then vegetative maturity corresponds to winter dormancy in the clone of red-osier dogwood used in this experiment.

A summary of the relationships between the development of vegetative maturity, onset of cold acclimation, winter dormancy under two environmental regimes, and rest is illustrated in Fig. 2. The relationship between vegetative maturity and the onset of cold acclimation in red-osier dogwood was recently reported by Nissila (5).

From a practical standpoint, the knowledge that vegetative maturity corresponds to winter dormancy as defined above provides a simpler means to determine vegetative maturity. The original method required daily re-defoliation of test plants and observation of resultant dip dieback after bud break the next spring. Using defoliation-induced bud break in the greenhouse as an index of vegetative maturity requires defoliating plants only once and then observing them for regrowth over the course of the next few weeks. This method will save time and space in studies related to vegetative maturity development.

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Ethylene Production as an Indicator of Seasonal Development in Red-osier Dogwood[1]

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Abstract. **Ethylene evolution from excised plant parts was tested as an indicator of stage of seasonal development in red-osier dogwood (*Cornus sericea* L., syn. *C. stolonifera* Michx.). A reduction in ethylene production occurs several weeks prior to the time when defoliation can be safely accomplished. This reduction occurs synchronously over the length of the plant, although ethylene production by basipetal tissues prior to the decrease was lower than that by more acropetal tissues. The pattern of change in ethylene production by nodal tissue, which included the axillary buds and about 5 mm of petiole, seemed to be least affected by environmental growing conditions. Ethylene could be used as a predictor for vegetative maturity stage in red-osier dogwood.**

Deciduous nursery stock must be defoliated before harvest and winter storage, but chemical defoliants applied at a premature stage of dormancy development may cause damage. The stage at which deciduous plants may be safely defoliated and harvested has been termed "vegetative maturity" by Fuchigami (7). There are no visual signs to distinguish a "mature" plant from one that is "immature," and the results of current defoliation tests for stage of development are not available until several weeks after testing. The nursery industry needs a rapid, reliable indicator of vegetative maturity of deciduous stock.

The development of vegetative maturity is intimately associated with dormancy development (7). Vegetative maturity coincides with the onset of winter dormancy in red-osier dogwood under the conditions of this test (16). Winter dormancy is defined to be the state when defoliation does not stimulate bud break under conditions conducive to active growth (16). Low levels of ethylene have been associated with dormancy in seeds (2, 3, 4, 5, 10, 11, 12), corms (8, 19), tubers (15), and buds (18, 19) and higher levels with active growth. Our preliminary research showed ethylene production in stem sections from actively growing plants of red-osier dogwood to be much greater than in dormant plants, but when this change occurred was not determined. This study was performed to ascertain whether the reduction in ethylene production could be used to rapidly and reliably predict vegetative maturity. The effects of tissue type and position on ethylene production were also investigated.

Materials and Methods

A clone of red-osier dogwood native to Wayland, Massachusetts, was propagated and grown as previously described (16).

On July 6, 1976, 2 groups of 50 pairs of plants were moved into controlled environment chambers with 10-hr photoperiods and temperatures maintained at a constant 21°C in one and day/night temperatures of 12°/7° in the other, as previously described (16, 17). A third group, containing 40 pairs of plants, was left under natural photoperiod and temperature in the lathhouse. All pairs were selected for similar size and growth habit. Weekly sampling of 5 pairs of plants from each controlled environment chamber began on July 6. Sampling of the plants in the lathhouse (5 pairs per week) began on August 19 and continued through Oct. 28.

Defoliation test for winter dormancy and maturity. At the

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time of sampling, one plant from each pair was defoliated and then maintained in a defoliated state as described previously (16). Briefly, plants were considered to be winter dormant when defoliation no longer induced bud break, and vegetatively mature when no visible injury occurred as a result of defoliation.

