One Entomologist's Experience with the Evolution and Practices of IPM Nationally and Internationally

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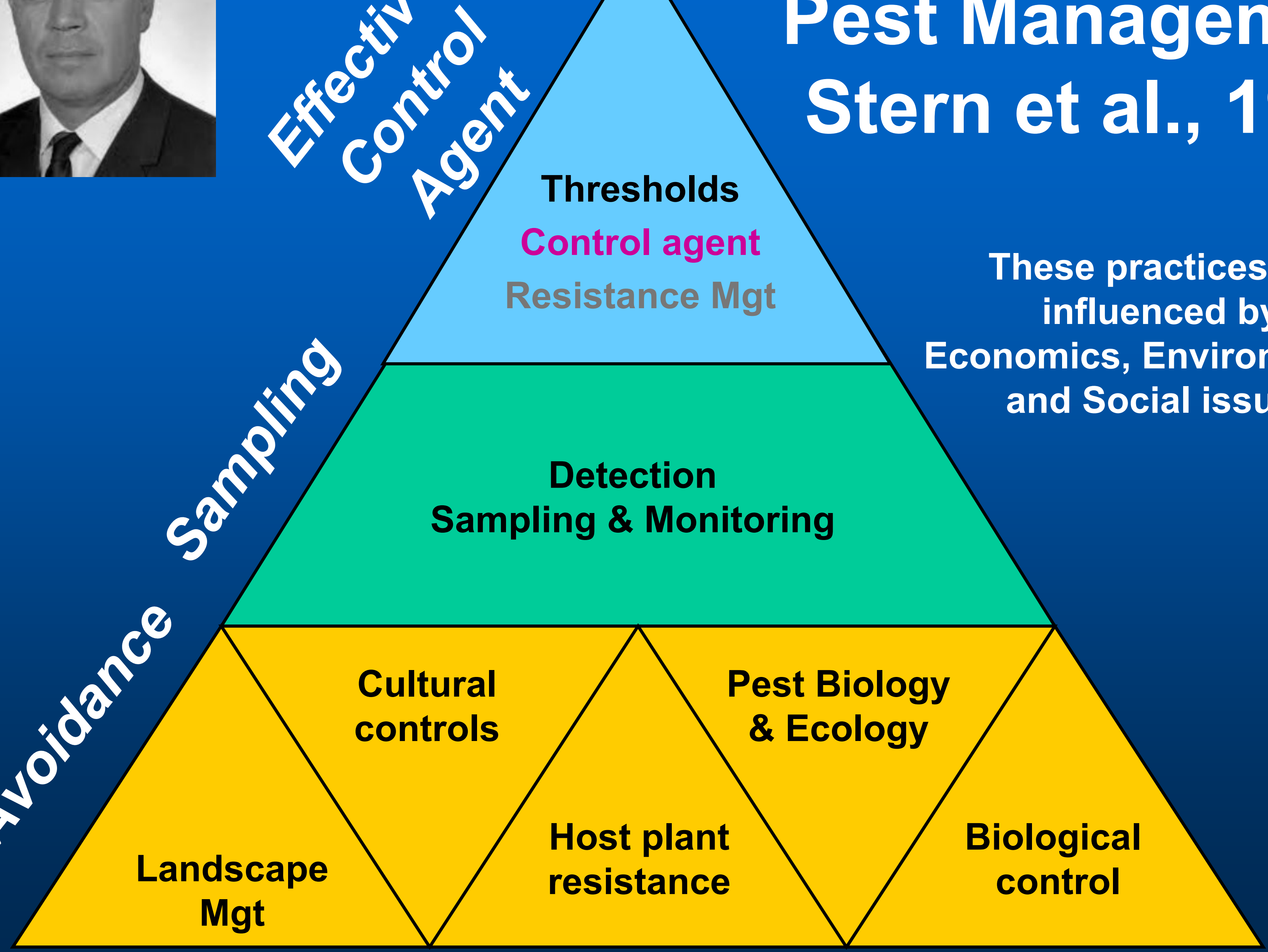
Integrated Pest Management Stern et al., 1959



These practices are influenced by Economics, Environmental and Social issues

Diagram:
S. Nananjo

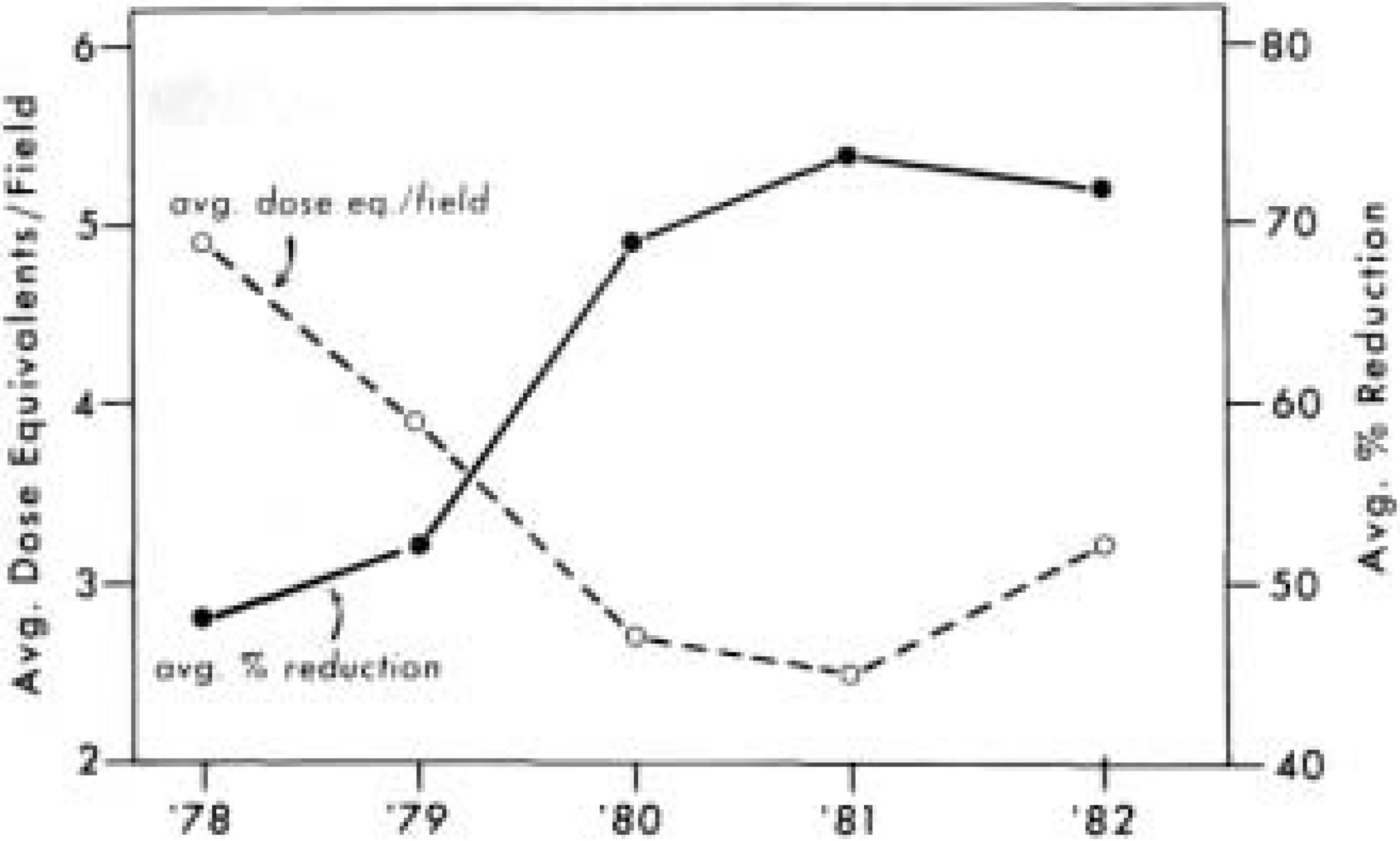
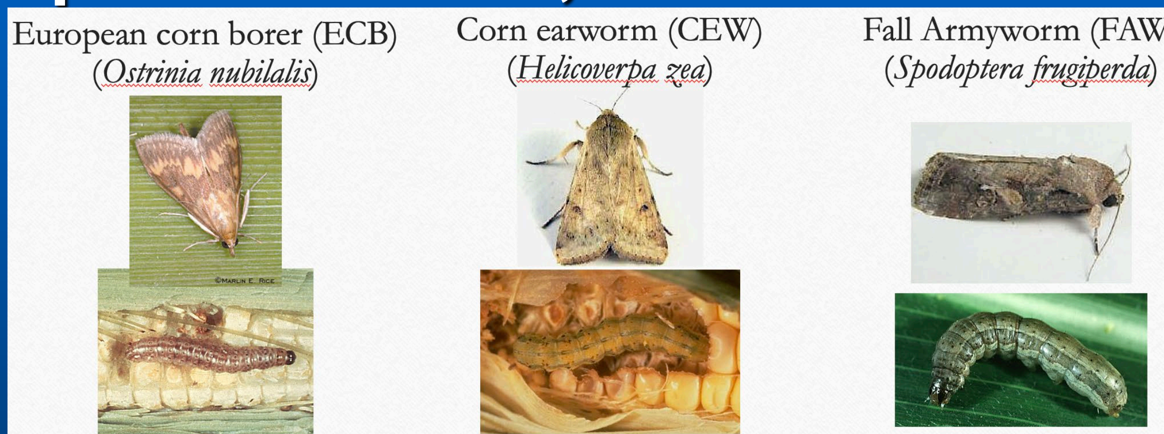


