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AN EVALUATION OF MODIFIED 4-AMINOPYRIDINE BAITS FOR PROTECTING SUNFLOWER FROM BLACKBIRD DAMAGE

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ABSTRACT: Bait preference studies with red-winged blackbirds (Agelaius phoeniceus) in North Dakota sunflower fields indicated that sunflower seeds and a combination of sunflower seeds and chopped corn (MIX) were more successful in producing affected blackbirds, primarily red-winged blackbirds, than pearl barley or chopped corn used separately. A subsequent study compared the effectiveness of commercial Avitrol FC Corn Chops-99S to 4-aminopyridine-treated MIX-99S baits for reducing blackbird damage to ripening sunflower. Both baits significantly reduced damage in fields nearest a blackbird roost (within two miles), but were largely ineffective in fields farther than two miles from a roost. The ramifications of these results are discussed.

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INTRODUCTION

Oilseed sunflower became an economically viable agricultural crop on the northern prairie of the U.S. in the late 1960s (Putt 1978). Blackbirds, primarily redwings, soon became an economic problem for growers of this crop; annual losses are estimated in millions of dollars. A 1980 damage survey estimated losses at $7.9 million in the Dakotas and Minnesota, with a $6.5 million loss in North Dakota, the major producing state (Hothem et al., in press). Although sunflower acreage in North Dakota has decreased from 5.3 million in 1979 (USDA 1980) to 1.2 million in 1987 (ND Ag. Stat. Serv. 1988), blackbird damage remains a substantial problem.

A number of bird control methods are used by growers to reduce sunflower losses. They include scare devices such as propane exploders, shell-crackers, scarecrows, and helium-filled balloons; hazing by aircraft and gunfire; and applications of a chemical frightening agent, Avitrol (4-aminopyridine; 4AP), which causes birds that consume a treated bait to emit distress calls and displays. None of these techniques used separately can completely prevent damage in all situations.

Although Avitrol FC Corn Chops 99S (AFCC-99S; active ingredient 4AP) was registered in 1976 and is the only chemical available for use against blackbirds in sunflower, it has not been without problems or critics. Initially, AFCC-99S appeared to be effective for protecting ripening sunflower from blackbirds (Besser and Cummings 1975, Besser and Guarino 1977). However, subsequent studies have shown variations in its effectiveness (Besser and Pfeifer 1978, Mott et al. 1980, Knittle et al. 1981, Besser et al. 1984). In the early 1980s, users noted a drastic decline in the performance of AFCC-99S and began to lose confidence in the product. Several reasons have been cited for this poor performance: (1) changes in cultural practices, i.e., narrower row-spacing and heavier fertilization by growers resulting in a denser vegetative canopy which tends to obscure baits from birds (Besser 1978, Besser and Pfeifer 1978); (2) loss of chemical from treated baits primarily through sublimation (Besser 1982, Cunningham 1983) and, to a lesser extent, from mechanical abrasion (Knittle et al. 1981); (3) breaking of bait particles by redwings, the primary target species, resulting in a less than optimum dose on consumed particles (Besser and Cunningham 1982, Besser et al. 1984); and (4) poor bait acceptance by redwings (Knittle et al. 1981, Besser 1982, Jaeger et al. 1983).

The problem of dense canopy cover can be minimized by applying AFCC-99S on baiting lanes created by removing a row of sunflower every 66 rows (assuming 30-in row-spacing) in a field (Besser and Pfeifer 1978, Besser et al. 1984). Although baiting lanes increase effectiveness, they are not yet included in the AFCC-99S registration. Amending the registration is dependent upon data currently being acquired to support this change. The sublimation problem was solved by adding hydrochloric acid to the bait treatment solution, thereby converting 4AP from the free-base form to the more stable acid salt, 4AP HCl (Cunningham 1983).

