FLOWERING OF JACK PINE SEEDLINGS TWO YEARS AFTER APPLICATION OF $GA_{4/7}$

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Abstract.--Jack pine (*Pinus banksiana* Lamb.) seeds were sown in the winter of 1978-1979. The seedlings were transplanted to a nursery in the spring and summer of 1979 and were sprayed biweekly with the gibberellin mixture $GA_{4/7}$ or $GA_{4/7}$ + naphthalene acetic acid. In 1980 ovulate strobili production increased four-fold. $GA_{4/7}$ was not applied in 1980. In 1981 the controls flowered better than the GA treatments, indicating there was probably no positive carryover or residual effect. Trees that flowered in both years produced more strobili in their second year (1981) than those that flowered for the first time in 1981.

Additional keywords: *Pinus banksiana*, carryover effect, gibberellins, ovulate strobili.

INTRODUCTION

Although early flowering is desirable in a tree breeding program, the trees usually don't cooperate. An exception to this generalization is jack pine (*Pinus banksiana* Lamb.) which can produce ovulate strobili 12 months after sowing (Rudolph 1979), but not at a high frequency. Cecich (1981) applied the gibberellin mixture $GA_{4/7}$, with and without the auxin naphthalene acetic acid (NAA), to jack pine seedlings ranging from 1-1/2 to 9-1/2-months old. When the seedlings were 12-, 15-, and 18-months-old, they flowered with increasing frequency depending on age and hormone treatment. The $GA_{4/7}$ application resulted in a 4-fold increase in strobili, except in the 12-month-old seedlings, which did not flower at all.

What is the flowering habit of trees the second year after the application of growth regulators? Pharis, Ross, and McMullan (1980) provided circumstantial evidence for a modest carryover effect in Douglas-fir seedlings. The jack pine in the previously described experiment (Cecich 1981) were kept in the nursery an additional year to observe the flowering in 1981 and to determine if there was a carryover effect. This paper discusses those observations.

MATERIALS AND METHODS

Materials and methods are described in detail in Cecich (1981), but will be reviewed here to put the 1981 flowering observations into perspective.

Jack pine (*Pinus banksiana* Lamb.) seeds were sown on October 28, 1978, January 3, and March 30, 1979; germinated on wet perlite, and transferred to a potting medium in Tubepack III bookplanters. Seedlings remaining in the greenhouse were maintained under an 18 h photoperiod at 24 °C until June 15

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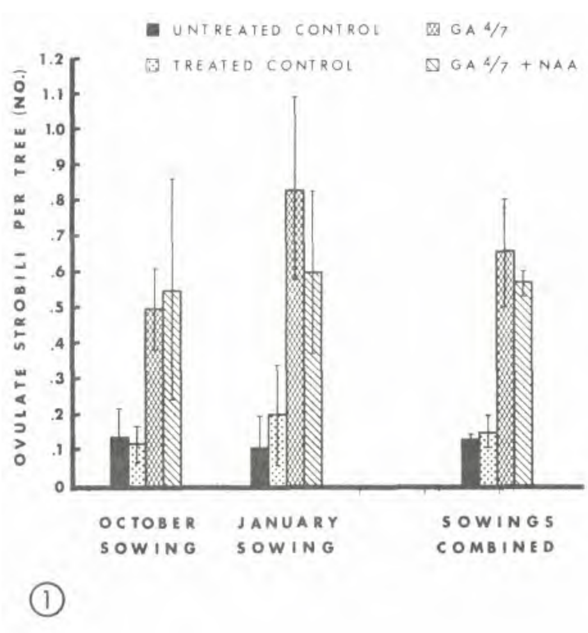
when natural light was used. On May 15, June 1, June 15, July 1, July 15, August 1, and August 15, eighteen trees from each sowing group were transplanted to the nursery.

