EVALUATING THE RESPONSE OF SLUG POPULATIONS AND ACTIVITY TO TILLAGE PRACTICES IN ANNUAL RYEGRASS GROWN FOR SEED

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Introduction

Slugs remain one of the most damaging economic pests of the grass seed industry in the Willamette Valley. As no-till acreage has increased, it appears that slug pressure has also increased (Dreves et al., 2014). No-till systems, coupled with full-straw-load residue management, provide ideal slug habitat. Slug counts in no-till annual ryegrass fields have been recorded at up to 29 times greater than in conventionally tilled fields (Fisher et al., 1996).

In theory, tillage should reduce slug populations by crushing and burying slugs, disrupting their burrows, and reducing the food source. However, slug populations within conventionally tilled acres may also reach economic-infestation levels, requiring control measures for successful crop establishment. While anecdotal information exists suggesting tillage reduces slug populations, little research has been done under controlled experimental conditions to evaluate this theory. As frustration rises for growers using both conventional tillage and no-till practices, it is apparent that more information is needed on the use of tillage as a slug management tool.

A long-term annual ryegrass seed production trial established in 2005 with varied tillage cycles offered the opportunity to evaluate treatment effects on slug populations. The present study was designed to determine the impact of four tillage treatments on slug emergence and total numbers during the fall of one season.

Methods

The study was conducted at OSU's Hyslop Research Farm near Corvallis, OR, in the fall of 2014. The study plots were part of an existing annual ryegrass cropping systems trial that was established in 2005 (Mellbye et al., 2009; 2011). The original study evaluated six treatments in a continuous annual ryegrass monoculture for seed production; the treatments were different combinations of conventional tillage, conventional planting, and no-till practices. The fall of 2014 was the ninth year of treatments imposed on these plots. An established population of slugs was confirmed in this location.

The experimental design was a randomized complete block with three replications. The following four tillage treatments were studied in 2014:

- Continuous conventional tillage (CT)
- Continuous no-till (NT)
- Alternate-year tillage (NT/CT)
- Third-year tillage (volunteer/NT/CT)

Each treatment plot area measured 25 feet x 60 feet. On all treatments, the crop residue was flail-chopped and left on the plots after harvest. Conventional tillage included plowing to a depth of 8 to 10 inches, disking, and harrowing. Treatments 1 and 3 were conventionally tilled on October 6, 2014, while treatments 2 and 4 were left to volunteer. None of the plots were reseeded in 2014, as there was sufficient seed in the soil for crop regrowth.

Once adequate fall moisture was received (about 1.5 inches), slug blankets were used to monitor slug emergence and numbers. In each plot, three slug blankets (18 inches x 18 inches, designed by Liphatech) were soaked in water and evenly distributed down the length of the center of the plot. In the no-till treatments, the residue was brushed aside to expose the soil surface before placing the blanket. The blankets were secured in place in the afternoon, and the number of slugs per blanket was recorded the following morning. Ten such slug counts were conducted between October 12 and November 28: every three days from October 12 to 24, and then at seven-day intervals from October 24 to November 28. Slugs were removed and blankets rewetted for each count.

For each date, the number of slugs per plot was determined by averaging the three slug blankets counted. Data were analyzed as a two-way factorial analysis of variance using Statistix 9.0 software. Main effects of tillage treatment and slug count timing and their interaction were run at the 95% confidence level ($P < 0.05$). Means within treatments were compared using LSD at the 5% significance level.

Results and Discussion

Tillage treatments, slug count timing, and the interaction between tillage treatments and timing of slug activity

Table 1. Average slug count per sample date in relation to recorded air temperature, soil temperature, and cumulative precipitation at Hyslop Research Farm, fall of 2014.

Sample date	Slug count[1]	Mean air temperature	Mean soil temperature	Cumulative precipitation[2]
		(°F)	(°F)	(inches)
Oct. 12	5.5 d	54.7	62.7	0.03
Oct. 15	13.5 bc	54.7	59.1	0.99
Oct. 18	9.1 cd	62.7	63.9	1.19
Oct. 21	11.3 cd	56.6	60.2	1.92
Oct. 24	12.3 cd	51.5	56.5	3.44
Oct. 31	21.2 b	53.9	58.3	4.94
Nov. 7	35.4 a	47.2	53.8	5.80
Nov. 14	11.5 cd	33.7	40.3	8.28
Nov. 21	30.8 a	50.0	47.2	9.28
Nov. 28	30.0 a	52.1	51.8	10.86

[1]Means followed by the same letter are not significantly different (P <0.05).
[2]Cumulative precipitation beginning October 1, 2014.

all produced significant differences (P <0.05). Over the course of the sampling period, average slug counts were naturally affected by the weather (Table 1). Slug populations tended to increase with moisture except under freezing conditions. There was a significant interaction between tillage treatment and sample date (P = 0.01). Therefore, the effect of tillage on the population and activity of slugs was significant, but varied over the fall (Figure 1).

