Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Growing Forward 2

Biological Control of Wireworms

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Presentation Summary

Growing Forward 2
A federal-provincial-territorial initiative

Monitoring wireworms to predict crop damage

Biopesticides refresher

Comprehensive wireworm biocontrol under GF2

- Biocontrol targeting click beetles
- Biocontrol targeting larvae
- Wireworm biocontrol summary

Current wireworm biocontrol products on the market

New discoveries

Wireworm monitoring to predict crop damage

Do I even HAVE a wireworm problem?

Can I expect a wireworm problem if I plant a susceptible crop in these fields?

-will I need to apply a pest control?

-should I just plant something else?

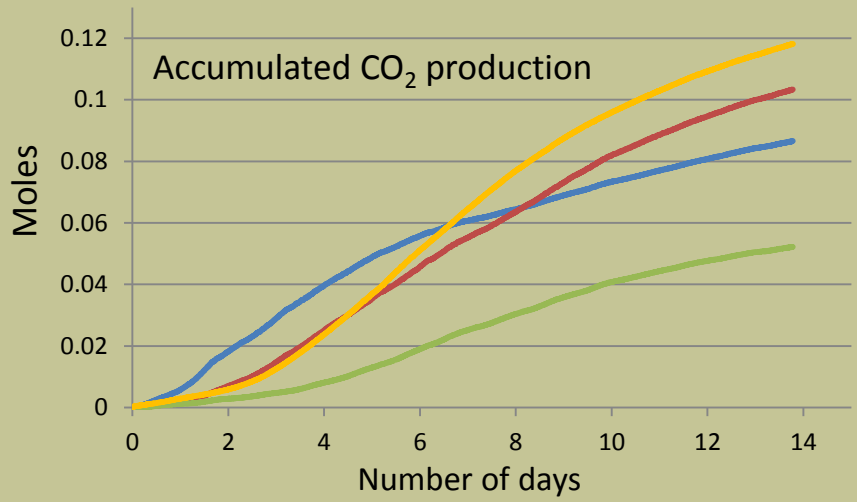
My role in this project

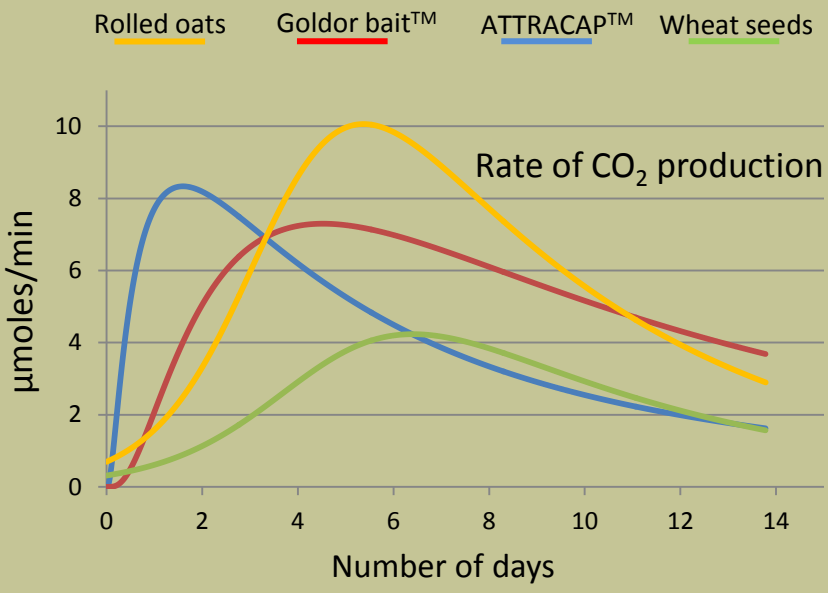
Optimizing the wireworm probe trap

Testing CO_2 production in 'The CO_2 Room' prior to testing trap efficacy in the field

- the best CO_2 – producing material
- trap design and CO_2 production
- how do environmental variables (moisture, temperature, competing vegetation, etc.) affecting CO_2 interact with the trap's ability to attract wireworms?

Example experiment: testing the total- and rate of CO_2 production of materials for use in wireworm probe trap

