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Vegetative Maturity of Red-osier Dogwood and Response to Herbicides[1]

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Abstract. **Plants of red-osier dogwood (*Cornus sericea* L.) treated with 2,4-dichlorophenoxyacetic acid (2,4-D) or 1,1'-dimethyl-4,4'-bipyridium ion (paraquat) after reaching vegetative maturity were much less affected by the herbicides than plants treated earlier. Data support the hypothesis that vegetative maturity is a distinct physiological stage in the development of woody plants, and that inconsistencies in herbicide efficacy can, in part, be explained by this phenomenon.**

Seasonal variations in brush control with herbicides are of considerable importance if, for reasons of economy or protection of the environment, minimum effective amounts of chemical are to be used. Timing of herbicide sprays to foliage of deciduous woody perennial plants has considerable influence on plant response (2, 5, 8, 9), and a number of physiological and environmental factors appear to be involved in optimum timing of herbicide application (1, 4). The influence of herbicides and plant growth regulators on various aspects of dormancy in perennial plants has been reviewed by Parker (11). Generally, studies (5, 8, 9) have shown that deciduous brush control with herbicides is less effective when application is made during the winter dormancy period. Unfortunately the reported results were too general and did not specify a stage of development after which plants become more tolerant of herbicides. Winter dormancy is a period encompassing a number of developmental changes.

In order to improve the effectiveness of brush control with herbicides, identification of the specific stage of development which is associated with a decline in plant susceptibility to herbicides is necessary. An identifiable stage of development, called vegetative maturity, in deciduous, woody plants, has been found in recent studies to coincide with the onset of winter dormancy (7, 12, 13) and cold hardiness, and it has been shown that plants become more tolerant of adverse conditions following vegetative maturity. Hand and chemical defoliation tests (6, 7, 10) have established that plants defoliated before reaching vegetative maturity suffer varying degrees of stem dieback. Defoliation, at or soon after vegetative maturity, resulted in delay of spring bud break (7).

In reviewing the results on brush control (5, 8, 9), greater herbicide effectiveness prior to winter dormancy seems related to development of vegetative maturity. Therefore, the objective of this study was to determine the end of the period in which effective application can be expected for 2 herbicides, in relation to the development of vegetative maturity in dogwood, a deciduous, woody plant.

Plants of red-osier dogwood, *C. sericea* (*C. stononifera* Michx.), were selected for uniformity from cuttings rooted earlier the same season. Plants with 2 stems were grown in 1.4 liter pots and kept in a lath house with natural photoperiod and temperature.

In 2 experiments, beginning in September 1973 and 1974, herbicides were applied as foliar sprays to plants about 50 cm tall at 3 rates and 4 times of application (Table 2). Paraquat and the dimethylamine salt of 2,4-D were applied in aqueous sprays of 336 liters/ha. A surfactant (X-77, containing alkylarylpolyoxyethylene glycols, free fatty acids and isopropanol) was added at a concentration of 0.1%. Plants were sprayed over the top with a table-type research sprayer. When the spray had dried, plants were returned to the lath house where they remained through the winter.

On the same dates that sprays were applied, as a part of the randomized treatments, sets of 5 plants were tested for vegetative maturity, according to the method of Fuchigami et al. (7), by hand defoliating and maintaining them leafless by subsequent removal of any regrowth.

To be certain that the time of application effect was due to developmental changes occurring in the plant, rather than differences in uptake of the herbicides as a result of leaf age, 2,4-D uptake was measured in the second year of this study. An additional set of 5 plants each, as described above, was sprayed with 1.12 and 4.48 kg/ha of 2,4-D and leaves were removed immediately after the spray had dried or 24 hr later. Those leaves collected after 24 hr were washed in 2 rinses of water and ethanol (50:50, by volume) to remove surface residues of 2,4-D and all samples were then frozen. The frozen samples were analyzed for 2,4-D by the procedure described by Chow et al. (3).

