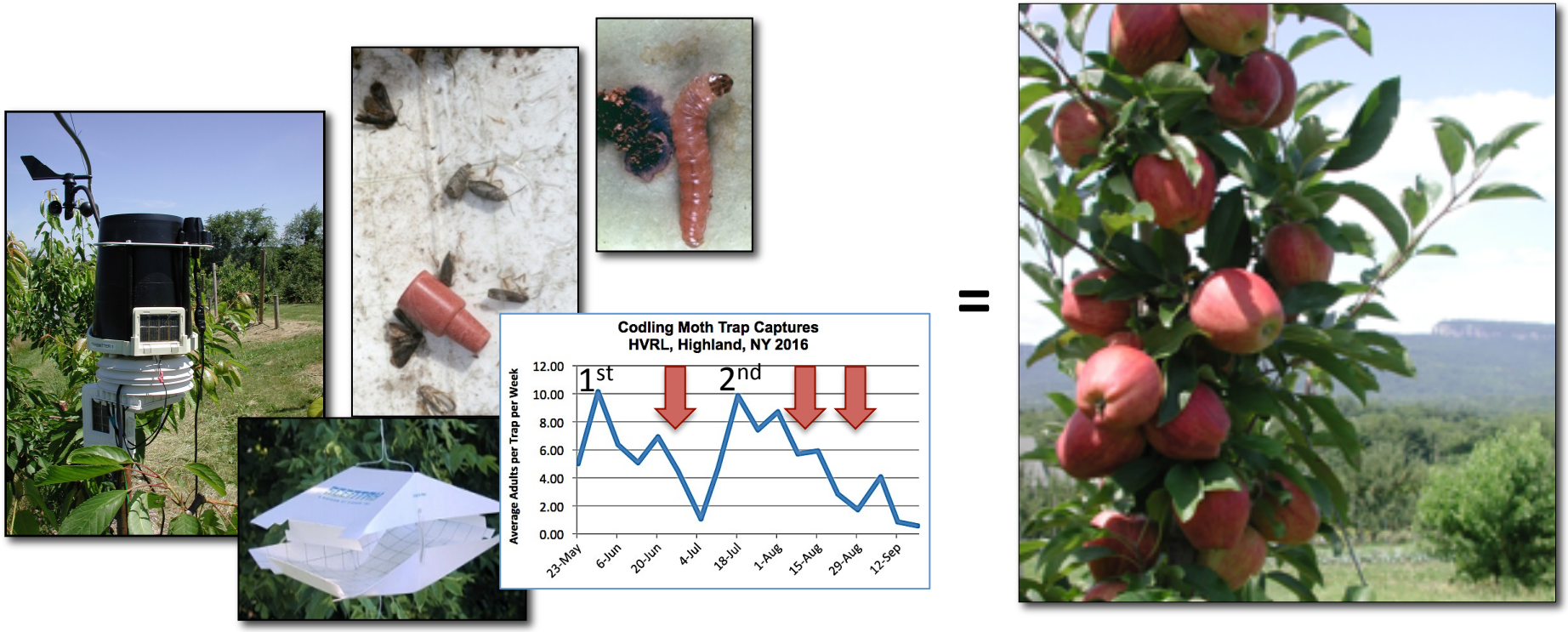
Monitoring, Modeling and Managing the Lepidopteran Complex in Apple: How Complex Is It ?



2017 VT Tree Fruit Growers Association And University Of Vermont Apple Program
Annual Educational Meeting

February 16, 2017

American Legion Hall, Middlebury, VT

Peter Jentsch
Senior Extension Associate – Entomology

Presentations can be found at:

http://blogs.cornell.edu/jentsch/presentations/

Hudson Valley Lepidopteran Pest Complex

Leafroller:

Obliquebanded leafroller, *Choristaneura rosaceana* (Harris)

Sparganothis Fruitworm *(Sparganothis sulfureana)*

Redbanded leafroller, *Argyrotaenia velutinana* (Walker)

Variegated leafroller, *Platynota flavedana* (Clemens),

Tufted apple bud moth, *Platynota idaeusalis*

Fruit tree leafroller, *Archips argyrospila* (Walker),

Internal Lepidopteran:

Oriental fruit moth

Lesser apple worm

Codling moth

Green Fruitworm

Trunk Borers

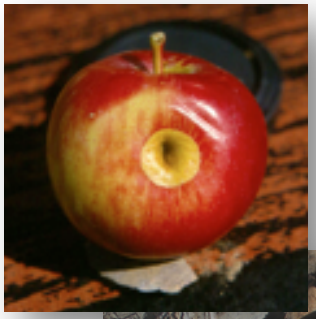
Leafminers

Hudson Valley Lepidopteran Pest Complex

Leafroller:

Obliquebanded leafroller, *Choristaneura rosaceana* (Harris)

Redbanded leafroller, *Argyrotaenia velutinana* (Walker)



Early-Season
Leafroller Injury

Late-Season
Leafroller Injury

Hudson Valley Lepidopteran Pest Complex

Leafroller:

Obliquebanded leafroller, *Choristaneura rosaceana* (Harris)

Redbanded leafroller, *Argyrotaenia velutinana* (Walker)

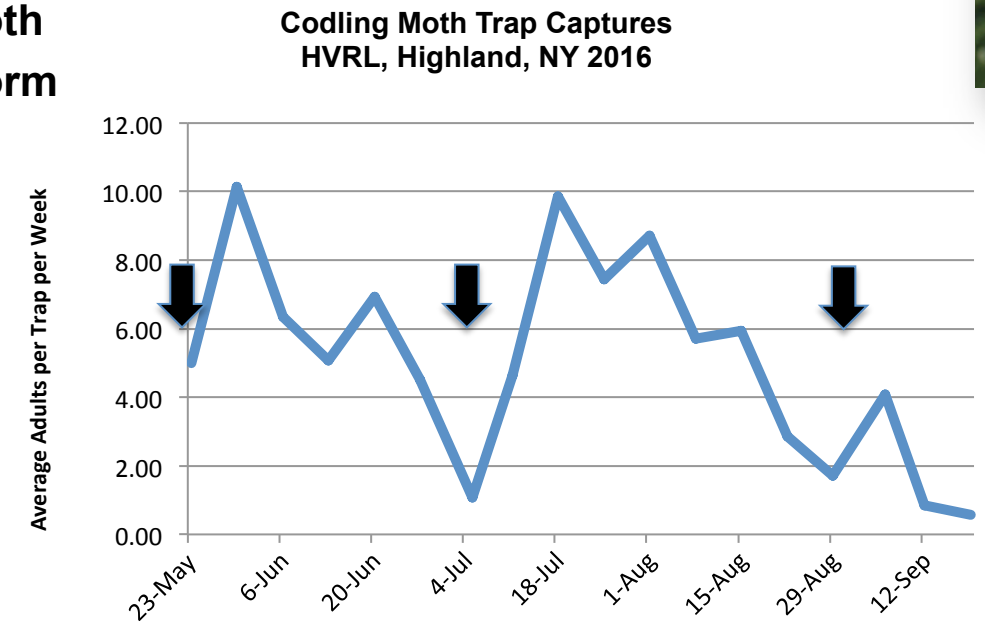
Internal Lepidopteran:

Codling moth

Oriental fruit moth

Lesser apple worm

Early & Late
Codling Moth Injury

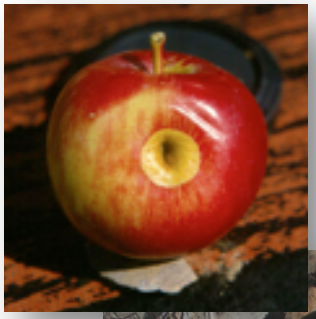


Hudson Valley Lepidopteran Pest Complex

Leafroller:

Obliquebanded leafroller, *Choristaneura rosaceana* (Harris)

Redbanded leafroller, *Argyrotaenia velutinana* (Walker)



Early-Season Leafroller Injury

Internal Lepidopteran:

Codling moth

Oriental fruit moth

Lesser apple worm

Early & Late Codling Moth Injury

Late-Season Leafroller Injury

*** Endemic – Reside in the orchard throughout the season.** Continuous exposure

*** Multiple generations:** Greater selection pressure

*** High Risk for Inseticide Resistance**

Obliquebanded Leafroller Management

Obliquebanded Leafroller (OBLR) A native of North America. Larvae feed on a wide range of Rosaceae, including apple, peach, and pear.

