Tree Planter's Notes, Vol. 36, No. 2 (1985)

Irrigation Effective in Increasing Fruitfulness of a Shortleaf Pine (*Pinus echinata* Mill.) Seed Orchard

R. C. Schmidtling[1]

Principal plant geneticist, USDA Forest Service, Southern Forest Experiment Station, Forestry Sciences Laboratory, Gulfport, MS

*Irrigation with a drip system significantly increased flowering and cone survival in a shortleaf pine (*Pinus echinata *Mill.) seed orchard in Arkansas. Irrigation was especially effective during the severe drought of 1980.*

Various irrigation systems are operational in some southern pine seed orchards. Considerable optimism has been expressed about their benefits, but sound experimental data are scarce. Spring droughts, common in the South, could very well be deleterious to both growth and seed production. In a recent study of a loblolly pine seed orchard (3), irrigation greatly increased female flower and cone production. On the other hand, Jett (4) found that irrigation inhibited female flowering. Abundant moisture may favor vegetative growth at the expense of reproductive growth. Thus, mild moisture stress at the time female strobili are initiated (probably late summer) may enhance strobili production. One well-controlled experiment indicated that midsummer to late summer drought, with abundant moisture at all other times, was beneficial to cone production in loblolly pine (2). Others report that abundant early summer rain, followed by a relatively dry late summer, resulted in good female flower crops in loblolly pine the following spring (6). In the same study, the opposite rainfall pattern, i.e., a dry early summer followed by a wet late summer, appeared to enhance male flowering.

The objective of the present study is to determine effects of the timing of irrigation on production of male and female strobili, cones, and seed in a shortleaf pine seed orchard. Year-to-year variation in male and female strobili will also be examined.

Materials and Methods

The study was established in a USDA Forest Service shortleaf pine seed orchard in central Arkansas. The orchard, near the western extremity of the southern pine region, where rainfall becomes a limiting factor, consists of 13,000 ramets of 50 clones. The majority of the ramets were planted in 1968 with 15- by 30-foot spacing. The clones were arranged sequentially with each adjacent row offset by five clones (fig. 1). The well-drained soils in the orchard are primarily Goldston shaley silt loams or Herndon gravelly silt loams. A drip system of irrigation seemed advantageous (5) for experimental work, for it allowed irrigation of individual trees with very little carryover to adjacent trees. Ten clones, adjacent or nearly adjacent within the rows, were chosen from those having a large number of ramets planted in 1968. Trees used in the study averaged 5 inches in d.b.h. and 20 feet in height at the beginning of the study.

A split-plot/completely random design was used. The main plots were the group of clones within a row, which were irrigated as a unit (fig. 1); subplots were ramets of a given clone within the main plots. The four treatments consisted of 1) full, irrigated entire growing season (when needed) (April 1 to October 2); 2) early, irrigated when needed before July 1; 3) late, irrigated when needed after July 1; and 4) none, nonirrigated control.

The 5 replications included 20 main plots and 200 trees. In the spring of 1980, polyvinyl chloride (PVC) pipe was laid on the ground along the rows next to the trees. Four emitters were installed in the pipe under each irrigated tree (fig. 1) to distribute the water evenly under the crown. The plots were arranged so that adjacent rows were not used, to prevent carryover effects from adjacent plots. Water was applied for 1 night (15 hours) any week in which less than 1 inch of rain fell. According to measurements of emitter output and area wetted, this approximated applying 1 inch of rain within the area beneath the crown of the trees.

[1] The author is grateful to James McConnell, Robert Kitchens, Jim McMahon, and Charles Studyvin, USDA Forest Service, Southern Region Tree Improvement personnel, for their assistance during the course of this study.

