Management of bollworm in cotton

Dawson Kerns

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Research/Extension Field Crops Entomologist

Bollworm management

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Bollworm management

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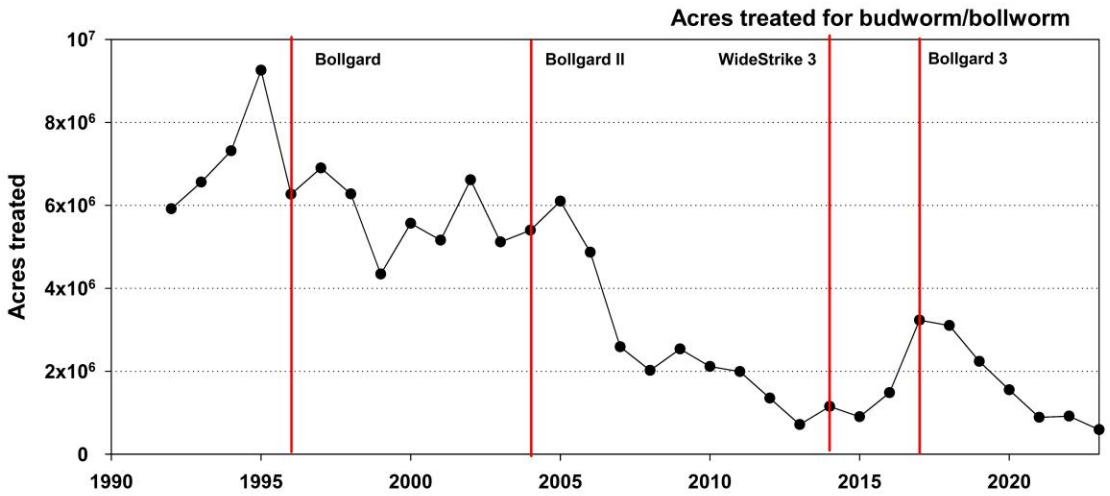
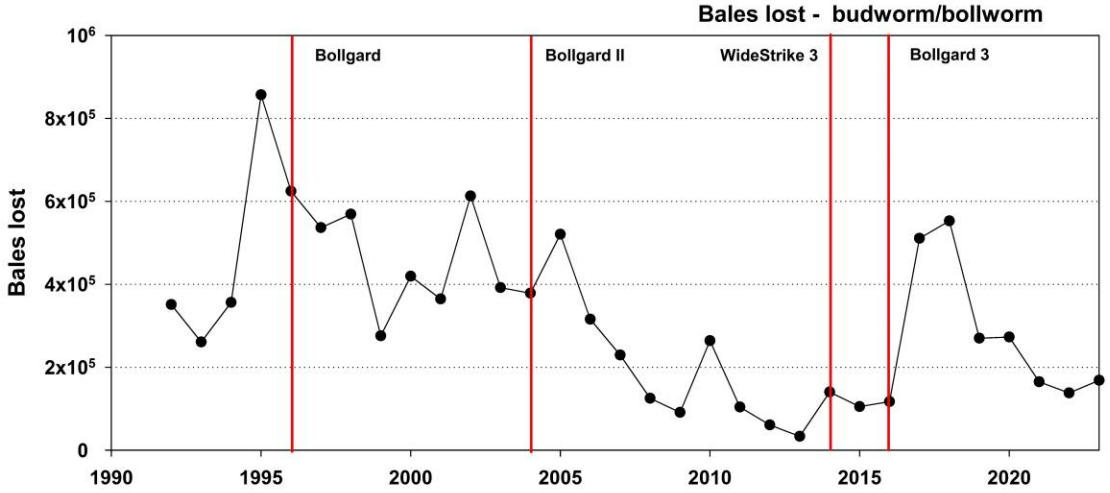
- Bt corn and cotton
  - Two-gene (2 Cry proteins)
  - Three-gene (2 Cry + 1 Vip protein)

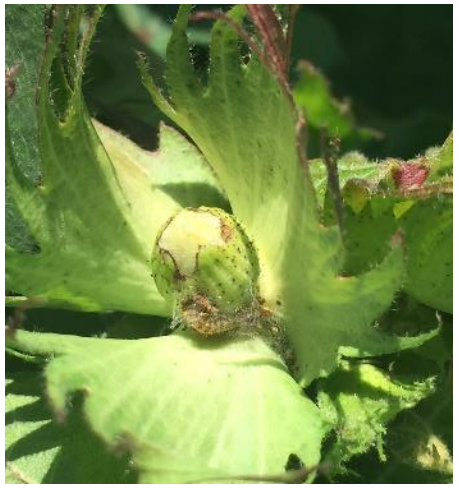
Bt proteins included in corn and cotton

Crop	Cry1	Cry2	Vip3A
Cotton	Cry1Ac, Cry1Ab, Cry1F	Cry2Ab, Cry2Ae	Vip3A19
Corn	Cry1Ab, Cry1F, Cry1A.105	Cry2Ab2	Vip3A20

Resistance to Cry proteins







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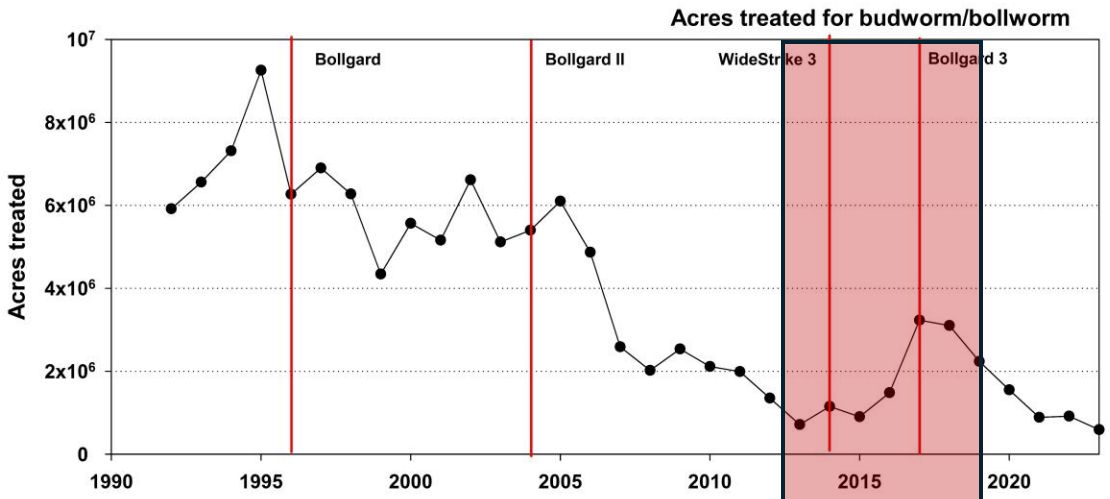

