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Biocontrol of *Fusarium Oxysporum* Using Endophyte -Mediated Resistance

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Abstract

Interactions between plants and the root-colonizing fungus *Fusarium oxysporum* (Fo) can be neutral, beneficial, or detrimental for the host. Fo is infamous for its ability to cause wilt, root and foot rot in many plant species, including many economically important crops. However, Fo also has another face; as a root endophyte, it can reduce disease caused by vascular pathogens such as *Verticillium dahliae* and pathogenic Fo strains.

Keywords- *Fusarium oxysporum*, *Verticillium dahlia,* Endophytes

Introduction

Fo endophytes such as Fo47 and CS-20 differ from Fo pathogens in their effector gene content, host colonization mechanism, location in the plant, and induced host-responses. The lower number of effector genes in endophytes as compared to pathogens provide a means to distinguish them from each other. Co-inoculation of a biocontrol-conferring Fo and a pathogenic Fo strain on tomato reduces disease and has surprisingly little effect on the xylem sap proteome composition. The Fo-induced resistance response in tomato appears to be distinct from induced systemic resistance (ISR) or systemic acquired resistance (SAR), as the phytohormones jasmonate, ethylene, and salicylic acid are not involved (Constantin *et al*., 2019).

Plant xylem colonization is the hallmark of vascular wilt diseases caused by phytopathogenic *Fusarium oxysporum* species complex. Recently, xylem colonization has also been reported among endophytic *F. oxysporum* strains. The study compared xylem colonization processes by pathogenic versus endophytic strains in *Arabidopsis thaliana* and *Solanum lycopersicum*, using Arabidopsis pathogen Fo5176, tomato pathogen Fol4287, and the endophyte Fo47, which can colonize both plant hosts. The shared progression of colonization was restricted to lateral roots and the elongation zone of the primary root. Only pathogens reached the xylem above the primary-root maturation zone (PMZ). Stronger induction of callose at the PMZ and lignin deposition at primary-lateral root junctions by the endophyte in both plants were also observed. Moreover, both pathogens encode more plant cell wall–degrading enzymes than Fo47 (Martínez-Soto *et al*., 2023).

The timing and amplitude of root responses upon colonization by endophytic or pathogenic *F. Oxysporum* differ

Generally, a very varied soil microbiota is exposed to plant roots. Plants use molecular patterns linked with microbes to identify microorganisms. (MAMPs) found in infections as well as nonpathogens and ß-glucan are two well-known fungus MAMPs. Pattern recognition receptors (PRRs) on the cell surface, like the CERK1 chitin receptor of Arabidopsis, mediate MAMP recognition. PRRs are mainly expressed in root zones vulnerable to pathogen entry resulting in a heterogenic and tissue-specific responsiveness to different MAMPs. Responsiveness to chitin, for instance, is mostly confined to the mature zone and other parts of the root system are relatively insensitive to this MAMP and do not mount immune responses upon exposure to chitin.

Host Colonization

Upon germination, both Fo endophytes and pathogens colonize the root surfaces of host and non-host plants. Contact with the root triggers hyphal branching, after which Fo produces hyphal swellings to invade the root. The fungal hyphae enter plant roots via wounds, cracks in the epidermis, lateral root emergence points, or by direct penetration of the root tip depending on the Fo strain and plant species involved. Hyphae reach the vascular stele via the apoplast of the root cortex. In some cases, intracellular growth is noticeable along with local host cell-death, a phenomenon observed more often among

nonpathogenic strains. Both pathogenic and non-pathogenic strains colonize the root cortex, but although the initial colonization pattern is similar, the extent and pattern of colonization differs during later stages. The amount of biomass of a pathogenic strain in the root is typically higher than that of an endophyte. This difference is already apparent at early stages.

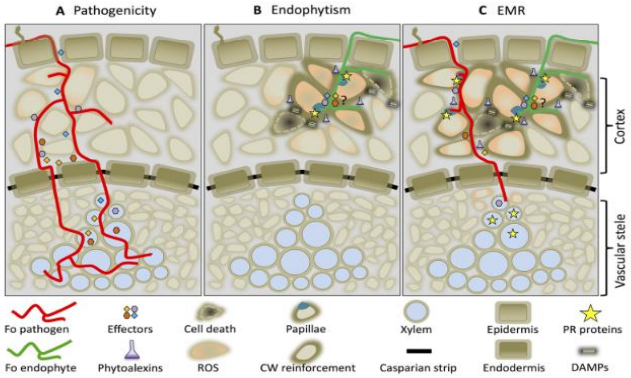

Fig 1- Endophyte-mediated resistance (EMR) working model. Cross-section of a root colonized by a Fo pathogen (red line) (A), an endophyte (green line) (B), or by both in a tri-partite interaction in which EMR is triggered (C). The drawings depict an interaction around 2 days after inoculation.

At 48 h post-inoculation (hpi) higher amounts of fungal biomass for the Fo40 pathogen were detected in roots of soybean plants than for the endophytic Fo36. A similar difference was reported for other systems, like the interaction between tomato and Fo47 or Forl. Two weeks post-inoculation Fo47 biomass was 10-fold less than that of the pathogen. These observations imply that in early stages of the interaction Fo endophytes are less efficient root colonizers than pathogens.

EMR involves localized cell death and accumulation of specific pr proteins in the xylem sap

Root colonization by Fo endophytes reduces wilt disease symptoms caused by pathogenic Fo strains but mechanism of endophyte-mediated resistance (EMR) against fusarium wilt is unclear. The colonization of non-pathogenic Fo47 and pathogenic Fo f.sp. *lycopersici* (Fol) strains were assessed in tomato roots and stems upon single and co- inoculation and followed by quantitative PCR of fungal colonized roots revealing that pathogen colonization was drastically reduced in both cultivated and non-cultivated tomato species. Endophytic colonization of tomato roots remained unchanged upon co-inoculation with Fol whereas in stems more extensive colonization was observed indicating that the endophyte may take advantage of the pathogen-induced suppression of plant defences (Constantin *et al*., 2020).

The root colonization pattern of f. Oxysporum pathogens differs from that of endophytes

Fo spores or hyphae that develop close to a root mark the beginning of the colonization process. Pathogenic fungi's chlamydospores germinate when sugar is added to the soil. According to Constantin., and *Fo f.sp. basilici*. Since exudates from many crops promote the germination of microconidia of *Fol and Fo f.sp. radicis-lycopersici* (Forl) pathogens, it is likely that root exudates in natural environments supply these carbohydrates. Since Fo uses autocrine pheromone signaling to govern germination in a conidial density dependent manner, hyphal exudations may also be involved in conidia germination. Certain root infections use chemotropism to grow toward roots efficiently.

Conclusion

Non-pathogenic *F. oxysporum* isolates are indeed a prospective group of endophytic fungi having potential antagonistic nature and disease suppressive ability in host plants. However, future research is highly essential to investigate the genes and the pathways involved in EMR as a result of their association and the possibility of conversion to pathogenic forms for their better utilization in disease management programme (de Lamo *et al*., 2020).

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