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Development of Polymer-Based Mulch Films for Disease Suppression

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Abstract

Gerbera jamesonii [Gerbera daisy) is a popular flowering plant susceptible to various microbial diseases. This paper explores disease control strategies for gerberas, focusing on the potential of novel polymer-based mulch films. Conventional mulching practices offer benefits in gerbera cultivation, including weed suppression that helps control pathogens. However, limitations associated with traditional mulch materials necessitate exploring alternative solutions. This study investigates the development of biodegradable polymer-based mulch films specifically designed for gerbera cultivation. The potential advantages of these films lie in their ability to: Suppress disease: Antimicrobial properties can be incorporated into the polymers to inhibit the growth of soil-borne pathogens that threaten gerberas. Enhance sustainability: Biodegradable polymers address environmental concerns linked to conventional, non-degradable mulch films Gerbera jamesonii is a popular and colorful flowering plant that belongs to the Asteraceae family. Gerbera flowers are prized for their striking, daisy-like appearance and vibrant colors, making them a favorite choice for floral arrangements, bouquets, and gardens. Gerbera flowers hold both aesthetic and ecological importance, making them significant in various contexts like ornamental value, economic importance, gardening and landscaping, and cultural and symbolic importance. The gerbera plant is susceptible to various microbial diseases, in this paper we are dealing with awareness about the diseases that affect the gerbera plant and its causal identification, and control measures which will be helpful for hobbyist gardeners as well as commercial growers.

Keywords: Gerbera, Mulch films, Biodegradable polymers, antimicrobial polymers, Sustainable agriculture

INTRODUCTION

Gerbera, scientifically known as Gerbera jamesonii, is a popular flowering plant indigenous to South Africa. It is part of the Asteraceae family, which also encompasses daisies, sunflowers, and asters. Commonly known as the "African daisy" or simply "gerbera daisy," this plant is widely cultivated for its vibrant blooms and is a popular choice for gardens, floral arrangements, and indoor decor.

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Gerbera daisies are known for their striking and colourful flowers. They typically have large, single blooms with a prominent central disk surrounded by radiating petals. There are numerous cultivars and varieties of gerbera daisies, each with its unique flower colours, sizes, and characteristics. Gerbera daisies are perennial plants in their native habitat but are often grown as annuals or treated as tender perennials in temperate climates. They thrive in well-drained soil and require plenty of sunlight to produce abundant flowers. They are also popular choices for container gardening. Gerbera daisies typically bloom during the spring and summer

months, although they can flower intermittently throughout the year under suitable conditions. Gerbera daisies are highly prized in the floral industry for their vibrant colours and long vase life. They are often used in bouquets, floral arrangements, and cut flower displays.

The genus Gerbera comprises approximately 40 species, with only one species, G. jamesonii, being cultivated [1]. They are versatile and adaptable plants that can brighten up gardens, homes, and celebrations with their vibrant and cheerful blooms.

Importance of Gerbera

The breeding of gerbera began at the close of the 19th century in Cambridge, England, through the hybridization of two South African species, G. jamesonii and G. viridifolia, by R.I. Lynch. The resulting hybrid was designated as Gerbera x cantebrigiensis, now commonly known as Gerbera hybrid. Presently, gerbera is acknowledged as a significant commodity in the global ornamental plant market, alongside species such as rose, chrysanthemum, carnation, and tulip. In 1991, gerbera held the sixth position in sales at Dutch flower auctions and is accessible for purchase in both cut flower and potted plant forms [2].

The flowers of Gerbera are celebrated for their durability, making them well-suited for transportation, while their enduring quality guarantees a favorable market price. This enduring herbaceous plant originates from South Africa and Asia, serving as a significant commercial bloom cultivated globally across a wide range of climatic conditions. Gerberas are commonly found in temperate and mountainous regions, with their distribution extending to the temperate Himalayas. In India, from Kashmir to Nepal, at elevations varying from 1,300 to 3,200 meters. Classified within the Asteraceae family, Gerbera can be propagated through both sexual and asexual means. However, the majority of commercially cultivated varieties are propagated vegetatively to maintain consistency and genetic integrity [3]. Gerbera enjoys a notable status as one of the leading cut flowers in demand throughout Europe, with a substantial portion of production originating from various countries, including India [2]. According to a study conducted by NASA, Gerbera plays a significant environmental role in removing chemical fumes and toxic gases [3].

