THE INFLUENCE OF MALEIC HYDRAZIDE ON THE BLOSSOMING AND FRUITING OF STRAWBERRIES AND THE FORMATIVE EFFECTS PRODUCED

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THESIS

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THE INFLUENCE OF MALEIC HYDRAZIDE ON THE BLOSSOMING AND FRUITING OF STRAWBERRIES AND THE FORMATIVE EFFECTS PRODUCED

By

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Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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Paul Rood

INTRODUCTION

Many practical applications have been found for growth regulating substances in recent years. They have been used for rooting cuttings, and for the setting of fruit. They can be used to thin the fruit on a tree, and later in the season, the pre-harvest drop of fruit and the formation of an abscission layer can be prevented by applications of the same substance at the same concentration. Growth regulating substances at higher concentrations are used as selective herbicides and in some instances for completely killing all weeds. They are also used to prevent sprouting of stored produce such as potatoes. The buds on potato tubers are vegetative, but growth regulating substances have been used to inhibit flower buds as well.

The experiments reported in this thesis were conducted primarily to determine if early spring applications of maleic hydrazide would inhibit or retard the development of the flower buds of strawberry plants, and then after a short period allow the plant to resume normal growth and development, and blossom. Naylor (15) suggests that maleic hydrazide affects plant metabolism through a disruption in sugar breakdown and utilization, and Kraus and Kraybill (8), and many other workers have determined that carbohydrates are essential for flower production. If maleic hydrazide would disrupt the sugar supply to the flowers for a short period and delay developement it would be important commercially.

If the time of blossoming could be delayed, many disastrous spring frosts could be avoided. It might mean that fruits could be grown outside the relatively frost free areas in which they are now grown, or be grown in areas nearer to their markets or in areas where the other factors of fruit production were more favorable. If the time of blossoming and subsequent fruiting could be controlled, the big demand for labor at harvest time could be lessened. This would also mean fruit from certain areas could be marketed over a longer period, perhaps at a time when the price was higher.

The major part of the work was done on strawberries because they were available, could be treated and harvested at a convenient time and were readily adapted to greenhouse experimentation. The study was limited to the macroscopically visible effects.

In order to make the experiments as clear to the reader as possible, they have been divided into three groups. The main greenhouse experiment was conducted early in the spring to serve as a preliminary guide to determine the best rates and time of application of maleic hydrazide sprays for the field experiment and to provide an opportunity to observe any effects caused by the treatments under greenhouse conditions. The field experiment was conducted to test the practicability under field conditions. The miscellaneous experiments were conducted to explore some other hypothesis but were not conducted on a large enough scale to be conclusive.

REVIEW OF LITERATURE

Maleic hydrazide was first tested for growth regulating properties at the Naugatuck Chemical Division of United States Rubber Company, Naugatuck, Connecticut. Schoene and Hoffmann (18) reported that concentrations of 500, 1,000 and 2,000 ppm of ammonium salt of maleic hydrazide caused an inhibition of growth of tomato plants in direct proportion to the concentration used. They also found that lawn grasses were inhibited and corn seedlings retarded. Naylor and Davis (15) found that concentrations of 500, 1,000, 2,000 and 4,000 ppm maleic hydrazide stunted sunflowers, tomatoes, peanuts, tobacco, cocklebur, corn, peas, barley, oats, wheat, and red top grass. However, in general, the stunting was not proportional to the concentration used.

Shoene and Hoffmann (18) noted that growth of their tomato plants was retarded for about two months. When terminal growth was resumed, some leaves with formative effects were produced. Most of the new growth on the tomato was from lateral buds. Naylor and Davis (15) found 500 ppm of maleic hydrazide generally produced a loss of apical dominance, and a development of the axillary shoots on representative monocots and dicots while 2,000 and 4,000 ppm usually caused death.

Naylor and Davis (15) also state that the respiration of root tips was inhibited in proportion to the proportion to the concentration of maleic hydrazide in the solution at pH 4.0 but not at pH 6.0. Other investigations (11) indicate concentrations as low as 5 ppm maleic hydrazide caused root inhibition on plants grown in Hoagland's solution.

Observing that treated corn plants exuded viscous droplets containing sucrose from their leaves, and these leaves accumulated a tremendous amount of anthocyanin pigments, Naylor (15) suggested that maleic hydrazide affects plant metabolism primarily through a disruption in sugar breakdown and utilization.

Another explanation of the action of maleic hydrazide is suggested by Andrew (1) who noticed that concentrations of 10,000 ppm maleic hydrazide caused the chromosomes in onion root tips to be shorter and abnormally shaped, and that no metaphase plate was formed during mitosis.

The possibility of using maleic hydrazide to delay the blossoming of strawberries was proposed by White (19). He applied 1,000 ppm maleic hydrazide to second year Premier strawberry plants which had formed flowers but had not blossomed yet. The plants began blossoming at the normal time but one month after treatment they ceased blossoming for a week and then resumed normal blossoming. The vegetative growth was retarded but no specific injury was observed. Unfortunately these experiments were plowed under. Black raspberries were also sprayed and blossoming was delayed from 24 to 38 days, and fruiting was delayed from 16 to 23 days. The fruit produced was normal. Golden Delicious apple trees were sprayed in the early pink stage which caused an early abscission of the fruit but no vegetative or floral retardation was produced. Fillmore (4) reported that 3,000 ppm maleic hydrazide inhibited vegetative growth and flowering of blueberries grown in the greenhouse. The treated plants began flowering 14 days later than those not treated, however no fruit was set.

A concentration of 5,000 ppm of maleic hydrazide applied soon after clipping a Pyracantha hedge completely inhibited new shoot growth for a month and retarded growth for a second month (7).

Wittwer (21) applied maleic hydrazide at concentrations of 500 to 2,500 ppm as pre-harvest foliage sprays on onions and carrots and found that it completely inhibited sprouting in storage.

Nelson (16) used maleic hydrazide on apple cuttings and found it either prevented rooting or killed the cutting. Fillmore (4) found that by treating dormant rose bushes with maleic hydrazide soon before taking cuttings, that growth of the cutting was inhibited on some varieties. _Prunus persica_, _P. sargenti_, and _P. yedoensis_ cuttings taken from dormant plants which had just been treated with maleic hydrazide were inhibited by 3,000 ppm but resumed growth later. Dormant sweet cherry seedlings were killed by 6,000 ppm maleic hydrazide. McIntosh apple scions which were treated with 6,000 ppm maleic hydrazide and then grafted upon ordinary seedlings, produced some callus formation and a fair union, but shoot growth was inhibited.

Langer (10) used concentrations of about 500 ppm to thin peaches. Miller and Erskine (13) found 1,000 ppm maleic hydrazide sprayed on Gingko trees prevented fruiting.

Currier and Crafts (3) found that 2,000 ppm maleic hydrazide acted as a selective herbicide in that it killed barley plants but had little effect upon cotton. The effect of maleic hydrazide varied with the species and stage of development of the plant. Harris and Leonard (5) report that wild onion can be controlled with maleic hydrazide sprays.

Unpublished investigations done at the University of California at Davis, California (17) indicate that concentrations of 2,000 ppm maleic hydrazide caused injury to most vegetable crops, however, asparagus seemed resistant. In some other experiments it was apparent that plants treated with maleic hydrazide on various soil types showed marked differences in response, but this response could not be correlated with clay content, moisture content, pH, or fertility level. The maleic hydrazide broke down in the soil quite rapidly and seemed to result in greater fertility.

Other growth regulators have been used in attempts to delay blossoming with inconsistent or impractical results. Winklepleck (20) reported that 125 mg. of naphthaleneacetic acid applied in a peach orchard before blossoming caused the treated trees to reach full bloom eleven days later than control trees. The petals of the flowers on treated trees were smaller, and the rate of maturation of fruit was delayed but the final size of the fruit was not affected.

After conducting a series of branch experiments in the greenhouse, Mitchell and Cullinan (14) concluded that napthaleneacetic acid did not retard the blossoming of peach fruit buds but did retard the growth of vegetative buds on detached peach twigs. In a later experiment napthaleneacetic acid applied to detached peach branches caused the buds to open earlier than buds on control twigs. Indoleacetic, indolebutyric and naphthalene acetamide were also tested. Indoleacetic acid caused the blossoms on detached peach twigs to open earlier when it was applied repeatedly.

Hitchcock and Zimmerman (6) applied sprays of 200, 400, and 800 mg. per liter of potassium a-napthalene-acetate on July 21, August 20, and September 17, to apple, cherry, and peach trees and reported that the opening of flower buds was delayed from a few to 14 days. Vegetative buds were delayed up to 19 days. Concentrations of 200 mg. per liter applied in July were about as effective as 400 mg. per liter in August, and as effective as 800 mg. per liter in September in retarding the date of blossoming in cherries. Peaches and plums were more sensitive to a given concentration of potassium a-napthaleneacetate than cherries, and apples were less sensitive. The cherries on treated trees were normal.