Six seedlings from each sowing-transplant combination were sprayed with an aqueous control solution of Aromox C/12 W detergent, 600 mg L^{-1} of $GA_{4/7}$, or 600 mg L^{-1} of $GA_{4/7}$ plus 10 mg L^{-1} naphthalene acetic acid (NAA). Trees were sprayed biweekly from the date of transplanting to August 16. No hormone treatments were given in 1980. The untreated controls were in an adjacent nursery bed rather than located among the hormone treatments. Ovulate strobili were counted in 1980 and 1981. Data were evaluated by analysis of variance.

RESULTS AND DISCUSSION

In 1980 the number of ovulate strobili on seedlings from the October or January sowings receiving either $GA_{4/7}$ or $GA_{4/7}$ + NAA increased fourfold over the Aromox-treated controls (Fig. 1). Most strobili were on seedlings transplanted by mid-July. Seedlings from the March sowing did not flower. They either were too small or did not have enough lateral long-branch primordia to differentiate into ovulate strobili. No trees produced pollen. About 10% of the control trees (untreated and treated, combined) had ovulate strobili in 1980, while approximately 30% of the $GA_{4/7}$ and $GA_{4/7}$ + NAA-treated trees had strobili (Fig. 2). This three-fold increase in the number of flowering trees was clearly related to the GA treatments (Cecich 1981).



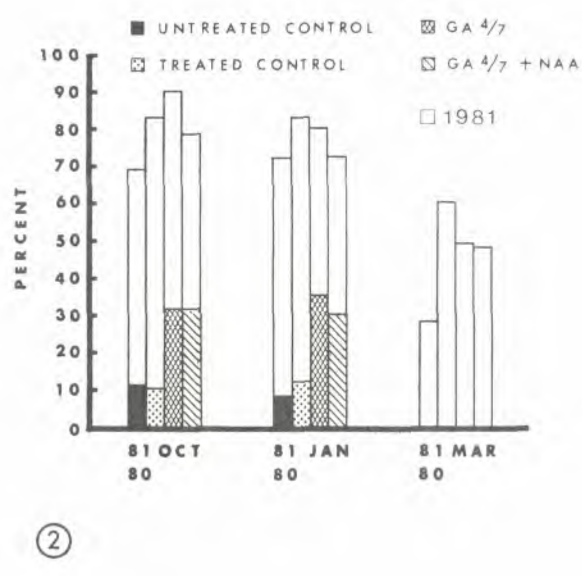


Figure 1.--Initial flowering in 1980 after application of hormone treatments in 1979. Figure 2.--Percentage of trees bearing ovulate strobili in 1980 and 1981.

The percentage of control trees flowering increased to about 75% in 1981 but only 80% of the former GA-treated trees flowered. Since there was no carryover effect in terms of the percentage of trees flowering, the amount of flowering per tree in 1981 was evaluated (Fig. 3). The flowering per tree in the March sowing was significantly reduced (P 2 .01) over that in the October and January sowings, as was found in the 1980 data. There was no difference among transplant dates in 1981. However, in 1980 the flowering was significantly reduced after the mid-July transplant. The treated controls had significantly ($P \geq .01$) more strobili than the GA + NAA treated trees. When all the transplants were combined, the flowering pattern was similar in all the sowings. The Aromox-treated controls flowered better than the former GA-treated trees. The difference between the controls and the $GA_{4/7}$ + NAA-treated trees was highly significant. Similar reductions in flowering are common in some genera after they bear a heavy flower or cone crop. Even the March sowing, which didn't flower in 1980, had the same pattern; that is, the treated controls outperformed the GA-treated trees. Hence, previous fruitfulness can't be the total explanation of the observed results. In addition, the trees receiving $GA_{4/7}$ + NAA in 1979 flowered less than the trees receiving only $GA_{4/7}$ (Fig. 3). Because the addition of NAA did not enhance flowering in the first year (Cecich 1981) and significantly reduced it the second year, its further use for jack pine is questionable. In some species, however, it appears to enhance male strobilus formation (Cecich 1981) but did not do so in the present study.