The problem of poor acceptance of chopped corn baits by redwings was addressed in 1984 and 1985 in North Dakota sunflower fields. Our objectives were (1) to identify a bait or combination of baits more preferred by redwings than chopped corn, and (2) to evaluate a preferred bait against commercial AFCC-99S for reducing blackbird, particularly redwing, damage in sunflower. Based on our results obtained in 1984, the EPA granted an Experimental Use Permit (No. 6704-EUP-29) in 1985 to test 4AP HCl-treated experimental MIX-99S baits containing a mixture of whole oil-sunflower achenes, sunflower meats (dehulled achenes), and chopped corn. The latter was included in MIX baits because it is readily accepted by common grackles (Quiscalus quiscula) and yellow-headed blackbirds (Xanthocephalus xanthocephalus), also contributors to sun-

flower damage (Besser et al. 1984). This paper presents summary results and conclusions of these studies.

METHODS

1984

Five different baits--chopped corn (CCN), pearl barley (BAR), millet (MIL), sunflower achenes (SFA), and sunflower meats (SFM)--were used in enclosure and field tests. In the enclosure test, two groups of six male and two groups of six female redwings were held in four separate enclosures erected over sunflower plants in a ripening sunflower field. Initially, each group was randomly offered one of the five untreated baits. After two consecutive days of feeding, remaining bait was removed, weighed, and another bait offered to each group of birds. All birds had access to sunflower heads in each cage as an alternate food source in an attempt to simulate the choice available in a field situation. Analysis of covariance was used to determine if there was any difference between consumption of seeds from heads in cages and any of the test baits. Bait consumption data were analyzed by two-way (bait-type, sex) ANOVA with differences among means separated by Student-Neuman-Keuls Test.

For the field test, CCN, BAR, SFA, and SFM were treated to contain 3% 4AP HCl and diluted 1:99 with the same kind of untreated bait. MIL was not used in field tests because single kernels are not large enough ($\bar{x}$=6 mg) to accommodate enough 4AP HCl necessary to be one-kernel effective. Also tested were commercially available AFCC-99S, used as the standard, and experimental MIX-99S, a mixture, by weight, of SFA (46%), SFM (31%), and CCN (23%), with each pound of MIX containing an equal number of each kind of bait particle. All 4AP-treated experimental baits were prepared using the method of Davis et al. (1986). 4AP was used as a toxic "marker" so that bait acceptance by free-ranging blackbirds could be determined. All baits were distributed in test fields in particle densities similar to that registered for AFCC-99S, i.e., about 13,000 particles per pound.

Whole fields or portions of fields 100 acres or smaller, in similar stages of maturity, and with at least 500 blackbirds observed feeding in them for one or more days, were selected as test fields. Each field selected was baited only one time; baits were applied on baiting lanes with a Herd Model GT-77 Seed Spreader mounted on a Honda ATC.

Bait preference was evaluated primarily by observing treated fields for blackbird activity and 4AP-affected birds. Each field was observed for a maximum of 2 h beginning 30 min after sunrise and, again, for a maximum of 2 h within 4 h of sunset each day for three days. These observation data were reduced to a ratio of the number of affected (A) and dead target redwings (RW) seen, heard, or found in a field, to the mean ($\bar{x}$) number of redwings (RW) observed per min (M; A&DRW:$\bar{x}$RW/M).

Baits were tested against each other in pairs of fields. In most cases, the preferred bait from a pair of fields was tested against another pre-selected bait in the next pair of fields. However, to ensure that each test bait was given at least one trial comparison, given the limited number of test fields available, the more preferred bait of a test pair was not always used in the next comparison if the A&DRW:$\bar{x}$RW/M ratios were similar. The comparisons continued until all candidate baits had been evaluated at least one time. Finally, a bait that appeared to be one of the more preferred was compared against commercial AFCC-99S.

Additional data were collected within each baited field by searching for dead blackbirds and by examining gizzard and gullet contents of birds found affected or dead in MIX-baited fields. We also used small bird-proof wire exclosures to determine if baits were being removed by insects or rodents.

