Field Crop 2024, Vol.7, No.3, 134-144
http://cropscipublisher.com/index.php/fc

Research Report Open Access

Impact of Seedling Diseases on Cotton Crop Establishment and Yield

Shanjun Zhu, Mengting Luo
Institute of Life Science, Jiyang College of Zhejiang A&F University, Zhuji, 311800, Zhejiang, China
Corresponding author: mengting.luo@jicat.org

Field Crop, 2024, Vol.7, No.3 doi: 10.5376/fc.2024.07.0014
Received: 10 Mar., 2024
Accepted: 20 Apr., 2024
Published: 10 May, 2024

Copyright © 2024 Zhu and Luo, This is an open access article published under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Preferred citation for this article:
Zhu S.J., and Luo M.T., 2024, Impact of seedling diseases on cotton crop establishment and yield, Field Crop, 7(3): 134-144 (doi: 10.5376/fc.2024.07.0014)

Abstract The establishment and yield of cotton crops are significantly impacted by seedling diseases, which are influenced by various biotic and abiotic factors. This study examines the effects of different pathogens, environmental conditions, and management practices on cotton seedling health and subsequent crop yield. Key pathogens such as Thielaviopsis basicola, Rhizoctonia solani, Pythium spp., and Verticillium dahliae have been identified as major contributors to seedling diseases, leading to reduced plant growth and yield losses. The role of cover crops, particularly winter legumes, in managing soilborne pathogens and their mixed effects on different pathogens is also discussed. Additionally, the impact of insect pests like thrips and the cotton-leaf crumple virus on seedling health and yield is considered. Biological control methods, including the use of endophytic fungi and Trichoderma spp., show promise in mitigating these diseases and improving yield. This study highlights the importance of integrated disease management strategies, including crop rotation, resistant cultivars, and biological control, to enhance cotton crop establishment and productivity under varying environmental conditions.

Keywords Cotton seedling diseases; Soilborne pathogens; Biological control; Crop yield; Integrated disease management

1 Introduction

Cotton (*Gossypium* spp.) is a globally significant fiber crop, cultivated extensively for its economic value and utility in producing textiles, oil, and animal feed. It ranks first among fiber crops and second among oilseed crops worldwide, with an annual production of approximately 119.8 million bales (Hasan et al., 2019). The cultivation of cotton has a profound historical and economic impact, particularly in countries like the United States, where it has shaped agricultural practices and contributed to significant historical events such as the westward expansion and the industrial revolution (Koenning et al., 2004). In India, cotton is a crucial crop, with vast areas under cultivation and significant contributions to the agricultural economy (Refai et al., 2022).

The health of cotton seedlings is critical for successful crop establishment and yield. Seedling diseases, caused by various soil-borne pathogens, can severely impact germination rates, root development, and overall plant vigor, leading to substantial yield losses. Pathogens such as *Rhizoctonia solani*, *Fusarium moniliforme*, and *Macrophomina phaseolina* have been identified as significant threats to cotton seedlings, causing damping-off and other detrimental effects (Refai et al., 2022). The presence of these pathogens can lead to high mortality rates in seedlings, necessitating the development of resistant cultivars and effective disease management strategies (Refai et al., 2022). Additionally, diseases like boll rot caused by *Sclerotium rolfsii* further complicate cotton cultivation by affecting the bolls and reducing market value (Mahadevakumar et al., 2016).

This study aims to comprehensively examine the impact of seedling diseases on cotton crop establishment and yield. The objectives are to identify and describe the major seedling diseases affecting cotton; Assess the economic and agronomic impacts of these diseases on cotton production; Review current management practices and breeding strategies aimed at mitigating the effects of seedling diseases; Highlight future research directions and potential innovations in disease resistance and crop protection. By synthesizing findings from various studies, this study seeks to provide a detailed understanding of the challenges posed by seedling diseases in cotton cultivation and to propose actionable insights for improving crop resilience and productivity.

2 Overview of Seedling Diseases in Cotton

2.1 Common seedling diseases

Cotton seedlings are susceptible to a variety of diseases that can significantly impact crop establishment and yield. Among the most prevalent seedling diseases are preemergence damping-off, postemergence damping-off, and various wilt diseases. Preemergence damping-off, often caused by pathogens such as Pythium spp. and Rhizopus oryzae, leads to seed decay and failure to emerge (Howell, 2002). Postemergence damping-off, caused by fungi like *Pythium* spp., *Rhizoctonia solani*, and *Fusarium* spp., results in seedling death shortly after emergence (Parkash et al., 2021). Wilt diseases, including *Verticillium* wilt and *Fusarium* wilt, are also common and can cause severe damage to cotton seedlings, leading to stunted growth and reduced yield (Halpern et al., 2017; Yuan et al., 2017).

2.2 Pathogens involved

Several pathogens are responsible for seedling diseases in cotton. *Pythium* spp., including *P. aphanidermatum* and *P. ultimum*, are major contributors to preemergence damping-off (Howell, 2002). *Rhizopus oryzae* is another significant pathogen causing preemergence damping-off (Howell, 2002). Postemergence damping-off is primarily caused by *Pythium* spp., *Rhizoctonia solani*, and *Fusarium* spp. (Halpern et al., 2017). *Verticillium dahliae* is the pathogen responsible for Verticillium wilt, a disease that severely limits cotton production (Yuan et al., 2017). *Fusarium oxysporum* f. sp. *vasinfectum*, particularly race, is a highly virulent pathogen causing *Fusarium* wilt, which can lead to severe early-season damage (Parkash et al., 2021). Additionally, *Bacillus* strains have been identified as pathogenic to cotton seedlings, causing damping-off and affecting seedling growth (Aly et al., 2022).

