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## October 26-30, 2026
## Naivasha, Kenya

WPC 2026 KENYA

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# Using crop rotation to control wireworms in agricultural fields

**Dr. Christine Noronha**

**Research Scientist IPM - Agriculture and Agri-Food Canada - Charlottetown, Prince Edward Island Canada**

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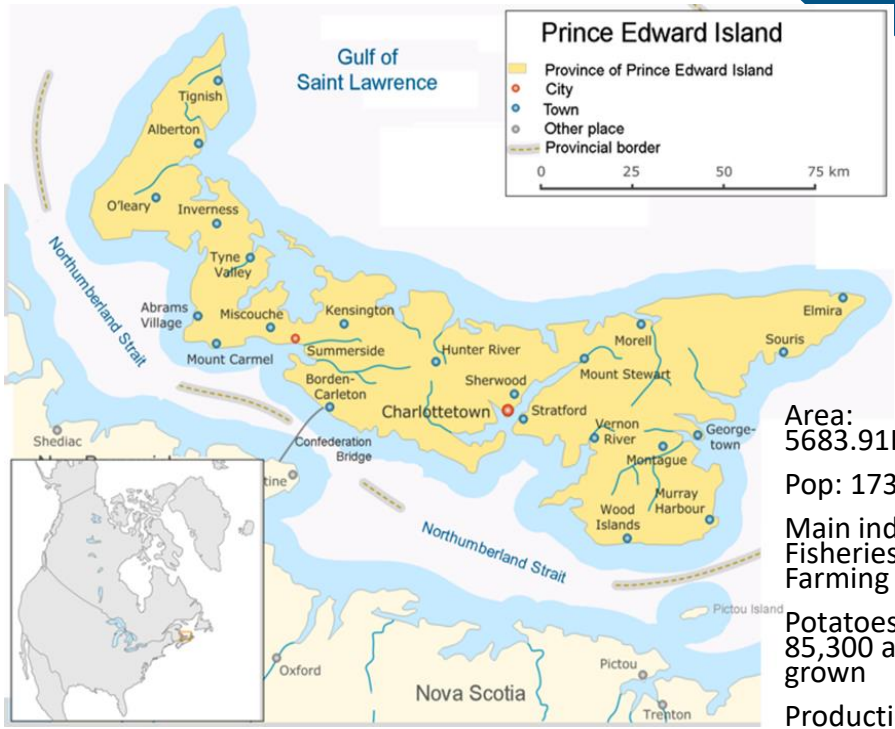
**December 10, 2025**

# CANADA


Area: 5683.91Km$^2$

Pop: 173,787

Main industry: Fisheries and Farming

Potatoes: 85,300 acres grown

Production: 25.93million Cwt

Exports to 20 countries

# Wireworms belong to the insect family Elateridae (click beetles)

The adults are called click beetles

The term “wireworm” refers to the larval stage

It is the larval stage that causes crop damage

# Distribution of wireworms

- Wireworms are a global pest
  - can be found in North America, Europe, Russia, Australia, New Zealand, China, Korea, Japan, India.
- They are most common in temperate climates and are generally less problematic in warm tropical regions.
- The are typically found in grasslands, arable fields, and weedy areas with high soil moisture.
- They are especially associated with areas where there is a history of grassland cultivation.

# Lifecycle of wireworms

They pupate in the soil and emerge as adults in the spring. Lifecycle 2-5 years depending on the species

Click beetles

Spring-early summer
Adults lay 100 -200 eggs in the soil

Spring – damage seeds and seedling roots

Summer

Fall damage root crops

Later fall – move deeper in the soil to diapause. Return to the surface in the spring.

Overwinter underground

2-5 yrs

# Crop Damage by Wireworms

Carrot

Onion

Corn field

Cabbage transplants

Potatoes

Turnip

Corn

# Diversity of wireworms

- More than 39 species across 21 genera of wireworms have been documented attacking potato crops.
- Species composition varies widely among geographic regions and even between individual fields.
- Multiple species may be present within the same location.
- In Prince Edward Island (PEI), the predominant species is *Agriotes sputator*.
- *Agriotes lineatus* and *Agriotes obscurus* also occur but are found in lower numbers and tend to have more localized distributions.

