EFFORTS TO ACCELERATE THE PRODUCTION OF FRASER FIR SEEDLINGS

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Abstract Fraser fir seedlings were grown in containers, in a greenhouse and were supplied with either 200, 308, 415 or 630 ppm nitrogen applied at a rate of 10ml/seedling/week. Seedlings were exposed to either 4 weeks of natural chilling, or 4 or 6 weeks of artificial chilling at 2 C to break dormancy. To determine the optimum light level for Fraser fir seedling photosynthesis, photosynthesis-light intensity curves were developed. Height growth of seedlings after 36 weeks was greatest at the 200 ppm nitrogen level where they averaged 8.3 cm. Four weeks of artificial chilling resulted in the best height growth and elongation. Fraser fir photosynthesis in both 8-month-old and 3-yearold seedlings became light saturated at approximately 550 uMol/m s PPFD.

Additional keywords: Abies fraseri , nitrogen fertilization, cold storage, height growth, photosynthesis.

Demand for Fraser fir (Abies fraseri. (Pursh) Poir.) seedlings continues to exceed their supply in most years. As a result, there is considerable interest in accelerating and increasing the production of Fraser fir seedlings.

Growing seedlings in containers, in a greenhouse, offers the potential for accelerating the production of plantable Fraser fir seedlings. Optimum growing conditions for Fraser fir seedlings in a greenhouse have not been determined. Past research has indicated that nitrogen fertilization can greatly enhance the growth of containerized Fraser fir seedlings (Black 1980); however, the optimum nitrogen level for maximizing seedling size has not been identified. In addition, no research has been done on the light-photosynthesis relationship of Fraser fir. Photosynthesis provides the carbohydrates for growth and the light level for maximizing photosynthesis is unknown. Fraser fir seedlings are often shaded during the summer months; however, how much shade can be applied before photosynthesis is reduced is unknown.

Even if given optimum growing conditions, Fraser fir seedling growth is limited in a greenhouse because seedlings become dormant or exhibit abnormal development. Short periods of chilling have been found to break this dormancy and allow Fraser fir to continue normal elongation (Hinesley 1982).

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The objectives of this research were to: 1) examine the effect of nitrogen fertilization on the height growth of Fraser fir; 2) evaluate the effectiveness of short periods of cold storage on breaking dormancy in Fraser fir, and 3) develop photosynthesis-light intensity curves for two ages classes of Fraser fir seedlings.

METHODS

Nitrogen Fertilization and Cold Storage Treatments

Fraser fir seed collected from Mt. Rogers, Virginia was planted in 175 cc Spencer-Lemaire Rootrainers (Edmonton, Alberta, Canada) filled with ProMix BX. Seedlings were grown under ambient light, supplemented with high pressure sodium vapor lamps to maintain a 16-hour photoperiod. Minimum temperature in the greenhouse was 21 C and the greenhouse was ventilated when temperatures reach 26 C.

Following germination and an initial two week growing period, seedlings were fertilized with either 200, 308, 415 or 630 ppm nitrogen. Rates of phosphorus and potassium were held constant at 90 ppm and 170 ppm, respectively, over the four treatments. Fertilizer was applied weekly at a rate of 10 ml per seedling throughout the Length of the experiment. Commercial fertilizers, Peters General Purpose (20N-20P-20K) and Peters Azalea Neutral (21N-7P-7K) (W.R. Grace Co., Fogelsville, Pa) were used singly, and in combination to provide all treatment combinations.

After 18 weeks of growth, supplemental lighting was removed and the seedlings were exposed to 6 weeks of ambient January and February day lengths. Seedlings were then chilled for 4 or 6 weeks at a constant 2 C in a coldroom or placed in an unheated greenhouse and exposed to 4 weeks of ambient March temperatures (natural chilling). The average day and night temperatures for the natural chilling period were 21 and 3 C, respectively. Six nights below freezing occurred with the lowest recorded temperature being -4 C. A control group of seedlings were kept in a heated greenhouse under a 16-hour photoperiod.

Seedling height and elongation following cold storage were measured after eight more weeks of growth, when the seedlings were a total of 36 weeks old.

A factorial arrangement of nitrogen fertilization and cold storage treatments were combined using a split-plot design with five replications of 16 seedlings each. Cold storage treatments were used as main plots and nitrogen treatments *as* subplots. The data were analayzed using analysis of variance followed by Duncan's multiple range test to seperate treatment differences.

