September 1985

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ABSTRACT

Blackbirds cause locally serious losses to rice. The Denver Wildlife Research Center, U. S. Fish and Wildlife Service, and the Rice Research Station, Louisiana State University Agricultural Center have been cooperating in tests to determine the efficacy of methiocarb seed treatments for protecting sprouting rice in Louisiana from blackbird damage. Results from four field tests (1980, 1982, 1983, and 1984) have shown that methiocarb provides good protection when applied to rice seed at the rate of 2.4 g and 1.25 g active ingredient (a.i.)/kg of rice seed (0.25 and 0.125%). Seed treated at 0.6 g a.i./kg appeared to be susceptible to damage; but, results were inconclusive due to low bird pressure on untreated fields. Fields planted with seed treated at 0.4 g a.i./kg were heavily damaged. Laboratory testing substantiated that >1 g of methiocarb/kg was required to achieve acceptable repellency. We recommend that future field testing be restricted to treatments of >1.0 g a.i./kg rice seed, and that >1.0 g a.i./kg be accepted as the minimum seed treatment level for formulations under consideration for registration or use in conjunction with emergency (Section 18) exemptions to FIFRA by the Environmental Protection Agency.

INTRODUCTION

Blackbirds (Icterinae) cause locally serious losses to many kinds of sprouting grains. Kalmbach (1937) noted severe damage in Louisiana rice plantings in 1924. More recently, Pierce (1970) reported that Arkansas rice farmers estimated that losses to blackbirds at planting time in 1968 were in excess of $1 million.

Methiocarb has shown promise for protecting seeded rice from damage by blackbirds (Besser 1973, Mott et al. 1976, Ruelle and Bruggers 1979). Holler et al. (1982) determined that Mesurol(R)[4/] 75% Seed Treater (Mobay Chemical Corporation) applied at the rate of 2.4 g active ingredient (a.i.)/kg seed (0.25% methiocarb) provided excellent protection to sprouting rice in Louisiana under conditions of high blackbird pressure. Based in part on those results, an application for registration of the formulation was submitted to the Environmental Protection Agency (EPA) by Mobay Chemical Corporation.

That application is still under consideration by the EPA, and additional data have been requested due to concerns about residues associated with water-planted fields. An emergency (Section 18) exemption from the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) was granted by the EPA for use of the formulation at 2.4 g a.i./kg seed during the 1982 and 1983 growing seasons. Initial use by growers of the formulation was low, largely due to treatment costs ($28/ha; Holler et al. 1982). Subsequent field and laboratory tests, reported here, of several methiocarb formulations provide a basis for recommendations as to the minimum level of methiocarb seed treatment to be used in future field testing or in use of formulations under emergency (Section 18) exemptions from FIFRA.

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4/Reference to trade names does not constitute endorsement by the Federal government.

D. J. LeBlanc and E. LeBoeuf, U. S. Fish and Wildlife Service, Crowley, Louisiana provided much valuable assistance in the field. Residue analyses were performed by D. J. Cunningham, Denver Wildlife Research Center (DWRC). D. L. Otis (DWRC) provided statistical guidance and assistance for the field tests and, with E. W. Schafer, Jr. (DWRC) provided suggestions for design of the laboratory test. R. C. Littell, Dept. of Statistics, Univ. of Florida performed statistical analyses of laboratory consumption data. D. G. Decker (DWRC) and R. J. Newberry (Univ. of Florida) assisted with care of birds and collection of laboratory data. R. A. Dolbeer and D. L. Otis provided helpful comments on an earlier version of this paper. Mesurol 75% Seed Treater for these tests was provided by the Mobay Chemical Corporation. Borderland Products Inc. made available Borderland Red 8% Seed Treater and provided support for the 1984 field test and laboratory evaluations.

