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DEVELOPMENT OF SEED TREATMENTS TO CONTROL BLACKBIRDS

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ABSTRACT: Bird repellents to protect seeds are a potentially important aspect of integrated vertebrate pest management strategies. Yet, there currently are no repellents registered for seed treatment uses. This is due not to lack of effective candidate compounds, but to monetary and regulatory constraints that inhibit commercialization of promising compounds. Two examples of this dilemma are methiocarb and anthraquinone, each of which has considerable potential for bird repellent uses and each of which faces considerable registration hurdles as prospective seed treatment compounds. A concerted, coordinated effort among private industry, producer groups, and state and federal agencies may be the best strategy to bring potentially useful repellents to commercial reality.

KEY WORDS: *Agelaius phoeniceus*, anthraquinone, bird repellent, boat-tailed grackle, crop protection, feeding deterrent, *Quiscalus major*, red-winged blackbird, rice, seed treatment

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INTRODUCTION

For centuries, growers of agricultural crops have treated their seed to ward off depredating birds. European settlers in eastern North America observed Native Americans applying extracts of Veratrum to corn seed as a repellent against crows, starlings and other birds (Benson 1966). The roots of the plant contain various alkaloid compounds (Viehoever and Clevenger 1922), and these probably produced the observed reactions of the birds.

The concept of applying repellent to seed is appealing for several reasons. The chemical is used efficiently because it is actually delivered to the target animals; i.e., those that feed on the seeds. By definition, a repellent is nonlethal, so their use is appealing on ethical grounds. Because many depredating species feed in flocks, there is the opportunity for social learning (Mason and Reidinger 1982), and in some situations, birds directly affected by a repellent can influence the behavior of those that have not, thereby extending the effect of the treatment (Avery 1994; Avery et al. 1995).

Despite the many appealing qualities, there has been surprising lack of approved, effective seed treatment products available to producers. There currently is no compound registered nationally as a bird-repellent seed treatment (S. Wager-Pagé, APHIS Pesticide Registration, pers. comm.). In September 1997, Gowan Company applied to the USEPA for a Section 3 label for methiocarb as a hopper box treatment on corn seed. In February 1998, the EPA proposed to revoke the tolerance on corn seed as of April 1, 1998. Nevertheless, several southeastern and midwestern states issued special local needs (24C) labels for the hopper box corn seed treatment for the 1998 growing season (M. Arnold, Gowan Co., Yuma, Arizona, pers. comm.).

The lack of a registered bird-repellent seed treatment is not due to lack of candidate materials. In cage and pen tests, the authors have evaluated many compounds as seed treatments against blackbirds and other species (e.g., Avery et al. 1994, 1996, 1997). These compounds included registered agricultural chemicals (Kocide, imidacloprid), approved food additives (methyl anthranilate, methyl cinnamate), and naturally occurring plant defense compounds (pennyroyal oil, caffeine). Despite the apparent effectiveness of many of these chemicals, none has become a registered bird-repellent seed treatment.

Discovery and identification of candidate of bird-repellent chemicals is just the first step in a long process that culminates in public use of a product (Mason and Clark 1992). Throughout the process, numerous decisions affect the ultimate fate of candidate materials. Since 1996, the authors have focused research efforts and conducted a variety of trials to evaluate the usefulness of two familiar compounds as potential bird-repellent rice seed treatments.

Methiocarb was originally developed by Bayer scientists in Germany as an insecticide, but testing soon revealed its potential as a bird repellent (Hermann and Kolbe 1971). In the United States, methiocarb was tested extensively as a bird repellent for numerous applications, including rice seed treatment (Holler et al. 1982, 1983). As a result, a Section 3 label application was submitted to USEPA, and emergency use permits (Section 18) were issued in 1983 and 1984 for methiocarb as a rice seed treatment (Holler et al. 1983). The Section 3 label was not obtained, however, and the rice seed treatment remained unavailable.

