SOME EFFECTS OF SODIUM 2, 4- DICHLOROPHENOXY ETHYL SULFATE (CRAG HERBICIDE 1) ON BLAKEMORE STRAWBERRY PLANTS

by

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INTRODUCTION

The history of weeds is older than the recorded history of human beings. Robbins and Weier (1952, p. 2) mentioned that our first evidence of man on the earth dates back to approximately 1,500,000 years ago, and our first evidence of plant cultivation was in the stone age about 6,000 B. C.

Weeds have been undesirable companions of cultivated field crops, orchard trees and vines, and garden crops through the ages, and still continue to be so in spite of the tremendous amount of money and labor used to control them. Robbins, Crafts, and Raynor (1942, p. 12) indicated that losses due to weeds have been estimated to exceed the combined losses from diseases of livestock and plants and insect pests of the animal and plant kingdoms. They also stated that the yearly reduction in yield of all field, orchard, and garden crops due to weed competition has been estimated at about 10 percent of their annual value. By 1934, over 5 million acres of valuable land in the United States were infested with noxious perennial weeds. Ahlgren, Klingman, and Wolf (1951, p. 9) gave $5,000,000,000 as a recent figure for annual losses from weeds in the United States.

Weeds interfere with agricultural operations, harbor insects and plant diseases, increase cost of labor, add to the cost of production, and reduce yields of economical crops by competing for space, moisture, mineral nutrients, and light. The advent of the use of chemical sprays for the control of weeds was one of the great agricultural milestones of recent years. Remarkable progress

in the use of chemicals for control of weeds has been made since 1942 when the growth regulating properties of 2, 4- dichlorophenoxy acetic acid were discovered by Zimmerman and Hitchcock.

Shoemaker (1950, p. 1) reported that strawberries formed about 25 percent of the total acreage of small fruits in the United States and were grown on about 200,000 acres of land which yielded about 300,000,000 quarts of fruit annually with a return which amounted to over 30 million dollars. In Kansas, most of the strawberry plantings were located in the northeastern section of the state. It was estimated that an acreage of 1,200 acres annually was devoted to this crop in the state.

Because of its low habit of growth, the strawberry plant is not able to compete with weeds as successfully as other fruits. Therefore, cultivation is necessary to control the weeds. Whether by hand or with power equipment, this cultural practice is expensive and represents one of the largest production costs. Growers are interested in anything that will reduce their growing costs including chemical weed control. The use of any chemical for weed control in cultivated crops, such as strawberries, is not practical if the chemical in question produces phytotoxic effects on the crops.

The purpose of this study was to determine some of the effects of sodium 2, 4- dichlorophenoxy ethyl sulfate (Crag Herbicide 1) on strawberry plants at different rates of application. Emphasis was placed on observing the results of applications of this chemical on total growth, runner production, plant production, rooting of runner plants, length of the leaf petioles, length and width of

leaflet blades, size of the root system, and carbohydrate and ash content of strawberry plants. The phytotoxicity of the chemical also was studied. The work was conducted at the Horticulture Farm near Manhattan, Kansas, and at the greenhouses of Kansas State College, Manhattan, Kansas.

LITERATURE REVIEW

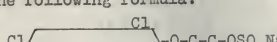
History

According to Blackman (1948), the most exciting discovery of selective action of plant hormones was made by Templeman in England in 1940 when he found that alpha-naphthyl acetic acid sprayed on oats killed charlock weeds without injuring the oats. Akamine (1948) indicated that, in the United States, the credit for suggesting the first use of plant growth regulators as herbicides was given to E. J. Kraus of the University of Chicago who was claimed to have suggested the idea as early as 1941.

King and Lambrech (1949), Finn (1951), and Woodward (1952) reported that sodium 2, 4- dichlorophenoxy ethyl sulfate was developed and tested in the laboratory and greenhouses of the Boyce Thompson Institute of Plant Research. In 1946, initial tests of the material were made at the New Jersey Agricultural Experiment Station. Later, it was given extensive field testing by various experiment stations and private agencies. The chemical is formulated and sold under the trade name of Crag Herbicide 1 by the Carbide and Carbon Chemical Company. It will be referred to here-

after as CH 1.

According to reports of Carroll (1952) and Vlitos (1952), CH 1 has the following formula:



It is a stable, nonvolatile, white crystalline solid which melts at 370° F. and is readily soluble up to 25 percent by weight in distilled water at room temperature.

Denisen (1952) recommended that the chemical should be washed off the hands and should never be allowed to get into the eyes because it may cause a skin irritation. In tests thus far conducted, the material has not appeared toxic to human beings.

Translocation

Crafts (1949) suggested that, in order to be readily absorbed from the soil by roots, herbicides applied to the soil should be in the form of dissociable salts or as compounds that will hydrolyze in the soil. Herbicides applied to the leaves of plants, in order to be absorbed into the living tissue, must penetrate the cuticle. This is a waxy coating, non-polar in nature, with a residual negative electrostatic charge. Negative ions in solution are repelled by the cuticle, and positive ones are attracted and held on the surface. This factor probably is the reason for undissociated substituted phenol and phenoxy acetic molecules being more effective than salts.

The failure of CH 1 to be absorbed from the surfaces of plant

foliage was suggested by Carroll (1952) to be due to its inability to be translocated from the surfaces of plant leaves to the phloem tissue in order to be carried downward to other parts of the plant. The chemical was found to move rapidly upward through the xylem when applied on stems and roots.

Activation

Hydrogen Ion Concentration. Carroll (1952) found that lowering the pH value increased the phytotoxicity of CH 1 solutions. Under acid conditions, the chemical hydrolyzed to yield 2, 4- dichlorophenoxy ethanol and sodium bisulfate. Vlitos (1952) suggested that a microbial factor was necessary in the chemical conversion of the herbicide in soils having a pH of 5.5 to 7.0. Below pH 5.5, the breakdown of the chemical to its active form was produced without microbial action. There was no observable activation at pH 8.0.

Sterilization. Results obtained by King (1950) showed that the percent of corn root elongation inhibition was very high when the chemical was applied to unsterilized soil, and that sterilization had a definite decreasing effect on the chemical's toxic activity. Therefore, the herbicidal property of the chemical was suggested by Finn (1951) to be due to its conversion to an active toxicant by soil micro-organisms. Bacillus cereus var. mycoides were found to be effective in such conversions which led Vlitos (1952) to suggest the possibility of an enzymatic hydrolysis. Carroll (1951) also suggested the hydrolysis of the chemical to its

active form 2, 4- dichlorophenoxy ethanol either in the presence of micro-organisms or acid conditions.

Temperature. A few reports have been made by field workers indicating that CH 1 is more effective at high temperatures than at cool temperatures. This idea was developed by Vlitos (1952) who reported that the herbicidal form of CH 1 was found to be present in the soil more readily at high temperatures (75.2° F. and 86.0° F) but little or no herbicidal action was observed at low temperatures (32.0° F.).

Soil Moisture. Water leaches CH 1 from the soil rather readily, so heavy rains falling shortly after an application will decrease the chemical's herbicidal potency. Likewise, the chemical was not highly effective during periods of drought if no moisture were present in the surface layer of the soil as found by Isleib (1952).

Ellison (1952) observed no significant difference in yields of Katahdin potatoes treated with CH 1 which received no rain or irrigation within 4 days after the treatment. One inch of simulated rain less than 24 hours after the treatment decreased the yields of potatoes. The effect of moisture on increasing the activity of the chemical was thought by Carroll (1951) to be due to the hydrolysis to its active herbical form 2, 4- dichlorophenoxy ethanol in the presence of micro-organisms or acid condition.

