The use of Canola Seed Meal and Enterra Natural Fertilizer for Controlling Wireworm

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Abstract

Wireworms are major soil-dwelling pests of both vegetable and fruit crops. They are root-feeding larvae of click beetles *(Coleoptera: Elateridae*). Wireworm management has long relied on synthetic pesticide applications. Organic management tactics are difficult because the larvae stay in the soil for 2-5 years. Incorporation of organic soil amendments, such as Enterra Natural fertilizer (ENF) and Rapeseed or Canola seed meals (Defatted Seed Meal, DSM), help to reduce wireworm effects and could be compatible with organic standards. Previous studies have found that DSM can reduce wireworm pressure, reduce soil borne plant pathogens and parasites, and increase yield, but few studies have evaluated effects of ENF on wireworm. I examined ENF and DSM's effects on wireworms. An experiment was conducted with four replicates and three treatments: (1) control (no fertilizer); (2) ENF applied at 7 t/hectare; and (3) DSM applied at 6 t/ac. All plots were planted to wheat after treatment in June, 2015. Wheat - baited wireworm traps were inspected six times in September and October, and aboveground wheat biomass was collected in November. Wireworm counts were higher in control plots than in plots treated with ENF or DSM fertilizer. No effect of treatment was detected on aboveground wheat biomass production. This project will play an important role in agriculture in advancing knowledge of farmers to replace synthetic pesticide use with an organic soil amendment for wireworm management, which may be friendlier to the environment, human health and soil health.

Keywords: wireworms; click beetles; *Agriotes obscurus;* Wheat; root-feeding; *Coleoptera: Elateridae;* Enterra Natural fertilizer; ENF; Rapeseed meal; Canola seed meals; Defatted Seed Meal; DSM; Plant; vegetable; fruit; Brassica; Biofumigation; Plant growth

Introduction

Wireworms are major soil-dwelling pests of both vegetable and fruit crops. They are root-feeding larvae of click beetles (*Coleoptera: Elateridae)* (Ansari et al. 2009; 2008). They are dangerous pests, indigenous in Europe and introduced to North America (Kabaluk 2014). More than 9,000 species are found worldwide, causing yield losses, and seed and root damage to plants. They are serious pests of potato, cereals, carrot, sugar beet, sugarcane and soft fruits (Barsics et al. 2013).

Wireworms go through larval, pupal and adult stages. The wireworm larva has a hard, slim, smooth and jointed body, with three pairs of legs behind the head. It can be reddish-brown, yellow or white in colour and its size is 1/16 to 1½ inches (Andrews 2008). Wireworm pupae are about 1/2 inch long, soft and very fragile, with white to cream colouring, becoming darker before transforming into the adult (Ansari et al. 2009; 2008). The adult is a click beetle, which is hard shelled, black-brown colour and makes a clicking sound when it is held in the hand or laid down on its back (Marrison 2003).

Below is wireworm life cycle from Andrews (2008) that gives us a quick description of their presence in the farm.

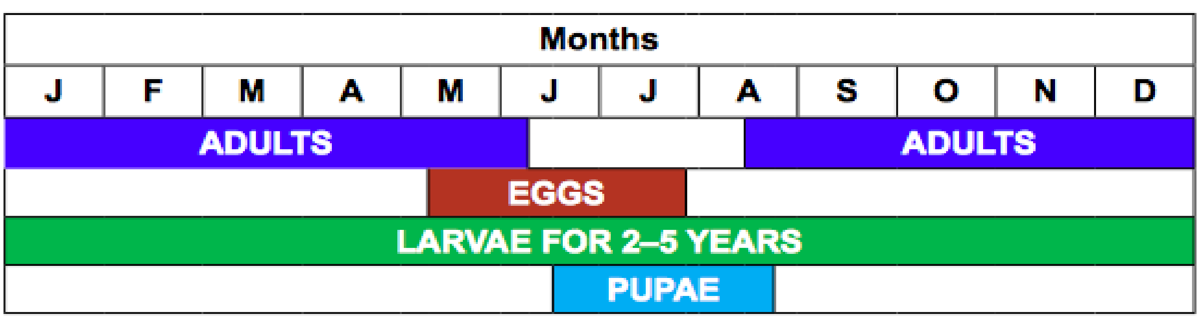

Figure 3. Wireworm life cycle. (Adapted from Berry, 1998)

Wireworm management has long relied on synthetic pesticide applications. Organic management tactics are difficult because the larvae stay in the soil for 2-5 years

(Kabaluk 2014). Incorporation of organic soil amendments, such as Enterra Natural fertilizer and Rapeseed or Canola seed meals, may help reduce wireworm effects and be compatible with organic standards.

