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DOCTORAL DISSERTATION
Characterization of the mechanisms of conductive phloem element differentiation in plants

Abstract

In the course of evolution, plants have developed tissues adapted to the efficient transport of substances. Xylem conducts water and mineral salts through tracheal elements, while phloem conducting cells known as sieve elements, distributing products of photosynthesis. The differentiation of these cells involves the adaptation to ensure the uninterrupted flow of solutions by reducing the cytoplasm and modifying the cell wall. Programmed Cell Death (PCD) mechanisms are involved in the development of xylem conducting cells. In the case of xylogenesis, tracheary elements become dead, therefore empty, and their walls become extensively thickened. Interestingly, analogically cells with reduced protoplast are formed during phloemogenesis as well. In the course of differentiation, sieve elements are deprived of most organelles, including the nucleus, but they remain alive, retaining part of the cytoplasm concentrated close to the cell wall. So far, little has been known about the processes responsible for the partial and highly selective reduction of the protoplast during phloemogenesis. The main process responsible for the removal of cytoplasmic structures is autophagy, and its occurrence during xylogenesis has already been confirmed. However, little is known about the role of selective autophagy in the development of phloem. The aim of the work was to verify the research hypothesis, assuming that degradative processes are involved in the differentiation of phloem conductive cells, but their operation is selective and does not lead to the lysis of the entire protoplast, as is the case of PCD during the development of xylem conducting cells. The research material consisted of the roots of model plants. Using the black cottonwood (Populus trichocarpa Torr. et A. Gray ex Hook.) as well as anatomical, cytological and molecular analyses, the mechanisms responsible for the reduction of cytoplasm in sieve 3 elements were characterized. Cytological and molecular markers of autophagy occurring during phloemogenesis were also identified. Moreover, by analyzing the roots of other evolutionarily distant species, ranging from ferns to dicotyledons, it was proven that autophagy is a process specific to the differentiation of both the xylem and phloem in vascular plants. However, no specific evolutionary pattern was found for the composition of the cell walls of conducting tissues. Compared to the conserved nature of autophagy, cell wall formation is very variable. For each examined species, different cell wall composition for xylem or phloem were documented. The thesis also proposes patterns of degradation mechanisms in plants under conditions of their normal development and in response to abiotic and biotic stresses. The differentiation of xylem and phloem, undergoing in the result of cell death or just partial reduction of organelles, is a very good research model for the mechanisms responsible for intensive changes in the composition of the cytoplasm and cell wall. The obtained results significantly extended the current knowledge on different pathways of cytoplasmic selective degradation and methods of their study.

Key words: selective autophagy, phloem, sieve elements, PCD, xylem, tracheary elements