2.3 Symptoms and diagnosis

The symptoms of seedling diseases in cotton vary depending on the pathogen involved. Preemergence damping-off is characterized by seed decay and failure to emerge from the soil. Postemergence damping-off symptoms include seedling death shortly after emergence, with affected seedlings showing signs of rot at the soil line. *Verticillium* wilt symptoms include wilting, chlorosis, and necrosis of leaves, as well as vascular discoloration in stems. *Fusarium* wilt symptoms are similar, with wilting, root rot, and stem discoloration being common indicators. Diagnosis of these diseases typically involves isolating and identifying the pathogens from infected plant tissues or soil samples. For instance, *Pythium* spp. and *Rhizoctonia solani* can be isolated from discolored or necrotic hypocotyls of cotton seedlings. Advanced diagnostic techniques, such as molecular assays, can also be used to accurately identify specific pathogens like V. *dahliae* and F. *oxysporum*. By understanding the common seedling diseases, the pathogens involved, and their symptoms, effective management strategies can be developed to mitigate the impact of these diseases on cotton crop establishment and yield.

3 Factors Contributing to Seedling Diseases

3.1 Environmental conditions

Environmental conditions play a significant role in the prevalence and severity of seedling diseases in cotton crops. Variations in soil temperature and moisture content have been shown to affect the incidence of seedling blight, with certain fungi thriving under specific conditions. For instance, *Pythium* spp. were most prevalent in cooler temperatures, while *Fusarium* spp., *Rhizoctonia solani*, and *Thielaviopsis basicola* were more common in warmer months (Hayat et al., 2020). Additionally, climate change and its associated weather patterns, such as extreme temperatures and altered rainfall, can exacerbate the occurrence of diseases by creating favorable conditions for pathogens and pests (Bhatti et al., 2020).

3.2 Soil health and composition

Soil health and composition are key factors influencing the development of seedling diseases. The presence of specific soil pathogens, such as *Pythium* spp., *Fusarium* spp., *Rhizoctonia solani* and *Thielaviopsis basicola*, is related to soil type and its crops Planting history. For example, soils that have not been planted with cotton have higher incidences of *Pythium* and *Fusarium* species, while soils with a history of cotton cultivation have higher incidences of *Rhizoctonia solani* and *Rhizopus* black rot (Hayat et al., 2020). In addition, soil characteristics such as pH, electrical conductivity, organic matter content, and the presence of trace elements such as zinc, copper, and

iron significantly affect cotton yield and disease susceptibility (Singh et al., 2010). At the same time, the significant impact of different consecutive planting years on the abundance of bacterial taxa in the two soils also provides an important reference for studying changes in soil microbial communities over time (Figure 1) (Ma et al., 2023).

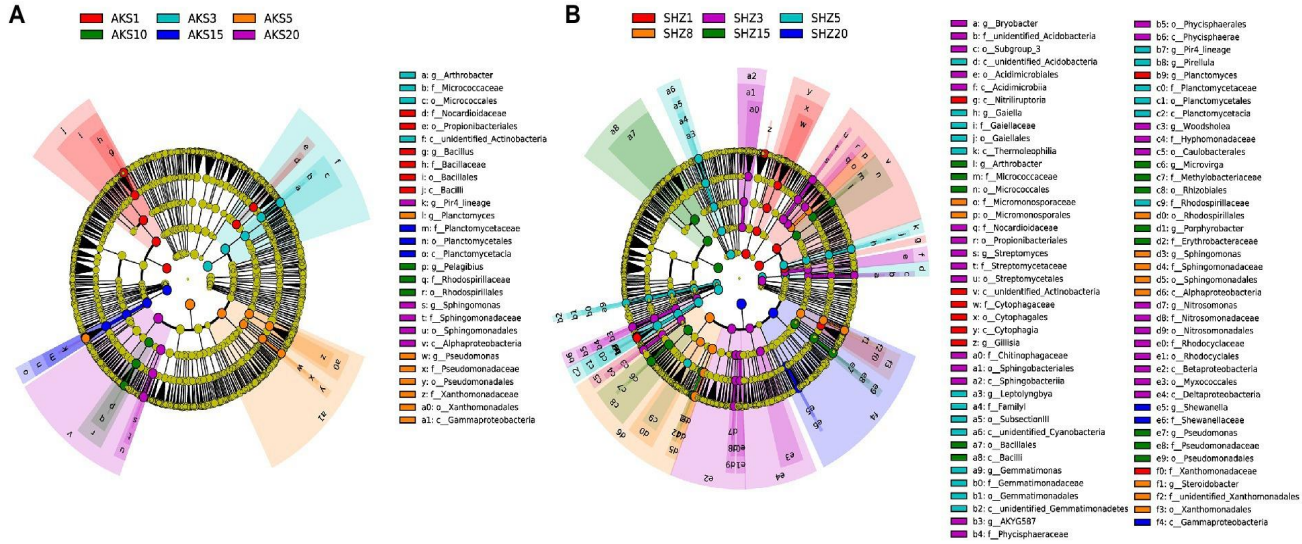

Figure 1 Cladograms of cotton field soil samples bacterial taxa with different continuous cropping years in AKS (A) and SHZ (B) soils based on linear discriminant analysis effect size (LEfSe) (Adopted from Ma et al., 2023)

Image caption: The image consists of two circular dendrograms (A and B), each depicting the taxonomic distribution of different microbial communities. These dendrograms are likely representing bacterial phylogenetic relationships and their abundance across various samples (Adopted from Ma et al., 2023)

3.3 Seed quality and treatment

The quality of seeds and their treatment before planting are crucial in managing seedling diseases. Seeds that are chemically coated or treated with fungicides can reduce the incidence of diseases by protecting the seedlings from pathogen attacks. The type of seed and its genetic resistance to diseases also play a role in determining the overall health and yield of the cotton crop. Studies have shown that the use of high-quality seeds and appropriate seed treatments can mitigate the adverse effects of environmental and soil conditions on seedling diseases (Singh et al., 2010; Dhage and Garg, 2021).

