The Good, The Bad, And The Ugly of Pesticide Pre-Mixtures

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UNIVERSITY OF MINNESOTA EXTENSION NDSU EXTENSION

Outline

- General comments
- Specific examples of concern
  - Fungicide seed treatments
  - Insecticides
  - Herbicides
- Summary/conclusions
- Questions

General Comments

The Good of pesticide pre-mixtures

- Broader spectrum of pest species controlled.
- Pesticide resistance management (if ≥2 sites of action).
- Reduced quantities of packaging materials.
- Reduces size of pesticide storage area.
- Easier to use, especially if just single use-rate.
- Can allow for synergistic efficacy.

The Good of pesticide pre-mixtures

- Saves time loading sprayer with the fewer containers.
- Allows incompatible pesticides to be in a single container.
- Control the active ingredients and rates for a product.
- Pre-mixtures usually cost less than tank-mixing.
- Allows for specific adjuvants to be included in pre-mixture.
- Allows creation of new patented product.

The Bad of pesticide pre-mixtures

- Financial gain by manufacturer to include active ingredients with limited efficacy.
- Not always having correct rate of each active ingredient in pre-mixture to control some pest species.
- Allows users to become complacent about what active ingredients are included in pre-mixture.
  - Marshal McGlamery quote "Can 'em and Confuse 'em"

The Bad of pesticide pre-mixtures

- Adding a different active ingredient to pre-mixture may cause compatibility issues.
- Advertisements for pre-mixture trade names say little to nothing about what active ingredients and rates are in the pre-mixture.
- Using the highest rate of a pre-mixture may preclude the use of one of those active ingredients in a second application.

The Ugly of pesticide pre-mixtures

- Multiple and/or cross-resistant pests.
- Antagonism from the active ingredients in the pre-mixture.
- Complacency of farmers not knowing what active ingredients and concentrations are in pre-mixtures.

Fungicide Seed Treatments

LumiGEN
Seed Treatments

PREMIUM Seed Treatment Package

PEST/DISEASE CONTROL	TREATMENT	ACTIVE INGREDIENT
Phytophthora Pythium Fusarium Rhizoctonia Phomopsis Early Season Aphid Seedcorn Maggot Wireworm Bean Leaf Beetle	**LumiTreo™** + **Lumiante®** + **Sebring®** + **L-2030 G** + **Phalanx™**	Oxathiapiprolin, Ipconazole, Picoxystrobin Ethaboxam Metalaxyl Bacillus subtilis and Bacillius Pumilus Thiamethoxam

Active ingredients and effective rates to control phytophthora root and stem rot

from Crop Protection Network

Active ingredient(s)	Example trade name (recommended rates)[1]	Effective application rates	Active ingredient per seed (mg)	FRAC code
Mefenoxam	Apron XL (0.64 fl oz/100lb seed)	6.75 g ai/CWT	0.024	4
Metalaxyl	AllegianceFL (0.75-1.5 fl oz/100lb seed)	6.80-13.61 g ai/CWT	0.024-0.049	4
Ethaboxam	Intego (2.11 fl oz/100lb seed)/Intego Suite(3.37 fl oz/100lb seed)	3.36 g ai/CWT	0.012	22
Oxathiapiprolin	Lumisena (0.56-1.12 fl oz/100lb seed)	3.36-6.72 g ai/CWT	0.012-0.024	49
Picarbutrazox	Vayantis	0.42-2.1 g ai/CWT	0.0015-0.0075	U17

Questions

- What rate of Lumiante is in LumiGen Seed Treatments?
  - 0.2 fl oz/100 lbs seed or 0.3 fl oz/100 lbs seed or some rate in between?
  - Is either product rate at the effective dose of ethaboxam for maximum control of phytophthora root and stem rot?
    - 0.2 fl oz/100 lbs seed = 2.27 g ai/100 lbs seed
    - 0.3 fl oz/100 lbs seed = 3.4 g ai/100 lbs seed
    - Effective rate is 3.36 g ai/100 lbs seed
  - Which Sebring product and rate is used?
    - Sebring 318 FS (2.65 lbs metalaxyl/gal) at 0.75 to 1.5 fl oz/100 lbs seed?
    - Sebring 480 FS (4.0 lbs metalaxyl/gal) at 0.5 to 1.0 fl oz/100 lbs seed?
    - Both meet the 6.8 to 13.61 g ai/100 lbs seed rate

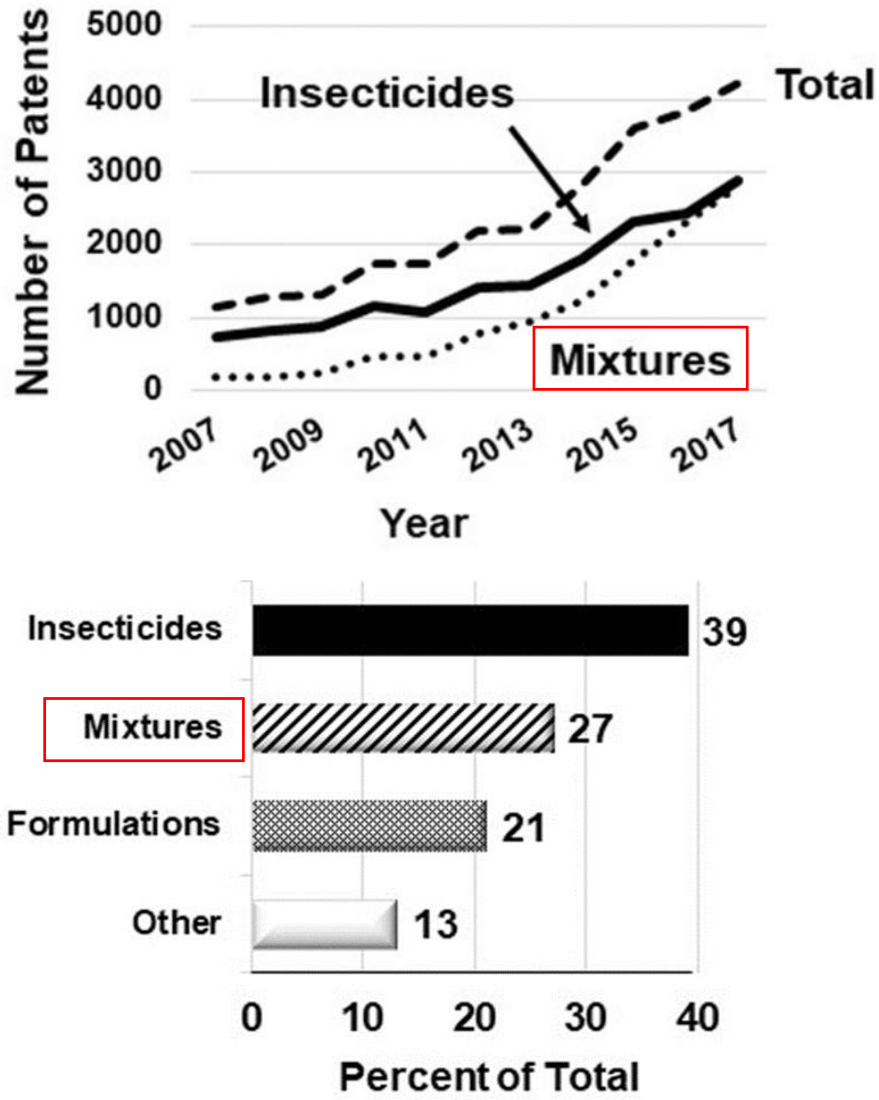
Insecticides

Insecticide mixtures: the good

Good

Intellectual property & marketing

- Industry perspective…
  - Maintain patent coverage
  - Create proprietary product from generics
  - Create new product without new AIs



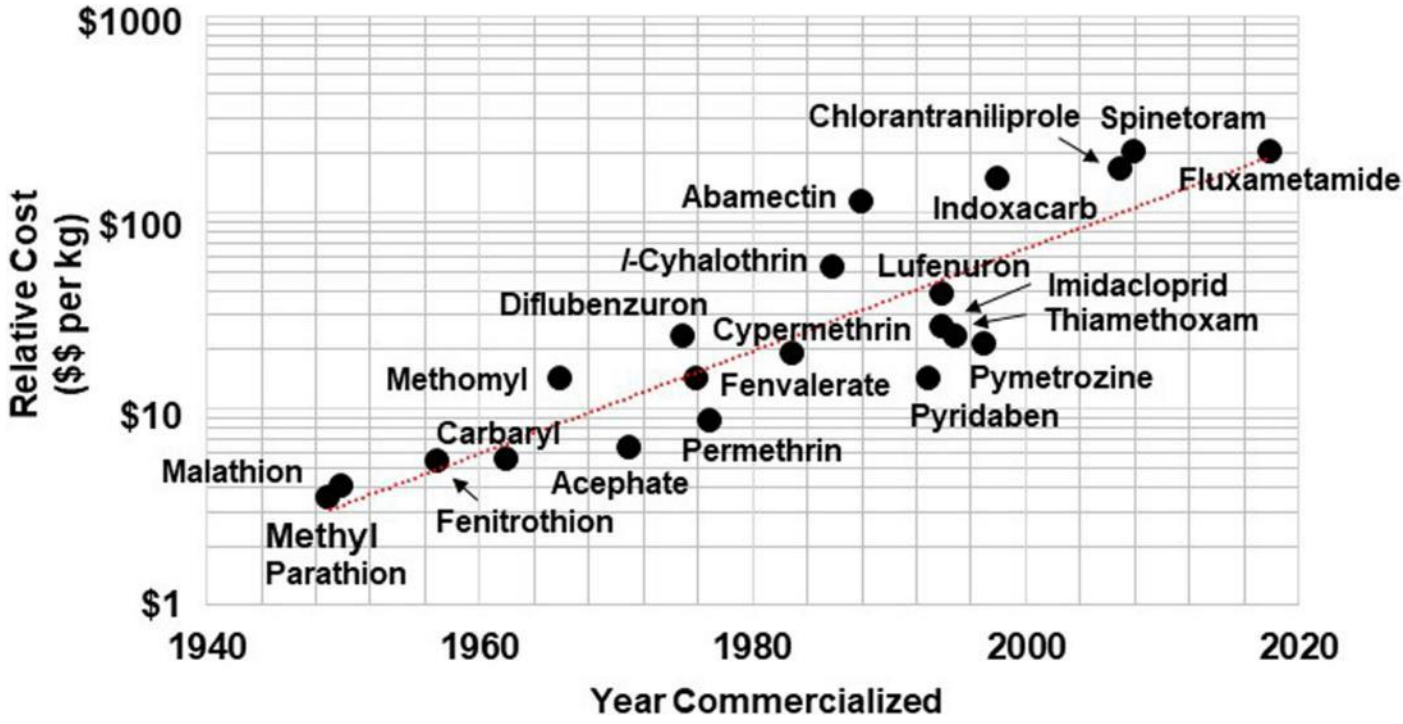
Sparks 2024

Good

Reduce costs of new AIs

- Industry perspective…
  - Newer insecticides are generally more expensive
  - Existing cheaper AI + Reduced rate of newer expensive AI

- Concern: Reduced rates promote development of resistance



Sparks 2024

Reduced rates?

	Sefina	Renestra
Soybean aphid rate	3.0 fl oz/ac = 0.0234 gal/ac	6.8 fl oz/ac = 0.0531 gal/ac
Afidopyropen	0.42 lb ai/gallon 0.0098 lb ai/ac	0.17 lb ai/gallon 0.0090 lb ai/ac

0.0090 / 0.0098 =
91.8%

Reduced rates?