Fig. 4—Amount of insecticides used and efficacy of insecticide treatments for control of Lepidoptera obtained by Cabbage IPM Program participants Ontario and Yates Counties, N.Y.

Sweet Corn in NY

- Grown on 25,000 acres, 60% fresh market and 40% processing, and valued at $40 M
- Main pests are ECB, CEW and FAW



Management of Lepidoptera on Processing Sweet Corn in Western New York

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J. Econ.Entomol 79: 1658-1661 (1986)

Insecticide use down 1/3 and no loss in yield

Additional Research Helped Refine the Sweet Corn IPM Program

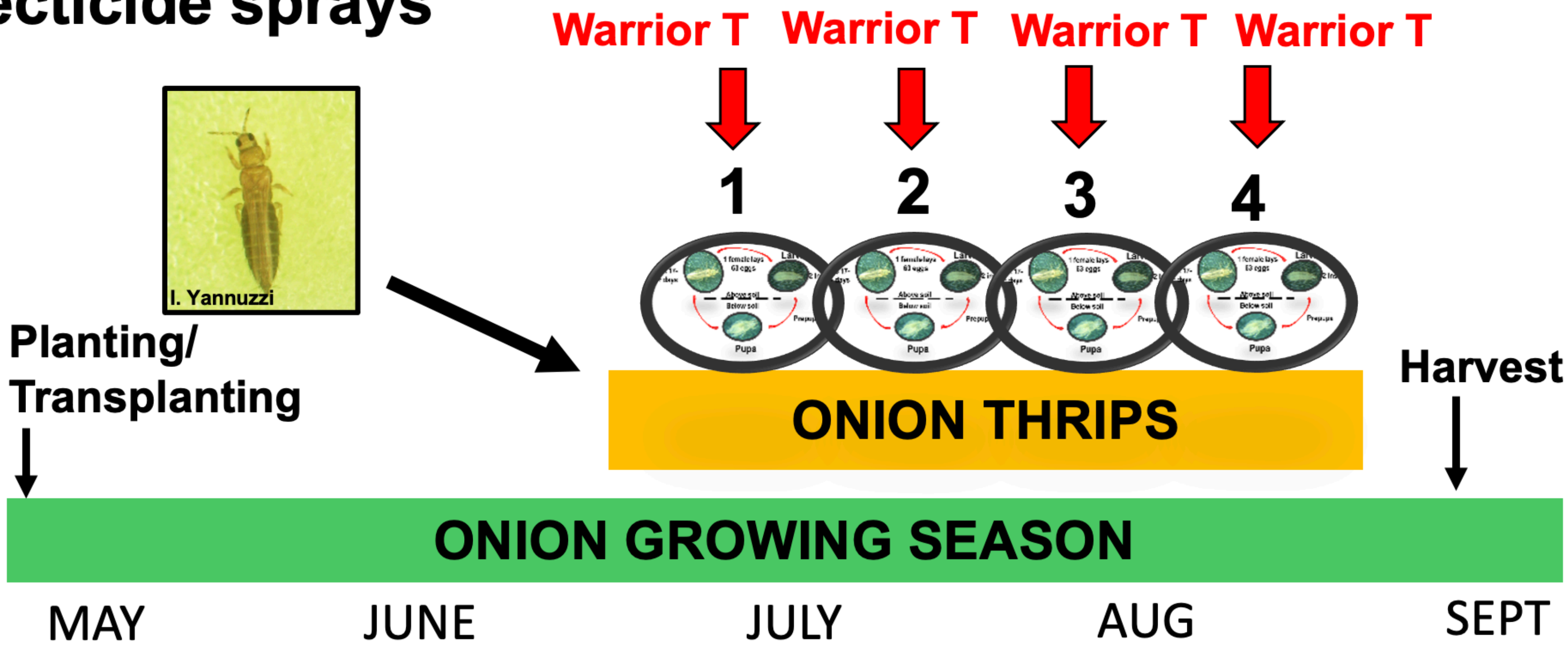
13 Journal Articles published between 1986-2016

• Sampling/Thresholds	ECB counts in processing sweet corn (2)
• Biological Control	a. *Trichogramma ostriniae* (2)
	b. Generalist predators (3)
• Host plant resistance	Bt sweet corn (2)
• Chemical control	Maximizing insecticide efficacy (2)
• Biology/management	*H. zea* review (1)
• IPM model	ECB management with HPR, biocontrol and insecticides (1)