Ethylene production. The other plant from each pair was used to measure ethylene production. The evening before a test, 1 plant from each pair was placed in a dark room maintained at 23° ± 2°C. The following morning parts of each plant were excised and placed in vials, which were then sealed with sleeve-type serum stoppers, and returned to the dark room. About 6 hr later a 1 ml sample of the atmosphere in each vial was injected into a Carle 210 analytical gas chromatograph equipped with a 1.22 m × 3.18 mm 80/100 mesh activated Alumina column and a flame ionization detector. The temperature was 100° and the flow rate was 20 ml/min. The peak assumed to be ethylene co-chromatographed with authentic ethylene on both the Alumina column and a Porapak N column. The tissues were weighed after forced air drying at 60° for 48 hr.

Nodes (including the axillary buds and about 5 mm of the petioles), leaves and internode sections were sampled from each of 3 positions on the longest leader of each plant. These positions included the first and second node below the growing point (positions 1 and 2, respectively) and the third node from the bottom of the leader (position 3) on plants grown in the controlled environment chambers. The first, second, and third nodes below the growing point were sampled on lathhouse-grown plants. The leaf petiole was cut with a razor blade about 5 mm above the abscission zone. Nodes and internode sections were cut with razor blades arranged at a fixed distance of 7.5 mm.

Ethylene production by leaves from the first and second positions was done separately and later averaged and called "leaves," and likewise "nodes" and "internodes" refer to ethylene production averaged across the first two positions.

Results and Discussion

As measured by the defoliation test, plants grown in the 21°C controlled environment chamber were vegetatively mature and in a state of winter dormancy on August 24, those in the 12°/7°C chamber on Sept. 7, and those growing under natural photoperiod and temperature on Sept. 28 (17).

Ethylene production declined in all tissues at all positions prior to the development of winter dormancy. When ethylene production by leaves and internode sections was plotted against time, the pattern in relation to dormancy development differed between growing conditions (data not shown). Therefore, choosing a threshold value of ethylene production by leaves or internode sections to predict winter dormancy and vegetative maturity was not possible. On the other hand, the pattern of change in ethylene production by nodes was very similar in the 3 growing conditions (Fig. 1). Such consistency under very dissimilar growing conditions suggests that the pattern would remain the same in different growing seasons. This is essential if ethylene production is to be used as a predictor of vegetative maturity. Based on the data shown in Fig. 1, plants are vegetatively mature 4 to 5 weeks after ethylene production by nodal tissue has dropped below 10 nl/mg dry wt per hr.

Ethylene production could be used to predict the date on which plants would be vegetatively mature, and verify the date of vegetative maturity. Studies performed by Nissila (14) suggest there are other tests which show promise for prediction of harvestability.

Fig. 2 shows the pattern of ethylene production by the nodes at position 1, which was near the top of the plant, compared to position 3 which was near the bottom of the leader for plants grown in the 12°/7° chamber. In all growing conditions, ethylene production prior to the decrease tended to be

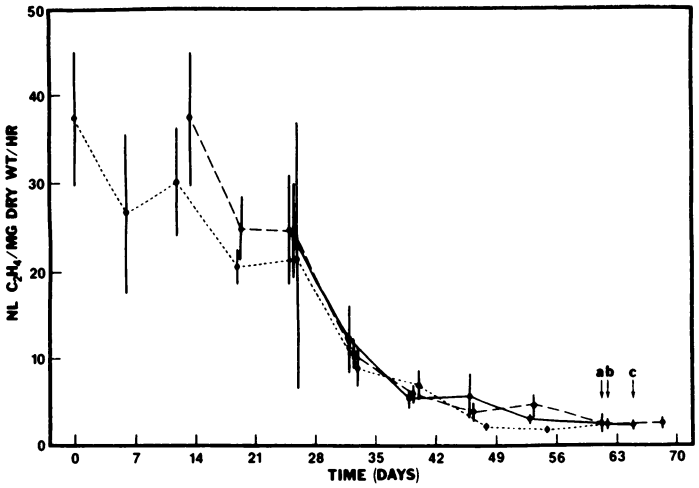

Fig. 1. The relationship between vegetative maturity and the reduction in ethylene evolution by nodes of red-osier dogwood. Ethylene curves were shifted in time and super-imposed to show their similarity. ●——●, lathhouse; ●– – –●, 21°C chamber; ●-----●, 12°/7° chamber. Arrows indicate the time of vegetative maturity corresponding to each curve; a = 12°/7° chamber, b = 21° chamber, c = lathhouse. Bars indicate standard deviations. Each point is the mean of 10 observations.

greater in the more acropetal tissues. The same pattern was generally apparent in all types of tissue, though it was most pronounced in internode tissue (16).