# Chemical Control

| Insecticide | Common name | Reduced WW damage | Percent Reduction in damage | How does it work |
|---|---|---|---|---|
| Phorate | Thimet | YES | 50-70% | Kills |
| Clothianidin | Titan | YES ? | 5-59% | Paralyses |
| Clothianidin +Bifenthrin | Titan high + Capture high rates | YES | 48-67% | Paralyses |
| Thiamathoxam | Cruiser high rate | NO | 3% | Paralyses |
| Bifenthrin | Capture high rate | YES | 43-78% | Paralyses |
| Lambda-cyhalothrin | Matador | NO | 1-27% | - |
| Tefluthrin | Force | NO | 30-55% | Kills |
| Broflanilide | Cimegra | Yes | 59-78% | Kills |

Broflanilide (Teraxxa) - seed treatment for small grain crops

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# What is crop rotation

- Crop rotation is the agricultural practice of planting different crops in the same field across a sequence of growing seasons or years. This practice helps maintain soil fertility, disrupt pest and disease cycles, and weed pressure.

- Some countries have long growing seasons that allow two or three sequential crops per year, while others, such as Canada, have shorter seasons and grow only one crop annually, with rotation occurring over multiple years.

- In PEI, growers follow a three-year crop rotation cycle which, prior to our study, consisted of potatoes, followed by barley under-seeded with clover, and then a full year of clover.

# Crop rotation strategy to reduce wireworm damage

Brown Mustard

Buckwheat

Alfalfa

Barley (Control – Standard)

# Rotation Crops Used

- Buckwheat (*Fagopyrum esculentum* var Mancan) 44 kg/ha
  - allelopathic properties
- Brown Mustard (*Brassica juncea* var Centennial) 11.2 kg/ha
  - possesses glucosinolates that are toxic to insects and nematodes
- Alfalfa (*Medicago sativa* var AC Brador) 16.8 kg/ ha
  – soil drying properties
- Barley (*Hordeum vulgare* var Chapais ) 156.8 kg/ha underseeded with Triple mix was 70 % Climax Timothy, 15 % double cut Red Clover and 15 % Alsike at 11.2 kg/ha)
  - Control - normal rotation

# Crop Rotation Study

The trial was conducted at three field sites in different areas of the province.

Four replicates /crop in a randomized design at each test site. Two plantings per year.

| Year 1 | Year 2 | Year 3 |
|---|---|---|
| Alfalfa | Alfalfa | Potatoes |
| Barley | Clover | Potatoes |
| Buckwheat | Buckwheat | Potatoes |
| Brown Mustard | Brown Mustard | Potatoes |

# Planted in the spring and incorporated before seeding mature and second crop planted

Original study tested extreme measure

- 2years X 2crops / year)
- Crop was plowed down before seed formation and second crop planted in the same area which remained in the ground until the following spring
- Potatoes planted in year three

# Crop Rotation study

- Tubers were assessed for the table and processing market
  - Number of holes per tuber.
  - Followed the processing industry procedure to evaluate damage.
    - Damaged area was removed by peeling and tubers that lost over 5% of their weight were classified unmarketable.
  - Based on severity of wireworm damage all other tubers was placed in the marketable or unmarketable group.
  - Yield of each group and total yield was estimated.

