

Title: A dual role of CLAVATA3 peptide signaling in vascular organization and stem cell maintenance in *Arabidopsis* shoots.

Abstract

Terrestrial plant biomass relies on the formation and development of vascular bundles (VBs), which contribute to secondary growth and wood formation. Stem VBs originate just below the shoot apical meristem (SAM) from procambial cells and subsequently develop into wedge-shaped structures composed of phloem, cambium, and xylem, arranged in a circular eustele pattern at the stem periphery in *Arabidopsis*. Most studies have focused on the molecular mechanisms required for secondary growth, but the developmental cues that govern vascular initiation, organization, and establish its connection with the SAM remain poorly understood. Here, we show that the conserved CLAVATA3 peptide (CLV3p)–receptor stem cell signaling pathway represses vascular transcriptional programs in the SAM. Loss of CLV3 and CLE25 peptide signaling results in the conversion of approximately one-quarter of the central stem pith into vascular-like tissue, accompanied by the deposition of mechanically strong lignified tissue. Moreover, this signaling pathway quantitatively regulates the number of peripheral VBs. Overexpression and mutational analyses of key phloem regulators reveal that CLV3p controls vascular and stem cell programs through a *DOF* (*DNA-BINDING WITH ONE FINGER*)–*SMXL* (*SUPPRESSOR OF MAX2 1-LIKE*) transcriptional module. Additionally, genetic manipulation of conserved CLV3p residues partially uncouples its roles in stem cell maintenance and vascular organization. Together, our findings uncover a novel role for CLV3p signaling in shoot vascular development and reveal a molecular pathway for fine-tuning secondary growth in the stem, with potential applications for modulating wood properties through biotechnological approaches.