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Darryl L. York
US Department of Agriculture, Animal and Plant Health Inspection Service, National Wildlife Research Center

John L. Cummings
US Department of Agriculture, Animal and Plant Health Inspection Service, National Wildlife Research Center

Richard M. Engeman
USDA-APHIS-Wildlife Services, s_r100@yahoo.com

James E. Davis Jr.
US Department of Agriculture, Animal and Plant Health Inspection Service, National Wildlife Research Center

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Darryl L. York*, John L. Cummings, Richard M. Engeman, James E. Davis Jr.

US Department of Agriculture, Animal and Plant Health Inspection Service, National Wildlife Research Center, 4101 LaPorte Avenue, Ft. Collins, CO 80521, USA

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Abstract

We conducted enclosure trials near Huron, CA in the San Joaquin Valley from 12 to 23 January 1999 to determine the efficacy of Flight Control™ (50% anthraquinone) and Mesurol® (75% methiocarb) in preventing horned lark damage to lettuce seedlings. Flight Control™ (FC) and Mesurol® were evaluated as foliar sprays at application rates of 2.79 and 2.27 kg ha^{-1}, respectively. Horned lark damage to lettuce seedlings treated with antraquinone was greater ($p = 0.015$) than for methiocarb®, 60 versus 20%, respectively, and seedlings in control plots were 100% destroyed. While this level of damage is probably unacceptable to lettuce growers, it should be remembered that the enclosure situation caused an artificially high bird pressure on the crop. Further studies in open fields under a more normal bird pressure are warranted.

Keywords: Anthraquinone; Bird repellent; Crop damage; *Eremophila alpestris*; *Lactuca sativa L.*; Methiocarb; Seedling treatment

1. Introduction

Lettuce (*Lactuca sativa L.*) is an important economic crop in California, with approximately 77,000 ha in production and a value of $735 million in 1996 (California Farm Bureau Federation web page, 1998). Bird damage to recently planted crops is a major problem in several of California's lettuce producing areas, including the San Joaquin Valley, the central coast, and southern California (Hueth et al., 1998). Forty-five percent of growers responding to a questionnaire survey regarded bird damage as a serious problem (DeHaven, 1974). Annual losses due to bird damage is estimated at $4.6 million which amounts to 0.6% of the total crop value, however this figure is based only on the amount invested at time of seedling emergence and actual market values may be higher (Mark Arnold, personal communication). Actual losses in years of high-market value could be several times greater.

The major damaging species is the horned lark (*Eremophila alpestris*), which takes the seeds, uproots seedlings and grazes seedling leaves (cotyledons). Damaged seedlings not uprooted will usually be stunted or disfigured, disrupting harvest schedules. Horned larks are the most numerous and damage lettuce most severely from November to January in the Central Valley of California. Lettuce seedlings are most susceptible to bird damage during the two week period immediately following seedling emergence, unless cold weather delays growth.

Growers have employed scaring methods such as shooting and propane exploders to alleviate damage, but few believed these methods to be effective. The current method of choice is scaring by shooting, which costs approximately $120/ha and provides a questionable level of protection against an elusive species like horned larks. Although the majority of growers use shooting, annual losses to horned lark damage are estimated at 1500 ha of planted lettuce (Cummings et al., 1998).

An effective, economical and environmentally safe repellent to deter horned lark damage to lettuce seeds and seedlings would be a valuable tool to integrate into damage reduction efforts. Flight Control™ (Environmental Biocontrol International [EBI], Wilmington, Delaware, USA), contains anthraquinone (50% a.i.), surfactants (2%), and a latex-based filler (48%). Flight Control™ (FC) is a light-tan liquid, miscible in water, and has a pH of 7.5–8.5. (FC Material Safety Data sheet,

* Corresponding author. Tel.: + 1-970-266-6121; fax: + 1-970-266-6138.

E-mail address: daryl.l.york@usda.gov (D.L. York).

