# SOME EFFECTS OF GIBBERELLIC ACID ON YEAR-OLD PECAN SEEDLINGS

by

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# TABLE OF CONTENTS

PAGE

INTRODUCTION....1

Definition of Terms....2

REVIEW OF LITERATURE....2

MATERIALS AND METHODS....5

RESULTS....7

DISCUSSION....10

SUMMARY....14

ACKNOWLEDGEMENTS....16

LITERATURE CITED....17

TABLES

TABLE PAGE

I. Some Effects on Growth of Year-old Pecan Seedling Trees From Aqueous Sprays of $GA_3$ at 5,000 ppm in 1966. Treatment Groups Included Trees Sprayed in June or July and Those Sprayed Both Months.............8

II. Comparison of Effects of Spray Applications of 5,000 ppm $GA_3$ on Growth and Development of Year-ol Pecan Seedlings.............................................9

# INTRODUCTION

The slow growth of the pecan seedling during its early years is a problem for nurserymen and others interested in pecan propagation. Under normal growing conditions, pecan seedlings may grow for three or four seasons before the diameter of the stem is large enough to be suitable for grafting or budding. Reducing the time required to grow pecan seedlings to a size convient for propagation would enable nurserymen to produce planting stock at reduced costs. Also, pecan orchard owners could benefit from lower priced planting stock, and, if the owners do the propagations themselves, they could gain in the shorter time required for trees to begin bearing nuts.

Gibberellic acid causes increased plant height of year-old seedlings of yellow poplar, sweetgum, cherrybark oak, willow oak, and southern red oak (12). $GA_3$ also caused increased height growth in rooted cuttings of eastern cottonwood and American sycamore. Treatment with $GA_3$ caused increased stem elongation of newly germinated pecan seedlings grown under greenhouse conditions (9). After treatment with $GA_3$, greenhouse grown seedlings of black walnut, willow oak, and loblolly pine had stems 40% taller and twice as thick as the controls (16).

Objectives of this study were to determine:1, if field applications of gibberellic acid increased pecan seedling growth to a size suitable for budding and grafting earlier than untreated pecan seedlings;2, if time of application affected response of pecan seedlings to $GA_3$; and, 3, how pecan seedlings responded to repeated treatment with $GA_3$.

## DEFINITION OF TERMS

Gibberellin. A general term for any of the plant stimulating substances produced by the Gibberella fungus.

Gibberellic Acid. The gibberellin also classified as $GA_3$, the type most abundantly secreted by the fungus (*Gibberella*) and easiest to extract.

## REVIEW OF LITERATURE

Nelson (12) found that a one percent solution of gibberellic acid in lanolin applied to terminal buds of year-old seedlings of yellow-poplar, sweetgum, cherrybark oak, willow oak and southern red oak significantly increased their height. The same solution applied to terminal buds of cuttings of eastern cottonwood and American sycamore also caused significant increases in height growth of these species. Stems of newly germinated white oak seedlings showed less marked increases as did year-old seedlings of white pine from treatments with $GA_3$.

Kenworthy (6) reported that treatment in excess of 1,000 ppm $GA_3$ dissolved in methanol and introduced directly into the xylem of the tree trunk of young peach trees resulted in rosetting of twigs and reduced growth by a decrease in twig length, leaf area, and dry weight of twigs. One hundred ppm $GA_3$ treatment applied in the same way resulted in increased twig length, leaf area, and dry weight of leaves.

Bilan and Kemp (2,3) observed that year-old loblolly pine seedlings treated with one, two, or three per cent solutions of gibberellic acid applied by soaking shoots only, roots only, or soaking the entire plant increased the height of the tree with increases being proportional to concentrations used.

Martin and Wiggins (9) have found that soaking pecan seeds in gibberellic acid at concentrations up to 5,000 ppm resulted in earlier germination. Treated seed had better germination, and the resulting seedlings' height was greater than control. They found that $GA_3$ caused only a limited amount of growth over a 51 day period when sprayed on the foliage of newly germinated pecan seedlings grown under greenhouse conditions.

Agricultural Research Service scientists (16) have found that young greenhouse seedlings of black walnut and loblolly pine sprayed with 400 ppm $GA_3$ solution developed stems 40% taller and were twice the thickness of controls at the end of one growing season.

