Maggot mayhem: How to protect onions from maggots in an era without Lorsban?

National Allium Research Conference
November 30, 2023

Brian A. Nault
Department of Entomology
ban6@cornell.edu
http://nault.entomology.cornell.edu/

Cornell AgriTech
New York State Agricultural Experiment Station

Cornell University

Leonardo Salgado

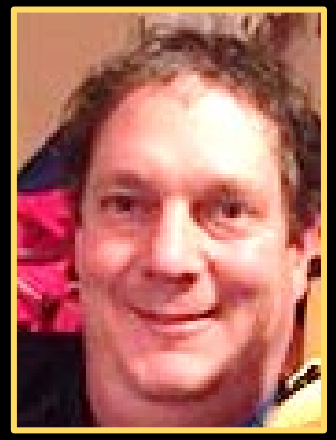
Alan Taylor

Ethan Grundberg

Christy Hoepting

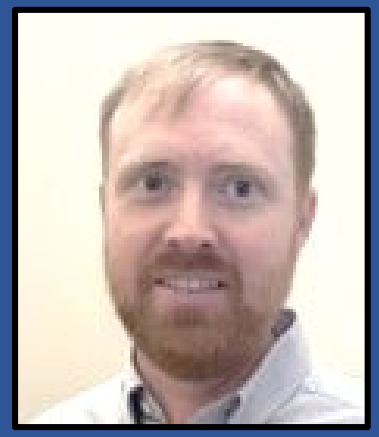
University of Guelph

Mary Ruth McDonald



Kevin Vander Kooi

University of California



Rob Wilson

Washington State University

Tim Waters

Outline

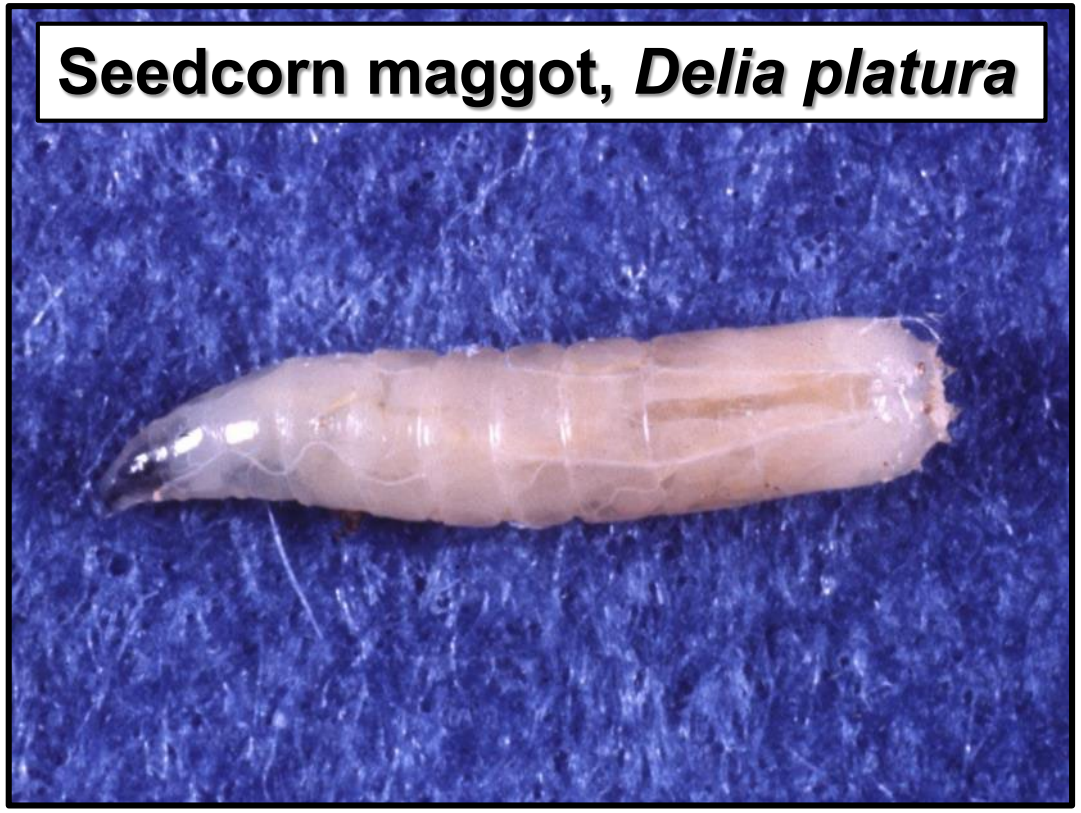
I. Maggot species prevalence

II. Management using seed treatments

III. Guidelines for seed treatment use

Cornell AgriTech
New York State Agricultural Experiment Station

Maggot species prevalence

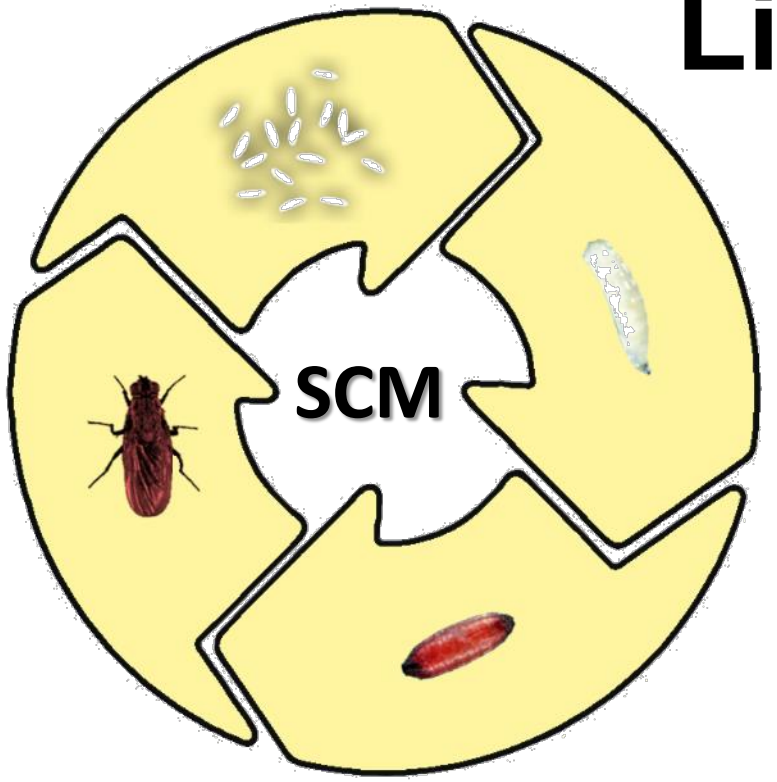


Diptera: Anthomyiidae

Cornell AgriTech
New York State Agricultural Experiment Station

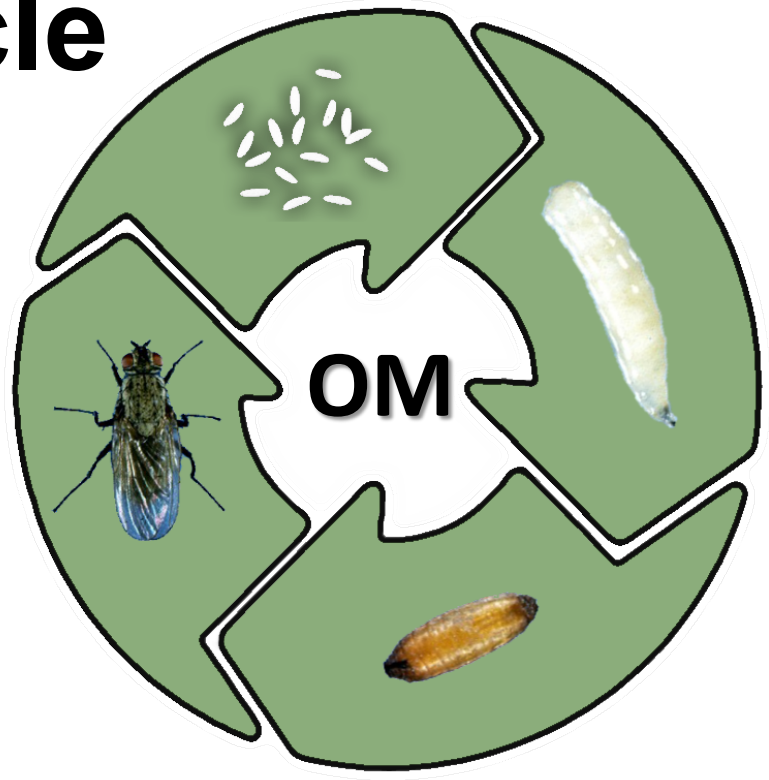
Maggot species prevalence

Life Cycle



Seedcorn maggot (SCM)

3 -5 generations/year



Onion maggot (OM)

3 generations/year

Maggot species prevalence

Seedcorn maggot (SCM)

- Feeds <u>on decaying organic material, but will attack onions and other crops</u>

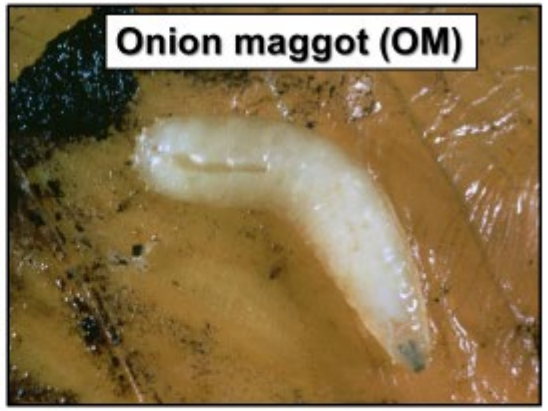
Onion maggot (OM)

