GA4/7 PROMOTES FLOWERING IN BLACK SPRUCE

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Abstract.--Gibberellins, GA4/7, GA9 and the auxin NAA were applied as a foliar spray to twenty-year-old black spruce trees. Flowering was promoted in treated trees compared to controls for both male and female flowers. Application in early July was more effective than in early August.

Additional keywords: Naphthaleneacetic acid, Picea mariana, foliar spray, application date.

Large quantities of seed are needed for reforestation programs in eastern Canada and black spruce (Picea mariana (Mill.) B.S.P.) is one of the most widely used species. Greater productivity can be achieved using genetically improved seed which although expensive itself, does not greatly increase reforestation costs. One method of obtaining genetically improved seed is by producing it in seed orchards. A major constraint on that production is the frequent failure of seed orchard trees to produce flowers. If this constraint could be overcome then the productivity of seed orchards would be increased.

Cultural methods including fertilization, girdling, root pruning water stress and manipulation of branch angle have been used. Results however have been inconsistent and in recent years attention has focused on physiological methods often used in concert with cultural methods. In various species of the Pinaceae enhanced flowering has resulted from treatment with the non-polar gibberellins (Pharis and Ross 1976, Pharis et al. 1976, Pharis 1979). Since the major reforestation species in Newfoundland is black spruce, it was decided to test gibberellins on this species.

METHODS

Black spruce trees originating from fire and forming part of a seed production area were used for the study. Trees were selected which apparently had not yet produced female flowers. All trees were growing in full sunlight and were about twenty years old. Each treatment was applied to four trees and the experiment was designed as a randomized complete block (Steel and Torrie 1960). Substances used were GA4/7, GA9[2] and NAA. They were dissolved in 60% ethanol and 1 m1/9. of the surfactant 'Aromox C12W' [3] was added to

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[2]GA/7 - 45.4%, GA4/7 - 92.5%, gibberellins supplied courtesy of ICI Ltd., Plant Protection Division.

[3]Aromox C12W supplied courtesy of Armak Chemicals Ltd., 100 Univ. Ave., Toronto, Ont. (Use of trade names does not imply endorsement of any particular item.)

improve penetration of the growth substances. The substances were applied as a foliar spray to the upper flower producing part of the crown and about 400 ml of solution was applied to each tree. Substances were applied on 7 July and 4 August when shoot elongation was half complete and nearly complete respectively.

The treatments were:

1. Control - 60% Ethanol
2. GA4/7 @ 0.2 mg/
3. GA4/7 @ 0.8 mg/
4. GA4/7 @ 0.2 mg/ + GA9 @ 0.01 mg/
5. GA4/7 @ 0.2 mg// + NAA @ 0.1 mg/

Numbers of female flowers were counted in the three years, and male flowers in the two years following treatment. Data were analyzed by ANOVA after arcsin transformation (Steel and Torrie 1960).

RESULTS AND DISCUSSION

All treatments applied in July resulted in increased production of flowers of both sexes (table 1). August treatments had no effect on females but GA4/7 + NAA stimulated male flowering. There was generally a greater response for male flowering than for females. Tree to tree differences were large, this resulted in no statistical difference between treatments although differences between treatment means were large. Differences between July and August treatments were statistically different, and four times as many flowers were produced after the July treatments.

Wide tree to tree variation has been reported previously for black spruce (Simpson and Powell 1981) and these results are consistent with that study. In general the promotion of flowering in black spruce is consistent with that reported in other Pinaceae; Douglas fir (Pseudotsuga menziesii Mirb. Franco)(Ross 1979), Jack pine (Pinus banksiana Lamb.)(Cecich 1983), and in white spruce (P. glauca (Moench) Voss)(Marquard and Hanover 1984).

