

TREMORS:

Are we in for a wireworm plague
in Canada?



Starring:

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Dr. Christine Noronha

Southern Crop Protection and Food
Centre, and Charlottetown
Research Centre,
Ag. and Agri-Food Canada,



Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada

Wireworms in Canada: Challenges, Surveys, Current and Future Control Options.

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Christine Noronha³

¹Pacific Agri-Food Research Centre, Agriculture and Agri-Food Canada,
Box 1000, Agassiz, British Columbia, CANADA, V0M 1A0

²Southern Crop Protection & Food Research Centre, AAFC,
1391 Sandford St., London, Ontario, CANADA, V0M 1A0

³Charlottetown Research Station, Agriculture and Agri-Food Canada,
Charlottetown, Prince Edward Island, CANADA

Setting the stage:

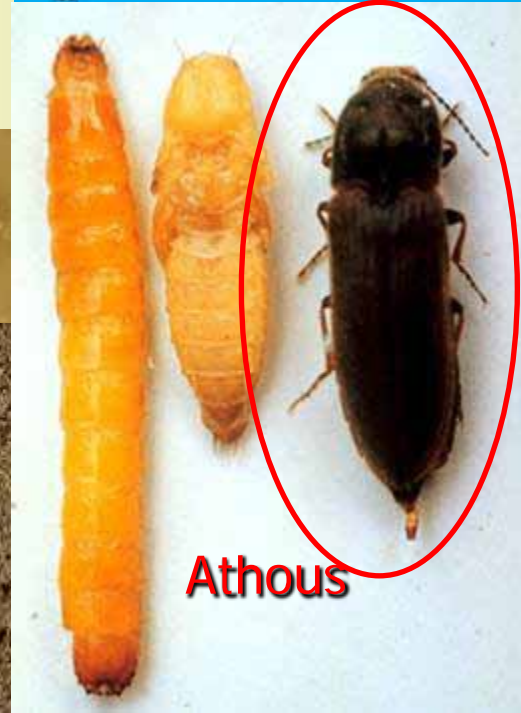
- Wireworms:

 - about 30 economic species in Canada



Examples of common pest species in Canada

- *Ctenicera destructor/aeripennis* (BC, AB, SK, MB)
- *C. lobata, C. morula* (AB, SK, MB)
- *C. pruinina* (OR, ID)
- *Agriotes obscurus, A. lineatus* (BC, NS, PEI)
- *A. sputator* (PEI, NS), *A. mancus* (MB, ONT, NB, NS, PEI)
- *A. sparsus* (BC, OR)
- *Athous spp* (AB, SK, MB)
- *Limonius canus, L. californicus* (BC, AB, SK, MB)
- *Melanotus spp* (ON)
- *Hypnoides spp* (SK, MB)



Identification of economic wireworms in Canada: 2004-2010 Surveys

Wim van Herk
Bob Vernon

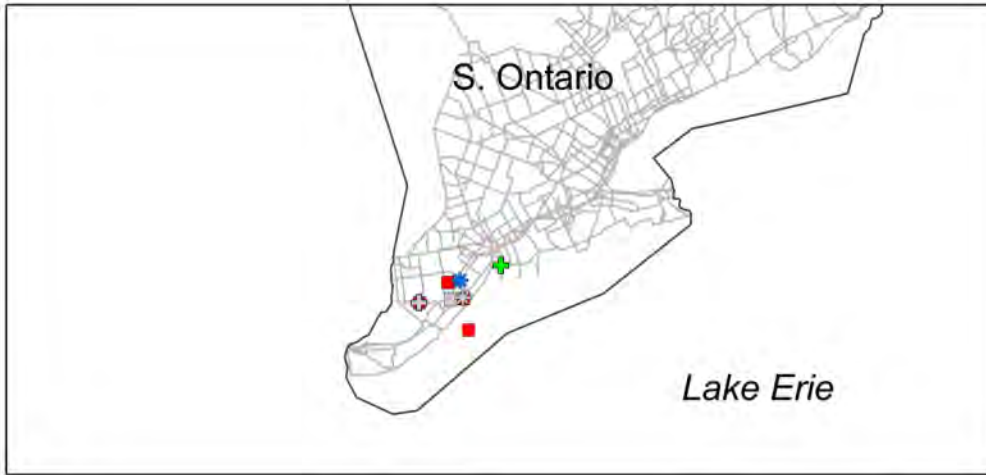
AAFC-Pacific Agri-Food Research Centre, Agassiz, BC



Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada

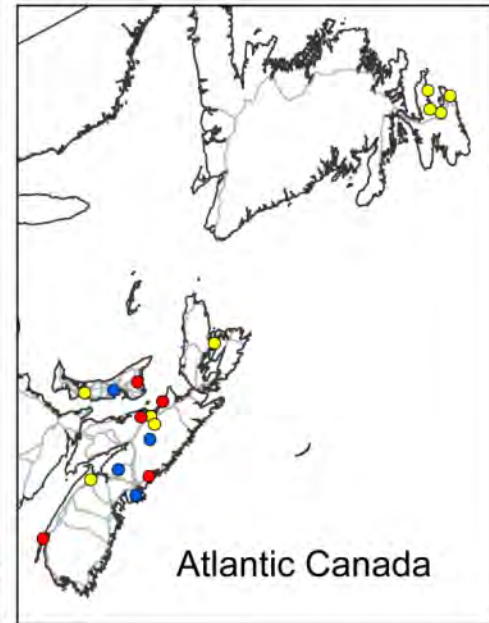
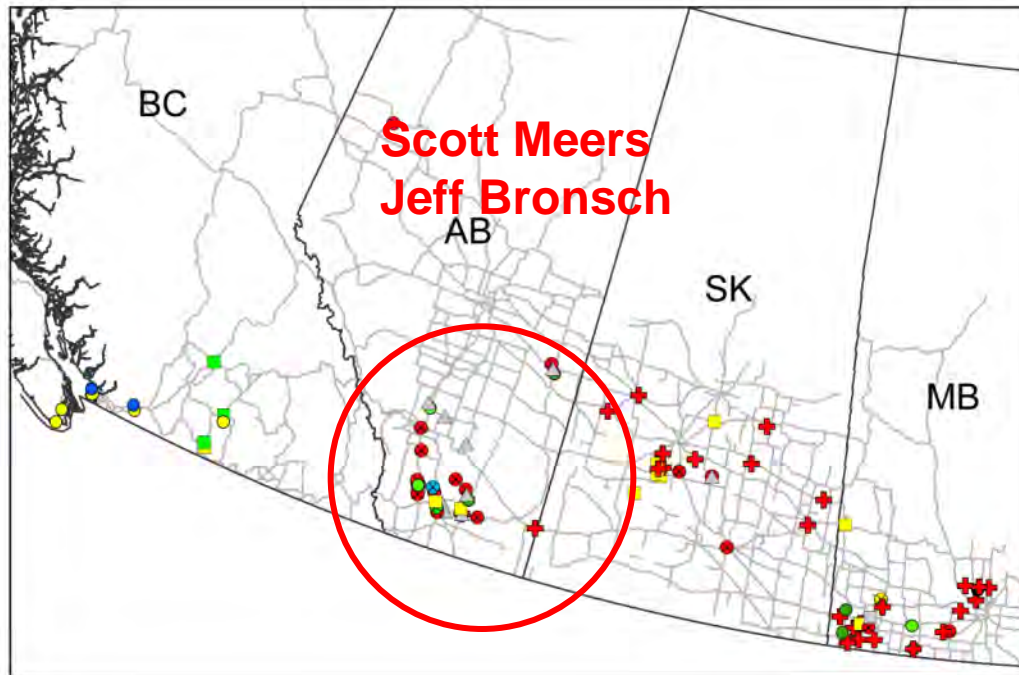
2004-2009 Surveys



Distribution of wireworm species in Canada, based on samples submitted to Vernon lab, PARC Agassiz, as of August 2009

Genus or species identified

- | | |
|---------------------|------------------------|
| ● A. criddlei | ● C. morula |
| ● A. lineatus | ● Ctenicera destructor |
| ● A. mancus | ⊗ Ctenicera sp. |
| ● A. mellillus | ⊕ H. abbreviatus |
| ● A. obscurus | ⊕ H. nocturnus |
| ● A. sputator | ⊕ Hemicrepidius sp. |
| ● Aeolus mellillus | ■ L. agonus |
| ● Agriotes criddlei | ■ L. californicus |
| ▲ Athous sp. | ■ L. canus |
| ⊗ C. cylindricornis | ■ Limonius agonus |
| ● C. destructor | ■ Limonius sp. |
| ● C. lobata | ● M. communis |
| | ● Melanotus sp. |



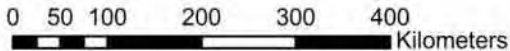
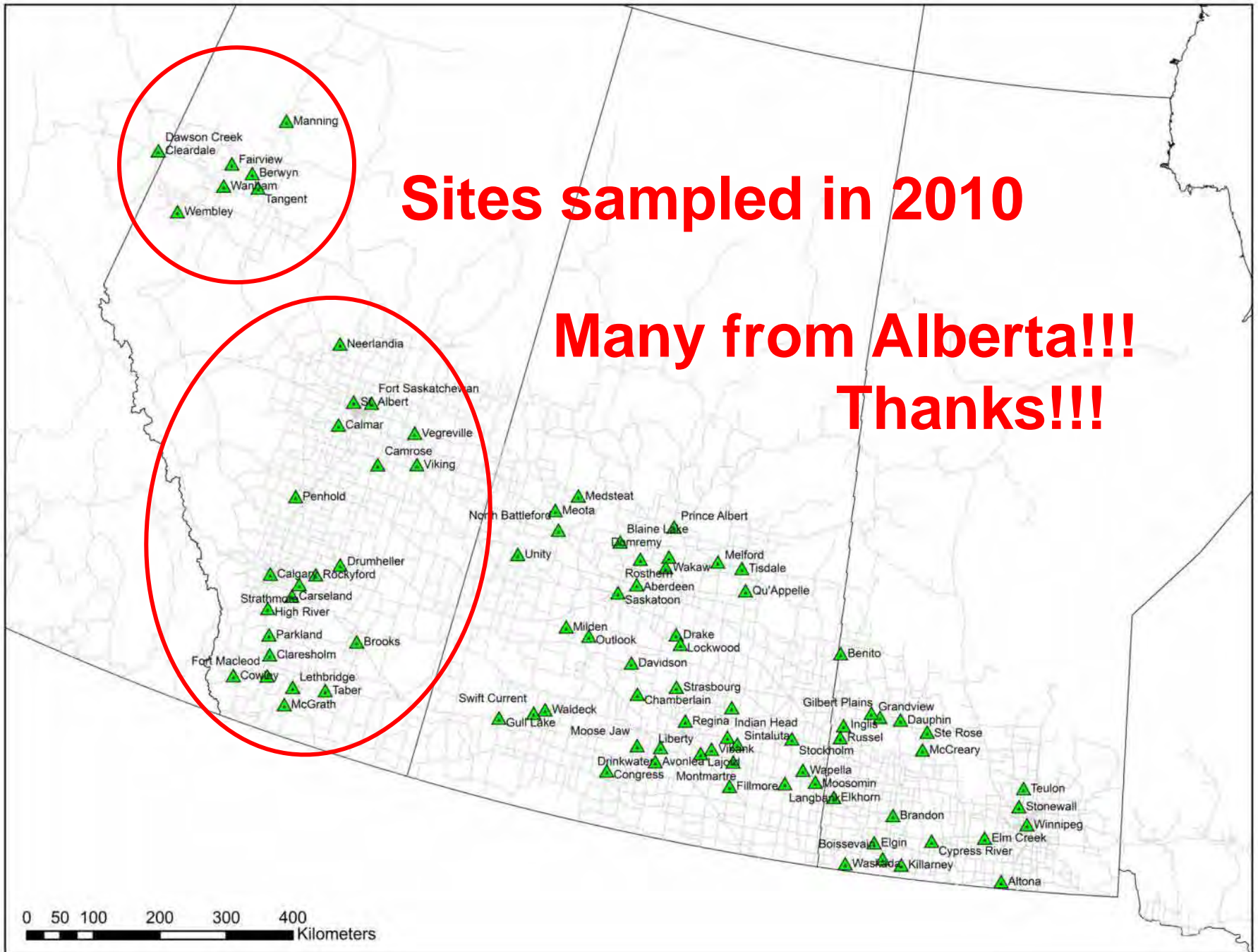
2010 Syngenta Crop Protection Canada initiative





