Neonicotinoid insecticide seed treatments in soybean: an indirect means of reducing CMV incidence in processing green beans

2018 Wisconsin Agribusiness Classic
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Wisconsin Agribusiness Classic

College of Agricultural & Life Sciences
University of Wisconsin-Madison

Cornell University

Presentation Outline – New Project

- Chronology of green bean viruses in Wisconsin
- Dynamics of virus spread
- 2017 – 2018 Research Objective – Determine whether low populations of soybean aphid, *Aphis glycines*, correspond with low infection rates of recent virus infections (Cucumber mosaic virus)
- Future directions and new steps

Total Impact of Specialty Crop Production and Processing *(Economic activity in $ millions per year)*

Total Impact of Specialty Crop Production and Processing[1] Industries in Wisconsin
(Economic activity in $ millions per year)

	Total Economic Activity	Total Jobs
Vegetable & Fruit Production	**$1,092**	**9,900**
Potatoes	$349	2,770
Cranberries	$300	3,400
Sweet Corn	$83	660
Green Beans	$63	490
Green Peas	$26	200
Carrots, Cucumbers & Onions	$28	220
Ginseng	$16	130
Specialty Crop Processing	**$5,268**	**24,800**
Total Impact	**$6,360**	**34,700**

[1]Production estimates based on 2006-2008 average farmgate values; processing estimates based on 2007 Economic Census values. Note: Sum of impacts may not equal total impact due to rounding.

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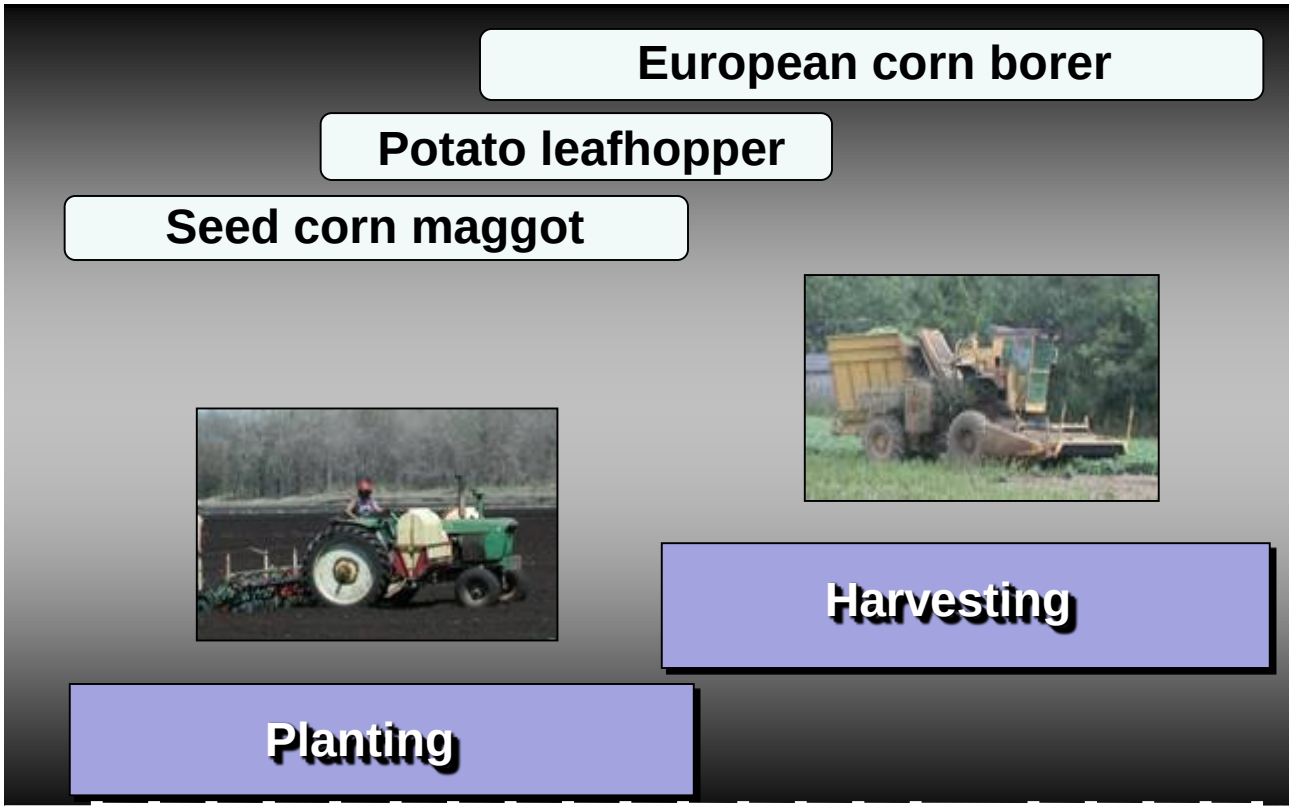
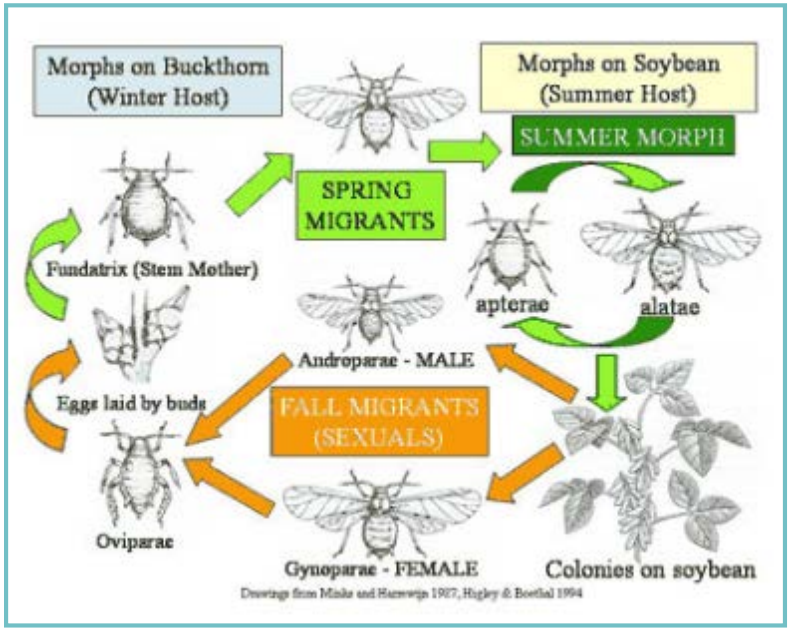
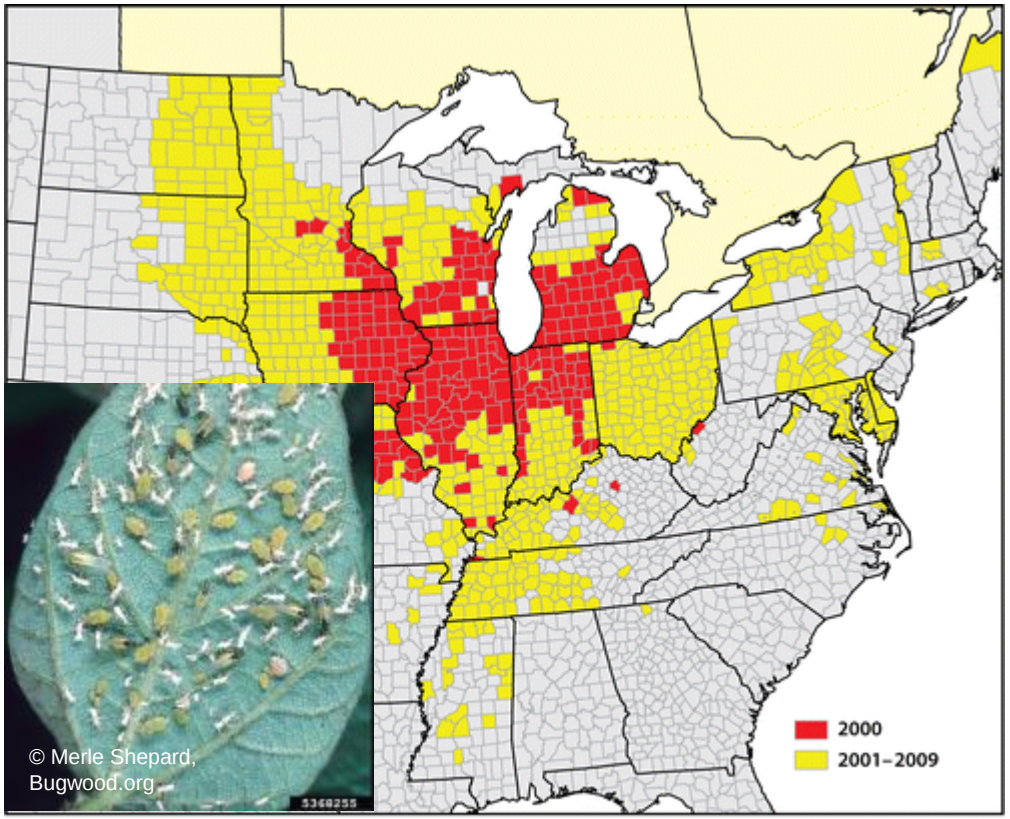
Keene and Mitchell, 2010

Processing Snap Bean: Pest Phenology in Wisconsin



Biology and Distribution of the Soybean aphid (*Aphis glycines* Matsumura)