Comparing the various treatments, female flowering was promoted only by GA4/7 and there was no response attributable to concentrations. Philipson (1985) also found no dosage-related response in Sitka spruce (P. sitchensis (Bong.) Carr. The reported synergistic effects of GA9 and/or NAA was not evident in black spruce (Pharis and Ross 1984). Male flowering was enhanced by GA4/7 at the higher concentration and when NAA was used. It is possible that the GA4/7 triggers female flowering at a low concentration and males are only formed following application at a higher concentration. This possible differential response could be exploited in a breeding program. Use of the auxin NAA promoted male but not female flowering. NAA has little effect on flowering in white spruce (Marquard and Hanover 1985); stimulates flowering in loblolly pine (Pinus taeda L.) and inhibits flowering in slash pine

Table 1.--Number of male and female flowers per tree on black spruce one year following treatment

Growth substances	Concentration mg/ℓ	Number of Flowers Per Tree			
		Male		Female	
		July	August	July	August
Control	-	1.8	1.8	1.0	7.8
GA4/7	0.2	7.2	2.2	27.8	0
GA4/7	0.8	118.2	0	28.2	.2
GA4/7 GA9	0.2 0.01	22.5	2.8	2.0	0
GA4/7 NAA	0.2 0.1	43.8	47.2	8.0	2.5

(P. elliottii Engelm.) and longleaf pine (P. palustris Mill.) (Hare 1984). In Japanese larch (Larix kaempferi (Lam.) Carr.) NAA has been found to inhibit male and female flowering (Hall 1977), but opposite effects have been reported in Douglas fir and Scots pine (P. sylvestris L.) (Ross et al. 1980; Luukkanen 1980). Results in black spruce most closely resemble those for larch. It is possible that NAA blocks or inhibits gibberellin activity.

Nearly all trees, both treated and controls, flowered in the second year (table 2). The difference between dates was significant in both male and female flowering in year two but differences were small in year three. When comparing control and treated trees it appeared that there may have been some inhibition of flowering on treated trees.

The increase in male flowering in year two could be attributed, in part, to the gradual increase in the male flowering zone as new shoots are formed and as females are initiated on new shoots which have not been treated. If growth hormones act in a manner to divert nutrients from vegetative to reproductive buds as has been reported (Ross 1979), then in year two the tree might be over-compensating for the temporary diversion of nutrients and act to reverse the process. This might explain the increased flowering of controls over treated trees. The effects could act differently for male and female and for early and late applications. These carry-over effects have been observed in other species, in Scots pine (Luukkanen and Johansson 1980), Japanese and European larch (L. decidua Mill.)(Bonnet-Masimbert 1982) and Sitka spruce (Philipson 1985). This may be due to an increase in levels of endogenous gibberellins occurring at the time of flower induction and which then remains high (Chalupka et al. 1982).

Table 2.--Number of flowers per tree for each treatment after one, two and three years

Growth substances	Conc. mg/ℓ	Years after treatment	Number of Flowers Per Tree			
			Male		Female	
			July	August	July	August
Control	-	1	1.8	1.8	1.0	7.8
		2	56.2	107.5	33.5	56.8
		3	-*	-	2.8	2.0
GA4/7	0.2	1	7.2	2.2	27.8	0
		2	43.5	15.5	63.8	13.0
		3	-	-	4.0	0.8
GA4/7	0.8	1	118.2	0	27.8	0
		2	185.5	12.2	41.0	9.2
		3	-	-	8.8	0.8
GA4/7	0.2	1	22.5	2.8	2.0	0
GA9	0.01	2	94.2	17.0	33.5	6.2
		3	-	-	0.0	1.2
GA4/7	0.2	1	43.8	47.2	8.0	2.5
NAA	0.1	2	40.0	115.5	4.8	9.2
		3	-	-	6.2	3.0

*Numbers of male flowers were not determined in year three.

CONCLUSIONS

The conclusions are influenced by the wide tree-to-tree variation in flowering levels. Variation would have been less if clonal material had been available for testing. Nevertheless some trends are obvious - mainly that foliar spraying of the gibberellin GA4/7 promotes flowering on twenty-year-old black spruce trees.

More precisely:

(i) Both male and female flowering was promoted in terms of number of flowers per tree and proportion of trees producing flowers. Response was greater for male flowering than for female flowering.

(ii) Female flowering was promoted at both concentrations of GA4/7 but male flowering was promoted only at 0.8 mg/ or when GA9 or NAA was combined with the low concentration of GA4/7.

(iii) Application of hormone in early July produced more flowers than did application in early August. The difference was statistically significant. Use of GA4/7 + NAA promoted male flowering when sprayed in August.

(iv) There are indications that the hormonal treatments have an effect up to two years after treatment. The effect is positive for females and negative for males.

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