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The Relationship between Vegetative Maturity and the First Stage of Cold Acclimation[1]

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Abstract. **Red-osier dogwood (*Cornus stolonifera* Michx.) plants were grown outdoors in a lathhouse to study the relationship between vegetative maturity and the first stage of cold acclimation. Both microscopic observations and electrical impedance ratios used to measure damage of frozen stem sections verified the close association of the onset of the first stage of cold acclimation and vegetative maturity. The relationship of these processes to dormancy development is discussed.**

Vegetative maturity of deciduous plants was recently defined as that stage of development when deciduous plants are able to overwinter without injury following complete manual defoliation (2, 6). Plants defoliated before this stage either die completely or suffer tip dieback. Unfortunately, the relationship of this stage to other known processes of dormancy development is not well understood. Fuchigami et al. (2) showed that vegetative maturity occurs several weeks prior to rest. Seibel (8) recently observed that vegetative maturity is closely related, and may be identical to the transition period between summer and winter dormancy. This stage is also referred to as the end of correlative inhibition when leaves are no longer necessary to prevent the lateral buds from growing (12).

Fuchigami et al. (3) reported that leaves are necessary for cold acclimation and related periodic hand defoliation studies to the first stage of cold acclimation. From these data, a close relationship between the first stage of acclimation and vegetative maturity can be inferred. The first stage of acclimation which is induced by short days, depends on the presence of a translocatable hardiness promoter produced in the leaves (1, 9, 10). Defoliation eliminates the receptor sites for the short-day stimulus and/or the source of the hardiness promoter (1, 3, 7). Previous studies to relate the onset of cold acclimation to a specific stage of development have suggested that the onset of hardiness occurs during winter dormancy or rest (11). More recent evidence demonstrates that cold acclimation occurs prior to rest (3, 7). As a result of previous studies reported earlier, the objective of this study was to determine a relationship of the onset of cold acclimation with specific stages of winter dormancy.

Materials and Methods

Red-osier dogwood plants were propagated from single node cuttings in the summer of 1975 and transplanted into 12.7 cm pots in a mixture of 1 sand: 1 soil: 1 peat (by vol). After over-wintering in a plastic covered lathhouse, they were pruned to a single leader and selected for uniformity on the basis of height and growth habit. The plants were from 70 to130 cm tall when experiments began in early July of 1976.

On each of 20 sampling dates, 10 plants were defoliated and left in the lathhouse under natural temperature and daylength. Temperature and humidity in the lathhouse were monitored with a Weathermeasure hygrothermograph. Defoliated plants were observed daily, and new growth removed. In March, tip dieback of these plants was measured and recorded as (dead stem length/total stem length) × 100.

For hardiness determinations, another 10 plants were selected at each sampling date and the stems cut into 2 cm internode sections. Four sections from each plant were wrapped in aluminum foil and frozen in a freezing chamber to -10^{o}C at 3^{o}/hr. Non-acclimated red-osier dogwood plants survive to -6^{o} (3). Therefore, survival below this temperature provides an indicator of the first stage of cold acclimation.

From microscopic observations of frozen stem sections, an injury scale of 0 to 3 was used to rate progressive stages of injury due to freezing. A value of 0 indicated no injury; 1 corresponded to pith damage; 2 displayed cambial injury; and 3 indicated injury to bark cortex and phloem as well as pith and cambial tissues. After freezing, stem sections were incubated for 48 hr at room temp (23^{o}C). Microscopic evaluations were then made and the data from all 40 sections from each sample were averaged to plot the graph shown in Fig. 1.

Impedance ratios (4, 5) were measured with a portable impedance ratio (kilohertz/megahertz) meter developed by the Weyerhaeuser Company. Stem sections were frozen, thawed. and warmed to room temperature as previously discussed before measuring impedance. The scale of the meter was not designed for the changes in megahertz values that occurred during dormancy development, so an arbitrary scale was designed to record the data. Megahertz values of the acclimating stem sections exceeded the range of the meter, therefore, instead of reporting actual values the results were reported

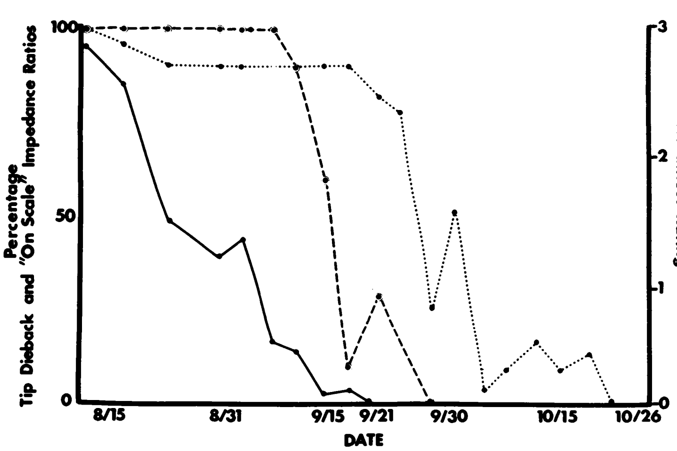

Fig. 1. Electrical impedance ratios, microscopic hardiness ratings of tissue frozen to -10^{o}C and tip dieback in lathhouse plants. Electrical impedance (⊛– – –⊛); hardiness (•-----•); tip dieback (•——•). Vegetative maturity was complete on Sept. 21.

