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Date of Pollen Shedding by Longleaf Pine Advanced by Increased Temperatures at Strobili

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Abstract. Air temperatures in the microenvironments of flower buds of *Pinus palustris* Mill. appear to be a major determinant of flowering date. Shoots bearing staminate strobili on each of 10 trees were bagged at different times and for varying lengths of time in January and February. Bagging treatments provided 488 to 3,852 additional degree-hr of heat above 50°F accumulated from January 1. Flowering date was advanced more or less in proportion to added heat, up to an average of 8.6 days ahead of unbagged controls. Individual trees varied widely in date of pollen shedding. **Forest Sci. 19:315–3 18.**

Additional key words. *Pinus palustris,* heat sums, phenology.

AIR TEMPERATURES have long been associated with pine flowering events, including growth and ripening of staminate strobili (Millett 1944, Fielding 1957, Snyder 1961) and the time of pollen shedding (Duffield 1953, Bingham and Squillace 1957, Wang et al. 1960). In all cases, processes were hastened by higher temperatures. A function based on degree-hr heat sums above 50°F accumulated from January 1 accounted for virtually all of the annual variation in date of peak pollen shedding by longleaf pine over a lo-year period (Boyer 1973). Since the genus *Pinus* is photoperiodically neutral (Mirov 1967), its flowering under natural conditions is not affected by changing photoperiod.

The manner and degree to which temperature affects flowering phenology of longleaf pine is uncertain. Is strobili development controlled principally by air temperature in the immediate vicinity of flower buds, or is it related to environmental fluxes affecting the whole tree? If the former, then increased temperatures at shoots with staminate strobili should force early pollen shedding. If so, at what periods during the winter will the addition of heat accelerate strobili development? The study described here was done to answer these questions. Shoots with staminate strobili were bagged for varying periods to provide differing temperature regimes, and the dates of pollen shedding were recorded.

Methods

Ten longleaf pine trees on the Escambia Experimental Forest in southwest Alabama were selected for study. They ranged from 9 to 17 inches and averaged 12 inches in dbh. All received full sunlight from the south. On each tree, 16 south-side shoots with staminate flower buds were selected and marked. Two of the 16 were randomly assigned to each of eight treatments that differed in timing and duration of bagging:

January 3-January 17 (2 weeks)
January l&February 1 (2 weeks)
January 3 l-February 14 (2 weeks)
January 3-January 3 1 (4 weeks)
January lo-February 7 (4 weeks)
January 17-February 14 (4 weeks)
January 3-February 14 (6 weeks)
Unbagged control.

Shoots were enclosed in 6- by 12- by 24-inch polyethylene bags. All were vented on the lower side to prevent excessive moisture accumulations and carbon dioxide deficiencies.

Two shoots with staminate flower buds were marked on the north side of eight study trees. These shoots were observed to compare rates of development of strobili in shade and in direct sunlight.

For each shoot the dates of three events were recorded :

Staminate strobilus beginning to shed pollen.
Most or all strobili shedding pollen (peak day).
All strobili nearly through shedding pollen.

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Air temperatures near flower buds were monitored by five maximum-minimum thermometers shielded from direct sunlight. Three, each on a different tree, were kept within bags, and two were attached to unbagged shoots. Temperatures recorded by these thermometers were considered typical of those near all other sample shoots.

A hygrothermograph in a standard weather instrument shelter on the Experimental Forest provided a continuous record of air temperature. Regressions were computed to determine the relationship between hygrothermograph and thermometer temperatures, both within bags and in the open. Temperatures for the 2 days per week when thermometers were not observed were estimated with these regressions. Detailed procedures are reported elsewhere.[1]

Daily degree-hr heat sums above 50°F were estimated from daily maximum and minimum temperatures at sampled shoots by the method of Lindsey and Newman (1956). In the study area such estimates of degree-hr heat sums for the three winter months combined have averaged, over a 6-year period, within 2 percent of values taken from a thermograph trace. Days and total degree-hr heat sums from January 1 to peak pollen shedding were computed for each sample shoot.

The effects of bagging treatment, aspect, and individual tree on both days and heat sums from January 1 to peak flowering and on duration of pollen shedding by individual shoots were tested by analysis of variance. Treatment means were compared through Duncan's tests at the 0.05 level.

Results and Discussion

of Peak Pollen Shedding. Bagging of staminate strobili resulted in earlier pollen shedding (Table 1). The date of pollen shedding was advanced more or less in proportion to added heat. Shoots bagged 6 weeks from January 3 to February 14 reached peak pollen shedding an average of 8.6 days ahead of unbagged controls. However, shoots bagged from January 3 to 17 flowered at the same time as unbagged controls. The small amounts of extra heat generated within bags early in January had no apparent effect on strobili development.

The effect of bagging on pollen shedding was similar for each of the 10 study trees. However, flowering dates within each treatment varied considerably by tree (Fig. 1). Ranges overlapped among treatments, and standard deviations within treatments ranged from 4.7 to 7.0 days. Treatments accounted for 25 percent of the variation in days to peak pollen shedding, while differences among individual trees accounted for 46 percent. There was no interaction between treatments and trees.

The large variation in date of pollen shedding among the 10 sample trees could influence gene exchange within a natural population of longleaf pines. The average date of peak pollen shedding by unbagged flower clusters ranged from March 19 for one tree to April 1 for another. Within treatments, an average of 7 days separated pollen shedding of earliest and latest flowering trees. There was virtually no overlap in pollen shedding between trees that shed second earliest and latest. Some trees were consistently early or late in flowering, a result reported for other pines as well (Bingham and Squillace 1957).

Staminate strobili on a given tree ripened at about the same time. Individuals of nine of the 10 unbagged pairs reached peak pollen shedding within 2 days of each other, as did both members of all eight pairs on the north side of study trees. Days to pollen shedding peak averaged 86.1 on northside and 85.3 on southside shoots.

Duration of Pollen Shedding on Individual Shoots. Bagging prolonged the pollen shedding period for individual shoots (Table 1). Shedding of all unbagged shoots lasted about 6 days. Bagging for 2 weeks or more after mid-January prolonged the shedding period, which reached a maximum of about 11 days on shoots bagged 6 weeks. This extension of the pollen shedding period was probably caused by temperature stratification within bags, which tended to ripen uppermost strobili ahead of those that had been lower in the bags. Temperature differentials ranging up to 6°C have been observed within the limited confines of a pollination bag (Rohmeder and Eisenhut 1959).

Heat Sums and Pollen Shedding. Heat sums to peak flowering were relatively uniform among bagging treatments, ranging from an

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[1] Boyer, W. D. The influence of temperature on date and duration of pollen-shed by longleaf pine. Ph.D. Thesis, Duke Univ., Durham, N. C. 159 p. 1969.

uary I through day of peak pollen shedding.

Bagging dates	Days to peak flowering	Duration of flowering (days)	Degree-hr above 50°F to peak flowering	
			Total	Increase due to treatment
January 3-17	86.4a[a]	5.7	13,019X"	488
January 18-February 1	84.2b	1.6	13,348XY	1,709
January 3 l-February 14	82.6b	7.8	12,970X	1,668
January 3-3 1	83.6bc	7.2	13,637XY	2,184
January lo-February 7	81.3cd	9.4	13,582XY	2,703
January 17-February 14	80.0d	8.5	13,850Y	3,364
January 3-February 14	77.5e	10.9	13,579XY	3,852
Unbagged controls	86.1a	6.2	12,313Z	0

[a] Means followed by the same letter do not differ significantly at the 0.05 level according to Duncan's test.

average of 12,970 to 13,850 degree-hr (Table 1). Heat sums for six of the eight treatments were not significantly different according to Duncan's test. A low heat sum for unbagged shoots (12,3 13 degree-hr) was largely responsible for a significant effect of bagging on heat sums to peak flowering.

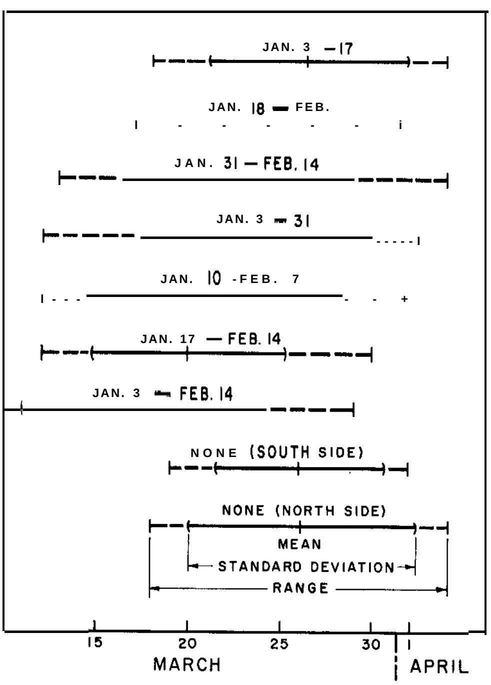

FIGURE 1. ***Means, standard deviations, and ranges in dates of pollen shedding peaks for longleaf pine shoots bagged during the periods shown.***

Seventy percent of the variation in heat sums to peak pollen shedding resulted from tree-to-tree differences, which ranged from 11,262 to 16,126 degree-hr. This effect is directly related to variations in date of flowering and apparently results from inherent differences among individual trees. For each tree, heat sums to peak pollen shed remained comparatively constant despite treatment-induced shifts in flowering date.

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