Marth, Havis, and Batjer (12) conducted orchard experiments for three years using sodium and potassium salts of a-naphthaleneacetic acid at concentrations of 200 to 800 ppm in August, September, October, November, and January. They found that although there was a slight delay in blossoming the following spring, it was only about two days long. The treatments caused moderate to severe injury to leaves and leaf buds and frequently flower buds and entire branches. A similar delay in blossoming was produced by mechanically removing the leaves in the fall at the same time the treatments were applied. The sprays applied in January were not effective and the high concentration sprays applied in August killed the branches.

Krishnamurthi (9) found that 100 ppm 2,4-D and 30 ppm napthaleneacetic acid applied to sweet and sour cherries in September caused some delay and considerable irregularities in the opening of floral and vegetative buds the next spring. However these treatments caused such severe killing of both kinds of buds and formative effects on leaves and fruit that it is impractical.

GREENHOUSE EXPERIMENTS

Plant Material - Premier strawberry plants were obtained which had been dug as rooted runner plants from beds on the college farms in the fall of 1949, and stored in peat moss in a cold storage at about 32°F. The plants were removed from storage, sorted, and planted March 1 and 2, 1950. Some of the plants had green leaves from the previous season and nearly all had put out new leaves by March 5, 1950.

Environment - These plants were grown in pots on benches in the Plant Science Greenhouse. The day temperature was about 50°F at the beginning of the experiment but gradually rose with the onset of summer.

A white wash shade was applied to the greenhouse June 16 and maintained. The plants were watered immediately after planting and regularly thereafter with tap water.

One plant was planted in each five inch clay pot in a soil mixture of one-half Brookston clay loam, one-quarter washed sand, and one-quarter muck. The lower leaves of the more vigorously growing plants, which were the check, and low concentration treatments, were turning red and dying so it was thought to be a nutritional factor. The soil was tested in the soil science laboratory on May 19, and was found to contain 50 pounds of available nitrogen, 84 pounds of phosphorus, and 184 pounds of potassium, per acre, by the Spurway reserve test, which should be more than ample supplies of these major elements. Since the soil was very alkaline and some minor elements might be unavailable, an attempt was made to correct it by watering each pot with about a quart of 1/50 normal sulphuric acid. Since this did not completely remedy the reddening of the bottom leaves, the pots were watered on May 22 with about 1/6 gram of ammonium sulphate per plant.

Bees were observed to be pollinating the flowers on May 4 and later days. Sprays of parathion were applied to control red spiders.

Design of Experiment - On March 9, 100 of the best plants were graded by eye into two groups, one containing 50 large sized vigorous plants, and the other containing 50 smaller sized, less vigorous plants. The treatments were replicated on five of the large plants and five of the small plants. This was done to be sure similar plants were used for all of the treatments. This division was found to be of little importance at the time records were taken so it was omitted. The treatments consisted of sprays of 0, 100, 250, 500, 750, 1,000, 1,250, 1,500, 2,000, and 3,000 ppm of an aqueous solution of maleic hydrazide.

The entire experiment was randomized as to position on the bench. The solutions were prepared in the laboratory using the diethanol amine salt of maleic hydrazide which contains 30% actual maleic hydrazide by weight. The same atomizer was used for all treatments starting with the low and ending with the high concentrations. The atomizer was emptied but not cleaned between treatments. The potted plants were removed from the bench for spraying so that there was no drift.

The plants were all sprayed between 4:00 and 7:00 p.m. on March 9, except for the distilled water on the check treatment and the 100 ppm maleic hydrazide treatments which were applied at 1:00 p.m. on the following day, March 10. At this time the plants had formed two to four leaves and were just beginning to grow after their dormant period. The plants were well watered prior to the treatment and were not watered for four days after treatment so none of the spray was washed off for at least four days. On April 25, the 750 and 1,250 ppm treatments were sprayed again with 1,000 ppm maleic hydrazide to see if any delay in blossoming might be obtained.

Records - When the flower buds became macroscopically visible they were counted for each plant at about six day intervals. The opened blossoms and set fruit were also counted. Later the number of runners was also counted.

Results - None of the treatments caused a significant delay in the time of visible appearance of flower buds, time of blossoming or time of ripening of fruit. Generally, as the concentration of maleic hydrazide was increased, the number of flower buds (table 1), flowers (table 2), mature fruit, and runners (table 3) produced by a plant decreased.

The higher concentrations of maleic hydrazide caused many abnormalities in the growth and development of the strawberry plants. After treatment those plants receiving over 500 ppm maleic hydrazide generally ceased forming new leaves and those that were out failed to expand normally and their petioles did not elongate. They were somewhat lighter in color than the new leaves of the check plants. The bud scales of the plant which received high concentrations of maleic hydrazide generally opened more, leaving a plant which appeared to have an open center. The flowers produced by these plants had such short peduncles that the flower was often inside the bud scales. The petals on many of the flowers were only about 3 mm wide and 3 mm long and did not overlap as they do on normal flowers, (Figure 6 A.). The anthers of some flowers developed brown centers and appeared dead. The pistils appeared brown soon after the petals dropped and the whole part of the receptical to which the achenes were attached turned brown and failed to expand.

Table 1.

THE NUMBER OF NEW FLOWER BUDS MACROSCOPICALLY VISIBLE IN THE MAIN GREENHOUSE EXPERIMENT. These figures represent the total increase in visible flower buds over the number of buds counted on the preceeding date. All ten replications are totaled together.

Treatment	April 26	April 30	May 4	May 10	May 16	May 22	Total
Check	25	10	17	23	4	4	83
100 ppm.	31	17	1	14	1	4	68
250 ppm.	21	19	5	6	5	2	58
500 ppm.	14	4	10	4	5	1	34
750 & 1,000 ppm.*	8	3	7	1	1	1	21
1,000 ppm.	12	4	3	2	0	4	25
1,250 & 1,000 ppm.*	0	0	0	0	0	0	0
1,500 ppm.	8	4	4	0	0	0	16
2,000 ppm.	5	4	6	0	0	0	15
3,000 ppm.	4	1	11	0	0	0	15

* 1,000 ppm. treatment applied April 25.

Table 2.

THE NUMBER OF NEW BLOSSOMS TO OPEN IN THE MAIN GREENHOUSE EXPERIMENT.

These figures represent the total increase in blossoms over the number of blossoms counted on the preceeding date. All ten replications are totaled together.

Treatment	April 26	April 30	May 4	May 10	May 16	May 22	Total
Check	8	7	9	28	30	13	95
100 ppm.	9	10	13	21	3	3	86
250 ppm.	4	2	11	18	23	12	70
500 ppm.	0	4	12	1	0	9	26
750 & 1,000 ppm.*	0	10	8	0	0	3	21
1,000 ppm.	2	4	9	0	0	0	15
1,250 & 1,000 ppm.*	1	3	9	0	0	7	20
1,500 ppm.	3	4	7	0	0	7	21
2,000 ppm.	1	4	6	0	0	0	11
3,000 ppm.	2	5	7	0	0	1	15

* 1,000 ppm. treatment applied April 25.

Table 3.

NUMBER OF NEW RUNNERS TO BECOME MACROSCOPICALLY VISIBLE IN THE MAIN GREENHOUSE EXPERIMENT. These figures represent the total increase in runners over the number of runners counted on the preceeding date. All ten replications are totaled together.

Treatment	May 30	June 9	June 28	July 13	Aug. 2	Total
Check	2	0	7	17	6	32
100 ppm.	1	4	10	16	2	33
250 ppm.	0	2	6	12	6	26
500 ppm.	0	6	6	8	1	21
750 & 1,000 ppm.*	0	0	1	2	0	3
1,000 ppm.	1	0	1	5	1	8
1,250 & 1,000 ppm.*	0	0	0	0	2	2
1,500 ppm.	0	0	0	0	0	0
2,000 ppm.	0	0	0	3	0	3
3,000 ppm.	0	0	0	1	0	1

* 1,000 ppm. treatment applied April 25.

However, the base of the recetical which contains no achenes expanded and elongated and formed a reddish conical tissue with the tip of brown dead achenes. The petal and sepal bases were also thickened (Fig. 5 A, B, & C). Some fairly normal appearing blossoms on plants receiving the higher concentrations of maleic hydrazide had a gummy fluid in their floral envelope at the time of full bloom.

