SOME EFFECTS OF GIBBERELLIC ACID ON THE GROWTH AND/OR FLOWERING OF AZALEA, LILY, AND PECAN

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INTRODUCTION

A soil-borne disease of rice, caused by the fungus *Gibberella fujikuror*, has been observed in all countries where rice is grown. This disease is in many ways similar to other *Fusarium* diseases, in that the fungus enters through the roots and/or crown, causing local necrosis and wilting of the shoots. However, there is one symptom unique to this particular disease. The stems and leaves of infected seedlings usually elongate more rapidly than those of healthy, non-diseased plants.

It is this particular characteristic that in 1926 attracted the attention of Kurosawa, a Japanese plant pathologist, working on the "bakanae" disease of rice (24). It was 1935, however, before Yabuta (54) announced the isolation of a crystalline active material from the asexual stage of the fungus, *Fusarium moniliforme*, which he called "gibberellin".

Early work on gibberellin was limited because of the difficulties involved in isolating the pure material. World War II and language barriers also restricted the flow of knowledge. Thus, it was 1950 before the first exploratory work in the United States was begun (31). Following work in Great Britain (45) and the United States (3) describing the methods of production and isolation of gibberellic acid, relatively large quantities were made available.

The study reported herein was designed to determine the effect of gibberellic acid on certain phases of the growth and development of azaleas, lilies, and pecans.

LITERATURE REVIEW

Most of the research conducted to determine the effect of gibberellic acid on plant growth have been described in recent review articles by Stowe and Yamaki (46), Wittwer and Bukovac (53), and Stodola (44). It is the purpose of the present literature review to discuss in some detail only those studies dealing with the types of growth related to the investigations reported herein.

Stem Elongation

The most readily apparent reaction of plants to gibberellic acid treatment is the elongation of stems. Many plant species, both herbaceous and woody, including sugar cane (12), tomato (15), oak, sycamore, and cottonwood (33), African violet (37), and wheat, celery, and bean (49), are affected in this manner. Plant height of sweet pea plants (*Lathyrus odoratus*) is increased by 500% over that of untreated plants by 3 weekly applications of 1.0 microgram of gibberellic acid per plant (8). Five-year-old *Hedera canariensis variegata* plants, treated with gibberellic acid, also grow much faster than untreated plants (36).

The most noticeable stem elongation occurs in dwarf plants. For example, Phinney (34) found that .001 microgram of gibberellic acid per plant causes a marked increase in the growth rate of dwarf mutants of *Zea maize*. Brian and Hemming (6) also reported that gibberellic acid causes dwarf peas (*Pisum sativum*) to grow at the same rate as normal plants.

Gibberellic acid treated dwarf plants seldom exceed the production of normal types (22), however, the reversal of dwarfism permits an opportunity to better understand the biochemical basis for heritable characteristics.

In working with the "bakanae" disease of rice Sawada and Kurosawa (40) reported that increased stem length was a result of increased cell division. However, following the studies of Kurosawa (24) in 1926 and Shimada (41, 42) in 1932 when actual cell measurements were made in the rice plant the undisputed view, held for several years, was that the main effect of gibberellic acid treatment was cell elongation. In 1939 it was shown that both cell elongation and cell division were responsible for the increased stem length of gibberellic acid treated rice plants (55).

Kato (20) treated Vigna sesquipedalis seedlings with lanolin, containing 0.01% gibberellic acid, and reported that accelerated growth of the stem resulted from cell elongation rather than cell multiplication. Feucht and Watson (16), working with Phaeolus vulgaris, also reported that cell elongation of the internodal tissue was the result of gibberellic acid treatment. In apricot spur shoots gibberellic acid was shown to stimulate the division of cells in the cambial zone (4). Lang (25) and Sachs and Lang (38, 39) working with Hyoscyamus niger concluded that gibberellic acid caused both cell elongation and cell division. Although there has been much controversy regarding the effect of gibberellic acid on stem elongation, evidence is sufficient at present to indicate that both cell division and/or cell elongation may occur.

Dry Matter Accumulation and Root Growth

An important characteristic of gibberellic acid, from the practical point of view, is its ability to alter the fresh and/or dry weights of various plant parts. Several workers have reported increases in both the fresh and dry weights of plants: Brian and Grove (8) with wheat (*Triticum vulgare*) and pea (*Pisum sativum*) seedlings; Robbins (36) with *Hedera canariensis variegata*; Hayashi, Takijima and Murakami (17), and Yabuta and Hayashi (55) with rice (*Oryza sativa*); Bukovac and Wittwer (9) with celery (*Apium graveolens*) and beans (*Phaseolus vulgaris*). Most plants normally respond only with an increased dry weight of top growth when treated with gibberellic acid (5).

Brian, Hemming, and Radley (7), and Kato (19) all found that inhibition of root growth occurred most often with high concentrations of gibberellic acid. Rice seedlings, grown in water culture and treated with gibberellic acid, were reduced in length, weight, and number of roots (17). Onion roots (*Allium cepa*) were unaffected by gibberellic acid treatments (20).

Although gibberellic acid usually does not promote root growth, exceptions have been reported. Whaley and Kephart (48) reported a 24 percent increase in the root length of *Zea maize* following treatments with gibberellic acid. Gibberellic acid also is reported to have increased root length of *Pseudotsuga menzieshii* (35). Experiments with Olymphic Red and White Wonder varieties of geranium (*Pelargonium hortorum*) indicated that the root/shoot weight ratio remained constant for up to 10 weeks after treatment with a 10 ppm. foliage spray (13).

Flower Induction

Gibberellic acid treatments have been shown not only to induce flowering, but also to cause more flowers, earlier flowers, or larger flowers to be produced.

The potassium salt of gibberellic acid, applied either to the foliage or the flower bud of Olympic Red and White Wonder varieties of *Pelargonium* hortorum, just prior to the appearance of color in the flower bud, resulted in an increase in the size of the inflorescence (13). This inflorescence was not only larger but also persisted ten days longer than did that of the control plants. Chrysanthemums were larger and flowered earlier after treatments with gibberellic acid (21).

Hydrangea macrophylla seedlings treated at weekly intervals, from May 23 to September 24, with 50 micrograms of gibberellic acid, produced flower buds while the control plants remained vegetative (23). Cyclamen indicum plants, which normally initiate flower buds during the spring and bloom only during the cool season in California, even flowered during California's adverse summer environment when treated with gibberellic acid (23).

Flowering of stocks (Mathiola incana) and petunias (Petunia hybrida) (27), larkspur (Delphinium ajacis), English daisey (Bellis perennis), China aster (Callistephus chinensis), and Transvaal daisy (Gerbera jamesonii) (51) occurred from ten days to six weeks earlier when they were treated with gibberellic acid. Taffata chrysanthemums also flowered earlier following two applications of 100 ppm or one application of 1000 ppm gibberellic acid (28). Chrysanthemum plant height was increased significantly.

Several long-day annuals, including head and leaf lettuce (Lactuca sativa and L. dentate), endive (Cichorium endiva), radish (Raphanus sativus), mustard (Brassica juncea), spinach (Spinacia oleracea), and dill (Anethum graveolens), flowered and produced seed under short day conditions when treated with gibberellic acid (50). Bunsow and Harder showed that gibberellic acid could substitute for the long-day requirements of Lapsana (11), and for either the short or the long day requirements of Bryophyllum crenatum, a short-long-day plant (10).

Boodley and Mastalerz successfully substituted high concentrations of gibberellic acid (1000 to 5000 ppm.) for the cold treatment normally required for potted azaleas (2). Gibberellic acid also was found to replace the cold requirement but not the long-day requirement, for flowering of *Hyoscaymus niger* (26).

Seed Germination

Many seeds require a cold treatment or exposure to light before they will germinate. Gibberellic acid seed treatments have been found to substitute for one or both of these conditions. Kahn, Goss and Smith (18) reported that gibberellic acid could substitute for the light requirement that is normally needed for germination of lettuce seed (*Lactuca sativa*). Donoho and Walker (14) used gibberellic acid as a partial substitute for the cold requirement of Elberta peach seeds (*Prunus persica*).

Gibberellic acid may promote better stands and earlier seed germination of some species. Pea (*Pisum sativum*) seedlings emerged earlier (32). Lettuce (*Lactuca sativa*) germination also was markedly improved by seed treatment (43). The sprouting of beans (*Phaseolus vulgaris*) and sweet corn (*Zea Mays var rugosa*) also was hastened (52).

Although gibberellic acid may stimulate earlier emergence it also may result in weaker stems and the ultimate loss of plants (49).

Tree Growth

Evergreen species normally are less responsive to foliar treatment with gibberellic acid than are the deciduous species (1). Marth, Audie and Mitchell (29) applied a 1 percent gibberllic acid in lanolin to several tree species, including boxwood, juniper, maple, pine, poplar, and spruce. They obtained increases in stem length of up to 400%. Only with white pine was their gibberellic acid treatment ineffective. Walnuts showed little or no effect from treatment with the potassium salt of gibberellic acid (47).

Although gibberellic acid treatments on trees usually result in stem elongation (29, 33), increases in node number, continuous growth of shoots, and growth from otherwise dormant buds also have been observed (30, 1).

MATERIALS AND METHODS

Various parts of three species of plants, azalea (*Rhododendron rutherfordiana*), lily (*Lilium longiflorum*), and pecan (*Carya illinoensis*), were treated with gibberellic acid[1] to determine its effect on growth and/or flowering. The various experimental procedures are described below.

Azaleas

Two experiments, using a gibberellic acid (GA) spray treatment as a substitute for the cold treatment normally required to force flowering of azaleas, were conducted. Dorothy Gish azalea plants, approximately 18 months old, and with flower buds approximately 1/4 inch in diameter, were purchased from a commercial grower[2] just prior to the start of each experiment. All of these plants originally had been grown in a 65° F. minimum night temperature greenhouse.

Experiment I: The first experiment was started December 16 and terminated March 30, 105 days later. The plants were sprayed with 3 concentrations of GA, 100, 500, or 1000 ppm, in water. Five different spray schedules were followed: (a) once, (b) 7 times at 3 day intervals, (c) 14 times at 3 day intervals, (d) 4 times at 6 day intervals, and (e) 7

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[1] Gibberellic acid furnished courtesy of Abbott Laboratories, North Chicago, Illinois, Eli Lilly and Company, Indianapolis, Indiana, and Merck and Company, Inc., Rahway, New Jersey.

[2] Furrow and Company, Guthrie, Oklahoma.

times at 6 day intervals. The spray was applied with a hand atomizer until all the leaves, buds, and stems were thoroughly wetted. "Tween-20"[3], at the rate of 0.2 ml. per liter of spray solution, was used as an adjuvant. On the date of the first spray application check plants were placed in 40° F. cold storage for 6 weeks. A 12 hour photoperiod, using incandescent lights which maintained a minimum reading of 25 f.c. at pot level, was maintained in the cold storage. The control plants which received no chemical or cold temperature treatment and those treated with GA were kept in a greenhouse at a daytime temperature of 70° to 75° F. (the average daily maximum temperature was 71.7° F.) and a night time temperature of 60° to 62° F. (the average night minimum temperature was 61.4° F.). After 6 weeks of cold treatment the check plants were moved to the same greenhouse. All vegetative shoots were kept pinched back during the experiment and the plants were watered as needed. Each flower bud was tagged to indicate the date when it appeared.

Experiment II: A second experiment was started March 15 and was terminated May 27, 73 days later. Three plants per treatment were sprayed with 1000 ppm GA. Four spray applications were made: (a) once, (b) 7 times at 3 day intervals, (c) 7 times at 6 day intervals, and (d) 4 times at 3 day intervals. The spray was applied with a hand atomizer again using "Tween-20" as an adjuvant. Control plants were given no special chemical or temperature treatment, but were kept in the greenhouse throughout the period of the experiment. Check plants were placed in cold storage for 6 weeks. Observations were made daily and each new flower tagged and dated. At the termination of the experiment the average daily maximum temperature had risen from 75° to 90° F. and the minimum temperature from 62° to 75° F.

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[3] Courtesy Atlas Powder Company, Wilmington, Del.

Lilies

Three experiments, using gibberellic acid (GA) and various combinations of GA and 3-indoleacetic (IAA), were conducted to determine their effect on the growth and flowering of Ace lilies. "Tween-20" again was used as an adjuvant. Bulbs for each of the experiments were planted November 26 in a potting mixture consisting of 1 1/2 parts soil, 1 part sand, and 1 part peat moss. Check plants not treated with GA or IAA were included in each experiment. Soil tests were made once every two weeks and fertilizer, in water solutions, applied as needed.

Experiment I: Uniform bulbs were soaked for 15 minutes in 0, 0.1, 1.0, 10, 100, or 1000 ppm GA, alone and in combination with equal volumes of 100 ppm IAA, before planting singly in 4-inch clay pots. Three plants were used for each treatment. Observations were made daily and each new flower, that opened to a diameter of 2 inches or more at the outer tip of the petals, was tagged. The length, from the outermost petal to the tip of the nearest sepal, and the diameter, width at the tip of the petals, of each flower was measured two days later. Lasting quality was determined by the number of days from the date of flowering for each individual flower in the cluster to the date when the flower petals began to change from a white to a grey color. Overall growth measurements, leaf number (those still living and less than 50% grey) and plant height (from ground line to the crotch of flower cluster), were made at the completion of petal fall.

Experiment II: Thirty six uniform bulbs were planted singly in 4-inch clay pots. When the plants had reached a height of two inches they were sprayed with 10, 100, or 1000 ppm GA, alone and in combination with equal volumes of 100 ppm IAA. All plants were sprayed with a hand atomizer until thoroughly wetted. "Tween-20" was used as a adjuvant, at the rate of 0.2 ml. per liter of spray solution. Treatments were applied either once of four times, at two week intervals. Growth measurements similar to those in Experiment I were made during the experiment.

Experiment III: Another group of 36 uniform bulbs also were planted in 4-inch clay pots. When the first flower bud of the flower cluster had bent to a horizontal position GA spray treatments were started. The plants were sprayed with 10, 100, or 1000 ppm GA, alone and in combination with equal volumes of 100 ppm IAA, using a hand atomizer. Spray applications were made either once or twice, at weekly intervals. Growth measurements similar to those in Experiment I were made during the experiment.

Pecans

Four experiments were conducted to determine the effect of gibberellic acid (GA) on the germination and seedling growth of two varieties of pecans, Western and Mahan. Each of the experiments were planted on January 1. They were grown in the same greenhouse maintained at a temperature of 70° ± 4° F. during the daytime and 60° ± 2° F. at night. Supplemental light was not provided during the course of the experiment.

Experiment I: Western pecan seeds were soaked in concentrations of 0, 50, 100, 500, 1000, or 5000 ppm GA in water for 0, 12, 24, 48, 96, or 192 hours before planting. Ten seeds were used for each treatment. "Tween-20" wetting agent, at the rate of 0.2 ml. per liter, was added to the soaking solution. Room temperature during the time of soaking was maintained at 68° to 72° F. The various treatments were started at different times so that all soaking treatments could be completed and planting done at the same time. The pecan seeds were planted approximately 4 inches deep in a greenhouse groundbed. Observations were made daily and the date of seedling emergence noted. The experiment was terminated after 120 days, when the plants were removed from the soil and the following measurements made: percent seed germination, average height of first true leaf from ground level, root length, total plant height (from ground line to apex), and average dry weight of leaves, stems, and roots.