	Transform	Ridgeback
Soybean aphid rate	0.75-1.0 oz/ac	6.9-13.8 fl oz/ac
Sulfoxaflor	0.023-0.031 lb ai/ac	0.017-0.033 lb ai/ac

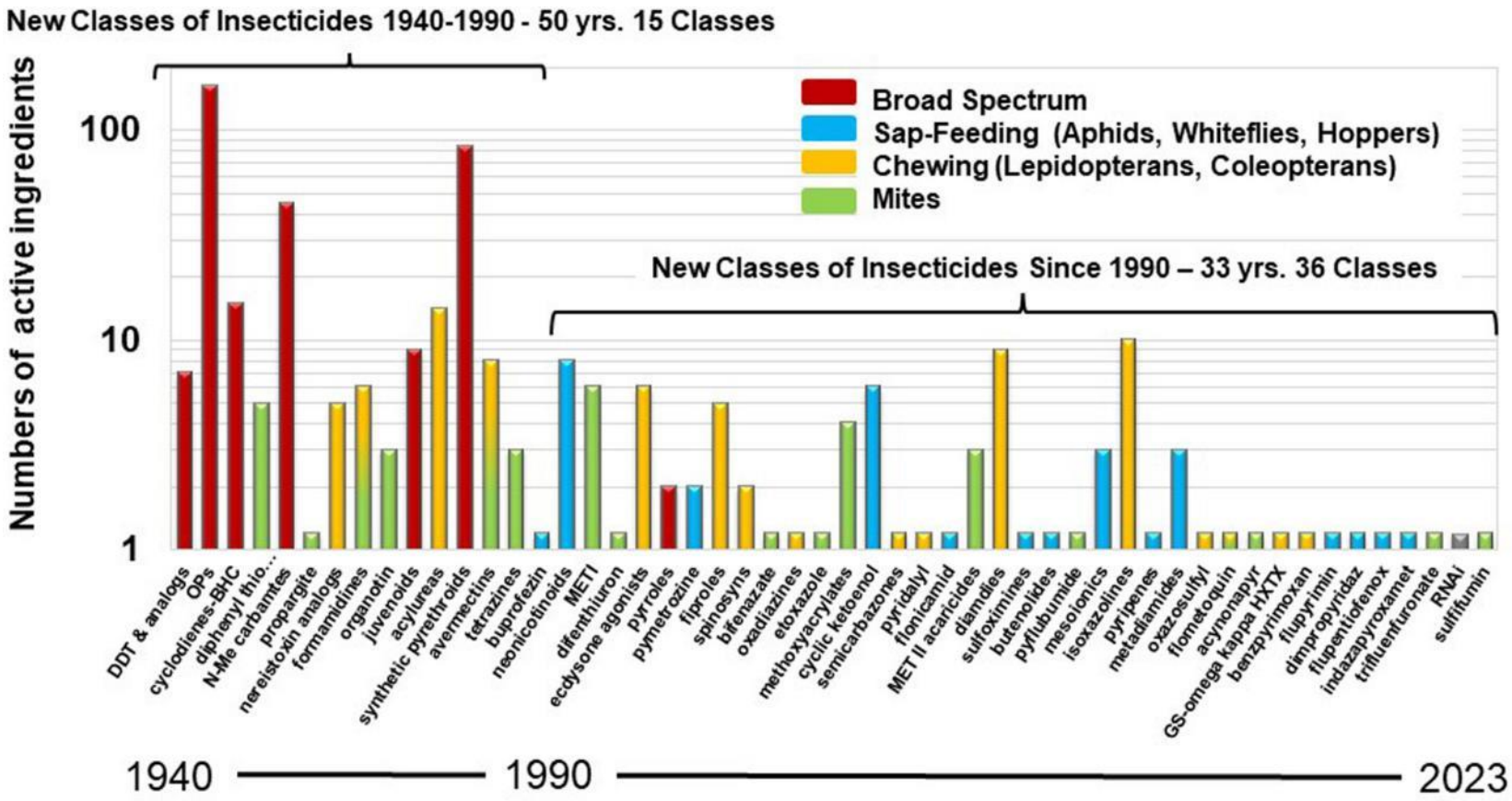
	Transform	Ridgeback
Resistant soybean aphid rate	0.75-1.0 oz/ac	>10.3 fl oz/ac
Sulfoxaflor	0.023-0.031 lb ai/ac	>0.025 lb ai/ac

Largely overlapping ranges

Good

Increase pest spectrum

- Newer insecticides are more specific



- Concern: Fit with IPM?
  - sub-economic pests
  - natural enemies
  - environment

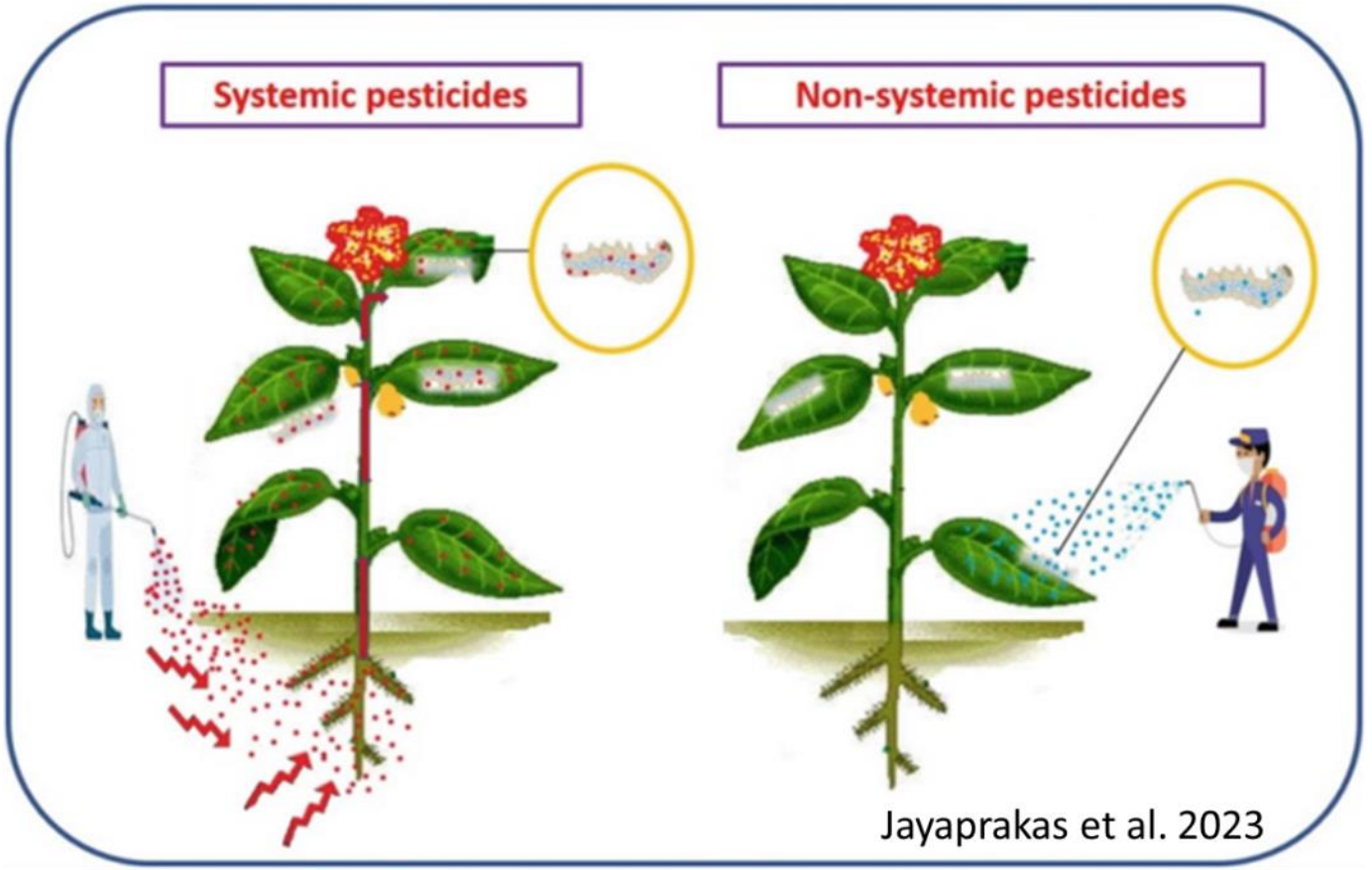
Sparks 2024

Good

Combine technical characteristics

- Improve control
  - Contact + Systemic
- Extend apparent residual control
  - Fast acting + Slow acting

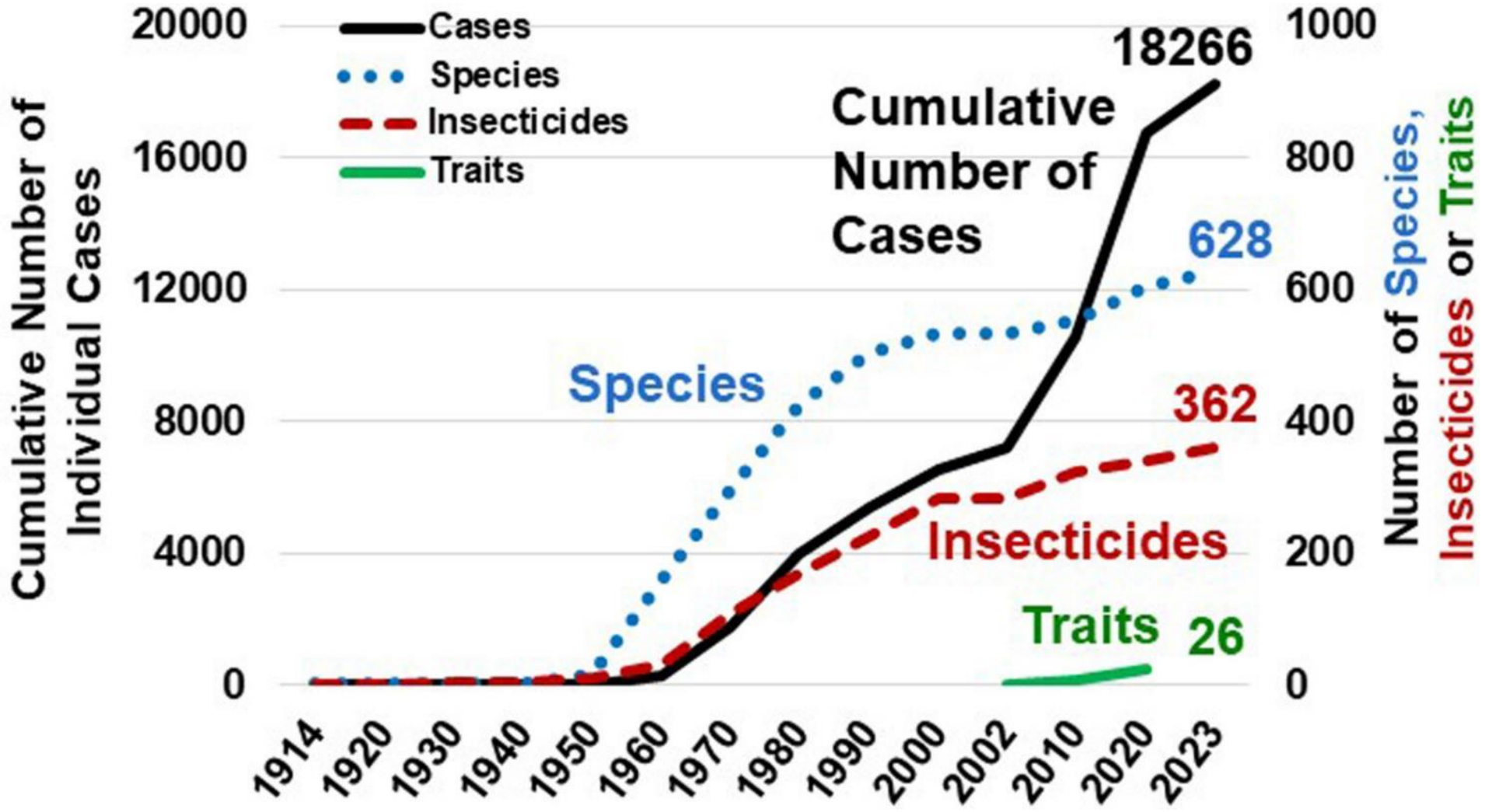
- Concern: Fit with IRM?
  - Differing residual activity



