Short Day Exposure to Induce Budset Prolongs Shoot Growth in the Following Year[1]

Kerry D. Odlum and Stephen J. Colombo[2]

Odlum, Kerry D.; Colombo, Stephen J. 1988. Short Day Exposure to Induce Budset Prolongs Shoot Growth in the Following Year. In: Landis, Thomas D., technical coordinator. Proceedings, Combined Meeting of the Western Forest Nursery Associations; 1988 August 8-11; Vernon, British Columbia. General Technical Report RM-167. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 57-59. Available at: http://www.fcnanet.org/proceedings/1988/odlum.pdf

Abstract.--Short day exposure applied in the greenhouse prior to overwintering container black spruce (Picea mariana [Mill.) B.S.P.) seedlings dramatically influenced the timing and duration of shoot growth in the first year after out-planting. When compared with seedlings grown under natural daylength bud initiation regimes in the year prior to planting, short daylength seedlings flushed sooner in the spring and set bud later at the end of the growing season, resulting in greater shoot growth. The extended duration of shoot growth in SD seedlings is expected to place them at greater risk of damage from both late spring and early fall frosts.

INTRODUCTION

Conifer seedling response to photoperiod has been studied a great deal since early work by Kramer (1936) and is well reviewed by Arnott and Mitchell (1982) and Lavender (1980). In spruce, terminal buds are induced under short daylengths while vegetative shoot growth continues under long days (Dormling et al. 1968). This knowledge is necessary for nurserymen to successfully grow spruce seedlings in a greenhouse. When height growth is needed in a crop, it can be ensured, regardless of the natural daylength, by artificially extending the daylength within the greenhouse or by interrupting the dark period during the night (Arnott 1974). Similarly, by shortening the daylength within the greenhouse a nursery manager can rapidly and uniformly terminate shoot growth and induce budset in his crop at any time of year.

Because of the greater control in production schedules afforded by the use of short daylength exposure, the procedure is now routinely applied in black spruce (Picea mariana [Mill.] B.S.P.) production at approximately 30% of all container seedling nurseries in Ontario.

Daylength treatments applied in the greenhouse are known to influence the timing and/or growth of seedlings the year following treatment, depending upon species (Arnott and Macey 1985, Heide 1974). The objective of this study was to determine whether similar after-effects occur with black spruce seedlings that have set bud under short daylengths in operational greenhouse production.

MATERIALS AND METHODS

Seedlings used in this study were grown operationally in 1986 at a greenhouse nursery near Englehart, Ontario (47°49'N, 94°55'W) where both natural daylength (ND) and short daylength (SD) bud initiation regimes were applied. Seedlings of a site region 3E (Hills 1960) seed source were grown using a schedule similar to that of Carlson (1983) with the exception of bud initiation regimes which are summarized in table 1. The three SD treatments (S1, S2 and S4) varied by time of application while the natural daylength

Table 1.--Greenhouse daylength regimes for bud initiation.

Treatment	Seeding date (1986)	Short day applied (1986)
S1	April 9	July 2
S2	April 9	July 17
S4	April 10	July 29
EG	April 29	n/a
ER	April 9	n/a

[1]Paper presented at the combined meeting of the Western Forest Nursery Council and Forest Nursery Association of B.C., Vernon, B.C., August 8-11, 1988.

[2]Kerry D. Odlum and Stephen J. Colombo are Research Scientists, Ontario Tree Improvement and Forest Biomass Institute, Ontario Ministry of Natural Resources, Maple, Ont.

treatments permitted bud initiation to occur either in the greenhouse (EG) or outside (ER). All seedlings were overwintered outside. On April 30, 1987, seedlings from two FH408 Japanese paperpot® trays were randomly sampled from each of the five treatments and were planted in a randomized block design in a cultivated field at the Midhurst Research Station of the Ontario Tree Improvement and Forest Biomass Institute (44°27'N, 79°44'W). A total of 150 seedlings per treatment were assessed weekly for bud break and shoot elongation. Beginning 39 days after planting and at weekly or biweekly intervals thereafter, a sample of 20 seedlings per treatment was removed randomly from the plantation and shoot tips were examined under a dissecting microscope for signs of bud initiation, evident as newly differentiated budscales at the base of the vegetative apex. Seedling height at planting and new shoot length were measured in the fall, after shoot growth had ceased.

RESULTS AND DISCUSSION

Seedlings that received SD bud initiation regimes in 1986 (treatments S1, S2, S4) began to break bud sooner than did seedlings from ND bud initiation regimes (fig. 1). In general, seedlings from the SD regimes attained maximum percentage bud break 14 days after planting while the seedlings from the ND regimes did not reach that point until 21 days after planting. Heide (1974) found a similar relationship between SD bud initiation regimes and the timing of bud break in Norway spruce (Picea abies (L,) Karst.). It is likely that the earlier flushing SD seedlings in this experiment were at greater risk of being damaged by late spring frosts. Although such frost damage was not observed in this 1987 experiment, it has occurred in a similar trial in 1988 where approximately 41% of the terminal shoots in SD seedlings were killed by late spring frosts as compared with 3% mortality in the shoots from ND bud initiation regimes. The extent of damage to SD seedlings could be expected to vary with timing and severity of frost exposure.