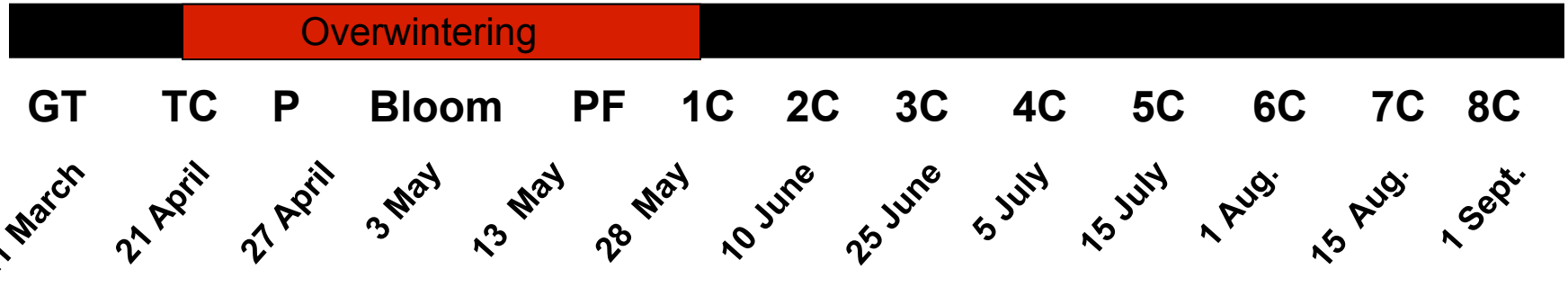
- 2 generations each season in NY.
- Female lay single clusters containing ≥200 eggs on the upper leaf surface, hatching in 10-12 days.
- Larva live and feed within curled and webbed foliage, feed only on the fruit surface, webbing leaves to clustered fruit for protection.
- Mature larvae reach 1 inch in length
- Monitor adult flight using *pheromone trapping*.

At sustained flight of **OBLR adults (Biofix)**, larval emergence is predicted after **340 DD_{43}** have been accumulated.

Obliquebanded Leafroller

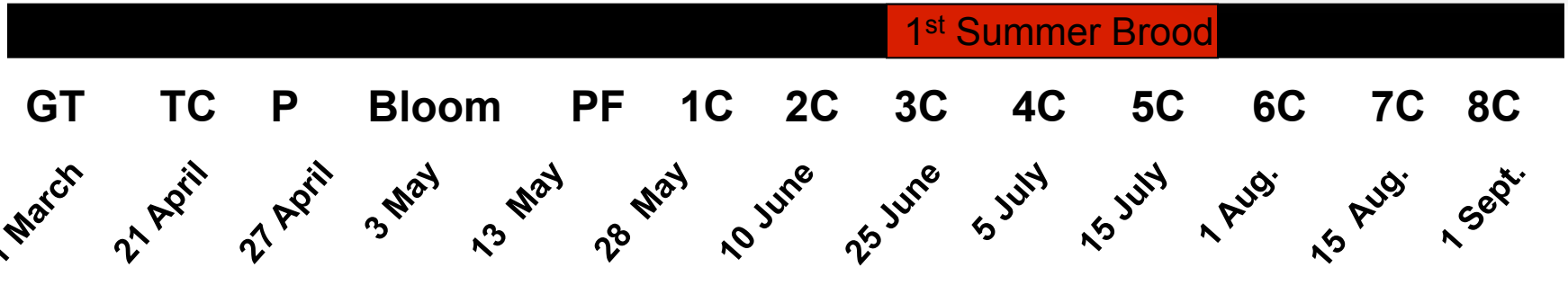
Family: Tortricidae

Overwintering larva damage to flowers, foliage and developing fruit



Obliquebanded Leafroller

1st summer brood larva damage to foliage and developing fruit



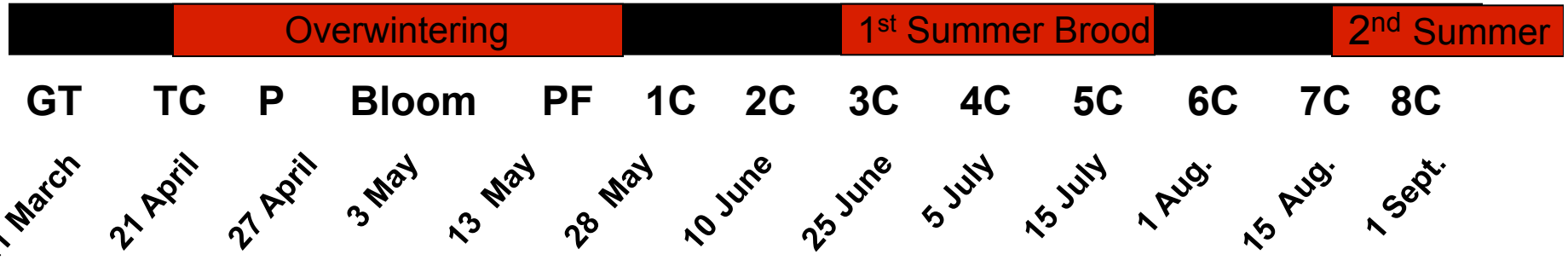
Obliquebanded Leafroller

2nd summer brood occurs in Mid-August

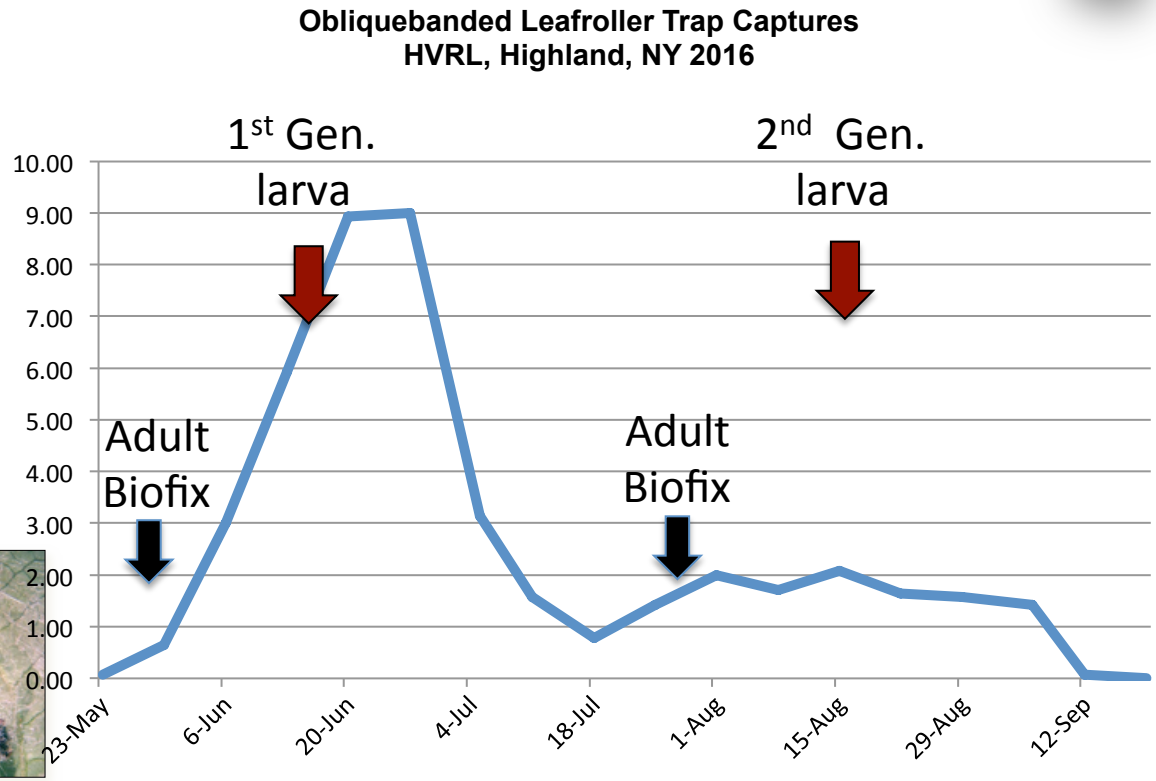
Larval emergence gives rise to the over-wintering generation.