- Feeds <u>only on onion</u> and related crops in the Allium genus

Cornell AgriTech
New York State Agricultural Experiment Station

Question

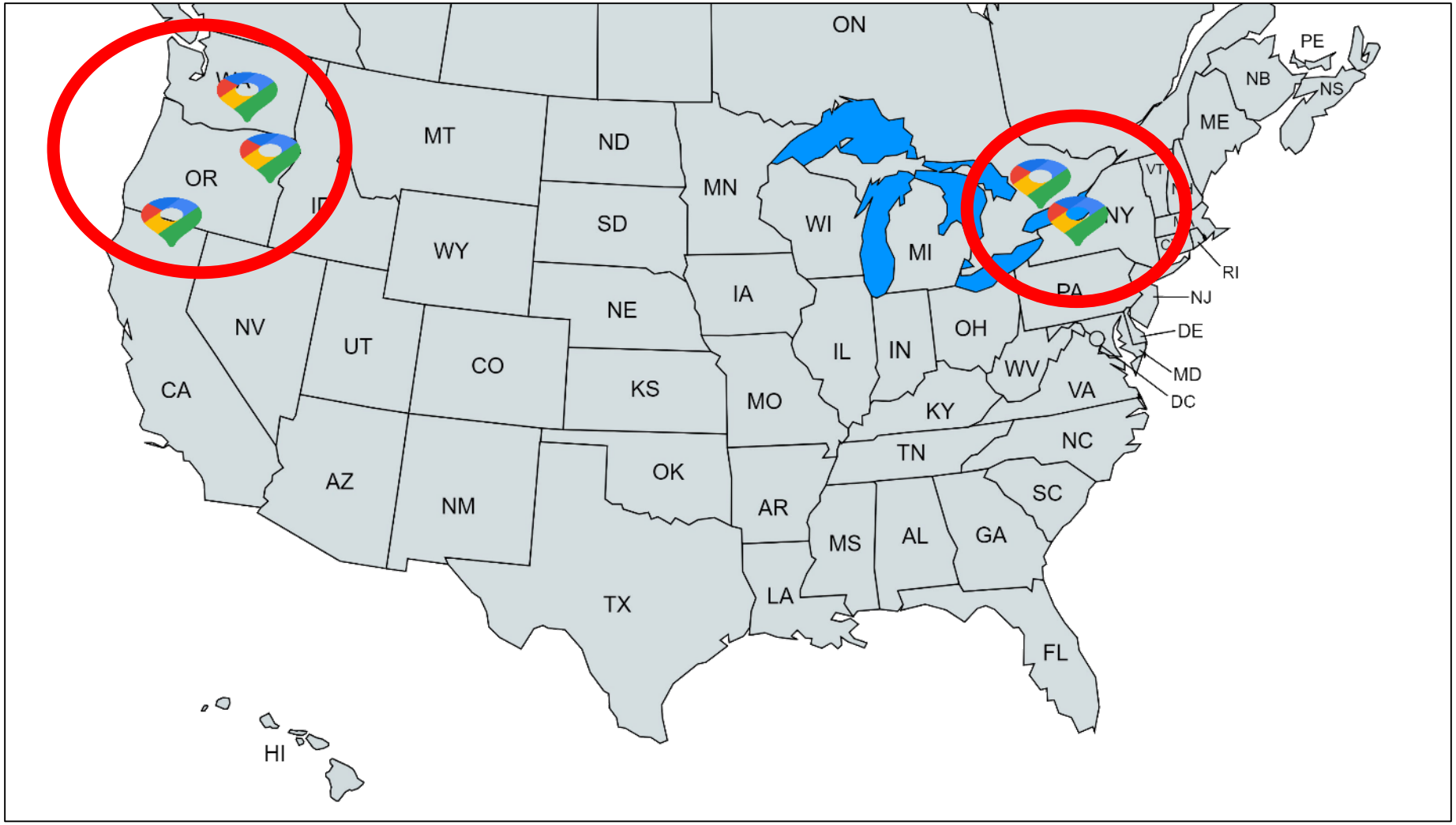
Q: Which maggot species is most common infesting onions in the west and east?



- **<u>Hypothesis</u>: SCM is the major pest in west; OM is the major pest in the east**

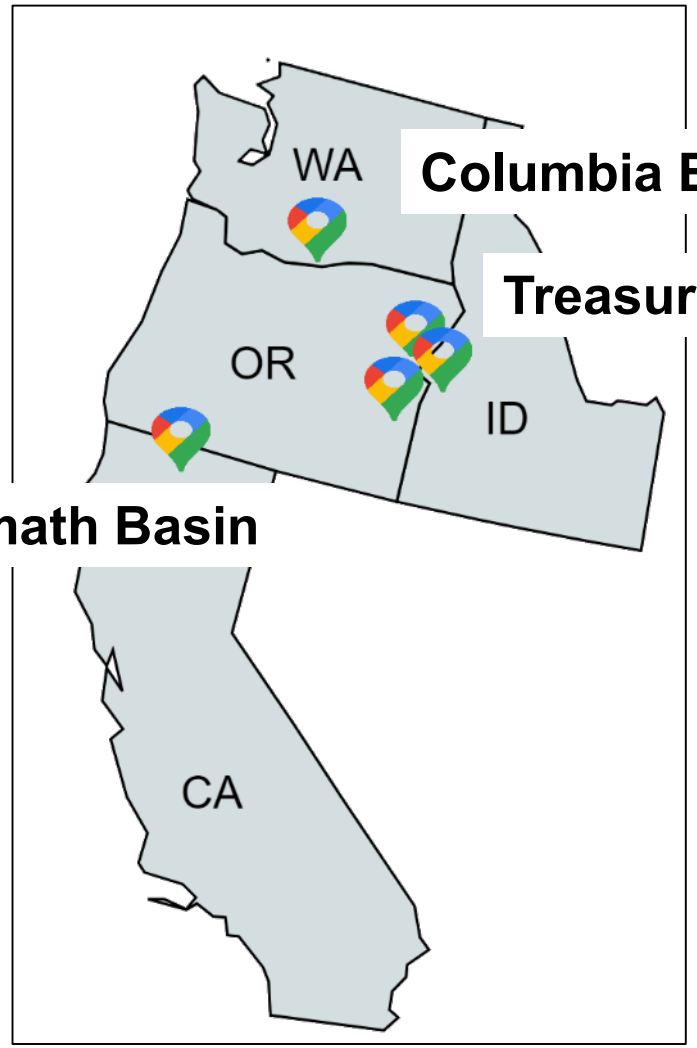
Cornell AgriTech
New York State Agricultural Experiment Station

