Chemical Weed Control Experiment With Strawberries and Blackberries

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One of the greatest problems in growing horticultural crops is that of weed control. Methods for the use of chemicals to control weeds and grasses in strawberries and blackberries were studied in 1949, 1955, 1956 and 1957. The purpose of the study was to thoroughly investigate the practical application aspects of chemical substances as an aid to weed control in strawberries and blackberries.

Blakemore strawberries and Lawton blackberries were used. Good cultural practices were followed such as irrigation, amounts, kinds and time of fertilizer applications, pruning, insect and disease control.

Chemicals used in the tests and the name of the company manufacturing each product are listed in Table I. These products are available through numerous retail and wholesale outlets.

The rates of spray applications described herein are on the basis of area of strips covered by the spray, not on the basis of the acres in the field. The combined area of all strips sprayed in a 3 to 5 acre strawberry field, or a 5 to 8 acre blackberry patch, may amount to no more than one acre of total area.

When the quantity of spray solution is 40 gallons per acre, one gallon will cover the following amounts of row area:

12 inch band will cover 1090 feet of row.
18 inch band will cover 818 feet of row.
24 inch band will cover 545 feet of row.
30 inch band will cover 436 feet of row.

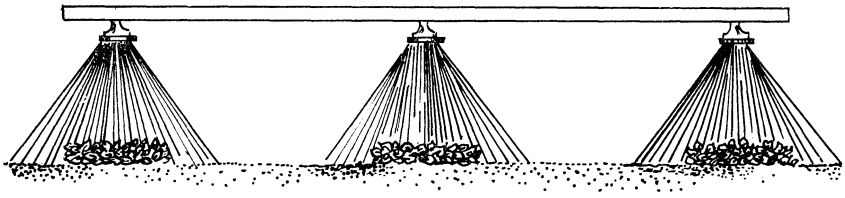
Strawberries

Methods

Spray applications of herbicides were directed over the crop row. The middles were cultivated as needed for grass and weed control. The materials and their amounts used per acre are given on the basis of actual area covered. For example, in a newly planted strawberry field, a sprayed strip twelve inches wide directly over the row was of ade-

quate width during the early part of the season. As runner plants produced a matted row, the width of the treated area was increased to 18, 24 or 30 inches.

The following sketch indicates the method of placement of the spray on strawberries.



Application of spray on strawberry plants.

Work reported earlier (3) demonstrated that there were no persistent harmful effects from 2,4-D (amine form) at the rate of 1½ pounds per acre or from 2,4-DES (formerly EH1) at 10 pounds per acre when applied at the proper time to Blakemore strawberries. Total numbers of established runner plants, earliness of runner plant development, fruit size, and total marketable fruit yield of treated plots were equal to or similar to the check plots.

Research reported by a number of workers (1, 2, 4, 5, 6) indicates that mid-September and October applications of 2,4-D at the rate of one-half pound or greater per acre resulted in epinastic growth of the foliage and caused serious abnormalities of the flowers and fruits the following spring.

During the past 15 to 20 years, Blakemore has been the variety of major importance in eastern Oklahoma. All herbicidal tests reported herein were conducted with the Blakemore variety. The tests were conducted at the Eastern Oklahoma Field Station located near Stilwell with virus-free indexed plants. The topography here is hilly, typical of the Ozarks with quite rocky soil.

Strawberries were planted on "old" land or "newly cleared" land. "Old" land consisted of an area which had been in cultivation for a number of years prior to setting to strawberries. "New" land was in native tree growth and was cleared for the purpose of planting strawberries. Clearing was completed during the winter of 1954-55 and the land prepared by "tilling."

TABLE 1. Chemicals Used as Herbicides in Experiments With Strawberries and Blackberries.