Kuskova (7) found that soaking of belladonna seeds, before sowing, with a 2% solution of gibberellin increases dry weight of the leaves and stems, increases the alkaloid content in the stems and leaves, and increases the alkaloid content of the entire plant while affecting only slightly the height of the plant. Supplementary spraying of belladonna plants with a 2% solution of $GA_3$ nearly doubled the height of the plant, did not affect the dry weight of the stems, reduced alkaloids in the leaves and roots, and increased the alkaloids in the stems.

Thomas et al (14) found that $GA_3$ applied in lanolin paste in a band on the last internode, foliage spray, and by a single drop to the apical bud of mango seedling stocks increased stem length and stem diameter of the plants over controls. Also, they found that each application of $GA_3$, even when supplemental, was followed by immediate stem elongation within a month of treatment. Trees treated twice or three times had longer stems and larger stem diameters than trees treated once.

Nanda and Purohit (11) reported that enhanced extension growth in Salmalia malabarica caused by gibberellin treatment is probably a consequence of mobilization of stored food, and that it appears that gibberellin causes mobilization of starch into sugar which becomes readily available for extension growth of cells.

Ting and Lockhart (15), experimenting with applied gibberellic acid on pinto beans, found that applied $GA_3$ moves with carbohydrates within the plant.

Marth and Mitchell (8) increased the size of black walnut seedlings from an average of 1.5 feet (controls) to 8.5 feet in one season by three consecutive applications of gibberellic acid applied in lanolin bands at the base of terminal buds. $GA_3$ prevented summer dormancy from occuring. Continuous growth throughout the season caused the plants to produce the equivalent of several seasons growth.

Zych(22) found that gibberellic acid, applied as a spray, inhibited rooting of Purple Autumn raspberry. Inhibition was greater for mature (basal cuttings) cuttings than for tips (terminal cuttings).

Mastalerz (10) reported that single applications of $GA_3$ applied as a spray increased the size and quality of Better Times roses. Repeated sprayings with the same concentration of $GA_3$ gave an increase in stem length but flowers were abnormal and of low quality.

Barker and Collins (1) found that $GA_3$ applied in lanolin or in water, as a fine spray, in concentrations as low as 20 ppm induces parthenocarpy in the low bush blueberry when applied to the flower immediately after anthesis. This concentration applied to parts of the plant other than the flowers did not induce parthenocarpy. None of the treatments at 20 ppm concentration caused an increase in stem growth.

## MATERIALS AND METHODS

Stratified hardy northern pecan seed was planted in a sandy loam soil at the Ashland Horticulture Farm, Manhattan, Kansas, in April 1965. Seeds were planted one every six inches in three rows which were spaced four feet apart. Seedlings were weeded and irrigated as needed. Twenty-four plots each containing nine seedling pecan trees with ten unsprayed control seedlings separating sprayed plots were studied. The leaves of five seedlings in each of the twenty-four plots were sprayed June 20, 1966, with an aqueous solution of 5,000 ppm $GA_3$. Each sprayed tree in each treated plot was separated from the other treated trees by an unsprayed tree.

Twelve previously untreated plots (60 trees) were sprayed July 20, as described above. Sixty trees sprayed June 20, received a second application of $GA_3$ at 5,000 ppm July 20.

Spray applications were made with a hand operated compressed air sprayer. Three drops of a surfacant, Tween 20, were added to each 135 milliliters of spray. The spray solution had a pH of 3.2. Plants were sprayed until run-off. Excessive spray drift was prevented by covering the seedling during spraying with a polyethelene bag and inserting the spray nozzle into the bag to make the application.

Fertilizer (20-10-5 NPK) was side-dressed at 350 pounds per acre August 20, 1966, to all seedlings. Fertilizer was applied uniformly in eight inch bands on each side of the row and then the plots were irrigated.

Twenty trees selected at random from groups treated each in June and in July and those sprayed twice were dug and prepared for sampling in early December as were 118 unsprayed control trees. Measurements recorded included stem and root length, collar and stem diameter four inches above the collar. All samples were cut into pieces approximately a half inch long and oven dried for ten days at 70 degrees Centigrade. Data collected following drying included dry weight of stems, roots and total plants. The ratio of dry weights of stem/root was calculated. Analysis of variance was calculated for each value obtained, and effects of treatments were compared by the Duncan Multiple Range

Test (4).

