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Preliminary evaluation of 9,10 anthraquinone bird repellent for managing blackbird damage to ripening sunflower

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RH: 9,10 anthraquinone bird repellent • *Linz et al.*

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1. Introduction

Blackbirds in the northern Great Plains aggregate in large flocks that feed on ripening crops, especially sunflower. Damage to the sunflower crop begins when the achenes reach the "milk" stage, which is in mid-August to late August. Direct economic losses from bird damage to sunflower probably exceed $5 million, annually (Peer et al., 2003). Growers incur additional costs trying to protect their crop from blackbirds. Growers can use several techniques singly and in combination to defend crops, including firearms, propane cannons, pyrotechnics, and fragmentation of dense cattails (*Typha* spp.). Except for cattail management with aerially applied glyphosate, most methods are time consuming, costly, and produce inconsistent results, particularly when used on large fields with many birds (Linz et al., 2011). Aerially applied feeding repellents may help protect sunflower in large fields, especially if used with other methods in an Integrated Pest Management Program (Linz et al., 2011). However, sunflower producers and USDA researchers have both reported inconsistent results with the only two repellents registered for use on ripening sunflower, Birdshield® and Flock Buster® (Linz et al. 2011).

Results from cage tests on blackbirds have indicated that chemical repellents can be very effective. A particularly promising candidate is 9,10 anthraquinone (Avery and Cummings, 2003). The anthraquinone (AQ) compound is classified as a biopesticide. AQ is naturally occurring and can be found in animals, plants, and bacteria. These organisms use AQ for chemical defense against predation, parasitism, and other types of attacks (e.g., herbivory). It has been tested and found to be an effective seed treatment for repelling granivorous birds from newly planted fields of canola, rice, corn, and sunflower (Avery and Cummings, 2003; Werner et al., 2011). The patent holder, Arkion™ Life Sciences LLC (551 Mews Drive Suite J., New Castle, Delaware, 19720, USA), has recently applied for a full national registration (EPA FIFRA Section 3) to use AQ repellent on corn seeds.

Several studies using caged blackbirds have consistently shown that feeding rates are reduced by ≥80% with AQ treatments, especially with sunflower. Werner et al. (2011) reported that AQ repelled COGR and RWBL confined within enclosures in fields of standing sunflower. Results from field trials in ripening rice were, however, equivocal (Avery and Cummings, 2003). For example, AQ protected field plots of ripening rice in Louisiana for 7 days following aerial application, but similar tests on wild rice in California yielded no treatment effect. The birds have to learn that AQ cause gastric distress by eating it, and its lack of effectiveness in wild rice was attributed to an influx of new, AQ-naive blackbirds at the study site. Of course, it is not unusual during the process of field-testing to have some inconclusive field trials. Thus, we remain committed to our immediate goal of expanding research on AQ to protect ripening fields of sunflower. This product could represent a major advance in blackbird damage management if repellency can be maintained at field application rates, with the caveat that residue levels at harvest meet the yet to be proposed food tolerance guidelines. We are now at the phase of testing that requires us to develop effective techniques for aerial and ground applications of a 9,10-anthraquinone product (Avipel®, Arkion™ Life Sciences; New Castle, DE).

From 15 August to 15 October 2011, we evaluated aerial field applications of Avipel on eight acres (3.2 ha) of oilseed sunflower planted in North Dakota. This was the first time that AQ has been tried on sunflower with an application method commonly used by the agricultural community. Our objectives were to 1) compare the repellency effects on blackbirds at 1.0 gal/acre (9.3 l/ha) in ripening fields of commercial oilseed sunflower and 2) assess the residue levels of AQ on treated sunflower fields immediately following treatment and at time of harvest.

2. Study Area

Our study area lies within the Prairie Pothole Region in McLean County, North Dakota (47.51 N, -100.92 W). Numerous shallow wetland basins occupy the landscape. These wetlands often have dense stands of cattail, which may be used by blackbirds for either daytime loafing sites or night roosts. The landscape's vegetation type was mixed-grass prairie. Most of the native grasslands have been converted for agriculture; 63% of the county's land area is in harvestable crops. In 2010, McLean County ranked sixth in production of oilseed sunflower among the 53 North Dakota counties, with production of 55.7 million pounds (25.3 thousand metric tons) (NASS 2012). In 2010, oilseed sunflower ranked as the third most planted crop (35,000 acres; 14,000 ha) in McLean County, behind small grains (370,000 acres, 150,000 ha) and canola (71,000 acres; 29,000 ha). During the 62-day study period between 15 August and 15 October, the average high was 73° F (23° C) and average low was 48° F (9° C). Total precipitation was 4 inches (11 cm), all as rainfall.

