Sucrosyl Oligosaccharide Metabolism and Cotton Fiber Development

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ABSTRACT

The object of this study was to determine which oligosaccharides correlate with cell wall synthesis in developing cotton fibers. This study employed bolls taken from sequential fruiting branches on the same plant to rule out environmental and plant to plant differences. Cold aqueous extracts of developing cotton fibers have been analyzed by HPAEC-PAD (Murray, 1998). Sucrosyl oligosaccharides appear to function as cell wall precursors. A decrease in sucrose concentration and a concomitant increase in raffinose concentration characterize maximal secondary wall synthesis in cotton fibers. We have confirmed the identification of raffinose, stachyose, verbascose and tentatively identified ajugose and other sugars in the series. Environmental conditions appear to influence the concentrations of glycerol, m-inositol, galactinol, melibiose, and manninotriose in developing cotton fibers. The relative concentrations of sucrosyl oligosaccharides were found to vary fibers from plants subjected to high stress in irrigation experiments. Differences in glycoconjugate profiles in the fibers are apparent in irrigation experiments several days before significant differences are apparent in leaf water potentials. Differences in glycoconjugate profiles are also apparent in fibers from bolls collected at 7am, noon and 7pm suggestive of a diurnal rhythm. This diurnal variation is of interest since the major portion of cell wall deposition occurs at night. (Murray, A. K., 1998, U.S. Patent No. 5,710,047).

Introduction

The differences in glycoconjugate profiles of developing cotton fibers have been documented from either tagged flowers or from bolls of various ages (Murray, 1996; Murray and Brown, 1996, 1997; Murray *et al.*, 1997). In this study, bolls from several fruiting branches on the same plant were collected at the same time to obtain information on the developmental sequence without the possibility of plant to plant variability or environmental variability. The glycoconjugate profiles obtained result in a biochemical plant map for glycoconjugates in the developing fibers. Other work in this laboratory had shown that the sucrosyl oligosaccharides can serve as precursors to cell wall polysaccharides, in vitro. Differences in the concentration of various di- and trisaccharides can alter the relative distribution of cell wall polymers extracted from the fibers following incubation. Since the sucrosyl oligosaccharides have been observed to undergo interconversion during the synthesis of wall polymers, *in vitro*, this investigation aimed to determine if the sucrosyl oligosaccharides vary in distribution with developmental age. Raffinose is formed from sucrose by the addition of an α-1,6 linked galactose and subsequent α-1,6-galactose residues are added to form the other oligosaccharides in the series (Figure 1). The galactosyl donor for this synthesis is galactinol (Kandler and Hopf, 1982; Lehle and Tanner, 1973; Tanner and Kandler, 1968).

Methods

Cotton plants were DP-50 grown in the Mississippi Delta region for the time of day samples that were collected at 7am, noon and 7pm at 25 DPA. Plants for the sequential bolls were also DP-50 grown in the Sacramento Valley of California and sequential bolls were taken at the same time on the same plant. Cotton fibers were subjected to aqueous extraction and analysis of the soluble carbohydrates by high pH anion chromatography with pulsed amperometric detection (HPAEC-PAD) (Murray, 1998). Additional extraction of the ~mers was achieved under conditions of dilute acid and elevated temperature prior to HPAEC-PAD.

Results

The presence of the sucrosyl oligosaccharides in developing cotton fibers has been observed under varying conditions of environmental stress. Under certain conditions the distribution can be altered significantly. The chromatograms shown in Figure 2 are for developing fibers from bolls on different fruiting branches of the same plant taken at the same time. This rules out plant to plant and environmental variation so the only difference is in developmental age of the bolls. The precursors, *myo*-inositol, galactinol and sucrose are present. The sucrosyloligosaccharides, raffinose, stachyose and verbascose have been identified. Ajugose has been tentatively identified. In addition, the invertase hydrolysis products of these

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sucrosyl oligosaccharides melibiose, manninitriose and verbascotetraose have also been identified.

Summary

Several of the sucrosyl oligosaccharides have been reported in cotton fibers previously (Jaquet, *et al.* 1982). In this work we have found the sucrosyl oligosaccharides to be in a dynamic state in developing cotton fibers. The relative concentrations vary with environmental conditions. Raffinose, stachyose and verbascose as well as their precursors *myo*-inositol, galactinol and sucrose have been found in normal developing cotton fibers. The invertase hydrolysis products melibiose, manninotriose and verbascotetraose have also been identified. The presence of the invertase hydrolysis products and the apparent role of the sucrosyl oligosaccharides in cell wall synthesis implies a key role for invertase in the utilization of these oligosaccharides.