# Crop Rotation study

Table 1. Total market yield, percent of undamaged tubers, ho*le*s per tuber, tonnes per hectare lost due to wireworm damage and marketable yield for the processing market in a potato crop following a 2-year rotation with Brown Mustard, Buckwheat, Alfalfa, and Barley/Clover at Hazelbrook in Prince Edward Island, Canada

| Crops | Total yield (t/ha) | Total market yield (t/ha) | Percent tubers with no Damage | Average Number of Holes per tuber | **lost** due to damage (for Processing) (t/ha) | Marketable for Processing (t/ha) |
|---|---|---|---|---|---|---|
| Brown Mustard | 56.90 a | 45.6a | 34a | 04 a | 0.5 a | 45.1 a |
| Buckwheat | 56.40a | 45.9a | 30a | 06 a | 2.6 a | 43.3 a |
| Barley | 55.10a | 47.3a | 7b | 20 b | 16.8 b | 30.5 b |
| Alfalfa | 53.50a | 45.2 a | 9 b | 21 b | 15.3 b | 29.9 b |

Initial no. of wireworms / bait at start of trail
28ww/bait

# Crop Rotation Study

Table 2. Total market yield, number of undamaged tubers, holes per tuber, tonnes per hectare lost due to wireworm damage and marketable yield for the processing market in a potato crop following a 2-year rotation with Brown Mustard, Buckwheat, Alfalfa, and Barley/Clover at Bonshaw in Prince Edward Island, Canada

| Crops | Total Yiels (t/ha) | Total Market yield (t/ha) | Percent tubers with no Damage | Average Number of Holes per tuber | **lost** due to damage (for Processing) (t/ha) | Marketable for Processing (t/ha) |
|---|---|---|---|---|---|---|
| Brown Mustard | 42.46a | 35.8a | 38.2a | 3a | 0.9a | 34.9 a |
| Buckwheat | 42.65a | 36.2a | 41.9a | 3a | 0.5a | 36.1a |
| Barley | 44.39a | 36.2a | 11.6 b | 8b | 7.1b | 29.1b |
| Alfalfa | 42.54a | 35.8a | 10.3b | 8b | 7.6b | 28.2b |

Initial no. of wireworms / bait when trail started 4ww/bait

# Crop Rotation study

Table 3. Total market yield, number of undamaged tubers, holes per tuber, tonnes per hectare lost due to wireworm damage and marketable yield for the processing market in a potato crop following a 2 year rotation with Brown Mustard, Buckwheat, Alfalfa, and Barley/Clover at Canoe cove in Prince Edward Island, Canada

| Crops | Total Yield (t/ha) | Total **Market** yield (t/ha) | Percent tubers with no Damage | Average Number of Holes per tuber | **lost** due to damage (for Processing) (t/ha) | Marketable for Processing (t/ha) |
|---|---|---|---|---|---|---|
| Brown Mustard | 34.87ab | 29.6a[1] | 29a | 3a | 0.8a | 28.8 a |
| Buckwheat | 33.36b | 28.3a | 24a | 3a | 1a | 27.3a |
| Barley | 37.64a | 31.9a | 3b | 8b | 8.9b | 23b |
| Alfalfa | 36.25ab | 30.2a | 12b | 5b | 3b | 27.2a |

Initial no of wireworms / bait when trail started
2ww/bait

# Tweaking the initial crop rotation strategy

2years X 2crops / year was an extreme measure used to address the urgent need.  Following the results