Diseases of Gerbera

Gerbera encounters challenges from over 20 species of arthropods, with the two-spotted mite, Tetranychus urticae Koch, 1836, recognized as a notable pest impacting not just gerbera but also various other ornamental plants. This mite is considered a key pest due to its ability to cause economic injury. Additionally, several pests, including T. urticae, have shown resistance to one or more pesticides commonly used in flower cultivation, posing challenges for pest management in gerbera cultivation in certain regions worldwide [4].

Powdery mildew stands out as a significant fungal disease affecting gerbera plants, attributed to two main species: Erysiphe cichoracearum DC. and Podosphaera (formerly known as Sphaerotheca) fusca (Fr.) S. Blumer [5]. Alternaria leaf blight emerges as a notable disease affecting gerbera (Gerbera jamesonii) globally. This disease has been reported in various flower-growing regions, including the Kashmir valley, indicating its widespread prevalence and significance in gerbera cultivation [2].

Whiteflies, leaf miners, thrips, red mites, cyclamen mites, caterpillars, and root knot nematodes represent the predominant insects that can impact gerbera plants. These pests can attack gerbera at any stage of growth, leading to significant losses in production and compromising plant vigor. Additionally, infestations by these insects can result in deformities in the plants, further impacting their overall health and aesthetic appeal. Efficient pest control strategies are essential to alleviate the harm inflicted by these pests and uphold the health and productivity of gerbera crops [3].

Gerbera daisies (Gerbera jamesonii) are popular flowering plants known for their bright and colourful blooms. Like any plant, gerbera daisies can be susceptible to various diseases, which can affect their growth and overall health. Here are some common diseases that can affect gerbera daisies.

Powdery Mildew

It is a fungal disease identified by the appearance of a white, powdery coating on the leaves and stems of gerbera daisies. This disease can adversely affect the plants by reducing photosynthesis and weakening their overall vigor. In gerbera, powdery mildew stands as a significant fungal ailment and can be triggered by two primary species: Erysiphe cichoracearum DC. and Podosphaera (formerly known as Sphaerotheca) fusca (Fr.) S. Blumer. Effective management strategies are essential to prevent and control powdery mildew infestations in gerbera cultivation [5].

In combating powdery mildew in gerbera daisies, bio fungicide products have shown promising results. When administered prior to the commencement of disease infection, these formulations have shown considerable efficacy in reducing powdery mildew in comparison to untreated plants. Consequently, they can be incorporated into a holistic disease management regimen as a substitute for conventional fungicides. This approach not only offers effective control of powdery mildew but also aligns with efforts to reduce reliance on conventional fungicides, thereby promoting sustainable and environmentally friendly practices in gerbera cultivation. [5].

Botrytis Blight (Gray Mold)

"Botrytis cinerea" is "gray mold fungus," which induces gray mold disease on gerbera daisies. It typically appears as brownish-gray spots on the leaves and flowers. Botrytis can lead to rotting and wilting of affected plant parts.

Botrytis cinerea demonstrates a temperature spectrum for germination and in vitro growth ranging from 5–30°C. In controlled climate chamber trials, flowers exhibited a heightened incidence of B. cinerea lesions at temperatures of 20 and 25°C in comparison to 10 and 15°C. Moreover, the infectivity of B. cinerea conidia was negatively impacted during a storage duration of 7 days at temperatures of 15, 20, and 25°C [6].

Therefore, if the flowers are maintained at 20 and 25°C gerbera can be protected from the *B. cinerea* conidia during their storage period.

Alternaria Leaf Spot

Leaf spot diseases induced by diverse fungi can present as circular or irregular lesions on the foliage, which may exhibit brown, black, or tan discoloration. In severe instances, impacted leaves may undergo yellowing and premature shedding from the plant.

Alternaria leaf blight is acknowledged as one of the most notable ailments affecting gerbera (Gerbera jamesonii) globally. It has been documented as widespread in all flower cultivation regions of the Kashmir valley. Symptoms of the disease are typically observed on both leaves and peduncles. Notably, lesions on peduncles tend to be longer rather than round.

