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Sweet corn in Ohio is an important high-value truck crop (74,000 acres in 1974--ohio Crop Rep. Serv., 1975) that is especially vulnerable to blackbird damage. For this reason, a chemical treatment that would repel birds from sweet corn would be advantageous.

A candidate chemical for this use is methiocarb [3,5-dimethyl-4-(Methylthio)-phenyl methylcarbamate = Mesurol (product of Chemagro, Division of Mobay Chemical Corporation)]. In addition to insecticidal, acaricidal, and molluscieidal properties (Hermann and Kolbe, 1971:286), Schafer and Brunton (1971) established in cage tests that methiocarb was a promising bird repellent because low concentrations (<0.16%) would repel birds from treated rice seed. The chemical apparently reinforces a bad taste by producing a conditioned aversion to its intoxicating effects (Rogers, 1974). When applied to corn seed prior to planting, methiocarb treatments reduced blackbird damage to sprouts (Hermann and Kolbe, 1971; Stickley and Guarino, 1972; Ingram, et al., 1974; Linehan, et al., 1975; Stickley and Ingram, 1975). However, Mitchell, et al. (1975) did not show significant protection, and Linehan, et al, (1975) showed some phytotoxicity in cold, wet growing conditions.

Methiocarb treatments also have shown indications of efficacy when applied to mature grain crops [rice at 10.0 and 3.2 lb (active material) per acre (DeHaven, et al., 1971), sorghum at 2.0 lb (active material) per acre (Mott, et al., 1974), and sorghum at 1.6 lb (active material) per acre (Mott and Lewis, 1975)]. Because of these results, we conducted a screening experiment in 1975 to determine the feasibility of methiocarb treatments for repelling blackbirds from ripening sweet corn.

J. M. Carroll, Refuge Manager at Ottawa National Wildlife Refuge, provided lands for the test, assisted in locating and laying out the fields, and provided liaison with Refuge cooperators. Cooperators G. J. Blausey, F. L. Hartmann, W. R. Millinger, D. C. Schimming, and R. R. Wehner prepared the ground and provided weed control; W. R. Millinger planted the corn. D. N. Laband, K. M. Simpson, S. B. Williams, R. A. Dolbeer, P. P. Woronecki, and J. L. Seubert helped with field work. R. P. Pflieger, Stokely-Van Camp, provided information on corn maturity. L. C. Gibbs aerially applied the methiocarb treatments. E. W. Schafer, Jr., Denver Wildlife Research Center, determined residues on the thin-layer chromatographic plates.

METHODS

Study Area and Agronomic Practices

Ottawa National Wildlife Refuge, located on the south shore of Lake Erie about 24 km east of Toledo, Ohio, was chosen as the test site because the area has a history of heavy bird damage to field corn (Stickley, et al., 1972). Twelve 1.62-ha fields of Gold Winner (79-day maturity) sweet corn were planted between 21 and 24 May by a single farmer using the same corn planter. Fields were located 150 m to 540 m apart within a 3.2-km^2 area (Fig. 1). The single insecticide used in addition to methiocarb was heptachlor for control of seed-corn maggot. Bladex was applied at planting time for weed control.

Treatments

We randomly assigned one of three methiocarb levels to the fields, ensuring that each was assigned to four fields. The three levels, described by the number of applications of 1.5-lb active ingredient per acre, are:

Methiocarb level	Description
Zero	no application
One	single application of methiocarb applied 12 days before estimated cannery harvest date
Two	two applications of methiocarb, the first applied 12 days before estimated cannery harvest date, and the second applied 7 days later

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A single application consisted of applying 75% methiocarb (wettable powder) at the rate of 1.5 lb/acre (1.68 kg/ha) of active ingredient or 2.0 lb/acre (2.24 kg/ha) of product. Thus, Treatment Level Two (hereafter "Level Two") resulted in a total of 3.0 lb/acre (3.36 kg/ha) active ingredient or 4.0 lb/acre (4.48 kg/ha) product being applied [3.0 lb/acre of active ingredient is the highest dosage deemed economically-feasible (personal communication, John Ivey, Chemagro)]. The water solution was aerially applied at the rate of 5 gal/acre (46.8 l/ha) by a Piper Pawnee plane equipped with an Agronomic spray pump and 44 Spray Systems nozzles (reference to commercial products does not imply endorsement by the U.S. Government).