Finn (1951) confirmed the effect of moisture on CH 1 activation by stating that the chemical must come in contact with moist soil in order to be converted to its active form.

Labor Savings

Carlson and Moulton (1951) have noted that CH 1 reduced the hand labor in strawberries from 63.3 hours to 18.8 hours per acre when applied at 4 pounds per acre rate. Denison (1952) observed that, in newly established Robinson strawberry beds, the hand labor needed for hoeing was cut 70 percent by CH 1 applications. King (1952) stated that the labor required to maintain weed free plantings of strawberries has been reduced as much as 76 percent when CH 1 was used.

Weed Control

Reports of King and Lambrech (1949), King (1950), Lachman (1951), Finn and King (1951), Jacob (1952), and Hemphill (1952) indicated that CH 1 at 1 pound per acre concentration gave moderate control of weeds in lima beans and corn but no control in strawberries.

The chemical at 2 pounds per acre rate gave satisfactory weed control in sweet corn, field corn, asparagus, lima beans, soybeans, beans, and strawberry plantings according to results obtained by King, Lambrech and Finn (1950), Fuellman (1950), Finn and King (1951), Finn (1951), Jacob (1952), Danielson (1952), Veatch (1952), and Bailey (1952). Satisfactory control of weeds was not obtained in strawberry plantings when 2 pounds per acre applications were used by Hemphill (1950).

Satisfactory to excellent weed control was reported by King and Lambrech (1949), King, Lambrech, and Finn (1950), King (1950),

Gilbert and Wolf (1950), Aldrich and Puffer (1951), Carlson and Moulton (1951), Carlson, Moulton, and Krone (1951), Lachman (1951), Finn and King (1951), Finn (1951), and Marshall (1952) when CH 1 was applied at the rate of 3 pounds per acre on lima beans, corn, gladiolus, and strawberries.

Hemphill (1950)(1951), Fuellman (1950), Hemphill and Roberts (1951), Marshall (1952), Bailey (1952), Denisen (1952), and Woodward (1952) indicated excellent weed control when 4 pounds per acre of CH 1 were used on corn, soybeans, and strawberries.

Very satisfactory results were obtained when the chemical was used at the 5 pounds per acre rate to control weeds in lima beans by King and Lambrech (1949) and Noll and Odland (1952).

Reports of Gilbert and Wolf (1950), Kachman (1951), Hemphill and Roberts (1951), Bailey (1952), and King (1952) indicated that CH 1 at 6 pounds per acre gave excellent weed control in strawberries and black and red raspberries.

Further reports by Hemphill and Roberts (1951), Noll and Odland (1952), and Bailey (1952) have shown the chemical to be effective against weeds among strawberries and lima beans when applied at 7.5 and 8 pounds per acre rates.

Experiments conducted by King and Lambrech (1949), King, Lambrech, and Finn (1951), King (1950), Gilbert and Wolf (1950), and Finn (1951) demonstrated that the following weeds were controlled effectively with CH 1 applications: crab grass, chickweed, purslane, carpetweed, lamb's quarter, redroot, low ragweed, velvet leaf, and foxtail.

Phytotoxic Effects

Reports of King and Lambrech (1949), Carlson, Moulton, and Krone (1951), Ellison and Jacob (1951), King (1951), Finn (1951), Jacob (1952), Marshall (1952), and Finn, King, and Vlitos (1952) indicated that CH 1 applications at the rate of 2 pounds per acre caused no phytotoxic effects on the plants nor reduced the yields of snapbeans, lima beans, alfalfa, gladiolus bulbs, potatoes, asparagus, corn, petunias, marigolds, verbenas, and strawberries.

Investigations of other workers, Stahler (1949), Dutton (1949), Hemphill and Roberts (1951), Denisen (1951), Danielson, Marshall, and Van Geluwe (1952), Sweet and Ries (1952), and Jacob (1952), showed that the chemical at 2 pounds per acre was injurious to flax, lima beans, soybeans, commercial sunflowers, barley, baby lima beans, red kidney beans, cucumbers, muskmelons, and strawberries. The chemical caused 10 to 30 percent reduction in vigor and stand of barley, decreased the number of strawberry plants and their total yields, and reduced the percent of their rooted runners. It caused about 50 percent injury to cucumbers and muskmelons with general reduction of their stand. Baby lima beans were damaged more than red kidney beans.

King and Lambrech (1949), Gilbert and Wolf (1950), Aldrich and Puffer (1951), Carlson and Moulton (1951), Carlson, Moulton, and Krone (1951), Ellison and Jacob (1951), Finn and King (1951), Finn (1951), Islieb, Aldrich and Bell (1952), Lachman (1952), and Finn, King, and Vlitos (1953) demonstrated no apparent phytotoxic effects due to CH 1 applications at the rate of 3 pounds per acre

on lima beans, snapbeans, gladiolus bulbs, asters, and strawberries. Other investigators, King (1950), Lachman (1951), Jacob (1951), Marshall (1952), and Lachman (1952), reported a delay in growth and slight to significant injury to corn by stunting the plants, injurious effects on snapbeans and cauliflower, and reduction in stand of lima beans.

The chemical at 4 pounds per acre rate applied on flax, gladiolus bulbs, potatoes, and strawberries caused no injurious effects according to Stahler (1949), Carlson and Moulton (1951), Carlson, Moulton, and Krone (1951), Ellison and Jacob (1951), Bailey (1952), and Isleib, Aldrich, and Bell (1952). Reports of other workers, Helgeson (1949), Mavis and Moore (1951), Denisen (1951), Marshall (1952), Denisen (1952), and Kolbe and Childs (1953), using the same concentration showed a reduction in growth, rooted runners, yield, and runner plants of strawberries. The chemical also injured corn and reduced the stand of sugar beets.

Applications of 5 pounds per acre rate caused no injurious effects on lima beans and snapbeans as stated by King and Lambrech (1949), but Noll and Odland (1950) found a significant reduction in yield and stand of lima beans due to the applications of the same concentration.

Gilbert and Wolf (1950), Carlson and Moulton (1951), Finn and King (1951), Bailey (1952), and Isleib, Aldrich, and Bell (1952) reported no injurious effect on strawberries and asparagus due to 6 pounds per acre applications of the chemical. Lachman

(1951) and Hemphill and Roberts (1951) indicated a reduction in number of plants and yield of strawberries and a decrease in marketable ears of corn due to the same concentration.

Noll and Odland (1950) applied CH 1 at 7.5 pounds per acre rate on lima beans and reported a reduction in yield and stand of the plants. Bailey (1952) used the chemical at 8 pounds per acre rate on strawberries and observed no injurious effects, but Denisen (1951) reported a reduction in number of rooted runners and yield of strawberries at the same concentration.

Denisen (1951) sprayed CH 1 at 2, 4, and 8 pounds per acre rates on spring planted Dunlap strawberries in June and found the percents of rooted runners in treatments compared with the unsprayed checks were 87 for 2 pounds per acre, 74 for 4 pounds per acre, and 45 for 8 pounds per acre. Denisen (1952) investigated the effects of CH 1 on strawberries and found that the chemical has no effect on leaves when sprayed on the foliage, but caused slight reduction in runner plants.