Experiment II: Ten mature Mahan pecan seeds were soaked in each concentration of GA and for the same length of time as those in Experiment I. They were planted in an adjacent groundbed and growth measurements similar to those described in Experiment I were made.

Experiment III: Ten mature Western pecan seeds were soaked in tap water for 48 hours and planted at a depth of 5 inches in each of 15 five gallon cans, containing a soil mixture of 1 part soil, 1 part peat moss, and 1 part sand. The cans were placed in the same greenhouse as Experiments I and II. On April 2, approximately 30 days after emergence, and when the plants were 6 to 8 inches tall, they were thinned to six uniform seedlings per can. All plants in the same can were then sprayed with 0, 50, 100, 500 and 1000 ppm GA, containing 0.2 ml. of "Tween-20" per liter of spray solution. Applications were made with a hand atomizer, until the leaves and growing tips were thoroughly wetted, once, twice, or four times, at weekly intervals. Increase in plant height was determined by measuring the plants before spraying and again at the end of the experiment, 51 days later. Increase in leaf number was determined in a like manner.

Experiment IV: Additional Western pecan seeds were planted in five gallon cans a few days later than in the previous experiment. On April 18 they were thinned to six uniform seedlings per can and Gibrel sprays applied so that the following GA concentrations were obtained: 0, 50, 100, 500, or 1000 ppm. "Tween-20" at a rate of 0.2 ml. per liter of spray solution was added to each solution. Applications were made once, twice, or three times, at weekly intervals. Plants were sprayed, with a hand atomizer, until the leaves and growing tips were thoroughly wetted. The same kind of growth response described in Experiment III were measured 35 days later.

RESULTS

The Effect of Gibberellic Acid on Flowering of Azaleas

Experiment I: In Figure 1 are shown the effects of various concentrations of gibberellic acid (GA) on the number of days from the start of treatment (December 16) until the first flower opened and the length of the flowering period (number of days during which new blooms were recorded). Increasing the concentrations of GA from 100 to 1000 ppm., and increasing the frequency of spray applications resulted in earlier flowering. In general, GA treated plants bloomed earlier than the control plants. GA treated plants also flowered earlier than those given a cold treatment of 6 weeks at 40° F. However, the cold treated plants completed their blooming period in considerably less time than did the GA treated plants. All GA treatments produced saleable plants. The untreated control plants, in comparison with the GA treated and cold treated plants, produced only a relatively few flowers which opened over a considerable period of time. Many potential flowers on the untreated control plants had not yet opened when the experiment was terminated after 101 days.

Experiment II: The effect of various concentrations of gibberellic acid (GA) on number of days from the start of treatment (March 15) until the first flower opened, and the length of the flowering period, is shown in Figure 2. All GA treated plants flowered earlier than those given a 6 week cold treatment, however, the frequency of GA applications had

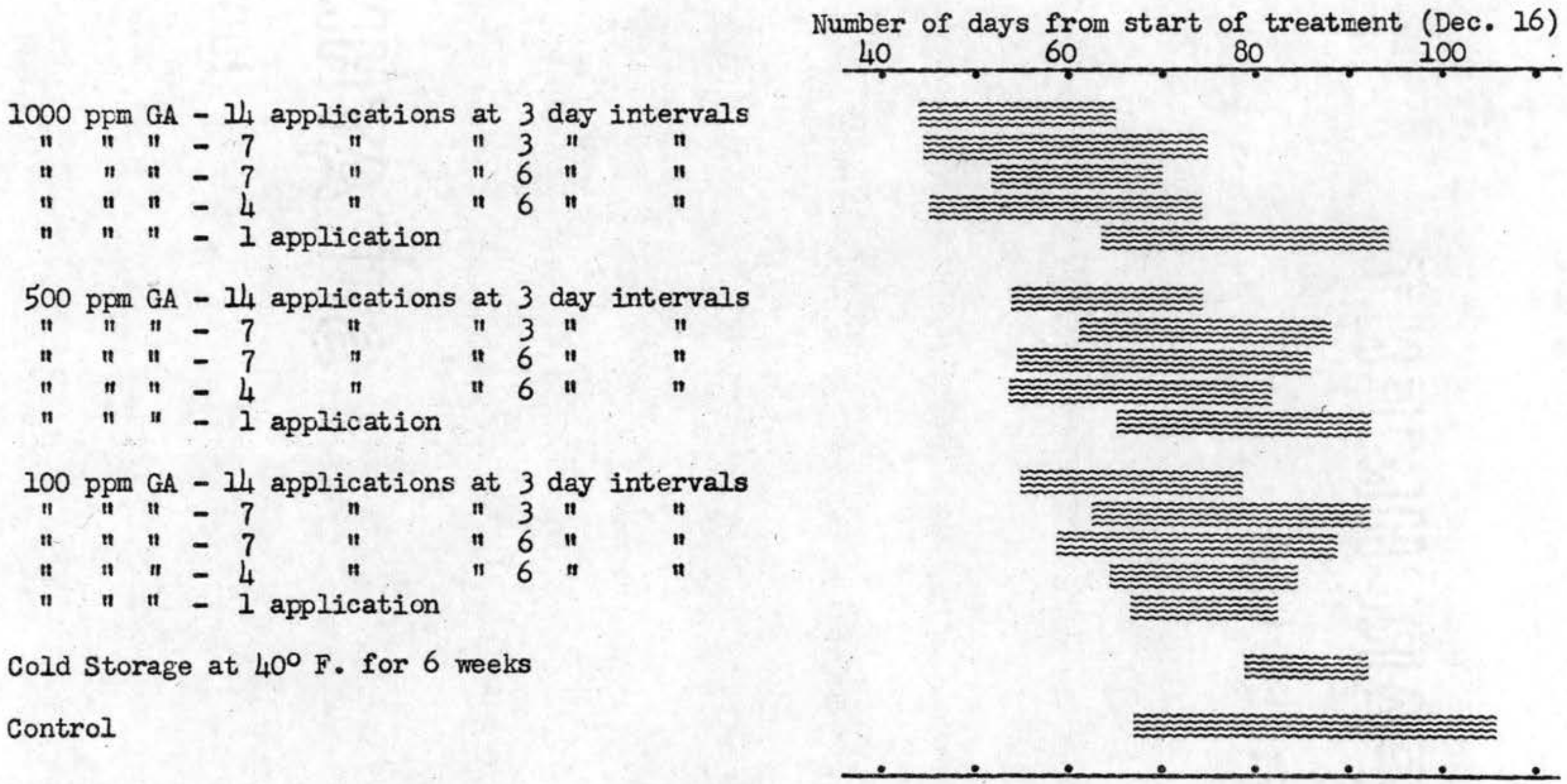


Figure 1. Flowering period of Dorothy Gish azalea plants after treatment with gibberellic acid sprays. First spray applied December 16.

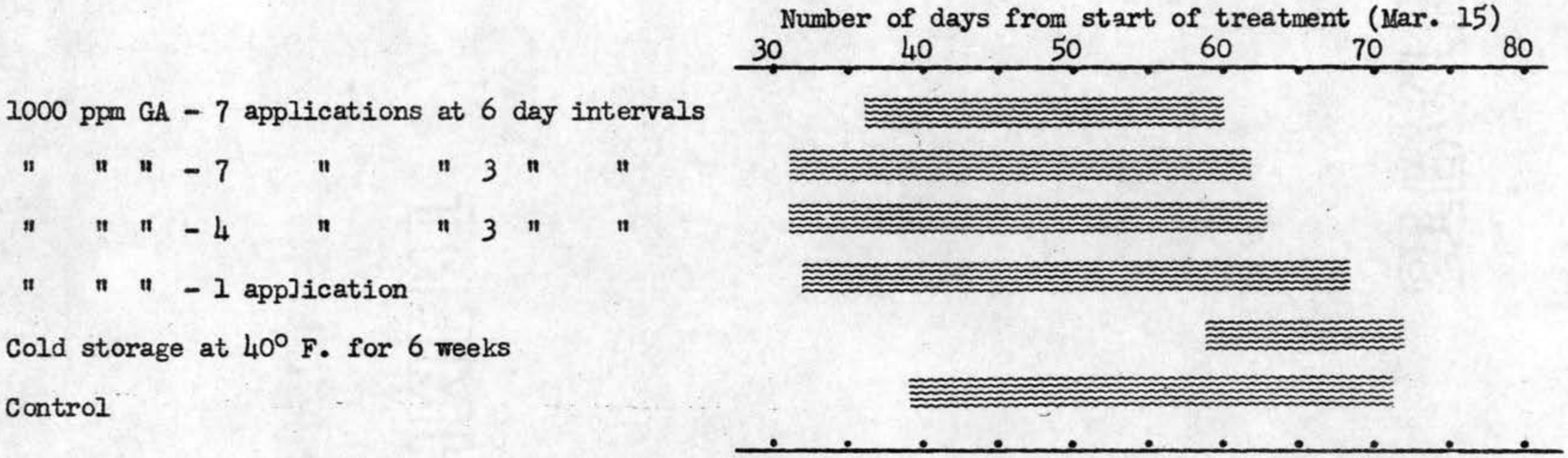


Figure 2. Flowering period of Dorothy Gish azalea plants after treatment with gibberellic acid sprays. First spray applied March 15. Each bar represents an average of 3 plants.

little effect on flowering. Both the GA treated and the control (non-treated) plants bloomed from 20 to 30 days earlier than the cold treated plants, however, there was less uniformity of flowering and they lacked the beauty and saleability of the cold treated plants.

The Effect of Gibberellic Acid and 3-indoleacetic Acid on the Growth and Flowering of Lilies

Experiment I: In Table I are shown the effects of soaking Ace lily bulbs in various concentrations of gibberellic acid (GA), alone and in combination with 100 ppm 3-indoleacetic acid (IAA) on plant height, number of leaves, number of buds, date of first flowering, flower size (length and width), and flower lasting quality. The average plant height of the treated plants was not markedly different from that of the control plants. Increasing the concentrations of GA, from 0 ppm (control) to 100 ppm, had little effect on leaf number, however, when the concentration of GA was increased to 1000 ppm there was an increase in leaf number over the control of from 73.5 to 97.3 leaves per plant. Combinations of 10 or 100 ppm GA with IAA also markedly increased the number of leaves per plant over that of the control plants. There appeared to be no relationship between the number of buds and various concentrations of GA or GA plus IAA. The date of first flowering from treated bulbs was delayed slightly in comparison with that of the control. There appeared to be a slightly greater delay in flowering with combinations of GA and IAA. In no case, however, was the delay in flower formation consistent with increased concentration of GA. Flower size was not affected by GA, alone or in combination with IAA. Increasing concentrations of GA and GA plus IAA also had no effect on flower keeping quality.

TABLE I

THE EFFECTS OF SOAKING ACE LILY BULBS FOR 15 MINUTES IN GIBBERELLIC ACID (GA), ALONE AND IN COMBINATION WITH 3-INDOLEACETIC ACID (IAA), ON PLANT HEIGHT, NUMBER OF LEAVES, NUMBER OF BUDS, DATE OF FLOWERING, FLOWER SIZE, AND LASTING QUALITY. BULBS WERE PLANTED NOVEMBER 26. (EACH FIGURE IS AN AVERAGE OF 3 PLANTS.)

	Plant Height (in.)	No. Leaves	No. Buds	Date of First Flowering	Size of Flower Length (cm.)	Size of Flower Width (cm.)	Lasting Quality (days)
0.1 ppm GA	15.0	74.0	4.0	3/17	14.8	11.6	7.0
1.0 " "	16.6	78.6	4.7	3/19	14.6	11.7	7.3
10 " "	15.3	76.0	5.0	3/19	14.7	11.7	6.5
100 " "	16.0	68.6	4.7	3/18	14.9	11.5	7.2
1000 " "	13.3	97.3	4.3	3/20	14.3	11.2	7.8
0.1 ppm GA & 100 ppm IAA	17.0	84.6	5.3	3/19	14.4	11.1	7.7
1.0 " " " " " "	17.3	78.0	5.7	3/20	14.2	11.4	6.8
10 " " " " " "	12.0	114.0	6.0	3/17	14.2	10.7	7.2
100 " " " " " "	14.0	102.3	4.0	3/22	14.5	11.2	7.2
1000 " " " " " "	17.0	76.6	3.7	3/20	14.7	11.6	7.4
Control	15.3	73.5	4.6	3/18	14.8	11.5	7.6

Experiment II: Table II shows the effect of spraying Ace lily plants (2 inches tall when treated) with various combinations of GA, alone and in combination with 100 ppm IAA on plant height, number of leaves, number of buds, date of first flowering, flower size (length and width), and lasting quality. In general, varying concentrations of GA, alone and in combination with IAA, had little effect on average plant height. Only with 1000 ppm GA treatments applied four times at two week intervals, was there any marked increase in plant height over that of the control. Increasing concentrations of GA, alone and in combination with IAA did not cause any variation in number of leaves. There also appeared to be no relationship between the number of buds and the concentration of GA or GA plus IAA. Plants sprayed four times, at two week intervals with GA or GA plus IAA tended to flower earlier than the controls, while those receiving only one spray treatement tended to flower a few days later than the controls. Neither the length or width of the flower nor the lasting quality of the flower was affected by any of the treatments.

Experiment III: Table III shows the effect of spraying Ace lily plants (first application made when the first bud in the flower cluster had bent over to a horizontal position) with various combinations of GA, alone and in combination with 100 ppm IAA, on date of first flowering, flower size (length and width), and lasting quality. Increasing the concentration of GA from 10 to 1000 ppm, alone or in combination with IAA, lessened the time to first flowering from 6 to 9 days. Increasing the concentration of GA, however, had little effect on increase in length or width of flowers. Plants sprayed with 1000 ppm GA, alone and in combination with IAA, lasted about 2 days longer than the controls or plants sprayed with 10 ppm GA, alone and in combination with IAA.

TABLE II

THE EFFECTS OF SPRAYING ACE LILY PLANTS (FIRST APPLICATION MADE AT TIME PLANTS WERE TWO INCHES TALL) WITH GIBBERELLIC ACID (GA), ALONE AND IN COMBINATION WITH 3-INDOLEACETIC ACID (IAA), ON PLANT HEIGHT, NUMBER OF LEAVES, NUMBER OF BUDS, DATE OF FLOWERING, FLOWER SIZE, AND LASTING QUALITY. BULBS WERE PLANTED NOVEMBER 26. (EACH FIGURE IS AN AVERAGE OF 3 PLANTS.)

