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Xylem Water Potential and Electrical Impedance Ratios as Measures of Vegetative Maturity in Red-osier Dogwood (*Cornus stolonifera* Michx.)[1]

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Abstract. **Xylem water potential (XWP) and electrical impedance ratios were used to determine the time of vegetative maturity in red-osier dogwood (*Cornus stolonifera* Michx.) grown under 2 temperature and a short-day dormancy inducing regime in growth chambers and a lathhouse under natural conditions. The decline in XWP correlated with the development of vegetative maturity as measured by tip dieback after defoliation. Under growth chamber conditions, average XWP values reached a minimum at the time of vegetative maturity. In all cases, however, variability within samples was so large as to preclude the use of XWP as an accurate, reliable index of vegetative maturity. A change in electrical impedance ratios at and after vegetative maturity caused the impedance meter to go "off scale." Compared with XWP values, changes in electrical impedance ratios were more consistent and show promise in predicting vegetative maturity.**

A decline in plant moisture occurs during dormancy development (4, 6). Changes in physiological and biochemical processes are correlated with this decline in moisture content, including an increase in the permeability of cell membranes to water (6), an increase in abscisic acid content (7), declines in cell division, protein and carbohydrate synthesis and metabolism (4), and lower yields from photosynthesis (8). Leaf senescence is accelerated and plant hardiness can be increased (5) when the available moisture declines.

The decline in moisture content is accompanied by a general decline in plant processes, so a measure of plant water status to determine the stage of dormancy development of the plant seems possible (4). Vegetative maturity, the transition from summer to winter dormancy, is that phase of development when deciduous plants are capable of surviving fall defoliation without injury (2, 4). A plant that is mature does not visibly differ from one that is not mature. Since vegetative maturity may occur at or a month before natural leaf fall (4), another method not dependent on visual characteristics must be used to determine the time of maturity.

Recently, vegetative maturity was related to the first stage of cold acclimation (9). Because of this association and the relationship of declining water content with hardiness, it seemed logical that XWP could be used to measure vegetative maturity.

In addition to XWP, electrical impedance ratios of stem sections were measured. Electrical impedance has been used to detect injury due to freezing (1, 3) or to predict hardiness (11, 12). A decline in impedance ratios has been associated with the development of dormancy (3) so a useful relationship between impedance ratios and vegetative maturity seemed plausible.

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This study attempted to relate plant water status, using XWP as measured with the pressure bomb (10, 13) and percentage moisture, with vegetative maturity as measured by tip dieback after defoliation (2). In addition, electrical impedance ratios were compared with vegetative maturity of the lathhouse grown plants.

Materials and Methods

Red-osier dogwood plants were propagated from single node cuttings and transplanted into 12.7 cm pots containing a mixture of 1 sand: 1 peat: 1 soil (by vol) in the spring of 1976. The plants were between 30 to 40 cm in height when the growth chamber experiments were initiated in early July. They were trimmed to 2 stems and uniform plants were selected into groups of 3 and arranged in 5 blocks of 30 plants in each growth chamber. The chambers were maintained at $13^{\circ} \pm 1^{\circ}C$ and $29^{\circ} \pm 1^{\circ}$, with a light intensity of 3634 $\mu w/cm^2$ and a photoperiod of 10 hr.

Beginning 1 week after placing plants in the chambers, a pair of plants were randomly chosen weekly from each of the 5 blocks. One plant from each pair was defoliated and placed in a warm ($21^{\circ}C$ days, 18° nights) greenhouse with natural daylength until Dec. 15 at which time they were transferred to a plastic-covered lathhouse. Defoliated plants were observed daily and any new leaves removed. Extent of tip dieback was determined in March. Percentage of tip dieback from both stems was recorded as (dead stem length/total stem length) × 100.

Pressure bomb measurements of XWP were taken from the remaining 5 plants using the top 5 to 8 cm of stem. XWP in bars was recorded before the lights were turned on in order to reduce variations due to transpiration. Percentage moisture was based on four 1 cm internode sections per plant from 5 plants of which were cut, weighed, and dried to constant weight in a $60^{\circ}C$ drying oven (48 hr).

The lathhouse grown plants, ranging from 70 to 130 cm in height, were selected for uniformity in height and growth habit. At 2 to 4 day intervals, beginning Aug. 15 and ending Oct. 26, 10 plants were defoliated and left in the lathhouse.

Tip dieback to determine vegetative maturity was recorded as described previously. At the same time plants were defoliated, XWP and moisture content were measured on another group of 10 plants.

