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Wireworm Management in Potatoes – Research Update

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WHAT ARE WIREWORMS

- Larvae live in the soil for 3-5 years.
- Damage several crop.
- Most damaging to roots crops and can render them unmarketable.

LIFECYCLE OF WIREWORMS

They pupate in the soil and emerge as adults in the spring. Lifecycle 3-5 years

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

Spring – damage seeds and seedling roots

Fall damage root crops

3-5 yrs

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

History

- 2004 first potato crop failure reported in PEI
- Thimet only chemical registered – was slated to be taken off the market
- Noticed a steady increase in populations

RESEARCH PROGRESS

Click Beetle Species

48 species of click beetles in PEI

Important pest species

- *Agriotes sputator*
- *Agriotes obscurus*
- *Agriotes lineatus*
- *Hypnoidus abbreviatus*

BIOLOGY OF *A. SPUTATOR*

~ 4 YEARS!!!

May **June** **July**

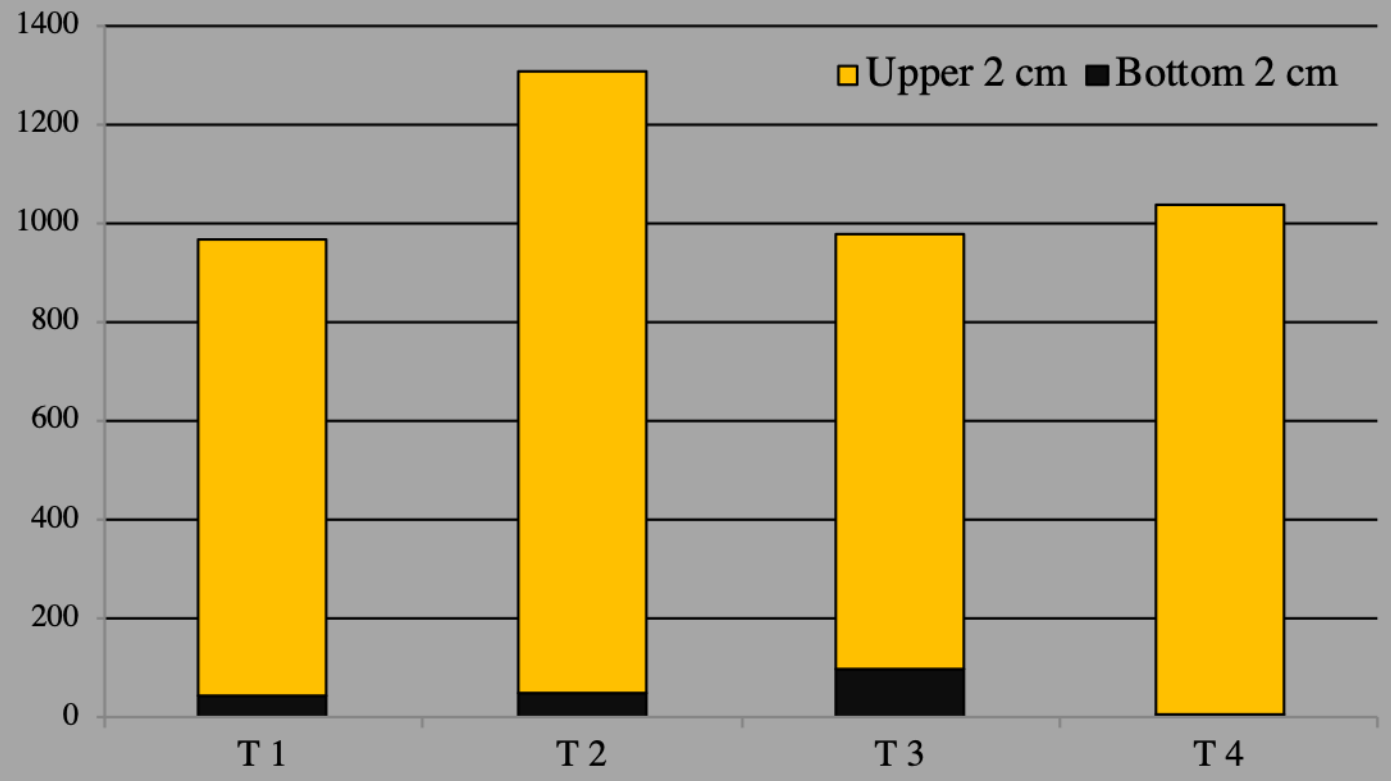
Beetle emerge peak

Egg production peak

Egg hatching peak

Pre-plant	Planting	Growth stage 1	Growth stage 2	Growth stage 3	Growth stage 4	Growth stage 4	Growth stage 5
Seed treatment	In-furrow	Sprout development	Vegetative growth	Tuber initiation	Tuber bulking	Tuber bulking	Maturity

OVIPOSITION SITE OF CLICK BEETLES



More than 95% of the eggs produced were laid in the **upper 2 cm** of the soil

INSECTICIDE EFFICACY RESEARCH

INSECTICIDE EFFICACY TESTING

- Extremely Challenging.
- Respond differently to most of the newer classes of insecticides.
- Evaluated registered products, new chemistries, and product combinations.

INSECTICIDES TESTED IN PEI

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

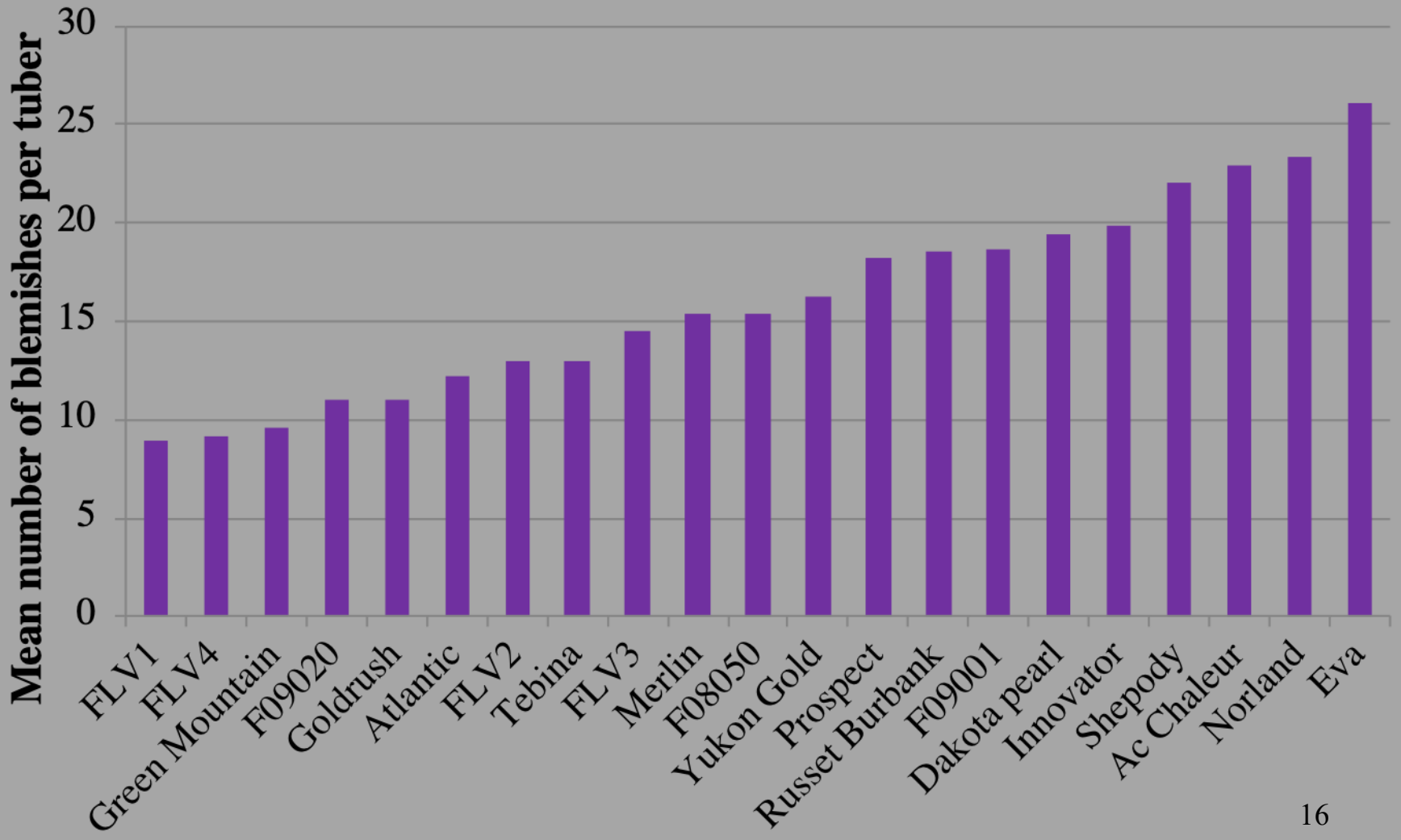
INSECTICIDES TESTED IN PEI

Insecticide	Common name	Reduced WW damage	Percent reduction in damage	How does it work
Spirotetramet	Movento high and low rates	NO	32%	-
Spirotetramet + Clothinadin	Movento +Titan	NO	-8%	-
Experimental	Fipronil treated wheat seed two rates	NO	18-25%	-
Cyantranilliprole	Cyazypyr	NO	21%	-
Fluensulfone	Nimitz	NO	2%	-
Azadirachtin	1405AZA	NO	14%	-
New product	Not yet registered	Yes	59-78%	Kills

RESEARCH ON CULTURAL CONTROL PRACTICES

SUSCEPTIBILITY OF TWENTY POTATO VARIETIES

Figure 2. Mean number of blemishes (holes+scars) in different potato varieties grown without an insecticide application to protect against wireworm damage



Take home message

1. Potato varieties differ in their attractiveness to wireworms.
2. We now have a list of susceptibility range of the varieties.
3. We know which varieties need to be treated with an insecticide at planting.

