 000 plant diseases are caused by 8000 different fungus species (Agrios, 2005). Based on the mode of infection, plant fungal pathogens can generally be divided into biotrophs, necrotrophs, and hemibiotrophs. Infections are caused by biotrophs, which feed on live tissues and do not harm their hosts. Some pathogens enter the host through the appressorium and use feeding organs like the haustoria to obtain nourishment from the cells around them. The hosts for the biotrophs are restricted, such as rust fungi and powdery mildew fungi (De Silva et al., 2016). Necrotrophs kill the afflicted area by infecting the living host. This is so that necrotrophic fungi, which require dead tissues to complete their life cycles, can exist. To obliterate the plant cells, these pathogens continuously create hydrolytic enzymes and poisons. In order for the pathogen to infect a particular host, such as Cochliobolus carbonum, necrotrophs create two different types of poisons, called host specific toxins. Second, some infections, such as Sclerotinia sclerotiorum, Alternaria brassicicola, and Botrytis cinerea, can infect and kill unrelated plant species thanks to broad-spectrum toxins (Wen, 2013). The hemi-biotrophs, such as Colletrichium, infect their hosts through similar mechanisms to biotrophs before killing them as necrotrophs (Agrios, 2005).

METHOD RESEARCH

The research method used in this study is a qualitative descriptive method. The type of data used in this study is qualitative data, which is categorized into two types, namely primary data and secondary data. Sources of data obtained through library research techniques (library study) which refers to sources available both online and offline such as: scientific journals, books and news sourced from trusted sources. These sources are collected based on discussion and discussion from one information to another. Data collection techniques used in this study were observation, interviews and research. This data is analyzed and then conclusions are drawn

RESULT AND DISCUSSION

A. Problems With Agricultural Production And Food Degradation Brought On By Plant Fungal Infections

Agriculture can produce sustainable plant products that can reduce hunger and poverty (Alexandratos and Bruinsma, 2012). The agricultural industry has suffered significant losses as a result of epidemics like the late blight diseases of potatoes, cereal rusts and smuts, ergot of rye and wheat, brown spot of rice, coffee rust, Sigatoka disease of bananas, chestnut blight, the downy and powdery mildews of grapes, wheat stem rust, and rubber leaf blight. Reduced plant quality and quantity caused by plant fungal infections can potentially be a concern to human health. This could result in forced food migration, altered country economic outlooks, increased political unpredictability, and forced people migration (Anderson et al., 2004; Ellis et al., 2008; Gould, 2009; Singh et al., 2012). Due to these phytopathogens, farmers, decision-makers, researchers, and consumers face huge challenges (Fletcher et al., 2006). According to Dean et alanalysis .'s of the top 10 plant fungal infections, farmers face a variety of challenging issues when producing plants (2012). Destructive diseases are caused worldwide by plant fungal pathogens such Magnaporthe oryzae and Colletotrichum spp. Blumeria graminis decreases crop amount while Fusarium graminearum lowers crop quality. One disease, such as Mycosphaerella graminicola, can mutate and infect different plant species in a same field, diminishing the ability of plants to fight off the infection. Similar to F. oxysporum, which possesses over 70 formae speciales, it can be challenging to pinpoint the important pathogen. A single species can spread disease to a wide range of plant species; for instance, F. oxysporum and Botrytis cinerea each have 200 plant hosts. A single pathogen, such as M. oryzae, can cause a significant reduction in grain output. Infections can fully shut down a plant's immune system when they coexist with other pathogens, such as F. graminearum and other Fusarium species. Additionally, pathogens like M. graminicola have a longer than 7-day symptomless colonisation period. Because of this, it is challenging to tell if the plant is diseased. Because some infections, like Ustilago maydis, can complete their life cycle in as little as two weeks, they can be extremely harmful. It is challenging to even produce other crops in crop rotation as a result of pathogens like Puccinia spp. Some pathogens have the ability to infect new plant species, afflict several plant species, or inflict disease on related plant species. Numerous weak infections can wreak havoc and start epidemics in closely related species across continents (Burdon and Thrall, 2009). In the pre- and post-harvest processes, plant fungi infections cause annual economic losses of more than $200 billion USD (Horbach et al., 2011). (Gonzalez-Fernandez et al., 2010). A billion dollars in yield and quality losses were attributed to the emergence of wheat and barley scab (cause: F. graminearum) in North America in 1993 alone (Mullins and Kang, 2001). It is obvious that fungi pose a wide range of issues and have the ability to have a significant impact on plant growth.