Abbreviation	Chemical Composition	Rate of Application expressed in terms of:	Source of Materials*	Physical Condition	
				Received As:	Applied As:
2,4-D	alkanolamine salts of the ethanol and isopropanol series of 2,4-dichlorophenoxyacetic acid	Acid equivalent	E. I. Dupont de Nemours and Co., Wilmington, Del. Dow Chemical Co., Midland, Mich.	liquid	solution
2,4-DES	2,4-dichlorophenoxyethyl sulfate	90% 2,4-DES	Carbide and Carbon Chemicals Co., 30 E. 42nd St., N.Y. 17, N.Y.	powder	solution
monuron	3-(p-chlorophenyl)-1, 1-dimethylurea	80% monuron	E.I. Dupont de Nemours and Co.	wettable powder	suspension
IPC	isopropyl N-phenylcarbamate	100% IPC	Dow Chemical Co.	powder	powder
CIPC	isopropyl N-(3-chlorophenyl) carbamate	100% CIPC	Carbide and Carbon Chemicals Co.	liquid	emulsion
TCA	trichloracetic acid	acid equivalent	Dow Chemical Co.	powder	solution
NPA alanap 2	N-1-naphthyl phthalamic	acid equivalent	United States Rubber Co., Naugatuck, Conn.	powder	suspension
ATA	3-amino 1,2,4-triazole	50% amino triazole	Amchem Co., Ambler, Pennsylvania	powder	suspension
Stoddard solvent	mixed hydrocarbons	100% mixed hydrocarbons	Purchased locally as dry cleaning solution	liquid	undiluted
ACP-L-483	low volatility isopropyl N-(3-chlorophenyl) carbamate	100% CIPC	Amchem Co.	liquid	emulsion

* With the exception of Stoddard solvent, all or portions of the materials were donated by the companies listed and we hereby express our appreciation.

Plants set during March, 1955 were spaced two feet apart in rows three and one-half feet apart. Strawberry plants were allowed to become established at random in the row. A 50-gallon "Bean" trailer-type sprayer, fitted with ¼" T "Tee jet" nozzles, was used to apply materials in bands over three rows simultaneously. The first weed control treatments were applied during late April to coincide with the germination

of early grasses. A second application was made four weeks later. No additional applications were made until after fruit harvest one year later. The middles were cultivated periodically and all plots were hand-hoed one time during September 1955.

At the end of the growing season in November, 1955, three representative row sections three feet in length were seleceted and counts made of the number of established strawberry plants. The rows were approximately 30 inches wide at this time.

One variable was added to the treatments in the "old" land section of the tests. Half of each plot in each of the treatments on "old" land was mulched with rye straw at the rate of two tons per acre. The mulch was applied during late December 1955, and completely covered the rows and middles. Approximately two-thirds of the mulch was raked into the middles at the beginning of strawberry plant growth in the spring. Newly cleared land in strawberries customarily is not mulched because of the difficulty in disposing of the mulch.

In the spring of 1956, data were collected on the time of bloom, time of harvests, yield of marketable fruit per harvest, and average number of berries per pound. "Marketable" fruit consisted of U. S| No. 1 and/or No. 2 quality. Berries of lesser quality were not included in the yield records. The yields were average for this area of Oklahoma in 1956.

Results of the treatments on newly cleared land are reported in Table II. Fruit harvests were made May 2, 7, 9, 11, 19, 23, and 28. Data on average number of berries per pound were collected only on the

TABLE II. Strawberries on Newly Cleared Land. Average Effects of Certain Herbicides on Production in 1956.

Treatments	Plants per 3-foot section of row in Nov. 1955	Yield per 500 ft. of row* Early May 7, 7, 9	Total for season	Number of berries per pound May 11	May 23
	No.	Qts.	Qts	No.	No.
Check, no herbicide	46.3	15.2	65.0	86	113
1 lb. per acre of 2,4-D	47.0	22.9	75.8	93	107
1½ lb. per acre of 2,4-D	44.0	17.5	91.1	92	107
4 gal per acre of CIPC	40.3	16.1	46.3	87	——
8 lb. per acre of 2,4-DES	42.6	10.6	27 0	86	——

* The total yields on an acre basis ranged from 672 to 2,267 quarts.

May 11 and 28 harvest dates. A minimum of three samples is represented in each average count of the number of berries or number of plants.

There was little difference in average number of rooted plants in November, 1955 between the check and 2,4-D treated plots. Smaller numbers of plants, which may have been caused by the treatments, developed in the CIPC and 2,4-DES treated plots.

The application of 1 lb. per acre of 2,4-D resulted in a marked increase in the yield of berries harvested early and 2,4-DES depressed early yield. There was little difference between the other two treatments and the check.

Total yields were depressed by CIPC and 2,4-DES.