The higher concentrations of maleic hydrazide caused definite formative effects on leaves developing from the treated plants. Many leaflets were lobed, deeply crinkled, and generally more elongated than leaves from normal check plants. The lobes occurred on any part of the leaf and although they never cut major veins, the veination was often different from normal. More leaves with one, two, or four leaflets were produced than on normal leaves, (Fig. 11). About four and a half months after treatment some of the plants which had been most severly stunted by high concentrations of maleic hydrazide began developing a tuft of new leaves in the center of the plant, (Fig. 2). The blades of these leaflets were only about one centimeter wide and had very deep serations along their margins, (Fig. 3). In other respects the leaves were normal, but small. The appearance of these leaves may have been stimulated by the nitrogen treatment for all the plants tended to grow more vigorously.

Figure 1. The Right and Left Plants Were Killed by Treatments of 2,000 ppm Maleic Hydrazide. Center Plant Was Not Treated.

Figure 2. Plants Showing Small Green Leaves Growing from Center of Stunted Plants Four and a Half Months after Treatment.
Left 1500 ppm Center 1250 & 1000 ppm Right 750 & 1000 ppm

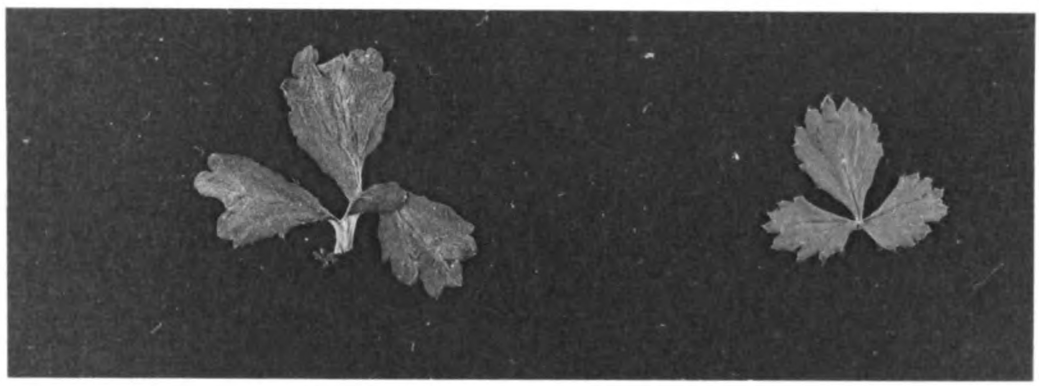


Figure 3. Leaves Which Grew from the Center of Plants Recovering from a Period of Inhibited Growth.

The higher concentrations of maleic hydrazide generally killed the plant in four months, (Fig. 1) and (table 4).

Table 4.

THE PERCENTAGE OF STRAWBERRY PLANTS WHICH DIED WITHIN FOUR AND ONE HALF MONTHS AFTER RECEIVING THE FOLLOWING MALEIC HYDRAZIDE TREATMENTS:

Treatment	Percentage of dead plants by July 13.
Check	0%
100 ppm.	10%
250 ppm.	0%
500 ppm.	0%
750 & 1,000 ppm.*	30%
1,000 ppm.	30%
1,250 & 1,000 ppm.*	40%
1,500 ppm.	60%
2,000 ppm.	60%
3,000 ppm.	80%

* 1,000 ppm. treatment applied April 25.

FIELD EXPERIMENT

Plant Material - Four varieties; Premier, Sparkle, Midland, and Robinson were available for the experiments in the field. The patch was set out in the spring of 1949, and 1950 was the first year it bore fruit. The Premier plants were of about normal vigor and had produced plenty of runner plants for a good stand but they were spotty in their distribution in the row. The Sparkle variety was very vigorous, producing large tall leaves. However, their stand was similar to that of the Premiers. The Midland variety was low in vigor and had produced few runner plants so the stand was quite poor. The Robinsons had produced runner plants profusely which formed a matted bed about 2 to 2½ feet wide. The plants were quite vigorous although they were so thick they were small in some cases.

The number of plants per ten feet of row varied from 0 to 155 for the extremes. However, when the number of plants in all seven replications were added together, the treatment with the lowest number of plants had about 75 per cent as many plants as the treatment with the most plants. Most treatments contained an equal number of plants.

The half of the experimental plots which were sprayed later had been part of a 2,4-D experiment the year before and had received treatments of one-half and one pounds per acre about two weeks after planting. However, no effects were observed on the strawberry plants and since whole rows had been treated the same in the 2,4-D experiment and each of my maleic hydrazide treatments appeared once in each row, any difference due to the 2,4-D experiment should be constant. The entire planting was mulched with straw in the fall of 1949. The mulch was removed from the plots which were to receive the early treatment on April 27, and from the plots that were to receive the late treatment on April 23.

Environment - The experiments were conducted on the college farm at East Lansing, Michigan. The light intensity and rainfall were about average for this locality. Because of the low spring temperatures, the plants were retarded about two weeks more than normal for the area. The rainfall was about normal and sufficient throughout the harvest season.

The soil was a uniform silt loam with about 3 per cent slope toward the west. The pH was 7.5, and the Spurway reserve test for phosphorus was 29 pounds per acre, and for potassium it was 192 pounds per acre, which was thought to be sufficient. A soil test for nitrogen is subject to so many variables that it was not made.

No attempt was made to control the weeds during the spring of 1950 when this study was made, and there were a great many throughout the plots.

No attempt was made to control insects and there were some spittle bugs (Philœnus lineatus) on the leaves of the plants.

Design of Experiment - Seven adjacent rows of each variety were chosen and each of the seven treatments were applied to a ten foot plot in each row. Treating seven rows of each variety resulted in seven replications of each treatment.

This pattern was laid out on adjacent blocks of the four varieties. A design of all four varieties was laid out next to the first design of plots. One design of plots was to be treated early in the season, and the other design of plots was to be treated later. The pattern used is shown in table 5.

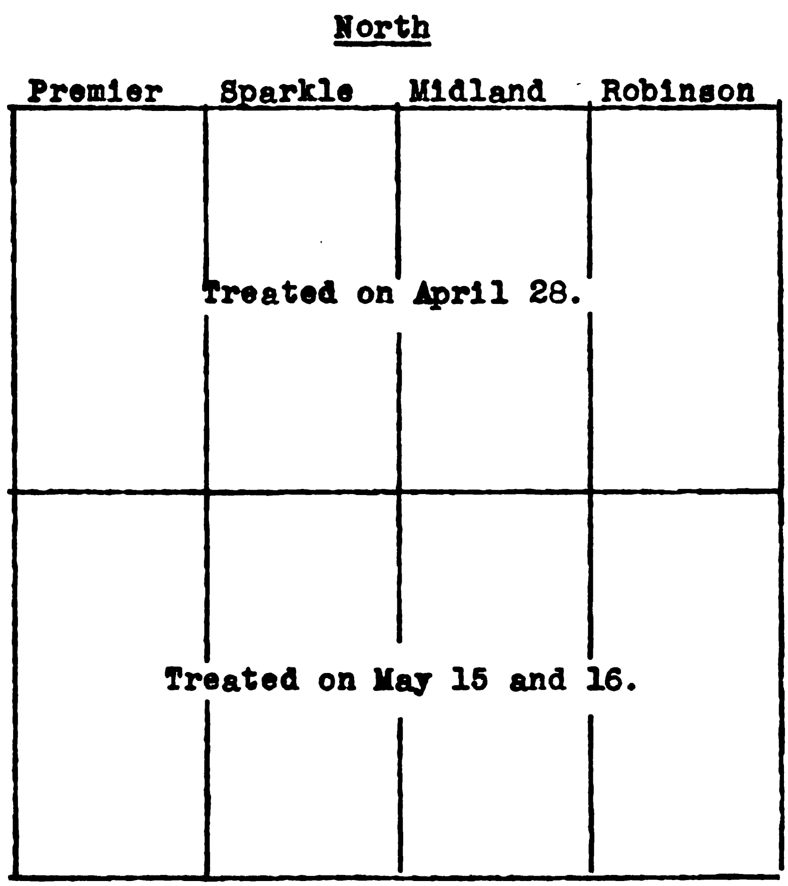
The treatments were: a check, which was not treated, 50, 500, 1,000, 2,000, 3,000 and 5,000 ppm of an aqueous solution of maleic hydrazide. The treatments in the field were applied with a knapsack sprayer with a fine fan nozzle which covered the plants very nicely. The solution was applied at the rate of about 150 gallons per acre.

One part was treated between 2:00 and 7:00 p.m. on April 28, which was as early in the season as it was thought safe to remove the mulch. The other part was sprayed between 8:00 and 10:00 a.m. on May 15 and 16, which was about as late in the season as was expected

Table 5 - PLOT DESIGN FOR FIELD EXPERIMENT.

