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Evaluation of Different Rice Baits and Chemicals to Improve Efficacy of 2% DRC-1339 to Reduce Blackbird Damage to Rice

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ABSTRACT: Blackbird damage to sprouting rice can be locally severe and costs Louisiana growers an estimated $4 million/year and Texas growers $4.4 million/year. DRC-1339 blackbird baiting programs probably will continue until available alternative control techniques (i.e., repellents) become available. We conducted 3 studies to evaluate different rice baits and chemicals to improve efficacy of DRC-1339 for use at staging areas. During the first study, individually caged red-winged blackbirds preferred untreated medium grain brown rice over long grain brown rice, rough rice, or rough rice soaked with sodium bisulfite. Of birds offered only medium (control), long, rough, and rough rice soaked with sodium bisulfite treated with 2% DRC-1339 diluted 1:25 with untreated carrier (medium, long, or rough rice), 90 to 100% died within 48 hrs. During the second study, individually caged red-winged blackbirds preferred untreated rice over rice treated with Harvest Guard or ethyl cellulose. Birds were offered only medium brown rice (control), Harvest Guard, or ethyl cellulose-treated medium brown rice treated with 2% DRC-1339 diluted 1:25 with untreated medium grain brown rice. With the medium grain brown rice (field bait), 100% mortality was observed within 48 hrs. With the Harvest Guard and ethyl cellulose treatments, ≤80% mortality was observed. The third study was an aviary test to determine if aging the chemical baits (sodium bisulfite, Harvest Guard, ethyl cellulose) for 3 days in Louisiana would affect mortality. Mortality with the fresh field and sodium bisulfite baits were 100%. We did not achieve ≥80% mortality with either the fresh Harvest Guard or ethyl cellulose bait. Mortality with the aged sodium bisulfite bait was 50%. None of the other aged baits produced >10% mortality. Degradation occurred with all the aged baits but occurred the least with the sodium bisulfite treatment. Future research will look at possibly combining sodium bisulfite with UV protectors to further reduce the degradation of DRC-1339 in the field.

KEY WORDS: 3-chloro-4-methylaniline, *Agelaius phoeniceus*, bait, bird damage control, blackbirds, CPTH, DRC-1339, efficacy, formulation, rice, waterproofing

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INTRODUCTION

Blackbird (*Icterinae*) damage to sprouting rice can be locally severe, resulting in significant yield reductions and necessitating replanting of some fields (Wilson et al. 1989). Spring-roosting blackbird populations are responsible for most damage, and the greatest rice losses are associated with proximity to roosts (Wilson 1985). Damage caused by blackbirds to newly-seeded rice costs Louisiana growers an estimated $4 million/year (Wilson et al. 1989) and Texas growers $4.4 million/year (Decker et al. 1990). Delayed planting of rice would likely reduce damage (Wilson et al. 1989), but is impractical in areas where multiple crops are planted on the same fields within the same season. The standard technique for damage control has involved using exploders, supplemented with shooting (Glahn and Wilson 1992). However, results are often variable and limited in effectiveness depending on the persistence of the user (Wilson 1985). Repellents such as Mesurol® (Holler et al. 1982) and anthraquinone (Avery et al. 1998; Cummings et al. 2002a, 2002b) have been tested on blackbirds with some success but are not registered for use. Methyl anthranilate (MA) is registered as a repellent on ripening rice but is of questionable efficacy (Werner et. al. 2005). DRC-1339 blackbird baiting programs will likely continue until effective alternative control techniques for use on blackbirds are developed.

DRC-1339 (3-chloro-4-methylaniline hydrochloride; 3-chloro-*p*-toluidine hydrochloride; CPTH) baiting is conducted in Louisiana under a state sponsored Emergency Use Permit through the EPA and in Texas under the new Compound DRC-1339 Concentrate - Staging Area label (56228-30; J. Eisenman, pers. comm.). DRC-1339 is applied in fields near roosts, which is more effective and requires less effort and time than baiting several widely scattered areas (Knittle et al. 1980). The DRC-1339 baiting program in Louisiana is timed to impact maximum number of blackbirds prior to the start of the rice-growing season, when natural foods are scarce and after migrants begin to depart for breeding grounds. DRC-1339 was originally selected for baiting programs because it is highly toxic to certain problem birds such as European starlings (*Sturnus vulgaris*), herring gulls (*Larus argentatus*), icterids and corvids, and of lower toxicity to house sparrows (*Passer domesticus*), accipiters, falcons, and most mammals (except cats, *Felis* spp.), thus minimizing the possibility of accidental poisoning (Decino et al. 1966, Cunningham et al. 1981, Eisemann et al. 2003). The mode of action in how DRC-1339 kills sensitive versus less sensitive species is not well understood (Schafer 1984). However, recent research indicates DRC-1339 is a nephrotoxin in sensitive species (Goldade et al. 2003).