Field observations made by Isleib, Aldrich, and Bell (1952) of the gross morphological responses of strawberry plants treated with 3, 4, and 6 pounds per acre rates showed that the above-ground parts of the plants were not markedly affected, but generally untreated plants made more total growth than treated plants. The growth of roots and tops was inhibited due to the treatments, but root development as observed through the glass in the flats appeared to be retarded more by chemical treatments in the early stages of the experiment. At harvest time, treated plants had

outgrown an initial retardation. Greenhouse experiments also showed this initial retardation.

Kolbe and Childs (1953) applied CH 1 on strawberries at 4 pounds per acre rate and their results showed that plots receiving the chemical once per week gave an indication of some injury and runner plants were rooted slowly. Hemphill and Roberts (1951) found that CH 1 applications at 4 pounds per acre as a preplanting spray followed the 2 summer foliage applications of 2 pounds per acre decreased the number of strawberry plants and their total yields.

FIELD EXPERIMENT

Materials and Methods

One year old Blakemore strawberry plants were used for this experiment. A total of 300 strawberry plants were planted at the Horticulture Farm near Manhattan, Kansas, on March 29, 1952. The strawberry plants were set 2 feet apart in rows 30 feet long and 4 feet apart.

Four treatments of 2, 4, 6, and 8 pounds per acre of CH 1 were used. The chemical, which had a 90 percent active ingredient by weight, was supplied by the Carbide and Carbon Chemical Company. Each of the four treatments was repeated four times as was an unsprayed control. The sections of rows used for the four different treatments and the control were selected at random.

On April 27, 1952, the first spray of the chemical was applied at the rates of 2, 4, 6, and 8 pounds per acre. For the spray

applications, a compressed air Hudson 5 gallon sprayer with a fan nozzle was used. On June 16, 1952, the second spray and on August 2, 1952, the third spray applications of the same chemical were made. An effort was made in all applications to apply finely atomized spray material on the plant and soil surfaces as evenly as possible. The field was cleared from weeds before each treatment by hand hoeing. Due to high temperatures and low rainfall during the growing season, the plants were irrigated with a sprinkler system when the irrigation was deemed necessary.

The total number of leaf petioles and their length in inches on 12 plants from each treatment, 3 plants from each replication, and length and width in inches of 9 plant leaflets on the same 12 plants used for leaf petiole length and number determination were taken on June 15, 1952, 50 days after the first spraying. The first count of plant leaflets, runner leaflets, runners, runner plants, and rooted runner plants was taken on June 27, 1952, 2 months after the first spraying. The second count was made on July 16, 1952, 1 month after the second spraying.

On January 29, 1953, 4 plants from each treatment, 1 from each replication, were dug out carefully from the soil and washed clean, then placed in the open air until the excess moisture had dried. They were then transferred directly to the laboratory where fresh weights of the roots were taken.

Table 1. Maximum and minimum temperatures for the period from March 29 to September 30, 1952. Horticultural Farm.

Days	March		April		May		June		July		August		September	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1			65	38	84	58	79	53	98	73	101	71	66	54
2			62	31	85	55	91	63	101	66	100	67	75	45
3			50	36	88	53	89	61	91	67	96	69	86	46
4			46	34	88	55	87	64	91	50	94	58	96	56
5			55	26	92	61	84	59	98	60	78	64	97	69
6			60	22	79	61	88	60	102	73	90	59	95	56
7			78	25	84	60	90	66	82	76	94	61	93	55
8			87	42	74	51	94	69	83	48	88	65	96	57
9			37	35	61	50	95	67	93	47	88	63	93	55
10			47	24	61	47	98	63	98	61	96	65	92	68
11			48	30	67	36	98	73	97	63	76	66	90	60
12			44	38	72	32	98	73	98	69	84	54	92	59
13			50	33	78	35	99	75	90	68	94	65	93	66
14			60	32	85	52	100	76	79	65	102	70	74	61
15			64	28	82	50	100	74	73	55	94	69	84	42
16			64	41	55	52	86	76	91	64	94	63	99	60
17			57	45	62	46	93	47	84	69	90	73	92	62
18			68	49	63	49	96	54	92	73	89	65	82	48
19			71	48	68	43	89	66	96	75	96	69	78	40
20			65	54	74	40	102	71	98	75	92	73	68	50

Table 1. (concl.)

Days	March		April		May		June		July		August		September	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
21			77	55	84	57	96	69	102	77	77	67	73	40
22			70	53	73	60	99	66	102	76	84	55	73	43
23			58	45	78	50	101	77	91	71	84	60	81	35
24			63	43	74	56	102	79	100	58	88	57	85	47
25			72	31	82	49	103	79	106	76	86	60	91	53
26			74	38	82	54	99	71	101	69	95	65	85	44
27			82	40	70	59	101	76	106	72	91	74	95	45
28			84	51	75	46	103	76	100	74	95	70	97	56
29	74	43	84	46	82	57	104	74	83	66	85	68	94	46
30	76	53	84	50	75	55	102	67	95	58	90	65	94	53
31	70	58			77	54			97	59	86	58		

Presentation of Data

Temperature and Rainfall. Table 1 shows the maximum and minimum temperatures in degrees Fahrenheit for the period from March 29 to September 30, 1952, at the Kansas State College Horticulture Farm near Manhattan, Kansas. As could be seen in Table 1, during much of the growing season, the temperatures were higher than the optimum temperature required for normal growth of strawberries, 73° F.

Table 2. Total rainfall in inches during the period from March 29 to September 30, 1952, at the Horticultural Farm compared with normal average for 1898 - 1942.

Month, 1952	Total rainfall (inches)	Deviation from the normal average
March		
April	2.27	- 0.39
May	4.17	- 0.26
June	0.27	- 4.34
July	1.39	- 2.34
August	4.75	+ 0.51
September	0.73	- 3.20
Total rainfall	13.58	
Total deficiency		-10.02

The rainfall during the summer months was very low. According to Flora (1948), usually about 70 to 77 percent of the annual total precipitation in Kansas occurs during the period from April to September. Table 2 gives the amount of precipitation during the period from March 29 to September 30, 1952, at the Horticultural Farm near Manhattan.

Lethal Effects. Monthly counts of the number of dead plants were made for the period May to August, 1952. The data collected were analyzed statistically and the analysis of variance revealed that the relative lethal effects of CH 1 sprays at 2, 4, 6, and 8 pounds per acre rates as measured by the number of dead plants were maintained throughout May, June, and July, but dropped sharply in August.

There was a significant difference between the control and various CH 1 treatments used, but the most significant difference was found between the control and the 6 and 8 pounds per acre treatments. The linear component of the sprays in the analysis of variance indicated that the lethal effect was directly proportional to the CH 1 spray concentrations used. Table 3 shows the number of dead plants for each month from May to August for various treatments of CH 1 used.

When the number of dead plants in the control treatment was compared with those of the 2 and 4 pounds per acre treatments, the data showed a small variation, but the difference was very distinctive for the higher concentrations of the 6 and 8 pounds per acre treatments. Therefore, it may be suggested that the chemical at 2 and 4 pounds per acre concentrations, could be used for weed control in strawberry plantings without seriously reducing the stand of the plants.

Effect on Leaf Petiole Length. All petioles were measured on 3 plants in each of four replicated treatments as shown in Table 4.

Table 3. Monthly lethal effects of CH 1 spray applications on Blakemore strawberry plants. Horticulture Farm, 1952.