References

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(Abbreviations: F, fruiting branch; DPA, days postanthesis; In, inositol; Gl, galactinol; S, sucrose; Mb, melibiose; Vt, verbascotetraose; R, raffinose; S, stachyose; V, verbascose; A, ajugose.)

Figure 1. Sucrocyl oligosaccharide structure.

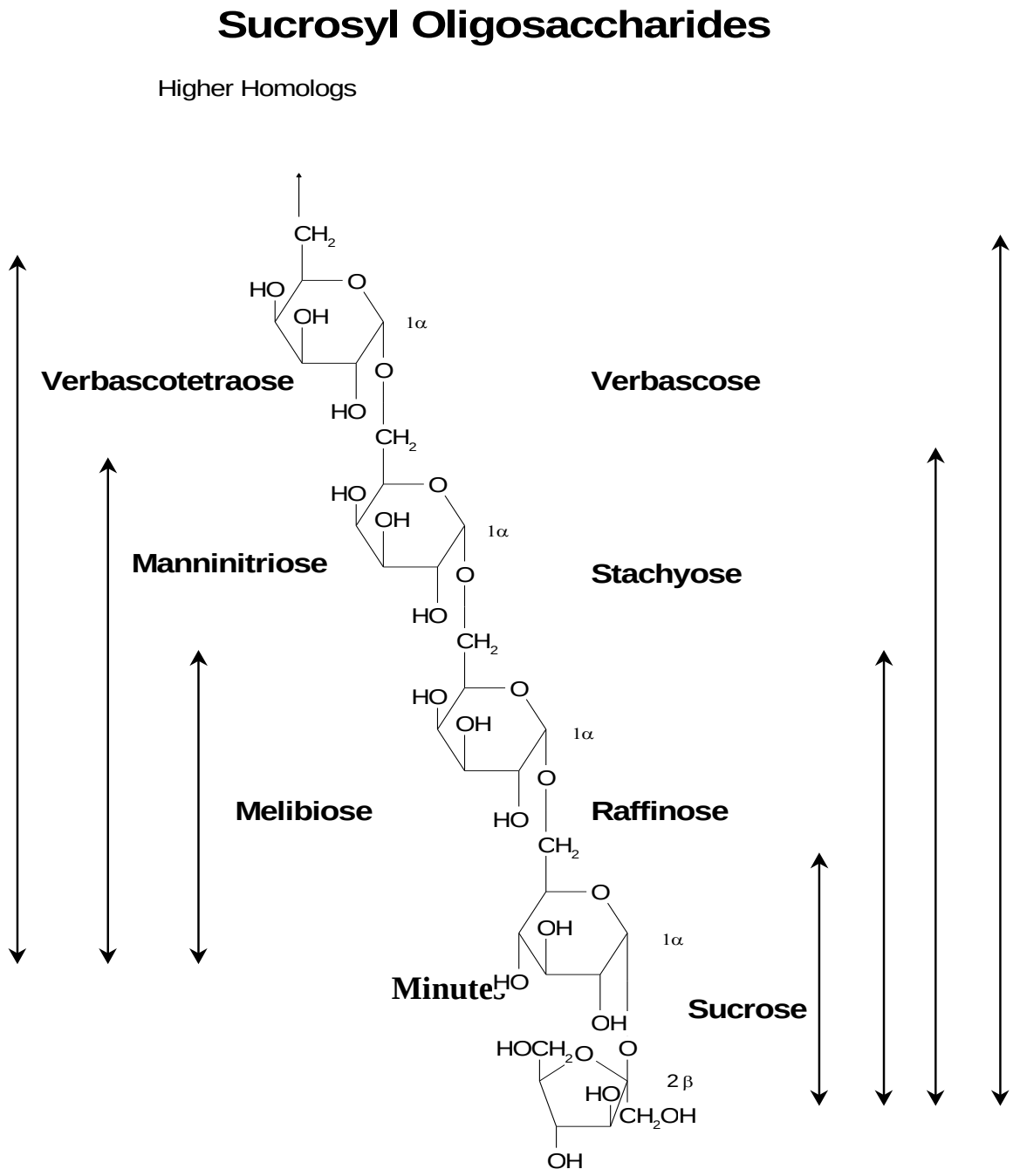

Figure 2. Sequential bolls on the same plant and time.