	Plant Height (in.)	No. Leaves	No. Buds	Date of First Flowering	Size of Flower Length (cm.)	Size of Flower Width (cm.)	Lasting Quality (days)
Single application:							
10 ppm GA	15.0	69.0	5.0	3/22	13.3	11.3	7.0
100 " "	13.0	62.0	4.0	3/14	14.7	11.4	6.8
1000 " "	17.3	78.3	4.3	3/22	14.8	12.0	6.8
10 ppm GA & 100 ppm IAA	16.5	87.6	4.7	3/28	14.6	11.6	8.1
100 " " " " " "	15.0	68.0	4.7	3/19	15.0	11.8	6.8
1000 " " " " " "	15.3	67.3	3.7	3/21	13.4	11.5	6.5
Four applications: (two week intervals)							
10 ppm GA	16.0	73.6	5.0	3/17	14.9	11.9	7.4
100 " "	17.6	73.6	4.0	3/25	14.7	12.5	8.0
1000 " "	18.3	96.3	5.7	3/17	14.9	12.3	8.1

TABLE II (Continued)

	Plant Height (in.)	No. Leaves	No. Buds	Date of First Flowering	Size of Flower Length (cm.)	Size of Flower Width (cm.)	Lasting Quality (days)
10 ppm GA & 100 ppm IAA	13.6	91.3	5.3	3/18	14.7	11.8	6.9
100 " " " " " "	13.6	83.6	4.0	3/13	14.4	11.7	7.6
1000 " " " " " "	18.5	72.5	5.0	3/14	15.0	12.6	8.4
Control	15.3	73.5	4.6	3/18	14.8	11.5	7.6

TABLE III

THE EFFECT OF SPRAYING ACE LILY FLOWER BUDS (FIRST APPLICATION MADE WHEN FIRST BUD IN CLUSTER BENT TO HORIZONTAL POSITION) WITH GIBBERELLIC ACID (GA), ALONE AND IN COMBINATION WITH 3-INDOLEACETIC ACID (IAA), ON DATE OF FLOWERING, FLOWER SIZE, AND LASTING QUALITY. BULBS WERE PLANTED NOVEMBER 26. (EACH FIGURE IS AN AVERAGE OF 3 PLANTS.)

	Date of First Flowering	Size of Flower Length (cm.)	Width (cm.)	Lasting Quality (days)
Single application:				
10 ppm GA	3/18	14.6	11.3	7.4
100 " "	3/22	14.4	11.9	7.5
1000 " "	3/9	16.1	11.7	9.0
10 ppm GA & 100 ppm IAA	3/28	14.7	11.4	7.8
100 " " " " " "	3/25	14.4	11.5	8.0
1000 " " " " " "	3/20	15.1	12.1	9.2
Two applications: (one week interval)				
10 ppm GA	3/23	14.6	11.7	7.0
100 " "	3/20	14.9	11.8	7.9
1000 " "	3/17	15.1	11.7	8.8
Control	3/18	14.8	11.5	7.6

The Effect of Gibberellic Acid on Germination and/or Seedling Growth of Pecans

Experiment I: The effect of soaking Western pecan seeds in gibberellic acid (GA) on the range of dates of seedling emergence is shown in Figure 3. Increasing the concentration of GA from 0 to 5000 ppm, in general, caused earlier seedling germination. Increasing the soaking time from 0 to 192 hours also resulted in earlier seedling germination.

Table IV shows the percent germination after 120 days from Western pecan seeds soaked in various concentrations of GA. Increasing the concentration, from 0 to 50 ppm, increased the average germination from 78 to 94 percent. Further increases in GA, however, had little effect on percent germination. Increasing the soaking time from 12 to 192 hours had little effect on the average germination percent. In the control only 4 of the 10 pecans had germinated after 120 days.

The effect of soaking Western pecan seeds in GA on the height of the first leaf is shown in Table V. Increasing the concentration from 0 to 5000 ppm tended to increase the average height of the first leaf. However, increasing the soaking time from 12 to 192 hours had little effect on the average height of the first leaf.

The average seedling plant height 120 days after planting from Western pecan seeds previously soaked in GA, is shown in Table VI. Increasing the concentration from 0 to 50 ppm caused a marked increase in plant height. Further increases in GA concentration, however, up to 5000 ppm, resulted in only a slight additional average plant height increase. Increasing the soaking period from 12 to 192 hours caused only a slight increase in the average plant height.

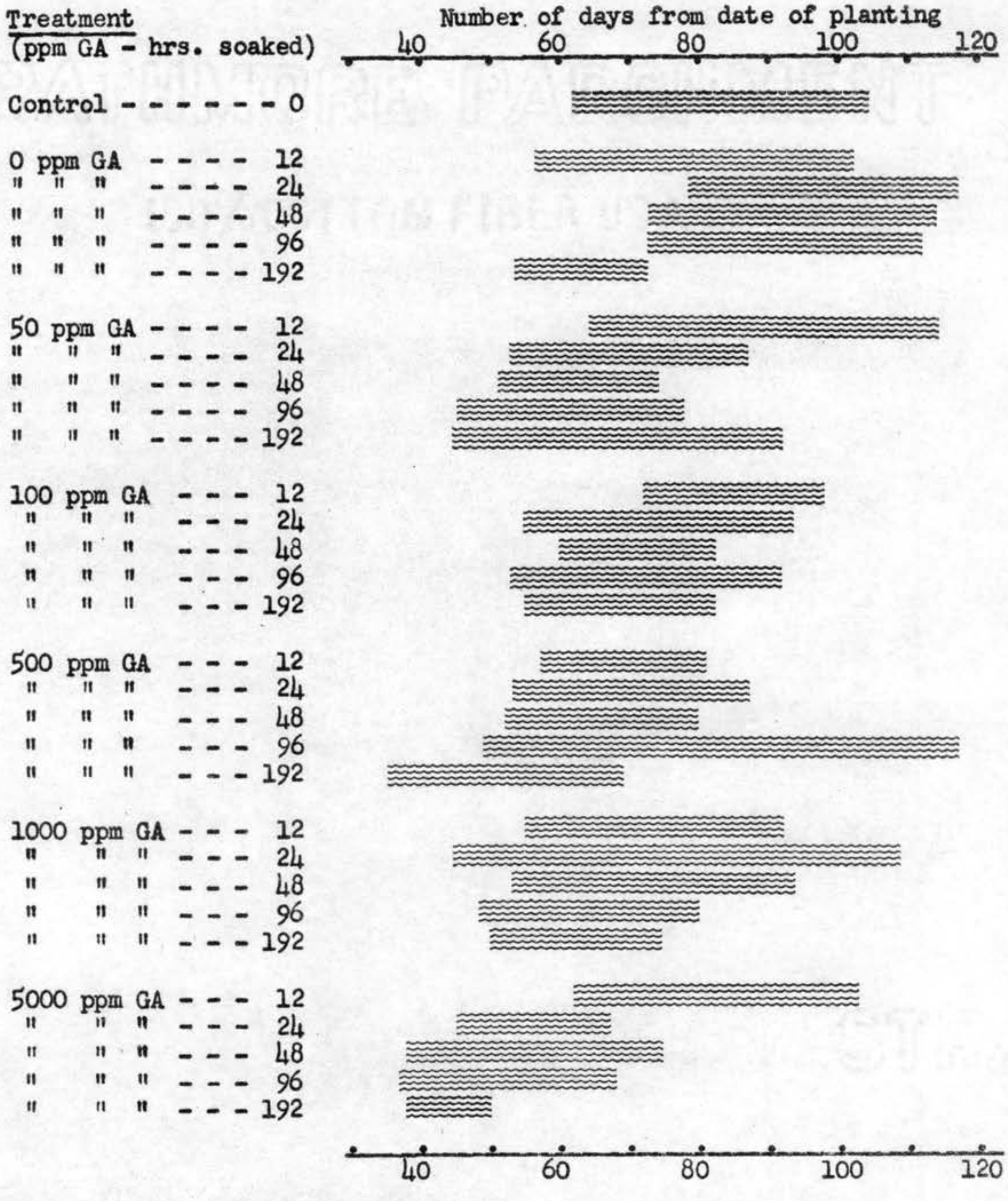


Figure 3. Days during which seedlings from Western pecan seeds, soaked in gibberellic acid (GA) before planting, emerged. (10 seeds per treatment)

TABLE IV

AVERAGE PERCENT GERMINATION, 120 DAYS AFTER PLANTING, OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Control (No treatment)	40	-	-	-	-	-	40
0 ppm GA	-	80	80	80	50	100	78
50 ppm GA	-	100	90	90	100	90	94
100 ppm GA	-	100	100	100	90	100	98
500 ppm GA	-	100	100	90	90	100	96
1000 ppm GA	-	100	100	100	100	100	100
5000 ppm GA	-	100	100	100	100	100	100
Average of all concentrations	40	97	95	93	88	98	

TABLE V

AVERAGE HEIGHT OF FIRST LEAF, 120 DAYS AFTER PLANTING, OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking 0 (cm.)	12 (cm.)	24 (cm.)	48 (cm.)	96 (cm.)	192 (cm.)	Average of all soak periods (cm.)
Control (No treatment)	20.0	--	--	--	--	--	
0 ppm GA	--	16.2	19.2	19.0	21.6	17.6	18.7
50 ppm GA	--	21.4	21.4	20.2	22.5	22.8	21.7
100 ppm GA	--	19.6	20.0	21.5	22.4	23.1	21.3
500 ppm GA	--	19.9	21.3	21.7	22.2	21.2	21.3
1000 ppm GA	--	23.4	21.6	18.1	21.4	18.8	20.7
5000 ppm GA	--	23.4	23.7	22.5	21.9	21.3	22.6
Average of all GA concentrations		20.7	21.2	20.5	22.0	20.8	

TABLE VI

AVERAGE SEEDLING PLANT HEIGHT, 120 DAYS AFTER PLANTING OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak Periods
	0	12	24	48	96	192	
	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)
Control (No treatment)	26.0	--	--	--	--	--	
0 ppm GA	--	23.3	34.8	29.2	25.7	29.8	26.6
50 ppm GA	--	29.7	29.1	30.4	30.8	30.5	30.1
100 ppm GA	--	28.4	29.0	34.7	33.2	35.1	32.1
500 ppm GA	--	27.5	34.7	28.5	34.1	32.3	31.4
1000 ppm GA	--	34.7	33.4	28.0	30.4	30.2	31.3
5000 ppm GA	--	34.5	33.4	31.0	32.3	30.9	32.4
Average of all GA concentrations		29.7	30.7	30.3	31.1	31.5	

Soaking Western pecan seeds in GA had little effect on seedling root length, 120 days after planting (Table VII). Neither increasing the GA concentration nor the time of soaking resulted in any marked change in the average root length.

The effect of soaking Western pecan seeds in GA on the number of leaves per seedling after 120 days is shown in Table VIII. Increasing the GA concentration from 0 to 100 ppm resulted in an increase of approximately one leaf per plant. Further increases in GA concentration, however, did not result in additional increases in the average leaf number. Increasing the soaking period from 12 to 192 hours had no appreciable effect on the average leaf number.

Table IX shows the effect after 120 days of soaking Western pecan seeds in GA on above ground dry weight. Plants from 27 of the 30 treatments had a higher average above ground dry weight per plant than the control plants. Increasing concentrations of GA up to 1000 ppm increased the average above ground dry weight. Increasing the soaking period from 12 to 192 hours markedly reduced the average above ground dry weight, from 2.18 to 1.68 grams.

The effect of soaking Western pecan seeds in GA on the root dry weight after 120 days is shown in Table X. In 28 of the 30 treatments the root dry weight was greater than in the control plants. Increasing the concentration of GA caused an increased average root dry weight. Increasing the soaking period from 12 to 192 hours, however, decreased the average root dry weight markedly.

The total plant dry weight of the 120 day old Western pecan seedlings is shown in Table XI. Increasing the GA concentration resulted in an increased average total plant dry weight. However, increasing the

TABLE VII

AVERAGE ROOT LENGTH, 120 DAYS AFTER PLANTING, OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking 0 (cm.)	12 (cm.)	24 (cm.)	48 (cm.)	96 (cm.)	192 (cm.)	Average of all soak periods (cm.)
Control (No treatment)	40.0	--	--	--	--	--	
0 ppm GA	--	24.6	34.4	32.0	39.4	43.3	34.7
50 ppm GA	--	57.7	34.9	41.6	36.0	35.8	41.2
100 ppm GA	--	50.6	46.3	58.3	42.4	31.3	45.8
500 ppm GA	--	36.8	28.8	38.8	45.9	42.6	38.6
1000 ppm GA	--	27.8	49.6	46.7	35.9	45.6	41.1
5000 ppm GA	--	34.5	40.9	22.4	41.9	41.0	36.1
Average of all GA concentrations		38.7	39.2	40.0	40.3	39.9	

TABLE VIII

AVERAGE NUMBER OF LEAVES PER PLANT, 120 DAYS AFTER PLANTING, OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
Control (No treatment)	5.8	--	--	--	--	--	
0 ppm GA	--	7.0	4.0	7.1	4.6	6.8	5.9
50 ppm GA	--	5.8	6.2	6.4	5.4	5.3	5.8
100 ppm GA	--	6.7	5.8	6.5	6.9	7.4	6.7
500 ppm GA	--	6.2	7.9	5.3	7.8	6.5	6.7
1000 ppm GA	--	6.3	6.7	6.9	6.7	6.8	6.7
5000 ppm GA	--	7.1	7.0	6.2	6.5	6.7	6.7
Average of all GA concentrations		6.5	6.3	6.4	6.3	6.6	

TABLE IX

AVERAGE ABOVE GROUND DRY WEIGHT, 120 DAYS AFTER PLANTING, OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)
Control (No treatment)	1.15	--	--	--	--	--	
0 ppm GA	--	1.86	1.02	1.50	1.06	1.43	1.39
50 ppm GA	--	2.60	2.12	1.88	1.77	1.63	1.99
100 ppm GA	--	2.01	2.18	2.04	1.40	1.79	1.88
500 ppm GA	--	1.83	2.00	2.10	2.05	2.06	2.01
1000 ppm GA	--	2.44	2.09	2.08	1.97	2.09	2.13
5000 ppm GA	--	1.36	1.93	1.94	2.24	1.10	1.91
Average of all GA concentrations		2.18	1.89	1.93	1.75	1.68	

TABLE X

AVERAGE ROOT DRY WEIGHT, 120 DAYS AFTER PLANTING, OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)
Control (No treatment)	1.53	--	--	--	--	--	
0 ppm GA	--	3.36	1.28	1.89	1.19	1.79	1.90
50 ppm GA	--	3.38	3.07	2.29	2.85	1.83	2.68
100 ppm GA	--	3.08	2.60	2.44	1.61	1.83	2.31
500 ppm GA	--	3.37	2.38	3.18	2.51	2.11	2.71
1000 ppm GA	--	2.58	2.59	2.90	2.51	2.59	2.63
5000 ppm GA	--	3.31	3.40	2.85	3.43	1.98	2.99
Average of all GA concentrations		3.18	2.55	2.59	2.35	2.02	

TABLE XI

AVERAGE TOTAL PLANT DRY WEIGHT, 120 DAYS AFTER PLANTING, OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)
Control (No treatment)	2.68	--	--	--	--	--	
0 ppm GA	--	5.22	2.30	3.47	2.25	3.22	3.29
50 ppm GA	--	5.98	5.19	4.17	4.62	3.46	4.68
100 ppm GA	--	5.09	4.47	4.48	3.01	3.62	4.20
500 ppm GA	--	5.20	4.38	5.28	4.56	4.17	4.72
1000 ppm GA	--	5.02	4.68	4.98	4.48	4.68	4.77
5000 ppm GA	--	5.67	5.33	4.79	5.67	3.08	4.91
Average of all GA concentrations		5.36	4.44	4.53	4.10	3.71	

soaking time, from 12 to 192 hours, markedly decreased the average total plant dry weight.