This information is provided to Private Scouting Services

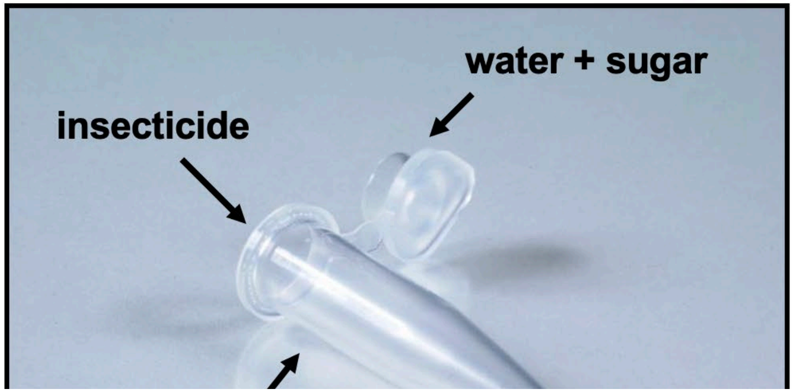
Onion Thrips Control (Not IPM)

In 1980s and 1990s, *T. tabaci* managed effectively with 3-4 insecticide sprays

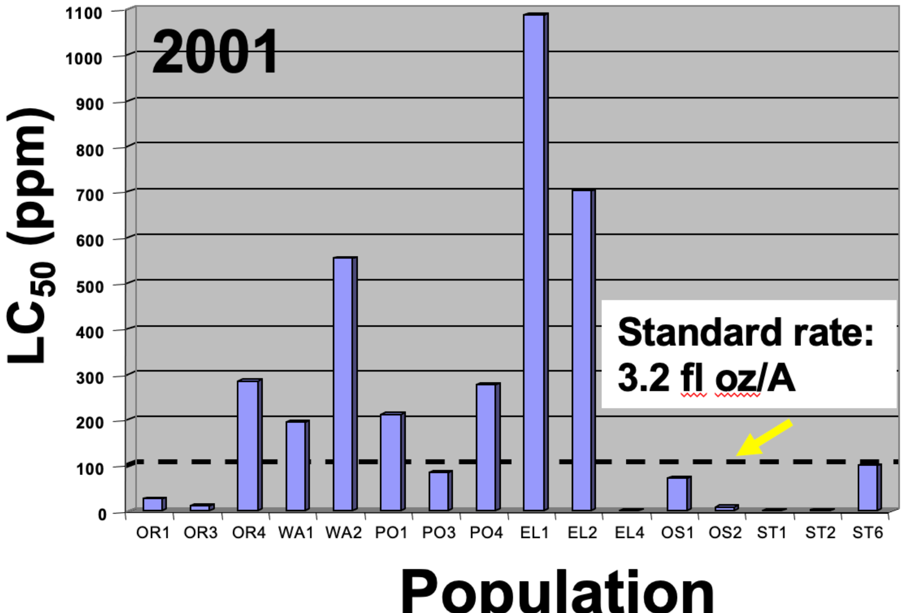


Control Failure!
Is It Resistance?

✓ Assessed *T. tabaci* susceptibility to insecticides using Thrips Insecticide Bioassay System (TIBS) Rueda & Shelton (2003) *Pest Manag. Sci.*

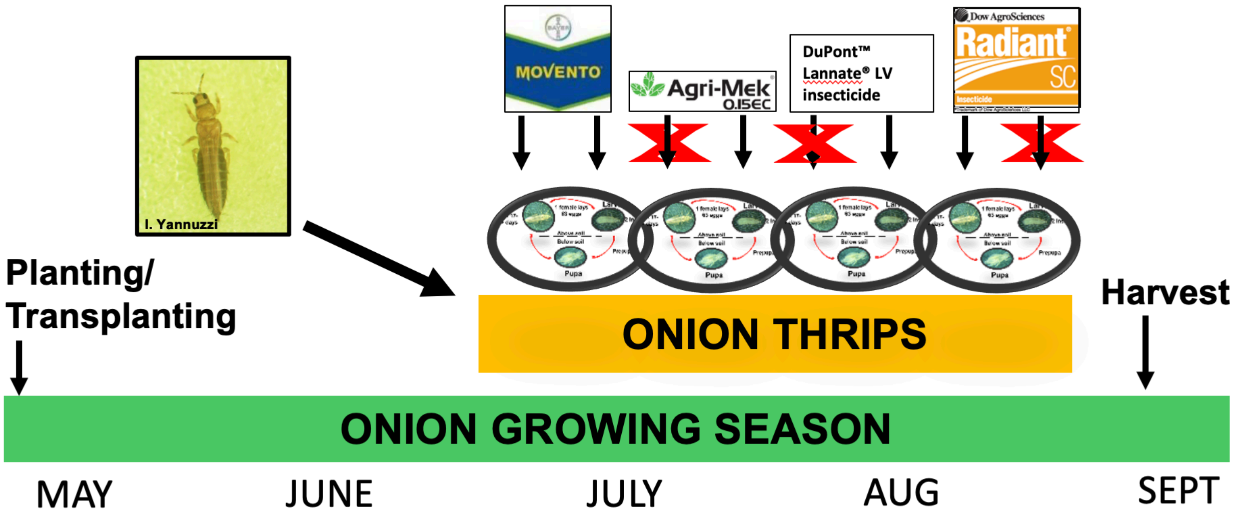


✓ LC_{50s} for *T. tabaci* populations to lambda-cyhalothrin (Warrior T) determined using TIBS Shelton, Nault, Plate & Zhao (2003) *J. Econ. Entomol.*



- Resistance to Warrior T detected in 7 of 16 *T. tabaci* populations across NY
- RR were >1,000 in 5 populations

✓ **<u>Insecticide Resistance Management Plan (3rd step)</u>: combine season-long sequence and action thresholds** Nault & Shelton (2009) *VegEdge*



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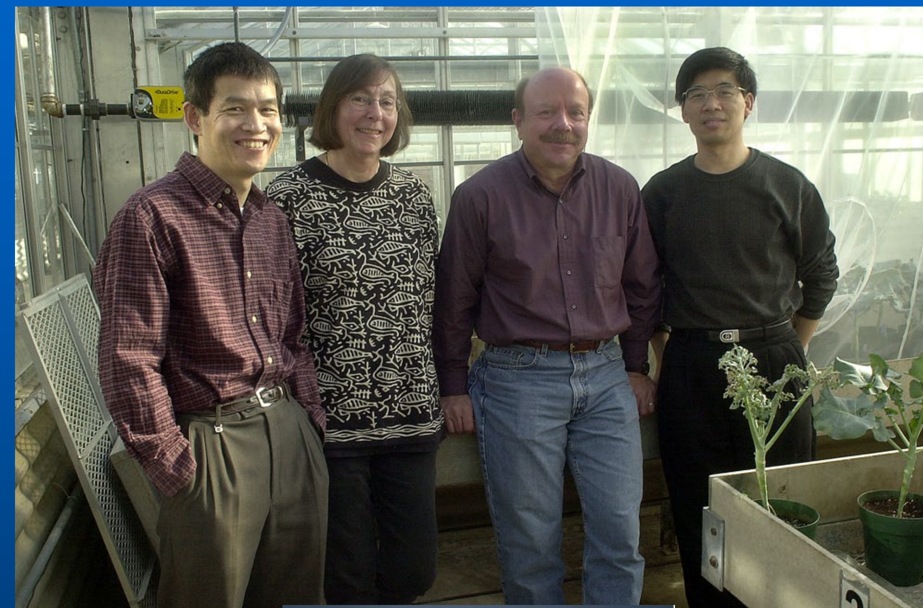
New York State Agricultural Experiment Station