Berry size on May 11 was slightly reduced by both 2,4-D treatments as indicated by the larger number of berries per pound than the check. The CIPC and 2,4-DES treatments apparently had no effect on berry size on May 11. By the time of the last picking on May 28 berries from both 2,4-D treatments were slightly larger than check berries and this may have counter-balanced smalled sized fruit earlier in the season.

The principal weeds[1] present in the check plots were: three seeded mercury—*Acalypha virginica*; cranesbill—*Geranium carolinianum*; yellow wood sorrel—*Oxalis stricta*; horseweed—*Erigeron canadensis*; daisy bleabane—*Erigeron strigosus*; evening primrose—*Oenothera biennis*; poor Jone—*Diodia teres*; common mullen—*Verbascum thapsus*; several plantains—*Plantago sp.*; pokeweed—*Phytolacca americana*; prostrate pigweed—*Amaranthus graecizans*; foxtail—*Setaria viridis* and *S. Lutescens*; downy brome—*Bromus tectorum*; crabgrass—*Digitaria sanguinalis;* goosegrass—*Eleusuine indica*; and barnyard grass—*Echinochloa crusgalli.*

Most broad-leafed weeds were seriously injured or killed following treatments with 2,4-D at the 1 or 1½ lb. rates. However, mullen apparently was not affected. Plants which were injured by 2,4-D, but frequently survived were yellow wood sorrell and the plantains. Most weeds, if relatively mature when treated, persisted for some time.

Grass plants were not materially affected by 2,4-D whereas grass seeds were either killed during germination or their development was arrested prior to germination. Plots treated with 2,4-DES had fewer grass plants but generally more broad-leafed weeds than 2,4-D treated plots.

Plots treated with CIPC and 2,4-DES resulted in better control of annual summer grasses than occurred with 2,4-D. Broad-leafed

[1] The nomenclature for specific names is based upon North Central Regional Publication No. 36, "Weeds of the North Central States." Illinois Agri. Expt. Sta. Circ. 1954.

weeds, however, were generally not as effectively controlled with CIPC or 2,4-DES as with 2,4-D.

The time required to hand-hoe herbicide treated strawberry plots was estimated to be about 60 percent of that required for check plots.

The data collected from the plots growing on "old" land are reported in Tables III and IV. Plots which were mulched, Table III, developed more slowly than non-mulched plots and were harvested only on May 11, 16, 19, 23, and 28. Harvests from non-mulched plots were made on May 2, 7, 9, as well as May 11, 16, 19, 23, and 28. The number of berries per pound was determined on May 16 and 23 for mulched plots and on May 11 and 23 for non-mulched plots.

Data on the number of rooted runner plants per three foot section of row were taken in November 1955 on both mulched and non-mulched plots.

With the exception of the CIPC treated plot, there were no sizable differences in number of rooted plants. There were, however, substantial differences in yields between herbicidal treatments. Mulching delayed flowering and early fruit harvests. Mulching very substantially increased total marketable fruit yields. This is especially noteworthy in view of the fact that there were no more than one-half as many plants in the old land mulch plots as in the new land non-mulched plots.

The application of 8 lbs. per acre of 2,4-DES resulted in the highest total yield for the season and was the only treatment that exceeded the check.

Total yields were depressed the greatest by 2,4-D at the 1½ lb. rate. Berry size appears similar in all treatments except 1 lb. rate of

TABLE III. Mulched Strawberries on Old Land. Average Effects of Certain Herbicides on Production in 1956.

Treatments	Plant per 3-foot section of row in Nov. 1955	Yield per 500 ft. of row*		Number of berries per pound	
		Early May 11	Total for season	May 16	May 23
	No.	Qts.	Qts	No.	No.
Check, no herbicide	20.6	0.5	167.5	86.5	102.5
1 lb. per acre 2,4-D	18.0	0.8	147.5	88.5	99.0
1½ lb. per acre 2,4-D	19.6	0.8	96.2	110.0	113.0
1 gal. per acre CIPC	12.0	1.5	135.0	83.5	109.5
8 lb. per acre 2,4-DES	21.3	2.2	202.0	83.5	103.5

* The total yields on an acre basis ranged from 2,394 to 5,027 quarts.

2,4-D. In this treatment there was a depressing effect on berry size at the two harvest dates.