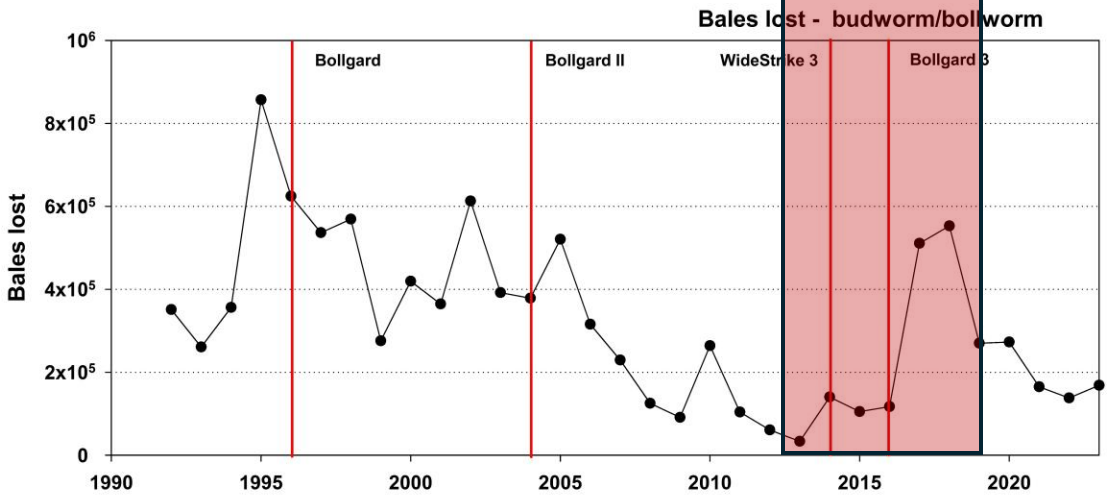

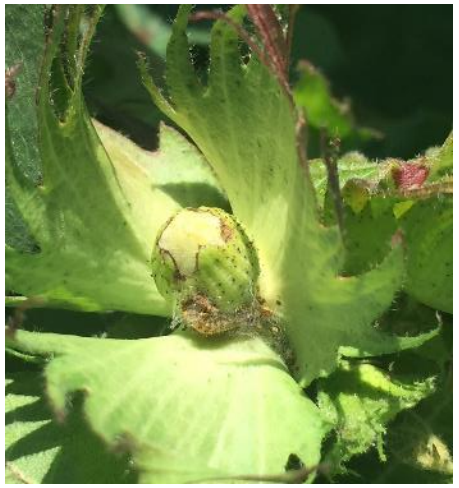

Bollworm management

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Bollworm management

- Wide host range: corn (preferred), cotton, soybean, sorghum, etc.
- Bt corn and cotton
  - Two-gene (2 Cry proteins)
  - Three-gene (2 Cry + 1 Vip protein)
- Supplemental insecticides

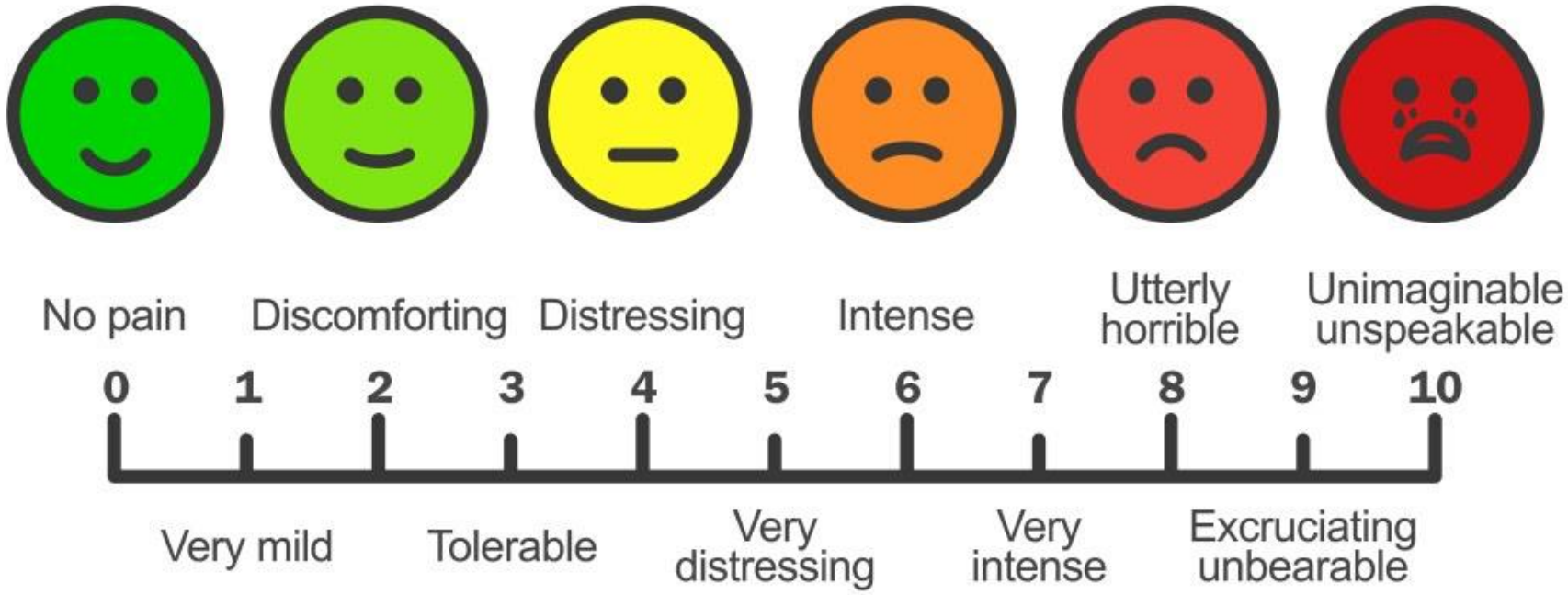
What is Resistance?

A heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species.

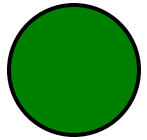
IRAC

Insecticide Resistance Action Committee

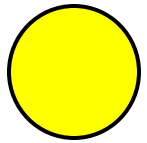
Resistance gradient



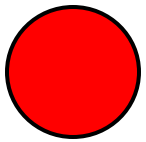
Categories of Bt resistance to crops



Susceptible – No significant decrease in susceptibility.



Early Warning – Field-evolved resistance where monitoring data show a statistically significant decrease in susceptibility, yet reduced efficacy of the Bt crop has not been reported.

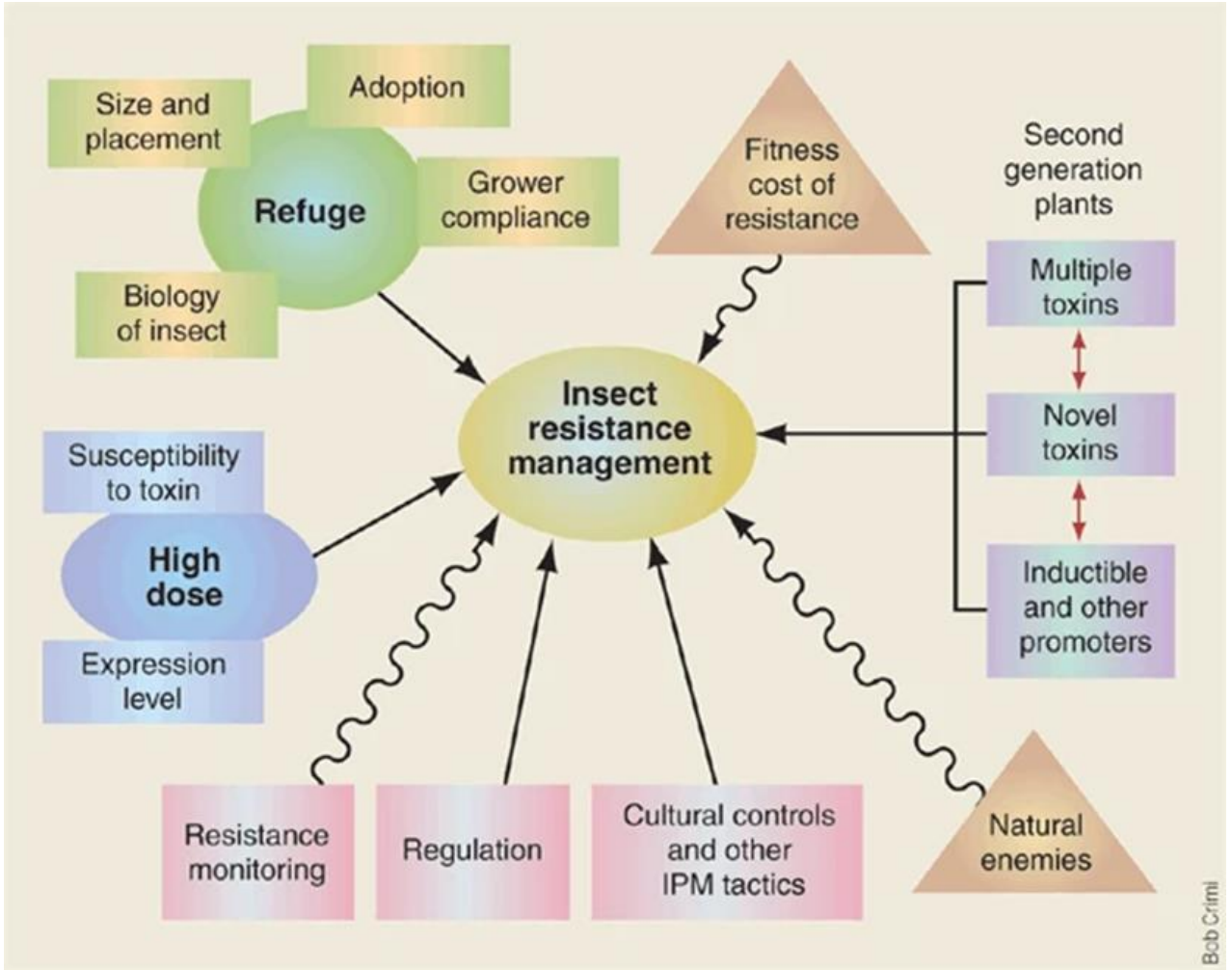


Practical Resistance – Where > 50% of individuals in a population are resistant and efficacy of the Bt crop is reduced.