Maturity of fields was monitored to determine timing of the first application. Corn was considered to be approximately 12 days from harvest for cannery use and ready for initial application when [based upon a survey of 50 randomly-selected corn stalks (with or without ears) in each field] silks were judged to average 50 percent brown. The first application was made on 31 July and the second on 7 August; thus, cannery harvest date was 12 August. To determine actual amounts of methiocarb applied to individual fields, just before application, we placed a thin-layer chromatographic plate at corn-ear height in each 0.4-ha section of each field scheduled to receive an application.

Damage Assessment

Damage was assessed twice. The first assessment on 7 August coincided with fresh market harvest (normally considered to occur 5 days prior to cannery harvest date), and the second assessment coincided with cannery harvest on 12 August.

For fresh market assessment, only percent-ears damaged was recorded for 15 randomly-located 40-ear subsamples (observational units), totaling 600 ears per field (experimental unit). A subsample consisted of every other ear (total of four) down a corn-row length of seven ears in each of 10 adjacent rows.

For cannery assessment, we followed the same sampling procedure (randomly selecting different subsamples than those used in the fresh-market assessment) except that we looked only at top ears and removed all damaged ears in each subsample from the field. We measured (in cm) trim damage (length of bird-damaged section of corn ear), extent of bird damage along each kernel row (hereafter referred to as row-cm of damage), and total length of corn for each damaged ear. We computed total trim, total row-cm of damage, and percent of ears damaged for each subsample.

Bird Censuses

Beginning 21 July, bird numbers [Red-winged Blackbirds (*Angelaius phoeniceus),* Grackles (*Quiscalus quiscula*), Cowbirds (Molothrus ater), Starlings (*sturnus vulgaris*), seed-eaters, insect-feeders, and others] were estimated for each test field twice daily, beginning at 0800 (shifting to 0900 on 9 August) and at 1700, by observing bird entry into, exit from, and presence in each field for a 5-minute period. P.M. censuses were terminated on 11 August, the day before cannery harvest; A.M. censuses were continued through 18 August. (No observations were made on 3 August.) The field to be censused first was randomly selected for each census period; succeeding fields were observed in any convenient order. From a location in the middle of the test area blackbird flights from a roost 2.4 km from the test area were censused on 8 mornings between 25 July and 12 August by the same observer.

Bird Searches

All fields were searched for sick or dead birds five days after the first application by walking 10% of the rows in each field. Level Two fields were searched six days after the second application by walking five % of the rows.

RESULTS

Treatment

Residues retrieved from the thin-layer chromatographic plates averaged 1.29 lb methiocarb/acre (range 0.92 lb to 1.77 lb/acre for the first application and 0.71 lb/acre (range 0.37 to 1.20 lb/acre) for the second application. Conditions were windy at time of second application.

Blackbird Damage

The fresh market assessment on 7 August revealed little damage. Of 7,200 ears examined, 23 (0.3%) were damaged. Damage occurred in five fields: three Level Zero fields (13 ears) and two Level One fields (10 ears).

Damage increased substantially in the 5-day interval between fresh market assessment on 7 August and cannery assessment on 12 August; overall, 26.3% of the ears were damaged. For the cannery assessment (Table 1), differences between the three treatment levels were not significant at the 0.05 level for the three measures of damage: percent of ears damaged, total trim, and total row-cm of damage. However, these differences were statistically significant for all measures of damage at the lower 0.10 level of significance (Table 2).

When Duncan's New Multiple Range Test was applied to the treatment level means, significant differences (a = 0.05) were found between Level Zero and Level Two (Table 2) for all three damage measures (percent ears damaged, total trim, and total damaged row-cm).

Mean blackbird damage figures per field (Table 1) show that Level Zero fields had 5.3 times the percent-ears damaged, 6.7 times the trim, and 9.6 times the row-cm of damage that Level Two fields had. When compared with Level One fields, Level Zero fields had 1.7 times the percent-ears damaged, 1.6 times the trim, and 1.6 times the row-cm of damage.

Bird Numbers

A significant ($P < 0.01$) difference existed among treatment levels in blackbird (primarily Red-winged Blackbird) numbers per census period for the interval spanning first day of methiocarb application through day before harvest (Table 3). The mean number of blackbirds observed during daily A.M. and P.M. census periods for the above interval is 99.40 for Level Zero fields, 34.08 for Level One fields, and 29.11 for Level Two fields. Duncan's New Multiple Range Test indicated that all of these means were significantly ($P = 0.01$) different.

Blackbird numbers in Level Zero fields averaged approximately the same over the first two application intervals but increased greatly in the interval following application of methiocarb to the Level Two fields. Blackbird numbers in the Level One and Level Two fields decreased in the interval between first and second methiocarb application and then increased after the second application to the Level Two fields (Fig. 2). The increase in the Level Two field average is due primarily to one count of 1,340 blackbirds in one field one morning; no blackbirds were observed in the field the subsequent afternoon or the next 2 days. But blackbird numbers in Level Two fields did increase the day before cannery harvest.