4 Impact of Seedling Diseases on Crop Establishment

4.1 Seedling mortality rates

Seedling diseases significantly impact cotton crop establishment by increasing seedling mortality rates. Various studies have shown that different tillage practices and environmental conditions can influence the incidence and severity of these diseases. For instance, stale seedbed production was found to increase the incidence and severity of seedling diseases in cotton, although the effect was minimal and manageable with in-furrow fungicides (Colyer and Vernon, 2005). Additionally, the use of winter legume cover crops was shown to affect soilborne pathogens, with some cover crops reducing the isolation frequency of pathogens like *Thielaviopsis basicola*, while others increased populations of *Rhizoctonia* spp. and *Pythium* spp. (Khan et al., 2017). These findings highlight the variability in seedling mortality rates depending on the agricultural practices employed.

4.2 Effects on plant vigor and growth

Seedling diseases not only increase mortality rates but also adversely affect the vigor and growth of surviving plants. Thrips, for example, are known to cause significant damage to cotton seedlings, leading to stunted growth, reduced leaf area, and compromised root development (Cook et al., 2011). Similarly, the presence of soilborne pathogens such as *Rhizoctonia solani* and *Pythium* spp. can lead to root and hypocotyl necrosis, further impairing plant growth (Knight et al., 2015). The use of fungicides and insecticides has been shown to mitigate some of

these effects, although their efficacy can vary based on environmental conditions and the specific pathogens present (Knight et al., 2015).

4.3 Delayed germination and emergence

Delayed germination and emergence are other critical issues caused by seedling diseases. The presence of pathogens in the soil can delay the germination process, leading to uneven plant stands and reduced crop uniformity. For example, the use of conservation tillage practices has been associated with reduced plant populations and delayed emergence due to increased seedling disease pressure (Colyer and Vernon, 2005; Knight et al., 2015). Additionally, the timing of sowing and planting density can influence the extent of these delays. Late sowing dates, combined with high planting densities, have been shown to exacerbate the effects of seedling diseases, leading to further delays in germination and emergence (Yuan et al., 2017).

Seedling diseases have a profound impact on cotton crop establishment by increasing seedling mortality rates, reducing plant vigor and growth, and causing delayed germination and emergence. Effective management practices, including the use of fungicides, insecticides, and appropriate tillage methods, are essential to mitigate these adverse effects and ensure successful crop establishment.

5 Impact on Cotton Yield

5.1 Yield reduction statistics

Seedling diseases significantly impact cotton yield by reducing plant populations and causing plant stress. For instance, research has shown that seedling diseases can lead to a reduction in plant populations, which directly correlates with lower yields. In a study comparing different tillage systems, it was found that plant populations were significantly different between tillage treatments, affecting the overall yield (Colyer and Vernon, 2005). Additionally, the presence of *Verticillium* wilt has been shown to decrease lint and seed yield in susceptible cotton genotypes (Bauer and Roof, 2004). Thrips infestations can also lead to substantial yield losses, with reports indicating potential lint yield reductions of up to 30-50% due to severe infestations (Karar et al., 2020).

5.2 Quality of cotton fibers

The quality of cotton fibers is also adversely affected by seedling diseases. *Verticillium* wilt, for example, significantly impacts fiber properties such as micronaire, maturity ratio, short fiber content, nep count, fineness, and immature fiber content. Infected plants showed a decrease in micronaire and maturity ratio, indicating poorer fiber quality (Bauer and Roof, 2004). Similarly, the presence of various pests and diseases in transgenic cotton cultivars in Pakistan has been shown to affect fiber quality traits, with some cultivars exhibiting higher susceptibility to pests and diseases, leading to compromised fiber quality (Karar et al., 2020).

5.3 Economic implications

The economic implications of seedling diseases on cotton crops are profound. Yield reductions and compromised fiber quality translate to lower market value and reduced profitability for cotton growers. For instance, the economic impact of fall armyworm infestations on cotton yields has been documented, with significant yield losses reported across various studies (Overton et al., 2021). The economic thresholds for managing these pests are crucial for minimizing losses. Additionally, the cost of managing seedling diseases through fungicide applications and other control measures adds to the overall production costs. In Pakistan, the economic returns from different transgenic cotton cultivars varied significantly, with some cultivars showing higher gross and net incomes due to lower pest susceptibility and higher yields (Karar et al., 2020). This highlights the importance of selecting disease-resistant cultivars to maximize economic returns.

6 Disease Management Strategies

6.1 Cultural practices

Effective management of seedling diseases in cotton crops is crucial for ensuring healthy crop establishment and optimizing yield. Various strategies can be employed to manage these diseases, including cultural practices, chemical control, and biological control, often integrated into an Integrated Pest Management (IPM) approach.

Cultural practices involve modifying the growing environment to reduce the incidence and severity of seedling diseases. Key cultural practices include crop rotation, stale seedbed techniques, and residue management. Rotating cotton with non-host crops can help break the life cycles of soil-borne pathogens like *Rhizoctonia solani* and *Thielaviopsis basicola*, thus reducing disease pressure in subsequent cotton crops (Delgado et al., 2005). Implementing stale seedbed production has shown variable effects on seedling diseases, but when combined with in-furrow fungicides, it can manage diseases effectively (Colyer and Vernon, 2005). Additionally, incorporating crop residues, particularly from crops like sugar beet, can reduce the incidence of black root rot by *Thielaviopsis basicola* (Delgado et al., 2005).

