Pectin May Hinder the Unfolding of Xyloglucan Chains during Cell Deformation: Implications of the Mechanical Performance of Arabidopsis Hypocotyls with Pectin Alterations

Abstract

Plant cell walls, like a multitude of other biological materials, are natural fiber-reinforced composite materials. Their mechanical properties are highly dependent on the interplay of the stiff fibrous phase and the soft matrix phase and on the matrix deformation itself. Using specific Arabidopsis thaliana mutants, we studied the mechanical role of the matrix assembly in primary cell walls of hypocotyls with altered xyloglucan and pectin composition. Standard microtensile tests and cyclic loading protocols were performed on mur1 hypocotyls with affected RGII borate diester cross-links and a hin dered xyloglucan fucosylation as well as qua2 exhibiting 50% less homogalacturonan in comparison to wild-type. As a control, wild-type plants (Col-0) and mur2 exhibiting a specific xyloglucan fucosylation and no differences in the pectin network were utilized. In the standard tensile tests, the ultimate stress levels (~tensile strength) of the hypocotyls of the mutants with pectin alterations (mur1, qua2) were rather unaffected, whereas their tensile stiffness was noticeably reduced in comparison to Col-0. The cyclic loading tests indicated a stiffening of all hypocotyls after the first cycle and a plastic deformation during the first straining, the degree of which, however, was much higher for mur1 and qua2 hypocotyls. Based on the mechanical data and current cell wall models, it is assumed that folded xyloglucan chains between cellulose fibrils may tend to unfold during straining of the hypocotyls. This response is probably hindered by geometrical constraints due to pectin rigidity.

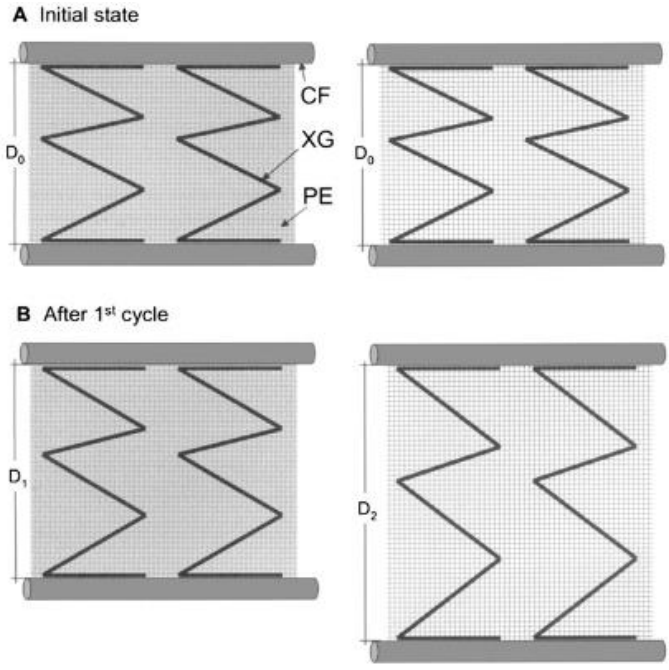

Figure 6. Simple Structural Model of the Influence of the Geometrical Interactions of Folded Xyloglucan Chains with Pectin.

Cell walls of hypocotyls with pectin alteration are illustrated with a wider mesh (CF, cellulose fibril; XG, xyloglucan chain; PE, pectin). **(A)** Initial state before straining with a given space between the fibrils D_0.

(B) Cell walls with pectin alterations (wider mesh) show larger plastic deformation after the first loading cycle than cell walls without pectin alteration ($D_0 < D_1 < D_2$).