VILLIN2 Emerges as a Master Builder in Rice

The architecture of a plant determines its ability to capture solar energy and thus has a striking effect on yield. Plant architecture is the product of coordinated patterns of cell division, expansion, and differentiation. Whereas the molecular mechanisms governing cell division are well established, those regulating cell expansion and differentiation are not. Studies indicate that the cytoskeleton, consisting mainly of microtubules and actin filaments, plays important roles in determining a cell’s final shape and size. Microtubules guide cellulose deposition in the cell wall and thereby determine the direction of growth (Paredez et al., 2006). Recent work in Arabidopsis thaliana suggests that actin microfilaments also regulate directional growth, as a mutant lacking two members of the villin/gelsolin superfamily has defects in actin bundling and produces twisted organs (van der Honing et al., 2012).

To decipher the molecular mechanisms that influence the architecture of an agronomically important crop, Wu et al. (2015) generated a T-DNA insertion library in the japonica variety of rice (Oryza sativa) and screened for mutants with morphological flaws. They identified a mutant with dramatic defects, including twisted leaf sheaths and roots (see figure), reduced growth, droopy leaves and panicles, and malformed grains. Histological studies showed that cells in the roots and leaves of the mutant were smaller than those of the wild type and that the twisting phenotype was due to asymmetrical expansion of cells, rather than to differences in cell number, on opposite sides of the organs. Thermal asymmetric interlaced PCR analysis followed by sequencing analysis showed that the mutant harbors an insertion in VILLIN2 (VLN2) and that the predicted translational product of VLN2 contains conserved residues thought to be important for actin regulation. Furthermore, qRT-PCR and promoter-GUS assays showed that VLN2 is ubiquitously expressed in rice but that expression is highest in growing tissues. Given VLN2’s predicted function in actin regulation, the authors next examined the actin cytoskeleton of the vln2 mutant using two different markers. As expected, the mutant had defects in actin dynamics and organization, and these defects could be complemented by a genomic fragment containing VLN2. Noting that the mutant had a hypersensitive gravitropic response, the authors then wondered if the distribution and transport of auxin, which regulates root gravitropism (Swarup et al., 2005), were affected in vln2. They found that auxin distribution was indeed altered in the mutant and that polar auxin transport was slower in the mutant than in the wild type. Furthermore, an analysis of transgenic rice plants expressing a GFP fusion of the auxin efflux carrier PIN2 showed that the mutant exhibited increased recycling of PIN2 at the plasma membrane.

Together, this work establishes a functional link between the actin cytoskeleton, polar auxin transport, and plant architecture and provides exciting insight into the role of actin in cell expansion.

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REFERENCES