✓ **Onion growers from Orleans (Elba) honored with 2019 NYS IPM Award primarily for their adoption of the thrips IRM plan**

- **#1 reason for IRM adoption - <u>mitigate insecticide resistance</u>, *not* to save money**
- **#2 reason why adoption was successful - <u>regular interactive meetings with growers</u> to build relationships and trust**

Bt Broccoli- DBM System
A Tool to Study IRM and BioControl



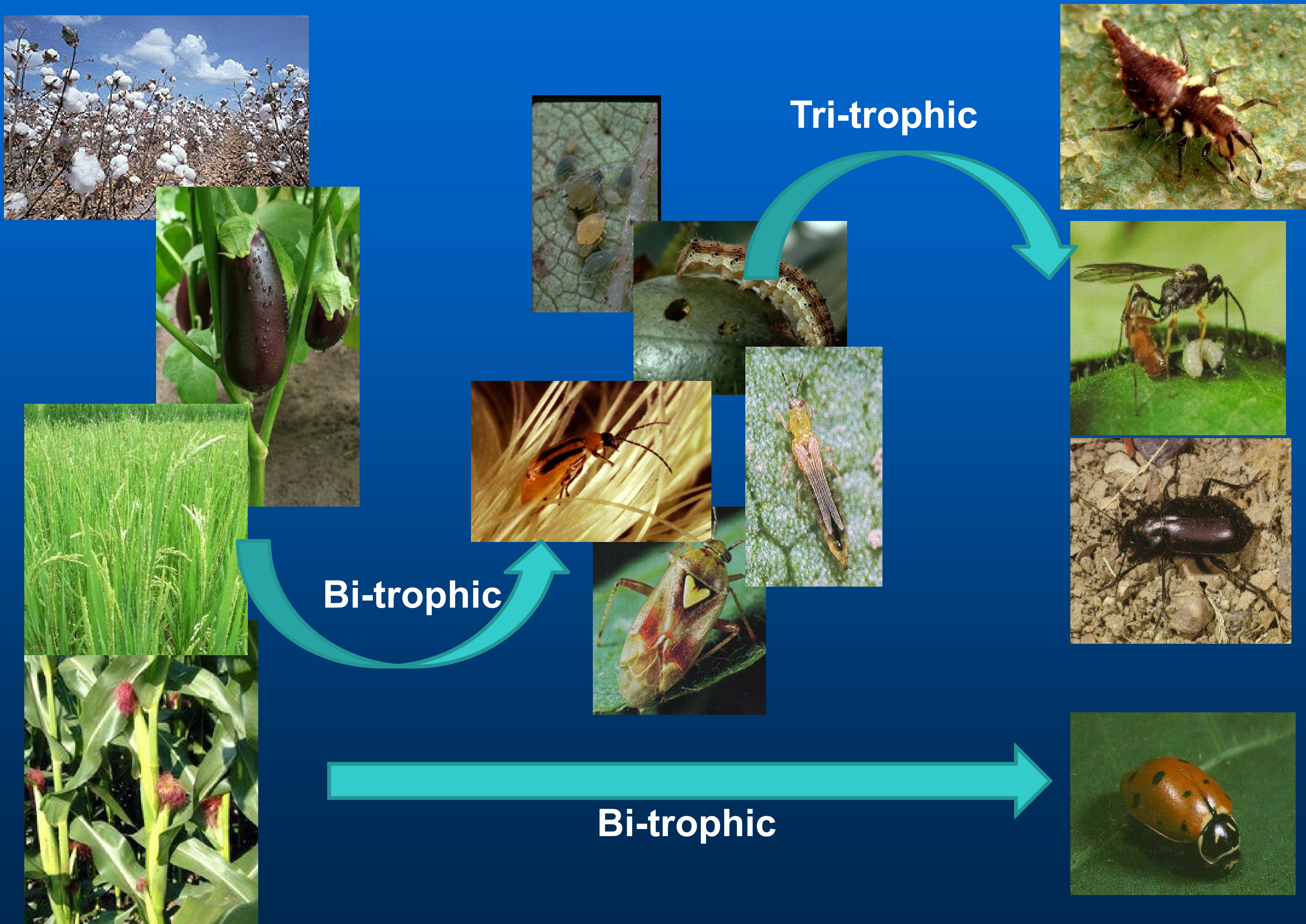
We have DBM populations resistant to Cry 1Ac and Cry 1C proteins and information on the genetics of resistance.

We developed broccoli plants expressing Cry 1Ac or Cry 1C toxins, or a combination of these toxins.

Results from Lab, Greenhouse and Field IRM Studies of Bt Broccoli- DBM System (Empirical Data Helps Inform EPA!)

- Refuges of non-Bt plants are <u>essential</u> for IRM
- Spatially <u>separate</u> refuges are superior to mixed refuges
- <u>Pyramiding</u> two Bt genes in plants will be more durable than single gene plants
- <u>Concurrent use</u> of Bt plants expressing a single gene and two Bt genes speeds insect resistant to the two gene plants

Are Bt Crops Harmful to Natural Enemies?



What Did We Learn?

Protein	Natural Enemy	Crop	Host	Effect
Cry1Ac, Cry2Ab, Cry1F	*Chrysoperla rufilabris*	Maize, cotton, broccoli	Fall armyworm, cabbage looper	No
Cry1Ac, Cry2Ab	*Geocoris punctipes*	Cotton	Cabbage looper	No
Cry 1F	*Cotesia marginiventris*	Maize	Cabbage looper	No
Cry1F	*Coleomagilla maculata*	Maize	Fall armyworm	No
Cry1Ac, Cry2Ab	*Coleomagilla maculata*	Cotton	Cabbage looper	No
Cry1C	*Diadegma insulare*	Broccoli	Diamondback moth	No
Cry1Ac, Cry 2Ab	*Geocoris punctipes*	Cotton	Onion thrips	No

Natural enemies delay insect resistance to transgenic insecticidal crops

Xiaoxia Liu[a, b], Mao Chen[b,1], Hilda L. Collins[b], David W. Onstad[c], Richard T. Roush[d], Qingwen Zhang[a], Elizabeth D. Earle[e] and Anthony M. Shelton[b,2]