Enterra Natural Fertilizer (ENF) is food waste digested by black soldier fly larvae and converted into high quality animal feed and fertilizer. The fertilizer component has shown some potential to protect plants from wireworms (Luymes 2014, Wayne et al. 2013). The frass of black soldier fly larvae are used as a fertilizer for protecting plants from wireworms (Bomford, pers. comm).

Enterra Natural Fertilizer contains important plant nutrients such as nitrogen, phosphorous and potassium, and is a good source of beneficial microbes and minerals to protect plants, benefit soil quality by having more than 80% organic matter as its composition (Enterra 2014). Below is complete chart of ENF fertilizer nutrients from Enterra (2014).

Rapeseed or canola seed meals (Defatted Seed Meal, DSM) are also amendments that may protect plants from wireworms. Canola DSM is a biofumigant containing glucosinolates (Furlan et al. 2010), which break down into gasses that are toxic to insects (Suszkiw 2006), including isothiocyanates (Barsics et al. 2013), nitriles, epithionitriles and thiocyanates (Furlan et al. 2010).

Complete Chemical Analysis (Dry Weight Basis)

Total	C/N	8.8
	pH	6.2
	Electrical Conductivity (EC)	27.5 mmhos/cm
	Bulk Density	0.5 g/cm3
	Ash	12.2%
	Dry Matter (DM)	71.0%
	Organic Matter (OM)	88.0%
	C	44.0%
	N	5.0%
	P	1.2%
	K	2.6%
	Ca	0.7%
	Mg	0.2%
	Na	1.5%
Available	Nitrate N	61 ppm
	Ammonia N	5000 ppm
	P	2340 ppm
	K	6268 ppm
	Ca	281.5 ppm
	Mg	121.8 ppm
	Cl	7592.5 ppm
	Sulphates	3133.3 ppm
	Na	3745.3 ppm
	Zn	4.3 ppm
	Mn	0.4 ppm
	Cu	1.2 ppm
	Fe	28.6 ppm
	B	2.6 ppm
	Mo	0.0 ppm
	Al	0.8 ppm

Source: Chemical analysis provided by SGS AgriFood Laboratories, Guelph, ON

I planted wheat in experimental plots at the KPU orchard site to test the hypothesis that ENF and Canola DSM can control wireworm. Wheat was selected as a crop that is attractive to wireworm, can be grown on small (10 m^2) plots, and can be planted in spring or fall (EPPO, 2005; Vernon et al. 2003; Savitch, 2000). The study tested two potential organic soil amendments for activity in controlling wireworms.

Although previous studies have tested these organic wireworm management tactics, it was not clear which amendment is more effective. This study allowed a direct comparison of both ENF and Canola DSM amendments. Results may enable farmers to replace synthetic pesticide use with an organic soil amendment for wireworm management, and promote future investment in organic fertilizers, which may be friendlier to the environment, human health and soil health.

My null hypothesis was that neither amendment would have any effect on wireworm pressure.

My alternative hypothesis was that one or more organic amendment would reduce wireworm pressure.

Literature Review.

Several studies have found that rapeseed meal or canola seed meal can reduce wireworm pressure and soil borne disease. For example, Cohen and Mazzola (2004) report that DSM has a high nitrogen content, which can reduce the need for nitrogen fertilizer and decrease the effect of soil-borne root diseases such as *Streptomyces* spp in apple trees. DSM increased vegetable and fruit yield by controlling soil borne plant pathogens and parasites (Cohen and Mazzola 2004; Traugott et al. 2013).