In Table XII the effect of soaking Western pecan seeds in GA on the average internode length 120 days after planting is shown. Although the average internode length of the treated plants was greater than the control the differences in average internode lengths were not consistent with the different concentrations of GA, or with the period of soaking.

Experiment II: The effect of soaking Mahan pecan seeds in gibberellic acid (GA) on the range of dates of seedling emergence is shown in Figure 4. Those soaked in GA germinated and emerged from 5 to 50 days earlier than those given no soaking treatment. High concentrations of GA, in general, caused somewhat earlier emergence than did the low concentrations. Increasing the period of soaking, from 12 to 192 hours, also resulted in earlier germination.

Soaking Mahan pecans in GA had little effect on the percent germination (Table XIII). Sixteen of the 30 treatments gave a lower germination percent than the control. No consistent differences in germination percents of the varying treatments were noted.

The effect of soaking Mahan pecans in GA for different periods of time on the height of the first leaf is shown in Table XIV. The height of the first leaf of the treated plants exceeded that of the control plants. However, the various treatments resulted in no consistent variation in the height of the first leaf.

Table XV shows the effect of soaking Mahan pecan seeds in GA on the total plant height after 120 days. Increasing the concentration of GA to 5000 ppm increased the average plant height, however, increased seed soaking time had little effect on the average plant height.

TABLE XII

AVERAGE INTERNODE LENGTH, 120 DAYS AFTER PLANTING, OF WESTERN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)
Control (No treatment)	1.2	--	--	--	--	--	1.2
0 ppm GA	--	1.1	1.8	1.6	0.8	2.1	1.5
50 ppm GA	--	1.7	1.4	1.9	1.3	1.7	1.6
100 ppm GA	--	1.5	1.8	2.4	1.5	1.8	1.8
500 ppm GA	--	1.2	1.9	1.5	1.5	2.0	1.6
1000 ppm GA	--	2.1	2.0	1.6	1.3	1.9	1.8
5000 ppm GA	--	1.8	1.6	1.6	1.6	1.6	1.6
Average of all concentrations	1.2	1.6	1.8	1.8	1.3	1.9	1.7

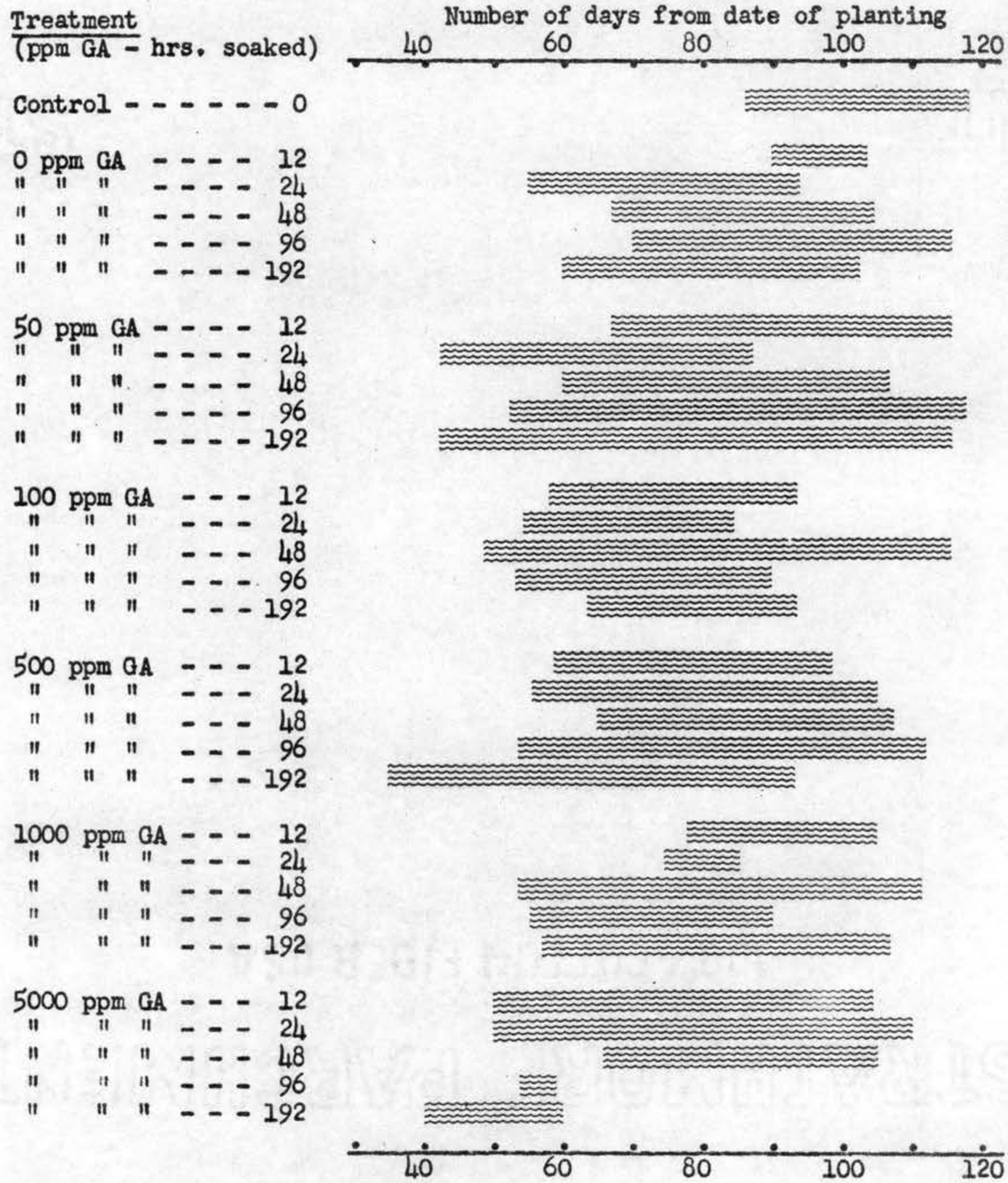


Figure 4. Days during which seedlings from Mahan pecan seeds, soaked in gibberellic acid (GA) before planting, emerged. (10 seeds per treatment)

TABLE XIII

AVERAGE PERCENT GERMINATION, 120 DAYS AFTER PLANTING, OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking 0 (%)	12 (%)	24 (%)	48 (%)	96 (%)	192 (%)	Average of all soak periods (%)
Control (No treatment)	60	--	--	--	--	--	--
0 ppm GA	--	40	60	50	50	60	52
50 ppm GA	--	50	70	70	40	60	58
100 ppm GA	--	60	70	50	50	50	56
500 ppm GA	--	90	50	40	70	60	62
1000 ppm GA	--	50	20	60	60	60	50
5000 ppm GA	--	40	50	30	30	60	42
Average of all GA concentrations		55	53	50	50	58	

TABLE XIV

AVERAGE HEIGHT OF THE FIRST LEAF, 120 DAYS AFTER PLANTING, OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)	(cm.)
Control (No treatment)	14.8	--	--	--	--	--	
0 ppm GA	--	18.0	19.6	18.8	17.7	19.5	18.7
50 ppm GA	--	18.5	18.6	18.3	21.0	18.1	18.9
100 ppm GA	--	18.3	18.5	18.2	16.5	18.2	17.9
500 ppm GA	--	18.4	16.0	19.0	17.8	17.8	17.8
1000 ppm GA	--	15.6	15.0	16.2	20.0	18.8	17.1
5000 ppm GA	--	33.3	20.6	18.3	20.6	24.8	23.5
Average of all GA concentrations		20.4	18.1	18.1	18.9	19.5	

TABLE XV

AVERAGE TOTAL PLANT HEIGHT, 120 DAYS AFTER PLANTING, OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking 0 (cm.)	12 (cm.)	24 (cm.)	48 (cm.)	96 (cm.)	192 (cm.)	Average of all soak periods (cm.)
Control (No treatment)	24.2	--	--	--	--	--	
0 ppm GA	--	23.2	29.3	24.2	22.2	26.8	25.1
50 ppm GA	--	25.7	25.1	23.0	33.0	26.1	26.6
100 ppm GA	--	25.1	26.4	27.5	26.5	25.2	26.1
500 ppm GA	--	25.2	22.2	22.8	21.8	23.8	23.2
1000 ppm GA	--	22.0	19.5	23.8	28.3	27.0	24.1
5000 ppm GA	--	42.6	30.6	27.0	31.3	36.0	33.5
Average of all GA concentrations		27.3	25.5	24.7	27.2	27.5	

The root length of Mahan pecan plants 120 days after planting is shown in Table XVI. The control plants had a greater root length than did the average of the treated plants, although increasing the concentration of GA from 0 to 5000 ppm resulted in an increased root length. Increasing the period of soaking from 12 to 192 hours also increased the root length.

The average number of leaves per plant 120 days after planting is shown in Table XVII. Increasing the concentration of GA from 0 to 5000 ppm tended to increase the total average number of leaves per plant. Changes in time of soaking had little effect on the average number of leaves. The number of leaves in the control plants exceeded that of the average of any of the treated plants.

Table XVIII shows the effect of GA seed soaking on the average above ground dry weight per plant of Mahan pecan seedlings 120 days after planting. GA had no effect on the average dry weight of the above ground part of the plant. However, increasing the soaking time, up to 96 hours markedly increased the dry weight of the above ground part of the plant.

The average dry weight of roots from the Mahan pecan seedlings is shown in Table XIX. Increasing the soaking period from 12 hours to 192 hours increased the average root dry weight from 1.78 to 2.30 grams. Increasing the concentration of GA from 0 ppm to 500 ppm increased the average root dry weight from 1.63 to 2.71 grams. However, higher concentrations of GA did not further increase the root dry weight.

Table XX shows the average total dry weight of seedlings grown from Mahan pecans soaked in GA. Increasing concentrations of GA had little effect on the average total plant dry weight. Increasing the

TABLE XVI

AVERAGE ROOT LENGTH, 120 DAYS AFTER PLANTING OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking 0 (cm.)	12 (cm.)	24 (cm.)	48 (cm.)	96 (cm.)	192 (cm.)	Average of all soak periods (cm.)
Control (No treatment)	32.5	--	--	--	--	--	
0 ppm GA	--	26.5	25.6	26.2	22.7	29.8	26.1
50 ppm GA	--	20.0	30.2	27.6	30.0	27.7	27.1
100 ppm GA	--	30.5	26.8	34.0	28.6	33.3	30.6
500 ppm GA	--	24.8	27.8	27.7	30.5	30.8	28.3
1000 ppm GA	--	24.3	29.0	22.3	33.7	31.6	28.2
5000 ppm GA	--	30.0	34.2	36.0	31.0	29.7	32.2
Average of all GA concentrations		25.9	28.9	29.0	29.4	30.1	

TABLE XVII

AVERAGE NUMBER OF LEAVES PER PLANT, 120 DAYS AFTER PLANTING, OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
Control (No treatment)	9.6	--	--	--	--	--	
0 ppm GA	--	5.5	10.0	7.4	4.7	8.1	7.1
50 ppm GA	--	8.0	7.6	6.0	8.0	6.5	7.4
100 ppm GA	--	8.8	7.1	8.0	8.0	9.5	8.3
500 ppm GA	--	7.0	8.4	7.0	9.0	10.0	8.3
1000 ppm GA	--	8.6	7.0	7.4	7.8	7.1	7.6
5000 ppm GA	--	8.6	9.6	10.0	10.6	7.4	9.2
Average of all GA concentrations		7.8	8.3	7.8	8.0	8.1	

TABLE XVIII

AVERAGE ABOVE GROUND DRY WEIGHT, 120 DAYS AFTER PLANTING, OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)
Control (No treatment)	1.41	--	--	--	--	--	
0 ppm GA	--	1.00	3.55	2.28	5.78	1.98	2.92
50 ppm GA	--	1.60	3.37	2.04	4.36	2.08	2.69
100 ppm GA	--	1.87	1.87	3.68	2.03	2.68	2.42
500 ppm GA	--	2.04	1.92	3.22	3.94	2.38	2.70
1000 ppm GA	--	0.87	0.95	1.74	2.73	2.19	1.69
5000 ppm GA	--	3.43	3.36	1.50	3.37	1.98	2.72
Average of all GA concentrations		1.81	2.51	2.41	3.70	2.22	

TABLE XIX

AVERAGE ROOT DRY WEIGHT, 120 DAYS AFTER PLANTING, OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0 (gm.)	12 (gm.)	24 (gm.)	48 (gm.)	96 (gm.)	192 (gm.)	(gm.)
Control (No treatment)	1.38	--	--	--	--	--	
0 ppm GA	--	0.93	1.90	2.33	1.25	1.74	1.63
50 ppm GA	--	1.95	2.36	1.27	2.60	2.43	2.12
100 ppm GA	--	2.75	2.20	3.80	1.50	2.20	2.49
500 ppm GA	--	1.76	2.14	2.08	3.78	3.78	2.71
1000 ppm GA	--	0.83	1.15	1.75	2.48	1.67	1.57
5000 ppm GA	--	2.47	3.24	1.73	3.05	2.00	2.49
Average of all GA concentrations		1.78	2.17	2.16	2.44	2.30	

TABLE XX

AVERAGE TOTAL PLANT DRY WEIGHT, 120 DAYS AFTER PLANTING, OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking						Average of all soak periods
	0	12	24	48	96	192	
	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)	(gm.)
Control (No treatment)	2.79	--	--	--	--	--	
0 ppm GA	--	1.93	5.45	4.61	7.03	3.72	4.55
50 ppm GA	--	3.55	5.73	3.31	6.96	4.51	4.81
100 ppm GA	--	4.62	4.07	7.48	3.53	4.88	4.91
500 ppm GA	--	3.80	4.06	5.30	7.72	6.16	5.41
1000 ppm GA	--	1.70	2.10	3.47	5.21	3.86	3.26
5000 ppm GA	--	5.90	6.60	3.23	6.42	3.98	5.21
Average of all GA concentrations		3.59	4.68	4.57	6.14	4.52	

soaking time, from 12 to 96 hours, increased the total plant dry weight, however, further increasing the soaking period to 192 hours did not further increase plant dry weight.

The effect of soaking Mahan pecan seeds in GA on the average internode length of 120 day old seedlings is shown in Table XXI. Neither GA nor time of soaking had any effect on the internode length.

