ADJUVANTS IN SPRAYS FOR INSECT CONTROL ON SWEET CORN [1]

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Everglades sweet corn must be sprayed at regular intervals to control the corn stem weevil (*Hyperodes humilis* (Gyllenhal)), budworms, and earworms. From eggs embedded in the leaf sheaths or hypocotyl of the young corn plant, corn stem weevil grubs hatch to mine through the stem. Beginning within a day of seedling emergence, about six sprays must be applied twice weekly or every four days to control this pest. The fall armyworm *Spodoptera frugiperda* (J. E. Smith), and the corn earworm, *Heliothis zea* (Boddie), feed within the whorls of the growing plants as budworms and also upon the ears as earworms. Budworm control sprays must be applied once or twice weekly between cessation of corn stem weevil sprays and initiation of earworm control sprays. From the day after the first silks appear until shortly before harvest, earworm control sprays must be applied daily or every other day depending upon population density and weather conditions.

DDT emulsions are more effective than DDT wettable powder sprays for sweet corn insect control (Harris 1961, 1961a). However, emulsions frequently damage plants, especially at the high concentrations needed for corn stem weevil control when the plants are young and tender. DDT wettable powder sprays are less likely to damage plants or be incompatible with the fungicide wettable powders that are frequently added to the spray. Therefore, it is desirable that the efficacy of DDT wettable powder sprays be made more nearly equal to that of emulsions by the use of adjuvants or by some other measure. Triton X-100 (a wetting agent made by Rohm and Haas Company) was evaluated as an adjuvant in DDT wettable powder sprays.

Under heavy population pressures, even the most effective of recommended practices may not adequately control sweet corn insects. At one time, 2.5 gallons of white mineral oil was recommended as an additive to 1 gallon of 25% DDT emulsifiable concentrate in 50 gallons of emulsion per acre (Anonymous 1956) to control earworms in Florida. The DDT emulsifiable concentrate was supposed to supply enough emulsifier to emulsify the mineral oil. Frequently poor yields and off-color husks resulted. The recommended amount of white mineral oil was first reduced to 1.75 gallons (Brogdon and Marvel 1959) but later completely withdrawn from recommendations (Brogdon, Marvel, and Mullins 1963).

A miscible spray oil[2] was substituted for the white mineral oil and evaluated at several dosages to seek a level less likely to affect sweet corn yield or quality adversely and yet increase the efficacy of DDT emulsion against earworms. The miscible spray oil was also evaluated at a single dosage in toxaphene and DDT emulsions for budworm control.

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[2] Sun Superior Spray Oil 7-N (70 SUS at 100° F, 94% unsulfonatable residue) plus emulsifier added by the supplier, Sun Oil Company.

Materials and Methods

Plots were four rows wide and 25 or 35 feet long. They were separated by two unplanted rows at the sides and by 20-foot alleys at the ends. Sweet corn rows were 36 inches apart.

Untreated plots were not randomized within any experiment but either bordered the experiment or separated groups of plots within the experiment.

DDT was used as a 50% wettable powder and as a 25% emulsifiable concentrate. The toxaphene formulation was an 8-pound per gallon emulsifiable concentrate.

Corn stem weevil control sprays were applied at 50 gallons per acre with two nozzles over each row, or at 100 gallons per acre with an additional nozzle on each side of the row. Budworm control sprays were applied at 100 gallons per acre with two nozzles over the row and a nozzle on each side of the row. For earworm control, DDT emulsions were applied at 50 gallons per acre through a single nozzle on each side of the row aimed directly at the silks; with each emulsion 2 pounds per acre of actual DDT were applied.

Triton X-100 with Wettable Powder Sprays for Corn Stem Weevil Control

Test 1: DDT wettable powder was used at 2 and at 4 pounds of actual DDT per 100 gallons with and without 8 ounces of Triton X-100. DDT emulsifiable concentrate was used at 2 pounds of actual DDT per 100 gallons without Triton X-100. The five treatments were replicated five times in each of two Latin Squares.

Golden Security sweet corn was planted 24 October 1960; seedlings emerged on 27 October. Sprays were applied at 50 gallons per acre every four days from 28 October through 21 November.

On 30 November, nine days after the final corn stem weevil spray, 10 plants from each row were examined to find the number mined by corn stem weevil grubs. A stand count was taken in each row on 12 December. The percent plants mined by corn stem weevil grubs and the calculated number of plants per acre are shown for each treatment in Table 1. Treatments did not satisfactorily reduce the incidence of corn stem weevil attack, probably because a nozzle was not added to each side of the row for better coverage as the plants grew larger. Treatments did not differ significantly in effect on incidence of corn stem weevil attack. However, Triton X-100 when added to DDT wettable powder sprays seemed to result in a lower percentage of mined plants. Only the DDT wettable powder spray that contained 4 pounds of DDT and 8 ounces of Triton X-100 seemed equal to the emulsion in reducing the percent mined plants.

