Neonicotinoid Seed Treatments: Agronomics and Environmental Impacts

Dick Sloan and Matt O'Neal

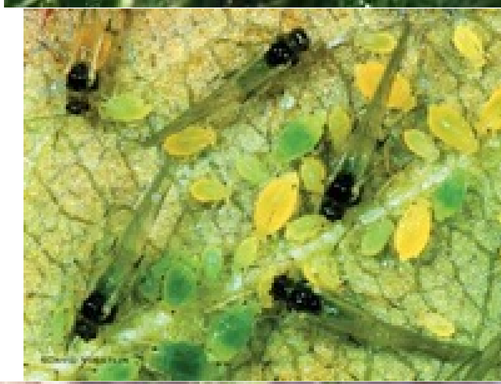
Matt's slides

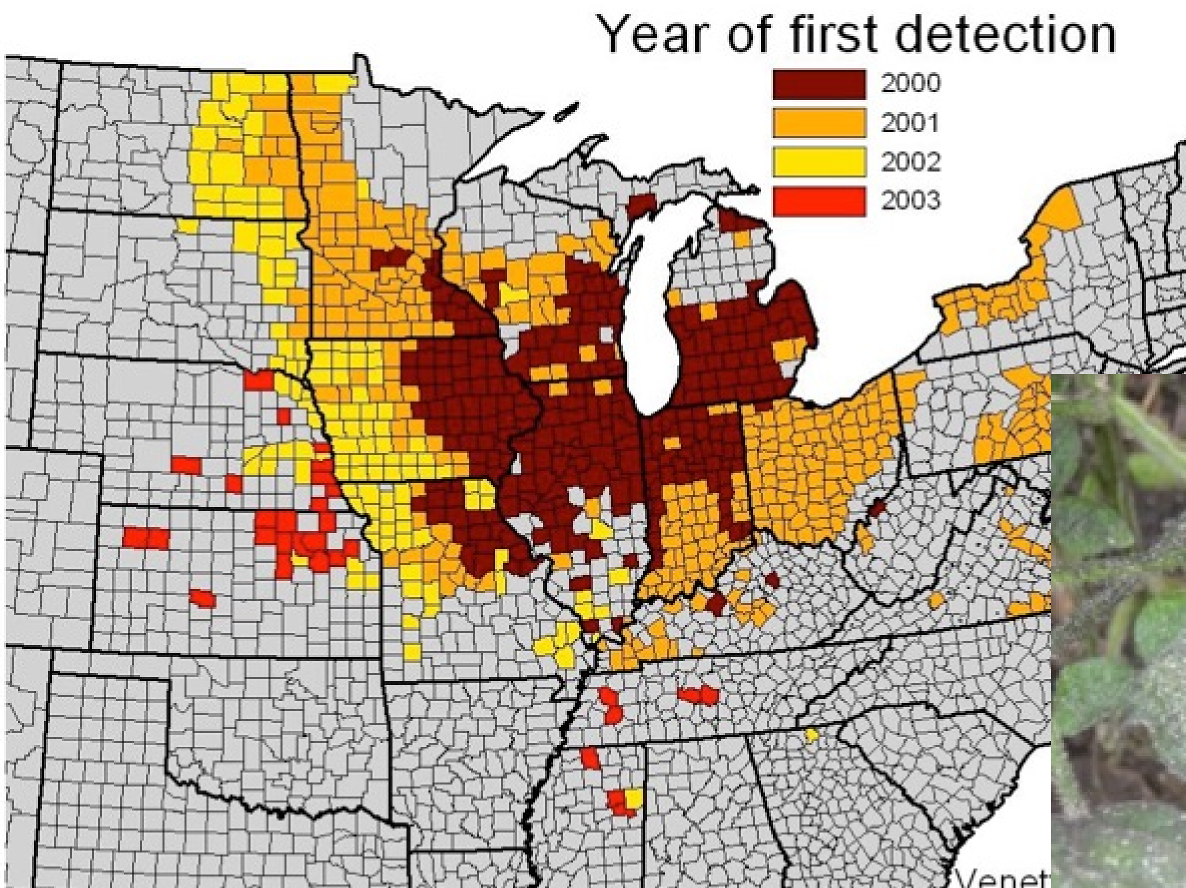
Midwest soybean pests - Before 2000

- Few soybean insect pests.

  1996 ~ 0 soybean acres treated with insecticides (USDA estimate).

