Managing corn earworm & other worms in sweet corn

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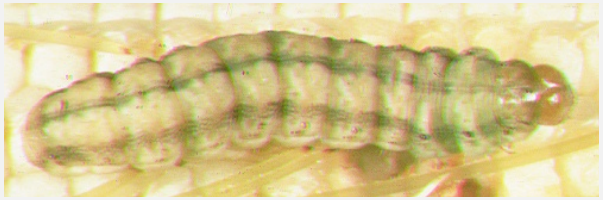
THE OHIO STATE UNIVERSITY

Caterpillars in Sweet Corn



- Key pests; can ruin the crop
- Pest management is complex
  - Several insect species
  - Sequential plantings
- The need to control them varies through the season
  - No control
  - Low intensity control
  - High intensity control

How to manage worms?

1. Spray insecticides

- or -

2. Plant transgenic hybrids

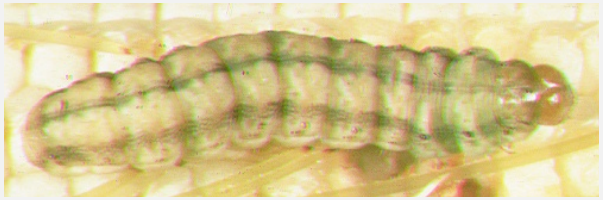
- or -

3. Transgenic + spray

Topics

- Species overview
- Transgenic options
- Monitoring
- Insecticide options

Caterpillars in Sweet Corn



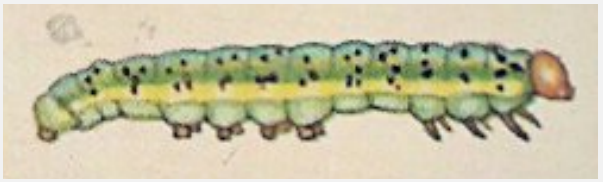
Corn Earworm

European Corn Borer

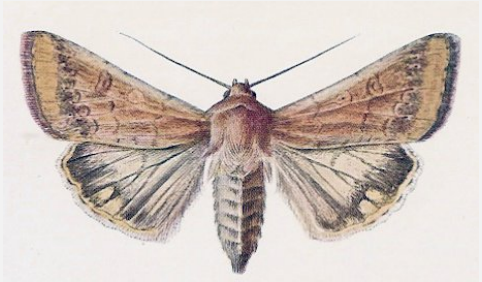
Fall Armyworm

Life Cycle

Caterpillar (Larva)



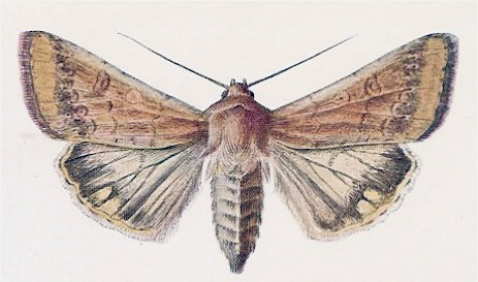
Pupa



Moth (Adult)

Egg

Do moths matter?



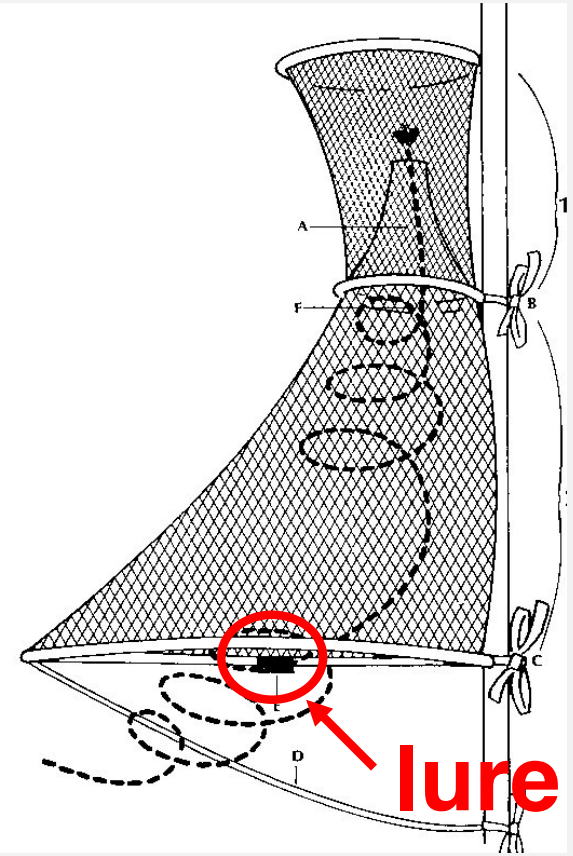
- Can be easier to monitor than caterpillars
- Give advance warning of caterpillars

