Title

Feronia: A Malectin-Like Domain-Containing Receptor Kinase in Arabidopsis Thalina

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Abstract

RAC/ROPs are a unique group of RAS-related monomeric G proteins (small G proteins) that constitute the sole family of Rho GTPases in plants. RAC/ROPs, like their counterpart Rho GTPases from mammalian and fungal systems, can interconvert between an active GTP and an inactive GDP bound state. These powerful signaling molecules lie upstream in many diverse signal transduction pathways. Their controlled regulation is critical to overall plant fitness, growth, development, and responses to abiotic and biotic stress. RAC/ROP activation is regulated by guanine nucleotide exchange factors (GEFs). The work in this dissertation initiated from the characterization of the expression and functions of RopGEF1, a broadly expressed GEF that localizes to the sites of root hair formation and regulates polarized cell growth. The focus of this dissertation is on FERONIA (FER), an upstream regulator of RopGEF1 that was initially identified as a RopGEF1 interacting protein in a yeast two-hybrid screen. FERONIA (FER) was found to regulate RAC/ROP-mediated signal transduction for auxin-regulated root hair growth and a number of other auxin-dependent responses, consistent with RAC/ROPs playing an important role in auxin signaling.

In flowering plants, pollen tubes deliver sperm to fertilize the female gametophytes located inside the ovules. Once a pollen tube enters it subsequently bursts releasing its sperm, which enables fertilization. Mechanisms are in place to coordinate tube rupture as well as repel late arriving pollen tubes from an already visited ovule. In this way not yet visited ovules have higher chances of fertilization and fertilized ovules avoid polyspermy. In this work, FER is demonstrated to mediate NADPH oxidase-dependent reactive oxygen species production required for pollen tube rupture. In addition, FER is also required for de-esterified pectin deposition outside the female gametophyte, which correlates with the ability of ovules to divert late arriving pollen tubes. Furthermore, the extracellular domain of FER, which contains predicted carbohydrate-binding malectin-like domains, interacts directly with pectin. This finding establishes FER as a cell wall-binding receptor kinase in plants and illuminates unprecedented mechanisms of pollen tube reception.

The presence of carbohydrate binding motifs in the extracellular domain of FER and its direct interaction with pectin prompted my investigation of its role in sugar sensing and signaling pathways. My work shows that*feronia* (*fer*) mutants are hypersensitive to sucrose, while over-expressing FER suppresses sugar signaling. Moreover, *fer* mutants accumulate elevated levels of starch, which demonstrates defects in their distribution of carbohydrate resources in source (sugar producing) and sink (sugar consuming) tissues. The *fer* mutants also display sucrose-induced cell wall defects, alterations to cellular morphology, and enhanced production of the stress-associated pigment, anthocyanin. These results suggest that FER functions as a negative regulator of sugar sensing and signaling pathways. Additional support for this model stems from the finding that FER is highly expressed in tissues involved in sucrose transport and its expression is stimulated by sucrose. Furthermore, and consistent with the hormone abscisic acid being part of the overall sugar sensing network, *fer*mutant seedlings are hypersensitive to ABA and display enhanced ABA response gene expression. Taken together, the data presented in this dissertation reveal the regulation of widespread and essential plant functions including RAC/ROP signaling, pollen tube reception, cell wall integrity, and sugar signaling by a single cell surface receptor kinase.

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