METHODS AND MATERIALS

Field Tests:

Field tests of candidate methiocarb formulations at varying treatment rates were conducted during spring 1982-84 (Table 1) in southwestern Louisiana. All tests followed the design used by Holler et al. (1982) with minor modifications as recommended by Otis et al. (1983). Rice seed (cultivars Saturn and LaBelle) was treated with methiocarb formulations at the rates shown in Table 1. Seed was placed in a powered concrete mixer in 45-kg batches, and an aqueous suspension (approximately 1.5 l) containing the proper level of methiocarb was sprinkled onto the seed in the activated mixer. Mixing continued for 10 min following addition of the methiocarb suspension after which the seed was returned to burlap bags and allowed to dry for at least 24 h prior to planting. Fields were randomly assigned for planting with seed treated at the test rates or with untreated seed each year. All fields were aerially planted with 112-157 kg of seed/ha using normal cultural practices. In 1982 seed for six of the nine fields was soaked to initiate germination prior to planting. Planting dates were determined by growers based on local weather conditions, but all fields were planted early in the growing season in an effort to assure adequate blackbird feeding pressure on the test seedlings.

Field sampling was as described by Otis et al. (1983). Each field was divided into five strata. There were 50 paired sample points per field, distributed among strata proportionalto

Table 1. Year, methiocarb treatment rate, number of fields and field size used in field tests to determine effective levels of methiocarb seed treatment for protecting sprouting rice from blackbird damage in southwestern Louisiana.

Year	Treatment Rate g methiocarb/kg seed	Formulation	No. Fields	Field Size ha x̄ (range)
1982	Untreated		3	5.6 (4.0-6.8)
	0.6	Mesurol 75% Seed Treater 1/	3	4.1 (3.4-4.5)
	2.4	Mesurol 75% Seed Treater	3	6.0 (4.0-7.5)
1983	Untreated		3	3.4 (2.7-4.4)
	1.25	Mesurol 75% Seed Treater	3	5.3 (4.1-6.9)
1984	Untreated		4	3.7 (2.9-4.6)
	0.4	Borderland Red 8% Seed Treater 2/	4	4.6 (4.0-5.4)

1/Mobay Chemical Corp., 2/Borderland Products Inc.

stratum area and located systematically along two field-edge to field-edge transects randomly placed within each stratum. Each paired sample point consisted of two 0.19m^2 plots, one protected with a wire mesh exclosure to enable determination of normal sprout density, and the other unprotected.

Undamaged seedlings were counted at all paired sample points when the sprouts were 4-8 cm high. The difference in seedling counts between enclosed and unprotected areas was defined as the response. To calculate absolute loss in the field, these differences (representing estimates of sprout loss in a 0.19 m^2 area) were then converted to estimates of total sprout loss in the field, using formulas appropriate for stratified random sampling (Otis et al. 1983). Percent loss estimates were calculated by dividing the expected numbers of sprouts in the field (obtained from sprout counts in the enclosed plots) into estimated sprout loss and multiplying by 100. Where appropriate, efficacy of the methiocarb seed treatment was evaluated using one-way ANOVA on the estimated total sprout loss. The log transformation was used in experiments with unequal treatment variances.

After fields were drained, but prior to damage assessment, relative bird use of the fields was determined by 30-min censuses conducted two to three times weekly from the field edge between sunrise and 1000 h. Blackbirds were recorded by species; numbers of birds on the field at the start of the census, and changes in numbers were recorded each min. Differences in the average number of blackbirds observed/min between treated and untreated fields during the first 2 weeks after draining were evaluated for significance by Wilcoxon's Rank Sum test.

The levees and perimeters of all fields were searched for dead or affected birds the day after seeding and weekly thereafter. Additionally, three 55-m^2 (1.8 x 30.5 m) strip transects were established in the nearest available cover adjacent to each field and searched the day after seeding and weekly thereafter.

