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Gibberellin $A_{4/7}$ enhances flowering of *Picea glauca* grafts in two consecutive years

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Introduction

Trees that flower abundantly in one year and then bear sparsely or not at all for several years are said to show periodicity of flowering. This infrequent, unpredictable flowering behavior has led to inefficient seed collecting and seed orchard operations. Therefore, treatments to alleviate such flowering problems in conifers have been the subject of much recent experimentation.

The mixture of gibberellins A_4 and A_7 ($GA_{4/7}$) can increase flowering in conifers if applied at the correct time, duration and concentration (Cecich, 1983; Marquard and Hanover, 1984; Pollard and Portlock, 1983). Except for Marquard and Hanover (1985), all experiments with $GA_{4/7}$ have been done on plants never previously treated. There have been no reports of $GA_{4/7}$ being applied to the same tree or seedling, or even the same branches, in two consecutive years. Our paper reports the results of an experiment on *Picea glauca* (Moench (Voss)) grafts in which $GA_{4/7}$ was applied to the same branches in two consecutive years in an attempt to overcome periodic flowering.

Materials and Methods

Readers are referred to Cecich (1985) for details of the experimental design and treatment procedures. The first $GA_{4/7}$ applications were made in 1982. In 1983, $GA_{4/7}$ was again sprayed on the same trees and branches on the same dates. Length of the terminal shoot on all the treated and control lateral branches was measured in August 1983 and 1984. Ovulate and staminate strobili were counted in early May 1983 and 1984. Flowering data were transformed to $\log_{10}(x + 1)$ and evaluated by a combined analysis of variance and Duncan's new multiple range test. Simple correlation coefficients were computed for the 1983 and 1984 flowering and branch length data.

Results

The 1983 flowering results for the 5 early-flushing (EF) and 5 late-flushing (LF) white spruce clones have been published elsewhere (Cecich 1985), but treatment means are summarized in Table I for convenience of comparison with the 1984 mean results. In both years, the $GA_{4/7}$-treated branches on ramets of the EF and LF clones produced significantly more ovulate and staminate strobili than

Table I. Mean flowering per branch of *Picea glauca* ramets after two seasons of applying $GA_{4/7}$.

Clones	*Year*	*Ovulate strobili*		*Staminate strobili*	
		control	*$GA_{4/7}$*	*control*	*$GA_{4/7}$*
Early-flushing	1983	0	0.7^{*}	0.3	2.6^{**}
	1984	0.3	32.6^{***}	23.3	47.0^{**}
Late-flushing	1983	0	4.9^{*}	0.1	2.0^{**}
	1984	1.5	50.2^{***}	5.2	29.3^{**}

*, **, *** Significantly different from controls, $P \leq 0.05, 0.01, 0.001$, respectively.

branches on their paired control ramets. In 1984, the LF clones again produced significantly more ovulate strobili than the EF clones. This was reversed for staminate strobili; that is, the EF clones produced more than the LF clones.

Spraying with $GA_{4/7}$ in 1982 had no effect on lateral branch length of either the EF or LF clones in 1983. However, in 1984 the $GA_{4/7}$-treated branches were about 25% shorter than the control branches. The EF clones had a mean length of 185 mm for the controls and 141 mm for the $GA_{4/7}$-treated branches. The LF control ramets had an average branch length of 217 mm, while the treated branches were 163 mm long.

Treated branches on EF and LF clones responded with significant increases in flowering in 1983 and 1984 (Table I). Interactions were due to a change in magnitude of response, rather than to a change in rank of the treatment combinations. Clone x treatment interactions for staminate strobilus production ($P \leq 0.01$) were apparently more complex than for ovulate strobilus production (NS) in that they were not related to flushing type but to specific clones.

Ovulate and staminate strobilus productions in 1983 and 1984 were significantly correlated ($r = 0.760^{*}$). Branch length was negatively correlated with production of ovulate strobili ($r = -0.758^{*}$) and staminate strobili ($r = -0.931^{**}$).

Discussion

This report is the first to describe the successful stimulation of male and female flowering in a conifer by consecutive annual treatments with $GA_{4/7}$. The 1984 results substantiated the 1983 observations that the treated LF ramets produced significantly more ovulate strobili than the treated EF ramets. In 1983, there was no difference in staminate strobilus production between EF and LF clones but, in 1984, the EF clones produced significantly more staminate strobili than the LF clones. In unpublished experiments, flowering was promoted by $GA_{4/7}$ in both flushing types; but the response was closely related to a common date (June 20), indicating a possible environmental control, or a larger than expected 'window' for treatment application. Needles of the elongating branch tips in the EF families began to harden on June 13, 1 wk before the optimum treatment date. Needle hardening was noted 1 wk later in the LF families. Hardening of the needles could potentially be used to determine when to apply $GA_{4/7}$.

Branch length reduction by a heavy flowering/cone crop could affect the use of a certain percentage of the previous year's growth as an index of when to apply $GA_{4/7}$. The final length of the treated branches in 1984 was 75% of the control length and 70% of the previous year's treated branch length. If one had used the proposed index of 90% (Owens and Molder, 1977) or 75% (Marquard and Hanover, 1984) for $GA_{4/7}$ application, the 'window' would have been missed. Under these circumstances, calendar dates, needle hardening and/or bud morphology may be preferred for scheduling treatments.

These results suggest that periodic flowering in white spruce can be overcome with judicious spray application of $GA_{4/7}$. Furthermore, the lack of significant interactions for clone x treatment and clone x year for ovulate strobili suggests that $GA_{4/7}$ can be used to overcome clonal variation in female flowering. However, unequal representation of clones as pollen parents, as exemplified by the strong clone x treatment interaction, might be a possible concern for an orchard manager.

Conclusions

Although the present data are encouraging that year-to-year regularity in seed production can be achieved, additional experiments are required to determine the number of years in which a significant response can be elicited.

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