Experiment III: The effect of gibberellic acid (GA) sprays applied to pecan seedling 1, 2 and 4 times at weekly intervals, on the increase in plant height is shown in Figure 5. Approximately 40 cm is the apparent maximum height increase attainable, using any concentration or number of applications of GA, in a 51 day period. For example, plants given only one application of 1000 ppm GA increased 41.2 cm in height after 51 days. However, applying the 1000 ppm treatment 2 or 4 times did not further increase the plant height. Using a 500 ppm GA treatment, 2 spray applications were required before the plants reached the 40 cm height. Plants treated with 100 ppm GA required 4 sprays to attain this much increase in plant height while plants sprayed 4 times with 50 ppm were only 20 cm high after the 51 day period.

The increase in height of the first leaf 51 days after treatment is shown in Figure 6. In only 2 of the 12 treatments, 100 ppm applied twice and 50 ppm applied four times, was the height of the first leaf greater than that of the control. Increasing the number of spray applications, or increasing the concentration of GA did not markedly affect the height of the first leaf.

As shown in Figure 7, spraying Western pecan seedlings with GA had little effect on the increase in number of leaves. The average increase

TABLE XXI

AVERAGE INTERNODE LENGTH, 120 DAYS AFTER PLANTING, OF MAHAN PECAN SEEDS SOAKED IN GIBBERELLIC ACID. (10 SEEDS PER TREATMENT)

Treatment	Hours of Soaking 0 (cm.)	12 (cm.)	24 (cm.)	48 (cm.)	96 (cm.)	192 (cm.)	Average of all soak periods (cm.)
Control (No treatment)	1.0	--	--	--	--	--	1.0
0 ppm GA	--	1.1	1.0	0.8	1.2	1.0	1.0
50 ppm GA	--	1.0	0.9	0.7	1.5	1.4	1.1
100 ppm GA	--	0.8	1.3	1.3	1.4	0.8	1.1
500 ppm GA	--	1.1	0.8	0.6	0.5	0.6	0.7
1000 ppm GA	--	0.8	0.7	1.1	1.2	1.3	1.0
5000 ppm GA	--	1.2	1.1	0.9	1.1	1.7	1.2
Average of all concentrations	1.0	1.0	0.9	0.9	1.1	1.1	

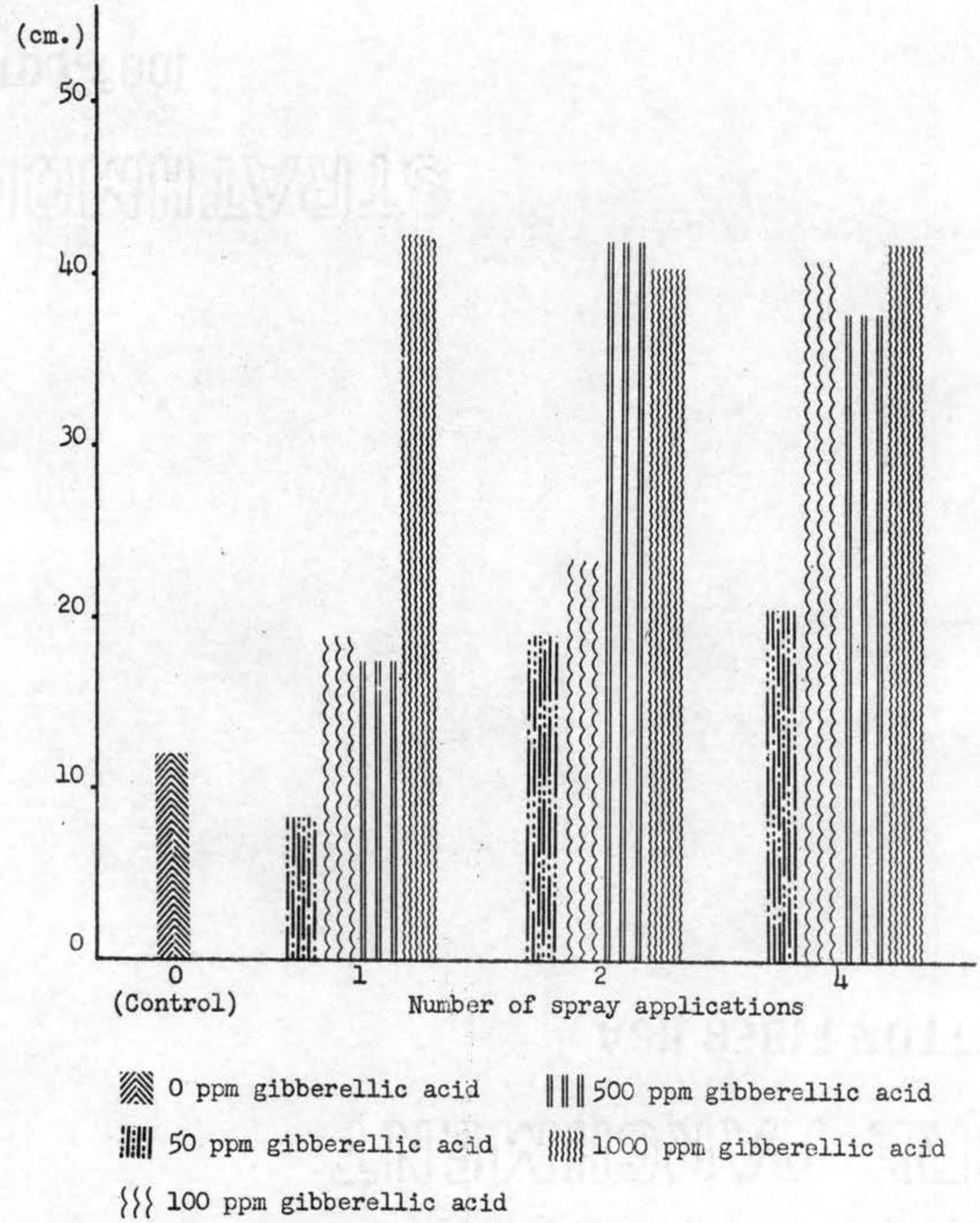
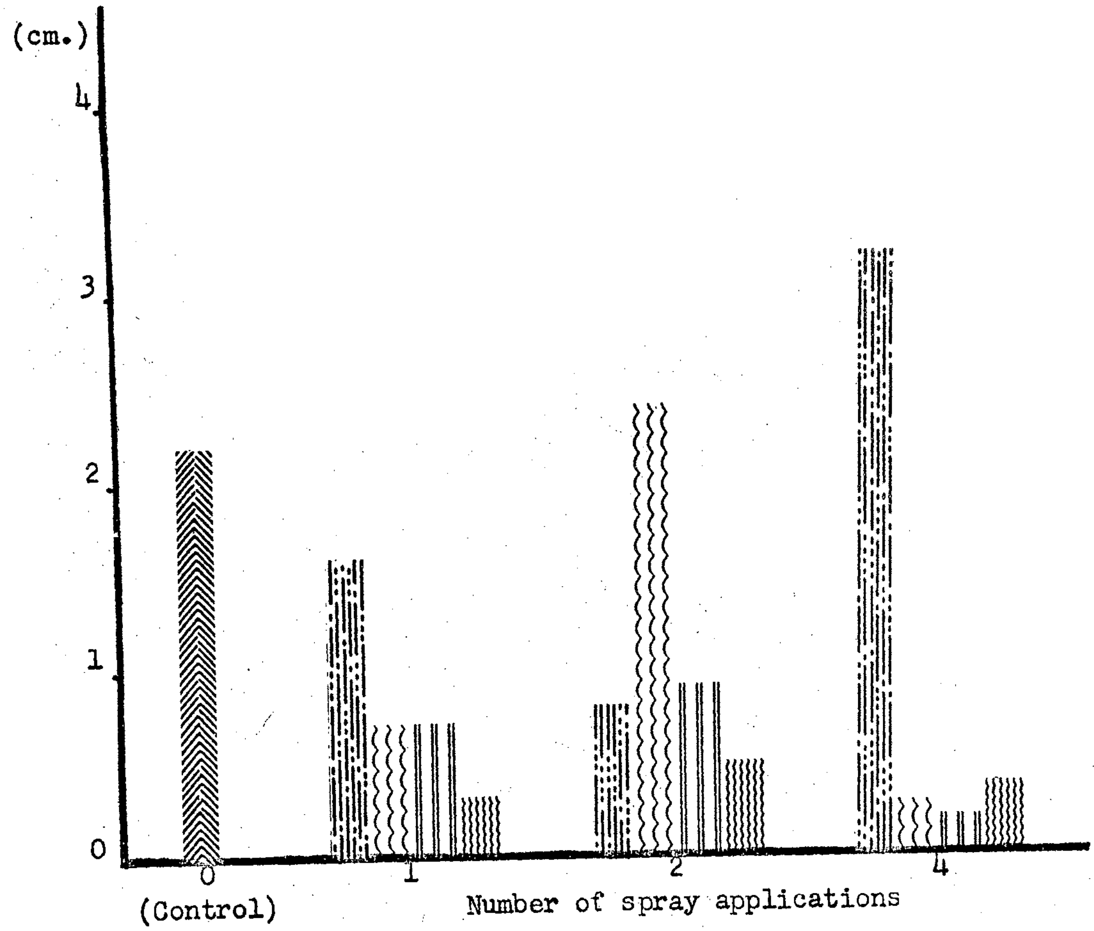


Figure 5. The effect of gibberellic acid sprays on Western pecan seedlings, at weekly intervals, on increase in plant height, 51 days after first treatment.



0 ppm gibberellic acid

50 ppm gibberellic acid

100 ppm gibberellic acid

500 ppm gibberellic acid

1000 ppm gibberellic acid

Figure 6. The effect of gibberellic acid sprays on Western pecan seedlings, at weekly intervals, on increase in height to first leaf, 51 days after first treatment.

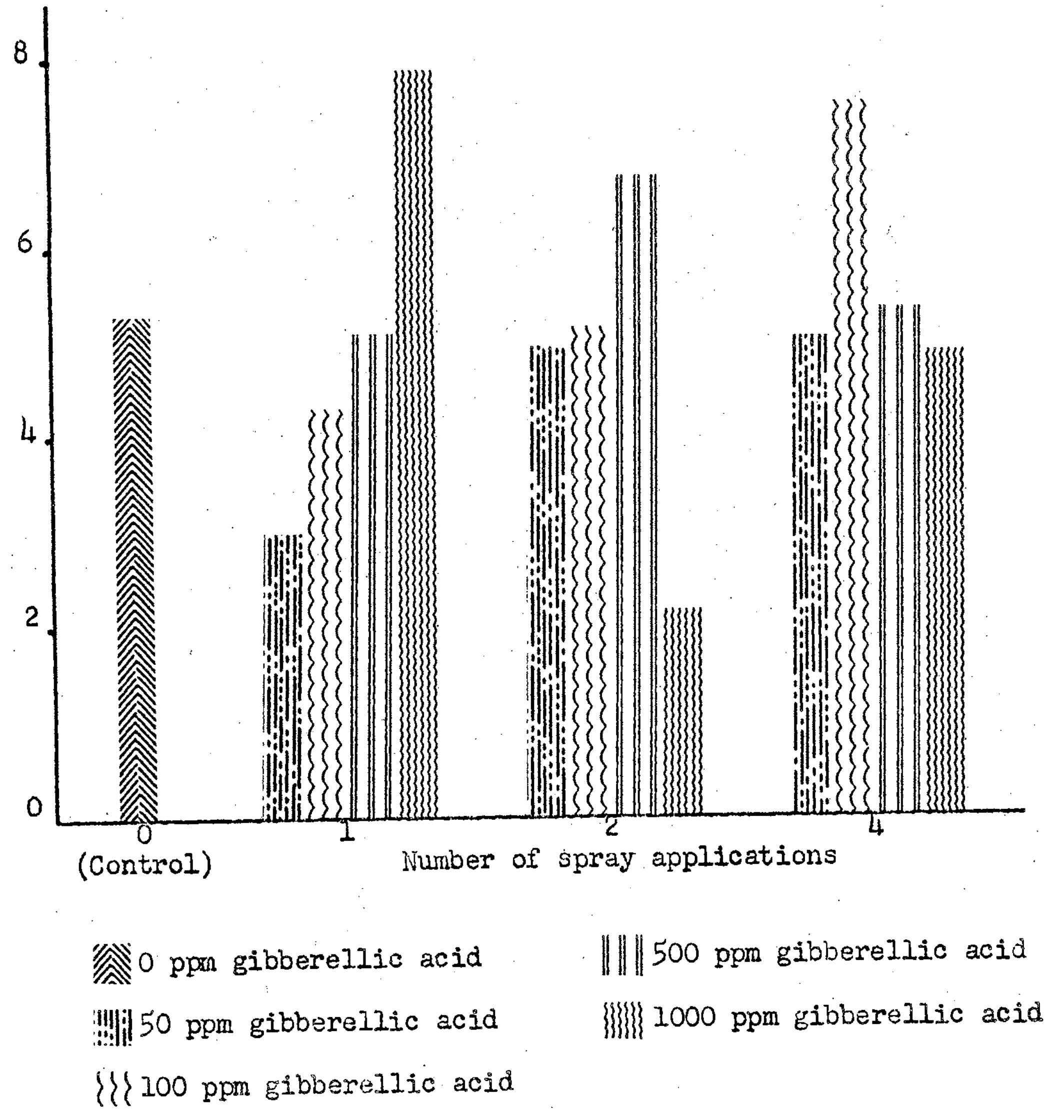


Figure 7. The effect of gibberellic acid sprays on Western pecan seedlings, at weekly intervals, on increase in number of leaves, 51 days after first treatment.

in number of leaves for the treated plants is approximately the same as that of the control plants.

The effect of GA sprays on length of internodes is shown in Figure 8. Two applications of GA resulted in longer average internodes in all concentrations except the 100 ppm treatment applied 4 times. Increasing the concentration of GA also resulted in an increase in internode length.

The effect of GA sprays on root length is shown in Figure 9. Neither increases in concentrations of GA nor increases in number of spray applications had any marked effect on root length.

The effect of GA sprayed on Western pecan seedlings on the dry weight of stems, leaves and roots is shown in Figure 10. Increasing the concentration of GA from 0 to 100 ppm increased the total dry weight of the stems, leaves and roots. However, further increases in GA caused a reduction in dry weight.

In Figure 11 is shown the effect of 1, 2, or 4 spray applications of GA on Western pecan seedlings, 51 days after the first weekly application. Two spray applications gave the maximum increase in total dry weight.

Experiment IV: The effect of Gibrel sprays on Western pecan seedlings, applied 1, 2, or 3 times at weekly intervals, on increase in plant height is shown in Figure 12. Two of the four concentrations, 50 and 1000 ppm, when applied 3 times, resulted in less increase in plant height than did the same concentrations applied twice. Only the 100 ppm concentration of GA caused a consistently greater increase in plant height with each succeeding application.