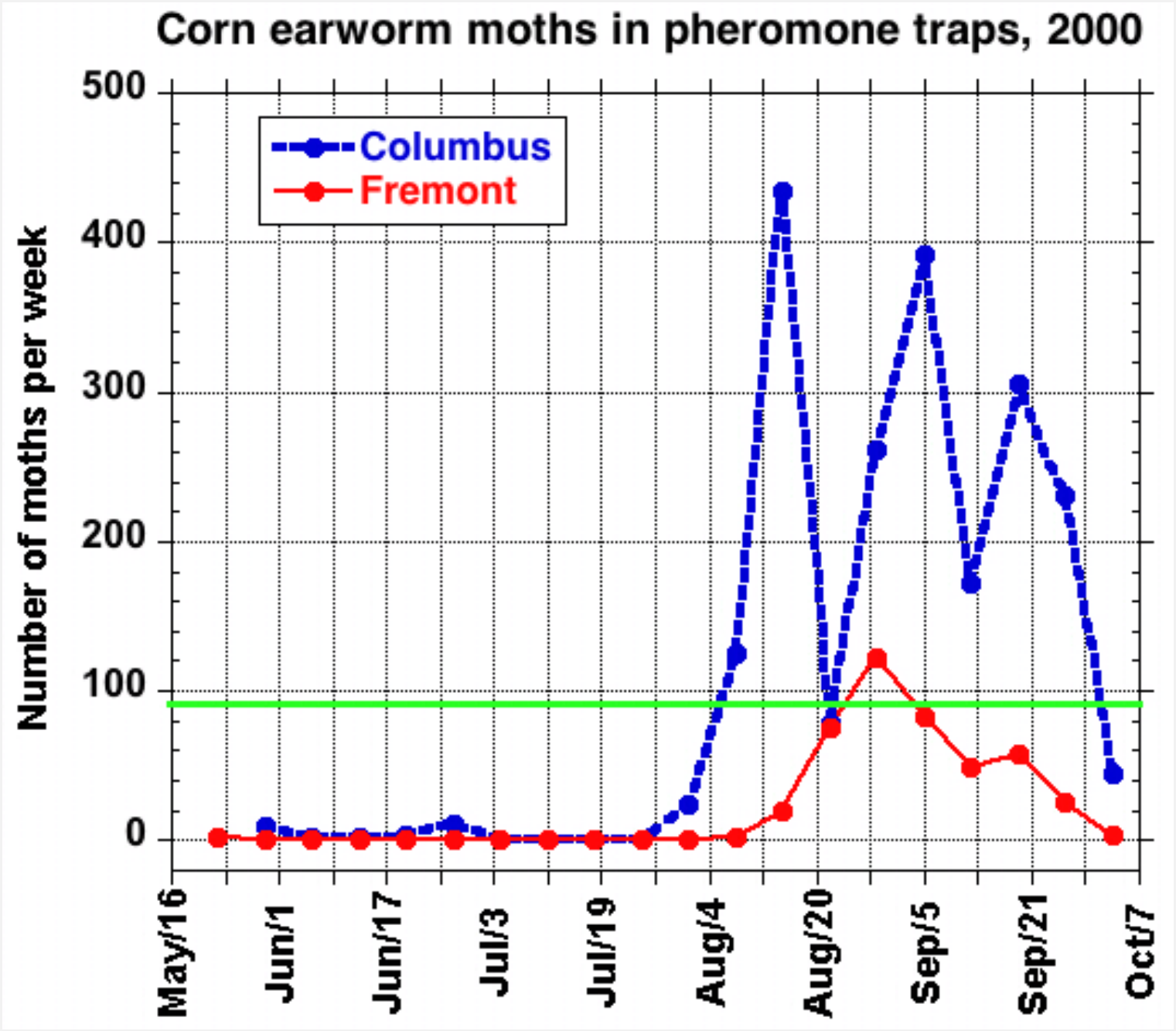
1. Corn Earworm

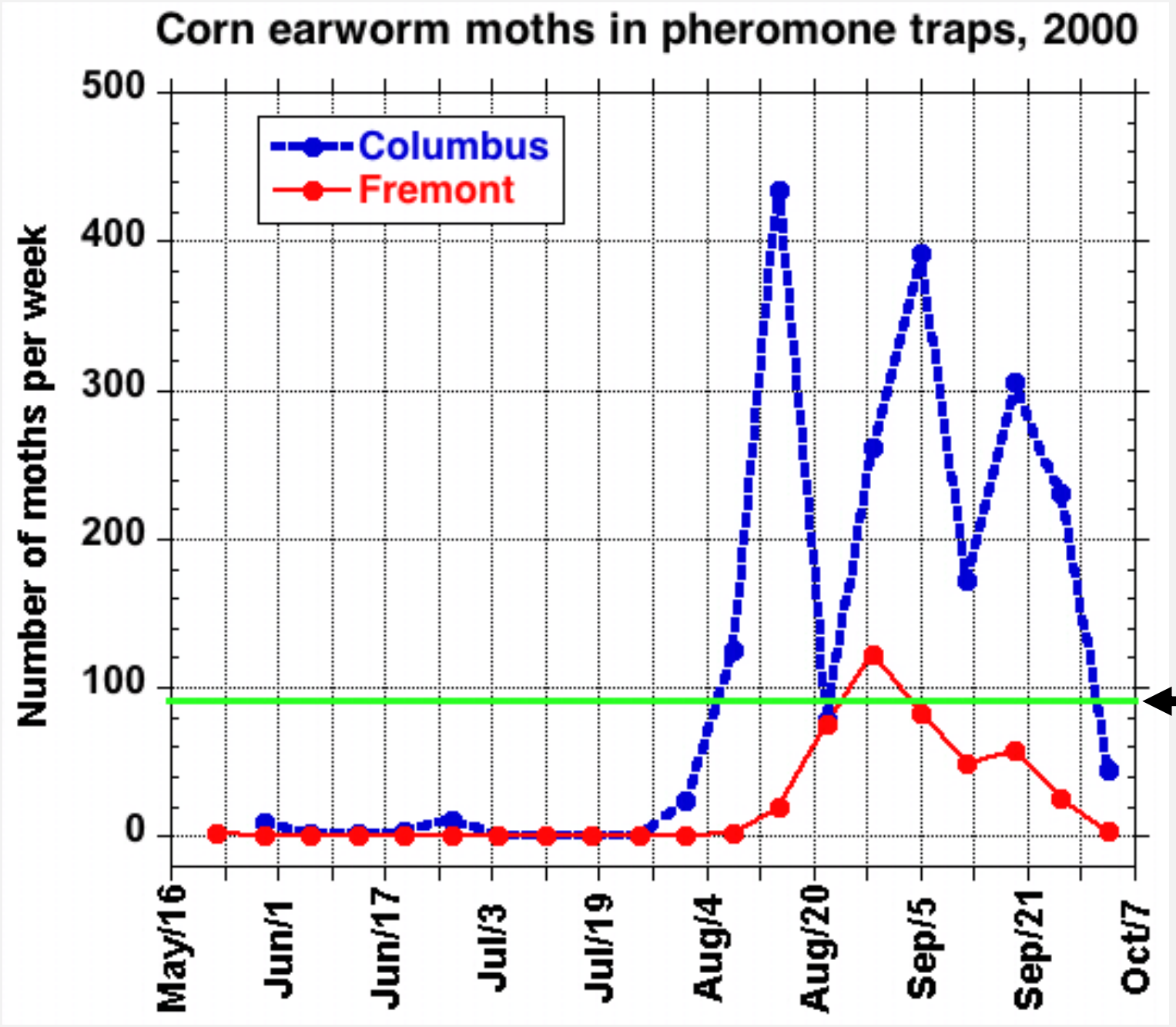
- **Moths migratory from South**
- **Arrival time varies**
- **Eggs laid on silk**
- **Eggs hatch in 48 hrs**

Trap to Monitor Corn Earworm

- Pheromone lure
- Attracts male moths
- Highly effective




Corn earworm moths in pheromone traps, 2000
Number of moths per week
500
400
300
200
100
0
Columbus
Fremont
May/16
Jun/1
Jun/17
Jul/3
Jul/19
Aug/4
Aug/20
Sep/5
Sep/21
Oct/7



intensive schedule when >13 moths per day (>90 moths per week)

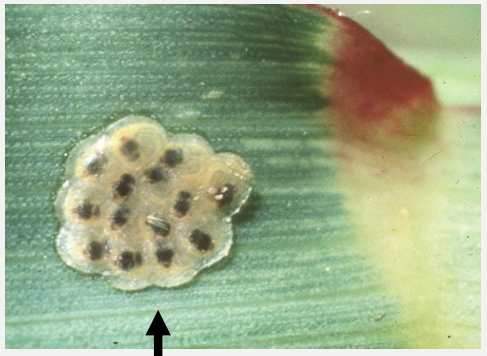
2. European Corn Borer

- 2 generations/year
  - when summer has average temperatures (60% of years in Ohio)
- 3 generations/year
  - when summer has high temperatures (40% of years)

European Corn Borer

- **Moths active:**
  - 1st flight:
    - Late May to late June
    - Most eggs on whorls
    - Move to tassel to ear
    - Control <u>before</u> silking
  - 2nd flight:
    - Late July to late August
    - Most eggs near ear
    - Control <u>during</u> silking
  - 3rd flight: September
- **Monitor with traps**

Difference in ‘Worm’ Invasion



	Corn earworm	European corn borer
Egg location	silks	ear leaf
Egg hatch	2-3 days	3-5 days
Moth source	migratory	local

3. Fall Armyworm

- Also migratory from South
- Arrival time varies
- Harder to kill
- Pheromone trap for adults

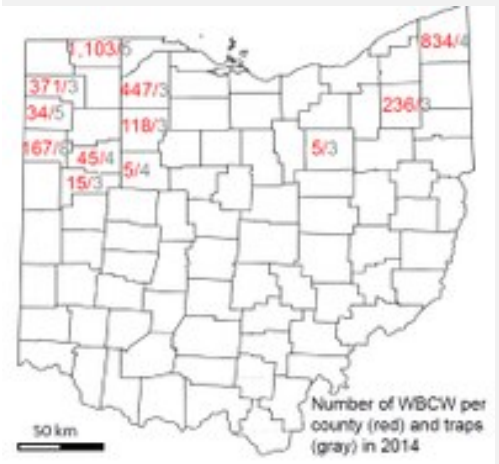
(4) Western bean cutworm

- **Long-time pest of corn & dry beans in Colorado & Nebraska**
- **Moving eastward (Iowa) starting 2000**
- **Now common in Illinois & Wisconsin**
- **Pest of sweet corn ears**