Maggot species prevalence



Maggot species prevalence

WEST

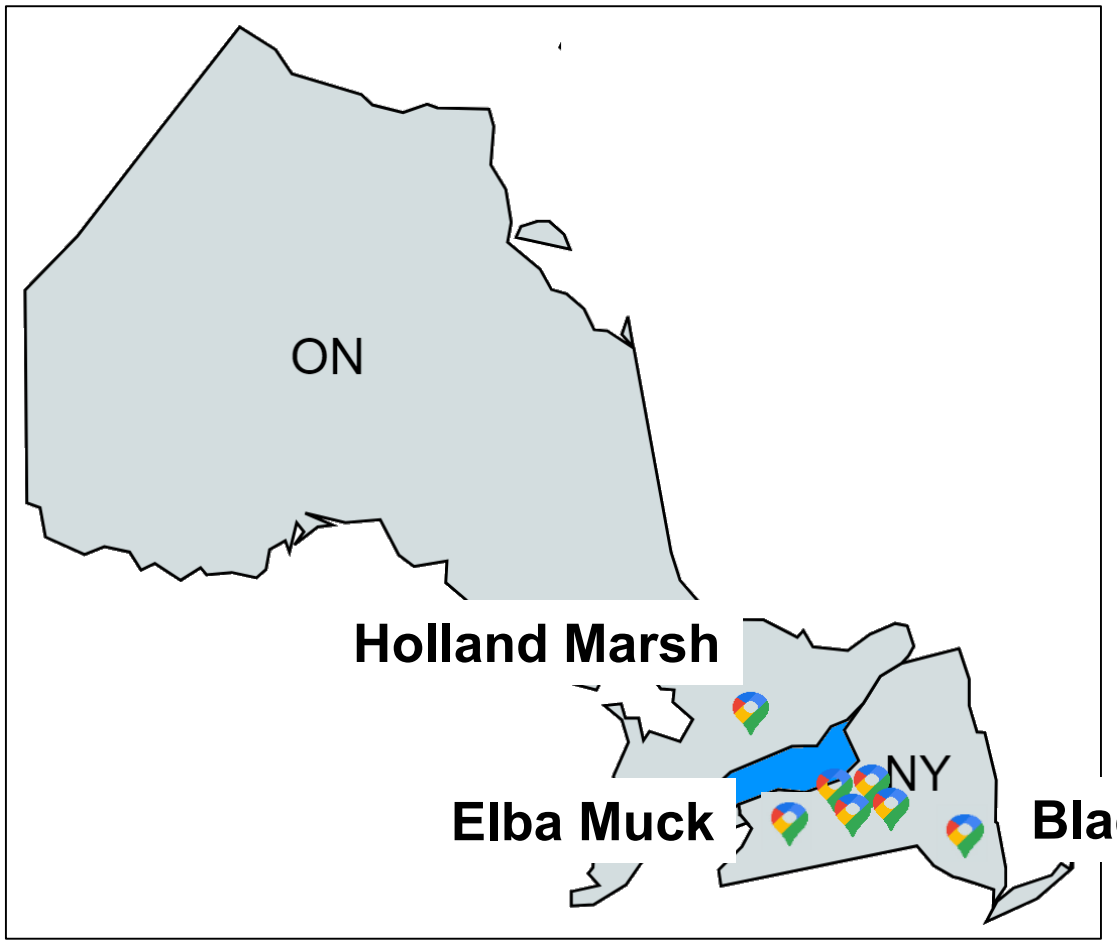


Columbia Basin

Treasure Valley

Klamath Basin

EAST



Holland Marsh

Elba Muck

Black Dirt

Cornell AgriTech
New York State Agricultural Experiment Station

Maggot species prevalence

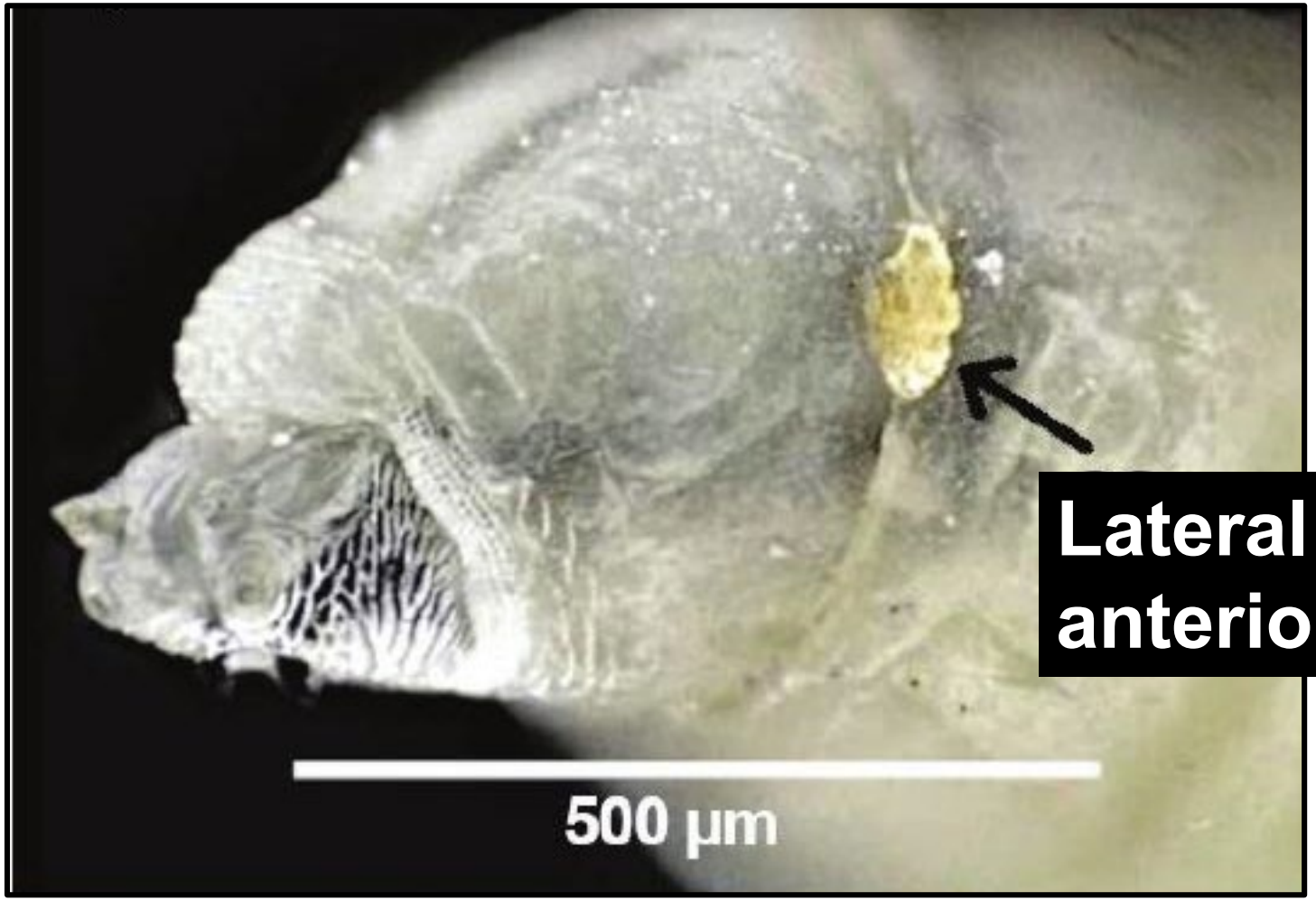
- Coordinated collections across North America in 2022 & 2023
- Maggots removed from plants and preserved in ethanol
- Specimens sent to him for identification

Leo Salgado
Ph.D. student

Photo: Leo Salgado

Cornell AgriTech
New York State Agricultural Experiment Station

Maggot species prevalence



How to distinguish SCM from OM?

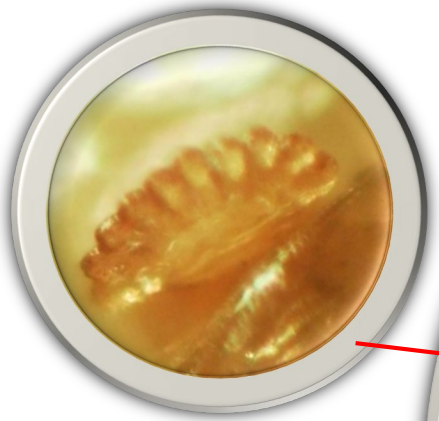
Lateral view of the anterior spiracle

Tejada-Reyes et al. (2023) *Florida Entomologist*

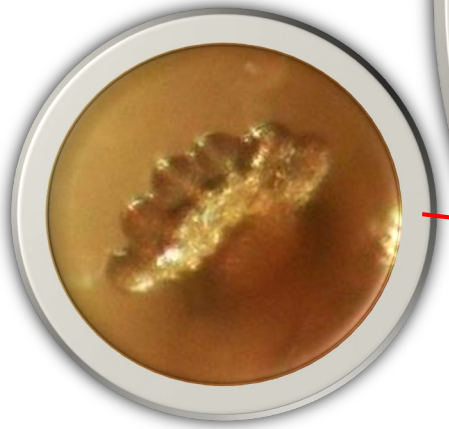
Cornell AgriTech
New York State Agricultural Experiment Station

