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2009

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Kandel, Hans; Johnson, Burton; Deplazes, Chad; Linz, George M.; and Santer, Michele, "Sunflower Treated with Avipel (Anthraquinone) Bird Repellent" (2009). *USDA National Wildlife Research Center - Staff Publications*. 928.
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Published in 31st National Sunflower Association Sunflower Research Forum http://www.sunflowernsa.com.

Sunflower Treated with Avipel (Anthraquinone) Bird Repellent

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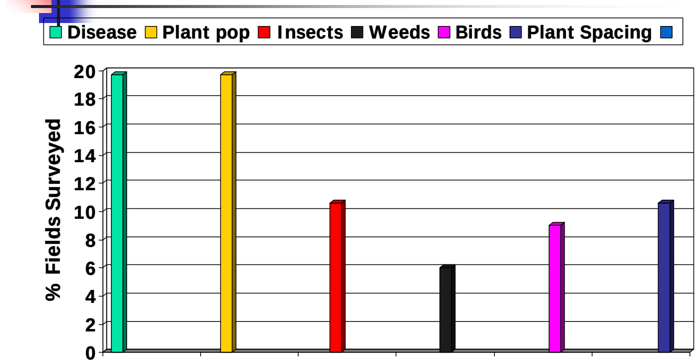
1) Description of the importance of the project

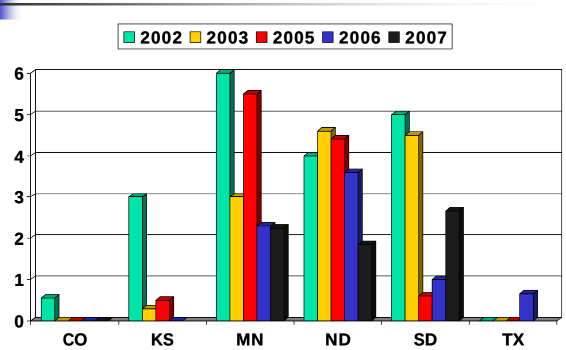
Maturing sunflower (*Helianthus annuus* L.) is susceptible to damage by birds, especially blackbirds (*Agelaius phoeniceus and Quiscalus quiscula)*. The National Sunflower Association (NSA) identified Blackbird damage as a major issue in the production of sunflower throughout the US. In 2007 bird damage was identified as the number one yield limiting factor in 9% of surveyed fields in North Dakota (Graph 1) .

Graph 1. Number One Yield Limiting Factors-2007 in North Dakota



Source: 2007 Sunflower survey by Dr. Berglund et al.

Graph 2. Percent Bird Damage



Source: 2007 Sunflower survey by Dr. Berglund et al.

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Bird damage is a problem in many sunflower growing states. Damage percentages observed during the national surveys are indicated in graph 2. These numbers reflect damage percentage at the time of the survey, which is around mid September. End of season losses would be higher than these estimated numbers in the surveys.
This research evaluated sunflower treated with Avipel (Anthraquinone), an experimental product, as a bird repellent.

2) Potential impact of the project

If birds can be kept out of sunflower fields and feeding can be reduced the sunflower yields will be higher and producers will achieve greater economic benefit.

3) Previous research

Strategies to reduce bird damage include:
a) Exclusion; using some sort of netting which is only practical for some horticultural crops.
b) Propane cannons, pistol or rifle shots, or other pyrotechnical devices to scare the birds.
c) Visual repellents like aluminum streamers, flags, artificial hawks etc. Birds get used to them and these may work for a short time.
d) Repellents. Some products specially designed may have some repellency. Some studies indicate that a number of the insecticides used in sunflower production have some bird repellent activity.
e) Management of roosting areas. This strategy is looking at eliminating habitat or modification of habitat so birds do not roost near sunflower fields.
f) Dessication of sunflower at physiological maturity of the plant. This strategy is aiming at speeding up the dry down so the sunflower is harvested earlier than naturally dried down sunflower.
g) It appears that a number of strategies will have to be incorporated to have the desired reduction of bird damage in sunflower in an integrated approach (Dolbeer R.A. 1975; Linz, G.M. et al. 2006; Werner, S.J. et al. 2005; Howatt, 2008).

4) The Project objectives

- Establish the amount of residue on a filter paper attached to the sunflower head after application of Anthraquinone
- Observe the plots for bird activity
- Establish the residue levels on the harvested sunflower seed
- Observe actual bird damage at harvest
- Measure yield, plant height, and seed weight per head
- Observe plant growth to make sure there is no negative effect of the Anthraquinone

5) Methods and Materials

Experiment:
The field experiments were established in Fargo, ND, on North Dakota State University Experiment Station land near the campus, where there was a known bird problem. The experimental design was a randomized complete block with eight replicates. The experimental units each had 10 rows of sunflower with a buffer of 4 sunflowers rows between each treatment. The sunflower hybrid Croplan 564CL,NS (Clearfield) was over-sown and hand-thinned to a plant population of about 22,000 plants per acre. Row spacing was 30 inches and treatment plot length was 25 feet.