Bt resistance management

Generating susceptible genotypes to overwhelm resistant genotypes

High dose Bt proteins



Pyramiding Bt proteins

Bt resistance management

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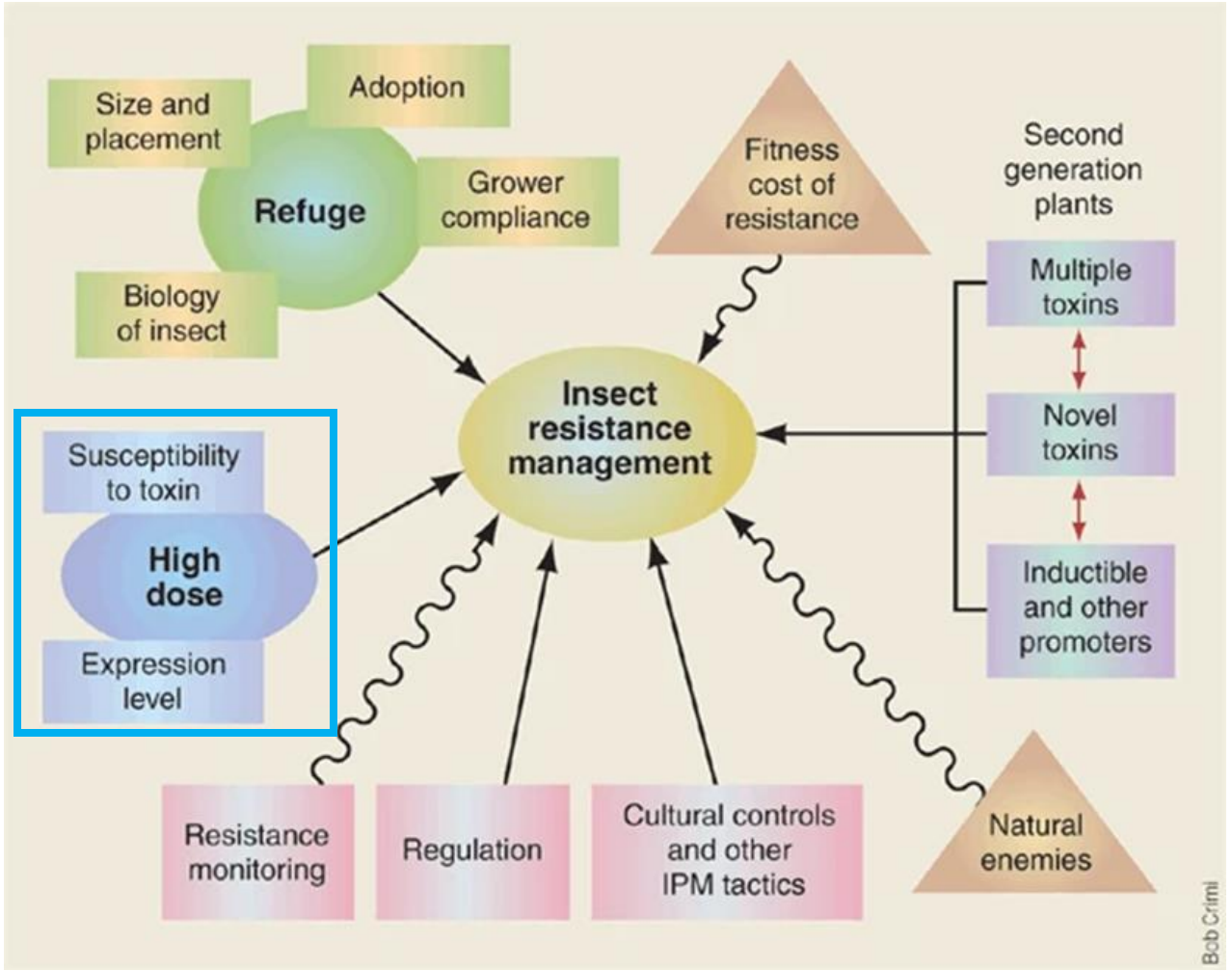


Pyramiding Bt proteins

High dose strategy

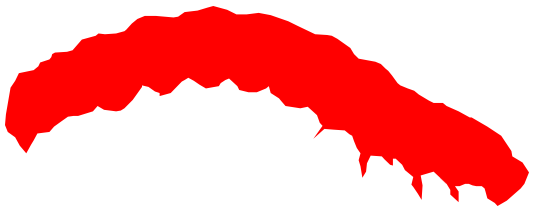
Goal: Bt protein in plant tissue is toxic enough to all susceptible and nearly all resistant heterozygotes

Inherent toxicity + Amount of toxin in plant = Dose level

SS:
Susceptible

RS:
Susceptible
to Moderate

RR:
Resistant



High dose strategy

Goal: Bt protein in plant tissue is toxic enough to all susceptible and nearly all resistant heterozygotes

Inherent toxicity + Amount of toxin in plant = Dose level

HIGH DOSE

SS

RS

RR

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Inherent toxicity + Amount of toxin in plant = Dose level