Samples of seed and post-drain seedlings (all years), and water (1982) were collected, frozen, and shipped to the Denver Wildlife Research Center for residue analyses. Pre-plant seed subsamples (10 g) were analyzed for methiocarb residues using an acetone extraction and thin-layer chromatography (TLC) procedure. Subsamples of post-drain seedlings were composites of 10 seeds or seedlings taken from a 500-seedling pooled sample of 100 seedlings from each of 5 randomly selected points in the field. Residue values were based on dry seed weight of 20.5 mg undergoing acetone extraction and partitioning with chloroform before TLC analysis (lower limit of objective detection was 30-47.2 ppm with an error factor of 10%). Lower limit of accurate estimation for water samples (1982) was 200 ppb.

Laboratory Repellency Tests:

Male red-winged blackbirds (*Agelaius phoeniceus*) were trapped near Gainesville, Florida and cage acclimated for at least 2 weeks prior to start of the study in August 1984. All birds were provided F-R-M 15% Grower Crumbles (Flint River Mills, Inc., Bainbridge, Georgia) and water before testing.

A total of 120 male redwings was randomly assigned to cages (three birds/cage; four cages/treatment; ie., four replications). Rice seed treatments tested were as follows: No repellent, with and without presoaking; Mesurol 75% Seed Treater 1.25 g a.i./kg seed, with and without presoaking; Borderland 0.51 g a.i./kg seed, 0.768 g a.i./kg seed and 1.03 g a.i./kg seed, each with and without presoaking.

Seed rice was treated at the appropriate rate in 2.27 kg batches placed in a revolving 18.9 liter mixer. Aqueous suspensions containing each test formulation were prepared and sprinkled onto respective seed batches in the activated mixer. Mixing continued for 10 min after which the seed was placed in cloth bags and allowed to dry for 24 h prior to presoaking or simulated water planting. Seed for use in presoak treatments was left in cloth bags and immersed in water for 24 h prior to simulated water planting. All seed was then broadcast into plastic-lined water-filled No. 10 wash tubs and left in water for 4 days (simulated water planting) then removed and presented to the test birds.

All birds were preconditioned to eat germinated rice seed and the mean time for consumption of 100 seeds was determined. As a result, a daily test period of 4 h was established. During the test, food was absent overnight. In the morning the birds were given a bowl containing their normal ration and an identical bowl containing 100 rice seeds with the appropriate treatment.

The test consisted of a 2-day pretreatment period during which each cage of birds was provided with the test ration of 100 untreated seeds for 4 h followed by a 2-day treatment period during which each cage of birds was provided 100 seeds with the assigned treatment for 4 h.

The number of seeds consumed was recorded at the end of each 4 h period. Consumption data were analyzed by analysis of covariance for a completely randomized design with two repeated measures (Snedecor and Cochran 1967). The covariant was the average daily pretreatment consumption of seed for each cage of birds. The response variable was the percent of rice seed consumed per day of the treatment period. Arcsine-square root transformation of percent consumption was used to stabilize variance (Snedecor and Cochran 1967). Factors in the experiment were Chemical (control, Mesurol, and Borderland 0.51 g, Borderland 0.768 g, and Borderland 1.03 g), Soak (presoak and no presoak), and Day (1 and 2). Six days following last exposure to treated seed all test groups were presented with 100 untreated seeds for 4 h and consumption was measured.

Residue values for seeds after simulated water-planting were based on dry 10-seed subsamples undergoing acetone extraction and partitioning with chloroform before TLC analysis (lower limit of objective detection was 50 ppm with an error factor of 10%).

RESULTS

Field Tests:

Results of the 1982 test comparing methiocarb seed treatments at rates of 0.6 g and 2.4 g a.i./kg seed were inconclusive due to inadequate blackbird pressure and highly variable damage among fields. The mean percent loss for fields planted with untreated seed, and seed treated at 0.6 g a.i./kg and 2.4 g a.i./kg was 26.9, 1.4, and 1.3 respectively. Treatment means were not significantly different ($F_{2,6} = 1.19$, $P = 0.37$). Methiocarb residues on seedlings immediately after draining were at the lower limit of detectability (47.2 ppm) for the 0.6 g a.i./kg treatment and averaged 141.5 ppm for the 2.4 g a.i/kg treatment. No response was observed among birds feeding in fields planted to seed treated at the 0.6 g a.i/kg rate. Most seed exposed on levees was hulled and eaten, and small groups of birds were often observed feeding in these fields for extended periods. Similar behavior was not observed in fields planted with seed treated at the 2.4 g a.i./kg rate.