Differences between tillage treatments were less pronounced early in the season, but measurable differences appeared in late October/early November. The data clearly indicate that alternate-year tillage resulted in both the lowest and most consistent population of slugs over the sampling period (Figure 1). Overall, continuous NT resulted in the earliest slug emergence and greatest total number of slugs. Tillage did delay slug emergence; however, continuous CT had the same average number of slugs as tillage only every third year (Table 2).

The annual ryegrass seed yield averages after six and eight years of this trial were consistently lowest in

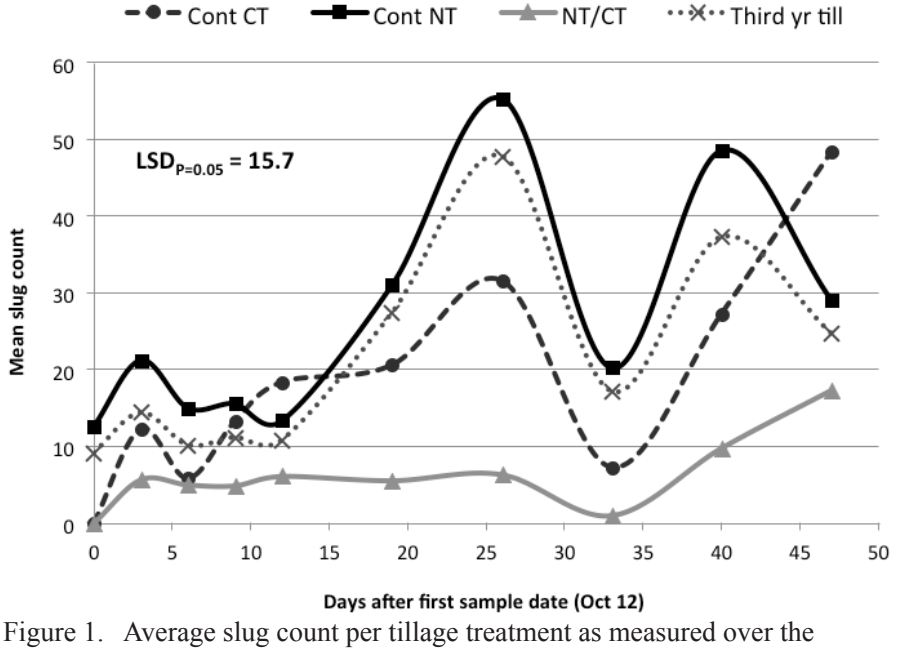

Figure 1. Average slug count per tillage treatment as measured over the course of the sampling period.

the continuous NT treatments (Mellbye et al., 2011; Chastain et al., 2014). The continuous CT, alternate-year tillage, and third-year tillage treatments all produced statistically similar yields after six and eight years. Both Mellbye et al. (2011) and Chastain et al. (2014) noted heavy slug pressure as a likely cause of yield reduction in the NT plots, and slug numbers in the current study were significantly higher in the NT treatments (Table 2).

As shown in Figure 1, the alternate-year tillage treatment resulted in both the lowest population of slugs as well as the most consistent population. The data suggest that some form of disruption (i.e., alternating CT and NT) decreased slug pressure—perhaps by simply altering conditions so that slugs did not become habituated. Similarly, Chastain et al. (2014) found that seed yields in CT treatments were increased when they were cycled with NT or volunteer treatments. In studying annual ryegrass cropping systems over time, it was determined that some frequency of tillage, disturbance of crops residues, and occasional removal of crop residues produced the best seed yields overall (Chastain et al., 2014). These results have been corroborated by growers' observations, who have noted improved slug management and yields when using tillage every other year. With regards to a slug management strategy, alternate-year tillage likely would lead to improved control of slugs with bait applications because of the consistency of slug activity. This scenario both alleviates the risk of "missing" the best opportunity to control slugs and has the lowest level of slug activity to control.

Results from this study indicate several opportunities for follow-up research. The hypothesis that slug activity is more consistent in alternate-year systems, and that slug bait applications therefore are more effective, should be studied with larger scale on-farm slug bait trials. It is important to note that slug migration between plots was highly possible in this study due to the narrow width of the plots. There is also interest from growers in assessing the impacts of shallower tillage on slug populations, as vertical tillage becomes more prominent in the Willamette Valley. Additional trials evaluating not only the efficacy of slug baiting under different tillage strategies, but also the economics of slug bait and land management practices, would be valuable to growers.

Table 2. Average slug count per tillage treatment.

Tillage treatment	Slug count[1]
Continuous tillage	18.5 b
Continuous no-till	26.3 a
Alternate-year tillage	6.3 c
Third-year tillage	21.1 b

[1]Means in a column followed by the same letter are not significantly different (P <0.05).

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