Xylem cells cooperate in the control of lignification and cell death during plant vascular development.

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Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av filosofie doktorsexamen i ämnet Växters cell- och molekylärbioologi framläggs till offentligt försvar i KB3A9 (”Lilla hörsalen”), KBC,
Fredagen den 4 Mars, kl. 13:00.
Avhandlingen kommer att försvaras på engelska.

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Abstract

The evolutionary success of land plants was fostered by the acquisition of the xylem vascular tissue which conducts water and minerals upwards from the roots. The xylem tissue of flowering plants is composed of three main types of cells: the sap-conducting tracheary elements (TE), the fibres which provide mechanical support and the parenchyma cells which provide metabolic support to the tissue. Both the TEs and the fibres deposit thick polysaccharidic secondary cell walls (SCWs), reinforced by a rigid phenolic polymer called lignin. The cell walls of TEs form efficient water conducting hollow tubes after the TEs have undergone programmed cell death (PCD) and complete protoplast degradation as a part of their differentiation. The work presented in this thesis studied the regulation of TE PCD by characterizing the function of the candidate PCD regulator METACASPASE 9 (MC9) in Arabidopsis thaliana xylogenic cell suspensions. These cell suspensions can be externally induced to differentiate into a mix of TEs and parenchymatic non-TE cells, thus representing an ideal system to study the cellular processes of TE PCD. In this system, TEs with reduced expression of MC9 were shown to have increased levels of autophagy and to trigger the ectopic death of the non-TE cells. The viability of the non-TE cells could be restored by down-regulating autophagy specifically in the TEs with reduced MC9 expression. Therefore, this work showed that MC9 must tightly regulate the level of autophagy during TE PCD in order to prevent the TEs from becoming harmful to the non-TEs. Hence, this work demonstrated the existence of a cellular cooperation between the TEs and the surrounding parenchymatic cells during TE PCD. The potential cooperation between the TEs and the neighbouring parenchyma during the biosynthesis of lignin was also investigated. The cupin domain containing protein PIRIN2 was found to regulate TE lignification in a non-cell autonomous manner in Arabidopsis thaliana. More precisely, PIRIN2 was shown to function as an antagonist of positive transcriptional regulators of lignin biosynthetic genes in xylem parenchyma cells. Part of the transcriptional regulation by PIRIN2 involves chromatin modifications, which represent a new type of regulation of lignin biosynthesis. Because xylem constitutes the wood in tree species, this newly discovered regulation of non-cell autonomous lignification represents a potential target to modify lignin biosynthesis in order to overcome the recalcitrance of the woody biomass for the production of biofuels.