Observations of disease development indicate that Alternaria leaf blight in the field typically emerges in early May as small brown scattered spots. Over time, these spots gradually enlarge, reaching a maximum diameter of 23 to 26 mm within 55 to 59 days. Coalescence of spots frequently occurs, covering a significant portion of the leaf area. Sporulation is commonly observed when spots exceed a size of 4 mm [2].

In the early stages of infection, symptoms of Alternaria alternata present as small, dispersed brown lesions on the leaves, which subsequently evolve into circular or irregular shapes. These spots tend to coalesce, leading to the development of large, affected areas on the leaves and subsequent defoliation. Infected plants frequently display diminished vigor, inhibited growth, and yield fewer, smaller, and deformed flowers [6].

In the gerbera cut flower business, increasing channelization is observed as more growers enter the market. However, several physiological disorders can affect gerbera production. These disorders can impact the quality and marketability of gerbera flowers, posing challenges for growers in maintaining consistent production standards [3].

Integrated Pest Management (IPM) which serves as a decision support system for selecting and implementing pest control tactics, either individually or in combination, to develop a comprehensive management strategy. This method entails conducting cost-benefit assessments that consider the concerns of producers, society, and the ecosystem. Farmers participating in Farmer Field Schools (FFS) have reported increased crop yields, annual income, and improved leadership skills compared to non-practitioners. Integrated Pest Management Farmer Field Schools has become a widely endorsed technology dissemination platform among policymakers, academics, technicians, and farmers in Nepal. Due to the scarcity of data concerning insect pests and diseases affecting gerbera, investigations were conducted to assess the prevalence of these concerns in Kathmandu Valley and to ascertain the management practices employed to mitigate them [3].

Root and Crown Rot Disorder

This disorders in gerbera are frequently instigated by soil-borne pathogens, encompassing diverse fungi and water molds. These ailments can induce deterioration of roots and the crown (the junction of stems and roots), ultimately leading to symptoms such as wilting, yellowing, and plant demise.

Farmers were employing biological control agents such as Trichoderma viride and Pseudomonas for the control of root rot, Fusarium wilt, and crown rot [3]. This is a fungal disease that affects the base of the plant, often near the soil line. It can cause dark, sunken lesions and eventually lead to the plant's collapse causes crown and stem rot. Root rot is another fungal disease caused by overly wet soil conditions and is characterized by rotting of the plant's root system. It can lead to wilting, yellowing leaves, and eventual plant death.

Ensuring that the soil is well-drained. Gerbera daisies are susceptible to root rot in waterlogged or poorly drained soils [7]. Avoiding heavy soils with organic matter to improve drainage. Plant gerbera daisies at the recommended spacing to provide good air circulation. Crowded plants are more prone to fungal diseases. Keep the garden free of plant debris and fallen leaves, as these can harbour pathogens. Remove and destroy infected plant material.

Viral Diseases

Gerbera disease is susceptible to various virus diseases, including Gerbera mosaic virus and Tomato spotted wilt virus [8]. Symptoms of these diseases may manifest as mottled or distorted leaves, stunted growth, and reduced flower production. Plant viruses are infectious entities consisting of a protein coat enclosing a nucleic acid core. They are classified according to the nature of their nucleic acid and the morphology of their protein shell. To date, only RNA viruses have been identified in gerbera, which may exist as either single or double-stranded. However, there are some instances of single-stranded negative-sense RNA [ss (-) RNA] viruses as well. Notably, Tomato spotted wilt virus (TSWV) and Impatiens necrotic spot virus (INSV) are classified within the tospovirus group. Their genetic material made up of single-stranded negative-sense RNA along with two ambisense single-stranded RNAs [1].

Severe deformities of flowers and the occurrence of necrotic lesions on the leaves were noted in greenhouse-cultivated Gerbera jamesonii plants.

CMV-Related Ailments in Gerbera

Cucumber Mosaic Virus (CMV) is a plant pathogenic virus that can infect a variety of host plants, including gerbera daisies [9]. Infected plants typically exhibit mosaic-like symptoms on their leaves.