- We asked four questions

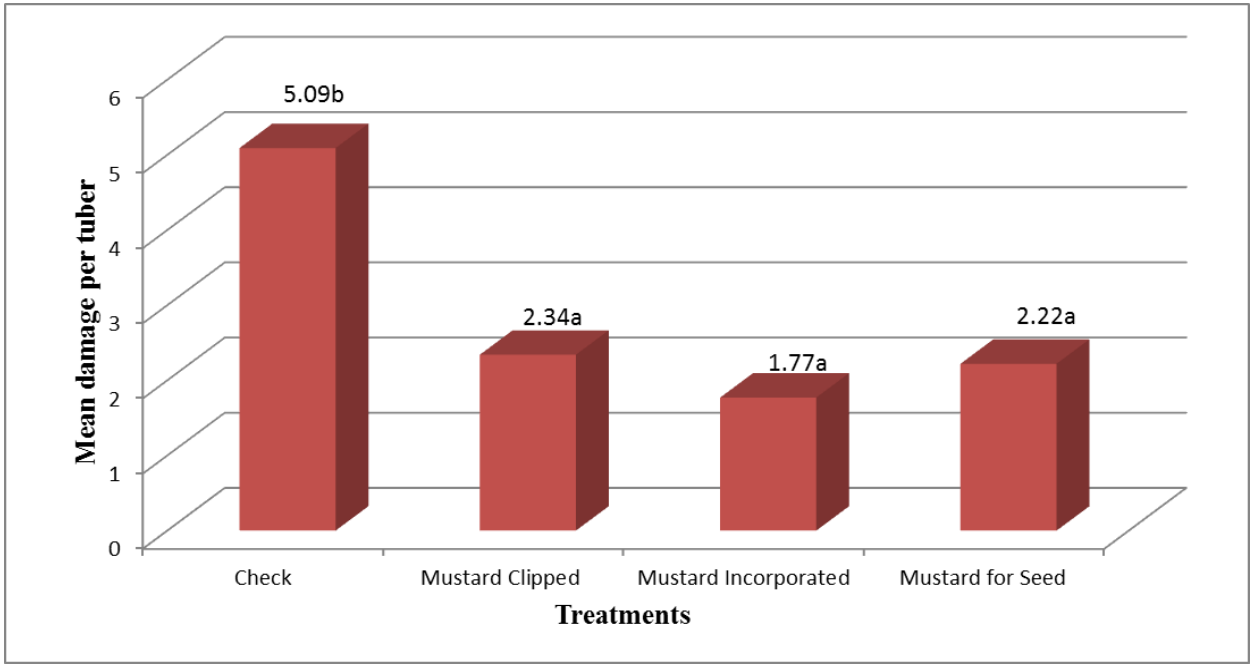
1. Can the plants be mowed and allowed to regrow so they continue providing a lethal food source for wireworms feeding in the fall?
2. Can the crops be grown for one year and give the same results?
3. Will seed harvest reduce chemical in the plant roots that are harmful to wireworms?
4. Will incorporation for biofumigation provide other benefits?

# ROTATION CROP MANAGEMENT

Buckwheat and Mustard
Mowed, Disked or Harvested for one year

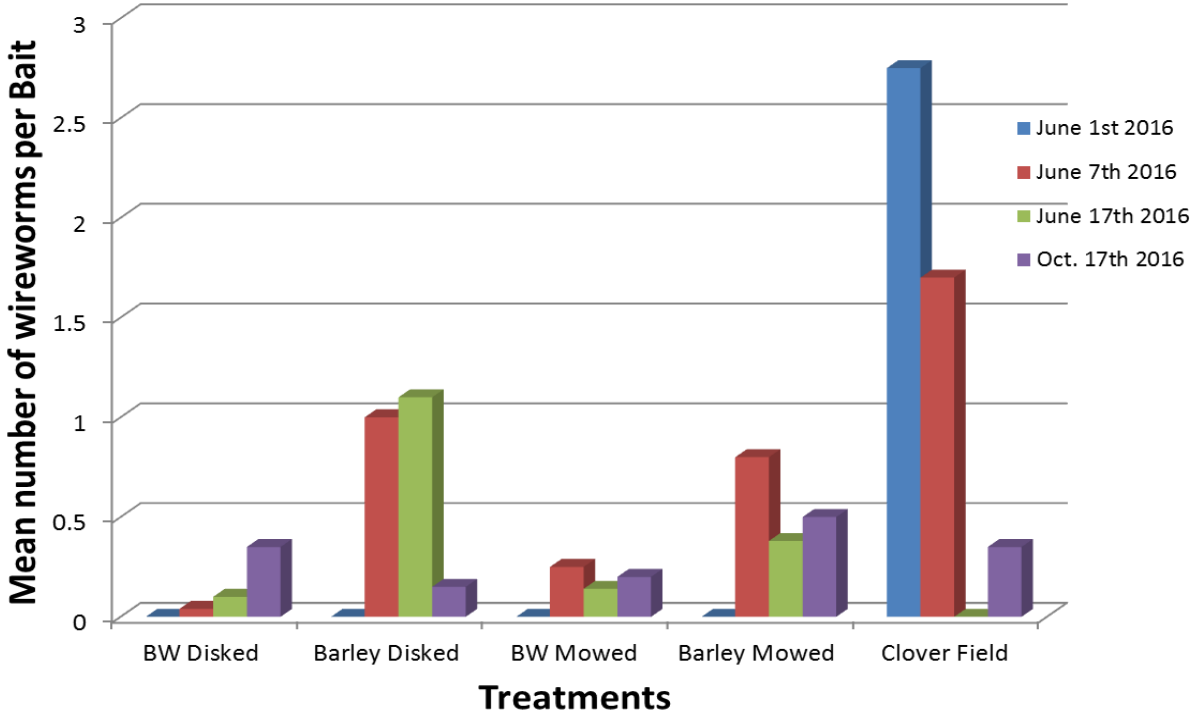
Initial no. of wireworms / bait when trail started
20 ww/bait