Pattern of treatments applied to each variety.

Row 1	Row 2	Row 3	Row 4	Row 5	Row 6	Row 7
Check	3,000	1,000	50	5,000	Check	500
50	5,000	Check	500	2,000	3,000	1,000
500	2,000	3,000	1,000	50	5,000	Check
1,000	50	5,000	Check	500	2,000	3,000
2,000	500	2,000	3,000	1,000	50	5,000
5,000	1,000	50	5,000	Check	500	2,000
3,000	Check	500	2,000	3,000	1,000	50



to have any results. The first blossoms had just appeared and it was about two weeks before full bloom. These particular times were chosen because there was no wind to cause the spray material to drift.

Records - The records taken on this experiment were the approximate time and number of blossoms on the part which was treated early and the time and total yeild of fruits on both parts. The number of blossoms were determined by counting all the blossoms with open petals until the petals fell, in a sample area. Little pollenation could take place before the petals opened and the stigmas and pollen turned brown and died at about the same time the petals fell. About three to five days elapsed for an individual flower between these two stages and so the presence of petals was used as an index of time of blossoming. A difference of much more than three days between treatments would be necessary before the maleic hydrazide would have any commercial use in delaying blossoming. The sample areas chosen to count the blossoms in were: the ten foot area of the check plot in the first row for the check treatment; the 50 ppm plot in the second row for that treatment, and so forth to all the blossoms in the 5,000 ppm plot in the seventh row. This was done for each of the four varieties on the part of the experiment treated early. Both normal and abnormal blossoms were counted together because it was impossible to separate the gradations between extremely abnormal and normal blossoms. Because the number of plants in ten feet of row varied, the total number of blossoms counted was divided by the number of plants in the plot to get comparable data. The blossoms on the part that was treated late were not counted because until the later part of the blossoming season no difference in the number of blossoms with petals were observed between the treatments.

Results - In the half of the experiments treated April 28, the early date, there was no significant delay in blossoming caused by any of the treatments. (Tables 6 & 7) Generally, the higher the concentration of maleic hydrazide used, the fewer blossoms there were per plant. (Fig.4 and Tables 6 & 7). Some of the flowers that received concentrations of 1,000 ppm. maleic hydrazide had small petals, short peduncles and pedicels, brown spots on the anthers, dying pistils, and occasionally sticky fluid in the floral envelope. A larger percentage of the flowers on the plants receiving 2,000 ppm maleic hydrazide were of this type and in the 3,000 and 5,000 ppm treatments nearly all the flowers had the small petals and other abnormal characteristics.

The half of the experiments treated May 15 and 16, the late date, showed no noticeable difference between

Check

1,000 ppm Maleic Hydrazide

2,000 ppm Maleic Hydrazide

5,000 ppm Maleic Hydrazide

Figure 4. Representative Areas of Plots on Robinson Variety Strawberries at Time of Full Bloom, May 30, Treatments Applied April 28, showing the decrease in number of blossoms as the concentration of Maleic Hydrazide increased.

Table 6. THE INFLUENCE OF MALEIC HYDRAZIDE TREATMENTS APPLIED APRIL 28 ON THE AVERAGE

Table 6. THE INFLUENCE OF MALEIC HYDRAZIDE TREATMENTS APPLIED APRIL 28 ON THE AVERAGE NUMBER OF BLOSSOMS PER PLANT.

Treatment	May 25	May 26	May 28	May 30	June 1	June 5	June 7	June 9
Robinson Variety								
Check	1.0	1.3	1.4	2.6	2.4	4.3	3.8	2.1
50 ppm.	.3	.4	.9	2.1	1.8	2.8	.3	2.0
500 ppm.	.3	.4	.7	1.6	1.6	2.5	3.2	1.8
1,000 ppm.	.2	.3	.5	.9	.9	1.5	1.4	1.2
2,000 ppm.	.2	.2	.5	1.1	1.1	1.4	1.4	.9
3,000 ppm.	.1	.1	.3	.5	.5	.4	.4	.4
5,000 ppm.	.0	.1	.2	.4	.4	.3	.1	.2
Midland Variety								
Check	1.1	1.1	2.1	2.4	1.6	2.4	2.3	.7
50 ppm.	2.7	2.9	3.0	2.9	2.5	3.3	3.3	1.4
500 ppm.	2.6	2.7	3.1	3.2	3.4	4.3	3.8	2.3
1,000 ppm.	.2	.3	2.5	2.6	2.3	1.5	1.2	1.7
2,000 ppm.	.2	.2	.8	.8	.7	1.6	1.1	.7
3,000 ppm.	.6	.6	1.8	1.6	1.5	1.3	1.4	.6
5,000 ppm.	.1	.2	1.0	1.4	1.1	.4	.3	.0

Table 7. THE INFLUENCE OF MALEIC HYDRAZIDE TREATMENTS APPLIED APRIL 28 ON THE AVERAGE NUMBER OF BLOSSOMS PER PLANT.

Treatment	May 25	May 26	May 28	May 30	June 1	June 5	June 7	June 9
Sparkle Variety								
Check	.4	.4	1.3	2.3	1.3	2.6	3.0	1.5
50 ppm.	.6	.7	1.3	1.7	2.4	3.8	3.1	1.7
500 ppm.	.8	.9	1.3	1.7	2.2	3.6	2.9	1.6
1,000 ppm.	.2	.3	.8	1.2	1.6	3.3	2.4	1.1
2,000 ppm.	.2	.4	1.3	.7	.8	.5	.4	.5
3,000 ppm.	.2	.6	1.0	1.1	.9	1.0	.6	.4
5,000 ppm.	.1	.2	.8	.4	.3	.1	.5	.2
Premier Variety								
Check	3.5	3.9	5.2	4.4	3.7	4.6	3.2	1.9
50 ppm.	4.5	5.0	4.5	4.2	3.2	5.2	3.3	1.3
500 ppm.	2.4	2.9	3.1	2.8	2.5	3.1	3.1	1.2
1,000 ppm.	.6	.8	1.1	1.0	1.2	1.3	1.3	.5
2,000 ppm.	1.5	1.8	3.0	1.6	2.3	1.3	1.3	1.0
3,000 ppm.	1.1	1.3	2.4	1.8	.3	.4	.4	.3
5,000 ppm.	.8	.8	1.9	1.5	.6	.1	.2	.3

treatments in the number or type of blossoms until the last of May which was near the end of the normal blossoming season. At that time the treatments receiving concentrations of 1,000 ppm or over of maleic hydrazide had practically ceased blossoming.

There were a few blossoms in all the plots throughout the picking season and there seemed to be a slight increase in the number of blossoms on the plots receiving over 1,000 ppm maleic hydrazide at the end of the harvest season in the middle of July. Some of these blossoms set fruit which matured about the first of August. However these blossoms and fruit never averaged more than one blossom to every four or five plants and the fruit formed was not large enough or thick enough to pay for picking.

During the last picking a few plants of the Midland variety which had received higher concentration treatments had some fruit with small green leaves about five millimeters long growing fron the achenes. Apparently the seeds had germinated in the fruit. This may have been influenced by the treatments.

Occasionally on all the varieties, plants treated with concentrations of 1,000 ppm or over would produce variegated, green and white, leaf like sepals. (Fig. 7) In the strawberry the calyx and corolla develope last in the flower bud, and the maleic hydrazide treatments

Figure 5.
Mature Strawberries from Plants in the Field Treated with Maleic Hydrazide May 15 and 16 Showing Abnormalities.

A. Abnormal fruit from treatments of 1,000 ppm or over of maleic hydrazide.

B. Abnormal fruit showing range in size occurring when compared with A.

C. Side view of A. showing conical fleshy tissue at base of torus and dead achenes.

D. Fruit with rosette of variegated green and white leaf-like sepals.

E. Normal fruit characteristic of those from treatments up to 750 ppm and occasionally higher.

F. Side view of sepals like D. which occurred occasionally in 3,000 and 5,000 ppm maleic hydrazide treatments.

Figure 6.
Flower and Strawberries from Plants in the Field Treated with Maleic Hydrazide April 28 Showing Abnormalities.

A. Abnormal flower with small petals and dead stamens.

B. Abnormal fruit from 1,000 ppm.

C. Abnormal fruit showing comparative size.

D. Normal fruit characteristic of those from treatments up to 750 ppm and occasionally higher.

E. Fruit with rosette of variegated green and white leaf-like sepals.

F. Fruit characteristic of intermediate response resulting occasionally from treatments over 1,000 ppm.

Figure 7.
Variegated Leaf-like Sepals from Calyx Shown in Figure 6-E.

