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EFFECTIVENESS OF IRON CHELATE MOLLUSCIDE BAITS FOR CONTROL OF GRAY FIELD SLUGS (DEROCERAS RETICULATUM M.) IN GRASS AND CLOVER SEED CROPS IN OREGON

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ABSTRACT

Crop damage caused by gray field slugs (*Deroceras reticulatum* M.) in western Oregon's seed production fields is extremely problematic and costly to growers. Despite years of research, attempts to reduce slug densities have only been partially successful in this high rainfall region. Three replicated experiments were conducted in 2010 and 2011 on commercial grass and clover seed fields to investigate the efficacy of newly available molluscide baits in controlling the gray field slug. Treatments included 2% and 5% iron chelate compared with an untreated control, 4% metaldehyde and 1% iron phosphate. In two of three trials, 5% iron chelate reduced slug densities while 2% iron chelate did not reduce densities in any trial. This study suggests that iron chelate may not be more effective than metaldehyde.

INTRODUCTION

Economically, slugs remain among the most damaging and costly pest species to seed crop production in western Oregon and other high rainfall agricultural regions around the globe. In recent years, the exclusion of field burning and an increase in no-till production has gradually eliminated these cultural control tools that were once heavily utilized in the region. In no-till and short-lived perennial grass and legume cropping systems, post-harvest residues increase surface soil moisture, thus creating a more desirable habitat for slugs to persist (DeFrancesco, et al., 1996). A variety of molluscidal compounds have been evaluated as active ingredients in baits for slug control (Fisher et al., 1995; Gavin et al., 2009; Henderson and Triebskorn, 2002). Despite documented efficacy, a single molluscide bait application typically ranges from 10 to 60% control (Godan, 1983; Barker et al., 1991) and is heavily dependent on environmental conditions such as soil moisture, wind, and soil and air temperature (Gavin et al., 2006). In western Oregon, multiple applications of slug bait treatments are commonly needed and result in added expenses for growers (Gavin et al., 2008). In 2006, Gavin et al., estimated that over 3 million pounds of slug bait per year are sold in the region, at an annual cost of 3.7 million dollars.

Four species of slugs are known to regularly occur in grass and legume seed crops in Oregon. By far the most common is the gray field slug (*Deroceras reticulatum* M.) (Figure 1), also called the grey garden slug, introduced from Europe in the late 1800's. Adult gray field slugs are grayish-brown in color and range from 400-600 mg in weight and 12-30 mm in length. Their lifespan is thought to range from 9 to 18 months under Oregon conditions. In Oregon, slugs begin to lay eggs in late fall, but the majority (70%) are laid in early spring. Each slug can lay up to 43 eggs per reproductive cycle, depending on their weight (Gavin et al., 2007). Once hatched, juvenile slugs begin feeding within one to two weeks and continue to cause crop damage (Figure 2) throughout adulthood. In the fall, most gray field slugs have completed development and are capable of reproducing.

Figure 1. Gray field slugs (*Deroceras reticulatum* M.) feeding in a grass seed field in western, Oregon.

Figure 2. Damage caused by gray field slugs to a seedling grass plant.

The most commonly used molluscide used for slug control is metaldehyde, a material formulated in various products in the United States (Deadline M-P's®, MetaRex®, Slug-Fest®, Durham®) and used since the early 1940's. An additional material with slug activity contains iron phosphate and has been distributed as Sluggo® since 1998. Sluggo® is approved for organic production. Several new baits (Ferrox® and Iron Fist®) containing the active ingredient sodium ferric EDTA (FeEDTA), also known as iron chelate, have recently become commercially available in the United States. Unlike metaldehyde baits, iron based baits need to be consumed by the slug before death can occur, which usually takes place away from the bait or even underground.

The objective of this work was to evaluate the newly available iron chelate molluscide baits for control of slugs in grass and legume seed fields in western Oregon. Fall-baiting is recommended after the fall rains commence to kill a portion of the population of slugs before eggs are laid. The study was conducted in mid-fall when slugs become active and begin feeding after a summer of hiding deep in the soil profile to avoid high temperatures and dry conditions. Too often the relatively easy and effective method of baiting does not provide adequate protection, particularly when no-till seeding is utilized or significant post-harvest vegetative residues are left on the soil. Thus, it is important to continue evaluating efficacy of new slug bait formulations as we search for tools that will effectively minimize crop damage and reduce input costs.

METHODS

Three trials were established in commercial grass and red clover seed fields in October 2010 and 2011. In 2010, two trials were conducted in an established tall fescue seed field that had not received tillage in three years (Washington County) and in a newly no-till planted intermediate ryegrass seed field (Linn County). In 2011, one trial was located on an established red clover seed field that had not received tillage in five years (Washington County). At each study site, 50 ft. X 50 ft. plots were established in a randomized block design with three replications.