NOT HIGH DOSE

SS

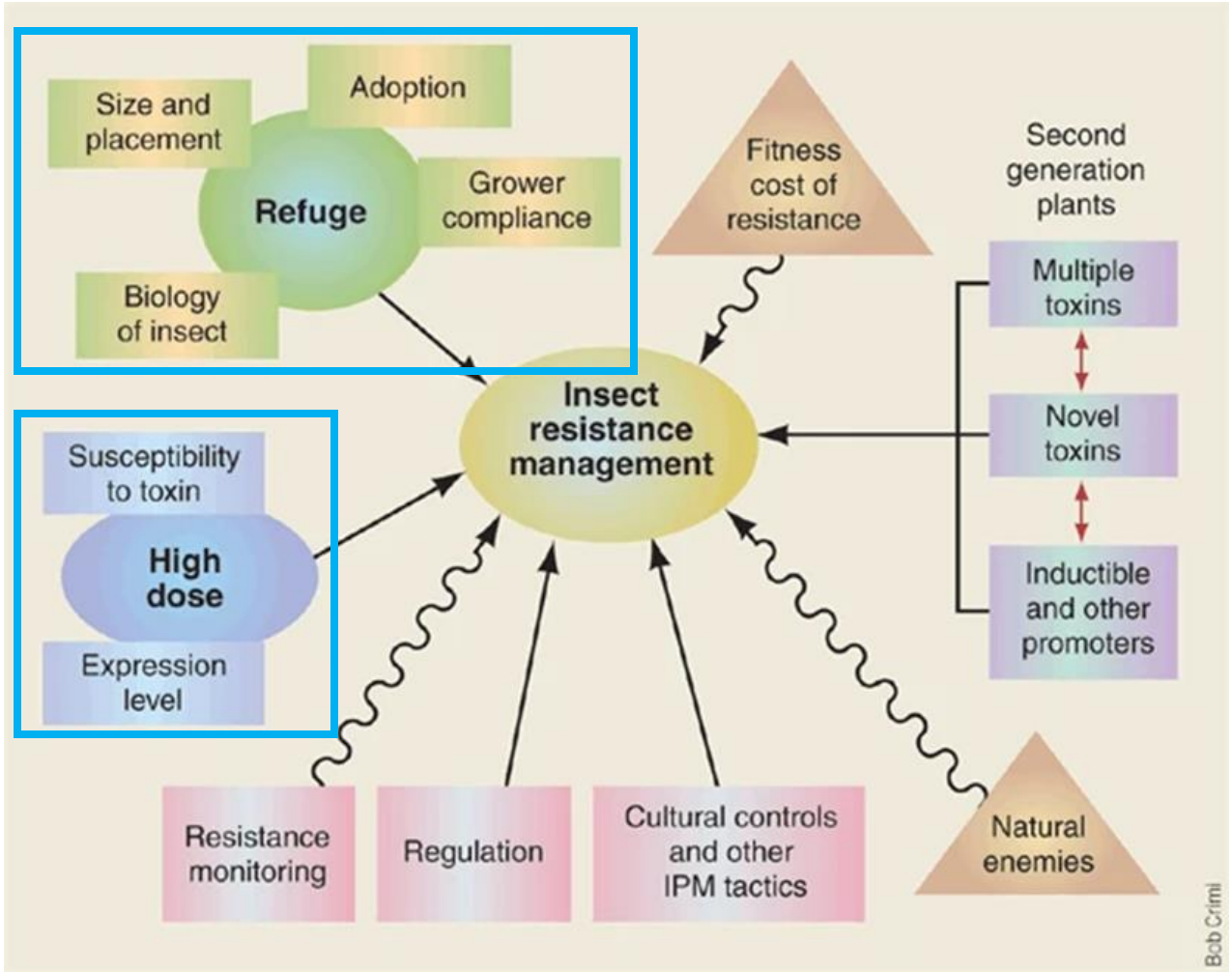
RS

RR

Bt resistance management

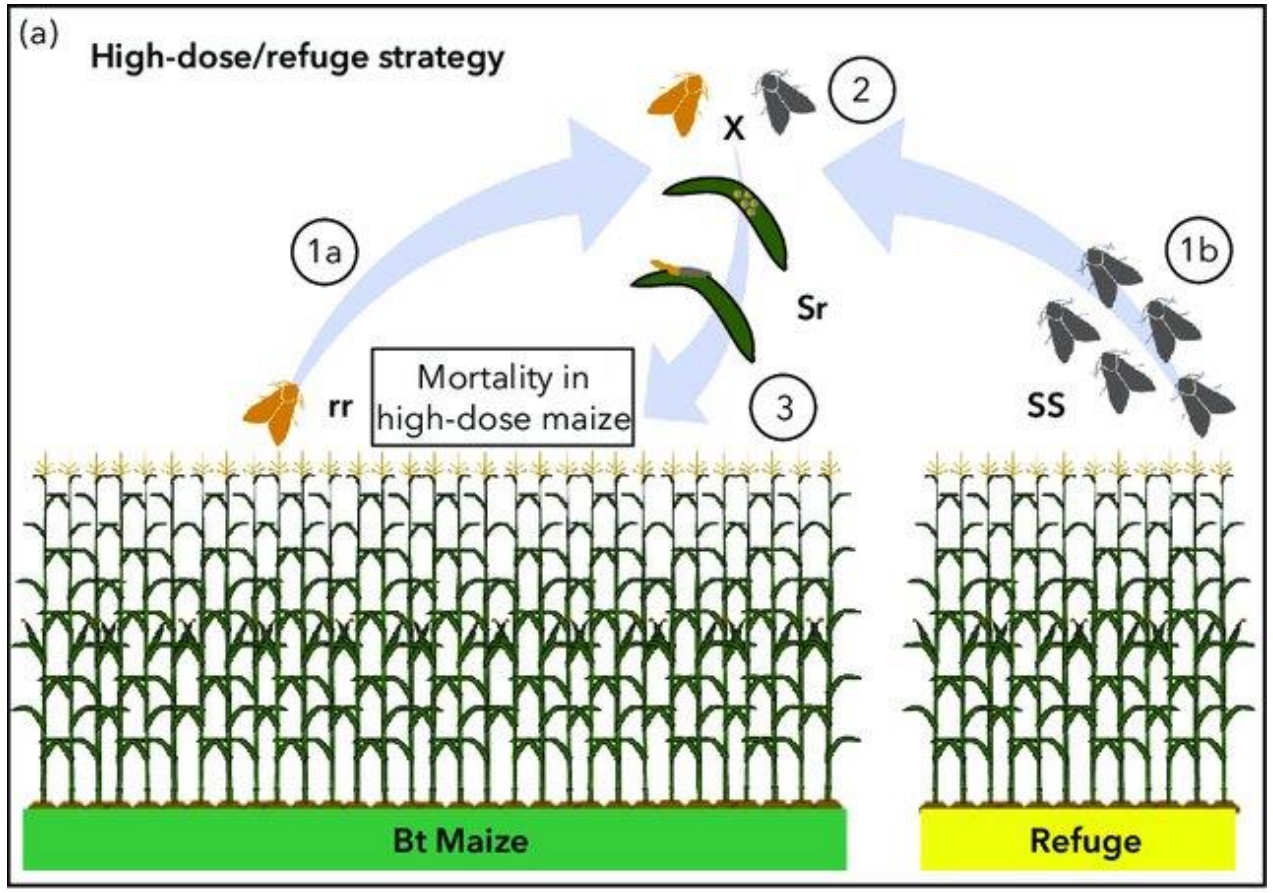
Generating susceptible genotypes to overwhelm resistant genotypes

High dose Bt proteins



Pyramiding Bt proteins

Refuge strategy



Naranjo et al. In Integrated Management of Insect Pest [Kogan& Heinrichs eds.] (2020)

