THE SELECTIVE HERBICIDAL ACTION OF VARIOUS CHEMICALS ON STRAWBERRIES

Thesis for the Degree of M. S.

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Lloyd Alfred Mitterling

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This is to certify that the

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The Selective Herbicidal Action
of Various Chemicals on
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presented by

Lloyd Alfred Mitterling

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of the requirements for

M. S. degree in Horticulture

Charles L. Hamner
Major professor

Date November 23, 1954

THE SELECTIVE HERBICIDAL ACTION OF VARIOUS CHEMICALS ON STRAWBERRIES

By

LLOYD ALFRED MITTERLING

A THESIS

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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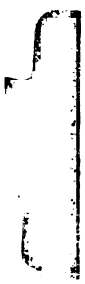

ACKNOWLEDGMENTS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES AND PLATES

Figure Page

Plate

THE SELECTIVE HERBICIDAL ACTION OF VARIOUS CHEMICALS ON STRAWBERRIES

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Approved . . Charles L. Hamner

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ABSTRACT

The Robinson and Premier varieties of strawberries were treated with isopropyl n-(3-chlorophenyl) carbamate (CIPC); isopropyl ester of 2,4-dichlorophenoxyacetic acid (isopropyl 2,4-D); and butyl ester of 2,4-dichlorophenoxyacetic acid (butyl 2,4-D) at four different concentrations.

The 2,4-D compounds satisfactorily controlled the broad-leaved weeds at all the rates used. The CIPC gave variable results in the numbers of broad-leaved weeds controlled. The grasses were not effectively controlled by any of the chemicals in the manner used.

There was a definite difference in the response of the strawberries due to the different chemicals. Plants treated with butyl 2,4-D showed greater injury than plants treated with the isopropyl 2,4-D or the CIPC in every criterion used with both varieties.

There were definite varietal differences between the plants due to the chemicals.

A cytological examination of meiotic material taken the spring following the treatments revealed no permanent injury or chromosomal changes to the plants in either variety.

INTRODUCTION

The importance of strawberry production in Michigan agriculture has been increasing sinceWorld War II. The dollar value of the strawberry crop for 1952 to the Michigan growers was $5,813,000. This is more than the combined value of the plum, grape, and pear crops for that year. It is 68 percent of the combined sweet and sour cherry crops. It equals more than 50 percent of the value of the apples produced, and exceeds the value of the peach crop (24). This serves to point out that the strawberry contributes considerably more to the income of the state than is ordinarily believed.

The largest expense item and the most troublesome aspect of strawberry culture has been the control of weeds (34). Although weed control by chemical means is feasible, much is yet to be learned. Further work is needed relating to timing, rates of application, effects under varying conditions of soil types, moisture, and climatic conditions (2, 5, 27). It was suggested that the testing of new compounds on strawberry plants should be undertaken (3, 6).

The experiment herein reported was conducted to evaluate three chemical compounds as herbicides when used on two of the leading commercial varieties of strawberries grown in Michigan.

REVIEW OF LITERATURE

Great impetus was given to chemical weed control in 1944 with the introduction by Hamner and Tukey of the selective herbicide 2,4-dichlorophenoxyacetic acid (17). In the year 1950 to 1951 more than three hundred new references were reviewed on subjects of herbicides and phytotoxicity (3). Because of the large amount of literature published on weed control work, the review of literature in this thesis generally is restricted to those papers which are quite specifically concerned with weed control in strawberries.

The strawberry was found to be relatively tolerant of 2,4-dichlorophenoxyacetic acid in 1947, and the suggestion was made by Carlson (5) that it showed promise as a selective herbicide for strawberries. Neville et al. (25) reported on the use of a sodium salt of 2,4-D and an ester formulation of 2,4-D with no difference being noted in the final effect on the strawberry planting. Viehmeyer (30) experimented with forty different clones using a sodium salt 2,4-D and some of the clones were found to be more tolerant. He also found differences in the tolerance of three commercial varieties tried and suggested that the differences were enough to be economically important.

Carlson and Moulton, in 1949 (8), found that isopropyl n-phenyl carbamate, when used in the fall, was effective in controlling common chickweed without reducing the yield of strawberries.

The use of an activated carbon on strawberry roots before transplanting to protect them from the effects of 2,4-D was used with success by Carlson et al. in 1950 (10). They stated that the untreated plants showed considerable mortality when only 0.3 inch of rain fell in the 24 days following planting. Gilbert and Wolf (16) found that severe injury may result from 2,4-D applied in extended drought and also that some varieties were more tolerant of the chemical than others. Denisen and Staniforth (13) found that the number of rooted runners may also be affected by extended drought and the use of 2,4-D. Heavy rains following the application of 2,4-D caused poor control of weeds, according to Wilson and Stamper (32). Hemphill (19) compared several chemicals with 2,4-D and concluded that the sodium salt of 2,4-D was not good for weed control when applied in summer at low rates. He also stated that the amine form of 2,4-D gave satisfactory results. One pound of isopropyl ester of 2,4-D or three to four pounds of the sodium salt of 2,4-D satisfactorily controlled broad-leaved weeds from July 9 to the end of the growing season in experiments conducted by Nylund (26). Lower rates

of the same chemicals required retreatment after five weeks to get comparable control. The air temperature at the first application on July 9 was 85° F., and the soil was wet--0.44 inch of precipitation had fallen in the preceding 24 hours. When the second application was made on August 11, the air temperature was 75° F., and the soil was wet. At this time 1.67 inches of precipitation had fallen in the preceding 24 hours. He found that none of the treatments resulted in reduced vigor of the plants as expressed by number of leaves and rooted runners, nor did they reduce the yield of fruit.

A comparison of the effects of the sodium salt and ester formulations of 2,4-D on the growth and yield of the Premier strawberry was made by Hill and Alban in 1951 (20). They stated that, in all three years of the trials, the ester formulations resulted in yield and plant stands significantly lower than the plots treated with the sodium salt. It was also found that an application of either form of 2,4-D in the spring before harvest gave a significantly lower yield of fruit. Treatments with 2,4-D were found by Havis and Moore (18) to stunt the mother plants, reduce runner development, and inhibit rooting of some runner plants. The sprayed plots appeared less vigorous than those which were not sprayed. No differential varietal response to the action of the sodium salt of 2,4-D

could be detected by Aldrich and Puffer (1). They reported that, although many of the 2,4-D amine-treated plots showed typical 2,4-D formative effects following treatment, the abnormalities did not persist. Carlson and Moulton (9) performed an experiment in which they recorded the amount of time needed to weed treated and untreated plots. They found that considerable labor could be saved, but that some chemicals retarded the production of daughter plants. A new herbicide, isopropyl n-(3-chlorophenyl) carbamate, was reported by Witman and Newton (33). This compound was believed to have more residual action than regular isopropyl n-phenyl carbamate.

The effect of this new chemical, called CIPC, was tested on various crops, and its residual properties in various soils were studied by Stevens and Carlson in 1952 (29). In their experiment they found that residual action was less in acid soils and that decomposition was very rapid under anerobic conditions. They believed that the chlorosis or injury induced by postemergence treatments was caused by the solvent, rather than the chemical. Ries (28) used CIPC for weeding spinach, and found that at the four-pound rate it was effective in controlling chickweed, purslane, smartweed, and most annual grasses, when the mean temperature following application was below 60° F.

The isopropyl ester of 2,4-D was compared to a sodium salt (E.H.-1, 2,4-dichlorophenoxyethyl sulfate), on the Robinson variety, by Denisen (12) in 1953. He believed that the reduction of rooted runners in the 2,4-D plots was probably due to two factors: (1) the chemical on the soil inhibiting root primordia for several days, and (2) the physiological reaction of the plant to the 2,4-D temporarily interrupted runner initiation. Carlson (7) conducted greenhouse and field experiments using different chemicals to deliberately inhibit runner formation, and stated that 2,4-D was among the more effective compounds. Experiments were conducted on the Blakemore variety of strawberries using CIPC by Danielson and France (11). They used two pounds of CIPC in 50 gallons of water, and as many as five applications in the season without injury to the strawberries. This was determined to be commercially acceptable.

