# TIMING OF NITROGEN APPLICATIONS IN A LOBLOLLY PINE SEED ORCHARD

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**Abstract.** To determine the optimal timing of ammonium nitrate fertilizer to stimulate female strobili production in loblolly pine *(Pinus taeda* L.) seed orchards, ammonium nitrate was applied on four different dates; April, June, July, and September in 1993, 1994, and 1995. The orchard was seven years old the first treatment year. Female strobili production increased throughout the study from an average of 40/tree in 1993 to 230/tree in 1995. Date of fertilizer application had very little affect on female strobili production in 1993 and 1994. Treatments made during the active growing season (April, June and July) resulted in equivalent number of female strobili. Following the 1995 treatment year, there were significantly fewer strobili only on trees fertilized late in the growing season (September). Differences among the 19 clones used in the study were huge and accounted for much of the variation in female strobili production. There was no clone by treatment interaction indicating that clones responded essentially the same to the different fertilizer treatments. The lack of fertilizer treatment differences suggests that applying ammonium nitrate virtually any time during the active growing season will stimulate flowering.

Keywords: *Pinus taeda* L., fertilization, female strobili.

## Introduction

The application of fertilizers to enhance strobili production in southern pine seed orchards has become a route practice. It is used to enhance seed orchard development during the first four to five years following orchard establishment, to promote female strobili initiation during the "production" phase of the orchard, and to maintain health and vigor of the trees throughout the life of the orchard. Of the fertilizer elements routinely applied to seed orchards to stimulate strobili production, many published reports indicate that nitrogen is the most important or at least the most efficacious (Puritch 1972, Owens and Blake 1984, and Owens 1991). While nitrogen fertilization is widely used to stimulate strobili production, it is unknown whether nitrogen is important for induction, bud development, or the path leading to seed maturation (Bonnet-Masimbert and Webber 1995).

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Despite the lack of understanding, nitrogen fertilization remains a prevalent practice in operational seed orchards. However, only scant attention has been paid to the timing of nitrogen fertilization to maximize the female strobili response. Schmidtling (1975) reported that in a fertilization timing study in a fully mature loblolly pine seed orchard, fertilization with ammonium nitrate in mid to late summer produced the greatest increase in female strobili production; the late-July treatment was deemed to be best, tripling strobili yield.

This paper reports the results of a nitrogen fertilization timing study in a young second generation loblolly pine seed orchard.

## Materials and Methods

The study was established in a 7-year-old second generation loblolly pine seed orchard in Oak Park, GA. Ammonium nitrate was applied at the rate of 400 pounds per acre in 1992, 1993, and 1994 at four different dates: April 27, June 8, July 27, and September 10. Nineteen clones with two ramets per clone received fertilization at each application time. The experimental design was a randomized complete block with three replication of each treatment and clone combination. The study area of the orchard received standard operational treatment for insects and turf management. Because the orchard was rogued in 1993, only 277 trees of the original 456 were analyzed in the study.

Complete female strobili counts were made in the spring of 1993, 1994, and 1995. Analysis of variance was performed using PROC GLM and clone mean correlation coefficients determined using PROC REG (SAS Institute, Inc. 1989).

## Results and Discussion

Female strobili production per tree increased significantly from 1993 to 1995 (40.4 strobili per tree in 1993 to 230.4 strobili per tree in 1995). As anticipated, clonal differences accounted for a substantial portion of the variation in strobili production (Table 1). Similar large clonal effects in seed orchard fertilization studies were also reported by Schmidtling (1975 and 1995).

Table 1. Sources and percent of variation by year in a loblolly pine seed orchard nitrogen timing study.

| | Percent of Variation | | |
|---|---|---|---|
| Source | 1993 | 1994 | 1995 |
| Block (B) | 0.8 | 1.4 | 3.7 |
| Treatment (T) | 0 | 0 | 0.9 |
| B x T | 0 | 0.5 | 0 |
| Clone (C) | 54.3 | 59.0 | 36.2 |
| B x C | 5.9 | 0 | 8.1 |
| T x C | 11.5 | 1.0 | 0 |
| BxTxC | 10.1 | 3.4 | 0 |
| Within | 17.4 | 34.6 | 51.2 |
| Total | 100 | 100 | 100 |

Another aspect of clonal response to fertilization observed in this study, and one that has been widely noted by seed orchard managers, was the year to year consistency of clonal fecundity. Very high (r=0.83** to r=0.84**) (Ps 0.001) clone mean correlations were obtained in this study (Fig. 1 and Fig. 2). Clone means were very repeatable from year to year; good flowering clones were always good and vice versa.