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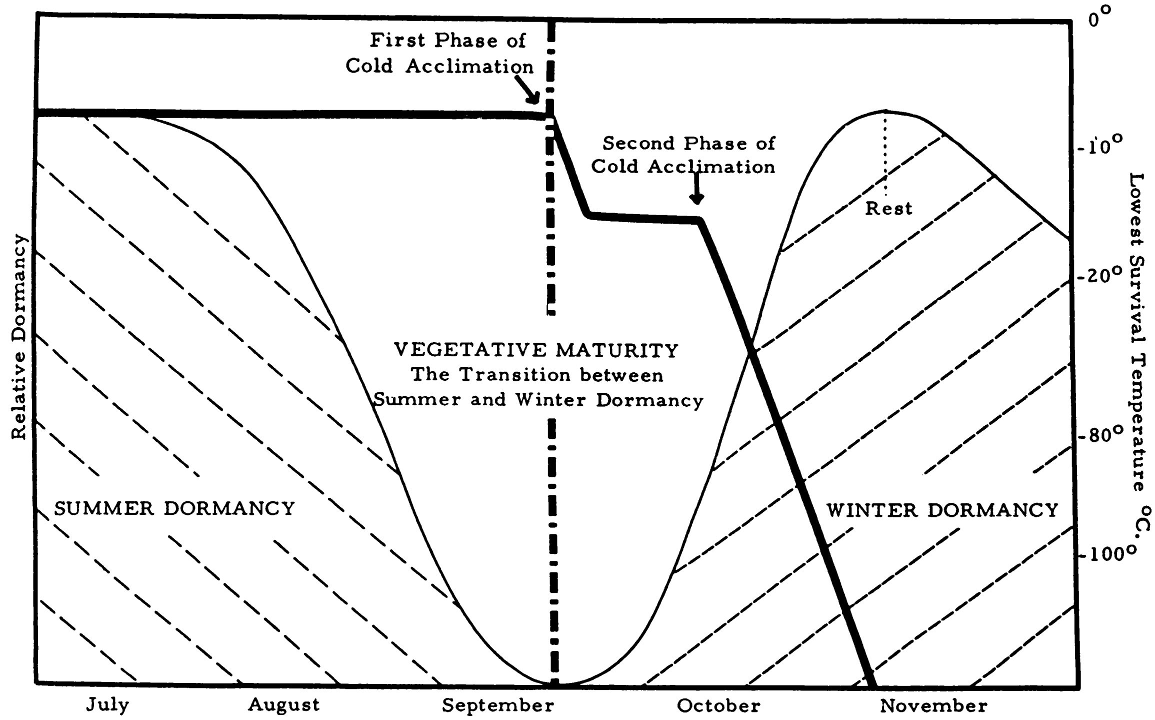

Fig. 2. Relationship between hardiness and dormancy development in red-osier dogwood.

accordingly. Stem sections that registered on the meter were designated "on scale." Those that did not were called "off scale." The curve plotted in Fig. 1 is drawn from (no. of 'on scale' readings/40) x 100, where 40 is the total no. of samples that were measured at each sampling period. This scale was adequate for showing the changes that occurred during maturation.

Results and Discussion

Fig. 1 illustrates the close association between the development of vegetative maturity and the onset of cold acclimation. Hand defoliation studies indicated that complete vegetative maturity occurred on Sept. 21 slightly before a pronounced change in hardiness, as determined by microscopic observation and electrical impedance, was observed. The change in impedance prior to Sept. 21 may indicate differences between individual plants or an increase in the initiation of cold acclimation not detectable by microscopic examination. Electrical impedance has been used by researchers and industry to determine the extent of freezing injury, and is thought to be more sensitive than other tests (4).

Fuchigami et al. (2) reported that vegetative maturity occurred about 6 weeks before rest occurred in red-osier dogwood. On the basis of their findings and results presented here, the onset of cold acclimation occurs before rest and at the vegetative maturity stage of development (Fig. 2). Recently, Seibel (8) showed that vegetative maturity and the transition between summer and winter dormancy are probably the same stage of development.

Fig. 2 illustrates the various stages of development occurring in red-osier dogwood as it goes from summer dormancy (correlative inhibition to winter dormancy and shows the relationship of cold acclimation to those phases of development.

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