CMV, part of the Cucumovirus genus within the Bromoviridae family, induces severe symptoms including chlorotic mosaic patterns on leaves, vein greening, floret color breaking, flower deformities, and impaired bloom growth. Additionally, CMV infection often leads to yellowing and mottling of gerbera leaves.

Diseases Caused by TRV In Gerbera

TRV, short for Tobacco Rattle Virus, is a plant virus known to affect various crops, including ornamental plants such as gerbera daisies.[10] It is primarily transmitted by soil-inhabiting nematodes, particularly species possession to the genera Trichodorus and Paratrichodorus.

TRV belongs to the family Virgaviridae within the genus Tobravirus. Symptoms of TRV infection include circular lesions and pale streaks on foliage, which may progress to necrosis in older leaves. In laboratory experiments, sap from affected leaves was transferred onto different plant species which leads to the manifestation of symptoms characteristic of TRV.

TRV is transmitted by nematodes, managing nematode populations in the soil is crucial. Rotate crops, use nematode-resistant plant varieties, and consider soil treatments to control nematode populations.

While TRV is transmitted by nematodes, other pests, such as thrips, can also vector the virus. Implement integrated pest management strategies to control vectoring insects.

Diseases Caused by INSV In Gerbera

INSV, also known as Impatiens Necrotic Spot Virus, is a plant virus belonging to the genus Tospo virus. While originally associated with peanut plants and referred to as Indian Peanut Clump Virus, INSV has been found to infect a variety of plants, including gerbera daisies.

INSV is highly mechanically transmissible and can cause severe damage to infected plants.[11] It spreads rapidly through insect vectors, particularly Thrips species. Reports indicate that INSV can affect more than 300 plant species. Symptoms of INSV infection encompass stunting, ringspots, brown to purple leaf or stem spots, stem browning (cankers), and flower breaking.

Impatiens Necrotic Spot Virus (INSV) can cause several symptoms in gerbera plants.[12]. Some common correlated signs with INSV infestation include:

- *Ring spots:* Circular or ring-like patterns of discoloration on leaves.
- *Necrosis*: Necrotic (dead) areas on leaves, often appearing as brown or black lesions.
- *Leaf curling*: Infected leaves may exhibit curling or distortion.
- *Stunting*: Reduced growth and stunted plant development.
- *Yellowing*: Yellowing of leaves, which may resemble nutrient deficiencies.
- *Mosaic patterns*: Mottled or mosaic patterns on leaves.

Development of Polymer-based Mulch Films for Disease Suppression

Gerbera cultivation benefits significantly from mulching practices. Mulch suppresses weed growth, which can compete with gerberas for resources and harbor disease-causing pathogens [13]. However, conventional mulching materials like plastic films often pose environmental challenges due to their slow degradation rates. This section explores the potential of novel, biodegradable polymer-based mulch films specifically designed for gerbera cultivation.

Advantages of Polymer-Based Mulch Films

Biodegradable polymer-based mulch films offer several advantages over traditional mulching materials:

Disease suppression: Antimicrobial properties can be incorporated directly into the polymers during film development.[14] These antimicrobial additives can gradually release over time, suppressing the growth of soil-borne pathogens that threaten gerberas. Sustainability: Biodegradable polymers address environmental concerns associated with conventional, non-degradable mulch films. These films decompose naturally after their useful life, reducing plastic pollution in agricultural settings.

Improved moisture management: Certain polymers can be designed to optimize soil moisture levels around gerbera plants. This can help prevent water stress while also discouraging the growth of moisture-loving fungal pathogens. Weed suppression: Similar to conventional mulch films, polymer-based mulch can effectively suppress weed growth. This reduces competition for resources and minimizes the risk of pathogens introduced by weeds.

Development of Antimicrobial Polymer Films

The development of effective polymer-based mulch films for gerberas requires careful consideration of several factors [15]:

Polymer selection: The choice of biodegradable polymers strikes a balance between durability during use and appropriate degradation rates after disposal. Polymers like polylactic acid (PLA) or cellulose-based bio composites are promising candidates due to their biodegradability and potential for incorporation of antimicrobial additives. Antimicrobial additives: Various antimicrobial additives can be explored for incorporation into the polymers. These additives could include natural antimicrobials like essential oils or chitosan, or synthetic antimicrobials designed for controlled release in the soil environment. Film properties: The physical properties of the mulch film, such as thickness and permeability to water and gases, need to be optimized for gerbera cultivation. The film should suppress weeds while allowing sufficient gas exchange and water penetration to support healthy plant growth.