Midwest soybean pests - *After 2000*



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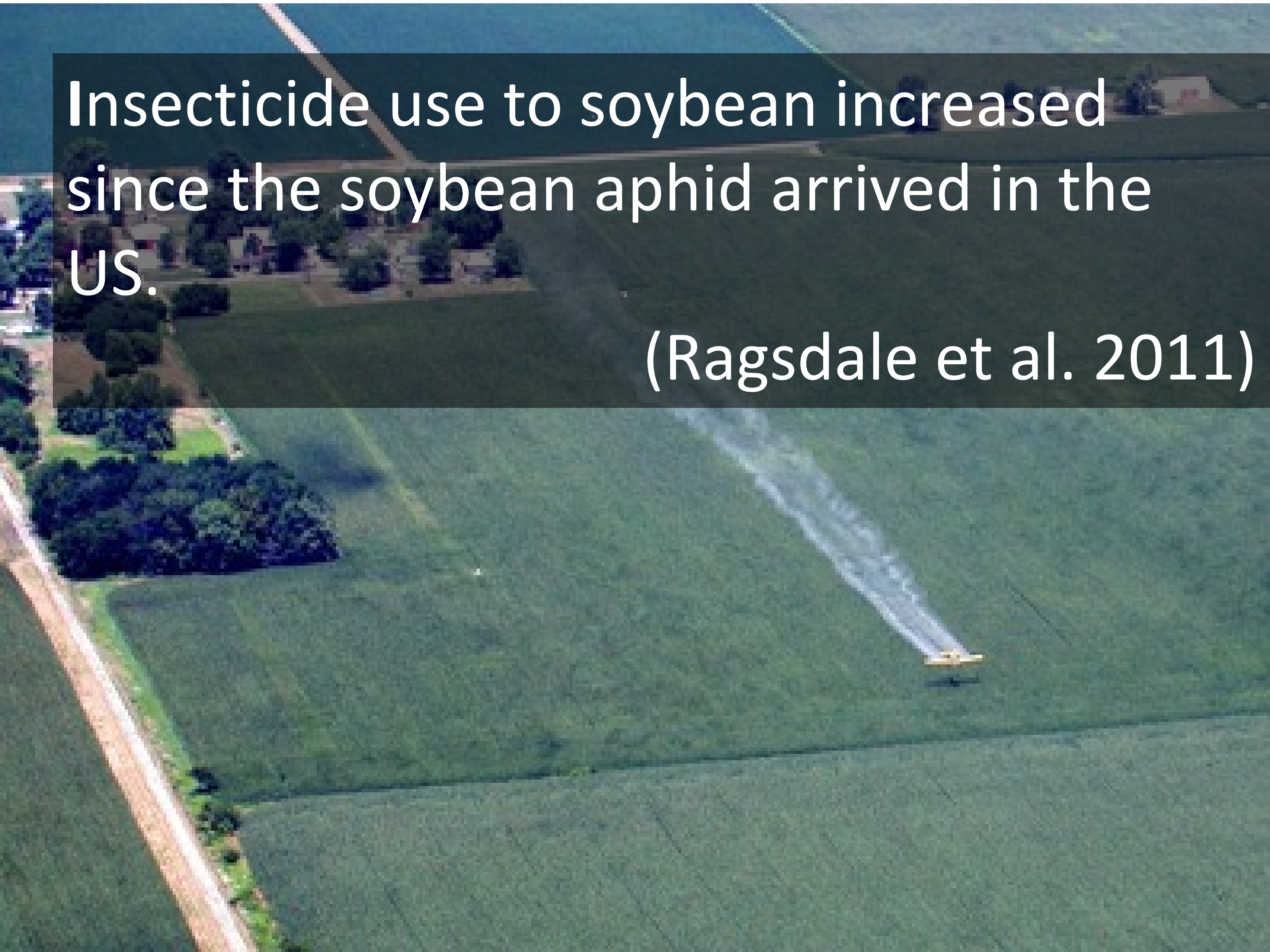
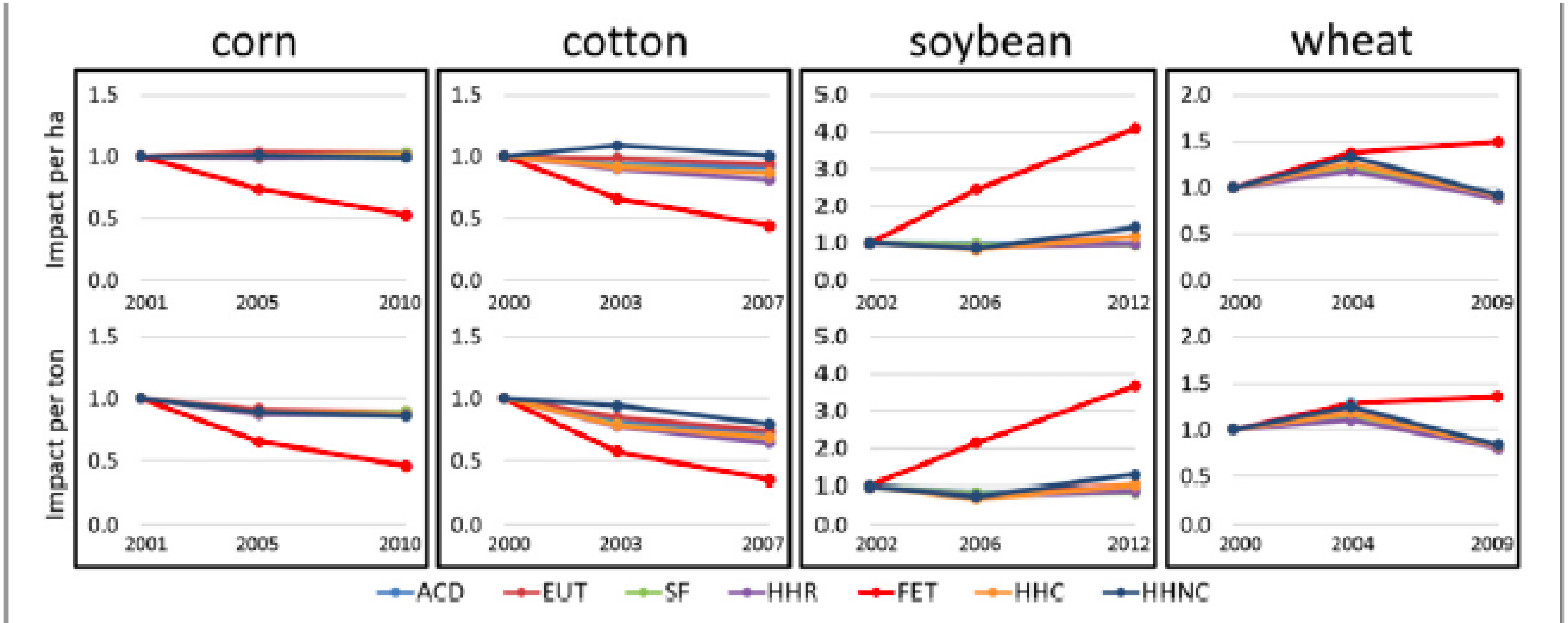