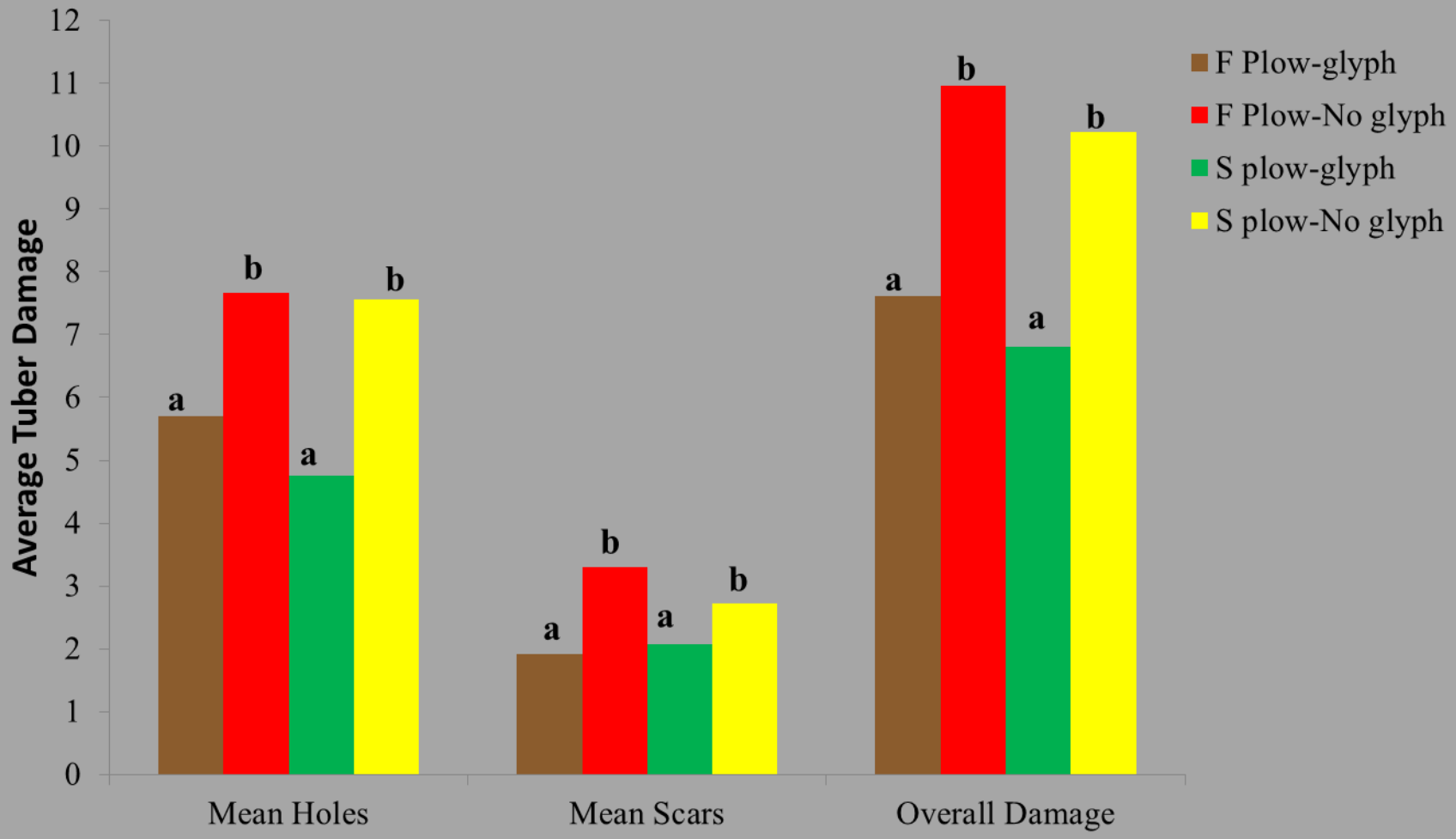
PLOW-DOWN OF GREEN MATERIAL (SOD)

Killing the crop with glyphosate before plowdown eliminates the presence of green material as a food source at the plow depth or waiting a year after plowing down sod before planting a cash crop.

Spring Plowed

Fall Plowed

Fig 1. Damage to tubers caused by wireworm feeding following a spring or fall plow-down of glyphosate treated or untreated sod .

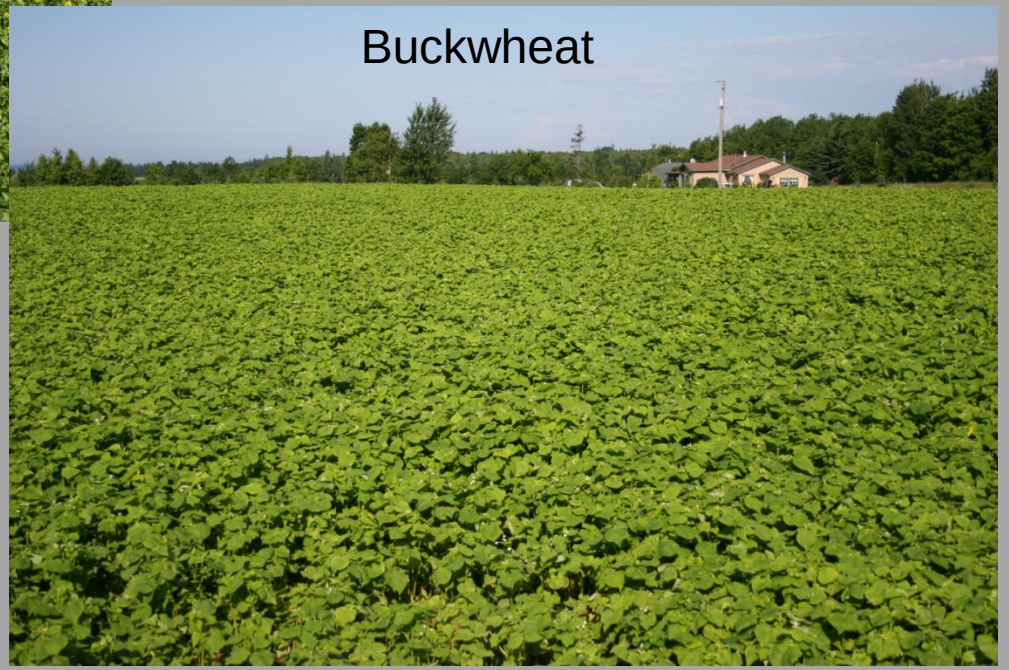


Take home message

- Killing sod in the spring before planting provides reduction in wireworm damage.
- Do not need to kill sod in the fall which is a good practice for soil conservation.