Figure 5.
[illegible] from Plants in the Field Treated with Maleic Hydrazide May 15 and 16 Showing Abnormalities.

A. Abnormal fruit from treatments of 1,000 ppm or over of maleic hydrazide.

B. Abnormal fruit showing range in size occurring when compared with A.

C. Side view of A. showing conical fleshy tissue at base of fruits and dead achenes.

D. Fruit with rosette of variegated green and white leaf-like sepals.

E. Normal fruit characteristic of those from treatments up to 500 ppm and occasionally higher.

F. Side view of sepals like D. which occur more abundantly in 2,000 and 3,000 ppm maleic hydrazide treatments.

Figure 6.
Flower and Strawberries from Plants in the Field Treated with Maleic Hydrazide April 30 Showing Abnormalities.

A. Abnormal flower with small petals and dead stamens.

B. Abnormal fruit from 1,000 ppm.

C. Abnormal fruit showing comparative size.

D. Normal fruit characteristic of those from treatments up to 500 ppm and occasionally higher.

E. Fruit with rosette of variegated green and white leaf-like sepals.

F. Fruit characteristic of intermediate response resulting occasionally from treatments over 1,000 ppm.

Figure 7.
Variegated Leaf-like Sepals from Calyx Shown in Figure 6-E.

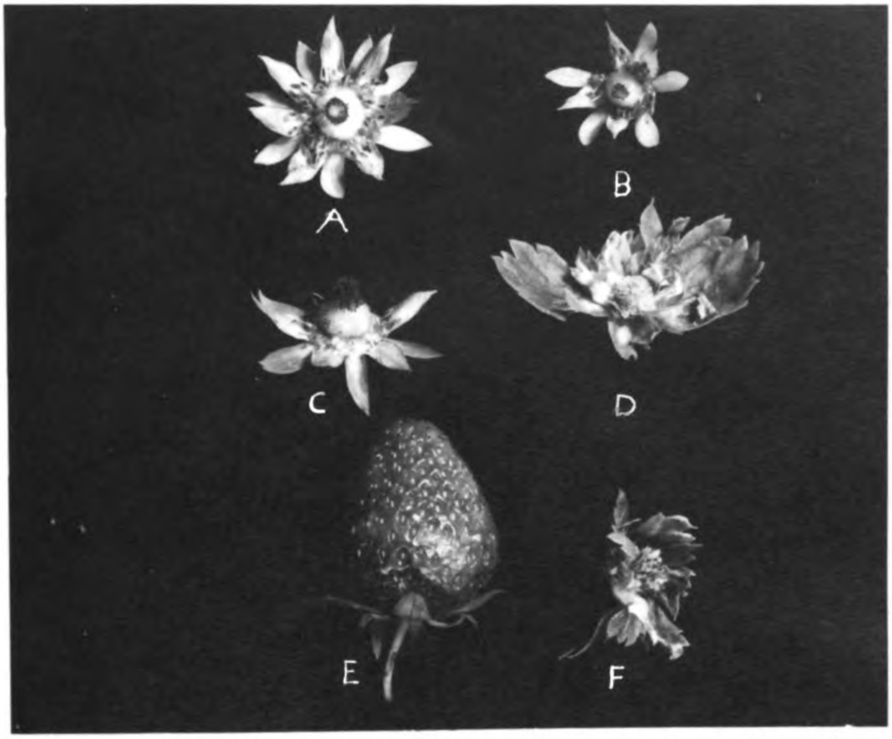


Figure 5. Representative Fruits from Maleic Hydrazide Treatments Applied May 15.

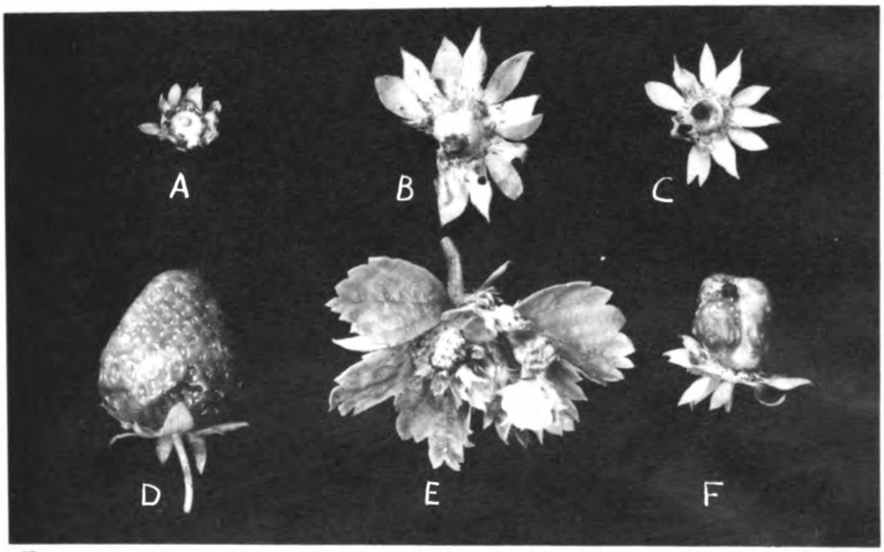


Figure 6. Representative Fruits and Flower from Maleic Hydrazide Treatments Applied April 28.

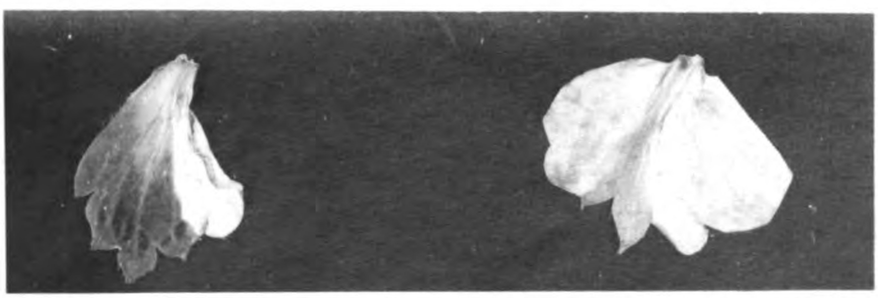


Figure 7. Varigated Leaf-like Sepals from Calyx Shown in Figure 6-E.

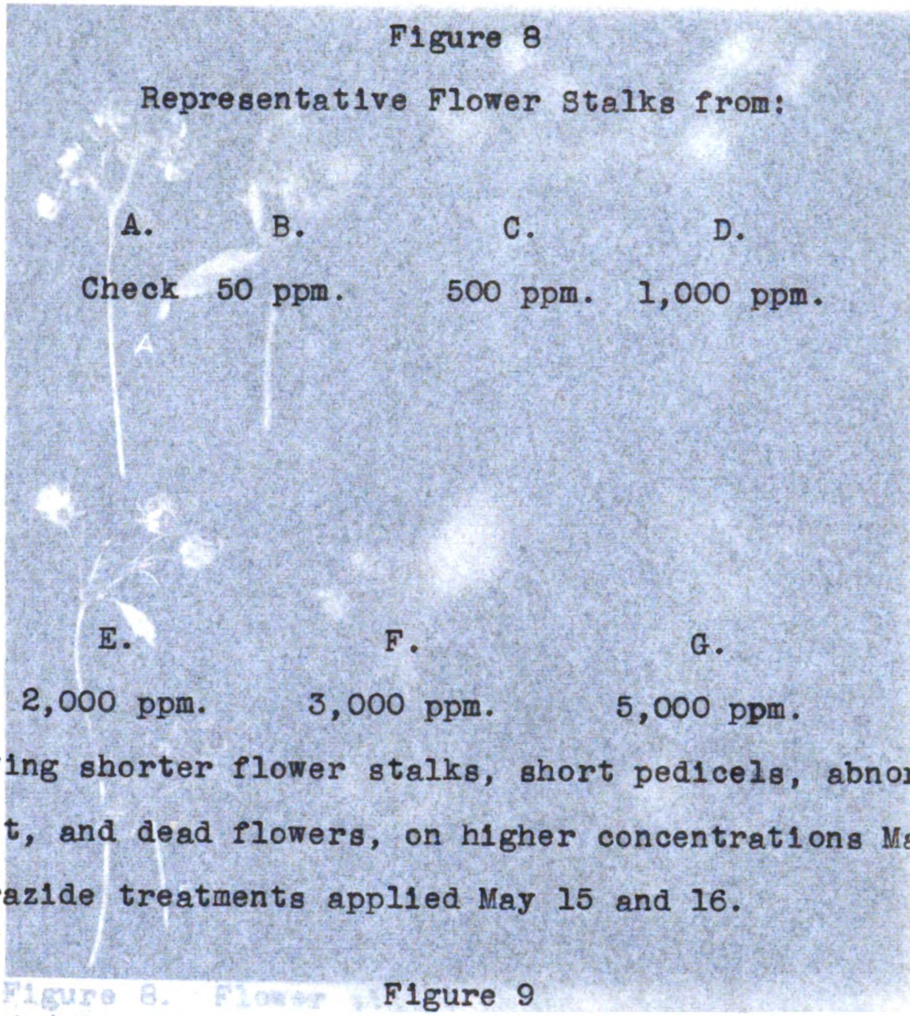


Figure 8

Representative Flower Stalks from:

A.	B.	C.	D.
Check	50 ppm.	500 ppm.	1,000 ppm.

E.	F.	G.
2,000 ppm.	3,000 ppm.	5,000 ppm.

Showing shorter flower stalks, short pedicels, abnormal fruit, and dead flowers, on higher concentrations Maleic Hydrazide treatments applied May 15 and 16.