Virus Management Strategies for Gerbera

Managing viral diseases poses significant challenges compared to diseases caused by other pathogens due to the complex disease cycle of viruses, efficient transmission by vectors, and the lack of effective virucides. [16] To address these challenges, various approaches have been integrated into management strategies for diseases caused by plant viruses [1].

By Cultural Practices

Preventive measures are essential for controlling viral diseases, as there is no cure for infected plants. In instances of suspected viral infection in gerbera plants, samples should be forwarded to testing facilities for confirmation. Once the disease is identified, the only course of action for management is to dispose of the infected plants. However, efforts can be made to minimize the spread of viruses by managing their vectors, such as the western flower thrips. To manage the dissemination of western flower thrips, tactics can be deployed to physically bar the pests on external openings to impede their ingress into the greenhouse. Monitoring using indicator plants, can offer early detection of thrips presence. It's worth mentioning that western flower thrips have the capability to acquire viruses during the larval stage and subsequently transmit them, particularly Tomato Spotted Wilt Virus. By inhibiting the maturation of adults, transmission of the virus may be diminished. [1].

By Cleanliness

It practices play a crucial role in enhancing crop production. Removing all plant debris, weeds, and flowering plants from cultivation fields and nearby production areas is essential, as they can serve as sources of new infections and infestations. Additionally, soil sterilization has been suggested as a method to eliminate developmental stages of vector species, further reducing the risk of disease transmission. These measures help maintain a clean and healthy environment for crop growth, ultimately leading to improved yields. [1].

By Biological Regulation

Biological interventions can efficiently regulate thrips species during periods of low population density. Numerous predatory life form has been recognized for the regulation of western flower thrips. Lady beetles, also known as ladybugs or ladybird beetles (Coleoptera: Coccinellidae), are prominent and well-known beneficial predatory insects that can contribute to thrips control. Their presence in the ecosystem can help regulate thrips populations and prevent outbreaks. [1].

By Employing Gerbera Planting Material Free from Viruses

Viruses can disseminate from parent plants to their progeny. This mode of transmission poses a significant risk of virus contamination within plant populations. Therefore, timely protection is crucial to prevent virus infection and ensure crop health. Accurate and timely detection of viruses is essential for developing successful disease control plans. Utilizing virus-free planting material is advised to mitigate the risk of viral spread Transplanting such material into greenhouses can help ensure better crop production by minimizing the spread of viruses and maintaining plant health. [1].

General Precautions

The problem of Leaf folding can be prevented by ensuring consistent and adequate humidity levels in the greenhouse or growing area to prevent excessive transpiration, which can lead to leaf folding. Pseudo and Twin flowers can be solved by ensuring that gerbera plants receive adequate and uniform light levels. Uneven or insufficient lighting can lead to incomplete flower development. Provide appropriate support to the gerbera stems to prevent bending. Stake plants as needed to ensure upright growth. Also, during the storage should be kept in good condition. Keep detailed records of your growing practices, environmental conditions, and any observed disorders.

CONCLUSION

There are many factors that can affect the growth of the gerbera plant. Control of these insects and viruses can help good growth the plant. The various diseases that can harm the gerbera plant are reviewed with the possible identification and solutions to it. This can help the growers to identify the diseases and know more about the cause of the disease. It can make more awareness about the disease and its prevention, also to better understand to tackle the diseases on gerbera plant. General precautions, sanitation, and hygiene are important to the plant, with well-maintained conditions in the polyhouse to protect the plant from possible insect pestes. The information compiled will be helpful for gerbera hobbyist gardeners as well as commercial growers, which will ultimately improve the financial and social standing of farmers who are involved in the gerbera industry. Additionally, a strategy for managing diseases has been proposed which neither poses a Regular monitoring and prompt action can help keep gerbera daisies healthy and free from diseases.

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