Pin hole feeding damage near harvest in mid-late season varieties (Jonagold)

Thoratic shield behind head of larva



Obliquebanded Leafroller
3 Management Periods



GT TC P Bloom PF 1C 2C 3C 4C 5C 6C 7C 8C

OW Larva Management
1 App (P, Bloom, PF)

340 DD_{43}

1st Gen. Larva Management
2 Apps 3rd & 4th C

340 DD_{43}

2nd Gen. Larva Management
1-2 Apps 7th C

Obliquebanded Leafroller Management

Resistance Management for Leps (OBLR):

Three management timings for OBLR using a single A.I. IRAC class for each generational window

I. Overwintering larvae (Pre-bloom, Bloom, PF)
II. 1st Generation larvae (**340 DD_{43}**)
III. 2nd Generation larvae (**340 DD_{43}**)

At sustained flight of **OBLR adults** (Biofix), larval emergence is predicted after **340 DD_{43}** have been accumulated.

Obliquebanded Leafroller

Pre-bloom, Bloom or Petal Fall

Classes	Formulation	Efficacy	Group (s)
1A	**Lannate 90SP/LV**	**High**	**(Carbamate) - Pink**
3A	Warrior II 2.08	Moderate	(Pyrethroid)
3A	Ambush 25WP	Moderate	(Pyrethroid)
3A	Asana XL	Moderate	(Pyrethroid)
3A	Baythroid XL 1EC	Moderate	(Pyrethroid)
5	Delegate 25WG	High	(Spinosyn)
5	Entrust 2SC	High	(Spinosyn)
6	**Proclaim 5SG**	**Moderate**	**(Emamectin Benzoate) - Petal Fal**
11A	**Dipel 10.3DF**	**Moderate / low**	**(Bacillus thuringiensis) - Bloom**
15	Rimon 0.83EC	High	(Novaluron)
18	**Intrepid 2F**	**Moderate**	**(Methoxyfenozide) – Petal Fall**
28	Exirel	High	(Cyantraniliprole)
28	Altacor 35WDG	High	(Chlorantraniliprole)
28	Belt 4SC	High	(Flubendiamide)
Premix			
3A/6	Gladiator EC	High	(Zeta-Cypermethrin/Avermectin B!)
3A/28	Voliam Xpress	Moderate	(Zeta-Cypermethrin/Avermectin B!)
4A/3A	Endigo ZC	Moderate	(Thiamethoxam/Lambda-cyhalothrin)
4A/28	Voliam Flexi WDG	High	Chlorantraniliprole/Thiamethoxam

Obliquebanded Leafroller

1st Generation (220 DD_{50})

Classes	Formulation	Efficacy	Group (s)
1A	Lannate 90SP/LV	High	(Carbamate)
3A	Warrior II 2.08	Moderate	(Pyrethroid)
3A	Ambush 25WP	Moderate	(Pyrethroid)
3A	Asana XL	Moderate	(Pyrethroid)
3A	Baythroid XL 1EC	Moderate	(Pyrethroid)
5	**Delegate 25WG**	**High**	**(Spinosyn) – Early hatch + 10-14d**
5	Entrust 2SC	High	(Spinosyn)
6	Proclaim 5SG	Moderate	(Emamectin Benzoate)
11A	**Dipel 10.3DF**	**Moderate / low**	**(Bacillus thuringiensis) – Early hatch + 5-7d**
15	**Rimon 0.83EC**	**High**	**(Novaluron) – Biofix + 50DD**
18	Intrepid 2F	Moderate	(Methoxyfenozide) – Petal Fall
28	Exirel	High	(Cyantraniliprole)
28	Altacor 35WDG	High	(Chlorantraniliprole)
28	Belt 4SC	High	(Flubendiamide)
Premix			
3A/6	Gladiator EC	High	(Zeta-Cypermethrin/Avermectin B!)
3A/28	Voliam Xpress	Moderate	(Zeta-Cypermethrin/Avermectin B!)
4A/3A	Endigo ZC	Moderate	(Thiamethoxam/Lambda-cyhalothrin)
4A/28	Voliam Flexi WDG	High	Chlorantraniliprole/Thiamethoxam

Obliquebanded Leafroller

2nd Generation (220 DD_{50})

Classes	Formulation	Efficacy	Group (s)
1A	Lannate 90SP/LV	High	(Carbamate)
3A	Warrior II 2.08	Moderate	(Pyrethroid)
3A	Ambush 25WP	Moderate	(Pyrethroid)
3A	Asana XL	Moderate	(Pyrethroid)
3A	Baythroid XL 1EC	Moderate	(Pyrethroid)
5	Delegate 25WG	High	(Spinosyn)
5	Entrust 2SC	High	(Spinosyn)
6	Proclaim 5SG	Moderate	(Emamectin Benzoate)
11A	Dipel 10.3DF	Moderate / low	(Bacillus thuringiensis)
15	Rimon 0.83EC	High	(Novaluron)
18	Intrepid 2F	Moderate	(Methoxyfenozide)l
28	**Exirel**	**High**	**(Cyantraniliprole)**
28	**Altacor 35WDG**	**High**	**(Chlorantraniliprole)**
28	**Belt 4SC**	**High**	**(Flubendiamide)**
Premix			
3A/6	Gladiator EC	High	(Zeta-Cypermethrin/Avermectin B!)
3A/28	Voliam Xpress	Moderate	(Zeta-Cypermethrin/Avermectin B!)
4A/3A	Endigo ZC	Moderate	(Thiamethoxam/Lambda-cyhalothrin)
4A/28	Voliam Flexi WDG	High	Chlorantraniliprole/Thiamethoxam

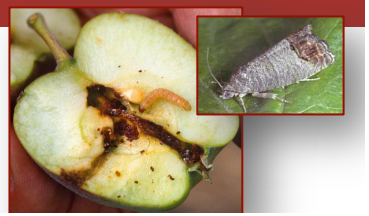
Codling Moth Management

Codling moth (CM) A European invasive pest

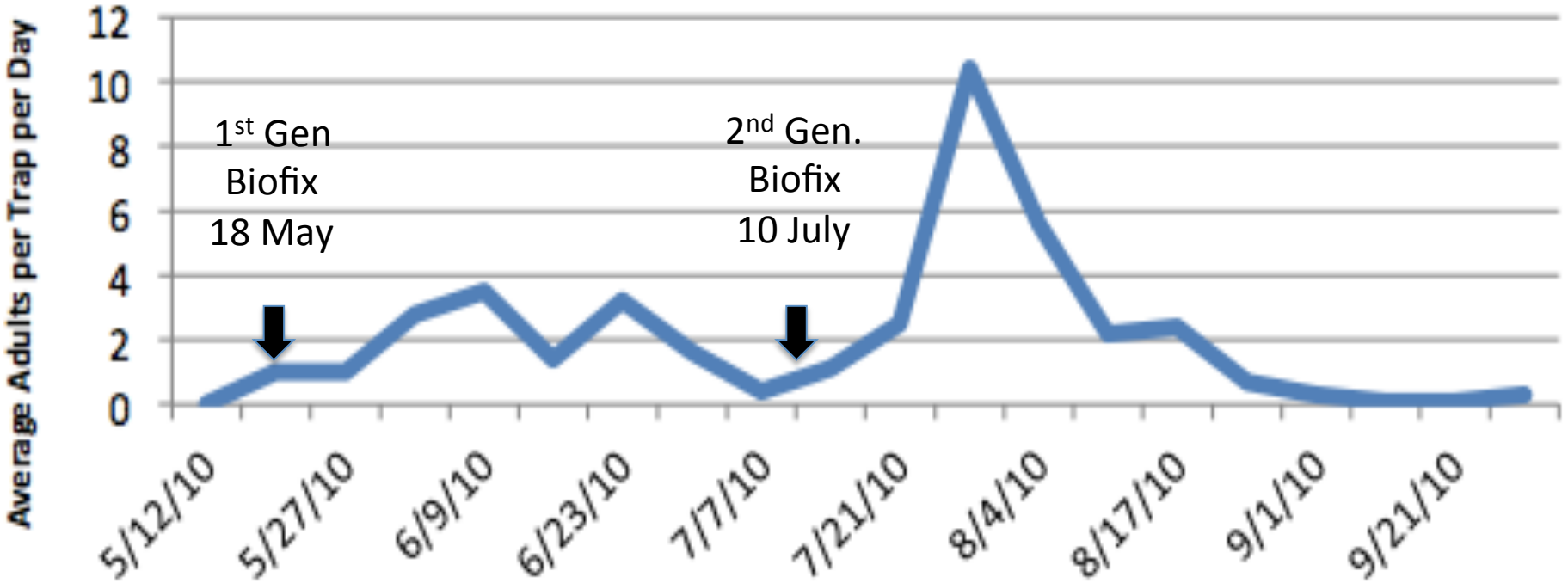
- Broad plant host range including tree fruit.
- Having 1.5 to 3.5 generations each season in NY.
- Female lay single eggs on fruit or foliage.
- Larva will remove the skin of fruit without ingestion, burrowing into the fruit to **feed on seeds.**
- Monitor adult flight using *pheromone trapping*.