6.2 Chemical control

Chemical control remains a widely used and effective strategy to manage seedling diseases in cotton. The use of fungicides can protect seedlings from various pathogens. Seed treatments with fungicides like Dynasty, Topsin-M, and Antracol have been effective in increasing seed germination rates and reducing disease incidence in different sowing conditions (Ehetisham-ul-Haq et al., 2014). Additionally, fungicides applied in-furrow during planting can significantly reduce seedling diseases. Studies have shown that in-furrow fungicides effectively manage diseases caused by pathogens such as *Pythium* spp. and *Rhizoctonia* spp. (Colyer and Vernon, 2005).

6.3 Biological control and integrated pest management (IPM)

Biological control and IPM involve using natural enemies and combining multiple control strategies to manage diseases sustainably. The use of endophytic fungi such as *Penicillium simplicissimum* and *Talaromyces flavus* has shown promise in controlling *Verticillium* wilt, a major seedling disease in cotton. These endophytes can reduce disease incidence and improve cotton yield (Yuan et al., 2017). Combining cultural practices, chemical treatments, and biological control methods forms the basis of IPM. This approach aims to minimize chemical use and promote sustainable agriculture. For instance, integrating conservation tillage with biological control agents and selective chemical applications can effectively manage seedling diseases (Sharma and Bambawale, 2008). By employing a combination of these strategies, cotton growers can effectively manage seedling diseases, ensuring healthy crop establishment and maximizing yield potential.

7 Advances in Research and Technology

7.1 Resistant varieties

The development of resistant cotton varieties has been a significant focus in combating seedling diseases and improving crop yield. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) cotton breeding program in Australia has made notable progress in this area. They have successfully released cultivars resistant to several major diseases, including Bacterial blight, *Verticillium* wilt, *Fusarium* wilt, and Cotton bunchy top. The program emphasizes the importance of utilizing genomic selection, high throughput phenomics, gene editing, and landscape genomics to continue developing resistant cultivars in the face of emerging biotic threats such as Black root rot and secondary pests (Egan and Stiller, 2022).

In Pakistan, the introduction of genetically modified cotton (Bt-cotton) has been a key strategy to combat bollworms. However, the susceptibility of these cultivars to other pests and diseases varies. For instance, the cultivar 'FH-Lalazar' has shown low pest susceptibility and high seed-cotton yield, making it a recommended choice for higher yield and economic returns in Multan, Pakistan (Karar et al., 2020).

7.2 Innovations in Disease Detection

Advancements in disease detection technologies are crucial for early identification and management of seedling diseases in cotton. High throughput phenomics, which involves the rapid measurement of phenotypic traits, is one such innovation being utilized in the CSIRO cotton breeding program. This technology allows for the efficient screening of large populations of cotton plants for disease resistance traits, thereby accelerating the breeding process (Egan and Stiller, 2022).

7.3 Precision agriculture and digital tools

The integration of precision agriculture and digital tools is transforming cotton farming by enabling more accurate

and efficient disease management practices. Precision agriculture involves the use of technologies such as GPS, remote sensing, and data analytics to monitor and manage crop health at a granular level. These tools help in the precise application of inputs like water, fertilizers, and pesticides, thereby reducing waste and improving crop health.

Digital tools, including mobile applications and online platforms, are also being developed to assist farmers in disease identification and management. These tools provide real-time information and recommendations based on the latest research and field data, helping farmers make informed decisions to protect their crops from seedling diseases.

8 Case Studies

8.1 Successful disease management examples

Effective management of seedling diseases in cotton has been demonstrated through various strategies. For instance, the use of insecticide applications has been crucial in controlling thrips infestations, which are a significant pest for cotton seedlings in the United States. Despite the lack of resistant cotton varieties, growers have successfully managed thrips through insecticide seed treatments, in-furrow, or foliar-applied insecticides, which have helped mitigate the damage and yield loss caused by these pests (Delgado et al., 2005).

8.2 Lessons learned from major outbreaks

Major outbreaks of seedling diseases have provided valuable lessons for cotton growers and researchers. The pathogenicity of soil-borne fungi such as *Rhizoctonia solani*, *Fusarium moniliforme*, and *Machrophomina phaseolina* has been a significant challenge. Studies have shown that these pathogens can drastically reduce seed germination, root shoot length, and increase seedling mortality rates. The variability in pathogenicity among different isolates and cultivars suggests that breeding for resistance is a complex but necessary approach. The introduction of resistance genes into cotton cultivars is essential for future disease management strategies (Colyer and Vernon, 2005).

Another critical lesson comes from the impact of Cotton Leafroll Dwarf Virus (CLRDV) on cotton plants. The disease, first reported in Alabama in 2017, has spread to multiple states, causing significant yield reductions. Research has shown that CLRDV severely limits stomatal conductance and photosynthetic activity, leading to stunted growth and a drastic decrease in boll number and mass. This highlights the need for ongoing research into disease tolerance and the development of resistant cultivars (Delgado et al., 2005).

8.3 Regional variations and specific challenges

Regional variations significantly influence the impact and management of seedling diseases in cotton. For example, the influence of *verticillium* wilt epidemics on cotton yield has been studied in southern Spain. The severity of yield loss due to *verticillium* wilt was found to be closely related to the timing of symptom appearance and the *inoculum* density of *Verticillium dahliae* in the soil. Early symptom development led to more significant yield reductions, while later symptom development had a minimal impact on yield. This regional study underscores the importance of timely disease detection and management to minimize yield losses (Ehetisham-ul-Haq et al., 2014). Successful disease management in cotton involves a combination of chemical treatments, breeding for resistance, and timely disease detection (Figure 2) (Xu et al., 2018). Lessons from major outbreaks emphasize the complexity of managing multiple pathogens and the critical need for ongoing research and development of resistant cultivars. Regional studies highlight the importance of understanding local disease dynamics to tailor management practices effectively.

9 Future Directions

9.1 Research needs and priorities

The impact of seedling diseases on cotton crop establishment and yield necessitates a multifaceted research approach. Future research should prioritize the identification and characterization of pathogenic fungi affecting cotton seedlings, such as *Rhizoctonia solani*, *Fusarium moniliforme*, and *Macrophomina phaseolina*, which have been shown to significantly reduce seed germination and increase seedling mortality (Refai et al., 2022).