Month	Total number of dead plants				
	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
May	3	1	6	10	15
June	3	5	4	10	15
July	2	3	3	16	7
August	0	1	2	2	4
Total	8	10	15	38	41
Average	2.00	2.50	3.75	9.50	10.25

Analysis of Variance

Factors	Degrees of freedom	Variance
Months	3	33.3
Sprays	4	62.7**
Control vs. sprays	1	60.5*
Sprays (linear)	1	168.0**
Sprays (residual)	2	11.2
Months X sprays	12	10.0
Total	19	

* Significant at the 5 percent level of confidence.
** Significant at the 1 percent level of confidence.

The data showed a slight decrease in the number of petioles due to 8 pounds per acre treatment, but no difference was observed among the rest of the treatments. The analysis of variance revealed that there was a significant difference at the 5 percent level between the control and four treatments used in average petiole length, but no significant difference was observed among

the treatments. The data indicated that the 2, 4, 6, and 8 pounds per acre spray treatments of CH 1 produced similar reducing effects in the length of petioles on Blakemore strawberry plants.

Table 4. The effects of CH 1 on leaf petiole length in Blakemore strawberry plants. Horticulture Farm, 1952.

	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
Total number of leaf petioles	64	68	65	65	50
Average length of leaf petioles (inches)	3.11	2.77	2.59	2.73	2.67

Analysis of Variance

Factors	Degrees of freedom	Variance
Replications	3	2.67
Treatments	4	2.50
Control vs. spray	1	8.80*
Among treatments	3	0.40
Reps. X treatments	12	2.06
Between plants	20	3.85
Between petioles in plants	272	0.56
Total	311	

* Significant at the 5 percent level of confidence.

Effect on Fresh Weight of Roots. Four strawberry plants, one from each replication of each spray treatment, were lifted from the soil carefully on January 29, 1953, and their roots were washed thoroughly with water, separated from the plants, dried between blotting papers, and weighed. Table 5 shows the average fresh weights in grams of the roots of Blakemore strawberry plants treated with 2, 4, 6, and 8 pounds per acre sprays on April 27, June 16, and August 2, 1952, and the unsprayed control plants.

Table 5. The effects of Crag Herbicide 1 on fresh weight of Blakemore strawberry roots. Horticulture Farm, 1952.

	Treatments				
	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
Average fresh weight in grams	29.4	21.4	21.8	21.5	15.3

Analysis of Variance

Factors	Degrees of Freedom	Variance
Replications	3	48.84
Treatments	4	101.16
Control vs. spray	1	296.06*
2-4-6 vs. 8 lbs./A	1	105.91
Other comparisons	2	1.35
Reps. X treatments	12	54.67
Total	19	

* Significant at the 5 percent level of confidence.

The analysis of variance of the data showed there was a significant difference between the control and the various treatments used, but no significant differences were found among the four treatments. The effect of 8 pounds per acre on the fresh weight of the roots was slightly greater than 2, 4, and 6 pounds per acre treatments. The data seemed to indicate that all CH 1 treatments were effective in reducing the weight of roots. Plates I, II, III, IV, and V show the effect of the chemical on the size of root systems. The greatest reducing effect could be observed in the 8 pounds per acre spray applications.

Effect on Plant Leaflets. All the plant leaflets of all sprayed treatments and the unsprayed controls were counted twice. The mean number of plant leaflets counted on June 27 and July 16, 1952, are shown in Table 6. Due to the considerable variation of counts, the following method of statistical analysis was used in order to obtain the significance of variations. The single degree of freedom for control vs. treatments was computed, and the sum of squares for among treatments was obtained by subtracting the sum of squares with one degree of freedom from the total sum of squares for treatments. The linear comparison among the treatments was then computed for means and percentage of sum of squares of means. This percentage was then multiplied by residual sum of squares obtained above and this percentage of squares was assigned to linear comparison among the treatments. The statistical analysis of variance showed, in both counts, that there was a direct linear relation between the decrease in number of leaflets and the increase in amount of chemical spray concentration.

EXPLANATION OF PLATE I

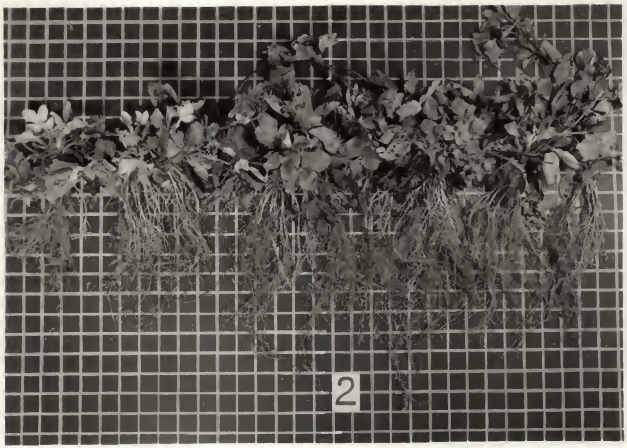
Root systems of unsprayed Blakemore strawberry plants. Horticulture Farm, 1952.

PLATE I

EXPLANATION OF PLATE II

Blakemore strawberry plants sprayed with CH 1 at the rate of 2 pounds per acre. Horticulture Farm, 1952.

PLATE II



EXPLANATION OF PLATE III

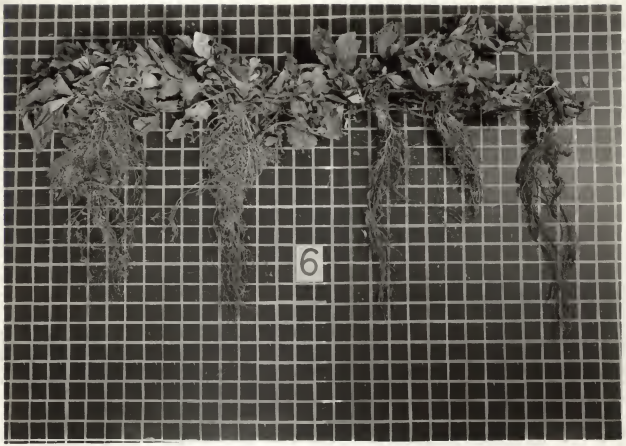
Blakemore strawberry plants sprayed with CH 1 at the rate of 4 pounds per acre. Horticulture Farm, 1952.

PLATE III

EXPLANATION OF PLATE IV

Blakemore strawberry plants sprayed with CH 1 at the rate of 6 pounds per acre. Horticulture Farm, 1952.

PLATE IV



EXPLANATION OF PLATE V

Blakemore strawberry plants sprayed with CH 1 at the rate of 8 pounds per acre. Horticulture Farm, 1952.

PLATE V

Table 6. The effect of CH 1 treatments on the number of plant leaflets of Blakemore strawberry plants. Horticulture Farm, 1952.

Date of count	Average number of plant leaflets per plant				
	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
June 27	20.5	24.1	20.2	16.1	14.7
July 16	23.8	28.2	24.0	23.5	20.7

Analysis of Variance

Factors	D.F.	Variance (first count)	D.F.	Variance (second count)
Replications	3	73.7	3	132.3
Treatments	4	687.8	4	352.8
Control vs. spray	1	91	1	19
Spray (linear)	1	2562**	1	1281**
Spray (residual)	2	49	2	111
Reps. X treatments	12	210.6	12	121.5
Sampling	250	105.0	224	137.8
Total	269			

** Significant at the 1 percent level of confidence.

The average increase in the number of leaflets was about the same for the control and the 2 and 4 pounds per acre treatments, while the 6 and 8 pounds per acre sprays showed a decrease in the number of leaflets at the time of the first count. The plants in both treatments seemed to grow considerably and the average number of plant leaflets for the 6 pounds per acre treatment at the second count was similar to that of the control. However, the 8

pounds per acre treatment, in spite of considerable gain in the number of plant leaflets, was still lower than all other treatments at the second count.