- Upon the first sustained flight of **CM adults** (Biofix), larval emergence is predicted using 50^{o}F developmental base temperature accumulations at **220 DD_{50}**.

Codling Moth Management



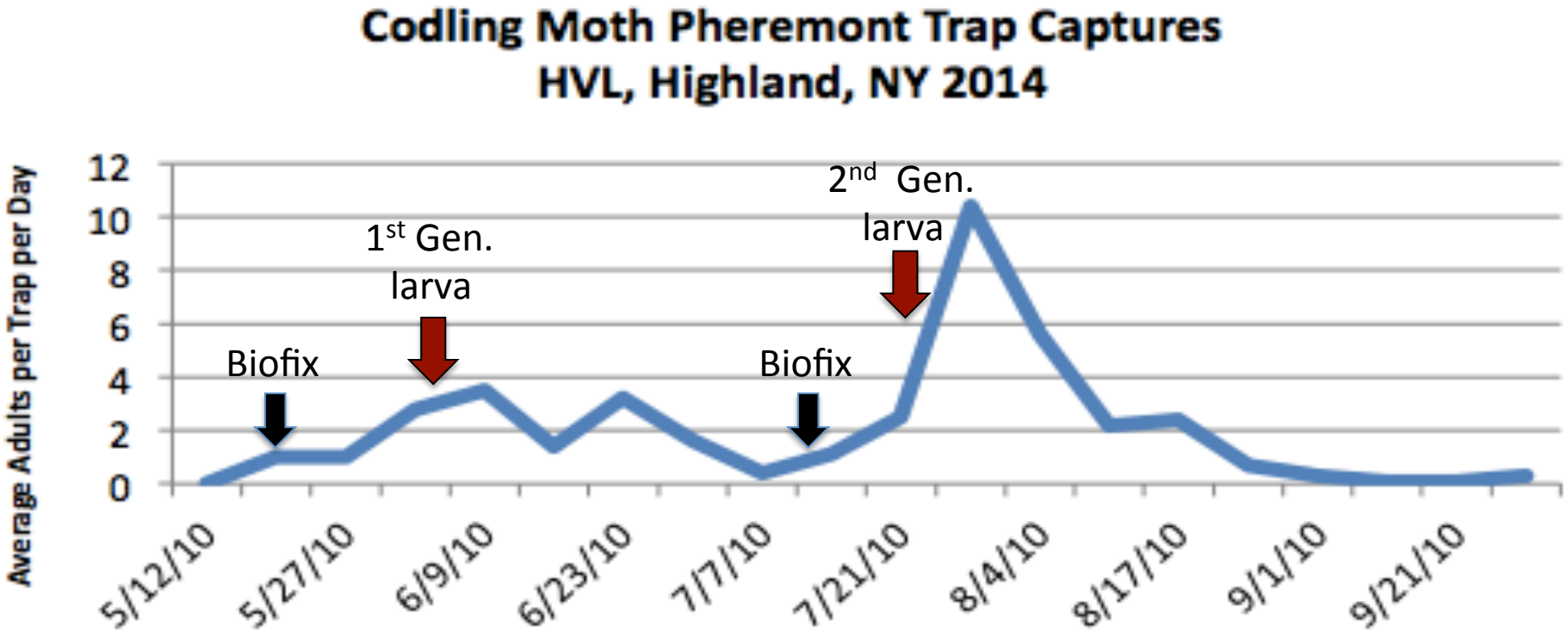
Codling Moth Pheremont Trap Captures
HVL, Highland, NY 2014



Codling Moth Management

- In 2014, the 1st generation **codling moth** (CM) adult flight occurred on 18 May. Larval emergence predicted for **4 June** using **220 DD_{50}** from the biofix.

- The 2nd generation CM management adult emergence using 10 July Biofix predicted 250DD to occur on **20 July** with treatments made for this insect on 18 July.



2014 Hudson Valley Insecticide Efficacy

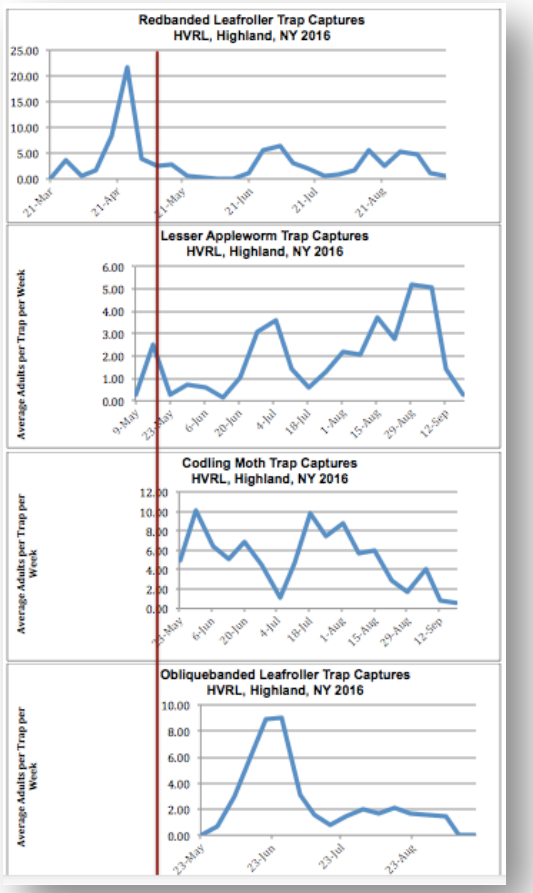
Evaluation 24 June, 2014 representing 1st generation CM injury

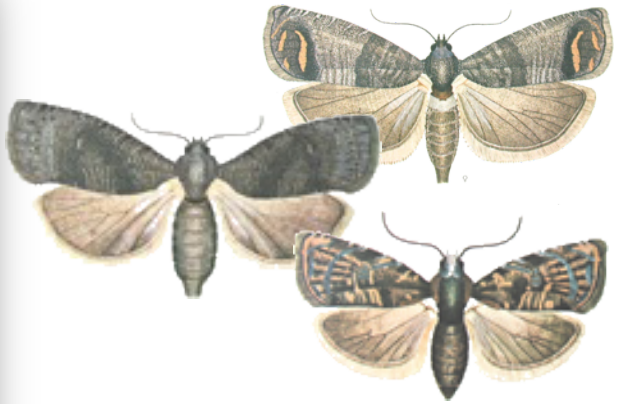
Treatment / Formulation	Rate	Timing	Incidence (%) Of Codling Moth Damaged Cluster Fruit [a] Ginger Gold	Red Delicious
1 Actara	5.5 oz./A	PF-1C	0.0 a	0.0 a
Movento	9.0 fl.oz./A	1C		
+ LI-700	0.5%	1C		
Belt	5.0 fl.oz./A	1st Gen CM + 14d		
Delegate WG	6.0 oz./A	2nd Gen CM + 14d		
Leverage 360	2.8 fl.oz./A	BMSB		
Assail	8.0 oz./A	AM		
10. Calypso	4.0 fl.oz./A	P	0.5 ab	0.0 a
Calypso	6.0 fl.oz./A	PF-2C		
Altacor	4.5 oz./A	1st Gen CM @ 14d		
Danitol	21.3 fl.oz./A	BMSB, AM		
Thionex 50WP	4.0 lb./A	BMSB		
Bifenthrin EC	12.8 fl.oz./A	BMSB, AM		
11. UNTREATED			6.0 d	4.0 b

[a]Evaluation was made on 24 June assessing 100 fruit in each of 4-tree plot per replicates of two varieties. Percent data were transformed using $\log_{10}(x+1)$ using Fishers Protected LSD ($P \leq 0.05$). Treatment means followed by the same letter are not significantly different. Arithmetic means reported.

‘Delta’ Trap

Species Specific Pheromone





Determine key biological events of the Lep. complex in orchards.

1. Presence of the insect in our orchard.
2. Determine the ‘Biofix’ or **start of a generation.**
3. Use NEWA to find the predicted date of larva emergence.
4. Make application based on optimum weather window on either side of larval hatch.