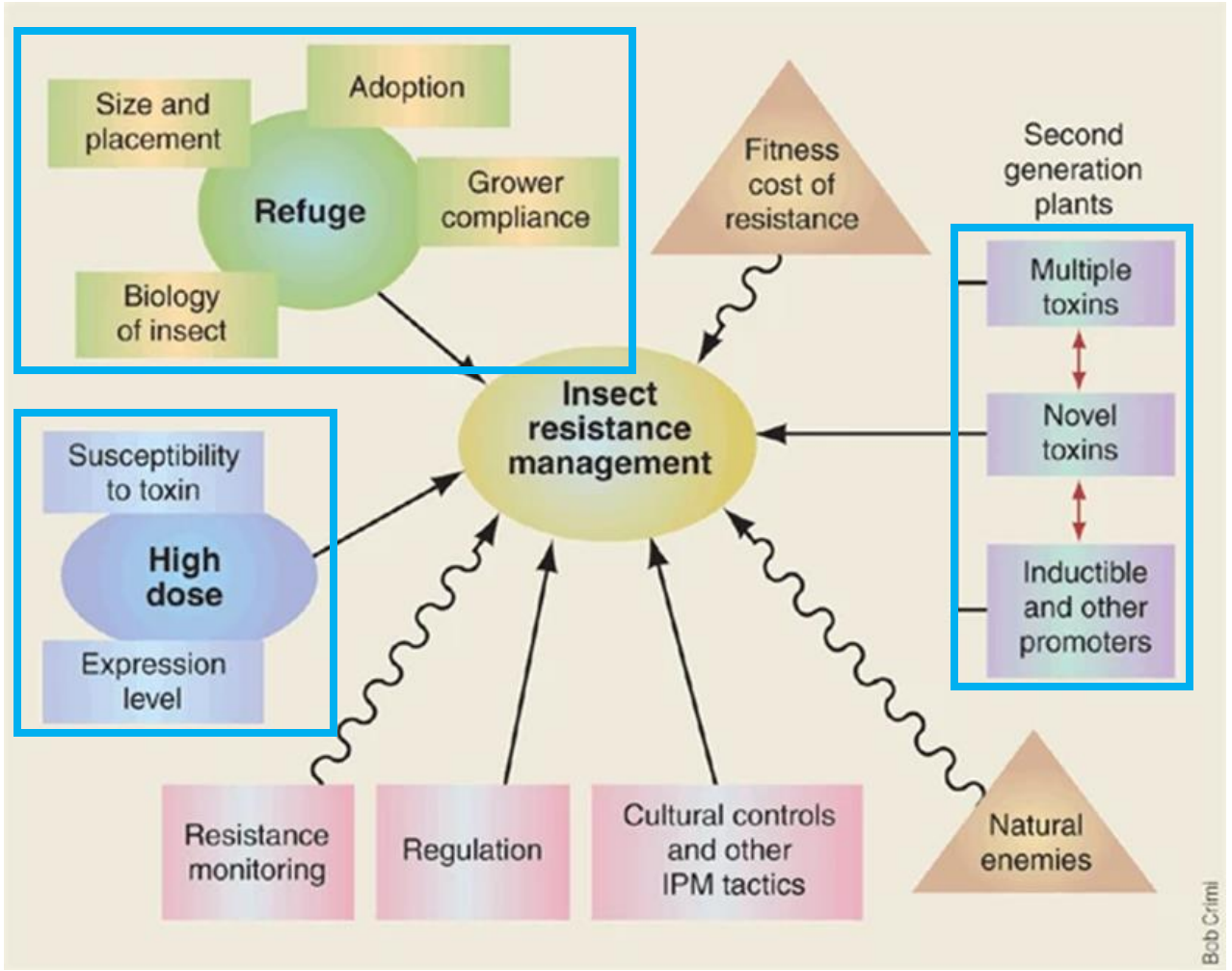
Key Assumptions for the Refuge

1. Resistance is recessive
2. Single locus
3. Rare initial resistance allele frequency
4. Random mating among genotypes
5. Sufficient near-by source of non-Bt corn to serve as a reservoir of synchronized susceptible moths to mate with rare resistant moths

Bt resistance management

Generating susceptible genotypes to overwhelm resistant genotypes

High dose Bt proteins



Pyramiding Bt proteins

Pyramiding strategy

Non-Bt

Cry1Ac

Cry1Ac + Cry2Ab

Non-Redundant

Redundant

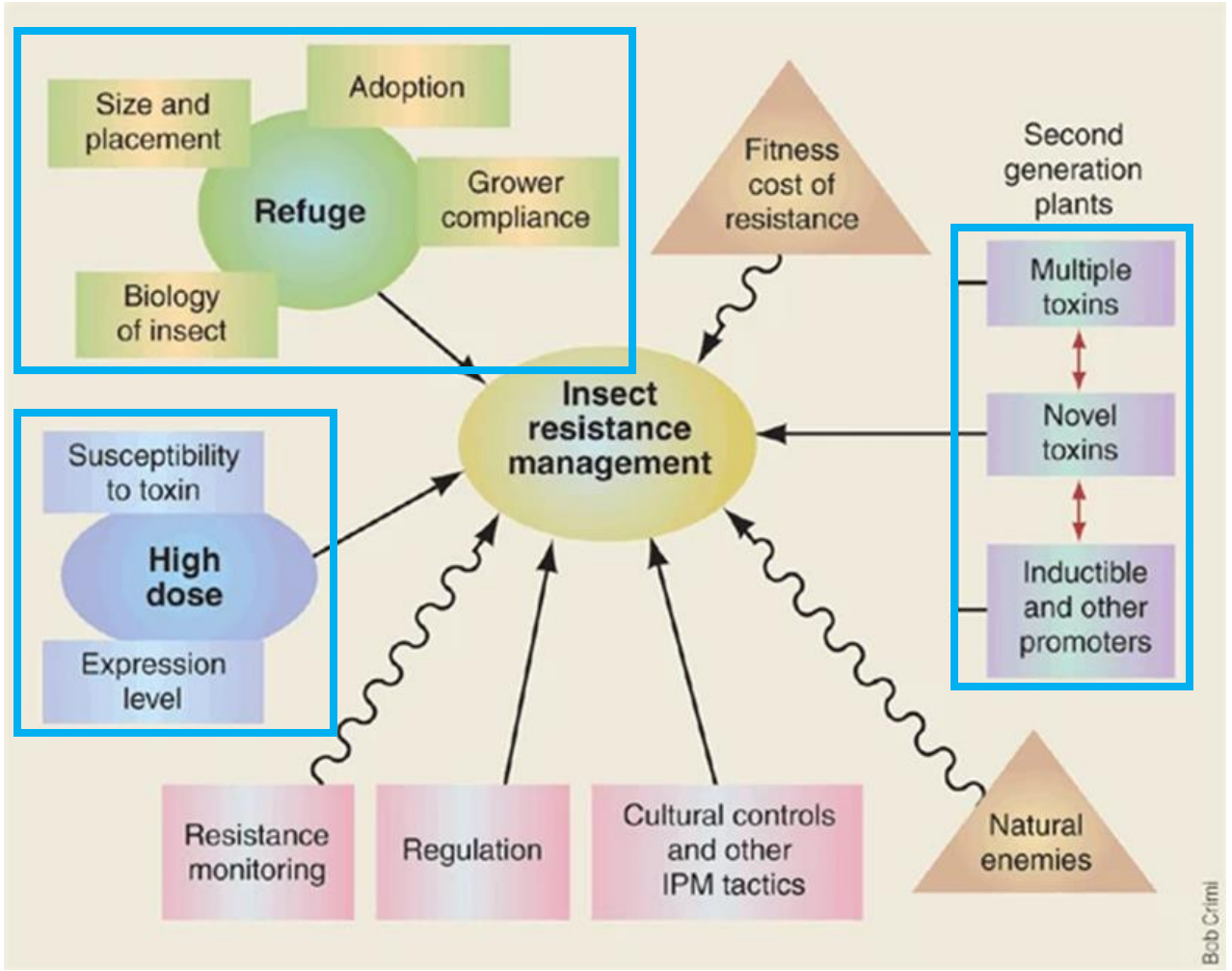
Key Assumptions for Pyramiding

1. Pyramided proteins must be effective on the same target pest
2. No cross resistance among pyramided Bt proteins
3. Redundant killing, which occurs when each toxin produced by a multi-toxin Bt cultivar kills all insects resistant to the other toxin