1985

One of three treatment forms (untreated control, AFCC-99S, or experimental MIX-99S) was applied to each of 26 ripening sunflower fields selected from fields in which at least 2000 blackbirds were observed feeding for two or more days within a week following the onset of anthesis. Fields were stratified into two zones; those closest to a blackbird roost, i.e., within 2 miles (Zone A), and fields greater than 2 miles from a roost (Zone B). The initial sequence of treatments was randomly assigned to the first three fields within a zone; subsequent treatments followed this same sequence as remaining fields became available. Baits were diluted (1:99 treated to untreated) and applied at a rate of 1 lb per field-acre in 15-ft swaths on baiting lanes (10 lb per baited-acre) using the method described previously. The criterion for rebaiting was based on counting a known number of bait particles in grids permanently placed at 200-yd intervals (segments) in each baiting lane. Grids were read at two-day intervals; if 80% of the particles were removed from the grid in a given segment, that segment of the lane was rebaited.

Blackbird damage to sunflower heads was primarily used to determine efficacy of treatments at 12 days following the initial treatment in each field. Seventy-five 5-ft linear plots were located in each field following the design of Jaeger et al. (1983) and total damage (cm^2) on each head measured with a gridded template (Otis 1981). The diameter and undeveloped center also were measured; the latter being subtracted from the total head area to determine an estimate of available seed per head. Estimates of percent of damage were subjected to square root transformation and analyzed by analysis of variance. Comparisons among treatment means were performed by using Tukey's studentized range test.

Supporting data were obtained by (1) observing bird activity in each field for 1 h each morning before 1100 h, (2) conducting searches for dead birds on baiting lanes following each observation period and randomly on 5% of the rows in a field at the conclusion of a 12-day test period, and (3) calculating benefit:cost ratios for the study.

RESULTS

1984

In cage tests, redwings showed a highly significant (p=0.0007) preference for MIL, with SFA and SFM being nearly equal second and third choices; BAR and CCN were the least preferred.

MIX baits were more preferred by redwings than Avitrol Chopped Corn baits in field tests (Table 1). In the 6 fields where SFM, SFA, and MIX baits were tested and where the flock composition favored redwings, the A&DRW:x̄RW/M ratios were reasonably consistent (1:65 to 1:114), implying that SFA and SFM baits were as readily accepted. However, in Field 5B, which was used twice, i.e., MIX was applied 4 days after AFCC-99S was evaluated, the preference by virtually the same population of redwings for MIX over AFCC-99S was a striking 19-fold difference (ratio of 1:67 to 1:1250). No dead blackbirds were found and a total of nine unidentified 4AP-affected blackbirds were observed in fields baited with BAR and lab-prepared 4AP CCN.

Examination of gullet and gizzard contents of 33 redwings found affected or dead in MIX-baited test fields revealed 31 (94%) contained sunflower seed particles exclusively; 5 (15%) of the 33 birds contained one or more CCN particles in addition to sunflower. Insect and small mammal removal of baits from wire bird exclosures was negligible.

1985

Overall, both AFCC-99S and MIX-99S baits provided significant (P=0.0044) protection from blackbirds in ripening sunflower fields; damage was 73% and 63% less in AFCC-99S and MIX-99S fields, respectively, than in untreated fields. However, baits performed much differently in fields near roosts (Zone A) than in those farther from a roost (Zone B), i.e., there was a significant interaction (P=0.0025) between zones and treatments. In Zone A, baited fields had significantly less damage than untreated fields (P<0.05), but neither bait differed significantly from the other; AFCC-99S provided 92% and MIX-99S 69% protection. In Zone B, there was no significant difference in damage levels among treated and control fields; AFCC-99S fields were damaged slightly more than untreated fields whereas MIX-99S baits provided 62% protection (Table 2). Blackbird flocks were composed of an average of 71% redwings, 21% yellowheads, and 5% common grackles over all test fields. In Zone A, there were from 2.2 to 2.6 times more birds observed per minute per acre in untreated fields than in baited fields, but, in Zone B, nearly the opposite was recorded; baited fields had 1.4 times more birds than

Table 1. Bait[a] preference by red-winged blackbirds (RW) in ripening sunflower fields in North Dakota, 1984.

