Scaffold-mediated Assembly of the Brassinosteroid Signaling Components by TTL proteins

Brassinosteroids (BRs) is a group of steroidal hormones that play critical roles in multiple aspects of plant growth and development. BR stimulation at the PM receptors initiates a series of phosphorylation events enabling the nuclear accumulation and activity of the key transcription factor BZR1 and BES1. Previous studies have shown that all BR components associate form an interconnected signaling pathway, although it is not known how these proteins are brought together for the prompt signal transduction upon BR perception. Here we report that plant-specific Tetratricopeptide Thioredoxin-Like TTL proteins are positive regulators of BR signaling functioning as a scaffold of the BR pathway in Arabidopsis. TTL3 interacts with most core components involved in transducing BR signaling, BRI1, BSK1, and BIN2 kinases, the BSU1 phosphatase and the transcription factors BZR1 and BES1. Consistent with this role in BR signaling, mutations in TTL1, TTL2, and TT4 genes cause reduced BR responses, defects that are highly enhanced in a triple ttl1/ttl3/ttl4 mutant. We also show that a functional TTL3-green fluorescence protein is mainly localized in the cytoplasm and that BR treatment increases the association to the plasma membrane. We also show that the cytoplasmic/plasma membrane localization of a functional TTL3-green fluorescence protein is dependent on BR. We propose a novel mechanistic model for optimized BR signaling, in which cytoplasmic/nuclear BR components bound to TTL proteins are translocated to the plasma membrane upon BR perception, which in turn allow the assembly of a BR signaling complex with the goal of ensuring TF de-phosphorylation and nuclear accumulation of the transcription factors.

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