In 2010, five treatments were included: 1) untreated control, 2) 4% metaldehyde at 10 lbs/a, 3) 1% iron phosphate at 15 lbs/a, 4) 2% iron chelate (FeEDTA) at 15 lbs/a, and 5) 5% iron chelate at 10 lbs/a. In 2011, 4 treatments were included: 1) untreated control, 2) 4% metaldehyde at 10 lbs/a, 3) 5% iron chelate at 10 lbs/a, and 4) 5% iron chelate at 20 lbs/a. The 2% iron chelate treatment was not included in the 2011 trial due to product unavailability.

Plots were established in areas of the fields where heavy slug populations were documented prior to baiting. Baits were applied when nightly temperatures were 45-55 °F, soil moisture was present, and wind speed was less than 5 MPH. With the exception of the Linn County intermediate ryegrass site in 2010, all baits were applied one time with a rotary bait spreader (Solo 421S) at dusk when slugs are active. Because slug counts in the intermediate ryegrass trial remained very high after baiting, the trial was rebaited with the same treatment materials 14 days after the first application. Seedling survival (stand counts) and number of damaged plants were recorded 18 days after the second baiting.

Slug densities were evaluated prior to-and post-application of test materials. Three 18 in. x 18 in. slug blankets (Figure 3) (designed by Liphatec Inc., UK) were soaked in water and arbitrarily placed a minimum of 10 ft. apart and secured in each plot. These blankets provide insulation and have moisture-holding capabilities. Plant material was removed from the blanket location to ensure that the blankets could be firmly secured to the soil surface.

In both years, the study began during the third week of October. Number of slugs counted under each blanket was recorded 2 days prior to the application of baits, 2 days post-application, and at 7, 10, and 14 days after treatment. At each evaluation, slugs were removed and blankets were re-wetted and set out in a new location within the plot where a blanket had not been previously placed. Evaluations were completed in the early morning, prior to sunrise, when slugs are active aboveground. To ensure the blankets were not an impediment to the efficacy of the molliscide application, all blankets were removed prior to the bait being applied and replaced immediately thereafter.

Figure 3. Slug blankets utilized to conduct slug density evaluations. One side of the blanket is black and perforated and the other side is silver-colored and reflective.

Data was statistically analyzed using analysis of variance (ANOVA) and means were separated using the Fisher Protected LSD test at a *P*-value equal to 0.05. Slug-days were calculated by averaging the number of slugs counted per plot on a given evaluation date by the number of slugs counted in the same plot on the previous evaluation date. This average was then multiplied by the number of days between the two evaluation days.

RESULTS

Pre-bait evaluations within plots revealed high numbers of gray field slugs present both years at each of the three sites. No significant differences were found between plots at this time ($P \leq 0.05$). A small number (< 5%) of brown-banded Arion slugs (*Arion circumscriptus*) were also documented.

2010

There were significant slug density differences ($P \leq 0.05$) between treatments at both sites. In the established tall fescue field, 2% iron chelate was the only treatment with significantly less slug days per blanket compared to the control (Table 1). Slug count numbers declined in both the control and treated plots. Cold temperatures at night (≤ 45° C) and wind speeds greater than 5 MPH, may have influenced the reduced numbers of slugs found under all blankets.

Treatment	Rate	Slug Days / Blanket[1,2]
Control	0 lbs/acre	40.2 ab
4% Metaldehyde	10 lbs/acre	37.9 ab
1% Iron Phosphate	15 lbs/acre	44.6 a
2% Iron Chelate	15 lbs/acre	23.9 b
5% Iron Chelate	10 lbs/acre	30.4 ab

[1] Each plot contained 3 blankets per plot, totaling 9 blankets per entry.

[2] Means were separated using LSD (0.05) test. Means followed by different letters are significantly different.

Table 1. Slug days per blanket in an established tall fescue field in Washington Co., Oregon.

In the newly established no-till intermediate ryegrass seed field, 5% iron chelate, iron phosphate, and metaldehyde treated plots had significantly less ($P \leq 0.05$) slug days per blanket compared to the control however, the 2% iron chelate treatment was not significantly different from the control (Table 2). Unlike the tall fescue site where nearly 95% of slugs counted were adults, approximately 35% of the slugs counted during the study period in the intermediate ryegrass site were juvenile. Fifty percent of the slugs counted during the last evaluation were juveniles.