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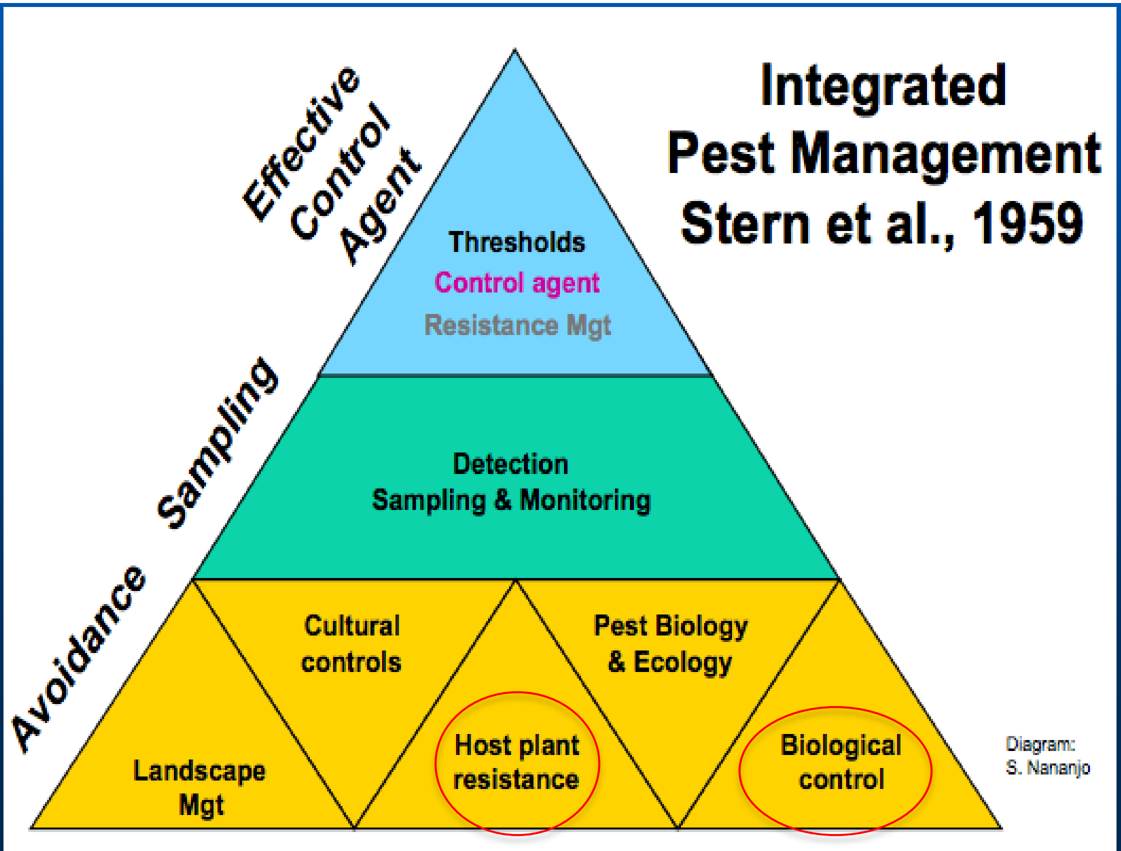
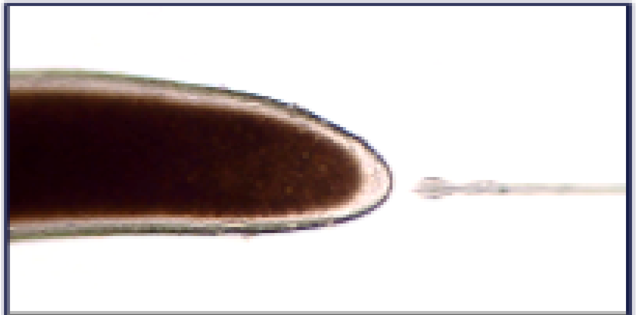
[1]Current address: GG3I, Monsanto Company, Chesterfield, MO 63017, USA; [2]To whom correspondence should be addressed. Anthony M. Shelton, Department of Entomology, Cornell University, NYSAES, 630 W. North St., Geneva, NY 14456, USA, Phone: 315-787-2453, FAX: 315-787-2326, E-mail: ams5@cornell.edu



Liu et al.
PLoS One 2014

Genetically Engineered, Self-limiting DBM
A Tool for the Future

How self-limiting insects are made



Injecting genes into insect egg

Self-Limiting Gene | Fluorescent Marker Gene

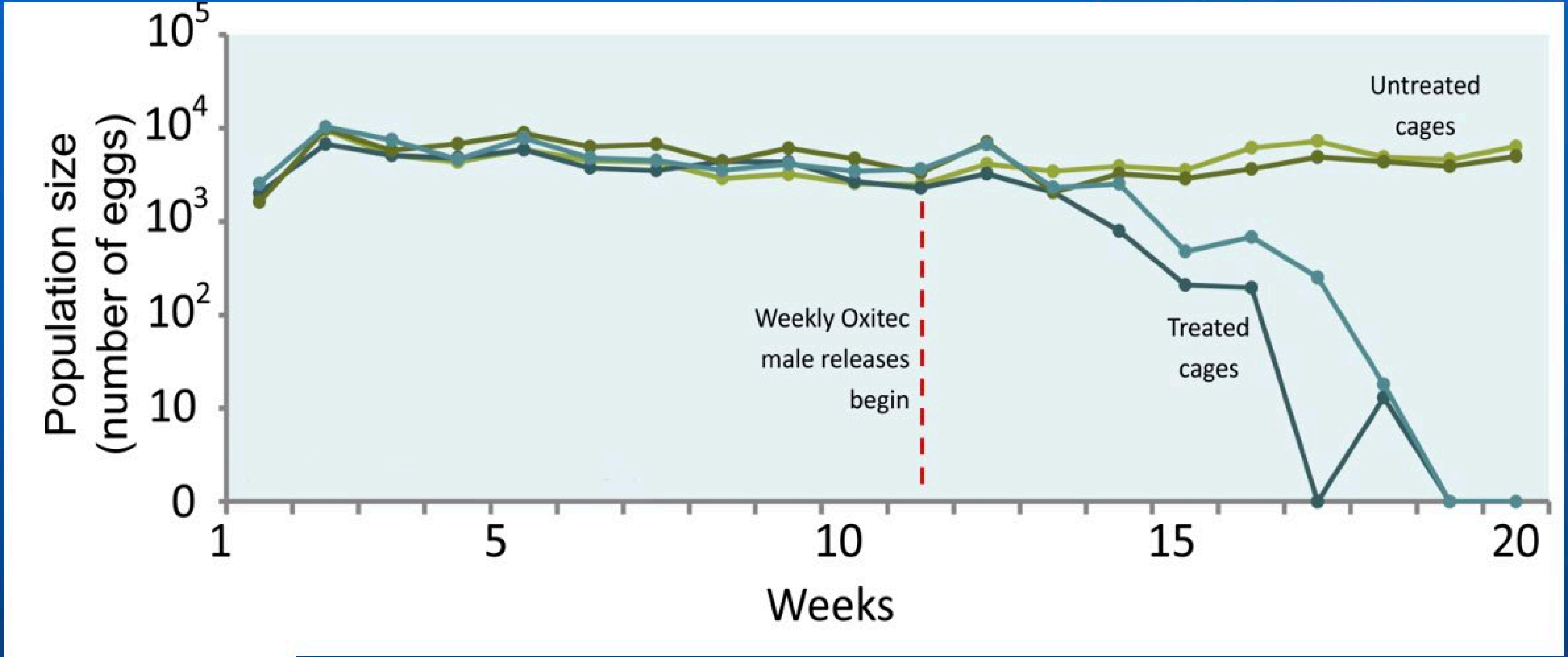
Self-Limiting Gene

- Inherited – female offspring do not survive into adulthood
- After releases stopped genes disappear from the gene pool and environment
- Repressed with an antidote during male insect production