3. Methods

We used flagging to mark 16 strips of sunflower [50 ft (15 m) x 873 ft (266 m)] in three oilseed sunflower fields. Field 1 contained eight strips; four AQ-treated strips paired with four untreated reference strips. Fields 2 and 3 each contained four strips; two AQ-treated strips paired with two untreated reference strips. Fields 2 and 3 shared a wetland that was used as a day roost by blackbirds. We estimated bird damage in the paired treated and untreated strips one day prior to treatment with AQ (21 September).

On 22 September we used a fix-winged airplane to apply a 5 gallon (46.7 l/ha) aqueous solution containing 1.0 gal/ac (9.3 l/ha) of AQ to the strips assigned to treatment. Immediately following the aerial application, we collected 200 g samples of sunflower seeds from 10 sunflower heads in each of the treated strips; seeds from four sunflower heads were collected from each of the untreated reference strips and pooled. All sunflower samples were sealed and frozen in a labeled plastic bag. The samples were analyzed by Arkion™ Life Sciences for AQ residues.

We visited the study fields randomly during daylight hours to record numbers and species of blackbirds using the fields. At the conclusion of the study, bird damage was again measured (12 October). We then destroyed the treated acres as per EPA regulations governing tests of unregistered pesticides.

We used a *t*-test to compare mean percentage change between the pre-application and pre-harvest damage surveys of treated and untreated strips. Descriptive statistics were used for reporting on use of the study fields by blackbirds and for reporting results of the AQ residue analyses.

4. Results

From 14 September to 9 October, blackbird numbers in 'Field 1' averaged 1,268 (SE = 345, range = 25-3,000). From 14 September to 10 October, blackbird numbers in 'Fields 2 and 3' (which shared birds from a common roost) averaged 2,638 (SE = 602, Range = 150-6,000). Change in percent damage between the pre-application and pre-harvest surveys of the paired strips ($n = 6$) did not differ ($P = 0.955$), averaging 8.8% (SE=3.72) and 9.1% (SE=5.40) in the untreated reference strips and treated strips, respectively.

Only four samples showed detectable residue levels of AQ, and the concentrations in the extracts were lower than that of the lowest standard in the calibration (Table 1). The highest concentration was 4.2 parts per million. Thus, residues were essentially nonexistent on the seeds. Residues on the 'back of the heads' were not analyzed.

5. Discussion

Obviously, AQ aerially sprayed at a rate of 1 gal/ac (9.3 l/ha) mixed in 5 gallons (46.7 l/ha) of water was not effective under the conditions of our experiment. Little AQ actually contacted the sunflower achenes and apparently the AQ coverage on the back of the heads was not sufficient to deter the birds from feeding on the treated strips of sunflower.

Reasons for the repellent's failure are speculative; however, we advance three possibilities: 1) the AQ product did not contact the achenes and the birds did not ingest the AQ while feeding, a likely scenario considering that most of the heads were downward facing; 2) the AQ application rate was insufficient and thus did not reach the threshold level needed to deter birds as they pulled bracts and other vegetative structures from the back of the heads ; and 3) the aqueous volume was too low to provide enough coverage on the back of the heads to elicit a treatment response.

6. Research Plans for 2012

In 2012, we plan to use a ground sprayer to test 2 gal/ac (18.7 l/ha) AQ mixed in 20 gal/ac (187 l/ha) aqueous solution. The acreage will be limited to 10 acres because of EPA rules governing unregistered pesticides. The treated area will destroyed following the conclusion of the study.

7. Acknowledgements

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Table 1. Residue analysis of a fixed-wing aerial application of anthraquinone (AQ, parts per million). The rate was 1.0 gal/ac (9.3 l/ha) in a 5 gal (18.9 l) aqueous solution. Sunflower head samples were collected from treated strips post-application (PA, 22 September 2011) and pre-harvest (PH, 12 October 2011). Reference samples were taken post-application and pre-harvest from untreated strips and pooled.

Survey	Field No.	Strip Pair No.	AQ
PA	1	1	0
PA	1	2	0.54
PA	1	3	0
PA	1	4	4.2
PH	1	3	0
PH	1	4	2.9
PA (Ref)	1	NA	0
PH (Ref)	1	NA	0
PA	2	1	0
PA	2	2	0
PH	2	1	0.55
PH	2	2	0
PA	3	1	0
PA	3	2	0
PH	3	1	0
PH	3	2	0
PA (Ref)	2&3	NA	0
PH (Ref)	2&3	NA	0