As new growth began in the spring following herbicide treatment, each plant was evaluated for date of vegetative bud break, date of full bloom of first flower, and an overall visual evaluation of plant response. Plant injury ratings were derived from observation of leaf color and size, stem injury, and spring growth and development rate as shown in Table 1. A plant with a response rating of 50 would be characterized with slight to moderate chlorosis, slight to moderate reduction in leaf size and moderate to severe delay in development. Stem tip dieback was measured and expressed as a percentage of the total stem length showing complete epidermal necrosis. Bud break and bloom date delay values were measured as deviations from the respective mean dates for these phenomena in untreated plants.

Experiments in each of the 2 years consisted of 5 single plant replications arranged as randomized complete blocks. Treatment means were compared by Newman-Keuls test following analyses of variance.

Plant responses that developed within 2 weeks following application of 2,4-D or paraquat were typical for these herbicides, as exemplified by epinasty and formative effects, followed by chlorosis and necrosis of leaves on 2,4-D-treated plants, and rapid necrosis development on paraquat-treated plants. The growth regulator type responses of 2,4-D were not apparent in regrowth

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Table 1. Rating scale of red-osier dogwood response to herbicides or defoliation.

Plant response					Rating scale value
Leaf chlorosis	Reduction in leaf size	Delay in development	Leaf and stem necrosis	Overall appearance	
				Normal	0
		Slight			20
Slight	Slight	Moderate			40
Moderate	Moderate	Severe	Slight		60
Severe	Severe		Moderate		80
			Severe	Dead	100

Table 2. Response rating in the spring of red-osier dogwood to timing of herbicide applications and defoliation the previous fall.

Treatment	Rate (kg/ha)	Plant response[z] Date[y] 1	Date 2	Date 3	Date 4
Paraquat	0.28	21a[x]	26a	13a	19a
Paraquat	0.56	56a	55a	22b	38b
Paraquat	1.12	70a	69a	25b	38b
2,4-D	0.56	12a	9a	12a	13a
2,4-D	1.12	11a	10a	13a	15a
2,4-D	2.24	35a	19ab	21ab	11b
Hand defoliated		21a	19a	10ab	1b

[z]Plant responses derived from visual evaluation (Table 1).

[y]Date 1 – Sept. 11, 1973, Sept. 19, 1974; Date 2 – Sept. 18, 1973, Sept. 26, 1974; Date 3 – Oct. 2, 1973, Oct. 3, 1974; Date 4 – Oct. 16, 1973, Oct. 17, 1974.

[x]Mean separation in rows by Newman – Keuls test, 1% level.

the following spring and foliar chlorosis and necrosis were much less severe.

According to the vegetative maturity test described by Fuchigami et al. (7), the hand defoliation treatments indicated that vegetative maturity occurred after September 19, 1973 and September 26, 1974, as evidenced by measured delay in spring bud break (Fig. 1) and growth response ratings (Table 2). On and before the above dates, the delay in bud break and growth response ratings were considerably greater than from later treatments. We did not investigate the beginning of this period of increased responsiveness to herbicides, but studies (7) with hand defoliation indicate that there is little change in the several weeks prior to vegetative maturity. Effect of treatments on bloom date followed the same pattern as for vegetative bud break but bloom date differences were not statistically significant (5% level) and are not reported here.

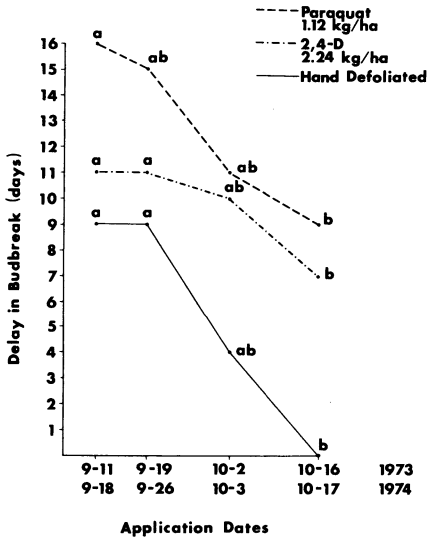

Fig. 1. Delay in budbreak as affected by date of herbicide application or defoliation the previous fall. Letters refer to mean separation between application dates, for each treatment, by Newman-Kuels test, 1% level.