Insecticide use to soybean increased since the soybean aphid arrived in the US.
(Ragsdale et al. 2011)

Changes in environmental impacts of major crops in the US.

Yi and Suh 2015.



"As a result [of the soybean aphid's invasion of the US], the total quantity of insecticides applied to soybean quadrupled between 2001 and 2012."

Key studies on neonicotinoids

- “Probability of cost-effective management of soybean aphid in North America” 2009. Johnson et al. https://doi.org/10.1603/029.102.0613
- “High-Input Management Systems Effect on Soybean Seed Yield, Yield Components, and Economic Break-Even Probabilities” 2016. Orlowski et al. https://acsess.onlinelibrary.wiley.com/doi/full/10.2135/cropsci2015.10.0620
- “Iowa State University Report of Insecticide” Hodgson et al. 2020.(every year). https://store.extension.iastate.edu/product/16055
- “Beyond the Headlines: The influence of insurance pest management on an unseen silent entomological majority.” 2020. Krupke and Tooker. https://doi.org/10.3389/fsufs.2020.595855

“Probability of cost-effective management of soybean aphid in North America”

2009. Johnson et al.

https://doi.org/10.1603/029.102.0613

4 methods compared in 3 states over 3 years*

1. untreated **control** = no insecticides.
2. **Prophylactic** = insecticide & fungicide applied to foliage when soybeans flower.
3. **Seed-treatment** = Cruiser only.
4. **IPM** approach = fields scouted and insecticide applied as needed.

*Johnson et al. 2009. Journal of Economic Entomology 102: 2101-2108.

Not all insecticide use pays off.
gain threshold = break even point

Table 6. Probability of yield gain from treatments exceeding the gain threshold at four soybean prices

Scouting cost	Treatment	Probability by soybean price per 27.2 kg[a]			
		$6.00	$8.00	$10.00	$12.00
$0.00 per ha	IPM	0.81	0.83	0.84	0.85
$19.76 per ha	IPM	0.69	0.74	0.77	0.79
NA	Prophylactic	0.51	0.63	0.70	0.74
NA	Seed-treatment	0.43	0.47	0.50	0.51

[a] 27.2 kg = 1 US bushel.

*Johnson et al. 2009. Journal of Economic Entomology 102: 2101-2108.