## RESULTS

Table 1 shows response in growth of pecan seedlings to spray applications of gibberellic acid at 5,000 ppm. Comparisons can be made among trees sprayed only in June or July and those sprayed both months.

Seedlings sprayed in June had longer stems and greater dry weights of stems than unsprayed trees. However, dry weight of treated roots was less than for unsprayed seedlings. The ratio of stem dry weights to root weights was greater in treated than in control trees. Stem and collar diameters, total dry weights, and length of roots of treated seedlings were not significantly different from controls.

Seedlings sprayed with gibberellic acid in July had longer stems, greater stem diameters, heavier oven dry weights of stems than controls. However, average dry weights of roots and root length were less than those of controls. Ratio of dry weight of stems to roots was greater for sprayed trees than for controls. Average diameters of collars and total dry weights were not significantly different from the controls.

Table 11 shows effects of date of treatment and accumulative effects of two $GA_3$ sprays.

Trees receiving $GA_3$ sprays in both June and July had significantly longer stems, greater stem dry weights, and less root dry weights than trees sprayed only once in June or July. Also,

Table 1. Some effects on growth of year-old pecan seedling trees from aqueous sprays of $GA_3$ at 5,000 ppm in 1966. Treatment groups included trees sprayed in June or July and those sprayed both months.

| | Mean measurements, inches | | | | Mean weights, grams | | | |
|---|---|---|---|---|---|---|---|---|
| Date treated | Stem length | Root length | Collar diameter | Stem diam. 4 in. above collar | Stem dry wt. | Root dry wt. | Total dry wt. | Ratio dry wt. stem/root |
| 6/20/66 | a. 17.930 | 18.952 | .388 | .333 | 11.894 | 25.868 | 37.761 | .544 |
| | ** | ns | ns | ns | * | * | ns | ** |
| | b. 11.180 | 21.280 | .441 | .295 | 8.450 | 36.342 | 44.788 | .238 |
| 7/20/66 | a. 21.515 | 20.280 | .437 | .388 | 14.927 | 15.245 | 30.172 | 1.058 |
| | ** | * | ns | ** | ** | ** | ns | ** |
| | b. 9.700 | 24.674 | .415 | .268 | 5.891 | 33.011 | 38.953 | .182 |
| 6/20/66 | a. 27.833 | 21.718 | .442 | .411 | 22.947 | 11.276 | 34.223 | 1.983 |
| and | ** | ns | ns | ** | ** | ** | ns | ** |
| 7/20/66 | b. 11.180 | 21.280 | .441 | .295 | 8.450 | 36.342 | 44.788 | .238 |

(a) treated seedlings * significant at 5% ns non-significant at 5%
(b) control seedlings ** significant at 1%

Table 11. Comparison of effects of spray applications of 5,000 ppm $GA_3$ on growth and development of year-old pecan seedlings.

| | Mean measurements, inches | | | | Mean weights, grams | | | |
|---|---|---|---|---|---|---|---|---|
| Date treated | Stem length | Root length | Collar diameter | Stem diam. 4 in. above collar | Stem dry wt. | Root dry wt. | Total dry wt. | Ratio dry wt. stem/ root |
| 6/20/66 | 17.930a | 18.952a | .388a | .333a | 11.894a | 25.868a | 37.761a | .544 |
| 7/20/66 | 21.515a | 20.280a | .437a | .388ab | 14.927a | 15.245a | 30.172a | 1.058 |
| 6/20/66 and 7/20/66 | 27.833b | 21.718a | .442a | .411b | 22.947b | 11.276b | 34.223a | 1.983 |

Values with the same letter have no significant difference
Values with unlike or no letters differ significantly

trees sprayed twice had significantly larger stem diameters than June sprayed trees. Furthermore, twice treated trees had significantly greater stem-root ratios than seedlings sprayed only once in June or July.

The only significant difference between trees sprayed only in June and trees sprayed only in July was in stem-root ratio; ratio was larger for July sprayed trees.

## DISCUSSION

Although seedlings sprayed in June only differed significantly from those sprayed in July only by just one factor, stem root ratio, other differences are large enough to indicate that time of treatment affects the response of pecan seedlings to gibberellic acid. Trees treated in July were 3.5 inches taller, roots 1.3 inches longer, and stem diameter .05 inches wider than comparative values for trees treated in June.