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EBI). FC has recently been registered with the US Environmental Protection Agency (Reg. No. 69969-1) as a general-use turf treatment against geese, and has showed promise as a bird repellent to protect rice seed from birds (Avery et al., 1998) and a seed-treatment repellent for brown-headed cowbirds (*Molothrus ater*) (Dolbeer et al., 1998). The active ingredient in FC, anthraquinone (AQ), exhibits relatively low toxicity (AQ : $LD_{50} > 100$ mg kg for red-wing blackbirds [*Agelaius phoeniceus*]) (Schafer et al., 1983), although LD_{50} values have not been determined for horned larks fed AQ.

In a review of research involving various fruit crops and depredating bird species, Dolbeer et al. (1994) found methiocarb (3,5-dimethyl-4-(methylthio)phenyl methylcarbamate; CAS # 2032-65-7), though relatively toxic, to be effective in reducing damage without adversely affecting birds (Methiocarb: $LD_{50} > 4.22$ mg kg^{-1} for horned larks) (Schafer et al., 1983). A formulation containing 75% methiocarb (a.i.) (Mesurol® 75% WP; Gowan Company, Yuma, Arizona, USA) showed promise in aviary tests in reducing horned lark damage to lettuce seedlings (Cummings et al., 1998). Presently, Gowan Company is resuming product registrations for Mesurol®.

In addition, FC and Mesurol® have both demonstrated potential as bird repellents when applied as a foliar spray on lettuce seedlings (National Wildlife Research Center [NWRC] unpublished data, 1997). Based on these results our objectives were to evaluate the efficacy of lower application rates of FC and Mesurol® in repelling horned larks from lettuce fields in the San Joaquin Valley, California.

2. Methods

2.1. *Flight Control™ trial*

The study was conducted in a lettuce field near Huron, CA with lettuce seedlings at the cotyledon stage, which according to lettuce growers is the growth stage most susceptible to bird damage. Six floorless, portable enclosures (1.8 m × 3 m × 7.6 m) were placed over 4 rows of lettuce seedlings, and each enclosure was separated by at least 4 rows (approximately 2 m apart). We mixed 55 ml of FC with 6.5 ml of sticker (Exhalt 800) and 19.8 l of water in the sprayer tank. We calibrated the Solo® gasoline powered backpack sprayer to deliver 2.79 kg ha^{-1} and applied the FC formulation to all lettuce seedlings in 3 of the 6 aviaries on 12 January 1999.

One screen exclosure (0.61 m × 0.61 m) was placed over a bed of seedlings in each enclosure to provide an accurate estimate of undamaged seedling density. We conducted an initial count of all seedlings in each treated and control enclosure ($\bar{x} = 229$, SE = 31 seedlings/aviary, $n = 6$) and under each exclosure ($\bar{x} = 12$, SE = 2 seedlings/exclosure, $n = 6$) prior to release of larks into enclosures.

The horned larks were wild caught birds housed in aviaries approximately 1 month prior to initiation of trials to accustom the birds to captivity. Prior cage and aviary studies using wild caught horned larks found these birds to readily consume planted lettuce seedlings (Cummings et al., 1998).

We released six horned larks into each of the six enclosures after the FC formulation had dried on the seedlings within treated enclosures. Horned larks were provided commercial, wild bird seed and water *ad libitum* to avoid forcing the birds into eating lettuce seedlings. Daily, we counted all lettuce seedlings in treated and control enclosures and under each screened exclosures for a total of 6 days, from 12 January to 17 January.

2.2. *Mesurol® trial*

On 18 January 1999 we initiated the Mesurol® trial by moving enclosures to a location in the same lettuce field that was undamaged by free-ranging larks and out of spray-drift range (>50 m) of the previous trial. The six enclosures were constructed over lettuce seedlings and every other cage was treated with the test substance comprising 26.2 g of Mesurol®, 6.5 ml of sticker (Exhalt 800), and 18.0 l of water. The Solo® sprayer was calibrated to deliver the Mesurol® formulation at a rate of 2.27 kg ha^{-1}. We duplicated the same procedures involving seedling counts and horned lark release into enclosures in this trial as described for the FC trial with the exception of using 6 larks which were not involved in the previous trial. An initial count of all seedlings in each enclosure ($\bar{x} = 263$, SE = 33 seedlings/aviary, $n = 6$) and under each exclosure ($\bar{x} = 12$, SE = 4 seedlings/exclosure, $n = 6$) was conducted on 18 January and repeated daily through 23 January.

