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EXPERIMENTS WITH DDT FOR THE CONTROL OF THE EUROPEAN
CORN BORER INFESTING SWEET CORN AT TOLEDO, OHIO, IN 1944

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The experiments described in this report were conducted in sweet corn grown near Toledo, Ohio, during 1944 for the purpose of determining dosage requirements and effectiveness of DDT as an insecticide for control of the first generation (June-July) of the European corn borer (Pyrausta nubilalis (Hbn.)). The DDT sprays and dusts were applied with a wheelbarrow sprayer, a self-propelled ground duster, and air-borne dispensing equipment designed for applying dusts and concentrated sprays. Although considered preliminary in nature, the experiments have produced information important to further use of this insecticide in field-plot tests and in commercial applications.

DDT Sprays Applied with Ground Machine (D. D. Questel)

The following water suspensions of DDT were tested as sprays in comparison with a spray containing rotenone: DDT (technical, undiluted), 10.8 percent of DDT in pyrophyllite, and 5 percent of DDT in an unknown diluent (Gesamol Spray Insecticide). Sodium monosulfonate of butylphenylphenol (Areskap) was added to all sprays.

The experimental plots were four rows wide and 25 feet long in randomized blocks. All treatments were replicated four times and each treatment consisted of three applications. For each application approximately 175 gallons of spray per acre were applied with a wheelbarrow sprayer operated by a gasoline engine and applied with a hand-directed nozzle that produced a solid cone of spray. At the time of the first application (June 17) the corn was 36 inches high with 70 percent of the tassels emerging. Additional applications were made on June 22 and 27. Dates and amounts of rainfall for the spraying season were as follows: June 19, 0.21 inch; June 22, 0.10 inch; and June 23, 2.13 inches. The results of these tests are given in table 1.

^{1/} The self-propelled ground equipment utilized in these experiments was designed and built by F. Irons and staff of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Mr. Irons and his staff also rendered valuable aid in the application of insecticide materials.

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Table 1.--Effectiveness of ground applications of DDT and rotenone in sprays for control of the European corn borer in sweet corn (4 replications)

Treatment ^{1/}	Active ingredient		No. 1 ears ^{2/} per 100 plants			No. 1 borer- free ears	Borer population per 100 plants		Reduction of borers	
	Per 100 gallons	Per acre- application	Borer- free	Infested	Total		In plants	In ears	In plants	In ears
	<u>Pounds</u>	<u>Pounds</u>	<u>Number</u>	<u>Number</u>	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Number</u>	<u>Percent</u>	<u>Percent</u>
DDT (technical):										
10.8% in pyrophyllite	4	0.76	112	4	116	96.6	38	4	97.9	99.2
Undiluted	1/2	.58	98	12	110	89.1	70	20	96.2	96.0
5% in unknown diluent (Gesamol Spray In- secticide)	8	.70	94	20	114	82.5	114	36	93.8	92.7
Cube, ground root (4.7% rotenone)	4	.33	94	18	112	83.9	160	30	91.3	94.0
Check (no treatment)	-	-	32	84	116	27.6	1834	496	-	-
Required difference for significance (19:1)	-	-	-	-	-	-	60	56	-	-

^{1/} Sodium monosulfonate of butylphenylphenol (Areskap) was added to all sprays at the rate of 1/3 pound per 100 gallons of water.

^{2/} A No. 1 ear is one of salable size (differing with variety), noninfested or infested only to a degree as to remain salable.

Owing to the unusually short period during which oviposition took place in these plots, only 3 applications were made; yet excellent control was obtained with these materials, without any apparent injury or other effect on the corn. The spray in which 10.8 percent of DDT in pyrophyllite was used as the source of the DDT was outstanding in control of the borer and reduced the population in the plants from 1834 to 38 and in the ears from 496 to 4. The mixture readily went into a water suspension, whereas much difficulty was encountered in attempting to put undiluted DDT into suspension.

DDT Dusts Applied with Ground Machine (C. H. Batchelder)

An experiment was conducted to establish the dosage required for application of DDT dust with ground equipment to infested corn. Data of this kind were also considered necessary in connection with the use of DDT in subsequent tests of new types of ground and aerial equipment. For these reasons special attention was given the mechanical adjustment of the duster equipment.