Ragsdale DW, et al. 2011. Annu. Rev. Entomol. 56:375–99

North Central Region – Aphid Suction Trap Network

- Weekly captures of dispersing aphid species.
- Dr. David Voegtlin, Illinois Natural History Survey

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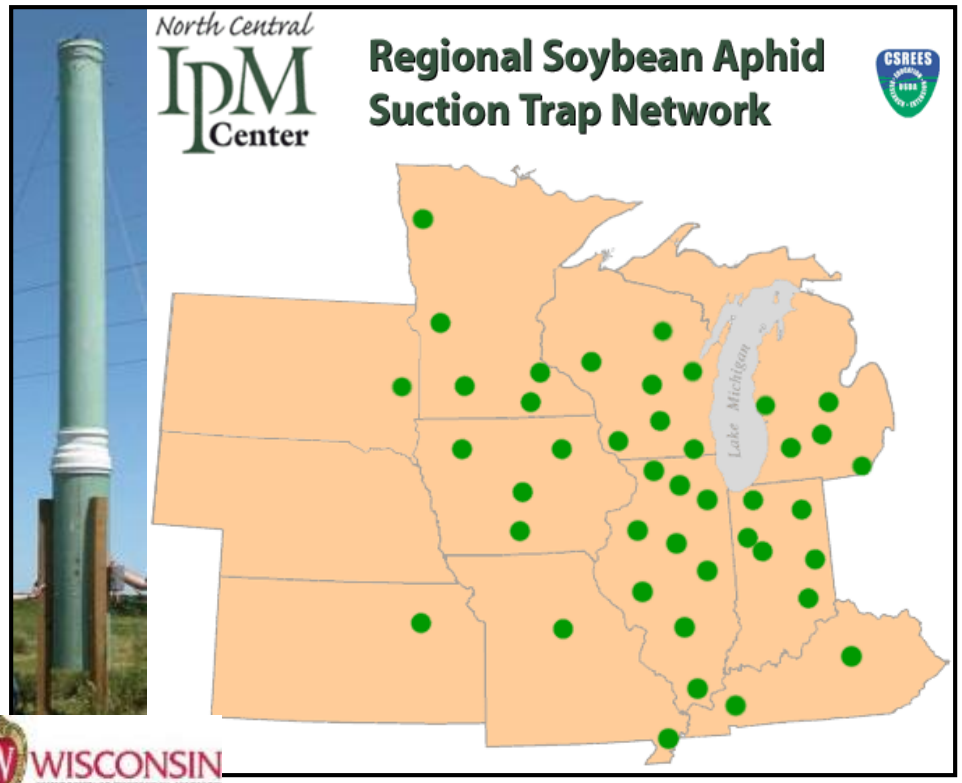

Acyrthosiphon pisum	"Pea aphid"
Aphis craccivora	"Black legume aphid"
Aphis glycines	"Soybean aphid"
Aphis gossypii	"Cotton- melon aphid"
Aphis helianthi	"Sunflower or dogwood aphid"
Aphis nasturtii	"Buckthorn - potato aphid"
Aphis spiraecola	"Spiraea aphid"
Brachycaudus helichrysi	"Leaf curling plum aphid"
Lipaphis pseudobrassicae	"Turnip aphid"
Macrosiphum euphorbiae	"Potato aphid"
Myzus persicae	"Peach potato aphid"
Rhopalosiphum insertum	"Apple grass aphid"
Rhopalosiphum maidis	"Corn leaf aphid"
Rhopalosiphum padi	"Bird cherry-oat aphid"
Schizaphis graminum	"Greenbug"
Sitobion avenae	"English grain aphid"
Therioaphis trifolii	"Spotted Alfalfa aphid"

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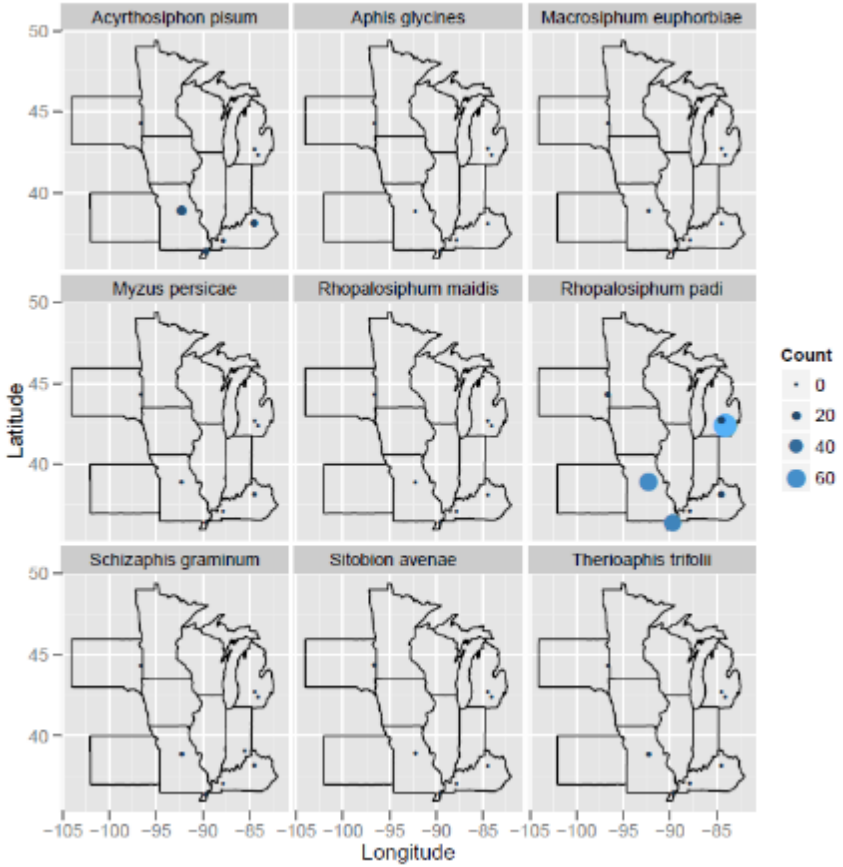
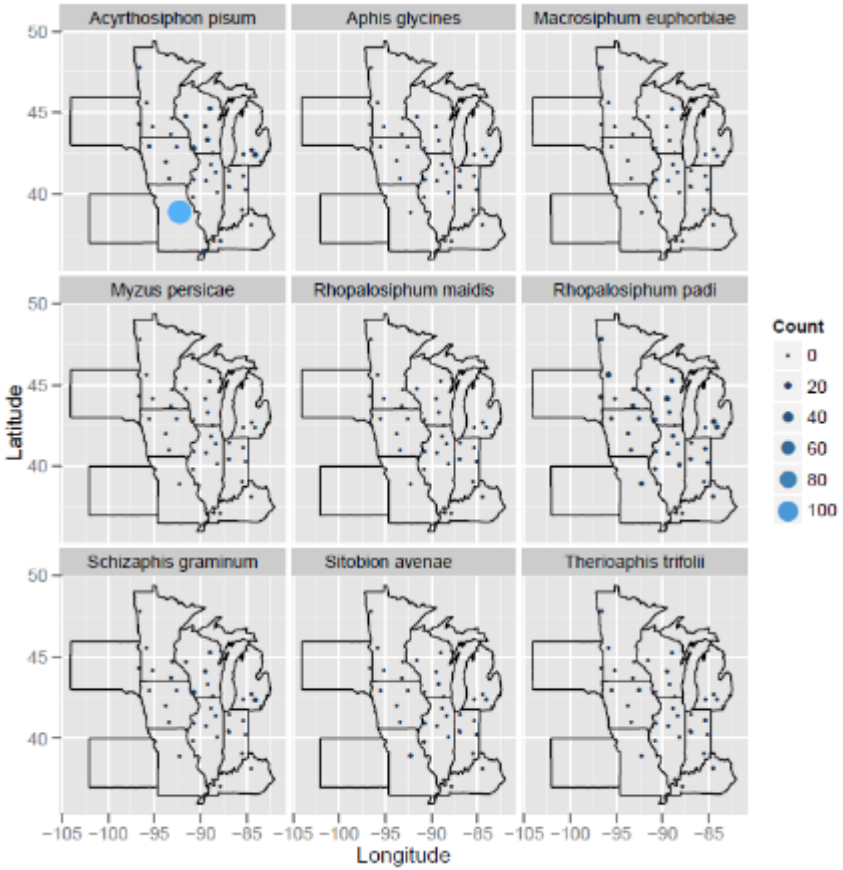
Seasonal Dispersal – 2007 Suction Trap Data

Week 19
(12-19 May)



Week 23
(9-16 June)



