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INDUCTION OF DORMANCY IN CONTAINER-GROWN WESTERN HEMLOCK (*Tsuga heterophylla* (Raf.)Sarg.)*

by

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Abstract

Western hemlock first year seedlings were grown for 26 weeks in a series of artificial environments. Early dormancy was induced by withdrawal of NPK or N from nutrient solution, short (8 hr.) photoperiod, tolerable water stress and low temperature (12°C - 17°C). Among all treatments only short photoperiod resulted in dormant seedlings with dark green foliage and higher nitrogen content than the control, while others had pale green foliage and lower nitrogen content.

Introduction

A problem reported by the Reforestation Division in the container nursery at Surrey is that seedlings continue to grow late in the first season at a time when they must be transported, perhaps temporarily stored, or planted out. A succulent condition renders plants susceptible to physical damage during these operations, and represents a general inability to withstand the water, nutrient and freezing stresses which accompany planting in relatively harsh conditions (1).

* This investigation (E.P. 721) was carried out by R. Timmis formerly of B.C. Forest Service. The author designed the harvest and conducted the analysis of experimental results.

It is known that imposition of unfavorable conditions tends to result in earlier growth cessation and induces premature dormancy. Seedlings in a dormant state are likely to have a higher ability to withstand stresses (2, 3, 4). Therefore the object of this investigation was to find which treatment would induce dormancy in container-grown western hemlock.

Materials and Methods

After stratification, seeds of a coastal western hemlock provenance were sown and germinated in a mixture of peat and vermiculite (3:1) in styroblock containers of 2 cu. in. capacity. The seedlings were grown in the greenhouse which provided a 16 hour photoperiod using artificial light to supplement natural light. Temperature was maintained at about 22°C. There were five treatments which included normal (control), withdrawal of nutrients, short photoperiod, water stress and low temperature.

Normal treatment (control). Seedlings were subjected to 16 hours photoperiod and a temperature of about 22°C. Nutrient solution (Table 1) was applied twice weekly and adequate moisture was maintained by watering.

Table 1. Source and concentration of nutrients used in control nutrient treatment.

Nutrient	Source	Concn., p.p.m.
Macronutrients		
N	NH_4NO_3	16.3
P	H_3PO_4	6.4
K	K_2SO_4	42.8
Ca	$CaCl_2$	28.6
Mg	$MgSO_4$	14.1
S	K_2SO_4+$MgSO_4$	17.6+18.9
Fe	Iron chelate	6
Micronutrients		
Mn	$MnCl_2$	0.2
Cu	$CuSO_4$	0.02
Zn	$ZnSO_4$	0.02
Mo	$NaMoO_4$	0.003
B	H_3BO_3	0.2

Withdrawal of nutrients. Nitrogen, phosphorus and potassium (NPK) were withdrawn from the nutrient solution starting at the 12th, 14, 16th, 18th and 20th week after sowing. N and PK were also withdrawn independently at the 14th week.

Short photoperiod. Seedlings were provided only 8 hours of natural light by means of removing and replacing a black polyethylene cover on a framework during the day. Treatments started at week zero, 14, 16 and 18, after sowing.

Water stress. Seedlings were maintained at a tolerable water stress level by automatically controlling water supplies. Watering would start when the weight of a reference styroblock was below a predetermined value. This treatment began at the 14th, 16th and 18th week after sowing.

Low temperature. At the 18th week after sowing the seedlings were transferred to a growth chamber which provided a 16 hour photoperiod of artificial light, and the temperature was held at 12°C for the first three weeks and at 17°C for the remaining five weeks.

Each sub-experiment was arranged in a completely randomized block and all treatment was replicated three times. Each replicate was a quarter styroblock containing 48 seedlings. The duration of this investigation was 26 weeks after sowing. At the end of the experiment, shoot length, number of lateral branches, percentage of protected terminal buds on the main stem, dry weights and nitrogen concentrations of root, shoot and whole seedling were determined. The color of foliage was also noted. Data presented in this report are means of three replicates totalling 45 measurements. For nitrogen analysis triplicate analyses of each treatment were carried out. Data were analyzed by Duncan's new multiple range test.

Results and Discussion

Two criteria were employed to determine induction of dormancy: the formation of a protected terminal bud on the main stem (leader) and the reduction of vegetative growth. The effects of the various environments upon the initiation of dormancy are summarized in Table 2. In general, dormancy was induced by all the test environments.

Vegetative growth. Shoot length, number of lateral branches and dry matter production were reduced by all treatments as compared with the control while the root/shoot dry weight ratios were higher than that of the control (Table 2). This indicates the reduction of vegetative growth was greater in the shoot than in the root system. In the nutrient withdrawal treatment at the 14th week, omitting NPK elements had the same effects as omitting N alone on all the parameters measured, while withdrawal of PK had no significant effects at all. This suggests that withdrawal of N, not PK, was largely responsible for the induction of dormancy.