“High-Input Management Systems Effect on Soybean Seed Yield, Yield Components, and Economic Break-Even Probabilities”

2016. Orlowski et al.

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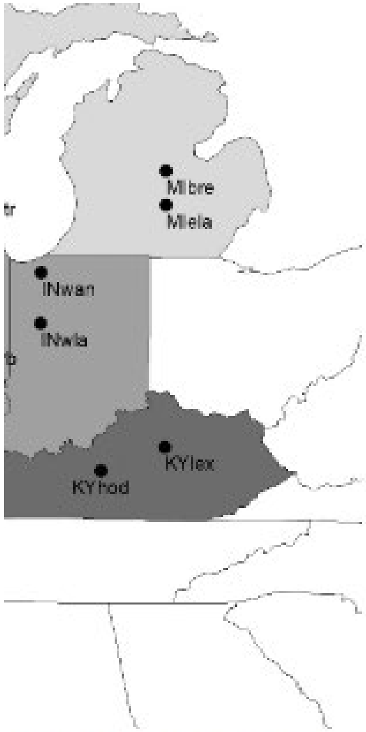
"In each site-year both individual inputs and combination high-input (SOYA) management systems were tested."*

Table 3. Additional marginal costs for inputs over the standard practice for experiments in 2012, 2013, and 2014.

Input†	Additional cost, $ ha^{-1}‡	
	2012	2013, 2014
Fungicide ST	21.61	21.61
Fungicide+Insecticide ST	52.49	52.49
Max ST	59.90	59.90
Defoliant	44.73	44.73
Nitrogen	109.22	109.22
Foliar fertilizer	46.93	46.93
N,N'-diformyl urea	51.38	51.38
Foliar Fungicide	63.92	96.08
Foliar Insecticide	29.66	34.06
Foliar Fungicide+Insecticide	73.83	110.38
SOYA	341.26	377.81
SOYA+D	385.99	422.54
SOYA-N	232.03	268.59
SOYA-FF	277.33	281.73
SOYA-FF and FI	267.43	267.43

† ST, seed treatment; D, defoliant; F, foliar fertilizer; FF, foliar fungicide; FI, foliar insecticide; SOYA, combination high-yield management.

‡ Costs differ between 2012 and 2013, 2014 due to the use of different input products.



considered the South region, while states
sidered the North region.

*Orlowski et al. 2016

A single application of an insecticide paid for itself 37%-93% of the time, fungicide-insecticide seed treatment did 0-29%.

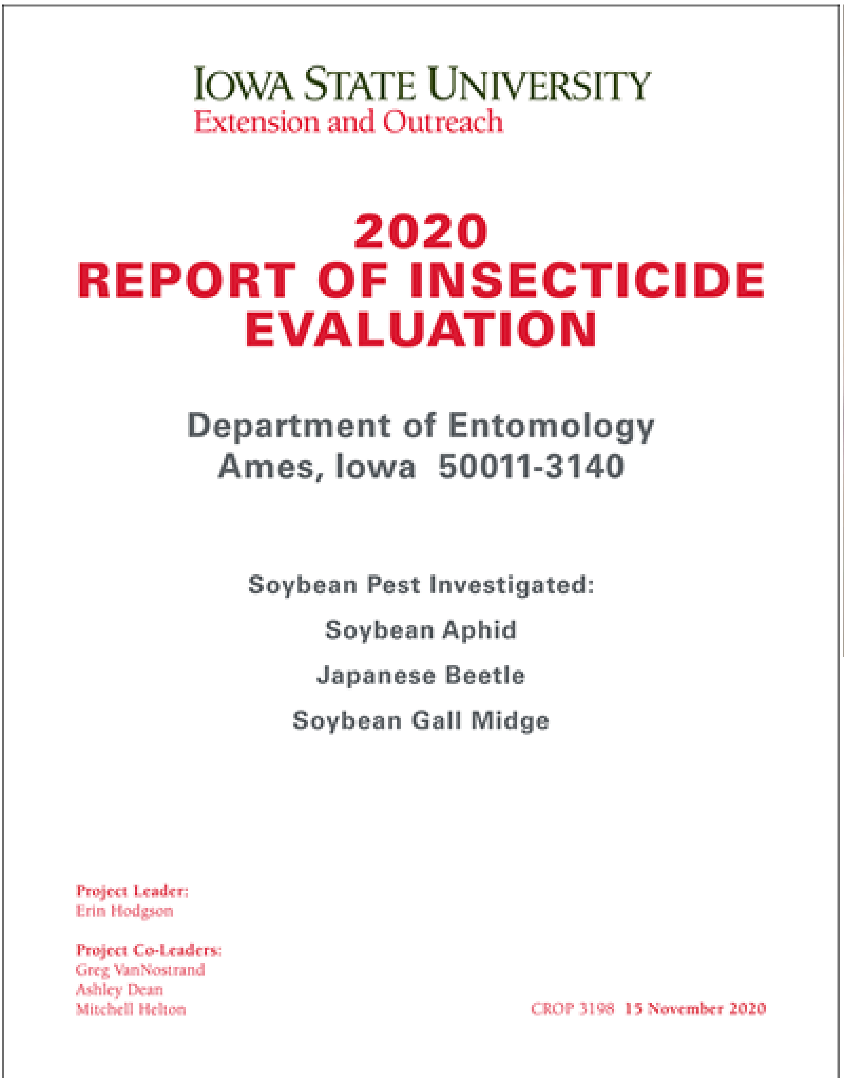
Table 8. Relative yield change and break-even probabilities for inputs compared to the standard practice at multiple yield levels and soybean sale prices across all environments between 2012 and 2014.