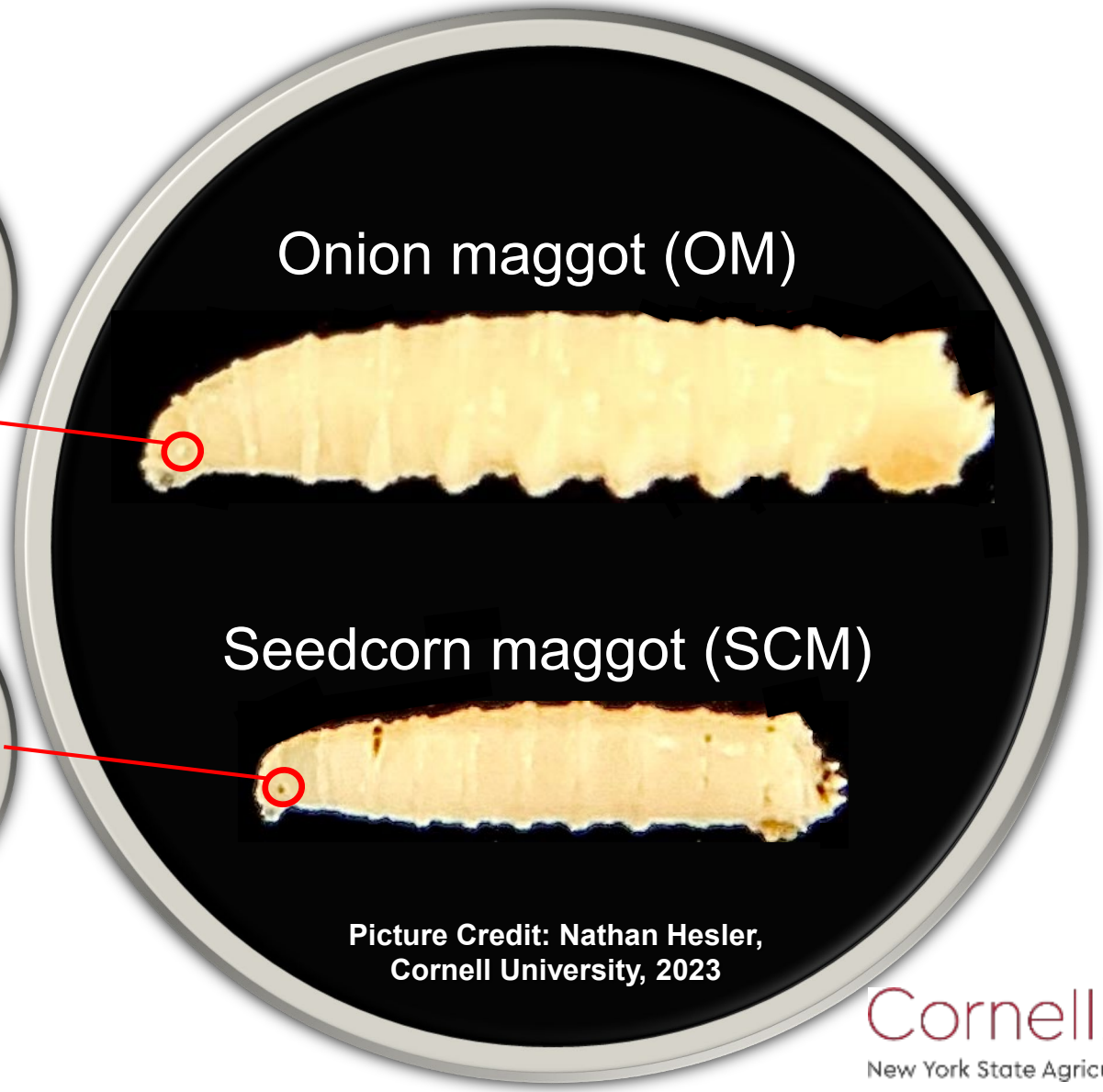
Maggot species prevalence

9-12 papillae



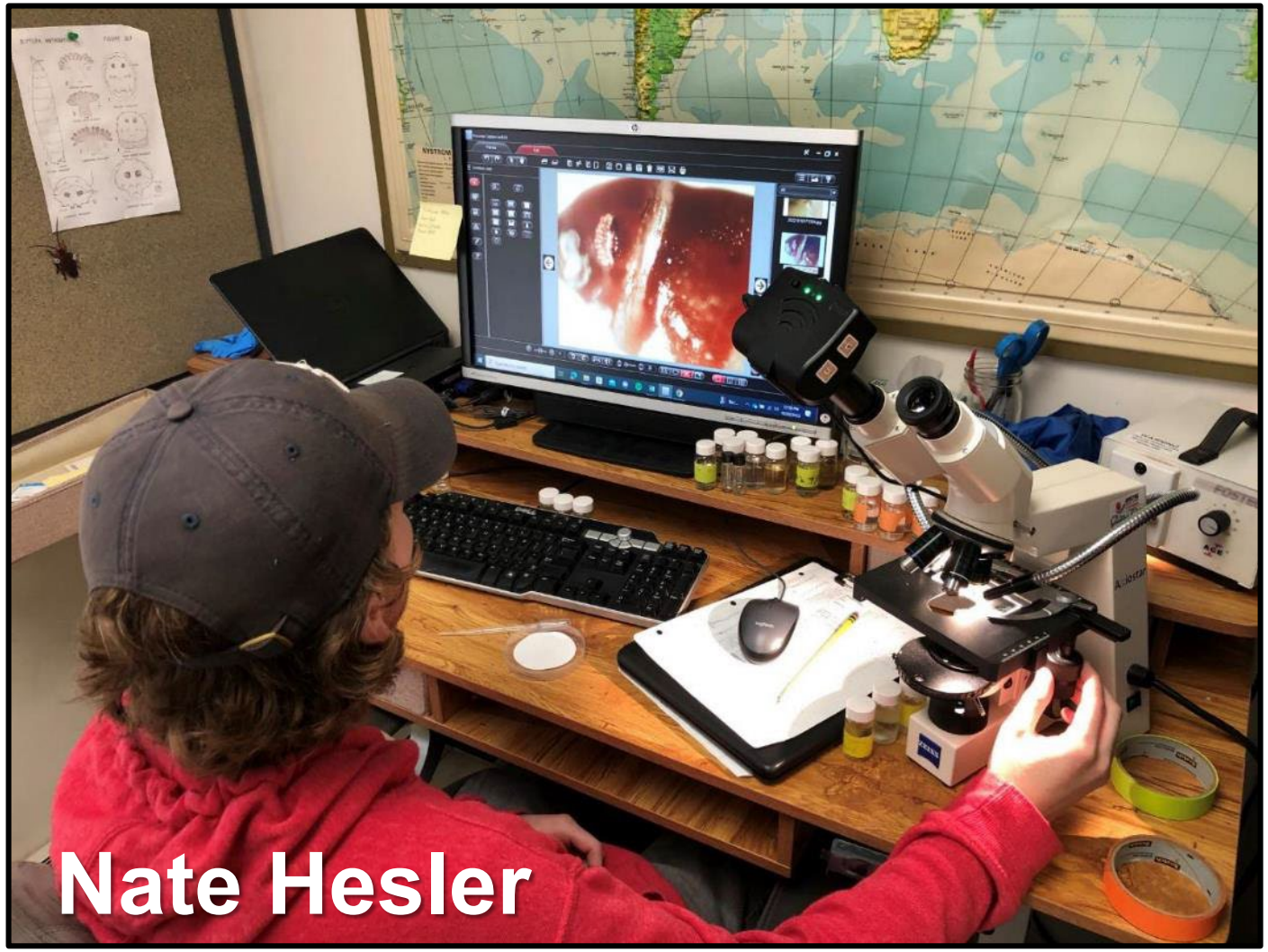
6-8 papillae





Cornell AgriTech
New York State Agricultural Experiment Station

Maggot species prevalence



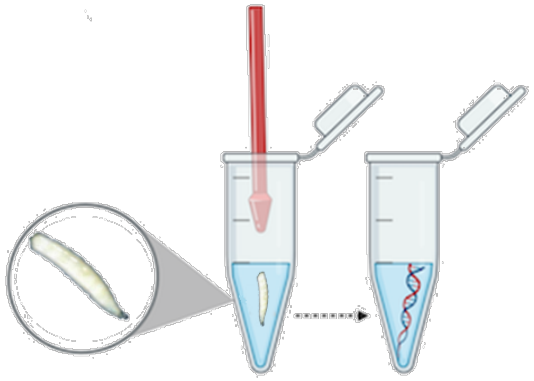
Maggots identified…

4,953+

Cornell AgriTech
New York State Agricultural Experiment Station

Maggot species prevalence

DNA Barcoding



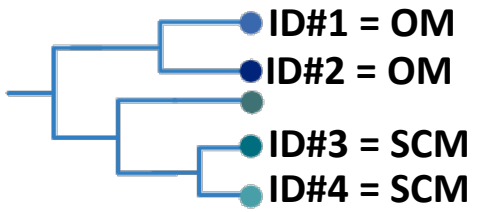
1. DNA was extracted with an extraction kit

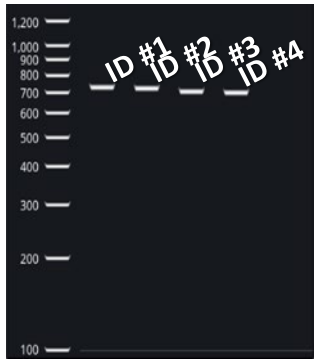
2. PCR of the COI barcoding gene (770bp)

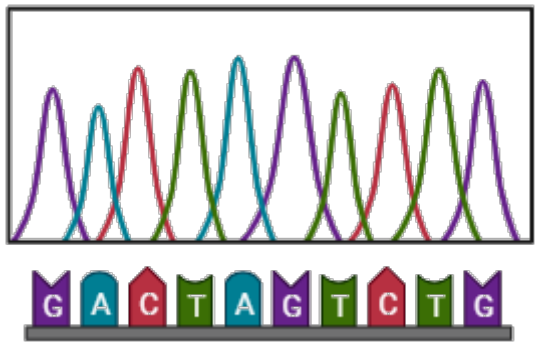
Ollie Vetrovec

Cornell AgriTech
New York State Agricultural Experiment Station

Maggot species prevalence







3. Amplified subsamples for each species and then sent to DNA Sequencing Facility in Ithaca, NY

- **All maggots morphologically identified as SCM and OM were genetically confirmed!**

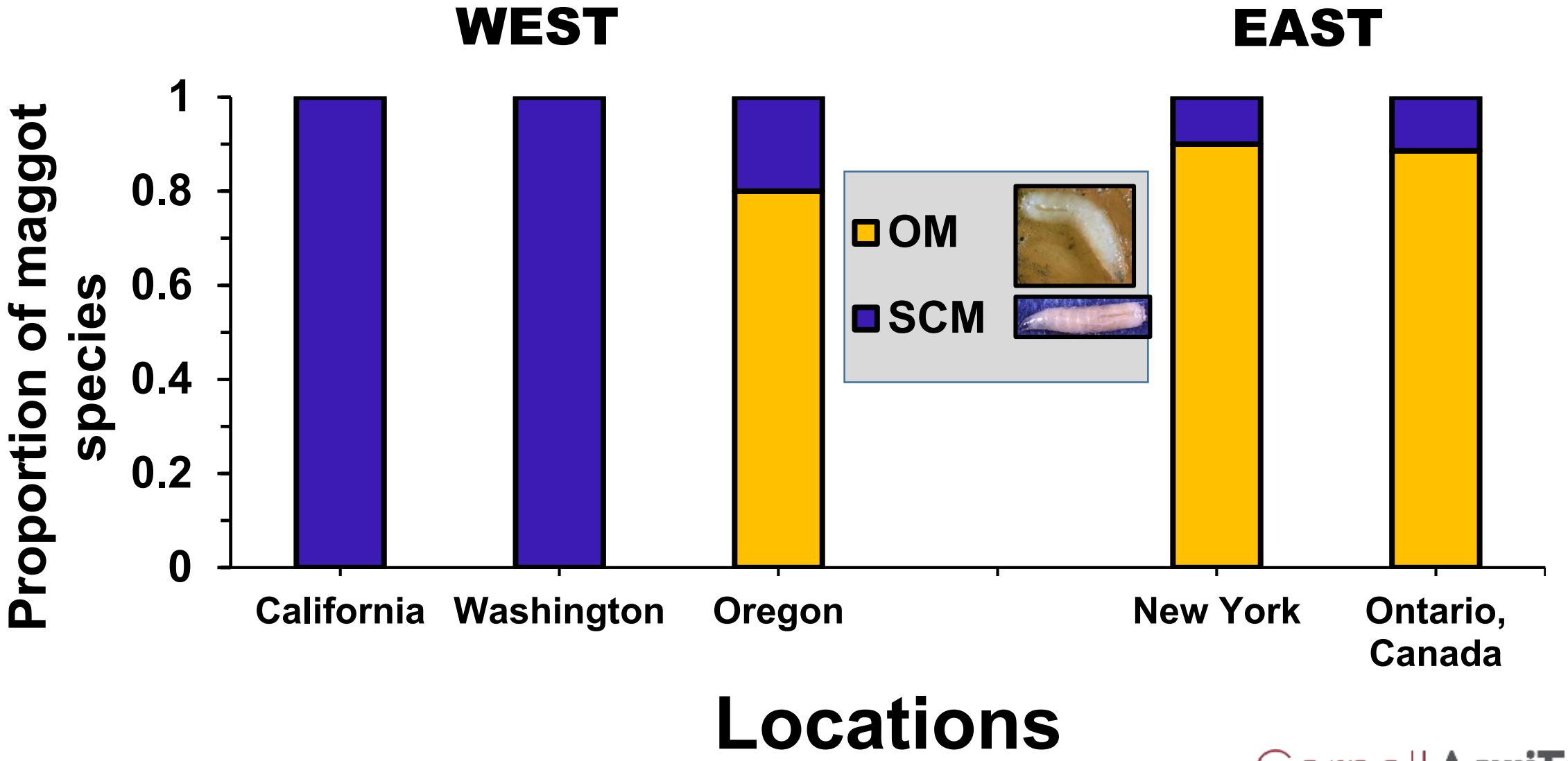
Cornell AgriTech
New York State Agricultural Experiment Station

Maggot species prevalence

		Number maggots sampled		
Region	Location	SCM+OM	Other	Total
West	California	44	9	53
	Washington	32	5	37
	Oregon	171	28	199
East	New York	5,259	362	5,621
	Ontario	44	11	55
Grand total		*93%*	*7%*	*5,965*

Salgado et al. (unpublished)

Maggot species prevalence



Salgado et al. (unpublished)

