ABSTRACT

THE ROLE OF NDR1 IN PATHOGEN DEFENSE AND ARABIDOPSIS PHYSIOLOGY

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Arabidopsis thaliana NDR1 (NON-RACE SPECIFIC DISEASE RESISTANCE-1), a plasma membrane localized protein, plays a critical role in resistance mediated by the CC-NB-LRR class of resistance (R) proteins, which includes RPS2, RPM1 and RPS5. Infection with Pseudomonas syringae pv. tomato DC3000 expressing the bacterial effector proteins AvrRpt2, AvrB and AvrPphB activate resistance through the activation of the aforementioned R proteins. Whereas the genetic requirement for NDR1 in plant disease defense signaling has been established, the global physiological role for NDR1 in Arabidopsis remained unknown. With the use of homology modeling, NDR1 was predicted to have a high degree of structural similarity to Arabidopsis LEA14, a protein implicated in abiotic stress responses, as well as to mammalian integrins, well characterized proteins involved in adhesion and signaling. This structural homology led to the examination of a physiological role for NDR1 in preventing fluid loss and maintaining the plasma membrane-cell wall continuum. Results demonstrated a substantial alteration in pathogen-induced electrolyte leakage in ndr1-1 mutant plants. As an extension of these analyses, using a combination of genetic and cell biology-based approaches, a role was identified for NDR1 in mediating plasma membrane-cell wall (PM-CW) adhesions through a specific protein motif. With the establishment of a distinct physiological role in PM-CW adhesion for NDR1 and the identification of a compromised PAMP-triggered immune response in ndr1-1, the focus shifted to the integration of NDR1 in early resistance signaling including pathogen perception, PAMP-triggered immunity (PTI) and effector delivery, recognition and

signaling. To this end, the PAMP-specific flg22- and elf26-dependent signaling mechanisms were analyzed to elucidate the breadth of NDR1 function in PTI. Mechanisms identified included a role for NDR1 in the regulation of stomatal closure in response to the PAMP flg22 and the hormone abscisic acid as well as a reduction in MAPK3/6 expression after both flg22 and elf26 exposure. Furthermore, the loss of NDR1 alters the type-three secretion system mediated delivery of the P. syringae effector AvrRpt2 to the cell interior. The structural similarities of NDR1 to LEA14, an abiotic stress protein, coupled with the identification of roles for NDR1 in maintaining PM-CW adhesion and regulation of stomata led to the examination of potential abiotic stress related functions for NDR1. By monitoring leaf relative water content as well as electrolyte leakage under severe drought conditions, NDR1 was shown to be required for drought tolerance in Arabidopsis. Further analysis revealed that NDR1 mediated drought tolerance is an ABA-dependent process and the over-expression of the NDR1 protein provides increased stress tolerance in Arabidopsis. Taken together, these data indicate not only a broad role for NDR1 in defense signaling through both PAMP and effector mediated pathways, but also in mediating basic physiological functions in Arabidopsis through the maintenance of the PM-CW continuum and a requirement in stomatal aperture dynamics.