1983 Field Test--Estimates of absolute sprout loss in untreated fields were greater ($t_4 = 5.02$, $P = 0.007$) than in treated (1.25 g a.i./kg) fields (Table 2). Sprout losses in fields with the seed treatment averaged 7.1% loss compared to 97.3% loss in untreated fields. Standard errors for treated plots were quite large (Table 2). Examination of the data from protected plots showed that sprout density in these two fields was quite variable, and that the small amount of damage that did occur was unevenly distributed.

Blackbird use of untreated fields was significantly greater ($P < 0.05$)

Table 2. Total sprout loss, percent sprout loss, and days from planting to draining and damage assessment in rice fields planted with untreated seed and seed treated with methiocarb at 1.25 g a.i./kg and 0.4 g a.i./kg in 1983 and 1984, respectively in southwestern Louisiana.

Year	Field (ha)	Estimated no. of sprouts lost (thousands ± SE)	Sprout Loss (% ± SE)	Planting to Draining (Days)	Planting to Damage Assessment (Days)
1983	Treated (1.25 g a.i./kg):				
	T-1 (4.8)	351 ± 524	10.8 ± 23.3	8	30
	T-2 (4.1)	268 ± 250	6.7 ± 9.0	11	35
	T-3 (6.9)	170 ± 393	3.8 ± 21.6	10	27
			$\bar{x}$ = 7.1	$\bar{x}$ = 9.7	$\bar{x}$ = 30.7
	Untreated:				
	U-1 (3.1)	1,228 ± 127	98.7 ± 1.5	8	32
	U-2 (4.4)	5,228 ± 546	93.6 ± 2.2	13	35
	U-3 (2.7)	3,095 ± 585	99.6 ± 0.3	8	26
			$\bar{x}$ = 97.3	$\bar{x}$ = 9.7	$\bar{x}$ = 31.0
1984	Treated (0.4 g a.i./kg):				
	T-1 (4.1)	5,707 ± 1,132	100.0 ± 0.0	8	18
	T-2 (4.8)	4,158 ± 432	99.6 ± 0.3	9	18
	T-3 (5.4)	11,959 ± 1,116	99.8 ± 0.2	8	20
	T-4 (4.0)	8,658 ± 270	99.6 ± 0.5	8	18
			$\bar{x}$ = 99.75	$\bar{x}$ = 8.25	$\bar{x}$ = 18.5
	Untreated:				
	U-1 (4.3)	9,916 ± 459	99.8 ± 0.2	3	15
	U-2	5,793 ± 490	99.8 ± 0.1	5	16
	U-3	6,142 ± 380	94.4 ± 2.6	6	27
	U-4	3,332 ± 134	100.0 ± 0.0	6	18
			$\bar{x}$ = 98.5	$\bar{x}$ = 5.75	$\bar{x}$ = 19.0

than use of treated fields (Table 3). During the 2 weeks following draining of the fields, blackbird use of untreated fields averaged 51.8 birds/min compared with only 1.8 birds/min in treated fields. The highest daily value for blackbird use (234 birds/min) was obtained in U-2 3 days after draining. The greatest bird use of a treated field was in T-1 (32 birds/min) on the sixth day following draining.

Nine dead red-winged blackbirds, five affected redwings (birds unable to fly or only able to fly erratically) and feathers from one mourning dove (*Zenaida macroura*) were observed in treated fields. No dead or affected birds were observed in untreated fields. Ducks were observed in treated fields but none showed signs of intoxication. Numerous shorebirds used the ricefields after drainage but no indications of hazard were observed.