Rejections of Apple Shipments From *Western* NY Processing Orchards Due to Increasing Internal Worm Infested Fruit

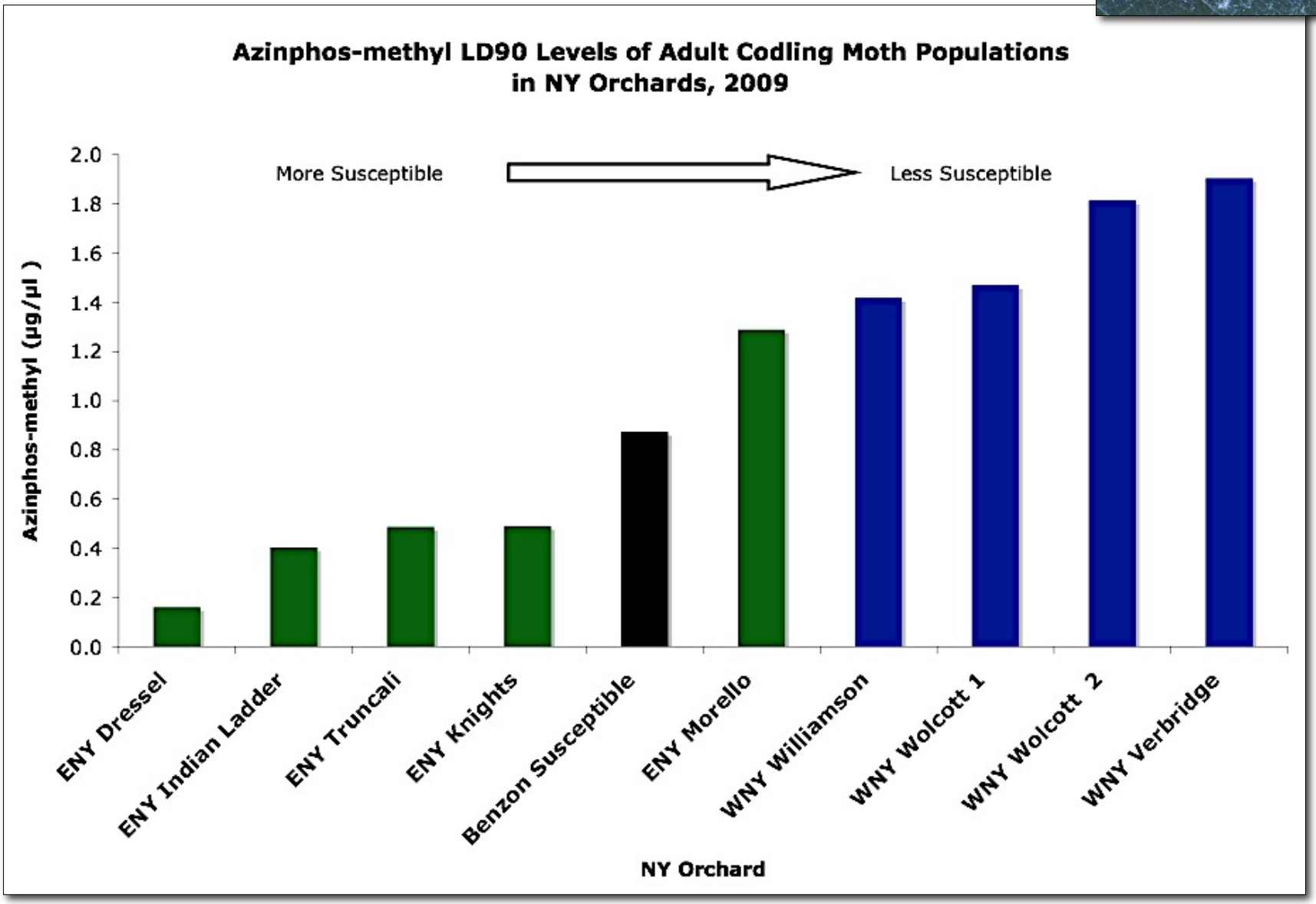
2001: 20 loads of infested fruit

2002: 80 loads of infested fruit from 42 growers in WNY[1]

2005: 100 loads of infested fruit from 60 farms.

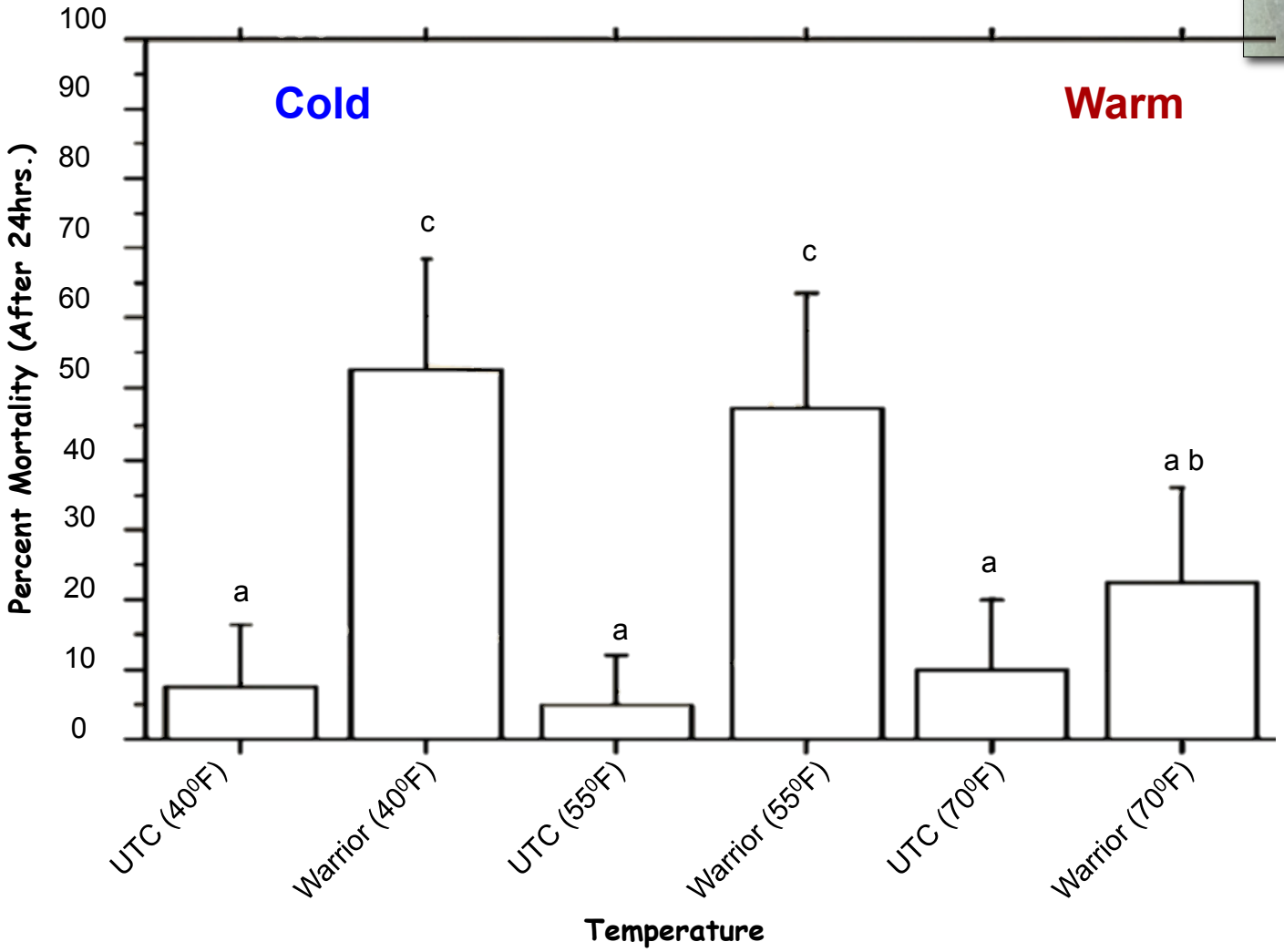
1. Rhode Island Greening (12 loads), Monroe (12 loads), Cortland (7 loads), Idared (7 loads), Jonagold (6 loads), Rome (4 loads)

Azinphos-methyl susceptibility levels



Codling Moth Larvae Bioassay (susceptible 'Benzon' Colony), NYSAES, Highland NY 2009[1]

Warrior @ 0.16 fl. oz. /A



[1] Bioassay conducted on 1st instar codling moth larva topically treated with 1µL droplet of lamda-cyhalothrin at 0.0005 µg A.I./ 1000 mL or 0.0005 ppm [**3% of the labeled field rate**] placed in temperature controlled chambers over 24 hours. (df = 3, F-value = 8.648, P-value = 0.0001).