Generally the injury from herbicide treatment was similar to that of the hand defoliation test for vegetative maturity. The growth response ratings indicated that significantly less injury occurred at the 0.56 and 1.12 kg/ha rates of paraquat and the 2.24 kg/ha rate of 2,4-D after the onset of vegetative maturity (Dates 3 and 4 in Table 2). The delay in bud break showed a similar relationship of vegetative maturity to time of herbicide application (Fig. 1). Treatment prior to vegetative maturity caused a considerably greater delay in bud break than later treatments. These results agree with those of Fuchigami et al. (7). They reported that the delay in spring bud break decreased as date of defoliation and defoliant application progressed from September 26 to October 24.

Additional evidence of the relationship between the date of herbicide application and date of vegetative maturity was found in the evaluation of stem dip dieback (data not included). This response was greatest with paraquat, with measured dieback resulting from sprays applied prior to vegetative maturity of 31, 36, and 84% for the 0.28, 0.56, and 1.12 kg/ha rates, respectively. In contrast, plants sprayed after vegetative maturity (October 2 or 3) showed no tip dieback (0%) the following spring.

Since there were no significant differences in 2,4-D uptake (Table 3), it is suggested that differences in response attributable to time of 2,4-D application (Table 2) are a result of developmental changes in the plant, and are not due to a reduction in efficiency of movement into the plant with the aging of leaves.

The close relationship of the herbicide timing effect to the defoliation test for vegetative maturity suggests that for maximum effectiveness, herbicides for controlling deciduous brush species must be applied prior to the onset of vegetative maturity. Previous reports (1, 8, 9) have shown a similar relationship of brush control with herbicide timing during the winter dormancy period, but, unfortunately, the precise developmental stage pivotal to herbicide effectiveness was not identified. The study reported here shows that a specific developmental stage, vegetative maturity, can be identified by measuring plant response. Vegetative maturity has been related to summer and winter dormancy (6, 7, 10, 12, 13) and procedures developed for determining vegetative maturity as a specific stage of plant development. A field test for the determination of the onset of vegetative maturity is being developed by research in progress. Further research in brush control by chemical or other methods should include a consideration of vegetative maturity and winter dormancy in these woody species.

Table 3. Uptake of 2,4-D by red-osier dogwood leaves (1974).

Treatment	Rate (kg/ha)		2,4-D residue (ppm fresh weight) Sept. 5	Sept. 19	Sept. 26	Oct. 3	Mean
2,4-D	1.12	Total applied	131	149	100	158	134
		Uptake (24 hr)	13	33	21	30	24
		Uptake (%)	10[z]	22	21	19	18
	4.48	Total applied	678	612	750	589	675
		Uptake (24 hr)	159	137	103	107	126
		Uptake (%)	23[z]	22	14	18	19

[z]No significant differences (5% level) in percentage uptake.

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Effect of Intermittent Nutrient Mist on the Propagation of Azaleas[1]

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Additional index words. Rhododendron sp., foliar absorption, nutrients

Abstract. Rhododendron **cuttings absorbed N and P from intermittent nutrient mist during propagation; there was no net uptake of K, Mg, or Ca. However, the foliage was injured and rooting was inhibited at all concentrations of nutrient mist. Cultivars differed in sensitivity to nutrient mist. 'Gloria' cuttings did not root under distilled water mist and developed symptoms resembling K deficiency. Azaleas have low nutritional requirements and nutrient mist during propagation was of no benefit.**

Foliar nutrition has been used during propagation of cuttings to correct nutrient deficiencies brought about by the leaching action of intermittent mist, and to provide nutrients for new growth produced during propagation (1, 2, 3, 7, 11). Azaleas are propagated by stem tip cuttings in large numbers and have a large leaf area for absorption, thin cuticles and low nutritional requirements (4). For these reasons azalea cuttings were used to evaluate the effectiveness of foliar nutrition in meeting nutritional requirements during, and perhaps, after propagation.