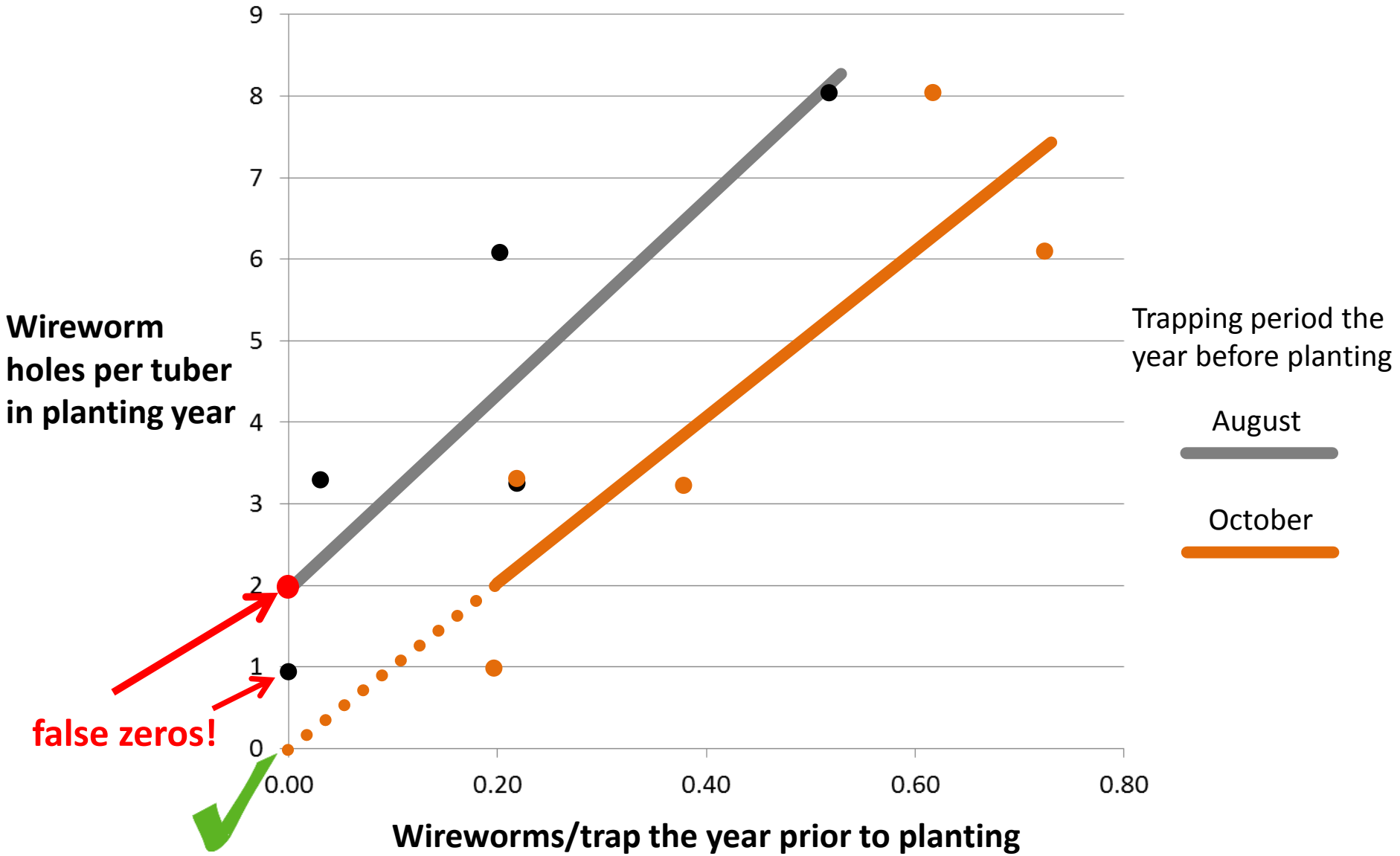





Trap during late summer/fall of year prior to planting
August
October
Potatoes in planting year
Rototill spring of year prior to planting
Corn in planting year

Relationship between wireworm trap catches (year prior to planting) and the damage in potatoes the following year (year of planting)

(each data point is the average from a single farm)



On-farm verification

On-farm field trials

-Prince Edward Island (Atlantic Agri-Tech)

Trap wireworms 2014	Evaluate tuber damage 2015	4 farms

New group of farms:

Trap wireworms 2015	Evaluate tuber damage 2016	4 farms
		8 farms

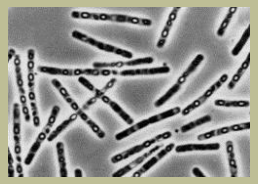
+

‘Click beetle back-up’

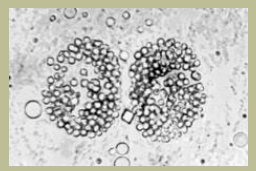
2017: Analyze data!

Microbial insecticides are insect diseases – common organisms

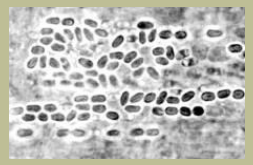
- Fungi
  - *Metarhizium* spp., *Beauveria* spp., *Paecilomyces* spp., *Lecanicillium* spp.



- Bacteria
  - *Bacillus thuringiensis*



- Viruses
  - viruses from source insects (e.g. *Cydia pomenella* (codling moth), *Spodoptera exigua* (beet army worm), *Anticarsi gemmatalis* (velvet bean caterpillar))



- Microsporidia / Protozoa
  - *Nosema locustae*

- Nematodes
  - *Steinernema* spp., *Heterorhabditis* spp.

Pesticides are BIG business

Global sales

Synthetic chemical pesticides
~$48 billion (3% growth rate)

Biopesticides
~$3.3 billion (15% growth rate!)

Biochemicals
(derived from natural substances e.g. plants and microorganisms)

Microorganisms
(insect diseases)

A Comprehensive Approach to Wireworm Biocontrol **targets both the adult (click beetles) and larvae (wireworms) mostly using the entomopathogen *Metarhizium* strain LRC112**

Wireworm biopesticide lingo

Metarhizium **LRC112**

-discovered by AAFC in 2000
-experimental, not registered
-kills a wide range of wireworm species – '*the most virulent overall'*

Metarhizium **ADRC161**

-discovered by AAFC in 2016
-experimental, not registered
-kills one species (*A. lineatus*) that is difficult to kill with other strains

Metarhizium **Met52**

-commercial, registered in Canada for ***other pests***
-NA distribution rights: Novozymes Biologicals Inc.
-for wireworms, it is still experimental
-kills *A. sputator* beetles only

Attracap (*Metarhizium* **C15**), Velifer (*Beauveria* **PPRI5339**), Naturalis (*Beauveria* ATTC **74040**)

Wireworm biocontrol products registered in Europe

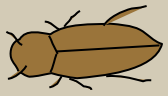
We make *Metarhizium* in our lab

- fungus is grown on rice or barley
- powdery green conidia spores are highly infectious to wireworms (and other insects)
- granules can be applied directly

OR

- conidia spores can be harvested, mixed with liquid and applied as spray
- *other creative formulations available*

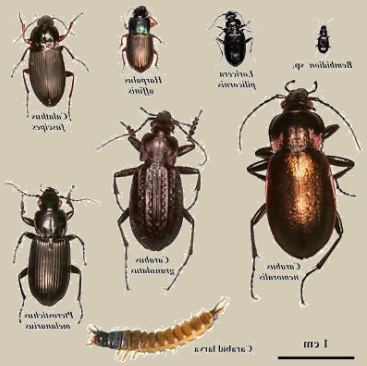
A Comprehensive Approach to the Biological Control of Wireworms …*includes*:

-Reducing the input of new larvae from adults 

-Reducing existing larvae to sub-threshold levels 

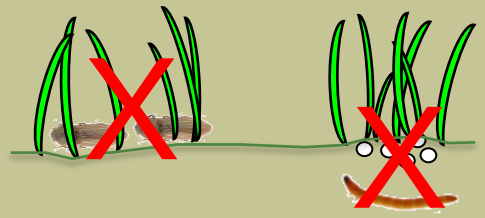
-Preventing wireworm build-up

-Achieving management with a minimal environmental impact



Comprehensive Wireworm Biocontrol

Biocontrol of beetles during this time would reduce egg laying and input of new larvae



Reduced wireworm density at planting

Biocontrol of larvae remaining in the soil

Year 1

Grain undersown with clover

Year 2

Clover

Year 3

Potato

Prime egg-laying sites for beetles, building up the wireworm population

Sustains wireworms already in the soil

Potatoes damaged by existing wireworms in the soil, including those arising from previous two years' rotation crops

Targeting click beetles during rotation years

Insect Pheromones

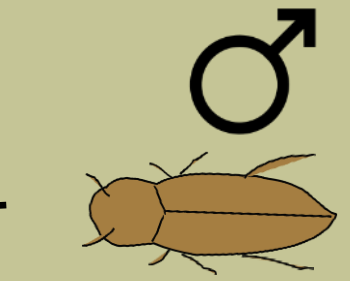
-attractant chemical(s), produced by females to attract males

-commonly liquid (as for click beetles)

Click Beetle Pheromone Granules

An Agriculture and Agri-Food Canada *Invention!*

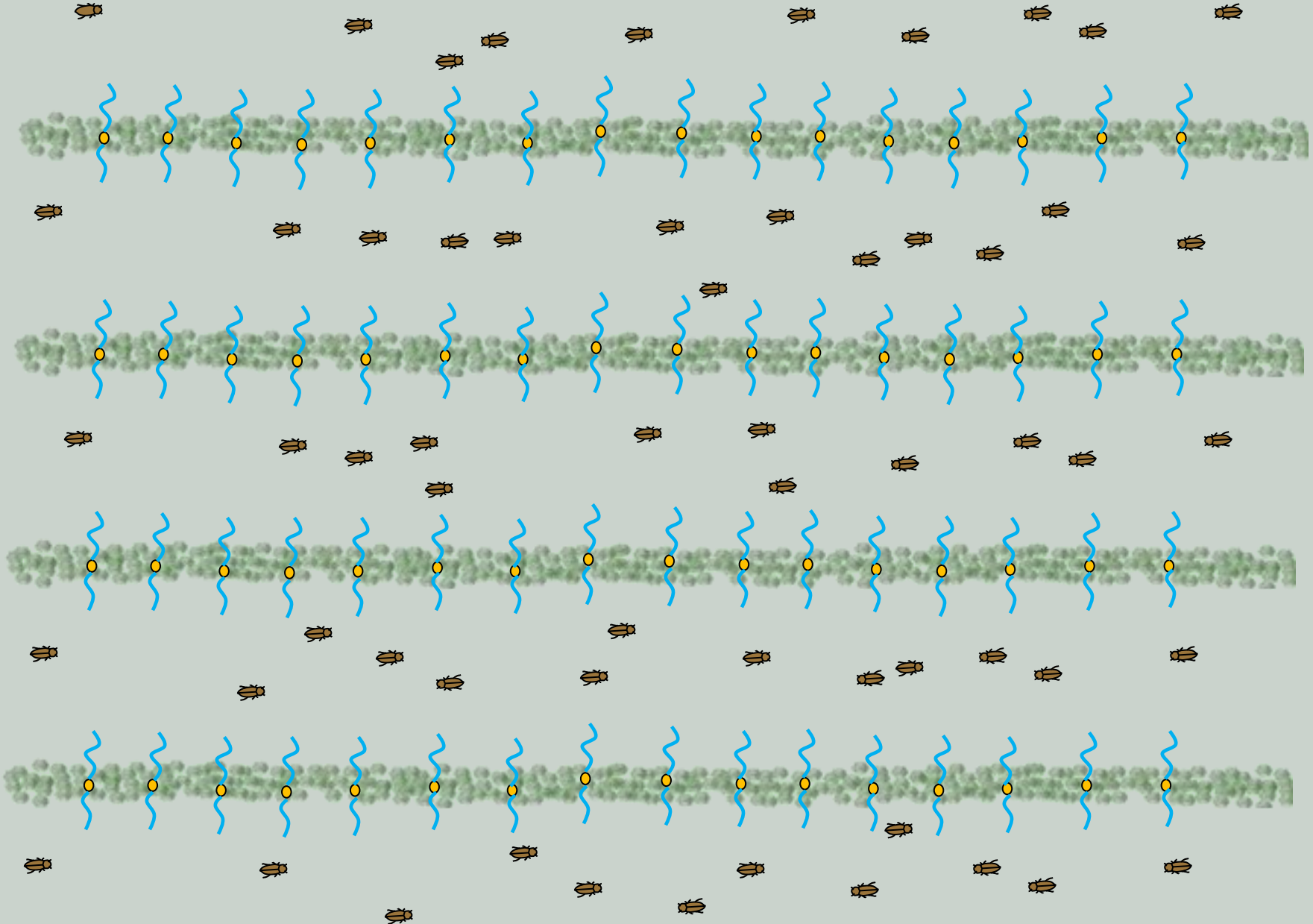
Une Agriculture et Agroalimentaire Canada *Invention!*