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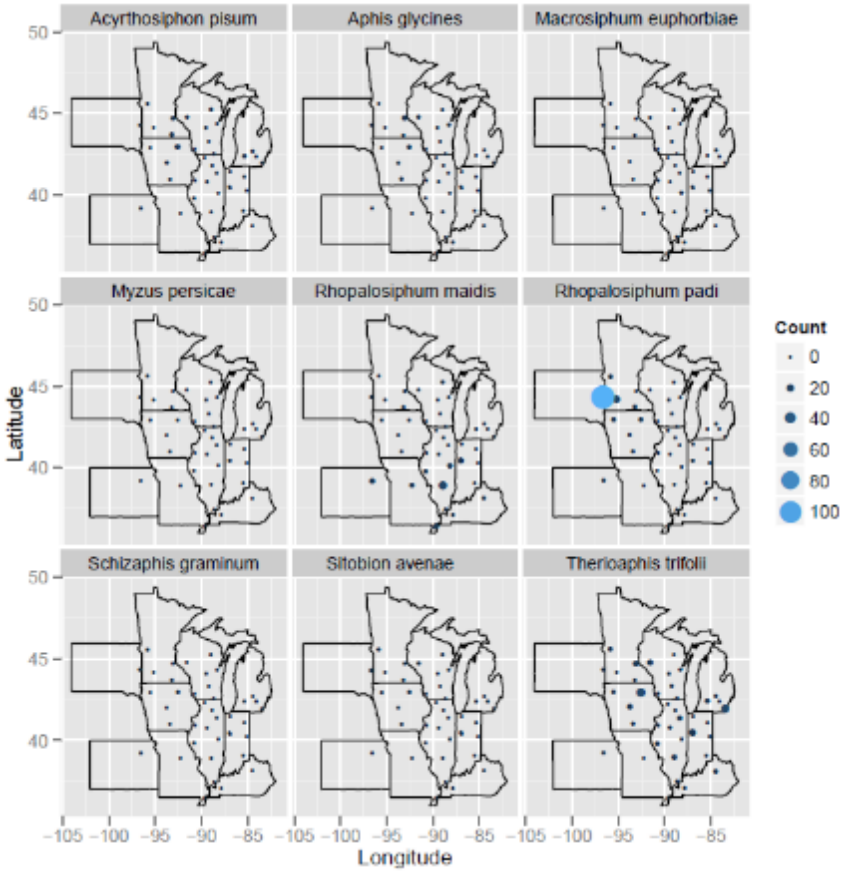
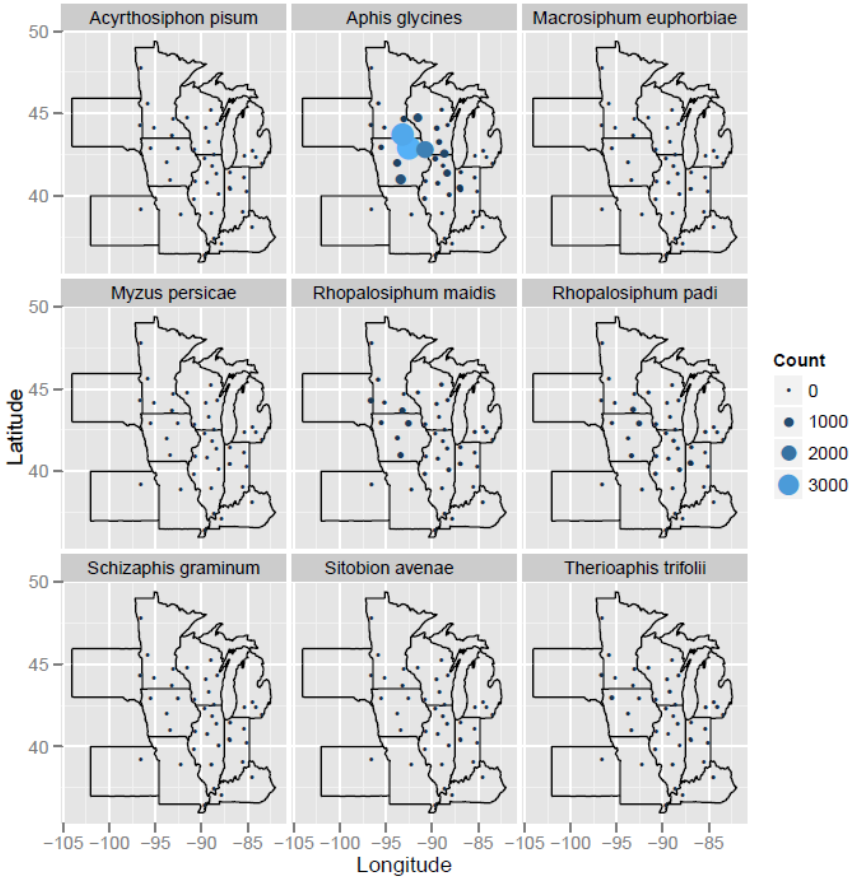
Seasonal Dispersal – 2007 Suction Trap Data

Week 27
(7-14 July)



Week 31
(4-11 August)



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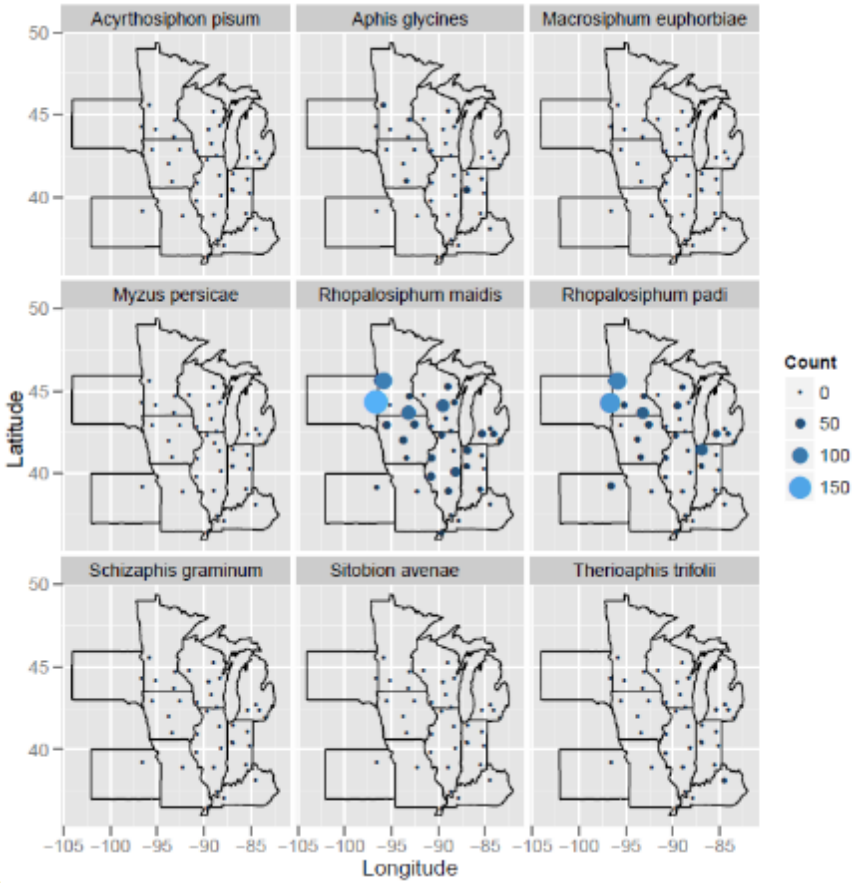
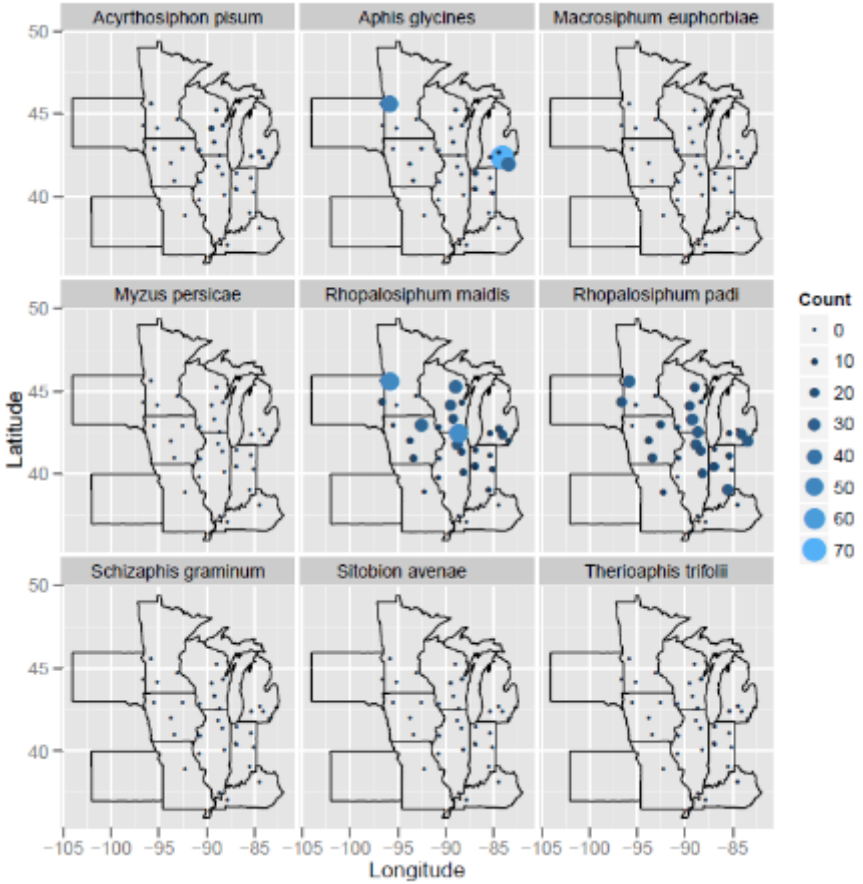
Seasonal Dispersal – 2007 Suction Trap Data

Week 35
(1-8 Sept)



Week 39
(29 Sept-6 Oct)