DDT wettable powder spray resulted in a significantly greater stand at 4 than at 2 pounds of DDT per 100 gallons.

Test 2: DDT wettable powder was used at 4 pounds of DDT per 100 gallons with and without 8 ounces of Triton X-100. DDT emulsifiable concentrate was used at 2 pounds of DDT per 100 gallons with no Triton X-100. Treatments were replicated three times in a Randomized Complete Block design.

Florigold 106 sweet corn was planted 18 August 1961. Four sprays of 100 gallons per acre were applied at 4-day intervals from 22 August, the day seedlings emerged. Weeds were controlled by pre-emergence herbicide applications and cultivation was delayed until after the final spray to obtain better corn stem weevil control with each treatment (Harris and Orsenigo 1961).

The mined plants among 25 plants from each of the two middle plot rows were counted 3 September 1961. The addition of Triton X-100 to DDT wettable powder sprays resulted in a lower incidence of mined plants. A stand count in the two middle rows of each plot on 14 September showed no significant differences among treatments. Results are shown in Table 1.

TABLE 1. EFFECT OF TRITON X-100 AND DDT CONCENTRATIONS ON CORN STEM WEEVIL CONTROL WITH DDT WETTABLE POWDER SPRAYS.

DDT formulation	Pounds of actual DDT per 100 gal.	Triton X-100 oz. per 100 gal.	Per cent damaged plants		Plants per acre (1000's)	
			Test 1	Test 2	Test 1	Test 2
DDT 50% WP	2	0	75	—	20.7	—
DDT 50% WP	2	8	71	—	20.9	—
DDT 50% WP	4	0	72	37	21.5	23.9
DDT 50% WP	4	8	63	28	22.1	23.6
DDT 25% EC	2	0	64	20	21.7	23.2
Untreated	—	—	96	63	14.5	21.0

TRITON X-100 WITH DDT WETTABLE POWDER SPRAYS FOR BUDWORM CONTROL.

TEST 1: The budworm damaged plants among 25 plants in each row of Test 1 of the preceding section were counted 28 November 1960. Results are shown as percent budworm damaged plants in Table 2. DDT wettable powder was highly significantly more effective at 4 pounds than at 2 pounds per 100 gallons. The addition of Triton X-100 to wettable powder sprays resulted in highly significantly fewer budworm damaged plants. DDT emulsion resulted in significantly fewer budworm damaged plants than the average of the wettable powder sprays. However, the wettable powder spray which contained 4 pounds of DDT and 8 ounces of Triton X-100 per 100 gallons resulted in slightly fewer budworm damaged plants than the DDT emulsion.

TEST 2: On 13 September 1961, the budworm damaged plants among 50 plants per plot of Test 2 for corn stem weevil control were counted and treatment results are shown as percent budworm damaged plants in Table 2. Triton X-100 seemed to increase the effectiveness of DDT wettable powder.

TEST 3: This experiment was conducted on the same sweet corn planting as Test 1 of the corn stem weevil control study. Each budworm treat-

ment followed each corn stem weevil treatment once and only once in each of the two Latin Squares. Thus, the experimental design consisted of two Greco-Latin Squares.

TABLE 2.—EFFECT OF TRITON X-100 AND DDT CONCENTRATIONS ON BUDWORM CONTROL WITH WETTABLE POWDER SPRAYS.

DDT formulation	Pounds of actual DDT per 100 gal.	Triton X-100 oz. per 100 gal.	Per cent budworm damaged plants		
			Test 1	Test 2	Test 3
DDT 50% WP	1	0	—	—	11
DDT 50% WP	1	8	—	—	7
DDT 50% WP	2	0	14	—	15
DDT 50% WP	2	8	8	—	8
DDT 50% WP	4	0	8	11	—
DDT 50% WP	4	8	3	5	—
DDT 25% EC	1	0	—	—	4
DDT 25% EC	2	0	5	1	—
Untreated	—	—	52	56	76

Wettable powder sprays contained 1 and 2 pounds of DDT with and without 8 ounces of Triton X-100 per 100 gallons. An emulsion contained 1 pound of DDT per 100 gallons. Sprays were applied 29 November and 6 December 1961. The budworm damaged plants among 25 plants in each row were counted 12 December; treatment results are shown as percent budworm damaged plants in Table 2.

The addition of Triton X-100 to DDT wettable powder sprays resulted in significantly fewer budworm damaged plants. The two concentrations of DDT wettable powder did not differ significantly. DDT emulsion resulted in significantly fewer budworm damaged plants than the average of the wettable powder sprays.

SPRAY OIL WITH DDT AND TOXAPHENE EMULSIONS FOR BUDWORM CONTROL.

