SEASONAL VARIATION IN CAMBIAL ELECTRICAL RESISTANCE IN JUVENILE GREEN ASH FROM DIFFERENT PROVENANCES

by Frank S. Santamour, Jr.

Abstract. Electrical resistance (ER) in the cambial zone of juvenile green ash from various provenances was highly correlated with growth rate and with certain climatic features of provenance origin. Initiation of cambial activity in the spring was related to ER but not dependent on provenance origin. Cessation of cambial activity in the fall, as indicated by ER, was significantly related to origin. ER measurements of reciprocally patch-grafted cambia indicated that variation in time of cessation would not be a major cause of graft incompatibility in inter-provenance grafts.

The Shigometer is a device that delivers a pulsed electric current and measures resistance to that current. In recent years, the instrument has been used to relate electrical resistance (ER) to defoliation stress (Wargo and Skutt 1975), growth rate (Smith and Others 1976; Shortle and Others 1977), and stem dormancy (Rietveld and Williams 1977). Davis and Others (1979) showed that ER in the cambial zone of three native tree species in New Hampshire followed a marked seasonal pattern.

As part of our studies on the physiology and biochemistry of graft compatibility, we were interested in using the Shigometer to detect the initiation and cessation of cambial activity. It seemed reasonable to assume that lack of cambial synchronization between stock and scion could result in physiological and physical stresses that might contribute to graft failure, especially when stock and scion were from widely differing geographic origins. Wilcox (1962), in discussing the differences in the periodicity of shoot growth commonly seen in provenance tests, stated that "corresponding differences occur in the beginning and cessation of cambial activity," but provided no references or data to support this statement.

Materials and Methods

The young green ash (Fraxinus pennsylvanica) trees used in this study were part of a range-wide provenance test being conducted by Dr. Kim C. Steiner of Pennsylvania State University. Dr. Steiner had supplied us with one-year-old seedlings of 48 provenances for spring planting in 1978. The seedlings were planted in 2 replicates of 4-tree plots at a 10-foot spacing in Beltsville, Maryland. Although some provenances were represented by as many as 4 mother-tree seedlots and were grown and identified as half-sib progenies in the nursery, these progenies were

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2Osmose Wood Preserving Co. of America, Buffalo, N.Y. The use of trade, firm, or corporation names in this paper does not constitute endorsement by the Science and Education Administration or the U.S. Department of Agriculture.
lumped together by provenance for the field testing. Only one tree died between planting time and the spring of 1979.

We began monitoring ER in the cambial zone of these seedlings on March 28, 1979 and continued the measurements at approximately weekly intervals throughout the growing season until November 29, 1979. Because of the small diameter of the seedlings in 1979, we did not use the rather coarse steel needle probes supplied with the Shigometer. Rather, we constructed smaller probes using two stainless steel map pins embedded (with epoxy resin) 1 cm apart in a plastic base. Electrical contact between these pins and the Shigometer was accomplished by a commercial clip-on test lead set.

All measurements were made with the pins in a vertical orientation at the base of the leading shoot produced in 1978. The pins were pushed through the bark and into the xylem. Probes inserted in this fashion measure the point of lowest ER along the probe path, that point being the cambial zone (Wargo and Skutt 1975). Only one reading was made for each seedling at each sampling date. ER of the seedlings was considerably higher than mature trees of the same species, often by a factor of 5 to 8. This difference was not the result of the smaller probe needles, since standard Shigometer needles gave similar readings. Preliminary work did show that the ER of cambia of young stems in several tree genera was consistently higher than that of older (20-year-old) trees.

The data were subjected to standard ANOVA techniques and correlation coefficients were determined by the least squares method.

On July 26, 1979 we made a number of reciprocal patch grafts between potted seedlings of the same provenances that had been field planted. A ring of bark roughly 1 inch wide was removed from the main trunk of each seedling of the pair to be grafted, with care being given to making the cuts at regions of similar diameter. The bark patches were then placed, in the proper polar orientation, around the stem of the other pair member and secured with rubber grafting bands. Thus we were able to make reciprocal grafts between seedlings from Manitoba and Tennessee, New York and Manitoba, Nebraska and Illinois, and several other combinations, including intraprovenance grafts. The grafting rubbers were removed after 10 days. All reciprocal grafts were successful.

