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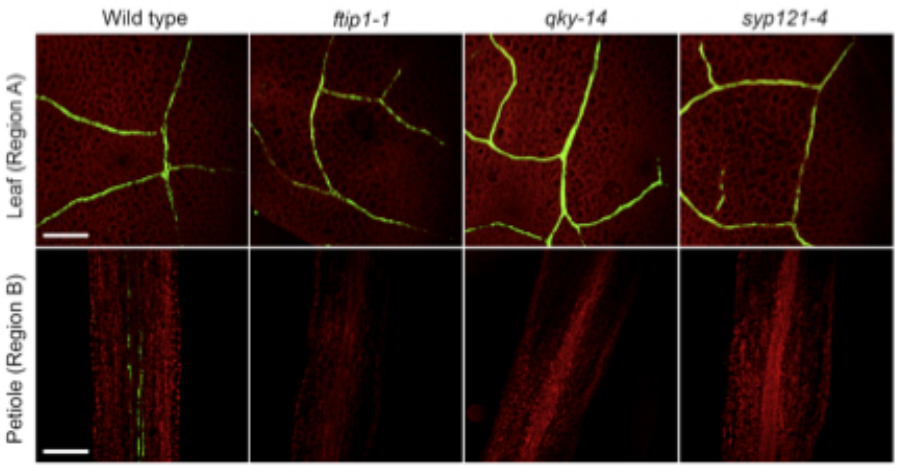
IN BRIEF

Moving on Up: An MCTP-SNARE Complex Mediates Long-distance Florigen Transport

Flowering plants integrate endogenous and external cues to accurately time the transition from vegetative to reproductive growth (Cho et al., 2017). Many plants, including *Arabidopsis thaliana*, sense changes in day length (photoperiod) to transition to flowering as the season changes. Decades of careful molecular genetic dissections have uncovered the photoperiod-induced flowering pathway of Arabidopsis, which is centered on sensing increases in day length within leaf phloem cells to activate the expression and transport of phloem-mobile florigen (FT, FLOWERING LOCUS T) to the shoot apical meristem to trigger the floral transition (reviewed in Song et al., 2015).

The underlying molecular mechanisms controlling FT movement from phloem companion cells (CCs) to sieve elements (SEs) for access to the phloem translocation stream are not well understood. To address this issue, **Liu et al. (2019)** genetically interrogated membrane-resident SNARE (soluble *N*-ethylmaleimide-sensitive factor protein attachment protein receptor) proteins controlling endosomal vesicular trafficking for potential roles in regulating the CC-to-SE movement of FT during photoperiod flowering in Arabidopsis. The authors identified a late-flowering phenotype exclusively in *syp121-4* (*syntaxin of plants 121*) mutants under long-day conditions that was recapitulated by artificial microRNA-mediated *SYP121* knockdowns in wild-type plants and complemented by transforming a genomic *gSYP121* fragment back into *syp121-4*.

To understand how *SYP121* contributes to photoperiod-induced flowering, the authors drew from knowledge of animal syntaxin function and performed yeast 2-hybrid interaction screens against truncated MCTPs (Multiple C2 domain-containing Transmembrane Proteins) lacking transmembrane domains. Surprisingly, this analysis revealed a specific interaction with QKY rather than FTIP1 (FT-INTERACTING PROTEIN1), an MCTP previously implicated in FT movement through the endoplasmic reticulum (Liu et al., 2012). Phenotypic analysis of *qky* mutants and knockdown lines demonstrated delayed flowering time in long days relative to wild-type plants (Liu et al., 2019). Expression analysis using promoter-reporter fusions revealed that *QKY* expression is restricted to phloem CCs, and subcellular localization studies determined that QKY-GFP is located in endosomal vesicles and co-localizes with RFP-SYP121 at the plasma membrane. Collectively, these data suggest that a SYP121-QKY complex regulates photoperiod-induced flowering.



SYP121 controls long-distance FT movement alongside the MCTP proteins QKY and FTIP1. In an estradiol-controlled *FT-GFP* expression system limited to phloem companion cells (pER22-SUC2:FT-GFP), estradiol induction triggers the accumulation of FT-GFP (green) in leaf vasculature, which moves to distal, untreated petioles in wild-type leaves but not in *ftip1-1, qky-14,* or *syp121-4* leaves. Scale bars = 200 µm. (*Adapted from Liu et al., [2019] Figure 5).*

Next, the authors addressed whether QKY interacts with FT to regulate its transport from CCs-to-SEs during photoperiod-induced flowering. As anticipated, protein-protein interaction assays confirmed that QKY interacts with FT, much like the MCTP protein FTIP1 (Liu et al., 2012). To assess the extent to which QKY, SYP121, and FTIP1 contribute to FT movement, the authors performed elegant FT transport assays in the wild type and mutant backgrounds. Using an estradiol-inducible *FT-GFP* expression system limited to CCs (*pER22-SUC2:FT-GFP*), the authors demonstrated that estradiol treatment in wild-type leaves led to the accumulation and transport of FT-GFP in distally located untreated petioles. By contrast, FT-GFP was not detected in *ftip1, qky,* or *syp121* petioles after estradiol induction in leaves (see Figure). Similarly, immunogold electron microscopy of plants transformed with *SUC2:FT-9myc* revealed FT in CCs and SEs in the wild-type background but in CCs and not SEs in the *ftip1 qky, syp121 qky,* and *ftip1 qky syp121* backgrounds. Therefore, a QKY-SYP121 complex mediates FT movement from CCs to SEs through endosomal vesicular trafficking to the plasma membrane, which occurs alongside the FTIP1-mediated transport of FT through the endoplasmic reticulum. Together, these parallel mechanisms ensure that FT is transported long-distance through the phloem to induce the floral transition.

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