On 12 August, the day of cannery assessment, substantial blackbird numbers (80 or more birds) were observed in seven of the 12 fields, including two Level Two fields. Blackbird numbers averaged 211 birds per A.M. census period in all fields on censuses taken between 13 and 18 August, compared with 71 birds per A.M. census between first treatment application (31 July) and cannery harvest (12 August).

Fields with the lowest blackbird numbers within each treatment level coincided with fields having the lowest damage within each treatment level. These were Fields 4, 5, 6, and 8 in the southwest section of the test area (Fig. 1).

Roost counts, in general, gave no indication of blackbird usage of the cornfields. The counts generally decreased over the test period, beginning with a high of 39,000 birds on 27 July and ending with a count of 15,000 on 11 August.

Aside from blackbirds, too few (16) insectivorous birds were observed in the fields to determine if methiocarb affected them. Numbers of seedeating birds, including House Sparrows (*passer domesticus*), in test fields were apparently not affected by methiocarb treatment between first treatment application and cannery harvest; Level Zero fields had 70% of pre-treatment seedeater numbers; Level One fields had 54% of pre-treatment seedeater numbers; and Level Two fields had 80% of pre-treatment seedeater numbers.

Bird Searches

No sick or dead birds were found during the searches.

Rainfall

Rain fell during the period 2-5 August (5.84 cm) and on 11 August (1.65 cm).

DISCUSSION AND CONCLUSIONS

This test was exploratory in nature, testing the feasibility of methiocarb treatments on maturing sweet corn. Thus, we feel that the differences in damage between treatments, even though they were significant only at the $P = 0.10$ level, are encouraging.

We speculate that the drop in bird activity in the treated fields from 31 July through 6 August (Fig. 2) may have been due, at least in part, to the insecticidal properties of methiocarb. Birds in the fields prior to the time the corn was damageable were likely feeding on insects. When methiocarb was applied on 31 July, insect populations might have been so reduced that the fields were no longer attractive to birds. This desertion of fields by birds after methiocarb application was particularly noticeable for Field 4 (Fig. 3). Prior to the first application, morning counts for this field averaged almost 700 birds; but, beginning on 31 July, the mean morning count for the next 12 days was only six birds. In no other field did this precipitous drop occur after first application; but then no other field had populations of this magnitude, nor did any other field receive as high a methiocarb dosage on the first application--1.77 lb/acre (measured).

Rain during the period 2-5 August could have reduced methiocarb remaining after the first application to the point that it was a factor in the increase in bird activity in Level One fields beginning on 9 August. But rain did not appear to be of significance in the increase in bird activity in Level Two fields, since the increase began the morning of 11 August before the rain began. Instead, this increase in bird activity in Level Two fields only four days after the second application could have been, at least partially, due to the low amount of methiocarb actually deposited on the corn plants during the second application.

RECOMMENDATIONS

We recommend that future field testing be conducted (1) to reaffirm the apparent blackbird-repellent capabilities of methiocarb in the protection of maturing sweet corn, and (2) if repellency is reaffirmed, to establish the most efficient (i.e., efficacious and economically feasible) application schedules for commercial use on sweet corn. Insect populations should be monitored in future tests to determine the effect of methiocarb on insect numbers. Future tests should include a treatment form with an application of methiocarb at 3-4 days before cannery harvest since this appears to be the key period for the initiation of most damage by blackbirds.

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TABLE 1. Mean blackbird damage on cannery harvest data grouped by treatment level, measure of damage, and fields, Ottawa NWR, 1975.

	Level Zero		Level One		Level Two	
Measure of damage	field	damage	field	damage	field	damage
Percent ears damaged	2	56.33	1	37.83	3	12.33
	8	9.33	5	1.50	4	0.50
	11	53.67	7	14.67	6	0.17
	12	57.33	9	51.17	10	20.50
	mean	44.17		26.29		8.38
Total trim-cm (per ear)	2	2.95	1	2.70	3	0.60
	8	0.36	5	0.06	4	0.03
	11	2.76	7	0.68	6	0.01
	12	3.04	9	3.06	10	0.81
	mean	2.28		1.47		0.34
Total damaged row-cm (per ear)	2	24.21	1	18.07	3	3.06
	8	1.91	5	0.25	4	0.12
	11	21.63	7	3.94	6	0.02
	12	23.13	9	23.47	10	4.20
	mean	17.72		11.43		1.85

TABLE 2. Analyses of variance and Duncan's New Multiple Range Tests on. blackbird damage data for Ottawa NWR sweet-corn fields, 1975. Analysis of variance performed using BMD08V program.

