Bioremediation of Pathogen-Infested Soils: The Case of Greenhouse Tomatoes

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Abstract

Problem Definition: Crown and root rot of tomatoes is a widespread disease complex and the main limiting factor for tomato greenhouse production in Bulgaria and beyond. Besides the dominant pathogen, *Fusarium oxysporum* f.sp. *radicis-lycopersici*, the aetiology of the disease involves other soilborne fungi, including *Colletotrichum coccodes*, *Pyrenochaeta lycopersici*, *Rhizoctonia solani*, and *Sclerotinia sclerotiorum*, as well as fungal-like *Phytophthora* spp. and *Pythium* spp. The build-up of these pathogens is associated with decline in soil productivity to the extent that tomato cultivation in greenhouses or elsewhere becomes no longer viable. The pathogens co-exist and persist in soils for extended periods and are difficult to eradicate through conventional or reductionist control strategies.
Remediation Objective: For the bioremediation ("healing") of heavily infested soils, a holistic systems approach that targets the entire consortium of soilborne pathogens is required in order to effectively restore and maintain soil health and economic productivity.
Integrated Remediation Concept: The objective of this bioremediation technology can be achieved through the implementation of an integrated approach, grounded on economically and ecologically sustainable plant disease management strategies. The technological package consists of three core components – stages of intervention – with synergistic and cumulative effects, as follows:

- Off-season reduction of the inoculum potential of the pathogens-infested soil
- Pre-crop enhancement of natural soil suppressiveness against pathogenic communities and their associated diseases
- On-season protection of infection courts by bio-augmentation of the root zone of cultivated plants with consortium of biocontrol microorganisms.

Empirical Approach: The integrated bioremediation technology outlined here is built in four phases: (1) Site assessment and baseline analysis to identify considerable disease conditions; (2) Selectively killing or weakening soil-borne plant pathogens and pests through the application of non-chemical, environmentally benign disinfestation techniques**,** including: thermal-assisted soil solarization, biosolarization or anaerobic soil disinfestation, soil inundation, cover crops, green manuring and biofumigation; (3) Enhancing general or specific soil disease suppressiveness. This phase involves pre-plant application of highly suppressive organic amendments, incorporation of aboveground forest floor (O soil horizon) biomass, addition of river silt sediments, use of inorganic amendments, and bio-augmentation with specific biocontrol agents, e.g. consortium of antagonistic *Trichoderma* spp., with the purpose of inducing reversible shifts in soil microbial community towards creating highly competitive biological environment, enhanced microbial diversity and activity; (4) On-season protecting the infection courts – bio-augmentation of the root zone of cultivated plants with specific consortium of antagonistic fungi (***Trichoderma* ssp**. based biopesticide).
Sustainability, Conclusions and Perspectives: The present integrated bioremediation technology is grounded in extensive empirical evidence, validated through over 120 individual

experiments and series of experiments. It represents a comprehensive strategy for biologically-based remediation of greenhouse soils affected by soil-borne fungal pathogens in tomato production. The conceptual framework provided here offers a solid foundation for implementation and adaptation to other pathosystems, crop plants and consortia of soil-inhabiting pathogenic organisms.

Key words: consortium of soil-borne plant pathogens, disease complex, greenhouse tomatoes, biologically-based remediation strategy, integrated empirical approach.