SL202 Physiological Functions of Apoplast in Higher Plants

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Do plants have blood? The question is readily raised by comparing the animal circulatory system with that of plant. These ten years plant scientists have come to recognize that apoplast plays various roles in manipulating signal and mass transport. The term, apoplast, was coined by German plant scientist, Münch, in 1930. He termed the water path apoplast, but now the apoplast attracts much more attention than he expected. The function of vascular systems, most part of which is apoplast, is well known as the path of water, nutrients, and assimilates, but the cell walls, all of which are apoplast, is also the path of many substances, including plant hormones, inorganic nutrients, sugars and water. Cell walls also contain many enzymes, not only related to the metabolism of cell wall polysaccharides but also to the defense mechanism against pathogens.

The recent finding of biosynthesis of indole-3-acetic acid in higher plants is the existence of enzyme activity in the cell walls, which converts indole-acetaldehyde to IAA (1). This finding led us to the idea that endogenous IAA concentration is higher in apoplast than in symplast. This was demonstrated in squash hypocotyl segments by GC-SIM. The IAA concentration in the apoplast (4×10^{-7} M) was 8 times higher than in the symplast (5×10^{-8} M) (2). The apoplastic IAA concentration corresponds to the effective dose response of elongation growth to exogenously applied IAA. Endogenous IAA concentrations formerly reported in higher plants are always less than 10^{-7} M which is not effective to induce physiological response. Large volume of low concentration of IAA in symplast probably masked the actual high concentration of apoplastic IAA. Barley seedlings contained five β-glucanases tightly bound to the cell walls. Of these glucanases, one exo- and one endo-glucanase were found to be involved in the process of 1,3:1,4-β-glucan degradation in the cell walls, which is prerequisite for the auxin-induced growth. The other three glucanases are exo- and endo-1,3-β-glucanases, which do not effectively digest the cell wall 1,3:1,4-β-glucan but might play a role in defense mechanism (3).

These findings suggest that apoplast plays a role in functioning as the circulatory system and buffer zone between environments and symplast, and it is the site of active regulation of plant growth, development, differentiation and defense.

(1) Tsurusaki, K. et al., Plant Cell Physiol. 38: 263-273 (1997)

(2) Tsurusaki, K. et al., Plant Cell Physiol. 38: 352-356 (1997)

(3) Kotake, T. et al., Plant Cell Physiol. 38: 194-200 (1997)