Additionally, there is a need to explore the genetic basis of resistance in cotton cultivars. The integration of advanced breeding techniques, including genomic selection and gene editing, can expedite the development of resistant varieties (Egan and Stiller, 2022). Research should also focus on optimizing agronomic practices, such as planting density and sowing dates, to mitigate the effects of seedling diseases and enhance overall crop productivity (Khan et al., 2017).

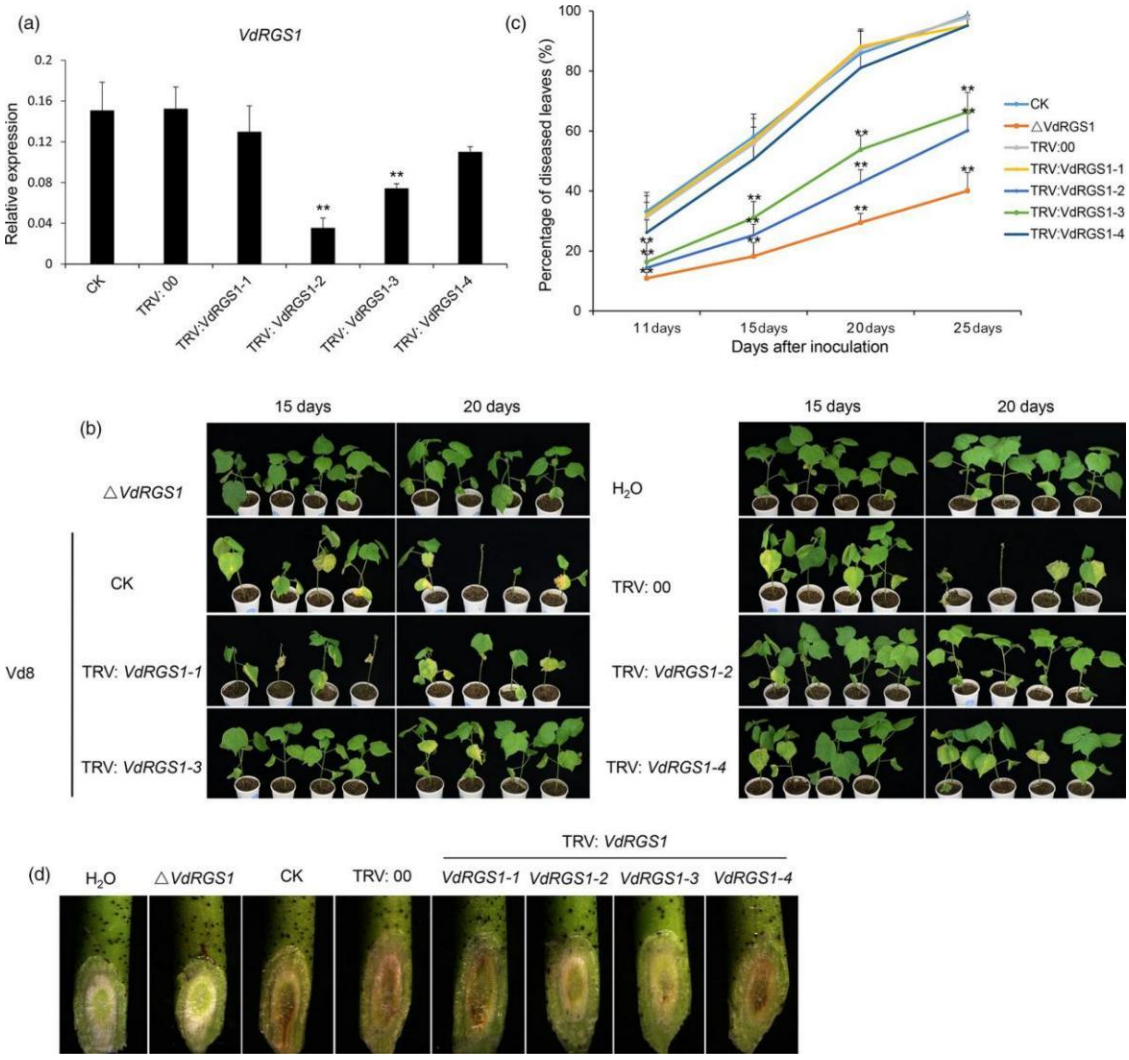

Figure 2 Virulence tests of DVdRGS1; a: Disease symptoms of cotton plants (Junmian 1) infected with DVdRGS1 compared with wild-type Vd8 and VdRGS1-com strains. Photographs were taken at 11, 15 and 20 days postinoculation; b: Vascular discoloration of cotton plants inoculated with indicated strains. Plants were inoculated with Verticillium dahliae spore suspensions (107 conidia/mL) for 15 days, and then, the stems were cut and photographed by stereoscope (Olympus MVX10, Tokyo, Japan); c: The percentage of diseased leaves inoculated with DVdRGS1 compared with wild-type Vd8 and VdRGS1-com strains; d: Disease index (DI) of cotton plants inoculated the wild-type Vd8, DVdRGS1 and VdRGS1-com at 20 dpi. These experiments were repeated for three times using at least 40 seedlings per treatment, Error bars show the standard deviation of three biological replicates, Asterisks indicate statistically signi fi cant differences in the percentage of diseased leaves and the DI of plants treated with DVdRGS1 and VdRGS1-com mutants and the wildtype Vd8 strain, as determined by Student's t-tests (*P<0.05, **P<0.01) (Adopted from Xu et al., 2018)

Image caption: This figure shows that the severity of plant diseases can be attenuated by inhibiting the expression of the VdRGS1 gene. These experimental results show the importance of the VdRGS1 gene in plant disease response, and reducing the expression level can effectively reduce the occurrence of disease. This provides important reference value for further research and application (Adopted from Xu et al., 2018)

9.2 Policy recommendations

To effectively manage seedling diseases in cotton, policy recommendations should emphasize the importance of developing and disseminating resistant cotton cultivars. Governments and agricultural bodies should support breeding programs that focus on host plant resistance (HPR) to ensure the availability of disease-resistant varieties to farmers (Egan and Stiller, 2022). Additionally, policies should encourage the adoption of integrated pest management (IPM) strategies that combine cultural, biological, and chemical control methods to manage seedling diseases sustainably. Investment in farmer education and extension services is crucial to ensure that farmers are well-informed about the latest disease management practices and resistant cultivars.