Cornell AgriTech
New York State Agricultural Experiment Station

Outline

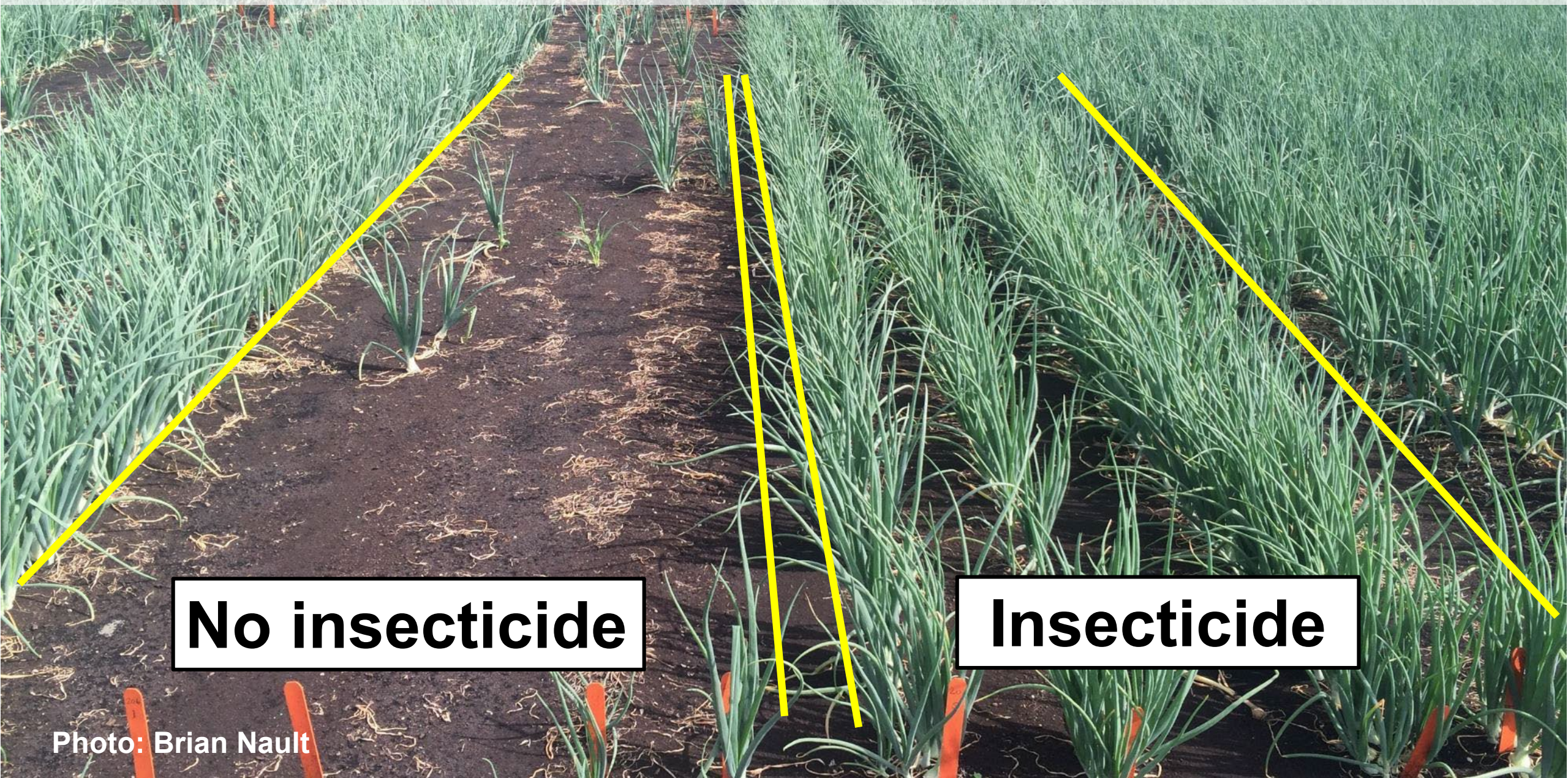
I. Maggot species prevalence

II. Management using seed treatments

III. Guidelines for seed treatment use

Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments



Management using seed treatments

United States Environmental Protection Agency

- EPA banned chlorpyrifos on all food crops on February 28, 2022; popular in-furrow drench treatment in onion for maggot control

Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments

Pre-plant incorporated or in-furrow drench treatments for maggot control in onion

Tradename	Active Ingredient(s)	IRAC
~~Admire Pro Insecticide~~	imidacloprid	4A
~~Capture LFR~~	bifenthrin	3A
~~Coragen SC~~	chlorantraniliprole	28
Diazinon AG500	diazinon	1B
~~Entrust SC~~	spinosad	6
~~Majestine XC~~	Heat-killed *Burkholderia*	UNB
~~Verimark~~	cyantraniliprole	28

NOT effective; **except Diazinon in WA**

Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments

"New" seed treatment for maggot control in onion

Corteva onion maggot trial (2022). Photo credit: Leonardo Salgado, Cornell University

CORTEVA™ agriscience

- **Active ingredient**: spinosad (same as Regard SC but is an 80% WP)
- **Also OMRI-listed** OMRI LISTED For Organic Use
- **Commercial seed treatment**
- **Registered in CA, WA, NE, ID (seed treatment companies are located)**

Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments

"Future" seed treatment for maggot control in onion

In the pipeline:

syngenta

PLINAZOLIN® technology (isocycloseram)

- Isoxazoline insecticide (IRAC Class 30); inhibits GABA gated chloride channel
- Predicted registration on…
  - Bulb crops (foliar use only) - late 2024?
  - Bulb crops (seed treatment) - 2025 or 2026?

Management using seed treatments

Insecticide seed treatments for maggot control

Tradename	Active Ingredient(s)	Group	Activity on Target Pests[1]	
Insecticides:		IRAC	Seedcorn Maggot	Onion Maggot
Lumiverd™	spinosad	5	Excellent	Excellent
Trigard®	cyromazine	17	Poor	Excellent
Cruiser® 5FS	thiamethoxam	4A	Poor	Poor
Sepresto 75 WS	clothianidin + imidacloprid	4A	Good	Good
PLINAZOLIN® technology*	isocycloseram	30	?	?

*Not registered

[1]NOTE: Input from C. Hoepting (NY), R. Wilson (CA), T. Waters (WA) & S. Reitz (OR)

Cornell AgriTech
New York State Agricultural Experiment Station

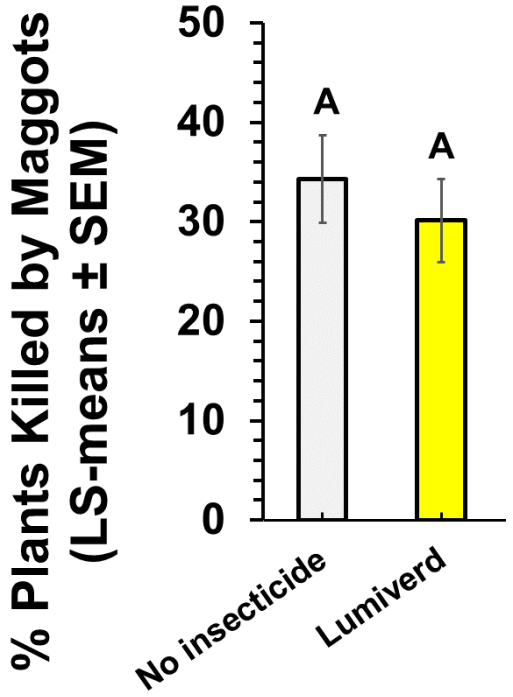
Management using seed treatments

- Lumiverd is the obvious choice (only option that controls both maggot species)…or is it?

Management using seed treatments

- Control failure using spinosad in NY in 2023 (Oswego County)

Onion maggot



Stand loss

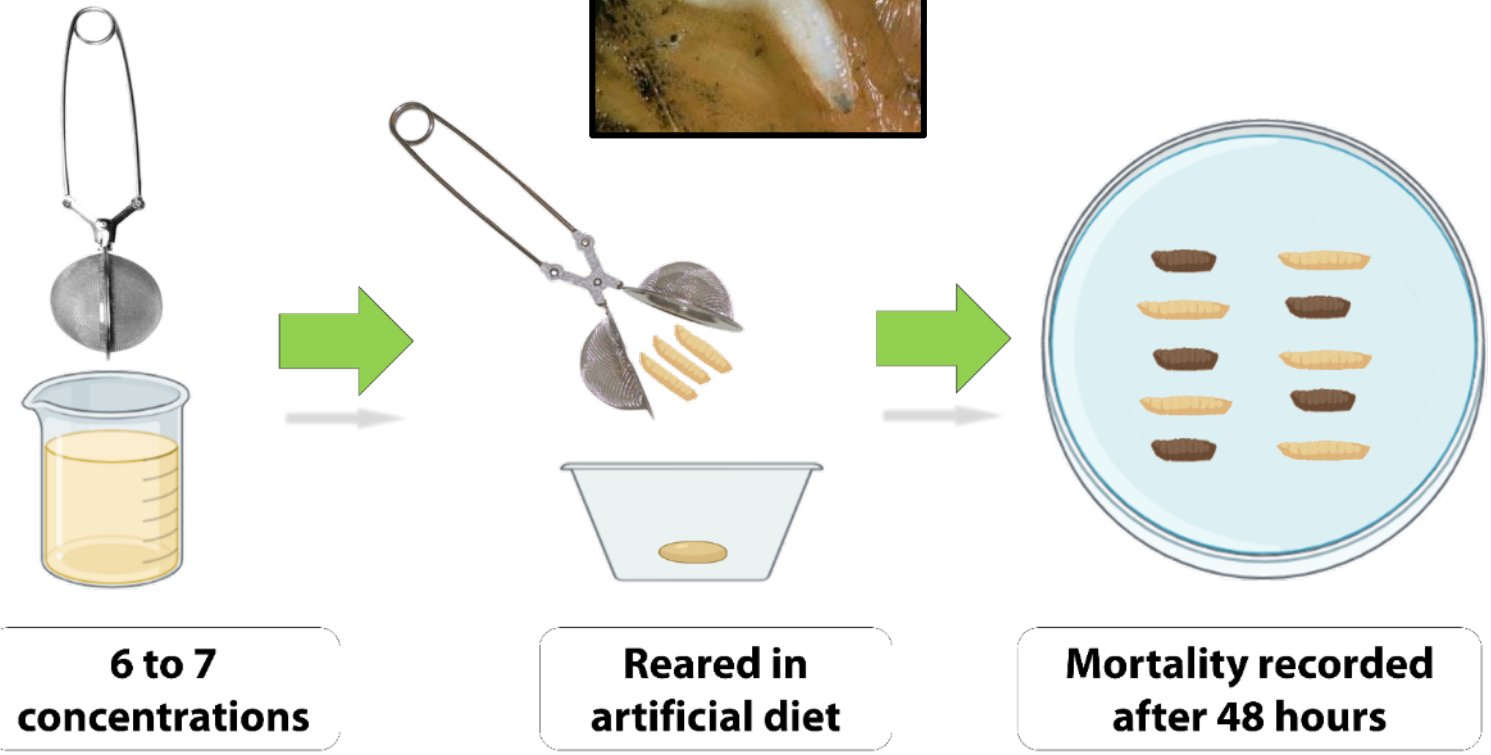
- Spinosad (i.e., FarMore FI500) used annually on this farm since ~2010; no crop rotation

Management using seed treatments

- Sensitivity to spinosad in a NY OM population using a lab bioassay

Lumiverd™

Layton Rosen



Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments

- **Sensitivity to spinosad in the same NY OM population using a lab bioassay**

Year	N	Slope (SE)	LC_{50} (ppm)	95% CL	χ^2 (DF)
2018*	241	1.34 (0.17)	**33**	24.3–43.6	3.85 (4)
2021	559	0.84 (0.06)	**3,624**	2,538.0–5,349.0	6.57 (4)
2023	104	0.39 (0.15)	**144,429**	10,708–9.3×10^{12}	6.97 (4)

***Reference population from *J. Econ. Ent.* 114 (2), 694–701**

LC_{50} is low (susceptible)
LC_{50} is high (resistant)

Salgado et al. (unpublished)

Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments

- Alternatives to Lumiverd needed for onion maggot resistance management

Trigard®

PLINAZOLIN® technology

Sepresto 75 WS

Cruiser® 5FS

Cornell AgriTech
New York State Agricultural Experiment Station

Question

Q: What are the most effective alternative insecticide seed treatments for maggot control in the west and east?