Codling Moth (+ Plum Curculio)

1st Generation (220 DD_{50})

Classes		Formulation	Efficacy	Group (s)
1A	Lannate	High	(Carbamate)	
1A	Sevin	Moderate	(Carbamate)	
1B	Imidan 70W	High	(Organophosphate)	
3A	Baythroid XL 1EC	Moderate	(Pyrethroid)	
4A	Assail 30SG	High	(Neonicotinoid)	
5	Delegate 25WG	High	(Spinosyn)	
5	Entrust 2SC	High	(Spinosyn)	
6	Proclaim 5SG	Moderate	(Emamectin Benzoate	
11A	Dipel 10.3DF	Moderate / low	(Bacillus thuringiensis)	
15	Rimon 0.83EC	High	(Novaluron)	
18	Intrepid 2F	Moderate	(Methoxyfenozide)	
22	Avaunt 30WDG	Moderate	(Indoxacarb)	
28	Exirel	High	(Cyantraniliprole)	
28	Altacor 35WDG	High	(Chlorantraniliprole)	
28	Belt 4SC	High	(Flubendiamide)	
UN	Neemix	Moderate	(Azadirachtin)	
Premix				
3A/6	Gladiator EC	High	(Zeta-Cypermethrin/Avermectin B!)	
4A/3A	Endigo ZC	Moderate	(Thiamethoxam/Lambda-cyhalothrin)	
4A/3A	Leverage 360	High	(Cyfluthrin/Imidacloprid	
4A/28	Voliam Flexi WDG		Chlorantraniliprole/Thiamethoxam	

Codling Moth (OBLR / Apple Maggot)

2nd Generation (220 DD_{50})

Classes		Formulation	Efficacy	Group (s)
1A	Lannate	High	(Carbamate)	
1A	Sevin	Moderate	(Carbamate)	
1B	Imidan 70W	High	(Organophosphate)	
3A	Baythroid XL 1EC	Moderate	(Pyrethroid)	
4A	Assail 30SG	High	(Neonicotinoid)	
5	Delegate 25WG	High	(Spinosyn)	
5	Entrust 2SC	High	(Spinosyn)	
6	Proclaim 5SG	Moderate	(Emamectin Benzoate	
11A	Dipel 10.3DF	Moderate / low	(Bacillus thuringiensis)	
15	Rimon 0.83EC	High	(Novaluron)	
18	Intrepid 2F	Moderate	(Methoxyfenozide)	
22	Avaunt 30WDG	Moderate	(Indoxacarb)	
28	Exirel	High	(Cyantraniliprole)	
28	Altacor 35WDG	High	(Chlorantraniliprole)	
28	Belt 4SC	High	(Flubendiamide)	
UN	Neemix	Moderate	(Azadirachtin)	
Premix				
3A/6	Gladiator EC	High	(Zeta-Cypermethrin/Avermectin B!)	
4A/3A	Endigo ZC	Moderate	(Thiamethoxam/Lambda-cyhalothrin)	
4A/3A	Leverage 360	High	(Cyfluthrin/Imidacloprid	
4A/28	Voliam Flexi WDG		Chlorantraniliprole/Thiamethoxam	

Insect Pest Management Success

And Management To Reduce The Resistance Potential

=

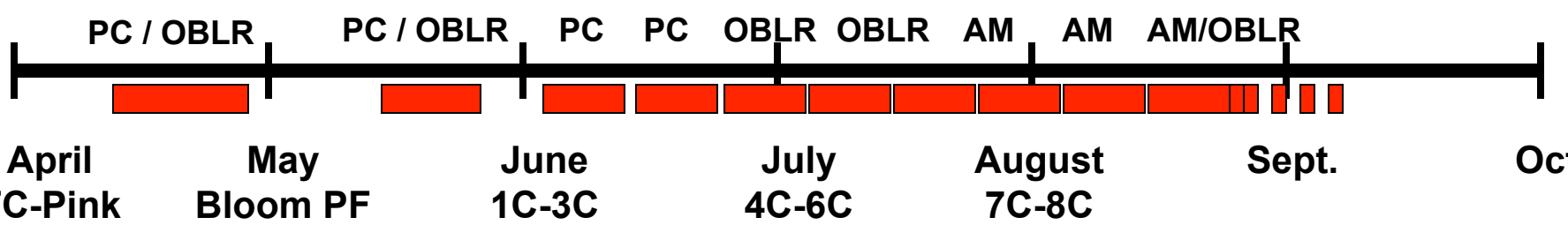
Proper Insecticide Selection

PC / OBLR | PC / OBLR | PC | PC | OBLR | OBLR | AM | AM | AM/OBLR

April TC-Pink | May Bloom PF | June 1C-3C | July 4C-6C | August 7C-8C | Sept. | Oct.

Use Insecticides With Efficacy To Manage:

I. Overwintering OBLR at PF (specific insecticide)



Use Insecticides With Efficacy To Manage:

II. Plum Curculio 2nd Application at 1st or 2nd cover (model)

+ CM Efficacy

PC / OBLR | PC / OBLR | PC | PC | OBLR | OBLR | AM | AM | AM/OBLR

April TC-Pink | May Bloom PF | June 1C-3C | July 4C-6C | August 7C-8C | Sept. | Oct.

Use Insecticides with efficacy to manage:

III. A Three Spray Program For OBLR + CM + AM Efficacy)

PC / OBLR | PC / OBLR | PC | PC | OBLR | OBLR | AM | AM | AM/OBLR

April TC-Pink | May Bloom PF | June 1C-3C | July 4C-6C | August 7C-8C | Sept. | Oct.

Use Insecticides with efficacy to manage:

IV. One Application For AM / CM

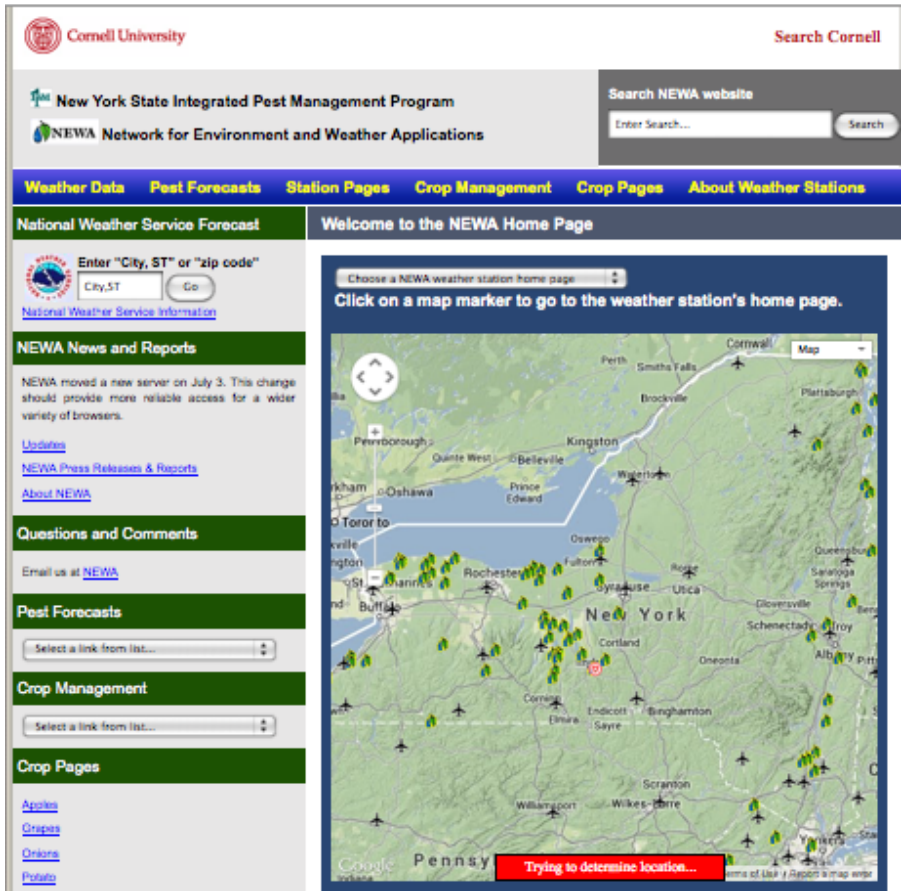
PC / OBLR | PC / OBLR | PC | PC | OBLR | OBLR | AM | AM | AM/OBLR

April TC-Pink | May Bloom PF | June 1C-3C | July 4C-6C | August 7C-8C | Sept. | Oct.

