Managing Wireworms (*Agriotes* spp.) in Western Washington Organic Vegetable Crop Production

Brook Brouwer[1], Beverly Gerdeman[2], Stephen Bramwell[3], and Todd Murray[4]

[1]Washington State University Extension, San Juan County, Friday Harbor, WA; [2]Washington State University, NWREC, Mount Vernon, WA; [3]Washington State University Extension, Thurston County, Olympia, WA; [4]Washington State University Extension, Pullman, WA

Project Abstract

Wireworms, the larval stage of click beetles (Coleoptera: Elateridae), can cause substantial damage to a wide range of agronomic and vegetable crops (Figure 1). Two introduced species of wireworm, *Agriotes lineatus* and *A. obscurus,* have spread in Washington State, resulting in serious economic damage to high value vegetable crops. Wireworms thrive on pasture and grain rotations, which are commonly used by organic growers to maintain and build soil organic matter. Growers in western Washington have indicated that wireworms are a primary pest challenge; yet options for control of this pest are very limited. Using a preferred host as a trap crop planted near the cash crop is potentially a low-cost, environmentally-friendly option for wireworm management. In this project, research personnel and cooperating farmers are using lettuce production beds to compare effects on wireworms of (1) trap cropping with wheat; (2) a spinosad insecticidal bait product; (3) combination of treatments and (4) a no-management control. On-farm trials were conducted at five western Washington locations in Thurston, Skagit and San Juan counties during the 2018 growing season. This study will be continued for two more growing seasons. At each site, lettuce survival and wireworm density was measured weekly in each plot. Soil temperature, which can influence wireworm activity, was recorded throughout the trial. Lettuce biomass was recorded at the end of the trial. Preliminary results indicate that trap cropping may reduce loss of lettuce transplants to wireworm feeding.

Figure 1. A. Wireworm (*Agriotes* spp.) larval stage; B. Click beetles, the adult stage of wireworms; C. Lettuce wilting from wireworm damage; D. Wireworm feeding on lettuce.

Methods

Trial Set-up: Initial wireworm density was estimated at each trial location by counting the number of wireworms caught in a bait trap (one cup of wheat soaked in water for 12 hrs and placed into a stocking and buried ~6 in. deep for one week) (Figure 2A, Table 1). Lettuce (cv 'Muir') was grown in 72-cell trays for three weeks prior to transplanting. Trial start dates varied depending on local growing conditions and farmer cooperator needs. Transplants were irrigated as needed. Soil temperature was monitored at a depth of 6 in. Each plot was 6 ft by 4 ft with a 3 ft buffer between plots. Treatments were established in a randomized complete block design with four replicates at each farm (Figure 2C).

Treatments: 1.) **Control:** lettuce transplanted without wireworm management; 2.) **Spinosad:** bait product (Seduce) applied one week prior to lettuce transplanting; 3.) **2x Spinosad**: Spinosad applied one week prior to and at transplanting; 4.) **Wheat**: Wheat trap crop planted one week prior to transplanting; 5.) **2X Wheat**: Wheat planted one week prior to and at transplanting. 6.) **Wheat + spinosad**: Wheat planted and spinosad applied one week prior to transplanting; 7.) **2x Wheat + Spinosad**: Wheat planted and spinosad applied one week prior to and at transplanting. Wheat was planted between lettuce rows at rate of 1 oz per 6 ft bed (Figure 2B). Spinosad bait was applied between lettuce rows in a furrow at rate of 0.18 oz product per 6 ft bed.

Measurements: Lettuce mortality from wireworm damage was recorded weekly. Wireworm density between lettuce rows was measured by taking soil cores and counting larvae weekly (Figure 2D). At the end of the trial, lettuce was harvested and weighed to determine yield (Figure 2E).

Analysis: Data were analyzed in R v3.5.1. A two-way analysis of variance (ANOVA) was conducted to check for location-by-treatment interactions. No significant interactions were identified, so treatment effects were analyzed using a linear mixed model with block (within location) as a random effect and treatment as a fixed effect. Model validity was checked using the Shapiro-Wilk test. Where necessary, data were transformed to meet assumptions of parametric analysis. For variables where a significant treatment effect was detected, pairwise contrasts between each treatment and the control were carried out (Dunnett's test). An treatment effect was determined to be significant if the p-value associated with this contrast was less then 0.05 (Table 2).

Figure 2. A. Setting wheat bait trap; B. Planting wheat trap crop; C. Transplanting lettuce; D. Counting wireworms in a soil core; E. Weighing lettuce at harvest.

2018 Results

Agriotes spp. wireworms were found in bait traps at three of the six farm sites (Table 1). Subsequent analyses included data from these sites only. There was evidence of a significant treatment effect on total wireworms found between lettuce rows, lettuce survival at four weeks after transplanting and final lettuce yield (Table 2). All treatments using wheat as a trap crop were significantly different from the control. No spinosad-only treatment was significantly different from the control.

Table 1. Number of wireworms (*Agriotes* spp.) in wheat bait traps set for one week (average of four to six traps per location).