Figure 13 shows the results of spraying Western pecan seedlings with Gibrel, on increase in number of leaves 35 days later. Increasing

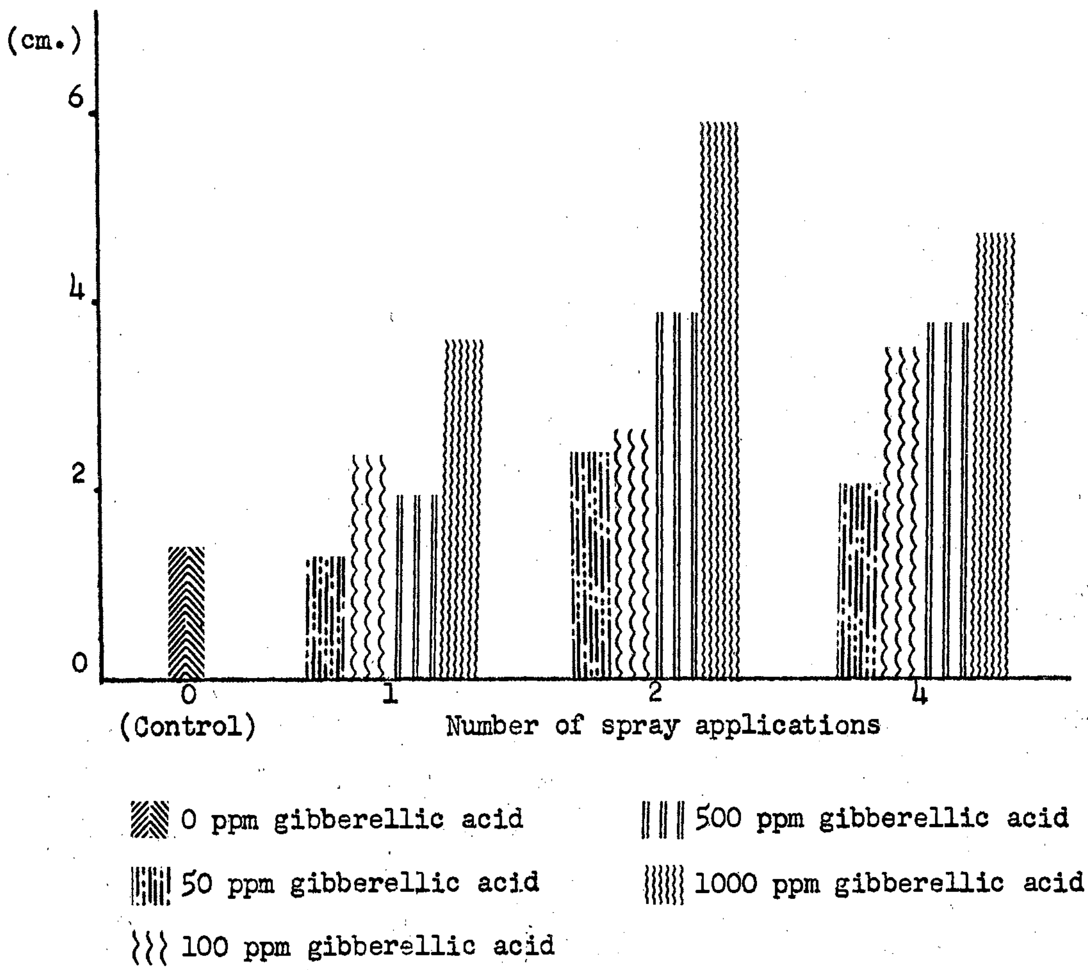


Figure 8. The effect of gibberellic acid sprays on Western pecan seedlings, at weekly intervals, on average length of internodes, 51 days after first treatment.

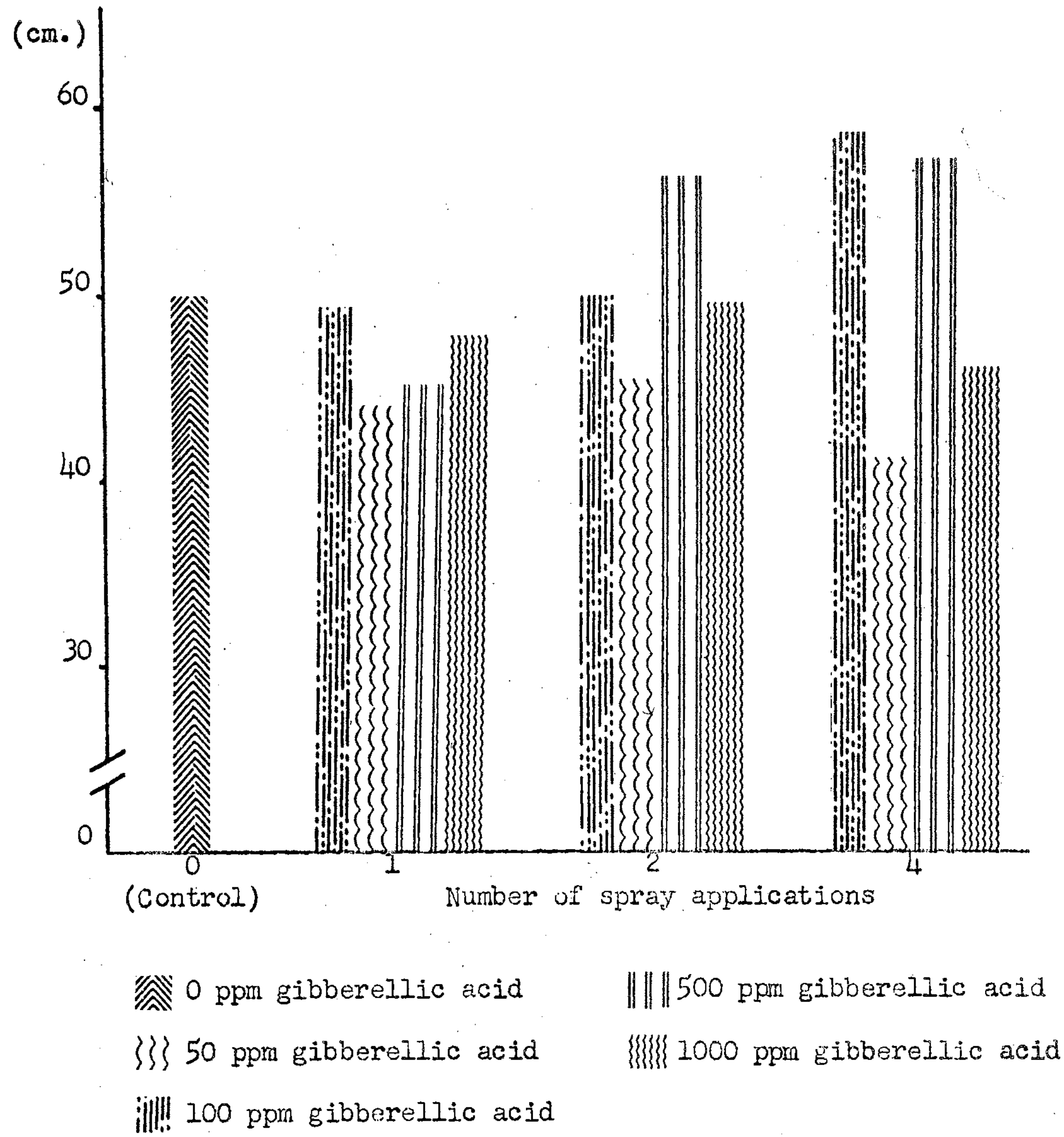


Figure 9. The effect of gibberellic acid sprays on Western pecan seedlings, at weekly intervals, on average root length, 51 days after first treatment.

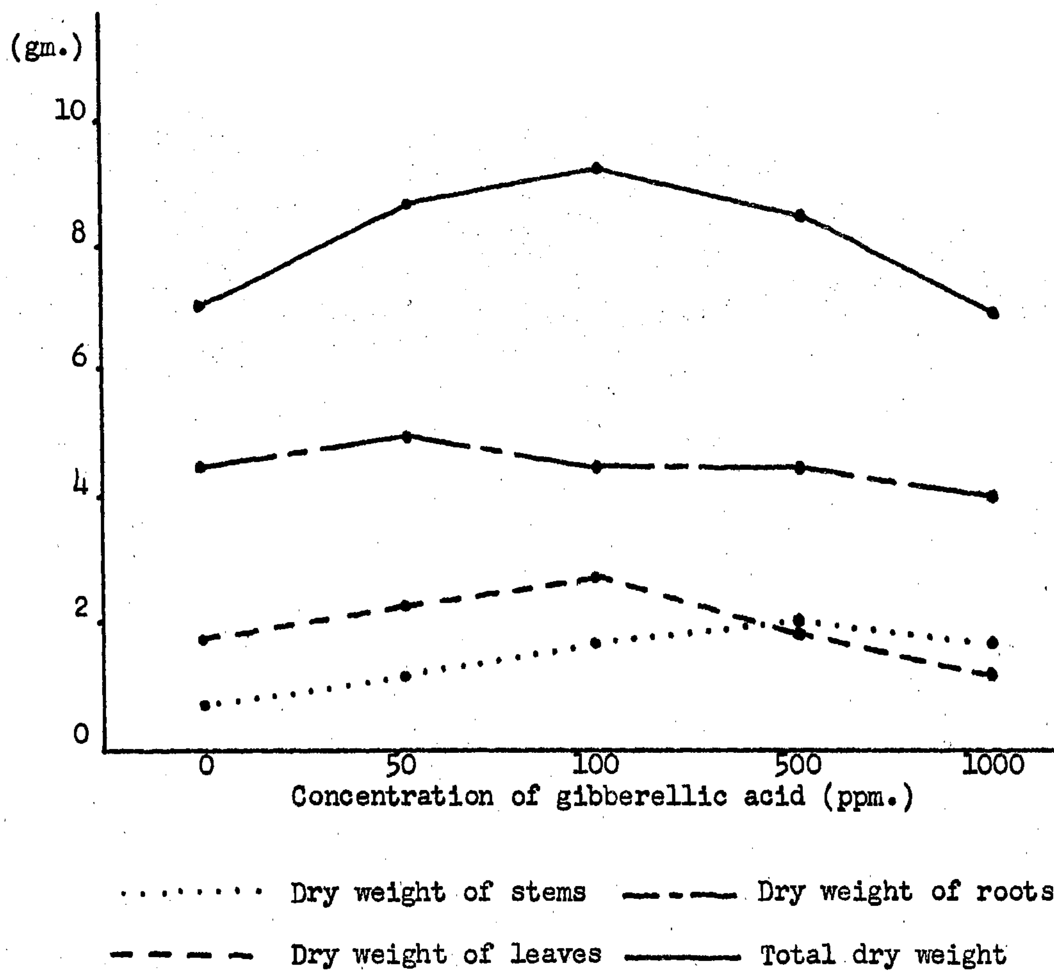


Figure 10. The effect of gibberellic acid sprays on Western pecan seedlings, at weekly intervals, on average dry weight of roots, leaves and stems, and on total plant dry weight, 51 days after first treatment. (An average of all spray applications)

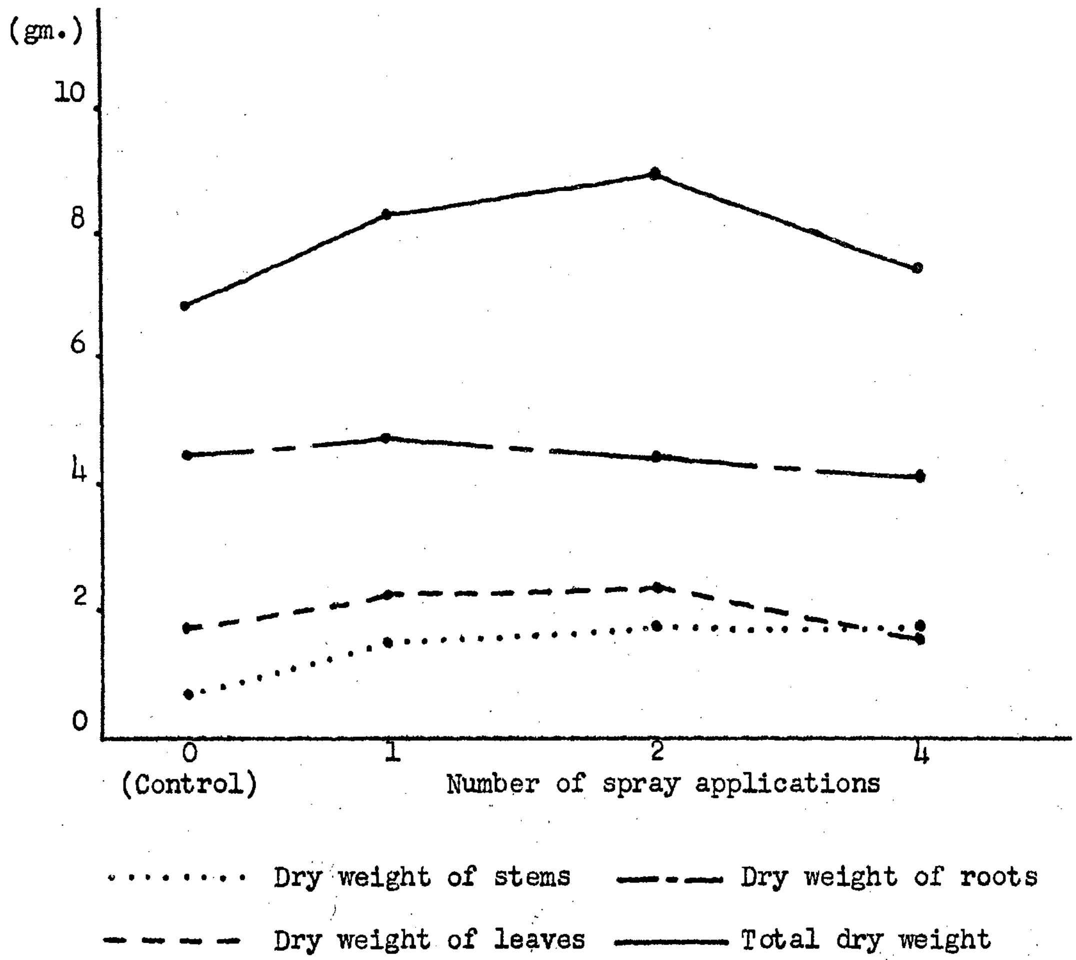


Figure 11. The effect of gibberellic acid sprays on Western pecan seedlings, at weekly intervals, on average dry weight of roots, leaves, and stems, and on total plant dry weight, 51 days after first treatment. (An average of all concentrations)