Good

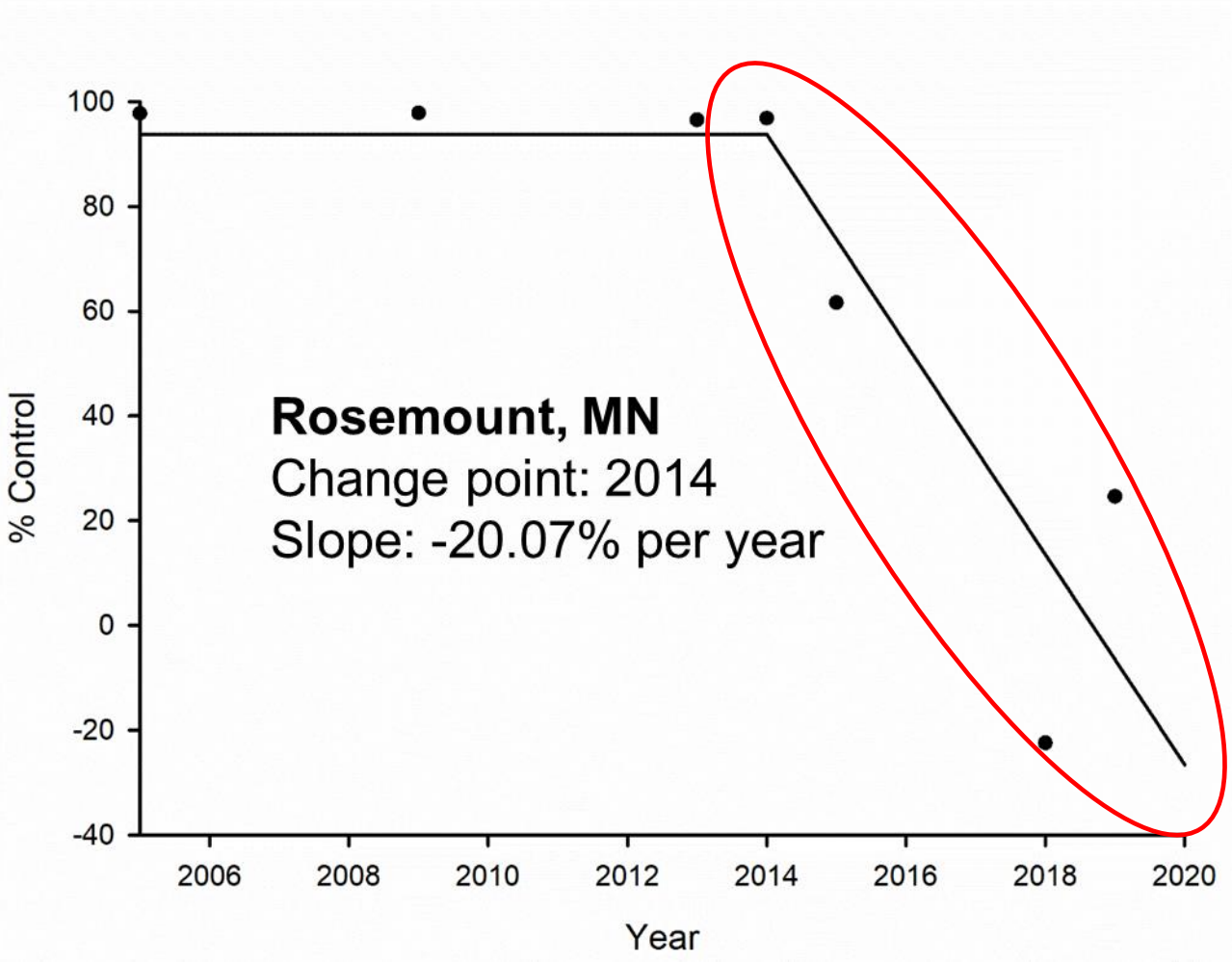
Insecticide resistance management (IRM)

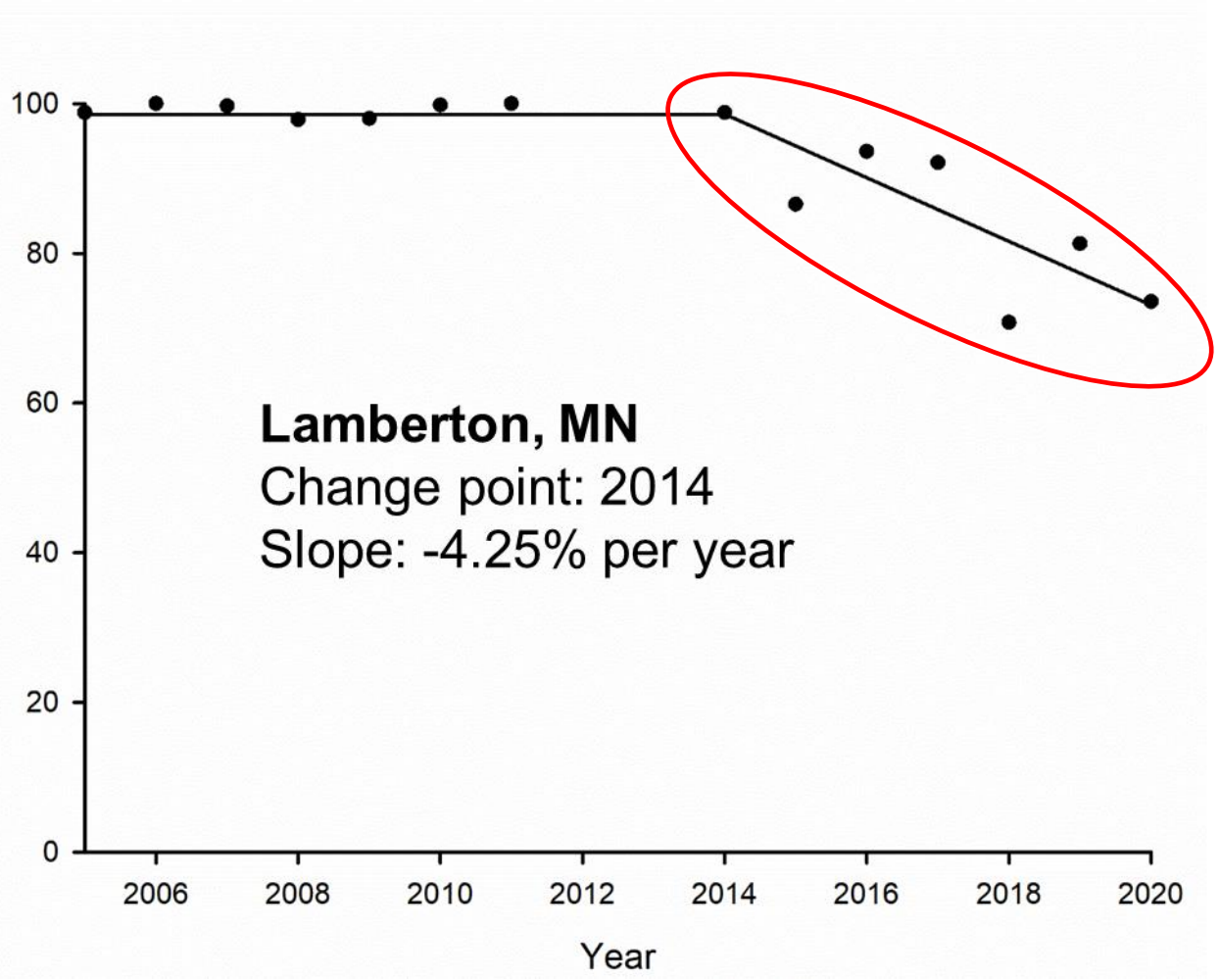
Insecticide resistance



Sparks 2024

Example: soybean aphid & pyrethroids





Menger et al. 2022

Good

IRM considerations

- AIs requiring different resistance mechanisms
  - Different MoA for target-site resistance
  - Metabolic resistance challenging to predict

Good

IRM considerations

- AIs requiring different resistance mechanisms
- No (or very limited) resistance of pest to any of the AIs
  - Redundant kill

Good

IRM considerations

- AIs requiring different resistance mechanisms
- No (or very limited) resistance of pest to any of the AIs
- Similar rates of decay (residual activity) for AIs
  - Prevent selection by only one component

Good

IRM considerations

- AIs requiring different resistance mechanisms
- No (or very limited) resistance of pest to any of the AIs
- Similar rates of decay (residual activity) for AIs
- Similar toxicities at application rates for AIs

Good

IRM considerations

- AIs requiring different resistance mechanisms
- No (or very limited) resistance of pest to any of the AIs
- Similar rates of decay (residual activity) for AIs
- Similar toxicities at application rates for AIs
- Pest biology
  - Mixtures better for sexually reproducing insects (beetles & caterpillars)
  - Mixtures less beneficial for asexually reproducing insects (aphids)

IRAC 2023, Sparks 2024

Insecticide mixtures: the bad

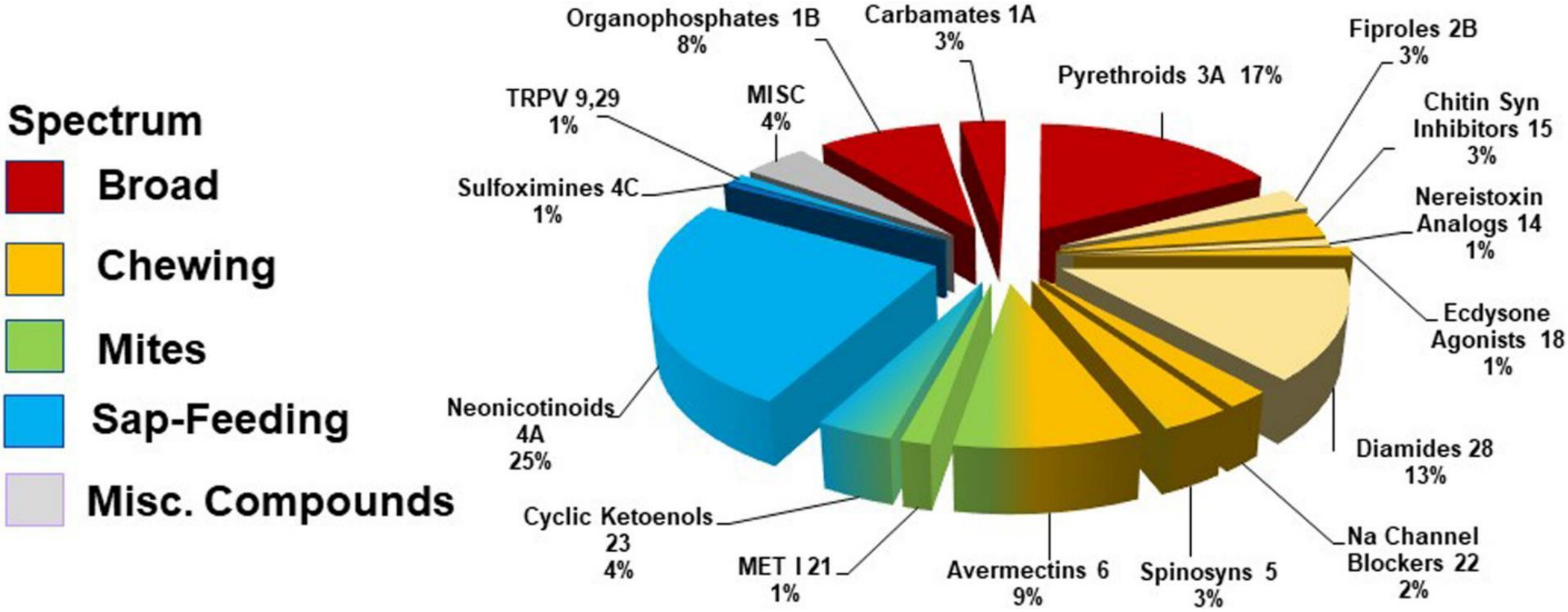
Bad

Negate benefits of selectivity

- Sub-economic pests don’t need control
- Usually only one significant pest in soybean at a time
  - **aphids**
  - caterpillars/beetles
  - mites

Bad

Negate benefits of selectivity



Sparks 2024

Bad

Negate benefits of selectivity

- Toxicity to natural enemies
  - Predators
  - Parasitoids
- Environmental impacts