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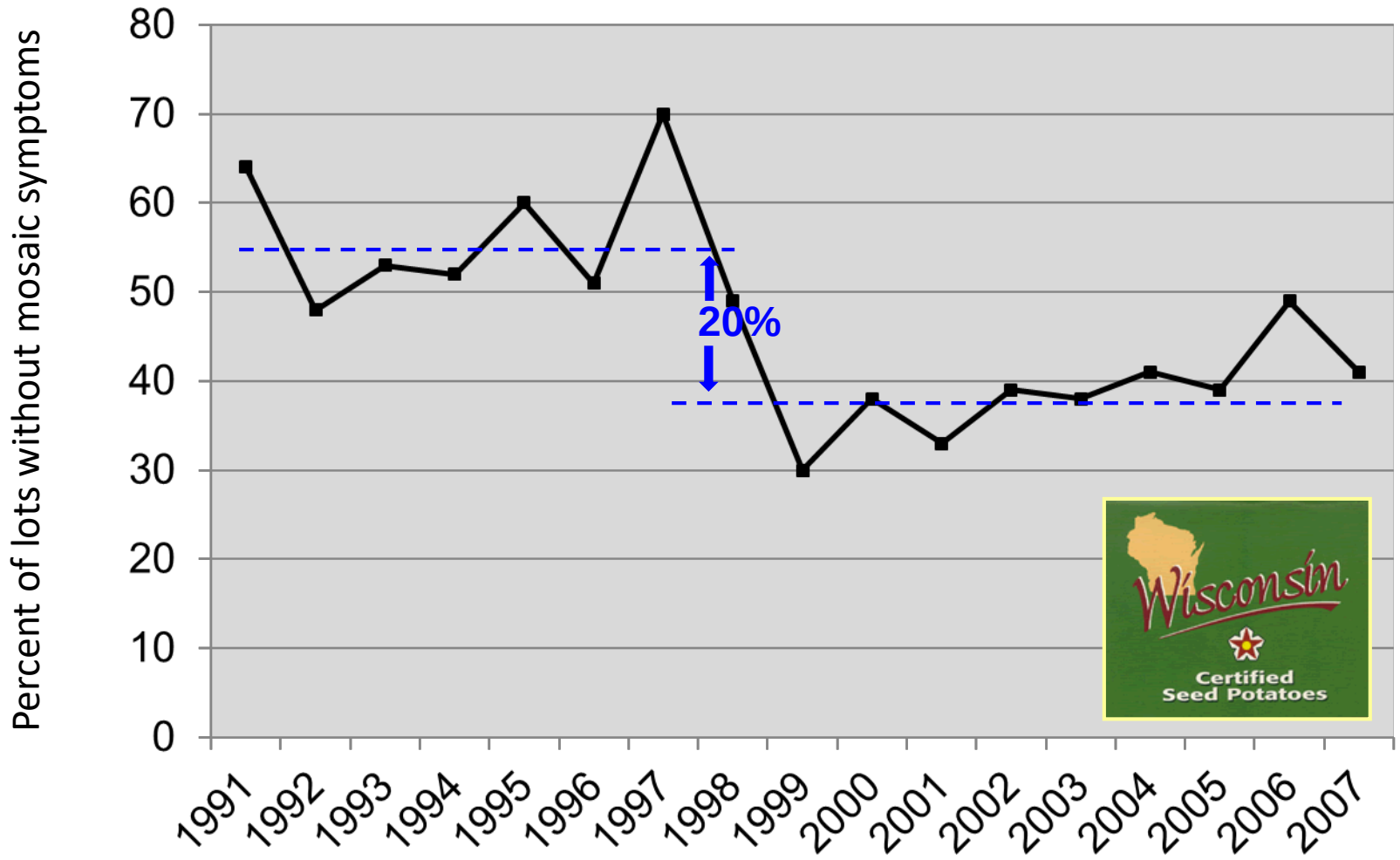
Proportion of lots not experiencing down-grades or rejections resulting from Potato virus Y - Potato



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Aphid species diversity 2005-2017

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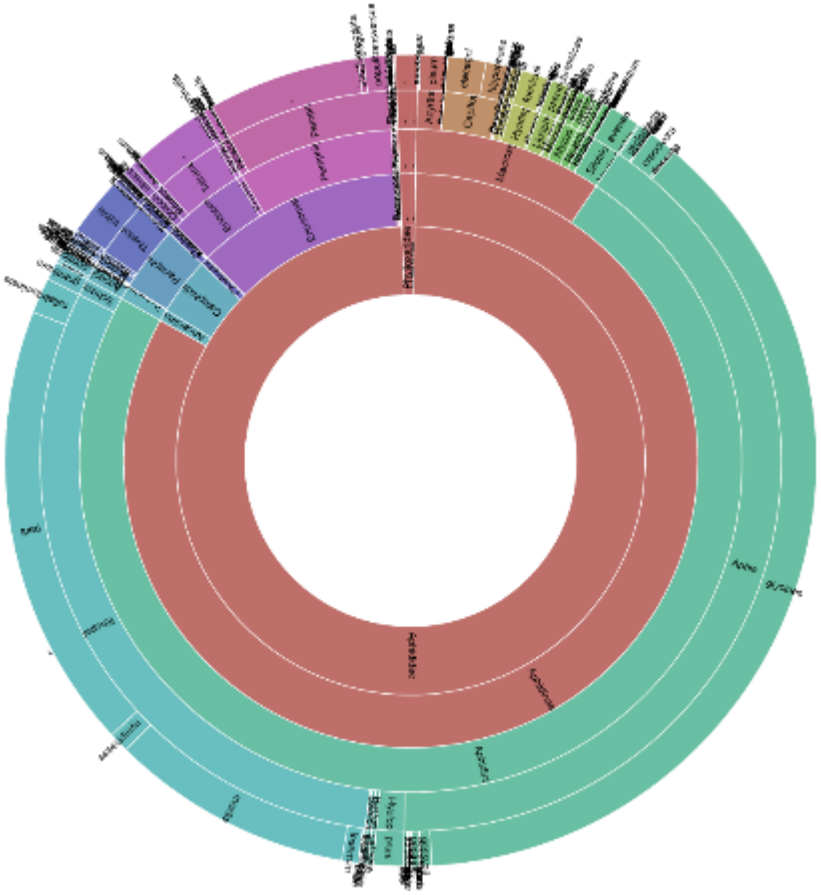
PRAIRIE RESEARCH INSTITUTE



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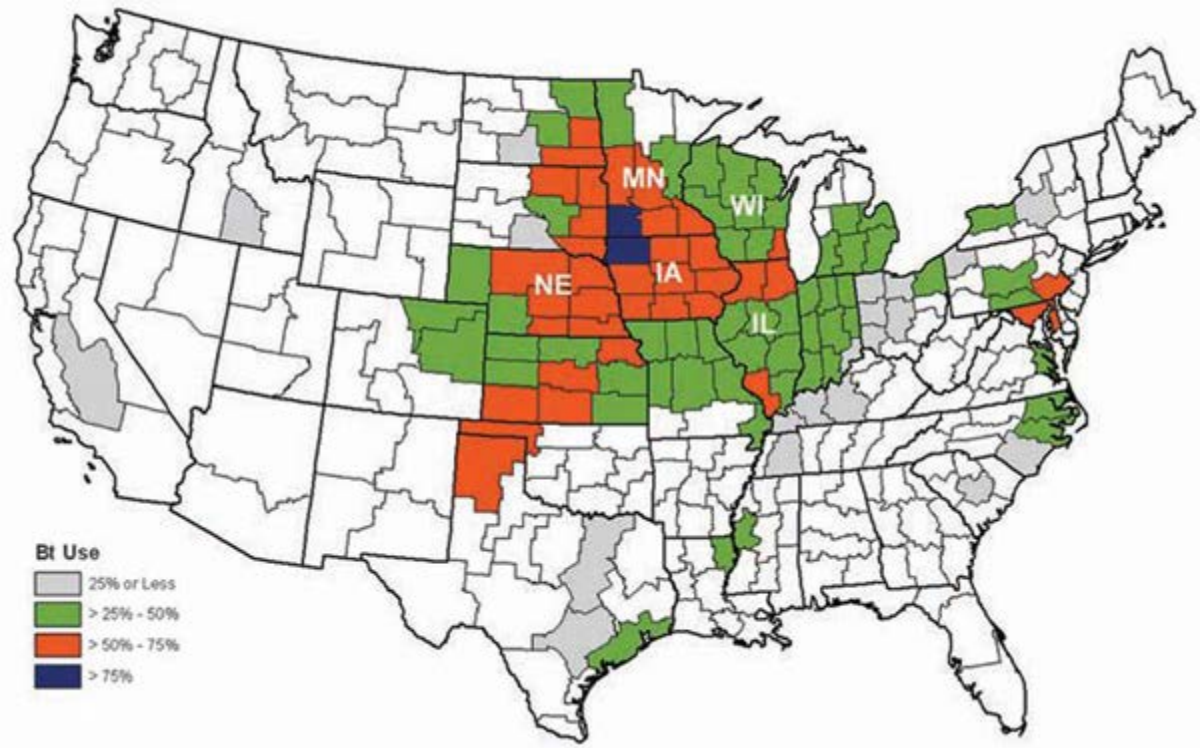
Rank	Species	Captures
1	*Aphis glycines*	313169
2	*Rhopalosiphum padi*	146799
3	*Rhopalosiphum maidis*	79793
4	*Pemphigus sp.*	50138
5	*Tetraneura sp.*	24010
6	*Therioaphis trifolii*	19439
7	*Capitophorus elaeagni*	12496
8	*Rhopalosiphum rufiabdominale*	11749
9	*Sitobion avenae*	10160
10	*Hyalopterus pruni*	9871
11	*Hyadaphis foeniculi*	9004
12	*Acyrthosiphon pisum*	8733
13	*Aphis craccivora*	8607
14	*Pemphigus populitransversus*	7581
15	*Capitophorus hippophaes*	7458
16	*Rhopalosiphum nymphaeae*	6710
17	*Schizaphis graminum*	6119
18	*Lipaphis pseudobrassicae*	6067
19	*Rhopalosiphum insertum*	5426
20	*Phylloxeridae*	5009
21	*Aphis asclepiadis*	4277
22	*Anoecia cornicola*	3656
23	*Aphis gossypii*	3636
24	*Colopha ulmicola*	3611
25	*Myzus persicae*	2770
26	*Uroleucon sp.*	2567
27	*Aphis nasturtii*	2522
28	*Myzus lythri*	2479
29	*Macrosiphum euphorbiae*	2460