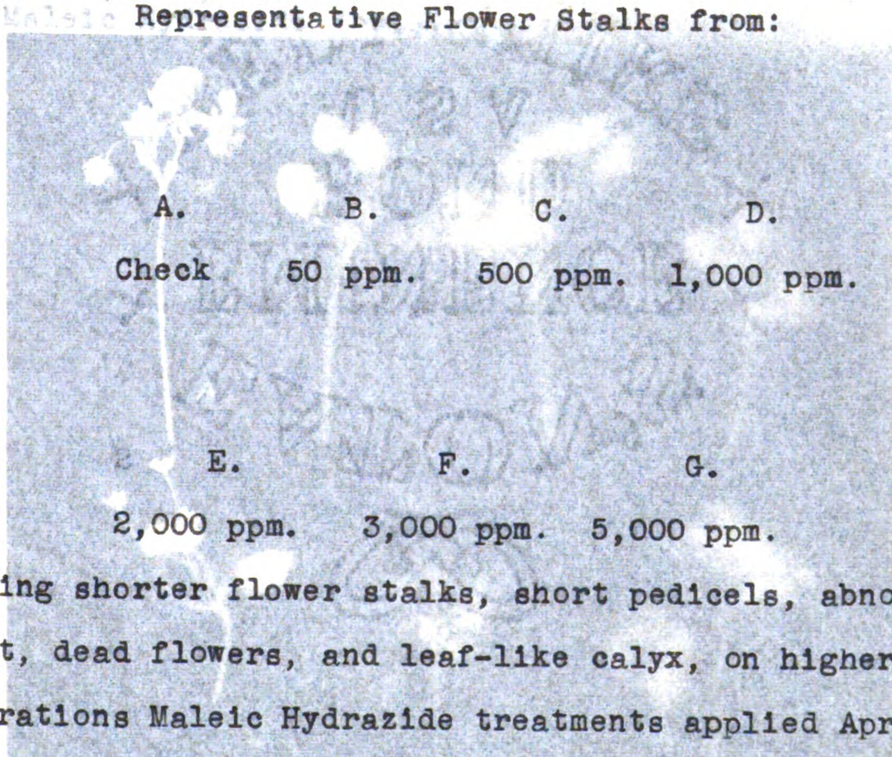


Figure 9

Representative Flower Stalks from:

A.	B.	C.	D.
Check	50 ppm.	500 ppm.	1,000 ppm.

E.	F.	G.
2,000 ppm.	3,000 ppm.	5,000 ppm.

Showing shorter flower stalks, short pedicels, abnormal fruit, dead flowers, and leaf-like calyx, on higher concentrations Maleic Hydrazide treatments applied April 28.

Figure 8

Representative Flower Stalks from:

A.	B.	C.	D.
Check	50 ppm.	500 ppm.	1,000 ppm.

E.	F.	G.
2,000 ppm.	3,000 ppm.	5,000 ppm.

Showing shorter flower stalks, short pedicels, abnormal fruit, and dead flowers, on higher concentrations Maleic hydrazide treatments applied May 15 and 16.

Figure 9

Representative Flower Stalks from:

A.	B.	C.	D.
Check	50 ppm.	500 ppm.	1,000 ppm.

E.	F.	G.
2,000 ppm.	3,000 ppm.	5,000 ppm.

Showing shorter flower stalks, short pedicels, abnormal fruit, dead flowers, and leaf-like calyx, on higher concentrations Maleic Hydrazide treatments applied April 8.

Figure 8. Flower stalks from: A-check, B-50, C-500, D-1,000, E-2,000, F-3,000, G-5,000 ppm Maleic Hydrazide Treatments Applied May 15.

Figure 9. Flower stalks from: A-check, B-50, C-500, D-1,000, E-2,000, F-3,000, G-5,000 ppm Maleic Hydrazide Treatments Applied April 23

apparently interfered with the normal development of the petals and sepals.

The flower stalks of plants generally decreased in length as the concentration of maleic hydrazide increased over 1,000 ppm. The pedicels were shorter also, giving these flower stalks a club appearance. The flower stalks from plants treated April 28 were generally shorter and more severly affected than the flower stalks from plants treated May 15 and 16. The plants treated at this later date often had some flower stalks which were short and some which were not, depending on the stage of development of the flower stalks when the treatment was applied.

Concentrations over 500 ppm maleic hydrazide inhibited new vegetative growth. The petioles failed to elongate. The leaflets were somewhat smaller than normal and lighter colored. (Fig. 10) When these photographs were taken during the last week in June, the leaves of plants treated at the late and early dates were so similar that separate pictures were not taken. The contrast in the lengths of the petioles of the low and high concentration treatments were nearly twice as great a few weeks before this picture was taken. The leaves which were already partially developed when the treatments were applied generally had short petioles but did not show formative effects. The leaves which were at an earlier stage of development at the time of treatment and appeared later were the ones which had

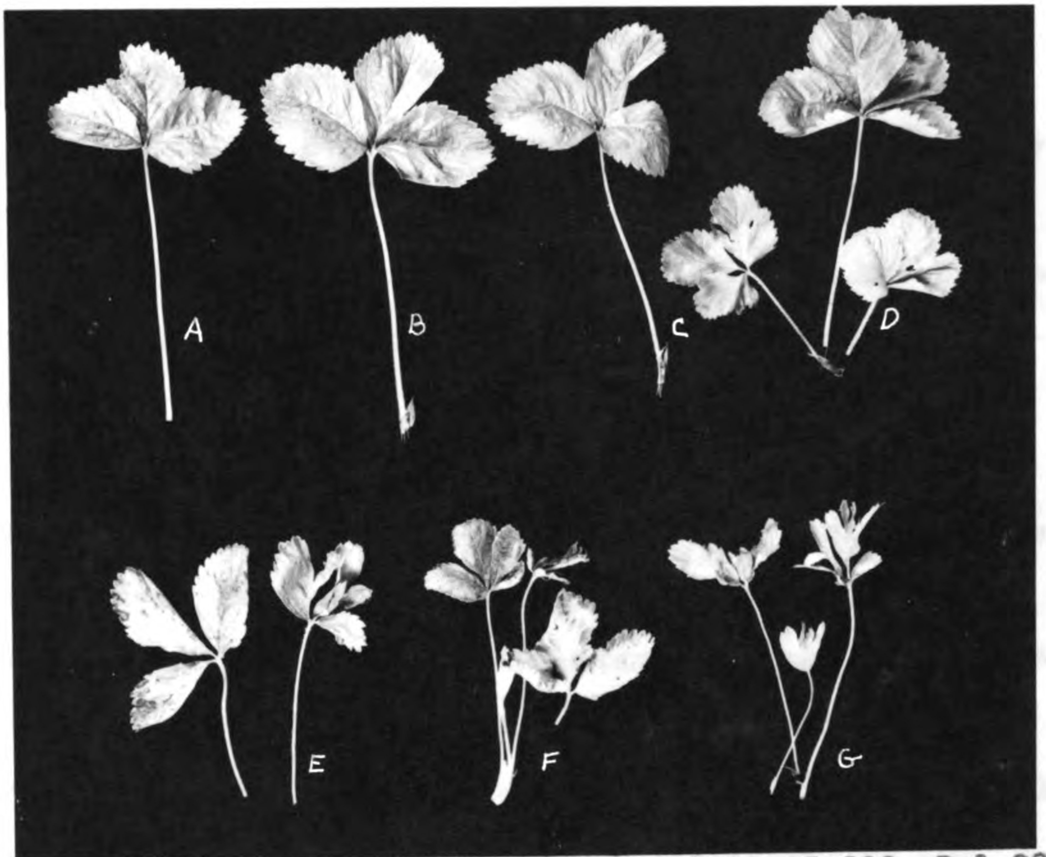


Figure 10. Leaves from: A-check, B-50, C-500, D-1,000, E-2,000, F-3,000, G-5,000 ppm Maleic Hydrazide Treatments Showing Formative Effects and Petiole Lengths.