Bt resistance management

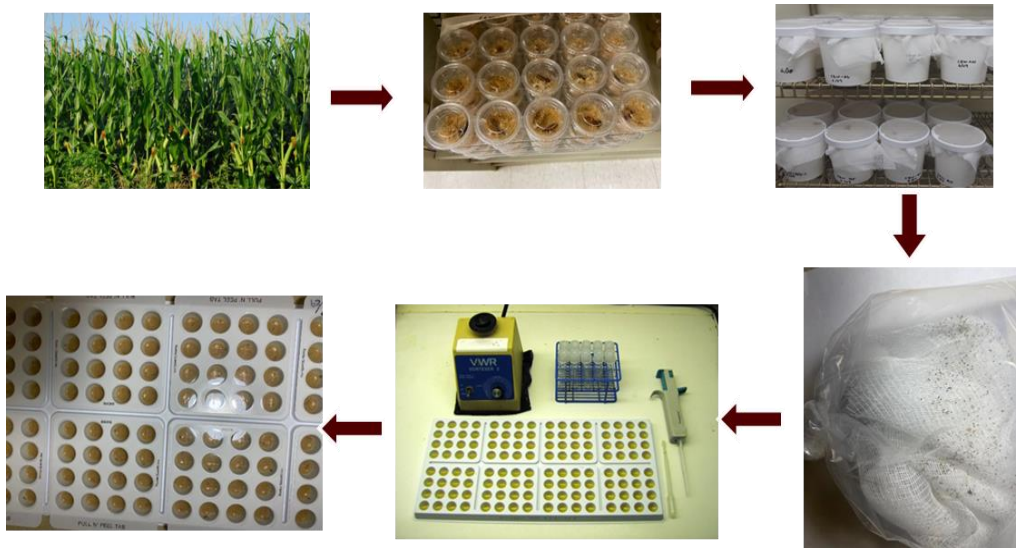
Generating susceptible genotypes to overwhelm resistant genotypes

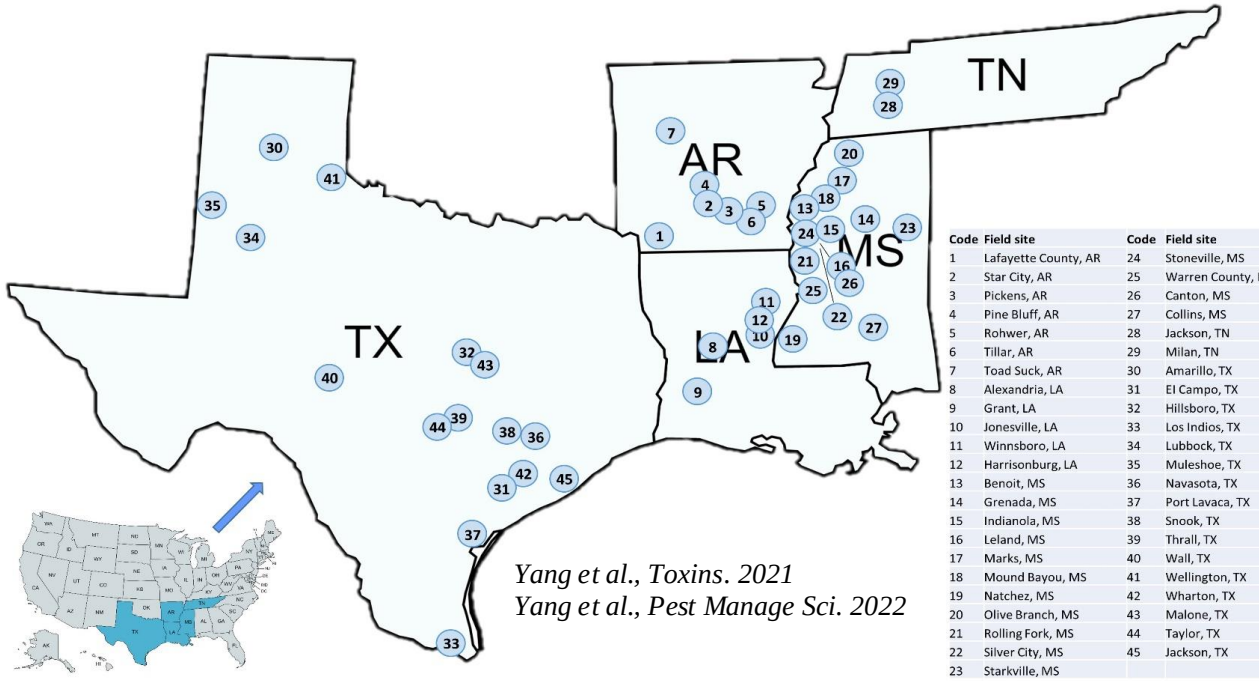
High dose Bt proteins



Pyramiding Bt proteins

Bollworm Bt resistance monitoring (Cry1Ac, Cry2Ab2, Vip3Aa)





Yang et al., Toxins. 2021
Yang et al., Pest Manage Sci. 2022

Code	Field site	Code	Field site
1	Lafayette County, AR	24	Stoneville, MS
2	Star City, AR	25	Warren County, MS
3	Pickens, AR	26	Canton, MS
4	Pine Bluff, AR	27	Collins, MS
5	Rohwer, AR	28	Jackson, TN
6	Tillar, AR	29	Milan, TN
7	Toad Suck, AR	30	Amarillo, TX
8	Alexandria, LA	31	El Campo, TX
9	Grant, LA	32	Hillsboro, TX
10	Jonesville, LA	33	Los Indios, TX
11	Winnsboro, LA	34	Lubbock, TX
12	Harrisonburg, LA	35	Muleshoe, TX
13	Benoit, MS	36	Navasota, TX
14	Grenada, MS	37	Port Lavaca, TX
15	Indianola, MS	38	Snook, TX
16	Leland, MS	39	Thrall, TX
17	Marks, MS	40	Wall, TX
18	Mound Bayou, MS	41	Wellington, TX
19	Natchez, MS	42	Wharton, TX
20	Olive Branch, MS	43	Malone, TX
21	Rolling Fork, MS	44	Taylor, TX
22	Silver City, MS	45	Jackson, TX
23	Starkville, MS		