In fall, winter, and spring of 1977-78, cuttings of *Rhododendron* cvs. Gloria, Prize, Solitaire, Whitewater, Dorothy Gish, Skyliner, and Kingfisher obtained from Yoder Brothers, Inc., Ft. Myers, Florida, were graded to uniform length, leaf number, and stem diameter. Cuttings were treated with Rootone F rooting substance (0.06% IBA, 0.1% NAA), inserted in flats containing horticultural grade No. 2 vermiculite and placed in the greenhouse (21°C minimum, no bottom heat) under an intermittent mist system with either tap or distilled water. For comparison, similar cuttings were misted with either tap or distilled water to which a soluble fertilizer[3] was added, at concentrations varying from 28 mg to 170 mg/liter of mist. Initially, the intermittent mist cycle provided 8-10 sec of mist every 2.5 min from 8 AM to 8 PM daily. As rooting proceeded, the interval between mistings was lengthened. Cuttings were maintained in a vegetative state with 60-watt incandescent lamps lit from 10 PM to 2 AM placed 1.2 m above cuttings and 1.2 m apart.

At the beginning of each experiment and at 1-3 week intervals (Table 1) throughout propagation, 2 replicate samples consisting of 3 or 5 cuttings/sample were harvested from each treatment. Grouping of several cuttings/sample was necessary because of the small size of individual cuttings. Differences in fresh weight and rooting were noted; degree of rooting was based on a rooting scale of 1 (no roots), to 10 (heavily rooted). Samples were dried for a minimum of 12 hr in a forced-air oven at 100°C and weighed. Dried cutting samples were ground in a 40-mesh Wiley mill and analyzed for N by the Kjeldahl method, K, Mg, and Ca with a Beckman DV Spectrophotometer, and P colorimetrically using a Spectronic 20 spectrophotometer (8). Nutrient content was expressed as milligrams per sample (mg/s). There were 3 separate experiments with up to 5 cultivars, 5-9 sampling dates, 3-5 cuttings/sample with 2 replications per experiment for a total of 2000 cuttings. Significant differences in the full factorial design were determined by an analysis of variance procedure (9).

Cuttings of all cultivars increased in fresh and dry weight during propagation (data not shown). Dry weight of 'Prize' cuttings increased from 1.1 g/s to 2.3 g/s under distilled water mist. Cuttings supplied with 57 mg and 113 mg/liter nutrient mist increased to 1.8 g/s and 2.0 g/s respectively.

There was no change in total N/sample in 'Prize' cuttings propagated under distilled water (Table 1). There was an increase in P in the water mist cuttings which could not be explained; analysis of tap water and root medium revealed only trace amounts of P. Cuttings of all cultivars under nutrient mist were deeper green with increases in N and P during propagation as compared with those under water mist. For example, with the 57-mg concentration, the N level in 'Prize' cuttings increased from 28 mg/s at week 0 to 42 mg at week 9. With the 113-mg concentration, the N increased to 52 mg/s. Major increases appeared after 7 weeks of treatment when cuttings were partially rooted (4.0 on the rooting scale). Thus, it is not possible to attribute increased N and P content from week 7 to 9 to foliar absorption alone, although Wott and Tukey (12) showed greater foliar uptake of ^{32}P after roots appeared on *Chrysanthemum*

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[3]Ra-Pid-Gro Plant Food, Ra-Pid-Gro Corporation, Dansville, NY 14437, analysis 23N-8P-14K, 4% ammonium N (ammonium phosphate), 5% nitrate N (KNO_3), 14% urea, $MgCO_3$, $MgSO_4$.