Photosynthesis-Light Intensity Curves

Net photosynthesis was measured on individual 8-month-old and 3-year-old seedlings from the same Mt. Rogers seed source at light intensities ranging from 10 to 1000 uMol/m /s photosynthetic photon flux density (PPFD). A high intensity sodium vapor lamp was used as the light source. Various levels of shade cloth were used to provide a wide range of light levels.

Seedling CO_2 exchange was measured using an open system. Flow rate was adjusted such that CO_2 depletion did not exceed 30 ppm. The seedling cuvette was supplied with a high speed fan to minimize boundary layer resistance and was placed under a water filter to prevent heat buildup within the cuvette. Temperature within the cuvette was 25 C ±2C and Relative humidity 50 ±5% . Photosynthesis was expressed as a percent of maximum at light saturation.

RESULTS AND DISCUSSION

Nitrogen Fertilization and Cold Storage Treatments

Nitrogen fertilization had a significant impact on seedling height and elongation following nine months of growth (Table 1). No interaction between nitrogen fertilization and cold storage treatments occurred. Best growth occured at the 200 ppm and 308 ppm nitrogen level which averaged 8.3 and 8.1 cm in height, respectively. Growth began to drop rapidly at the 415 ppm level and was poorest at the 630 ppm level. Elongation exhibited the same pattern as total height growth in response to the nitrogen treatments.

Conclusions as to whether 200 ppm nitrogen is optimum for Fraser fir growth can not be made. Growth was maximum at this rate, but possibly some lower level would produce equivalent or greater growth. In contrast, Black (1980) found ten-week-old Fraser fir seedling height to increase linearly with up to 317 ppm nitrogen applied at nearly twice the rate as this study. No higher concentrations were used in Black's (1980) study. Differences in these studies could possibly be due to the young age of Black's seedlings.

The effect of cold storage on seedling height and elongation is shown in Table 2. Both total height growth and elongation were greatest following four weeks of natural chilling. Control seedlings never exposed to cold or short days grew the poorest. The differences in total height following cold storage is due largely to differences in elongation. Four weeks of natural chilling maximized elongation, while seedlings never exposed to any cold exhibited extremely poor elongation (Table 2). A large percentage of control seedlings exhibited stunted and abnormal elongation similar to that reported by Hinesley (1982).

Photosynthesis-Light Intensity Curves

Light saturation curves for 8-month-old and 3-year-old containerized seedlings are shown in figure 1. Both seedling ages exhibit maximum photosynthesis at approximately 550 $uMol/m^2 s$ PPFD. These results compare well with balsam fir _(Abies balsamea_ (L.) Mill.) which was found to light saturate at 3000 foot-candles (approximately 550 $uMol/m^2 s$ PPFD) (Clark 1961). Based on these curves, shading should not be used if light levels are reduced much below 550 $uMol/m^2$

s PPFD since photosythesis begins to$_2$ drop rapidly below this light level. Light levels below 550 uMol/m s PPFD often occur in glasshouses during the winter months; therefore, supplemental lighting could be beneficial.

Table 1. Height growth of 36-week-old containerized Fraser fir seedlings as affected by nitrogen fertilization

Nitrogen Level	Total Height	Elongation
(ppm)	(cm)	(cm)
200	8.3 a	5.1 a
308	8.1 a b	4.9 a b
415	7.7 b	4.6 b
630	6.8 c	3.7 c

Means within columns followed by the same letter do not differ significantly (alpha = 0.05).

Table 2. Height growth of 36-week-old containerized Fraser fir seedlings as affected by cold storage.

Cold Treatment	Total Height	Elongation
	(cm)	(cm)
4 weeks, Natural	8.8 a	5.8 a
4 weeks, Cold Room	8.1 a b	5.2 a b
6 weeks, Cold Room	7.2 b c	4.3 b
Control, No Cold	6.6 c	3.1 c

Means within columns followed by the same letter do not differ significantly (alpha = 0.05)