Other organic wireworms management tactics include using entomopathogenic fungi, such as *Beauveria bassiana* (Balsamo) Vuillemin, or entomopathogenic nematodes (Ansari et al. 2009; 2008. p.1).

Furlan et al. (2010) describes and supports the use of biofumigant DSM because it reduces CO_2 emissions, produces more organic matter and is less toxic to soil microorganisms than synthetic pesticides. Applications of DSM to potato and maize protected these crops from wireworm attack (Furlan et al. 2010). For example, 92% more maize was protected in DSM treated plots than untreated plots, exceeding the control achieved by applying conventional insecticides (Furlan et al. 2010).

Kabaluk (2014) applied *Metarhizium brunneum* LRC112 DSM and found it reduced the recapture of *Agriotes obscurus* click beetles.

Few studies have evaluated ENF for wireworm control, but Wayne et al. (2013) report some positive results. Further, Radley et al (n.d.) report ENF to be a good source of plant nutrients that can control wireworm damage to the plants.

Methods and materials

An experiment was conducted at the KPU orchard in South Richmond, BC. Before the experiment, ten bait traps were deployed at the site in May, 2015 to confirm that wireworms were present. The bait trapping method is the most effective of several sampling methods (Andrews et. al., 2008). Five traps consisted of a 10 cm × 10 cm mesh bag of wheat and another five traps consisted of 50 grams of wheat in 9 inches flower pots, buried 1 to 2 inches below the soil surface for 10 days (EPPO, 2005). Traps were removed after 10 days and the number of wireworms in each trap was recorded.

The experiment used a completely randomized design with three treatments and four replicates. A completely randomized design was selected because all the plots had similar soil quality and weather conditions. Treatments were (1) a control (no fertilizer); (2) ENF applied at 2.83 t/ac; or (3) DSM applied at 6 t/ac. Each plot was 2 m wide and 5 m long. The arrangement of treatments was randomized in the R statistical computing environment (Figure 1). Buckwheat was planted between plots to prevent wireworms moving from one plot to another (Chaput 2009).

All plots were seeded with organic hard red spring wheat on June 23, 2015 at 70 lbs/ac (Dewald et al. 2009). Each plot contained 10 rows of spring wheat, spaced 8 inches apart. Wheat was grown until early November 2015 (Fieldstone Granary Ltd. 2012). The wheat was irrigated for 30 minutes every morning and evening until fall rains began in September.

Wireworms were sampled using the bait traps method. Two bait traps were deployed in each plots in the first week of September. Each trap consisted of a plant pot containing 50 grams of wheat buried 1 to 2 inches below the soil surface for 7 days. Bait traps were removed after 7 days and the number of wireworms was recorded in each trap. Wireworms were separated from soil by hand to count them. Trapping was conducted for six consecutive weeks between early September and mid-November. Any wireworms caught were removed from the farm to prevent recapture. At the end of the experiment, wheat plants were counted and aboveground wheat biomass was removed and weighed from three 1 m^2 sections of each plot.

Wireworm counts from all six trapping periods were pooled. Treatment effects on wireworm count, wheat plant count, and wheat biomass were evaluated by ANOVA, and means were separated by Tukey's HSD test in the R statistical computing environment

(α=0.05).