B. Plant Fungi That Cause Post-Harvest Issues And Food Deterioration

The customer may be exposed to post-harvest illnesses and food spoilage brought on by plant fungi at any time during the processing process, including during harvesting, handling, storage, packaging, and transportation (Agrios, 2005). Fresh fruit and vegetable rot in postharvest procedures is mostly caused by fungi (Gatto et al., 2011). The majority of postharvest infections are caused by more than 100 species of fungi, and they can reduce crop output by 10 to 30 percent (Tripathi and Dubey, 2004). (Agrios, 2005). The loss of perishable goods might reach 50% in impoverished nations and tropical areas (Tripathi and Dubey, 2004). Due to microbial deterioration, certain plant fungal diseases generate considerable losses during storage. Fungi include Penicillium italicum and P. digitatum (green rot of citrus), Penicillium expansum (blue rot of apples and pears), Penicillium glabrum (onion), and Penicillium funiculosum (onion), as well as Botrytis cinerea (fruits such as raspberries, strawberries, grapes, kiwi fruit, pears, peaches, plums, and cherries; vegetables such as (Moss, 2008). Fusarium, Geotrichum, and Aspergillus are a few fungal species that cause fruit and vegetable deterioration, leading to considerable financial losses and unpleasant features in plant-based products (Agios, 2005). Fruits that have been preserved can be completely destroyed by colletotrichum infections (Dean et al., 2012).

C. Issues Brought On By Mycotoxins

Molds create mycotoxins, which are low-molecular-weight substances. These secondary fungal metabolites have no impact on the formation or growth of the fungus and are poisonous to vertebrates at very low quantities (Hussein and Brasel, 2001). Mycotoxins are present in a wide variety of foods and are significant because they can result in both human and animal disorders like cancer and dermatitis (Agrios, 2005; Kumar et al., 2008). Consumption of tainted plant foods or animal feed containing mycotoxins can also result in a variety of metabolic issues such liver function decline, interference with protein synthesis, or other conditions like skin sensitivity, necrosis, or severe immunodeficiency (Sweeney and Dobson, 1998). Up to 25% of global crops are infected with mycotoxins every year, which has a serious impact on food security and the economy by causing the loss of 1 billion tonnes of food and food products (Matny, 2015). Aspergillus, Fusarium, and Penicillium species are frequently responsible for the mycotoxin-related illnesses (Agrios, 2005). Aside from having detrimental impacts on human and animal health, toxins such aflatoxins, ochratoxins, trichothecenes, zearalenone, fumonisins, tremorgenic toxins, and ergot alkaloids also have a negative economic and agricultural impact (Hussein and Brasel, 2001). Therefore, plant fungal diseases play a very detrimental impact in the efforts to feed the world's ever-increasing population. Plant fungal infections and the toxins they create seriously endanger agricultural production by reducing the quality and quantity of plant commodities, which causes financial losses both before and after harvesting. Various management and control methods are utilised to try and reduce the harm that fungi can do in agricultural settings.

