MERITS OF USING MECHANICAL TREATMENTS TO STIMULATE CONE PRODUCTION OF SLASH AND LONGLEAF PINES

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Abstract. Four mechanical treatments (untreated, partial girdling in the spring, partial girdling in summer, and banding in spring) stimulated cone production of pole-sized slash and longleaf pines. A 2- to 3-fold increase in slash pine seed production was limited to the first crop originating after the treatments were applied. However, the treatments killed half the longleaf pines, preventing any overall increase in seed productivity. Although mechanical stimulation of cone production has been reported for decades, the method cannot be generally recommended for use in slash and longleaf pine seed orchards where the value of individual trees is great and where susceptibility to injury may vary by species and clonal family.

Keywords: *Pinus elliottii* Engelm., P. *palustris* Mill., seed orchard, girdling, seed quality.

INTRODUCTION

In the last several decades numerous studies have evaluated ways to increase the seed production of various species of southern pines. Loblolly pine (*Pinus taeda* L.) has been the focus of much of this research because it is the most widely grown species in southern pine seed orchards. Crown release, fertilization, irrigation, and, to a lesser extent, injury and chemicals have been used to stimulate early and heavy flowering. Wheeler and Bramlett (1991) recently reported flower stimulation of loblolly pines from girdling and gibberellin $(GA_{4/7})$ treatments. Most of the response resulted from the girdling treatments.

The use of injury to stimulate flowering of fruit trees was documented as early as the 18th century. Injuring forest trees to stimulate seed production was attempted in the early 1920's. Since these early tests, injury has been researched extensively in many coniferous species, but it has been used infrequently in seed orchards for fear of harming valuable trees and inconsistency of response. There also has been concern that injury will weaken trees, resulting in greater susceptibility to insects or mortality.

The purpose of the study reported here was to determine the response of slash pine (P. *elliottii* Engelm.) and longleaf pine (P. *palustris* Mill.) to girdling and strangulation. The treatments were evaluated by measuring cone production, seed yield and quality, and tree growth and mortality.

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METHODS

Four treatments were tested: (1) partial girdling in spring and (2) in summer, (3) banding with wire in spring, and (4) an untreated control, applied to 23-year-old slash and longleaf pines located on the Palustris Experimental Forest near Alexandria, Louisiana. Study trees ranged in diameter from 11.0 to 12.9 inches and were selected for uniformity in crown size, vigor, and past cone production. Treatments were replicated 10 times in a randomized block design. Trees were grouped into blocks of four on the basis of promixity and treatments were assigned at random within each block. Analyses of variance and orthogonal comparisons were used to test treatment differences at the statistical significance level of 0.05.

Girdling was done using a girdling machine that cut through the bark and cambium. The girdles consisted of two semi-circular cuts approximately 1-inch wide. They were 4 inches apart vertically and overlapped 1 inch on each end. Girdling was done in early April and late June. Following treatment, an insecticide was applied to the wounded areas to reduce bark beetle attack.

Wire bands for the strangulation treatment were applied in early April and consisted of three strands of #9 wire. Loose bark was removed so that the wire made uniform contact around the trees.

At the time of establishment, d.b.h., total height, and length of live crown were measured. Also, previous cone production was estimated. Slash pines were remeasured after 2 1/2 years. Each year after treatment, cone production was estimated in July or August using one-position, binocular counts (Hoekstra 1960).

In the second-year after treatment, 10 cones were collected from each slash pine tree to evaluate seed yield per cone and seed viability. Due to the mortality of the longleaf trees, cones were not collected for this species. All empty seeds were removed by flotation (Barnett 1971) and 50 sound seeds per tree were tested following standard laboratory procedures (AOSA 1980).

RESULTS

Cone Production

Cone production was not affected by injury until the second year after treatment (+2). In that year, slash pine cone production was increased 62 percent over the control by banding, 133 percent by spring girdling, and 200 percent by summer girdling (Table 1). Individual degree of freedom comparisons showed that injured trees yielded significantly more cones than control trees, but that there were no significant differences in yields between banding and girdling or between spring and summer girdling. There were an estimated 21 cones per tree for the control and an average of 49 cones per injured tree. In the following year (+3), counts for slash pine ranged from 50 cones per control tree to 99 cones per tree for the summer girdling treatment, but differences were not statistically significant (Table 1). It does appear that banding may have a greater lag in response than girdling.

Table 1. Average cone production by treatment, year[x], and species, based on one-position binocular counts.