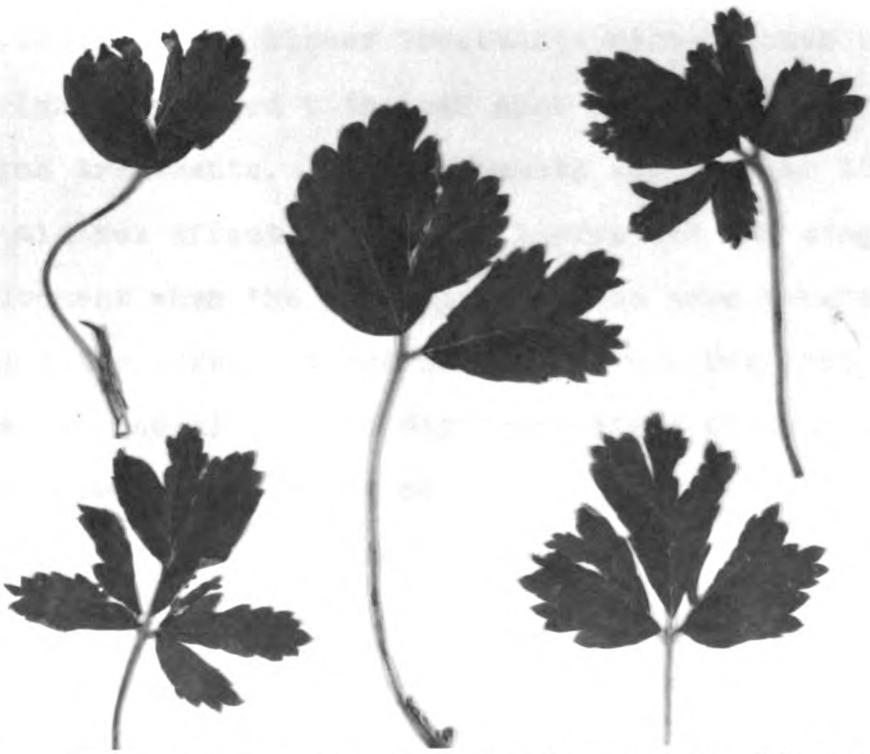


Figure 11. Leaves Showing the Formative Effects Caused by Concentrations over 1,000 ppm Maleic Hydrazide.

the formative effects. The formative effects produced by concentrations over 1,000 ppm Maleic hydrazide include lobing and division of leaves at almost any place, abnormal leaf veination, crinkling, curling, and the production of leaves with one, two, four, or five leaflets instead of three. (Fig. 11).

The 500 ppm treatment of the half of the experiment treated April 28 resumed vegetative growth during the last half of May, the 1,000 and 2,000 ppm treatments during the first half of June, and the plants of the 3,000 and 5,000 ppm treatments which lived, resumed growth during July. The 3,000 and 5,000 ppm concentrations of maleic hydrazide were toxic to some of the plants of all varieties but especially the Midland variety which is generally less vigorous. By the first of August it was noticed that the plants receiving the higher treatments were greener and not nearly as infected with leaf spot as the lower concentration treatments. The treatments applied May 15 and 16, did not affect the mature leaves and the stage of development when the developing leaves were treated determined the effect it had on them. This resulted in plants which had all of the different kinds of leaves.

The ripe fruit was picked for each plot on the dates shown and the weight recorded in grams. (Tables 8 to 11.) The fresh weight was used as a measure of quantity instead of volume because many of the plots only yielded a fraction of a quart, and that would be hard to estimate. There was no delay of any importance in the time of ripening caused by any treatment, and generally the only effect increasing concentrations of maleic hydrazide had on the yield of strawberries was to decrease the yield. The results for the different varieties and the two times of application were quite similar. (Tables 8 through 11). Although there seem to be two peaks in the data, these peaks occur in the check and low concentration treatments and can not be attributed to the treatments. Although other factors may enter in, probably the first peak occurred when the terminal blossom of the inflorescence opened and the second peak occurred when most of the lateral blossoms ripened.

Table 8. YIELD OF FRESH FRUIT IN GRAMS FROM FIELD EXPERIMENTS. PREMIER VARIETY.

Each number is the sum of the yeilds of the seven replications, for that day.

Plots treated April 28.

Treatment	June 12	June 14	June 18	June 21	June 28	July 2	July 5	July 10	Total
Check	497	681	4117	3309	2929	3695	1540	666	17434
50 ppm.	365	730	3303	3590	2590	2710	676	351	14315
500 ppm.	217	635	3709	3014	3345	4337	1644	593	17494
1,000 ppm.	310	440	2008	1539	2625	3837	1230	586	12575
2,000 ppm.	53	14	372	162	704	892	472	420	3089
3,000 ppm.	81	5	137	489	507	540	384	825	2968
5,000 ppm.	0	8	96	8	273	472	198	718	1773

Plots treated May 15 and 16.

Treatment	June 12	June 15	June 19	June 22	June 28	July 3	July 6	July 10	Total
Check	170	1050	4800	2514	2591	2210	642	196	14173
50 ppm.	5	968	3965	2080	2705	2340	1025	273	13361
500 ppm.	0	915	3118	2520	2121	2691	1264	336	12965
1,000 ppm.	0	1583	5825	1799	1284	1264	660	186	12601
2,000 ppm.	0	859	1809	398	126	231	159	141	3723
3,000 ppm.	0	301	837	172	131	173	74	71	1759
5,000 ppm.	0	193	382	92	60	46	49	32	854

Table 9. YIELD OF FRESH FRUIT IN GRAMS FROM FIELD EXPERIMENTS. SPARKLE VARIETY.

Each number is the sum of the yields of the seven replications, for that day.

Plots treated April 28.

Treatment	June 12	June 14	June 18	June 21	June 28	July 2	July 5	July 10	Total
Check	81	259	1166	2556	2480	5086	1940	2698	16266
50 ppm.	59	208	1419	2634	2733	4996	3352	4186	19587
500 ppm.	63	104	1330	650	2128	4134	2670	2821	13900
1,000 ppm.	38	6	275	188	843	3576	1836	2572	9334
2,000 ppm.	9	5	15	436	109	835	568	781	2758
3,000 ppm.	12	7	51	12	1	232	262	404	987
5,000 ppm.	0	0	25	326	11	146	196	295	1004

Plots treated May 15 and 16.

Treatment	June 15	June 19	June 22	June 28	July 3	July 6	July 10	Total
Check	0	2229	2688	2380	4158	2655	1698	15808
50 ppm.	143	1666	2916	2073	4363	2577	1704	15442
500 ppm.	0	1636	2270	2456	3456	2594	1907	14319
1,000 ppm.	0	1321	2322	1331	1660	1226	750	8610
2,000 ppm.	0	846	1038	601	704	450	287	4726
3,000 ppm.	12	63	475	198	193	70	284	1277
5,000 ppm.	0	62	226	0	106	32	36	460

Table 10. YIELD OF FRESH FRUIT IN GRAMS FROM FIELD EXPERIMENTS. MIDLAND VARIETY.

Each number is the sum of the yields of the seven replications, for that day.

Plots treated April 28.

Treatment	June 15	June 21	June 28	July 2	July 5	July 10	Total
Check	2171	2436	2255	2474	1031	299	10666
50 ppm.	1967	3218	1738	1923	1813	649	11308
500 ppm.	1193	1632	1490	2328	1564	738	8945
1,000 ppm.	1109	1742	1421	2338	1425	546	8581
2,000 ppm.	165	10	201	358	381	332	1447
3,000 ppm.	0	14	85	111	284	340	834
5,000 ppm.	0	0	41	74	86	30	231

Plots treated May 15 and 16.

Treatment	June 15	June 22	June 28	July 3	July 6	July 10	Total
Check	1053	3808	1424	1918	1932	288	10223
50 ppm.	907	3284	1620	2575	1483	310	10179
500 ppm.	456	1480	991	416	964	92	4399
1,000 ppm.	998	2278	633	315	458	92	4775
2,000 ppm.	306	396	66	9	36	11	824
3,000 ppm.	255	172	14	0	46	0	487
5,000 ppm.	72	30	0	16	0	0	118

Table 11. YIELD OF FRESH FRUIT IN GRAMS FROM FIELD EXPERIMENTS. ROBINSON VARIETY.

Each number is the sum of the yields of the seven replications, for that day.

Plots treated April 28.

