Blackout and Post Planting Bud Phenology in SxS Spruce Seedlings[1]

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Abstract.--Spruce stock grown under three blackout regimes in 1987 was cold stored over the winter and farm-field planted in May 1988. Blackout treatment did not affect root egress but the longest blackout treatment resulted in earlier spring flush, later fall bud set, and increased the susceptibility of seedlings to freezing temperatures.

INTRODUCTION

Sxs spruce (Picea glauca (Moench) Voss and its naturally occurring hybrid with P. sitchensis (Bong.) Carr.) displays typical hybrid vigor making the control of its height growth in the nursery quite difficult. Usually moderate moisture and/or nutrient stress (Macey and Arnott 1986) is used to control height in this species. However, these techniques can have negative biological side effects (Johnson 1985).

Photoperiodic induction of bud set does result in cessation of height growth in spruce (Colombo et al. 1981) and in Sxs it can be an effective means of height control (Table 1). However, Colombo, Odlum and co-workers[4,5] have observed that buds initiated under shortened photoperiods (PP) resulted in shoots which grew four weeks later into the year than did shoots from buds which had been initiated under ambient PP. Prolonged growth, such as this, has the potential to delay frost hardiness/dormancy induction processes, and with it, increase the probability of early fall and/or winter low temperature damage.

The effects) of nursery blackout regimes on the first farm-field season bud phenology of Sxs spruce is described here.

METHODS

Sxs stock was germinated in an under bench heated 20° C greenhouse and was raised using thermal and 20-20-20 fertilizer regimes as described by Hawkins et alb. Three levels of blackout (as described in table 1) were applied in growth chambers for five weeks commencing on 15 July 1987. After blackout treatment, stock was grown under ambient photoperiod in a greenhouse until lifting and storage on 02 November 1987. The stock, was planted in a farm-field[7] at Red Rock Research Station (lot. 53°45′ N; long. 122°41' W) on 19 May 1988.

The total number of new roots produced greater than one cm and the average number of days to flush in a growth chamber were determined. As well, the total number of new roots (? 1 cm) produced 26 days after farm-field planting was assessed.

Bud phenology was assessed, using a

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[4]S.J. Colombo, K.D. Odlum and C. Glerum. 1986. Measuring and improving the pysiological quality of planting stock. Stock Production Development Activity Seminar, December 1-4, 1986. Timmins, Ontario.

[5]Odlum, K.D. and S.J. Colombo. 1988. Short day exposure to induce budset prolongs shoot growth in the following year. Paper presented at these meetings.

[6]Hawkins, C.D.B., D.A. Draper and R.Y.N. Eng. 1988. Heating system, germination .... fertilizer effects on white spruce nursery growth. Poster presented at these meetings.

[7]4 blocks each containing 24 seedlings were planted for each treatment.

subjective scale (see table 2), at weekly intervals for the first six weeks after planting and then at approximate fortnightly periods until early November 1988.

RESULTS AND DISCUSSION

The relationship between treatments for the total number of new roots produced (≥ 1 cm) was not the same for growth chamber and field assessments (table 2). This is probably a response to the different soil temperatures for the two determinations. However, under both conditions, new root production was very good. The lowest IRG (Burdett 1979) was 4 for the ambient stock tested in the growth chamber, and 5 for all other treatments.

The average number of days to flush in the growth chamber was greatest in the ambient treatment and least in the 10 h PP treatment (Table 2). This suggests that not only may seedlings grown under blackout regimes have altered fall phenology as reported by Colombo et al.[4,5] but spring phenology also may be altered. The earlier flushing observed for blackout treated stock could predispose it to damage by late spring frosts.

Twenty-two days after planting, 85% of the 10 h PP seedlings had elongating leaders while only 26% of the ambient PP trees were flushing (table 3). Again, the rate of flush of the blackout treated seedlings could increase the occurrence of spring frost damage. However, one week later, all the stock was flushing (table 3, day 28), indicating that the potential window of enhanced damage for the 10 h and 12 h PP treatment stock was not appreciably longer than for ambient PP seedlings.

Table 1.--End of season (02 November 1987) mean morphological measurements[1] and standard error (SE) for height (Ht), caliper (Cal), root (RDW) and shoot dry weights (SDW) of Sxs grown under blackout' for 5 weeks[3] and then returned to ambient photoperiod until lifting and storage.

PP	Ht cm	Cal mm	RDW mg	SDW mg
Ambient	29.8	3.63	600	2378
SE	1.0	0.14	57	151
12 h	24.1	3.20	620	1930
SE	0.8	0.15	70	152
10 h	20.1	2.50	450	1458
SE	0.5	0.10	38	107

[1]B.C. Forest Service stock standards for Sxs are: Ht, min/target/max, 14/18/30 cm; Cal, min/target, 2.2/2.6 mm; and RDW, min/target, 500/700 mg. There are no mass standards for the shoot. Each measurement is the mean of 20 trees.

[2]Three blackout treatments applied on 15 July 1987 were: ambient PP, natural day length decreasing from 18:19 h to 16:01 h over the 5 weeks; 12 h constant and 10 h constant PP both applied for 5 weeks.

[5]All stock exceeded minimum height when blackout was applied.

Table 2.--Mean[1] and standard error (SE) of the total number of roots produced (≥ 1 cm) after one week in the growth chamber[2] (GC), 26 days after field planting (AP), and the mean number of days to flush (TF) in a growth chamber for the three photoperiod treatments.