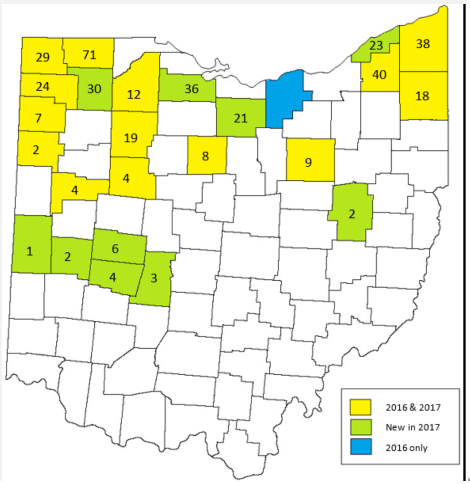
Where is WBCW?

- **Confirmed catches**
  - **NW Ohio: 2007**
  - **Central Ohio: 2009**
  - **NE Ohio: by 2014**
  - **Heavy in 2017**

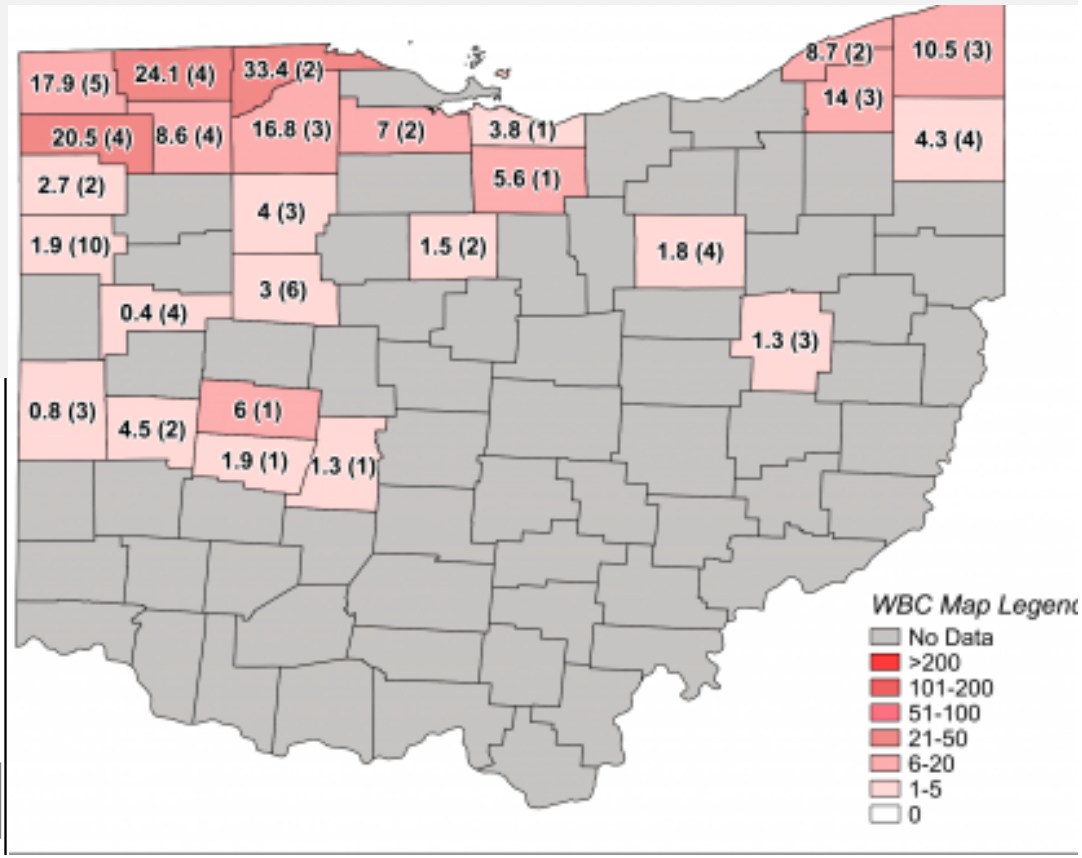
2014



2017



2018



Western bean cutworm?

- Pheromone lure in trap
  - Unitrap or milk jug
- One generation per year
- Adults active in July
- Trap mid-June to mid-August

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Transgenic option: B.t. sweet corn ('Biotech sweet corn')

- Less developed than field corn
- Rejected by some consumers
- Lower residue of insecticides

B.t. = *Bacillus thuringiensis*

History of B.t. sweet corn

Hybrid name	Company	Year	
Attribute	Rogers/ Syngenta	2003	

History of B.t. sweet corn

Hybrid name	Company	Year	
Attribute	Rogers/ Syngenta	2003	
Performance Series	Seminis/ Monsanto	2011	
Attribute II	Syngenta	2013	

Insect-resistance genes/traits

Hybrid name	Company	Year	Gene/trait
Attribute	Rogers/ Syngenta	2003	*Cry*1Ab
Performance Series	Seminis/ Monsanto	2011	*Cry*1A.105 + *Cry*2Ab2 + *Cry*3Bb1
Attribute II	Syngenta	2013	*Vip*3A + *Cry*1Ab

Features of B.t. series

- 'Attribute':
  - European corn borer: excellent
  - Corn earworm: adequate
- 'Performance Series'
  - Insect protection
    - Above ground (all worms, including earworm)
    - Below ground (rootworms)
  - Weed control: glyphosate tolerant
- 'Attribute II'
  - Add Western bean cutworm
  - Add herbicide tolerance: glyphosate, glufosinate