Precise control in the mechanical operation of the power-operated and self-propelled duster used in this experiment assured uniform dosage by regulation of travel speed, feed rate, ratio of dust to air volume, and physical condition of each hopper load. Dusts containing 0.75, 1.5, 3, and 6 percent of DDT were made from a 10.8 percent DDT-pyrophyllite mixture by the addition of more pyrophyllite. These dusts were applied at the rate of 40 pounds per acre-application to obtain dosages of 0.3, 0.6, 1.2, and 2.4 pounds of DDT per acre. No accessory agents were included in the mixtures.

This experiment was conducted in a commercial planting of extra-early hybrid sweet corn, Spancross, and the plots were arranged in randomized blocks. All treatments were replicated 4 times, and each treatment consisted of 4 applications. An infestation of 10 larvae per plant (primary stalk and ears) prevailing at the time of harvest caused severe loss in untreated plots.

Applications were made on June 18, 25, and 30, and July 5. They would have been started 5 days earlier but for mechanical difficulties encountered in assembling the duster equipment. The first application was made when the plants were in late whorl and early green tassel, the second during late tassel, and the last two during silking growth stages.

As shown in table 2, borer reduction increased with each increase in dosage without indication of leveling off within the dosage range. Although a dosage of 1.2 pounds of DDT did not provide a sufficiently high degree of control in these experiments, borer mortality might have been considerably greater and 2.4 pounds might have been more than necessary had there been no delay in the application schedule.

Table 2.-Borer reduction in extra-early hybrid sweet corn, Spancross, treated in dosage-mortality test of DDT applied in dust form with ground equipment (4 replications, 40 pounds of mixed dust per acre-application)

Concentration of DDT	Dosage of DDT per acre- application	Borers per 100 plants surviving at time of harvest		Reduction in borers	
		In plants ^{1/}	In ears	In plants ^{1/}	In ears
<u>Percent</u>	<u>Pounds</u>	<u>Number</u>	<u>Number</u>	<u>Percent</u>	<u>Percent</u>
6	2.4	91	19	91.0	95.1
3	1.2	277	90	72.5	76.9
1.5	.6	359	156	64.3	60.0
.75	.3	546	197	45.8	49.5
Check (untreated) -		1007	390	-	-

^{1/} Primary stalk and its appendages but not including tillers.

Ears of salable size were graded in three classes: (1) No. 1 and borer-free, (2) salable-infested, having borers in silks or shank but no injuries of kernels or husks, and (3) culled due to borers or to borer injuries of kernels and husk. The yields are summarized in table 3 according to treatment. Borer reduction is reflected in the yields obtained in plots treated at the several dosage levels. Particularly noteworthy are the higher yields in numbers of ears of salable size in treated plots as compared with untreated plots. All dosages more than doubled the number of salable as well as No. 1 and borer-free ears, and the quality of the yield improved continuously with dosage increase. No injury or other effect on the growth of the corn was observed.

Table 3.--Yield increase in extra-early hybrid sweet corn, Spancross, treated in dosage-mortality test of DDT applied in dust form with ground equipment. (4 replications, 40 pounds of mixed dust per acre-application)

Concen- tration of DDT	Dosage of DDT per acre- appli- cation	Ears per 100 plants			Increase in ears		Distribution of ears of salable size		
		Culls due to borers	Sal- able- in- fested	No. 1 and borer- free	Total sal- able	No. 1 and borer- free	Culls due to borers	No. 1 and borer- free	Total sal- able
<u>Percent</u>	<u>Pounds</u>	<u>Number</u>	<u>Number</u>	<u>Number</u>	<u>Per- cent</u>	<u>Per- cent</u>	<u>Per- cent</u>	<u>Per- cent</u>	<u>Per- cent</u>
6	2.4	15	7	126	280	530	10.1	85.1	89.9
3	1.2	33	22	106	266	430	20.5	65.8	79.5
1.5	.6	44	26	71	177	255	31.2	50.3	68.8
.75	.3	66	26	46	106	130	47.8	33.2	52.2
Check (untreated)		96	15	20	-	-	73.3	15.3	26.7

DDT in Dusts and in a Concentrated Spray Applied by Airplane
(C. H. Batchelder)

Preparations of DDT were dispensed with airplane equipment to determine their suitability and effectiveness when so applied for corn borer control in plantings of sweet corn subject to heavy infestation and damage. The materials used in these tests were a DDT dust, a cube-pyrophyllite dust, and a concentrated spray containing DDT in an oil vehicle. The dusts were applied at a rate of about 40 pounds and the spray at about 2.25 gallons per acre-application. There was great variability, however, in the amount of material deposited from the center of the swath laterally in each direction as well as along the line of flight taken by the plane.