# Comparison of the mean damage per tuber between three Brown Mustard cropping systems and a Barley check conducted **one year** before planting potatoes



# Buckwheat Management

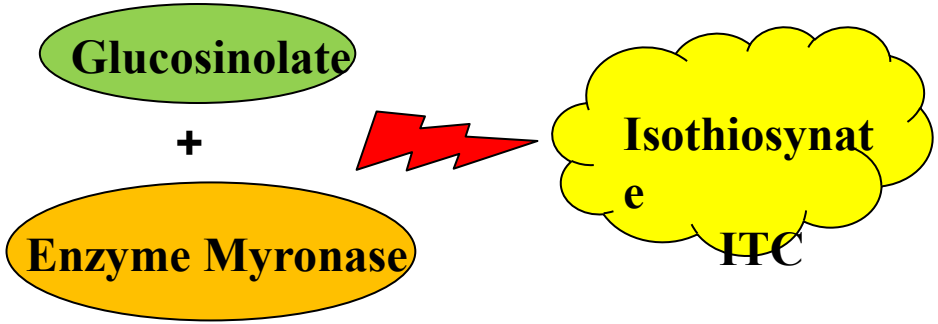
Figure 2: Mean number of wireworms per bait in cabbage after two years of Buckwheat and Barley treatments



# Why does Brown Mustard *Brassica juncea* work?

- Because the plant tissue has Allyl-glucosinolate (GTC).
- When plant material starts to breakdown and enzyme Myronase reacts with the tissue to produce Isothiocynates (ITC).

It roots contain **2-phenylethyl** which is toxic to insects.