Recently, Gowan Company purchased the rights to methiocarb from Bayer and began to investigate re-establishing bird repellent applications. The Mesurol® 75% seed treater formulation used in earlier studies (Holler et al. 1982, 1983) was no longer available, however. Instead, Gowan decided to examine the possibility of using the 75% wettable powder (WP) or 50% hopper box (HB) formulation on rice seed. Furthermore, the technology of treating and planting rice seed has changed since the earlier field trials, and it is not clear how such changes affect repellent performance. One significant change concerns soaking the seed prior to planting. Previously, seed was treated dry, and then soaked to stimulate germination before actually being flown onto flooded fields. Current practices for water-seeded rice call for seed to be treated dry and flown onto the fields without presoaking or for rice to be treated after it is soaked and germinated. These changes were mandated by environmental regulations governing disposal of the water in which chemically-treated seed was soaked. Thus, the authors conducted cage and pen studies and limited field trials to evaluate the effectiveness of the 75% WP and 50% HB formulations.

For many years, anthraquinone has been recognized as an avian feeding deterrent. The first United States patent was obtained in 1944 (Heckmanns and Meisenheimer 1944), and early bird repellent uses emphasized protection of pine and rice seeds (Royall and Neff 1961). In extensive evaluation of potential rice seed treatments, Neff and Meanley (1957) considered anthraquinone the standard against which other potential bird-repellent chemicals were compared. Despite generally favorable results, anthraquinone was never registered as a bird repellent in the U.S. Recently, however, Environmental Biocontrol International (EBI), Wilmington, Delaware, initiated an effort to register and commercialize anthraquinone as a bird repellent.

The authors' latest research on methiocarb and anthraquinone was motivated by the renewed interest of private industry to commercialize these compounds as bird repellents. The studies reported here were conducted to support the eventual use of these compounds as registered rice seed treatments.

METHODS

Cage Trials

Methiocarb formulations (75% WP and 50% HB) were provided by Gowan Company. The authors obtained technical grade 9,10-anthraquinone (Chemical Abstracts Service Registry No. 84-65-1) from Aldrich Chemical Company, Milwaukee, Wisconsin. Purity was listed as 97%. Formulated anthraquinone was provided by ABCO Industries, Inc., Roebuck, North Carolina, and Environmental Biocontrol International (EBI), Wilmington, Delaware. Each product contains 50% anthraquinone, by weight. The ABCO product is used in the paper industry. The EBI product is being developed specifically as a bird repellent.

The authors treated rice seed that had been soaked and presprouted by mixing the appropriate amount of chemical with 25 ml of a commercial adhesive and then applied the mixture to 1 kg of rice seed in a rotating tumbler. An exception was the methiocarb 50% HB formulation which was mixed with corn oil instead of a commercial adhesive, according to instructions provided by Gowan. Treated seed was stored in an air-conditioned lab until used.

Birds were captured in decoy traps in Alachua County, Florida, and housed by species in communal cages (1.2 x 1.2 x 1.7 m) in a roofed outdoor aviary two to six months before testing. Unless otherwise stated, birds had free access to water and maintenance food, Quail Starter (Hillandale Farms, Lake Butler, Florida).

The authors removed birds from holding cages, determined mass, and assigned them at random to form treatment groups. After three days of acclimation to the smaller cages, the birds were tested for three hours on four consecutive mornings. The authors removed maintenance food at 0700 and presented test food at 0800. Aluminum pans suspended beneath each cup caught spillage. Food cups containing each treatment were placed in vacant cages to determine moisture gain or loss. The authors removed test food at 1100, replaced the maintenance food, and determined consumption by subtraction, after correction for spillage and changes because of moisture. After the final test day, the authors determined mass, banded, and released each bird.

The authors tested male red-winged blackbirds (*Agelaius phoeniceus*) (n = 6 birds/level) with rice seed treated with technical anthraquinone at 0.10, 0.25, and 0.50% (g/g), and at 0.5% and 1.0% with each of the formulated products. They also tested female boat-tailed grackles (*Quiscalus major*) with technical anthraquinone at 0.50% (n = 8 birds) and at 1.0% (n = 5) using the ABCO formulation. Red-winged blackbirds were given rice seed treated with 75% WP or 50% HB methiocarb formulations at rates of 0.05% and 0.1% (a.i.). They tested grackles with the 75% WP formulation only.