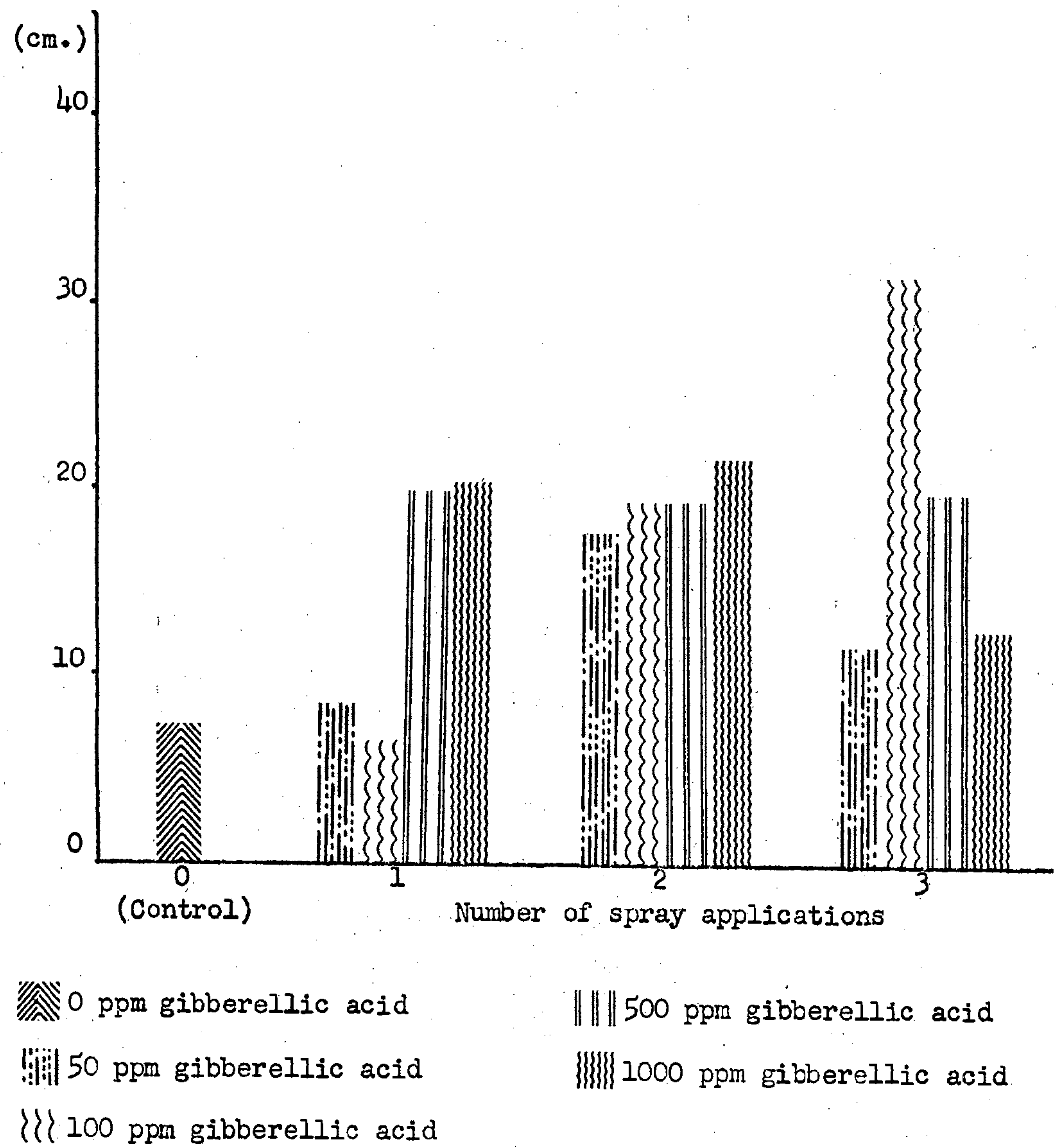


Figure 12. The effect of Gibrel sprays on Western pecan seedlings, at weekly intervals, on increase in plant height, 35 days after first treatment.

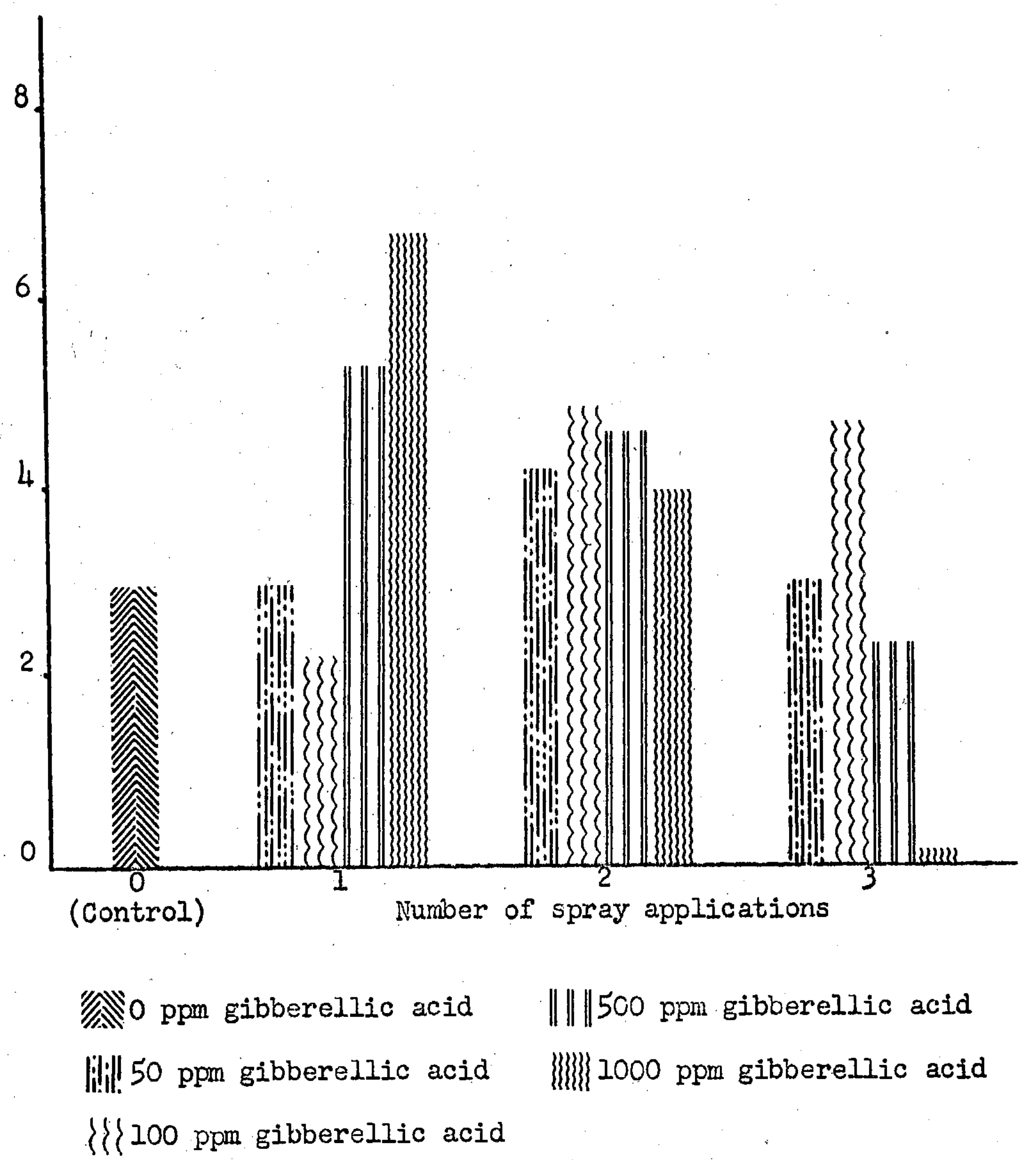


Figure 13. The effect of Gibrel sprays on Western pecan seedlings, at weekly intervals, on increase in leaf number, 35 days after first treatment.

concentrations of Gibrel applied one time, resulted in an increase in leaf number. However, plants receiving 2 or 3 applications of Gibrel showed little effect of increasing GA concentrations on leaf number. The 1000 ppm GA treatment, sprayed 3 times, increased less than one leaf per plant after 35 days.

The average internode lengths of pecan seedlings 35 days after treatment with Gibrel sprays, are shown in Figure 14. All of the plants receiving Gibrel sprays had longer internodes than did the control plants. Increasing the number of applications increased the average internode length. Increasing the concentration of Gibrel, from 50 to 1000 ppm GA, also tended to increase the internode length.

The effect of 1, 2, or 3 Gibrel sprays on Western pecan seedlings on root length, 35 days after first treatment, is shown in Figure 15. None of the roots of seedlings receiving Gibrel sprays were as long as the control plants. The roots of plants given two or three applications of Gibrel were approximately 10 cm longer than those sprayed only once.

Figure 16 shows the effect of various concentrations of Gibrel on the dry weight of stems, leaves and roots. Increasing the concentration of Gibrel had little effect on total dry weight. However, it tended to increase the dry weight of stems and to decrease the dry weight of the leaves.

The effect of 1, 2, or 3 applications of Gibrel on dry weight of Western pecan seedlings is shown in Figure 17. Increasing the number of applications had little effect on total plant dry weight. However, increasing the number of spray applications tended to increase the average dry weight of stems and to decrease the average dry weight of leaves.

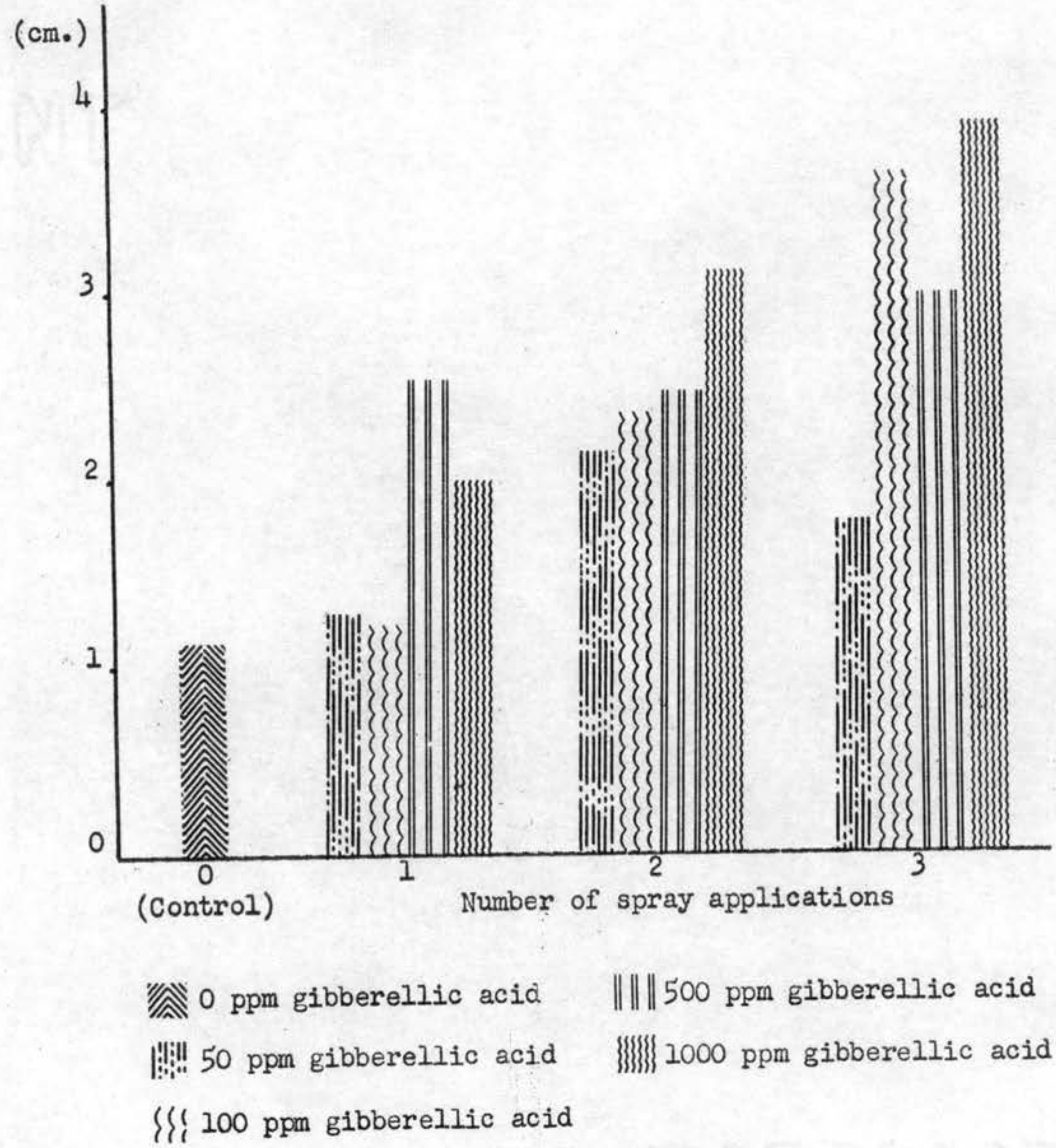


Figure 14. The effect of Gibrel sprays on Western pecan seedlings, at weekly intervals, on length of internodes, 35 days after first treatment.

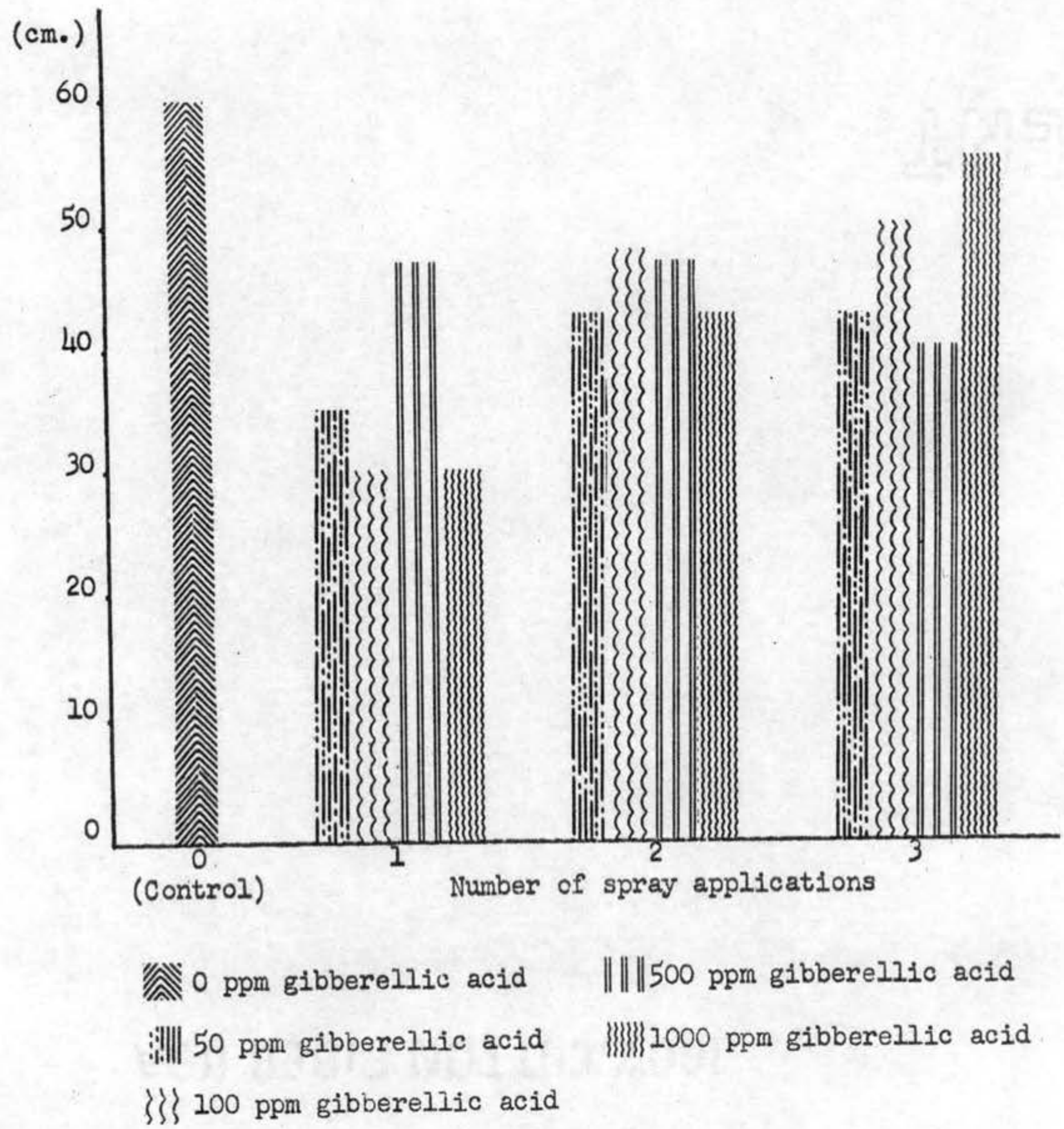


Figure 15. The effect of Gibrel sprays on Western pecan seedlings, at weekly intervals, on length of roots, 35 days after first treatment.