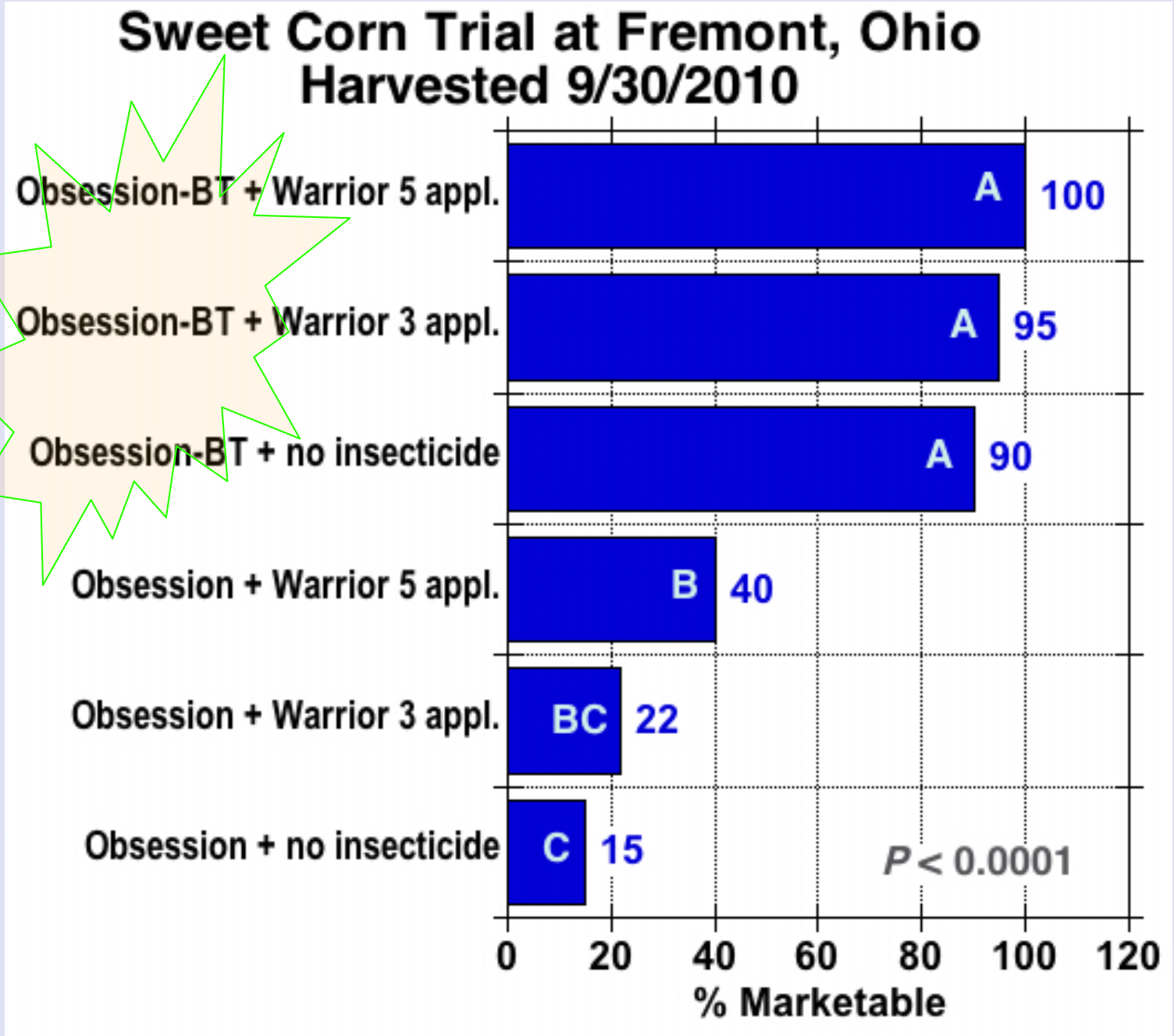
Regulatory requirements

- Refuge of non-BT sweet corn is NOT required
- Plants must be destroyed after harvest
  - No later than 30 days
  - Preferably by 14 days
  - To minimize survival of resistant insects

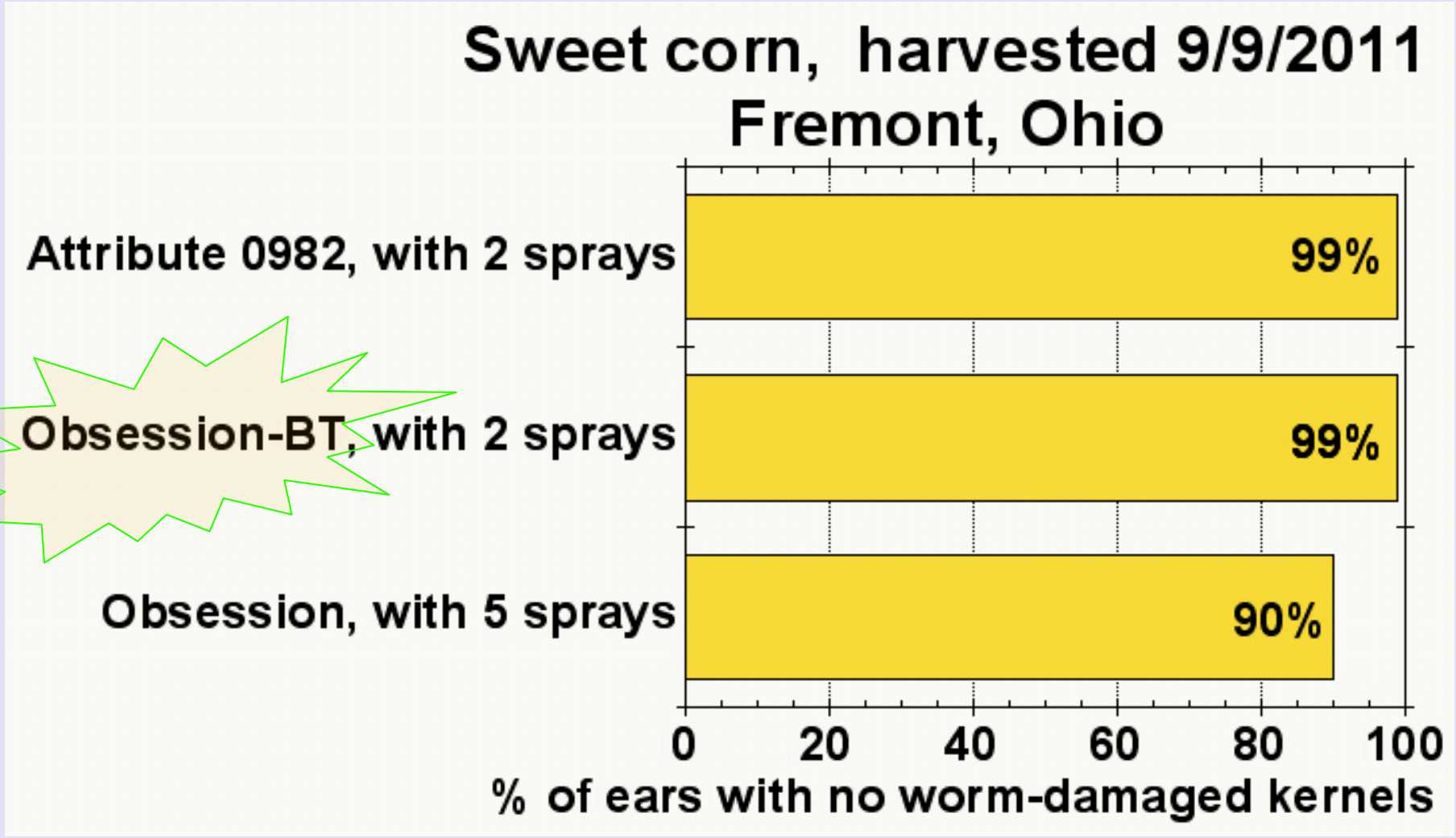
B.t. sweet corn varieties

Attribute	Seminis	Attribute II
BC 0805	Obsession II	Remedy
BC 0822	Passion II	Milky Way
GH 0851	Temptation II	Aspire
WH 0809	Anthem II	Protector
GSS 0966	SV9010SA	Pursuit (new)
WSS 0987	SV9012SD	Patriarch (new)
BSS 0977	SV9014SB	
BSS 0982	SV9813SC	

2010


Sweet Corn Trial at Fremont, Ohio
Harvested 9/30/2010
Obsession-BT + Warrior 5 appl.
A
100
Obsession-BT + Warrior 3 appl.
A
95
Obsession-BT + no insecticide
A
90
Obsession + Warrior 5 appl.
B
40
Obsession + Warrior 3 appl.
BC
22
Obsession + no insecticide
C
15
P < 0.0001
0
20
40
60
80
100
120
% Marketable

2011


Sweet corn, harvested 9/9/2011
Fremont, Ohio
Attribute 0982, with 2 sprays
99%
Obsession-BT, with 2 sprays
99%
Obsession, with 5 sprays
90%
0
20
40
60
80
100
% of ears with no worm-damaged kernels

2018

	Treatment	% of husked ears with no worm damage[a,b]
0 sprays	Remedy	97.5 A
6 sprays	Standard (Asana+Coragen, Coragen, Hero, Lannate)	87.5 B
	FMC-1 (Hero, Coragen, Mustang)	82.5 B
	FMC-2 (Brigade+Mustang, Coragen, Warrior)	80.0 B
	Warrior only	75.0 B
	Untreated	0.0 C
	ANOVA treatment effect	*P < 0.0001*

Worm management with B.t. sweet corn

- If corn earworm pressure low
  - No insecticide sprays needed during silking
- If corn earworm pressure high
  - Use 2 sprays
  - First spray: 75% fresh silk
  - Second spray: 4 days later

How is B.t. sweet corn best used?

