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– Molecular Biology –

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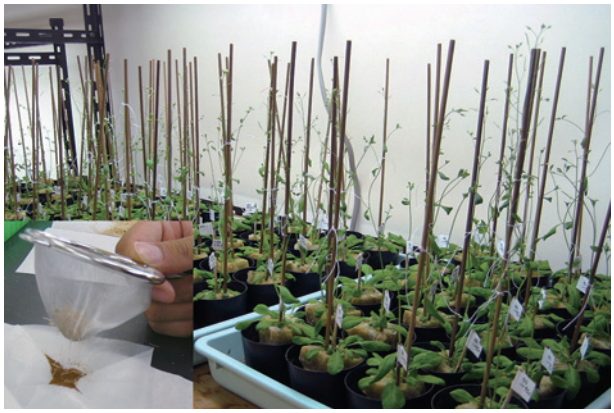
Scope of Research

This laboratory aims at clarifying molecular bases of regulatory mechanisms for plant development, especially plant morphogenesis, with techniques of forward and reverse genetics, molecular biology, and biochemistry. Current major subjects are phospholipid signalings in cell morphogenesis, the transcriptional network for cytokinin responses, COP9 signalosome modulating signal transduction in the nuclei, and the endoreduplication cell cycle in cell differentiation.

KEYWORDS

Morphogenesis
Signal Transduction
Phospholipid
COP9 Signalosome
Cytokinin



Selected Publications

Taniguchi YY, Taniguchi M, Tsuge T, Oka A, Aoyama, T: Involvement of *Arabidopsis thaliana* Phospholipase Dζ2 in Root Hydrotropism through the Suppression of Root Gravitropism, *Planta*, **231,** 491-497 (2010).

Kusano H, Testerink C, Vermeer JEM, Tsuge T, Shimada H, Oka A, Munnik T, Aoyama T: The *Arabidopsis* Phosphatidylinositol Phosphate 5-kinase PIP5K3 is a Key Regulator of Root Hair Tip Growth, *Plant Cell*, **20,** 367-380 (2008).

Menon S, Tsuge T, Dohmae N, Takio K, Wei N: Association of SAP130/SF3b-3 with Cullin-RING Ubiquitin Ligase Complexes and Its Regulation by the COP9 Signalosome, *BMC Biochem*, **9,** 1 (2008).

Taniguchi M, Sasaki N, Tsuge T, Aoyama T, Oka A: ARR1 Directly Activates Cytokinin Response Genes that Encode Proteins with Diverse Regulatory Functions, *Plant Cell Physiol.*, **48,** 263-277 (2007).

Imai KK, Ohashi Y, Tsuge T, Yoshizumi T, Matsui M, Oka A, Aoyama T: The A-type Cyclin CYCA2;3 is a Key Regulator of Ploidy Levels in *Arabidopsis* Endoreduplication, *Plant Cell*, **18,** 382-396 (2006).

Mechanism Fixing and Sustaining the Polarity of Plant Cells

Root hairs have been used as a model system for studying molecular mechanisms involved in plant cell morphogenesis, because of their accessibility for experimental observation and a wide variety of their mutants. Root hairs are cellular protuberances resulting from the polar outgrowth of specific root epidermal cells called tricoblasts (Figure1). During root hair morphogenesis, a bulge is initially formed at the distal end on the outer tricoblast surface, the fixed position through a mechanism for planar polarity. Subsequently, the bulge protrudes further, perpendicular to the root surface, by highly polarized cell expansion, resulting in a thin cylindrical structure. This type of cell expansion is called tip growth, because all of the events involved in the growth, including cell wall and plasma membrane synthesis, are limited to the tip.

Figure 1. Root of *Arabidopsis thaliana*. A main root of a young seedling with root hairs is shown. Bar = 1 mm.

Once root hair tip growth begins, the polarity is strictly sustained, resulting in straight root hairs without branches. We hypothesized a mechanism for sustaining this highly polarized growth, which can not only localize events underlying cell expansion to the tip continuously but also maintain its own localization at the tip against the diffusion concomitant with cell expansion. This mechanism is possibly involved also in the planar polarity fixation, where regulatory factors for tip growth should be recruited to the locus of bulge initiation with a peaky pattern.

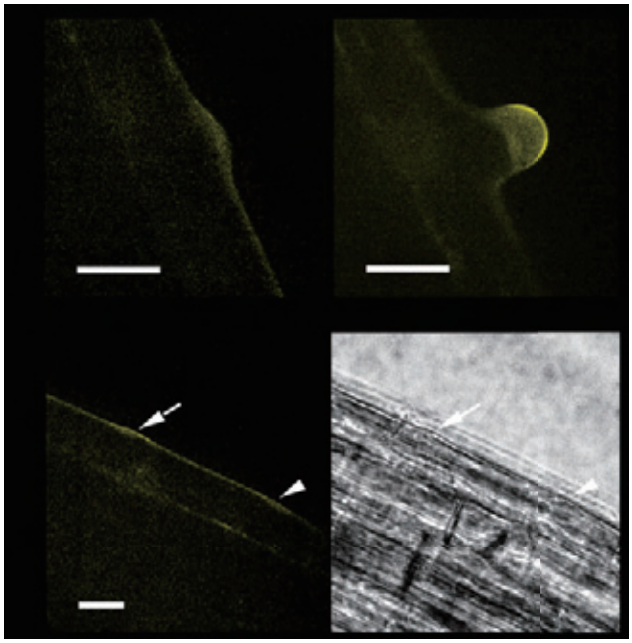


Figure 2. PIP5K3-YFP fusion protein driven by the *PIP5K3* promoter localized not only to apices of bulges (upper panels), but also to apparently flat sites where bulges were expected to appear (indicated by arrows in lower panels). Bar = 20 μm.

Of the regulatory factors identified so far for root hair tip growth in *Arabidopsis thaliana*, Rho-type GTPase of plants (ROP) and phosphatidylinositol 4-phosphate 5-kinase (PIP5K) are known to function positively. We found that PIP5K3 localizes to the bulge-expected position on the apical plasma membrane of tricoblasts similar to ROP2 (Figure 2). When both PIP5K3 and ROP2 were overexpressed in developing root hairs, synergistic effects on thier morphgenesis were observed; root hairs were abnormally elongated and branched (Figure 3). We assume that ROPs and phosphatidylinositol 4,5-bisphosphate produced by PIP5Ks are involved in the mechanism for sustaining the root hair tip growth.

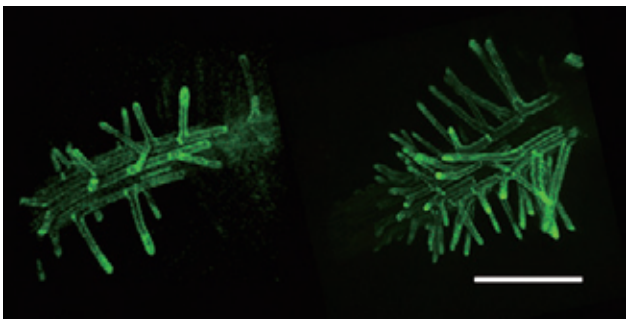


Figure 3. ROP2 overexpression caused slightly longer root hairs than normal (left panel). Additional overexpression of PIP5K3 resulted in even longer and branched root hairs (right panel). Bar = 20 μm.