At harvest the height of the sunflower was measured from the soil surface to the crook of the sunflower head. Sunflower heads were harvested from 20 feet in the two middle rows of each treatment plot. Each head was observed for bird damage and percent damage was recorded. After harvest heads were dried and threshed with a Hege 125B plot combine. Samples were cleaned, weighed, and seed weight per head was determined by dividing the plot yield in grams by the number of harvested heads. Analysis of variance was performed using Statistix 8 (Analytical Software, Tallahassee, FL).

The treatments for the residue testing were:

- Control (no treatment)
- Application at R5.1 (Schneiter and Miller, 1981)
- Application at R5.5
- Application at R5.9

Heads at bloom R5.1 at application of bird repellent , August 13th 2008.

Heads at bloom R5.5-5.7 at application of bird repellent, August 19th 2008.

The treatments for the yield testing were:

- Control (no treatment)
- Application at R5.5
- Application at R5.9

Application:

- Rate 1 gallon of 'Avipel' liquid per acre
- Active ingredient 9,10-Anthraquinone 54.5% and other ingredients 45.5%
- One gallon 'Avipel' in 10 gallons of water
- Spray direction; facing the sunflower head
- Spray pressure 35 Psi

Management dates 2008:

- Planting date May 29
- Beyond Herbicide application July 1
- Application of Anthraquinone August 13 (R5.1 and R5.5)
- Application of Anthraquinone August 19 (R5.9)
- Harvest October 9-10

Spray Rate Verification:

Before treatment, 9.0 cm diameter number 2 filter paper circles were placed on random sunflower heads in rows 4 and 7 (near the center of treated area). Three circles per experimental unit were used in Reps 5 to 8 and two circles were used per experimental unit in Reps 1 to 4. Filter papers were removed, with tweezers, from sunflower heads two hours after application of Avipel. Filter paper circles were folded in half with the exposed surfaces together. The filter paper was folded one more time before placing in a labeled 16 x 100mm polyethylene tube for shipment to laboratory for analysis.

August 13th Application

Sampling at Harvest:
Three mature sunflower heads were harvested in Rep 5 to 8 and two heads per experimental unit in Rep 1 to 4. Heads were harvested from all experimental units. Care was taken not to handle the disk surface where Avipel had been applied. Each sunflower head was placed in a polyethylene bag and labeled. Samples were put in a freezer within one hour after completing the sampling. All samples were shipped on dry ice and arrived at the lab frozen.

<u>Analytical Methodologies:</u>

Filter paper:
Whatman 9.0 cm number 2 filter papers were placed in glass vials, with Teflon lined caps. Ten ml of acetonitrile was weighed into each glass vial before sonicating for 45 minutes. After cooling, extracts were filtered through 0.2u nylon filters into auto sampler vials and analyzed by HPLC.

Filter paper top at
R 5.1

Filter paper right at
R5.9

Before spraying sunflower heads were marked with a ribbon and at harvest heads were bagged and shipped to the Lab.

Sunflower seed residue determination*:*
USDA method 121A was used with the following modifications. Sunflower seed samples were ground using a laboratory grinder. A 0.5 gram sample was weighed into a 40 ml glass vial with a teflon lined cap. Once the remaining extraction and cleanup steps were completed the sample was reconstituted using acetonitrile instead of methanol.

Bird observations:
Bird point counts and activity of birds were recorded. Observations were collected on Monday, Wednesday, and Friday mornings within 3 hours after sunrise. Data collection began on August 20, 2008 and ran through the end of September.
Observations consisted of estimating the number and species of birds in the study area. In addition, bird activities seen during the observational period were recorded. Observations consist of 12, three minute scans conducted near randomly selected rows. A total of 18 points existed in the study area. Survey points were restricted to the edges of the study area to reduce human influence on bird behavior. Counts began after a 2 minute acclimation period. Recorded data included date, observer, time, species, count and behavioral observations.

6) Results

Filter papers taken from treated plots showed large variations in Anthraquinone concentrations. There should not have been any Avipel on the filter paper of the control plot (Table 1). We speculate that Anthraquinone on the filter paper of the control plot is due to the handling of the filter paper as there was no Anthraquinone found on the sunflower seed of the control (Table 2). The highest concentration intercepted by the filter paper was when the sunflower heads were in the R5.5 stage (Table 1). Hardly any spray was intercepted at the R5.9 growth stage. We speculate this was a result of the heads facing down instead of facing east. After application of Avipel the spray containers were empty and white spots could be seen on the leaves and back of the heads. The right amount was applied relative to a flat (horizontal) area but limited quantities of Anthraquinone were intercepted by the filter paper (on the front of the sunflower heads, vertical at R5.1-R5.5). The filter paper reading is a proxy for the amount of Anthraquinone intercepted by the head. As the heads in the experimental plots were at slightly different growth stages and angles during the application time (due to natural variability between plants), the actual amount of Avipel on each head was most likely different.

Table 1. Gallon Avipel per acre intercepted by the filter paper.

