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

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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 season. At each site lettuce survival and wireworm density was measured weekly in each plot. Soil temperature, a parameter 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, adult stage of wireworms; C.) Lettuce wilting from wireworm damage; D.) Wireworm feeding on lettuce.

Methods

Trial Set Up: Wireworm presence was determined using a bait trap, one cup of wheat was soaked in water for 12hrs, buried ~6in deep for one week at each site before counting the number of wireworms (Figure 1A). Lettuce (cv 'Muir') was be grown in 72 cell trays for three weeks prior to transplanting. Trial start date varied depending on local growing conditions and farmer cooperator needs. Soil temperature was monitored at a depth of 6in. Each plot was 6ft by 4ft with a 3ft 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 spınosad 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 0.5 ounce per 3ft (Figure 2B). Spinosad bait was applied between lettuce rows at rate of 20 lbs product/acre according to product label.

Measurements: Lettuce mortality was recorded weekly. Wireworm density between lettuce rows was measured by taking soil core 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 analyze in R v3.5.1. A two way ANOVA was conducted to check for location by treatment interactions. No significant interactions were identified so treatment effects were analyzed using a mixed linear model with location as a random effect and treatment as a fixed effect. Normality was checked using Shapiro-Wilk test, data were square root transformed as needed to meet assumptions of normality. Significant differences between individual treatments and control were checked using Dunnett's test. An effect was determined to be significant if the p-value for a test was less then 0.05.

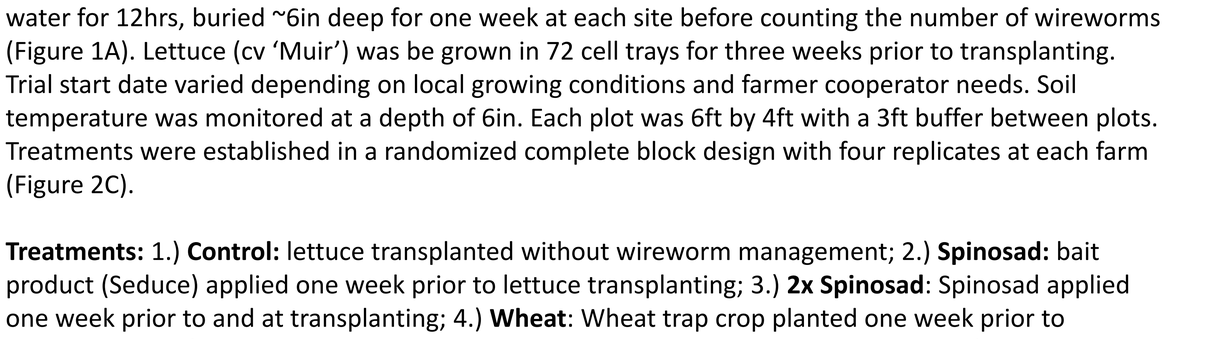

Figure 2. A.) setting wheat stocking bait trap; B.) Planting wheat trap crop; C.) Transplanting lettuce; D.) Sampling soil core for wireworms; E. Weighing lettuce at harvest.

2018 Results

Agrioties spp. wireworms were found in bait traps at 3 of the farm sites (Table 1). Subsequent analysis was conducted using data from these sites. Treatment was significant for total wireworms found between the 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. None of the spinosad alone treatments were significantly different from the control.

Table 1. Presence of wireworms (*Agrioties spp.*) in wheat bait traps after 1 week.

County	Farm	Average Wireworms/ Bait Trap
San Juan	Maple Rock	7
San Juan	Lopez Harvest	2
San Juan	Mama Bird	33
Skagit	Skagit Flats	0
Skagit	Viva Farms	0
Thurston	Calliope Farm	0

Table 2. [1]Mean wireworms counted between lettuce rows in each plot over 6 week sampling period ± standard deviation. [2]Mean lettuce survival 4 weeks after transplanting ± standard deviation. [3] Mean lettuce yield calculated as grams per meter squared ± standard deviation. *p-value <0.05, **p-value <0.01, ***p-value <0.001 significantly different from control based on Dunnett test