Some of the compounds used as herbicides have been shown to cause mitotic aberrations. Ennis (15), in 1948, demonstrated that isopropyl n-phenyl carbamate interrupts cell division, and suggested that it may have an effect similar to that--found by Blakeslee and Avery (4)--of colchicine. Polyploidy was induced in the strawberry by treatment with colchicine in 1938 by Dermen and Darrow (14). Wilson has shown that, at some concentrations, 2,4-D interrupts

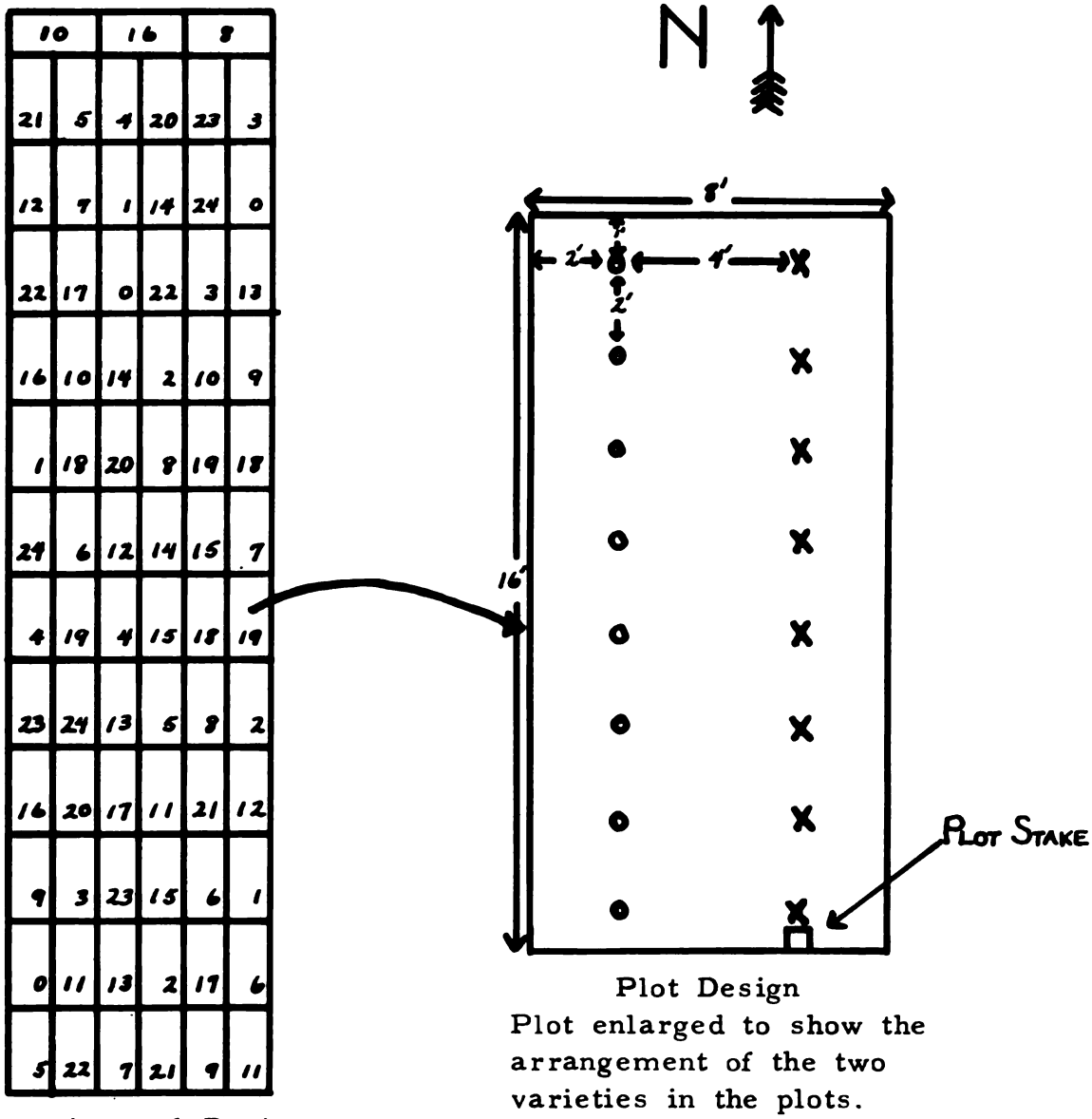
or affects the prophase stage of cell division (31). The Premier variety of strawberry has been found to have fifty-six somatic chromosomes and regular meiosis (21, 22).

MATERIALS AND METHODS

The Premier and Robinson, two leading strawberry varieties in Michigan, were used in these experiments. The variety Premier is not a prolific producer of stolons, usually establishing a moderate number. On the other hand, the variety Robinson is a prolific producer, and usually sets many more than are needed or conducive to maximum fruit production (23). These two varieties were planted on the College Experimental Farm in a well-tilled Hillsdale sandy loam which had been sown to a rye cover crop the previous year. The area was divided into seventy-five plots, with each plot containing 128 square feet (Figure 1).

A standard commercial practice was used to prepare the site for planting during the first week in April, 1953. The plants were purchased from a commercial concern and planted April 15. They were observed closely after planting, and those which died were replaced immediately from the college plots. This was done by transplanting a ball of earth around the roots, thus facilitating their establishment at the time of first treatment. A complete fertilizer with an analysis of 8-8-8 was applied at the rate of 800 pounds per acre on June 30. The patch was mulched with clean wheat straw

Figure 1. Diagram of experimental and plot design.



Experimental Design showing the randomization of the treatments in the experiment.

Plot Design

Plot enlarged to show the arrangement of the two varieties in the plots.

✘ denotes plant of Robinson variety.

o denotes plant of Premier variety.

on December 4, and on the following April 21, 1954, the mulch was removed.

Three growth-regulating chemicals were used for the various treatments, namely: (1) isopropyl n-(3-chlorophenyl) carbamate (CIPC, 48 percent active); (2) isopropyl ester of 2,4-dichlorophenoxyacetic acid (isopropyl 2,4-D, 30 percent active); and (3) butyl ester of 2,4-dichlorophenoxyacetic acid (butyl 2,4-D, 43.8 percent active).

Each of the three chemicals was applied at four concentrations (Table I). The treatments were randomized and replicated six times when the first application was made on May 26, 1953. One-half of them were treated again on July 6, 1953, making a total of 24 treatments and three control plots. The chemicals were applied in the order of lowest to highest concentration, expediting the spraying operation by reducing time spent in washing equipment. The CIPC was applied first, followed by the isopropyl 2,4-D and the butyl 2,4-D in that order.

A three-gallon, hand-type compressed air sprayer was used to spray the plots. A boom was attached with two fan-type nozzles mounted 14 inches apart. A nozzle with a 3/64-inch orifice was used, allowing ample time to cover each plot once in each direction with 1,000 ml of material. Forty strokes on the hand pump exerted

TABLE I

THE RATES AND TIMES OF APPLICATION OF VARIOUS CHEMICALS TO STRAWBERRY PLANTS OF THE ROBINSON AND PREMIER VARIETIES

Chemical	Application (ppm in 1,000 ml of Water)	Application[1] (equivalent lbs./acre)	Plots Treated 5-26-53	Plots Treated 7-6-53[2]	Total Application (lbs./acre)
CIPC	500	0.80	6		0.80
				3	1.60
	1,000	1.60	6		1.60
				3	3.20
	2,000	3.20	6		3.20
				3	6.40
	3,000	4.80	6		4.80
				3	9.60
Isopropyl 2,4-D . .	500	1.25	6		1.25
				3	2.50
	1,000	2.50	6		2.50
				3	5.00
	2,000	5.00	6		5.00
				3	10.00
	3,000	7.50	6		7.50
				3	15.00
Butyl 2,4-D . .	500	0.85	6		0.85
				3	1.70
	1,000	1.70	6		1.70
				3	3.40
	2,000	3.40	6		3.40
				3	6.80
	3,000	5.10	6		5.10
				3	10.20

[1] In 90 gallons of water.

[2] One-half of those plots treated on 5-26-53 were given exactly the same treatment again on this date.

13 pounds pressure on the material at the boom. The pressure dropped to 11 pounds by the time the supply had been exhausted.

The weed counts were made in 3 square feet per plot. A square-foot counting frame was used, and the three areas counted were randomized.

The plant material used in the cytological work was taken from one replication of the treatments. It was gathered over a two-week period, from April 28 through May 9, 1954. Killing and fixation were obtained by use of a standard cytological solution which consists of three parts absolute ethyl alcohol and one part of glacial acetic acid. After the calyx had been removed from the flower, the staminate and pistillate portions were placed in a vial of the above fixative. Squash preparations were then made of the anthers and were stained by the aceto-carmine method.