The authors evaluated rice seed consumption among treatments and days in two-way repeated measures analysis of variance (ANOVA). They used Tukey's HSD test (Steel and Torrie 1980) to isolate differences (P < 0.05) among means.

Field Trial

At each of four study sites in southwestern Louisiana, the authors established a five acre treated plot and a nearby five acre control plot. At two sites, the treated plots were sown with seed treated with methiocarb at the rate of 0.1% mixed 50:50 with untreated rice. Research conducted in the 1980s demonstrated that total seed treatment with methiocarb was extremely effective in reducing blackbird damage, and the authors did not feel it necessary to repeat those trials. Rather, it was more important to determine if aquatic residue levels of methiocarb could be reduced and efficacy maintained by using a mixture of treated and untreated seed. Aquatic residues are a major concern to the EPA, and any means of reducing them could facilitate the registration process. The other two sites were used to evaluate anthraquinone-treated rice at the rate of 1.0% (a.i.).

The authors seeded all plots at 100 lb/acre with Lafitte foundation seed stock provided by the Louisiana State University Rice Research Station, Crowley, Louisiana. Seed was treated in 50-lb batches using a rotating seed treatment machine. Seed was treated and planted dry, without presoaking. For anthraquinone, the commercially available industrial formulation, ABCO AQ50® (ABCO Industries Ltd., Roebuck, SC) was used. Methiocarb was in the form of Mesurol® 75% wettable powder, provided by Gowan Co., Yuma, Arizona. In addition, 2.4 ml of Exhalt 800® (PBI-Gordon Corp., Kansas City, Kansas), a tank-mix encapsulator, was added to each 50-lb batch of seed.

Treated seed was then stored in burlap bags and flown onto flooded fields within five days. Samples of treated and untreated seed were put into cloth bags that were placed in the flooded plots when the seed was applied. The bags were retrieved one, three, and five days later for analysis of chemical remaining of the seeds. The condition of the seed in the plots was monitored for germination and the water drained after five days. Bird activity was then documented by recording the numbers of birds in each plot at five minute intervals for one to two hours each day.

Two to three weeks after seeding, sprout density was assessed by counting the number of rice sprouts per square foot at 150 points randomly located on six transects throughout each of the plots. At each study site, the authors compared mean sprout counts from transects in the treated plot with those in the untreated plot by applying one-way ANOVA (Steel and Torrie 1980).

RESULTS

Cage Trials, Anthraquinone

With the technical grade chemical, rice seed consumption by red-winged blackbirds declined substantially at each level. At the 0.5% level, reduction from pretreatment was 84%. Results using the formulated products were similar; at 0.5%, consumption was reduced 86% and 89% with the ABCO and EBI formulations, respectively (Figures 1 and 2).

Boat-tailed grackles exposed to 0.5% (a.i.) technical anthraquinone reduced consumption 73%, from 4.86 g/bird (SE = 0.25) to 1.31 g/bird (SE = 0.13). Using formulated anthraquinone presented at a rate of 1.0% (a.i.), rice consumption by female grackles was reduced 86% with ABCO AQ50 and 94% with the EBI formulation.

Cage Trials, Methiocarb

For red-winged blackbirds, mean reduction in consumption from pretreatment levels using the 75% WP formulation was 89.8% and 92.2% at the 0.05% and 0.1% rates, respectively, compared to 79.2% and 92.5% reductions with the HB50 formulation (Figure 3). Reductions in rice consumption among boat-tailed grackles averaged 93.1% and 96.8% with the 75% WP formulation.