- **Late plantings**
  - **Silking when field corn not silking**
- **Fields adjacent to houses**
- **Remember:**
  - **Much easier for grower** 🙂
  - **Possibly undesirable to consumer** ☹️

Monitoring
&
spray guidelines

Sweet Corn Development

- Seedling
- Whorl stage
- Emerging tassel stage **
- Fresh silk ***
- Dry silk

Emerging-Tassel Stage

- Scout (examine plants)
  - 50 plants in small plantings (<2A)
  - 100 plants in large plantings (>2A)
  - Record # with fresh feeding damage
- Action threshold
  - Spray if fall armyworm and/or European corn borer on >10% of plants

Most critical time for earworm invasion: silking

- For 3 week period before harvest
  - Stages: fresh, wilting, dry & brown
- Pests attracted to fresh silk
- Silk grows rapidly (up to 1.5” per day)
  - If sprayed, next day new silk unprotected
- Start spray schedule when fresh silk begins to show, IF moths active

Relative importance of pests during silking

Rank	Pest	Spray Interval
1	Corn earworm	2-6 d
2	Eur. corn borer	5-7 d
3	Fall armyworm	5-7 d
4	Sap beetles	4-5 d
5	Silk clip. beetles	(1 spray)

Insecticide Issues During Silking

in Main Season & Late Season Corn

** Spray interval

** Coverage of ear zone

* Choice of insecticide

How often to spray during silking?

Moths active?		*Insecticide need to control larvae*
Corn earworm	*Eur. corn borer*	
+	+ or -	More intensive
-	+	Less intensive
-	-	None

Corn Earworm Insecticide Spray Schedule

Number moths per pheromone trap per day	*Spray interval*	
	Maximum daily temp. <80 F	*Maximum daily temp. >80 F*
< 0.2	No spray	No spray
0.2 - 0.5	Every 6 days	Every 5 days
0.5 - 1	Every 5 days	Every 4 days
1 - 13	Every 4 days	Every 3 days
> 13	Every 3 days	Every 2 days

European Corn Borer on Sweet Corn: spray during silking if moths active (> 1 moth per night = 7 moths per week in pheromone trap)

- 1st spray when 10-20% of plants silking
- Spray every 5 - 7 days
  - 5-day during peak egg hatch
  - 5-day when temperatures hot (>80 F)
  - else: 7-day

Pheromone Lures for European Corn Borer

Two lure types available:

- **'Iowa' strain:**
  - **Also known as *'Z'* -strain**
  - **Best for most of Ohio (exception in far NE corner)**
- **'New York' strain:**
  - **Also known as *'E'* -strain**
  - **Not needed in most of Ohio**

Fall Armyworm During Silking

- Pheromone trap
  - All-green unitrap
- Spray every 5-7 days during silking if more than 3 moths per week in trap

fall armyworm moth

Spray Coverage

- Direct spray to ear zone
- Drop nozzles effective

Spraying for organic production

- Use same spray schedule rule
- 'Entrust' allowed
  - A.I.: spinosad
  - On OMRI list
  - Excellent for caterpillar control
  - Rate: 3 - 6 fl oz/acre
  - Cost: $403 - 489/quart!
    (>$37/A)

Organic Alternative for Earworm & Borer in Sweet corn: B.t. + Oil

(Ruth Hazzard, Univ. Mass.)

- **'Zea-later II' applicator**
  - Hand-held
  - $109 (Johnny's Selected Seeds)
- **Mix:**
  - 900 ml food-grade corn oil
  - Lecithin 5% (emulsifier)
  - 28.6 grams DiPel DF (a B.t.)
  - 100 ml water
- **Treat:**
  - Once, 5 days after silking begins
  - Squirt 0.5 ml of oil mix into each ear tip

Traps for Corn Pest Moths

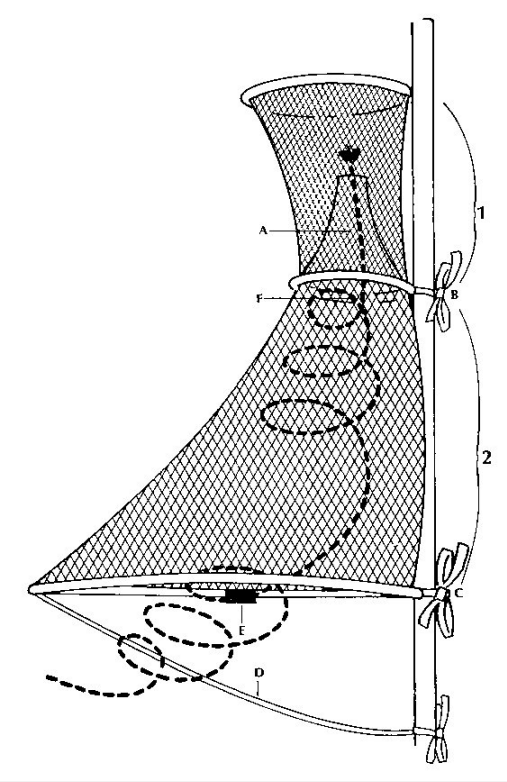
Suppliers:

- **Great Lakes IPM (Vestaburg, Mich.)**
- **Gempler's (Madison, Wisconsin)**
- **GreenStar Cooperative, Inc.** (formerly Salem Fruit Growers Co-op; **Salem, Ohio)**

Traps for Corn Earworm & European Corn Borer

	Trap	*Lures*	
Manufacturer:	**Scentry**	**Hercon**	**Trécé or Scentry**
Life span:	**2 - 5 yrs**	**2 wks**	**2-3 wks**
# per season:	**1 (minimum)** **2 (preferred)**	**10**	**7**
Cost:	**@ $56 - 85** ***(plus optional spare tops @$17 – 28)***	**$17**	**$13**

Traps for Corn Earworm & European Corn Borer



- **Set up:**
  - **At edge of corn field**
  - **June: near earliest corn**
  - **July-Sept.: near fresh silking**
  - **ECB: over long grass is best**
- **Maintenance:**
  - **Count moths 2 to 3 times per week**
  - **Replace lure every 2 weeks**

Corn earworm control, sweet corn field trials 2007-2015 & 2018

Jim Jasinski & Celeste Welty

- Concern about pyrethroid resistance
- Start spray program at 1st silk
- 6 sprays at 3- to 4-day intervals