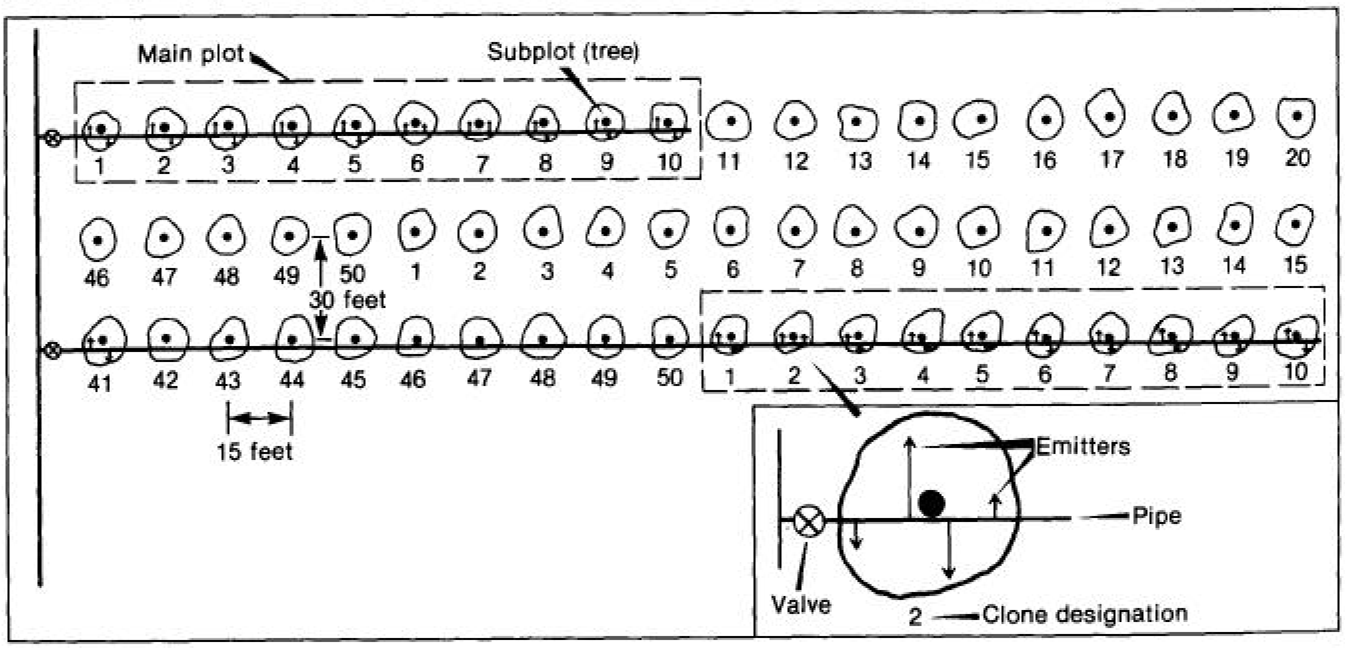

Figure 1—*Diagram of the orchard showing clone arrangement, experimental plot, and irrigation system layout.*

Female strobili and male strobili clusters were counted in the spring of 1979, 1981, 1982, and 1983. Cones were counted in the fall of 1980 and 1981; at the same time a 5-cone sample was taken from each ramet for seed-yield information.

Analysis of variance appropriate for the split-plot/completely random design was used to test the significance of treatment, clone and treatment by clone effects at P = 0.05. Duncan's multiple range test was also used to separate treatment means.

Results and Discussion

Year-to-Year Clonal Variation. Both male and female flowering varied considerably over the length of the experiment (fig. 2). Severe drought in the summer of 1980 in Arkansas (8) undoubtedly accounts for the poor flowering in 1981. Male and female flowering in 1982 was four times as great as in 1981 but dropped off slightly in 1983.