# How does buckwheat supress wireworms does it kill or repel

# Collected females using the NELT™

NELT™

Night view

Adult males and females

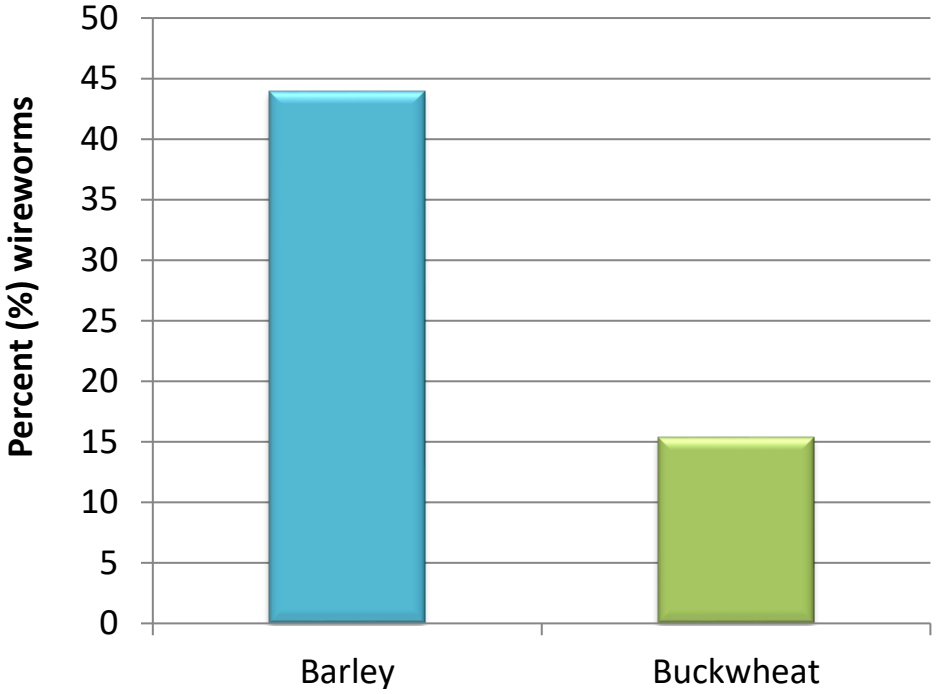
Eggs collected

# Effects of feeding on Buckwheat roots on neonate wireworms

Neonate wireworms

Barley & Buckwheat plants

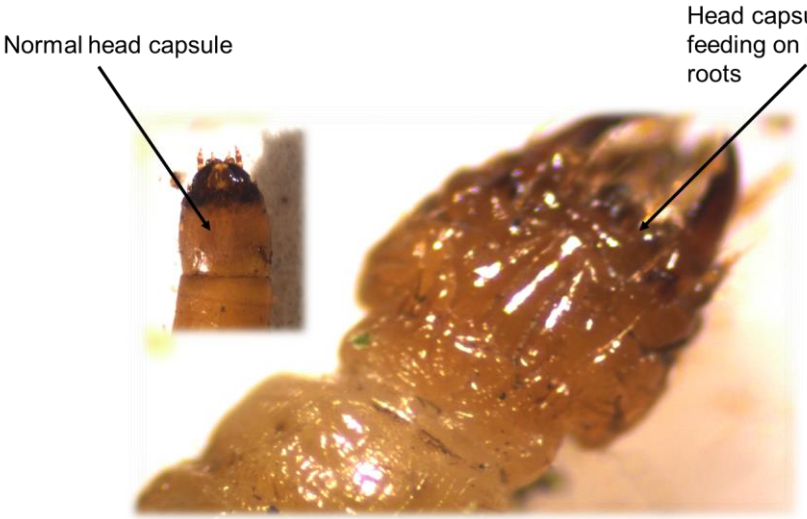
Figure: Survival of neonate wireworms after feeding on Barley or Buckwheat roots for four months