County	Sample Month	Farm	Wireworms per trap
San Juan	August	Maple Rock	7
San Juan	July	Lopez Harvest	2
San Juan	August	Mama Bird	33
Skagit	June	Skagit Flats	0
Skagit	August	Viva Farms	0
Thurston	July	Calliope Farm	0

Table 2. Mean values ± standard deviation for total wireworms, lettuce survival and lettuce yield across three San Juan County locations.

Treatment	Total Wireworms	Lettuce (% Survival)	Lettuce Yield (g/m²)
Control	1 ± 1	17 ± 22	29 ± 48
Spinosad	2 ± 1	19 ± 24	32 ± 66
2x Spinosad	1 ± 1	25 ± 19	45 ± 71
Wheat	7 ± 7***	50 ± 25**	69 ± 63**
Wheat + Spinosad	7 ± 7***	47 ± 22**	65 ± 68*
2x Wheat	5 ± 4***	53 ± 16***	77 ± 58**
2x Wheat + Spinosad	8 ± 5***	41 ± 23*	56 ± 60*

*$p \le 0.05$, **$p \le 0.01$, ***$p \le 0.001$. significantly different from control based on Dunnett's test

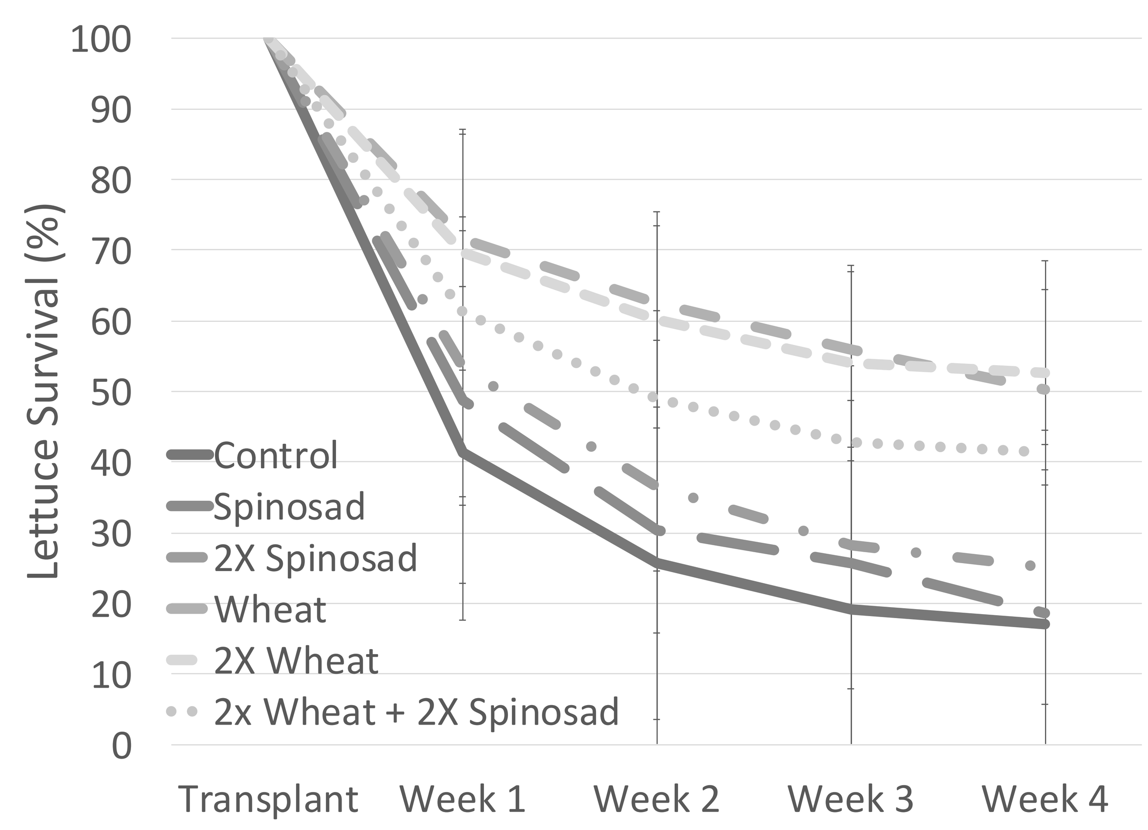

Figure 3. Percent survival of lettuce transplants at 7-day intervals following transplanting. The Y-axis shows mean values across three San Juan County locations; error bars show standard deviation.

Figure 4. A. Wheat treatment; B. Control treatment.

Figure 5. Wireworm feeding on wheat trap crop.

Conclusions

In these trials, spinosad bait did not attract wireworms and was not effective at reducing damage when applied in- furrow between rows. Wireworm density was higher between lettuce rows interplanted with wheat, indicating that the larvae were attracted to the wheat (Figure 5). Wheat trap cropping may help reduce loss to wireworms by providing an alternative food source during plant establishment. However, under high levels of wireworm feeding pressure there was still substantial loss of lettuce transplants. Future research needs to address strategies for reducing overall wireworm population in organic production systems.

Acknowledgements

This project was funded by Western SARE grant #OW18-018. Spinosad bait was donated by Certis. On farm trials were hosted by Mama Bird Farm, Lopez Harvest, Maple Rock, Calliope Farm, Skagit Flats Farm and Viva Farms.

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