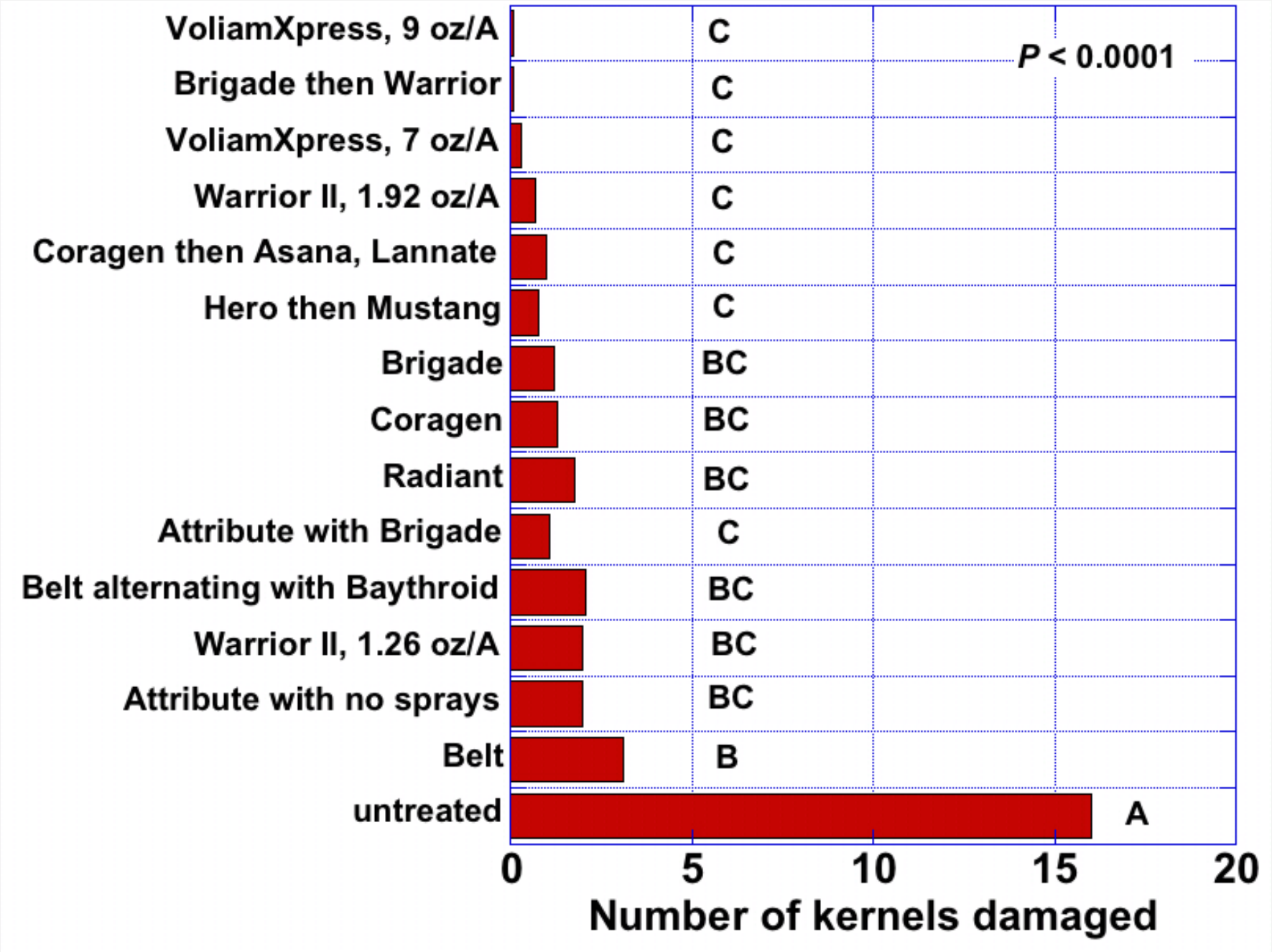
Treatments

- Older a.i.s:
  - pyrethroids: Brigade (= Capture), Warrior, Asana, MustangMax; Hero
  - Carbamates: Lannate, Larvin
  - Virus: Gemstar
- Newer a.i.s:
  - Radiant
  - Coragen
  - Belt
  - Blackhawk
- Pre-mix:
  - Voliam Xpress (= Besiege)
- Hybrids
  - BT corn
  - isoline

Evaluation

- Intensive!
- 10 or 20 ears/plot
- Count # damaged kernels

Sample results: 2009

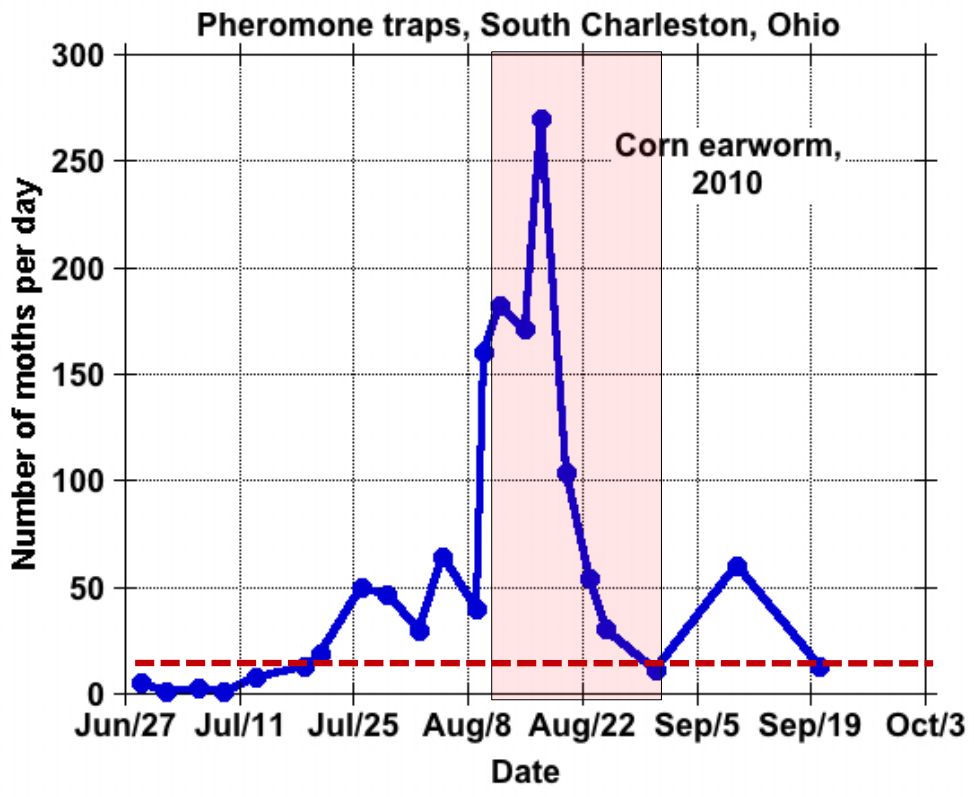


Year	SPECIES: # larvae per ear in **unsprayed** plots		
	Corn earworm	Eur. corn borer	Fall armyworm
2007			
2008			
2009			
2010			
2011			
2012			
2013			
2014			
2015			
2018			

Year	SPECIES: # larvae per ear in unsprayed plots		
	Corn earworm	Eur. corn borer	Fall armyworm
2007	2.7	0.9	0.01
2008	0.1	0.6	0.01
2009	1.3	0.1	0.10
2010	0.8	0.9	0.10
2011	0.1	0.04	0.01
2012	0.2	0.1	0
2013	0.1	1.1	0.05
2014	1.8	0.9	0
2015	1.0	1.1	0.02
2018	1.6	0.4	0

Corn earworm seasonal activity

- red shading = silking = spray period
- red dashed line = “high” moth density, 13 moths/trap/day