		Yield level, Mg ha^{-1}								
		3.0			4.0			5.0		
		Soybean sale price, \$ kg^{-1}								
Input†	RYC‡	0.33	0.44	0.55	0.33	0.44	0.55	0.33	0.44	0.55
	%	% probability of break-even								
Fungicide ST	−0.2	5	11	17	11	18	24	17	24	29
Fungicide+Insecticide ST	0.5	0	0	1	0	2	5	1	5	10
Max ST	1.7	0	2	11	2	15	31	11	31	48
Foliar fertilizer	0.7	0	2	6	2	8	17	6	17	27
Defoliant	−2.5	0	0	0	0	0	0	0	0	1
Nitrogen	1.7	0	0	0	0	0	1	0	1	7
N,N'-diformyl urea	0.5	0	0	2	0	3	8	2	8	15
Foliar fungicide	2.5	0	0	0	0	1	5	0	5	17
Foliar insecticide	2.7	37	64	78	64	81	88	78	88	93
Foliar fungicide+Insecticide	4.9	0	1	13	1	21	59	13	59	85
SOYA	7.4	0	0	0	0	0	0	0	0	0
SOYA+D	4.9	0	0	0	0	0	0	0	0	0
SOYA-N	5.2	0	0	0	0	0	0	0	0	0
SOYA-FF	5.6	0	0	0	0	0	0	0	0	0
SOYA-FF+FI	3.7	0	0	0	0	0	0	0	0	0

† ST, seed treatment; FF, foliar fungicide; FI, foliar insecticide; D, defoliant; SOYA, combination high-yield management.

‡ RYC, relative yield change vs. standard practice.

Insecticide evaluations continue…


IOWA STATE UNIVERSITY
Extension and Outreach

2020
REPORT OF INSECTICIDE EVALUATION

Department of Entomology
Ames, Iowa 50011-3140

Soybean Pest Investigated:

Soybean Aphid

Japanese Beetle

Soybean Gall Midge

Project Leader:
Erin Hodgson

Project Co-Leaders:
Greg VanNostrand
Ashley Dean
Mitchell Helton

CROP 3198 15 November 2020

https://store.extension.iastate.edu/product/16055

Table 1. List of treatments and rates for soybean aphid at the Northwest Research Farm in 2020

Seed treatment only

Seed treatment AND foliar-applied insecticide

	Treatment and Formulation	Group[a]	Active Ingredient(s)[b]	Rate[c]	Timing
	1. Untreated Control	—	—	—	—
	2. Warrior II CS	3A	lambda-cyhalothrin	1.92 fl oz	11 Aug
	3. Sniper EC	3A	bifenthrin	4.0 fl oz	11 Aug
X	4. Cruiser 5FS (A)	4A	thiamethoxam (ST)	0.0756 mg ai/seed	—
X	5. Cruiser 5FS (B)	4A	thiamethoxam (ST)	0.1512 mg ai/seed	—
	6. Transform WG (A)	4C	sulfoxaflor	0.66 oz	11 Aug
	7. Transform WG (B)	4C	sulfoxaflor	0.794 oz	11 Aug
	8. Pyrifluquinazon SC (A)	9B	pyrifluquinazon	0.8 fl oz	11 Aug
	9. Pyrifluquinazon SC (B)	9B	pyrifluquinazon	1.2 fl oz	11 Aug
	10. Pyrifluquinazon SC (C)	9B	pyrifluquinazon	1.6 fl oz	11 Aug
	11. Sefina DC	9D	afidopyropen	3.0 fl oz	11 Aug
X	12. Cruiser 5FS and Warrior II CS (A)	4A 3A	thiamethoxam (ST) lambda-cyhalothrin	0.0756 mg ai/seed 1.92 fl oz	— 11 Aug
X	13. Cruiser 5FS and Warrior II CS (B)	4A 3A	thiamethoxam (ST)lambda-cyhalothrin	0.1512 mg ai/seed 1.92 fl oz	— 11 Aug
X	14. Leverage 360 SC	4A + 3A	imidacloprid + beta-cyfluthrin	2.8 fl oz	11 Aug
X	15. Endigo ZCX (A)	3A + 4A	lambda-cyhalothrin + thiamethoxam	3.5 fl oz	11 Aug
X	16. Endigo ZCX (B)	3A + 4A	lambda-cyhalothrin + thiamethoxam	4.5 fl oz	11 Aug
X	17. CruiserMaxx Vibrance + Saltro FS	4A + 7[d]	thiamethoxam + pydiflumetofen (ST)	0.1695 mg ai/seed	—
X	18. CruiserMaxx Vibrance FS + Saltro FS and Warrior II CS	4A + 7[d] 3A	thiamethoxam + pydiflumetofen (ST) lambda-cyhalothrin	0.1695 mg ai/seed 1.92 fl oz	— 11 Aug