PP	Roots > 1 cm GC	Roots > 1 cm AP	TF days
Ambient	20.1	76.9	16.8
SE	4.2	8.4	1.3
12 h	59.9	60.9	10.9
SE	3.5	12.9	0.6
10 h	32.3	45.7	8.4
SE	4.3	4.3	0.3

[1]Each measurement is the mean of 16 seedlings.

[2]In growth chamber at 30/25° C, 16/8 h, day/night, RH 75% light intensity 500 H mols for one week; standard BCFS RGC conditions.

[3]See table 1 for treatment descriptions.

Blackout treated stock flushed sooner and continued leader elongation later into the season (table 3, day 112) than did stock from the ambient treatment. On 17 September (day 121), there was a near record low temperature of -6.9° C. This apparently resulted in considerable mortality of terminal buds in the 10 h PP treatment seedlings (table 3, day 137). The altered and presumedly delayed phenology observed in the 10 h PP treatment resulted in the increased mortality following exposure to fall frosts for this treatment. The response of the 12 h PP stock was intermediate between the other two treatments (table 3). On days 135 and 172 this treatment responded more like the ambient treatment than the 10 h PP treatment stock, whereas, very early in the season it responded more like 10 h PP stock (table 2, TF). This suggests that a reacclimation (towards ambient) is possible.

By the time of the last assessment, more than one-third of the trees in the 10 h PP treatment had dead terminal buds and all seedlings with surviving terminal buds were in bud class 5 (table 3, day 172). In just over one month, bud mortality in the 10 h PP stock increased from 25 to 35 percent, indicating the severity of damage to this treatment. However, seedling survival was 100% for all treatments at this time.

The time available for frost hardiness and dormancy induction processes was likely much less in the blackout treated seedlings because of their growing later into the season, and their delay in initiating terminal buds as indicated b

Table 3.--The total number of seedlings, as a percentage, in a given subjective bud class[1] on each sample day in the 1988 farm-field outplanting at RRRS for Sxs spruce subjected to ambient (A), 12 h (12), or 10 h (10) photoperiod treatments (PPT) for five weeks in the nursery during 1987.

Day[2]	Percentage of trees in each bud class																				
	0			1			2			3			4			5			D		
	PPT			PPT			PPT			PPT			PPT			PPT			PPT		
	A	12	10	A	12	10	A	12	10	A	12	10	A	12	10	A	12	10	A	12	10
0	100	100	100[3]																		
11	69	52	16	31	48	84															
22	1	0	1	63	30	14	36	70	85												
28				3	0	0	97	100	100												
54							7	1	0	93	99	100									
96							1	0	1	99	100	99									
112										39	61	79	61	39	21						
137													80	77	70	14	13	5	6	10	25
172																92	86	65	8	14	35

[1]The subjective bud classes are:
Class 0, resting spring terminal bud;
Class 1, swelling terminal bud;
Class 2, flushing (elongating) leader;
Class 3, lateral buds visible on leader;
Class 4, terminal bud scales, bud filling;
Class 5, resting fall terminal bud; and
Class D, dead terminal bud, frost killed.

[2]Days since planting on 19 May 1988, for brevity and clarity, not all sample days are shown.

[3]84 seedlings were sampled for each treatment

increased bud mortality. There is a distinct possibility that the 10 h PP seedlings will also undergo considerable winter damage when compared to the other treatments because of the shorter time available for completion of their frost hardiness and dormancy induction processes prior to winter. However, this will not be known until spring 1989 assessments.

CONCLUSIONS

Blackout of Sxs does alter seasonal bud phenology both in the spring and the fall of the following growing season. Stock from shorter day length treatments is placed at greater risk to frost injury in the fall because of the longer fall damage window duration. The duration of altered phenology induced by the blackout treatments is yet to be determined. It appears that stock from the intermediate treatment can reacclimate towards responses more typical of control stock, while stock from the longest PP treatment changes little. If the effect lasts into the second field season it could have a significant impact on seedling form and growth and plantation form and survival.

The present data set does not preclude the use of blackout for height control. A morphologically acceptable seedling was produced from an intermediate blackout treatment which, while altering seedling phenology, did not result in bud damage significantly different from control stock. Therefore, it is reasonable to assume that a compromise can be achieved between blackout period and duration, nursery stock standards, and early field phenological response.

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LITERATURE CITED

Burdett, A.N. 1979. New methods for measuring root growth capacity: Their value in assessing lodgepole pine stock quality. Can. J. For. Res. 9:63-67.

Colombo, S.J., D.P. Webb and C. Glerum. 1981. Cold hardiness and bud development under short days in black and white spruce seedlings. p 153-161. In Proceedings of the Canadian Containerized Tree Seedling Symposium (eds. J.B. Scarratt, C. Glerum & C.A. Plexman). Can.-Ont. Joint For. Res. Comm. Proc. 0-P-10.

Johnson, C.J.S. 1985. How to use seedling quality measurement in container nurseries. p. 84-86. In Proceedings: Intermountain Nurseryman's Association Meeting, 1985 (eds. T.W. Landis & J.W. Fischer). USDA-For. Ser. Gen Tech. Rep. RM-125.

Macey, D.E. and J.T. Arnott. 1986. The effect of moderate moisture and nutrient stress on bud formation and growth of container-grown white spruce seedlings. Can. J. For. Res.16:949-954.