STIMULATION OF FLOWERING IN SWEETGUM

J.B. Jett and George Finger[1/]

Abstract. --A study was undertaken in 1969 to stimulate flowering in a seven-year-old clonal sweetgum seed orchard which had to that time been essentially non-productive.

Four treatments, consisting of two forms of nitrogenous fertilizers, a chemical growth retardant and a control, were randomly applied to four non-flowering ramets of four clones and replicated four times.

Results indicate that both ammonium nitrate and diammonium phosphate were very effective in st mulating flowering. Use of the chemical growth retardant "B995" provided no meaningful stimulation of flower production.

Based upon results of this study, the orchard has received an operational mid-summer application of ammonium nitrate in 1970, 1971, and 1972. Subsequent flower crops have been excellent. However, the bulk of the last two flower crops has been lost due to late spring frosts. The possibility exists that the heavy applications of nitrogenous fertilizer have increased susceptibility of sweetgum flowers to cold damage.

Additional keywords: Fertilization, growth retardants, Liquidambar styraciflua.

The high establishment and maintenance costs of a seed orchard make it mandatory that early and abundant seed yield be obtained as quickly as possible. Methods to accomplish this are fairly well understood for the pines, but information for the hardwoods is limited. Although at present there are few hardwood seed orchards in the south, it is important to determine the management techaiques required to insure productivi y of existing and anticipated orchards.

Attempts to stimulate seed production in forest tree species have generally involved either the application of soil amendments or some form of plant mutilation. In numerous instances soil amendments have been shown to significantly increase seed production of coniferous species.. Heavy application of nitrogen, and frequently phosphate, have produced the most dramatic results. Plant mutilation, involving practices such as stem strangulation, partial girdling, bark-ring inversion and root pruning, are occasionally sufficient to initiate flowering but the effects are normally temporary. Additionally, mutilation increases the risks of insect and disease attack, thereby limiting its usefulness. Although commonly used on several horticultural crops to stimulate or regulate flowering, chemical growth retardants have received little attention for use on forest tree species.

[1/] The authors are respectively, Liaison Geneticist, Cooperative Programs, School of Forest Resources, N.C. State University, Raleigh, and Manager, Southern Seed Orchards and Nurseries, Weyerhaeuser Company, Hot Springs, Ark.

The current investigation was undertaken to stimulate flowering in a clonal sweetgum (Liquidambar styraciflua L.) seed orchard using two forms of a nitrogenous fertilizer and a chemical growth retardant. The orchard belonging to Weyerhaeuser Company, and located at Washington N.C. was seven years old at the initiation of the study and was essentially non-productive. The soils in this orchard are loam underlain by clay at depths of from 6 to 15 inches and are moderately to poorly drained. Fertilization prior to this study consisted primarily of annual applications of a balanced fertilizer, such as 10-10-10, at an average rate of approximately 200 pounds per acre.

METHODS

Four treatments, replicated four times, were randomly applied to four non-flowering ramets of four clones the first week of June, 1969. Treatments consisted of the following:

A. Diammonium phosphate (DAP); applied at the rate of one-half pound per inch of basal stem diameter to an area within the crown dripline.

B. Ammonium nitrate (NH_4NO_3); same rate and application as for the diammonium phosphate.[4]

C. Growth retardant "B995" (sucinic acid 2, 2-dimethyl hydrazide}[2/] two applications separated by an interval of two weeks in a solution of 5000 ppm applied to the point of run-off from the foliage.

D. Control - no treatment.

The total height of each tree was measured at the initiation of the study and subsequent remeasurement was made at bi-weekly intervals throughout the growing season. The effectiveness of the treatments to initiate flowers was evaluated during the spring of 1970. A total count of all flowers on each treated ramet was made as soon as flowers and floral buds were readily distinguishable from vegetative buds.

The analyses of variance for the effect of treatment on flowering and on height growth follow a factorial arrangement. Components of error were pooled to provide a single error term for testing the significance of main effect differences and the treatment x clone interaction term.

RESULTS AND DISCUSSION

Results of the analysis of variance for flowering (Table 1) indicate that highly significant differences exist among treatments, and among clones, and significant differences exist for the interaction of treatments x clones.

[2/] Provided by the United States Rubber Company - Chemical Division

Table 1. --Analysis of variance for the effects of nitrogen fertilizer and a growth retardant upon flowering of sweetgum

Source	df	SS	MS	F[a/]
Replications	3	64846	21615	
Treatments	3	722127	240709	8.99**
Clones	3	572837	190946	7.13**
Treatments x clones	9	550246	61138	2.283*
Error	45	1205053	26778	

a/ *Statistically significant at the .05 level
**Statistically significant at the .01 level

A comparison of the mean number of flowers per ramet for each treatment (Table 2) reveals that the two fertilizer treatments were significantly more effective in stimulating flowering than was the "B995", and that there were no significant differences between the forms of nitrogenous fertilizer used despite the large differences in number of flowers per ramet (240.69 versus 179.19) for ammonium nitrate and diammonium phosphate, respectively. From a biological and practical sense the difference among fertilizer treatments is very real. If differences of this magnitude were consistently obtained, most orchard managers would favor the ammonium nitrate over diammonium phosphate.