The Lepidopteran Complex In NYS Tree Fruit Resistance Management

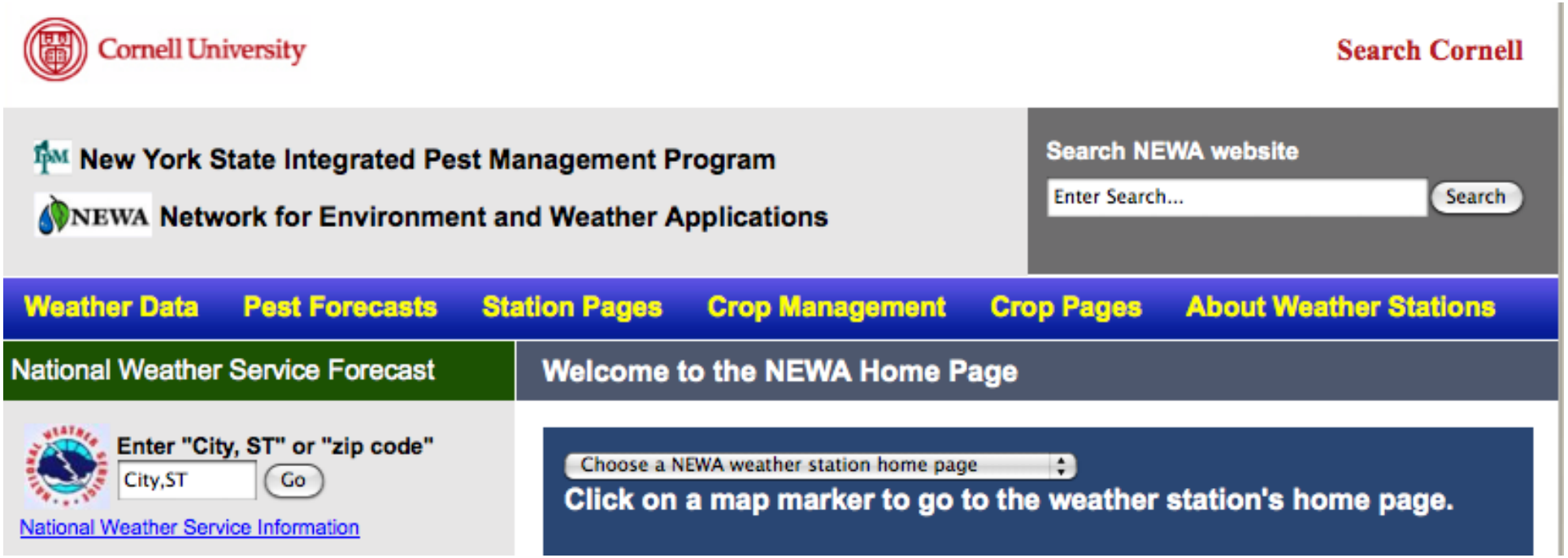
Using NEWA Weather Stations To Make Pest Management Decisions.

http://newa.cornell.edu/



The Lepidopteran Complex In NYS Tree Fruit Resistance Management

Using NEWA Weather Stations To Make Pest Management Decisions.



The Lepidopteran Complex In NYS Tree Fruit Resistance Management

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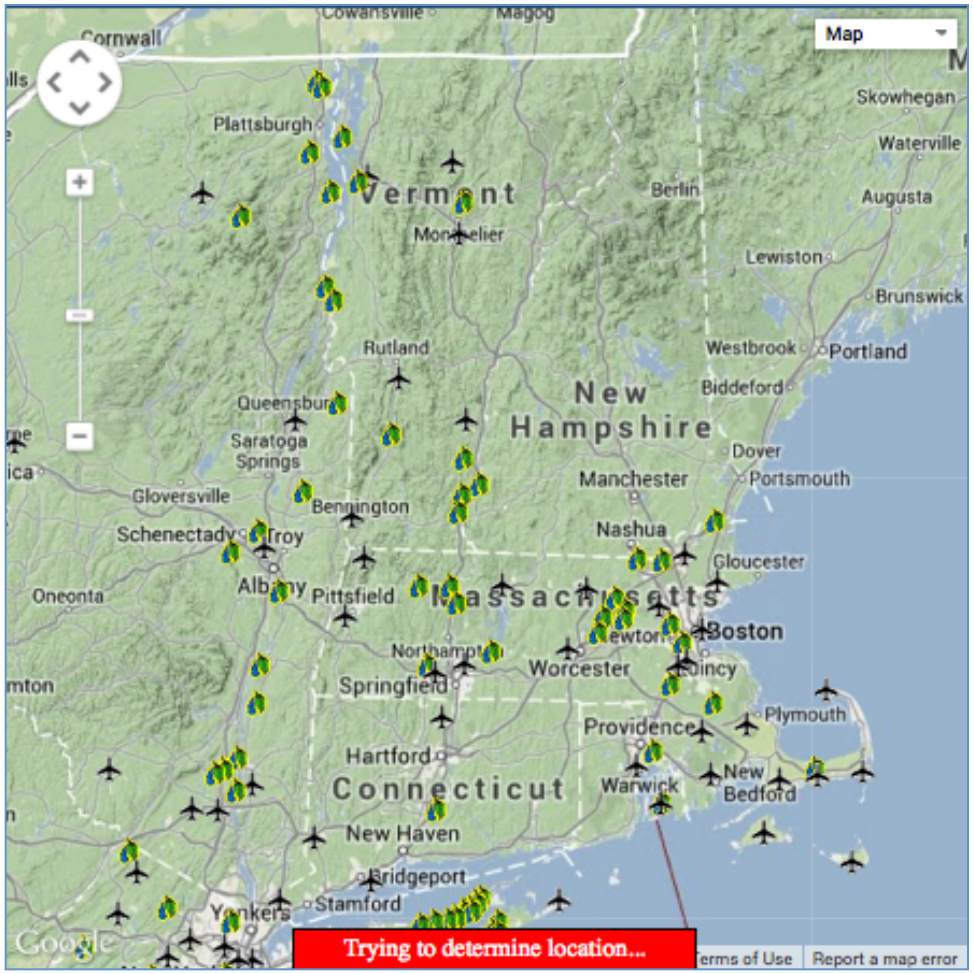
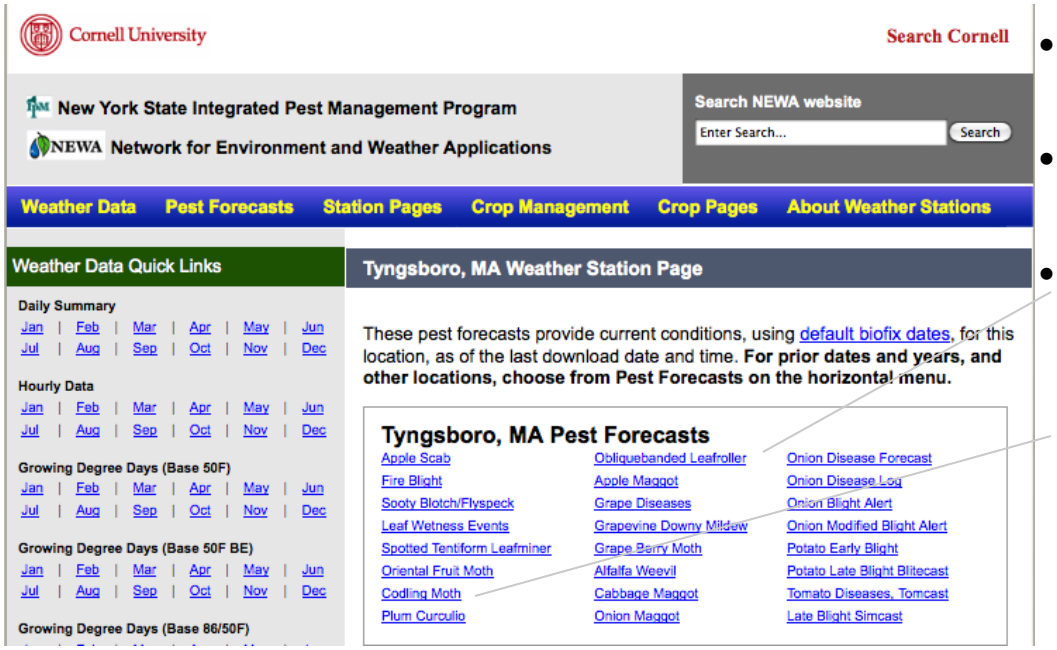


- Choose site based on your location

The Lepidopteran Complex In NYS Tree Fruit Resistance Management

Using NEWA Weather Stations To Make Pest Management Decisions.