Observed differences in response by trees sprayed in June and trees sprayed in July are probably due to the amount of $GA_3$ that penetrated into the leaves of treated trees. Two of the factors that apparently affect the penetration of growth substances are temperature (20) and surface area treated (13). The average high temperature for five days before to five days after the June 20 treatment was just above 85 degrees Fahrenheit and the average low temperature for the same period was nearly 63 degrees Fahrenheit (17). Average high temperature five days before to five days after the July 20 treatment was nearly 94 degrees F and the average low temperature for the same period was nearly 79 degrees Fahrenheit (18). According to Van Overbeek(20), natural permeation barriers of leaves have a higher permeability with increased temperature. Sargent (13) reports that it seems likely that a growth regulator will diffuse through surface layers at a net rate proportional to its concentration gradient across the layers. There was less leaf area to be covered on the June treated trees than on the July treated trees.

These same factors that influenced penetration of growth substances, temperature and surface area treated, probably account for the differences in response to $GA_3$ treatment between trees sprayed twice and those sprayed once in June or July.

Results of supplemental spraying observed in this study are similiar to the findings of Nanda and Purohit (11) in their research involving supplemental $GA_3$ treatment of Samalia malbarica. They found that increasing the concentration of applied $GA_3$ caused increased growth of the stem with a corresponding increase in the dry stem-root ratio. Martin and Wiggins (9) found that increasing the soaking time of pecan seed treated with $GA_3$ from 12 to 192 hours reduced root dry weight and total dry weight of the plant. Kuskova (7) observed a similiar response to $GA_3$ by belladonna plants. Supplemental spraying with $GA_3$ on belladonna resulted in doubled stem height and reduced root dry weight. However, stem dry weight was not affected.

Increased stem-root ratio from greater concentrations of applied gibberellic acid is probably the result of increased stem growth at the expense of root development. Halevy et al(5) found that the effect of $GA_3$ on translocation of assimilates is to increase the mobilization of stored materials and to enhance distribution toward stem tips. Nanda and Purohit (11) report that gibberellic acid causes mobilization of starch into sugar which becomes readily available for extension growth of cells.

Pecan seedlings treated with 5,000 ppm gibberellic acid developed leaves that were smaller than controls and the leaves were pale and lacking the green color of leaves on controls. Trees sprayed in June had leaves that were a normal green color by July 20, 1966; although they were still smaller than leaves of control seedlings. Seedlings sprayed for the first time in July and those treated in June and again in July developed new small pale leaves on new stem growth. Fertilizer was applied August 20, 1966, and, within two weeks, leaves became a normal green. However, leaves remained small as did the leaves of the trees sprayed only in June. Results of fertilization are similar to those reported by ARS scientists (16) who reported that paleness in the green of developing leaves on plants treated with $GA_3$ was changed to a deeper green by the addition of fertilizer.

The growing points of trees treated with $GA_3$ in July only and the growing points of trees treated both in June and July were damaged by frost on October 16 (19). However, the rest of the stem did not appear to be damaged. Trees sprayed in June only and control seedlings were not injured other than leaf-kill by the frost.

If the normally extensive root system of pecan seedlings could be substantially reduced in overall development, lifting and transplanting of this species would be correspondingly easier; less labor would be required in lifting operations, packing, handling, and storage would require less space. Furthermore, it would be logical to assume that a smaller root system could result in lifting of seedlings with less injury to the taproot thereby resulting in more rapid early growth of transplanted seedlings than now occurs.

Root length was significantly reduced in seedlings sprayed with $GA_3$ in July only, and root length was less than controls, though not significantly so, in trees treated in June only. However, root length was slightly greater than controls for trees treated both in June and July. These findings indicate that additional research with gibberellic acid on pecan seedlings could discover the ideal combination of time of treatment, fertilizer, and concentration of applied $GA_3$ that will decrease seedling root size to a degree that will benefit growers. Also, other gibberellins (21) may hold promise in such research.

This study generally confirms the findings of Martin and Wiggins (9) with one exception. They found that gibberellic acid can cause only a limited amount of growth of pecan seedlings over a 51 day period of growth regardless of concentration used or number of spray applications. The observations reported in this study show that repeated application of $GA_3$ does cause increased growth of stems of year-old pecan seedlings. Further, they found that increasing the soaking time of pecan seeds with $GA_3$ from 12 to 192 hours reduced the root dry weight and total dry weight of seedlings germinated. Increased dry stem-dry root ratio is in agreement with the findings reported in this paper.