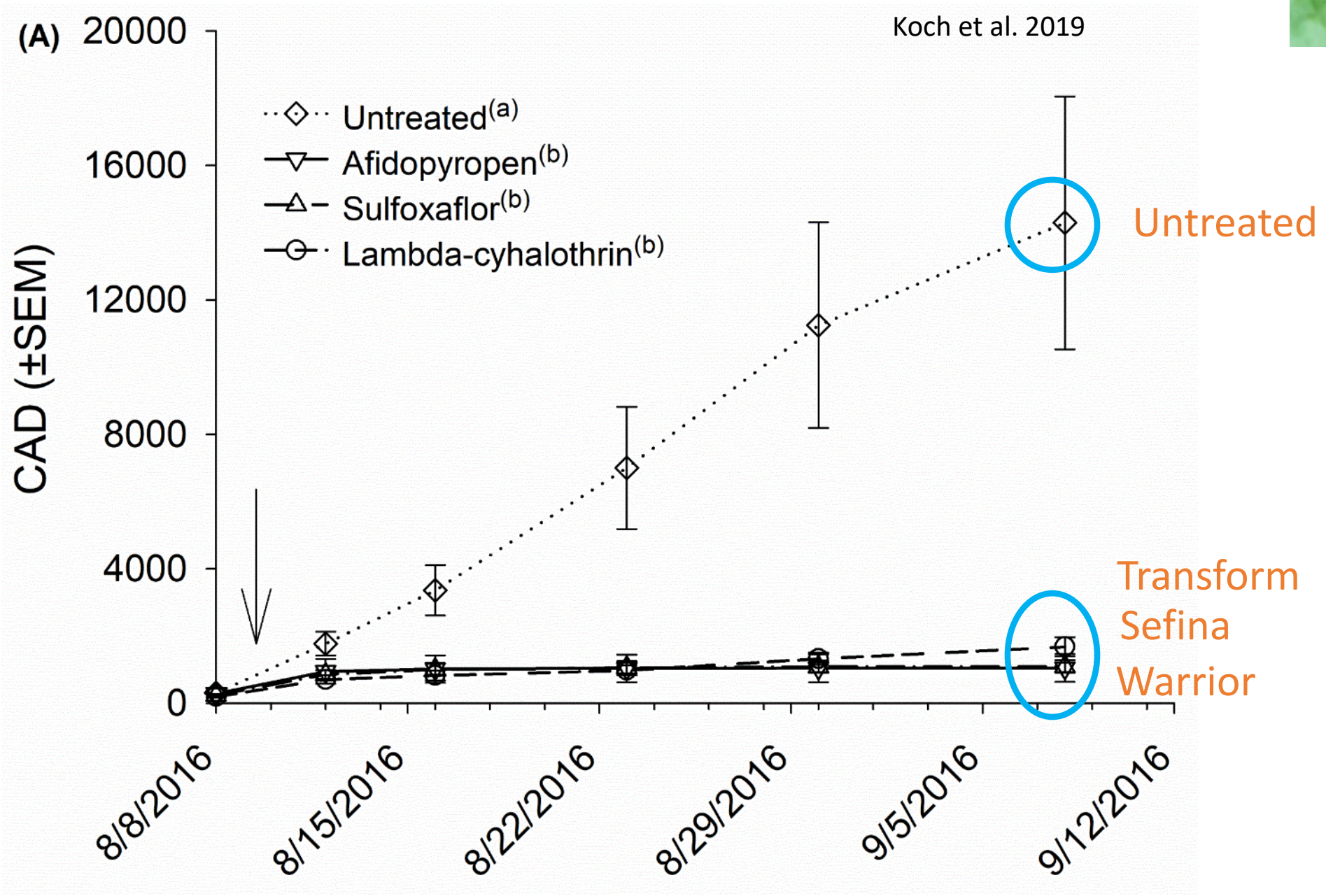
Fewer options for rotation

Bad

-- toolbox for soybean aphid is already small

1A: Carbamates 1B: Organophosphates
3A: Pyrethroids
4A: Neonicotinoids 4C: Sulfoxamines 4D: Butenolides
9A: Pyropenes