Marker Gene

- Fluorescent protein detected by special light
- Identifies self-limiting vs. pest insects
- Allows estimation of pest population sizes
- Monitoring of pest population suppression
- Releases adjusted in nearly real time

Evaluating performance of the self-limiting DBM in greenhouses



Greenhouse cage suppression trials at Geneva

Harvey-Samuel et al. *2015. BMC Biology.*

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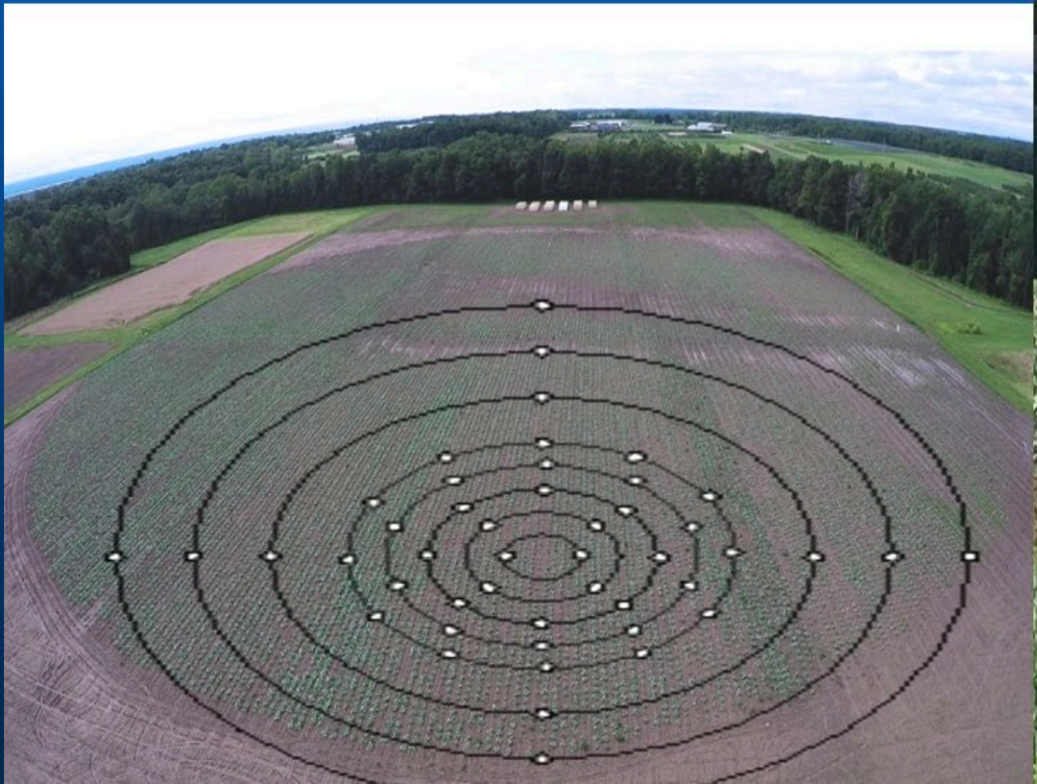
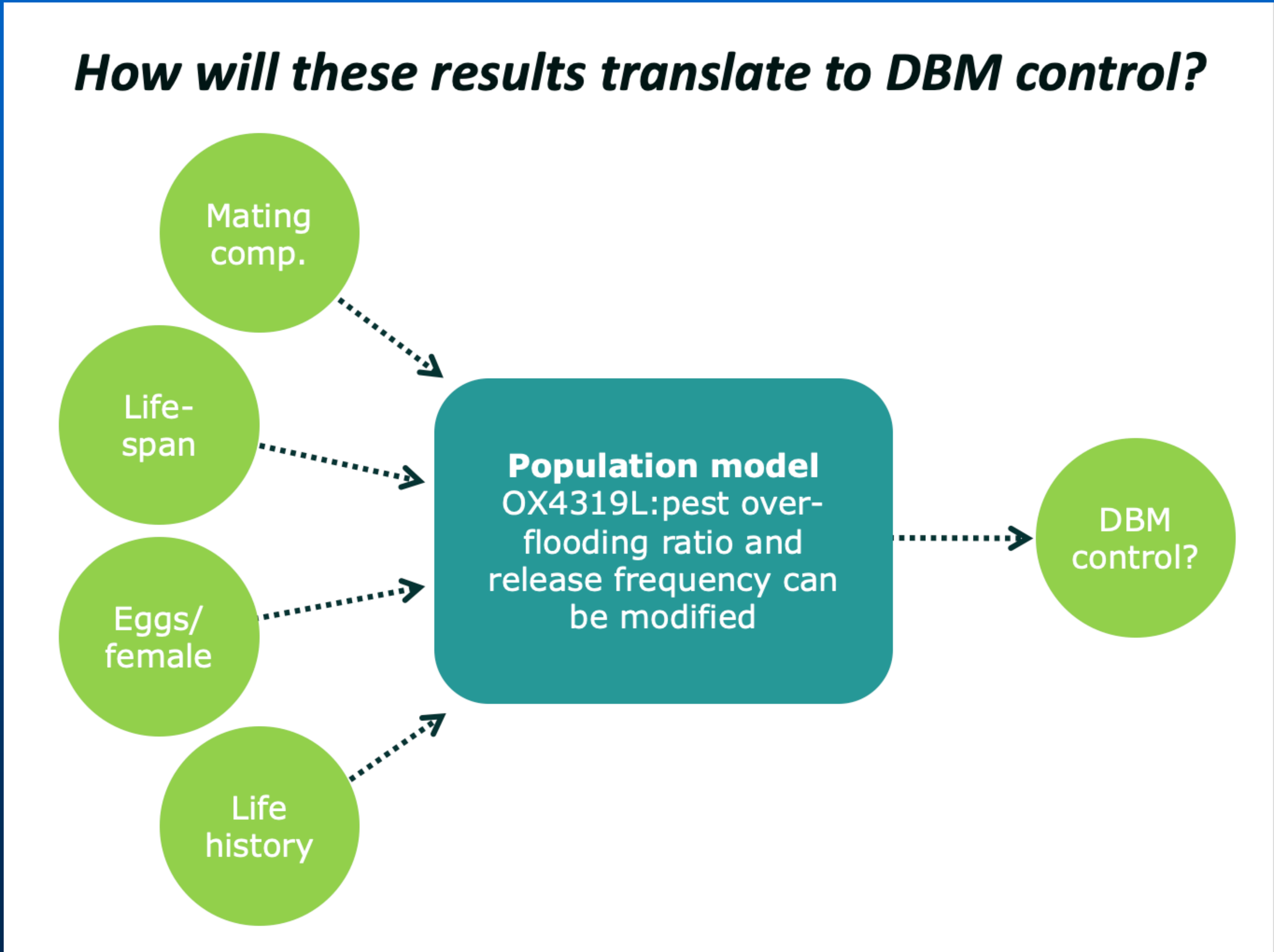
Open field releases to study GE DBM, 2017