2010 Biotechnology Endorsement Estimates – proportion of acreage adopting transformation technology



Hutchison et al. 2010

Insecticide Seed Treatment Gains Traction as a Standard Agricultural Practice

2010 SEED TREATMENT	
	% of Total Acres Planted with Treated Seeds
CROP	TOTAL NEONICOTINOIDS (Clothianidin, Imidacloprid, Thiamethoxam)
Canola	100%
Cereals	42%
Corn	94%
Cotton	42%
Rice	51%
Sorghum	75%
Soybeans	32%
Sugar Beets	65%

*CTN 2010 Seed Treatment study
**A total of 147 million US acres are planted with neonicotinoid-treated seeds.

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Green Bean Virus Complex (2003 – Present)

Major Viruses:

Bean common mosaic virus (BCMV – seedborne/aphid)
Bean yellow mosaic virus (BYMV - aphid)
Cucumber mosaic virus (CMV - aphid)
Alfalfa mosaic virus (AMV – aphid)
Clover yellow vein virus (CLYVV – aphid)

Minor Viruses:

Tobacco ringspot virus (TRV-nematode)
Tomato ringspot (TmRSV-nematode)
Soybean mosaic virus (SMV – seedborne/aphid)
Watermelon mosaic virus-2 (WMV-2 - aphid)

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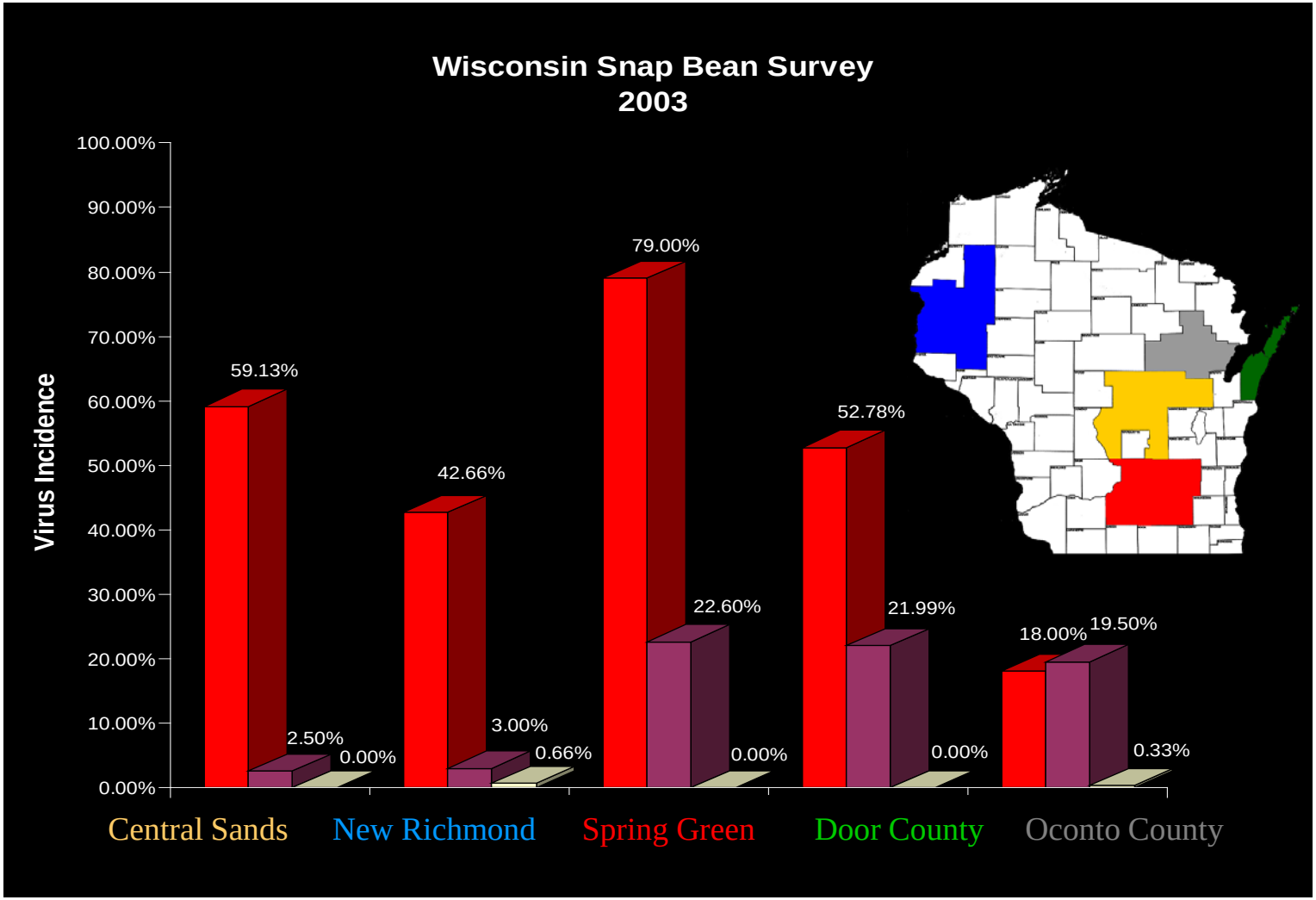
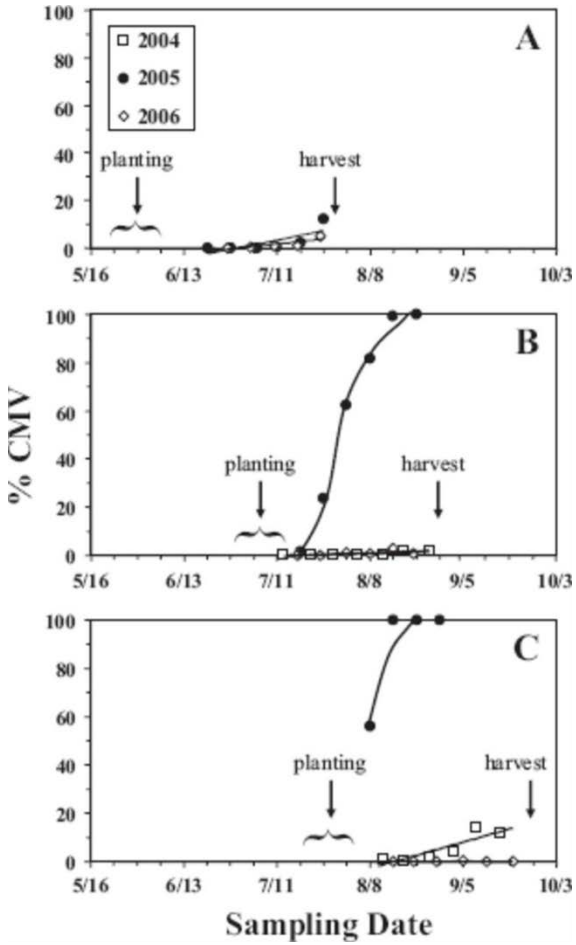
Emerging bean viruses: the problem (Wisconsin)



German et al. (2004)