All of the fruit was harvested with the calyx and portion of the peduncle attached to it. The yield of each plot was then measured in grams.

RESULTS AND DISCUSSION

All three of the compounds used in the experiment were plant growth-regulating chemicals and, as such, it was expected that the physiological activity of the strawberry plants would be changed as a result of their application. Within 24 hours after treatment, on May 26, 1953, it was observed that the plants in some of the plots were responding with gross morphological changes. No varietal differences could be ascertained at this time and the response noted above was determined to be in the plots treated with the 2,4-D chemicals.

The plants in the CIPC-treated plots did not show any macroscopic effects immediately after the first treatment. Those in the isopropyl 2,4-D plots showed distortion, epinasty, and hyponasty, at all concentrations. The reaction of the plants to the butyl 2,4-D appeared to be most severe at the 2,000 and 3,000 ppm levels, where most of the plants were wilted.

Evidence of the physiological reaction of the strawberry plants to the 2,4-D chemicals was reflected by morphological symptoms to a lesser degree one week after treatment. Those treated

with CIPC responded with various degrees of chlorosis, especially on the young leaves which unfolded following treatment.

When the above observations were made, it was noted that there was a typical response of the strawberry plants to each of the different chemicals applied. No varietal differences could be ascertained. However, when counts were made of the surviving plants, a difference between the two varieties could be observed. When survival, soon after treatment, was the criterion used, the Robinson appeared to be more readily injured by the chemicals than the Premier variety (Figure 2). The CIPC appeared to have been least toxic, and the butyl 2,4-D the most toxic to both varieties.

Another criterion used to test the effect of the chemicals on the strawberry plants was stolon counts (Figure 3). In general, stolon formation or development was inhibited to a greater degree in the Premier variety. The CIPC treatments appear to have stimulated stolon formation in the Robinson variety, while all but the 500 ppm concentration inhibited it in the Premier. Both of the 2,4-D chemicals arrested stolon formation in each of the varieties. A possible explanation is that butyl 2,4-D is less volatile, and therefore requires smaller amounts to gain comparative effectiveness.

Figure 2. The toxic effect of CIPC, Isopropyl 2,4-D and Butyl 2,4-D when used at various concentrations on strawberry plants of the Premier and Robinson varieties 23 days after treatment.

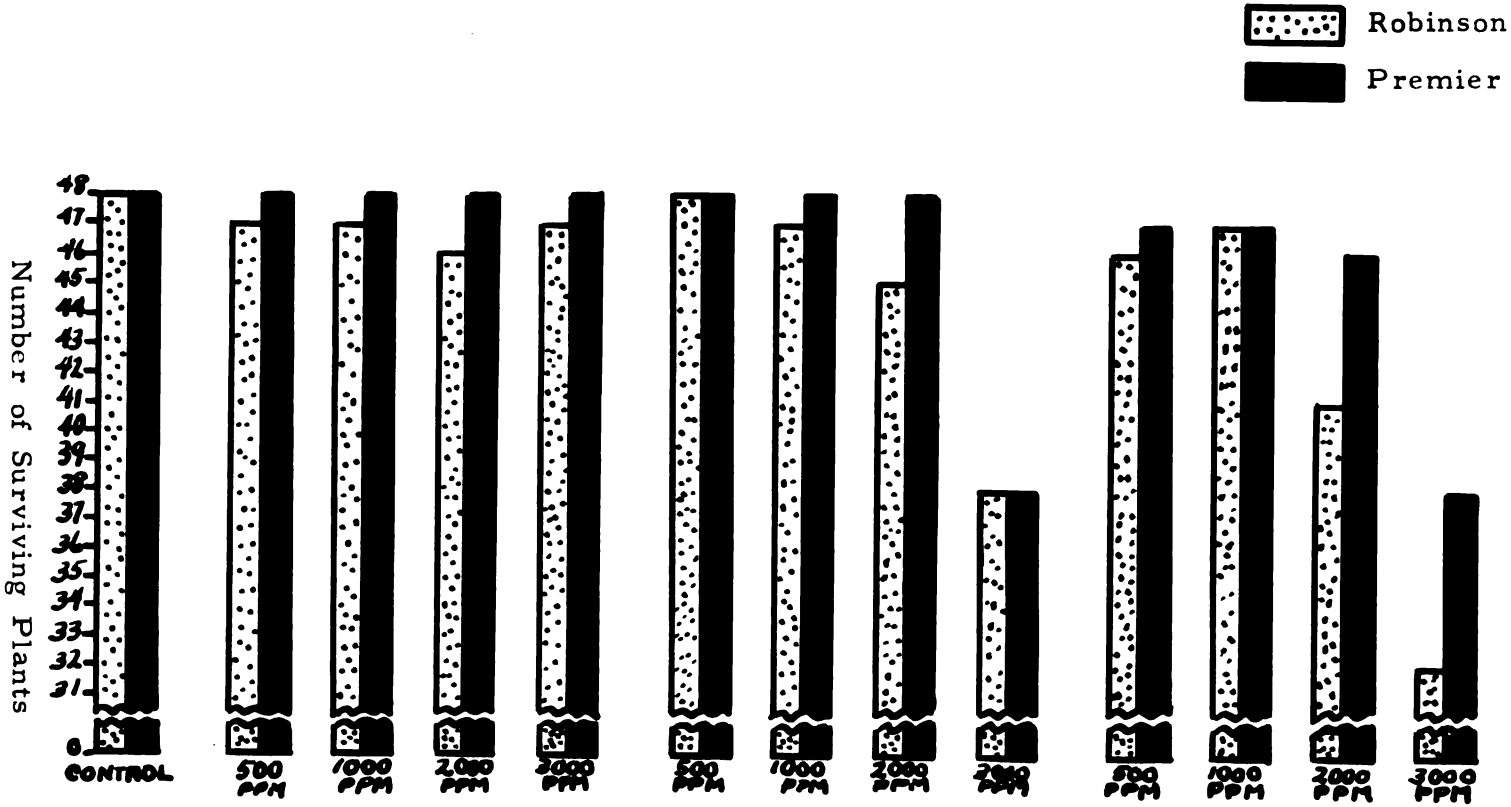
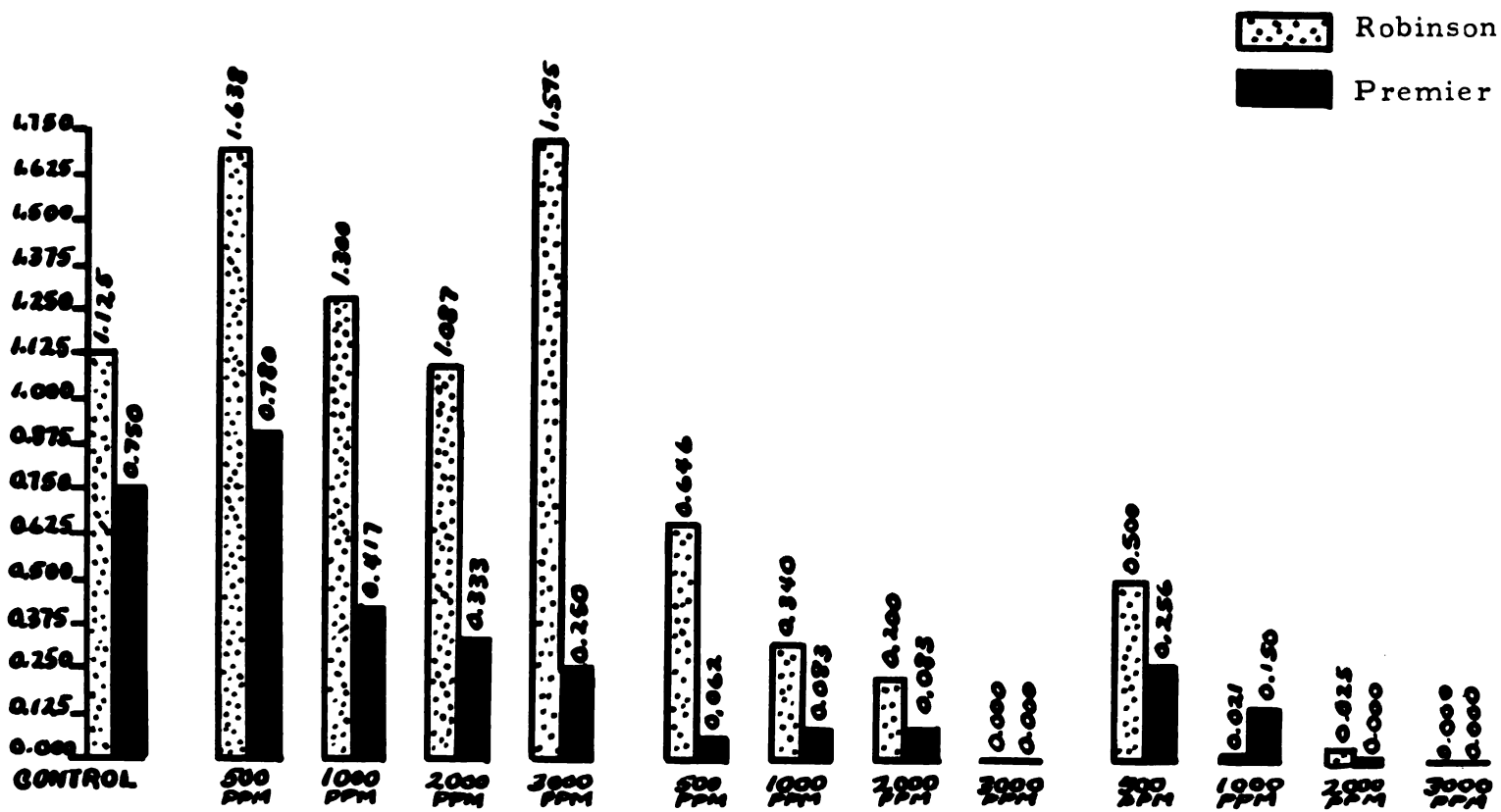