Sax and Dickson (1956) showed that the wood produced under the bark of such patch grafts resulted from cambial activity of the donor patch. Thus, we were interested to see whether the ER would be influenced under the new set of environmental conditions caused by grafting.

We began monitoring the ER above, within, and below the patch graft on October 17, 1979 and continued, at weekly intervals until November 29, 1979. In 1980, we made several measurements during the spring and summer months, started weekly testing on August 26, 1980 and continued this until November 15, 1980.

Results and Discussion

Table 1 gives the seasonal variation in cambial ER of seedlings from randomly selected provenances having a wide range of January temperatures and lengths of growing season. The trends that seem obvious from these data are reflected in the correlation coefficients listed in Table 2. Both the length of growing season and the average January temperature of the origin of the provenance were highly inversely correlated with cambial ER on November 29, 1979 but the correlations with ER readings on July 17, 1979 were non-significant. The correlation between ER during the dormant spring period (March 28, 1979) and source January temperature was highly significant but that with length of growing season was non-significant.

The average day of bud break for all seedlings was April 29, 1979 (Day 119) and the average electrical resistance at the time of bud break was 39 K ohms. The day of bud break was not significantly correlated with seed origin climatic conditions and although there was a significant inverse correlation between ER at bud break and length of growing season the significance was at a very low level.

It appeared that the threshold resistance for bud break to occur was near 50 K ohms. Therefore we were interested in the date that the resistance
of the various provenances rose above 50 K ohms late in the growing season. The data in Table 1 and Table 2 indicate a highly significant correlation between seed source climatic data and the possible onset of dormancy as indicated by rising ER.

ANOVA showed highly significant differences among seedlots in both 1978 and 1979 shoot growth, and the growth was highly significantly correlated with the length of the growing season and average January temperature of the seedlot origin (Table 2). This relationship was not unexpected.

ANOVA also showed highly significant differences among seedlots in ER at 3 sampling dates. There was a consistent highly significant inverse correlation between growth and ER at 3 sampling dates (Table 3). Wargo and Skutt (1975) reported a similar inverse relationship between ER and diameter growth in 3 oak species.

If we assume that 50 K ohms may represent the approach of cambial “dormancy,” it would appear from Table 1 that more northern provenances reach that point about 2 weeks earlier than southern provenances. However, the ER in the fall did not reach the level of the first (March 28, 1979) measurement, for any seedlot, until November 29, 1979. The lowest temperature recorded during the month of November 1979, up until the last resistance measurement, was only –0.6°C. Lower temperatures may have resulted in wider provenance differences, but we are not
certain this would be the case. The rise in ER from November 20, 1979 to November 29, 1979 was dramatic, in most instances more than doubling the November 20 reading and in a few seedlots nearly tripling the November 20 measurement. The drop in ER from March 28, 1979 to April 11, 1979 was nearly as dramatic.

The onset of cambial activity in the spring, whether indicated by time of bud break or decreasing ER, was not related to geographic origin of these young ash trees, and may be merely associated with increasing temperature, such as determined by Wilcox and others (1956) for bark peelability. In the present study, the increase of ER in the fall appeared to be related to the cessation of cambial activity and ER was significantly correlated with growth rate. Wilcox and others (1956) also found that increase in resistance to bark peeling was related to tree physiological behavior. Thus, our findings of correlations between ER and the climatic features of provenance origin might be a reflection of the high correlation between growth rate and climate of provenance.

Even with the brief “adjustment” period of patch-grafted cambia in 1979, it can be seen that the grafted cambia became somewhat “synchronized” in ER with the tissue above and below the graft (Table 4). During 1980, the synchroniza-

Table 4. Cambial electrical resistance (K ohms) above, within, and below patch grafts between green ash seedlings from various provenances-1979.

<table>
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Citations:


