GEOGRAPHIC LOCATION AFFECTS FLOWERING OF LOBLOLLY PINES

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Abstract.--Loblolly pine seedlings and grafts were planted in four locations: south Florida, north Florida, south Mississippi, and north Mississippi. Male and female flowering were measured each year for 6 years. Grafts and seedlings flowered first in the south Florida planting. Flowering in all plantings was inversely proportional to latitude through the fourth year, i.e., the plantings in order of fruitfulness were south Florida > north Florida > south Mississippi > north Mississippi. After age 4, flowering was best at the north Florida planting, possibly because of better site and management.

The tendency for more southern orchards to flower earlier is confirmed, although orchard site quality and management were also important.

Early and abundant flowering can greatly enhance production of improved seed and shorten breeding generation intervals in southern pine tree-improvement programs. Thus it is important to determine the extent of locational effects on flowering and seed production for use in selecting locations for future seed orchards.

Evidence has accumulated (Schmidtling 1977, 1979, Gansel 1973) that geographic location can strongly affect flowering in southern pines. Flowering and seed production seem to be greater in southern locations when compared to northern locations (Sarvas 1970, Werner 1975).

The objective of this study is to determine the extent of geographic variation in flowering of loblolly pine seedlings and grafts. Seedlings as well as grafted loblolly pines were included in this study to examine two different but closely related aspects of flowering: (1) will location affect the quantity of flowers and seeds produced in reproductively mature trees, and (2) will location affect the age of first flowering in seedlings ("ripeness to flower").

MATERIALS AND METHODS

The experimental plantings were established using grafts of 10 loblolly pine clones and also seedlings from 5 of the same clones. Scions from the 10 scion clones varying widely in flowering potential were collected from ramets located in the Eranbert Seed Orchard in south Mississippi and grafted on potted seedling rootstocks in January of 1977. Original ortets were located in south and central Mississippi (fig. 1).

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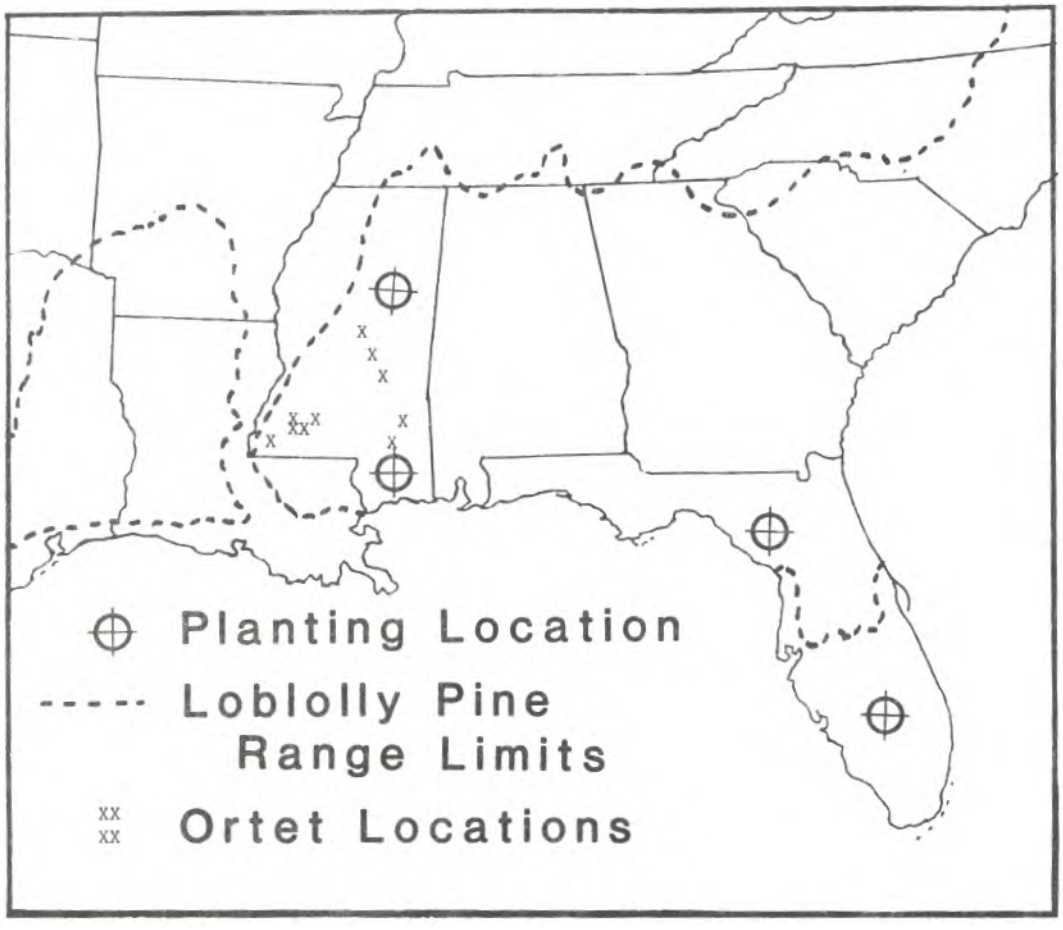

Figure 1.--Map of southeastern United States showing the planting locations, the locations of the original ortets used for grafts and seedlings, and the botanical range limits of loblolly pines (adapted from Critchfield and Little 1966).

Five successful grafts of each scion clone were outplanted as single-tree plots at each location in June of 1977. Five potted seedlings from each of five families were also outplanted, for a total of 75 trees at each location (50 grafts + 25 seedlings). Trees that died the first season were replaced in March of 1978 with potted grafts and seedlings of the same age that were held for that purpose in a lath house at the Harrison Experimental Forest in South Mississippi.

The planting locations (fig. 1) vary not only in latitude but also in site quality (table 1). The south Florida planting is in Glades County, located in what was formerly a pasture but is now planted in eucalyptus. The site is poorly drained and has been bedded, with rock phosphate applied to correct a phosphate deficiency. There has been no maintenance other than the initial site preparation.

The north Florida planting is contiguous to a producing seed orchard, and receives the same care as the orchard. It is consequently in excellent condition.

The south Mississippi planting is located on the Harrison Experimental Forest. It has been mowed for competition control annually, but has received no other treatments.

The north Mississippi planting is located on a fertile but poorly drained site. It has also been mowed annually, but has received no other treatments.

Table 1.--Site characteristics and survival data for the four planting locations

Location	Latitude	Soil Series/ Surface Texture	Drainage	6th-year survival grafts	6th-year survival seedlings
	---°N---			--------%---------	
South Florida	27.1	Myacca Fine loamy sand	Poorly to somewhat poorly	50	80
North Florida	29.6	Lake Fine sand	Well	96	100
South Mississippi	30.5	Saucier Fine sandy loam	Moderately well	98	96
North Mississippi	33.3	Urbo Silty clay loam	Poorly to somewhat poorly	38	44

Female strobili and male strobili clusters were counted and their heights measured each year. Flowering data from the seedlings were handled as a qualitative trait, i.e., either the seedlings flowered or they did not. Flowering indicates reproductive maturity or "ripeness to flower." The ripeness to flower concept assumes that once flowering occurs, it is not reversible (Schmidtling 1981), even though flowering may not occur in subsequent years. Proportion of total trees flowering was arc-sine square root transformed for analysis.

Flowering data for grafts was handled as a quantitative trait. Counts were square-root transformed for analysis. Analysis of variance was used to compare location and clone means. Differences were tested at the 0.05 level of probability.

RESULTS AND DISCUSSION

Survival of trees planted at the two mid-latitude sites, north Florida and south Mississippi, was excellent, ranging between 96 and 100 percent for both seedlings and grafts (table 1). Survival in the northernmost and

southernmost plantings was not as good. The same two factors adversely affected survival in both plantings: poor drainage and animal damage. In south Florida, many trees were trampled by cattle; in north Mississippi dana was caused by some unknown animal, perhaps beavers, stripping bark from the trees. In addition, the south Florida planting suffered from lack of competition control. In spite of poor survival, all 10 clones and 5 families were represented at all locations.

For the first 3 years, female flowering conformed to the expectations that the more southern plantings would flower better (fig. 2). Flowering of grafts commenced the first year after planting in south Florida, although the differences were not statistically significant (Fig. 2a). Flowering was best in the south Florida planting and second best in the north Florida planting through the third year. The fourth year (1981) there was essentially no flowering. At age 5, flowering in the north Florida planting equaled the south Florida planting; by age 6 the north Florida planting greatly exceeded the south Florida planting, when the grafts averaged 31 female strobili in north Florida vs 8 female strobili in south Florida.

There was very little flowering in the south Mississippi planting until the fifth year (fig. 2a). Flowering was consistently poor in the north Mississippi planting, and there were no female strobili at all the sixth year of the study.

In the statistical analyses, location effect was very strong. Clone effects, though significant, were much smaller. Location x clone interaction was not significant. This was not expected. In previous flower induction experiments, clonal effects were very strong, and clone x treatment interactions were significant (Schmidtling 1974).