2010

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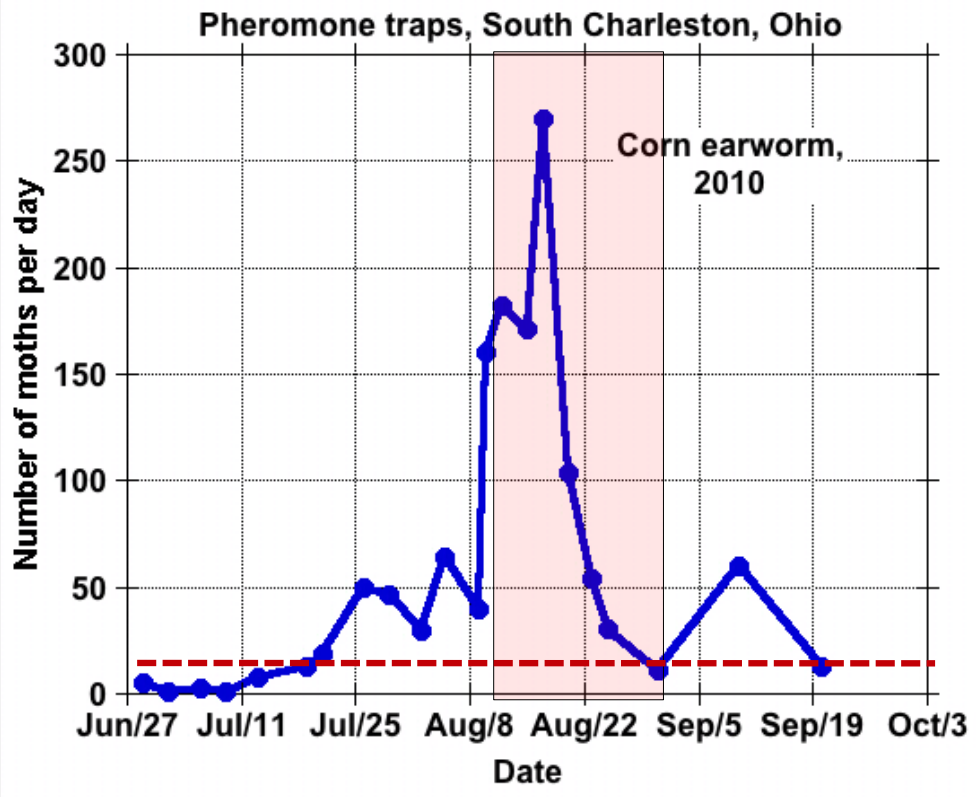

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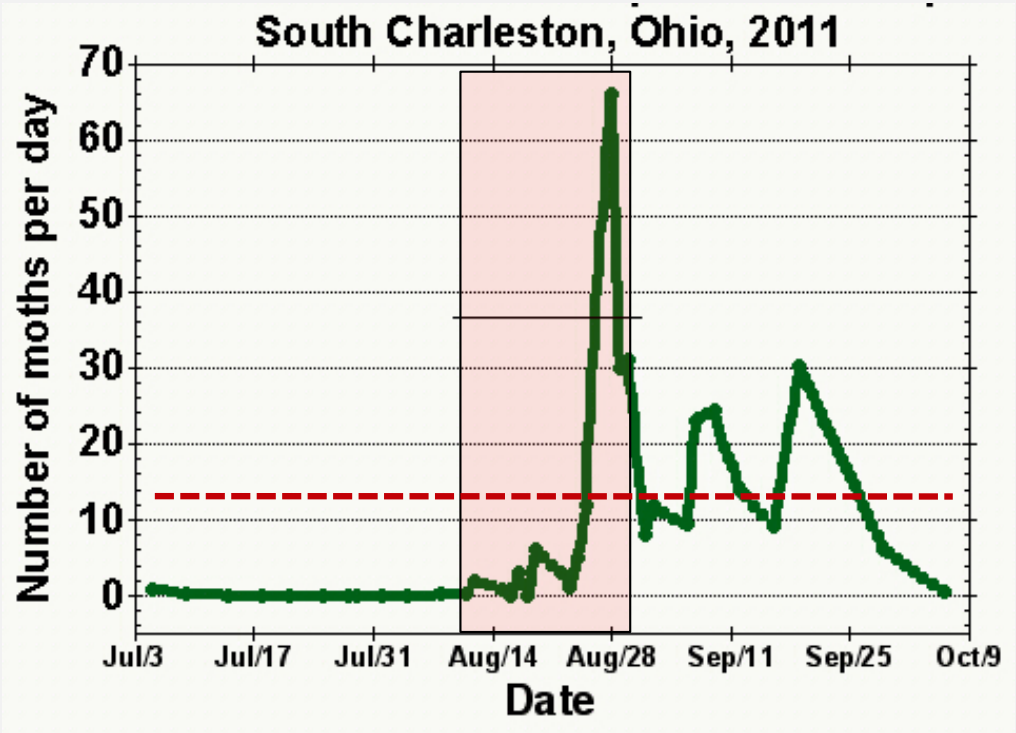
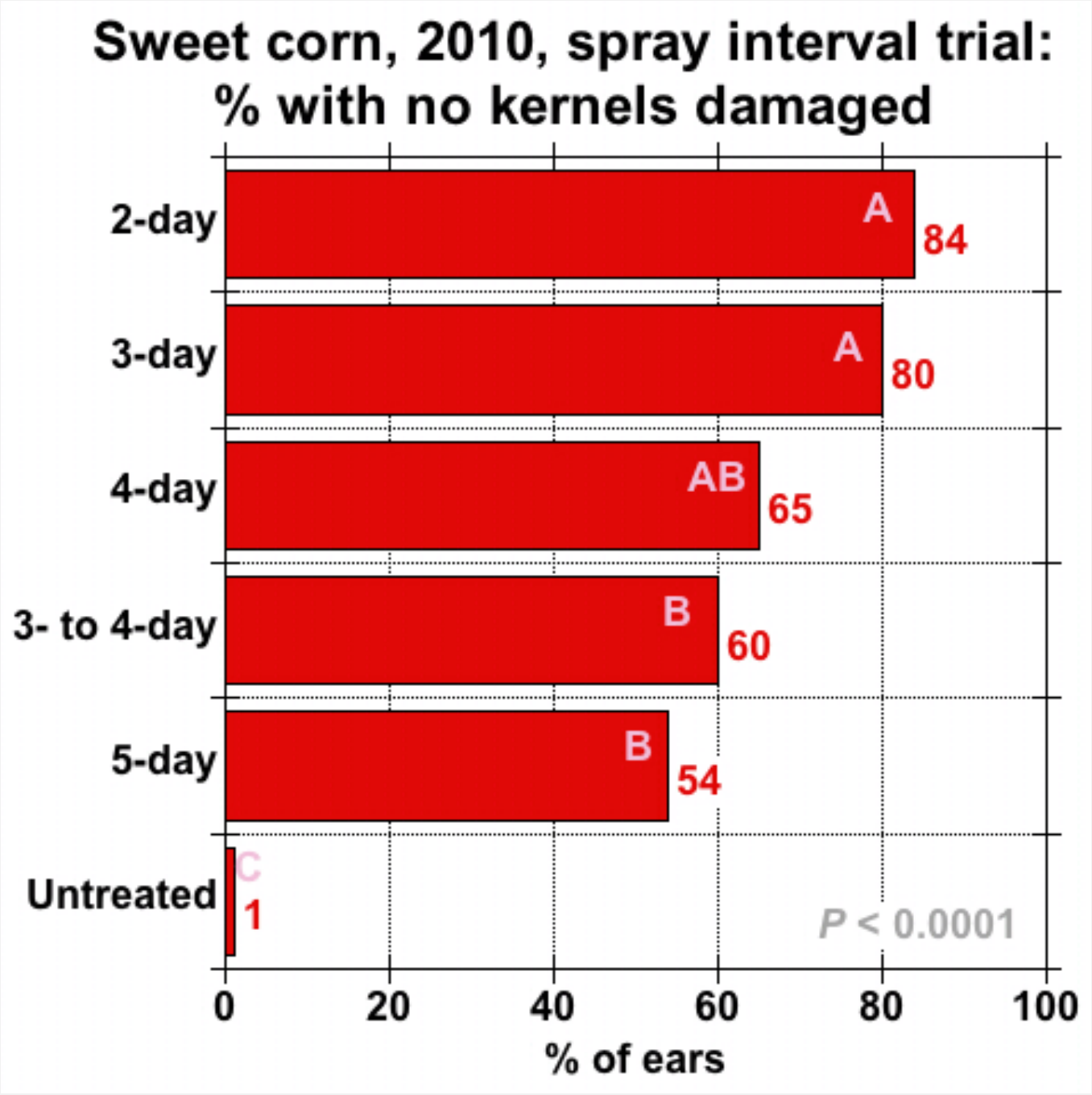


