RESEARCH NOTE

No. 73 1975

INDUCTION OF DORMANCY IN CONTAINER-GROWN WESTERN HEMLOCK: EFFECTS OF GROWTH RETARDANTS AND INHIBITORS

by

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E.P. 721.01

ABSTRACT

A preliminary study of the effects of three growth retardants (CCC, Phosphon-D and Ethrel) and two growth inhibitors (MH, and TIBA) on seven-months old container-grown western hemlock seedlings was conducted in a greenhouse for a duration of two months. Reduction of vegetative growth and bud dormancy was obtained by spraying foliage with MH and Ethrel, but not with CCC, Phosphon-D and TIBA. Both MH and Ethrel treatments resulted in dark green foliage, and suppression of shoot elongation and shoot dry matter production. In contrast to Ethrel, MH caused extensive damage to foliage and developing shoots.

Abbreviations:

CCC:	2-chloroethyl trimethyl ammonium chloride
Phosphon-D:	2, 4-dichlorobenzyl tributyl phosphonium chloride
Ethrel:	2-chloroethyl phosphonic acid
MH:	maleic hydrazide
TIBA:	2, 3, 5-triiodo benzoic acid

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INTRODUCTION

Western hemlock seedlings grown in styroblocks at forest nurseries tend to continue their growth well into the winter season and as a result they are still in a succulent condition when they are harvested. The seedlings also become over-sized if they have to be retained in the nurseries for a lengthy period. Succulent seedlings often show an inability to withstand harsh conditions associated with transportation, cold storage, or planting out in the field. Over-sized seedlings are not only difficult to handle, but the dense foliage creates a humid microenvironment favoring Botrytis infection. Therefore it is desirable to induce early cessation of growth so that the plants are in a dormant state when they are harvested.

Growth retardants are known to retard shoot elongation and increase green color of leaves without causing malformation of the plants. Treated plants are temporarily retarded, but the rate of development and the vigor of the plants are not ultimately affected (1). Although the effects of growth retardants on many plants have been documented (1), there were only a few reports concerning conifers (1-7). From these reports, the response of coniferous species to growth retardants varies from inactive, toxic, to highly selective. There are no published data on the effects of growth retardants on western hemlock.

Using growth inhibitors to control growth is common. MH has been used effectively to inhibit growth of many plants including trees (8). In conifers, MH was shown to inhibit bud break, shoot and root growth in Douglas fir (9) and Sitka spruce (10). The inhibition of growth in cypresses and pines by MH was also reported (11).

The objective of this preliminary study was to assess the effects of three growth retardants (CCC, Phosphon-D, Ethrel) and two growth inhibitors (MH, TIBA) on the growth of container-grown western hemlock seedlings.

MATERIALS AND METHODS

Western hemlock seedlings of about seven months old were used in this experiment. The seedlings were sown and grown at the Duncan Nursery in a mixture of peat and vermiculite (3:1) in styroblock containers of 2 cu. in. capacity.

The experiment was carried out in November 1973 in a greenhouse which provided a 16-hour photoperiod using artificial light to supplement natural light. A themoperiod of 15^{o} C night and 25^{o} C day was maintained.

Three growth retardants (Ethrel, CCC, Phosphon-D) and two growth inhibitors (MH, TIBA) were used. The concentrations of each compound applied were found to be effective in other plants (6, 9, 12, 13, 14) and are listed in Table I. They were sprayed to run off once weekly for three consecutive weeks as an aqueous solution in 0.1% Tween 20. The duration of the experiment was two months after the first spray. The seedlings were supplied with nutrient twice weekly (15). Adequate moisture was maintained by watering.

For each regulator treatment, three replicates were run. Each replicate consisted of 16 seedlings, from which four seedlings were randomly selected for measurements. The replicates for each treatment were arranged in a randomized block design. Measurements were taken of shoot length at the beginning and at the end of the experiment, while dry weight of shoot and root was determined at the end of the experiment only. Bud set during the experiment was noted. Data were analyzed by Duncan's new multiple range test.

RESULTS AND DISCUSSION

The results are presented in Table I.

Phosphon-D, CCC

The application of either Phosphon-D or CCC at all concentrations failed to retard vegetative growth. Shoot elongation was slightly depressed but was not significant statistically. Both compounds caused chlorosis at the apex of the needles. This effect was more prominent at the higher concentrations. No bud dormancy was found.

TIBA

This inhibitor suppressed shoot elongation and at higher concentrations reduced dry matter production of shoot and root. However these reductions were not statistically significant. At 2,000 ppm, the shoot/root ratio was significantly higher than that of the control. This indicates a relatively greater reduction of root growth than that of shoot. At higher concentrations, the new foliage appeared to be stunted. The young needles were small in size and epinastic. Chlorosis occurred in the older needles. Bud dormancy did not occur.