Sites sampled in 2010

**Many from Alberta!!!
Thanks!!!**

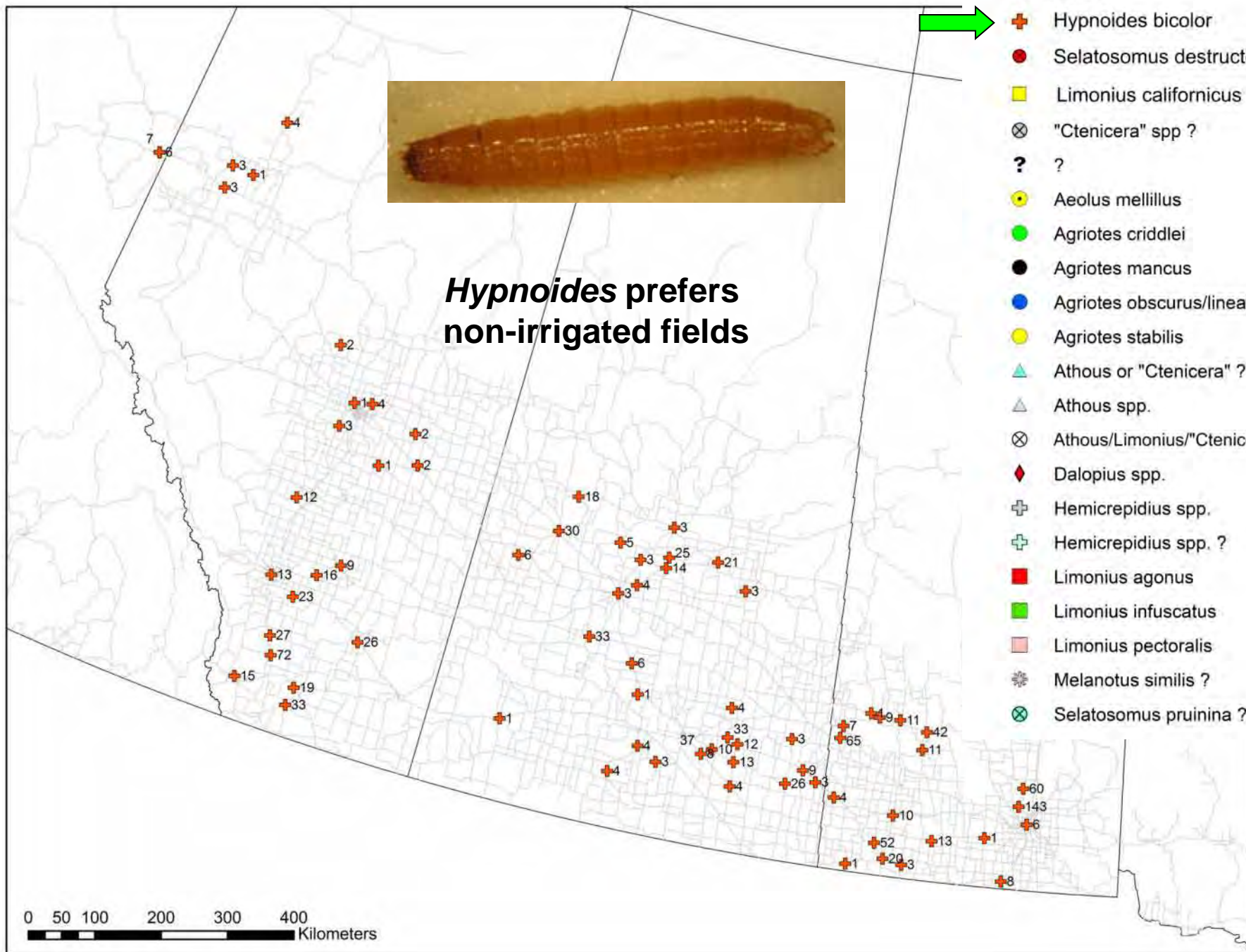


SPECIES

- + Hypnoides bicolor
- Selatosomus destructor
- Limonius californicus
- ⊗ "Ctenicera" spp ?
- ? ?
- Aeolus mellillus
- Agriotes criddlei
- Agriotes mancus
- Agriotes obscurus/lineatus
- Agriotes stabilis
- ▲ Athous or "Ctenicera" ?
- ▲ Athous spp.
- ⊗ Athous/Limonius/"Ctenicera" ?
- ◆ Dalopius spp.
- + Hemicrepidius spp.
- + Hemicrepidius spp. ?
- Limonius agonus
- Limonius infuscatus
- Limonius pectoralis
- ✻ Melanotus similis ?
- ⊗ Selatosomus pruinina ?



***Hypnoides* prefers
non-irrigated fields**



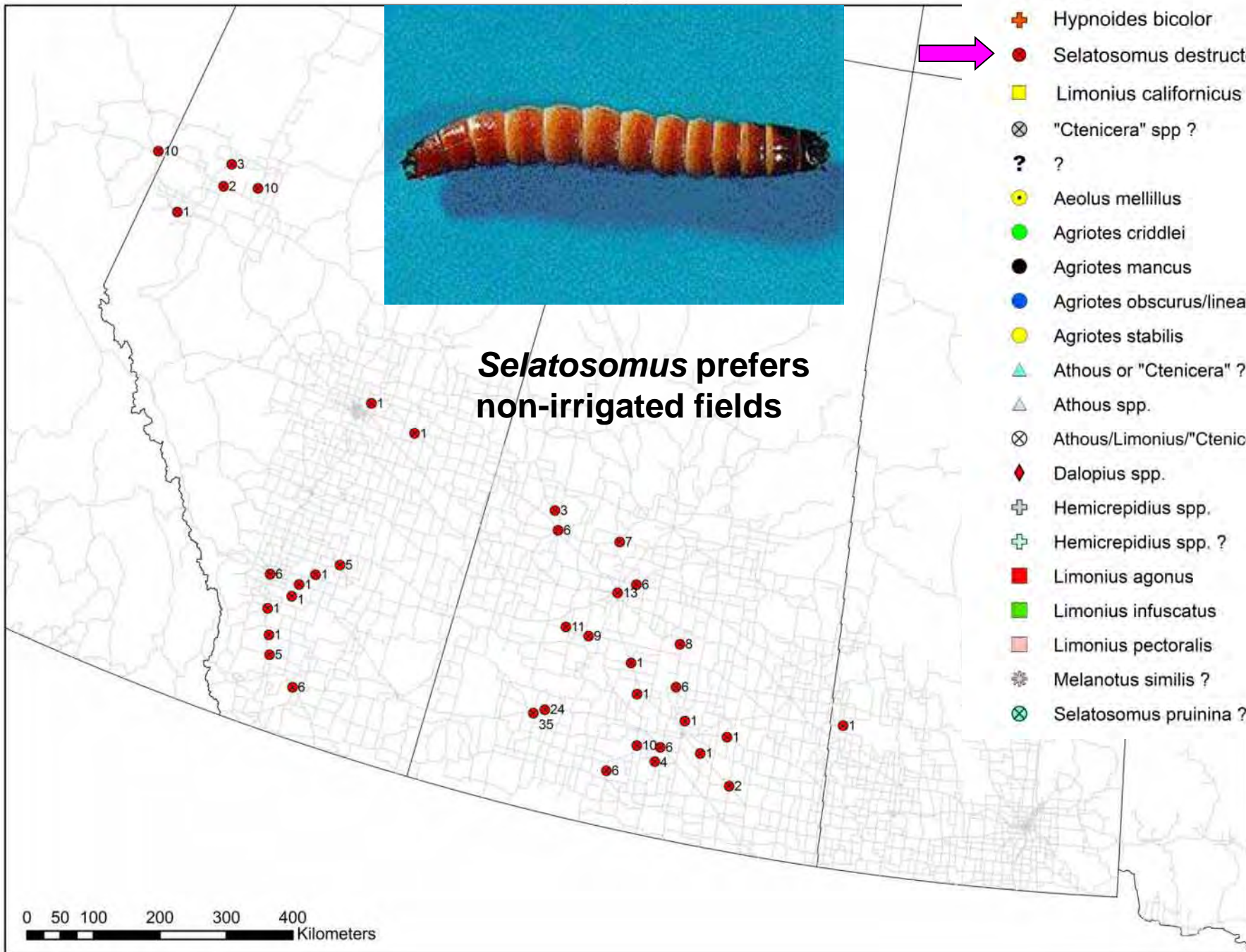
0 50 100 200 300 400
Kilometers

SPECIES

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- ✻ Melanotus similis ?
- ⊗ Selatosomus pruinina ?



***Selatosomus* prefers
non-irrigated fields**



0 50 100 200 300 400
Kilometers

SPECIES

- + Hypnoides bicolor
- Selatosomus destructor
- Limonius californicus
- ⊗ "Ctenicera" spp ?
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- Limonius agonus
- Limonius infuscatus
- Limonius pectoralis
- ✻ Melanotus similis ?
- ⊗ Selatosomus pruinina ?



***Limonius* prefers irrigated fields!!**

0 50 100 200 300 400
Kilometers

Results: overview (2010)

identifications by Dr. van Herk, Agassiz



	# wws	<i>Hypnoides bicolor</i>	<i>Selatosomus destructor</i>	<i>Limonius californicus</i>	Other
BC	68	7	10		51
AB	403	297	45	41	20
SK	589	366	163	39	21
MB	496	467	1		28
ON	75	7			68
QC	5				5

69.9%

13.4%

4.9%

11.8%

Results: overview (2010)



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69.9%

13.4%

4.9%

11.8%

– Main species in Alberta:

– *Hypnoides bicolor* (74% of total, 23 sites)



– *Selatosomus destructor* (11% of total, 16 sites)



– *Limonius californicus* (10% of total, 3 sites)



– So what?

– The two main species are radically different in size and obviously impact crops differently

Size does matter!!

Selatosomus destructor

(up to 2.5 cm)



Hypnoides bicolor

(up to 1.0 cm)



- Main species in Alberta:
 - *Hypnoides bicolor* (74% of total, 23 sites)
 - *Selatosomus destructor* (11% of total, 16 sites)
 - *Limonius californicus* (10% of total, 3 sites)
- So what?
- The two main species are radically different in size and obviously impact crops differently
- Lots of Unknowns:
 - What is their susceptibility to new insecticides? Little info.
 - Feeding abilities/amounts, crops damaged? Little info.
 - Behaviour, repellency, life history? Little info.

Survey plans for 2011 and beyond:

- Continue with survey as in 2010 with assistance from industry and growers.
- In Spring, need to know sites where wws are present in high #s to collect for Agassiz.

Selastomus destructor,
Hypnoides bicolor and
Limonius californicus.



- Focus on new field work in prairies will be on these 3 species.

-Vauxhall/Taber/Saskatoon/Winnipeg (wheat and/or pots.)

-Hector Carcamo & Ian Wise (AAFC), Doug Waterer (U of S)

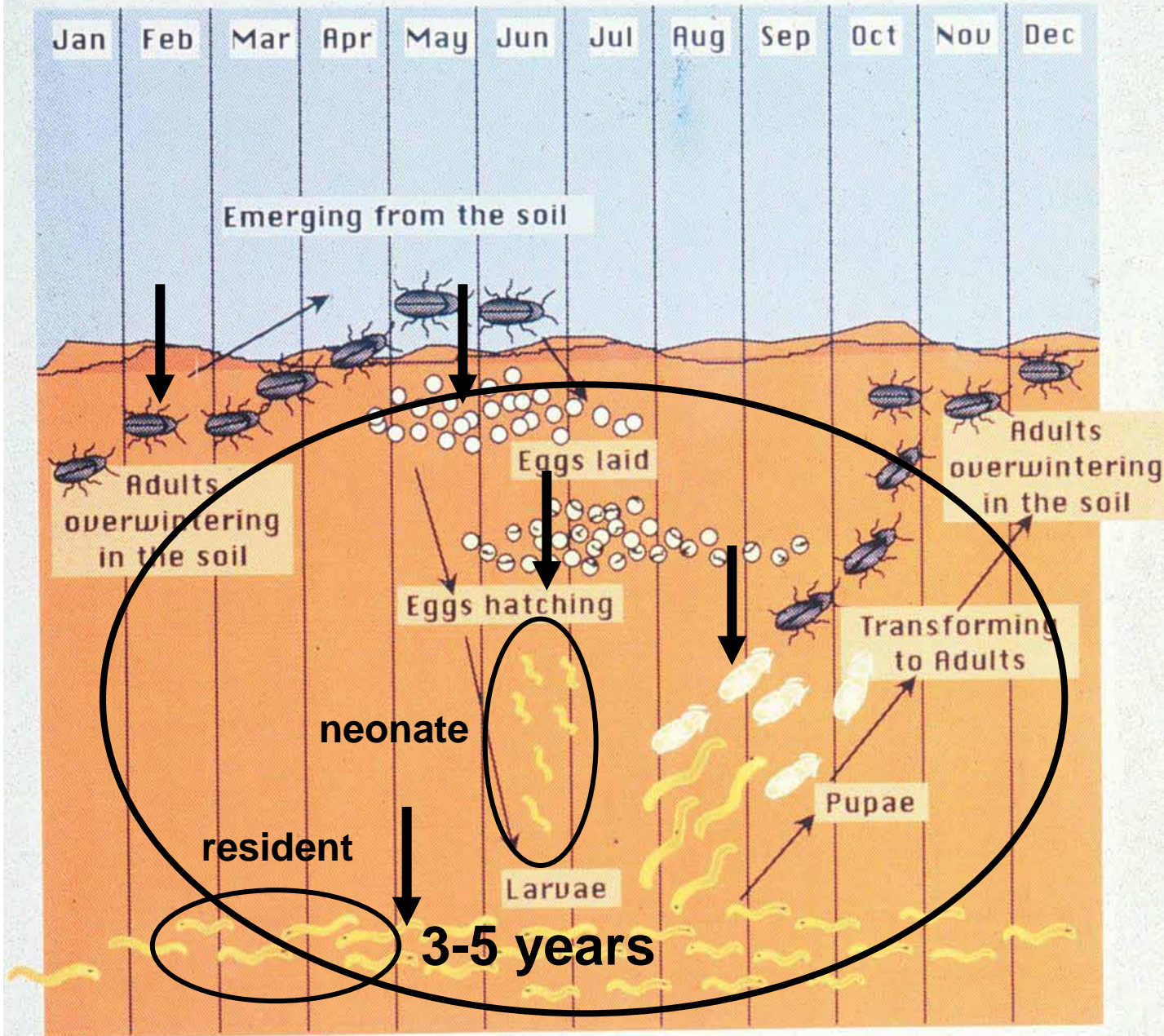
Setting the stage:

-Wireworms:

- about 30 economic species in Can.
- typically live for 3-5 years in soil



Life Cycle of Click Beetles



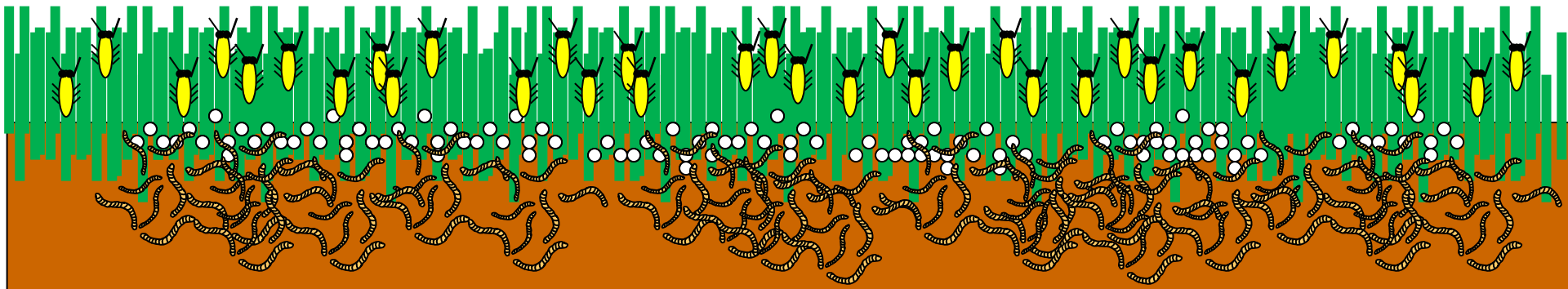
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- typically live for 3-5 years in soil
- populations may be > 3 million/ha



Wireworm Life History: Important Information to Know



Click Beetles enter grassy fields, cereal crops, etc. in April, May and June.

Eggs are laid in soil, and hatch within 3 weeks.

Larvae feed on roots of grassy hosts or most other crops for 3-5 years.

The longer a field is in cereals or pasture, the higher the population.

Setting the stage:

-Wireworms:

- about 30 economic species in Can.
- typically live for 3-5 years in soil
- populations may be > 3 million/ha
- attack most economic crops
 - cereals and grasses preferred



Setting the stage:

-Wireworms:

- about 30 economic species in Can.
- typically live for 3-5 years in soil
- populations may be > 3 million/ha
- attack most economic crops
- populations & damage growing



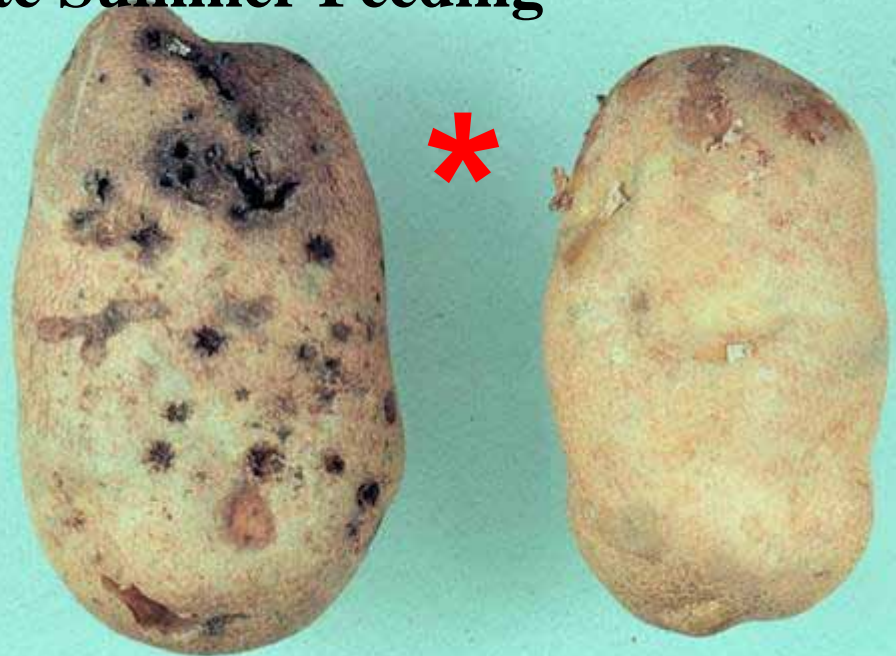


Damage in Corn
Agriotes obscurus



Damage in wheat:
Ctenicera destructor

Feeding Early in Tuber (Late Summer Feeding)



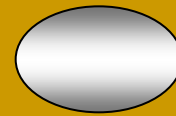
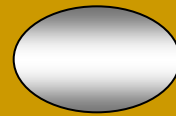
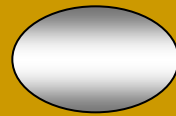
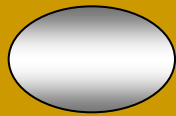
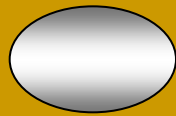
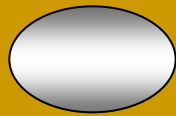
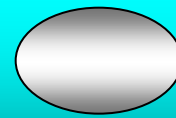
Setting the stage:

-Wireworms:

- about 30 economic species in Can.
- typically live for 3-5 years in soil
- populations may be > 3 million/ha
- attack most economic crops
- populations & damage growing
- Wireworms attracted by CO₂



Untreated wheat seed



CO₂
CO₂
CO₂
CO₂

CO₂
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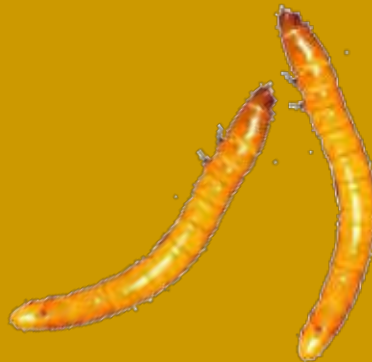
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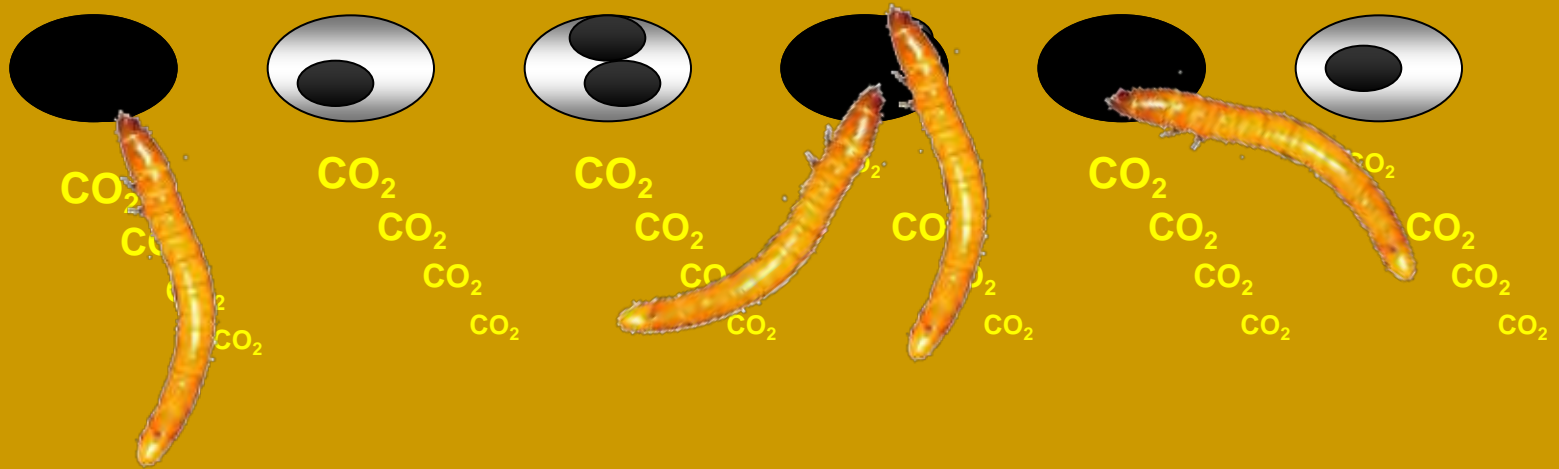
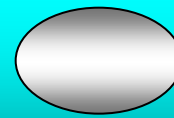
Wireworms are attracted to CO₂!!!!



Resident
wireworms
'large'



Untreated wheat seed



*A wireworm can easily consume 2 or more seeds. They also eat roots and other below-ground parts later.

WIREWORM ARSENAL:

CANADA

THIMET: GONE 2012

TEMIK: LONG GONE

MOCAP: NEVER REG.

DY

FURADAN: GONE

CHLORPYRIFOS: MU

COUNTER: GONE

LINDANE: GONE

U.S.A.

THIMET: STILL AVAIL.

TEMIK: STILL AVAIL.

MOCAP: STILL AVAIL.

All kill wireworms!!!

FURADAN: GONE

CHLORPYRIFOS: NOT REG

COUNTER STILL AVAIL.

LINDANE: GONE

CANADA

THIMET: GONE 2012

TEMIK: LONG GONE

MOCAP: NEVER REG.

DYFONATE: GONE

FURADAN: GONE

CHLORPYRIFOS: BC

COUNTER: GONE

Won't kill wireworms!!!

NEONICOTINOIDS: NEW

U.S.A.

THIMET: STILL AVAIL.

TEMIK: STILL AVAIL.

MOCAP: STILL AVAIL.

DYFONATE: GONE

FURADAN: STILL AVAIL.

CHLORPYRIFOS: NOT REG

COUNTER STILL AVAIL.

LINDANE: GONE

FIPRONIL: POTATOES.

CAPTURE: POTs.