Generally, there was no significant difference between the treatments as a whole and the control. It seemed that 2 pounds per acre application induced a slight stimulating effect by increasing the number of plant leaflets, and 6 and 8 pounds per acre applications had some growth retarding effect at the start, as shown by the first count, but the plants regained their growth gradually and there was no considerable difference among all treatments at the time when the second count was made.

Effect on the Number of Runners. The data showed that the chemical exerted a reducing effect on runner production. There was a linear decrease in the number of runners due to an increase in the concentration of the chemical. For the first count, there was no significant difference between the control and the four treatments used. However, a significant difference between the control and various treatments was observed on the second count. A similar effect was obtained with 6 and 8 pounds per acre treatments on the July count. This suggested that the chemical at 6 pounds per acre and higher concentrations definitely reduced runner production.

Generally, it seemed that a significant reduction in the number of runners may result due to CH 1 spray applications on strawberries. This reduction was found to be directly proportional to the chemical concentrations, until the 6 pounds per

acre limit was reached, where the effect tended to remain constant.

Table 7. The effect of CH 1 on the number of runners of Blakemore strawberry plants. Horticulture Farm, 1952.

Date of count	Average number of runners per mother plant				
	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
June 27	1.29	1.45	1.05	0.71	0.78
July 16	2.12	1.72	1.46	0.95	0.95

Analysis of Variance

Factors	D.F.	Variance (first count)	D.F.	Variance (second count)
Replications	3	3.00	3	3.67
Treatments	4	5.08	4	12.25
Control vs. spray	1	3.00	1	28.0**
Spray (linear)	1	13.00*	1	19.0**
Spray (residual)	2	2.50	2	1.0
Reps. X treatments	12	2.75	12	3.33
Sampling	250	2.09	224	2.81
Total	269			

* Significant at the 5 percent level of confidence.
** Significant at the 1 percent level of confidence.

Effect on Runner Plants. The second count showed an increase in the average difference among the treatments and there was a significant difference at the 1 percent level between the

control and chemical treatments. There was no significant difference among the chemical treatments used, but generally all treatments induced approximately similar effects on the production of runner plants.

Table 8. The effects of CH 1 on the number of runner plants on Blakemore strawberry plants. Horticulture Farm, 1952.

Date of count	Average number of runner plants per mother plant				
	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
June 27	1.69	1.59	1.32	0.83	1.11
July 16	2.82	2.33	2.03	1.33	1.46

Analysis of Variance

Factors	D.F.	Variance (first count)	D.F.	Variance (second count)
Replications	3	3.33	3	11.00
Treatments	4	6.50	4	17.75
Control vs. sprays	1	9.0	1	41.00**
Spray (linear)	1	9.0	1	25.00
Spray (residual)	2	4.0	2	2.50
Reps. X treatments	12	6.83	12	7.08
Sampling	250	4.26	224	8.02
Total	269		243	

** Significant at the 1 percent level of confidence.

Table 9. The effect of Crag Herbicide on the number of runner plant leaflets on Blakemore strawberry plants. Horticulture Farm, 1952.

Date of count	Average number of runner leaflets per plant				
	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
June 27	11.5	12.0	9.7	5.3	8.9
July 16	27.6	23.1	19.2	13.1	14.3

Analysis of Variance

Factors	D.F.	Variance (first count)	D.F.	Variance (second count)
Replications	3	440.7	3	1042
Treatments	4	379.5	4	1743
Control vs. sprays	1	259	1	3098
Spray (linear)	1	509	1	3204
Spray (residual)	2	375	2	335
Reps. X treatments	12	525.5	12	999
Sampling	250	247.0	224	758
Total	269		243	

Effect on Runner Plant Leaflets. Of the 270 plants, 145 or about 54 percent had no runner plant leaflets on June 27, 1952, and 105 of 244, or about 41 percent, still had no runner plant leaflets on July 16, 1952. The analysis of variance for the first and second counts showed no significant differences among all treatments. Generally, there was a slight reduction in the number of runner plant leaflets due to the increased

concentration of the chemical, but no treatment was significantly effective when compared with a subsequent one. Table 9 shows the average number of runner plant leaflets for all treatments.

Table 10. The effect of CH 1 on the rooting of runner plants on Blakemore strawberry plants. Horticulture Farm, 1952.

	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
Total number of mother plants	57	55	54	39	39
Total runner plants	161	128	110	52	57
Total runner plants rooted	111	93	72	30	45
Average number of runner plants rooted per plant	1.94	1.69	1.33	0.77	1.13

Effect on Rooting of Runner Plants. No analysis of variance was computed for the June 27, 1952, count due to an insufficient number of rooted runner plants, 26 out of 270. On July 16, 1952, about 40 percent of the runner plants were rooted.

The analysis of variance for the July count disclosed no significant difference in any of the treatment comparisons. Therefore, it is not stated here. Generally, there was a slight reduction in the average number of rooted runners due to the chemical treatments as shown in Table 10. The effect was more

demonstrative with the 6 pounds per acre treatment than with the others.

Table 11. The effect of CH 1 on length of Blakemore strawberry leaflet blades. Horticulture Farm, 1952.

	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
Average length of leaflet blade (inches)	2.41	2.17	1.85	1.81	1.82

Analysis of Variance

Factors	Degrees of freedom	Variance
Replications	3	3.33
Treatments	4	8.00
Control vs. treatments	1	22.0**
2 lbs. vs. 4 lbs.	1	6.0*
2 and 4 lbs. vs. 6 lbs.	1	3.0
2, 4, and 6 pounds vs. 8 lbs.	1	1.0
Reps. X treatments	12	1.33
Plants	40	1.65
Leaflets on plants	480	0.79
Total	539	

* Significant at the 5 percent level of confidence.
** Significant at the 1 percent level of confidence.

Effect on Length of Leaflet Blades. The average length of 9 leaflet blades in inches on 3 plants of each replicated treatment is shown in Table 11. There was a significant difference at the 1 percent level between the control and the four treatments used. The analysis, however, showed that the difference between the control and the 2 pounds per acre treatment was

slight. The chemical reduced the length of leaflet blades significantly at the 4, 6, and 8 pounds per acre levels. The 2 pounds per acre treatment was the only treatment which had no significant reducing effect on the length of the leaflet blades among the chemical treatments used.

Table 12. The effect of CH 1 on width of Blakemore strawberry leaflet blades. Horticulture Farm, 1952.

	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
Average width of leaflet blades (inches)	1.74	1.57	1.38	1.31	1.34

Analysis of Variance

Factors	Degrees of freedom	Variance
Replications	3	0.67
Treatments	4	3.50
Control vs. treatments	1	9.8**
2 lbs. vs. 4 lbs.	1	2.0
2 and 4 lbs. vs. 6 lbs.	1	1.7
2, 4, and 6 lbs. vs. 8 lbs.	1	0.5
Reps. X treatments	12	1.25
Plants	40	0.78
Leaflets	480	0.09
Total	539	

** Significant at the 1 percent level of confidence.

Effect on Width of Leaflet Blades. The average width of the same 9 leaflets used for length of leaflet blades determination in inches for each treatment is shown in Table 12.

The analysis of variance revealed that the width of the blades when studied showed a significant difference between the control and various treatments used at the 1 percent level. However, there was no significant difference among all chemical treatments used. From the statistical analysis, it appeared that all chemical treatments induced a reduction in the width of leaflet blades and this effect was more prominent at higher concentrations than with the 2 pounds per acre treatment.