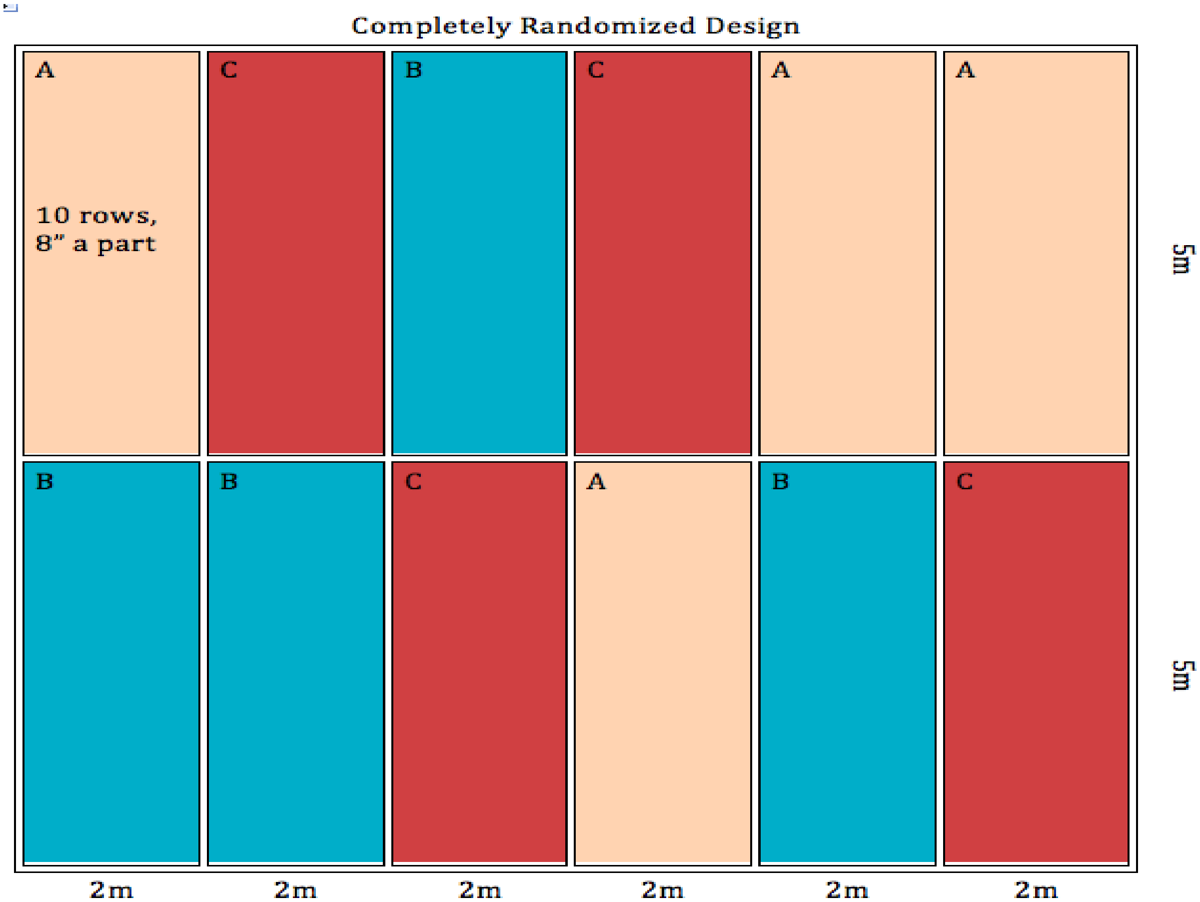

Figure 1. Randomization of treatments, as determined by R. A = Control (Orange), B = DSM (Red), C = ENF (Blue).

Results

Raw data are shown in Appendix A. Wireworms were less abundant in the fertilized plots than the control plots (P = 7.7 x 10-6; Fig. 2). Wireworms were seven times more abundant in control plots than DSM plots and four times more abundant in control plots than ENF plots. No difference was detected between DSM and ENF treatments (P=0.278).

The number of wheat plants did not significantly differ between the control plots and fertilized plots (P = 0.47; Fig. 3). Wheat biomass did not differ significantly between treatments (P = 0.28; Fig. 4).

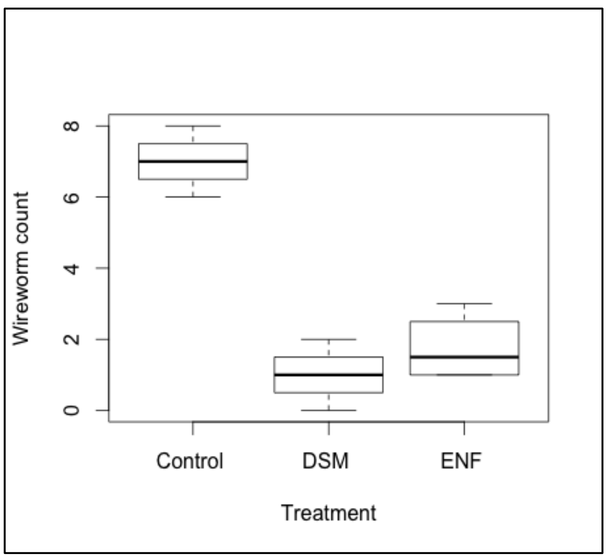

Figure 2. Wireworms per plot by treatment.