The concentrated spray was assembled in the following proportions:

	Pounds per gallon
DDT, technical (GNB-A-DDT)	0.67
Solvent, petroleum distillate (Sunoco 7-T)	1.34
White-oil vehicle, Superla grade (125 seconds Saybolt)	5.36
Emulsifying agent (Triton X-100, an aralkyl polyether alcohol)	.16
Total	7.53

The petroleum distillate was a low-priced commercial preparation containing olefinic and aromatic hydrocarbons. This material compared very well with other common solvents in its ability to dissolve DDT and with reference to plant tolerance. The white oil has been used for earworm control and was selected because of its safety and availability. It is believed that grades of white oil with lower viscosity would be just as satisfactory. The emulsifying agent was included to increase the mobility of residues in the presence of surface moisture; it may not have been necessary.

The insecticides were applied with a Piper Cub plane carrying interchangeable dusting and spraying equipment. Owing to uneven delivery and also to reduction in deposit laterally from the central rows of the treatment swath by both types of equipment, it was not possible to compute exact delivery rates. Rates of 1.5 pounds of DDT and of 0.5 pound of rotenone per acre-application are therefore considered approximate averages for the five central rows of the treatment swath. It is probable that improvements in airplane equipment now in progress will eventually result in more even and better controlled dosages of dusts and sprays.

Tests in single-strip plots were made in a field providing three flight strips with ample buffer and check areas. The field had been planted with three varieties of sweet corn—Earligold, Whipcross, and Evergreen. These varieties differed in growth rate as well as in rate of infestation and characteristic yields.

Treatments were applied on June 21, 24, and 29, and July 4. It is of interest to note that, although it was impossible to keep to schedule with the ground duster on account of a muddy field following rain on June 23, the condition of the field was no hindrance to plane operation.

Reduction of population in the plants and in the ears for a five-row swath, and maximum reduction as obtained in the center row of the swath, on which the average dosage was heavier than it was on the lateral rows, have been summarized in table 4. The data show that considerable variation in control occurred according to the variety. In Evergreen DDT in an oil vehicle gave 92 percent reduction of borers in ears in the swath, and 100 percent in the center row of the swath, but in Whipcross it gave only 65 percent reduction in the swath and 85 percent in the center row of the swath. This was apparently due to differences in the growth stage of these varieties at the time of treatment and accompanying differences in the development of the infestation. Comparison of borer reductions on Evergreen following applications of DDT in dust and in solution showed the concentrated spray to be superior. It is also noteworthy that an average borer reduction of 89 percent prevailed in the ears of Earligold treated with cube dust. The potentiality of DDT as a corn borer insecticide was shown by the 100 percent protection provided the ears of Evergreen in a central row of the plot treated with the solution of this insecticide in oil.

Table 4.—Borer reduction in sweet corn with aerial dispenser equipment, showing control obtained in 5 rows of swath, and maximum control as obtained in center row of swath. (1.5 pounds of DDT and 0.5 pound of rotenone per acre-application)

Treatment	Control obtained in 5 rows of swath				Maximum control as obtained in center row of swath			
	Borers per 100 plants surviving treatment		Reduction attributable to treatment		Borers per 100 plants surviving treatment		Reduction attributable to treatment	
	In plants ^{1/} and ears		In plants ^{1/} and ears		In plants ^{1/} and ears		In plants ^{1/} and ears	
	Number	Number	Percent	Percent	Number	Number	Percent	Percent
Evergreen								
DDT (technical):								
Concentrated spray	23.3	5.0	92.5	92.6	5.0	0	98.4	100.0
3.75% in pyrophyllite	81.0	12.0	74.1	82.3	60.0	10.0	80.8	85.3
Check (untreated)	313.0	68.0	-	-	313.0	68.0	-	-
Whipcross								
Concentrated spray	155.0	23.0	63.6	65.4	70.0	10.0	83.6	85.0
Check (untreated)	426.0	66.5	-	-	426.0	66.5	-	-
Earligold								
Cube, rotenone 1.22% in pyrophyllite	60.5	13.0	83.4	89.0	20.0	2.5	94.5	97.9
Check (untreated)	364.0	118.0	-	-	364.0	118.0	-	-

^{1/} Primary stalk and its appendages but not including tillers.

