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Integrated Disease Management in Tea Cultivation: Leveraging Beneficial Microorganisms for Sustainable Production

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Tea (*Camellia spp*.) is one of the most economically important plantation crops and the second-largest non-alcoholic beverage in the world next to water being consumed by people in different forms. It is cultivated mainly in Assam, West Bengal covering the regions such as Darjeeling, Dooars, Terai, and South India in about 6.36 lakh hectares with a production of about 1338 million Kg made teas. Darjeeling tea is world famous for its specific aroma and flavor whereas Assam is known for premier CTC teas

Tea Diseases

Tea plantations are subjected to attack by hundreds of fungal pathogens. Majority of these infect plant leaf, stem, and root, which ultimately decreases the quantity and quality of made tea. Several diseases are prevalent in the North, North East, and South India. The thorny blight of stem, charcoal stump rot, brown root rot, and blister blight diseases are more prevalent in Darjeeling. Phytopathogens such as *Fusarium solani*, *Cephaleuros spp*., *Corticium spp*., *Poria hypobrunnea*, *Ustulina zonata*, and *Fomes lamaoensis* are important to cause immense losses in terms of yield and quality.

Chemical fungicides are much more effective, however, there are certain problems associated with their frequent use such as environmental pollution, health hazards, phytotoxicity, development of resistance, resurgence, and residues in made tea and hence; such fungicides are not permitted in organic tea crop production. Under such a perspective, usage of certain fungi, bacteria, and viruses could be safer and ideal components of integrated disease management (IDM) for production sustainability. This review focused on the management of major tea diseases through the application of microorganisms.

Blister blight (Causal organism: *Exobasidium vexans*)

Exobasidium vexans Massee is responsible for this disease and it can be classified systematically under Subdivision –Basidiomycotina, Order – Exobasidiales, and Family – Exobasidiaceae. Blister blight is one of the most economically important foliar diseases that have emerged as a threat to the tea industry affecting its production and quality in terms of export.

- ❖ Beneficial microorganisms such as *Trichoderma harzianum, Gliocladium virens*, Serratia marcescens, *Pseudomonas fluorescens*, and *Bacillus subtilis* could effectively manage this disease
- ❖ *Pseudomonas fluorescens* increased indole acetic acid production that helped in the development of a good root system. This bacterium produces antibiotics, siderophores, and hydrogen cyanide playing role in biocontrol activities. *T. viride*, *T. harzianum*,
- ❖ *B. subtilis*, and actinomycetes are reported as potential microbes for the control of blister blight under field conditions in North East India. B. subtilis is a successful microbial candidate for the management of certain tea diseases. Antagonist Trichoderma is efficient in controlling certain stem as well as soil-borne root diseases. The isolates of actinomycetes showed an encouraging response toward the control of tea plantation diseases. The spray of Ochrobactrum anthropi strain BMO-111 controlled the blister blight and improved the chlorophyll, polyphenols, and catechins content in the pluckable tea shoots

Blister Blight

Black Rot

Leaf Blight

Red Rust Leaf

Black rot (Causal organism: *Corticium theae and Corticium invisum*)

It is caused by fungal phytopathogen *Corticium theae* and *Corticium invisum*. The pathogens infect the older foliage leading to the steady tea bush health wear and tear which ultimately results in crop yield loss. The sclerotia of fungus germinate in March and April and infect the plantation from May to July. The active stage of the phytopathogenic fungus may last up to September in the field. The overwintering of fungal sclerotia takes place in the stem of tea bushes generally in its cracks and crevices during unfavorable conditions. Such sclerotia again germinate with the advent of favorable environmental conditions and start the fresh infection on the tea bushes. Its seasonal incidence and disease progress occur under the existing weather factors of Darjeeling.

- ❖ Application of *B. subtilis* was effective against this pathogen during both active and dormant phases. Its repetitive application at fortnightly intervals provided better disease control. The hand plucking of tea leaves helps in reducing the disease incidence.

Leaf blight (Causal organism: *Pestalotiopsis theae*)

Leaf blight of tea is yet another important disease that is classified into two types, namely, brown and gray blight. *Pestalotiopsis theae*, causing gray blight, is a fungal phytopathogen of global occurrence in tea cultivating areas which has endophytic behavior and is responsible for huge crop losses around the globe

- ❖ Trichoderma isolates reduced the growth of *Glomerella cingulata* significantly, and therefore, it is suitable to include in the IDM strategies for controlling brown blight disease

Stem Diseases

Branch canker caused by *P. hypobrunnea* as well as thorny blight incited by *Tunstallia aculeata* is also of economic significance, infecting the tea bushes in plain and hilly regions of tea growing Indian states. Both pathogens enter through cuts that occurred on the bushes due to the commencement of heavy pruning operations and infect the plant. Therefore, to protect from disease, proper care of fresh pruning cuts is of primary significance, it may be achieved through the application of suitable microbes.

- ❖ Immediately after pruning operation, the application of Trichoderma on the pruned cuts is quite effective in managing both diseases. In the case of rejuvenation and medium pruning, its higher concentration is helpful while in the case of light pruning, its lower concentration is applicable. It was noted that the application of the paste of Talc based Trichoderma formulation on pruned cuts and its soil application at 1 kg/bush was found effective in managing stem diseases *T. harzianum* and G. virens were used against collar canker of tea.

Red rust (Causal organism: *Cephaleuros parasiticus* (Stem) and *Cephaleuros mycoides* (Leaf)

Alga, *Cephaleuros parasiticus*, is the primary causative agent of red rust. In general, the disease infects the young stems of tea bushes. Eventually, the symptoms of the disease appear on leaves. It is comparatively more harmful to young tea plants. The pathogen destroys the stem tissues in patches which ultimately turn into dieback. The appearance of variegation with yellow patches on the leaves of the infected branches is the characteristic feature of this disease. Symptoms of the disease appear as small translucent water soaking spots on leaves. On the upper surface, the spot becomes purple-red, then black with a purple margin. On the under surface, it is purple-red becoming gray-brown with the advancement of time. If it attacks the petiole at its junction with the stem, the leaf falls and its sporangia are spread by wind or rain.

- ❖ Species of Azotobacter, Azospirillum, Bacillus, Pseudomonas, Streptomyces, Trichoderma, etc., protected the tea plantation from red rust under field conditions

Conclusion

Tea is one of the most commonly consumed non-alcoholic beverages in the world after water. Its cultivation encounters the challenges of various diseases. Although these diseases could be controlled by various fungicides, from the health point of view, usage of chemical fungicides is not advisable in tea crop production. Under such circumstances, the IDM approach is the best way to have healthy tea production. Disease resistant or tolerant genotypes, the use of beneficial microbes for the management of diseases, are the components of IDM, which is a vital, economic, Eco friendly viable, and long-lasting successful strategy. To find out resistant/ tolerant tea genotypes, the development of a “disease screening nursery” is of prime need for its sustainability. For the biological control of diseases, local strains of beneficial microbes should be explored followed by their evaluation and commercialization. Disease progress depending on weather factors should be undertaken to realize the role of these factors in the initiation and development of economically important diseases.

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