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How the Assam Tea Industry Copes with Fungal Infections: Setbacks and Prospects

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The tea industry is of immense importance to Assam, both economically and culturally. Assam is one of the largest tea-producing regions in the world, and the industry plays a vital role in the state's economy, society, and global reputation. The tea industry is a major contributor to Assam's economy. Assam tea accounts for a significant portion of India's tea production, and the region's tea estates are among the largest producers of black tea globally. In 2023, Assam contributed around 50-55% of India's total tea production. The industry provides direct and indirect employment to millions of people. According to estimates, over 1.5 million people are employed on Assam's tea plantations, including workers involved in tea plucking, processing, packaging, and marketing. The Assam tea industry is one of the largest and most important in the world, but it faces significant challenges due to fungal infections that affect tea crops. These fungal diseases, such as Blister Blight, Red Rust, and Leaf Spot, can cause severe damage to both the quality and yield of tea, posing a threat to the livelihood of tea producers and the global supply chain. This article explores the ways in which the Assam's tea industry has been coping with these fungal infections, including the application of chemical fungicides, integrated pest management (IPM), and research into disease-resistant tea varieties. It also examines the setbacks these solutions face, such as resistance development, environmental concerns, and labor shortages. Finally, the article highlights the prospects for the industry, including the potential for organic farming, innovative research in plant breeding, and greater adoption of sustainable practices that could mitigate the long-term impact of fungal diseases on Assam's tea production.

Key words: Integrated Pest Management, chemical fungicides, disease-resistant tea varieties

Introduction

Tea (*Camellia sinensis* [L] O. Kuntze) is a perennial, herbaceous, and dicotyledonous plant that belongs to the *Theaceae* family. It ranks second only to water in global consumption of non-alcoholic beverages. In India, commercial tea cultivation began around 1835 with the establishment of several gardens by two tea companies in Assam. Assam tea is renowned globally for its robust flavor and quality, making it a critical component of India's tea industry. Over the past fifty years, both the production and the area under tea cultivation have expanded significantly. However, one of the major threats to its production comes from fungal infections that have plagued tea plants for decades. Diseases like **Blister Blight**, caused by the fungus *Exobasidium vexans*, and **Red Rust Disease**, caused by *Dothichiza fagyrea*, have caused significant crop losses in the region. This article delves into how the Assam tea industry copes with these fungal infections and the challenges and opportunities that lie ahead.


Fig. 1, 2: **Pictures depicting tea plantations in Assam**

Tea diseases

Tea plantations are vulnerable to numerous fungal pathogens. Most of these fungi infect the leaves, stems, and roots of the plants, leading to a reduction in both the quantity and quality of the harvested tea. Blight (blister, gray, and brown), dieback, charcoal stem rot, root rot (brown and violet), and black rot are the major threat to tea sustainability.

Blister blight: Blister Blight is a major concern for tea growers, particularly in humid and rainy tea-growing regions like Assam. It is caused by the fungus *Exobasidium vexans***.** It is one of the most damaging diseases in tea plantations, the disease primarily targets the leaves of the tea plant but can also affect stems and buds, leading to considerable losses in both yield and quality of tea. The most distinctive symptom of Blister Blight is the formation of blister-shaped lesions on the upper side of the tea leaves. These lesions are initially pale green or yellow, later turning reddish-brown and eventually leading to the death of the affected areas. The infected leaves may become deformed, curled, or distorted. This hampers the normal photosynthetic process and reduces the plant's overall vigor.

The application of *Pseudomonas fluorescens* led to an increase in the production of several defense enzymes, including peroxidase, polyphenol oxidase, phenylalanine ammonia-lyase, chitinase, β-1,3-glucanase, and phenolics, which are essential for triggering systemic resistance in plants against diseases. Root-colonizing bacteria also promoted plant growth, seed emergence, and overall yield. Additionally, the use of plant growth-promoting rhizobacteria improved seed germination, drought resistance, shoot and root weight, vegetative growth, and crop yield. *P. fluorescens* enhanced the production of indole acetic acid, which supported the development of a strong root system. This bacterium also produces antibiotics, siderophores, and hydrogen cyanide, contributing to its biocontrol capabilities. Other beneficial microorganisms, such as *Trichoderma viride*, *T. harzianum*, *Bacillus subtilis*, and actinomycetes, have been identified as effective biocontrol agents for managing Blister Blight in field conditions in Northeast India.

Black rot: It is caused by fungal phytopathogen *Corticium theae* and *Corticium invisum*. The first signs of Black Rot are small, reddish-brown or orange spots that appear on the upper surface of the tea leaves. Over time, these spots enlarge and coalesce, leading to the formation of irregular-shaped lesions. The affected areas turn dark and leathery, eventually leading to the death of the leaf tissue. This reduces the plant's ability to photosynthesize effectively.