Two limitations of DRC-1339-treated rice are that

blackbirds generally do not encounter dehulled rice in natural settings, and that the bait degrades quickly causing an aversion among target birds. The neophobic response and/or aversion of blackbirds, especially when baiting smaller flocks, has been observed frequently enough by USDA APHIS Wildlife Services personnel that a better bait and/or formulation is needed.

Blackbirds readily accept rough rice as they become familiar with it in natural settings. However, red-winged blackbirds (*Agelaius phoeniceus*) could potentially avoid the toxicant by removing the hull of treated rough rice. Therefore, we compared a DRC-1339 surface-coated treatment to a soaked treatment using sodium bisulfite to determine if one application method would be superior to the other. In addition, long grain brown rice was evaluated because of a concern that birds might break long grains and thus reduce the chance of receiving a lethal dose.

The rejection response caused by degradation of DRC-1339 baits may be due to either the pungent odor of the treated baits, likely caused by the free amine (CPT), or the orange-red discoloration of bait caused by presumed degradation products (Hurley et al. 1999). Harvest Guard (pbi/Gordon Corp., Kansas City, MO) and ethyl cellulose have some waterproofing properties that could reduce degradation. Sodium bisulfite was added to the soaked treatment to react with the aldehyde groups known to form colored compounds with DRC-1339.

One of the research areas identified in the 2001 USDA APHIS WS NWRC Research Needs Assessment was to develop a replacement avicide for DRC-1339 (Bruggers et al. 2001). Development of new chemicals for registration with the EPA for non-food uses can take 6 years and cost $2.7 million for the data alone (does not include external costs, which are an additional $11.9 million; E. Marshall, LiphaTech, Inc., Milwaukee, WI, unpubl. data). Considering the cost and time, it is unlikely that DRC-1339 will be replaced by another avicide any time soon. Therefore, enhancing acceptance of DRC-1339 by improving baits to increase blackbird acceptance is needed to provide critical management tools to the USDA-WS operational program. We evaluated acceptance of different rice baits and chemicals for use with DRC-1339 at staging areas by running 3 different tests. In the first test, we determined if there was a difference in consumption between medium grain, long grain, rough, and rough rice soaked with sodium bisulfite in a choice test. The final part of the first test was to determine if these rice baits produce ≥80% mortality in red-winged blackbirds when treated with 2% DRC-1339 diluted 1:25 with untreated rice in a no-choice test. In the second test, we evaluated the consumption of brown rice coated with Harvest Guard or ethyl cellulose in a choice test. The final part of the second test was to determine mortality and consumption of 2% DRC-1339-treated brown rice coated with Harvest Guard or ethyl cellulose diluted 1:25 with untreated rice. In the third test, we evaluated the waterproofing agents and sodium bisulfite in an aviary trial to determine if aged DRC-1339-treated rice coated with the chemicals performed better than the current field formulation.

METHODS

Adult male red-winged blackbirds were captured near Fort Collins, Colorado and quarantined for ≥14 days before testing in outdoor cages with about 50 birds per cage (3 × 3 × 6 m; 2 rows of 5 cages). During quarantine, birds had free access to a combination of hen scratch mix, sunflower seeds, and millet (80:10:10 mix, respectively) and water. Three days prior to moving birds to individual cages, a combination of equal amounts of medium grain, long grain, and rough rice was added to the birds' diet (about a 50% rice mix to a 50% hen scratch mix).

Following quarantine, 60 adult male red-winged blackbirds were assigned to 6 test groups (n = 10/group) based on weight so that the 6 heaviest birds were assigned one to each group, the next 6 heaviest birds assigned one to each group, and so forth. These birds were individually housed in 183 × 91 × 91 cm test cages in the outdoor aviary (19.5 × 30.5 m). Two trays below each cage captured spilled food from its respective side.