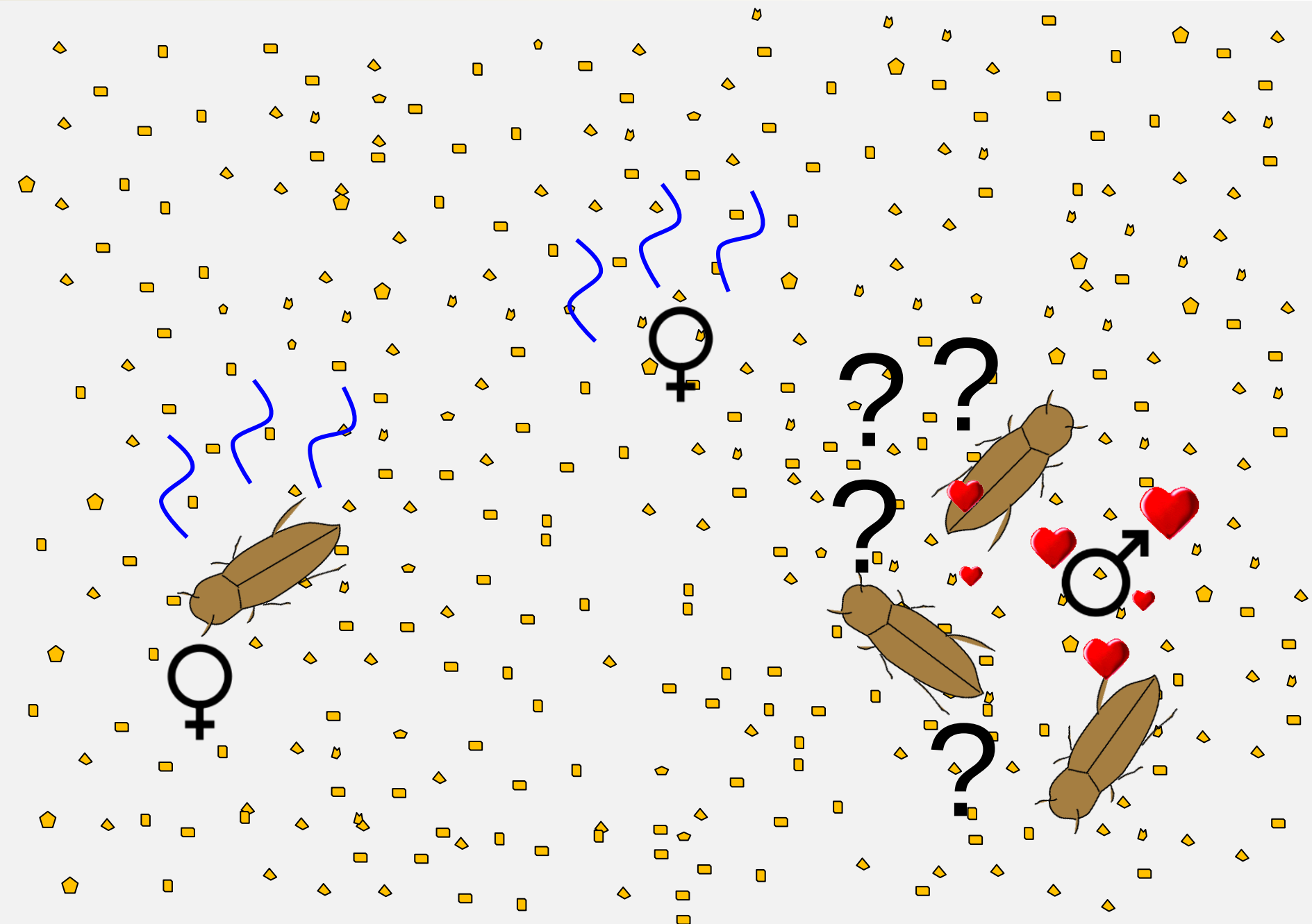
We make pheromone granules in our lab

Controlling click beetles during rotation years

Attract and Kill *with bands of Metarhizium and pheromone granules (attracts ♂ but would also kill females passively encountering the Metarhizium* granules*)*