Figure 3. The effect of CIPC, Isopropyl 2,4-D and Butyl 2,4-D on stolon formation of the Premier and the Robinson varieties of strawberries 23 days after treatment.



Isopropyl n-(3-chlorophenyl) carbamate

Isopropyl ester 2,4-Dichlorophenoxyacetic acid

Butyl ester 2,4-Dichlorophenoxyacetic acid

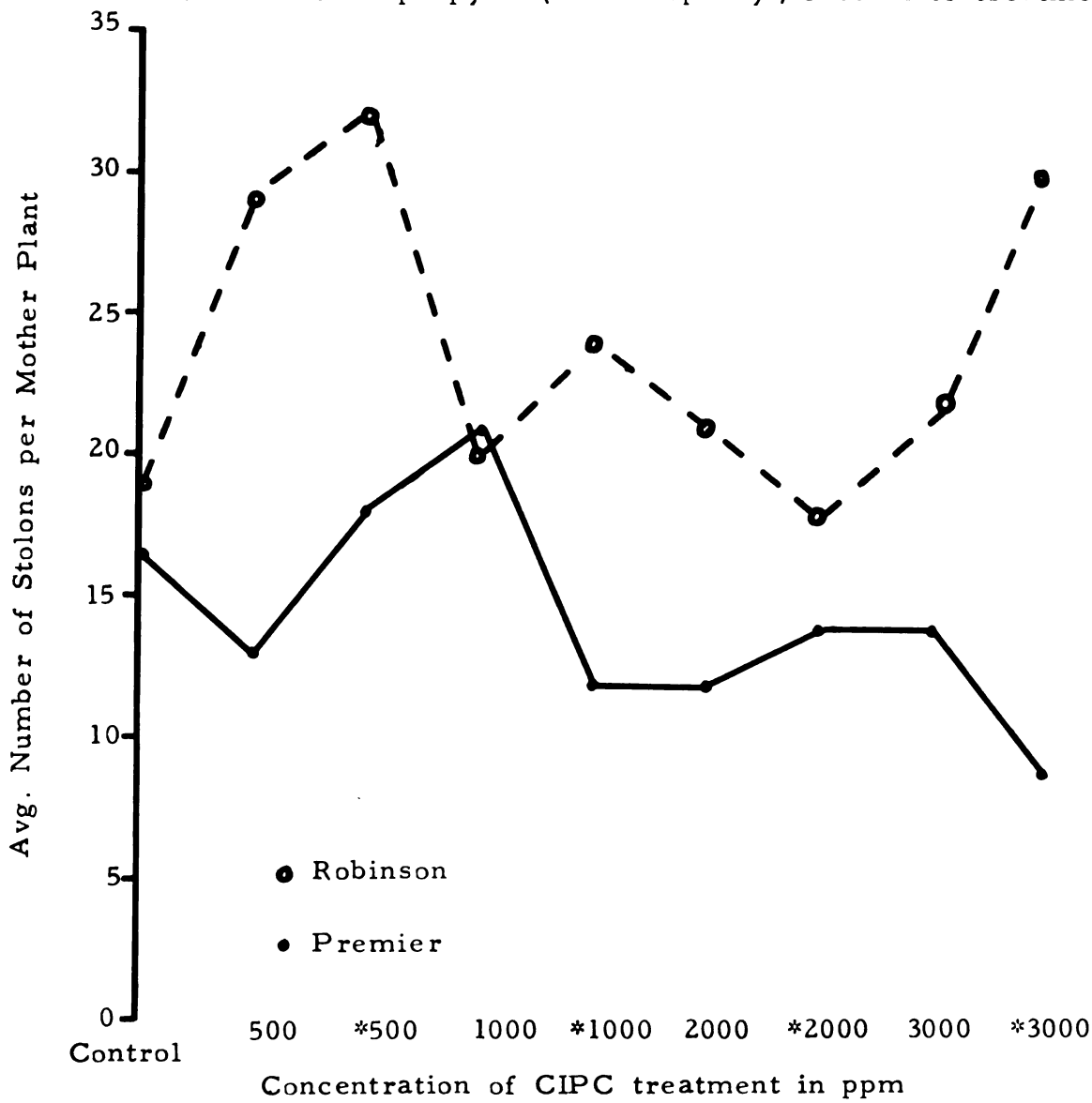
Treatment and Concentration

The spring following treatments and after removal of the mulch, stolon counts were made again (Figures 4, 5, 6). The data indicated that the response appeared to be similar to that made the previous summer. The Robinson responded with an increase in stolons from the CIPC treatment, while the Premier was inhibited. Both 2,4-D compounds arrested stolon development.

The broad-leaved weeds were effectively controlled by most of the treatments, but the grasses were not (Tables II, III). The soil moisture at both times of treatment was considered to be adequate for the materials to give effective control of the weeds. The air and soil temperatures at the time of the first application were somewhat lower than when the second one was applied (Tables IV, V). The lower temperatures still did not seem to make any difference in the effectiveness of the chemicals in controlling the weeds.