Choice Tests

During choice tests, one food dish was positioned on each side of each cage at about 0800 hrs. Positions were alternated daily to avoid a bias based on location. Water was available *ad libitum* throughout the study in front and centered in each cage. Birds were acclimated to cages for 2 days prior to testing during which the food was collected but not weighed. The first day of acclimation, the birds were offered the 25 g of the rice/hen scratch mix in each dish. On the second day of acclimation and during testing, the blackbirds were offered 25 g of medium grain brown rice in one dish and 25 g of the assigned untreated carrier (rice bait or waterproofing agent) in the other dish each morning.

DRC-1339 No-Choice Test

Blackbirds were offered 50 g of their respective untreated carrier in a single food dish each day at about 0800 hrs. Birds were acclimated to the no-choice for a 2-day acclimation period during which the food was collected and weighed. On the third day, each bird was given a dish containing 50 g of its assigned treatment. During the following 5 days, birds were given a dish containing 50 g of maintenance diet (hen scratch mix). Each day at about 0800 and 1530 hrs, the birds were monitored for signs of DRC-1339 intoxication. Sick birds were left alone to see if they would die of DRC-1339 poisoning, as required by the Environmental Protection Agency protocol for studies involving the registration of pesticides.

During the 5-day choice test, the no-choice 2-day pretreatment period, and the no-choice treatment day, all food was collected from the dishes and trays the day after it was offered, air dried in the lab overnight, and weighed. One cup of food of each treatment was set out in the building each day to determine water loss. Consumption was calculated as: (Initial Weight – Water Loss) – Remaining Weight = Bait Consumed, where initial weight is the amount of food offered to the birds, water loss is the change in weight of the food (desiccation), and the remaining weight is the amount of food left after the

bowl is removed from the bird's cage.

Aviary Test

The treatments were sent to Kaplan, Louisiana for aging, because conditions in Colorado or in an environmental chamber were not sufficient to mimic conditions that exist in Louisiana. About 50 - 95 g of fresh frozen bait stored in individual ziploc bags was shipped overnight to Louisiana and placed outside on screens away from areas of high bird, insect, or crawfish activity. At the end of about 72 hrs, the bait was placed into clean ziploc bags and shipped overnight back to Fort Collins, Colorado.

Eighty new red-winged blackbirds were randomly housed by weight as previously described in one of 8 pens (10 birds/3 × 3 × 6 m cage). Five-hundred grams of untreated brown rice was offered to the blackbirds for 9 days. On Day 10, each cage of birds was offered 520 g of one of the following treatments: (1) fresh 2% DRC-1339-treated rice diluted 1:25 with untreated rice (field formulation); (2) fresh rice soaked in sodium bisulfite and DRC-1339 and mixed 1:25 with untreated rice; (3) fresh 2% DRC-1339-treated rice over-coated with Harvest Guard diluted 1:25 with untreated rice; (4) fresh 2% DRC-1339-treated rice over-coated with ethyl cellulose diluted 1:25 with untreated rice; and (5, 6, 7, & 8) each of the above described treatments aged for 3 days in Louisiana. On Days 11-15, each cage of birds was offered 500 g of maintenance diet for 5 days. During this post-treatment period (120 hrs), birds were observed 2 times daily (~0730 hrs and ~1530 hrs) for signs of DRC-1339 toxicosis. Food was collected the following morning (~0730 hrs), air dried in the lab overnight, and weighed. Fresh food was offered each morning. Food spillage was ignored except on the day following DRC-1339 treatments when all spilled food was vacuumed from the floor prior to offering fresh maintenance diet.

Necropsies were conducted by making an incision just below the ribcage shallow enough to avoid puncturing the thoracic cavity. The ribcage was then lifted up to expose the heart and liver. Visual inspection of the heart and liver were then conducted for presence of white uric acid deposits, and discoloration of the liver was noted. Descriptive statistics were used to show consumption, changes in weights, time to death, and observed loss of DRC-1339.

RESULTS

Choice Tests

For the grains that were tested, medium grain brown rice was preferred over long grain brown rice, rough rice, and rough rice soaked with sodium bisulfite (Figure 1). For the chemicals that were tested, the medium grain brown rice was preferred over the Harvest Guard and ethyl cellulose-treated rice (Figure 1).