Efficacy: Lamberton, MN - 2016

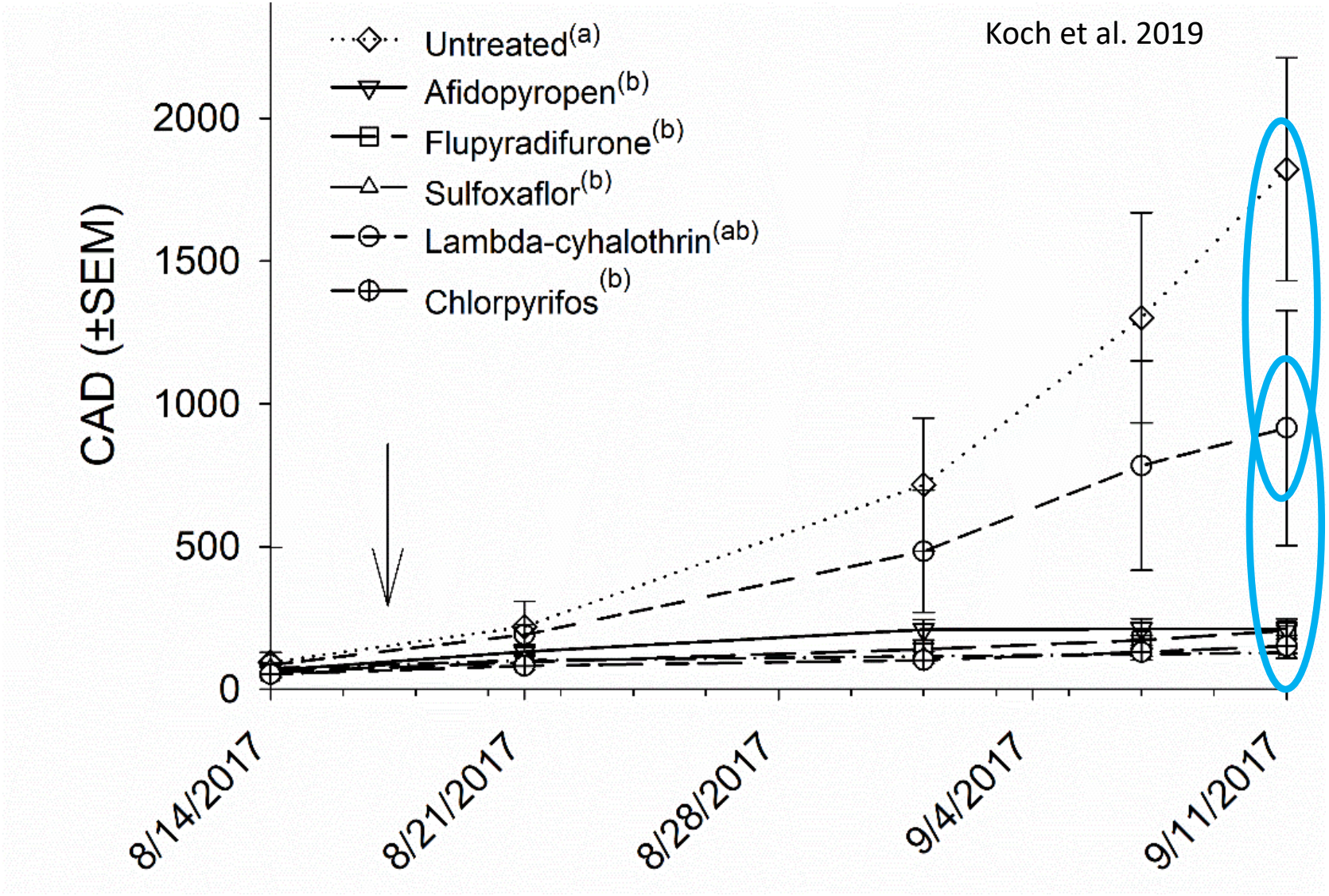


Koch et al. 2019

Untreated

Transform
Sefina
Warrior

Efficacy: Nashua, IA - 2017

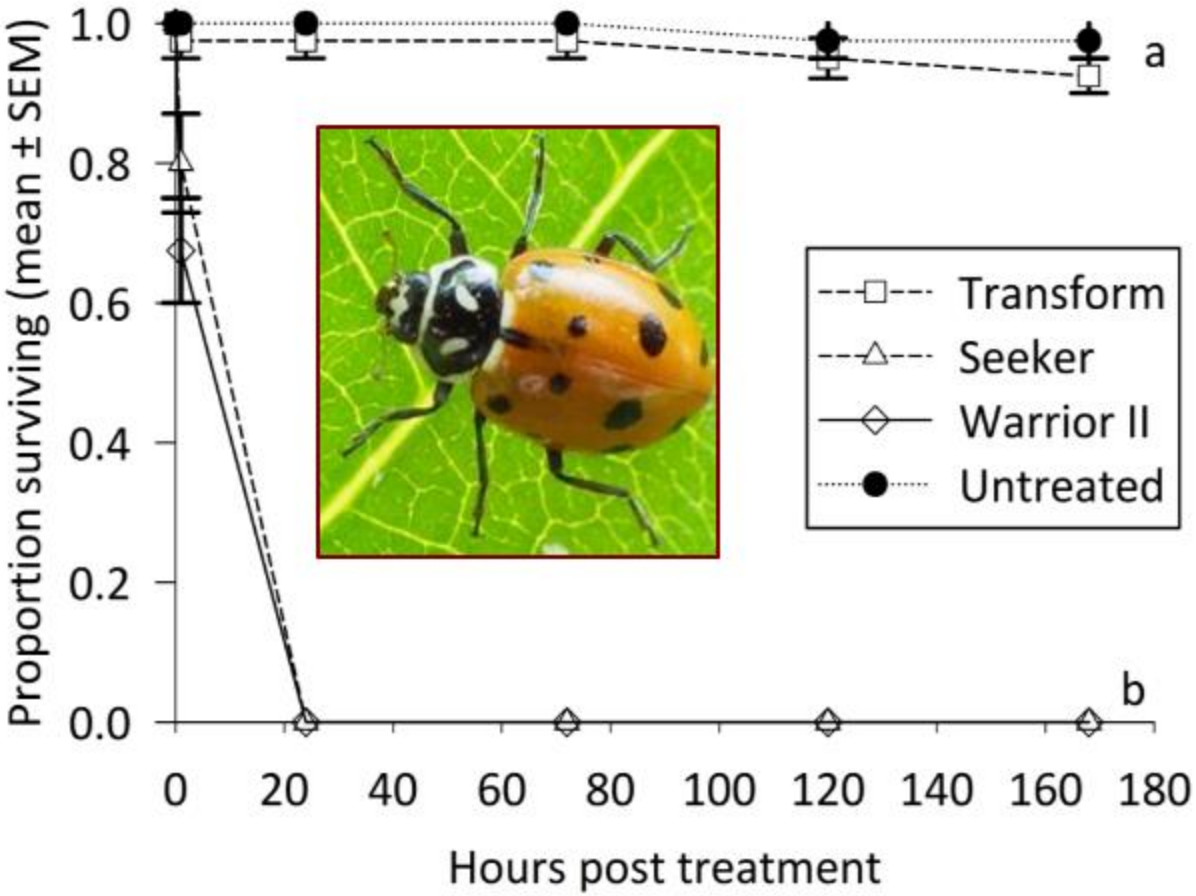


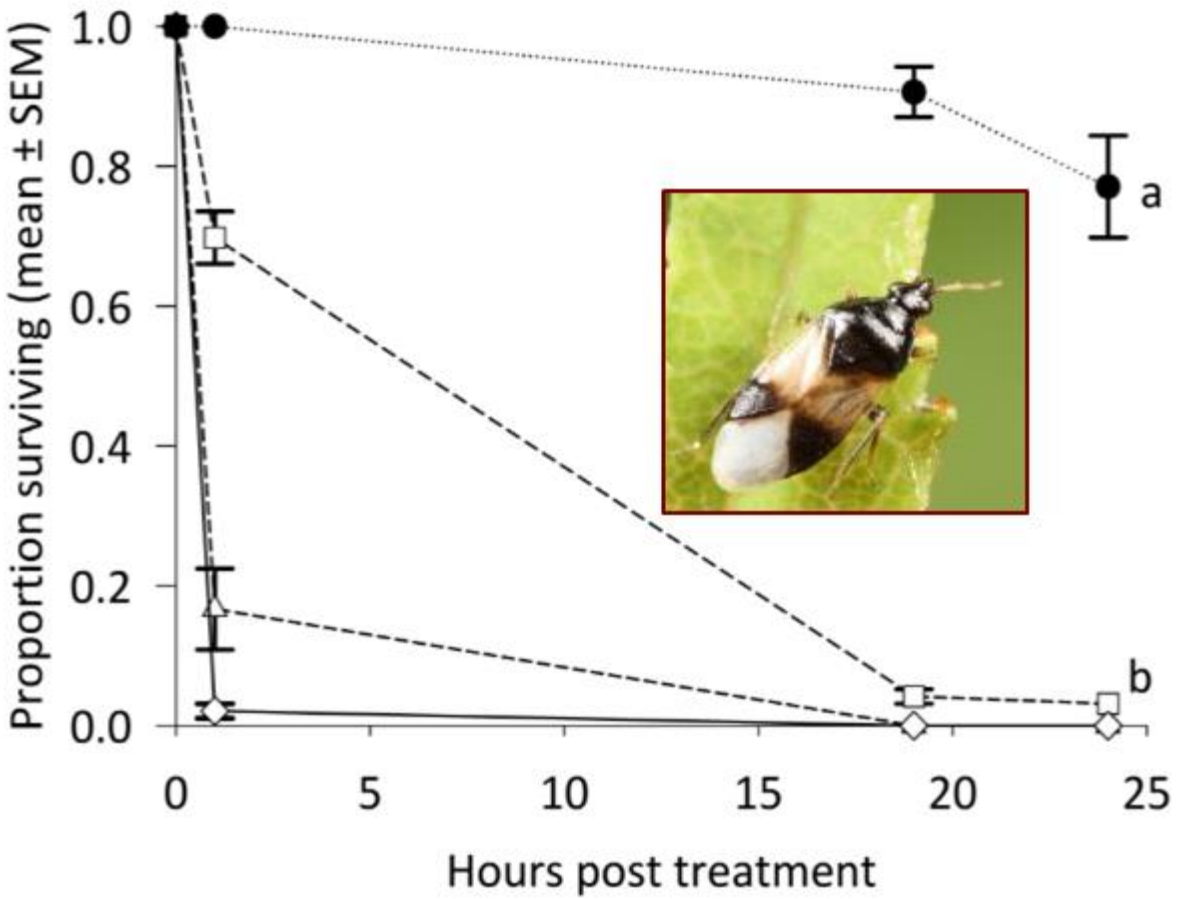
Untreated

Warrior

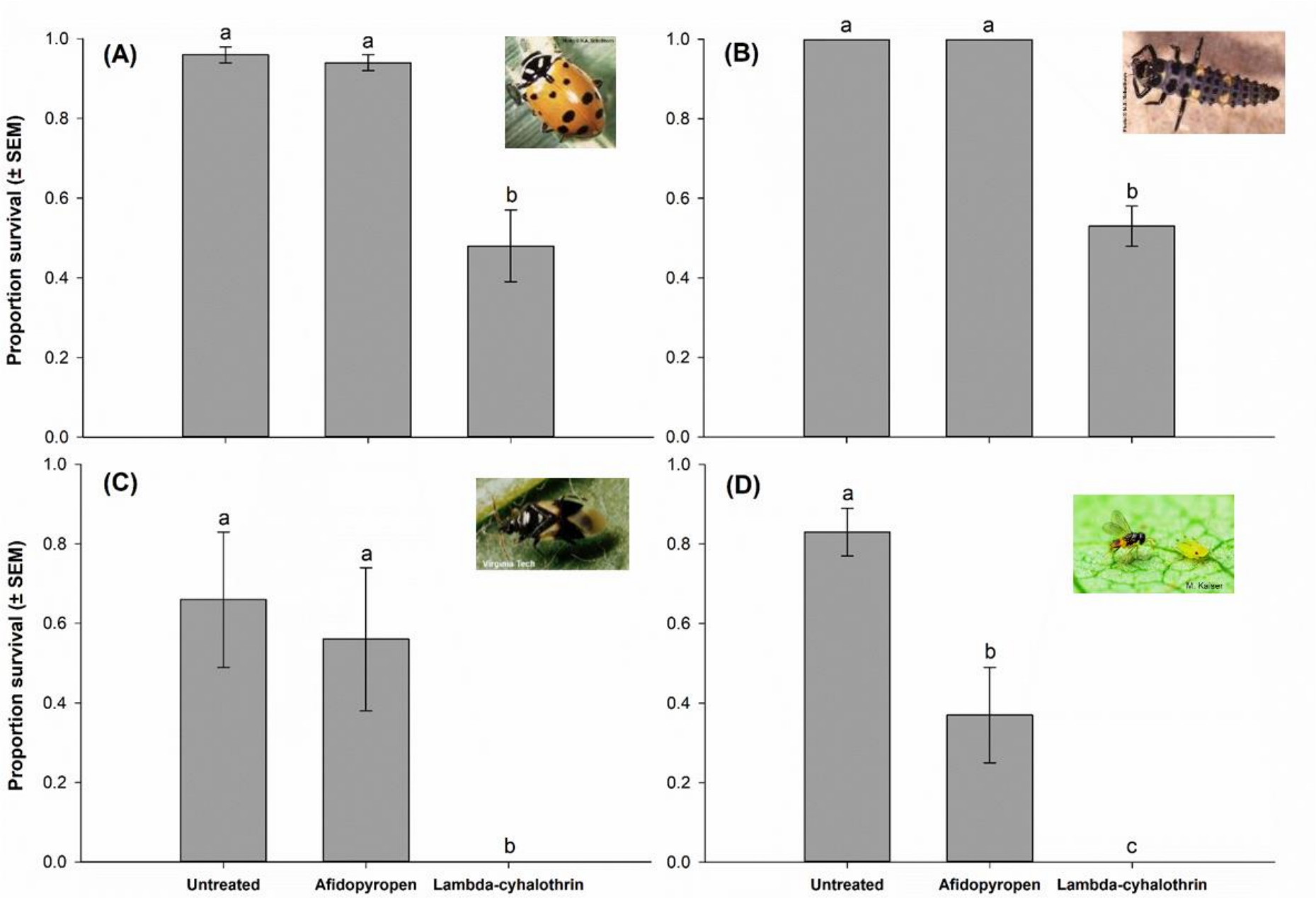
Sefina
Sivanto
Transform
Lorsban

Selectivity of sulfoxaflor





Selectivity of afidopyropen



Insecticide mixtures: the ugly

Mixtures for soybean aphid

IRAC Mode-of-Action Group #	Group	Active Ingredient	Premix (Trade Names)
28	Diamides	chlorantraniliprole	Besiege
3A	Pyrethroids	lambda-cyhalothrin	
28	Diamides	chlorantraniliprole	Elevest
3A	Pyrethroids	bifenthrin	
3A	Pyrethroids	bifenthrin	Hero
3A	Pyrethroids	zeta-cypermethrin	
3A	Pyrethroids	beta-cyfluthrin	Leverage 360
4A	Neonicotinoids	imidacloprid	
3A	Pyrethroids	bifenthrin	Brigadier
4A	Neonicotinoids	imidacloprid	
3A	Pyrethroids	bifenthrin	Skyraider, Swagger
4A	Neonicotinoids	imidacloprid	
3A	Pyrethroids	lambda-cyhalothrin	Endigo ZC
4A	Neonicotinoids	thiamethoxam	
3A	Pyrethroids	bifenthrin	Ridgeback
4C	Sulfoximines	sulfoxaflor	

Rosemount, 2018

Application: 8/17 (R5); 181 aphids/plant

Ugly

		8/23	8/30
Group	**Treatment**	**7 DAT**	**14 DAT**
-	Untreated Check	453 a	83 a
3A	Warrior II (1.6 oz)	246 b	102 a
3A+4A	Endigo ZC (4 oz)	39 c	43 ab
4D	Sivanto Prime (14 oz)	43 c	11 b
9D	Sefina (3 oz)	80 c	3 b
3A+4A	Argyle OD (5 oz)	6 c	2 b
3A+4A	Argyle OD (8 oz)	0.7 c	0.9 b
	P-value	<0.0001	<0.0001

da Silva Queiroz et al. 2019

Rosemount, 2019

Application: 8/22 (R5); 407 aphids/plant

Ugly

		8/28	9/5
Group	**Products**	**6 DAT**	**14 DAT**
-	Untreated Check	544 a	634 a
3A	Warrior II (1.6 oz)	294 ab	478 ab
3A+4A	Endigo ZC (4 oz)	57 bc	96 bc
3A+4A	Endigo ZCX (3.5 oz)	47 bcd	86 bc
3A+4A	Endigo ZCX (4.5 oz)	16 cd	27 cd
3A+4A	Argyle OD (5 oz)	16 cd	15 d
3A+4A	Argyle OD (6 oz)	12 d	8 d
9D	Sefina (3 oz)	49 bcd	13 d
	***P*-value**	<0.0001	<0.0001

Aita et al. 2019

Rosemount, 2024

Application: 8/19 (R5); 624 aphids/plant

Very Ugly

		8/27	9/3
Group	**Products**	**8 DAT**	**15 DAT**
-	Untreated Check	537 a	83 b
3A+4A	Leverage 360 (2.8 oz)	325 a	222 a
4D	Sivanto Prime (7 oz)	88 c	30 c
29	IKI-220 (1.43 oz)	47 c	12 d
29	IKI-220 (1.14 oz)	17 c	11 d
9D	Sefina (3 oz)	46 c	2 e
	P-value	<0.0001	<0.0001

2.7x higher

Koch & Ribeiro 2025

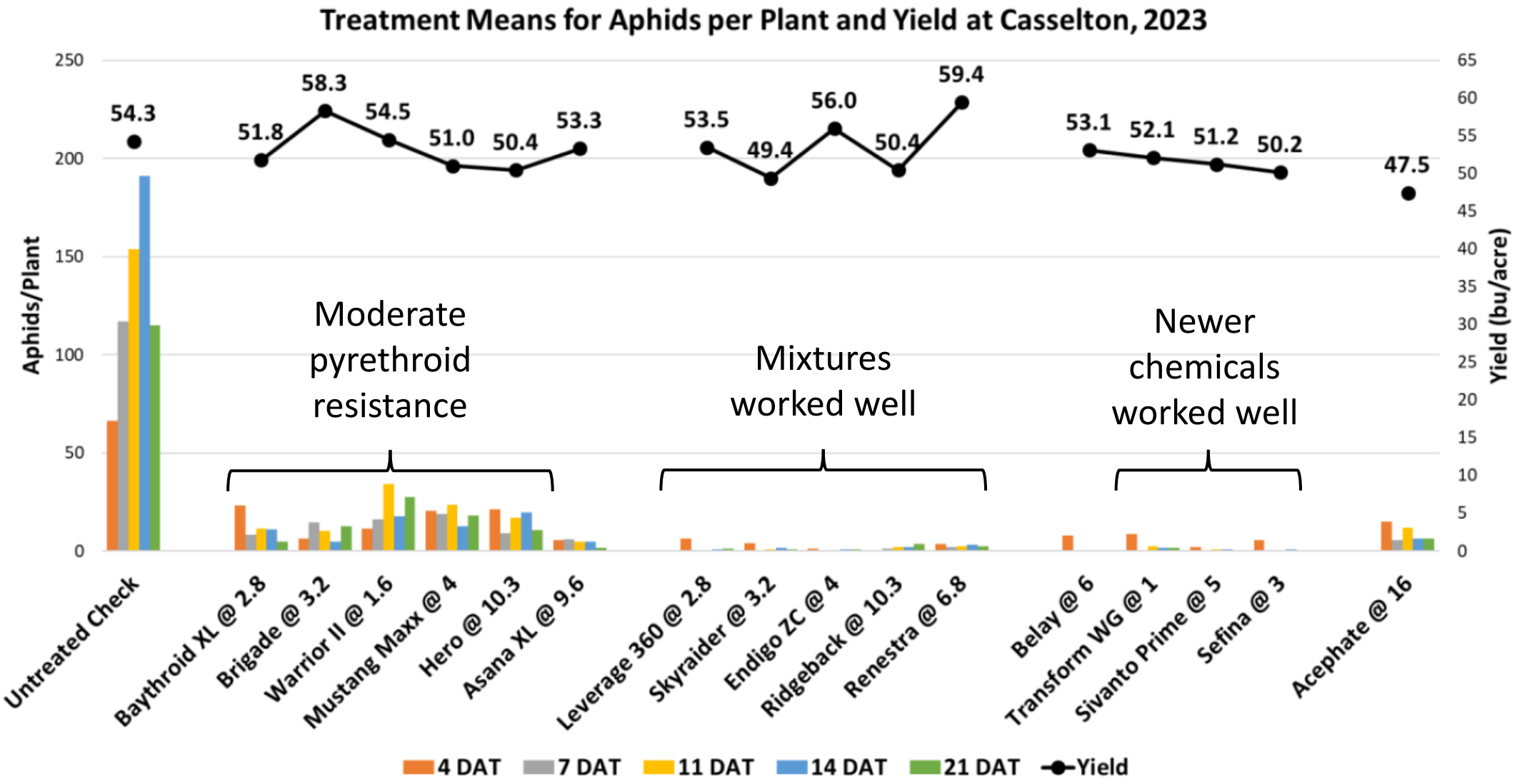
North Dakota State University

CROP & PEST REPORT

NDSU EXTENSION

Janet Knodel &
Patrick Beauzay

July 25, 2024



Resources on insecticide mixtures

Perspective

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(wileyonlinelibrary.com) DOI 10.1002/ps.7980