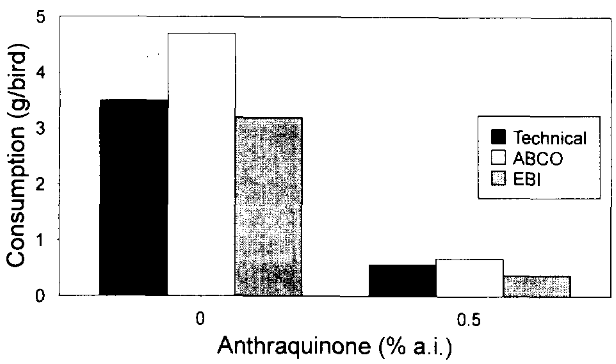

Figure 1. Mean rice seed consumption by individually caged male red-winged blackbirds exposed to seed treated with technical grade anthraquinone, ABCO AQ50, and EBI formulation PCC990. Treatments were at the level of 0.5% active ingredient.

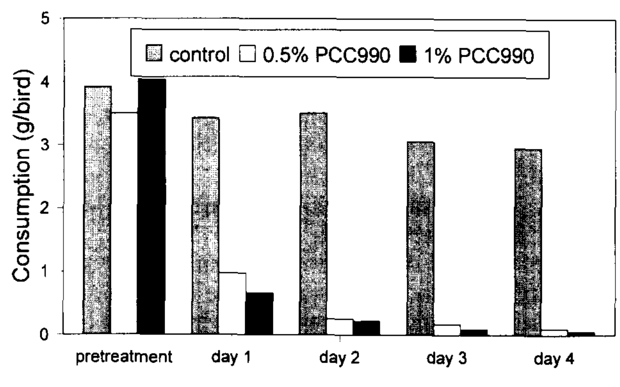

Figure 2. Mean daily rice seed consumption by individually caged male red-winged blackbirds exposed to seed treated with EBI formulation PCC990 at rates of 0.5% and 1.0%.

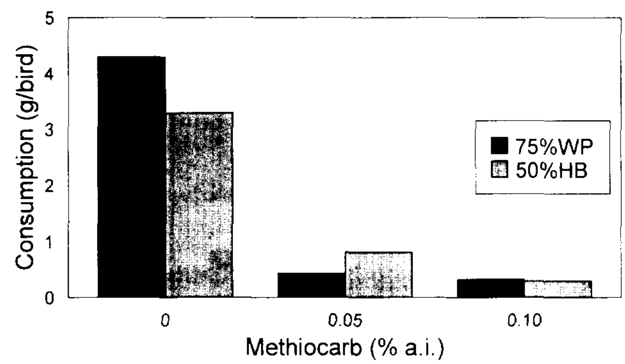

Figure 3. Mean daily rice consumption by individually caged male red-winged blackbirds exposed to seed treated with methiocarb formulations 75% WP and 50% HB.

Field Trial 1997, Anthraquinone

There were obvious, marked differences in sprout density between treated and control plots at each site (Table 1). The treatment effect was especially pronounced at the Taylor site where virtually no sprouts remained in the control plot.

Observations of bird activity at these two sites were consistent with the sprout count results. At the Unkel site, twice as many birds were observed in the control plot ($\bar{x}$ = 28 birds/count, SE = 6) as in the plot treated with AQ50 ($\bar{x}$ = 14, SE =4). Red-winged blackbirds were predominant at the Unkel site, with brown-headed cowbirds (*Molothrus ater*) and common grackles (*Quiscalus quiscula*) also present. At the Taylor site, birds were far more numerous in the control plot ($\bar{x}$ = 16, SE = 6) than in the treated plot ($\bar{x}$ = 1, SE = 1). Redwings and boat-tailed grackles consistently used the control plot for six days after water was drained, after which birds were seldom observed on either plot.

Analyses of treated seed showed anthraquinone levels of 0.740% to 0.752%. Thus, the amount on the seed was approximately three-fourths of the proposed initial

Table 1. Numbers of rice sprouts counted in one square foot sampling quadrats ($\underline{n}$ = 150/plot) throughout blackbird repellent test plots within the test plots at four locations in southwestern Louisiana, March to April 1997.