CROP ROTATION STRATEGY TO REDUCE WIREWORM DAMAGE

Two crops per year



DAMAGE TO TUBERS FOLLOWING A TWO YEAR CROP ROTATION WITH BROWN MUSTARD, BUCKWHEAT OR BARLEY

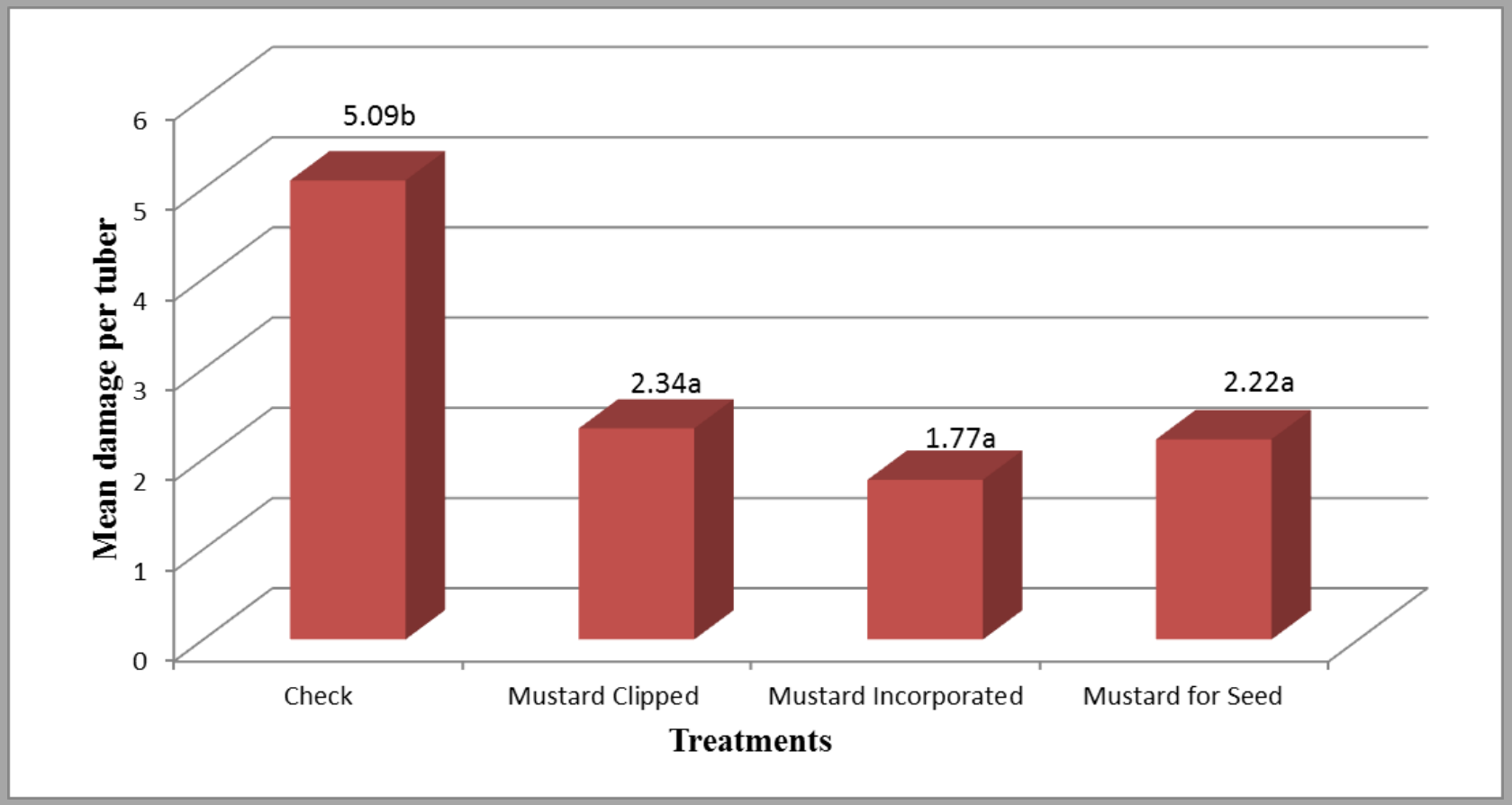
Crop	Percent Marketable tubers	Percent tubers not damaged	Percent tubers lost
Brown Mustard	98%	34%	2%
Buckwheat	93%	30%	7%
Barley	64%	6%	36%

Extreme approach (2years X 2crops / year)

ROTATION CROP MANAGEMENT

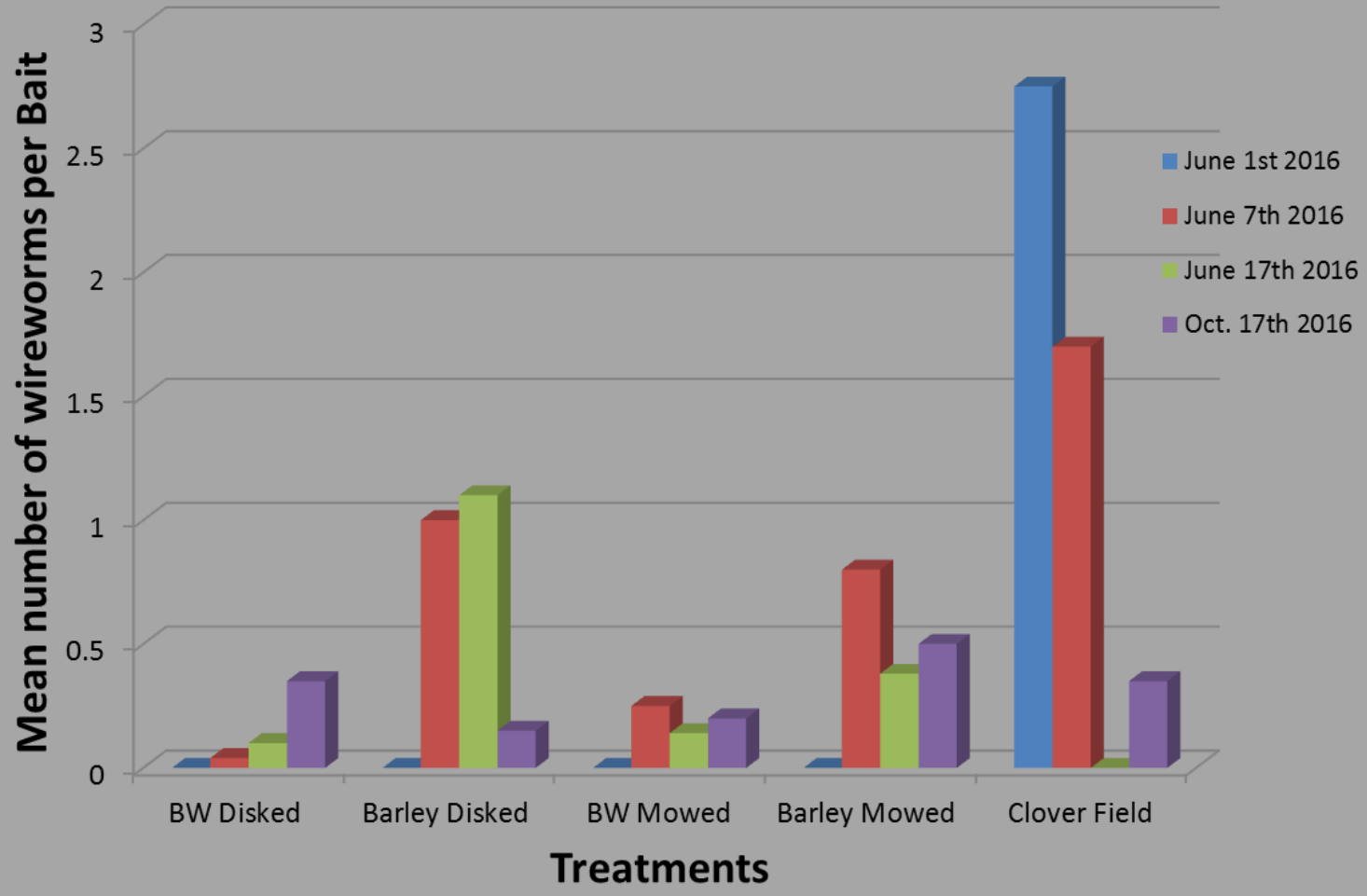
Mustard and Buckwheat
Mowed, Disked or Harvested

Comparison of the mean damage per tuber between three brown mustard cropping systems and a barley check conducted the year before planting potatoes.



Buckwheat Management

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



TAKE HOME POINTS

1. Need to evaluate your field to determine the wireworm population.

2. A decision on which management option is needed based on the problem in that field.

3. Brown Mustard and Buckwheat can be grown for one year if you have low levels of ww infestation.

4. If wireworm pressure high, should grow Brown Mustard or Buckwheat for two years.

5. Can either mow, incorporate or harvest Brown Mustard or Buckwheat and still have wireworm control.

TAKE HOME POINTS

1. Incorporations of Brown Mustard provides biofumigation action, which can decrease disease and nematode pressure.

2. A growing crop will provide some biofumication but it is at a lower level.

3. Market for Brown Mustard and potentially for Buckwheat.

MOWING A BROWN MUSTARD OR BUCKWHEAT CROP

Best way to mow the crop

Flail Mower (4”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Flail Mower (8”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Flail Mower (12”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Best way to mow the crop

Disk Mower (4”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Disk Mower (8”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Disk Mower (12”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Best way to mow the crop

Rotary Mower (4”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Rotary Mower (8”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Rotary Mower (12”cut) on July 23rd 2014, regrowth picture taken August 8th, 2014

Mustard regrowth after mowing at different heights

The Rotary mower gave regrowth at 8” and 12” cut, however, the possibility of seeds developing and maturing is higher following the 8” and 12”cut. The crop will have to be monitored and a second cut may be needed.

No regrowth was observed at the 4”cut but roots remained alive.

The disk mower left significant debris on top of the plants which prevented plant regrowth and deterioration of the cut material.