D. Preventing Plant Pathogens

Many people around the world would go hungry and suffer from some of the terrible illnesses and outbreaks that occasionally occur if there were no control over or induced plant defences. Various agrochemical agents have been developed and utilised to combat the recurring attack of plant fungal infections on agricultural crops. Some of these agrochemicals are hazardous to people, so there must be a waiting period before harvesting after the final dose. Numerous of these fungicides also harm plant pollinators, insects, and soil-dwelling creatures. Farmers are paying increasing attention to using natural ingredients in the manufacturing of organic food, which is strongly backed by environmentalists and certain customers.

E. Building Up Fungal Resistance

Utilizing plant defence molecules in agricultural production to promote resistance to invasive fungal infections is the foundation of natural resistance (Nega, 2014). When different crops are plagued by diseases, salicylic acid and its analogues are utilised to create systemic acquired resistance. According to research, 30 g of benzo(1,2,3)thiadiazole-7-carbothioic acid S-methyl ester (BTH) can shield wheat crops from Puccinia recondita and Septoria species for an entire season (Reignault and Walters, 2007). Jasmonic acid and its derivatives can increase crop resistance and the synthesis of chemicals that are beneficial to health (Wasternack, 2014). Methyl jasmonates prevent degradation of "Marsh Seedless" grapefruit by P. digitatum and postharvest infections of strawberries by B. cinerea in agricultural settings (Tripathi and Dubey, 2004). Other natural substances that promote resistance against fungi include chitosan, -aminobutyric acid, glucosinolates, propolis, fusapyrone, deoxyfusapyrone, ethephon, microbial products, and plant extracts. These goods are utilised in agricultural settings all over the world to improve quality and yields (Tripathi and Dubey, 2004; Thakur and Sohal, 2013).

F. Fungicides

Synthetic compounds have offered much-needed relief in the management of plant fungal disease in agricultural output since the initial use of fungicides in the 1800s. Over time, the use of diverse synthetic compounds in agricultural production has reduced the impact of numerous plant fungi diseases, boosted plant crop yield, and generated profits (Gianessi and Reigner, 2006). Farmers, however, have struggled with the growth of fungicide resistance since the 1970s (Ishii, 2006; Possiede et al., 2009). This causes financial losses to occur. Fungicide sales were roughly 5.9 billion US dollars worldwide in 1996. (Martinez, 2012). The USA spends more than 600 million dollars on synthetic chemicals every year (Gonzalez-Fernandez et al., 2010). Japan had the largest fungicide market in the world in 2002, with sales of 818 million US dollars (Ishii, 2006). Fungicides frequently cause environmental imbalances by being poisonous to non-target animals like earthworms, bacteria, and people (genotoxicity) (Nega, 2014, Patel et al., 2014). Numerous of these compounds decay slowly and are challenging to eliminate. These might contaminate rivers and waterways as well (Stamatis et al., 2010).

G. Biological Defence

Numerous scientists are looking for alternatives to synthetic chemicals that are biological in order to address the issues with such substances (Martinez, 2012; Nega, 2014). Chemicals generated from microbial, botanical, and animal sources are classified as biological pesticides. At the moment, there are hundreds of products using more than 245 registered biopesticide-active chemicals in the USA. These make about 20% of all pesticide active chemicals that are registered in the nation (Yoon et al., 2013). Based on the fact that bacteria are antagonistic to the fungi that cause fungal illnesses in plants, they may be used in their treatment. The findings of investigations using microbial antagonists against plant fungal infections in the lab and in the field are encouraging (Sharma et al., 2009). Numerous fungal and bacterial antagonistic commercial products, such as GiloGard (Trichoderma harzianum - several soilborne illnesses), F-Stop (Gliocladium virens - seedling diseases of ornamentals and bedding plants), Agrobacterium radiobacter K-84, Gallex, or Galltrol (T. harzianum/T. polysporum - to prevent wood deterioration), Problems related to plant fungal infections are successfully treated with Dagger G (Pseudomonas fluorescens - Rhizoctonia and Pythium damping-off of cotton) and Kodiac (Bacillus subtillis - seed illnesses) around the world (Agrios, 2005).

