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Insights into the Mechanobiology of Phytophthora

J. Harish*, Chethan D, N Vamsidharreddy, Karan R, N Karunakarreddy, Vineeth M, Arif

Department of Plant Pathology, University of Agricultural sciences, India

***Corresponding author:** Harish J, Department of Plant Pathology, University of Agricultural sciences, Bengaluru, Karnataka, 560065, India, Tel: (+91) 8660799656; Email: harishbpl5021@

Editorial

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Abbreviations: CWP: Cell Wall Porosity; PM: Plasma Membrane.

Introduction

Phytophthora species, classified as oomycetes, are among the most destructive plant pathogens worldwide and pose a substantial threat to food security. Plant pathogens have developed various methods to breach the cuticle and walls of plant cells. For example, plant-pathogenic fungi use a 'brute-force' approach by producing a specialized and fortified invasion organ to generate invasive pressures [1]. Unlike in fungi, Phytophthora pathogens harness a specialized form of invasive tip growth to slice through the plant surface, wielding their hypha as a microscopic knife known as "naifu" invasion [2].

Bronkhorst, et al. [2] employed a combination of techniques, including surface-deformation imaging, molecular-fracture sensors and modeling, to uncover how *Phytophthora infestans*, *P. palmivora*, and *P. capsici* infiltrate host tissues by slicing through the plant surface. Phytophthora uses different method of entry compared to the most aggressive strategy employed by fungi that utilize appressoria. It relies on the generation of polarized forces directed obliquely onto the surface, resulting in the concentration of stresses at the invasion site, facilitating surface penetration. It leverages actin-mediated polarity, surface adhesion, and turgor generation to enable pathogen to invade host plants without the need for specialized organs or extensive turgor generation.

Michels, et al. [3] introduces two fluorescent molecular sensors, CWP-BDP and NR12S, designed to unveil the micromechanical behavior of the cell wall-plasma membrane continuum in *P. infestans* during its invasive growth and in response to chemical treatment. Through live-cell imaging, CWP-BDP provides insights into changes in cell wall porosity (CW), while NR12S sheds light on variations in chemical polarity and lipid organization within the plasma membrane (PM). Observed distinct and localized alterations in the CW structure as a result of mechanical interactions between the pathogen and a surface.

Furthermore, these molecular sensors are capable of revealing the impact of chemical treatments on both the CW and PM, thus pinpointing the specific site of action of crop protection agents.

The destructive Phytophthora pathogens employ a specialized form of invasive tip growth to cut through the plant's surface, employing their hyphae as microscopic knives. Successful slicing necessitates a sharp hyphal tip that remains unblunted at the point of mechanical interaction. An actin-based mechanostat in Phytophthora infestans that regulates tip sharpness during the penetration process. When the hyphae are mechanically stimulated, an aster-like actin arrangement emerges, providing rapid, localized, and quantitative feedback to the surrounding stress. This actin configuration functions as an adaptive mechanical framework, sharpening the invasive tool and preventing it from becoming dull. The hyphal tip mechanostat facilitates the efficient conversion of turgor pressure into localized invasive forces necessary for successful host penetration [2].

This mechanically induced remodeling of Actin cytoskeleton coincides with the sudden sharpening of the hyphal tip at the first stimulus and the maintenance of tip sharpness as the force on the organism grows during host entry. Demonstrating the potential inhibition of Phytophthora invasion through cytoskeletal disruption or the obstruction of adhesion provides valuable insights that may pave the way for the discovery of novel targets in the quest for more efficient control strategies.

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