Formation of protected terminal buds on main stem. All treatments eventually resulted in a significantly high percentage of terminal bud dormancy while the control continued flushing throughout the experimental period (Table 2). Short photoperiod treatment, in particular,

displayed a complete (100%) terminal bud dormancy even for the latest treated seedling (at the 18th week). In the water stress treatment, formation of terminal buds was affected by the time of application, i.e. a higher percentage for withdrawal at the 16th week than for withdrawal at the 14th and 18th weeks. This suggests that there could be an optimum response time to treatment for the formation of terminal buds.

Nitrogen content in seedling. Nitrogen concentration was found to be significantly lower in seedlings subjected to withdrawal of NPK and N, water stress and low temperature than in control seedlings (Table 2). Short photoperiod treatment, however, resulted in a significantly higher nitrogen concentration.

Foliage color. As a result of withdrawal of NPK (at 12th and 14th weeks) and N (at 14th week), water stress and low temperature treatments, the foliage color appeared to be pale or yellowish green as compared to the green color of the control. Short photoperiod treatment on the other hand resulted in dark green foliage.

Considering all the experimental results, it can be concluded that early dormancy of western hemlock seedlings was induced by the withdrawal of NPK or N, by water stress, by low temperature and by short photoperiod treatments. By virtue of its dark green foliage, high seedling nitrogen concentration and complete and early attainment of terminal bud dormancy, short photoperiod treatment could be the better method of producing dormant seedlings. Seedlings of white spruce, with dormancy induced by short photoperiod, were reported to have the ability of resisting severe drought (5). Short photoperiod treatment is practical but problems may develop, such as heating of covered stock, if it is to be used on container seedlings grown by current methods. However the ultimate success of short photoperiod, or any other treatment, mainly relies on the ability of the dormant seedlings to withstand handling, and their survival and performance after planting.

References

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TABLE 2. Effect of imposed stresses on shoot length, number of lateral branches, formation of protected terminal buds on the main stem, dry matter production, and nitrogen concentration, of western hemlock.

Treatment	Treatment started at week	Shoot Length (cm)	Number of lateral branches	% protected terminal buds on main stem	Dry Weight (g) Shoot	Root	Whole plant	Root/shoot Weight Ratio	N concn. as % of dry weight Shoot	Root	Whole plant
Control	0	16.2	13.3	0	0.690	0.252	0.942	0.365	0.859	1.078	0.918
- NPK	12	7.9^{S} **	6.8^{S}	88.9^{S}	0.215^{S}	0.152^{S}	0.367^{S}	0.710^{S}	0.520^{S}	0.464^{S}	0.497^{S}
- NPK	14	9.9^{S}	7.9^{S}	77.8^{S}	0.352^{S}	0.206	0.559^{S}	0.588^{S}	0.468^{S}	0.522^{S}	0.488^{S}
- NPK	16	14.5	12.3	0	0.588	0.218	0.805	0.371	0.985	1.038	1.000
- NPK	18	14.7	12.6	0	0.627	0.253	0.880	0.401	0.950	0.942^{S}	0.948
- NPK	20	16.1	13.2	2.2	0.641	0.258	0.898	0.400	0.987	0.536^{S}	0.865
- N	14	11.0^{S}	9.9^{S}	51.1^{S}	0.339^{S}	0.230	0.569^{S}	0.679^{S}	0.597^{S}	0.913^{S}	0.725^{S}
- PK	14	15.3	12.6	2.2	0.624	0.257	0.881	0.411	1.028	0.892^{S}	0.988
Short Photoperiod	0	1.7^{S}	0.1	100^{S}	0.012^{S}	0.007^{S}	0.019^{S}	0.570^{S}	2.012^{S}	2.376^{S}	2.145^{S}
Short Photoperiod	12	7.9^{S}	6.8	100^{S}	0.243^{S}	0.196^{S}	0.439^{S}	0.810^{S}	1.471^{S}	1.146	1.326^{S}
Short Photoperiod	14	9.6^{S}	8.3	100^{S}	0.289^{S}	0.204^{S}	0.493^{S}	0.712^{S}	1.515^{S}	1.224^{S}	1.395^{S}
Short Photoperiod	16	10.9^{S}	9.4	100^{S}	0.359^{S}	0.225	0.584^{S}	0.631^{S}	1.334^{S}	1.162	1.268^{S}
Short Photoperiod	18	14.4	12.9	100	0.490^{S}	0.182^{S}	0.673^{S}	0.371	1.257^{S}	1.120	1.220^{S}
Water Stress	14	9.8^{S}	8.4	60.0^{S}	0.339^{S}	0.205	0.544^{S}	0.603^{S}	0.534^{S}	0.615^{S}	0.564^{S}
Water Stress	16	11.9^{S}	10.6	66.7^{S}	0.490^{S}	0.289	0.779	0.592^{S}	0.494^{S}	0.561^{S}	0.519^{S}
Water Stress	18	13.0^{S}	11.6	44.4^{S}	0.591	0.320	0.911	0.542^{S}	0.568^{S}	0.623^{S}	0.587^{S}
Low Temperature	18	7.4^{S}	7.2	60.0^{S}	0.374^{S}	0.242	0.616^{S}	0.647^{S}	0.629^{S}	0.858^{S}	0.719^{S}

** Values marked by the letter S are significantly different ($p = 0.05$) from the control.