WEST

PLINAZOLIN® technology

EAST

PLINAZOLIN® technology

and

Trigard® + Cruiser® 5FS

- **Hypothesis: PLINAZOLIN® best in the west; PLINAZOLIN® & Trigard + Cruiser in the east**

Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments

Trt#	Product(s)	Insecticide Active ingredient(s)	Rate (mg ai/seed)
1	No insecticide	N/A	N/A
2	Trigard 75WP	cyromazine	0.225
3	Lumiverd	spinosad	0.2
4	PLINAZOLIN® technology	isocycloseram	0.0909
5	Cruiser 70WS	thiamethoxam	0.2
6	Sepresto 75WS	(clothianidin + imidacloprid)	0.32
7	Trigard + Cruiser	cyromazine + thiamethoxam	0.225 + 0.2
8	Trigard + Sepresto	cyromazine + (clothianidin + imidacloprid)	0.225 + 0.32
9	Lumiverd + Cruiser	spinosad + thiamethoxam	0.2 + 0.2
10	Lumiverd + Sepresto	spinosad + (clothianidin +imidacloprid)	0.2+ 0.32
11	PLINAZOLIN® + Cruiser	isocycloseram + thiamethoxam	0.0909 + 0.2
12	PLINAZOLIN® + Sepresto	isocycloseram + (clothianidin + imidacloprid)	0.0909 + 0.32

- Study conducted in CA, WA (2 locations), NY (4 locations) and ON
- All seed treated with FarMore F300 + EverGol Prime
- Kamterter (Waverly, NE) treated all seeds

Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments

Tulelake, California 2023

F = 19.9; df = 11, 44; *P* = 0.001

Final Stand Count @ July 11
(LS-Means ± SEM)

400
300
200
100
0

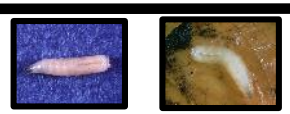
Sepresto 75WS	A
PLINAZOLIN® + Cruiser	A
PLINAZOLIN® + Sepresto	A
Lumiverd + Sepresto	A
Trigard + Sepresto	A
Lumiverd + Cruiser	AB
PLINAZOLIN® technology	ABC
Cruiser 5 FS	ABCD
Lumiverd	BCDE
Trigard + Cruiser	CDE
Trigard 75WP	DE
No Insecticide	E

42% reduction

Wilson (unpublished)

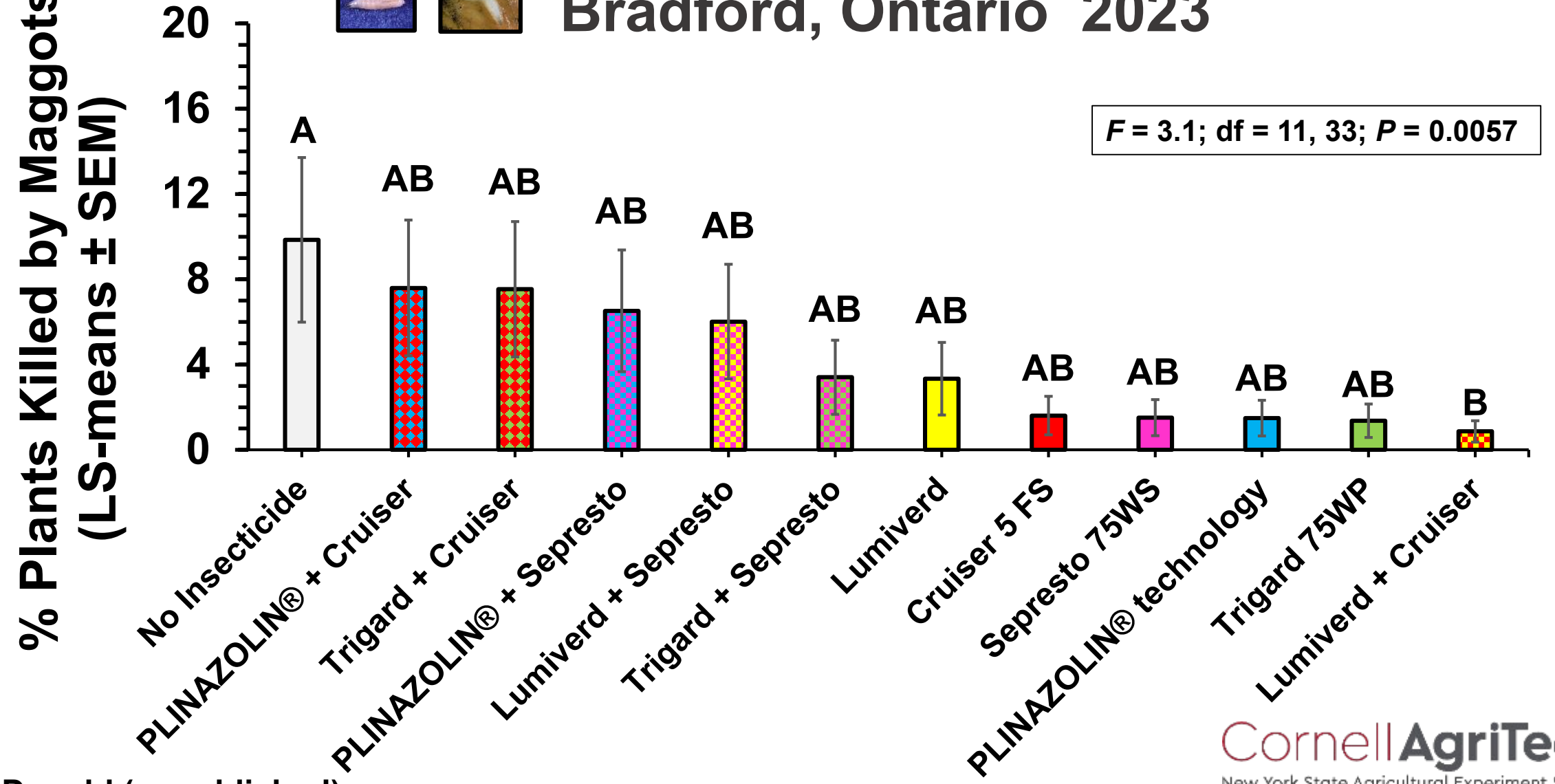
Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments



Bradford, Ontario 2023

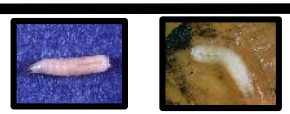
$F = 3.1$; df = 11, 33; $P = 0.0057$



McDonald (unpublished)

Cornell AgriTech
New York State Agricultural Experiment Station

Management using seed treatments



Oswego, New York 2023

F = 14.0; df = 11, 44; *P* < 0.001

% Plants Killed by Maggots
(LS-means ± SEM)

50
40
30
20
10
0

A
A
B
BC
BC
BC
BC
BC
BC
BC
C
C

No insecticide
Lumiverd
Cruiser 5 FS
PLINAZOLIN® technology
PLINAZOLIN® + Cruiser
Trigard 75WP
Trigard+Cruiser
72% control
Sepresto 75WS
Lumiverd+Cruiser
76% control
Lumiverd+Sepresto
PLINAZOLIN® + Sepresto
Trigard+Sepresto
88% control

Salgado et al. (unpublished)

Cornell AgriTech
New York State Agricultural Experiment Station

Question

Q: What are the most effective alternative insecticide seed treatments for maggot control in the west and east?

2023

WEST (Tulelake, CA)

A: PLINAZOLIN tech. and Sepresto; most combinations that included neonics

EAST (Oswego, NY)

A: PLINAZOLIN tech., Trigard & Sepresto; combinations that included neonics

Outline

I. Maggot species prevalence

II. Management using seed treatments

III. Guidelines for seed treatment use

Cornell AgriTech
New York State Agricultural Experiment Station

Guidelines for seed treatment use

Insecticide seed treatments for maggot control

Tradename	Active Ingredient(s)	Group	Activity on Target Pests[1]	
Insecticides:		IRAC	Seedcorn Maggot	Onion Maggot
Lumiverd™	spinosad	5	Very good	Very good**
Trigard®	cyromazine	17	Poor	Very good
Cruiser® 5FS	thiamethoxam	4A	Poor	Poor
Sepresto 75 WS	clothianidin + imidacloprid	4A	Good	Good
PLINAZOLIN® technology*	isocycloseram	30	Very good	Very good