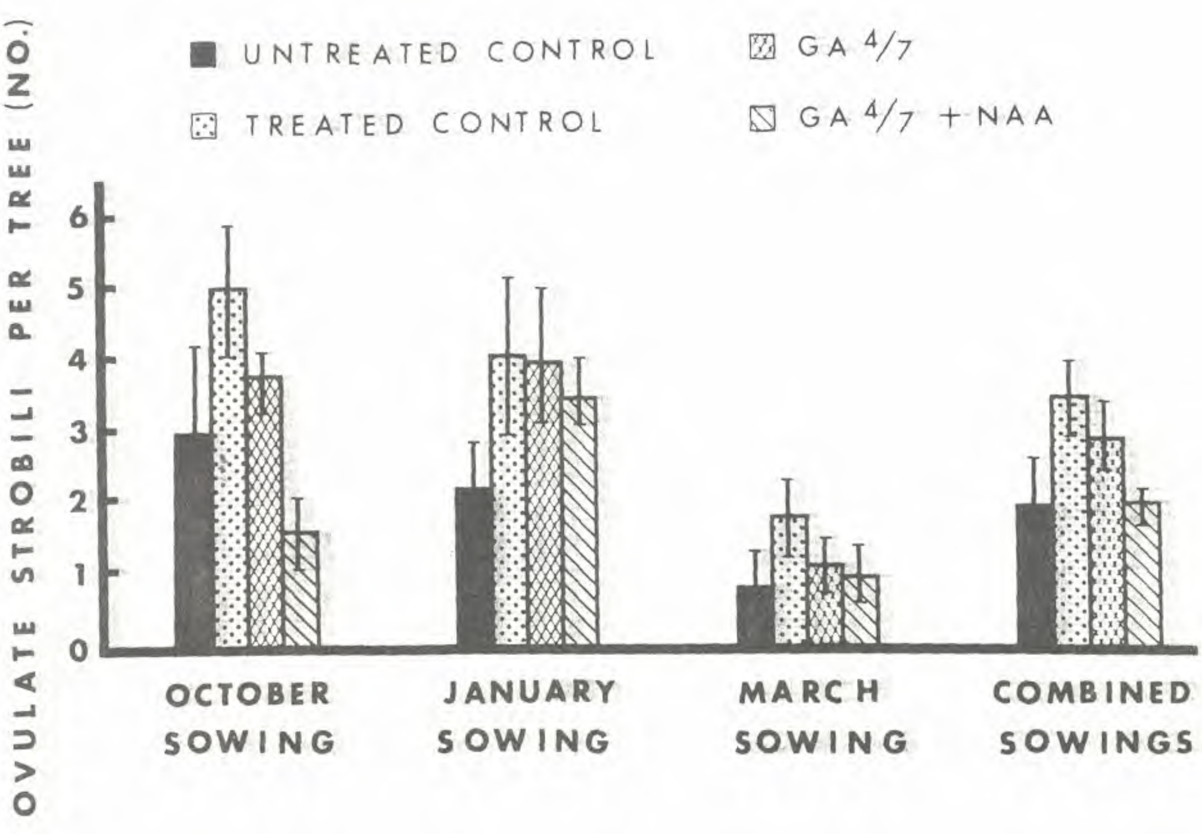


Figure 3.--Carryover effect of $GA_{4/7}$ on subsequent flowering of all trees. (Transplant dates combined)

The untreated controls flowered less than the Aromox-treated controls, suggesting that Aromox alone may slightly stimulate flowering. However, the untreated controls were in an adjacent nursery bed and not physically associated with the hormone-treated trees. When all the sowings were combined (Fig. 3), the treated controls flowered slightly better than the GA treatments and the significant reduction in flowering after the $GA_{4/7}$ + NAA application was evident.