The yields of 99 and 100 percent for No. 1 and borer-free ears obtained with DDT in oil, shown in table 5, indicate higher protection in Evergreen than has been obtained with other insecticides. Ears of salable size were graded in three classes as described in the preceding experiments with ground-duster equipment. Dust preparations of DDT and cube provided similar proportions of total salable and No. 1 and borer-free ears, although these treatments were applied to different varieties. As might be expected from the lower borer-reduction shown in table 4, the yields of salable and borer-free ears in Whipcross treated with DDT in oil were also lower than those obtained in the later Evergreen variety. The percentage of salable-size ears culled because of borer infestations was much less in all treated than in untreated plots, and no injury or other effect on the growth of the corn was observed.

Table 5.—Yield increases in sweet corn following treatments applied with aerial dispenser equipment, showing control obtained in 5 rows of swath, and maximum control as obtained in center row of swath. (1.5 pounds of DDT and 0.5 pound of rotenone per acre-application)

Variety and treatment	Ears per 100 plants			Increase in ears		Ears of salable size		
	No. 1 and borer- free	Salable- infested	Culls due to borers	Total salable	No. 1 and borer- free	Culls due to borers	No. 1 and borer- free	Total salable
	<u>Number</u>	<u>Number</u>	<u>Number</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
Control obtained in 5 rows of a swath								
Evergreen								
DDT (technical):								
Concentrated spray	196	0	1	161	180	0.6	99.4	99.4
3.75% in pyrophyllite	161	0	27	115	130	14.4	85.6	85.6
Check (untreated)	70	5	70	-	-	48.3	48.3	51.7
Whipcross								
DDT, concentrated spray	81	1	23	134	170	21.9	77.1	78.1
Check (untreated)	30	5	75	-	-	68.2	27.3	31.8
Earligold								
Cube, rotenone 1.22 %								
in pyrophyllite	104	2	19	165	247	15.2	83.2	84.8
Check (untreated)	30	10	74	-	-	64.9	26.3	35.1

Table 5.--(Continued)

Variety and treatment	Ears per 100 plants			Increase in ears		Ears of salable size		
	No. 1 and borer- free	Salable- infested	Culls due to borers	Total salable	No. 1 and borer- free	Culls due to borers	No. 1 and borer- free	Total salable
	<u>Number</u>	<u>Number</u>	<u>Number</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
Maximum control as obtained in center row of swath								
Evergreen								
DDT (technical):								
Concentrated spray	195	0	0	160	178	0.0	100.0	100.0
3.75% in pyrophyllite	180	0	15	157	157	7.7	92.3	92.3
Check (untreated)	70	5	70	-	-	48.3	48.3	51.7
Whipcross								
DDT, concentrated spray	95	0	15	171	217	13.6	86.3	86.3
Check (untreated)	30	5	75	-	-	68.2	27.2	31.8
Earligold								
Cube, rotenone 1.22% in pyrophyllite	120	0	5	200	300	4.0	96.0	96.0
Check (untreated)	30	10	74	-	-	64.9	26.3	35.1

Summary

In 1944 three applications with ground-sprayer equipment near Toledo, Ohio, at 5-day intervals to early-market sweet corn gave excellent borer control with three DDT preparations. Of three materials tested, 10.8 percent of DDT in pyrophyllite was outstanding from the standpoint of reducing borer populations in the plant as well as of the ease with which it could be put into a spray suspension. This material gave 97.9 percent reduction of borers in the plant and 99.2 percent reduction in the ears, when applied with a wheelbarrow sprayer run by a gasoline engine and applied with a hand nozzle that produced a solid cone of spray.

Four applications of dusts containing 0.75, 1.5, 3, and 6 percent of DDT in pyrophyllite were made 5 to 7 days apart with a ground machine to sweet corn in dosages of 0.3, 0.6, 1.2, and 2.4 pounds per acre-application. Borer reduction increased with each increase in the dosage rate, and at the highest rate provided 95 percent reduction of corn borer larvae infesting the ears, even though the applications were begun too late for best results against newly hatched larvae. The yield resulting from treatments applied at a rate of 2.4 pounds of DDT per acre-application was graded 89.9 percent salable and 85.1 percent No. 1 and borer-free.

On the variety Evergreen four airplane applications 3 to 5 days apart of a concentrated spray containing 8.9 percent of DDT in white oil, at the rate of about 2.25 gallons per acre, provided borer reductions in plants of 98 percent with all ears salable size and borer-free in center rows of the treated swath. DDT in dust form applied by airplane to the same variety was somewhat less effective than the concentrated spray. Aerial dust treatments resulted in 82.3 percent reduction of borers in the ears, and a yield 85.6 percent of which was No. 1 and borer-free.

All treatments resulted in an increase in the number of ears of salable size as compared with the yield of untreated check plots.