Table 2. --Mean number of sweetgum flowers per ramet by treatments

Treatment	Mean number of flowers
NH_4NO_3	240.69
DAP	179.19
"B995"	3.38
Control	0.62

L.S.D. (.05) = 116.52 flowers. Means not connected by the same vertical line differ significantly

As expected, clonal response differences and the clone x treatment interactions were statistically significant (Table 1). The magnitude of clonal response is indicated in Table 3.

Table 3. --Mean number of sweetgum flowers per ramet by clone

Clone	Mean number of flowers
3	268.56
20	64.69
4	57.62
5	33.00

L.S.D. (.05) = 116.52 flowers. Means not connected by the same vertical line differ significantly

Such clonal differences in response to fertilizers have been well established for several coniferous species, Croker (1964), Schultz (1970), Shoulders (1967), and Swan (1964). Based upon accumulating evidence obtained in loblolly pine (P. taeda L.) seed orchards, it appears that fertilization increases the differences between clones with different flowering intensities (Bergman, 1968)

Height growth also showed a differential response to treatment (Table 4).

Table 4. --Analysis of variance of the effects of nitrogen fertilizers and a growth retardant upon height growth of sweetgum

Source	df	SS	MS	F[a/]
Replications	3	.5355	.1785	
Treatments	3	6.0929	2.0310	15.236**
Clones	3	2.1293	.7098	5.325**
Treatment x clones	9	2.5564	.2840	2.131*
Error	45	5.9970	.1333	

a/ * Statistically significant at the .05 level
** Statistically significant at the .01 level

Clonal differences as well as those of clone x treatment interaction were significant at the .01 and .05 level, respectively. However, the range in mean height growth per ramet by treatments was 1.06 ft. to 0.33 ft.(Table 5), representing a difference of only 0.73 ft. between the high effect of ammonium nitrate and the low effect of "B995". It is doubtful that this difference has any real practical implication. Results obtained from a fertilization study in Catawba Timber Company's loblolly seed orchard revealed that height was not affected by treatment, while diameter increased directly with fertilization and irrigation, (Anonymous, 1972). Gregory (1968), working with loblolly pine seed orchards, reported that seed production could be stimulated by irrigation and fertilization without unduly increasing height growth of the trees. He observed that, while there was no significant increase in height growth, the trees did exhibit a significant

increase in diameter growth following fertilization. Diameter measurements were not obtained in this study on sweetgum and consequently no assessment can be made of this growth aspect.

Table 5.--Mean height growth for all clones by treatments

Treatment	Mean height growth (feet)
NH_4NO_3	1.06
DAP	0.98
Control	0.50
"B995"	0.33

L.S.D. (.05) = 0.26 feet. Means not connected by the same vertical line differ significantly

Numerous examples of differential growth of clones for coniferous species exist in the literature (Zobel and Roberds, 1970). Genotype-x-fertilizer interactions for hardwoods have been reported for (Populus deltoides Bartr.) which exhibited differential growth response among clones (diameter, height, and volume) to nitrogen fertilization (Curlin, 1967) and for sycamore (Platanus occidentalis L.), where 48 open-pollinated families responded differentially to nitrogen fertilization (Kitzmiller, 1972).

As for flowering, the data from this study indicate that there are clonal responses to treatments (Table 6), with one clone responding much more than did the other three. However, the differences among the four clones represented

Table 6.--Mean height growth (feet) per ramet by clone

Clone	Mean height growth (feet)
3	1.02
4	0.68
20	0.59
5	0.58

L.S.D. (.05) = 0.26 feet. Means not connected by the same vertical line differ significantly

CONCLUSIONS AND SUMMARY

Results from this study indicate that both ammonium nitrate and diammonium phosphate were very effective in stimulating flower production of seven-year-old

sweetgum grafts. Based upon these results, It has become routine management in this sweetgum orchard to apply a midsummer application of 200 pounds of ammonium nitrate per acre. Flower crops following this fertilization regime, begun in 1970, have been excellent. However, the bulk of the flower crops in 1971 and 1972 was lost to late spring frosts. There is a possibility that the heavy applications of ammonium nitrate have increased susceptibility to cold damage, either by making the sweetgum more succulent or causing earlier than normal flower formation.

Most dicotyledonous plants are responsive to "B995" with the most obvious effect being a reduction in vegetative growth through reduced internode elongation.[4/] Among other reported "side" effects are an increase in the number of flowers and promotion of floral buds. The theory behind the flower stimulation effect of growth retardant "B995" provided no meaningful flower stimulation and no significant retardation of growth.

Although not included as a treatment in this study because of the limited amount of material available, an additional growth retardant, UNI-F529, was[5/] applied to 12 ramets of a fifth, non-flowering clone at a rate of 2500 ppm. UNI-F529 (N - pyrolidino - succinic acid), is reported to be more persistent in its effects during the summer months than "B995" (Cathy, 1969). Normally, UNI-F529 applied at one-half the dosage of "B995", is reported to produce **similar** growth retarding effects. Based upon observation only, no detectable differences in the performance of the two chemical retardants could be seen. The 12 ramets treated with UNI-F529 produced a total of 40 flowers versus 54 flowers on 20 ramets treated with "B995".

In summary, the use of nitrogenous fertilizers to stimulate flowering of sweetgum is a highly successful, efficient orchard management tool. Not only was flower production initiated and maintained, but the general health and vigor of the entire orchard was improved.

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