9.3 Role of global collaboration in disease management

Global collaboration is essential in addressing the challenges posed by seedling diseases in cotton. International research partnerships can facilitate the exchange of knowledge, *germplasm*, and technologies, thereby accelerating the development of resistant cotton varieties (Egan and Stiller, 2022). Collaborative efforts can also lead to the establishment of global surveillance systems for emerging pathogens, enabling timely interventions and reducing the spread of diseases. Furthermore, joint initiatives can promote the standardization of disease management practices and policies across different cotton-growing regions, ensuring a coordinated and effective response to seedling diseases. By focusing on these future directions, the cotton industry can enhance crop establishment and yield, ultimately contributing to the sustainability and profitability of cotton production worldwide.

10 Concluding Remarks

The impact of seedling diseases on cotton crop establishment and yield is profound and multifaceted. Various pathogens and pests contribute to significant losses in cotton production. Thrips, for instance, are a major insect pest that affects cotton seedlings, causing distortion, malformation, and reduced growth, which can lead to a 30-50% reduction in lint yield potential. Similarly, soil-borne pathogens such as *Pythium* spp. and *Rhizopus oryzae* cause preemergence damping-off, significantly affecting seedling survival rates. The cotton-leaf crumple virus (CLCV), transmitted by the sweetpotato whitefly, also leads to reduced growth and yield, with infected plants showing a 24% reduction in seed-cotton yields. Additionally, pathogenic fungi like *Rhizoctonia solani*, *Fusarium moniliforme*, and *Macrophomina phaseolina* have been identified as detrimental to cotton seedlings, reducing germination rates and increasing mortality. The practice of stale seedbed production has been shown to increase the incidence of seedling diseases, although the application of in-furrow fungicides can mitigate these effects. Continuous cropping of cotton further exacerbates soil-borne diseases, altering soil bacterial communities and reducing plant health.

Continuous monitoring and management of seedling diseases are crucial for maintaining cotton crop health and optimizing yield. The variability in pathogen presence and severity across different regions and years necessitates regular surveillance and tailored management practices. For instance, the application of insecticides is essential for controlling thrips, as no resistant cotton varieties are currently available. Similarly, seed treatments with fungicides like Metalaxyl can control diseases caused by *Pythium* spp., although they are less effective against *Rhizopus oryzae*, highlighting the need for integrated disease management strategies. The use of biological control agents, such as *Trichoderma* spp., has shown promise in managing preemergence damping-off. Moreover, understanding the impact of agricultural practices, such as tillage and continuous cropping, on soil health and disease incidence is vital. The adoption of conservation tillage practices, coupled with appropriate fungicide applications, can help manage seedling diseases effectively. Continuous cropping requires careful management of soil microbiomes to prevent the proliferation of soil-borne diseases.

Enhancing cotton crop establishment and yield in the face of seedling diseases requires a multifaceted approach. Breeding for disease-resistant cultivars remains a long-term goal that could provide sustainable solutions to many of the challenges posed by seedling diseases. In the short term, integrated pest and disease management strategies, including the use of chemical, biological, and cultural controls, are essential. The application of insecticides and fungicides, combined with practices such as crop rotation and the use of cover crops, can help manage pest and pathogen pressures. Additionally, advancements in soil health management, including the use of soil amendments

and microbiome management, can mitigate the adverse effects of continuous cropping. Ultimately, a combination of vigilant monitoring, adaptive management practices, and ongoing research into disease-resistant cultivars and sustainable agricultural practices will be key to improving cotton crop establishment and yield in the face of seedling diseases.

Acknowledgments

Authors extend sincere thanks to two anonymous peer reviewers for their invaluable feedback on the manuscript of this paper.

Conflict of Interest Disclosure

Authors affirm that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Abbas H., Wahid M., Sattar A., Tung S., Saleem M., Irshad S., Alkahtani J., Elshikh M., Cheema M., and Li Y., 2022, Foliar application of mepiquat chloride and nitrogen improves yield and fiber quality traits of cotton (*Gossypium hirsutum L.*), PLoS ONE, 17: 7. https://doi.org/10.1371/journal.pone.0268907

Aly A., El-Mahdy O., Habeb M., Elhakem A., Asran A., Youssef M., Mohamed H., and Hanafy R., 2022, Pathogenicity of bacillus strains to cotton seedlings and their effects on some biochemical components of the infected seedlings, The Plant Pathology Journal, 38: 90-101. https://doi.org/10.5423/PPJ.OA.11.2021.0173

Ayele A., Wheeler T., and Dever J., 2020, Impacts of verticillium wilt on photosynthesis rate, lint production, and fiber quality of greenhouse-grown cotton (*gossypium hirsutum*), Plants, 9: 57. https://doi.org/10.3390/plants9070857

Bauer P., and Roof M., 2004, Nitrogen, aldicarb, and cover crop effects on cotton yield and fiber properties, Agronomy Journal, 96: 369-376. https://doi.org/10.2134/AGRONJ2004.3690