The 1981 flowering per tree did not differ among the transplant dates, but the sowing x transplant dates interaction was significant ($P \geq .05$) and can be visualized by linear regression lines (Figs. 4-6). In 1980 the October and January sowings were similar -- good flowering in the transplants up to mid-July and almost none thereafter. In 1981 the treated controls of the October sowing had a similar pattern to the 1980 flowering (Fig. 4); that is, reduced flowering after mid-July. However, the flowering response did not differ, when looking at the transplant days, in the $GA_{4/7}$-treated trees; but the $GA_{4/7}$ + NAA treatment had a positive-sloping regression line, demonstrating that the August transplants flowered better than the earlier transplants. The controls in the January sowing also flowered similarly to the trees in 1980, as did the $GA_{4/7}$ treatment (Fig. 5). However, the $GA_{4/7}$ + NAA-treated trees had a slight negative slope, opposite to those sown in October. In the March sowing (Fig. 6) all treatments had a positive slope to the regression lines; thus, differing from the October and January sowings. Although presently unexplainable, the different flowering responses of the sowing groups to transplanting and hormones are interesting and will have to be explored further if gibberellin application will not be made yearly.

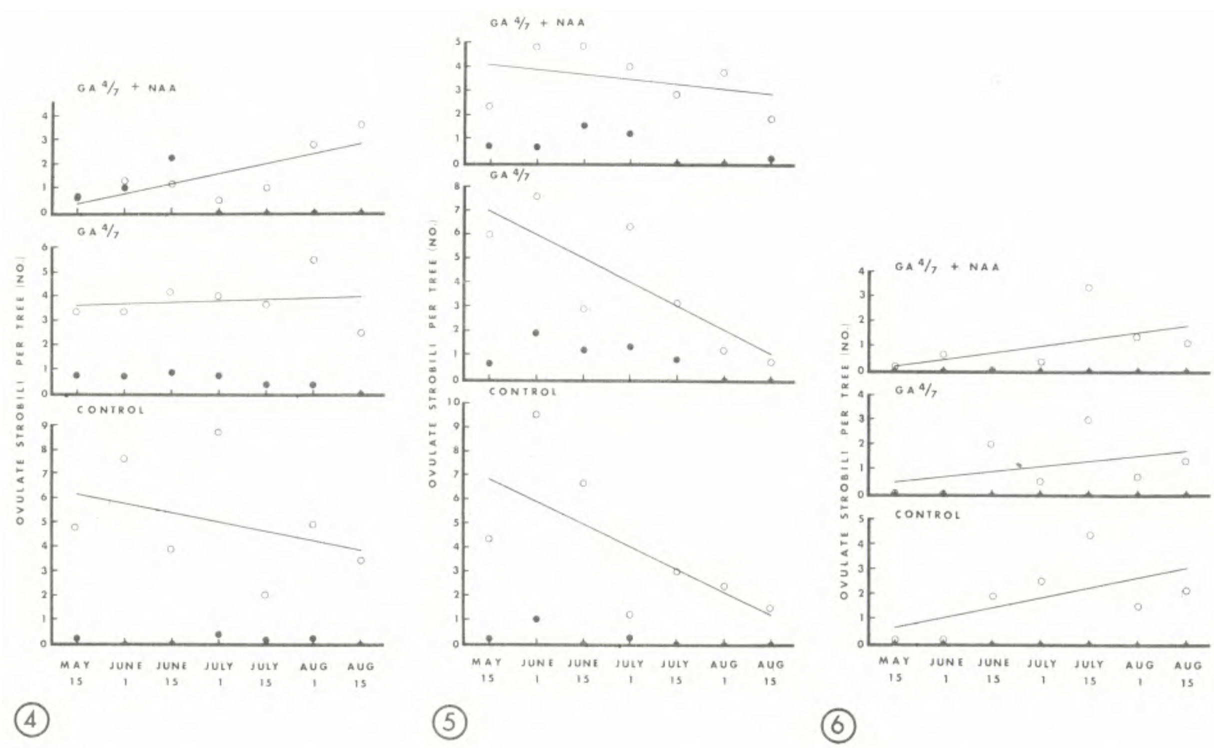


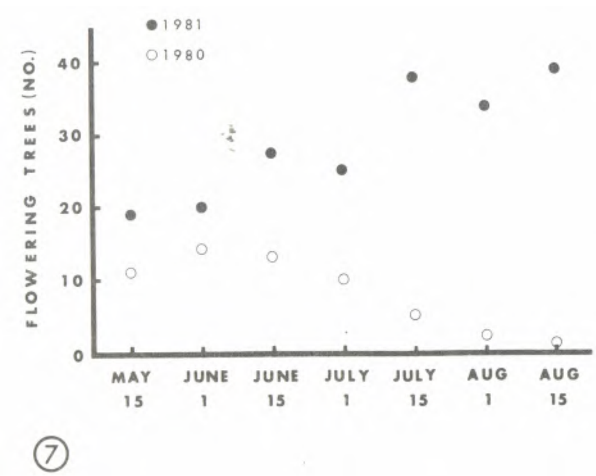
Figure 4-6.--Linear regressions of transplanting dates and flowering as related to hormone application in 1979 and sowing dates. Fig. 4.--October sowing. Fig. 5.--January sowing. Fig. 6.--March sowing.

To further evaluate the carryover effect of GA in the second year, one must examine the individual trees. There was no statistical analysis of the individual tree data. Among the 59 trees that flowered in 1980, only 3 did not flower in 1981 (Table 1). Based on this sample, there is about a 95% probability that if a tree flowered in the first year, it will flower again. The number of flowering trees per transplant date is also similar to the number of ovulate strobili per tree in the 1980 data (Cecich 1981); the earlier transplants have more flowering trees than the later ones (Fig. 7).