Species and treatment	Cones per tree per year				
	-1	0	+1	+2	+3
Slash pine					
Banding	26	21	50	34bY	82
Spring girdling	30	16	43	49h	70
Summer girdling	19	10	36	63b	99
Untreated control	30	19	43	21a	50
Average	26	16	43	42	75
Longleaf pine					
Banding	50	10	55	5	22(8)z
Spring girdling	53	11	3[1] (7)	8(5)	3(1)
Summer girdling	62	18	52	18(5)	10(2)
Untreated control	41	10	39	9	22
Average	49	12	44	10	14

[x]The year of treatment application is indicated by 0, years before or after this year are shown by (-) or (+).

'Values followed by different letters are significantly different at the 0.0 level.

Figures in parentheses are the number of living trees used for production estimates. Dead trees were assigned a value of zero in computing means for treatments.

Half of the girdled longleaf pines died before the cone counts in year +2. Therefore, analysis of the +2 and +3 year data compared only banding and the control. There were no significant differences between these treatments in either year.

Average values for living longleaf pine trees indicate that both spring and summer girdling may have increased cone production, especially in year +2. On this basis, spring girdling increased production 78 percent in year +2 and 36 percent in year +3. Summer girdling boosted production 300 percent and 127 percent, respectively, in the 2 years. These increases roughly parallel results with slash pine which suffered no mortality during the study, but mortality precluded a statistical analysis. However, treatments actually decreased net production if mortality is considered (Table 1). Average cone counts for living longleaf trees were as follows:

Treatment	Year +2	+3
	Number	
Banding	5	28
Spring girdling	16	30
Summer girdling	36	50
Untreated control	9	22

Seed Yield and Germination

The influence of increased slash pine cone production on numbers of sound seeds per cone and seed viability was determined for cones collected in year +2, the only year there were significant increases in cone production. The seed yields were low, averaging only 13 per cone (Table 2). There was a trend toward total higher seed yield from injured trees, but the differences were not significant. Nevertheless, the increased cone yield increased seed production on injured trees.

Table 2. Average sound seeds per cone and germination percentages for seeds produced during year +2, and tree heights of slash pines used in the study.

Treatment	Sound seeds per cone	GerminationX	Height Yr. -1	Height +
	Number	Percent	--Feet--	
Banding	14	98	56	63
Spring girdling	11	97	58	64
Summer girdling	18	90	58	64
Untreated control	10	97	57	64
Average	13	96	57	64

x Values based on data from 10 cones per tree.

Germination was high, averaging 96 percent for all treatments, and was not significantly affected by treatments (Table 2). Summer girdling resulted in the lowest germination, but this was largely due to seeds from one tree that germinated only 42 percent.

Mortality and Growth

None of the slash pines died; however, by year +2, half of the girdled longleaf trees were dead (there were 10 trees per treatment). Longleaf pine mortality by treatment in year +3 was as follows:

Treatment	Number of dead trees
Banding	2
Spring girdling	9
Summer girdling	8
Untreated control	0
Total	19

The treatments had little effect on height growth, which averaged 6 to 7 feet for all over the 3 1/2 year period. (Because of swelling above the injuries, d.b.h. measurements were not valid.)

DISCUSSION

Mortality of study trees largely precludes any realistic appraisal of the effects of the treatments on longleaf pine cone production. Only banded and control trees survived sufficiently to measure cone yields. There were no statistical differences between these two treatments and overall production was low.

Banding and girdling significantly increased slash pine cone production only in year +2--27 to 30 months after the treatments were applied. These results support Hocher's (1962) conclusions that injury increases yields of the first cone crop originating after the treatments are applied but have little effect on subsequent crops.

According to Hoekstra (1960), only 45 percent of slash pine cones on a tree are visible through binoculars from a single location. When this correction is applied to cone counts obtained from slash pine trees in year +2, the cone production per tree averaged 47 and 109 for control and injury treatments, respectively. Even with stimulation, this production is low and meaningless for seed production.

The results of this study confirm earlier tests that indicated that mechanical injury can stimulate flower and cone production in southern pines (Bilan 1960, Grano 1960, White and Wright 1987, Wheeler and Bramlett 1991). However, the results also indicate that caution must be used with these techniques. First, the magnitude of the response, although statistically significant, may not justify the risk of the treatment. Second, species seem to differ in their susceptibility to these types of injury. Longleaf pine, in particular, seems sensitive to injury. Third, girdling technique may be important. In this study the girdles were about 1-inch across, but in the tests of Wheeler and Bramlett (1991) the cuts were made with a saw and were only about 1/4-inch wide. Also, wire has been used to stimulate male flowering by banding branches (White and Wright 1987).

In general, crown release, fertilization, and irrigation have proved more reliable in the past than injury in stimulating flower and cone production of southern pines because response is more predictable and the treatments less harmful to the trees. Injury to stimulate cone production of slash and longleaf pines should be used only in special cases where some higher level of risk is acceptable.

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