Mulching provides favorable conditions for plant growth and fruit development and its use reduces weed and grass competition. The conditions of less fluctuating soil moisture and lower soil temperature under mulch appear to allow for an intensification of the herbicidal effects of 2,4-D and CIPC with resultant depressing effects on yields. When the same treatments were applied in non-mulched plots, the moisture and temperature fluctuations presumably lessen these effects.

There were no appreciable differences in the average number of rooted plants in November 1955 in any except the CIPC treatment which developed substantially fewer plants.

The early yield from mulched plots was insignificant. Applications of 1 and 1½ lb. per acre of 2,4-D on non-mulched plots resulted in a slight increase in yield of berries harvested early, while 2,4-DES materially depressed early yield. The plot treated with CIPC varied litle from the check.

The total yield from plots treated with 1 lb. or 1½ lbs. of 2,4-D or CIPC were definitely depressed when these materials were applied on mulched strawberries grown on "old" land. Similar treatments with 2,4-D on non-mulched "old" land plots resulted in increased yields comparable to the results on non-mulched plots on newly cleared land (Table III). CIPC on non-mulched "old" land resulted in the greatest yield whereas similar treatment on non-mulched newly cleared land depressed the yield. The largest yield from any treatment in 1956 occurred on mulched plots on "old" land treated with 2,4-DES, which

TABLE IV. Non-mulched Strawberries on Old Land. Average Effects of Certain Herbicides on Production in 1956.

Treatments	Plants per 3-foot row section in Nov. 1955	Yield per 500 ft. of row*		Number of berries per pound	
		Early May 2, 7, 9	Total for season	May 11	May 23
Check, no herbicide	20.6	3.7	37.0	90.5	110.0
1 lb. per acre 2,4-D	18.0	6.0	44.0	85.0	109.0
1½ lb. per acre 2,4-D	19.6	5.8	54.5	87.0	110.0
1 gal. per acre CIPC	12.0	4.1	60.0	92.0	108.0
3 lb. per acre 2,4-DES	21.3	1.5	47.5	92.0	107.5

* The total yields on an acre basis ranged from 920 to 1,493 quarts.

also resulted in considerable yield increase on non-mulched plots on "old" land. This is particularly interesting because the same treatment on newly cleared land markedly reduced the total yield.

Berry size was reduced somewhat by 1½ lbs. of 2,4-D applied on mulched plots on "old" land. All other treatments on both mulched and non-mulched plots apparently had little or no effect on berry size.

The culture of all plots was continued in 1956 and treatments were repeated following harvest. Unfortunately freezing temperatures of 22° F. at bloom time in 1957 reduced the yields so much that results for that season were of no value.

Blackberries

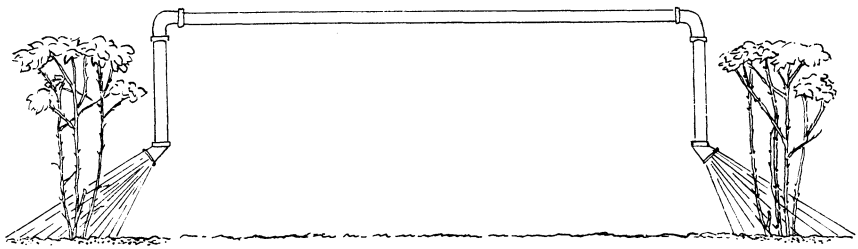
Methods

The method of spray application used on blackberries was at the side of the row as shown in the drawing. It is very important that the spray be applied at the side and not directly down on the foliage.

The Lawton variety of erect blackberry is widely adapted in Oklahoma and is tolerant of certain chemical herbicides. The nature of random development of suckers in the row makes hand-weeding very difficult and expensive. Some fields are relatively neglected due to this problem.

One-year old Lawton blackberry plants were set during February 1948 at the Perkins farm and spaced four feet apart in rows 10 feet apart. The area was cultivated and hand-hoed as needed during the first year.

Duplicate plots containing 10 plants each were selected and treatments applied April 28, 1949. This coincided with early germination



Application of spray on blackberry plants.

of annual summer grass seed and preceded blackberry bloom by one week.