Rice seed contained a mean of 1,163 ppm methiocarb, 92.8% of the theoretical treatment rate of 0.125%, immediately prior to planting and 720 ppm immediately after draining of the fields (i.e., exposure to blackbirds; Table 4). Residues in water samples at draining were below the lower limit of objective detection (200 ppb).

1984 Field Test--Almost total sprout loss occurred in fields with the seed treatment (0.4 g a.i./kg) and in untreated fields, averaging 99.75% and 98.5% respectively (Table 2). Due to this high level of loss,

Table 3. Blackbird observations (birds/min) during 2 weeks post-draining in ricefields planted with untreated seed and with seed treated with methiocarb at 1.25 g a.i. and 0.4 g a.i./kg seed in 1983 and 1984, respectively in southwestern Louisiana.

Year	Field	No. observation periods	Birds/min	Range (Daily means)
1983	Treated (1.25 g a.i./kg):			
	T-1	7	4.8	0-32
	T-2	6	0.4	0-1
	T-3	5	0.1	0-1
		$\bar{x}$ = 6	$\bar{x}$ = 1.8	
	Untreated:			
	U-1	7	39.1	0-103
	U-2	4	88.3	16-234
	U-3	7	28.2	0-156
		$\bar{x}$ = 6	$\bar{x}$ = 51.8	
1984	Treated (0.4 g a.i./kg):			
	T-1	4	123.0	30-282
	T-2	4	73.7	59-110
	T-3	4	278.3	79-500
	T-4	4	170.5	15-437
		$\bar{x}$ = 4	$\bar{x}$ = 161.4	
	Untreated:			
	U-1	4	39.2	1-82
	U-2	4	257.0	3-783
	U-3	3	99.2	10-274
	U-4	4	125.0	10-514
		$\bar{x}$ = 3.75	$\bar{x}$ = 130.1	

Table 4. Seed, seedling (ppm) and water (ppb) methiocarb residues for samples collected from ricefields planted with untreated seed and with seed treated with methiocarb at 1.25 g a.i./kg (1,250 ppm) in southwestern Louisiana, 1983.

Sample (N treated/N untreated)	Residue means (range): Treated fields (ppm seed and seedlings, ppb water)	Residue means (range): Untreated fields (ppm)
Seed, aircraft hopper (3/1)	1,163 (1,080-1,230)	Not detected
Seedling, post-draining (3/3)	720 (340-1,080)	Not detected
Seedling, 1 week (3/2)	660 (390-980)	Not detected
Seedling, 2 week (3/2)	490 (200-780)	Not detected
Water, early draining (4/0)	<200 (1 field) Not detected (2 fields)	

absolute sprout loss estimates were not compared statistically between treated and untreated fields.

During the 2 weeks following draining of the fields, blackbird use of treated and untreated fields was similar ($P > 0.05$) averaging 161.4 and 130.1 birds/min respectively (Table 3). Greatest bird use of a treated field (500 birds/min) was observed in T-3 2 days after draining; greatest use of an untreated field (783.3 birds/min) was in U-2 1 day after draining. One dead red-winged blackbird was found in T-4 and one in U-4 during damage assessment. No affected blackbirds were observed. Although numerous shorebirds and some ducks used the treated fields, there were no indications of nontarget hazard.

Rice seed contained an average of 250 ppm at planting (62.5% of the theoretical treatment rate of 400 ppm) and less than 30 ppm immediately post-draining, a loss of at least 82% between planting and draining. Additional residue data were not obtained due to the low values obtained for seedlings after draining of fields.