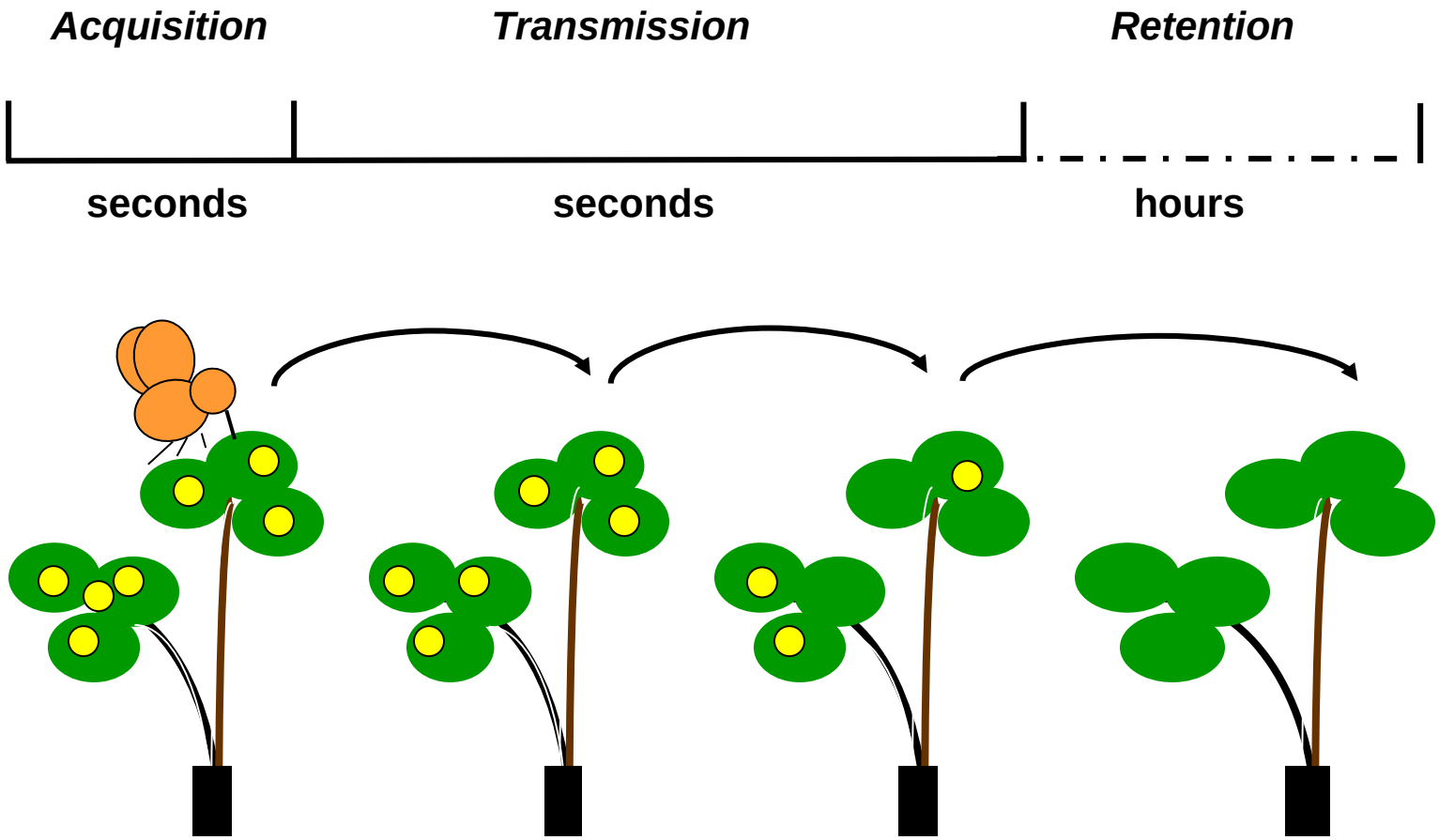
Emerging bean viruses: the problem (New York)



Mean percent of snap bean plants with CMV in (A) early-planted, (B) middle-planted, and (C) late-planted snap bean fields in New York (n = 4 fields/yr).

Nault et al. (2009)

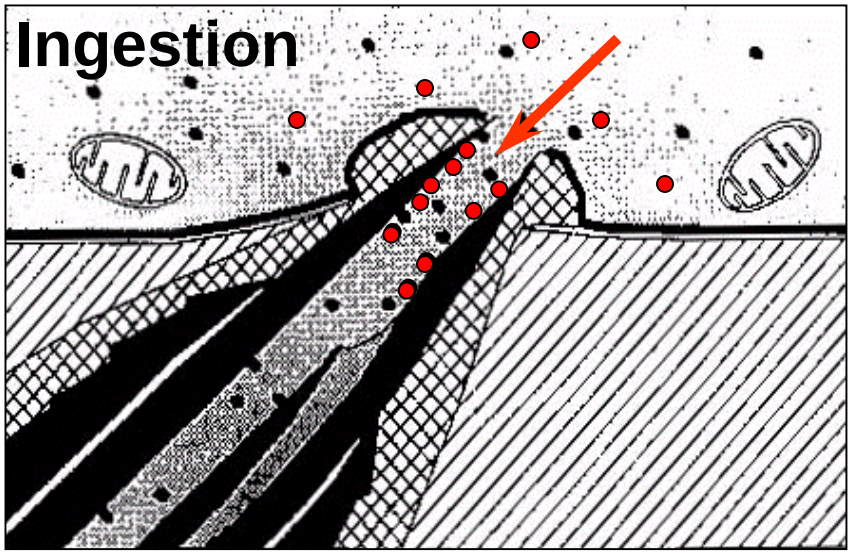
Non-Persistent Transmission



Non-Persistent Transmission: Movement in Insects

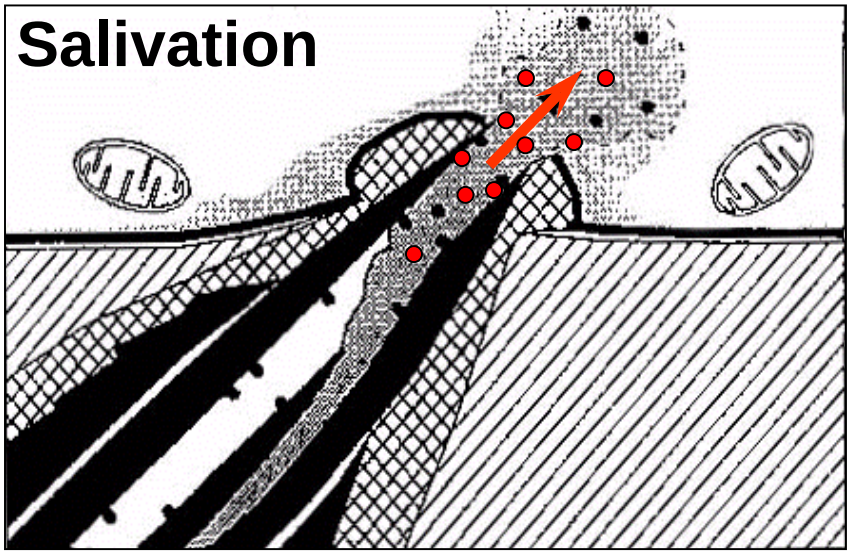
- Food Ingestion

- Pathogen particles attach to maxillary lumen



- Egestion

- Pathogen particles released with saliva



Non-Persistent Transmission: Challenge for control

- Acquisition time - time required to acquire pathogen
  - seconds
- Inoculation time - time required by infectious insect to inoculate a susceptible host
  - seconds
- Latent period - (minimum time between acquisition of a pathogen and ability to transmit)
  - zero
- Retention time - time after acquisition that a vector remains capable of transmitting the virus
  - minutes to hours

Virus Incidence Testing, Plover, WI

- Two Years (2017 & 2018) – Portage and Waushara Counties
- Green beans (Del Monte Foods, 2 ‘Blue Lakes’ varieties)
- 200 individual plants sampled / field (DAS-ELISA)
- 20 fields sampled: mid- (N=10) and late-season (N=10) planting dates
- 30 alfalfa field locations (Columbia and Waushara Counties) – late planting sampling times (08/11/2017)
- At-plant seed treatments (THMX)

Results

Crop Sampled	Number of fields in which CMV was detected	Number of plants infected with CMV
Snap bean - NY	1/45	1/ 23,000
Snap bean - WI	1/20	1/ 4,000
Alfalfa - NY	0/12	0/ 960
Alfalfa - WI	0/10	0/ 1,000

Soybean aphid abundance 2005-2017

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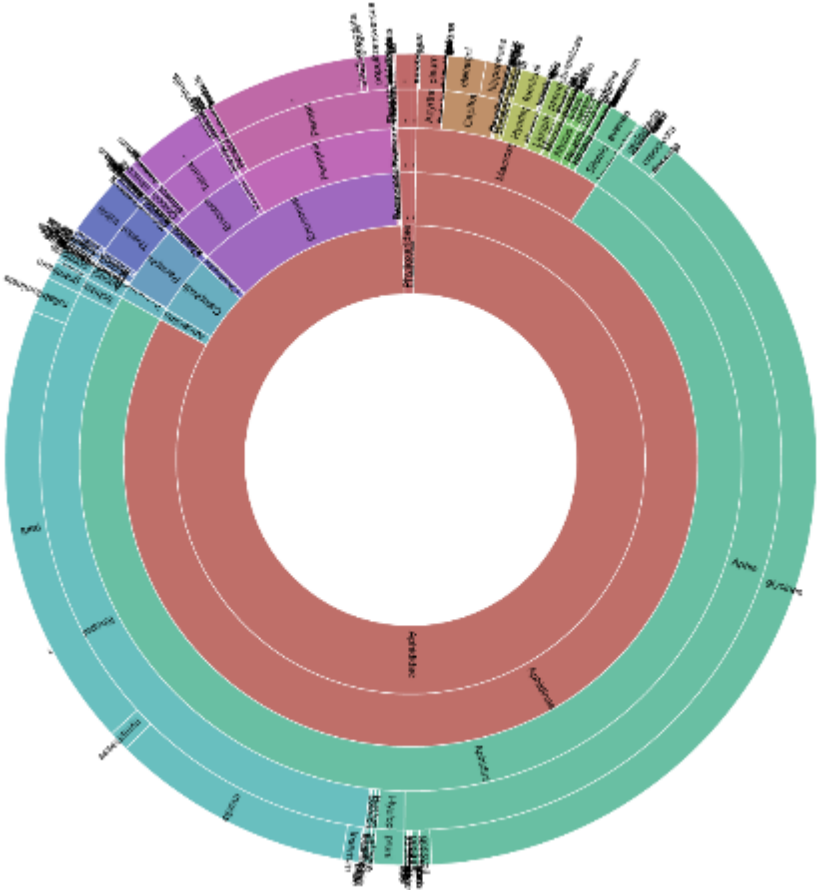