Results and Discussion

Moisture content declined gradually as the plants matured in the 3 environments (Fig. 1 and 2). Because of similar results, the date for the 3rd environment is not shown. These results confirm the findings of others (4) that deciduous plants lose water during dormancy development. The decline in percent moisture is too gradual and not definitive enough to warrant its use as an index of maturity.

The correlation (r = .404) between tip dieback and the decline in XWP in the lathhouse plants was in agreement with the results reported by Hotze (4). However, the span of values for XWP during the testing period ranged from −3.5 to −14 bars (Fig. 2). Of these values, 99% of the plants with an arbitrarily elected XWP of −7.5 or lower were mature, but almost 40% of the plants with XWP of greater than −7.5 were also mature. Under growth chamber conditions, similar trends were observed, with the lowest average XWP coinciding with vegetative maturity (Fig. 1). Unfortunately, variability within samples decreased the value of XWP as a tool for predicting maturity. These data support the conclusions drawn by Hotze (4) that it is not likely that the XWP measurements will become a nursery practice for timing defoliation.

Electrical impedance ratios were measured with a Weyerhaeuser Company designed meter on recently excised unfrozen 2 cm internode sections of the lathhouse plants using methods described previously (9). Impedance ratios showed a rapid decline beginning a few weeks before vegetative maturity (Fig. 2). No plants recorded "on scale" values after vegetative maturity. Changes in moisture content and the concentration of cellular chemical contents of the cells in response to this decline in moisture may be responsible for the changes in impedance (3).

The rapid change in impedance was quite consistent in all samples measured and suggests that this technique may be used to predict vegetative maturity. Further testing to determine the critical changes in impedance values is necessary before their use as an index of vegetative maturity can be recommended.

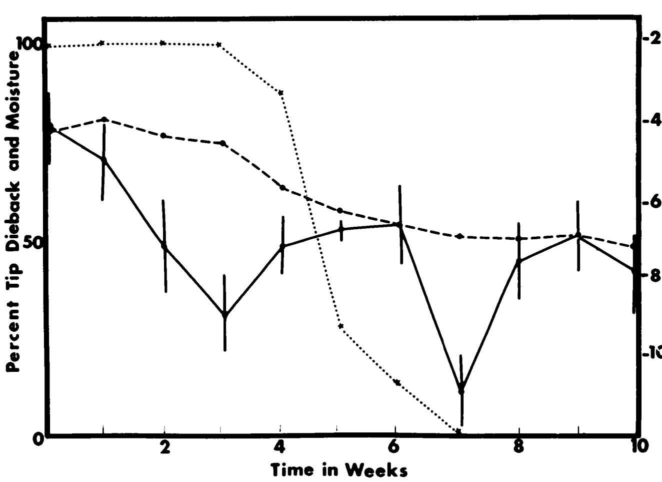

Fig. 1. Average XWP, Moisture content, and tip dieback in plants grown at 13°C. XWP (●——●); % moisture content (●– – –●); tip dieback (★-----★). XWP values listed with ± one standard deviation. Vegetative maturity occurred during week 7. Each data point represents the mean of 5 samples.

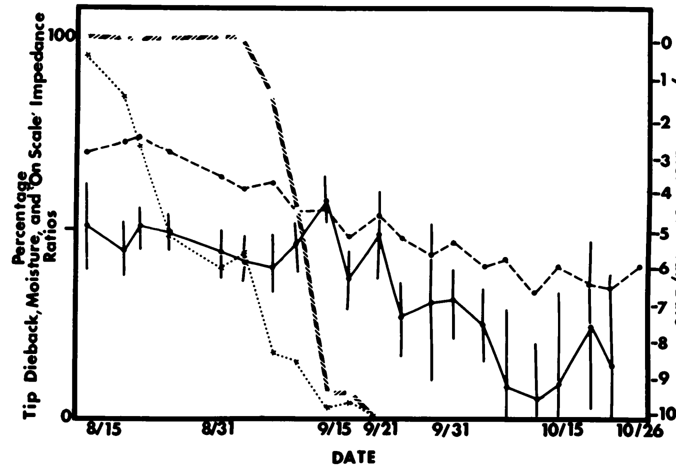

Fig. 2. Average XWP, moisture content, electrical impedance values, and tip dieback in plants grown under natural conditions. XWP (●——●); % moisture content (●– – –●); electrical impedance ratios (○▬▬○); and tip dieback (★-----★). Maturity was complete on Sept 21. Each data point represents the mean of 10 samples.

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