Table 1.--Number of trees bearing or not bearing ovulate strobili in 1980 and 1981

Did it flower in:		Transplant date						
1980	1981	May 15	June 1	June 15	July 1	July 15	August 1	August 15
Yes	Yes	11	14	13	10	5	2	1
Yes	No	1	1	1	0	0	0	0
No	Yes	19	20	27	25	38	34	39
No	No	20	17	12	14	10	15	13

The flowering in 1981 occurred in two groups of trees; those that flowered in 1980 and 1981 and those that flowered initially in 1981. The number of trees that flowered initially in 1981 increased in the later transplants, just opposite to what occurred in the first year of flowering (Fig. 7). Even when the two groups are combined, the trend is still for an increase in the later transplants (Fig. 8).



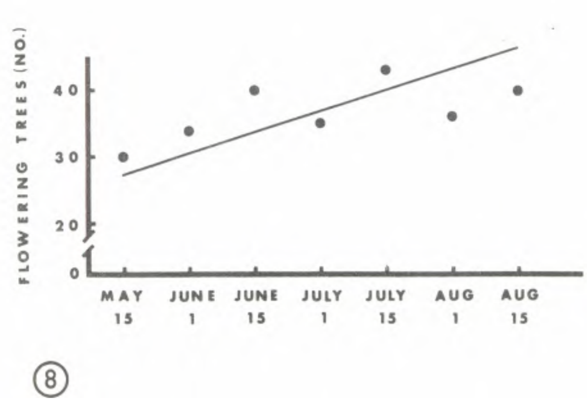


Figure 7.--The number of flowering trees per transplant date. Figure 8.-- The number of flowering trees per transplant date for the 1980 and 1981 data combined. The trend is for more flowering trees in the later transplants.

Comparisons of the number of ovulate strobili per flowering tree were made of the different hormone treatments (Fig. 9-10). In Fig. 9 the number of strobili per flowering tree in 1980 is compared to that in the same tree in 1981. The increase in flowering caused by the $GA_{4/7}$ treatments in 1980 is not evident in 1981. There was no carryover stimulation of flowering by $GA_{4/7}$ and, in addition, the depression in flowering from the application of NAA in the October sowing is evident.

The trees that flowered for the first time in 1981 were compared to the trees that flowered in both years and two trends became evident (Fig. 10). The NAA-related depression was observed in both flowering groups in the October sowing. Secondly, the trees that flowered in both years produced more strobili per tree in 1981 than those trees that flowered initially in 1981. When the October and January sowings were combined, both of these trends were more clearly demonstrated.