Year	Species	Captures
2005	*Aphis glycines* (soybean aphid)	39,452
2006		57,806
2007		58,561
2008		40,138
2009		34,804
2010		17,842
2011		23,920
2012		25,684
2013		8,735
2014		5,531
2015		2,245
2016		1,804
2017		2,523
	Total	313,369

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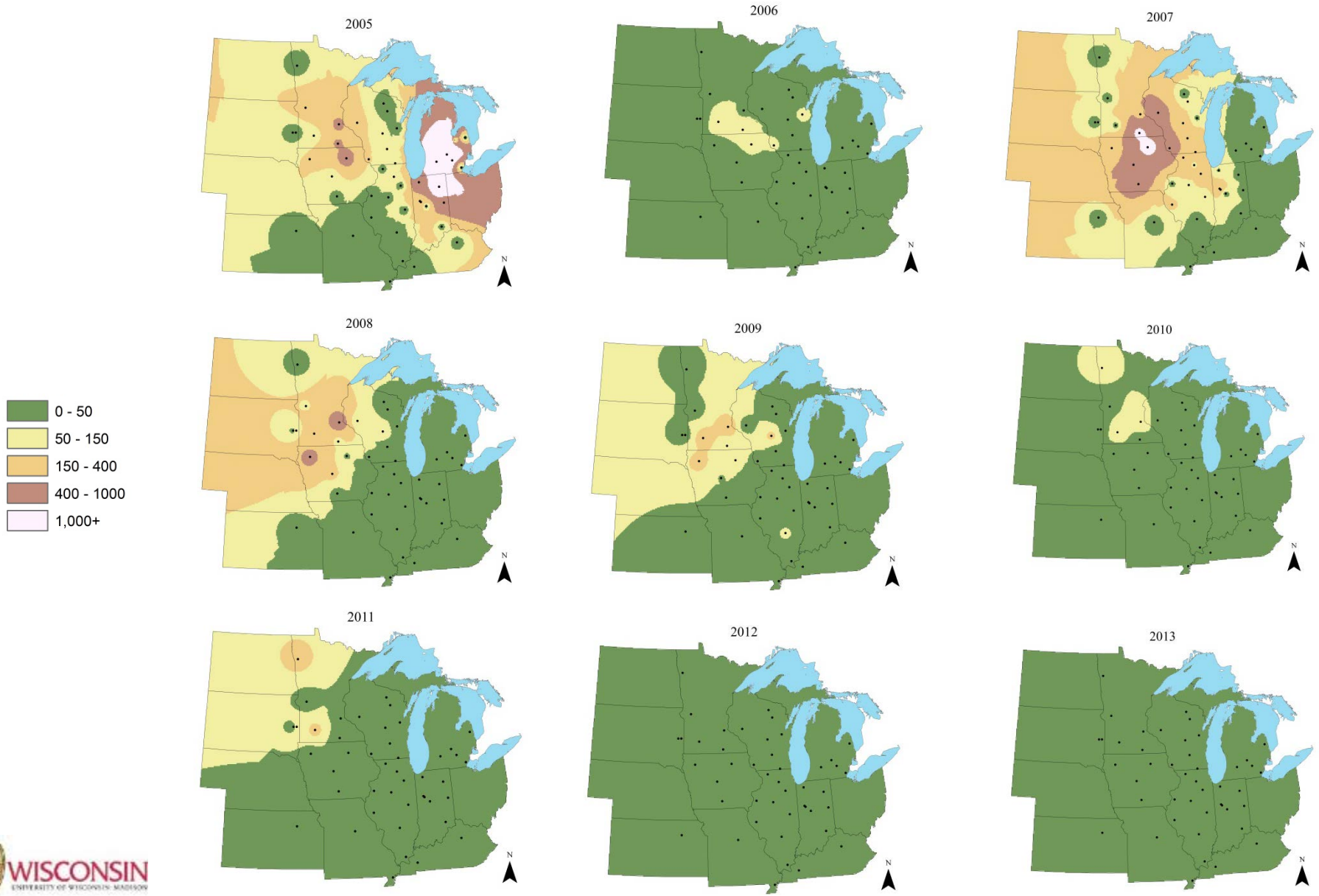
2005 – Current: Soybean aphid numbers dramatically decline



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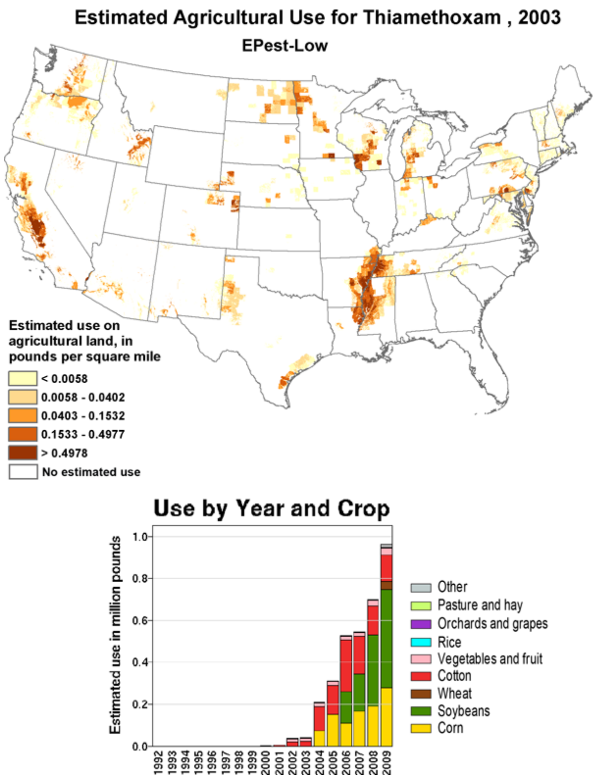
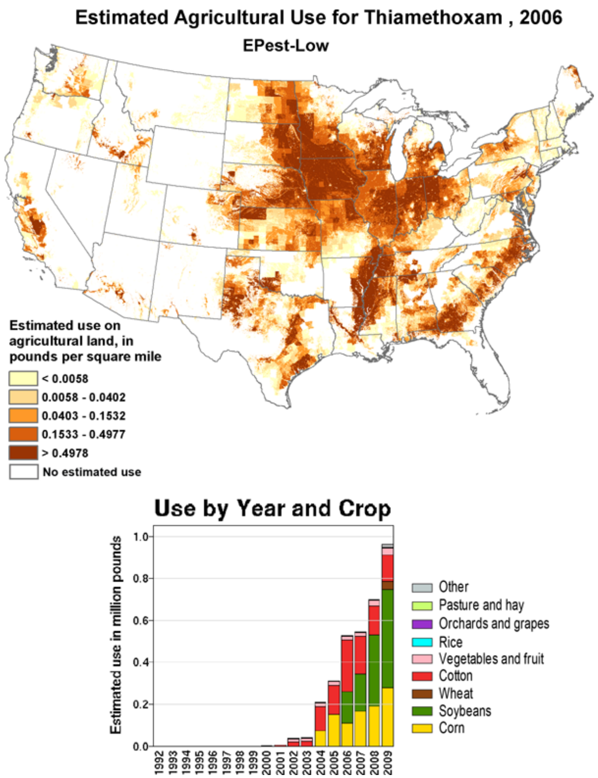
Global Insecticide Seed Treatment Use is Increasing

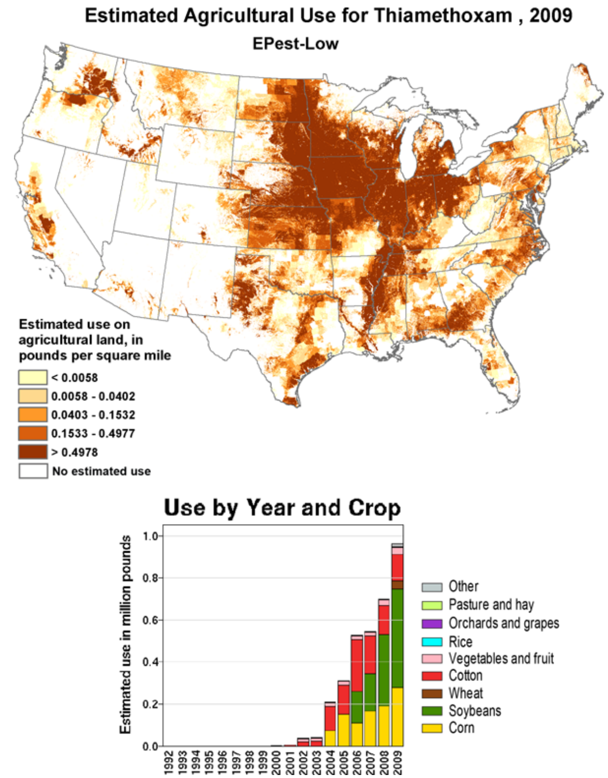
“The global insecticide seed treatment market is projected to reach nearly $1.6 billion by 2016, growing at a CAGR of 11.4%.”