Table 13. The correlation coefficient between length and width of leaflet blades on Blakemore strawberry plants sprayed with CH 1. Horticulture Farm, 1952.

	Control	2 lbs./A	4 lbs./A	6 lbs./A	8 lbs./A
Correlation coefficient between length and width	0.823	0.803	0.603	0.914	0.938

Correlation Coefficient Between Width and Length of Leaflet Blades. The measurements of the length and width of the blades of 9 leaflets on 3 plants in each replicated treatment were taken. The correlation coefficients of length and width are shown in Table 13.

From the statistical analysis of the data, it appeared that the 4 pounds per acre treatment had a lower coefficient of correlation than the others but, generally, all the treatments showed the same value of coefficient correlations and no significant difference among the correlations was detected.

EXPLANATION OF PLATE VI

Fig. 1. Blakemore strawberry plant dead due to CH 1 spray applications. Horticulture Farm, 1952.

Fig. 2. The effect of 6 pounds per acre spray applications of CH 1 on weed control in Blakemore strawberry field. Horticulture Farm, 1952.

Fig. 3. An unsprayed Blakemore strawberry field infested with weeds. Horticulture Farm, 1952.

PLATE VI

Fig. 1

Fig. 3

Fig. 2

EXPLANATION OF PLATE VII

Fig. 1. Note the absence of weeds in the row sprayed with CH 1 at the rate of 8 pounds per acre. Horticulture Farm, 1952.

Fig. 2. The effect of 6 pounds per acre treatment of CH 1 on weed control in strawberries is shown. Horticulture Farm, 1952.

Fig. 3. Note the effect of 4 and 2 pounds per acre treatments of CH 1 on weed control in strawberries as compared with untreated control. The bottom row was sprayed with 4 pounds per acre of CH 1, the middle row was unsprayed and the top row received an application of 2 pounds per acre. The area between the rows was cultivated.

Fig. 1

Fig. 2

Fig. 3

Field Observations

On April 19, 1952, a total of 22 strawberry plants was found dead. They were replaced with new one year old Blakemore strawberry plants on that date. On June 5, 1952, a total of 46 strawberry plants were dead. They were replaced with new one year old Blakemore strawberry plants before the second spray application on June 16, 1952. The purpose of these replacements was to maintain the same number of plants in all treatments before each spray application. All blossoms and fruits were pinched off in order to encourage runner formation and general growth. On July 16, 1952, most of the plants in all 4 replications had runner plants and about 70 percent of all runner plants were rooted.

Higher concentrations of CH 1 spray applications gave better weed control than lower concentrations as can be seen in Plates VI and VII.

GREENHOUSE EXPERIMENT

Materials and Methods

One year old Blakemore strawberry plants were planted on December 24, 1952, in a greenhouse bench one foot apart in 4 rows also one foot apart. The bench was divided into 4 equal plots. Each plot contained 4 rows 14 feet long with 13 strawberry plants in each. The Latin Square design was employed to replicate the treatments in the 4 plots. Treatments at the rate

Table 14. The fresh weight of the individual Blakemore strawberry plants when planted on December 24, 1952. Greenhouse, 1952.

Number of plants	Individual weight of strawberry plants															
	3 lbs./acre				4 lbs./acre				5 lbs./acre				Control			
	Rep. No.				Rep. No.				Rep. No.				Rep. No.			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
1	4.3	4.1	4.8	5.9	5.0	7.1	7.5	5.8	4.2	6.1	6.9	6.4	5.7	5.9	4.2	3.8
2	4.9	5.4	3.8	5.7	6.0	4.2	4.0	4.9	6.8	3.8	5.2	4.9	6.5	4.9	3.5	4.4
3	5.6	6.2	3.9	6.7	4.5	7.5	4.2	7.5	7.3	6.9	3.7	6.8	6.9	4.6	4.9	3.1
4	5.3	5.0	3.2	5.1	4.5	5.6	8.1	4.8	6.3	7.3	3.9	3.5	7.0	7.7	4.5	2.9
5	4.7	3.2	2.8	5.5	6.5	4.6	6.6	5.5	6.3	6.9	5.0	7.5	8.6	3.9	3.5	4.0
6	3.7	6.5	2.8	8.9	6.6	4.6	4.1	8.0	6.8	7.0	3.2	3.8	3.6	5.0	3.7	3.4
7	6.8	5.6	6.0	6.0	7.3	5.1	4.0	5.4	5.4	6.8	6.9	4.2	5.8	8.0	3.6	9.7
8	5.4	4.3	6.9	5.2	3.1	4.1	6.2	4.3	3.7	8.9	7.2	4.4	5.5	8.6	3.3	4.3
9	4.4	6.1	5.2	4.2	5.3	8.1	5.6	3.8	4.4	5.7	3.7	5.6	3.3	6.5	3.6	5.2
10	4.2	4.9	5.5	4.2	5.6	9.6	8.1	5.5	3.9	5.3	4.4	5.7	3.7	4.3	6.2	4.0
11	3.9	4.7	7.5	4.5	4.9	5.1	6.0	4.8	2.9	6.1	5.8	4.5	3.0	5.2	5.8	6.0
12	5.8	4.1	4.8	4.9	5.9	5.9	6.5	4.8	5.3	6.6	4.6	4.2	5.5	7.7	6.7	3.2
13	5.0	6.3	4.5	2.8	2.8	7.9	6.8	5.8	3.6	7.6	6.8	3.3	3.0	6.2	3.3	3.1

of 3, 4, and 5 pounds per acre of CH 1 were used. One row in each plot was left as a control row. The fresh weight of each individual plant is recorded in Table 14.

On February 1, 1953, the strawberry plants were sprayed at 3, 4, and 5 pounds per acre rates. A 5 gallon compressed air sprayer was used to apply the spray. On March 4, 1953, the second spray of CH 1, at the same rates, was applied. The third spray followed on April 2, 1953. Several plant leaflet and dead plant counts were taken throughout the experiment. Most of the emphasis in the greenhouse experiment was placed on the effects of CH 1 on growth and development of the strawberry plants and on the carbohydrate and ash contents.

Presentation of Data

Effect on Dry Weight. Three months after the first spray application was made, plants selected at random from each treatment and the unsprayed control were carefully lifted from the soil, washed free of the soil, and dried between two layers of blotting paper. The total fresh weights were obtained and the strawberry plants were fractioned at once into leaves, stems, crowns, and roots. These parts were placed in paper bags and autoclaved for 5 minutes under 15 pounds of pressure at a temperature of 226° F. Then the bags were put in a ventilated automatic electric drying oven and dried over night at 176° F. The materials were placed in desiccators and later their dry weights were determined. Table 15 shows the average dry weight of 12

plants of each treatment and the average dry weight of their leaves, stems, crowns, roots, and regression of dry weight on fresh weight of plants.

Table 15. Effect of CH 1 sprays on the average dry weight in grams of 12 Klahemore strawberry plants and average dry weight of their leaves, stems, crowns, and roots with the regression of dry weight on fresh weight. Greenhouse, 1953.

Sources	Control	3 lbs./A	4 lbs./A	5 lbs./A
Average total dry weight per plant	10.27	7.43	7.38	6.50
Average dry weight of leaves	5.58	3.51	3.82	3.45
Average dry weight of stems	0.99	0.81	0.62	0.60
Average dry weight of crowns	0.94	0.89	0.63	.46
Average dry weight of roots	2.75	2.22	2.32	1.99
Regression of dry weight on fresh weight	0.2377	0.1984	0.1949	0.2089

Analysis of Variances

Leaves

Factors	Degrees of freedom	Variance
Control vs. treatments	1	35.63*
Among treatments	2	0.92
Error	12	8.04
Sampling	32	2.59
Total	47	

Table 15. (concl.)