MH

MH completely suppressed shoot elongation at 500, 1,000 and 2,000 ppm. At 100 ppm, the lowest concentration applied, shoot elongation was only 2% of that of the control. Shoot dry matter production was significantly depressed at all concentrations. Root dry matter production was not affected at 100 and 1,000 ppm, but there was a considerable decrease at 500 and 2,000 ppm. Although the decrease was not statistically significant, it did result in higher shoot/root dry weight ratios than those of 100 and 1,000 ppm. The latter ratios were significantly lower than that of the control. Bud dormancy was observed to occur at

TABLE I. Growth response of western hemlock seedlings treated with growth regulators

Initial age of seedlings-seven months. Values represent % of untreated control seedlings
S = Value differs significantly from the control (p=0.05)

Regulator	concn (ppm)	shoot elongation (%)	bud set	shoot dry wt. (%)	root dry wt. (%)	shoot/root dry wt. ratio (%)
Phosphon-D	100	74	NO	117	122	93
	500	65	NO	109	100	111
	1000	80	NO	108	85	121
	2000	86	NO	114	93	116
CCC	500	82	NO	84	85	101
	1000	92	NO	89	82	109
	2000	80	NO	85	89	105
	3000	85	NO	110	123	96
TIBA	100	95	NO	118	98	105
	500	74	NO	120	106	107
	1000	64	NO	97	75	117
	2000	57	NO	84	74	119^s
MH	100	2^s	YES	70^s	101	68^s
	500	0^s	YES	55^s	61	88
	1000	0^s	YES	74^s	104	71^s
	2000	0^s	YES	61^s	72	89
Ethrel	100	76	NO	97	112	90
	500	34^s	YES	71^s	98	79^s
	1000	24^s	YES	81^s	100	85^s
	2000	9^s	YES	71^s	116	62^s

about the third week of the experiment for all concentrations. The foliage appeared dark green but some showed chlorosis and turned brown, especially in the apex regions. Toward the end of the experiment, defoliation started and this effect increased with increasing concentrations. When the seedlings were kept for another two months in the greenhouse, growth did not resume but defoliation intensified.

Obviously at the concentrations used in this study, MH was very effective in suppressing growth of western hemlock seedlings, but its extensive damaging effects to the seedlings render it impractical for use in controlling growth. Perhaps a more desirable response may be obtained at lower concentrations.

Ethrel

At concentrations of 500, 1,000 and 2,000 ppm, ethrel significantly retarded shoot elongation of western hemlcok seedlings. This effect increased with increasing concentrations. Shoot dry matter production was also significantly reduced but no reduction occurred in root dry matter production. The shoot/root dry weight ratios were lower than that of the control. At all concentrations, the foliage was dark green and no chlorosis appeared throughout the experiment. Dormant buds started to form at about the third week of the experiment. However, when the seedlings were kept for another two months in the greenhouse, shoot growth resumed, but the new growth appeared normal.

To further check the practical application of ethrel, a small-scale test was conducted in mid-November of 1974. Three styroblocks of seven-months old western hemlock seedlings were treated as before with 1,000 ppm ethrel in the greenhouse. The seedlings were overwintered at the Duncan nursery under a plastic house which had no heating system. Within approximately three weeks the seedlings stopped height growth and the foliage became dark green. Dormant buds formed and persisted throughout the winter. Bud break subsequently occurred in the spring, whereas the untreated seedlings continued to grow and became branchy with thick foliage. Unlike the ethrel-treated ones, the untreated seedlings showed signs of frost damage and serious Botrytis infection.

The mechanism exerted by ethrel on the plant is not yet fully understood. The growth regulatory effects of ethrel have been attributed to the liberation of ethylene at cytoplasmic pH within plants (16). The dormant buds formed by western hemlock after ethrel treatment, flushed again in the greenhouse. This may indicate that ethrel can induce only the early stage of dormancy, i.e. predormancy (17). However, a true dormant state could be obtained, as shown in this study, by further subjecting the treated plant to winter conditions, perhaps chiefly low temperature. It would be interesting to see if a true dormant state can be achieved by applying higher concentrations of ethrel to the seedlings.

The foregoing experiments indicate that ethrel treatment has considerable potential for improving production of western hemlock container nursery stock, primarily through its effects on induction of dormancy and delay of bud break. Application of ethrel is practical since automatic fluid feeding systems have been developed for container nurseries.

Additional information on the effects of ethrel are required, especially with respect to the minimum period of post-treatment time needed to induce early dormancy and its relation to temperature, the effects of higher ethrel concentrations, the frequency and time of application, and the long term effects of ethrel treatment after planting in the field. Investigations are now underway to study some of these effects.

ACKNOWLEDGEMENTS

I wish to thank several members of the British Columbia Forest Service Research Division: Mr. M. Kovats for statistical analysis, Mr. D. B. Russell for technical assistance, Mr. R. L. Schmidt for valuable suggestions during the preparation of this research note, and to the British Columbia Forest Service Reforestation Division for providing the western hemlock seedlings for this study.

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