Measure of damage	Analysis of Variance: source	df	mean square	F-ratio
Percent ears damaged (arc sine)	methiocarb	2	3.7147	3.098*
	experimental error	9	1.1992	44.914***
	observational error	168	0.0267	
Total trim-cm	methiocarb	2	91493.8	3.126*
	experimental error	9	29270.6	25.879***
	observational error	168	1131.1	
Total damaged row-cm	methiocarb	2	6131880.9	3.194*
	experimental error	9	1920098.8	19.026***
	observational error	168	100919.9	

* significant, $P < 0.10$; $F_{2,9}$ (0.10) = 3.01

*** significant, $P < 0.01$; $F_{9,120}$ (0.01) = 2.56

	Duncan's New Multiple Range Test (α = 0.05)[a]: Methiocarb level:	Two	One	Zero
Percent ears damaged (arc sine)	mean:	0.2042	0.4682	0.7015
Total trim-cm	mean:	13.42	59.97	91.74
Total damaged row-cm	mean:	74.0000	457.2500	708.3333

[a]Horizontal lines under means encompass values not significantly different at P = 0.05 level. For means differing by two steps (i.e., Two and Zero), the level of significance for the comparison is P = 0.10.

TABLE 3. Analysis of variance and Duncan's New Multiple Range Test for blackbird census data for Ottawa NWR sweet-corn fields, 1975. Days of observation analyzed span the 11-day period from day of first treatment through day before harvest. Analysis of variance was performed using BMD08V program.

Analysis of Variance

Source	df	sums of squares	mean square	F-ratio
Methiocarb (M)	2	153.3495	76.6748	19.17**
Replications (R/M) within methiocarb	9	36.0039	4.0004	
Periods (P)	1	93.4782	93.4782	34.29**
Days (D)	10	152.2718	15.2272	5.59**
P * M	2	6.9891	3.4946	1.28NS
M * D	20	89.0970	4.4549	1.63NS
Residual error[1]	219	296.9570	2.7258	

** Significant, P <0.01

NS not significant, P > 0.05

[1] composed of:

Source	df	Sums of squares
P * D	10	51.7016
P * R/D	9	37.5089
D * R/D	90	272.5747
P * M * D	20	38.0372
P * D * R/M	90	198.1354
Error	0	-
Residual error	219	596.9578

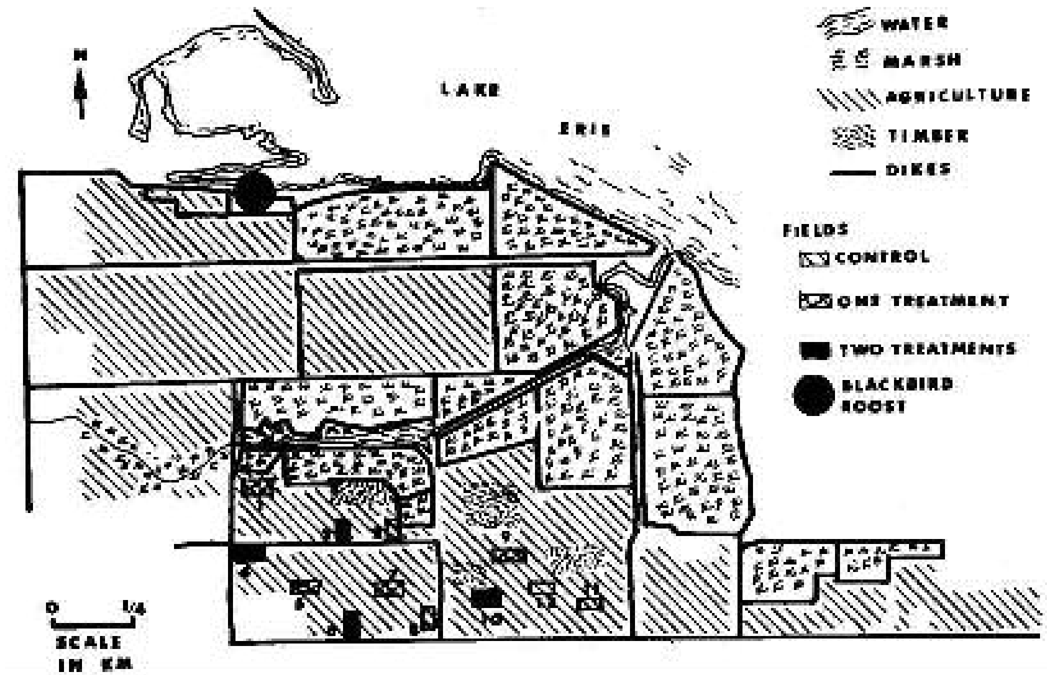

Fig. 1. Map of 1975 methiocarb-sveet-corn test area at Ottawa NWR.