Bhatti M., Umar U., and Naqvi S., 2020, Cotton diseases and disorders under changing climate, Agronomy Journal, 10: 271-282. https://doi.org/10.1007/978-981-15-1472-2_14

Chakma S., Chileshe S., Thomas R., and Krishna P., 2021, Cotton seed priming with brassinosteroid promotes germination and seedling growth, Agronomy, 10: 66. https://doi.org/10.3390/AGRONOMY11030566

Cheng M., Wang H., Fan J., Zhang S., Wang Y., Li Y., Sun X., Yang L., and Zhang F., 2021, Water productivity and seed cotton yield in response to deficit irrigation: a global meta-analysis, Agricultural Water Management, 255: 107027. https://doi.org/10.1016/J.AGWAT.2021.107027

Cianchetta A., and Davis R., 2015, Fusarium wilt of cotton: management strategies, Crop Protection, 73: 40-44. https://doi.org/10.1016/J.CROPRO.2015.01.014

Colyer P., and Vernon P., 2005, Impact of stale seedbed production on seedling diseases in cotton, Plant Disease, 89: 744-748. https://doi.org/10.1094/PD-89-0744

Cook D., Herbert A., Akin D., and Reed J., 2011, Biology, crop injury, and management of thrips (thysanoptera: thripidae) infesting cotton seedlings in the united states, Journal of Integrated Pest Management, 2: 1-9. https://doi.org/10.1603/IPM10024

Delgado A., Franco G., Paez J., Vega J., Carmona E., and Avilés M., 2005, Incidence of cotton seedling diseases caused by rhizoctonia solani and thielaviopsis basicola in relation to previous crop, residue management and nutrients availability in soils in sw spain, Journal of Phytopathology, 153: 710-714. https://doi.org/10.1111/J.1439-0434.2005.01044.X

Dhage S., and Garg V., 2021, Analysis of impact of environmental factors on cotton plant diseases and detection using cnN, International Conference on Computing Sciences (ICCS), 11: 234-238. https://doi.org/10.1109/ICCS54944.2021.00053

Egan L., and Stiller W., 2022, The past, present, and future of host plant resistance in cotton: an australian perspective, Frontiers in Plant Science, 13: 77. https://doi.org/10.3389/fpls.2022.895877

Ehetisham-ul-Haq M., Anjum F., Hussain S., Khan M., Rashid A., and Raza M., 2014, Prediction of cotton seedling germination against pre-emergence damping off on the basis of environmental factors and seed applied fungicides, Archives of Phytopathology and Plant Protection, 47: 1875-1884. https://doi.org/10.1080/03235408.2013.861135

Gulmurodova S., and Sattarova R., 2023, New protectants against cotton seeding diseases (root rot and gommosis), E3S Web of Conferences, 51: 46. https://doi.org/10.1051/e3sconf/202338903046

Halpern H., Bell A., Wagner T., Liu J., Nichols R., Olvey J., Woodward J., Sanogo S., Jones C., Chan C., and Brewer M., 2017, First report of fusarium wilt of cotton caused by fusarium oxysporum f. sp. vasinfectum race 4 in texas, U.S.A., Plant Disease, 102: 446-446. https://doi.org/10.1094/PDIS-07-17-1084-PDN

Hasan I., Rasul S., Malik T., Qureshi M., Aslam K., Shabir G., Athar H., and Manzoor H., 2019, Present status of cotton leaf curl virus disease (CLCUVD): a major threat to cotton production, Plant Disease, 1: 1-13.
https://doi.org/10.33865/ijcrt.001.01.0240

Hassan A., Ijaz M., Sattar A., Sher A.S., Rasheed I., Saleem M., and Hussain I., 2020, Abiotic stress tolerance in cotton, Advances in Cotton Research, 10: 72.
https://doi.org/10.5772/intechopen.89622

Hayat A., Amin M., and Afzal S., 2020, Statistical investigation to explore the impact of soil and other characteristics on cotton yield, Communications in Soil Science and Plant Analysis, 51: 1434-1442.
https://doi.org/10.1080/00103624.2020.1781152

Howell C., 2002, Cotton seedling preemergence damping-off incited by rhizopus oryzae and pythium spp, and its biological control with trichoderma spp, Phytopathology, 92(2): 177-180.
https://doi.org/10.1094/PHYTO.2002.92.2.177

Huseth A., Chappell T., Chitturi A., Jacobson A., and Kennedy G., 2018, Insecticide resistance signals negative consequences of widespread neonicotinoid use on multiple field crops in the u.s. cotton belt, Environmental Science and Technology, 52(4): 2314-2322.
https://doi.org/10.1021/acs.est.7b06015

Karar H., Bashir M., Haider M., Haider N., Khan K., Ghramh H., Ansari M., Mutlu Ç., and Alghanem S., 2020, Pest susceptibility, yield and fiber traits of transgenic cotton cultivars in multan, pakistan, PLoS ONE, 15: 40.
https://doi.org/10.1371/journal.pone.0236340

Khan A., Najeeb U., Wang L., Tan D., Yang G., Munsif F., Ali S., and Hafeez A., 2017, Planting density and sowing date strongly influence growth and lint yield of cotton crops, Field Crops Research, 209: 129-135.
https://doi.org/10.1016/J.FCR.2017.04.019

Khan A., Wang L., Ali S., Tung S., Hafeez A., and Yang G., 2017, Optimal planting density and sowing date can improve cotton yield by maintaining reproductive organ biomass and enhancing potassium uptake, Field Crops Research, 214: 164-174.
https://doi.org/10.1016/J.FCR.2017.09.016

Knight I., Rains G., Culbreath A., and Toews M., 2015, Conservation tillage and thiamethoxam seed treatments as tools to reduce thrips densities and disease in cotton and peanut, Crop Protection, 76: 92-99.
https://doi.org/10.1016/J.CROPRO.2015.06.012