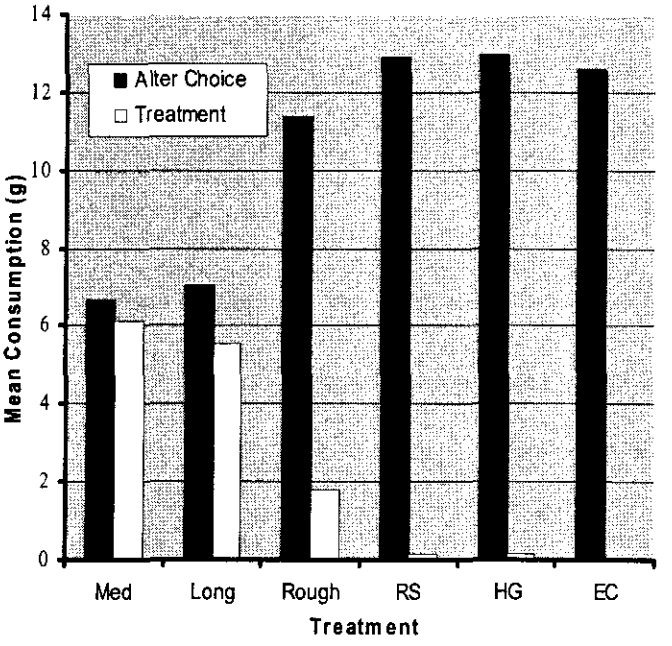

Figure 1. Consumption of rice baits (g) by red-winged blackbirds during choice tests in individual outdoor cages, 14-18 February 2003, Fort Collins, CO. Med = medium grain rice, Long = long grain rice, Rough = rough rice, RS = rough rice soaked with sodium bisulfite, HG = Harvest Guard, EC = Ethyl Cellulose, Alter Choice = alternate choice of medium grain rice.

Table 1. Results of the no-choice tests conducted in individual outdoor cages, 19-24 February 2003, Fort Collins, CO.

			Bird Weight		Consumption (g)				Mortality (hrs)		
							3-d Post				
Trt[a]	CPTH %	N	Pre (Mean, SE)	Post (Mean, SE)	2-d Pre (Mean, SE)	DRC-1339 (Mean, SE)	Died (Mean, SE)	Survivor (Mean, SE)	N	Time to Death (Mean, SE)	Positive Necropsy (N)
M	1.9	10	68.9, 1.1	65.9, 0.9	12.1, 0.2	4.3, 0.8	0.4, 0.4	----	10	25.3, 2.5	9
L	2.0	10	68.4, 0.9	64.8, 0.8	11.5, 0.4	2.1, 0.3	----	----	10	22, 0	9
R	2.1	10	68.7, 0.8	64.8, 1.2	12.4, 0.3	6.2, 0.9	0.1, 0.1	----	10	29.5, 3.0	8
RS	1.8	10	68.4, 0.9	63.5, 1.5	11.8, 0.7	7.3, 1.4	0.1, 0.1	8.2, 3.2[b]	9	27.7, 2.7	6
HG	2.0	10	68.3, 0.9	61.5, 1.9	10.7, 0.4	9.7, 0.4	3.6, 1.1	10.4, 1.1[b]	6	50.5, 6.5	4
EC	1.5	10	68.4, 1.1	65.3, 1.2	9.1, 0.4	9.2, 0.7	1.3, 1.1	11.3, 0.4	8	34.4, 3.6	5

[a] M = medium, L = long, R = rough, RS = rough sodium bisulfite, HG = Harvest Guard, and EC = ethyl cellulose.

[b] One bird reduced their consumption by Day 3. It is unknown if the bird would have survived if not euthanized at 144 hrs.

DRC-1339 No-Choice Test

For the grains that were tested, consumption of treated bait was lower for all the rice baits than during pretreatment (Table 1). The amount of DRC-1339 present on the formulated baits is given in Table 1. Nincty to 100% of the birds died, all within 48 hrs. Sixty percent of the birds that died had white uric acid deposits on the heart, and an additional 22% of birds were positive, but the amount of white uric acid deposition was so low they might have been mistaken for negative by an untrained observer.