Wireworm Insecticide Research

Wheat Trials

- Great study crop
- Easy to work with
- Major crop in Canada

Laboratory Trials

Field Trials

Multi-species
Lab Toxicity and
Repellency Trials



POTTER SPRAY TOWER
AAFC, LONDON, ONT.
Dr. Jeff Tolman



LC₅₀S
LT₅₀S



Wireworm health examined weekly for up to 300 days

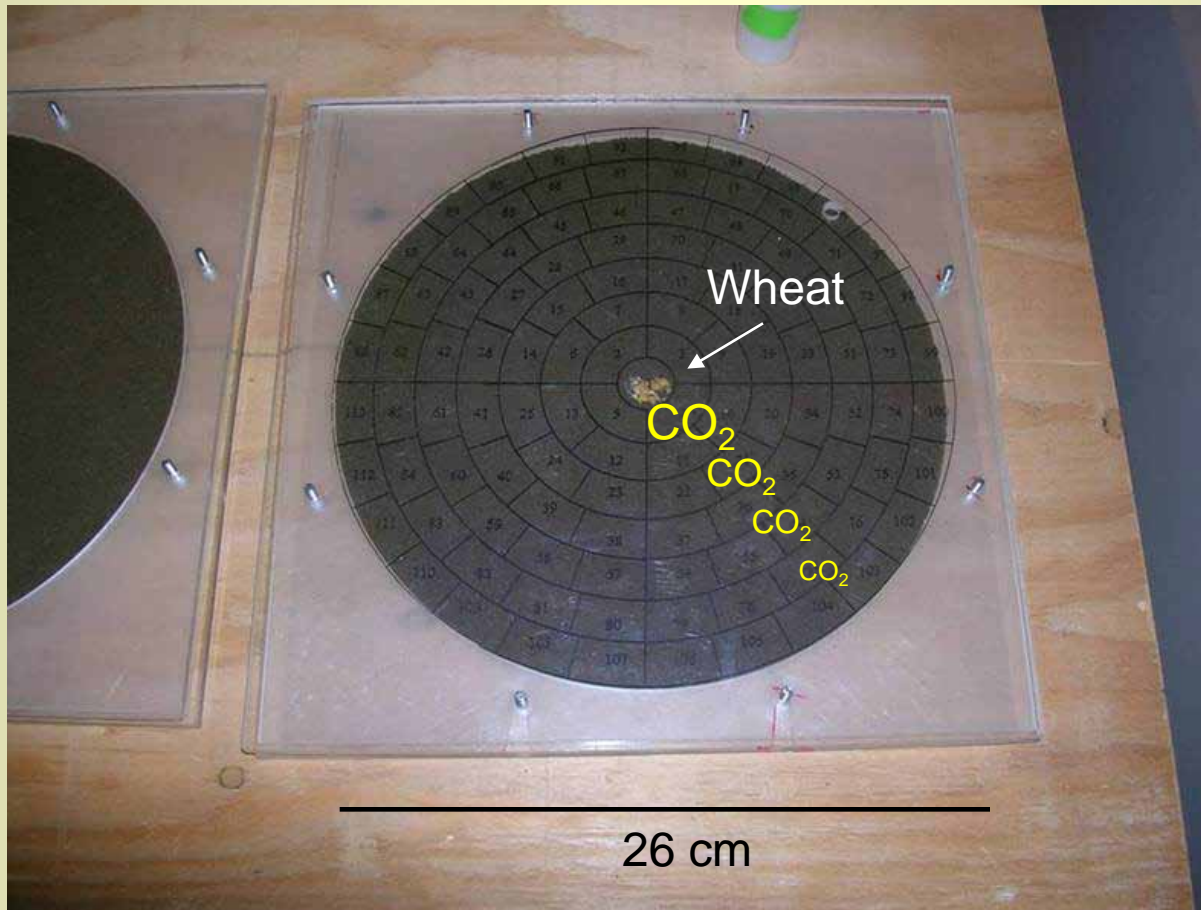


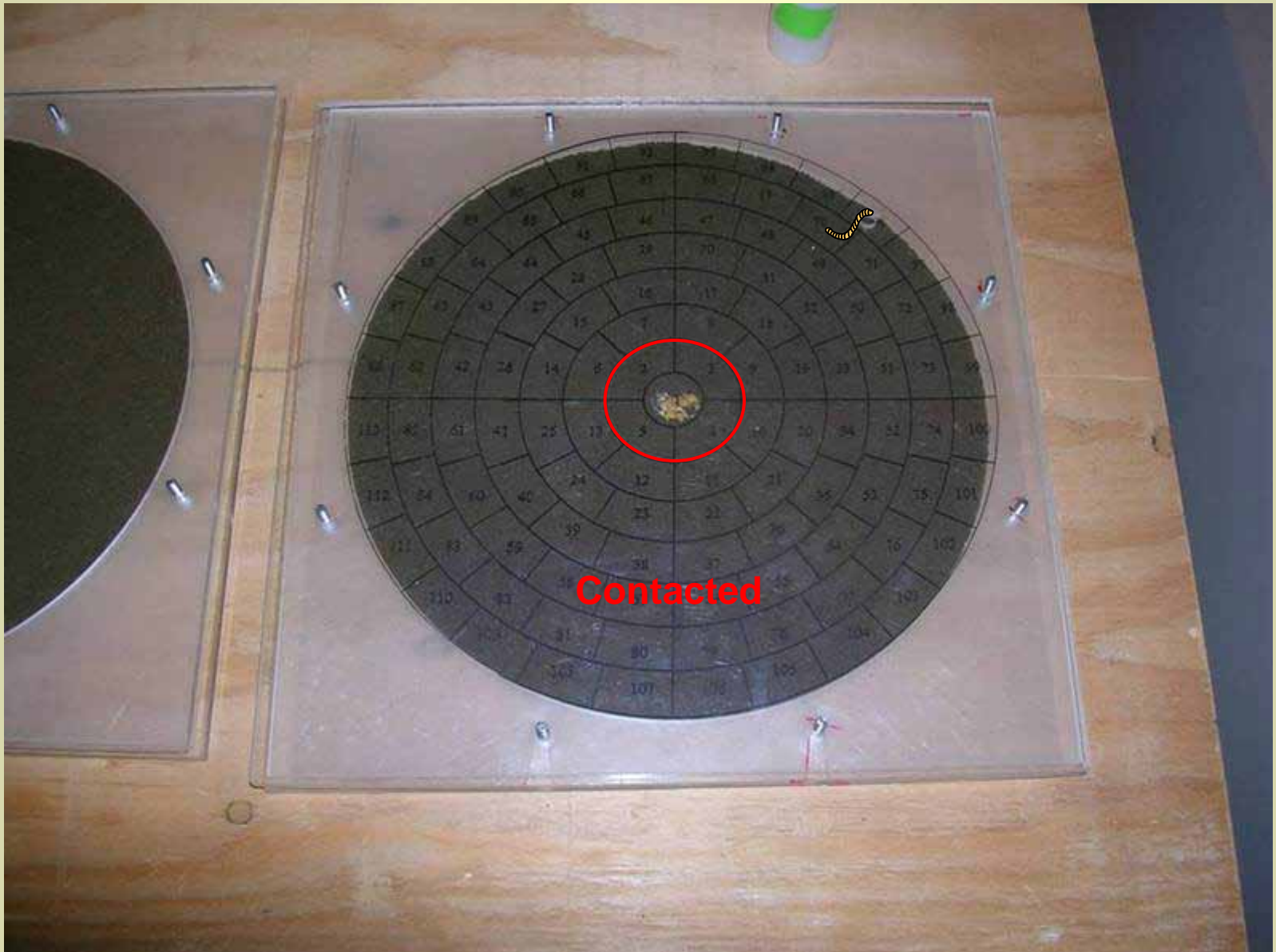
Routine Health Checks:

- Categories of health:
 - *Alive*: can move out of 10cm circle in Petri dish
 - *Writhing*: full body movement, but uncontrolled
 - *Leg & Mandibles*: no visible movement except legs & mandibles
 - *Mandibles*: no visible movement except mandibles
 - *Dead*: decomposing, moldy
- Some "*Mandibles*" wireworms, which appear dead, are capable of full recovery, hence what we term the '*Lazarus Syndrome*'.

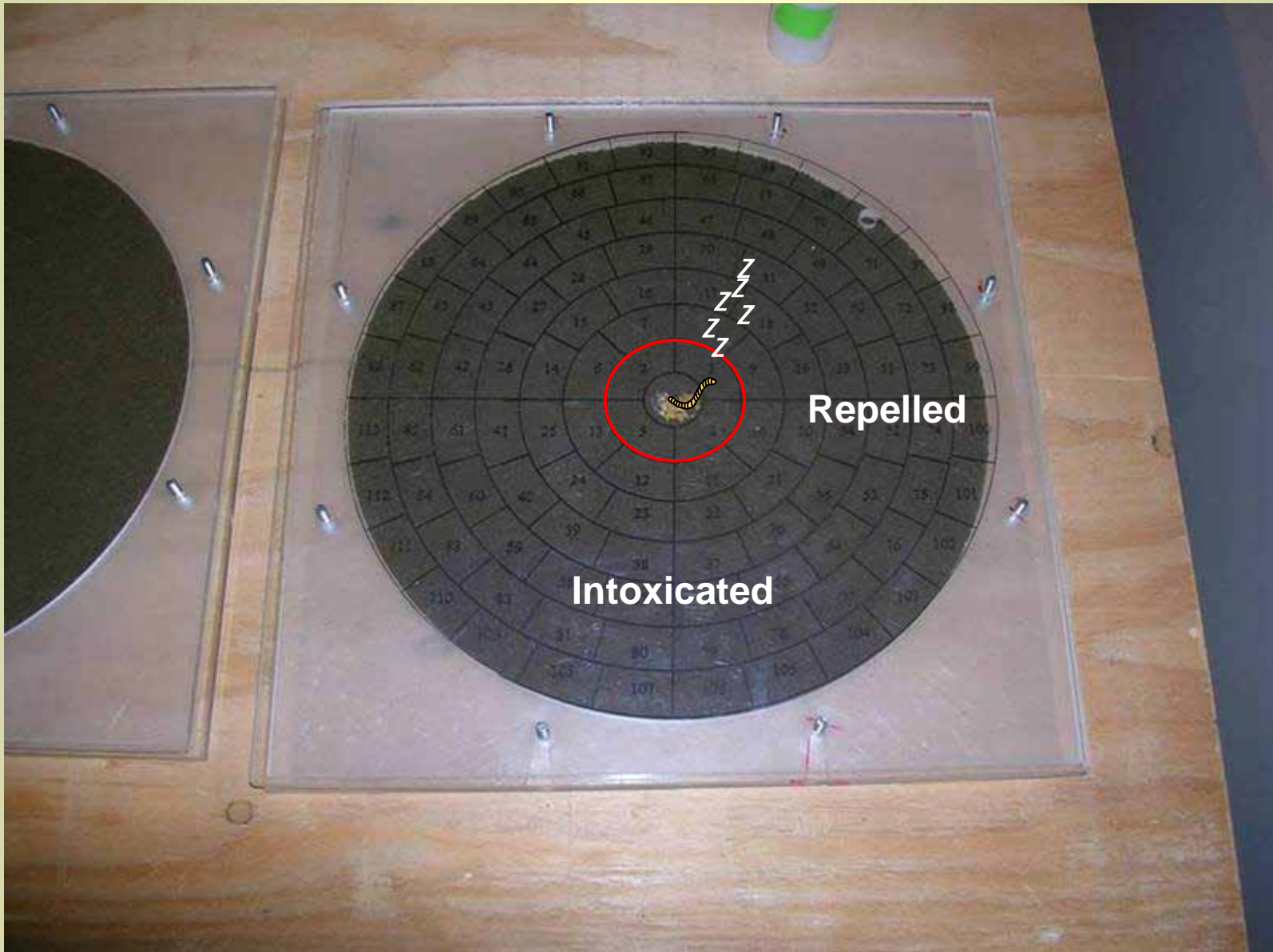
Laboratory Repellency Studies

- Soil bioassays ‘Volatiles, contact, ingestion’





Contacted



Wireworm Management Research

Wheat Trials
-Great study crop
-Easy to work with
-Major crop in Canada

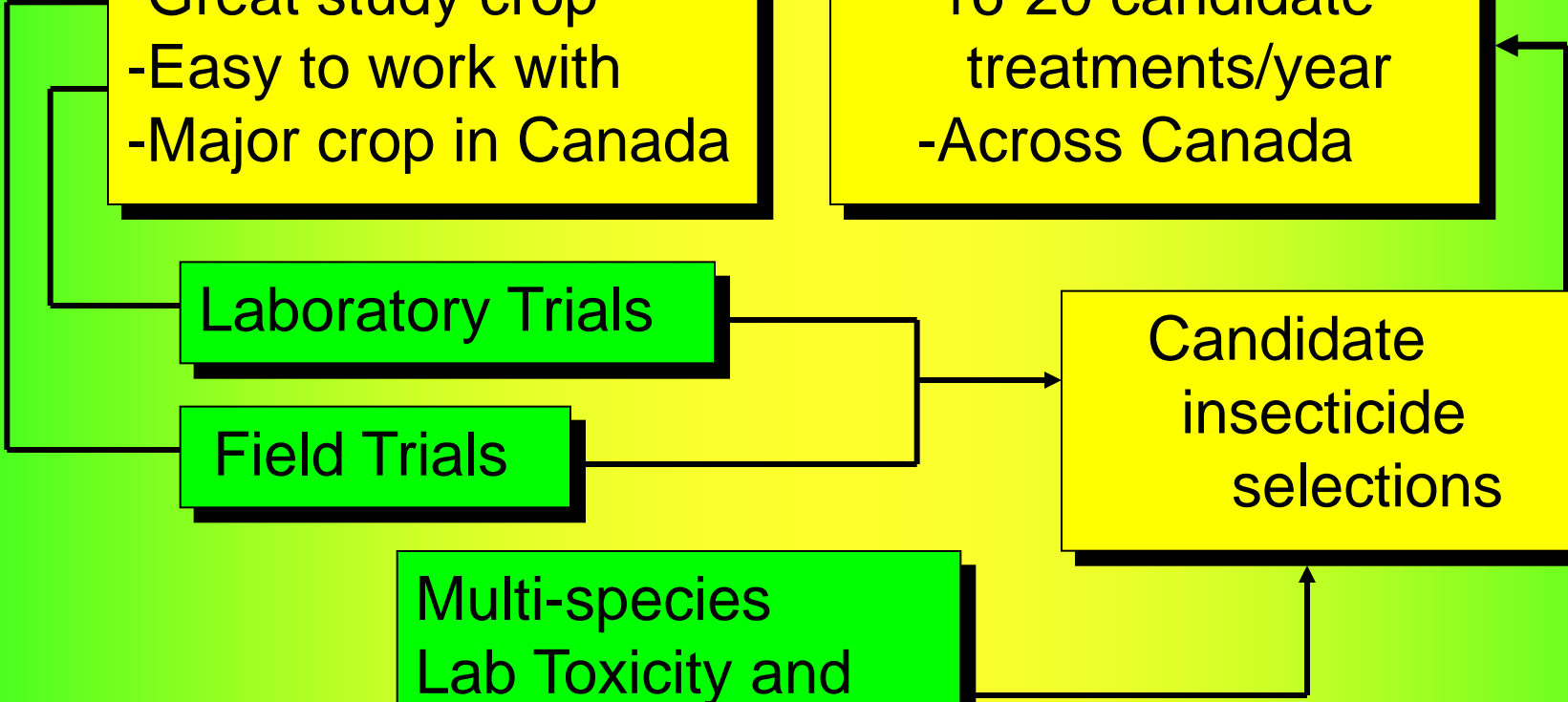
Potato Trials
-16-20 candidate treatments/year
-Across Canada

Laboratory Trials

Field Trials

Multi-species Lab Toxicity and Repellency Trials

Candidate insecticide selections

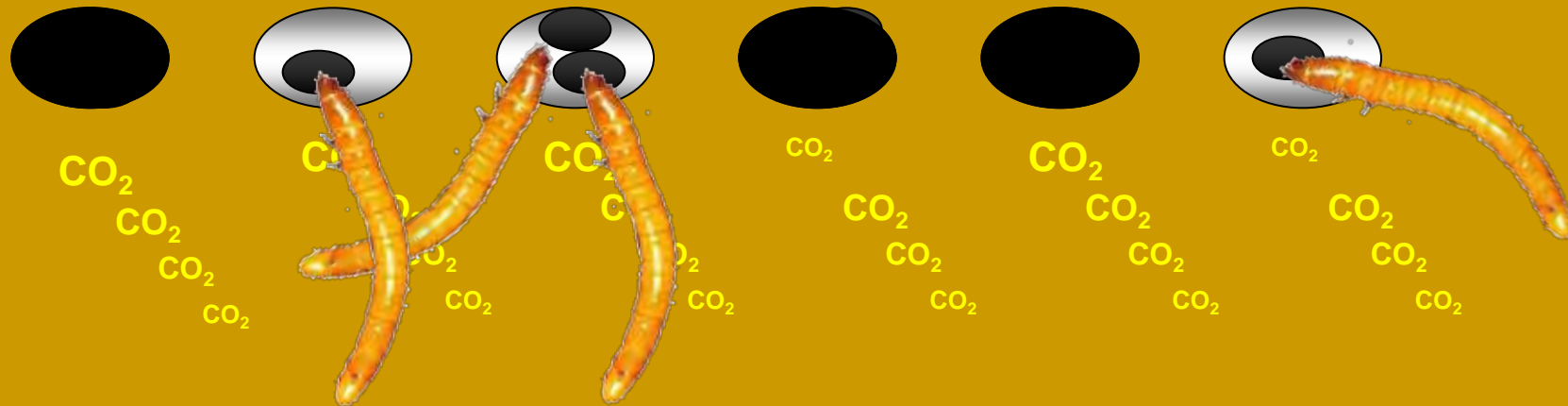
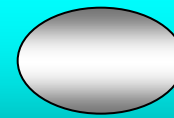


What have we discovered?

