Observations on the Ultrastructure of the Thickened Sieve Cell Wall in *Pinus strobus* L.

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With 6 Figures

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Summary

The thickened sieve cell wall of white pine is shown to comprise a crossed-helical polymembranous structure in which the predominant microfibrillar orientation is greater than 45° with respect to the cell axis. The previously reported observation that microfibrils may be oriented other than parallel to the plane of the cell wall is disputed and it is demonstrated that such an appearance may derive from appropriately oblique sectioning of the wall.

1. Introduction

In structural studies on phloem, emphasis has historically been placed on the sieve element protoplast and the sieve plate, and on the role which sieve elements play in translocation (ESAU 1969, SPANNER 1971). Relatively few authors have considered basic wall structure in this cell type (e.g., ABBE and CRAFTS 1939, MÜHLETHALER 1950, ESAU and CHEADLE 1958, ROELOFSON 1959, 1965, SRIVASTAVA 1969, BEHNKE 1971) and only recently has a detailed description of wall ultrastructure emerged (SRIVASTAVA 1969). Reference has been made to a "characteristic helical structure" (ABBE and CRAFTS 1939) and to a dominant transverse orientation or the additional presence of a crossed-helical structure (ROELOFSON 1959, 1965). SRIVASTAVA (1969) has advanced a somewhat unorthodox concept of microfibrillar orientation for the sieve cell walls of white pine. He envisages a wall composed of lamellae in which microfibrils are aligned at an angle to both

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the horizontal and vertical axes of the cell. That is, not only are microfibrils considered to subtend an angle with the horizontal as seen in surface (tangential) view, but also with the vertical axis when the wall is observed in sectional (radial) view.

This paper presents clarifying information on wall structure in the mature sieve cells of white pine and suggests, as an alternative to that of Srivastava, an interpretation which is consistent with the generally accepted view of microfibrils lying flat in the plane of the cell wall.

The thickened wall, which is present in the differentiated sieve cells of many plant species, is considered by some authors to be secondary (Esau 1969, Srivastava 1969). Mühlethaler (1950) disagrees with this denotation, however, and there is little evidence to support the designation of this wall as either primary or secondary (Esau 1969) in accordance with the definition of Kerr and Bailey (1934). For the purpose of the following discussion, therefore, we refer only to the “thickened” sieve cell wall which designates that wall which is evident during and following the final stages of differentiation.

2. Materials and Methods

Fresh white pine phloem was fixed in 70% alcohol, dehydrated and embedded in Epon. Thin sections were cut with a Reichert O MU2 Ultramicrotome, picked up on copper grids and either stained with uranyl acetate and lead citrate or shadowed with platinum-palladium or chromium following removal of the plastic embedding medium (Mayor et al. 1961). Other material was extracted for 18 hours in two parts hydrogen peroxide and one part acetic acid and either macerated or embedded in Epon for subsequent sectioning, shadowing and examination in a Philips 100 electron microscope. Wet, two-stage replicas were made with a portion of the macerated cells. Other macerations were prepared for optical microscopy and were examined with the polarizing microscope either in the unstained condition or after staining with chlor-zinc-iodine or with a 0.1% solution of congo red. One or two micron sections of Epon embedded material were additionally prepared for observation between crossed nicols. A Reichert “Zetopan” research microscope was used for all optical observations.

3. Results and Discussion

3.1. Light Microscopy

Observations made on macerated sieve cells between crossed nicols (Red I selenite plate inserted) indicated that the orientation of the highest index of refraction of the wall lay approximately perpendicular to the cell axis,

Fig. 1. Light micrograph of portion of macerated sieve cell showing crossed helical striations. Stained with congo red and photographed between crossed nicols near the orthogonal position. ×1,070

Fig. 2. Electron micrograph of transverse section of sieve cell wall showing lamellations and generally transverse orientation. Irregularities of microfibrillar arrangement suggest possibility of other orientations. Shadowed with platinum-palladium following removal of embedding medium. ×43,000. Lu—Cell lumen