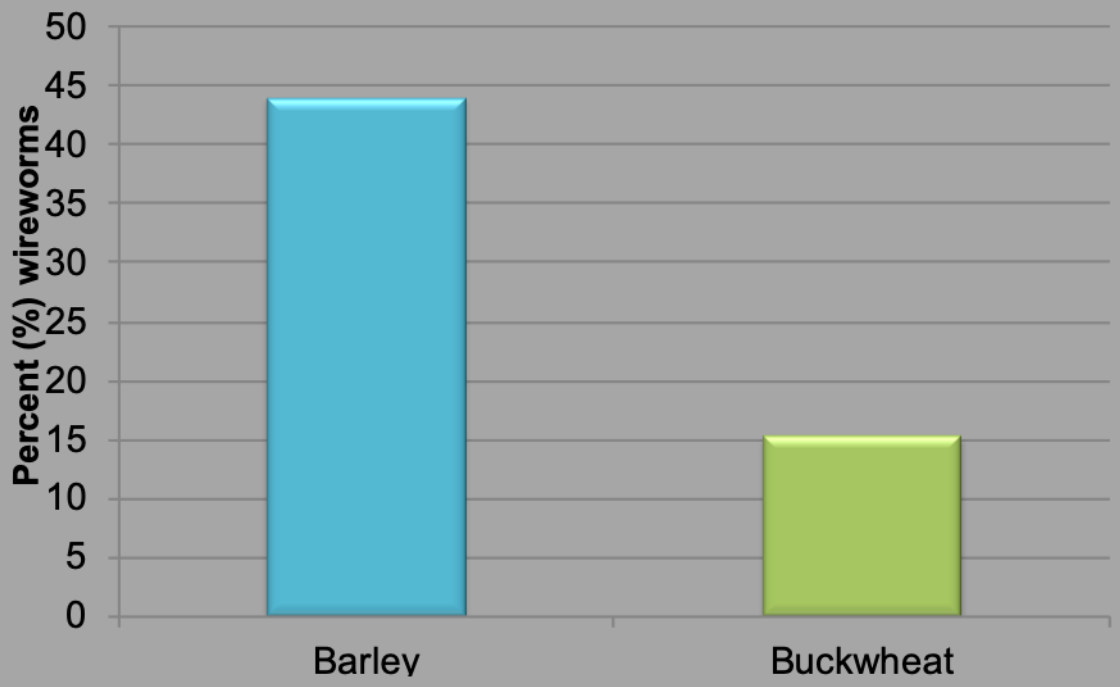
CROP ROTATION RESEARCH

EFFECTS OF FEEDING ON BUCKWHEAT ROOTS ON NEONATE WIREWORMS IN THE LABORATORY

Barley & Buckwheat plants

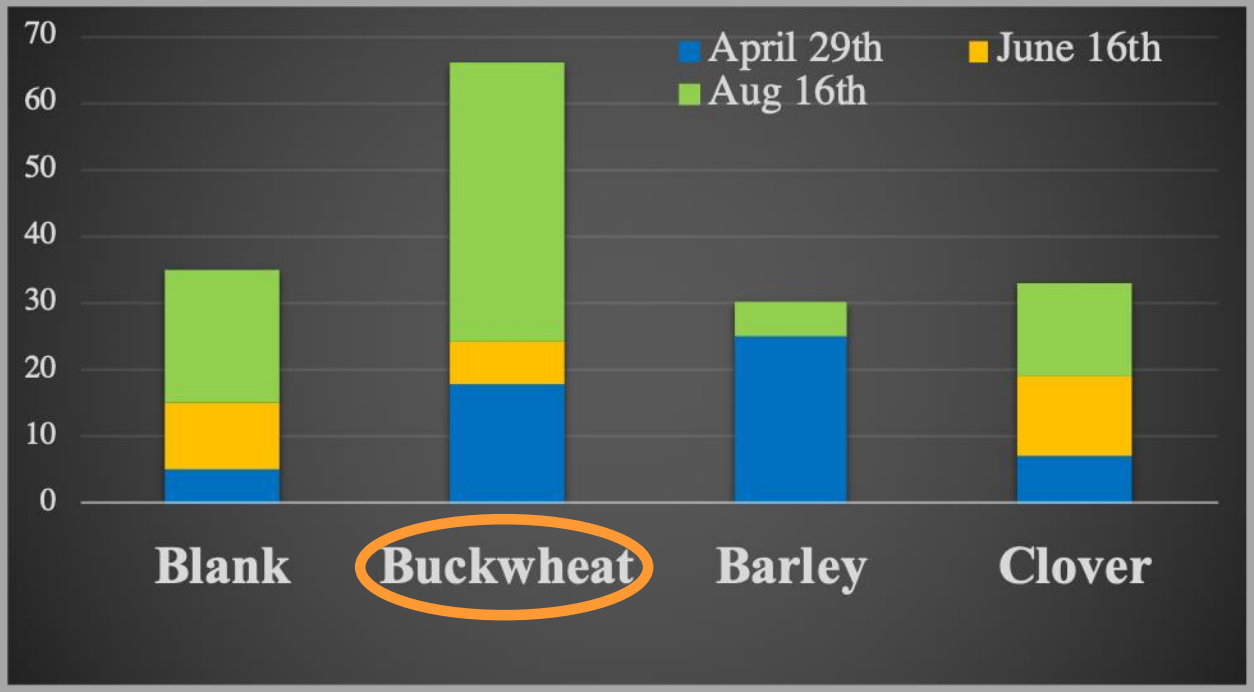
Neonate wireworms

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



ROTATION CROP - WIREWORM INTERACTION

Rotation crop - Wireworm Interaction



Accumulated wireworm numbers in different treatments (n=164)

RESEARCH ON MECHANICAL CONTROL AND MONITORING

TRAPPING CLICK BEETLES

Pheromone trap

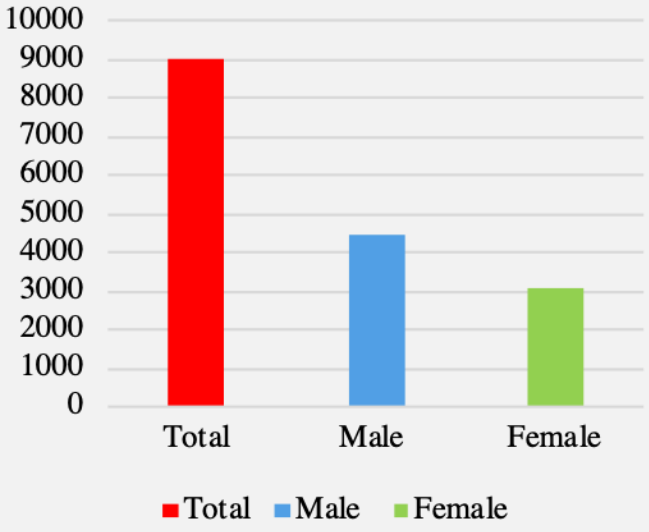
- Pheromone traps (only male beetles).
- Species specific.

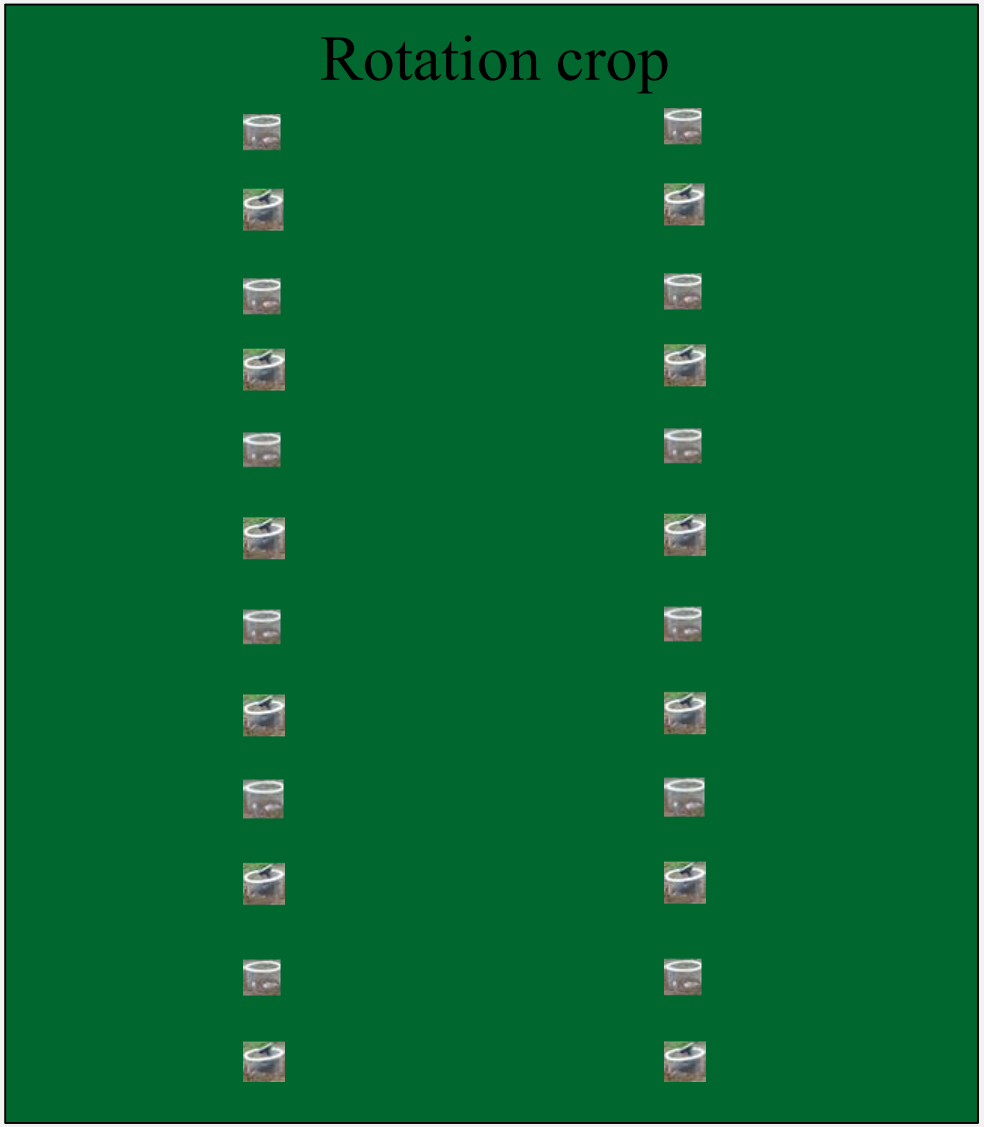
NELT™

- Uses light to attract female and male beetles.
- Not species specific.
- Currently being tested in an IPM strategy.