Treatment	Rate	Slug Days / Blanket[1,2]
Control	0 lbs/acre	440.8 a
4% Metaldehyde	10 lbs/acre	271.3 c
1% Iron Phosphate	15 lbs/acre	328.9 bc
2% Iron Chelate	15 lbs/acre	369.1 ab
5% Iron Chelate	10 lbs/acre	291.1 bc

[1] Each plot contained 3 blankets per plot, totaling 9 blankets per entry.

[2] Means were separated using LSD (0.05) test. Means followed by different letters are significantly different.

Table 2. Slug days per blanket in a newly no-till seeded intermediate ryegrass field in Linn Co., Oregon.

Two variables were used to estimate slug damage in the intermediate ryegrass field that was baited twice: the number of seedling per linear foot; and the percentage of the seedlings damaged. The percent of seedlings damaged could have been partly confounded by seedling loss, for a heavily damaged seedling might have disappeared and not been recorded as damaged. Neither of these variables was significantly impacted by the slug control treatment (Table 3). However the differences among entries in the number of seedlings was significant at $P = 0.06$.

Treatment	No. of Seedlings	Damaged Seedlings
	(ft^2)	(%)
Control	1.2	93.3
4% Metaldehyde	5.8	43.4
1% Iron Phosphate	3.0	72.2
2% Iron Chelate	2.9	57.8
5% Iron Chelate	4.1	44.1

Table 3. Seedling stand counts and percent damaged by slug feeding after molluscide treatments in a newly no-till seed intermediate ryegrass field in Linn Co., Oregon .

2011

Treated plots significantly reduced slug numbers compared to the control plots *($P \leq 0.05$)*. There was no significant difference between plots treated with metaldehyde and iron chelate. Additionally, there was no significant difference between the iron chelate treatments (Table 4). Slug counts greatly increased in the control plots 10 days post treatment (data not shown). Warm nightly temperatures during that period may have influenced the higher numbers of slugs found in the untreated plots.

Treatment	Rate	Slug Days / Blanket[1,2]
Control	0 lbs/acre	183.7 a
4% Metaldehyde	10 lbs/acre	96.6 b
5% Iron chelate	10 lbs/acre	120.7 b
5% Iron chelate	20 lbs/acre	121.1 b

[1] Each plot contained 3 blankets per plot, totaling 9 blankets per entry.

[2] Means were separated using LSD (0.05) test. Means followed by different letters are significantly different.

Table 4. Slug days per blanket in an established no-till red clover field in Washington Co.

DISCUSSION

This study indicated that control of large slug populations continues to be a challenge in western Oregon cropping systems. As seen by the large variation in slug-days per blanket, slug densities differ greatly between fields. Seedling grasses and clovers are most susceptible to damage and crop loss in the seedling stage. As seen in 2010 at the seedling intermediate ryegrass site, fall seedling establishment is problematic if a large population of slugs is not controlled prior to seedling emergence. Several applications appear necessary to reduce high adult populations prior to egg-laying. Spring applications most likely will be required to control juvenile slugs from eggs that were laid in the fall.

At all three study locations, 5% iron chelate significantly reduced slug populations. None of the locations where 2% iron chelate was applied showed significantly reduced slug populations. However, the standard metaldehyde bait iron phosphate baits were effective at all sites where they were applied except for the tall fescue location in 2010The efficacy of each of these materials is likely to vary between fields, years, population levels and age, and environmental conditions. Unfortunately, EDTA has been shown to be toxic to earthworms, unlike metaldehyde (Edwards et al., 2009; Langan and Shaw, 2006). Large populations of earthworms have been observed removing up to 25% of pelleted slug baits applied to western Oregon fields (Gavin et al., 2012).

At the intermediate ryegrass site we observed more juvenile slugs under blankets compared to adults which suggests younger slugs may be more difficult to control with baits than older slugs. Juvenile slugs may not feed as much on the baits, so are more difficult to kill. They are a continual source of re-infestation and may require additional baiting in some situations. It is important that adequate slug control coincides with the emergence of seedling crops to ensure good establishment.

No attempt was made to quantify differences between bait mixtures of multiple products (iron chelate, metaldehyde, iron phosphate) versus single product treatments. Future studies should include combining iron chelate and other newly formulated baits with multiple applications in replicated field trials as there is a continued need for product development and registration to provide adequate control of these damaging pests.

If choosing to apply a molluscide, growers and crop consultants should know the ideal conditions for application, how to evaluate bait effectiveness and closely monitor fields, especially when the crop is in the seedling stage or when tillage has not be recently used. Evaluation of the baits can effectively completed by performing slug counts at dawn and by inspecting new plant tissue for injury. Employing multiple management strategies, including the use of molluscide baits and sprays, tillage and crop rotation can help growers manage this difficult pest problem.

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