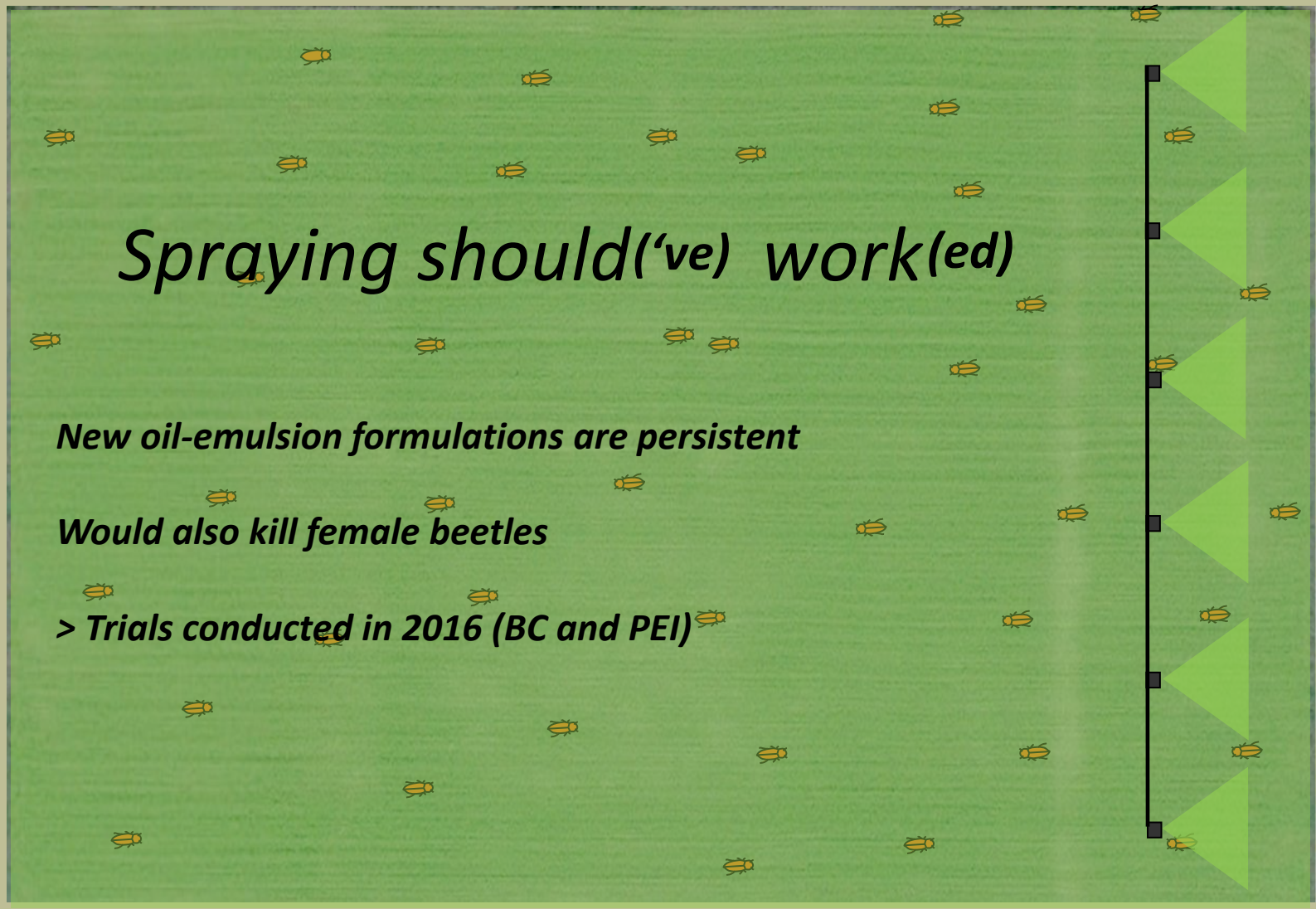


Bonus! Use of pheromone granules for mating disruption →

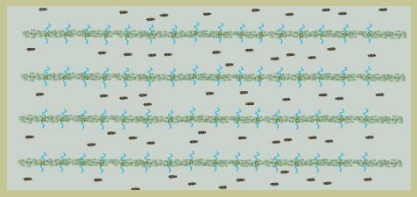


Controlling click beetles during rotation years

What about *Metarhizium* field sprays?



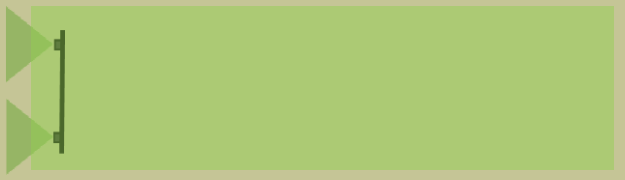
Results from Click Beetle Control Trials



Attract and kill using *Metarhizium* and pheromone granules
-it just works.

Outstanding challenge: persistence of *Metarhizium* after rain; general pheromone longevity
Proposed solutions: new formulation of *Metarhizium*; pheromone antioxidants
→ *trials in summer 2017*

Metarhizium oil emulsion spray
-won't show you the data because it didn't work $%^&*!



Outstanding challenge: PEI beetles burrow in the grass thatch
Proposed solutions: secret strategy to flush out the PEI beetles from grass;
application to minimally vegetated or tilled soil
→ *trials in summer 2017*

Targeting the larvae (wireworms)

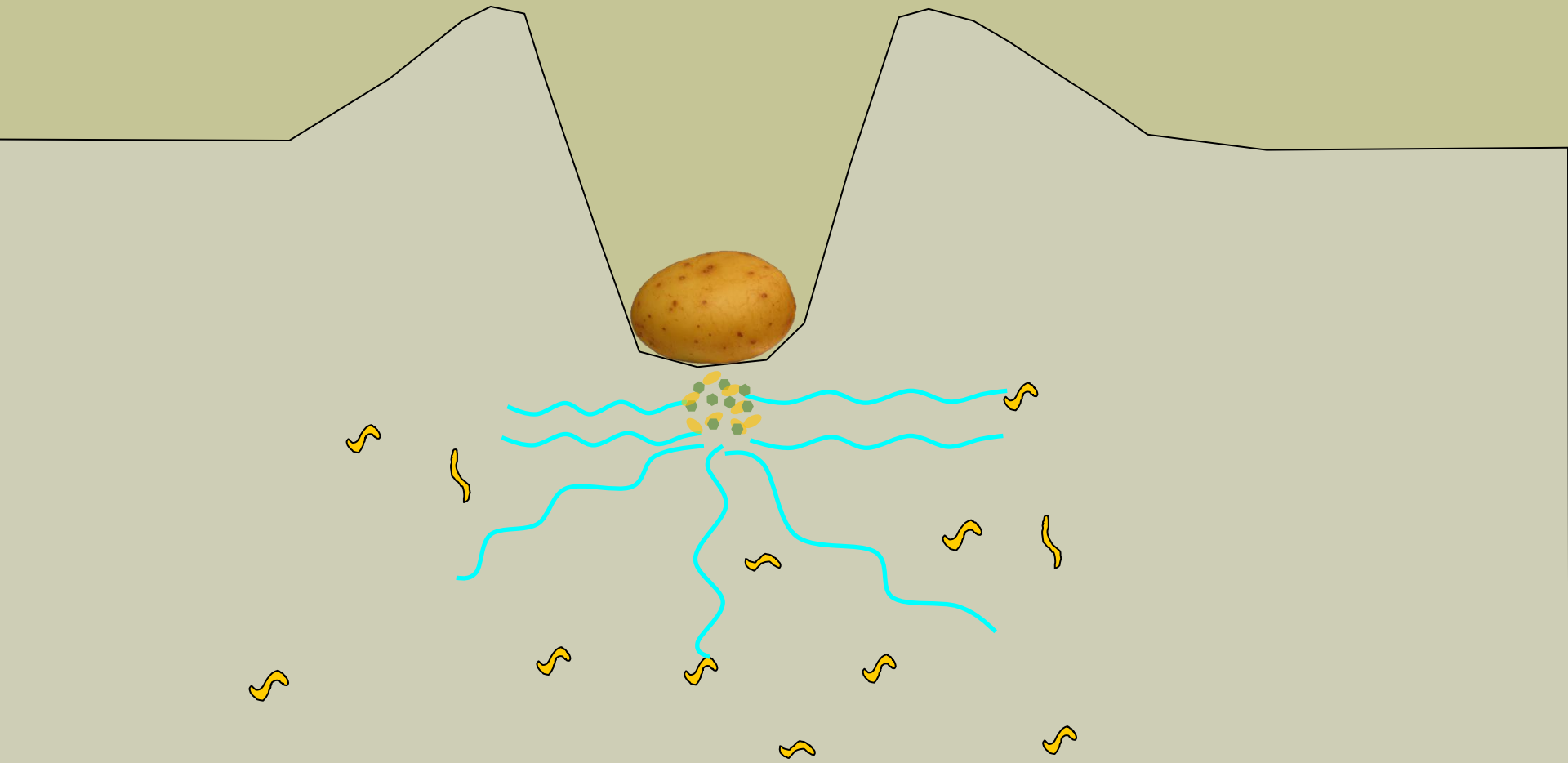
Simple attract (CO_2) and kill (MetLRC112) product