Analysis of Variances

Stems

Factors	Degrees of freedom	Variance
Control vs. treatments	1	0.89*
Among treatments	2	0.32
Error	12	2.01
Sampling	32	0.24
Total	47	

Crowns

Factors	Degrees of freedom	Variance
Control vs. treatments	1	0.72
Among treatments	2	0.57
Error	12	0.29
Sampling	32	0.83
Total	47	

Roots

Factors	Degrees of freedom	Variance
Control vs. treatments	1	3.00*
Among treatments	2	0.35
Error	12	1.59
Sampling	32	0.73
Total	47	

* Significant at the 5 percent level of confidence.

The regression of dry weight on fresh weight indicated that there was an average increase of 1 gram in total fresh weight for an average increase of 0.2 grams in total dry weight. The regressions for the three treatments were not significantly different from each other, but were different from the control.

The sprayed plants had an average regression value of .2007 grams of dry weight per gram of total fresh weight as compared with 0.2377 for the control plants. The difference of 0.037 between the control and CH 1 treated plants in regression coefficient indicated that about 20 percent more dry material was added to control plants for each additional gram of total fresh material gain. When the analysis of variance was separately computed for dry weights of leaves, stems, and roots, the results indicated that there was a significant difference between the control and all three chemical treatments, but no difference was detected among all the CH 1 treatments used. The effect of the chemical on the dry weight of the crowns was not significant.

Effect on Fresh Weight. The fresh weight of the strawberry plants was taken at the time of planting, then again at the end of the experiment, from which the total fresh weight gains in grams per plant were obtained. Table 16 shows the gain in fresh weight of 12 Blakemore strawberry plants for the period December 24, 1952, to April 30, 1953.

The analysis of variance revealed that there was a considerably greater gain in fresh weight by the control plants than with the three chemical treatments used. There was no significant difference among the various chemical treatments. From the study of data, it seemed that CH 1 spray treatments at 3, 4, and 5 pounds per acre concentrations reduced total fresh weight gain of strawberry plants grown in the greenhouse. It

did not appear that the differences in gain could be attributed to the difference in the original weight as correlations between the original weight and gain were negligible.

Table 16. Effect of CH 1 spray applications on the increase in fresh weight of Blakemore strawberry plants. Greenhouse, 1953.

Mean weight of 12 plants (grams)	Control	3 lbs./A	4 lbs./A	5 lbs./A
Original fresh weight	4.4	4.7	5.6	5.3
Gain in fresh weight	35.8	24.4	32.0	28.4

Analysis of Variance

Factors	Degrees of freedom	Variance
Control vs. treatments	1	509**
Among treatments	2	175
Replications	32	438
Error	12	592
Total	47	

** Significant at the 1 percent level of confidence.

Effect on Carbohydrate Content. The dried plant materials used for dry weight determination were ground with a Wiley Mill and grinding was completed with a mortar and pestle until all material passed through a 40-mesh sieve. Leaves, stems, and crowns of each replicated treatment were combined and ground together, making a composite sample for the above ground portions of the plants. Roots of each treatment likewise were

combined and ground together. Five gram samples were used for carbohydrate analysis.

Table 17. Effect of CH 1 on the carbohydrate content of Blakemore strawberry plants. Greenhouse, 1953.

Treatments	Top portions		Root portions	
	Total sugar	Starch	Total sugar	Starch
	mg. gr. invert sugar in 1 gr. sample	mg. gr. invert sugar in 1 gr. sample	mg. gr. invert sugar in 1 gr. sample	mg. gr. invert sugar in 1 gr. sample
3 pounds per acre	102.73	21.05	67.43	56.94
4 pounds per acre	103.47	21.27	65.46	55.71
5 pounds per acre	102.52	20.78	66.13	53.26
Control	101.92	21.11	68.61	59.55

Table 17 shows the amount in milligrams of total sugar determined by the acid hydrolysis method, and starch determined by the saliva digestion method with subsequent acid hydrolysis as described by Loomis and Shull (1937, p. 267-289). The invert sugar values of Cu_2O were found from the Munson and Walker table. From the data, it appeared that CH 1 spray treatments had no significant effect on the carbohydrate content of the vegetative portions of the strawberry plants.

Effect on Ash Content. One gram samples from the eight samples of the material used for the carbohydrate analysis were taken and ashed in an electric furnace at 1076° F. for 12 hours. Table 18 shows the percent of ash in one gram of tops and roots of strawberry plants for the four treatments used. From the data, it appeared that there was no significant effect of CH 1 treatments on ash content of strawberries.

Table 18. Effect of CH 1 sprays on the ash content of Blakemore strawberry plants. Greenhouse, 1953.

Treatments	Percent of ash	
	Tops	Roots
3 lbs./acre	8.80	12.31
4 lbs./acre	7.63	14.84
5 lbs./acre	8.24	17.25
Control	8.13	16.59

Effect on Plant Leaflets. Five counts of the total number of leaflets per strawberry plant were taken at two week intervals. Table 19 shows the average number of plant leaflets per plant for each treatment. February 19 and March 4 counts indicated little or no effect of the first spray applications. For the subsequent counts, the difference between the control and chemical sprays was significant, increasing gradually with the elapse of the time, indicating a significant linear trend. There was no significant difference among the three spray treatments for any of the five counts.

Table 19. Effect of CH 1 spray applications on the number of strawberry plant leaflets. Greenhouse, 1953.

Date of count	Average number of leaflets per plant			
	Control	3 lbs./A	4 lbs./A	5 lbs./A
February 19	16.3	14.6	15.4	15.9
March 4	18.9	16.5	17.4	18.6
March 18	23.5	19.8	21.3	21.9
April 2	27.9	22.4	24.2	26.3
April 16	31.7	22.8	24.2	26.6

Analysis of Variance

Factors	Degrees of freedom	Variances				
		Feb. 19	March 4	March 18	April 2	April 16
Rows	3	1.98	7.80	15.44*	14.61*	24.66*
Columns	3	4.15	9.70	12.27*	15.26*	20.38*
Control vs. treatments	1	3.17	5.98	20.15	41.72*	158.89*
Among treatments	2	1.95	5.05	4.50	15.70	15.55
Error	6	0.66	3.60	4.46	6.17	8.90
Total	15					

* Significant at the 5 percent level of confidence.

The general conclusion reached was that the 3, 4, and 5 pounds per acre spray treatments of CH 1 reduced the number of plant leaflets and the effect was more pronounced in lower concentrations.

Lethal Effects. Five counts of dead plants in all four treatments were made. Table 20 shows the number of dead plants observed at each count. The data showed that all treatments of

CH 1 induced approximately the same lethal effects on strawberry plants. None of the control plants died during the period of the experiment.

Table 20. Lethal effect of CH 1 spray applications on Blakemore strawberry plants. Greenhouse, 1953.

Date of counts	Number of dead plants per treatment			
	Control	3 lbs./A	4 lbs./A	5 lbs./A
February 19	None	4	1	2
March 4	None			
March 18	None		1	1
April 2	None		1	
April 16	None			
Total	None	4	3	3
Total (percent)		7.6	5.7	5.7

Greenhouse Observations

No effort was made to count the number of weeds, but general observation revealed that more weeds were present in the control and the 3 pounds per acre treatment than in the 4 and 5 pounds per acre treatments. The chemical was found to induce more herbicidal effects on broad leaved weeds than grasses.