IPM TRIAL

NELT™





USING MONITORING OF ADULTS TO PREDICT FUTURE DAMAGE

A risk assessment factsheet was developed which can be found on the PEI potato board's website.

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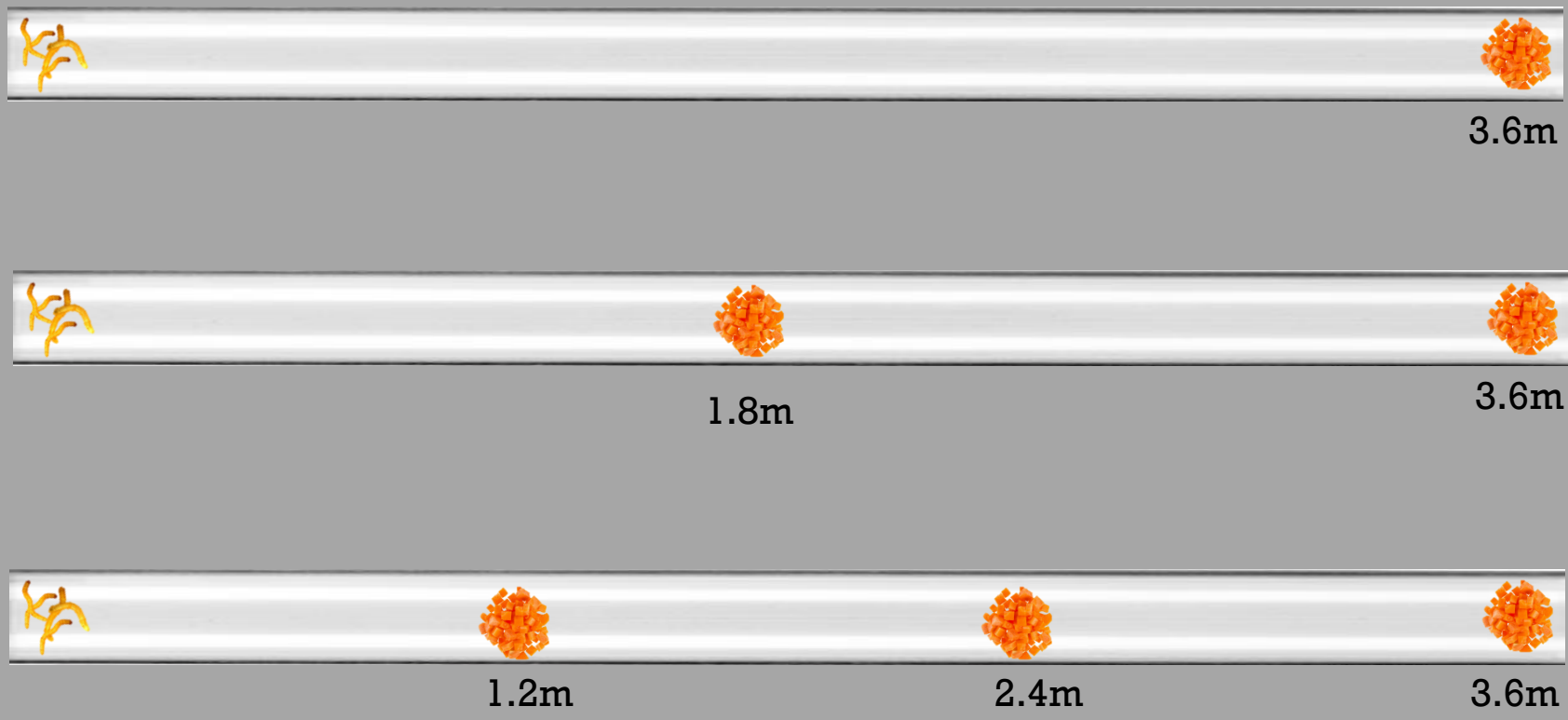
Pheromone trap

WIREWORM MOVEMENT

Agriotes sputator

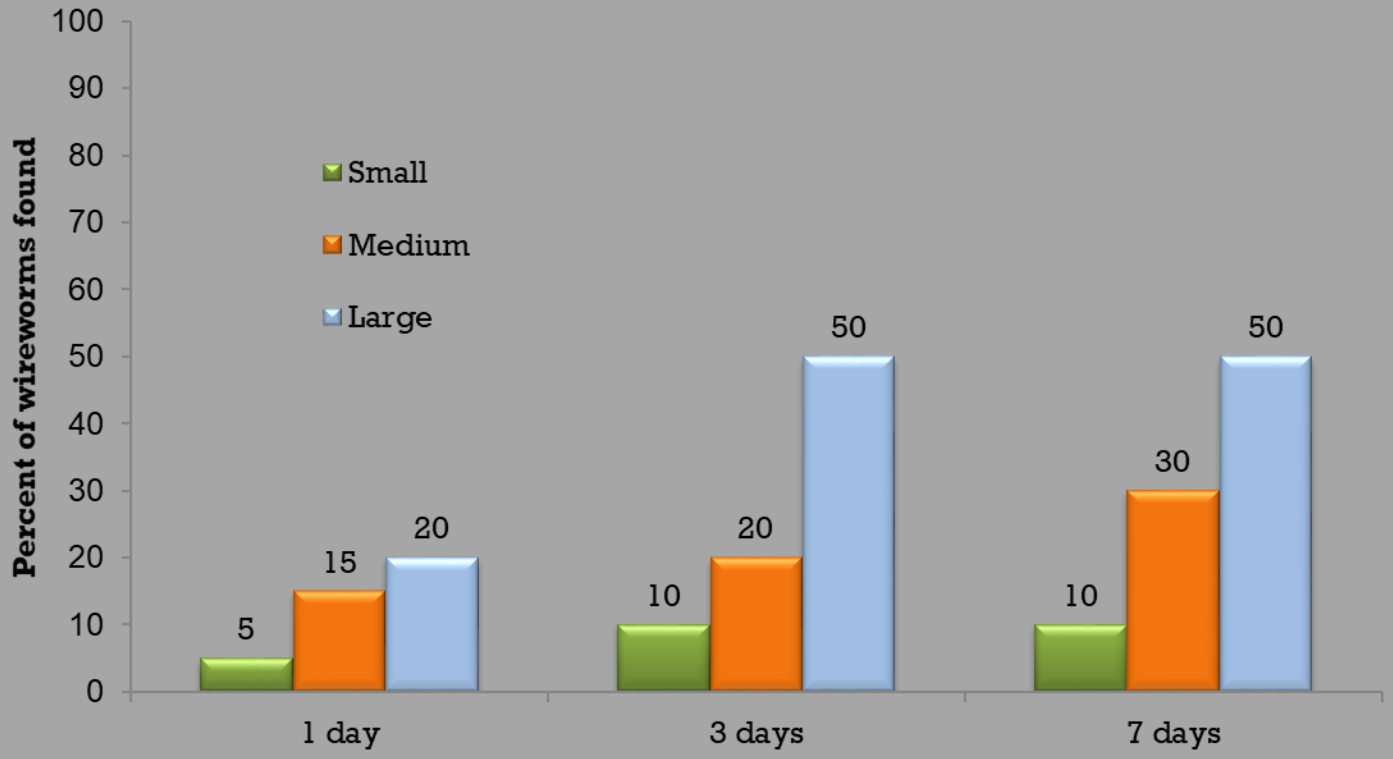
- Horizontal Movement
- Vertical Movement