Treatment	**Gallon 'Avipel" per acre**
Control	0.008b
Bloom R5.1	0.089b
Bloom R5.5	0.593a
Bloom R5.9	0.002b
Mean	0.17
C.V. %	250
P≤0.10	

Table 2 provides data on Anthraquinone on the harvested seed. The higher concentration was found on the seed samples from the sunflower heads when sprayed at the R5.1 stage. These heads were smaller at the application time compared to the diameter of heads at the R5.5 or R5.9 application time. Heads sprayed at the R5.1 flowering stage were also smaller at harvest time. Based on Table 1 it was expected that the lowest seed Anthraquinone concentration would be found on the heads which received Avipel at the R5.9 stage. In this study the concentration of Anthraquinone on the seed was most likely not sufficient to provide the anticipated repellency effect.

Table 2. Anthraquinone residue on sunflower seed.

Treatment	Anthraquinone (ppm)
Control	0b
Bloom R5.1	15.7a
Bloom R5.5	6.6a
Bloom R5.9	1.4b
Mean	5.9
C.V. %	175
P≤0.05	

Table 3 provides an example of the bird behavior aspect of the study. Birds observed during the project included American Goldfinch, House sparrow, Rock dove, Mourning Dove, Red-winged blackbird, American Crow, Barn swallow, Dark-eyed junco, European starling, Killdeer, Least flycatcher, Song sparrow and Vesper's sparrow. The observers did not record a difference in behavior between the different treatments. Most damage occurred during the last week before harvest. Pieces of the sunflower hull were observed on top of the sunflower heads where birds had been eating the sunflower seeds. Most head damage occurred on the outer areas of the head (see pictures below).

Table 3. Example of observations recorded on bird feeding activity in 2008.

Observer: LM	Condition	Species	Total #	Behavioral Observations
Observer SG	Sunny mid 40's East breeze 5 mph			
6		AmGo	1	Perching on head, not eating
4			0	There are no birds
11			0	~25 AmGo flew over, none in plot
5		RoDo	1	on ground
16		AmGo	6	Perching on head, not eating
18		AmGo	2	Not on heads, not eating
12		AmGo	3	Not eating
9		RoDo	2	flushed from ground when I approached
1		AmGo	1	Perching on head, not eating
13		RoDo	1	flushed from ground when I approached
3			0	There are no birds
17		AmGo	1	flushed when I approached

Species: AmGo is American Goldfinch, RoDo is Rock dove
Source: Shannon Gaukler, Michelle L. Petersen, and Laurel Moulton.

Crop height

The percent head damage was slightly higher in the control plots but did not significantly differ from the treated plots. The yield of the control was slightly lower than the treated plots, but not significantly different from the treated plots (Table 4). The adjusted yields were nearly identical (Table 4). We conclude that the damage estimate based on the average damage percent of 48 heads (Table 5) provided a good estimate of yield loss. Plant height, number of harvested heads, and seed weight per head were not influenced by the Anthraquinone treatments. The control treatment was numerically lowest for seed weight per head (Table 5) and yield (Table 4).

Table 4. Mean sunflower yield, head damage and adjusted yield (yield if there would be not damage).

Treatment	**Yield**	**Head damage**	**Adjusted yield**
	(lb/a)	**(%)**	**(lb/a)**
Control	1866	18.1	2291
Bloom R5.5	1927	15.8	2273
Bloom R5.9	1926	16.1	2297
Mean	1911	16.4	2283
C.V. %	10.4	29.3	9.3
P<0.05	NS	NS	NS

Table 5. Mean sunflower plant height, harvested heads (20 feet x 2 rows) and seed weight per head.

Treatment	**Plant height**	**Harvested heads**	**Seed weight per head**
	(inch)	**(heads)**	**(gram)**
Control	65.9	49.0	44.1
Bloom R5.5	64.6	47.6	47.5
Bloom R5.9	64.9	48.1	46.4
Mean	65.0	48.1	46.4
C.V. %	4.3	11.5	17.0
P<0.05	NS	NS	NS

7) Conclusions:

- Sunflower plant growth does not appear to be negatively influenced by the application of Anthraquinone.
- It was difficult to get the timing of the application right as the individual sunflower plants were at different growth stages at any given time.
- As the heads start to bend over it will be more challenging to apply the repellent to the front of the head.
- In the beginning of sunflower seed fill period there were no differences in bird damage visible.
- Relative low amounts of Anthraquinone were found on the filter paper.
- Earlier application had more Anthraquinone residue on the seed than later application.
- No significant differences in the amount of bird damage were observed among the treatments.
- No significant differences in yield, plant height, harvested heads, or seed weight per head were observed among the treatments.
- The amount of Anthraquinone on the seed in this study was not sufficient to repel the birds.
- Future research could include different methods, timing and rates of application of Anthraquinone.

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Acknowledgement:

The authors want to recognize the bird observation work done by Shannon Gaukler, Michelle L. Petersen, and Laurel Moulton graduate students in the Department of Biological Sciences at NDSU.