The accomplishments of Marth and Mitchell (8) and other Agricultural Research Service scientists (16) in increasing the growth of black walnut seedlings with applications of gibberellic acid would indicate the possibility of inducing a greater growth in pecans than reported by Martin and Wiggins (9) or reported in this study. Additional research with the effects of gibberellic acid on pecan seedlings for stocks should attempt to determine the best time for $GA_3$ application, the best method of $GA_3$ application, and to find the $GA_3$ concentration that will yield the best results.

There are thirteen known gibberellins and three gibberellin-like substances that have been detected (21). Additional research to improve pecan stocks with gibberellic acid should also investigate the effects of other gibberellins on pecan seedling growth.

## SUMMARY

Field application of 5,000 ppm gibberellic acid to year-old pecan seedlings significantly increased stem diameter on seedlings treated in July and those treated both in June and July. Effects of gibberellic acid on stem diameter were not as great on the seedlings sprayed in June. However, the diameter

increase was large enough in each case to improve the suitability of the seedlings for budding and grafting.

There was a difference in response to 5,000 ppm $GA_3$ spray between pecan seedlings treated in June and those treated in July. Although the only significant difference was in dry stem-dry root ratio, other differences were large enough to indicate that time of treatment is an important factor in response of pecan seedlings to gibberellic acid.

A second application of 5,000 ppm gibberellic acid in July to seedlings that had been previously treated in June gave significant increases over other treatments in stem length, dry stem-dry root ratio, and stem dry weight. Root dry weight was significantly less than root dry weight of seedlings sprayed only once in June or July. Stem diameter was significantly larger than the same measurement for trees treated only in June but not significantly different from stem diameters of trees treated only in July.

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Stratified hardy northern pecan seed was planted in sandy loam soil at Ashland Horticulture Farm, Manhattan, Kansas, in April, 1965. Seeds were planted one every six inches in rows which were spaced four feet apart. Seedlings were weeded and irrigated as needed. Twenty-four plots were studied each containing nine seedling pecan trees with ten unsprayed control seedlings separating each plot. Five seedlings in each of the twenty-four plots were foliage sprayed June 20, 1966, with an aqueous solution of 5,000 ppm $GA_3$. Sprayed trees in each plot were separated from the other treated trees by an unsprayed guard tree.

Twelve previously untreated plots (sixty trees) were sprayed July 20, as described above. Sixty trees sprayed June 20, received a second application of $GA_3$ at 5,000 ppm July 20.

Spray applications were made with a hand operated compressed air sprayer. A few drops of a surfacant, Tween 20, were added to each spray treatment. The pH of the spray solution was 3.2. Plants were sprayed until run-off was observed.

Fertilizer (20-10-5 NPK) was side dressed at 350 pounds per acre, August 20, 1966, to all seedlings.

Twenty trees from each treated group as well as 118 unsprayed control trees were dug and prepared for sampling in early

December. Measurements recorded included stem and root length, collar and diameter of stem four inches above the collar. All samples were cut into pieces about ½ inch long and oven-dried for ten days at 70 degrees Centigrade. Data collected following drying included dry weight of stems, roots, and total plant. Stem/root ratios were calculated. Analysis of variance was calculated for each value obtained, and effects of treatments were compared by the Duncan Multiple Range Test.

Seedlings sprayed in June had longer stems and greater dry weight of stems than unsprayed trees. However, dry weight of treated roots was less than for unsprayed seedlings. Stem/root ratios were greater in treated than in control trees.

Seedlings sprayed with $GA_3$ in July had longer stems, greater stem diameters, and heavier dry stem weights than controls. However, average dry weight of roots and root lengths were less than those of controls. Stem/root ratios were greater for treated trees than for controls.

Trees sprayed in both June and July had significantly longer stems, greater stem dry weight, less root dry weight, and a greater stem/root ratio than trees sprayed only once in June or July. Trees treated in both June and July had significantly larger stem diameters than trees treated only in June.

The only significant difference between trees sprayed in June and those sprayed in July was in stem/root ratios which were larger for July treated trees.

Differences in response to treatment were probably due to temperature at the time of treatment and the size of the tree when $GA_3$ was applied; both are factors that may affect the amount of $GA_3$ utilized by the plant.