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ABSTRACT: In east Texas, bird damage to sprouting rice was reduced in two of seven study plots when rice seed was treated with the fungicide Kocide® SD at the maximum label rate (8 fluid oz/100 1b seed). Foraging rates of male red-winged blackbirds *(Agelaius phoeniceus)* in treated plots were lower (P = 0.02) than were those in control plots. We suspect that the copper in Kocide SD produces physiological effects that suppress feeding activity that results in reduced losses in some cases. Because it is registered for use on rice and is relatively inexpensive, Kocide SD may be a useful component of some bird damage reduction strategies.

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INTRODUCTION

Bird damage to newly planted rice costs growers in southwestern Louisiana and eastern Texas millions of dollars annually (Wilson et al. 1989, Decker et al. 1990). Methiocarb is an effective bird repellent (Holler et al. 1985), but it is unavailable to growers because it is not EPA-registered. Lethal control using rice bait treated with DRC-1339 (3-chloro-4-methylaniline HC1) may reduce local bird populations, but its effectiveness as a general damage reduction tool remains to be demonstrated (Glahn and Wilson 1992).

Alternatively, bird-resistant, nontoxic seed coatings have proven effective in various cage and small enclosure trials (Daneke and Decker 1988, Avery and Decker 1992, Avery et al. 1993). In particular, Kocide® SD, a seed treatment fungicide currently registered for use on rice, has proven effective as a bird repellent in cage feeding trials and flight pen tests (Avery and Decker 1991). This multi-year study was performed to evaluate the field efficacy of Kocide SD, applied at the current fungicide label rate, as a deterrent to birds feeding on newly planted rice in east Texas.

METHODS

Experimental Design and Damage Assessment

1990—We selected study sites based upon willingness of growers to cooperate and their intention to plant about 1 April. Three fields met those criteria, but uncommonly heavy rainfall in March and early April delayed planting two to three weeks. The sites differed in several respects (Table 1), but based on recent history, each was expected to receive heavy bird pressure. At each study site, paired treated and control plots were situated along the field edges where we anticipated high levels of bird activity. The sizes of the treated and control plots were identical at each site but varied among sites (Table 1) due to differences in field configuration.

Table 1. Characteristics of study sites used to evaluate Kocide SD as a bird repellent rice seed treatment, east Texas, 1990-1991. In 1990, all sites were seeded by air whereas those in 1991 were drill-seeded.

Site	Seeding			Plot size	Seed treatment
	Date	Rate (lb/ac)	Variety	(ac)	(per 100 lb seed)
1990					
Jenkins	17 Apr	100	Gulfmont	13.6	4 oz. Dithane + 4 oz. zinc
White	22 Apr	100	Lemont	10.0	4 oz. Vitavax
Wilcox	26 Apr	130	Mars	9.5	4 oz. Vitavax + 8 oz. zinc
1991					
Kraft 1	25 Apr	120	Lemont	25	2 oz. Vitavax + 4 oz. zinc
Kraft 2	30 Apr	120	Lemont	25	2 oz. Vitavax + 4 oz. zinc
Beard	27 Apr	120	Lemont	25	2 oz. Vitavax + 4 oz. zinc.
Manville	24 Apr	100	Maybelle	25	2 oz. Vitavax + 4 oz. zinc.

Prior to seeding, we marked 32 pairs of sampling quadrats (0.19 m^2) in each treated and control plot. Sampling transects, at least 10 m apart, were located perpendicular to the long axis of each treated and control plot at 8 (White) or 16 (Jenkins and Wilcox) randomly selected points. The total length of the transects was divided by the number of sampling points (32) to determine the distance between the sampling quadrats. A random number between one and this inter-quadrat distance specified the location of the initial sampling point on the first transect. Subsequent sampling points were separated by the predetermined inter-quadrat distance, with distance counts carrying over from one transect to the next.

One quadrat of each pair was protected by a bird-proof exclosure. The pairs of sampling quadrats provided data by which evaluations of treatment effectiveness were made. We counted sprouts in sampling quadrats four to five weeks after planting when the threat of bird damage had passed. Sprout counts under exclosures gave information on the expected number of sprouts in each study plot. These were then compared to the numbers on exposed quadrats to yield estimates of sprout loss. We applied analysis of variance to compare sprout loss between treatment and control plots within sites and to compare sprout counts among sites (McKone and Lively 1993).