Treatment	Total Wireworms[1]	Lettuce (% Survival)[2]	Lettuce Yield (g/m²)[3]
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-value	*<0.0001*	*<0.0001*	*<0.0001*

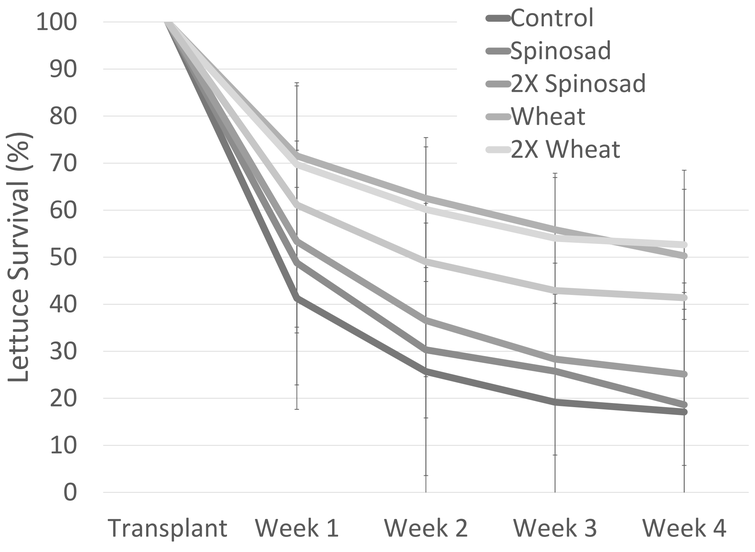

Figure 3. Percentage (%) survival of lettuce transplants at 7 day intervals following transplanting. Values are means across three San Juan County locations ± standard deviation.

Conclusions

Trap cropping with wheat may reduce lose of lettuce plants to wireworm damage. Spinosad bait was not found to be effective in reducing damage when applied between rows. Wireworm density was higher between lettuce rows with wheat indicating that they are attracted to the wheat whereas spinosad bait did not appear to attract wireworms (Figure 5). Wheat trap cropping may help reduce lose to wireworms by providing an alternative food source during plant establishment. Future research should focus on management for reducing wireworm populations.

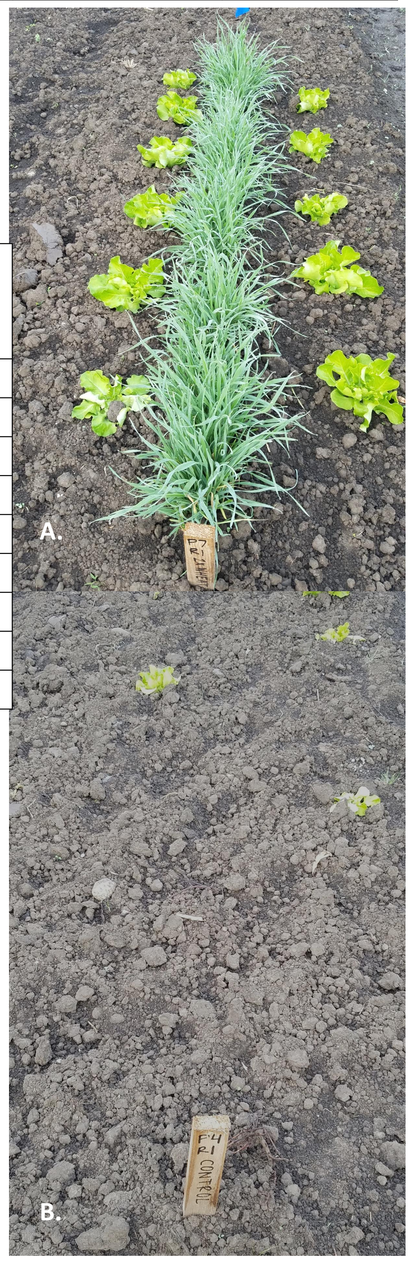

Figure 4. A.) Wheat treatment; B.) Control treatment.

Figure 5 Wireworm feed on wheat trap crop.

Acknowledgements

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