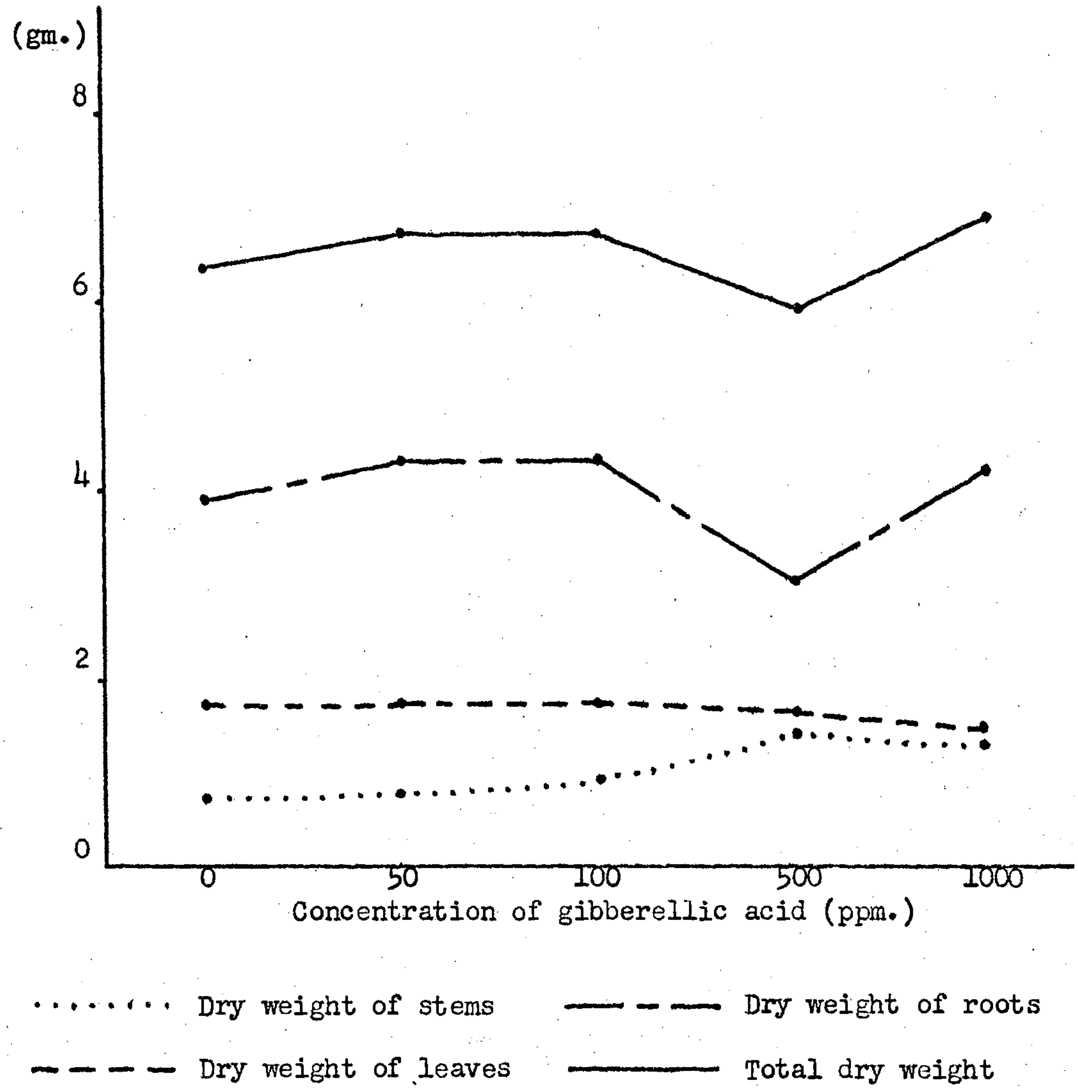


Figure 16. The effect of Gibrel sprays on Western pecan seedlings, at weekly intervals, on dry weight of various plant parts, 35 days after first treatment. (An average of all applications)

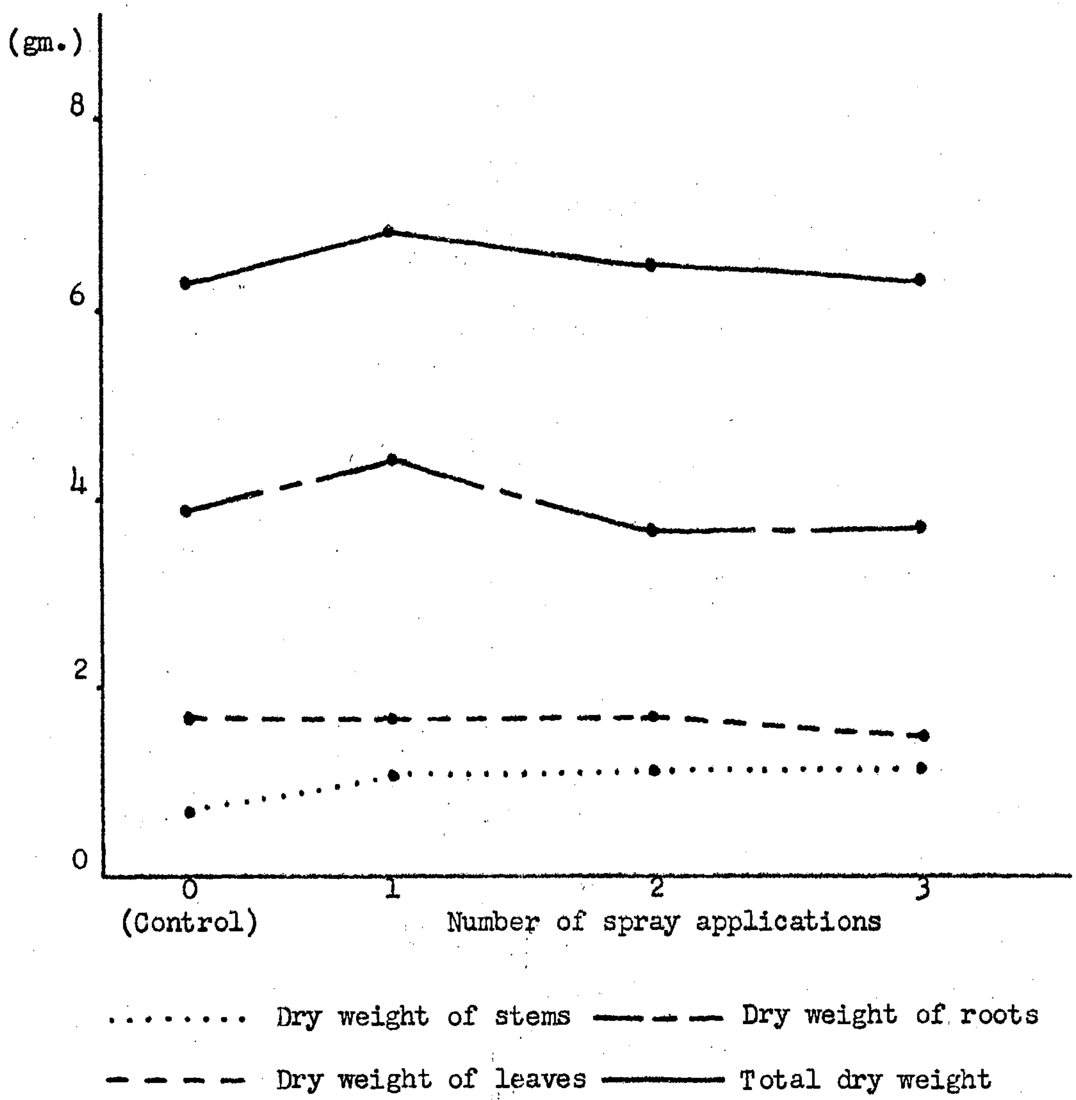


Figure 17. The effect of Gibrel sprays on Western pecan seedlings, at weekly intervals, on dry weight of various plant parts, 35 days after first treatment. (An average of all concentrations)

DISCUSSION AND CONCLUSIONS

The exposure of budded azalea plants to 40° to 45° F. for a period of four to six weeks before forcing at warmer temperatures apparently activates some chemical change or changes within the plants which causes the immature flower buds to develop rapidly and to open uniformly when exposed to warmer temperatures. Only the larger florists presently are able to grow and flower azaleas satisfactorily at all seasons of the year due to the high costs of building and maintaining the expensive cold storage facilities required.

At the time this research problem was planned there was no published literature available regarding the effect of gibberellic acid on flowering of azaleas, although it had been reported to be effective in causing more flowers, earlier flowers, and larger flowers in a wide variety of species. There was a verbal report, however, of some work being done at Pennsylvania State University, in which high concentrations of gibberellic acid had been used for force Hexe and Sweetheart Supreme azaleas into flower without a prior cold treatment.

In the study reported herein buds of Dorothy Gish azaleas were caused to flower satisfactorily only during the winter by the use of gibberellic acid spray treatments. In the experiment started in March, during which time a warming temperature trend was experienced, the gibberellic acid treated plants did not flower satisfactorily. Apparently when the temperature becomes too high gibberellic acid fails to be effective in promoting uniform development and opening of the flower buds.

On the basis of these results it is believed that gibberellic acid can be successfully substituted for the cold treatment normally given azaleas. However, further research must be done to determine the temperature range in which gibberellic acid will function to cause azaleas to flower uniformly. In addition it is believed that temperature conditions present during the early flower bud development period prior to treatment may have an important bearing on the effectiveness of any gibberellic acid treatments applied. It is possible that the cold temperature conditioning effect is accumulative and that some conditioning or maturation of the buds may occur at temperatures as high as 60° to 65° F., when such conditions are present over a period of several weeks or months.

Although previous reports suggested that gibberellic acid was ineffective in altering the growth of bulb crops it was thought that perhaps combinations of gibberellic acid and 3-indoleacetic acid might be effective in altering the time of flowering and/or plant height of lilies. However, from the results obtained in this study it appears doubtful that gibberellic acid, alone or in combination with 3-indoleacetic acid, has any appreciable effect on Ace lilies.

Pecan seeds normally germinate and grow so slowly that plantings are difficult to establish due to weed competition. If a means could be devised to speed up seedling growth, named varieties could be grafted sooner and earlier production would be possible. Since many reports in the literature indicated that gibberellic acid had a stimulatory effect on seed germination it was considered desirable to see if gibberellic acid might have any such effect on pecans.

Of the two varieties of pecans used in these experiment, Western gave considerably better germination with all treatments including the control. The Mahan variety was characterized by the presence of many immature kernels, accounting in part for the poor germination percentage.

In general, longer soaking periods resulted in earlier seed germination. Part of this timewise advantage undoubtedly was caused by the fact that all soaking treatments were started at different times so that all seeds could be planted at the same time. Thus, pecan seeds soaked for 192 hours (8 days) had the opportunity to commence embryo growth at least four days before seeds receiving a shorter soak treatment. It was of interest to note, however, that increased soaking periods, even though they caused the embryo to start growth earlier, actually resulted in a decrease in dry weight.

The liquid "Gibrel", when used as a foliar spray at high concentrations, resulted in extensive tip burn of the leaves, and in many cases caused marked defoliation. Apparently the solvent in which the active ingredient was dissolved contained some agent which was toxic to pecan leaf growth.

From these results it may be concluded that gibberellic acid, in general, may increase the germination percent and lessen the time required for seedling emergence. Gibberellic acid used as a foliar spray on pecan seedlings might possibly reduce the time required to produce pecan understocks in the nursery. However, further research is needed to determine its long range effects.

SUMMARY

The studies reported herein relate to the effect of gibberellic acid on certain phases of the growth and development of azaleas, lilies, and pecans.

Greenhouse grown Dorothy Gish azalea plants, approximately 18 months old and with floral buds approximately 1/4 inch in diameter, were sprayed, starting December 16 and March 15, with various concentrations of gibberellic acid over periods of 3 and 6 weeks. Earlier blooming occurred on plants receiving gibberellic acid treatments than was obtained from the untreated control plants or those given a 6-week cold treatment at 40° F. All gibberellic acid treatments produced saleable plants, although the plants treated in March were less desirable than those treated in December.

Ace lily bulbs were soaked for 15 minutes prior to planting in various concentrations of gibberellic acid, alone and in combination with 100 ppm. 3-indoleacetic acid. Ace lily plants also were sprayed, either when they were two inches tall or when they were in the intermediate flower bud stage, with the same gibberellic acid treatments. None of the treatments resulted in any marked differences in plant height, number of leaves, number of buds, date of first flower, flower length, flower width, or lasting quality.

Western and Mahan pecan seeds were soaked in various concentrations of gibberellic acid before planting in a greenhouse groundbed. High concentrations of gibberellic acid, 1000 and 5000 ppm., tended to hasten

emergence and increase the germination percent. Total plant dry weight also was increased by increasing the concentration of the gibberellic acid soak. However, gibberellic acid concentration had little effect on height of first leaf, root length, or internode length. Long soaking periods before planting, caused marked reductions in plant dry weight. Western pecan seedlings, 6 to 8 inches tall, also were sprayed with various concentrations of gibberellic acid. After 51 days all treated plants were taller, had longer internodes, and had a greater dry weight accumulation than did the control plants. "Gibrel", containing from 0 to 1000 ppm. gibberellic acid, when sprayed on Western pecan seedlings produced plants that had longer internodes and were taller than the untreated control plants. However, all Gibrel treated plants had shorter roots than did the control plants after 35 days.

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