Growers provided seed which was already treated with their usual fungicides and nutrients (Table 1). At the Texas A&M University Agricultural Research and Extension Center, we applied Kocide SD (furnished by the manufacturer) to the seed in 50-lb (23-kg) lots at the rate of 8 fluid oz Kocide/100 1b (1.1 ml/kg) seed. The rice was poured into a cement mixer, and the Kocide SD plus an equal amount of water were slowly added as the mixer tumbled the rice. The rice was tumbled for five minutes to ensure thorough mixing and drying. For each study site, approximately 50 grams of rice were removed from one 50-lb lot prior to Kocide SD treatment. Another 50-gram sample was taken from the same lot immediately after treatment. Samples were stored in sealed plastic bags and refrigerated for later analysis of copper content (Mr. Bill Jackson, Kocide Chemical Co., Houston, TX). Kocide SD-treated seed was flown on dry (i.e., not pre-soaked) at each site, and samples of the treated seed (approximately 15 grams) were collected opportunistically from the ground immediately after seeding.

To analyze for copper content, 5-gram samples of seed were placed in a beaker with 5 ml concentrated HNO_3 and 25 ml deionized water. This was boiled for two minutes and then allowed to cool. The mixture was diluted to 100 ml, and the copper content was determined by atomic absorption. Two 5-gram replicates were analyzed from each sample of seed.

We determined feeding rates of birds in the test and control plots were determined opportunistically throughout the study. We watched actively feeding birds through a 25X spotting scope and recorded the number of rice seeds eaten during timed feeding bouts.

1991—We selected four study sites in Ft. Bend County, Texas, based upon growers' willingness to cooperate and the expectations of bird damage. Growers prepared sites according to local practices, and all rice was drill-seeded.

At the seed treatment facilities of the Richmond Irrigation District, rice was treated with Kocide SD (8 oz/cwt), Vitavax (2 oz/cwt), and Zn starter (4 oz/cwt). We removed five random samples of about 50 grams each from each lot of rice immediately before and immediately after treatment with Kocide SD. We placed the samples in plastic bags and sent them to Kocide Chemical Company, Houston, Texas, for determination of copper concentrations on the seed.

In rice fields seeded by air, seed density is highly variable and unpredictable between control and treatment plots and among quadrats within plots. Thus, sprout counts on quadrats protected by exclosures are needed to provide a basis for comparison with the counts in the unprotected sampling quadrats. In contrast, seed and sprout densities in dri.l-seeded fields are relatively uniform, and we felt it unnecessary to use an exclosure at each sampling point. Instead, we assumed a common initial seed density and directly compared sprout densities in control and treatment plots.

We divided each treatment and control plot into four equal-sized strata, and within each stratum, we randomly located six sampling transects. Each transect consisted of five randomly determined sampling points that we marked with short plastic flags. Three to four weeks after planting, we counted sprouts two meters from each flag in a randomly determined direction. We used analysis of variance to compare sprout counts between treatment and control plots within fields, and to compare sprout counts among sites (McKone and Lively 1993).

RESULTS

Copper Analyses

In 1990, the copper concentration on the rice seed prior to Kocide SD treatment averaged 0.033 (range 0.009 to 0.077) mg Cu/g rice seed. Seed collected from the fields immediately after sowing averaged 1.071 (range 1.024 to 1.140) mg Cu/g seed. In 1991, untreated Lemont and Maybelle rice seed averaged 0.010 (range 0.004 to 0.017 and 0.013 (range 0.010 to 0.018) mg Cu/g seed, respectively. After treatment, Lemont and Maybelle averaged 1.216 (1.073 to 1.314) and 1.135 (1.026 to 1.217) mg Cu/g seed, respectively. Theoretically, rice seed treated with Kocide SD at the rate of 8 fl. oz/100 lb rice should possess 1.23 mg Cu/g seed.

Damage Estimates

1990~Losses from the treated plots averaged 15.0% compared to 26.6% from the control plots (Table 2), but only at the Wilcox site was there statistical difference between plots ($F = 8.36$; 1,90 df; $P < 0.01$). Sprout counts differed ($F = 20.42$; 2,90 df; $P = 0.05$) among the three sites.

1991-We found a significant difference ($P < 0.05$) in the number of rice sprouts in treated and control plots only at the Beard site (Table 3). Overall, sprout counts differed ($F = 89.35$; 3,952 df; $P < 0.001$) among the four sites.

Table 2. Estimated sprout loss from control and Kocide SD-treated plots in three rice fields in Chambers County, Texas, April 1990.

	Estimated number of sprouts (millions)					
	Expected[1]		Actual[2]		Estimated % loss (SE)	
Site	Treated	Control	Treated	Control	Treated	Control
Jenkins	8.8	10.3	8.8	9.1	0.2 (0.5)	12.2 (6.5)
White	5.8	7.1	5.5	6.4	5.6 (7.6)	9.6 (3.3)
Wilcox	2.2	1.4	1.4	0.6	39.2 (10.5)	58.1 (7.1)[3]

[1] - estimates derived from quadrats protected from birds.
[2] - estimates derived from quadrats exposed to birds.
[3] - difference between treated and control plots significant at $P < 0.01$.