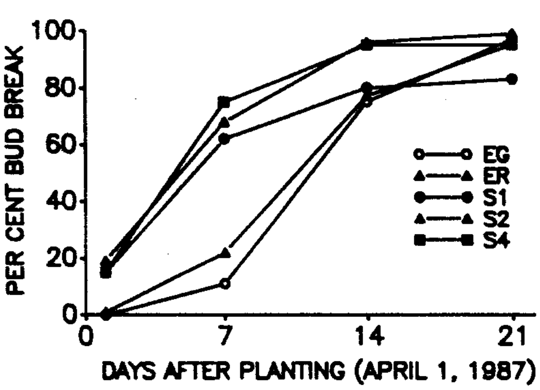

Figure 1.--Bud break in seedlings grown under natural daylength (EG, ER) and short daylength (S1, S2, S4) bud initiation regimes in the previous season.

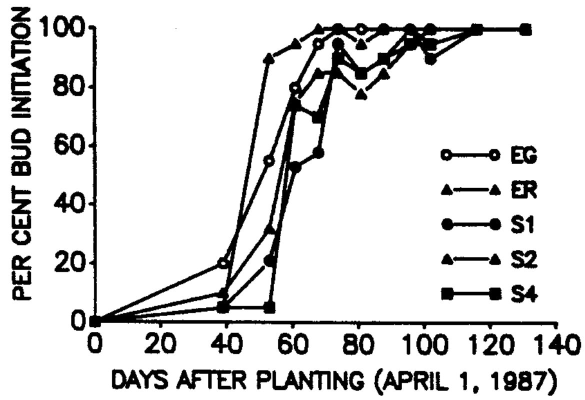

Figure 2.--Bud initiation after planting in seedlings grown under natural daylength (EG, ER) and short daylength (S1, S2, S4) bud initiation regimes in the previous season.

First signs of bud initiation were detected in all treatments 39 days after planting (fig. 2) but 100% bud initiation was not reached in each of the SD treatments until 3 to 6 weeks later than in the ND treatments (fig. 3). The effect of later bud initiation is apparent in the relative proportion of seedlings still exhibiting active growth throughout the late summer (fig. 4). Active seedlings were those in which weekly terminal shoot elongation exceeded 5 mm. After June 3, there were always more SD seedlings active in the plantation than there were ND seedlings. By August 12, 8% of the SD seedlings were still elongating while less than 13 of the ND seedlings were. Because of the greater proportion of SD seedlings continuing growth, a larger number of SD seedlings would be at risk of being damaged by late summer frosts.

Although seedlings from the SD regimes were shorter when planted, their growth after outplanting at the end of the first growing season was greater than seedlings from the ND regimes

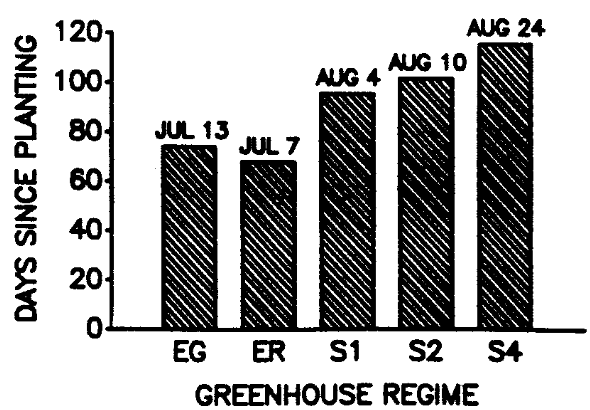

Figure 3.--Date and number of days after planting when 100% bud initiation was attained in seedlings grown under natural daylength (EG, ER) and short daylength (S1, S2, S4) bud initiation regimes in the previous season.

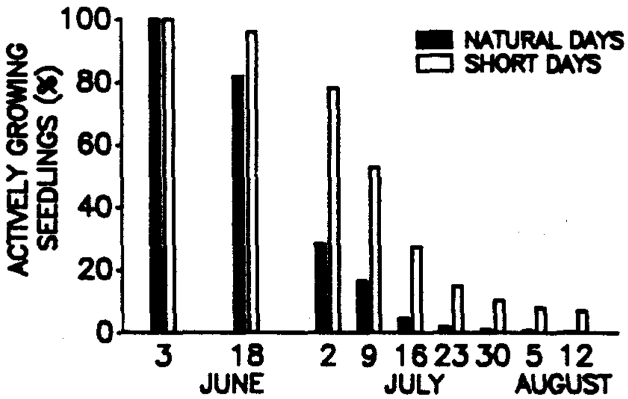

Figure 4.--Percentage of seedlings exhibiting active shoot growth in first season after planting. Natural day values are grand means from EG and ER treatments and short day values are grand means from S1, S2 and S4 treatments.