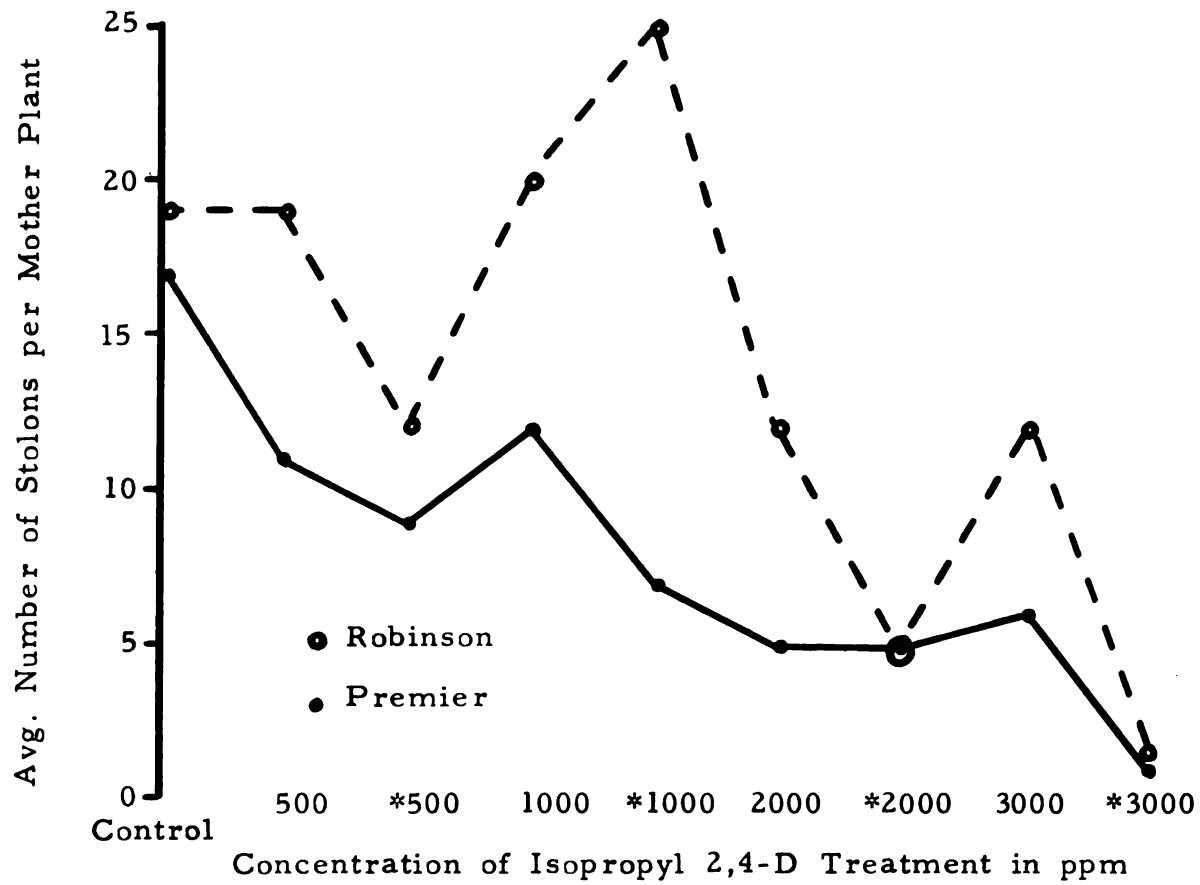
The true significance of any chemical treatment in an experiment such as this lies in its effect on the fruit harvest. If the total yield of fruit is reduced out of proportion to the effectiveness of the weed control gained by its use, then as a practical aid it would be of little value. However, because the plants were being treated at the time of stolon formation and initiation, and it has been shown that some chemical compounds can cause mitotic

Figure 4. A comparison of the number of established stolons, the spring following treatment in the Premier and Robinson varieties of strawberries, in response to different concentrations of Isopropyl n-(3-chlorophenyl) carbamate treatments.



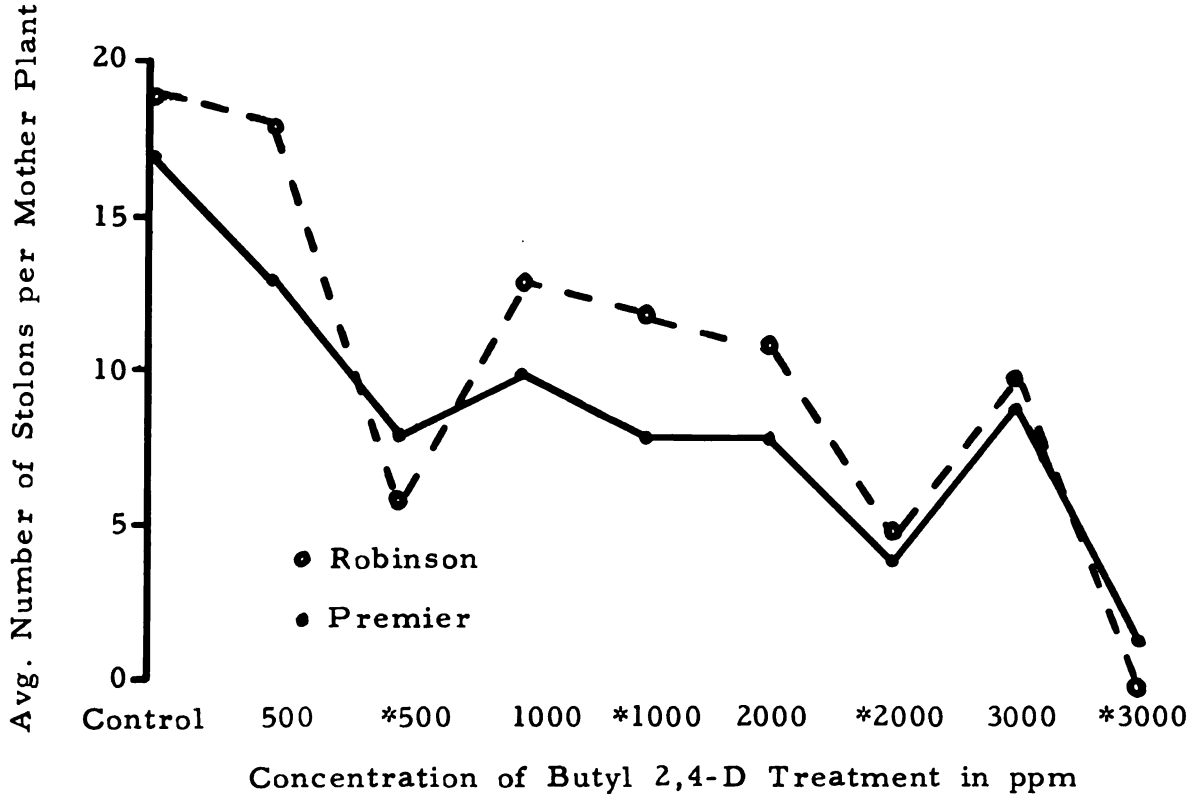
* All plots received an application on 5-26-53 and those marked with an asterisk received a second one on 7-6-53.

Figure 5. A comparison of the number of established stolons, the spring following treatment in the Premier and Robinson varieties of strawberries, in response to different concentrations of Isopropyl 2,4-Dichlorophenoxyacetic acid treatment.



* All plots received an application on 5-26-53 and those marked with an asterisk received a second one on 7-6-53.

Figure 6. A comparison of the number of established stolons, the spring following treatment in the Premier and Robinson varieties of strawberries, in response to different concentrations of Butyl 2,4-Dichlorophenoxyacetic acid treatments.



* All plots received an application on 5-26-53 and those marked with an asterisk received a second one on 7-6-53.

TABLE II

THE EFFECT OF CIPC, ISOPROPYL 2,4-D AND BUTYL 2,4-D APPLICATIONS, AT VARIOUS CONCENTRATIONS, ON THE BROAD-LEAVED WEEDS IN A PLANTING OF PREMIER AND ROBINSON VARIETIES OF STRAWBERRIES
(plots were sprayed on 5-26-53; counts were made on 6-8-53*)

Application and Weed Count	Concentration (ppm)				
	0	500	1,000	2,000	3,000
Isopropyl n-(3-chlorophenyl) Carbamate (CIPC)					
Equivalent pounds per acre applied	0.0	0.80	1.60	3.20	4.80
Avg. weed counts	39.2	20.2	24.2	13.4	24.2
Isopropyl ester 2,4-Dichlorophenoxyacetic Acid (Isopropyl 2,4-D)					
Equivalent pounds per acre applied	0.0	1.25	2.50	5.00	7.50
Avg. weed counts	39.2	4.5	4.5	1.7	1.0
Butyl ester 2,4-Dichlorophenoxyacetic Acid (Butyl 2,4-D)					
Equivalent pounds per acre applied	0.0	0.85	1.70	3.40	5.10
Avg. weed counts	39.2	8.8	5.9	2.6	0.7

* For the grasses the F distribution was not significant.

TABLE III

THE EFFECT OF CIPC, ISOPROPYL 2,4-D AND BUTYL 2,4-D APPLICATIONS, AT VARIOUS CONCENTRATIONS, ON THE BROAD-LEAVED WEEDS IN A PLANTING OF PREMIER AND ROBINSON VARIETIES OF STRAWBERRIES
(plots were sprayed on 7-7-53; counts were made on 7-22-53*)

Application and Weed Count	Concentration (ppm)				
	0	500	1,000	2,000	3,000
Isopropyl n-(3-chlorophenyl) Carbamate (CIPC)					
Equivalent pounds per acre applied	0.00	0.80	1.60	3.20	4.80
Avg. weed counts	3.73	2.73	3.30	0.86	1.77
Isopropyl ester 2,4-Dichlorophenoxyacetic Acid (Isopropyl 2,4-D)					
Equivalent pounds per acre applied	0.00	1.25	2.50	5.00	7.50
Avg. weed counts	3.73	0.50	0.23	0.10	0.13
Butyl ester 2,4-Dichlorophenoxyacetic Acid (Butyl 2,4-D)					
Equivalent pounds per acre applied	0.00	0.85	1.70	3.40	5.10
Avg. weed counts	3.73	0.53	0.23	0.90	0.10

* The F distribution was not significant for the grasses.