WHEAT



Untreated wheat seed



*Questions:

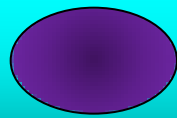
- *Can wireworm **DAMAGE** be controlled with seed treatments?
- *Can wireworms actually be **KILLED** with seed treatments?

Cereal Seed Tmts: “PAST”

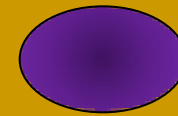
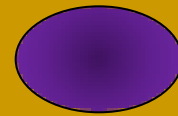
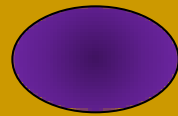
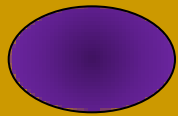
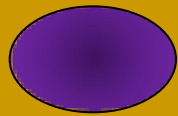
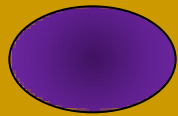
- Lindane (Vitavax) seed treatment used
- Provided good stand protection AND...
- Killed wireworms quite effectively
(3 or 4 years)
- BUT!!!
- Banned in NA in 2004.



Lindane
(Organochlorine)



60g AI/100kg seed



CO₂
CO₂
CO₂
CO₂

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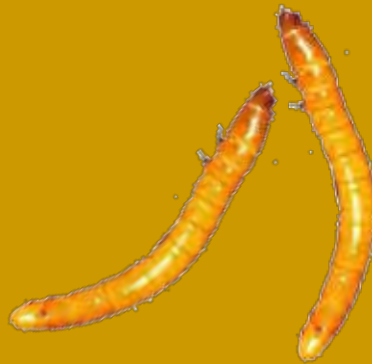
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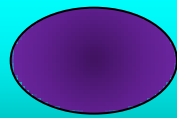
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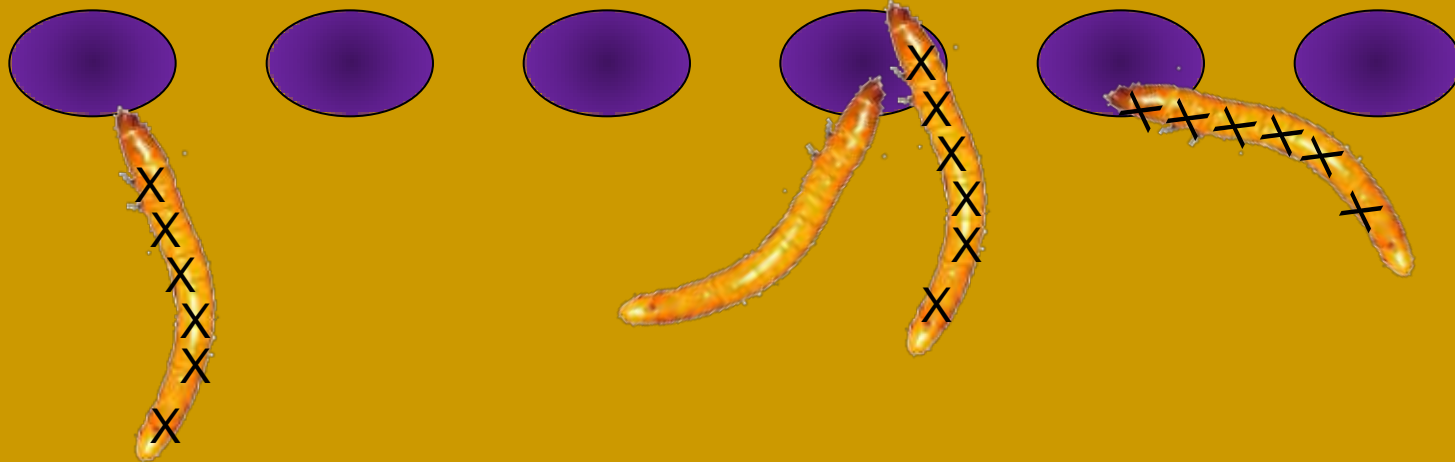
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Lindane
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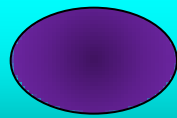


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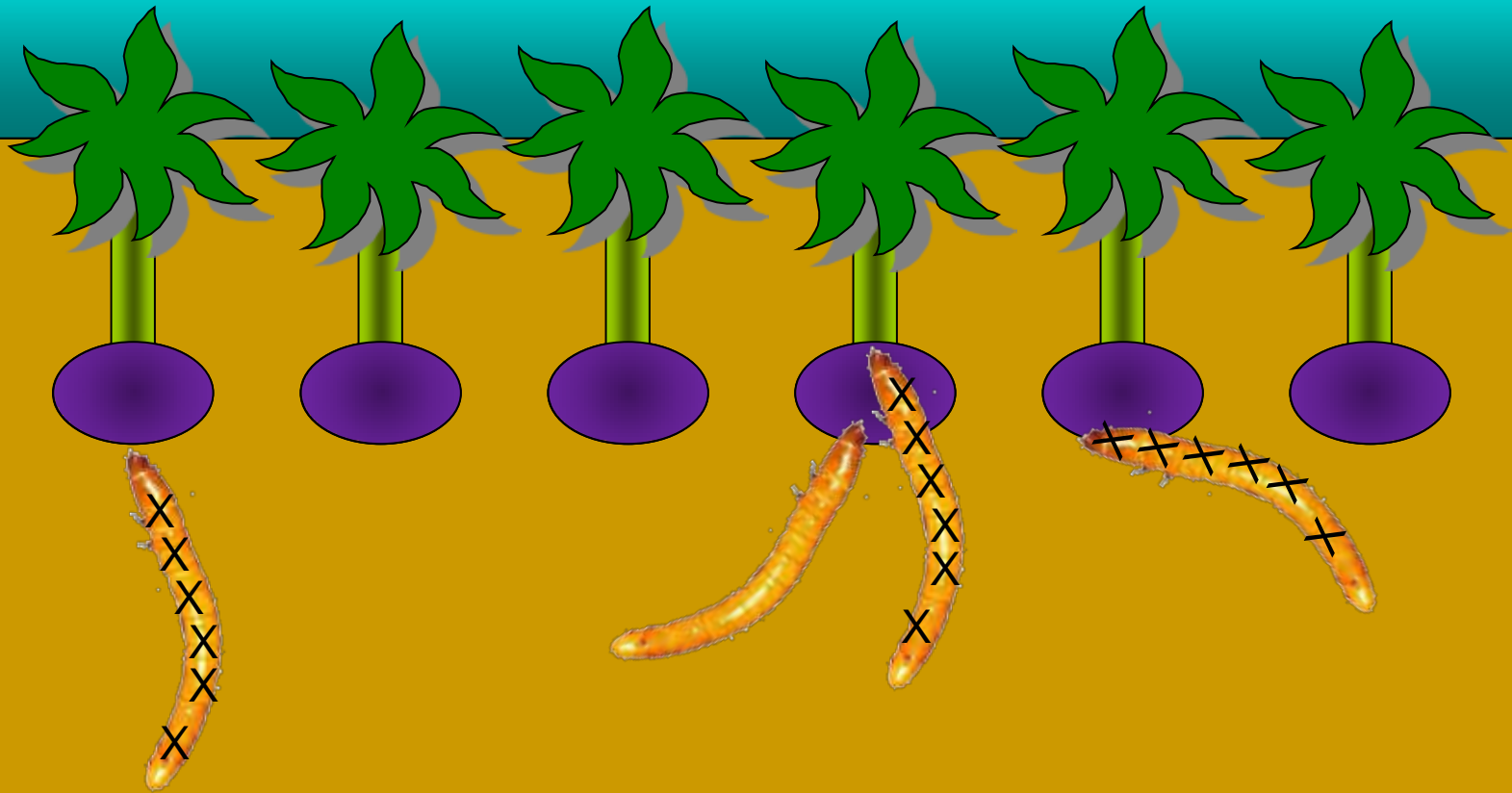


Wireworms feed and die within a month or so
-65-70% of residents die during growing season

Lindane

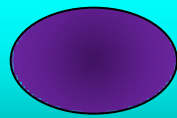


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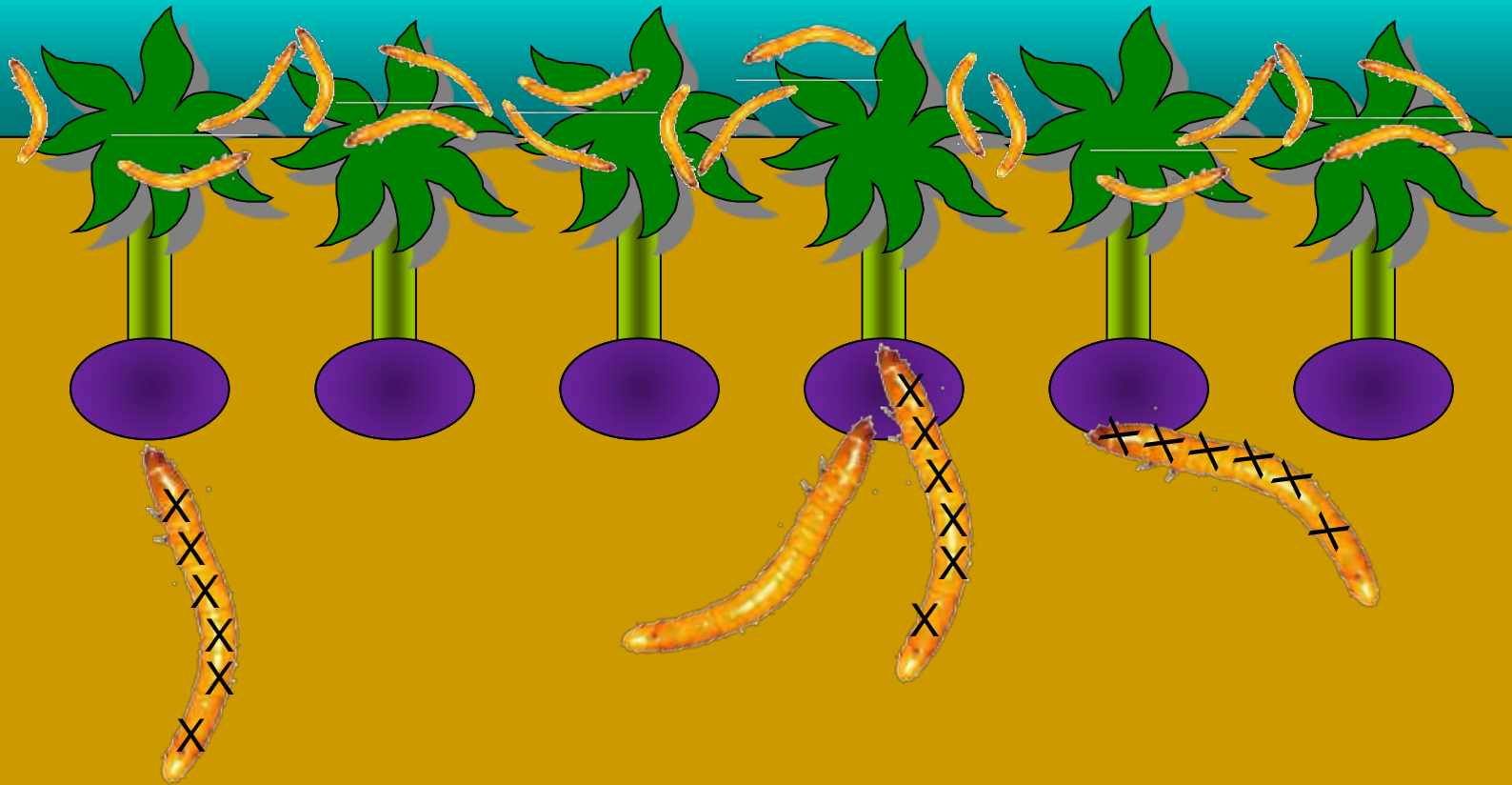