Bird damage was expressed as a percentage of lettuce seedlings available that were eaten by birds. Because no variability existed in final consumption on control plots for both FC and Mesurol®, one sample *t*-tests were used to compare the results from treated plots to the 100% damage level. A single factor repeated measures ANOVA using SAS PROC GLM (SAS, 1988) was used to compare exclosure counts over the days of each experiment.

3. Results

Horned lark damage to lettuce seedlings treated with FC was 60% (505 of 841 seedlings destroyed in treated enclosures), and seedlings in control enclosures were completely destroyed, (100%). The 60% damage rate differed substantially from the total destruction observed for the control ($t = 6.725$, df = 2, $p = 0.011$). In the Mesurol® trial we counted a 20% reduction in seedlings (163 of 800 seedlings destroyed in treated enclosures) compared to a complete destruction of seedlings in the

control plots (100%). The 20% damage rate for the Mesurol® trial also differed substantially from the total destruction in control plots ($t = 11.519$, df = 2, $p = 0.004$). The 60% consumption of FC-treated seedlings differed from the 20% consumption of Mesurol®-treated seedlings ($t = 4.12$, df = 4, $p = 0.015$).

By Day 1 of the FC trial, we recorded cumulative lark consumption rates of 36.0% in treated cages ($n = 3$), 42.1% by Day 2, 48.6% by Day 3, 50.7% by Day 4, and 60.0% by Day 5. In control cages ($n = 3$) larks consumed 96.4% of seedlings by Day 1, 99.0% by Day 2, and 100% by Day 4. Average exclosure counts in the FC trial increased monotonically from 12.20 pretreatment to 14.3 on Day 6 ($F = 3.51$, df = 5, 25, $p = 0.015$).

In the Mesurol® trial, we recorded cumulative lark consumption rates in treated cages ($n = 3$) of 1.6% by day 1, 14.4% by Day 2, 16.9% by Day 3, 19.5% by Day 4, and 20.3% by Day 5. In control cages ($n = 3$) larks consumed 10.0% of total seedlings by Day 1, 78.0% by Day 2, 89.0% by Day 3, and 100% by Day 4. The average exclosure counts in the Mesurol® trial remained identical each day of the experiment ($\bar{x} = 11.67$).

4. Discussion

A 60% (FC) or 20% (Mesurol®) rate of damage would be unacceptable to most growers investing in a chemical repellent. However, when considering these results, one should keep in mind that each test plot induced a constant pressure of approximately 15,000 horned larks/ha for all 6 days of the test. This presented a severe test of each repellent. That 40% of the FC-treated seedlings and 80% of the Mesurol®-treated seedlings survived this pressure is notable especially since not a single control seedling survived past Day 4 of the experiment.

The increase in screened exclosure seedling counts in the FC trial indicated some seedling emergence during the 6-day trial. This does not have a bearing on the significance of FC efficacy except to suggest that more seedlings were consumed than initially counted. However, these seedlings would not have been treated because they had not yet emerged during the original application.

Losses associated with bird damage to sprouting lettuce is severe enough in certain cases that growers are willing to pay up to $370/ha for a reliable chemical repellent (California Farm Bureau Federation web page, 1998). Even if the most effective application rates of FC and Mesurol® are twice those tested in this trial, these repellents might prove cost effective depending on severity of bird damage and current market value of lettuce. However, FC and Mesurol® currently are not registered as foliar sprays for lettuce seedlings. Future tests should be conducted in open fields, under natural bird pressure, to evaluate the efficacy of additional concentrations, and to register one or both repellents for use on lettuce seeds and seedlings.

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