2011

Comparison of spray schedules, 2010

- One product: Warrior, at max rate
- Treatments during silking:
  - Spray every 2 days (11 times)
  - Spray every 3 days (7 times)
  - Spray every 4 days (6 times)
  - Spray every 5 days (5 times)
  - Usual: start 3-day, then 4-day (6 times)


Sweet corn, 2010, spray interval trial:
% with no kernels damaged
2-day
A
84
3-day
A
80
4-day
AB
65
3- to 4-day
B
60
5-day
B
54
Untreated
C
1
P < 0.0001
0
20
40
60
80
100
% of ears

Corn earworm in traps

Year		#moths/day at peak
2007		388
2008		5
2009		63
2010		270
2011		66
2012		37
2013		5
2014		15
2015		53
2018		114

Corn earworm in traps

Year	Corn earworm trap trend	#moths/day at peak
2007	Very high, prolonged	388
2008	Low/Moderate	5
2009	High but quick	63
2010	Very high	270
2011	High but late	66
2012	Moderate	37
2013	Low/Moderate	5
2014	Moderate but late	15
2015	High but quick	53
2018	High, early	114

Corn earworm in traps

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2015	High but quick	53
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Year-to-year differences in damage

Year	CEW in trap	% of ears with no kernel damage	
		Unsprayed	
2007	Very high	3%	
2008	Low/mod	59%	
2009	High, quick	9%	
2010	Very high	1%	
2011	High, late	82%	
2012	Moderate	61%	
2013	Low/mod	51%	
2014	Mod., late	0%	
2015	High, quick	2%	
2018	High, early	0%	

Year-to-year differences in damage

Year	CEW in trap	% of ears with no kernel damage	
		Unsprayed	
2007	Very high	3%	√
2008	Low/mod	59%	
2009	High, quick	9%	√
2010	Very high	1%	√
2011	High, late	82%	?
2012	Moderate	61%	
2013	Low/mod	51%	
2014	Mod., late	0%	?
2015	High, quick	2%	√
2018	High, early	0%	√

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2011	High, late	82%	?
2012	Moderate	61%	√
2013	Low/mod	51%	√
2014	Mod., late	0%	
2015	High, quick	2%	
2018	High, early	0%	

Year-to-year differences in damage

Year	CEW in trap	% of ears with no kernel damage	
		Unsprayed	Warrior (max rate)
2007	Very high	3%	49%
2008	Low/mod	59%	96%
2009	High, quick	9%	94%
2010	Very high	1%	60%
2011	High, late	82%	99%
2012	Moderate	61%	96%
2013	Low/mod	51%	99%
2014	Mod., late	0%	18%
2015	High, quick	2%	8%
2018	High, early	0%	75%

Year-to-year differences in damage

Year	CEW in trap	% of ears with no kernel damage	
		Unsprayed	Warrior (max rate)
2007	Very high	3%	49%
2008	Low/mod	59%	96%
2009	High, quick	9%	94% ← ?
2010	Very high	1%	60%
2011	High, late	82%	99% ← ?
2012	Moderate	61%	96%
2013	Low/mod	51%	99%
2014	Mod., late	0%	18% ← ?
2015	High, quick	2%	8%
2018	High, early	0%	75%

Conclusions from 10 years of field trial data - 1

- Relief that pyrethoids still ok
  - When earworm low/moderate
  - but max rates needed
- Relief that new a.i.s now available
  - Coragen & Besiege
  - Radiant
  - Blackhawk

Conclusions from 10 years of field trial data - 2

- Concern about variability in performance of new a.i.s
  - but whole-field better than small plot
- Worry about whether efficacy of pyrethroids will suddenly drop

Conclusions from 10 years of field trial data - 3

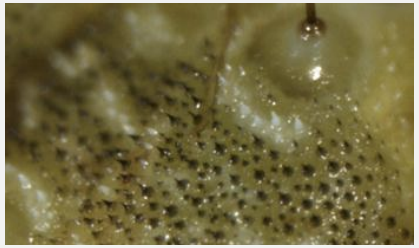
- Confirms utility of traps
  - to track trends in moth populations
  - in deciding spray schedule

If worms found at harvest?

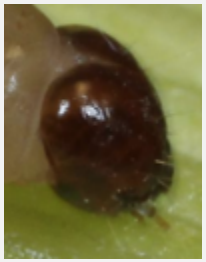
- Identify the species
- Review spray schedule
  - Timing of first spray
  - Interval between sprays

Caterpillar i.d.

	Corn earworm	European corn borer	Fall armyworm
			
Body color	Variable: yellow, green, brown, or pink	Cream to light brown	Light brown top, dark brown sides
Body marks	Distinct stripes	Subtle stripes, round dots	Stripes
Texture	Dense microspines	Smooth; few sparse hairs	Smooth



Caterpillar i.d.

	Corn earworm	Eur. corn borer	Fall armyworm
			
Head size	Large	Small	Large
Head color	Light orange/ brown, mottled 	Dark brown 	Dark sides, light in middle 

How to identify WBCW?

	Western bean cutworm	Corn earworm

How to identify WBCW?

	Western bean cutworm	Corn earworm
Number of worms per ear	Many	One
Prothorax (segment behind head)	Broad dark stripes	No stripes
Micro-spines on body	None	Many
Net-like marks on head	No	Yes

Got trap?

- If yes:
  - good!
  - Compare your catch with others
- If no:
  - Buy one!
  - See what others are catching:
    - http://u.osu.edu/pestmanagement/trap-reports/vegetable/

On-line trap reports

http://u.osu.edu/pestmanagement/trap-reports/vegetable/

CORN EARWORM: NUMBER OF MOTHS CAUGHT IN TRAPS, S					
County:	Clark	Clark	Franklin	Franklin	Wayne
Location:	South Charleston	Springfield	Columbus	Columbus	Andy Yoder
Trap type:	Hartstack	Scentry "Heliothis"	Hartstack	Scentry "Heliothis" ;;	Scentry "Heliothis"
Date					
May 6-12			set	set	
May 13-19			3	1	
May 20-26			1	1	
May 27-June 2	set		4	1	
June 3-9	3		8	0	
June 10-16	4	set	7	0	
June 17-23	11	0	1	1	set
June 24-30	1	1	6	0	3
July 1-7	3	0	5	0	1
July 8-14	18	0	0	0	1
July 15-21	1	0	3	0	0
July 22-28	1	0	28	2	11
July 29-Aug 4	1	0	23	0	3
August 5-11	800	2	476	57	2

the end

Info on fruit & veg. pests
u.osu.edu/pestmanagement/

Questions?

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