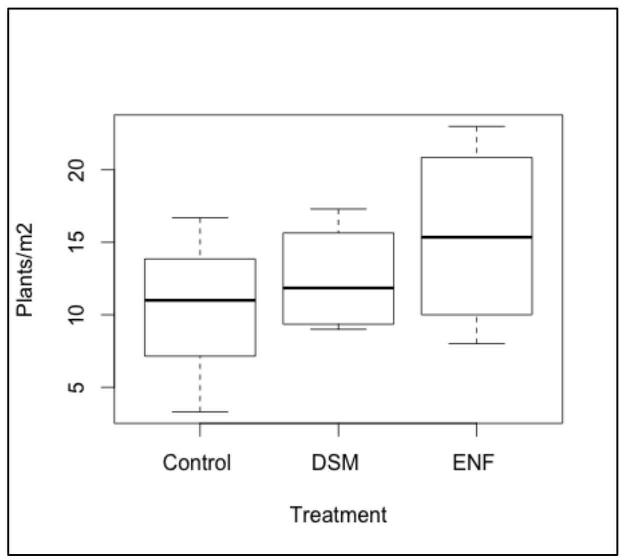

Figure 3. Plant number by treatment.

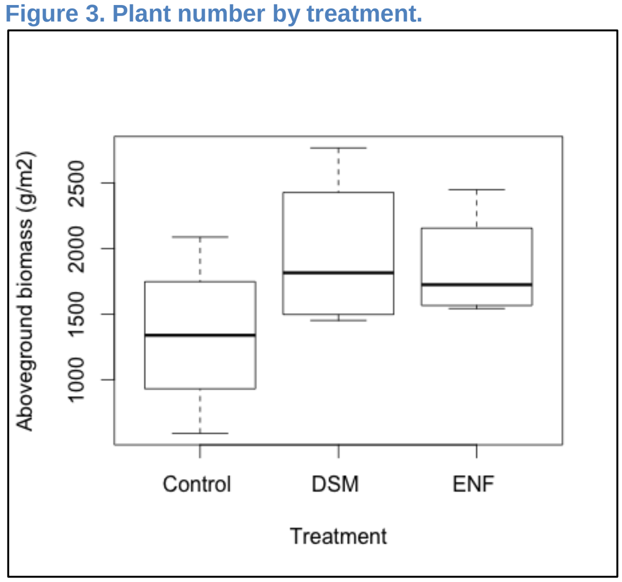

Figure 4. Aboveground biomass by treatment

DISCUSSION

Results of this experiment suggest that wireworms can be controlled by both Canola Seed Meals and Enterra Natural Fertilizer. Although, these fertilizers did not help increase yield and plant population, they did reduce wireworm abundance in treatment plots.

Irrigation problems at the beginning of the study led to poor wheat germination on one side of the experimental area. This problem was fixed later but final plant counts were noticeably lower in plots that received insufficient irrigation at the beginning of the study. This unanticipated source of variation may have contributed to the lack of significant treatment effects on wheat yield and survival. Other limitations of the study included small plot size and minimal (1 m) separation between plots, due to lack of available land. Future studies are needed to compare effects of DSM and ENF fertilizers in larger plots with greater separation between plots.

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Appendix A: Raw Data

Table 2. Raw data.

Plot	Treatment	Wireworms/plot	Wheat plants (#/m²)	Wheat biomass (g/m²)
1	Control	7	3.3	589.7
2	Control	7	11	1270.1
3	Control	6	11	1406.2
4	Control	8	16.7	2086.5
5	DSM	2	9.7	1542.2
6	DSM	1	14	2086.5
7	DSM	1	9	2766.9
8	DSM	0	17.3	1451.5
9	ENF	1	18.7	1587.6
10	ENF	1	12	1542.2
11	ENF	3	23	1859.7
12	ENF	2	8	2449.4