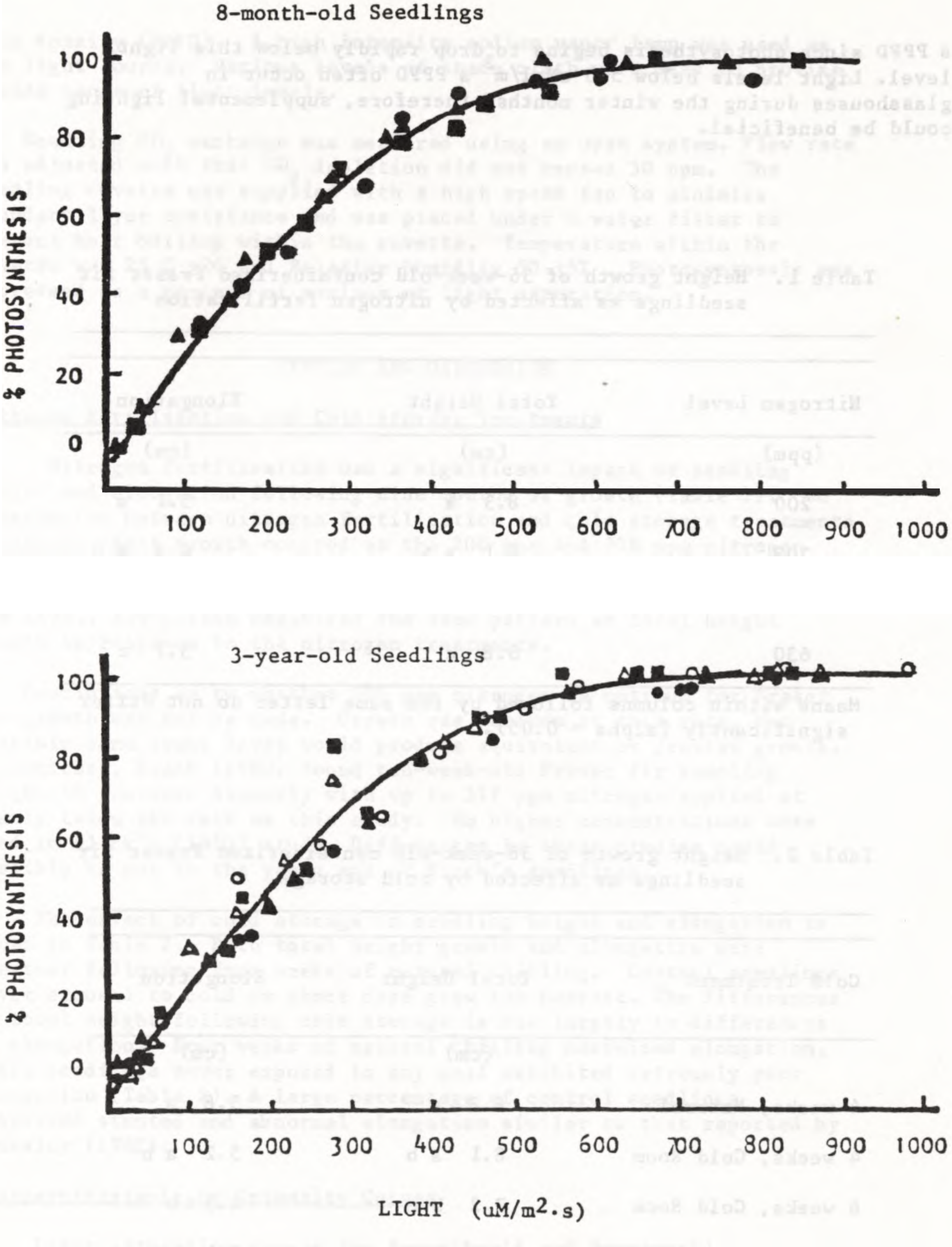

Figure 1. Light saturation curves for 8-month-old and 3-year-old containerized Fraser fir seedlings. Each symbol represents a separate seedling.

SUMMARY AND CONCLUSIONS

Short periods of chilling greatly improved the growth of containerized Fraser fir. Seedlings which were not chilled exhibited poor elongation and abnormal development. Nitrogen fertilization above 200 ppm applied at a rate of 10ml/week/seedling did not increase growth, and at levels of 415 and 630 ppm nitrogen, growth was decreased. Frazer fir photosynthesis in both 8-month-old and 3-year-old seedlings became light saturated at approximately 550 uMol/m^2 s PPFD. Artificial shading that reduces light below this level should be avoided.

LITERATURE CITED

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