- Choose site based on your location
- Obliquebanded leafroller
- Codling moth

CORNELL'S Hudson Valley LABORATORY

NEWA Apple Insect Models

Select a pest:

Obliquebanded Leafroller

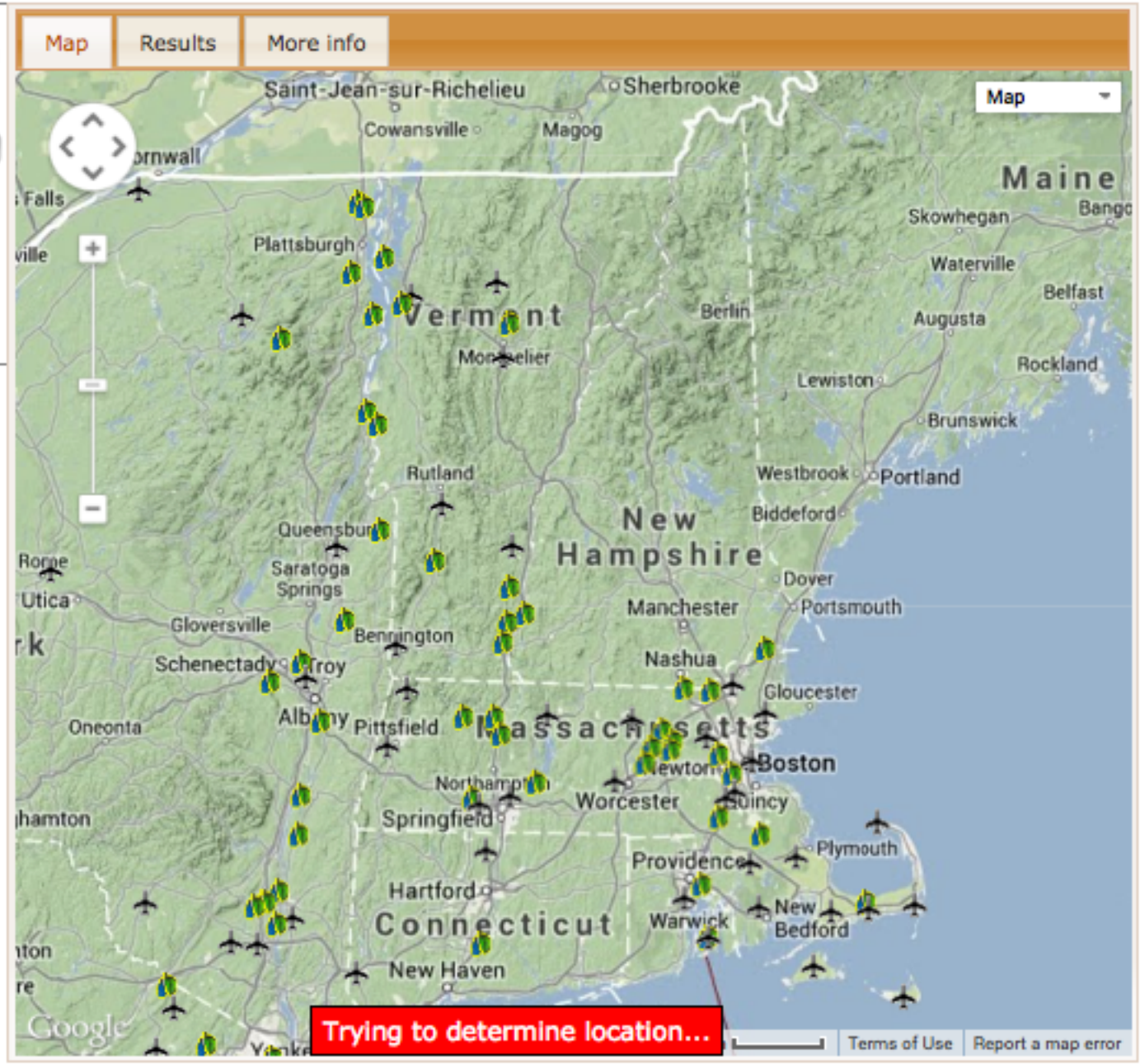
Weather Station:

Tyngsboro, MA

Accumulation End Date:

06/01/2013

Calculate



NEWA Apple Insect Models

Select a pest:
Obliquebanded Leafroller

Weather Station:
Tyngsboro, MA

Accumulation End Date:
06/01/2013

Calculate

Map | Results | More info

Obliquebanded Leafroller Results for Tyngsboro

Accumulated degree days (base 43°F) 1/1/2013 through 6/1/2013: 816 (0 days missing)

Phenological stage: Post Petal Fall

The phenological stage above is estimated. Select the actual stage and the model will recalculate recommendations.

Pest stage: First generation moths emerge

Pest Status	Pest Management
Adult flight begins. In western NY first flight usually occurs around the middle of June.	No control measures are recommended for adults. Sprays to control summer generation of larvae are timed to coincide with the first hatch of eggs.

Disclaimer: ***These are theoretical predictions and forecasts.*** *The theoretical models predicting pest development or disease risk use the weather data collected (or forecasted) from the weather station location. These results should not be substituted for actual observations of plant growth stage, pest presence, and disease occurrence determined through scouting or insect pheromone traps.*

NEWA PMEP Powered by ACIS Northeast Regional Climate Center

NEWA Apple Insect Models

Select a pest:
Obliquebanded Leafroller

Weather Station:
Tyngsboro, MA

Accumulation End Date:
06/24/2013

Calculate

Map | Results | More info

Obliquebanded Leafroller Results for Tyngsboro

First Trap Catch: 6/10/2013

First Trap Catch date above is estimated based on degree day accumulations or user input. Enter the actual date for blocks of interest and the model will calculate the protection period after first trap catch more accurately.

Accumulated degree days (base 43°F) first trap catch through 6/24/2013: 353 (0 days missing)

Pest stage: Peak moth flight, first egg hatch

The pest stage above is estimated. Select the actual stage and the model will recalculate recommendations.

Pest Status	Pest Management
First hatch of summer OBLR eggs. Adult catches in pheromone traps are near peak numbers.	In order to verify model predictions, monitor growing terminals at 600-700 DD base 43F after biofix to check for the detection of the first summer generation larvae. It is too early now to monitor populations of summer larvae at this time to determine if control sprays are necessary because most eggs will hatch later during the summer. However, applying protective sprays with the first spray timed to coincide with the first hatch of larvae at approximately 350 DD base 43F after biofix followed by a second spray 10-14 days later are recommended in orchards that have had a past history of severe OBLR fruit damage or if populations of overwintering larvae were high. Pesticide information

Use Insecticides with efficacy to manage:

Active Ingredient (AI) Rotational Strategies For Resistant Mgt.

Different IRAC Group For Each Generation

PC / OBLR | PC / OBLR | PC | PC | OBLR | OBLR | AM | AM | AM/OBLR

April TC-Pink | May Bloom PF | June 1C-3C | July 4C-6C | August 7C-8C | Sept. | Oct.

CORNELL'S Hudson Valley LABORATORY

Use Insecticides with efficacy to manage:

Active Ingredient (AI) Rotational Strategies For Resistant Mgt.

For CM: 2 Different IRAC Groups

PC / OBLR | PC / OBLR | PC | PC | OBLR | OBLR | AM | AM | AM/OBLR

April TC-Pink | May Bloom PF | June 1C-3C | July 4C-6C | August 7C-8C | Sept. | Oct.

CORNELL'S Hudson Valley LABORATORY

Use Insecticides with efficacy to manage:

Active Ingredient (AI) Rotational Strategies For Resistant Mgt.

For OBLR: 3 Different IRAC Groups

Intrepid or Proclaim

Delegate + Delegate @ 14d

Altacor

PC / OBLR | PC / OBLR | PC | PC | OBLR | OBLR | AM | AM | AM/OBLR

April TC-Pink | May Bloom PF | June 1C-3C | July 4C-6C | August 7C-8C | Sept. | Oct.

CORNELL'S Hudson Valley LABORATORY

Use Insecticides with efficacy to manage:

Active Ingredient (AI) Rotational Strategies For Resistant Mgt.

For OBLR: 3 Different IRAC Groups

Intrepid or Proclaim

Delegate + Delegate @ 14d

Assail

PC / OBLR | PC / OBLR | PC | PC | OBLR | OBLR | AM | AM | AM/OBLR

April TC-Pink | May Bloom PF | June 1C-3C | July 4C-6C | August 7C-8C | Sept. | Oct.

CORNELL'S Hudson Valley LABORATORY

Thank You…Questions??

CORNELL'S
Hudson Valley
LABORATORY