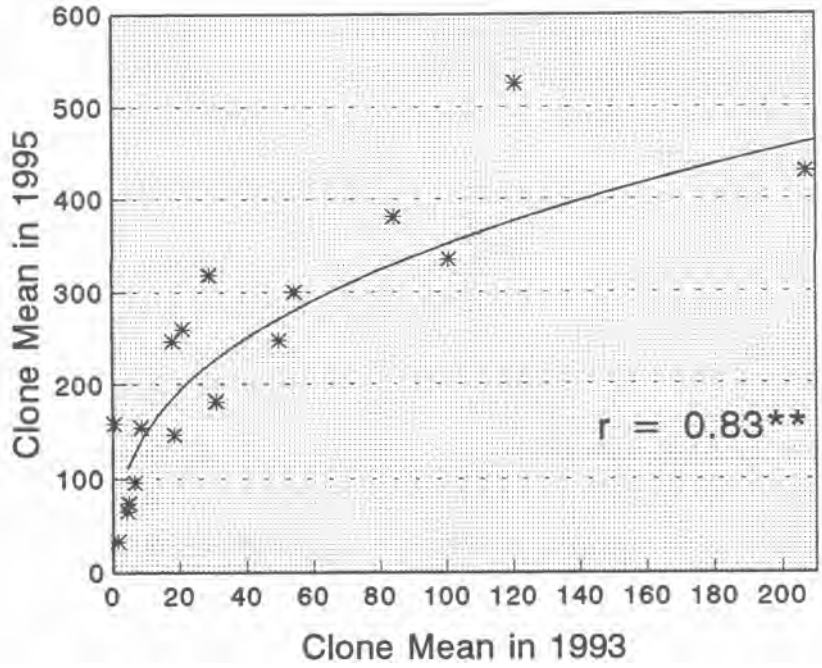


Figure 1. Correlation of clone means for female strobili counts from 1993 (log 1993 counts) with counts from 1995.

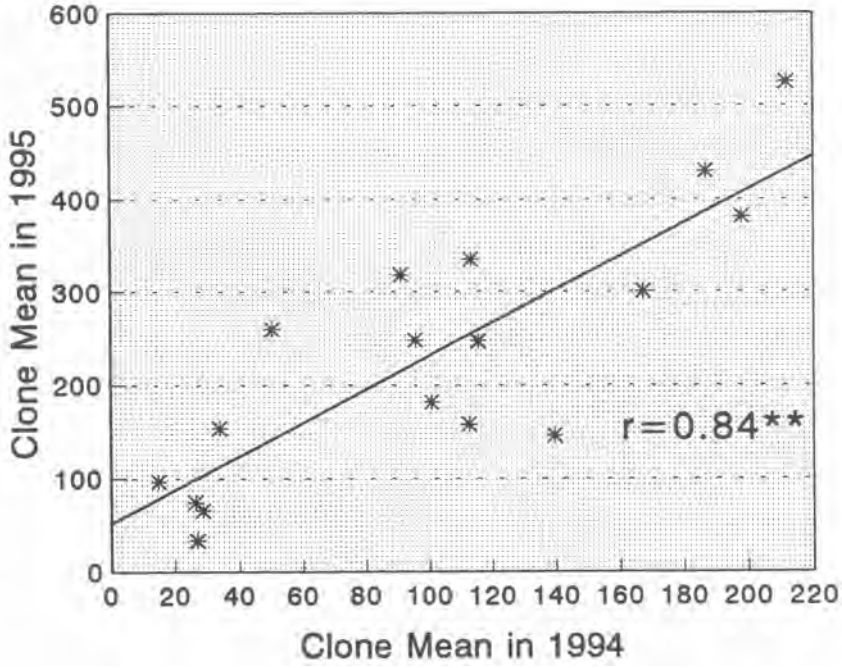


Figure 2. Correlation of clone means for female strobili counts from 1994 and 1995.

In contrast to the large clonal effects, there was virtually no Clone x Treatment interaction. Only 10 percent of the total variation was accounted for by the Clone x Treatment interaction in 1993 and this dropped to 0 percent by the third year of the study (Table 1). A similar lack of clone x timing treatment interaction for female strobili production was also observed by Schmidtling (1975). From an operational seed orchard manager's perspective, this lack of clone by time of fertilizer application greatly simplifies orchard fertilization to promote flowering.

The date of nitrogen application had little influence on female strobili production in 1993 and 1994 (Fig. 3). However, in 1995 the September application date was significantly different ($P < 0.05$) from the other application dates (Fig. 3). The lack of a treatment effect in 1993 and 1994 is in direct contrast to the results presented for an older loblolly pine seed orchard by Schmidtling (1975), where there was a marked peak of female strobili production with an August timing of fertilizer application. While the results of the 1995 treatment year do not mimic Schmidtling's results, they too indicate that applications of nitrogenous fertilizers in late summer and early autumn are not as effective as applications made earlier during the growing season (Fig. 3). However, in contrast to Schmidtling's study (1975), the results of this study indicate that there is more latitude in when nitrogen can effectively be applied to stimulate female strobili production. This is evidenced by the lack of treatment differences between the April, June and July application times.

