Agritech, March, 2026, Vol.3(1): 7-9

Nature's Shield: Biocontrol Solutions for Managing Taro Leaf Blight

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Taro (*Colocasia esculenta* (L) Schott), a starchy tuber crop which belongs to Araceae family is an important staple or subsistence crop for millions of people in developing countries. It has substantial cultural, economic, and nutritional value in many parts of the world, especially Asia, the Pacific Islands, and Africa. Taro continues to be an essential part of regional cuisines, religious rituals, and customs due to its long history of consumption. The crop's high nutritional value, adaptability to different agroecological settings, and resistance to adverse environmental factors are the main reasons for its appeal. However, a variety of biotic and abiotic factors pose significant obstacles to taro farming, with illnesses being a major factor in yield losses. The crop capitulates to several fungal, bacterial, and viral diseases as well as some diseases of uncertain etiology. Major among them is *Phytophthora colocasiae* Rac., primarily a foliar pathogen, which affects taro and causes taro leaf blight disease. The disease is associated with 90% and 50% loss in leaf and corm yield of taro, respectively. Taro leaf blight disease appears as small spots initially and then it gets enlarged in its circumference and spreads to other healthy parts. Under cloudy weather conditions with intermittent rains and temperature around 280C, disease spreads fast and the entire field gives a blighted appearance. Reduction in corm yield of 25 to 50% has been reported in the Pacific and 25 to 35% in Philippines. Losses may be greater among highly susceptible cultivars. In Hawaii, leaf yield loss of 95% was reported in susceptible varieties.

Growing risks of conventional chemical control

Managing taro leaf blight caused by *Phytophthora colocasiae* is a challenging task that requires an integrated and sustainable approach. Traditionally, chemical fungicides such as metalaxyl and phosphonates have been used to control the disease, as they can effectively suppress the pathogen and provide quick relief under severe infection. However, excessive and repeated use of these chemicals poses serious concerns, including the development of fungicide-resistant pathogen strains, environmental pollution, and negative effects on non-target organisms such as beneficial microbes, insects, and aquatic life. Fungicide runoff can contaminate soil and water bodies, posing risks to ecosystems and human health, which makes chemical control an unsustainable long-term solution. Owing to these drawbacks, chemical methods are often considered a last resort and must be applied cautiously following recommended doses and intervals.

Healthy taro plant (left); Taro leaf infected with *P.colocasiae* (centre and right)

The biological transition: Embracing nature-based solutions

Biocontrol management plays a crucial role in taro leaf blight control by offering an environmentally safe, ecologically balanced, and sustainable alternative. Bio-control strategies rely on beneficial microorganisms and naturally occurring antagonists like Trichoderma, Pseudomonas, and Bacillus species that suppress the pathogen, compete for resources, and stimulate the plant's own defence mechanisms, thereby reducing disease severity over time. Biopesticides derived from natural compounds, including chitosan and plant extracts, further strengthen plant resistance while reducing pathogen activity. Beyond just replacing chemicals, biocontrol agents offer a more complete solution by improving soil microbial diversity and enhancing plant vigor, which supports long-term disease suppression without leaving harmful residues or disrupting the ecological balance. Therefore, adopting biocontrol-based strategies is crucial for sustainable taro

cultivation, ensuring environmental safety, crop health, and improved productivity.

The transition from chemical-based disease control to biologically driven systems require a clear understanding of how natural agents function and how they can be effectively deployed. Current research highlights two major non-chemical strategies for controlling *Phytophthora colocasiae*: the application of bioactive plant-derived compounds and the use of antagonistic microorganisms as biocontrol agents.

Botanical interventions: Essential oils and plant extracts

Botanical extracts and essential oils represent a promising alternative to systemic fungicides such as metalaxyl, primarily because of their complex chemical composition, which reduces the likelihood of rapid pathogen adaptation. These plant-derived compounds exhibit antifungal activity through both vapour-phase and direct contact mechanisms, effectively inhibiting pathogen growth. Essential oils such as *Eucalyptus globulus* have been extensively evaluated under laboratory conditions. Similarly, *Cinnamomum verum* (cinnamon) oil has shown dual functionality, serving as both a foliar protectant and a corm treatment. Its application at concentrations between 0.156 and 5.0 mg/ml has proven effective in reducing pathogen establishment on aerial and underground plant parts. Recent studies have expanded the range of effective botanical agents, identifying sage and tea tree oils as efficient foliar applications at doses of 2.5 to 5.0 mg/ml. In addition, extracts from *Citrus aurantifolia* (lime) and *Zingiber officinale* (ginger) have exhibited significant antifungal activity, with effective concentrations reported at 1000 ppm and 1250 ppm, respectively. Collectively, these findings underscore the potential of botanical interventions as environmentally safe tools that can be integrated into broader disease management programs.

Microbial antagonists: Biological control agents

Microbial bio-control strategies rely on the introduction of beneficial fungi and bacteria that act as natural antagonists to *P. colocasiae*. Unlike chemical fungicides, these organisms not only suppress the pathogen but also enhance soil health, promote plant growth, and strengthen host defense responses, thereby contributing to long-term disease suppression.

A. Fungal antagonists: Trichoderma species

Among fungal bio-control agents, Trichoderma species are the most extensively studied due to their ability to parasitize pathogenic fungi, compete for nutrients, and produce antifungal metabolites. Their effectiveness has been demonstrated across laboratory, green house, and field conditions. Corm treatment with *Trichoderma viride* at a rate of 4 g/kg has been shown to provide effective protection during the early stages of plant establishment. Additionally, specialized strains such as *Trichoderma* strain TR7 (Whose), applied at concentrations of 2×103 spores/ml, and *T. harzianum* conidial suspensions (100 ml) have been successfully used for leaf-dipping and soil application to suppress pathogen spread under greenhouse conditions. Recent studies also highlighted the potential of *T. asperellum* when applied at higher concentrations (2–8 mg/ml), offer broad-spectrum protection against foliar infection.

B. Bacterial antagonists: Pseudomonas and Rhizobacteria

Beneficial bacterial species provide an alternative mode of bio-control for taro leaf blight by producing antimicrobial compounds, competing with the pathogen *P. colocasiae* for ecological niches, and inducing systemic resistance in the taro plant. *Rhizobacteria* play a crucial role in protecting the root zone and improving overall plant health. The *Rhizobacterial* strain S1B3 has demonstrated high efficacy when applied through a combined approach involving corm treatment, soil application, and foliar spray at a dosage of 10 g per plant. Similarly, *Pseudomonas fluorescens* has been widely reported as an effective bio-control agent against TLB; applications at concentrations of 109cfu/ml suspension via soil drenching and corm treatment have resulted in substantial reductions in both root and foliar infections. Emerging bacterial candidates, including *Serratia plymuthica* and *Serratia rubidaea*, have also shown promise, particularly as corm treatments when applied as bacterial suspensions at 2×104 cfu/ml.

Conclusion

The integration of botanical extracts and microbial antagonists represents a robust and sustainable strategy for managing taro leaf blight. Rather than replacing chemical control entirely, biological approaches can significantly reduce chemical dependence when incorporated into integrated disease management frameworks. Future research should focus on field-level validation, formulation development, and the combined use of compatible bio-control agents to enhance consistency and effectiveness under diverse agroclimatic conditions.

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