CO_2
-rolled oats (yes, the breakfast cereal)
-produces more CO_2 than any substance I've tested

Pest control
-*Metarhizium* (MetLRC112) granules
-infectious conidia spores
-common mass production technology
-we make this in our lab

Attract and kill wireworm biocontrol

-production of CO_2 by rolled oats (and potato seed tuber) attracts wireworms
-co-location of *Metarhizium* MetLRC112 granules with rolled oats brings wireworms to control product
-placement is key to efficacy



2016 potato field trial

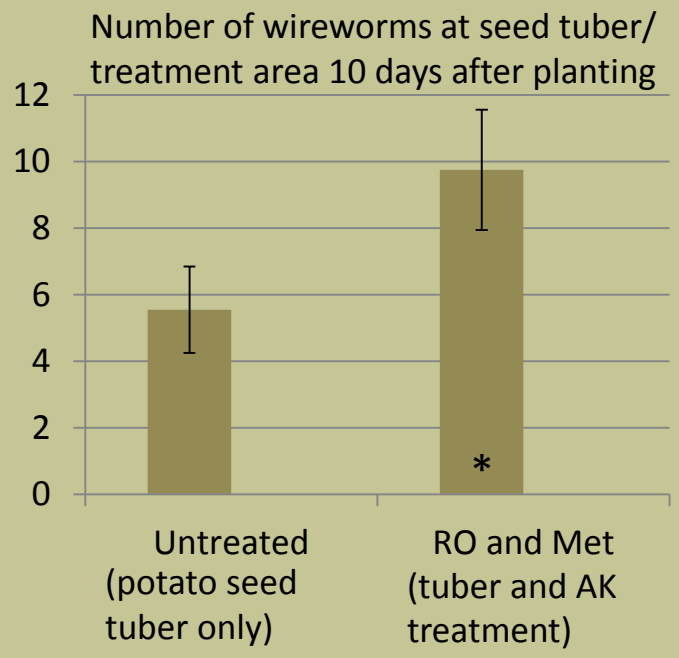
-RO & Met
-untreated control

Planted and treated: June 17

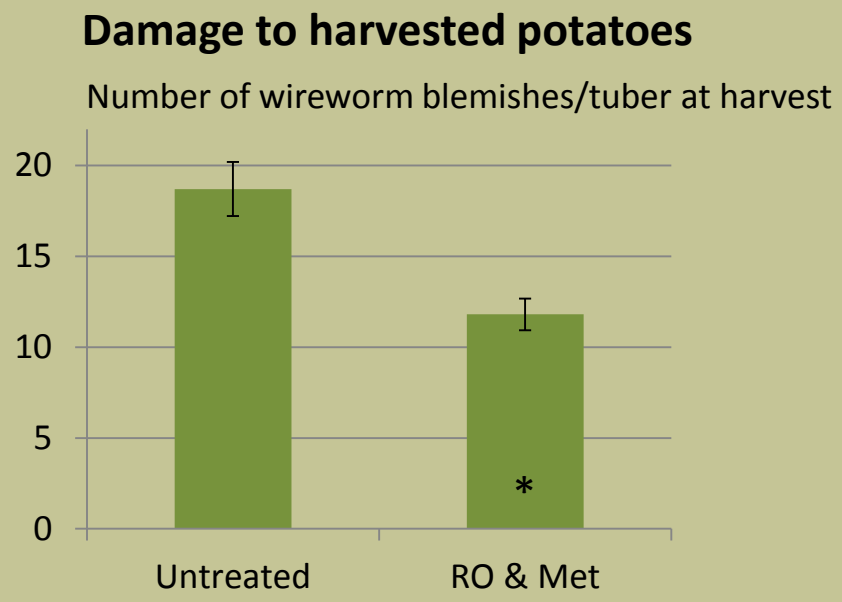
Sampled for wireworm attraction to seed tuber area: June 27
10 replications x 2 tuber locations/plot assessed = 20 tubers/treatment assessed

Harvest October 4, followed by wireworm damage assessment
10 replications x 100 assessed tubers/plot = 1,000 tubers/treatment assessed

Wireworm attraction



Damage to harvested potatoes

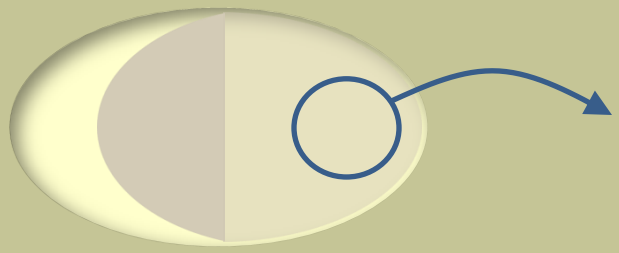


Attracap^{TM} -a new European 'designer' wireworm biocontrol product

-rapid production of CO_2, beginning within hours
-impregnated with *Metarhizium* (unconventional fungal tissue – mycelia)
-placement is key to efficacy

- contains mycelia that aren't infective to wireworms; must grow conidia spores
- produces CO_2 immediately
- beautiful and ingenious product

AAFC – Georg-August University/BioCare partnership to work with Attracap in Canada …formulated with MetLRC112

