

Exploring the Role of Wall Associated Receptor like Kinases (Waks) During Plant-Fungal Mutual Interaction

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Abstract

Plants possess the capability to perceive effector molecules released from microbes which is recognized by receptors which in turn triggers the defense system. Wall-associated receptor-like kinase (WAKs) belong to plant receptor-like protein kinases (RLKs) family which regulate the signaling cascades encompassing plant immune system and development by forming protein complexes with cell wall components and receptors. In this review, we provide the perspective that WAKs might play a critical role in signaling event involving endophytic colonization in host plant.

Keywords: Wall-associated receptor-like kinase; *Piriformospora indica*; Basal defense

Mini Review

Plants respond to a large number of external and endogenous stimuli, which are translated into cellular responses that enable their adaptation to changing environmental conditions. Most of the land plants including crop plants are involved in beneficial symbiotic or parasitic interactions with a range of micro-organisms, which has a strong impact on agriculture and forestry. Fungi interact with plants as pathogens or benefactors. The cellular and molecular responses of plants to microbe interaction have been studied extensively [1-3].

Receptor protein kinases (RPKs) are key molecules in animal cell interactions and signal recognition. Many plant receptor-like protein kinases (RLKs) have been identified by both molecular and genetic approaches. In contrast to animals, where most RPKs are tyrosine kinases, plants RLKs are ser-thr kinases. Wall-associated receptor-like kinase (WAKs) are reported to have important roles in cell expansion, heavy-metal stress tolerance and pathogenic bacteria resistance in the plants [4-7]. This is also documented that protein kinases involved in maintaining plant-specific cytoskeleton-cell wall continuum [8], osmotic stress signaling [9], integrating environmental stimuli into a cellular response mediated by H₂O₂ to effect stomatal closure [10]. These evidences suggest that these WAK protein kinase might play a role in fungal invasion inside the root cortex by regulating cell wall-cytoskeleton interface, priming defense/immune system of plant thereby conferring resistance against pathogen and abiotic stresses and affecting plant growth and development.

The WAKs family is represented by 26 members in Arabidopsis and 125 members in rice [11]. WAKs can be structurally categorized into three parts:

- i. an extracellular N-terminal ligand-binding domain followed by
- ii. a hydrophobic transmembrane (TM)-spanning helix, region and
- iii. a cytoplasmic kinase region which is sandwiched between transmembrane and kinase domain [12].

The members of this family are known to be involved in disease resistance, hormone signaling, legume-rhizobium symbiosis, pollen development, senescence, abiotic and in wounding stress responses [13,14]. The maintenance of continuity between cell wall-plasma membrane (CW-PM) is a crucial factor that governs plants' response to various stimuli and is crucial for resistance against pathogens [15].

An endophytic fungus *Piriformospora indica*, of the Sebacinaceae family, colonizes the roots of a wide variety of plant species and promotes their growth, in a manner similar to mycorrhizal fungi. Its hosts include the cereal crops rice, wheat, and barley as well as many Dicotyledoneae, including Arabidopsis [16]. The establishment of a transformation system and the full genome sequence of the fungus [17,18] will likely stimulate great progress towards further functional analysis. The positive effects of fungus have been observed for several plant species implicated a biotrophic interaction between the

fungus and its host [19]. The coincidence of host cell death with the fungal proliferation increases upon tissue maturation and accompanied by host cell death. This incidence suggests a new type of mutualistic interaction attributed to *P. indica* [20]. Many studies have been performed to identify genes involved in successful colonization and defense system induced as a result of *P. indica* infestation [21,22]. There were many genes RLKs have been identified such as LysM receptor-like kinases, CERK1, BAK1 etc that participates in chitin recognition and MAMP-triggered immunity (MTI) or other defense responses [21,23,24]. It remains to be investigated the exact role of LysM receptor-like kinases during establishment of the fungal symbiosis. Several mutant analyses of WAK genes provided evidence for their involvement in disease resistance [4,25,26]. This establishes the fact that WAKs are important components of basal defense.

Studies revealed the involvement of WAK/WAKL members in plant functions but the nature of their ligand binding and the mechanism of their intracellular signal transduction is still lacking. However, it have been shown that the extracellular domain of WAK1 binds to cell wall carbohydrate components such as pectins [27,28] and cell wall proteins such as the Gly-rich protein, AtGRP-3 [29].

An extracellular EGF (Epidermal Growth Factor) domain in WAK known to bind small peptides in animals [30] and form homo and heterodimers with receptors [31]. In plant, pattern-recognition receptors (PRR) proteins recognize pathogen derived Pathogen Associated Molecular Patterns (PAMPs) and Damage Associated Molecular Patterns (DAMPs) that produce from the damages caused by pathogen invasion. This perception of pathogen through PRRs induces PAMP triggered immunity (PTI) or basal defense [32]. There is evidence that PRR/DAMP protein complex interact with Arabidopsis Wall-Associated Kinase 1 (AtWAK1) and oligogalacturonides (OGs) [25], a derivatives of pectin which is component of the plant cell-wall [33].

Fungal cell wall are mainly composed of polysaccharides (chitin, glucan) and proteins [34]. It is suspected that the *P. indica* CWE (cell wall extract) might contain an active proteinaceous factor instead of chitin [35]. It is demonstrated that the early transcriptional regulation of the rice OsWAK genes is triggered by chitin and is partially under the control of the chitin receptor CEBIP [36]. In our previous study, a rice WAK gene was found to be highly upregulated in response to *P. indica* invasion [37]. WAKs have been known to regulate various gene involved in disease resistance against fungal pathogen but their possible involvement in plant-fungal mutual interaction is yet to be established. However, it is possible that WAKs genes might play a crucial role in endophytic development in host plant and the resulting induction of basal defense against pathogen in similar or different fashion.

We hope that this insight into the role of WAKs in plant-fungal association will stimulate the important area of research

that will provide the ways to develop new strategies for crop protection and sustainable agriculture.

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