HORIZONTAL MOVEMENT OF *A. SPUTATOR*



HORIZONTAL MOVEMENT OF *A. SPUTATOR*

Carrot baits placed at 3.6m from the ww release site
N=75

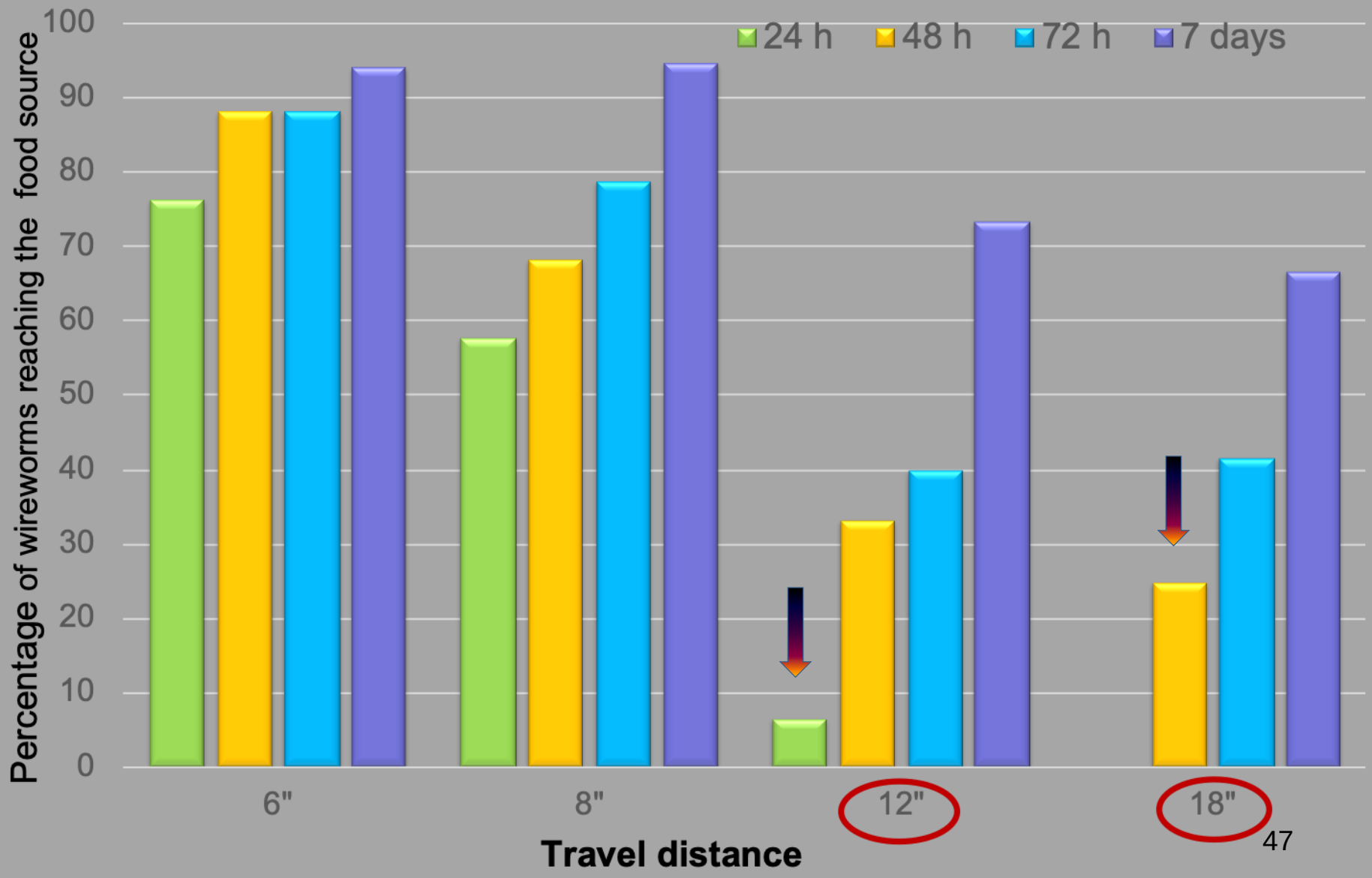



16cm
32cm
48cm
64cm
80cm
16cm
32cm
48cm
64cm
80cm
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN

DISTANCE TRAVELED BY *A.SPUTATOR* NEONATE

- Tube Length: 15cm (6”), 20cm (8”), 30cm (12”), and 45cm (18”).
- Five replicates/distance.
- Five neonate wireworms per replicate.
- Carrot as food source placed at the bottom of the tube.

DISTANCE TRAVELED BY *A.SPUTATOR* NEONATE



Take home message

1. Larvae can travel long distances in search of food.

2. Neonate larvae are not as fragile as thought and can also travel long distances in search of food.

3. Wireworms overwinter just below the frost line.

4. In the spring the best time to bait for wireworms is May when majority are feeding at the surface.

5. Best time in the fall to bait for wireworms is from mid-September to mid-October.

YOUR QUESTIONS

Question: Which past, present and potential new wireworm insecticides cause mortality and approximate %?

This question has already been addressed at the beginning of this presentation.

Question: Two parts to this question

A. Do any of these crops we use to control wireworm actually work?

Results shown earlier in this presentation demonstrate that it is an effective strategy to reduce damage

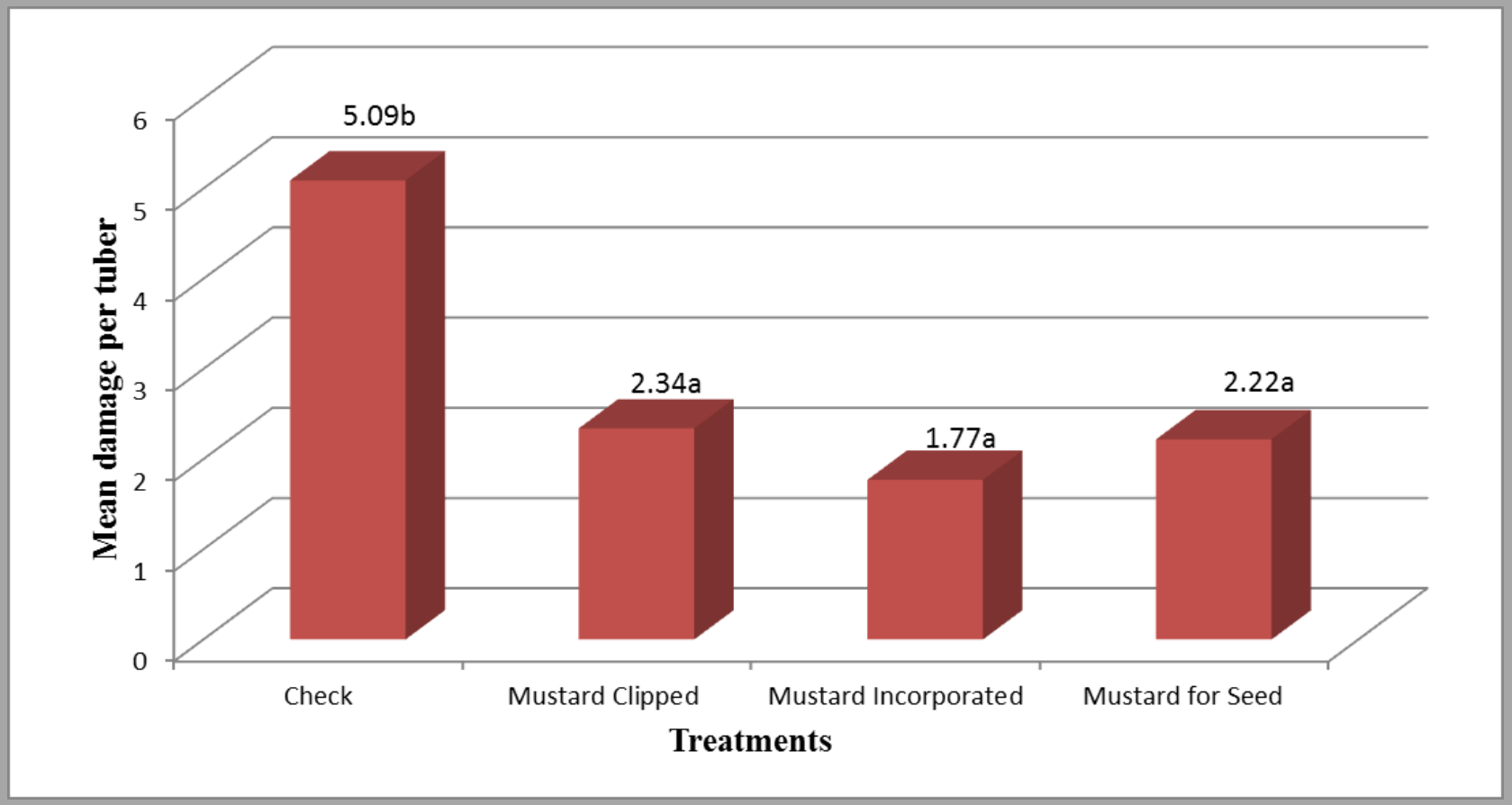
Trials in commercial fields have been conducted over several years and we have always found significant reduction in damage following brown mustard and buckwheat in all cases

Crop Rotation

Table 1. Wireworm damage and marketable yield for the processing market in a potato crop following a 2 year rotation with brown mustard, buckwheat, barley/clover in a commercial field in Prince Edward Island, Canada.

Crops	Total Market yield (t/ha)	Tubers with no Damage (t/ha)	Average Number of Holes per tuber	Tonnes/ha **lost** due to damage (for Processing) (t/ha)	Tonnes/ha Marketable (for Processing) (t/ha)
Brown Mustard	45.6 a[1]	16.2 a	04 a	0.5 a	45.1 a
Buckwheat	45.9 a	12.6 a	06 a	2.6 a	43.3 a
Barley	47.3 a	2.3 b	20 b	16.8 b	30.5 b

Comparison of the mean damage per tuber between three brown mustard cropping systems and a barley check conducted the year before planting potatoes.