		Sprout Density (plants/square foot)			
		Treated		Control	
Repellent	Site	$\bar{x}$	SE	$\bar{x}$	SE
Anthraquinone	Unkel	19.5	2.1	14.6	1.0[a]
Anthraquinone	Taylor	12.4	0.4	0.1	0.1[a]
Methiocarb	Monceaux	18.7	1.4	18.8	1.4
Methiocarb	Sweet Lake	3.8	0.4	0.3	0.1[a]

[a]Statistically significant difference ($P < 0.05$) between treated and control plots.

treatment rate of 1.0%. Anthraquinone remaining on seed placed in the field dropped to approximately 0.61% after 24 hours, but did not decline appreciably during five days in the water.

Field Trial 1997, Methiocarb

Sprout counts were markedly different between the two methiocarb sites. At the Monceaux site, counts were consistently high throughout both plots, whereas at Sweet Lake, counts were very low, especially in the control plot (Table 1). The statistically significant difference in sprout densities between plots at Sweet Lake is relatively unimportant given the very low counts recorded. Bird activity was sporadic at the Monceaux site ($\bar{x}$ = 4, SE = 2) where flocks consisted principally of brown-headed cowbirds and common grackles. Red-winged blackbirds and boat-tailed grackles were usually present in low numbers ($\bar{x}$ = 5, SE = 2) at Sweet Lake, but ibis, little blue herons (*Egretta caerulea*), blue-winged teal (*Anas discors*), and numerous other species of water birds also used the site. Lush aquatic weed growth throughout the plots at Sweet Lake might have contributed to the attractiveness of the site for the nongranivorous species.

Chemical analyses revealed that initial treatment levels ranged from 0.079% to 0.086%, slightly below the intended level of 0.1%. Seed samples placed in the Sweet Lake test plot had 0.0625% methiocarb after 24 hours and then remained stable for five days when the plots were drained.

DISCUSSION

The wettable powder formulation used in the methiocarb trial was not designed for treatment of water-planted rice seed. Although initial levels on the seed were adequate, after the seed was planted sufficient amount the chemical was not retained to deter birds when the test plots were drained. Field trials conducted in Louisiana in the 1980s showed that rice seeds were not protected at methiocarb levels substantially below 0.1%. Thus, low residues (between 0.06% and 0.07%) on treated seed at the Sweet Lake site were probably not repellent which would account for the meager sprout count obtained there (Table 1). Low residues also adversely affected the partial treatment approach employed at the Sweet Lake site. For partial treatment to be effective, birds eating a treated seed must encounter a strong repellent stimulus to deter further sampling of the available seeds (Avery 1994). Evidently, the low methiocarb residues were not sufficiently aversive to support partial treatment.

Because the field results are limited, inferences on the effectiveness of anthraquinone must be made cautiously. Preliminary indications, however, suggest that the anthraquinone treatment very effectively protected seeded rice from blackbird damage. Current information suggests that an anthraquinone-based rice seed treatment will cost <$30/ha (K. Ballinger, Jr., EBI, Wilmington, Delaware, unpubl. data). The relatively low cost suggests that rice can be treated as a prophylactic measure with relatively little expense.

For both compounds, efficacy is not an issue, but regulatory issues remain a major concern. In February 1998, EPA issued a notice of intention to revoke the existing tolerance for methiocarb on corn seed, so the prospects for obtaining a new tolerance for use on rice seed in an aquatic environment appear remote. It is also evident that additional development and testing is needed to produce an acceptable methiocarb seed treatment formulation for water-seeded rice. A tolerance also has to be established for anthraquinone, and it has to be shown conclusively that an anthraquinone seed treatment does not produce harmful residues in the edible portion of the mature crop.

It is unlikely that a repellent for crop use will be registered without substantial involvement of private industry. A company's ability to make a profit will largely determine the extent of its interest in commercialization of a bird repellent. Given the current regulatory climate, it seems likely that partnerships will have to be formed to develop the information necessary to obtain registrations. The best approach at this time seems to be a consortium of private industry, producer groups, and state and federal agencies. This model has been effective in maintaining use of chemical toxicants (Fagerstone 1995), and needs to be seriously considered as a strategy to make safe, effective bird repellents available for public use.

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