GENERAL DISCUSSION

From 1946, the date of the initial trials of sodium 2, 4-dichlorophenoxy ethyl sulfate at New Jersey, to the present time a great deal of research has been conducted at various

places in the United States to determine the value of the chemical as a herbicide and its effect on various cultivated crops. In a few of these studies, strawberries were used as test plants but none of the workers conducted a detailed experiment on the phytotoxic effects of the chemical on the general growth of the plants. Due to the lack of extensive investigation and the necessity of obtaining a foundation data, the door was open for obtaining new information concerning some of the effects of the chemical on strawberry plants.

The results already presented are not, by any means, conclusive and there is a great deal of opportunity for further investigation. No attempt was made to find out the effects of the chemical on yield, formation of fruit buds, blossoming time, sugar content of fruits, nitrogen and various mineral element contents of strawberries. Future investigations aimed toward these points and many others, no doubt, will increase the present knowledge, complete the data, and make a good source for other graduate work.

The field experiment was conducted under rather unfavorable climatic conditions of high temperature and low precipitation characterized the summer conditions. Water was provided by irrigation when it was urgently needed but 13 percent of the plants in the control rows died, presumably due to the unfavorable environmental factors. The percentage of plants that died was higher in all of the spray treatments than in the unsprayed controls.

Results presented from the field experiment will apply only to Kansas environmental conditions under which the data were collected. All favorable environmental factors were provided for the greenhouse experiments. The temperature was kept at about 73° F., the optimum for strawberry growth, and the moisture was supplied by irrigating twice a week. Therefore, the extreme variations in temperature and moisture factors were eliminated.

Results of the greenhouse experiment agreed generally with results of the field experiment. It is assumed, therefore, that the phytotoxic effects of the chemical were not determined by the environmental factors but by the concentrations of the chemical spray applications.

The data already presented indicated that high temperatures and dry weather conditions increase the herbicidal activity of the chemical. The number of plants that died during June and July with maximum temperatures reaching 104° and 106° F., respectively, was very high in the 6 and 8 pounds per acre treatments compared with the control. The chemical decreased the total growth and root development of the strawberry plants.

SUMMARY

1. Field and greenhouse experiments were conducted to determine some effects of CH 1 on Blakemore strawberry plants. Four treatments of 2, 4, 6, and 8 pounds per acre for field and 3, 4, and 5 pounds per acre for green-

house tests were used.

2. Both field and greenhouse experiments indicated that CH 1 at all rates of spray applications had a reducing effect on the general growth of strawberry plants.

3. The trend in the increase of the chemical's lethal effects showed a direct proportional relation to the increase in spray concentrations.

4. The chemical in field applications shortened the length and lessened the number of leaf petioles and the fresh weight of roots.

5. Field applications resulted in a slight reduction in the number of runner plant leaflets, but no one treatment was significantly more effective than others.

6. A decrease in the number of runners resulted from the field applications and this decrease was directly proportional to an increase in the spray concentrations.

7. Field and greenhouse applications induced a reduction in the number of runner plants produced.

8. The chemical curtailed the rooting of runner plants in all treatments.

9. The chemical at 2 pounds per acre rate had no significant effect on the length of leaflet blades, but the 4, 6, and 8 pounds per acre rates induced approximately similar significant shortening on the length of leaflet blades compared with the control.

10. Field applications shortened the width of leaflet blades, and the effect was more demonstrative at rates higher than 2 pounds per acre.

11. The chemical, in greenhouse applications, decreased the dry weights of leaves, stems, crowns, and roots of strawberry plants.

12. The chemical reduced the number of plant leaflets in greenhouse applications.

13. The average fresh weight gain per plant was higher in the control than chemical treatments in the greenhouse experiment.

14. The carbohydrate analysis (total sugars and starch) and ash contents of tops and roots of plants of all treatments in the greenhouse experiment showed no significant difference.

15. The chemical at 2, 3, and 4 pounds per acre concentrations could be used for weed control in strawberry plantings with minimum detrimental effects on the general growth of the plants.

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SOME EFFECTS OF SODIUM 2, 4- DICHLOROPHENOXY ETHYL SULFATE (CRAG HERBICIDE 1) ON GLADIOLUS GREENHOUSE PLANTS

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AN ABSTRACT OF A THESIS

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INTRODUCTION

Because of its low habit of growth, the strawberry plant is not able to compete with weeds as successfully as some other fruit plants. Therefore, weed control practices form one of the main production problems. Hence, the farmer is interested in any method of control, including the use of various chemicals, which costs him less.

PURPOSE

Crag Herbicide 1 (CH 1) or sodium 2, 4- dichlorophenoxy ethyl sulfate was introduced in 1946 as a herbicide. Reports of many scientists indicated satisfactory results when the chemical was used as a pre-emergence spray to control broad-leaved weeds and grasses.

The purpose of this study, which was conducted at the Horticulture Farm near Manhattan, Kansas, and at the greenhouses at Kansas State College, was to determine some effects of the herbicide on total growth, runner production, runner plant production, rooting of runner plants, length and width of leaflet blades, length of leaf petioles, lethal effects, size of root systems, and carbohydrate and ash contents of top and root portions of strawberry plants.

THE CHEMICAL

The herbicide is readily absorbed by the roots and carried upward through the xylem tissue. Lowering the pH value increases the phytotoxicity of the chemical. Soil sterilization has been found to decrease the herbicide's toxic activity. The herbicidal form is found to be present in the soil more readily at temperatures of 75.2° to 86.0° F., but no herbicidal activity is observed at 32.0° F.

MATERIALS AND METHODS

Field Experiment

One year old Blakemore strawberry plants were planted on March 29, 1952, at the Horticulture Farm. Four treatments, each of 2, 4, 6, and 8 pounds per acre of CH 1 were applied on April 27, June 16, and August 2, 1952.

Greenhouse Experiment

One year old Blakemore strawberry plants were planted on December 24, 1952, in a greenhouse bench. Three treatments, each of 3, 4, and 5 pounds per acre of CH 1, were applied on February 1, March 4, and April 2, 1953.

RESULTS

Both field and greenhouse experiments indicated that CH 1, at all rates of application, had a reducing effect on the general growth of strawberry plants. The trend in the increase of the chemical's lethal effects showed a direct proportional relation to the increase in spray concentrations.

The chemical, in field applications, shortened the length, decreased the total number of runners, leaf petioles, rooted runner plants, runner plant leaflets, and fresh weight of the roots of strawberry plants, but no one spray treatment was significantly more effective than others.

Field and greenhouse applications induced a shortening effect on the length of leaflet blades, but the 4, 6, and 8 pounds per acre rates induced approximately similar effects on the length of leaflet blades compared with the controls. It also lessened the width of the leaflet blades, and the effect was more demonstrative at rates higher than 2 pounds per acre.

The chemical, in the greenhouse applications, reduced the dry weights of leaves, stems, crowns, roots, and likewise the number of leaflets of strawberry plants.

The average fresh weight gain per plant was higher in the control plants than those sprayed with the chemical in the greenhouse experiment. The carbohydrate analysis (total sugars and starch) and the ash content of top and root portions of the

plants of all the treatments in the greenhouse experiment showed no significant differences between the sprayed and the unsprayed plants.

It is concluded that the chemical, at 2, 3, and 4 pound per acre rates, could be used for weed control in strawberry plantings with minimum detrimental effect on the general growth of the plants.