H. The Use Of Plant Extracts

Numerous studies on the in vitro antifungal activity of plant extracts have been reported. The reason why many antifungal chemicals in plant extracts are very non-polar and do not disperse well in the aqueous agar matrix is why many authors, unfortunately, have employed techniques like agar diffusion experiments that do not perform well with plant extracts. Because so many factors affect the findings of agar diffusion, it is also very challenging to compare data between various laboratories. Different strategies for defending people or animals against fungus have been covered by Eloff and McGaw (2006) and McGaw and Eloff (2010). To determine the antibacterial activity of plant extracts, a serial dilution technique using tetrazolium violet as an indicator of growth was created and is now widely used (Eloff, 1998a). This approach has been improved and is excellent for fungi (Masoko et al., 2005). This technique allows for the calculation of the extracts' minimum inhibitory concentration (MIC). Only MICs of 0.1 mg/ml and lower should be thought of as having significant activity, according to several authors (Eloff, 2004; Rios and Recio, 2005; Cos et al., 2006). Using bioautography, it was also possible to determine how many antifungal chemicals were present in plant extracts (Masoko and Eloff, 2005). Acetone was typically the best extract when multiple extractants were employed (Eloff, 1988b). Water extracts often exhibited relatively little antibacterial action (Kotze and Eloff, 2002). Traditional leads might not be very helpful because water is the major extractant available to traditional healers. As a result, acetone tree leaf extracts were randomly tested for efficacy against nosocomial bacteria and fungus. Only a few extracts, many of which had MICs of 0.02 mg/ml and lower, had a MIC higher than 2,5 mg/ml when the antibacterial activity of 717 crude extracts of 537 tree species was assessed against four bacteria and two fungi (Pauw and Eloff, 2014). The antifungal properties of numerous plant species have been researched (Eloff and McGaw, 2014; Raut and Karuppayil, 2014). In storage circumstances, many essential oils prevent post-harvest fungal infections and extend the shelf life of many crops (Tripathi and Dubey, 2004). Additionally, a variety of fungi species formation of mycotoxin is inhibited by essential oils (Sivakumar and Bautista-Banos, 2014).

It is obvious that fungi provide significant challenges to the plant production sector and that poor management might have detrimental effects on the ability to produce food. Fungi can have an impact on the production of medicinal plants as well as their safety after harvesting in the same ways that phytopathogens do on the food and floricultural industries. In order to deal with the advent or outbreaks of plant fungal diseases, the existing control strategies are insufficient (Ishii, 2006; Possiede et al., 2009). Consequently, further research is needed, particularly using plant-based goods, to produce affordable, safe, and efficient biological products (Martinez, 2012). Fighting plant fungal diseases may be made easier by control using plant-based products (Tripathi and Dubey, 2004). Despite extensive study on testing plants for their antifungal activity against phytopathogens, only a small number of secondary metabolites have been identified (Cowan, 1999). Finding novel plant-based antifungal chemicals is one strategy, but another option is to use a complex plant extract. The benefit of the latter strategy is that, if the various antifungal components in an extract target various receptors, resistance may be less likely to develop. However, there is a drawback in terms of maintaining high quality control and activity variation due to genetic or environmental factors when compared to employing a single chemical product.

CONCLUSION

Research on plants that can defend plants against fungi is a fruitful and significant topic of study, and there have been many publications on the use of plant products in human or animal medicine. Although an essential field, employing plant products to give organically grown plants or medicine won't soon replace chemical antifungals. Aspects of quality control raise the cost of plant production, harvesting, and extraction. However, using plant-based treatments to treat plants during the period before harvesting could be crucial to agriculture in order to allow the concentration of chemical control agents to fall to acceptable levels. Even if there have been several publications on the use of plant products in human or animal medicine, research on plants that can defend plants against fungi or against livestock could be a useful field of study to improve the quality of life for people living in rural areas.

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