Insecticide mixtures—uses, benefits and considerations

Thomas C Sparks*

Abstract

Insecticides remain an important tool for the control of many insect pests. There has long been an interest in insecticide mixtures (in-can and tank-mix) as a means to provide the needed efficacy and/or spectrum to control many insect public health, crop pests or crop pest complexes. This aspect has become more important since insecticides developed in the last 30 years tend to be narrower in spectrum with many primarily focused on either sap-feeding or chewing insect pests. Insecticide mixtures are also seen as an important approach to insect resistance management (IRM) with certain requirements for optimal implementation. Additionally, insecticide mixtures can also address certain agronomic, commercial and intellectual property needs and opportunities. This perspective will review some of the drivers and considerations for insecticide mixtures and their potential uses.

Keywords: insecticide resistance; insecticide discovery; insect resistance management

1 INTRODUCTION

A range of factors impact the ability of growers to effectively manage pest insect populations in their crops including climate change, public perception, increasingly stringent regulatory requirements, and insect resistance to the available insect control tools (Fig. 1). These factors have influenced the numbers and types of insecticides that have been developed, especially over the past 30 years, with an increasing trend towards more selective insecticides that can meet environmental and regulatory demands[1,2] (Figs 2 and 3). The focus on more selective insecticides also impacts control of pest complexes, often requiring the use of insecticide mixtures to provide the needed degree of

2 DRIVERS FOR INSECTICIDE MIXTURES

There are a number of factors or drivers influencing the use of insecticide mixtures. Some of these drivers are directly related to IRM while others are more pragmatic relating to grower needs and/or business considerations (Table 1). Some of the considerations regarding the use of insecticide mixtures have been recently laid out in a set of guidelines from the Insecticide Resistance Action Committee (IRAC)[5] and others.[3,25] Aspects of some of the key drivers and their considerations are examined below.

2.1 Spectrum

Expanding the insect pest spectrum is among the most common

Insecticide Mixtures and Resistance Management – Updated Guidance

August 30th 2023

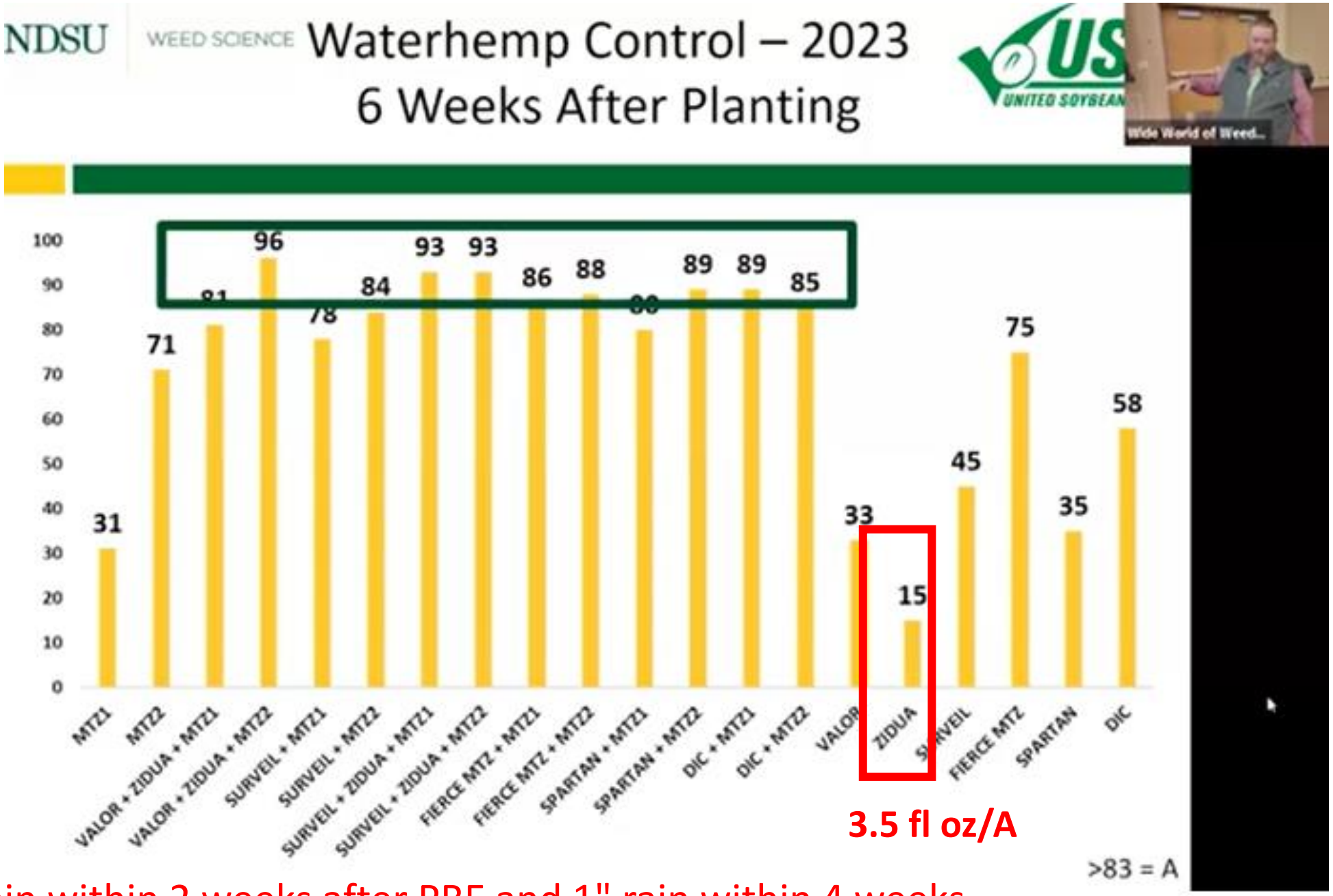
IRAC

Insecticide Resistance Action Committee

Summary: Insecticide mixtures

- Some mixtures contain reduced rates of a newer AI
  - Allows lower cost
  - Potential issue for IRM
- Mixtures can broaden spectrum of control
  - Don’t often have multiple pests at economic levels in soybean
  - Increases toxicity to natural enemies & environment
- Insecticide resistance management is essential
  - Mixtures can help, but under certain conditions
- Decreased performance of some mixtures for soybean aphid in recent years

Herbicides

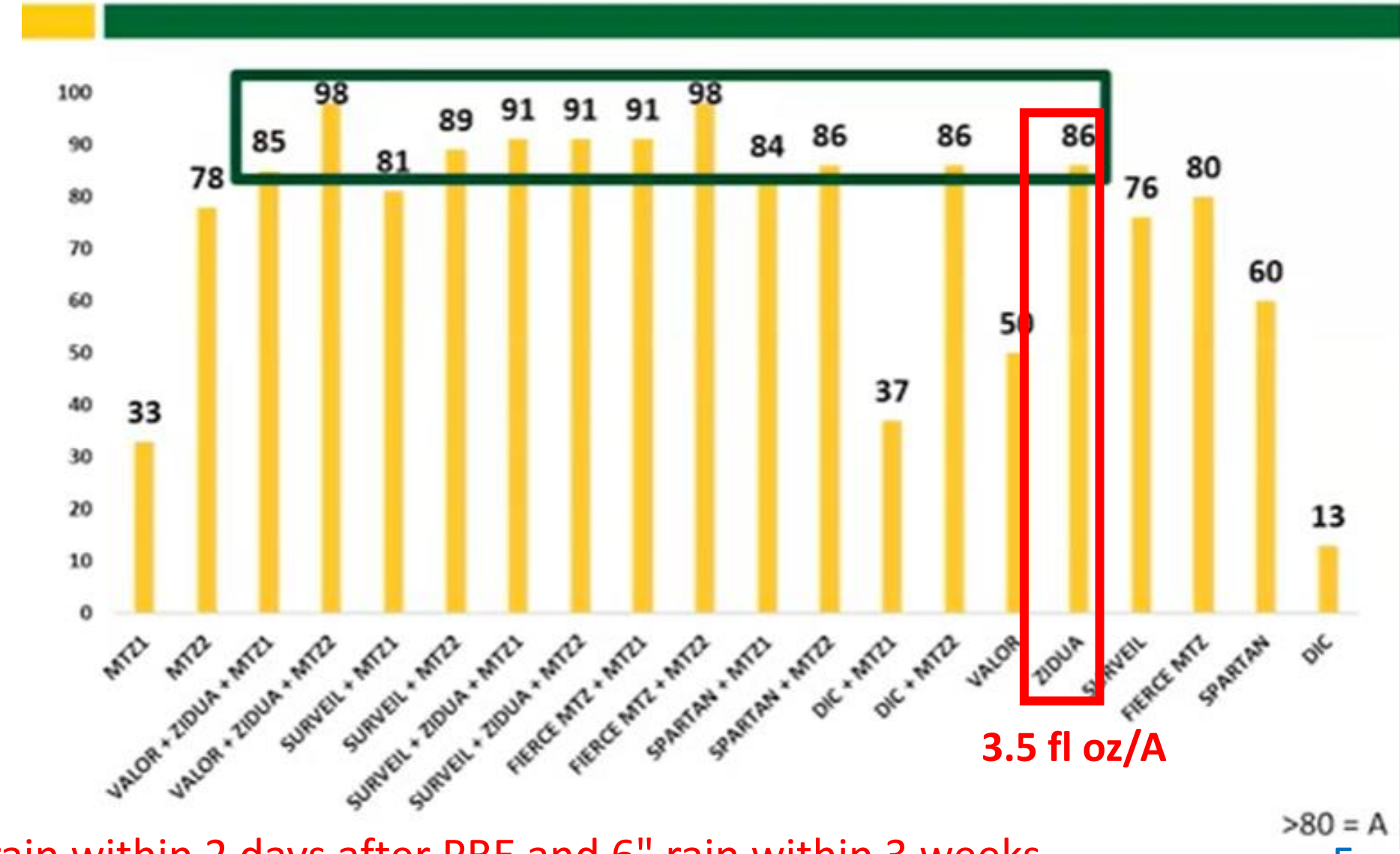


< 0.5" rain within 2 weeks after PRE and 1" rain within 4 weeks.

From Joe Ikley

NDSU WEED SCIENCE

Waterhemp Control – 2024
6 Weeks After Planting



1" rain within 2 days after PRE and 6" rain within 3 weeks.