Treatment	June 18	June 21	June 28	July 2	July 5	July 10	Total
Check	334	2402	2152	5378	4084	2123	16473
50 ppm.	368	2374	2126	6066	5544	2668	19146
500 ppm.	95	851	1490	4868	5500	2410	15214
1,000 ppm.	10	374	930	2941	6431	1730	12416
2,000 ppm.	53	156	583	1373	1919	1184	5268
3,000 ppm.	0	482	118	478	620	381	2079
5,000 ppm.	19	64	36	402	490	290	1301

Plots treated May 15 and 16.

Treatment	June 22	June 28	July 3	July 6	July 10	Total
Check	2966	1932	6957	4293	2554	18702
50 ppm.	3067	2543	7244	4834	2146	19834
500 ppm.	2790	2055	6020	4027	1536	16428
1,000 ppm.	2158	1274	2480	1127	786	7825
2,000 ppm.	1818	1091	1623	1056	314	5902
3,000 ppm.	548	470	641	638	374	2671
5,000 ppm.	98	16	70	12	72	268

MISCELLANEOUS EXPERIMENTS

Effect on Mature Plants - Several pots of mature Premier strawberry plants were obtained which were blossoming and forming fruit. Concentrations of Check, 100, 250, 500, 750, 1,000, 2,000, and 3,000 ppm of maleic hydrazide were replicated twice. Five days after treating, the margins of the leaves were reddened and the vegetative growth was depressed. However, these symptoms were rather inconsistent and the replications so few that no definite conclusions could be drawn.

Effect of Temperature - Eight Premier plants which were about a week past blossoming were sprayed with 1,000 ppm maleic hydrazide, and eight similar plants were sprayed with 3,000 ppm maleic hydrazide. Half of the plants receiving each treatment were grown in a greenhouse with a day temperature of 80° and the other half of the plants were grown in a greenhouse with a day temperature of 60°. The plants grown in the hotter house grew less and were less thrifty.

Movement of Maleic Hydrazide through Runners - Eight Robinson plants which had produced runners with several runner plants each were obtained for an experiment to see if maleic hydrazide was translocated through the runners. Various combinations of runner plants or mother plants were treated with 1,000 ppm maleic hydrazide and no formative effects appeared on the untreated plants connected with a treated plant by a runner. Later similar treatments of 3,000 ppm maleic hydrazide were applied and no effect was observed on untreated plants connected to the treated plant by a runner. The runners were green and healthy in appearance, however, the daughter plants were rooted and could take up nutrients. It is not certain that anything was transported through the runners. In the main experiment, runner plants produced by treated mother plants which showed formative effects, have not shown formative effects.

Inhibition of Runner Formation - Forty of the Premier plants which had been planted March 4, but not used in the main experiment were used to see if applications of maleic hydrazide would inhibit the growth of runners. A few of the plants had just begun producing runners by June 3, so treatments of Check, 100, 250, 500, 750, 1,000, 1,250, 1,500, 2,000 and 3,000 ppm of maleic hydrazide were replicated on four different plants each. These were mature plants which had reached their full size, so the treatments did not affect the size of the plants. Formative effects were produced on developing leaves in the same manner as on the main greenhouse experiment, however, more crinkling of the leaves was observed than in the other greenhouse experiments. No significant decrease in the number of runners per plant was produced by the treatments . (table 12).

Table 12. NUMBER OF NEW RUNNERS TO BECOME MACROSCOPICALLY VISIBLE ON PLANTS SPRAYED WHEN FIRST RUNNERS FIRST APPEARED.

Treatment	June 9	June 28	July 13	Aug. 2	Total
Check	1	5	2	0	8
100 ppm	0	3	5	0	8
250 ppm	3	3	7	1	14
500 ppm	0	5	5	0	10
750 ppm	0	4	2	1	7
1,000 ppm	0	2	2	0	4
1,250 ppm	0	4	1	1	6
1,500 ppm	0	6	2	1	9
2,000 ppm	0	3	2	1	6
3,000 ppm	1	4	2	2	9

Germination of Seeds - Several strawberries were taken from the check, 100 ppm and 250 ppm maleic hydrazide treatments of the main greenhouse experiment and some fruits from plants which had been treated with 1,000 ppm maleic hydrazide just a few days before the fruit was picked. These fruits were smashed in a mix-master and planted in medium vermiculite to see if they would grow. Fruits from higher concentration treatments were not included because they were abnormal in shape and their achenes appeared dead. The seeds from fruits from the check, and 100 ppm maleic hydrazide treatments and from the 1,000 ppm maleic hydrazide treatments applied soon before picking, all germinated and produced seedlings. However, the seeds from the 250 ppm maleic hydrazide treatment which was applied at the beginning of the plants growing season, did not germinate. This experiment can not be regarded as conclusive because of its small scale.

Influence on Peaches, Cherries, Pears, and Apples - On April 23, as the buds were just beginning to swell, concentrations of 500, 1,000 and 4,000 ppm of maleic hydrazide were applied to branches of several fruit trees in the college orchard. Two Hale Haven peach trees, two Early Richmond sour cherry trees, one Dana Hovey, and one Anjou pear trees, and one Gano and one Baldwin apple trees were treated. Adjoining untreated branches were protected from any drift and used as checks. On May 10, when apples and pears were in a pre-pink stage of development, similar treatments were applied to one Winter Nelis, and one Bartlett pear trees, and to two Baldwin apple trees. The flower buds on the peach trees had been killed by low temperature during the winter. The treatments had no noticeable effect on the blossoms of either the cherry or apple trees, which produced normal blossoms and normal fruit. On the pear trees the 1,000 and 4,000 ppm maleic hydrazide applied at the pre-pink stage killed some of the blossoms which were more developed. The treatment acted as a thinning agent at this time. The early application had no effect on the pear blossoms.

At no time did any concentrations cause formative effects on the leaves. No sticker or spreader was used in any treatment and it is hard to determine if any of the maleic hydrazide was absorbed through the branches.

Inhibition of Lawn Grasses - Applications of 50, 500 and 1,850 ppm maleic hydrazide were applied to 3 ft. by 6 ft. plots on a blue grass and white clover lawn one day after it had been cut. The grass in the areas treated with 500 and 1850 ppm turned a little darker green and more dead spears occurred. The 50 ppm maleic hydrazide treatment apparently was not effective but 500 ppm maleic hydrazide retarded the growth effectively for about two weeks and the 1,850 ppm maleic hydrazide retarded growth for over five weeks. At that time crab grass was coming into the plots and replacing the bluegrass which was still not growing.

Influence on Lily of the Valley - A treatment of 1,850 ppm of maleic hydrazide was applied to some lily-of-the-valley plants. When the young leaves which were not unrolled or fully developed at the time of treating did expand they had a series of cracks between the veins which appeared to have been an area which had been at the base of the developing leaf where the maleic hydrazide had accumulated. The growth of this area was retarded and as the tissue above this affected area grew, it caused the retarded area to split and crinkle.

SUMMARY

1. Replicated experiments were conducted to determine the effect of early spring applications of maleic hydrazide upon the flowering and fruiting of strawberry plants.

2. Treatments ranging from 50 to 5,000 ppm concentrations of maleic hydrazide in an aqueous solution, were applied to plants in the greenhouse and in the field. The sprays in the field were applied April 28, which was as early as it was thought safe to remove the mulch, and May 15 and 16, which was about two weeks before full bloom. The plants in the greenhouse were sprayed as soon as the leaves were out.

3. The higher the concentration of maleic hydrazide applied, the fewer the number of blossoms and the lower the total yield of fruit there was per plant. Very little, if any, delay in blossoming or ripening of fruit resulted.

4. The concentrations over 1,000 ppm maleic hydrazide applied in the field and those over 500 ppm applied in the greenhouse severly inhibited any new vegetative growth and, the flowers produced had very short peduncles and pedicels and very small, dwarfed petals.

5. The fruit which developed from these flowers was very abnormal. The achenes all died and only the base of the torus, which has no achenes, enlarged into a small conical tissue with the dead achenes at its tip.

6. On some plants from the 3,000 and 5,000 ppm

maleic hydrazide plots the petals and sepals were combined to form a variegated leaf-like rossette where the calyx usually is.

7. Formative effects were produced on the leaves which continued to develop. They include; a lobing anywhere on the leaf blade, an alteration of the venation, crinkling and curling, and many more leaves with one, two, four, or five leaflets.

8. After four and one half months, some of the plants treated with more than 2,000 ppm maleic hydrazide produced very small green leaves from the center of the plant and resumed growth. However, many of the plants were killed by concentrations over 3,000 maleic hydrazide.

9. Since increasing concentrations of maleic hydrazide per treatment produced no delay in blossoming and did cause a very definite decrease in yield, I believe spring applications of maleic hydrazide have little, if any, use of commercial importance in delaying the blossoming of strawberries.

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