Laboratory Test:

Primary analysis of the data on mean consumption of treated and untreated rice seeds by each test group of blackbirds (Table 5) indicated that presoaking had no effect (P = 0.86), that there were differences due to chemical (P = 0.0001) and day (P = 0.0001), and that there was a chemical x day interaction (P = 0.02). Therefore, a secondary analysis of covariance was run to test for contrasts with the factors presoak and no presoak removed from the model. The results (Table 6; Figure 1) showed: (1) there was no difference (P = 0.79) in consumption between treatment days for birds receiving untreated seed; (2) consumption on Day 2 was significantly less (P = 0.0001) than on Day 1 of the treatment period for all methiocarb treatment groups; (3) the differences in consumption between treatments were essentially the same (P = 0.87) on Day 1 and Day 2 of the treatment period; (4) consumption of seed for all methiocarb treatment groups was less (P = 0.0008) than for the control group on Day 2 of the treatment period; (5) increasing the application rate of the Borderland treatment significantly (P = 0.0003) reduced consumption of treated seed; (6) consumption of seed treated with Mesurol (1.25 g a.i./kg) was significantly less (P = 0.0001) than consumption during the treatment period of seed treated with Borderland at all treatment rates tested. Six days following last exposure to treated seed all test groups showed very little aversion to untreated seed, consuming 89-98% of seeds presented.

DISCUSSION

Good repellency and adequate protection of sprouting rice were obtained in

Table 5. Mean consumption of untreated rice seed and of seed treated with methiocarb seed treatments at 4 rates, with and without presoaking of seed, by red-winged blackbirds, and methiocarb residues on seed after simulated water-planting, Gainesville, Florida, 1984. (four replications for each test group)

Treatment	Seeds Consumed: Pretreatment Total	Seeds Consumed: Treatment Total	Mean Difference	Methiocarb (ppm dry wt.)
Untreated (NPS)[1/]	175.8	180.8	+ 5.0	—
Untreated (PS)[2/]	185.8	190.8	+ 5.0	—
1.25 g a.i./kg (NPS)	195.5	96.6	- 98.9	900
1.25 g a.i./kg (PS)	196.5	80.0	-116.5	750
0.51 g a.i./kg (NPS)	185.8	155.9	- 29.9	450
0.51 g a.i./kg (PS)	176.8	140.1	- 36.7	150
0.768 g a.i./kg (NPS)	161.6	121.5	- 40.1	450
0.768 g a.i./kg (PS)	181.5	142.8	- 38.7	450
1.03 g a.i./kg (NPS)	188.3	93.8	- 94.5	600
1.03 g a.i./kg (PS)	180.8	114.3	- 66.5	450

1/ NPS = rice seed was not pre-soaked; 2/ PS = rice seed was pre-soaked.

Table 6. Adjusted mean consumption rate (95% confidence intervals) on Day 1 and 2 of the treatment period, of untreated rice seed and of seed treated with methiocarb seed treatments at 4 rates, by red-winged blackbirds, Gainesville, FL, 1984. (eight replications of each test group).

	Seeds Consumed	
Treatment	Day 1 (95% C.I.)	Day 2 (95% C.I.)
Untreated	96.47 (89.45, 99.78)	95.38 (97.72, 99.44)
Mesurol[1/] 1.25 g a.i./kg	56.81 (42.45, 70.61)	20.43 (10.19, 33.11)
Borderland[2/] 0.51 g a.i./kg	92.11 (82.90, 97.96)	61.08 (47.02, 74.25)
Borderland 0.768 g a.i./kg	90.70 (80.84, 97.25)	50.76 (36.60, 64.85)
Borderland 1.03 g a.i./kg	75.46 (62.42, 86.46)	29.80 (17.82, 43.37)

1/ Mobay Chemical Corp., 2/ Borderland Products Inc.

field tests of methiocarb seed treatments at the rate of 2.4 g a.i./kg seed (Holler et al. 1982) and 1.25 g a.i./kg seed. Bird observations in fields planted with seed treated with 0.6 g a.i./kg indicated inadequate protection although bird pressure was not adequate for statistical evaluation of efficacy. Seed treated at 0.4 g a.i./kg did not afford protection, with losses being almost total. Results from the laboratory test closely paralleled results from field work and indicated that methiocarb treatments of >1 g a.i./kg seed will be required to achieve efficacy in the field.