All materials which required mixing with water before application were diluted at the rate of 40 gallons per acre. Herbicides were directed into the row from a low angle at each side in order to avoid contact with most of the blackberry foliage. The treated areas in each plot was three feet wide and 40 feet long.

Plots received similar treatments four weeks later. The blackberry fruits at this time had begun to change color from bright green to brownish green. The first harvests were made approximately three weeks later.

All middles were cultivated for the first time three weeks prior to harvest. Later cultivations of the middles of plots followed the fruit harvest period. The check plots were hand-hoed after harvest was finished but treated plots were not hoed.

Data were recorded of the total yields of good berries and these were typical of commercial yields from a young patch. At the third harvest, June 21, the average weight of berries was determined by counting the number in a pound from three comparable samples. The effects of herbicides on weed and grass control in the rows was evaluated by observation. No control, exemplified by check plots, was rated "10" and complete control was rated "1". The results are presented in Table V.

Four chemicals were used: 2,4-D,TCA, Stoddard solvent and IPC The first three materials were applied with a knapsack sprayer and the IPC was mixed with fine quartz sand which was broadcast with a hand shaker. The rates used are listed in Table V.

The yields from plots treated with three different concentrations o 2,4-D were little different than the check plots. The average weight of the berries from these treatments were somewhat greater than check berries. Stoddard solvent used at the rate of 60 gallons per acre did no materially reduce yield and berry weight was slightly increased. However, 80 gallons of Stoddard solvent depressed the yield without apparently affecting berry size. IPC reduced the yield and average berry weight. Plots treated with TCA resulted in the lowest yield of fruit and berries of the least weight.

The principal grass and weed plants found in the blackberry tes plots were: gumweed—*Grindelia squarrosa*; horse nettle—*Solanum carolinense*; horseweed—*Erigeron canadensis*; smartweed—*Polygonun pennsylvanicum*; lambsquarter—*Chenopodium album;* morning glory—*Ipomoea purpurea*; barnyard grass—*Echinochloa crusgalli*; crabgrass—*Digitaria sanguinalis*; and goosegrass—*Eleusine indica.*

Horse nettle persisted in all treated plots although the plants developed considerable chlorosis and malformed growth. All other broad

TABLE V. Average Effects of Herbicidal Treatments on the Yield and Size of Lawton Blackberries and Comparative Weed Control at Perkins, Oklahoma in 1949.

Treatment	Ave. yield per 40-foot plot (*)	Ave. berries per pound	Weed and grass rating (**)
	Qts.	No.	
Check	34.0	205	10
½ lb. per acre, 2,4-D	33.5	177	6
1 lb. per acre, 2,4-D	37.0	169	4
1½ lbs. per acre, 2,4-D	35.5	180	3
60 gals. per acre, Stoddard solvent	30.0	186	5
80 gals. per acre, Stoddard solvent	26.0	206	3
8 lbs. per acre, IPC	27.5	234	10
10 lbs. per acre, TCA	22.0	270	4

* The total yield on an acre basis ranged from 2,395 to 4,029 quarts.
** 10=no control; 1=complete control.

leafed weeds listed were classified as intermediate to susceptible to 2,4-D sprays. Grass plants were not affected by 2,4-D but grass seed germination was prevented. Plots treated with monuron had very few grass plants.

Although no treatment resulted in complete control of weeds and grasses, the 1½ lb. rate of 2,4-D did very well without reducing yield. The 80 gallon rate of Stoddard solvent also controlled weeds but resulted in a decreased yield. The IPC was no better than the check plots and the other treatments were moderately good as herbicides.

Leaf twisting was caused by 2,4-D at the 1½ lb. rate. This condition usually persisted for two or three weeks. Occasionally leaves on current season's canes developed a yellowish green color, but changed again to the normal green color two or three weeks later. Curvatures of these young canes occurred sometimes, when they were less than 12 to 16 inches high at the time of spray application.

Stoddard solvent caused scorching of the basal leaves which were contacted by the spray. The 60 gallon rate did not cause any evident injury to canes but current season's canes were severely injured by Stoddard solvent at the 80 gallon rate. Leaves of plants treated with

TCA developed a chlorotic condition which persisted throughout most of the season. In some early-season juvenile foliage veins remained green whereas interveinal areas became necrotic. Later in the season, additional leaves on young canes yellowed interveinally. Other treatments did not cause any visual injuries.