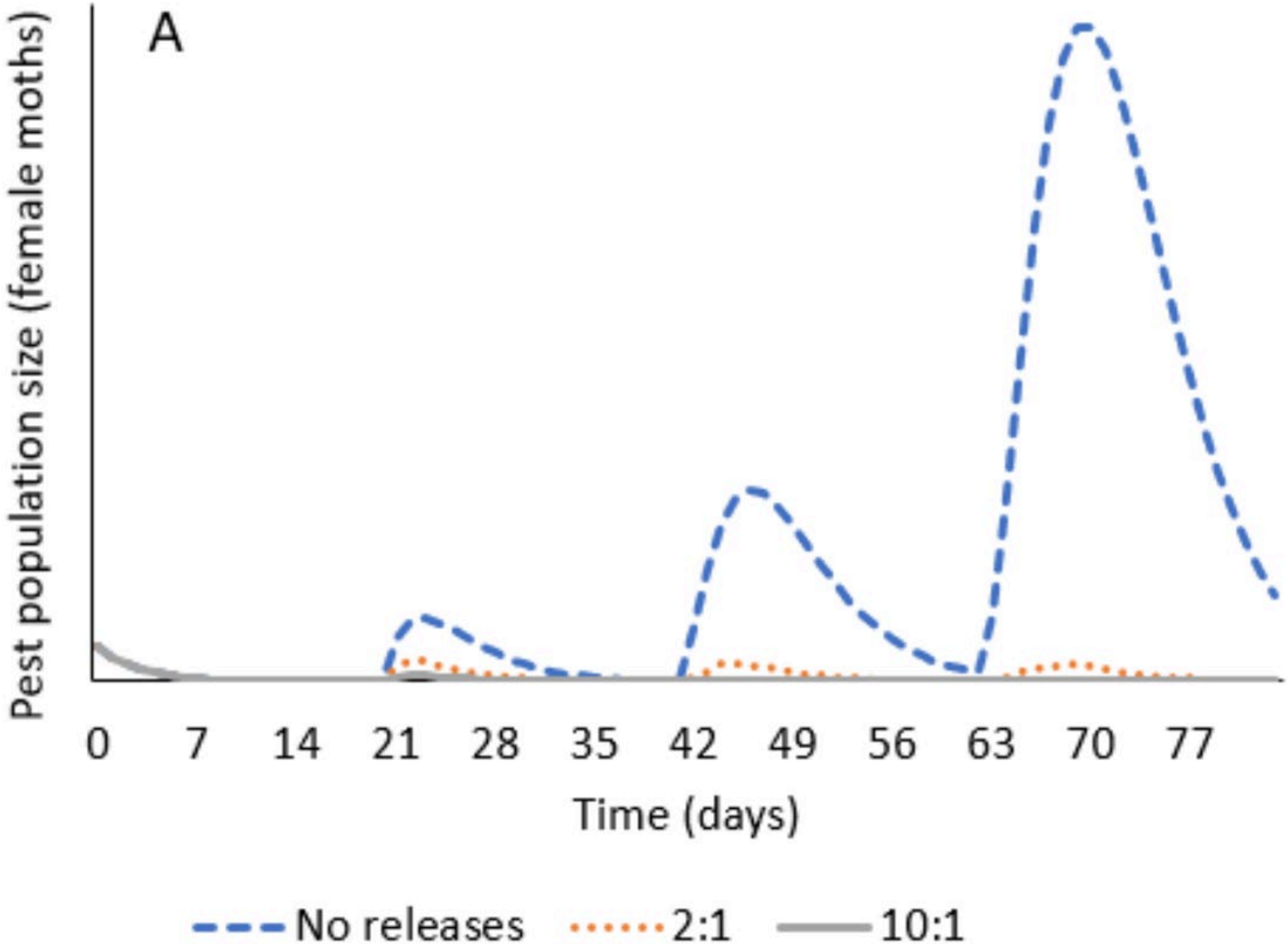
- We conducted a series of releases of <u>Oxitec and Georgia</u> males and monitored their movement patterns in an 8-acre field of cabbage using sticky traps baited with pheromone



What Did We Learn from Greenhouse Lab and Field Studies?



Single early season immigration on Day 1



FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Eggplant/Brinjal in Bangladesh

- Brinjal is the 2nd most important vegetable crop in Bangladesh
- Grown by 150,000 resource-poor farmers on 50,000 hectares
- Farmers spray insecticide 80-100 times to project brinjal from FSB
- Concerns about human health and the environment

Non-infected fruit of **Bt Uttara**

Infected fruit & shoot of **non Bt Uttara**

Honorable Minister for Agriculture

Ms. Matia Chowdhury MP

distributing seedlings of Bt Brinjal among the selected farmers on 22 January 2014