TABLE IV

MONTHLY AVERAGE TEMPERATURE, IN DEGREES FAHRENHEIT, AND TOTAL PRECIPITATION, IN INCHES, FOR MAY, JUNE, AND JULY, 1953[1]

Measurement	May	June	July
Temperature (°F.):[2]			
Average	58.6	68.1	71.2
Average maximum	68.7	79.5	82.8
Average minimum	48.4	56.7	59.5
Precipitation (inches):[2]			
Total	2.39	4.09	2.39
Greatest day	0.73	1.14	0.81
Date (greatest day)	5-12-53	6-28-53	7-29-53

[1] These records are from data obtained at the College Experimental Farm by the United States Weather Bureau.

[2] This was determined to be no departure from normal.

TABLE V

DAILY PRECIPITATION, IN INCHES, AND AIR TEMPERATURE AND SOIL TEMPERATURE, IN DEGREES FAHRENHEIT, DURING THE PERIODS OF TREATMENT[1]

Date (1953)	Precipitation	Air Temp.		Temp. 3 in. Above Ground at 8:00 p.m.	Soil Temp. at 8:00 p.m.	
		Max.	Min.		1 in. Below Ground	4 in. Below Ground
5-25	0	80	58	68	65	65
5-26	0.06	72	50	67	69	70
5-27	0	65	47	60	62	64
5-28	0	68	41	59	68	69
5-29	0	76	50	65	69	69
5-30	0.10	87	56	66	73	73
5-31	0	77	52	71	71	71
7-5	0	88	61	81	82	81
7-6	0.40	80	68	70	78	78
7-7	0.16	81	57	72	70	82
7-9	0.04	68	50	*	*	*
7-10	0	75	48	*	*	*
7-11	0	78	51	*	*	*

[1] These records are from data obtained at the College Experimental Farm by the United States Weather Bureau.

* No data.

aberrations which may result in changes to the plant tissue, it was decided to investigate whether or not this did occur. No chromosome aberrations were found in meiosis in any of the daughter plants in any treatment, and the chromosome count of the treated and untreated plants was 56 (Plate I). This was true for both the Premier and Robinson varieties.

When the yield of fruit from the various treatments was determined, it was found that the response of the Robinson variety to the CIPC treatments varied as follows (Figure 7, Table VI): The plants responded to the 500 and 1,000 ppm solutions when applied twice, with an increase in the yield per plant and in the total yield when compared to those concentrations applied only once. At the two highest concentrations, 2,000 and 3,000 ppm, the greatest yield per plant and total yield was obtained from those treated only once. When compared to the control, the yield per plant remained about the same, while the total yield was greatly increased, probably due to the increase in the number of stolons mentioned previously. It is peculiar that when one application at the 2,000 ppm level was applied, the Robinson responded with an increase in the number of stolons and the yield per plant; this in spite of the increased competition for the available moisture and nutrients.

PLATE I

PHOTOMICROGRAPHS OF MEIOTIC MATERIAL FROM STRAWBERRY PLANTS SPRAYED THE PREVIOUS SUMMER

(all material studied was determined to be normal)

1. Diakinesis. Blossom buds taken from a plant of the Premier variety, treated with CIPC, 1,000 ppm, on May 26, and again on July 6, 1953. X 1250.

2. First Metaphase. Taken from a plant of the Premier variety, treated with butyl 2,4-D, 500 ppm, on May 26, 1953. X 1250.

3. Diads. Same slide as (1) above. X 1250.

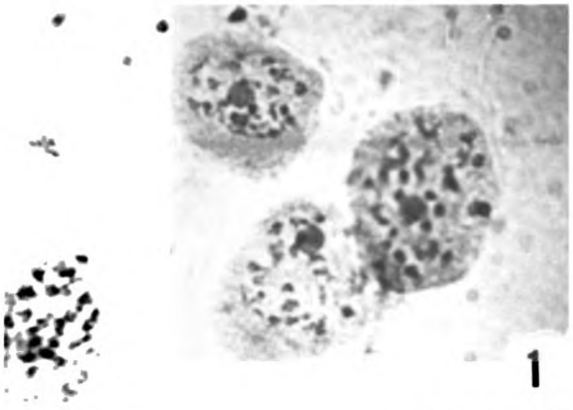
4. Second Metaphase and Second Anaphase. Same slide as (2) above. X 1250.

5. Tetrads. Taken from a plant of the Premier variety, treated with CIPC, 3,000 ppm, on May 26, and again on July 6, 1953. X 1250.

6. Fresh Pollen. Taken from a control plant of the Robinson variety. X 450.

Scale: For photographs 1, 2, 3, 4, and 5, each division equals 10μ. For photograph 6, each division is approximately equal to 100μ.

Photographed from permanent slides by P. G. Coleman, Agricultural Experiment Station Photographer.



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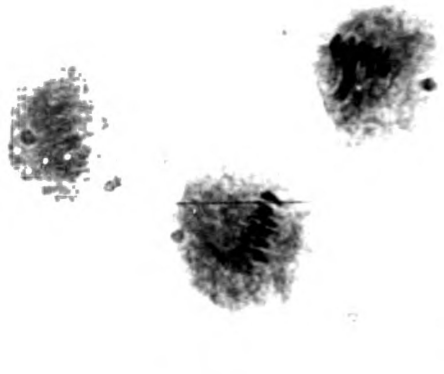

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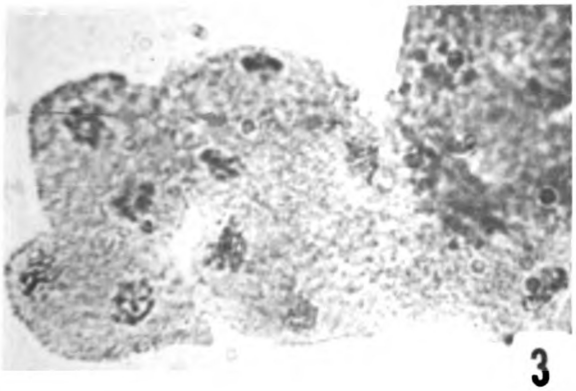

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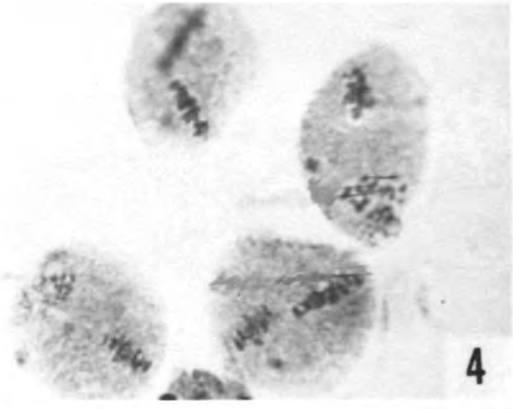

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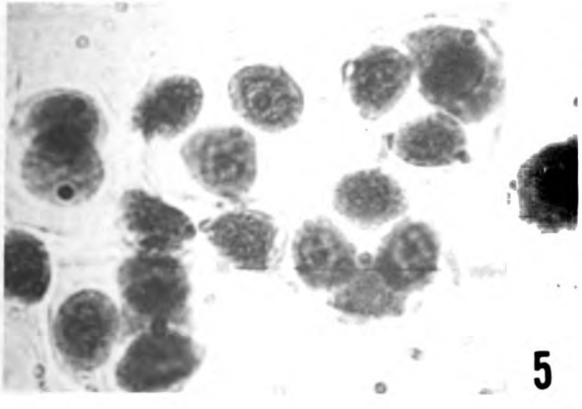

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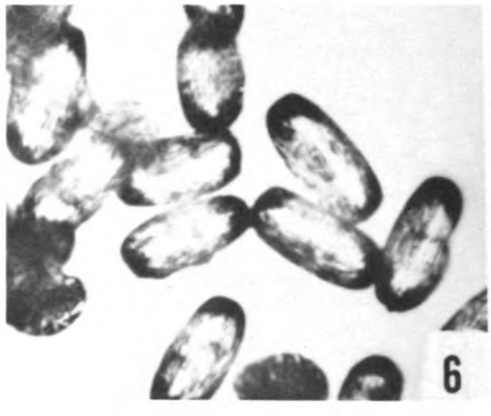