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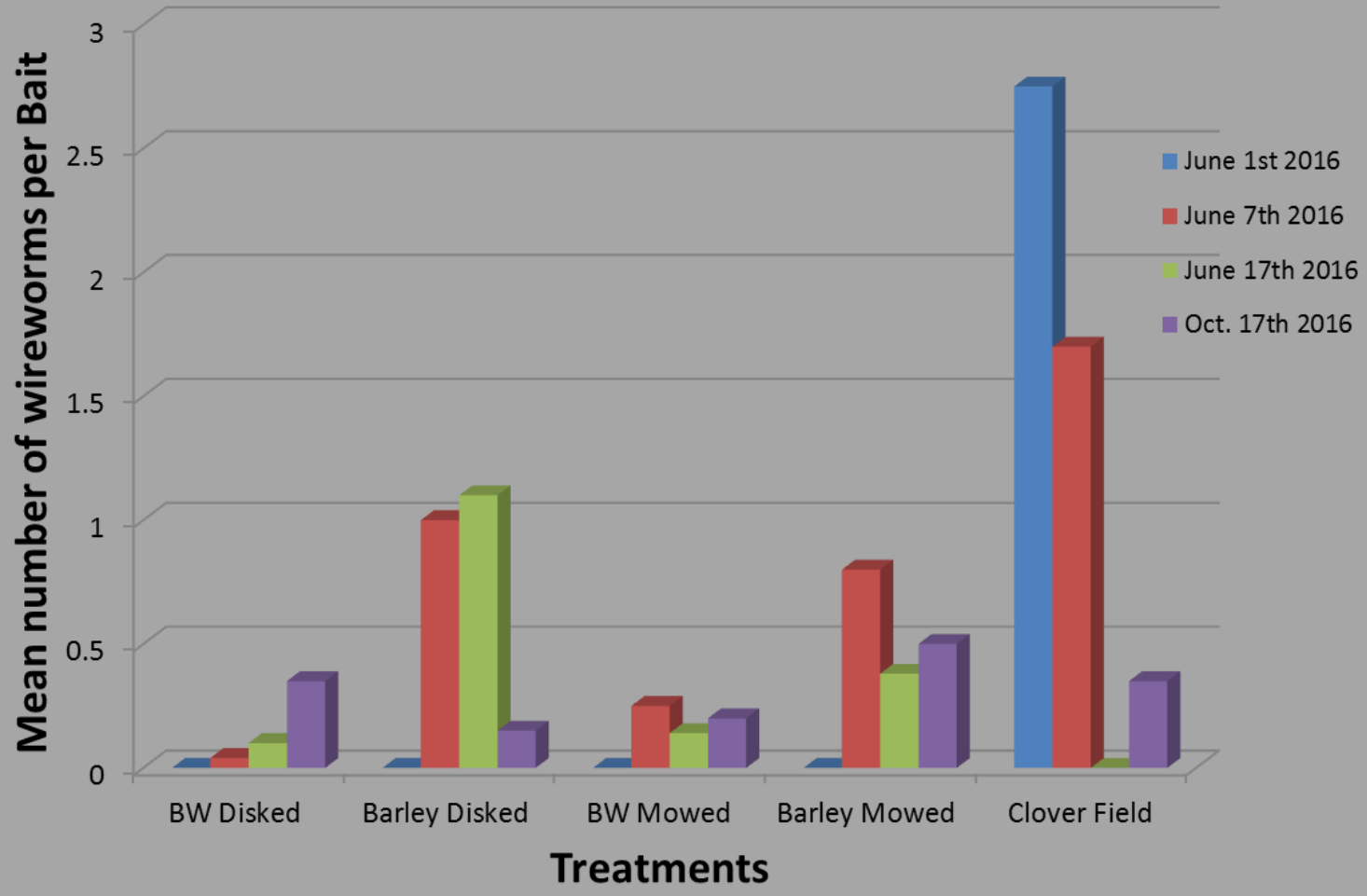

QUESTION: B. We tend to plant these crops later in the spring when the beetle is finishing its cycle to lay eggs so it stands to reason that there will be less wireworm damage in future years?

BIOLOGY OF *A. SPUTATOR*

~ 4 YEARS!!!

May **June** **July**

Beetle emerge peak

Egg production peak

Egg hatching peak

EFFECTS OF FEEDING ON BUCKWHEAT ROOTS ON NEONATE WIREWORMS IN THE LABORATORY

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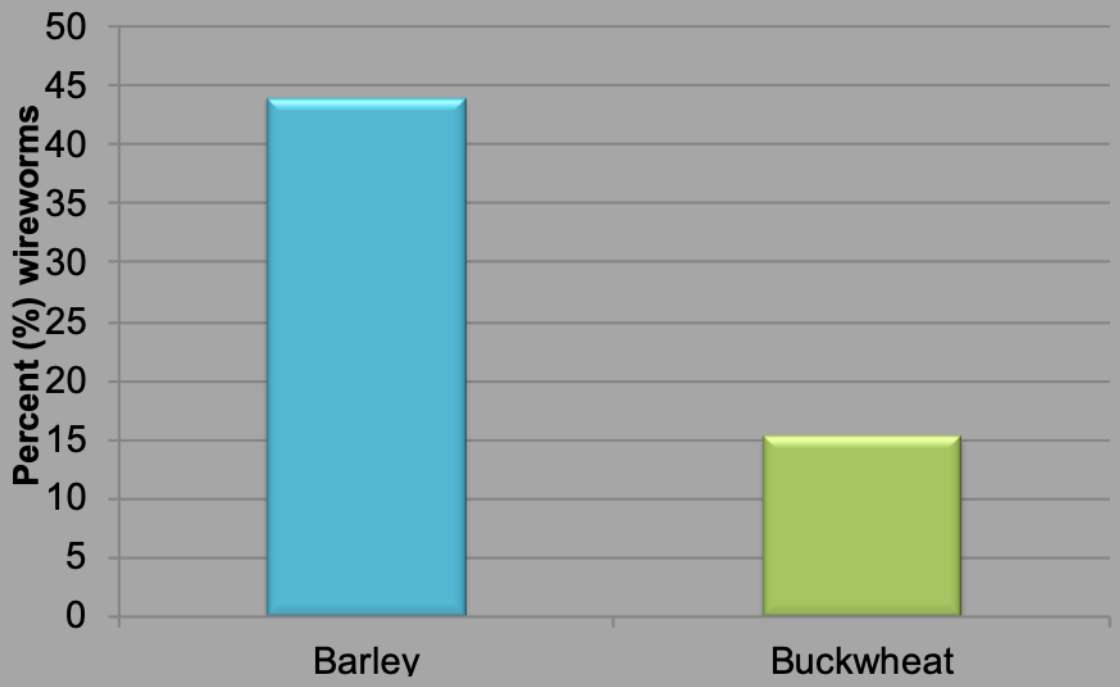
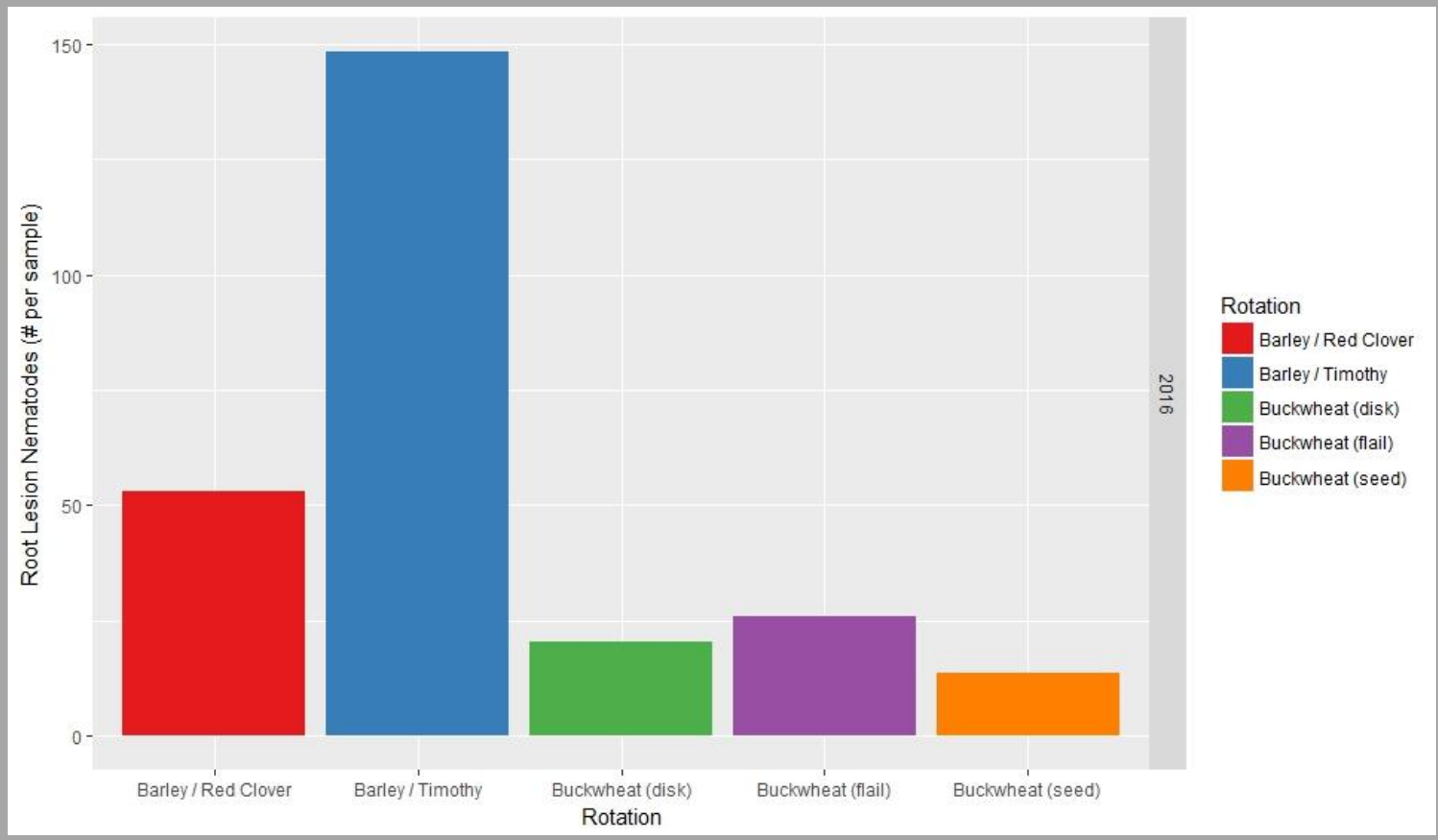