There was a strong year-by-clone interaction for both male and female flowering (fig. 3). Although, in general, good-flowering clones perform well

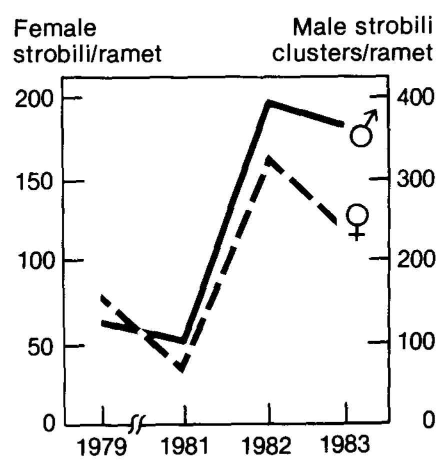

Figure 2—*Variation in male and female flowering in the orchard for each year during the experiment. Based on nonirrigated controls.*

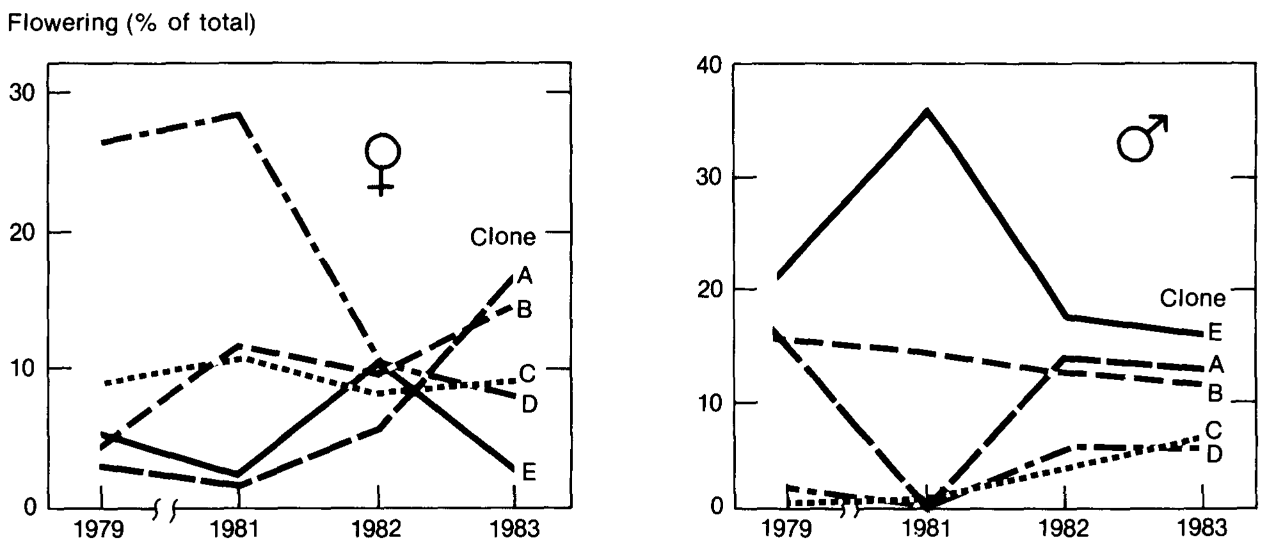

Figure 3—*Clonal variation in male and female flowering over the course of the study of 5 of the 10 experimental clones. Based on nonirrigated controls.*

every year, it is evident in figure 3 that the considerable change in rank for both male and female flowering is similar to that which has been observed in loblolly pines (7). Year-to-year variation in flowering results in genetic variation in the seed produced each year, even in seeds collected separately by clone.

Irrigation effects. *Female flowering.* In 1981, the first spring after the irrigation system was used, late-season and full-season irrigation nearly doubled the female flower crop (fig. 4) over that of both controls and over that of the early-season irrigation treatment. However, the system was only used twice before July 1, in late June, and only a very limited amount of water was applied. Some problems with clogged filters reduced water flow in the first 2 months of the use of the system. In July, August, and September of 1980, the system was used nearly every week in treatments 1 and 3 because of the extended drought.

In 1982, after the second year of irrigation, treatment effects followed the pattern that was expected: i.e., early-season irrigation was best, late-season irrigation was not effective, and full-season irrigation was intermediate (fig. 4). Rainfall was nearly average in 1981, the previous year, although the system was used six times before July 1 and eight times after July 1.