The increased ethylene production observed at position 1 on 12°/7° chamber plants in the 10th week (Fig. 2) was concomitant with natural leaf abscission in these plants. Leaves which had not yet abscised (and were therefore still available for sampling) also displayed elevated levels of ethylene production, but ethylene production by internode sections was unaffected. Leaves at position 3 had abscised early in the

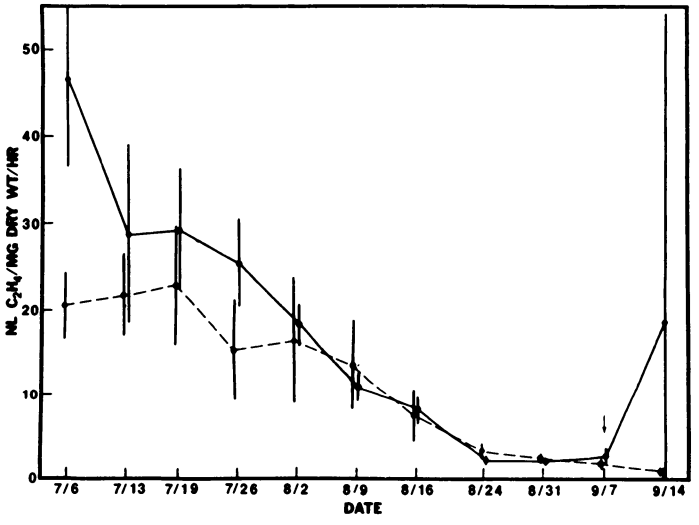

Fig. 2. Average ethylene production by nodes from 2 positions on plants grown in the 12°/7° chamber. (●——●) position 1, (●– – –●) position 3. Bars indicate standard deviations for 5 observations. Arrow indicates the date of vegetative maturity and winter dormancy development.

experiment, and no increased ethylene production can be observed at this position during the tenth week (Fig. 2).

The cause of the apparent slow-down in ethylene production during dormancy development was not determined from this study. Almost certainly wound-induced ethylene was measured in addition to normal endogenous ethylene production (1). M. Saltveit (Personal communication) found a temporary increase in ethylene production by stem sections of several woody plants beginning about 30 min after excision, with the peak occurring about 2 hr after excision. Our preliminary tests compared ethylene production by stem sections of 3 different lengths from actively growing and dormant plants. The greater the ratio of cut surface to volume, the more ethylene was produced per mg dry weight, which indicates that some of the ethylene was induced by wounding. The decrease in ethylene production during dormancy development could have been caused by a reduction in the capacity of the plants to produce ethylene, an increase in tolerance to stress by wounding, or both.

Leopold et al. (13) have used a method which allows the measurement of internal levels of ethylene before the response to wounding has occurred. A. C. Leopold and K. M. Brown (unpublished) measured ethylene content of white pine stems in the autumn and spring using this method. Ethylene content was low in Sept. and not detectable in Oct. After bud elongation began in the next spring, ethylene levels increased until the beginning of June, after which they decreased to a steady state around 0.1 or 0.2 ppm. These results indicate a seasonal pattern of ethylene production in white pine. Such a pattern may exist in red-osier dogwood and be responsible at least in part for the changes observed. Ethephon treatments prior to the vegetatively mature stage postpone the development of vegetative maturity (6). It is possible that a reduction in ethylene production is not only coincidental with, but also necessary for normal dormancy development.

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