Ultimately, post-draining methiocarb levels on seed determine bird-repellent efficacy. Initial treatment rate is one factor determining post-draining methiocarb levels on seed; the other factor is percentage of the chemical that is lost during water planting. The process of planting rice in water is highly variable; seed may be exposed to water as little as 24 h and as much as 11 days. Post-draining methiocarb levels on seed treated at 1.25 g a.i./kg were adequate to repel birds even after exposure to water for 8-11 days, providing good seed protection under the most severe planting conditions.

Protection obtained with the 1.25 g a.i./kg treatment was comparable to that reported by Holler et al. (1982) for the 2.4 g a.i./kg rate. Cost for treatment at the higher rate was estimated to be $28/ha (Holler et al. 1982). While judged to be cost effective when damage is severe (replanting costs estimated at $100-162/ha), it was still considered prohibitive by growers. This is primarily because of the unpredictable nature of blackbird damage, and the reluctance of farmers to pay this cost to prevent damage that may not occur. Treatment at the rate of 1.25 g a.i./kg seed should result in considerable savings and encourage more widespread use. Use of methiocarb at this rate would also substantially reduce residues of the chemical in aquatic environments.

We recommend that future field testing be restricted to treatment rates of >1.0 g methiocarb/kg rice seed. We also recommend that >1.0 g a.i./kg be accepted as minimum treatment level for formulations under consideration for registration or use in conjunction with emergency (Section 18) exemptions to FIFRA by the EPA.

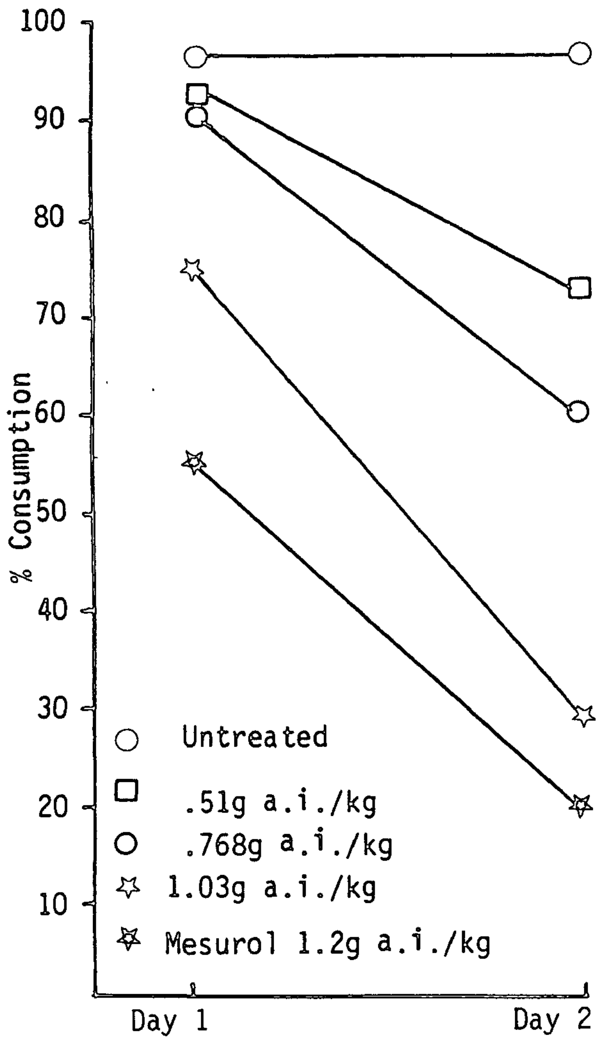

Figure 1. Adjusted mean treatment period consumption by red-winged blackbirds of untreated rice seed and of seed treated with methiocarb seed treatments at 4 rates, Gainesville, FL, 1984.

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