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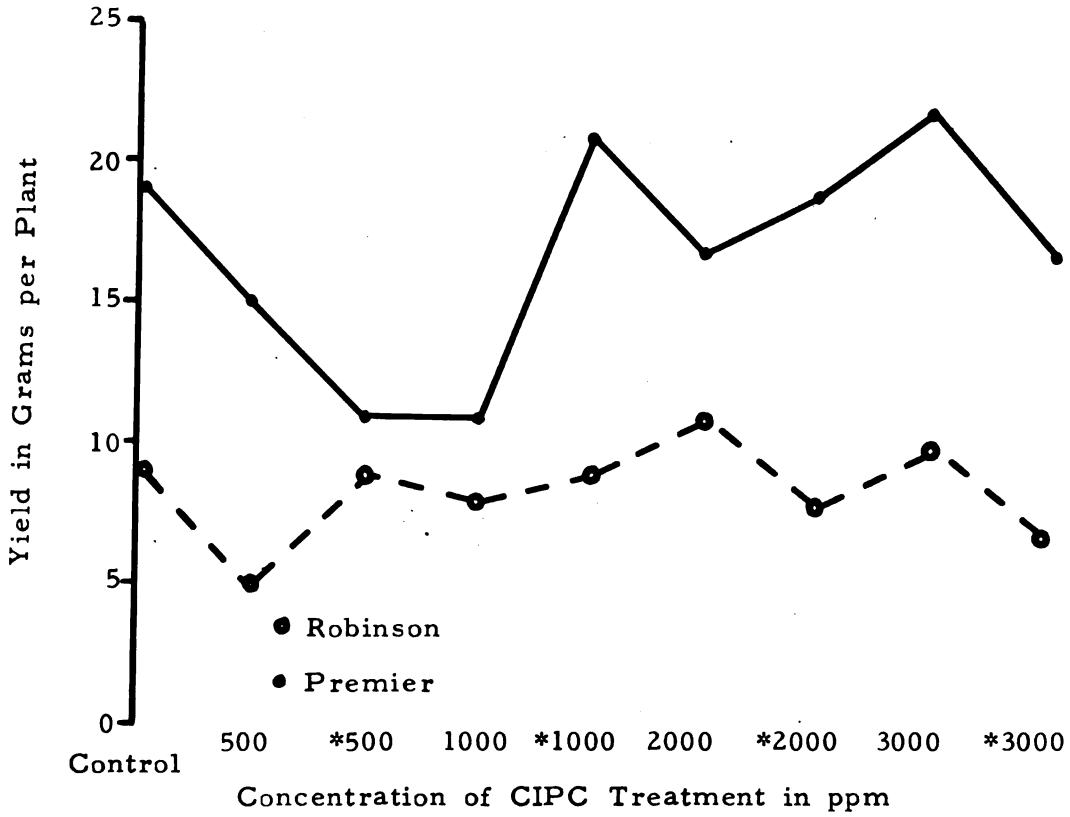
Figure 7. A comparison of the fruit harvest of the Premier and Robinson varieties of strawberries when treated for weed control with various concentrations of Isopropyl n-(3-chlorophenyl) carbamate.



* All plots received an application on 5-26-53 and those marked with an asterisk received a second one on 7-6-53.

TABLE VI

THE TOTAL NUMBER OF ESTABLISHED STOLONS AND THE ACTUAL WEIGHT IN GRAMS OF FRUIT HARVESTED FOR THE PREMIER AND ROBINSON VARIETIES OF STRAWBERRIES FROM THE DIFFERENT WEED-CONTROL TREATMENTS

Treatment (ppm)	Premier Variety		Robinson Variety	
	Mother and Stolon Plants	Yield of Fruit	Mother and Stolon Plants	Yield of Fruit
None	240	4531	312	2769
Isopropyl n-(3-chlorophenyl) Carbamate				
500	188	2911	459	2361
500*	292	3284	511	4715
1000	90	1015	302	2424
1000*	160	3415	407	3955
2,000	178	3055	367	4211
2000*	253	4566	306	2587
3000	252	5595	353	3594
3000*	106	1824	391	2742
Isopropyl 2,4-Dichlorophenoxyacetic Acid				
500	165	1918	204	2724
500*	153	2712	118	1823
1000	217	4090	364	4737
1000*	148	2920	475	5175
2000	34	460	171	1932
2000*	45	1594	40	476
3000	37	619	106	1496
3000*	17	722	19	665

TABLE VI (Continued)

Treatment (ppm)	Premier Variety		Robinson Variety	
	Mother and Stolon Plants	Yield of Fruit	Mother and Stolon Plants	Yield of Fruit
	Butyl 2,4-Dichlorophenoxyacetic Acid			
500	224	4636	262	3044
500*	87	1084	59	628
1000	182	1881	132	1159
1000*	118	3218	213	2766
2000	135	2158	118	1733
2000*	60	1330	19	383
3000	135	2205	89	2762
3000*	26	687	0	0

* All plots received an application on 5-26-53, and those marked with an asterisk received a second one on 7-6-53.

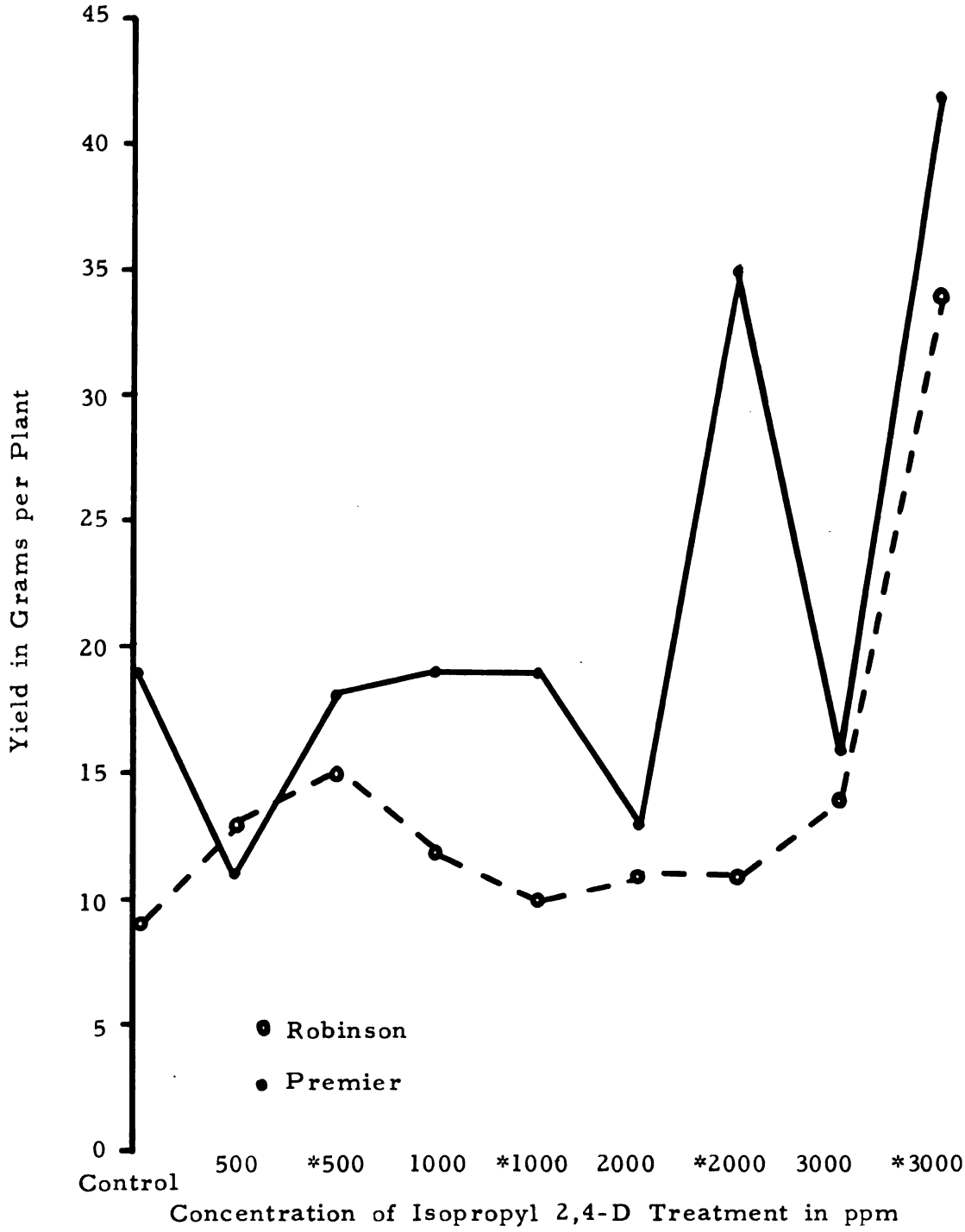
The Premier variety differed in response to the CIPC treatments in that, at the lower concentrations, the yield per plant and the total yield were consistently reduced when compared to the control (Figure 7, Table VI). At the higher concentrations, the yield per plant and the total yield compared to it, or remained about the same as the control. The Premier variety responded with a reduced yield per plant when the concentrations of CIPC were such that there were fewer established stolons, hence less competition for available moisture and nutrients.