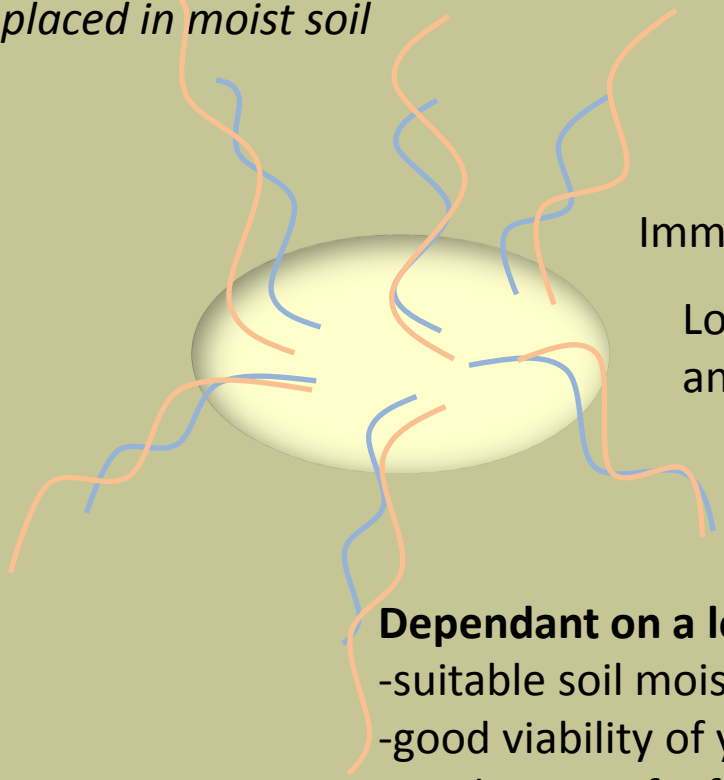


CO_2
-yeast, starch, amylase, fungus

Pest control
-*Metarhizium*

-mycelia
-not infectious to wireworms
-grow and sporulate into conidia
(conidia *IS* infectious)

When placed in moist soil



Attracap

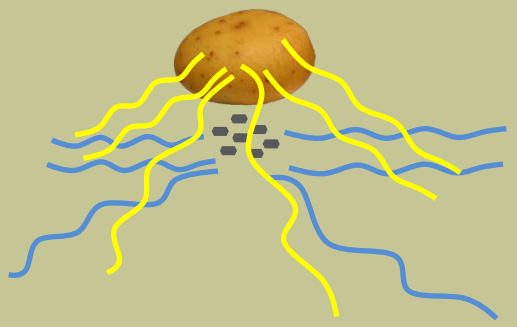
Immediate CO_2 from yeast

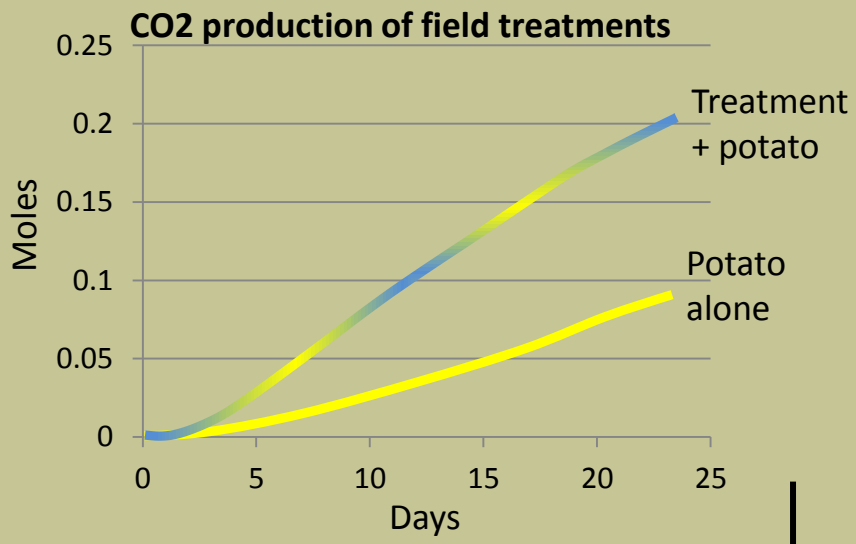
Longer term CO_2 from *Metarhizium* growth and sporulation (= green 'conidia' highly infections to wireworms)

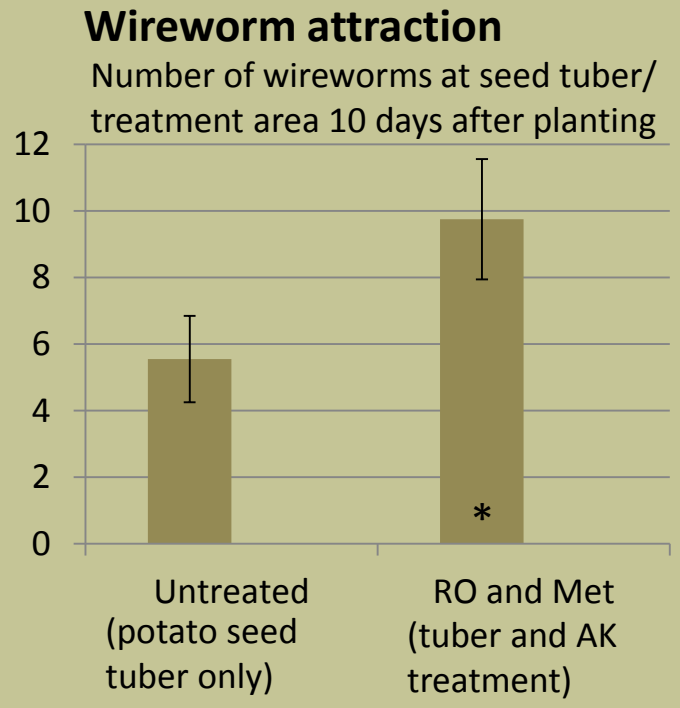
Dependant on a lot of favourable factors (which are often variable)
-suitable soil moisture and temperature
-good viability of yeast and *Metarhizium*
-production of infectious conidia timed with wireworm activity
-wireworm activity before the seed tuber sprouts