# Effects of feeding on Buckwheat roots on neonate wireworms

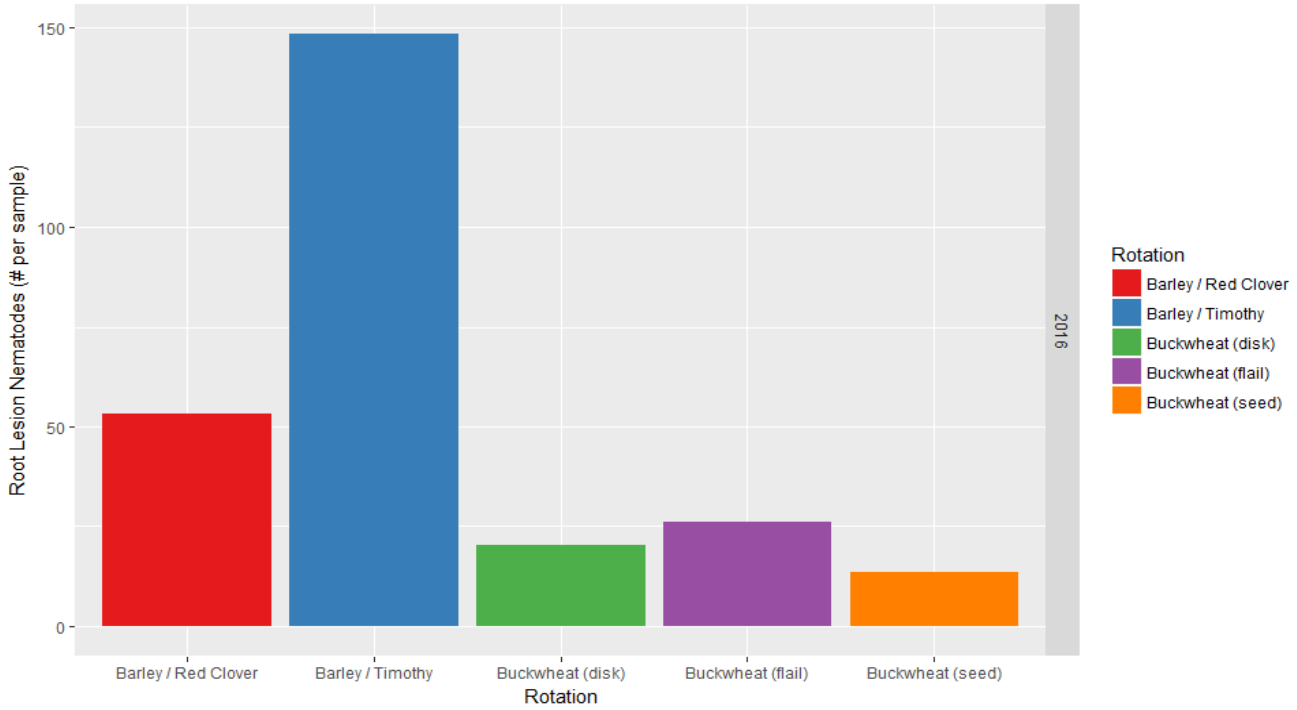
Barley fed ww larvae

Buckwheat fed ww larvae




Our chemist identified a novel compound (acyl-sucroses) which exhibits biopesticide activity

# Effects of Buckwheat on root-lesion nematode




Courtesy of Dr. Aaron Mills - CRDC

# Studies with other rotational crop

Buckwheat

Barley

Sorghum Sudangrass

Flax

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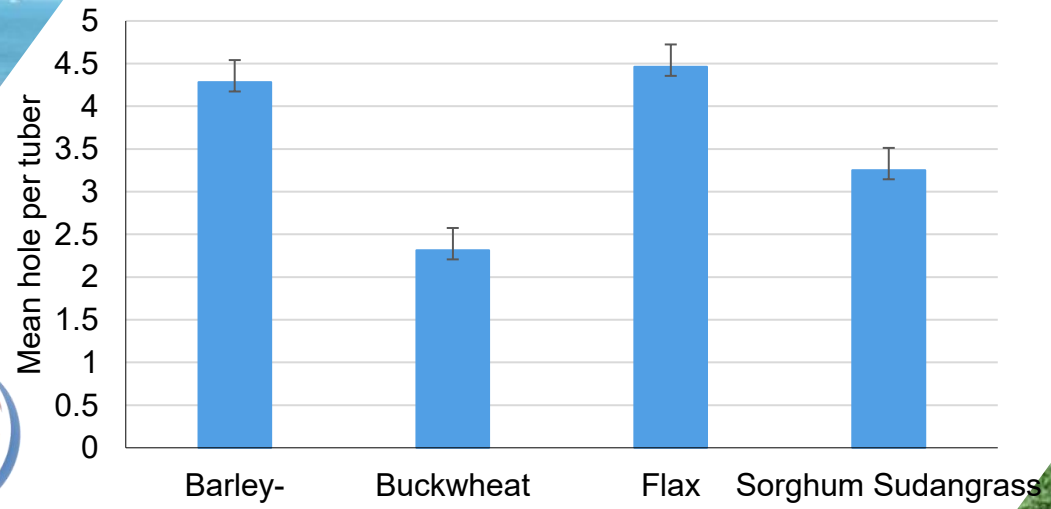
# Damage caused by wireworms

