Cell-Wall Composition of Corn Internodes of Varying Maturity

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Introduction

Lignification of the cell wall during normal plant development is likely the primary limitation to microbial fermentation of wall polysaccharides in the rumen of cattle. A simple reduction in lignin concentration may be a limited option for improving digestibility because lignin provides the structural scaffold for the plant and has a defensive role in avoiding pathogen invasion and environmental stress. Our research seeks to identify key steps in lignification that can maximize wall polysaccharide digestibility while avoiding reduction in agronomic fitness of plants. The molecular composition of the lignin polymer may account for much of the wall's resistance to microbial attack while in the rumen. We examined the relationship of cell-wall constituents to stage of tissue and internode development of corn. This information provides a better understanding of the sequential deposition of wall components and changes in cross-linkage patterns of polysaccharides to lignin during wall development.

Materials and Methods

Rind and pith internode tissues were separated from corn plants grown in a growth chamber and harvested at the 15th leaf stage of development. Determinations were made of cell-wall neutral sugars, uronic acids, Klason lignin, hydroxycinnamic acids, and the syringyl-to-guaiacyl ratio (S/G) of lignin.

Results and Discussion

From the youngest internode (I13) to the oldest (I7), cell-wall concentration increased continually in the rind tissue, but in the pith tissue, concentrations increased through I10, and then plateaued (Fig. 1). Commensurate with these changes, the lignin proportion of the wall increased from about 75 to 140 g kg^{-1} and neutral sugar and uronic acid proportions of the wall decreased from 836 and 101 g kg^{-1} to 759 and 36 g kg^{-1}, respectively. Internode rind vascular tissue, which lignified earlier and to a greater extent than pith material, had significantly higher levels of Klason lignin and ferulic acid (FA) and *p*-coumaric acid (PCA) esters. There was a marked increase in PCA ester concentration with internode maturity (Fig. 2) and this pattern mirrored a steady rise in the S/G ratio of the lignin. Ferulate ester levels were high in young internodes, but concentrations declined in more mature internodes (Fig. 3). The ether-linked form of FA increased sharply during the early stages of internode lignification, but then also declined.

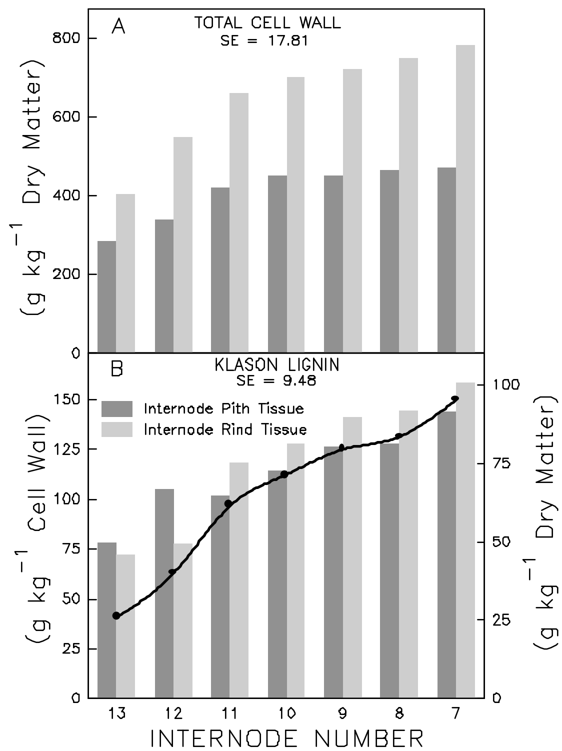

Figure 1. Concentrations of total cell wall (a) and Klason lignin (b) in the pith and rind of Internodes 13 through 7 of corn. Spline plots represent concentration of Klason lignin on a g kg^{-1} dry matter basis.

Conclusions

Composition of lignin changes during cell development with lignin deposited later in lignification being richer in syringyl units. Neutral sugar and uronic acid proportions of total wall fall with internode maturation. The change in FA linkage form with cellular development is consistent with the hypothesis that FA esters of arabinoxylan are laid down early and incorporated into the developing and elongating primary wall. Ferulic acid then becomes linked to the growing lignin polymer, thereby cross-linking lignin to polysaccharide during secondary wall thickening.

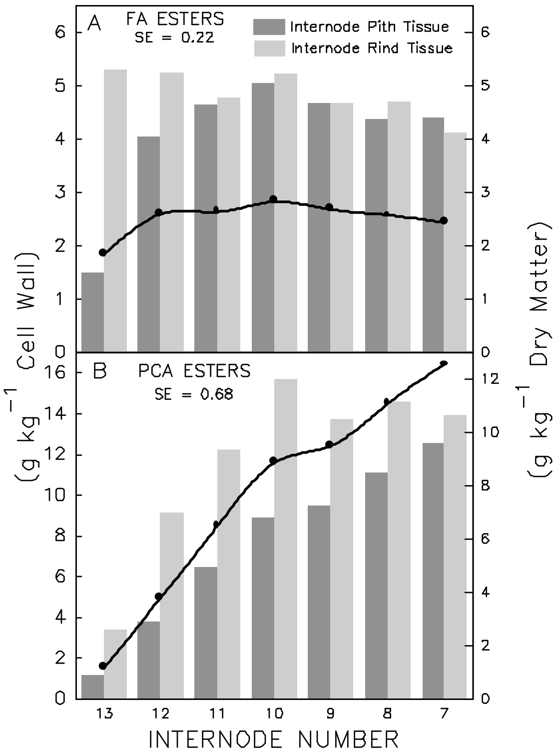

Figure 2. Concentrations of FA (a) and PCA (b) in the pith and rind of Internodes 13 through 7 of corn. Spline plots represent concentrations on a g kg^{-1} dry matter basis.

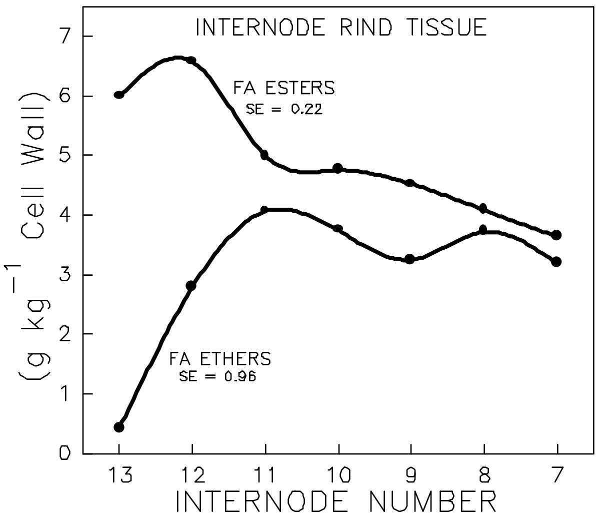

Figure 3. Concentrations of FA esters and ethers in the rind tissues of Internodes 13 through 7 of corn.