Question: When planting hot mustard to mulch and incorporate to kill wireworm, when wireworm may not be present. Can you have a measurable gain in killing nematodes?

Yes there is indication in the literature that mulching brown mustard as a green manure can reduce diseased such as verticilium and nematodes.

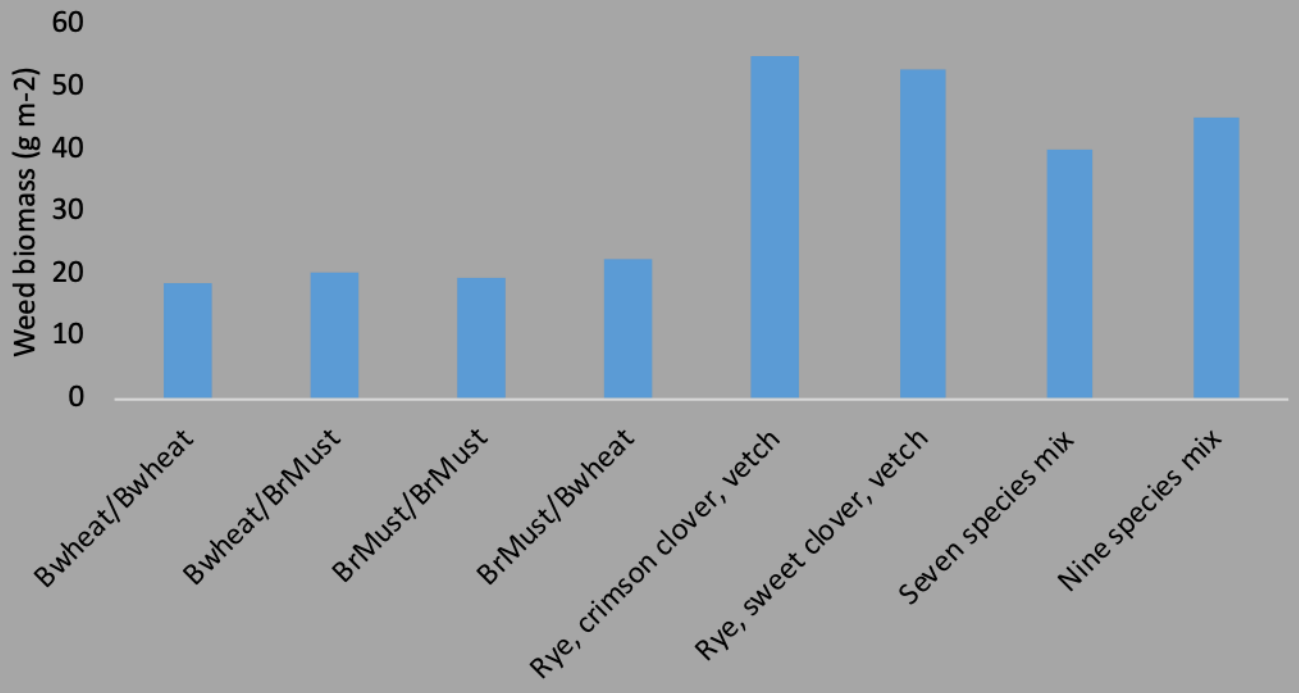
Other studies with Buckwheat and Mustard

Effect of buckwheat on root lesion nematodes



(Courtesy of Dr. Aaron Mills)

Weed biomass following different rotation crops



Courtesy of Dr. Andrew Mackenzie-Gopsill

Question: Why wasn't wireworm an issue in the fall of 2019? I couldn't find any wireworms in the soil during harvest?

Several factors need to be consider to understand why no wireworms were observed

1. Was is a problem in this field the year before.
2. What measures were taken to reduce pressure.
3. What time of the year was the crop harvested, mid - late in October when majority of wireworms move lower down into the soil to overwinter.
4. Conditions when harvesting, if dry wireworms may be lower down in the soil not readily visible.

Question: Has crambe been tested to deter wireworms?

Yes, we have tried crambe and the wireworms were happily feeding on it.

Question: We use manure before potatoes. No wireworm here?

There no evidence in the literature that manure reduces wireworms population.

Question: Which methods burn the least carbon and have the least environmental impact?

Mowing the crop and keeping it as ground cover over the winter would have the least environmental impact and burn the least carbon.

Question: Cost of different rotational crops to the

% of damage?

Approximate cost of growing rotation crop Brown Mustard the before potatoes

(Rotation Crop one year prior to potatoes)	**Rate Kg/ha**	**cost per ha**	**yield (t/ha)**	**Price /ton**	**price /ha**	**net**
Barley	179	642	3.7	$269/ton	$995.3	$ 353
mustard mowed	11.2	275	0	$685/ton	$ 0	$ -275
mustard incorporated	11.2	275	0	$685/ton	$ 0	$ -275
Mustard seed	11.2	275	1.24	$685/ton	$ 849.4	$ 574.4

(Potatoes)	cost per ha (Potatoes)	Price Per Ton	Total Yield mt/ha	Total Revenue	net	**Revenue after 2 years**
Barley/potatoes	2918.22	$240	20.19	4845.6	1927.38	2280.00
mustard mowed/potatoes	2918.22	$240	21.9	5256	2337.78	2062.78
mustard incorporated/potatoes	2918.22	$240	23.27	5584.8	2666.58	2391.58
Mustard seed/potatoes	2918.22	$240	22.86	5486.4	2568.18	3142.58

Cost of production

Rotation	Year 1				Year 2				Year 3				Total Revenue (3-yr)
	Grain Yield kg/ha (t/ac)	Costs/ac*	Revenue	Net	Grain Yield kg/ha (t/ac)	Costs/ac*	Revenue	Net	Mark. Yield Mg/ha (cwt/ac)	Costs/ac*	Revenue	Net	
Barley/Red Clover/Potato	2919 (1.16)	$260	$313	$53	0	$60	$0	-$60	33 (294)	$2,132	$3,131	$999	$992
Barley/Timothy/Potato	2829 (1.12)	$230	$302	$72	0	$60	$0	-$60	30 (267)	$2,132	$2,843	$711	$723
Buckwheat seed X 2 / Potato	338 (0.135)	$171	$57	-$114	410 (0.164)	$171	$69	-$102	39 (347)	$2,132	$3695	$1563	$1347
Buckwheat flail X 2 / Potato	0	$171	$0	-$171	0	$171	$0	-$171	38 (339)	$2,132	$3610	$1478	$1136
Buckwheat disk X 2 / Potato	0	$171	$0	-$171	0	$171	$0	-$171	40 (356)	$2,132	$3791	$1659	$1317

Barley @ $270 / t

Buckwheat @ $425 / t

Potato @ $10.65

* seed + fertilizer + inputs + fixed costs

(Courtesy of Dr. Aaron Mills)

Question: Is there a "silver bullet" in sight?

We should not hold our breath for a silver bullet. With a pest that has a five year life cycle you need apply a management strategy every year to keep populations at a non economic damaging level.

The best strategy is management
A multi-pronged approach

ACKNOWLEDGEMENTS

English:
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French:
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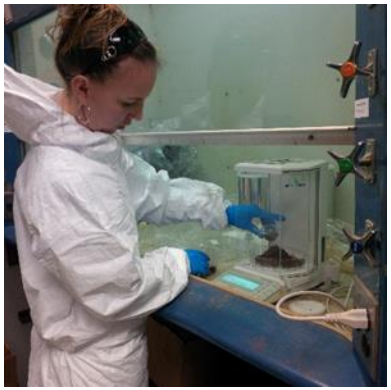
La voix des **producteurs de fruits et légumes du Canada**

And a special thanks to the growers whom we have worked with

Charlottetown Entomology Team

Dr. MD Bahar

Dr. Suqi Liu



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