Field No.	Bait[b] Type	Species Composition (%RW,YH,CG)[c]	Total RW Bird-Min.	Total Min. Obsv.	Mean No. RW/Min.	Total No. Affected Dead RW[d]	A&DRW: x̄RW/M[e]
1A	CCN[f]	(67,13,20)	95,759	360	266	6 unk)	N/A
1B	SFA	(5, 5,90)	7,448	163	46	3 (13)	1:15
2A	SFA	(95, 3, 2)	185,857	335	555	6 (0)	1:92
2B	SFM	(98, 1, 1)	1,358,325	360	3773	37 (0)	1:102
3A	SFM	(56,42, 2)	250,699	200	1253	11 (13)	1:114
3B[g]	BAR	(67,30, 3)	493,939	394	1259	(3 unk)	N/A
3B[g]	SFM	(67,30, 3)	220,075	140	1572	24 (5)	1:65
4A	MIX	(12, 2,86)	77,864	128	608	1 (68)	1:608
5A	MIX	(99, 1, 0)	105,375	165	638	9 (3)	1:71
5B[i]	ACC[h]	(97, 1, 2)	7,787,378	519	15,005	12 (11)	1:1250
5B[i]	MIX	(99, 0, 1)	7,275,807	589	12,353	183 (0)	1:67

[a]Treated to contain 3% 4AP HCl and diluted 1:99 with untreated baits.
[b]SFA (sunflower achenes; whole oil seeds), SFM (sunflower meats; hulled achenes), BAR (pearl barley), CCN (chopped corn), MIX (SFA, SFM, CCN mixed in equal numbers of particles/lb).
[c]YH = yellow-headed blackbird; CG = common grackle.
[d]Other blackbirds in parentheses.
[e]Ratio of affected and dead redwings to mean no. redwings per min.
[f]DWRC lab-prepared 4AP HCl chopped corn baits.
[g]Same field; rebaited with SFM 4 days after BAR test completed.
[h]Commercial Avitrol FC Corn Chops-99S.
[i]Same field; rebaited with MIX 4 days after Avitrol test completed.

Table 2. Estimated losses per acre in control fields and fields treated with AFCC-99S and MIX-99S baits, North Dakota, 1985.

Zone[a]	Treatment	(n)	Acres	Bait used (lbs)	Bird activity (b/m/a)[b]	Yield loss (lbs/a)[c]	Value of loss ($/a)[d]
A	Control	(3)	152	0	9.8	259	25.90
	MIX	(6)	246	395	3.8	81	8.10
	AFCC	(6)	261	343	4.4	20	2.00
B	Control	(5)	227	0	4.2	61	6.10
	MIX	(3)	178	293	6.2	23	2.30
	AFCC	(3)	173	263	6.0	74	7.40
A+B	Control	(8)	379	0	6.5	150	15.00
	MIX	(9)	424	688	4.8	56	5.60
	AFCC	(9)	434	606	5.0	41	4.10

[a]Fields in Zone A nearest a roost (within 2 miles); Zone B farther from a roost.
[b]Observed average number of birds per minute per acre.
[c]Obtained by multiplying absolute cm^2 loss/acre by 0.2 g/cm^2.
[d]1985 market price of about $0.10/lb.

untreated fields (Table 2). Using the total number of 4AP-affected and dead blackbirds (215; 56 were unidentified) observed in the study as one measure of acceptance of the two test baits, there were twice as many of these birds recorded in MIX-baited fields (142) than in AFCC-99S fields (73). Of 159 identified blackbirds, 41% (65) were redwings from MIX-baited fields and 17% (27) were from AFCC-99S fields.

A benefit:cost (B:C) ratio of $2.75:$1 was obtained for all AFCC-99S baited fields and $1.88:$1 for MIX-99S fields. However, in fields near a roost, B:C ratios were $6.87:$1 and $3.99:$1, respectively; negative B:C ratios were obtained in treated fields 2 miles or more from a roost (Table 3).