The Robinson variety responded to the isopropyl 2,4-D with a slight increase in the yield per plant at the lower concentrations and at the highest concentration the greatest, or 34 grams per plant (Figure 8, Table VI). The total yield was reduced at all concentrations except the 1,000 ppm level, whether sprayed once or twice. At this level the number of established stolons was increased over that of the control, and the total yield was therefore increased.

The Premier variety responded with a reduced yield per plant and lesser total yield, despite fewer stolons, when sprayed with isopropyl 2,4-D regardless of the concentration (Figure 8, Table VI).

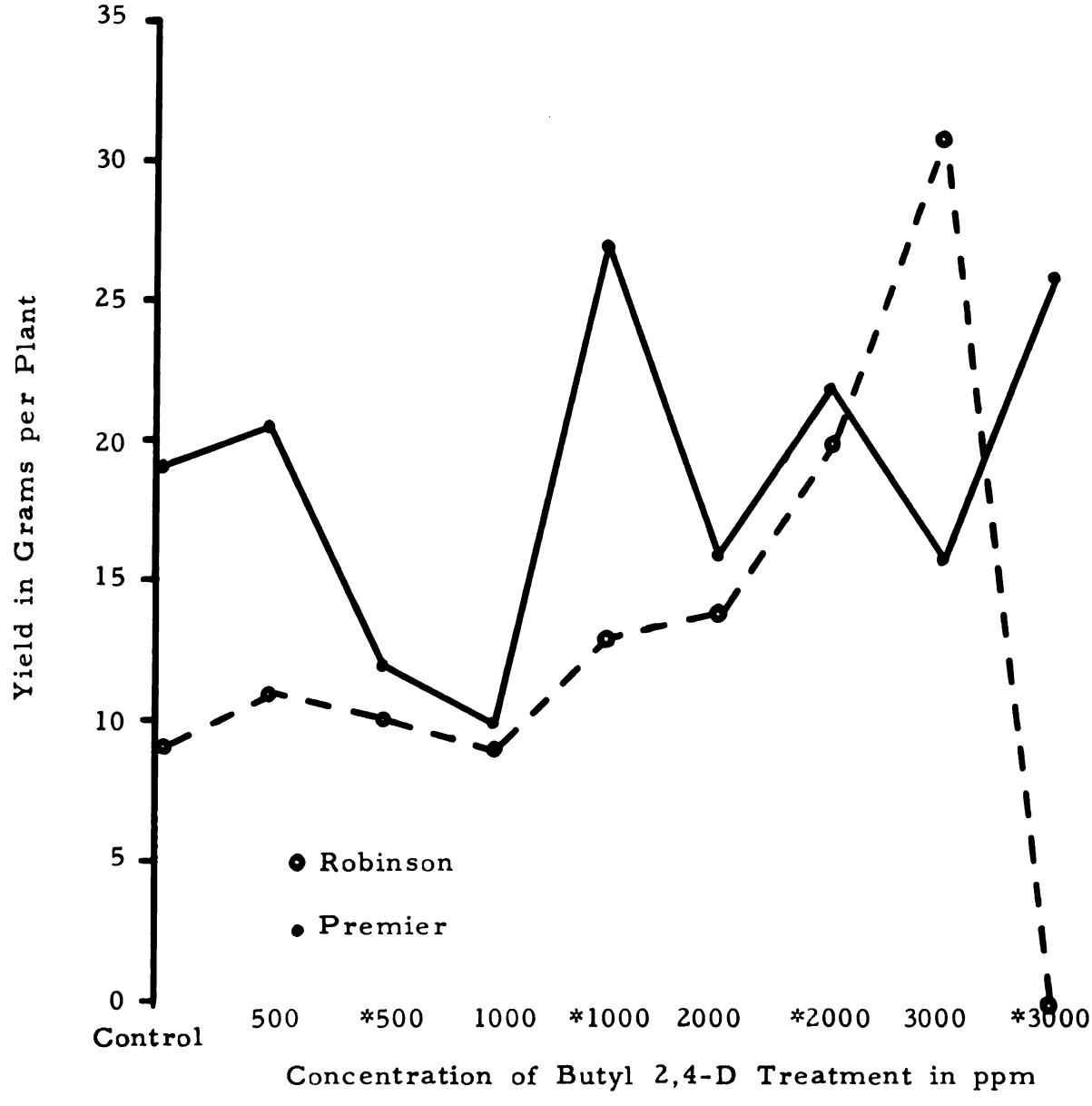
The response of both varieties to the butyl 2,4-D was similar to that from the isopropyl 2,4-D (Figure 9, Table VI). However, at

Figure 8. A comparison of the fruit harvest of the Premier and Robinson varieties of strawberries when treated for weed control with various concentrations of Isopropyl 2,4-Dichlorophenoxyacetic acid.



* All plots received an application on 5-26-53 and those marked with an asterisk received a second one on 7-6-53.

Figure 9. A comparison of the fruit harvest of the Premier and Robinson varieties of strawberries when treated for weed control with various concentrations of Butyl 2,4-Dichlorophenoxyacetic acid.



* All plots received an application on 5-26-53 and those marked with an asterisk received a second one on 7-6-53.

the lowest concentration, or 500 ppm of solution, the plants responded with an increase in yield per plant and a greater total yield. The increased yield per plant may have been due to the fewer established stolons and reduced competition for available moisture and nutrients.

SUMMARY

1. The Robinson and Premier varieties of strawberries were treated with isopropyl n-(3-chlorophenyl) carbamate (CIPC); isopropyl ester of 2,4-dichlorophenoxyacetic acid (isopropyl 2,4-D); and butyl ester of 2,4-dichlorophenoxyacetic acid (butyl 2,4-D) at four different concentrations.

2. Isopropyl 2,4-D and butyl 2,4-D at the rates used satisfactorily controlled the broad-leaved weeds, but not the grasses. CIPC gave variable results in the numbers of broad-leaved weeds controlled, but did not control the grasses.

3. There was a definite difference in the response of the strawberries due to the different chemicals. Plants treated with butyl 2,4-D showed greater injury than plants treated with the isopropyl 2,4-D or the CIPC in every criterion used with both varieties.

4. There were definite varietal differences between the plants due to the chemicals, as follows:

   (a) As a result of treatment with CIPC, the Robinson variety of strawberry produced a greater number of stolons than did the untreated plants without reducing the yield of fruit per plant, and hence total yield was increased.

As a result of treatment with CIPC, the Premier variety apparently was injured; the number of stolons, the yield per plant, and the total yield were reduced.

(b) When the Robinson variety was treated with isopropyl 2,4-D, stolon production was inhibited; this resulted in a greater yield per plant. However, the total yield was reduced in most cases probably as a result of fewer plants.

When the Premier variety was treated with isopropyl 2,4-D, stolon formation, yield per plant, and total yield were markedly reduced.

(c) Both the Premier and Robinson varieties of strawberry were injured following treatment with butyl 2,4-D; this is reflected in a reduction in stolon production, yield per plant, and total yield. The injury was more pronounced than with isopropyl 2,4-D.

5. Cytological examinations of meiotic material taken the spring following the treatments revealed no permanent injury or chromosomal changes to the plants in either variety.

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