Toxaphene and DDT were used at 1.5 and 1 pound, respectively, per 100 gallons of emulsion. Each was used with and without 10 pints of miscible spray oil per 100 gallons. Treatments were replicated four times in each of two Latin Squares.

Florigold 107 sweet corn was planted 11 March 1964, and seedlings appeared 15 March. Sprays were applied 23, 26, and 30 March and 2, 6, and 20 April. On 6 April, the plants that received spray oil had become yellowed.

The budworm damaged plants among 50 plants per plot were counted on 14 April. Results are shown as percent budworm damaged plants in Table 3. There were highly significantly fewer damaged plants in DDT than in toxaphene treated plots. Miscible spray oil significantly reduced the incidence of damaged plants.

TABLE 3.—EFFECT OF SPRAY OIL ON BUDWORM CONTROL WITH DDT AND TOXAPHENE EMULSIONS.

Insecticide formulation	Active ingredient per 100 gal.	Per cent budworm damaged plants	
		Without spray oil	10 pts. spray oil per 100 gal.
DDT 2 lb/gal EC	1.0	1.3	0.5
Toxaphene 8 lb/gal EC	1.5	11.0	2.8
Untreated	—	15.2	—

SPRAY OIL WITH DDT EMULSIONS FOR EARWORM CONTROL

TEST 1: Spray oil was added at 20, 5, and 1.25 pints per 50 gallons of DDT emulsion. DDT emulsion was also used without spray oil. Treatments were replicated among four randomized complete blocks. Florigold 107 sweet corn that silked 9 April 1964, was sprayed every other day from 9 April through 25 April.

The ears of U. S. Fancy conformation and size, disregarding earworm damage, in the two middle rows of each plot were counted on 28 April. The earworm damaged ears among 50 of these ears in each plot were counted. Nearly all of the earworms that occurred in this experiment were corn earworms.

Treatment results are shown as percent worm-free ears and crates per acre of U. S. Fancy ears, ignoring earworm damage, in Table 4. Spray oil highly significantly increased the percentage of worm-free ears obtained with DDT emulsion. The dosages of spray oil did not differ significantly in earworm control. The highest spray oil dosage reduced yield and caused the plants to yellow. Even with the highest spray oil dosage, ear husks were not off-color.

TABLE 4.—EFFECT OF SPRAY OIL CONCENTRATIONS ON EARWORM CONTROL WITH DDT EMULSIONS.

Pts. spray oil in 50 gal. per acre	Per cent worm-free ears		Crates per acre of U. S. Fancy ears including earworm damaged ears	
	Test 1	Test 2	Test 1	Test 2
20	92	—	219	—
10	—	60	—	216
7.5	—	55	—	186
5.0	96	54	329	202
2.5	—	53	—	238
1.25	92	—	275	—
0	78	32	298	190
Untreated	33	0	293	171

TEST 2: Spray oil was used at 10, 7.5, 5, and 2.5 pints per 50 gallons of DDT emulsion. DDT emulsion was also used without spray oil. Florigold 107 sweet corn that silked 30 April 1964, was sprayed every other day from 1 May through 17 May 1964. Each treatment was replicated five times in a Latin Square.

On 21 May, all ears of U. S. Fancy size and conformation, disregarding earworm damage, in the two middle rows of each plot were counted and examined for earworm damage. Treatment results are shown in Table 4 as percent worm-free ears and crates per acre of U. S. Fancy ears including earworm damaged ears. Nearly all earworms observed were corn earworms rather than fall armyworms.

Spray oil dosages did not differ significantly in effect on percent worm-free ears, but spray oil significantly increased the percent worm-free ears obtained with DDT emulsion. The level of control was far below commercial standards, probably because emulsions were not applied daily as recommended for sweet corn silking in May.

Treatments did not differ significantly in effect on yield of ears of U. S. Fancy size and shape. Plants that had received 10 pints of spray oil per 50 gallons of emulsion were slightly yellowed but the ears seemed to be unaffected.

CONCLUSIONS AND DISCUSSION

The results with adjuvants in insecticide sprays on sweet corn are encouraging. Triton X-100 seemed to improve corn stem weevil control and definitely improved budworm control when added to DDT wettable powder sprays. Types and dosages of wetting agents should be evaluated in future experiments.

Spray oil increased the effectiveness of DDT and toxaphene emulsions against budworms but caused the foliage to become yellowed at the concentration used. Miscible spray oil at a concentration much lower than that formerly recommended for white mineral oil greatly increased the effectiveness of DDT emulsion in earworm control. At concentrations of 7.5 pints and less per 50 gallons there was no evident adverse effect on the plants. For both budworm and earworm control, miscible spray oils of differing viscosities should be evaluated at several concentrations. Also, the interaction between spray oil concentrations and application frequency should be evaluated.

Adjuvants should be of great importance in improving the effectiveness of insecticide sprays on sweet corn but we need to know much more about their proper utilization.

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