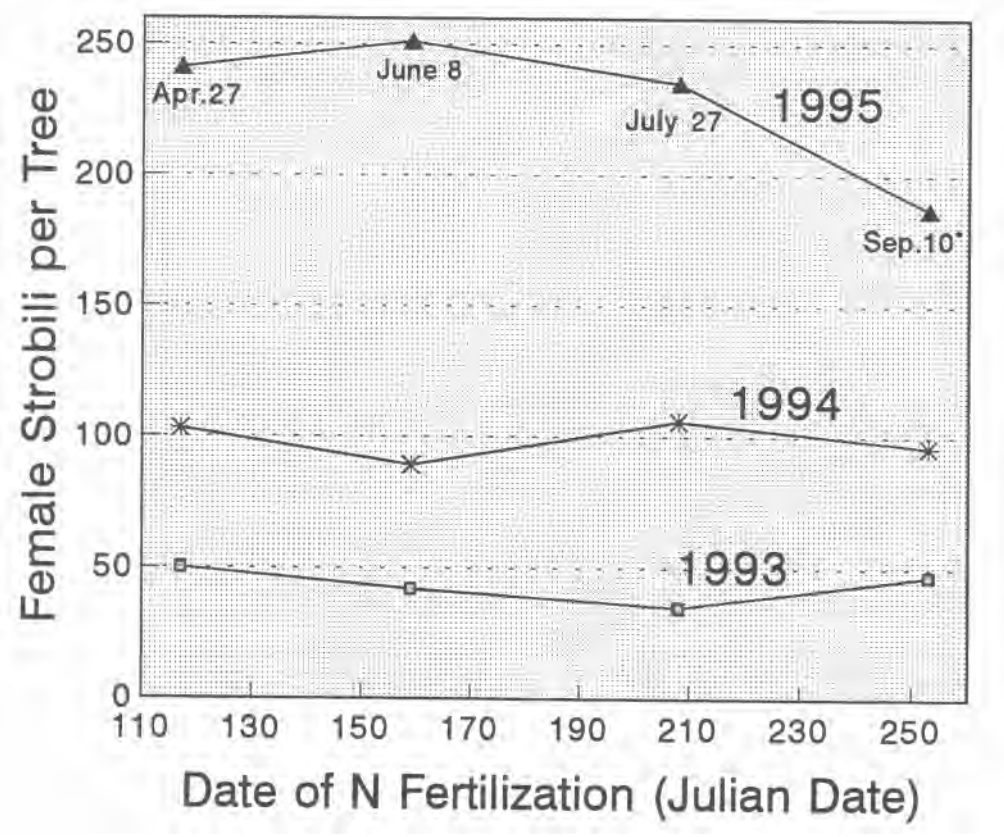


Figure 3. Female strobili counts for different treatment dates for N fertilization in 1993, 1994, and 1995. The only significant treatment difference with any year was the September 10, 1995 application.

## Conclusions

This nitrogenous fertilization timing study in a young second generation loblolly pine seed orchard further expands our understanding of seed orchard fertilization practices to promote female strobili formation. There is no evidence that the traditional late-July early-August application of ammonium nitrate is optimal for female strobili stimulation. Female strobili response was similar as long as trees were fertilized during the active growing season. This provides the orchard manager with greater flexibility in scheduling operational nitrogen fertilization. As previous research has also indictaed, very late season application of nitrogenous fertlizers should be avoided.

## Literature Cited


Bonnet-Masimbert, M. And J.E. Webber. 1995. From flower induction to seed production in forest tree orchards. Tree Physiology 15: pp.419-426.

Owens, J.N. and M.D. Blake. 1985. Forest tree seed production. Petawawa Natl. For. Instit., Canadian For. Serv. Info. Rept. PI-X-53. 161p.

Owens, J.N. 1991. Flowering and seed set. *In* Physiology of Trees. Ed. A.S. Rahhavendra. John Wiley and Sons Inc. pp. 247-271.

Puritch, G. S . 1972. Cone production in conifers. Pacific For. **Res.** Ctr., Canadian For. Serv. Info. Rept.. BC-X-65. 94p.

SAS Institute Inc. 1989. SAS/STAT User's Guide, Version 6, Fourth Edition, Vol. 2, Cary, NC 846pp.

Schmidtling, R.C. 1975. Fertilizer timing and formation affect flowering in a loblolly pine seed orchard. *In* Proc. 13th So. For. Tree Improv. Conf., Raleigh, NC. pp.153-160.