(fig. 5), primarily as a result of earlier bud break and later bud initiation. Similarly, Heide (1974) found greater growth in Norway spruce seedlings exposed to SD in the previous year for up to 3 years after planting, but did not attempt to correlate this with the timing and duration of shoot growth. In contrast, our results from a plantation established in 1986, indicate that after-effects did not persist past the first season in the field.

The mechanism by which a two week short daylength treatment can have such a dramatic effect on the timing and duration of shoot growth in the field more than one year after exposure is still unknown. At the Ontario Tree Improvement and Forest Biomass Institute, studies are currently in progress to determine some of the consequences of this growth phenomenon. For example, frost hardiness testing in the late summer and autumn is being carried out on out-planted black spruce seedlings from SD and ND regimes to determine whether differences in the timing of frost hardening occur. Intensive monitoring of operationally planted seedlings is underway to assess the risk of damage from frost associated with planting seedlings that flush sooner and set bud later. Needle production in the field is being compared to needle primordia content of the bud prior to planting to determine if free growth accounts for the greater growth found in the SD seedlings. It is yet to be determined whether the nursery production benefits and greater first-year seedling growth potential derived from SD treatment outweigh the risk of frost damage associated with earlier bud break and later budset in black spruce seedlings.

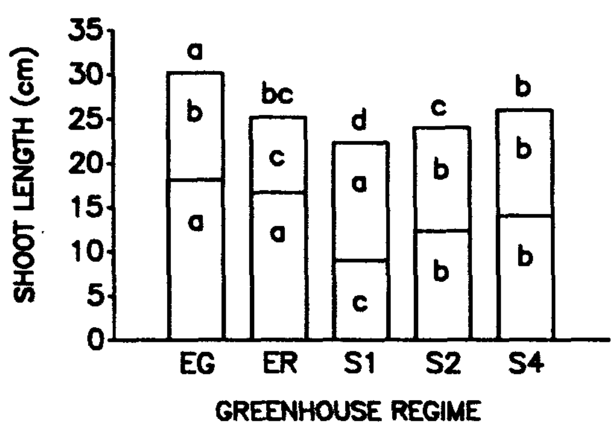

Figure 5.--Shoot measurements for seedlings grown with natural daylength (EG, ER) and short daylength (S1, S2, S4) bud initiation regimes in the previous year. Different letters indicate significant differences ($p<0.05$) between treatment means for seedling heights at planting (lower bars), shoot elongation after planting (upper bars) or total seedling heights (combined bars).

LITERATURE CITED

Arnott, J.T. 1974. Growth response of white-Engelmann spruce provenances to extended photoperiod using continuous and intermittent light. Can. J. For. Res. 4: 69-75.

Arnott, J.T. and D.E. Macey. 1985. Effect of supplemental light intensity on white spruce, Engelmann spruce and mountain hemlock seedlings grown under an extended photoperiod. Can. J. For. Res. 15: 295-300.

Arnott, J.T. and A. Mitchell. 1982. Influence of extended photoperiod on growth of white and Engelmann spruce seedlings in coastal British Columbia nurseries. _In Proceedings of the Canadian Containerized Tree Seedling Symposium. Edited by J.B. Scarratt, C. Glerum and C.A. Plexman. Environment Canada, Can. For. Serv. COJFRC Symposium. Proc. 0-P-10.

Carlson, L.W. 1983. Guidelines for rearing containerized conifer seedlings in the Prairie Provinces. Environ. Can., Can. For. Serv., North For. Res. Cent. Inf. Rep. NOR-X-214E.

Dormling, I., A. Gustaffson and D. von wettstein. 1968. The experimental control of the life cycle in Picea abies [L.] Karst. Some basic experiments on the vegetative cycle. Silvae Genet. 17: 41-64.

Heide, O.M. 1974. Growth and dormancy in Norway spruce ecotypes (Picea abies). I. Interaction of photoperiod and temperature. Physiol. Plant. 30: 1-12.

Hills, G.A. 1960. Regional Site Research. For. Chron. 36(4): 401-423.

Kramer, P.J. 1936. Effect of variation in length of day on growth and dormancy of trees. Plant. Physiol. 11: 127-137.

Lavender, D.P. 1980. Effects of the environment upon the shoot growth of woody plants. _In Proceedings Control of shoot growth in trees. Edited by C.H.A. Little. Joint Workshop of IUFRO working parties on xylem and shoot growth physiology. Fredericton, New Brunswick. p. 76-106.