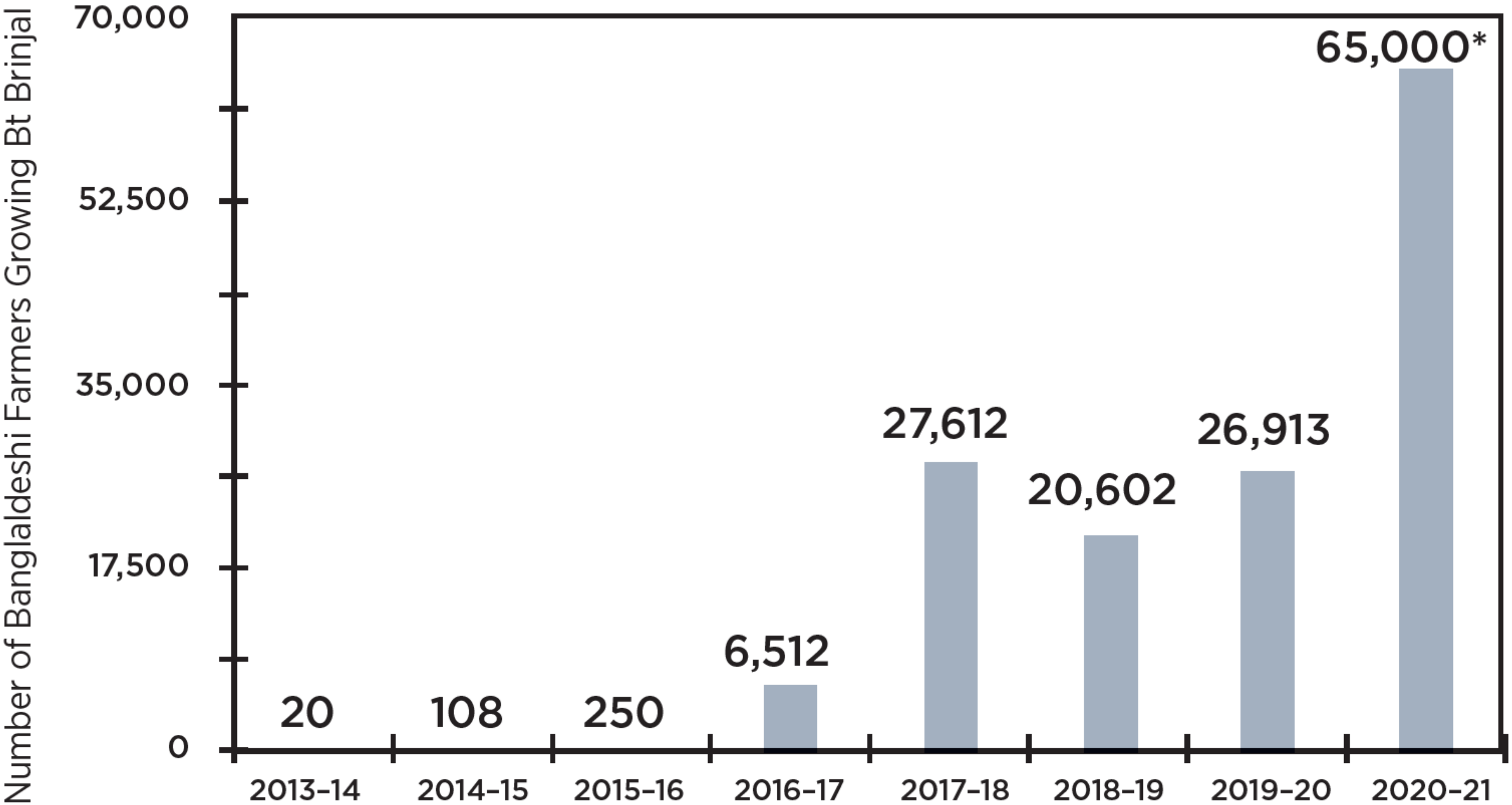


Fig. 4. Number of farmers growing Bt brinjal in Bangladesh by year (* indicates preliminary data). Farmers received seed from the Bangladesh Agricultural Research Institute (BARI), Department of Agricultural Extension (DAE), and the Bangladesh Agricultural Development Corporation (BADC).

Bt Brinjal: Success in Bangladesh

- Bt brinjal infestation was 0.04-0.88% compared to 48-57% in non Bt brinjal
- Insecticide use reduced by 61-98%
- Farmers realized a 6-fold increase in the net returns
- Studies have shown no harmful effects of Bt brinjal on non-targeted organisms
- Thousands of farmers have been trained
- Bangladesh Agricultural Research Institute (BARI) has adopted more rigorous stewardship practices

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FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

Shelton, A. M. 2021. Bt eggplant: a personal account of using biotechnology to improve the lives of resource-poor farmers. American Entomologist 67:3

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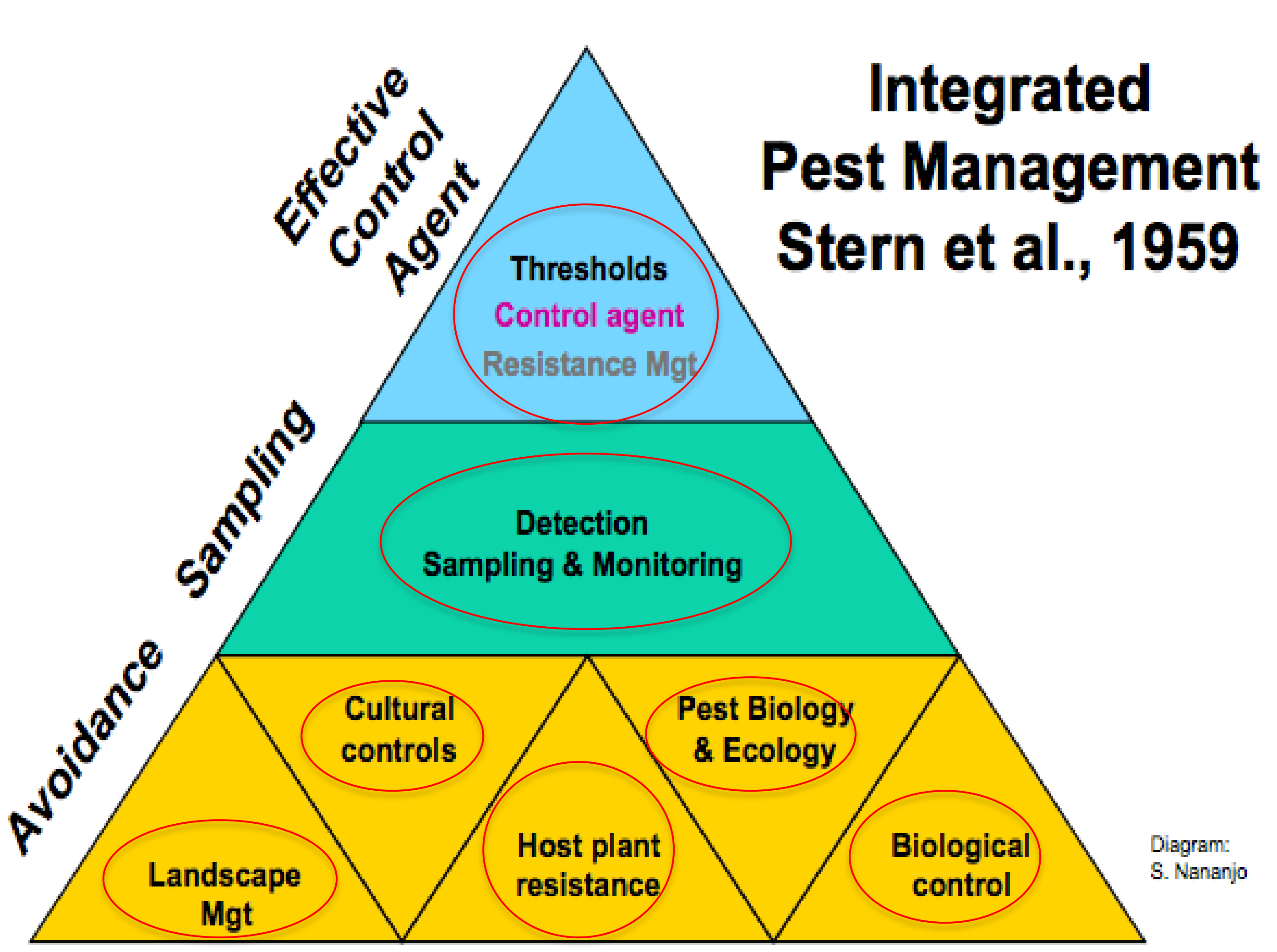

Thanks to the Those Who Contributed to Our Program

- 41 MS and PhD students
- 47 postdocs and visiting scientists
- > 250 technicians
- Dozens and dozens of colleagues nationally and internationally
- Federal, State and Industry Funding