The use of *Bacillus subtilis* proved effective in controlling this pathogen during both its active and dormant phases. Regular applications every two weeks offered improved disease management. Additionally, hand plucking of tea leaves helps reduce the incidence of the disease.

Leaf blight: Leaf blight in tea is another significant disease, which is categorized into two forms: brown blight and gray blight. *Pestalotiopsis theae* , the fungus responsible for gray blight, is a widespread phytopathogen found in tea-growing regions worldwide. It exhibits endophytic behavior and is known to cause substantial crop losses globally. The primary symptom of Leaf Blight is the appearance of irregular, dark brown or black lesions on the tea leaves. These lesions often have a yellowish or chlorotic halo around them, which distinguishes them from other leaf diseases. T. viride (KBN-24) and T. harzianum (KBN-29 – accession number: ITCC-7764) were also found efficient in controlling P. theae in a laboratory study.

Stem diseases: Branch canker, caused by *P. hypobrunnea*, along with thorny blight induced by *Tunstallia aculeata*, are economically important diseases that affect tea plants in both flat and hilly regions of tea-producing states in India. Both pathogens typically enter the plants through wounds caused by intensive pruning activities, leading to infection. Applying Trichoderma to pruned cuts immediately after pruning is highly effective in controlling both diseases. For rejuvenation and medium pruning, a higher concentration of Trichoderma is recommended, while a lower concentration is suitable for light pruning. It has been observed that using a talc-based Trichoderma paste on pruned cuts, along with a soil application of 1 kg per bush, effectively manages stem diseases. Additionally, *T. harzianum* and *G. virens* have been used to combat collar canker in tea.

Red rust: Red rust in tea is caused by the fungus *Cephaleuros virescens*. This disease manifests as reddish-brown, rusty patches on the leaves, stems, and even on young shoots of the tea plant. The affected areas become covered with a rusty or powdery, orange-red fungal growth, which is visible on the upper surface of the leaves. Over time, these lesions can cause the leaves to dry out, leading to defoliation, reduced photosynthesis, and overall weakening of the plant. In severe cases, it can result in stunted growth and lower yields. Species of Azotobacter, Azospirillum, Bacillus, Pseudomonas, Streptomyces, Trichoderma, etc., protected the tea plantation from red rust under field conditions.

Root diseases: Charcoal stump rot and brown root rot are commonly found in the tea plantations of Assam. Tea bushes may show signs of wilting and stunted growth due to the fungus affecting the roots and base of the plant. The disease typically begins at the stump or root collar, where dark, sunken lesions appear. The roots become soft, decayed, and discolored, often appearing blackened or charcoal-like, which leads to the plant's inability to absorb nutrients and water. The genus *Trichoderma* has proven effective in managing these diseases. Applying this bioagent to planting pits and the excavated soil has been shown to be beneficial. Additionally, treating the collar region of young tea plants with *Trichoderma* has been found to be highly effective in controlling the diseases.

Setbacks faced by the industry

1. **Increased Dependency on Chemical Fungicides:** While chemical fungicides offer a quick solution to fungal infections, their overuse has led to resistance development in some fungal strains. This has prompted tea growers to use even more aggressive treatments, which can harm the environment and increase production costs. Moreover, chemical treatments may leave harmful residues on the leaves, potentially reducing the appeal of Assam tea in export markets where organic certifications are valued.

2. **Climate Change and Favorable Conditions for Fungal Growth:** The changing climate patterns in Assam, including more frequent rainfall and higher humidity, have created conditions that are more conducive to the spread of fungal diseases. Warmer temperatures and increased precipitation allow fungi to thrive, leading to outbreaks of diseases like root rot and blight.
3. **Lack of Awareness and Technical Expertise:** Many tea farmers in Assam may not be fully aware of integrated pest management (IPM) strategies or the latest developments in fungal disease control. This lack of awareness, combined with a lack of technical expertise in sustainable farming practices, contributes to the ineffective management of fungal infections.
4. **Financial Constraints:** The high cost of acquiring and applying biological control agents or other alternative methods of disease management is often beyond the reach of small-scale tea farmers. Consequently, many continue to rely on chemical solutions, which, as previously mentioned, may have long-term environmental and health consequences.