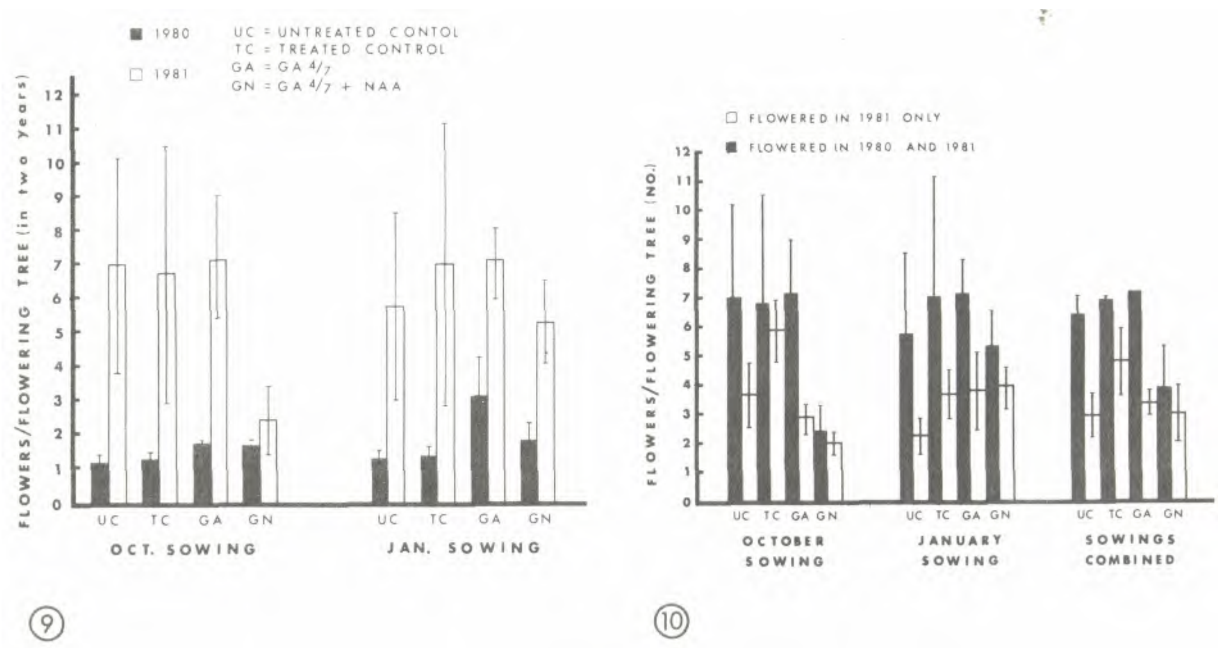


Figure 9.--A comparison of the number of strobili on the same trees in 1980 and 1981. Figure 10.--The average number of strobili on trees that flowered in both years and those that flowered only in 1981.

CONCLUSIONS

The carryover or residual effect of gibberellins on subsequent flowering in conifers has not been adequately explored. The present data suggest that the transplant dates and the hormones affect the flowering response in the second year. Although this interaction is interesting from a theoretical standpoint, it is apparently so confounded by developmental changes within the trees that it doesn't lend itself to hypothesis formation at present. The number of flowers per flowering tree increases in the later transplants. There does not appear to be a positive carryover effect on flowering related to the hormones. Because almost all trees that flowered in both years did so in greater amount than those trees that flowered initially in 1981, the use of GAs to enhance initial flowering should be considered. In a breeding program that needs supplemental early flowering, GA application has already provided encouraging results.

LITERATURE CITED

Cecich, R. A. 1981. Applied gibberellin $A_{4/7}$ increases ovulate strobili production in accelerated growth jack pine seedlings. Can. J. For. Res. 11: (in press).

Pharis, R. P., Ross, S. D., and McMullan E. 1980. Promotion of flowering in the Pinaceae by gibberellins. III. Seedlings of Douglas-fir. Physiol. Plant. 50: 119-126.

Rudolph, T. D. 1979. Female strobili on 12-month-old jack pine. Tree Plant. Notes 30 (2): 24-26.