*Wireworms are dying or dead while crop establishes

Lindane

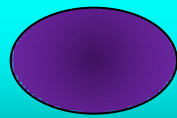


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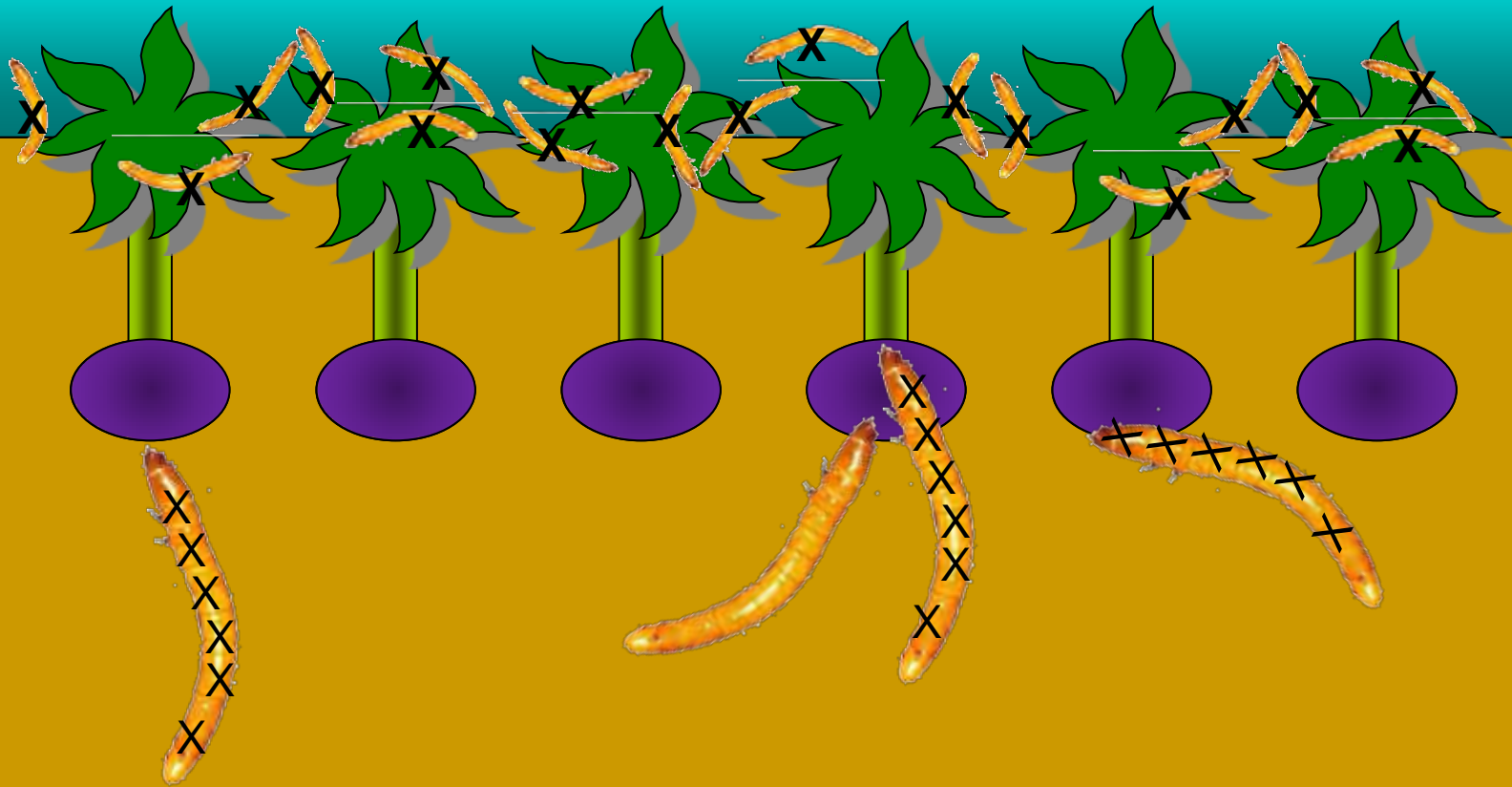


Around mid summer, click beetles lay eggs in wheat and neonate wireworms are produced.

Lindane



60g AI/100kg seed

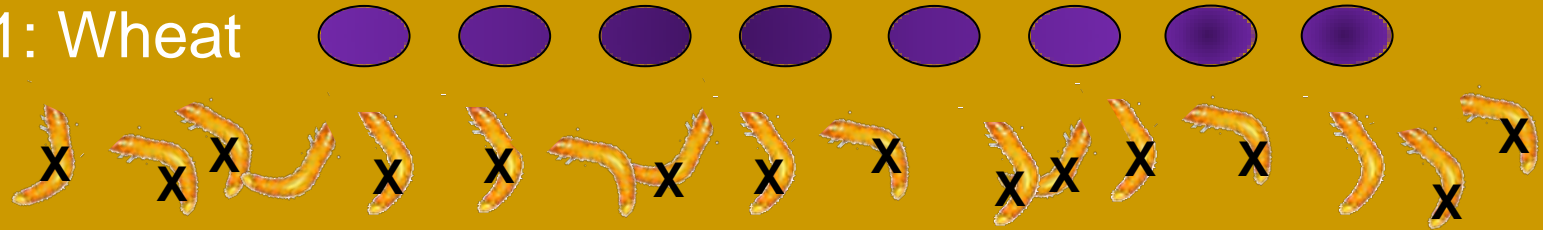


Lindane also kills neonate wireworms!!!
> 85% reduction in 7 field studies.

Wireworm populations would not recover to
damaging levels for 3+ years!!

Why control for 3+ Years?

Year 1: Wheat



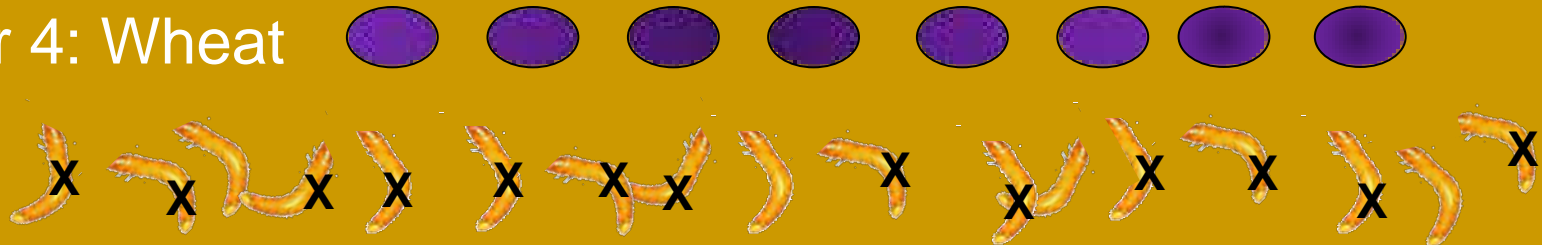
Year 2: Potatoes; canola; pulse crops.

- No WWs

Year 3: Wheat; potatoes; canola; pulse crops.

- Few, small WWs.

Year 4: Wheat



Candidate Insecticides for Canada:

Neonicotinoids:

clothianidin (Poncho, Titan)

thiamethoxam (Actara, Cruiser Maxx)

imidacloprid (Gaucha, Raxil ww).

Synthetic pyrethroids:

tefluthrin (Force); bifenthrin (Capture)

lambda cyhalothrin (Matador).

Phenyl pyrazole:

fipronil (Regent).



Wheat field trials since 1996

-Agassiz

-*Agriotes obscurus*



Plot preparation

- Roundup in March
- Field disced, not ploughed
- Clods removed

20 08 2007

Preformed furrows

No CO2!!!!

Does crop protection
=
Wireworm Mortality?

Precision seeding by hand

Weekly counts

Resident wws



Harvest Yield

neonates

28 08 2007

1 year later



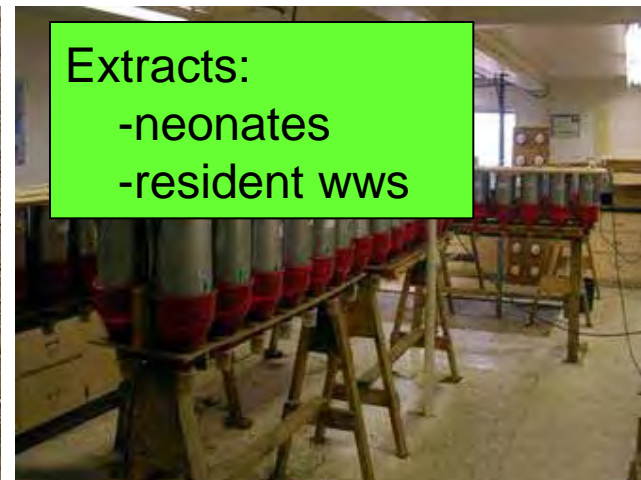
Bait Traps Installed: 4/plot

Extracts:

- neonates
- resident wws



20 08 2007



What have we discovered?

Neonicotinoids:

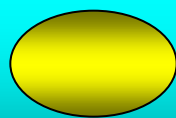
Clothianidin (Poncho)

Thiamethoxam (Cruiser Maxx)

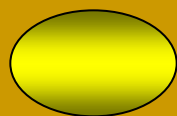
Imidacloprid (Raxil ww)



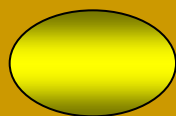
Neonicotinoid



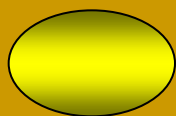
10-30g AI/100kg seed



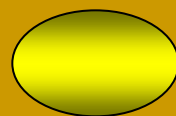
CO₂
CO₂
CO₂
CO₂



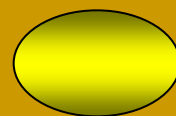
CO₂
CO₂
CO₂
CO₂



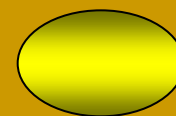
CO₂
CO₂
CO₂
CO₂



CO₂
CO₂
CO₂
CO₂



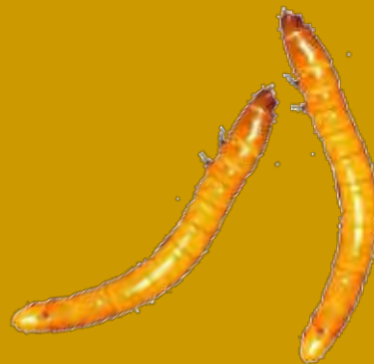
CO₂
CO₂
CO₂
CO₂



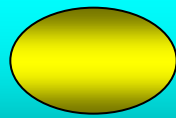
CO₂
CO₂
CO₂
CO₂



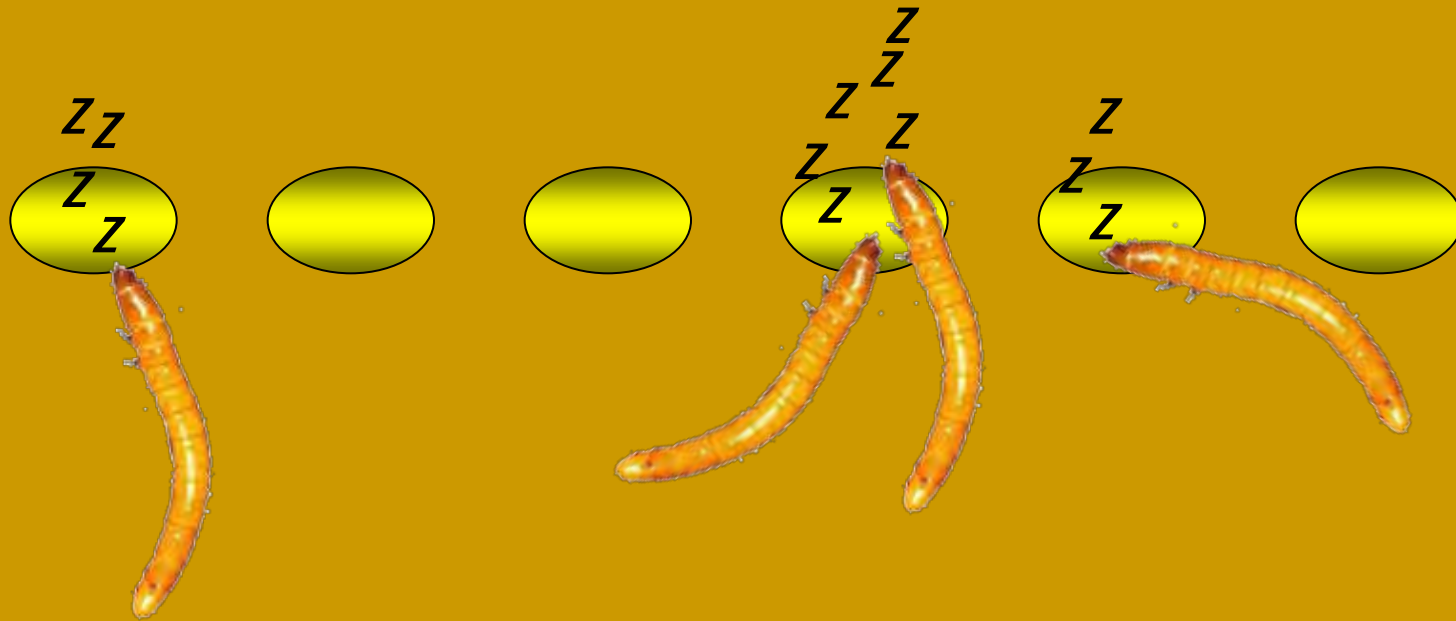
Resident
wireworms
'large'