DISCUSSION

In 1984, MIX bait produced more 4AP-affected redwings than AFCC-99S baits. SFA and SFM baits produced A&DRW:xRW/M ratios consistent with MIX baits when redwings were the predominate species in fields. In 1985, MIX-99S also produced more affected redwings in test fields than AFCC-99S, but this did not necessarily translate into greater protection in ripening fields. Sunflower seed baits, particularly SFM, tend to decompose and mold after 3 or 4 days of field exposure, primarily from ambient moisture, greatly reducing their palatability and effectiveness. Moreover, birds which select an SFA bait immediately remove the hull, thereby discarding a substantial amount of 4AP and presumably reducing the effective dose. Consequently, fields containing these baits may have been largely unprotected for short periods of time before rebaiting occurred. Conversely, chopped corn baits are more resistant to decomposition and their extended availability may explain why AFCC-99S afforded better and more cost-effective protection in treated fields close to a roost.

We believe the reasons both MIX-99S and AFCC-99S were efficacious and cost-effective in reducing damage in fields near a roost in 1985 was because of the feeding patterns of blackbird flocks and the lack of stomach-fill. Large flocks of blackbirds tend to feed voraciously in the first available ripening field as they emanate from a roost in the morning. As they become partially satiated, large flocks move farther down the flight-line from a roost, diffuse into flocks as small as a few hundred birds, and disperse into many more fields (DeGrazio 1963). Small flocks appear to be much more difficult to disperse from these fields treated with 4AP baits because of the reduced probability that small numbers of birds will find treated baits.

Flocks in fields near roosts in 1985 were about 2.5 times larger than in fields farther from roosts and, overall, redwings outnumbered other blackbirds nearly 3 to 1. Sultana (1985) has shown that fasted redwings have almost a 3-fold faster response time to 4AP baits than nonfasted birds and that birds dosed in the morning showed a faster response time than those dosed near noon. Thus, large flocks of blackbirds, composed mostly of redwings, taking their first feeding in fields close to roosts in the early morning are likely to be affected more quickly by 4AP baits and in greater numbers than smaller, nearly surfeit flocks in fields farther from the roost later in the day.

Table 3. Cost-effectiveness of commercial AFCC-99S and MIX-99S baits tested to reduce blackbird damage in 18 baited fields in North Dakota, 1985.

Zone[a]	Treatment (acres)	Costs ($) Bait[b]	Lanes[c]	Total	Benefits ($)[d] Total saved	B:C ratio
A	MIX (246)	691	406	1097	4379	$3.99:1
	AFCC (261)	480	431	911	6259	6.87:1
B	MIX (178)	513	294	806	678	0.84:1
	AFCC (173)	368	285	654	-225	0.34:1
A+B	MIX (424)	1204	700	1904	3574	1.88:1
	AFCC (434)	848	716	1565	4301	2.75:1

[a]Fields in Zone A within 2 miles of a roost; fields in Zone B more than 2 miles from a roost.
[b]$1.40/lb for AFCC baits and ca. $1.75/lb for MIX baits.
[c]1.5% of field-acres destroyed; average yield approximately 1100 lbs/a @ 10 cents/lb = $1.65/a loss.
[d]Difference between total loss (cm^2) in untreated and treated fields X mean of 0.2 g/cm^2 X 454 g/lb X 10 cents/lb.

Because of the problems mentioned in using sunflower seed baits as a carrier for 4-aminopyridine, and the difficulty of applying the chemical to these baits, we plan no further testing. With improvements in the chemical stability of 4-aminopyridine in the commercial Avitrol product, the possible label amendment to include its use on baiting lanes, and its effectiveness shown in fields near blackbird roosting marshes, we feel that Avitrol FC Corn Chops-99S should be reconsidered as a cost-effective method for reducing blackbird damage in certain ripening sunflower fields. The overriding consideration should be that this control method will not provide total protection in all circumstances; it is merely one of several available tools that, when appropriately used in an integrated program, may help reduce blackbird damage.

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