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Elizabeth J. Cahoon
University of Minnesota

ELIZABETH J. CAHOON
University of Minnesota, Minneapolis

BOTANY

Correlation of Size with Number of Protophloem Points in Roots of ZEA MAYS L.

DeBary as long ago as 1884 recognized that the number of primary xylem arms ("radial plates") varies more or less in proportion to the size of the root. It remained for Wardlaw (1928) and Bower (1930) to put this relationship into quantitative terms in the mature primary body of various vascular plants. In this same vein Thoday (1939) called attention to the probability that "the unit element of the pattern at its initiation varies in dimensions only within narrow limits, so that the number of repetitions is determined by the spatial relations at this early stage." Wardlaw in 1952 (p. 340) points out that the factors responsible for the size-structure correlation must be studied in the meristematic region where the pattern first becomes apparent. Torrey applied this precept in his 1955 work with excised pea root tips. He found that the number of vascular points was correlated, not with the size of the mature stele, but more nearly with the diameter of the meristematic stele.

In none of the above studies has protophloem been the primary object of investigation. Phloem sieve elements mature around the circumference of the still meristematic stele at a level where the protoxylem pattern is not recognizable. The purpose of this study of the meristematic region of corn roots was to reveal any relationships between the number of protophloem points and size factors present at the level of sieve element initiation. Thus this paper explores size-form correlations in a new histological context.

Corn was selected for study because of the great range in size of its roots; the large prop roots have diameters more than ten times those of small branch roots.

MATERIALS AND METHODS

Two aerial prop roots and five subterranean branch roots were taken from two plants of a common genetical condition supplied by the Division of Agronomy, University of Minnesota Institute of Agriculture, St. Paul. The roots were fixed in Karpechenko's killing fluid. Serial, transverse sections were cut at ten and twelve microns and were stained with safranin and fast green. Data were collected from the section of each root which contained the youngest complete representation of protophloem. Only those sieve elements located next to the pericycle were considered to constitute a protophloem point. Two sieve elements in contact laterally were considered to represent one point.

The largest prop root lacked an active meristematic region, thus no completely comparable section was available in it. Observations were therefore made on the youngest level measurable. Although this section had mature sieve elements, its protoxylem lacked secondary walls, the endodermis lacked Casparian strips, and metaphloem was not mature. Since the data from this root are so closely comparable to those from the smaller prop root they are presented here.

OBSERVATIONS AND DISCUSSION

The vascular pattern shown by prop roots is similar to but not identical to the pattern shown by branch roots. The data in Table 1

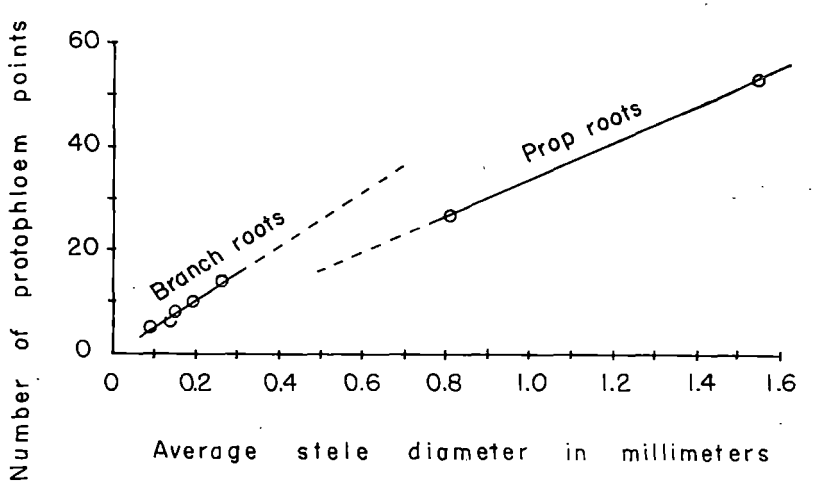

Fig. 1. Number of protophloem points in relation to stele diameter.

show several of these differences. A comparison of the diameter of the stele to the number of protophloem points which develop (Table 1, third column) shows a distinct difference between the subterranean branch roots and the aerial prop roots. There are appreciably fewer protophloem points per unit of the diameter in prop roots. Figure 1, in which number of protophloem points is plotted against stele diameter, shows this difference graphically. The line which closely approximates the sequence of points representing branch roots follows a different course from that passing through the points representing prop roots. A similiar tendency may be discerned in Bower's analysis (1930) of Wardlaws study of *Colocasia* (1928). Here the number of vascular points per unit of stele diameter decreases with increasing size of stele.

TABLE 1.—*Comparison of Certain Histological Features of Branch and Prop Roots*

Average* stele diameter microns	Number of protophloem points	Column 1 / Column 2	Mean inter-protophloem distance microns
Branch Roots			
92	5	18.4	42.2
138	6	22.9	56.3
152	8	19.0	48.5
190	10	19.0	49.6
260	14	18.6	51.3
Prop Roots			
765	27	29.4	86.3
1546	53	29.2	91.1

*of two diameters at right angles to each other.

Another difference between the two groups of corn roots is their interprotophloem distance, *i.e.* the actual distance in microns between two adjacent protophloem points. The right hand column of Table 1 contrasts the small mean interprotophloem distances of branch roots with the larger ones observed in prop roots.

The data should not leave the impression that interprotophloem distances are relatively constant in any root. On the contrary these

distances are extremely variable. For example the range of interprotophloem distances in the smaller prop root is from 27 to 131 microns.

Prop roots show a greater variability in the distance between adjacent protophloem points than do branch roots. In the entire group of branch roots the interprotophloem distances range from 35 to 74 microns. The limited variation of interprotophloem distances in branch roots suggests the hypothesis that after a certain maximum separation of two protophloem initials a protophloem point can differentiate midway between them.

SUMMARY

This study has shown that a relationship exists between the diameter of the meristematic stele and the number of protophloem points which are initiated in corn roots. There may, however, be significant differences between the pattern of vascular development in subterranean branch roots and aerial prop roots. This tentative conclusion is supported by three lines of evidence.

1. The ratio of meristematic stele diameter to number of protophloem points is larger in prop roots than in branch roots.

2. Although interprotophloem distances are variable in all the roots, there is a wider range of distances in prop roots.

3. The average interprotophloem distance in prop roots is definitely larger than the same average in branch roots.

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