Neonicotinoid

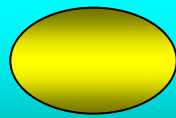


10-30g AI/100kg seed

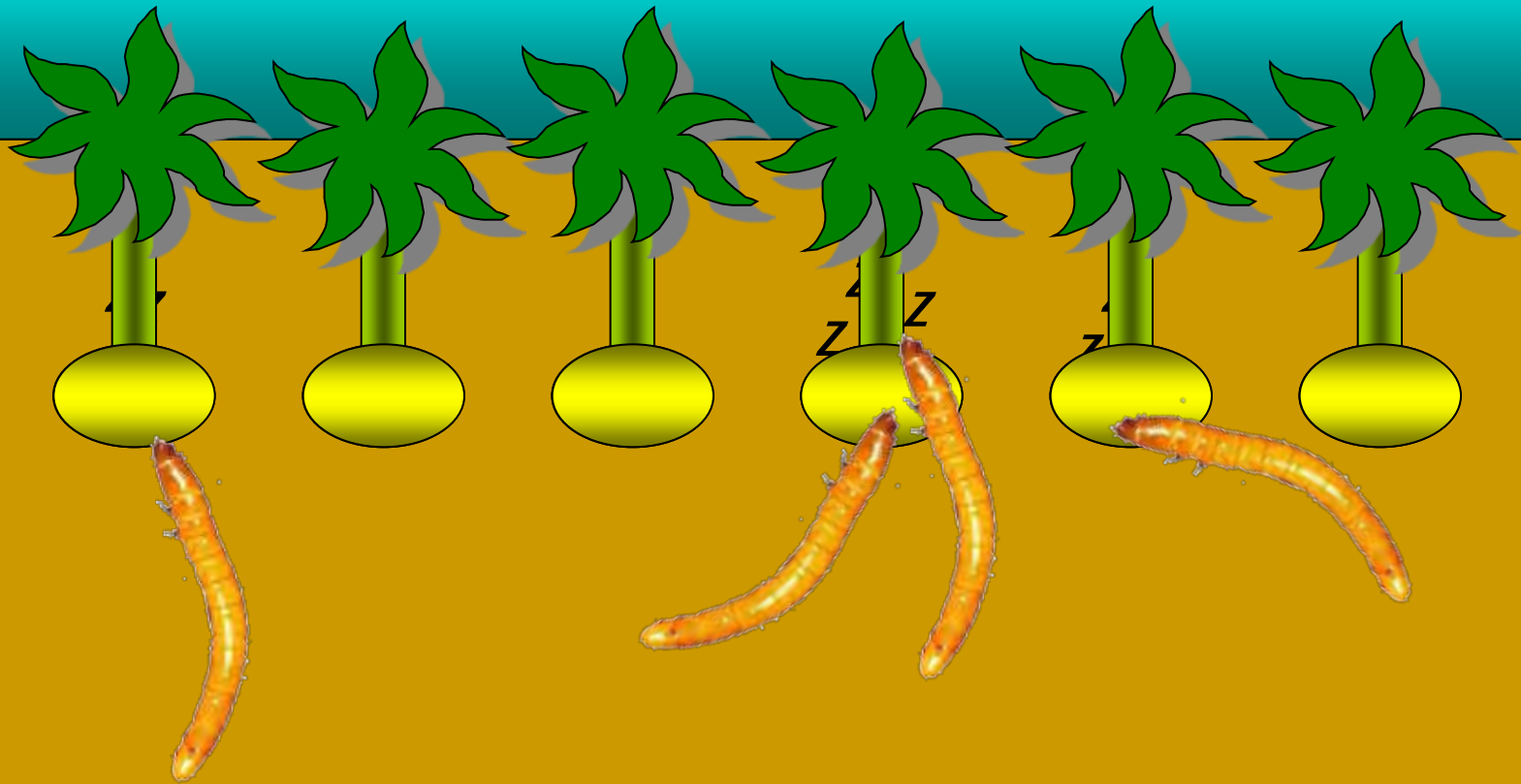


*Wireworms rapidly become intoxicated/moribund

Neonicotinoid



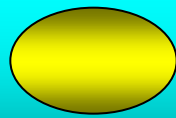
10-30g AI/100kg seed



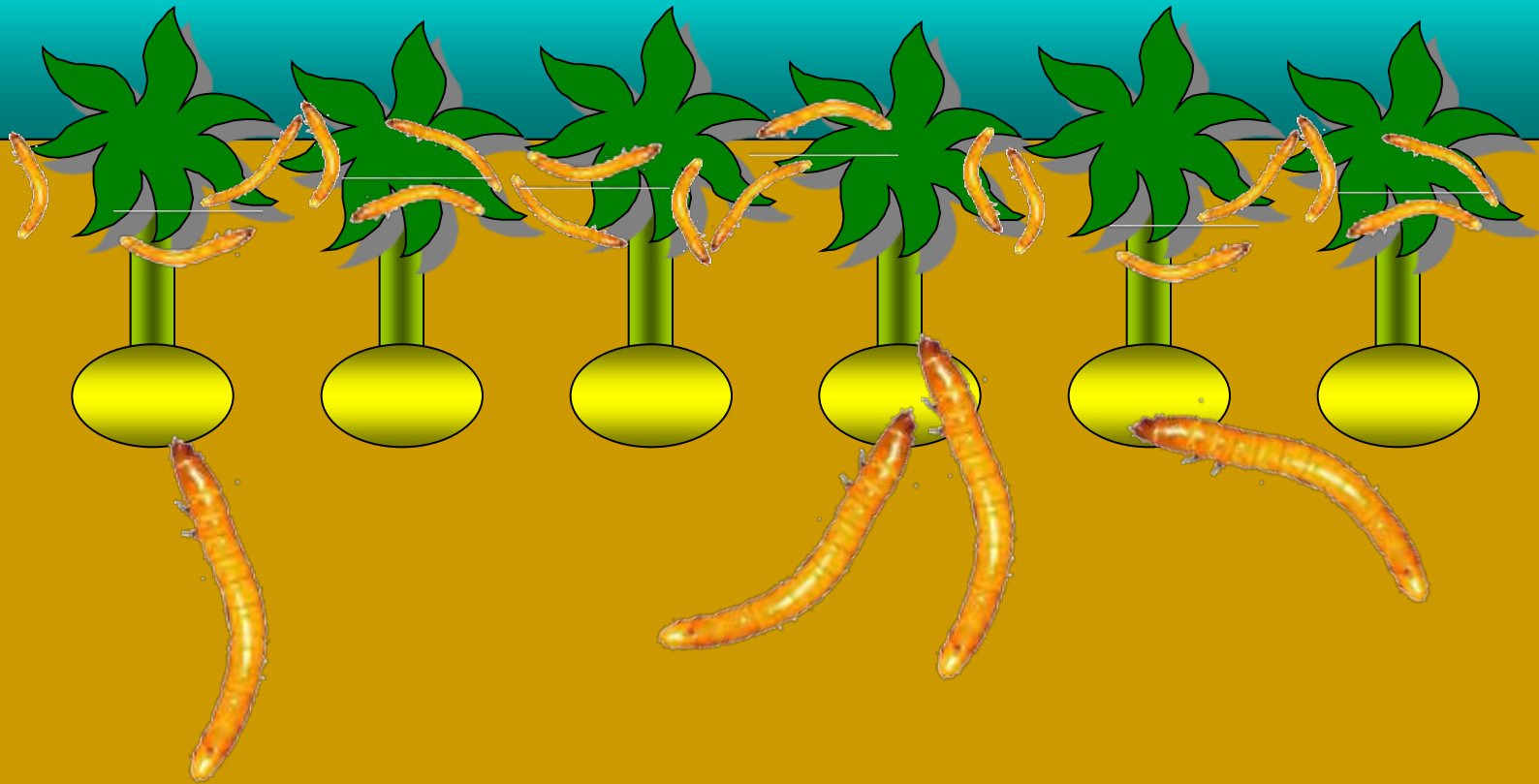
*Wireworms are intoxicated while crop establishes

*Most wireworms recover fully by mid-summer

Neonicotinoid



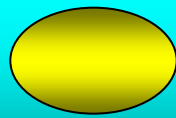
10-30g AI/100kg seed



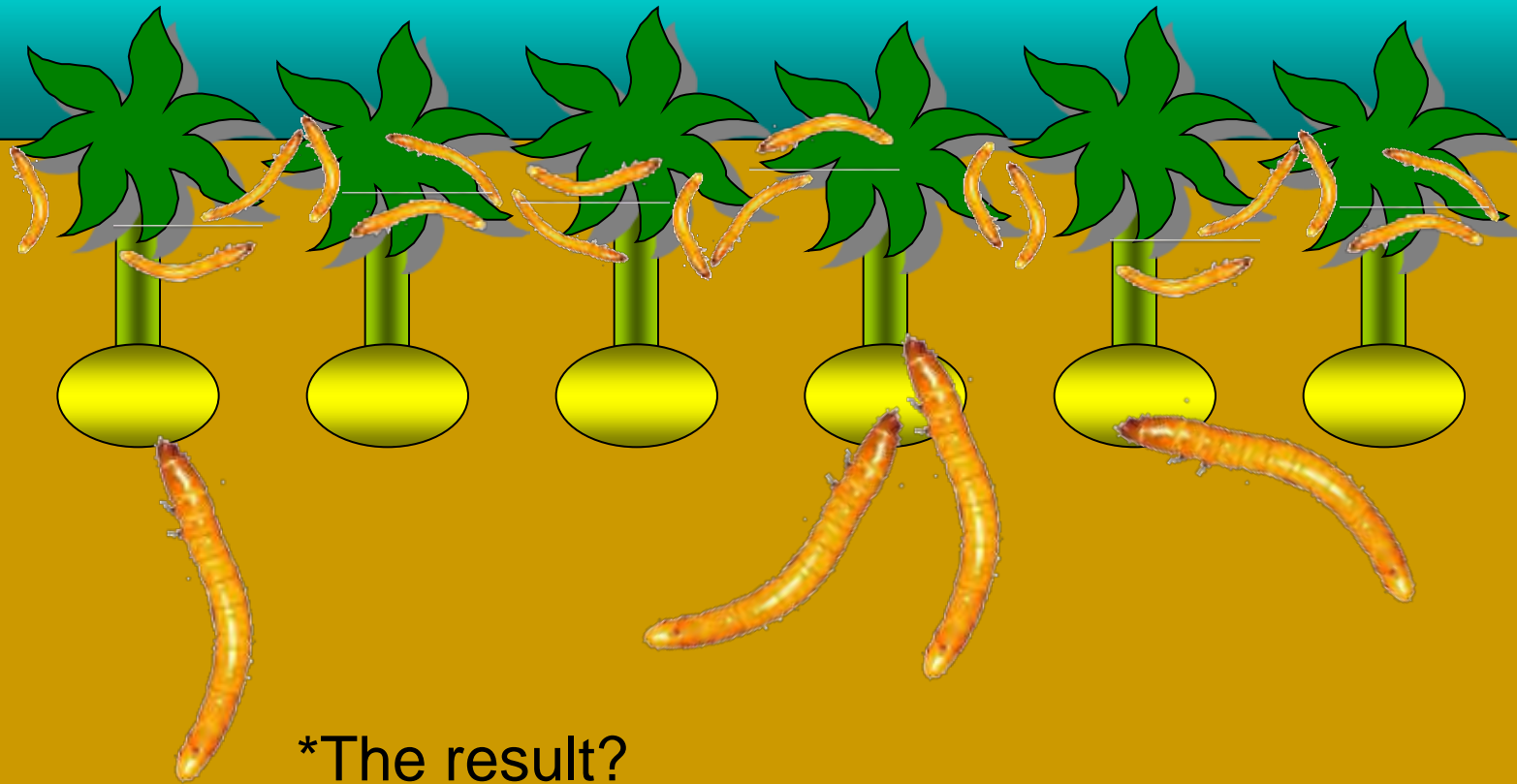
Early to mid summer, click beetles lay eggs in wheat and neonate wireworms are produced.

BUT, no kill of neonates occurs with neonicotinoids.

Neonicotinoid



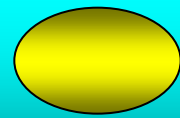
10-30g AI/100kg seed



*The result?

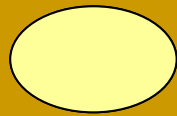
- Great crop establishment and yield, BUT.....
- Little reduction in resident wws and no reduction of neonates
- Wireworms are there the next year
- True for all neonicotinoids tested

Neonicotinoid

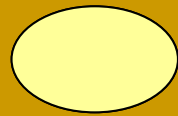


10-30g AI/100kg seed

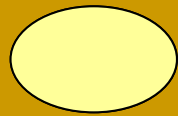
Effectiveness is reduced if germination delayed, since insecticide levels drop over time.



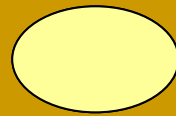
CO₂
CO₂
CO₂
CO₂



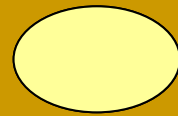
CO₂
CO₂
CO₂
CO₂



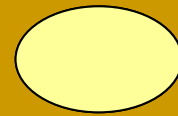
CO₂
CO₂
CO₂
CO₂



CO₂
CO₂
CO₂
CO₂



CO₂
CO₂
CO₂
CO₂

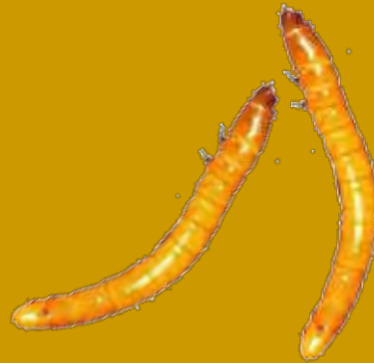


CO₂
CO₂
CO₂
CO₂

Wireworms most active at near or > 10 C in soil!!!