Table 3. Number of sprouts per sampling quadrat in four Ft. Bend County, Texas, rice fields, April 1991. In each 25-acre treated and control plot, 120 quadrats ($0.19m^2$) were counted.

	Treated		Control		
Site	$\bar{x}$	SE	$\bar{x}$	SE	P
Kraft 1	60.0	1.4	61.3	1.3	>0.10
Kraft 2	55.8	1.4	59.4	1.9	>0.10
Beard	49.8	1.1	44.9	1.1	<0.01
Manville	43.1	0.1	42.1	0.7	>0.10

Feeding Behavior

In 1990, we determined feeding rates for 61 individuals of five species (Table 4). Length of feeding bouts averaged 112 seconds (S.D. = 38). Overall, feeding rates did not differ among species (P = 0.98; F = 0.14; 4,55 d.f.), but there was an indication (F = 3.70; 1,59 df; P = 0.06) of differential feeding rates between treated and control plots (Table 5). When the analysis was restricted to male red-winged blackbirds, feeding rates were substantially higher (F = 6.33; 1,38 df; P= 0.02) in control plots than in treated plots (Table 5). Observations of male redwings feeding on treated and untreated rice in a 0.2 ha flight pen yielded similar results (Avery and Decker 1991).

DISCUSSION

In general, the Kocide SD treatment did not produce effects as great as previously obtained in flight pen tests where rice seed loss averaged 2% in treated plots and 33% in untreated plots (Avery and Decker 1991). In the flight pen, control and treated plots were discrete and separated from each other by intervening unseeded areas. In contrast, the field study plots were embedded in larger seeded areas and there were no distinct borders between plots. The lack of consistent, substantial reduction in seed loss in Kocide SD-treated field plots may have been due to the foraging birds' inability to distinguish the treated plot from the surrounding untreated areas.

Other factors could also have been involved. For example, the flight pen trials used only male redwings, while the field plots were visited by several depredating species of both sexes (Table 4). Interspecific and intersexual differences in sensitivity to the Kocide SD treatment are possible. Also, the composition of each flight pen test group remained constant while it is probable that the complement of birds eating rice in the field plots varied throughout the study. As the number of new untrained individuals visiting the treated plots increased, it is likely that the amount of damage increased also.

The difference in damage between treated and untreated plots that was detected was probably due chiefly to the reduced feeding rates displayed by birds, especially redwings, eating Kocide SD-treated rice. In this respect, the field trial results are remarkably similar to those of captive birds in a flight pen test (Table 5). This suggests that the reduced feeding rate of male redwings on Kocide SD-treated seeds is not context-dependent, but instead results from a basic, but as yet unknown, physiological response to the fungicide.

Our results indicate that Kocide SD is not as effective a deterrent to birds as methiocarb (Holler et al. 1985). Nevertheless, it is readily available for rice seed treatment, and in some cases it appears to reduce bird damage by lowering the feeding rates of red-winged blackbirds, the principal depredating species. Kocide SD is relatively inexpensive (approximately $3/ha) and also provides protection from fungal pests. Thus, this material appears to be a cost-effective tool that could be a valuable component of integrated pest management strategies for seeded rice.

Table 4. Feeding rates of birds observed eating rice seed at study sites in east Texas, April 1990.

Species	Sex	Feeding rate (seeds/min)		
		N	Mean	SD
Red-winged blackbird	♂	40	3.7	2.2
	♀	5	4.2	1.7
Great tailed grackle (*Quiscalus mexicanus*)	♂	5	4.5	3.2
	♀	1	3.7	-
Boat-tailed grackle (*Q. major*)	♂	3	4.1	3.8
Brown-headed cowbird (*Molothrus ater*)	♂	1	4.0	-
	♀	1	3.2	-
Dickcissel (*Spiza americana*)	♂	4	3.5	1.3
	♀	1	2.5	-
Total (5 species)		61	3.8	2.2

Table 5. Feeding rates of birds eating rice seed in control and Kocide SD-treated plots in east Texas rice fields and in trials conducted with captive birds in a 0.2-ha flight pen.

Birds	Feeding rate (seeds/min)					
	Treated			Control		
	n	Mean	S.D.	n	Mean	S.D.
All species	40	3.4	2.1	21	4.5	2.1
Male redwings						
Field	28	3.2	1.9	12	5.0	2.4
Flight pen[1]	16	3.3	2.7	22	5.5	1.4

'Avery and Decker (1991).

Recommendations for this use will depend in part upon results of further field evaluations, particularly during the early weeks of the rice season when blackbird populations are greatest. Such trials will provide additional information on which to base a cost-benefit analysis of Kocide SD use for blackbird damage reduction. In addition, the precise physiological mechanism that results in reduced feeding on Kocide SD-treated seed remains to be elucidated.

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