WHY TREATMENT PLACEMENT IS KEY

- big CO_2 source directly from the seed tuber-treatment area
[seed tuber CO_2 + product CO_2], concentrating wireworms at treated area







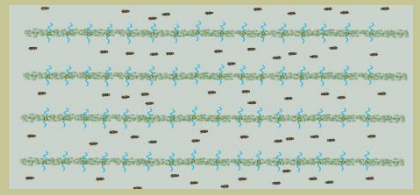
wireworm attraction $\propto$ CO_2 production

Overview of wireworm biocontrol products on the market

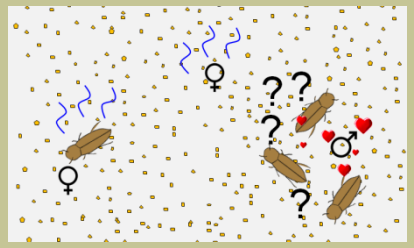
	Registered			Potential
	Attracap (Biocare)	**Velifer (BASF)**	**Naturalis (Intrachem)**	**Met52 (Novozymes)**
	ATTRACAP Granulate			
Formulation	Granules	Dispersible oil	Dispersible oil	• Emulsifiable concentrate • Granules
Use pattern	In-furrow, below tuber (unique pattern)	In-furrow spray	In-furrow spray	• Spray / drench (EC) • In-furrow (G)
Target	*Agriotes* larvae	*Agriotes* larvae	*Agriotes* larvae	Non-wireworm pests
Active ingredient Strain	*Metarhizium brunneum* C15	*Beauveria bassiana* PPRI 5339	*Beauveria bassiana* ATCC 74040	*Metarhizium brunneum* F52
Registration	Emergency Germany, Austria	Emergency Germany, Austria	Europe	Canada Not registered for wireworms

Comprehensive Wireworm Biocontrol - Summary

Attract and kill
-*Metarhizium* and pheromone granules

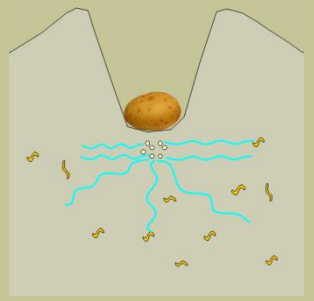


Oil-emulsion spray



Mating disruption

Reduced wireworm population level



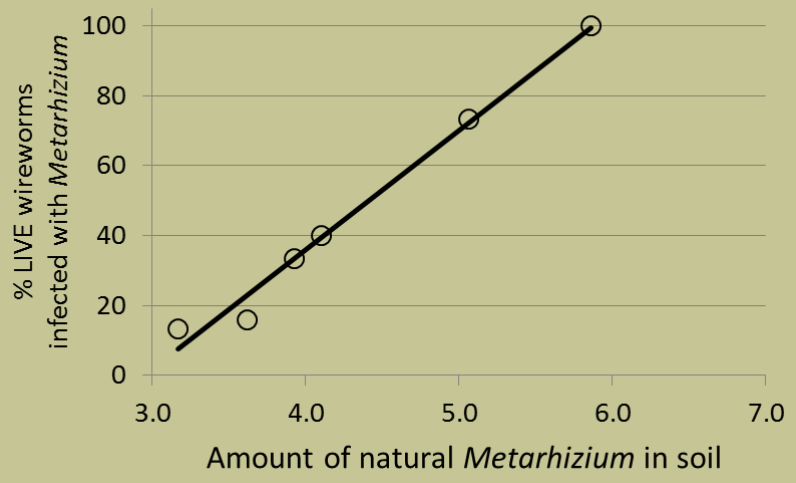
Attract and kill

In-furrow spray?

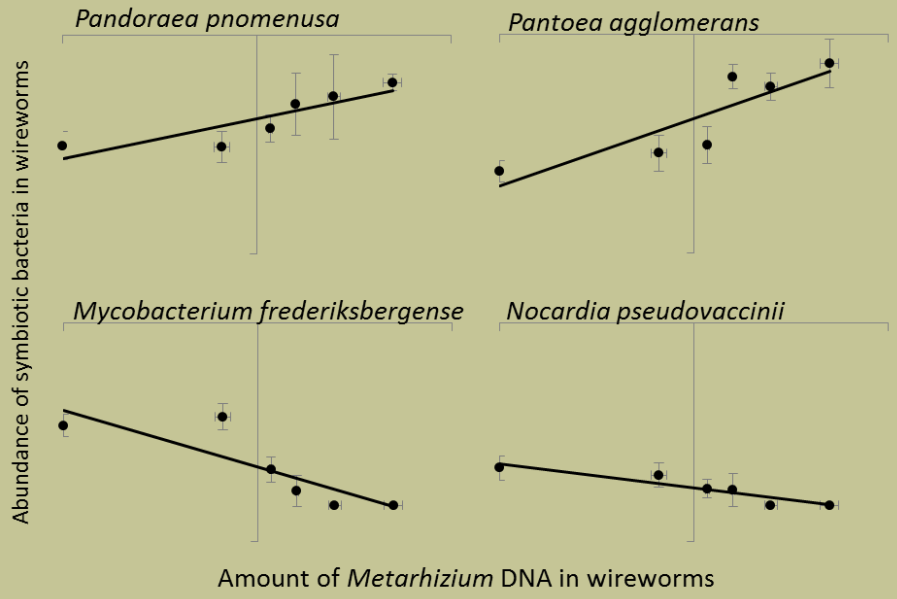
New Discoveries…on the basic science side of things

Natural Metarhizium in soil is common. Wireworms are naturally infected but are able to resist succumbing to it

Association between natural *Metarhizium* levels in soil, and infected live wireworms



Association of *Metarhizium* and symbiotic bacteria levels in wireworms



Their resistance is associated with levels if ‘symbiotic bacteria’ - bacteria that protect insects from fungal infection

Do symbiotic bacteria reduce the efficacy of *Metarhizium* applied to control wireworms?

KEEP CALM AND ASK QUESTIONS