In 1983, after the third year of irrigation, the irrigated treatments had more female strobili that did the controls, but irrigation regimes did not differ significantly (fig. 4) among themselves. Carryover effects from the previous 2 years' treatment may have affected 1983 results. Mean diameter growth from 1980 through 1983 is in the same order as flowering for 1983: the control averaged 6.8 centimeters, those irrigated early averaged 7.1 centimeters, those irrigated late averaged 7.2 centimeters, and those irrigated the whole season averaged 7.9 centimeters of growth.

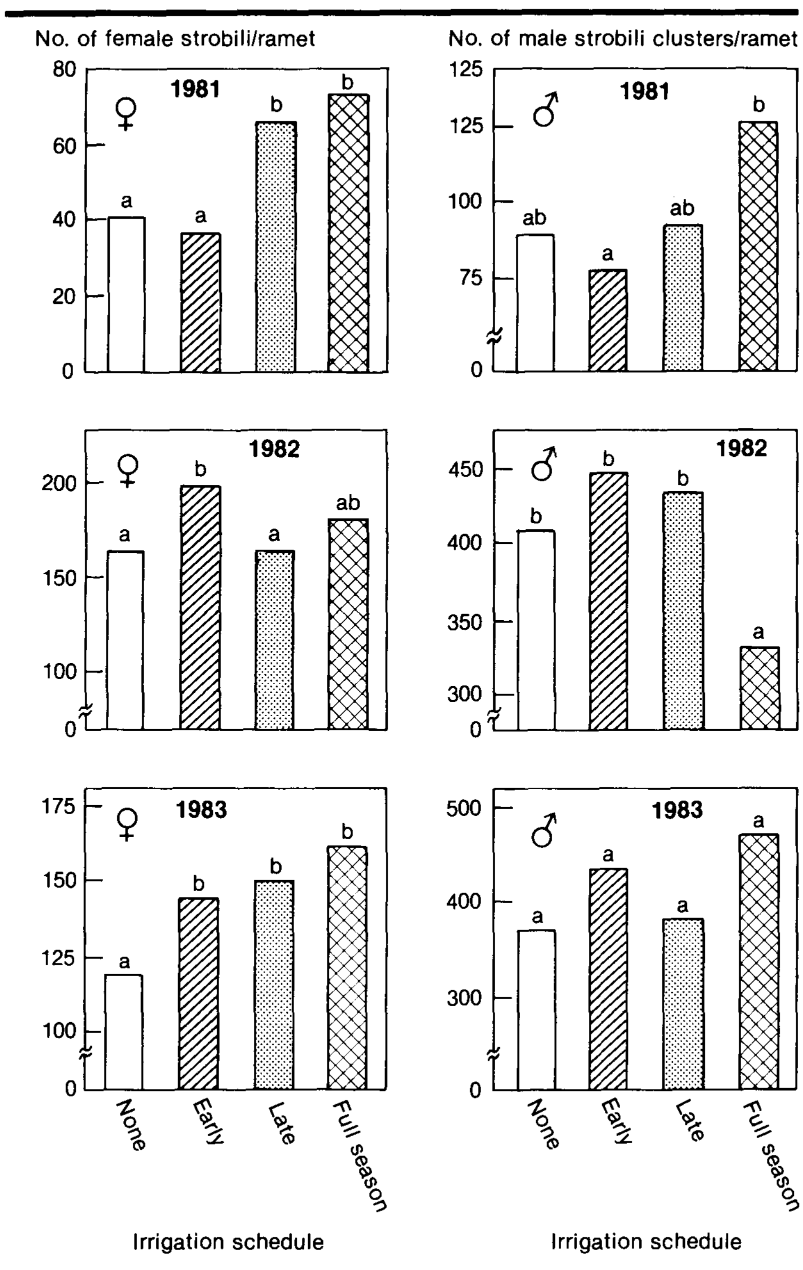

Figure 4—*Effects of irrigation on male and female flowering in the orchard for 1981-83. Bars topped by the same letter do not differ significantly (P = 0.05) according to Duncan's multiple range test.*