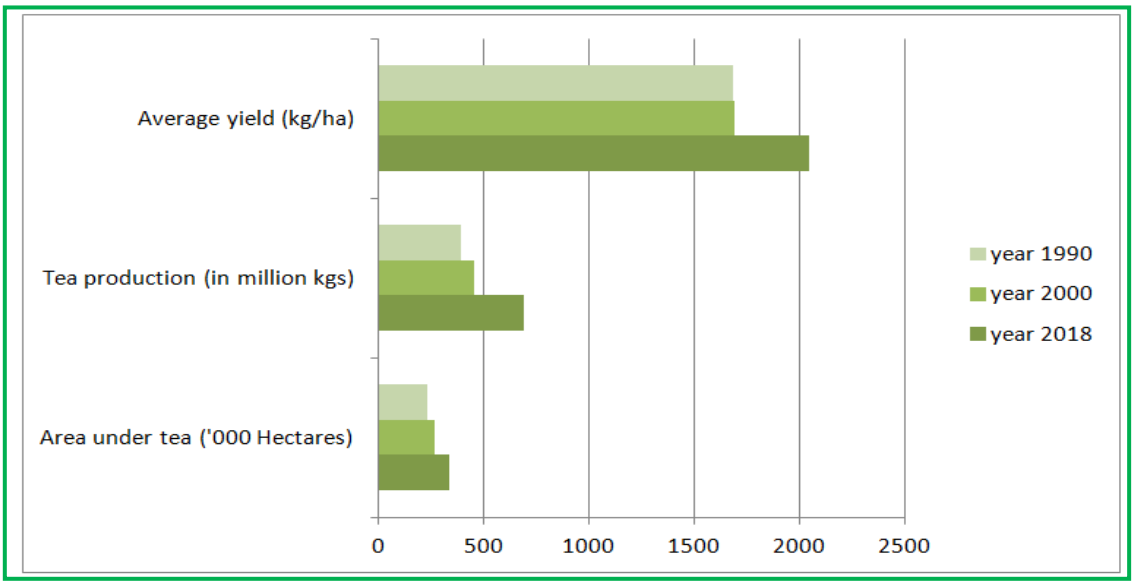

Fig. 3: Graph depicting transformational changes in Assam Tea Sector

Prospects for Overcoming Fungal Infections

Despite the challenges, the Assam tea industry is gradually moving towards more sustainable methods for controlling fungal infections. Several promising strategies and prospects for future growth are emerging:

1. **Adoption of Biological Control:** Biological control, the use of natural predators, antagonists, or microbial agents to control fungal pathogens, is gaining traction in Assam. The genus *Trichoderma*, for example, has shown great potential in managing root and stump rot diseases. By applying *Trichoderma* to pruned cuts and planting pits, tea growers can suppress fungal growth without resorting to harmful chemicals. Additionally, the use of beneficial microorganisms like *Bacillus* spp. and *Pseudomonas* spp. has been explored as part of an integrated approach to disease management.
2. **Integrated Pest Management (IPM):** IPM combines cultural, biological, and chemical control methods to manage fungal diseases in a more sustainable manner. Practices such as crop rotation, proper sanitation, and the use of resistant tea varieties can help minimize fungal outbreaks. IPM encourages a more holistic approach that reduces the reliance on chemical treatments, thus promoting environmentally friendly practices.
3. **Use of Resistant Tea Varieties:** Research into developing or identifying tea varieties resistant to specific fungal diseases is underway. By breeding or selecting varieties that

exhibit natural resistance to fungal pathogens, tea plantations can reduce the incidence of diseases such as root rot and blight, decreasing the need for costly treatments.

4. **Climate-Smart Agriculture:** Given the role of climate change in exacerbating fungal infections, adopting climate-smart agriculture practices is critical. These may include optimizing irrigation systems, managing waterlogging, and adjusting planting schedules to avoid peak disease periods. Enhancing the resilience of tea plants through these methods can reduce vulnerability to fungal infections.
5. **Farmer Education and Capacity Building:** Educating tea farmers on the benefits of biological control and integrated pest management can lead to greater adoption of sustainable practices. Extension services, workshops, and partnerships with agricultural research institutions can empower farmers with the knowledge and skills needed to tackle fungal infections more effectively.
6. **Government Support and Policy Advocacy:** Government initiatives to support sustainable tea farming practices, including subsidies for the purchase of biofungicides or training programs, can provide much-needed assistance to tea growers. Additionally, policies that encourage research into disease-resistant tea varieties and climate adaptation measures will help the industry cope with the growing threat of fungal infections.

Conclusion

The Assam tea industry, with its rich heritage and global reputation, faces significant challenges in managing fungal infections. However, through a combination of sustainable agricultural practices, research-driven innovations, and greater awareness, the industry can overcome these setbacks. Biological control methods, integrated pest management, climate-smart practices, and farmer education offer promising prospects for the future, enabling Assam's tea plantations to thrive in the face of fungal diseases. As the industry moves towards more sustainable and environmentally conscious approaches, it can continue to produce high-quality tea that meets both consumer demand and ecological standards.

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