Additional information on the effects of herbicides on Lawton blackberry plants was obtained during 1955 and 1956. Herbicide treatments listed in Table VI were applied on plants which had been set in February 1954. The sprays were directed into the row from each side at a low angle with a knapsack sprayer. The first treatments were applied approximately one week prior to bloom on April 1955 on single 5-plant plots. Second applications were made four weeks later. Check plots were hand-hoed at full bloom but treated plots were not hoed. All middles were cultivated as necessary to control weeds and grasses. Identical treatments on the same plots were repeated in the spring of 1956. At this time, an additional treatment was added—ACP-L-483.

The total yield of fruit was not measured because the plants did not develop uniformly in several plots. This lack of uniformity was

TABLE VI. Average Effects of Herbicidal Treatments on the Size of Lawton Blackberries and Comparative Weed Control at Stillwater, Oklahoma during 1955 and 1956.

Treatments	Average berries per pound		Grass and weed ratings (*)	
	1955	1956	1955	1956
	No.	No.		
Check	144	138	10	10
5 qts. per acre, CIPC	150	143	6	7
2 lbs. per acre, 2,4-D	185	157	3	3
4 lbs. per acre, ATA	180	161	7	7
8 lbs. per acre, ATA	164	170	5	6
2 lbs. per acre, NPA**	187	163	6	7
4 lbs. per acre, NPA**	252	238	3	4
3 lbs. per acre, m monuron	198	174	3	3
6 lbs. per acre, mounron	265	275	1	2
10 lbs. per acre, 2,4-DES	240	198	4	5
1 pt. per acre, ACP-L-483	——	216	—	9

* 10=no control; 1=complete control.
** Alanap No. 2.

not caused by herbicidal treatments, however, and therefore total yields would have been misleading. The average size of the berries was measured by counting the number in three one-pound samples per plot. Sampling was done on June 15, 1955, and June 9, 1956, at a time when there were at least three ripe berries per fruiting shoot. Data on average number of berries per pound as well as weed and grass control ratings are presented in Table VI.

The largest berries developed on check plots although CIPC resulted in slight reduction. All other treatments apparently caused measurable reduction in berry size that sometimes was definitely undesirable. In this experiment it was not possible to evaluate what the effects of the treatments were on total yield, however. It is particularly interesting to note that 2 lbs. of 2,4-D reduced berry size measurably as compared with an apparent increase in size by 1½ lbs. of 2,4-D used at Perkins in 1949 (see Table V).

The principal weeds and grasses in this experiment were similar to those described earlier for the Perkins' experiment. Several treatments resulted in satisfactory weed and grass control (2,4-D; 4 lbs. NPA; nonuron) but in each instance berry size was reduced measurably and such treatments would not appear safe.

Plants treated with 2,4-D developed symptoms of injury similar to those in the Perkins' experiment. Those sprayed with 6 lbs. of monuron developed chlorotic foliage and in 1956 some of the current season's canes died following application. Other treatments did not cause visual injuries.

SUMMARY AND CONCLUSIONS

The results of using herbicides to control weeds and grasses in strawberries indicate that the responses of similar treatments on plants grown on newly cleared land may not be the same as those with plants grown on "old" land. The reasons for this are not known although it suggests that differences in soil composition such as organic matter content and the ratio of stone to soil, may be associated with the differences in response.

The responses of similar treatments on plants grown on "old" land with mulch may not be the same as with those plants not mulched. Again the reasons are not known although the differences in response are thought to be associated with differences in soil composition and perhaps available moisture and cooler root temperatures.

Under the conditions of these experiments the best herbicidal treatments were: On newly cleared land, not mulched—1½ lbs. per

acre, 2,4-D; on "old" land, not mulched—1 gal. per acre CIPC; and on "old" land, mulched—8 lbs. per acre 2,4-DES.

Mulching of strawberries on "old" land more than tripled the total yield as compared with non-mulched plots on "old" or newly cleared land. The results of using herbicides to control weeds and grasses in blackberries indicate that most of the herbicides used, which satisfactorily controlled weeds and grasses, were injurious to blackberry plants as evidenced by visual injuries, reduction in berry size, and total yield.

Under the conditions of these experiments the best herbicide treatment was 1½ lbs. 2,4-D per acre.

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