Resident
wireworms
'large'



Candidate Insecticides for Canada: What have we discovered?

Synthetic pyrethroids:

- tefluthrin (FORCE)
- bifenthrin (Capture)
- lambda cyhalothrin (Matador)

All are repulsive, not lethal
to wireworms

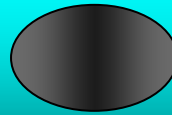


What have we discovered?

Phenyl pyrazole:
-fipronil (Regent)



Fipronil
(phenyl pyrazol)



50 g AI/100kg seed



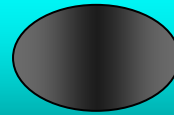
Rapidly kills resident wireworms!!!

100% reduction in two field studies

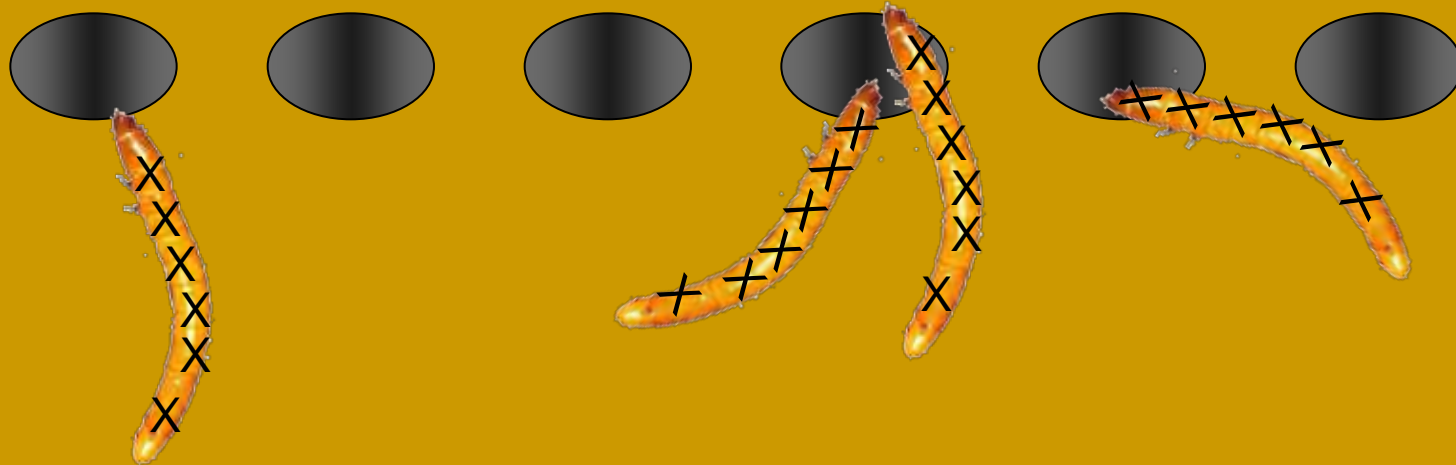
Also kills neonate wireworms later on!!!

100% reduction in two field studies

Fipronil
(phenyl pyrazol)

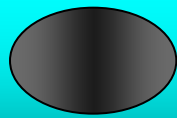


1g AI/100kg seed

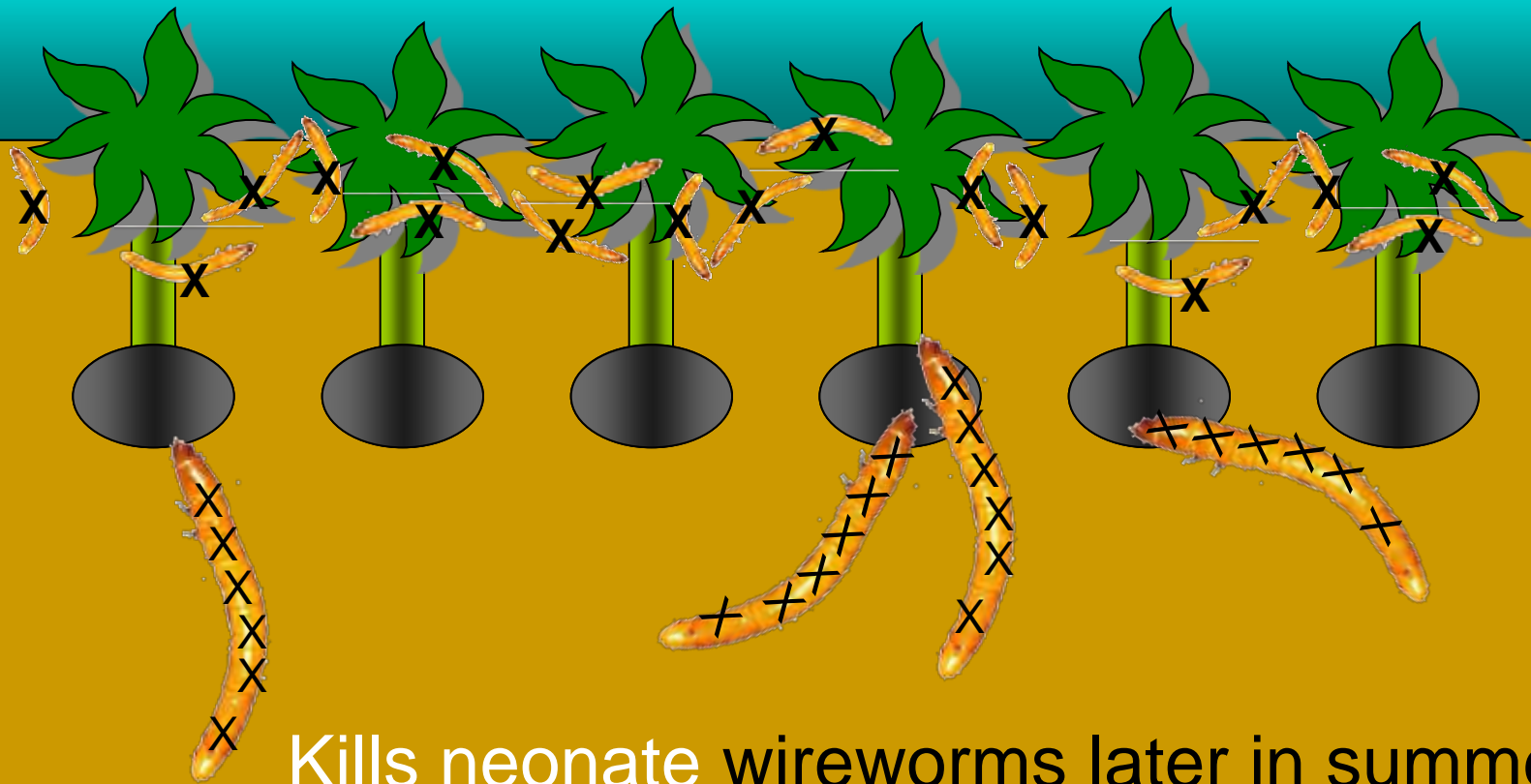


Latently kills resident wireworms!!!
> 90% reduction in two 2008/09 studies

Fipronil



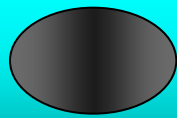
1.0g AI/100kg wheat



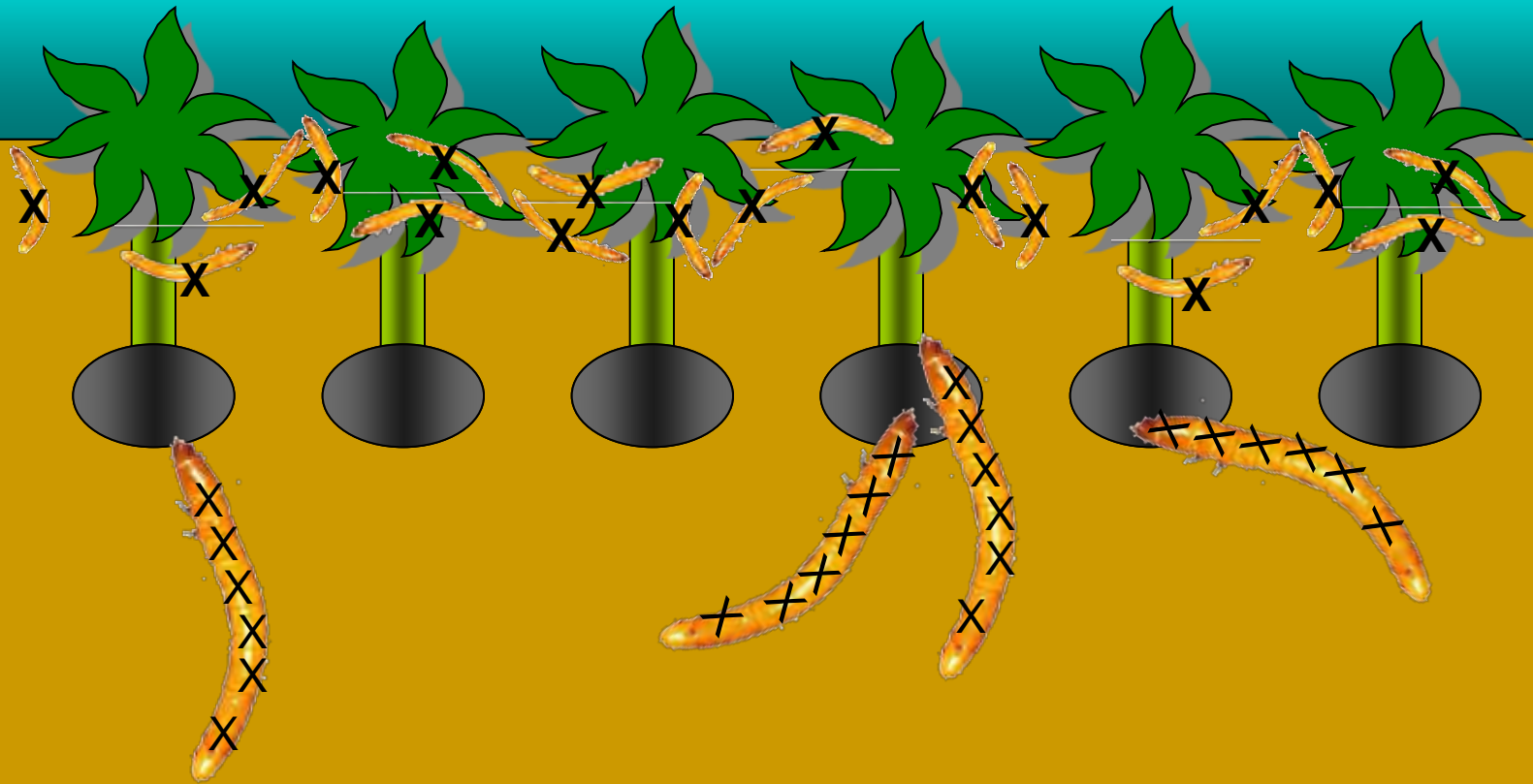
Kills neonate wireworms later in summer!!!
> 92% reduction in two 2008/09 studies

Wireworm populations will not recover to
damaging levels for 3+ years, just like Vitavax!!!!

Fipronil



1.0g AI/100kg wheat



BUT....

Wheat stand not optimal with fipronil
at 1.0g AI/100kg wheat!!

Sooooo

How do we accomplish both goals of:

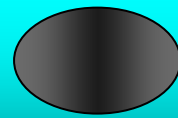
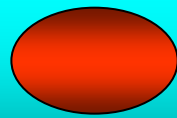
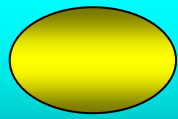
a) Protecting a wheat seed from damage

AND

b) Killing wireworms?



Thiamethoxam
(10g AI/100kg)



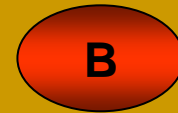
Fipronil
(1g AI/100kg)

Thiamethoxam + Fipronil BLEND

Thiamethoxam + Fipronil BLEND

10g

1g



- Excellent wheat stand (vigour effects).
- Excellent kill of **resident** and **neonate** wws.
- WW pops will not recover for 3+ years
- Proven over 3 years of field trials.

Cereal Seed Tmts: “PRESENT”

Neonicotinoids:

Thiamethoxam (Cruiser Maxx)

Imidacloprid (Raxil ww)

- Provide current season damage protection
- Probably no wireworm population reduction
- Work best in soil temperatures favouring both rapid germination and high wireworm activity.



Cereal Seed Tmts: “FUTURE”

Neonicotinoid + Fipronil Blends (?)

- Requires registration of fipronil in Canada
- Will work on all wireworm species
- New methods being developed where fipronil will kill most wireworms with less than 1 gram/ha.

New insecticides are tested every year.



Special thanks to:

- Agriculture and Agri-Food Canada, National Wireworm Project
- Pest Management Centre, AAFC.
- BC Potato Industry Development Committee
- Potato Growers of Alberta
- Syngenta CropProtection Inc.
- Bayer CropScience, Inc.
- FMC and other industry collaborators
- A horde of eager summer students.