For the chemicals that were tested, there was no difference in consumption of pretreatment or treated bait (Table 1). The amount of DRC-1339 present on the Harvest Guard and ethyl cellulose baits is given in Table 1. With the medium grain brown rice (field bait), 100% mortality was observed within 48 hrs. Sixty percent of birds offered the Harvest Guard treatment died within 76 hrs. Eighty percent of the birds offered the ethyl cellulose treatment died within 48 hrs. Sixty-nine percent of birds that died had limited white uric acid deposits on the heart, and 2 birds (8%) also had very small amounts of white deposits on their livers. An additional 6% of birds were positive, but the amount of white uric acid deposition was so low they might have been mistaken for negative by an untrained observer.

Aviary Test

Mortality with the fresh baits was 100% within 48 hrs with the field bait, 100% within 72 hrs with the sodium bisulfite bait, 70% within 96 hrs with the Harvest Guard, and 60% within 104 hrs with the ethyl cellulose (Table 2). Mortality with the aged baits was 50% within 56 hrs with the sodium bisulfite and 10% within 32 hrs with the Harvest Guard. There was no mortality observed with the aged ethyl cellulose or field bait within 120 hrs. The amount of DRC-1339 on the baits, along with baits that were not used on test because they were rained, upon is given in Table 3. Ninety percent of birds that died were positive for the presence of white uric acid deposits. Most (67%) had white deposits on both the heart and liver, with 4 birds (10%) having more than 50% of the heart covered (Figure 2). An additional 10% of birds were positive, but the amount of white uric acid deposition was so low they might have been mistaken for negative by an untrained observer.

Figure 2. The heart of a red-winged blackbird showing extensive white uric acid deposits. This bird was offered aged 2% DRC-1339 soaked with sodium bisulfite diluted 1:25 with untreated rice. It died within 24 hrs of being offered the DRC-1339 bait.

Table 2. Results of the aviary test, 12-18 March 2003, Fort Collins, CO.

Treatment		N	Bird Weight (g)		Consumption (g)			Mortality (hrs)		
			Pre (Mean, SE)	Post[a] (Mean, SE)	9-d Pre (Mean, SE)	DRC-1339 (Mean)	4-d Post (Mean, SE)	N	Time to Death (Mean, SE)	Positive Necropsy (N)
Fresh	Field	10	67.3, 2.5	69.5, 2.3	11.6, 0.4	5.8	0.3, 0	10	31.2, 3.0	10
	Sodium Bisulfite	10	67.0, 1.1	67.8, 1.3	12.0, 0.5	7.0	2.2, 1.5	10	40.0, 6.1	10
	Harvest Guard	10	67.3, 1.0	64.2, 2.4	11.7, 0.4	8.8	3.8, 0.5	7	60.3, 6.5	7
	Ethyl Cellulose	10	66.0, 1.5	66.3, 1.8	12.4, 0.4	9.7	6.1, 0.7	6	57.0, 7.5	6
Aged	Field	10	67.2, 1.2	68.3, 1.6	12.7, 0.5	10.8	9.3, 0.2	0	----	----
	Sodium Bisulfite	10	66.1, 1.2	64.5, 2.0	11.7, 0.4	7.3	7.4, 1.0	5	35.2, 7.0	5
	Harvest Guard	10	66.4, 1.3	67.5, 1.0	11.7, 0.4	11.1	9.3, 0.2	1	56.0, 0	1
	Ethyl Cellulose	10	67.1, 0.9	68.1, 0.6	12.5, 0.4	10.6	9.3, 0.1	0	----	----

[a] The fresh field had 2, fresh sodium bisulfite had 1, and fresh Harvest Guard had 2 birds weighed-back that were noticeably wet.

Table 3. Analysis of treated baits for amount of DRC-1339 (CPTH) present in undiluted bait, 12 March 2003, Fort Collins, CO.

Treatment	Observed CPTH (%)		
	Used on Test		Not Used On Test[b] ~0.32 cm Rain on Bait (% lost)
	Fresh	Aged (% lost)[a]	
Field	1.92	0.31 (84)	0.06 (97)
Sodium Bisulfite	1.85	1.15 (38)	0.96 (48)
Harvest Guard	1.92	0.65 (66)	0.08 (96)
Ethyl Cellulose	1.29	0.78 (40)	0.32 (75)

[a] Aged March 6 at 0830 hrs through March 9 at 1200 hrs, 2003 (75.5 hrs exposure).

[b] Aged March 1 at 1500 hrs through March 3 at 1810 hrs, 2003 (51 hrs exposure; pulled early because of rain).