Male flowering. Significant differences occurred among irrigation treatments in male flowering in 1981 and 1982, but the pattern of variation is difficult to explain. In 1981, the only clear difference appeared between full-season irrigation, which averaged 125 male strobili clusters per ramet, and the early irrigation, which averaged only 75 per ramet (fig. 4). The control and late-season irrigation treatments were intermediate, averaging around 85 male strobili clusters per ramet. In 1982, the pattern of variation seemed the reverse of the 1981 pattern. The control and early- and late-season irrigation treatments averaged around 430 male strobili clusters per ramet, whereas the full-season irrigation averaged only 330 clusters per ramet. Treatment differences were not significant in 1983.

Barnes and Bengtson (1), not finding a significant effect of irrigation on male flowering of slash pines, did find a significant irrigation-by-clone interaction in male flowering. Clone-by-irrigation interactions were not significant for any trait in this study, but the effects of irrigation on male flowering are clouded.

Cone and seed yields. Seed yield per cone was unaffected by irrigation in either 1981 or 1982. Conelet survival was affected by irrigation in 1979-80. Survival was only 21 percent in the controls, lower than the 46-percent average for the 3 irrigated treatments. Differences among irrigation regimes were not significant. Since irrigation was not applied until June of 1980, the treatments must have enhanced cone survival in the second growing season. Further, because all three irrigation regimes enhanced survival, a period around July 1 may be critical to survival. Second-year cones are growing rapidly at this time, and they reach full size by the end of July.

Cone survival for 1981-82 did not vary significantly by treatment. Rainfall was near average for both years, so apparently conelet survival is affected only in severe droughts such as the one that occurred in 1980.

Conclusions

Irrigation can apparently be effective in increasing female flowering in a shortleaf pine seed orchard. In a severe drought, irrigation not only increases female flowering but also enhances conelet survival. It does not appear that male flowering can be increased reliably by irrigation, although both male and female flowering would eventually be enhanced in subsequent years because irrigation increases the size and vigor of the ramets.

Literature Cited

1. Barnes, R.L.; Bengtson, G.W. Effects of fertilization, irrigation, and cover cropping on flowering and on nitrogen and soluble sugar composition of slash pine. Forest Science 14: 172-180; 1968.
2. Dewers, R.S.; Moehring, D.M. Effects of soil water stress on initiation of ovulate primordia in loblolly pine. Forest Science 16: 219-221; 1970.
3. Gregory, S.D.; Guinness, W.M.; Davey, C.B. Fertilization and irrigation stimulate flowering and cone production in a loblolly pine seed orchard. Southern Journal of Applied Forestry 6: 44-48; 1982.
4. Jett, J.B. The impact of irrigation and supplemental nitrogen fertilization on the development of a young loblolly pine seed orchard. (Ph.D. dissertation, North Carolina State University at Raleigh; 48 p.). Dissertation Abstracts International B (44) 5: 1289-129013; 1983.
5. O'Loughlin, T.C. Trickle irrigation for seed orchards. In: Proceedings, 15th southern forest tree improvement conference, Starkeville, MS. Mississippi State: Mississippi State University; 1979: 86-92.
6. Schmidtling, R.C. The genetic and environmental basis of fruitfulness and growth in loblolly pines. (Ph.D. dissertation, University of Florida, Gainesville; 104 p.) Dissertation Abstracts International B (41) 6: 199813; 1980.
7. Schmidtling, R.C. Genetic variation in fruitfulness in a loblolly pine (*Pinus taeda* L.) seed orchard. Silvae Genetica 32: 76-80; 1983.
8. Yeiser, J.L.; Burnett, F. Fate of forest trees stressed by heat and drought in southeastern Arkansas. Southern Journal of Applied Forestry 6: 194195; 1982.