Aphid populations in 2020 were low.

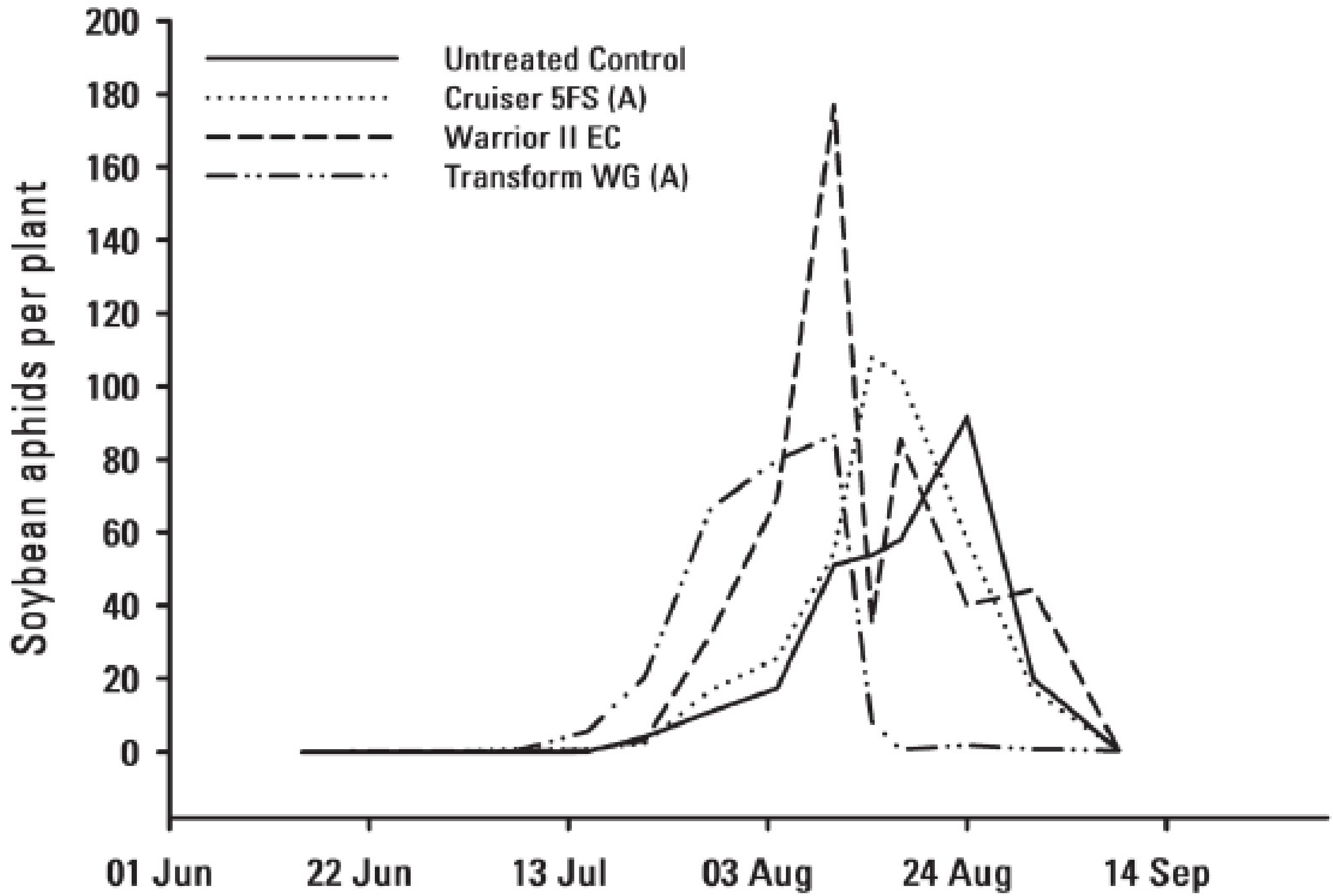
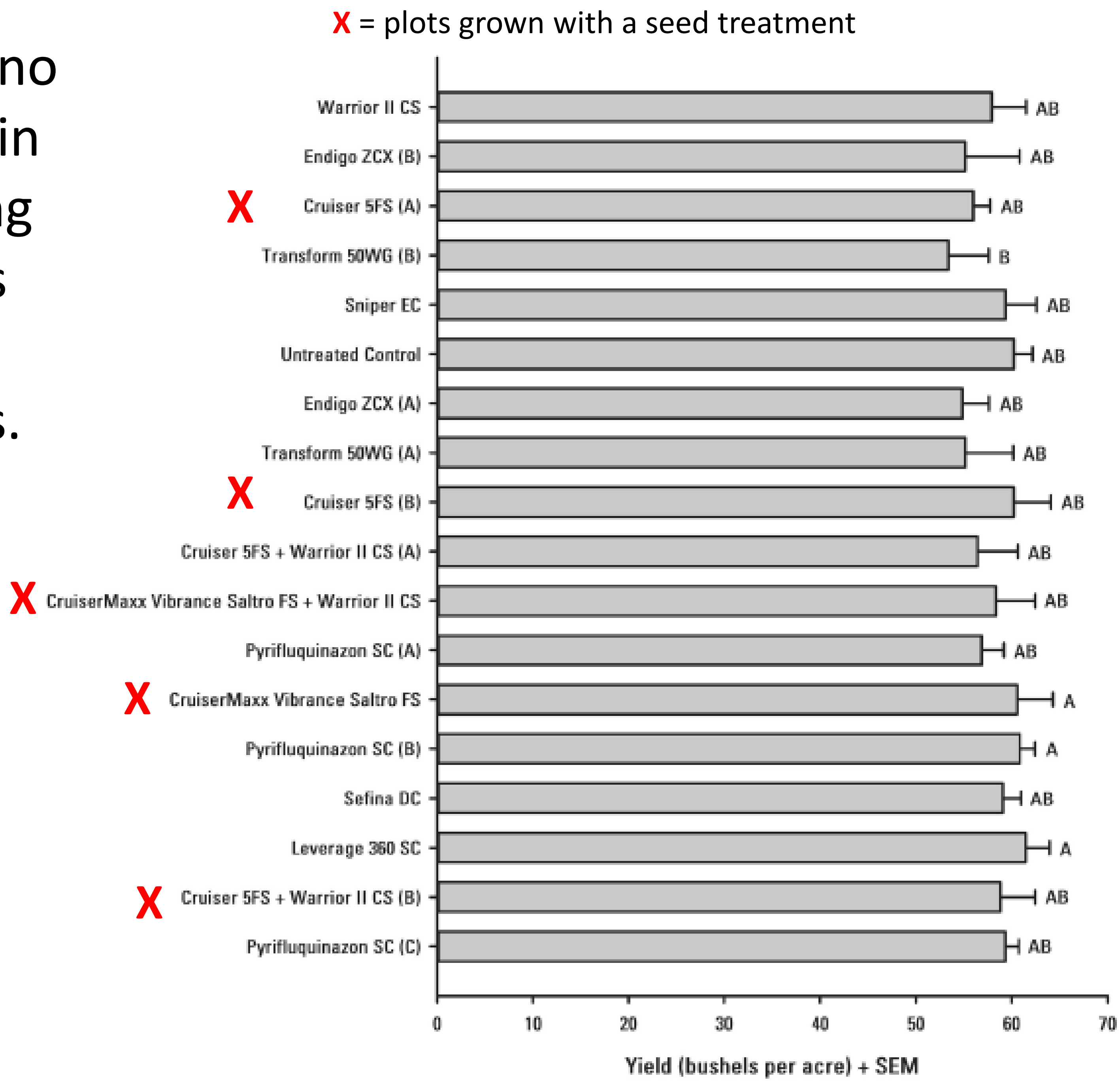


Figure 1. Mean number of aphids per plant in 2020 at the Northwest Research Farm.

Limited to no difference in yield among the various insecticide treatments.