From Joe Ikley

Can pyroxasulfone be applied POST to soybean after Fierce EZ is applied PRE at 8 fl oz/A?

- 8 fl oz/A / 128 fl oz/A X 1.7 lb ai/gal = 0.119 lb ai/A (3.6 Zidua)
- Coarse soils (sand, loamy sand, sandy loam) = NO
- Medium and fine soils?
  - Yes
  - But at what rate (lb ai/A) ?
    - 0.067 lb ai/A
    - 0.186 lb ai/A maximum rate – 0.119 lb ai/A = 0.067 lb ai/A remaining
  - How much Zidua in fl oz/A is this?
    - 2.05 fl oz/A
    - 0.067 lb ai/A / 4.17 lb ai/gal X 128 fl oz/gal = 2.05 fl oz/A
  - Will this dosage provide effective weed control?
  - Is enough rainfall likely to occur with POST application to maximize weed control?

Weed control with fall-applied Anthem Flex

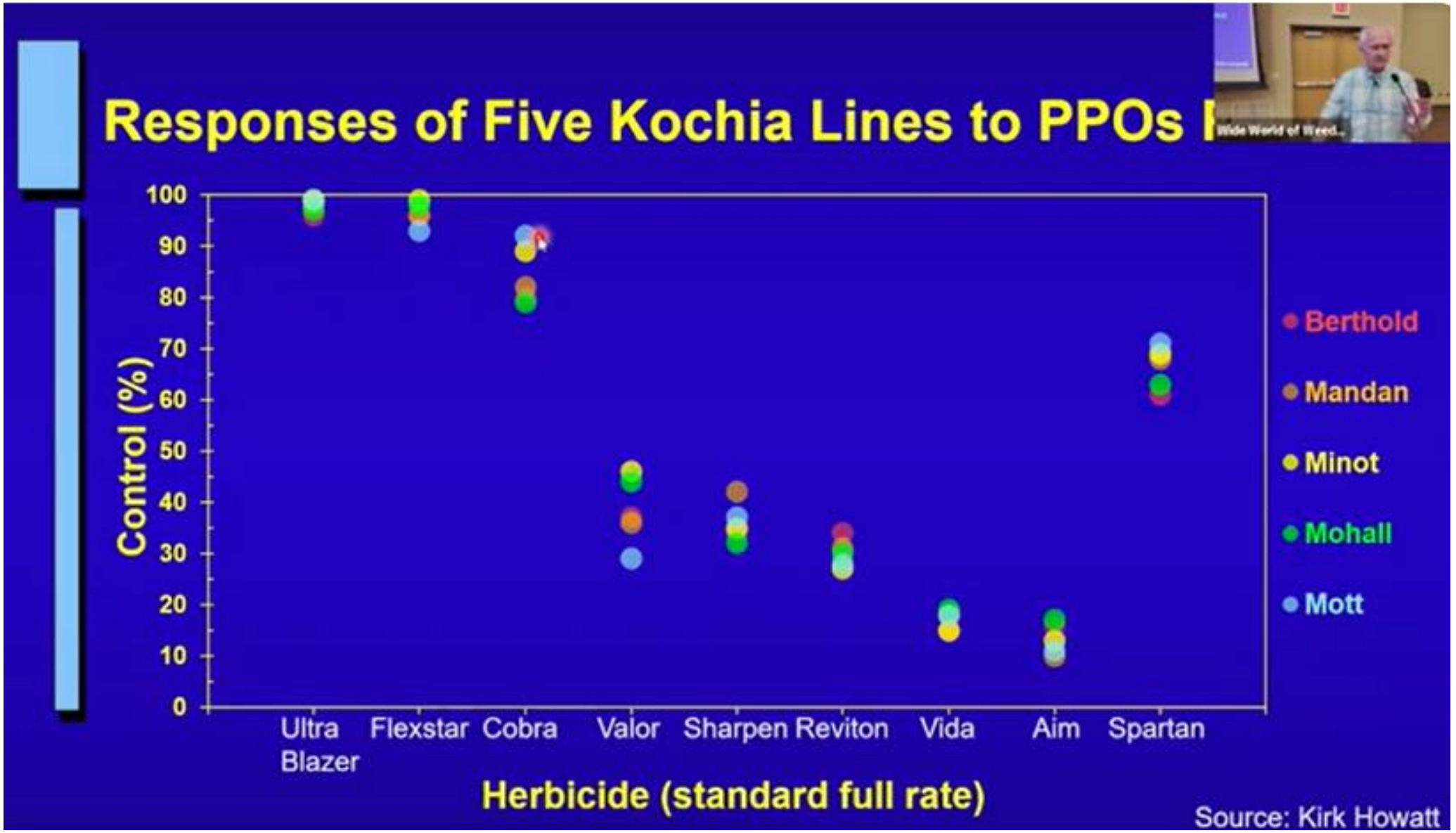
Treatment	Rate	Weed Control						
		Kochia			Green foxtail			
		May 20	May 31	June 27	May 20	May 31	June 27	
		----------%----------			----------%----------			
Untreated		0	0	0	0	0	0	$/A
Anthem Flex	3 oz	68	67	52	40	79	63	18
Anthem Flex	4 oz	74	75	70	42	82	72	23
Anthem Flex	6 oz	87	87	92	75	88	88	35
Anthem Flex + Metri	3.5 oz + 0.33 lb	92	93	90	70	80	69	24
LSD (0.05)		8.1	6.0	22.0	9.9	3.7	4.2	

*Treatments applied Oct 16, 2023

Anthem Flex = Zidua + Aim

4 fl oz/A = 0.116 lb ai/A of pyroxasulfone; 6 fl oz/A = 0.174 lb ai/A of pyroxasulfone

From Brian Jenks



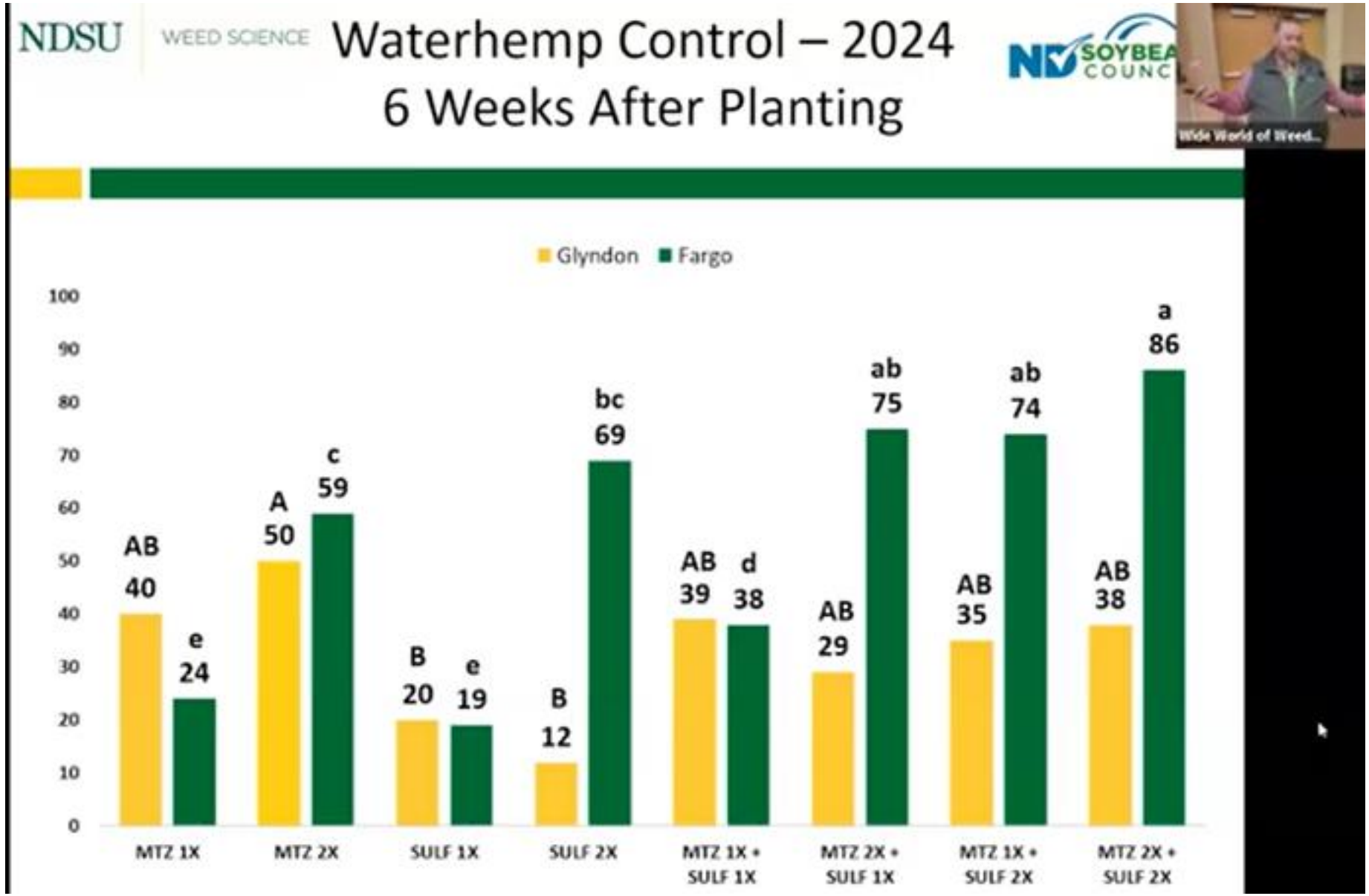
Adjuvants = MSO + AMS

Metribuzin and Sulfentrazone Rates

- Funded by North Dakota Soybean Council
- Crop Safety and Weed Control
  - Fargo, Glyndon, Carrington, Minot, Hettinger, Williston
- Metribuzin
  - 4 oz ai (5.33 oz of 75DF)
  - 8 oz ai (10.7 oz of 75DF)
- Sulfentrazone
  - 2 oz ai (4 fl oz of 4F)
  - 4 oz ai (8 fl oz of 4F)