DISCUSSION

Medium grain, long grain, and rough rice were equally effective as carriers for DRC-1339. However, the blackbirds needed to consume only about half of the long grain compared to the medium grain brown rice to ingest a lethal dose of DRC-1339. Possibly, the larger surface area of the long grain brown rice provided for a larger dose of DRC-1339 than the medium grain brown rice so that the birds felt sick sooner and thus reduced their consumption. In the field, analysis of esophagus/gizzard contents from red-winged blackbirds collected within about 10 mins after feeding (before they could have felt the effects of DRC-1339), indicated they ate about 40% less treated rice compared to pretreatment (Pipas 2003, unpubl. data), possibly because less treated bait is applied and therefore less is available to the birds. Alternatively, birds might have avoided the DRC-1339 baits themselves. The effectiveness of long grain rice in this study indicates that it should be just as effective in the field.

Unexpectedly, the blackbirds got a lethal dose of DRC-1339 from the surface-coated rough rice treatment. We thought the birds would be able to avoid a toxic dose of DRC-1339 by dehulling the treated rice. Possibly, birds might have ingested a lethal dose simply by handling and dehulling the seeds, although, the esophagus/gizzard contents of the blackbirds were not examined to determine if all the birds dehulled the rough rice before consuming it. Examination of the remaining contents of the food bowls and stomach contents collected from the field (Pipas 2003, unpubl. data), indicates that the majority of rough rice is dehulled before being consumed. If the DRC-1339 is primarily on the hull of the rice grain, weathering probably would reduce the effectiveness of rough rice treated baits. Analysis of the hull separate from the rice grain would be necessary to determine whether DRC-1339 is absorbed through the hull onto the rice grain.

It was not unexpected that the blackbirds avoided the undiluted Harvest Guard, ethyl cellulose, and sodium bisulfite-treated rice during the choice tests. However, consumption was not different between the pretreatment and DRC-1339 treatments during the no-choice test for the Harvest Guard and ethyl cellulose treatments. Perhaps the Harvest Guard and ethyl cellulose temporarily masked the affects or interfered with absorption of the DRC-1339, so the birds did not detect its effects as soon as with the rice bait treatments. The reduced consumption with the sodium bisulfite treatment was not any less than with the rice bait treatments, indicating that there should not be any difference in effectiveness in the field other than reduced aging.

Birds from the individual cage tests had very few white uric acid deposits, whereas birds from the aviary test had very extensive white deposits covering entire organs (i.e., heart, liver or both). Peoples and Apostolou (1966) showed that the blood uric acid level decreased between 12 and 16 hrs in starlings dosed with 12.5 mg/kg of DRC-1339 (in water) by oral intubation, and they suggested the drop correlated with the deposition of uric acid crystals on the serous surfaces of the organs. However, that explanation would not entirely account for the differences we observed, as birds from the individual cage tests that died after that period still had fewer white deposits than those that died at comparable times in the aviary test. Johnston et al. (1999) suggested that necropsy methods for determining DRC-1339 exposure in boat-tailed grackles is inaccurate in birds exposed to less than 2.28 mg or in birds that died after 17 hrs. Birds in the individual cage tests ate slightly less DRC-1339-treated rice than birds in the aviary test but died quicker, indicating they did not receive a significantly lower dose. Additional contributing factors may have been 1) the outdoor ambient temperature during the individual cage tests was lower (mean temperature -6.8°C, SE = 3.2°) than during the aviary test (mean temperature 10.5°C, SE = 1.3°) on the day DRC-1339 was offered and up until 120 hrs post-treatment, and 2) group versus individual feeding dynamics or behaviors.

Degradation occurred with all the aged baits but was the least with the sodium bisulfite treatment. The aged baits all had the characteristic red-orange color, except for the sodium bisulfite which had a dark brown color but only on one surface. The brown color was likely a photochemical product. The ethyl cellulose performed similarly to the sodium bisulfite treatment when aged without rain, but it was not initially formulated at a high enough concentration to achieve mortality. However, both the ethyl cellulose and Harvest Guard treatments on the rain-exposed baits performed less than satisfactorily (about 30% more loss than the non-rain-exposed baits), likely due to insufficient protection from water. Future research will look at possibly combining sodium bisulfite with UV protectors to further reduce the degradation of DRC-1339 in the field.

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