(Source: marketsandmarkets.com. January 2012).

Annual Changes in Crop Uses in the U.S.
Thiamethoxam: 2003 – 2006 - 2009







https://water.usgs.gov/nawqa/pnsp/usage/maps/compound_listing.php

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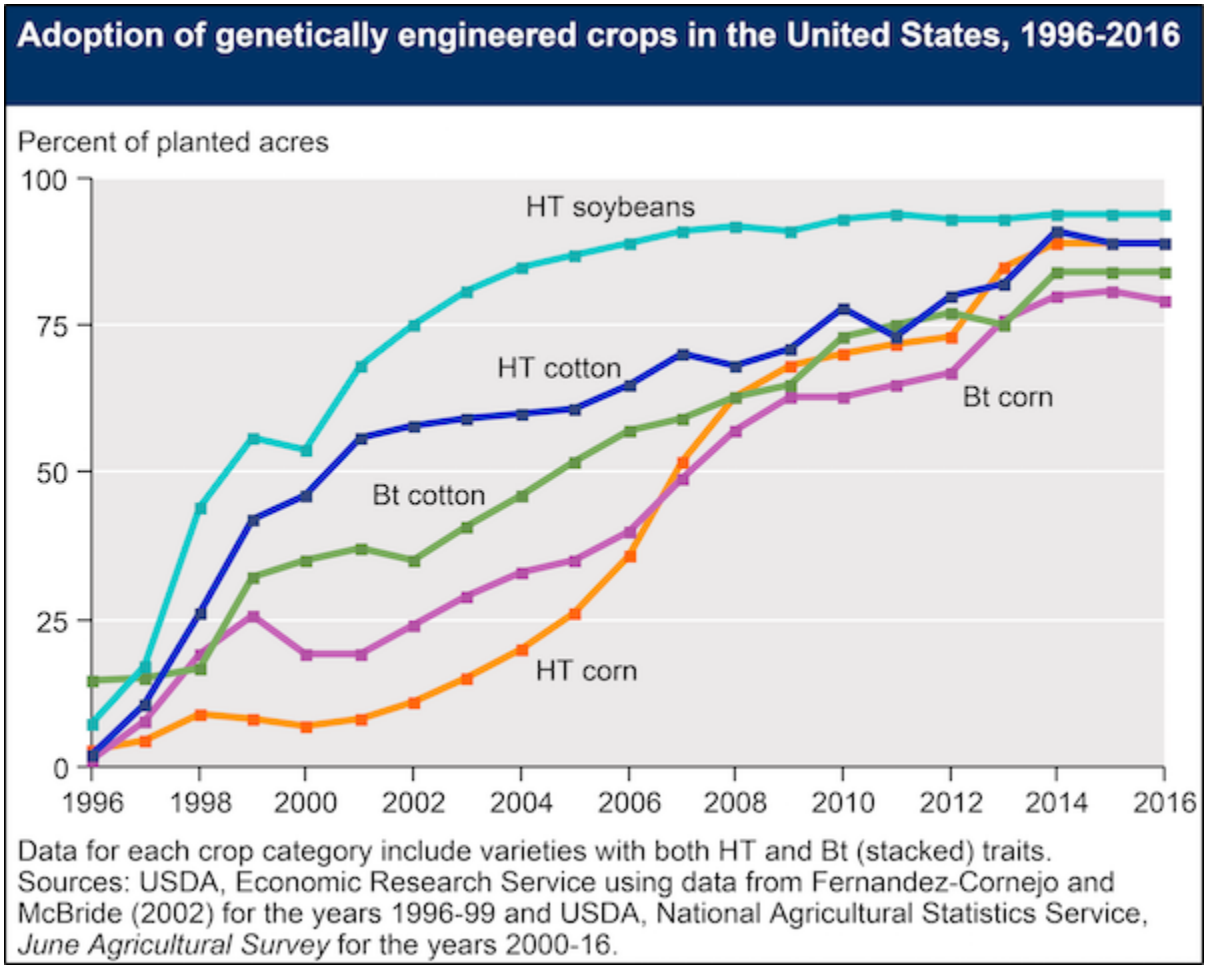
2016 - Current Trends in Biotechnology Endorsement



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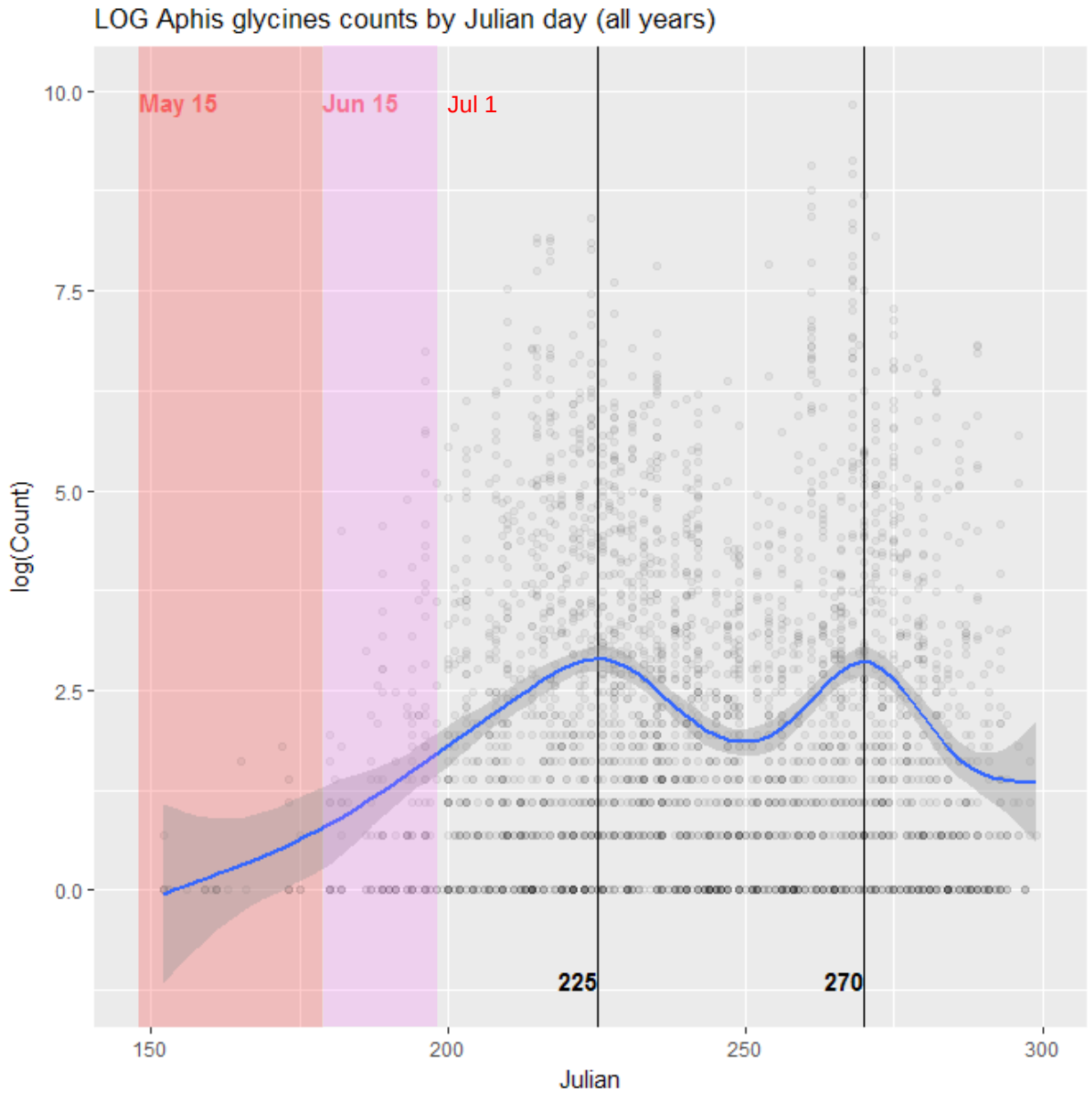
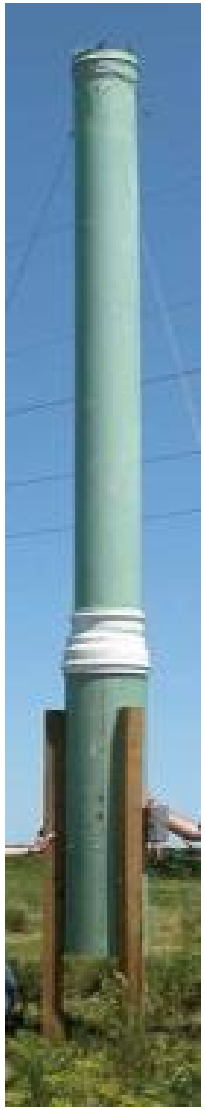
Neonicotinoid concentrations and planting date





Summary

- **CMV virtually absent from snap bean fields in NY and WI in 2017**
- **Fewer aphids captured than a decade ago; species identified 2018**
- **Implications – dependence on CMV- tolerant cultivars could be relaxed**

Acknowledgements

Research Grant Funding:

- Midwest Food Processors Association
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National Institute of Food and Agriculture

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- Del Monte Foods (Plover, WI): Matthew Badtke, Mike Johnson, and Don Caine