Female flowering of the seedlings closely paralleled flowering of the grafts, although flowering did not begin until the third year (fig. 2b), when 33 percent of the south Florida seedlings flowered and 4 percent of the north Florida seedlings flowered. None of the seedlings in the other plantings flowered until age 5. By age 5, the north Florida seedlings exceeded the south Florida seedlings in "ripeness," and by age 6, 92 percent of the north Florida seedlings had flowered, compared to 72 percent in south Florida, 53 percent in south Mississippi, and 10 percent in north Mississippi.

Light and sporadic male flowering occurred on grafts in south Florida the second and third year, and none in the other three plantings. The pattern among locations for male flowering was similar to that for female flowering. At age 6, grafts and seedlings in north Florida averaged 5.8 pollen clusters per tree and 14.7 clusters per tree, respectively. Grafts and seedlings averaged 0.5 and 2.6 clusters per tree, respectively, in south Florida. There were only a few male strobili clusters at the other two locations.

Management and site conditions of the north Florida planting undoubtedly account for much of this planting's superiority in flowering in later years. The north Florida planting was fertilized along with the adjacent production orchard, and the site is well drained and more suitable for pines than the South Florida site.

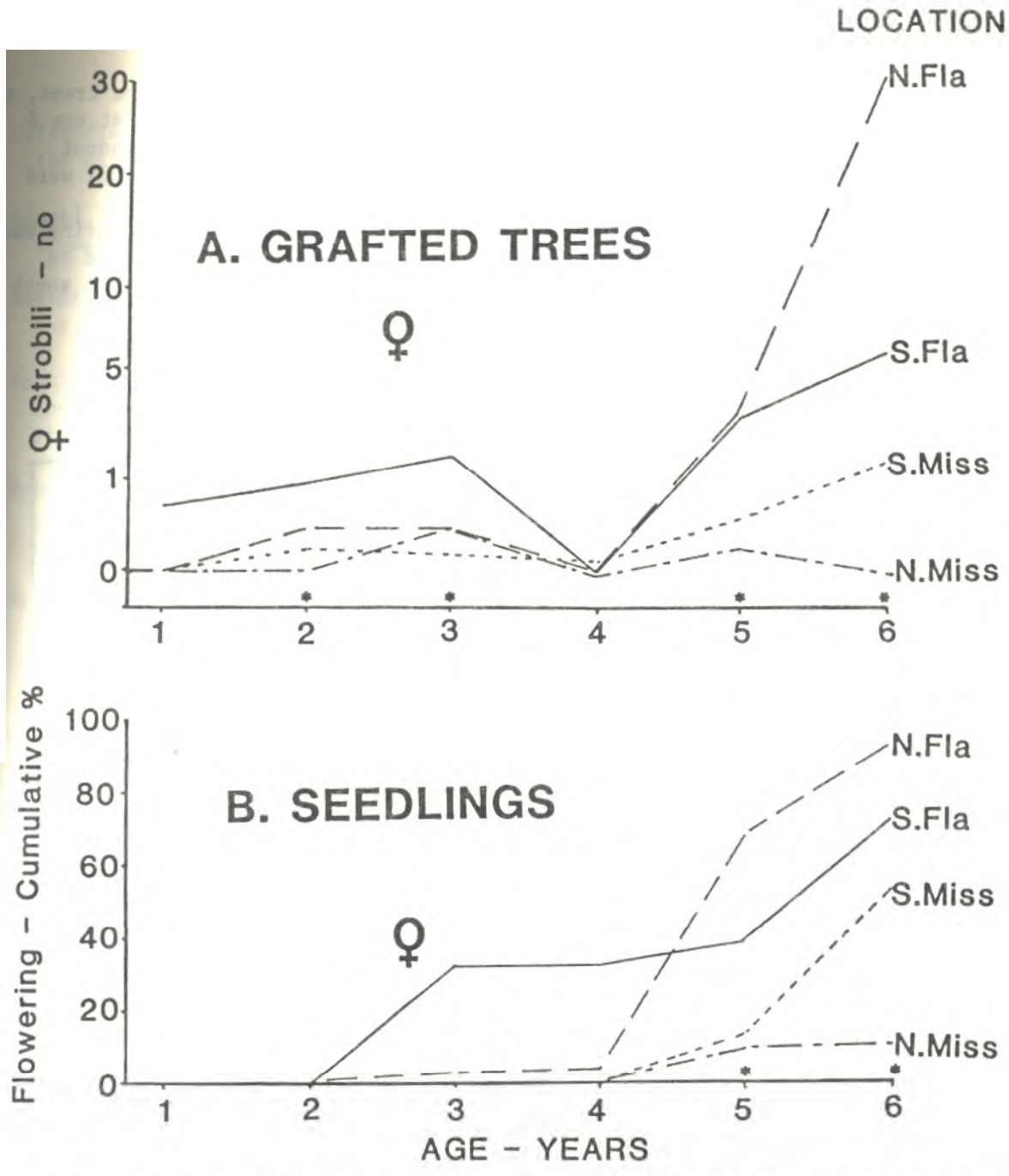

Figure 2.--Female flowering of grafted and seedling loblolly pines planted in four locations. Data recorded over 6 years. Vertical axis of (A) is square-root scale. *indicates that location differences for that year were statistically significant.