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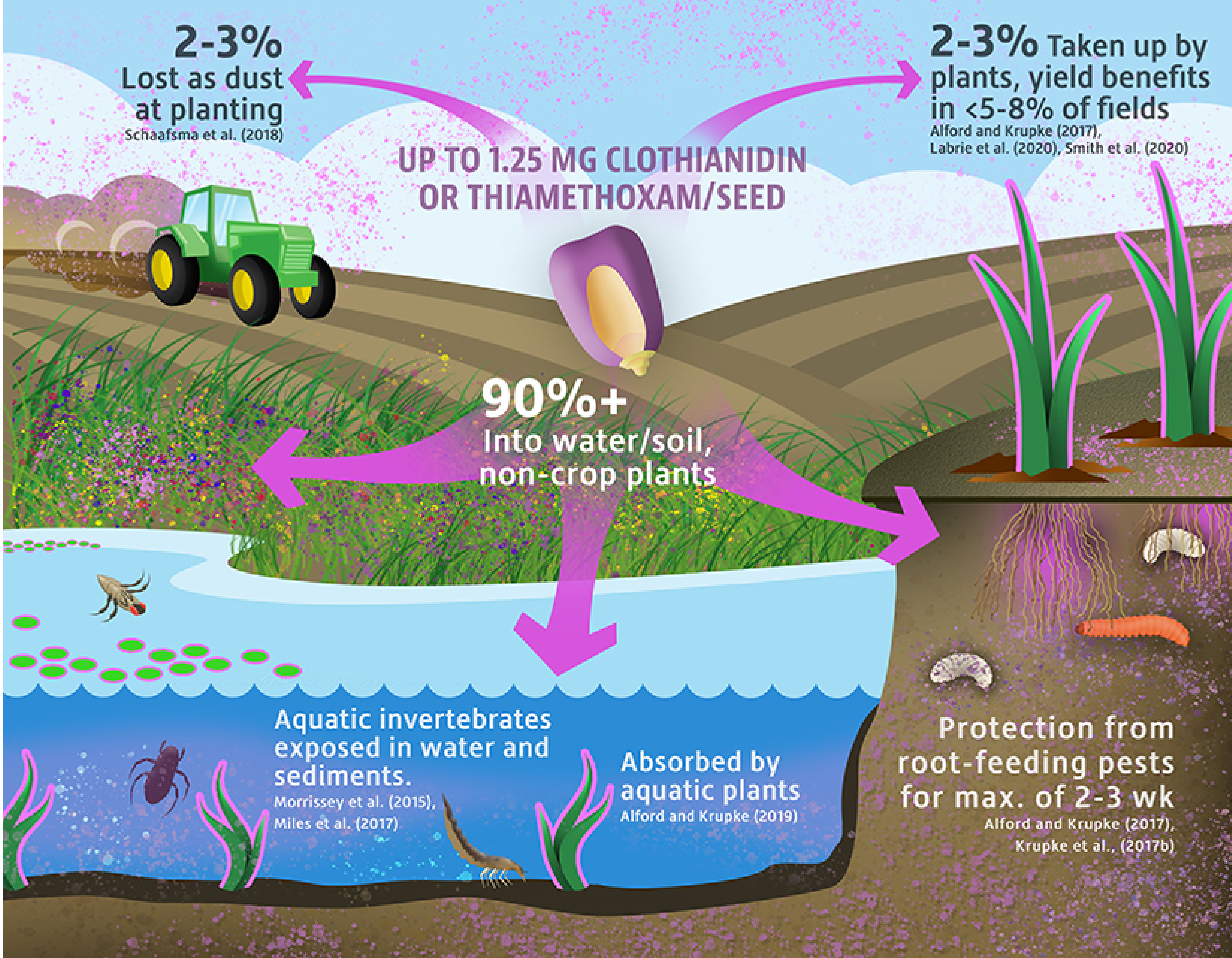
2-3%
Lost as dust at planting
Schaafsma et al. (2018)
2-3% Taken up by plants, yield benefits in <5-8% of fields
Alford and Krupke (2017), Labrie et al. (2020), Smith et al. (2020)
UP TO 1.25 MG CLOTHIANIDIN OR THIAMETHOXAM/SEED
90%+
Into water/soil, non-crop plants
Aquatic invertebrates exposed in water and sediments.
Morrissey et al. (2015), Miles et al. (2017)
Absorbed by aquatic plants
Alford and Krupke (2019)
Protection from root-feeding pests for max. of 2-3 wk
Alford and Krupke (2017), Krupke et al., (2017b)

On-going research at ISU: do neonics accumulate within prairie strips.

Looking for clothianidin, imidacloprid, and thiamethoxam in soil, leaf and bees.