NDSU | WEED SCIENCE

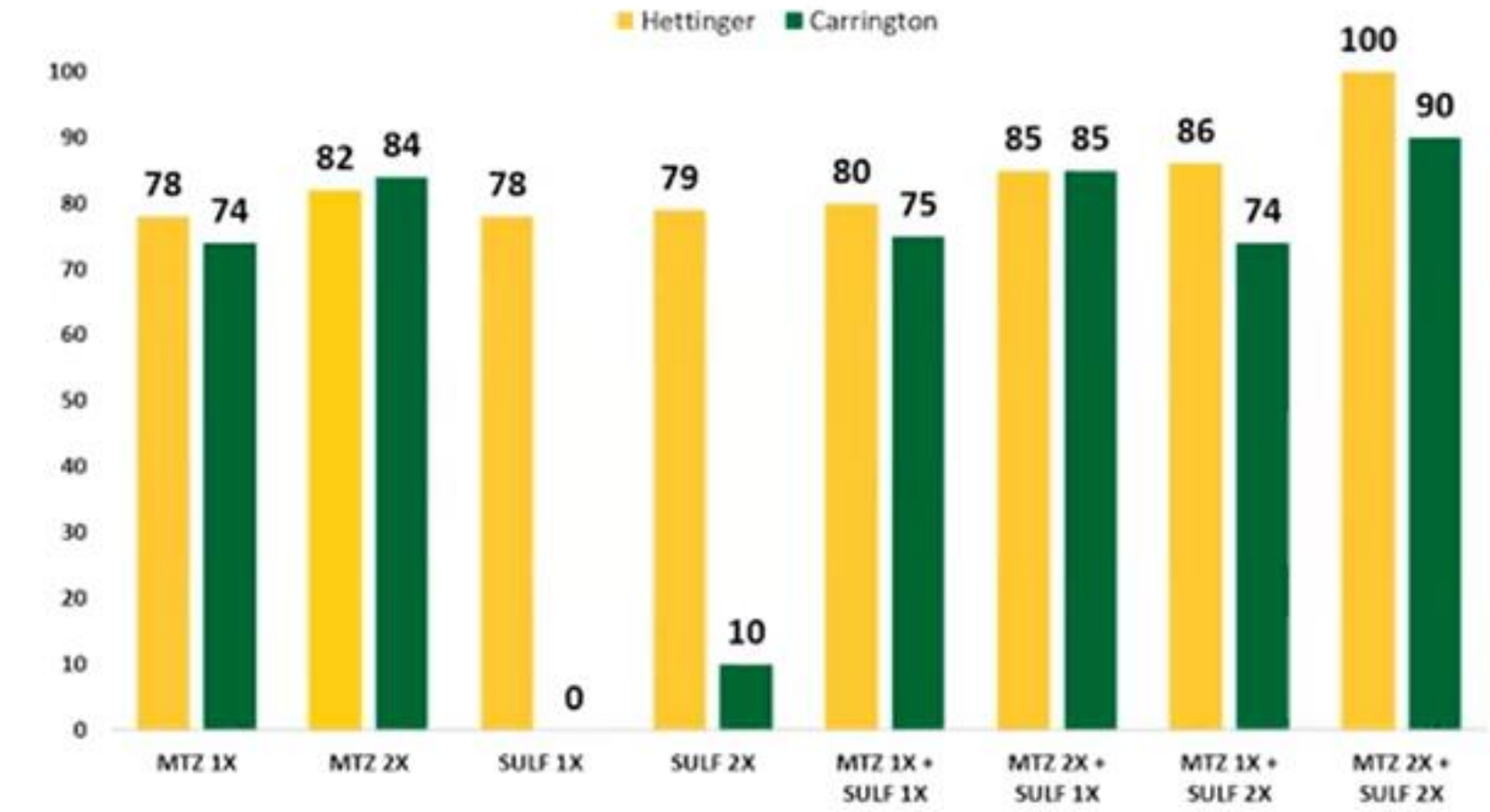
From Joe Ikley



From Joe Ikley

NDSU | WEED SCIENCE

Kochia Control – 2024
6 Weeks After Planting



From Joe Ikley

Metribuzin and Sulfentrazone Rates Crop Safety

- No difference between soybean variety at any site
  - MTZ-tolerant, PPO-sensitive
  - MTZ-sensitive, PPO-tolerant
- No sulfentrazone injury observed at any site
- High rate of metribuzin led to slight crop injury (<10%) at:
  - Glyndon, MN – sandy loam, pH of 8.2
    - 8 inches of rain within first 3 weeks after planting
  - Minot
- No difference in yield observed at any site except:
  - Fargo – silty clay, pH of 8
    - 6 inches of rain within first 3 weeks. Standing water
    - Tank-mix of high rate of sulfentrazone + metribuzin
      - 7 bu A^{-1} less than weed-free

NDSU | WEED SCIENCE

From Joe Ikley

Best kochia and waterhemp control from Spartan 8 fl oz/A + Metribuzin 75 DF 10.7 oz/A

- What is the sulfentrzone rate of Spartan 4L and Metribuzin 75 DF needed?
  - 0.25 lb ai/A sulfentrazone
    - 8 fl oz/A Spartan / 128 fl oz/gal X 4 lb ai/gal = 0.25 lb ai/A sulfentrzone
  - 0.5 lb ai/A metribuzin
    - 10.7 oz/A / 16 oz/lb X 0.75 lb ai/ lb product = 0.5 lb ai/A metribuzin

Best kochia and waterhemp control from Spartan 8 fl oz/A + Metribuzin 75 DF 10.7 oz/A

- If use Preview 2.1 at 23 fl oz/A, do we achieve the rates of these two AI's?
  - NO
  - How much Spartan 4FL must be added to achieve 0.25 lb ai/A sulfentrazone?
    - 1.6 fl oz/A Spartan 4FL
      - 0.25 lb ai/A sulfentrazone – 0.2 lb ai/A sulfentrazone = 0.05 lb ai/A needed
      - 0.05 lb ai sulfentrazone / 4 lb/gal X 128 fl oz/gal = 1.6 fl oz/A Spartan 4 FL
  - How much Metribuzin 75 DF must be added to achieve 0.5 lb ai/A metribuzin?
    - 2.1 oz/A Metribuzin 75DF
      - 0.5 lb ai/A metribuzin – 0.4 lb ai/A metribuzin = 0.1 lb ai/A metribuzin needed
      - 0.1 lb ai/A metribuzin / 0.75 lb ai/pound product = 0.13 lb pr/A X 16 oz/lb = 2.1 oz/A Metribuzin 75 DF

Special restrictions

- Soil texture
- Soil pH
- Soil OM
- Rainfall
- Do the results of this one-year study at seven locations mean these rates can be used in all ND fields?
  - NO

Kochia control in HRSW in ND?

- When was kochia first confirmed resistant to dicamba in ND?
  - 1995
- Why was Starane labeled in HRSW in ND and when?
  - Increasing frequency of dicamba-resistant kochia and 1998
- Please read the Starane Ultra label, what should the minimum rate be to control kochia?
  - 0.4 pt/A Starane Ultra
    - What is the rate of fluroxypyr?
      - 0.4 pt/A / 8 pt/A X 2.8 lb ai/gal = 0.14 lb ai/A
- What was original rate of Starane?
  - 0.12 to 0.25 lb ai/A
- What rate of fluroxypyr was used in 2009 in SD?
  - 0.086 lb ai/A

If minimum fluroxypyr rate should be 0.14 lb ai/A,

- Do any HRSW herbicide pre-mixtures (31) contain this rate of fluroxypyr?
  - Almost NONE (28)
  - Which pre-mixtures contain 0.14 lb ai/A fluroxypyr?
    - OpenSky (1.25 pt/A) = 0.14 lb ai/A fluroxypyr
      - 1.25 pt/A / 8 pt/gal X 0.95 lb ai/gal = 0.14 lb ai/A
      - Problem: no bromoxynil included to maximize kochia control.
    - Sentrallas (14 fl oz/A) = 0.14 lb ai/A fluroxypyr
      - 14 fl oz/A / 128 fl oz/gal X 1.3 lb ai/gal = 0.14 lb ai/A
      - Problem: no bromoxynil included to maximize kochia control.
    - TruSlate Pro (2 pt/A) = 0.16 lb ai/A fluroxypyr
      - 2 pt/A / 8 pt/gal X 0.64 lb ai/gal = 0.16 lb ai/A
      - Problem: no bromoxynil included to maximize kochia control.

Kochia control in HRSW in ND?

- When was kochia first confirmed resistant to fluroxypyr in ND?
  - 2012
- At a fluroxypyr rate of 0.12 lb ai/A, approximately what rate of control can you expect?
  - 72%
- Is this acceptable?
  - NO
- How many HRSW herbicide pre-mixtures have at least 0.11 to 0.13 lb ai/A in them?
  - 18

Kochia control in HRSW in ND?

- Should fluroxypyr ever be used alone?
  - NO
- At least what active ingredient should be added to fluroxypyr?
  - Bromoxynil
- How many fluroxypyr pre-mixture herbicides contain bromoxynil?
  - ONLY 4

Kochia control in HRSW in ND?

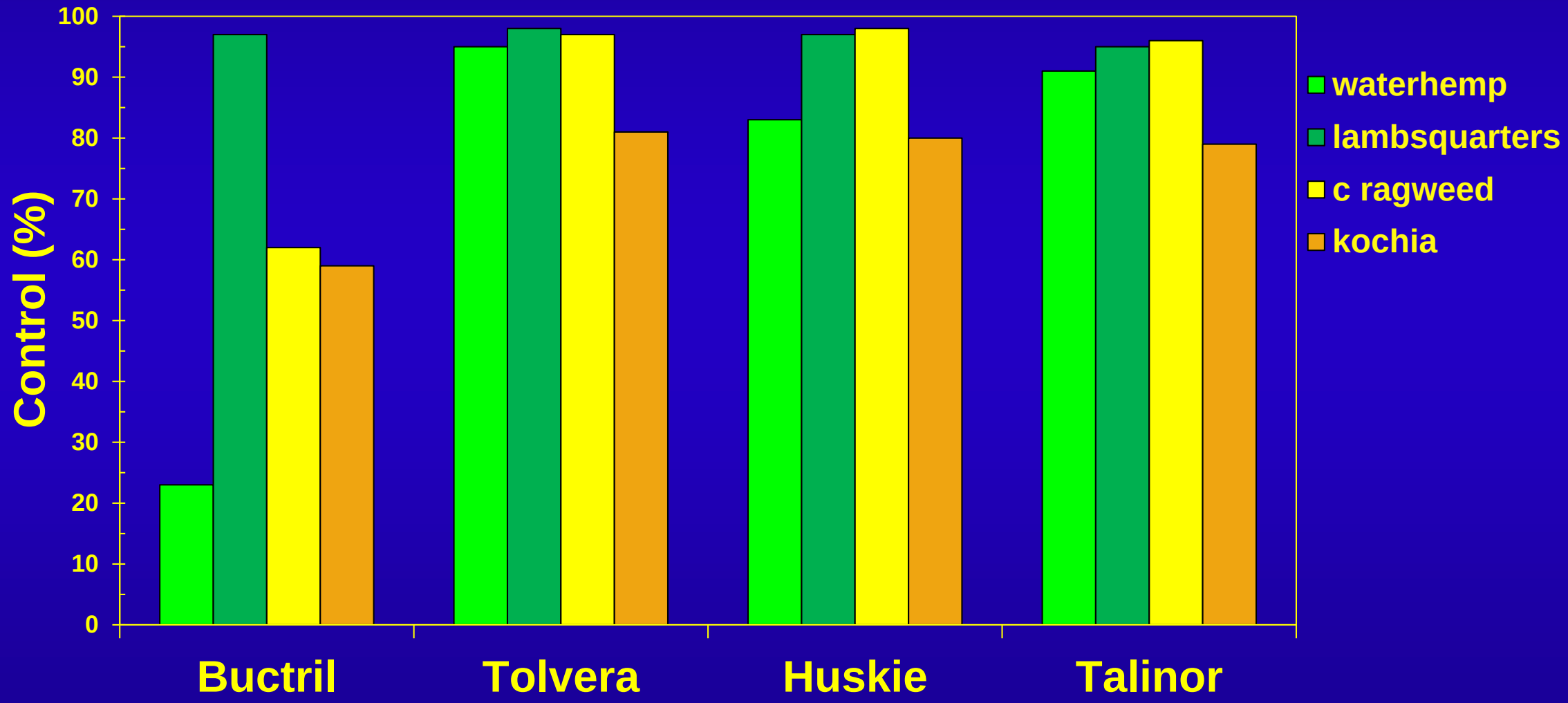
- How much fluroxypyr is in Huskie FX (18 fl oz/A)?
  - 0.08 lb ai/A!
  - 18 fl oz/A / 128 fl oz/gal X 0.6 lb ai/gal = 0.08 lb ai/A

- How much Starane Ultra, must be added?
  - 2.6 fl oz/A
  - 0.14 – 0.08 lb ai/A = 0.06 lb ai/A / 2.8 lb ai/gal = 0.021 lb pr/A X 128 fl oz/A = 2.6 fl oz/A

Kochia control in HRSW in ND?

- What is the minimum bromoxynil rate to be mixed with fluroxypyr?
  - 0.37 # ai/A or 1.5 pt/A of Moxy 2EC
- How much improvement in kochia control is possible with this rate of bromoxynil?
  - 20% (only 9% additional control at 1 pt/A)
- Are there other options to controlling kochia POST in HRSW?
  - No

Broadleaf Control with Group 27 Premixes



From Kirk Howatt

Summary/Conclusions

Summary/Conclusions

- There are many positive attributes of pesticide pre-mixtures.
- There are beginning to become more negative issues with pesticide pre-mixtures, particularly with herbicides due to lower than effective rates of certain active ingredients resulting in less effective weed control.
- Pre-mixtures can be both positive and negative to reducing pesticide resistance, depends on active ingredients and rates.

Summary/Conclusions

- Make sure the appropriate rates of other products containing the desired active ingredient(s) to obtain the effect dose.
- Are all active ingredients in pre-mixtures necessary for the pests within a field?

Questions