The superior management and site are evident in the size of the trees, as the seedlings and grafts in the north Florida planting were taller at age 6 than those in the other three plantings (fig. 3). But size alone cannot account for differences in flowering. The grafts in north Mississippi were nearly as tall as those in north Florida, and the seedlings in north Mississippi were second in height among the four plantings, yet flowering was consistently poorest in north Mississippi. Also, grafts and seedlings in south Florida are the shortest of all four plantings, but flowering in south Florida ranges from best to second best.

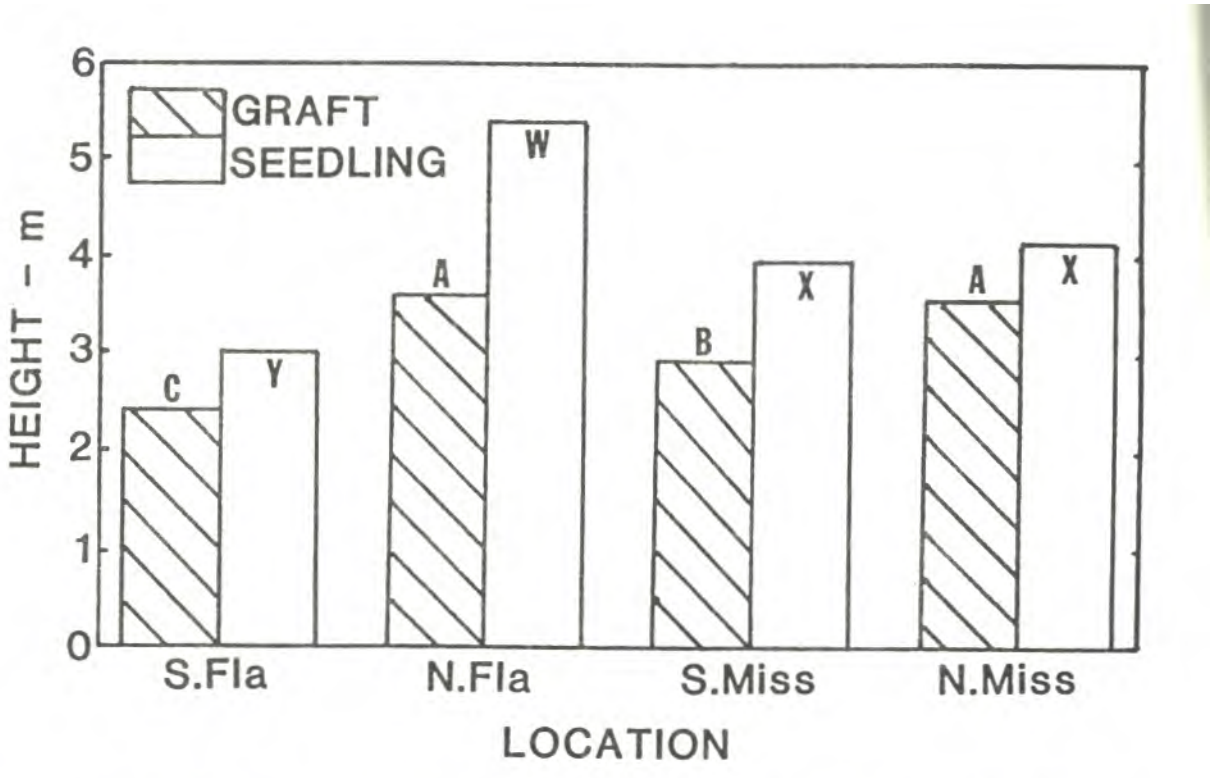

Figure 3.--Height of grafted and seedling loblolly pines planted in four locations after 6 years in the field. Bars topped by the same letter do not differ significantly according to Duncan's multiple range test (seedlings and grafts analyzed separately).

CONCLUSIONS

The results of this study support the observations that orchards sited in more southerly locations have a tendency to flower better. It is also clear that site and management are at least as important as location. Site quality was confounded with location in this study but it is interesting that the south Florida planting, where maintenance and growth were poorest, ranged from best to second best out of the four plantings in flowering. A better site with good maintenance in south Florida might have yielded consistently superior results across all years.

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