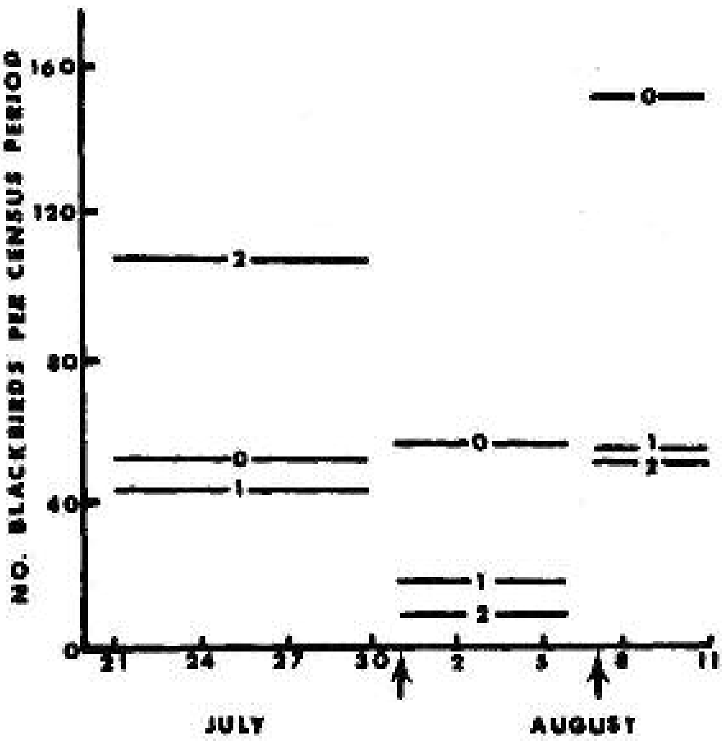

Fig. 2. Average blackbird numbers (horizontal lines) for each treatment level of methiocarb during three time intervals (before first methiocarb application, between first and second methiocarb applications, and after second methiocarb application) in the test of methiocarb on sweet corn at Ottawa NWR 1975. Number in center of each horizontal line indicates treatment level; arrows indicate dates of application.

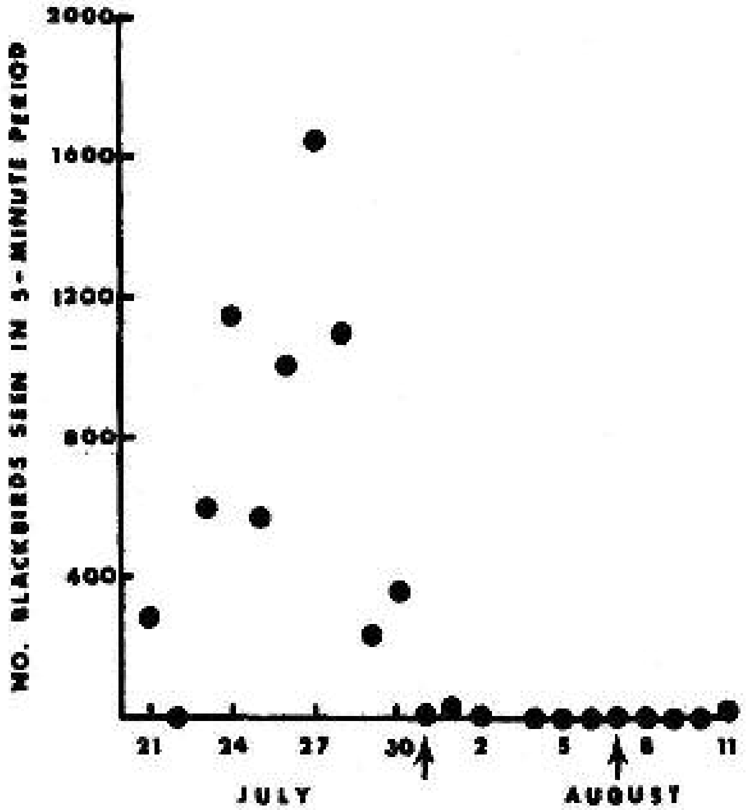

Fig. 3. Chronology of A.M. blackbird numbers in Field 4 (arrows indicate times of application of methiocarb), Ottawa NWR, 1975.