*Not registered

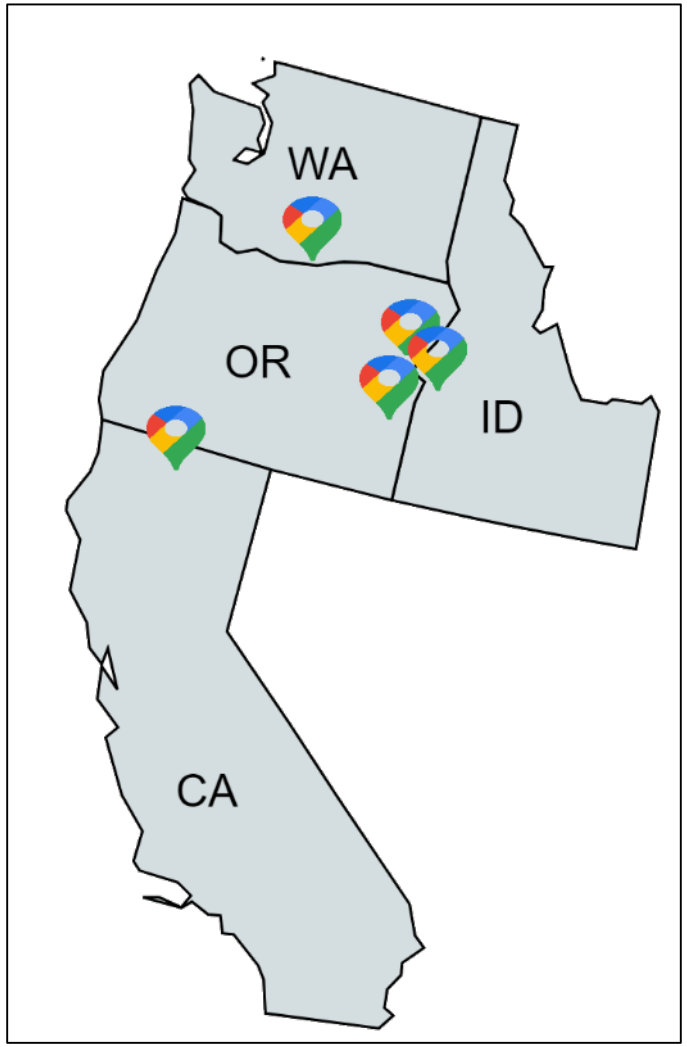
** OM resistance

[1]NOTE: Input from C. Hoepting (NY), R. Wilson (CA), T. Waters (WA) & S. Reitz (OR)

Cornell AgriTech
New York State Agricultural Experiment Station

Guidelines for seed treatment use

WEST



Location	Species	Product(s)
California & Washington	SCM 	Lumiverd™ + Cruiser® 5FS Lumiverd™ + Sepresto 75 WS
Oregon	OM SCM  	Lumiverd™ + Cruiser® 5FS Lumiverd™ + Sepresto 75 WS Trigard® + Cruiser® 5FS Trigard® + Sepresto 75 WS

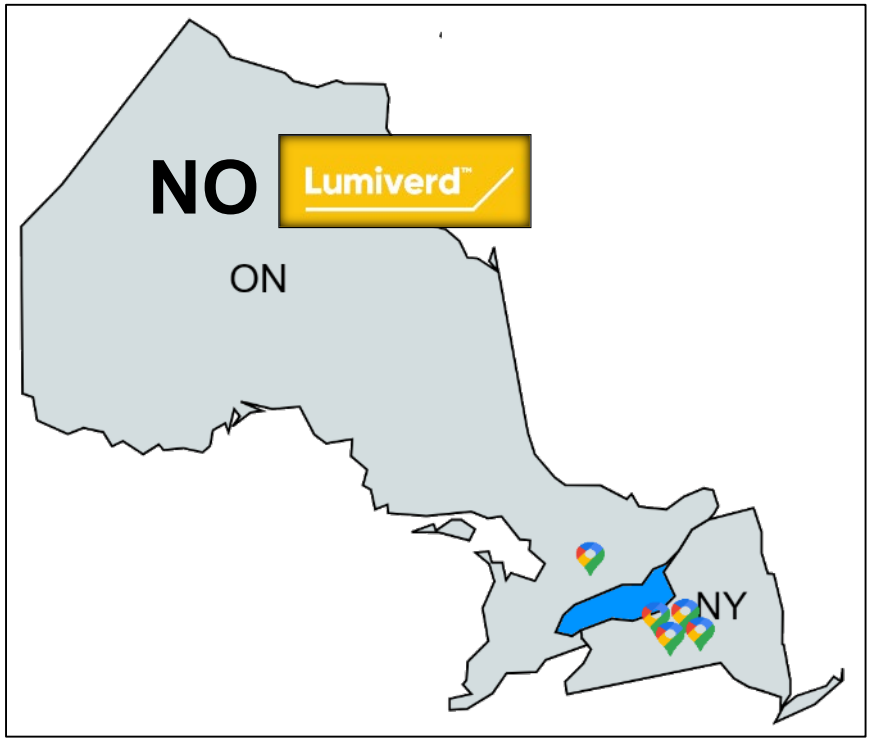
Add FarMore® F300 + EverGol® Prime

Cornell AgriTech
New York State Agricultural Experiment Station

Guidelines for seed treatment use

Location	Species	Product(s)
New York	OM  SCM 	Lumiverd™ + Cruiser® 5FS Lumiverd™ + Sepresto 75 WS Trigard® + Cruiser® 5FS Trigard® + Sepresto 75 WS
Ontario	OM  SCM 	Sepresto 75 WS Trigard® + Cruiser® 5FS

EAST



Add FarMore® F300 + EverGol® Prime

Insecticide resistance management strategy for onion maggot

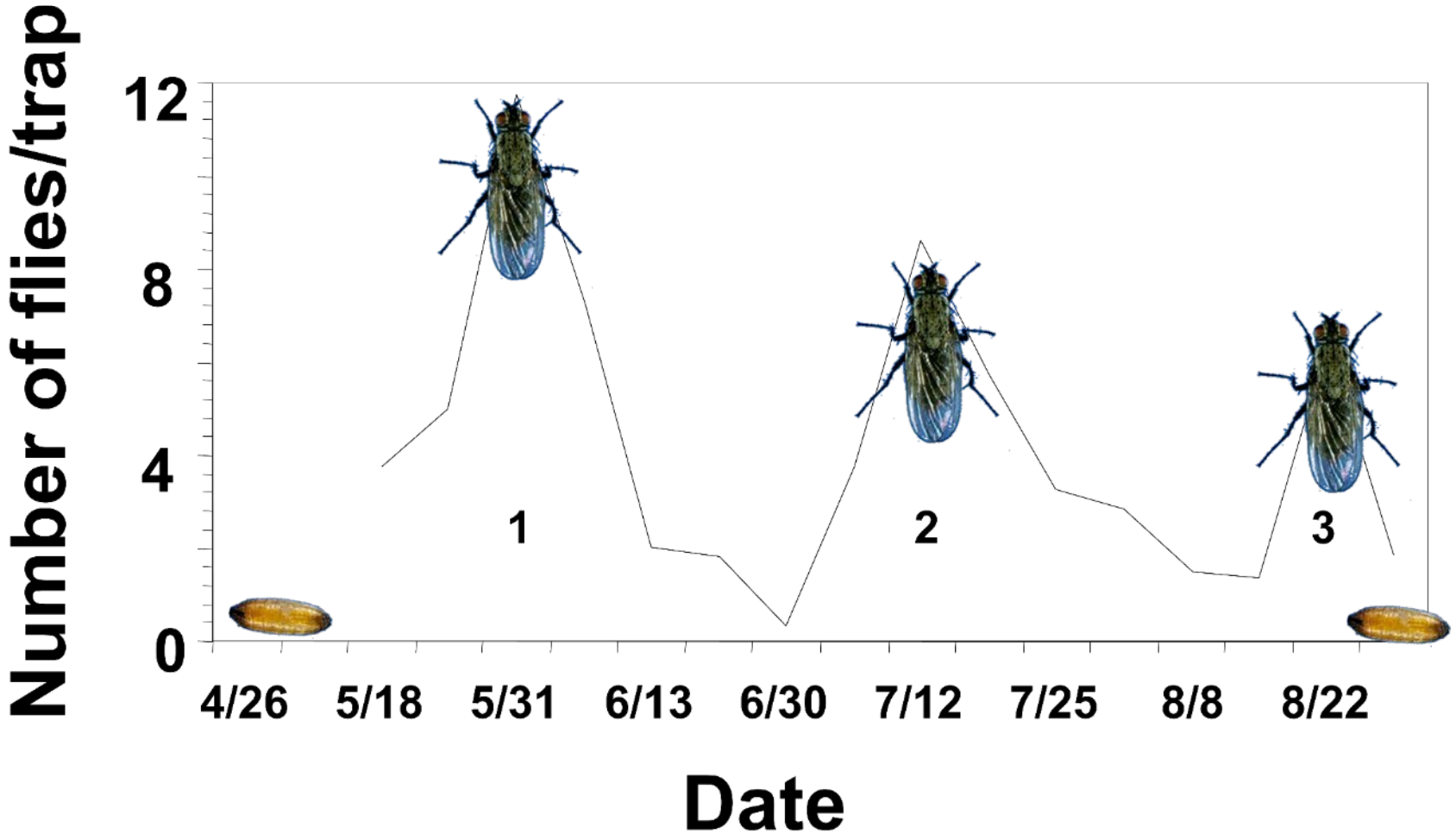
- **Rotate KEY insecticide active ingredients every year**

Lumiverd™

Trigard®

Cornell AgriTech
New York State Agricultural Experiment Station

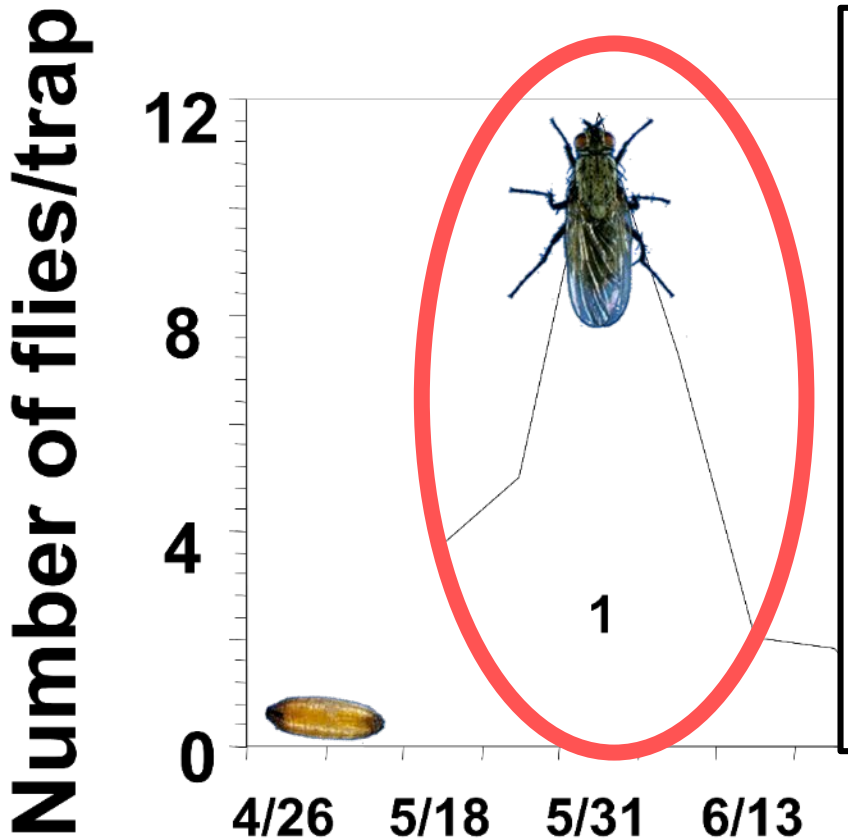
Insecticide resistance management strategy for onion maggot



[1]Eckenrode et al. 1975 – Env. Ent.