Knight I., Rains G., Culbreath A., and Toews M., 2017, Thrips counts and disease incidence in response to reflective particle films and conservation tillage in cotton and peanut cropping systems, Entomologia Experimentalis et Applicata, 162: 19-29.
https://doi.org/10.1111/eea.12523

Koenning S., Wrather J., Kirkpatrick T., Walker N., Starr J., and Mueller J., 2004, Plant-parasitic nematodes attacking cotton in the united states: old and emerging production challenges, Plant Disease, 88(2): 100-113.
https://doi.org/10.1094/PDIS.2004.88.2.100

Li N., Yao N., Li Y., Chen J., Liu D., Biswas A., Li L., Wang T., and Chen X., 2021, A meta-analysis of the possible impact of climate change on global cotton yield based on crop simulation approaches, Agricultural Systems, 193: 103-221.
https://doi.org/10.1016/J.AGSY.2021.103221

Liu X., Woodward J., Kelly B., Lewis K., Byrd S., and Chen Y., 2021, Effects of production practices on temporal disease progress of verticillium wilt of cotton (gossypium hirsutum l.) in the texas high plains, USA, Crop Protection, 140: 105-429.
https://doi.org/10.1016/j.cropro.2020.105429

Ma Z., Li P., Yang C., Feng Z., Feng H., Zhang Y., Zhao L., Zhou J., Zhu H., and Wei F., 2023, Soil bacterial community response to continuous cropping of cotton, Frontiers in Microbiology, 14: 28.
https://doi.org/10.3389/fmicb.2023.1125564

Mahadevakumar S., Tejaswini G., Shilpa N., Yadav V., Dharanendraswamy S., and Janardhana G., 2016, First report of sclerotium rolfsii associated with boll rot of cotton in india, Plant Disease, 100: 214-216.
https://doi.org/10.1094/PDIS-06-15-0689-PDN

McKinion J., Jenkins J., Akins D., Turner S., Willers J., Jallas E., and Whisler F., 2001,. Analysis of a precision agriculture approach to cotton production. computers and electronics in agriculture, Frontiers in Microbiology, 32: 213-228.
https://doi.org/10.1016/S0168-1699(01)00166-1

Nelson R., Wiesner-Hanks T., Wisser R., and Balint-Kurti P., 2017, Navigating complexity to breed disease-resistant crops, Nature Reviews Genetics, 19: 21-33.
https://doi.org/10.1038/nrg.2017.82

Overton K., Maino J., Day R., Umina P., Bett B., Carnovale D., Ekesi S., Meagher R., and Reynolds O., 2021, Global crop impacts, yield losses and action thresholds for fall armyworm (spodoptera frugiperda): a review, Crop Protection, 10: 41.
https://doi.org/10.1016/J.CROPRO.2021.105641

Parkash V., Sharma D., Snider J., Bag S., Roberts P., Tabassum A., West D., Khanal S., Suassuna N., and Chee P., 2021, Effect of cotton leafroll dwarf virus on physiological processes and yield of individual cotton plants, Frontiers in Plant Science, 12: 86.
https://doi.org/10.3389/fpls.2021.734386

Patel B., Sandipan P., Patel R., and Chawada S., 2020, Screening of different non systemic and systemic fungicides for the wilt disease of cotton under in vitro condition of south gujarat, International Journal of Current Microbiology and Applied Sciences, 9: 820-825.
https://doi.org/10.20546/IJCMAS.2020.912.098

Qaim M., and Zilberman D., 2003, Yield effects of genetically modified crops in developing countries, Science, 299: 900-902.
https://doi.org/10.1126/SCIENCE.1080609

Refai T., Ali I., Nabi H., Aly A., Khalil M., and Abd-Elsalam K., 2022, Pathogenicity assay of some soil-borne fungi isolated from cotton seedlings, Egyptian Journal of Agricultural Research, 21: 154.
https://doi.org/10.21608/ejar.2022.96759.1154

Sharma O., and Bambawale O., 2008, Integrated management of key diseases of cotton and rice, Journal of Agricultural Research, 1: 271-302.
https://doi.org/10.1007/978-1-4020-8571-0_14

Singh Y., Rao S., and Regar P., 2010, Deficit irrigation and nitrogen effects on seed cotton yield, water productivity and yield response factor in shallow soils of semi-arid environment, Agricultural Water Management, 97: 965-970.
https://doi.org/10.1016/J.AGWAT.2010.01.028

Wei Z., and Yu D., 2019, Rhizosphere fungal community structure succession of xinjiang continuously cropped cotton, Fungal Biology, 123(1): 42-50.
https://doi.org/10.1016/j.funbio.2018.11.007

Xi H., Shen J., Qu Z., Yang D., Liu S., Nie X., and Zhu L., 2019, Effects of long-term cotton continuous cropping on soil microbiome, Scientific Reports, 9: 1.
https://doi.org/10.1038/s41598-019-54771-1

Xu J., Wang X., Li Y., Zeng J., Wang G., Deng C., and Guo W., 2018, Host-induced gene silencing of a regulator of g protein signalling gene (VdRGS1) confers resistance to verticillium wilt in cotton, Plant Biotechnology Journal, 16: 1629 - 1643.
https://doi.org/10.1111/pbi.12900

Yuan Y., Feng H., Wang L., Li Z., Shi Y., Zhao L., Feng Z., and Zhu H., 2017, Potential of endophytic fungi isolated from cotton roots for biological control against verticillium wilt disease, PLoS ONE, 12: 57.
https://doi.org/10.1371/journal.pone.0170557

Disclaimer/Publisher's Note

The statements, opinions, and data contained in all publications are solely those of the individual authors and contributors and do not represent the views of the publishing house and/or its editors. The publisher and/or its editors disclaim all responsibility for any harm or damage to persons or property that may result from the application of ideas, methods, instructions, or products discussed in the content. Publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.