Mean number of holes per tuber in a potato crop following one year of Barley, Buckwheat, Flax and Sorghum Sudangrass rotation crops

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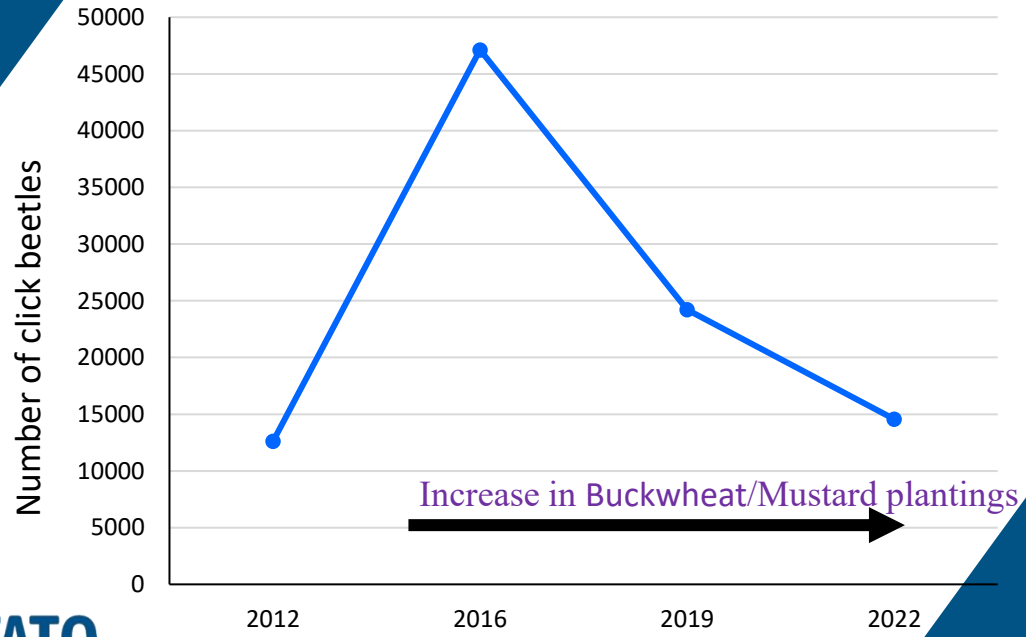
# Click beetle survey sites
## 2009 (60), 2012, 2016,2019,(85), 2022 (84)

# Monitoring populations in PEI 2012-2022

Total number of click beetles collected in the spring using pheromone traps

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# Monitoring the species spread in PEI Summary

**Total number of all species of click beetles trapped**

2012 - 12,604
2016 - 47,126
2019 - 24,216
2022 - 14,604

**Total number of fields with click beetles**

| | |
|---|---|
| 2012 - 85 fields | all |
| 2016 - 85 fields | all |
| 2019 - 85 fields | all |
| 2022 - 84 fields | 62 |

Only three fields had 1000+ beetles, compared to twelve in 2016.

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# OUTCOME OF CROP ROTATION RESEARCH

## A management strategy to reduce wireworm damage

1. Need to evaluate the field to determine the wireworm population.
2. A decision on which management option is best to address the problem in that field.
3. If wireworm pressure is low, Brown Mustard and Buckwheat can be grown for one year.
4. If wireworm pressure is high, grow Brown Mustard or Buckwheat for two years.

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# OUTCOME OF CROP ROTATION RESEARCH

## A management strategy to reduce wireworm damage

5. Incorporations of Brown Mustard provides biofumigation which can decrease disease and nematode pressure.
6. A growing crop will also provide some biofumication.
7. There is a market for Brown Mustard (for Dijon Mustard) and Buckwheat (for Flour).

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- Funding agencies










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