Cornell AgriTech
New York State Agricultural Experiment Station

Insecticide resistance management strategy for onion maggot



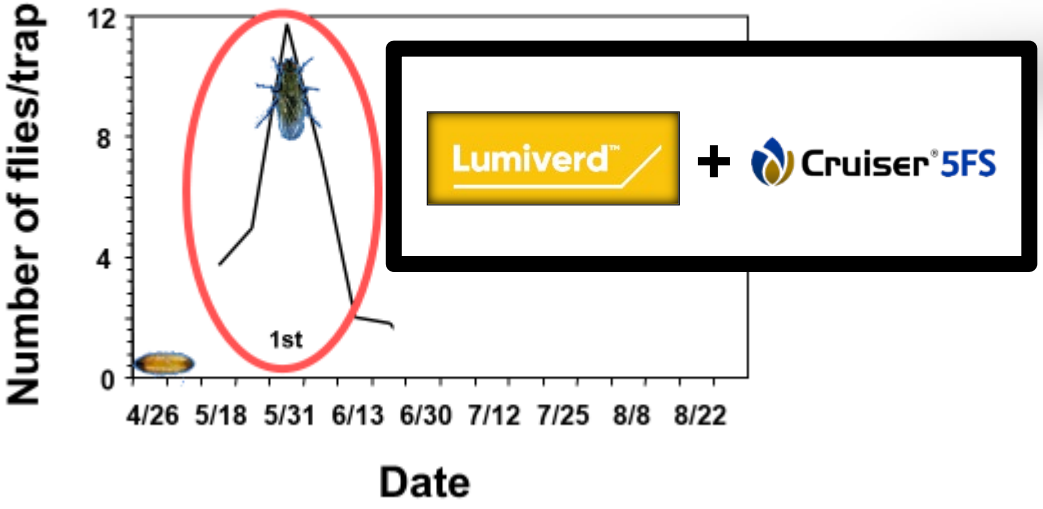
- Seed treatment only controls 1st-generation
- No selection pressure on the other two generations to develop resistance

[1]Eckenrode et al. 1975 – Env. Ent.

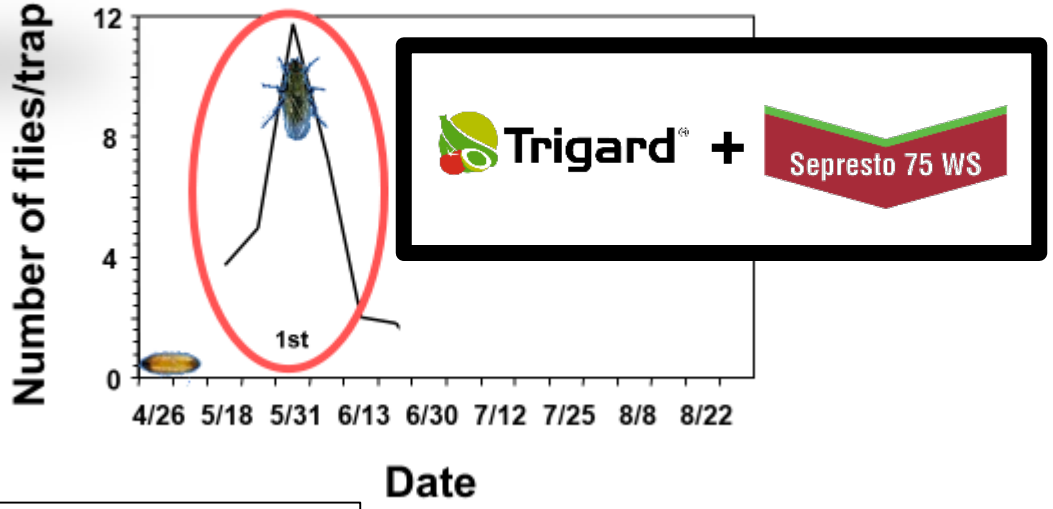
Cornell AgriTech
New York State Agricultural Experiment Station

Insecticide resistance management strategy for onion maggot

2024



2025

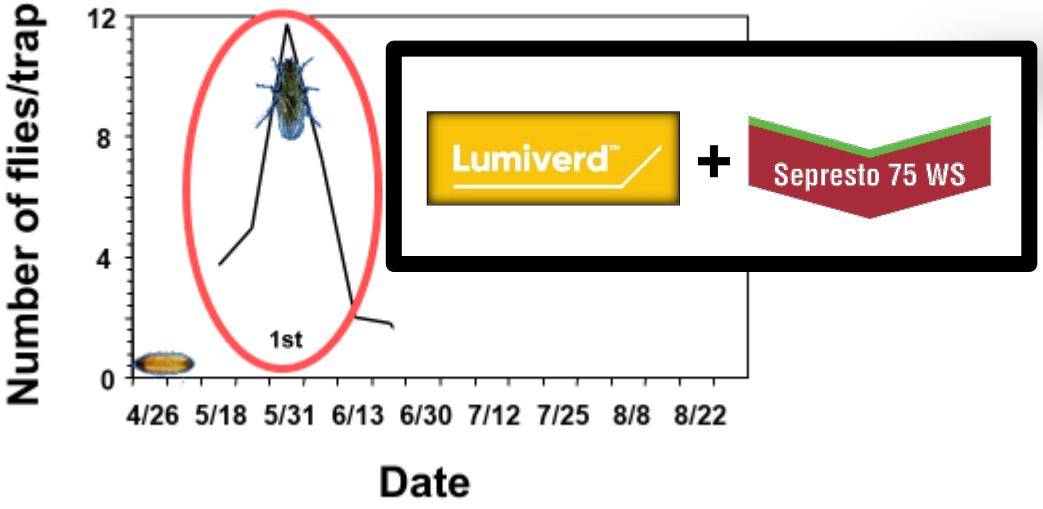


*** Only 1 of 6 generations will be exposed to either Lumiverd+Cruiser or Trigard+Sepresto every 2 years; will slow down resistance**

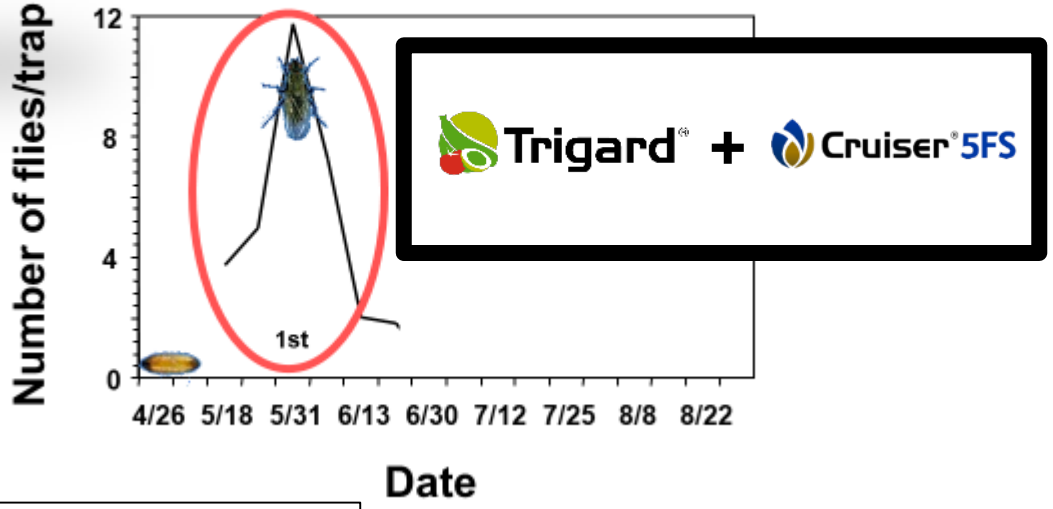
Cornell AgriTech
New York State Agricultural Experiment Station

Insecticide resistance management strategy for onion maggot

2024



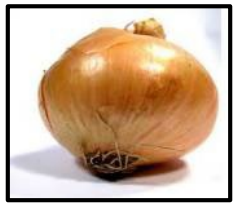
2025



*** Only 1 of 6 generations will be exposed to either Lumiverd+Sepresto or Trigard+Cruiser every 2 years; will slow down resistance**

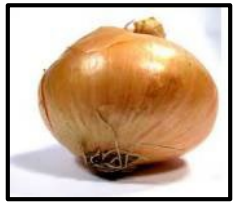
Cornell AgriTech
New York State Agricultural Experiment Station

Summary – Maggot Control



- SCM dominant in CA & WA; OM dominant in OR, NY & ON
- Best performing seed treatment combinations:
  - Lumiverd + (Cruiser or Sepresto) in west and east
  - Trigard + (Cruiser or Sepresto) in OR and east
- Trigard and Lumiverd should be rotated annually to mitigate OM resistance development
- PLINAZOLIN® technology promising for future

Future Research – Maggot Control



- Repeat insecticide seed treatment trial in 2024
- Evaluate new active ingredients
- Identify solutions that do not include neonics

Acknowledgements

Nault Lab 2023

Email: ban6@cornell.edu
Web site: https://nault.entomology.cornell.edu/

Cooperators

Abe Datthyn Farms
Big "O" Farms
DiSalvo Farms
Dunsmoor Farms
Gianetto Farms
Jacobson Farms
Sorbello Farms

Lamterter Products, L.L.C.

Funding

New York Onion Research & Development Program

NEW YORK STATE OF OPPORTUNITY. Agriculture and Markets

Questions?

Brian A. Nault
Professor
Department of Entomology

ban6@cornell.edu