174 field populations with >267,264 insects from 2016-2023

Diet-overlay Bioassays (2016-2023)

Bt protein	Percentage of populations with resistance							
	2016 (5)	2017 (14)	2018 (34)	2019 (30)	2020 (5)	2021 (12)	2022 (37)	2023 (37)
Cry1Ac	/	100%	94%	96%	100%	92%	100%	100%
Cry2Ab2	80%	77%	73%	73%	100%	92%	74%	97%
Vip3Aa	0%	0%	0%*	0%*	0%	0%	0%	0%

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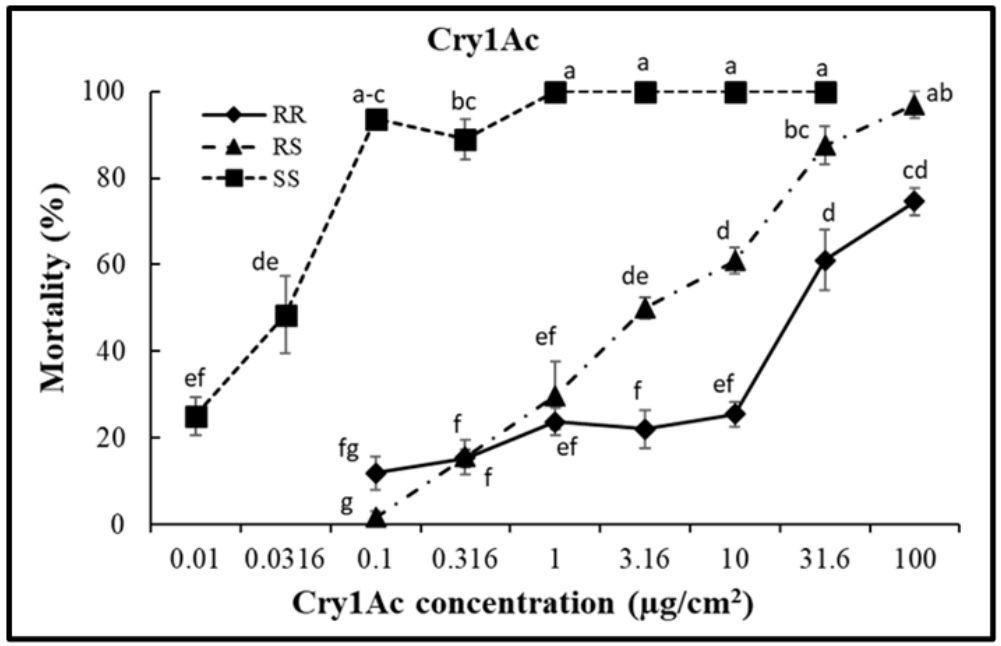

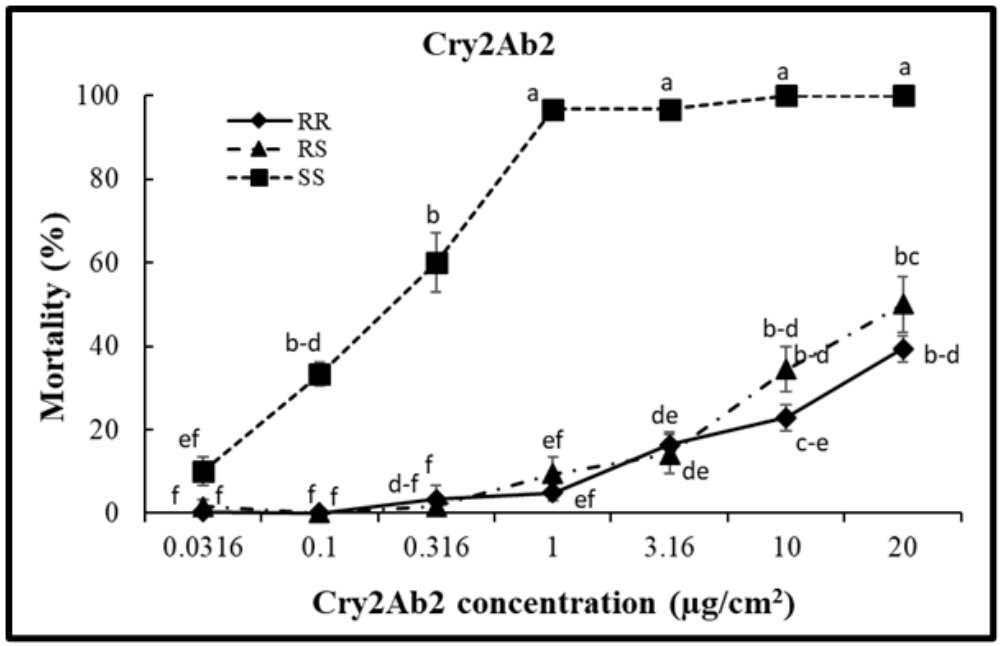

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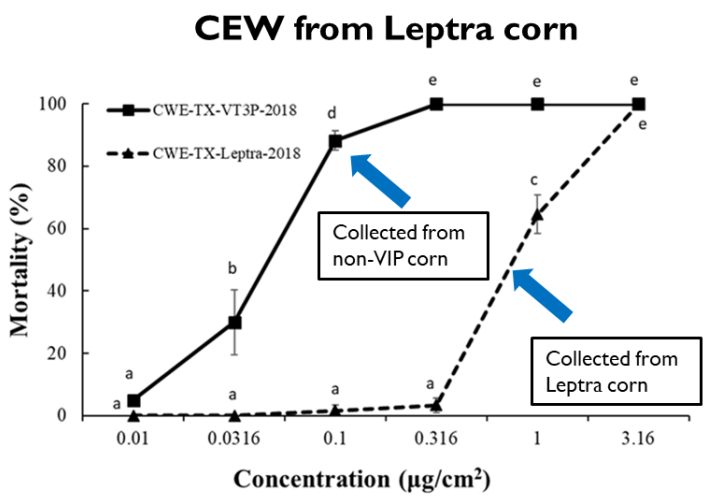
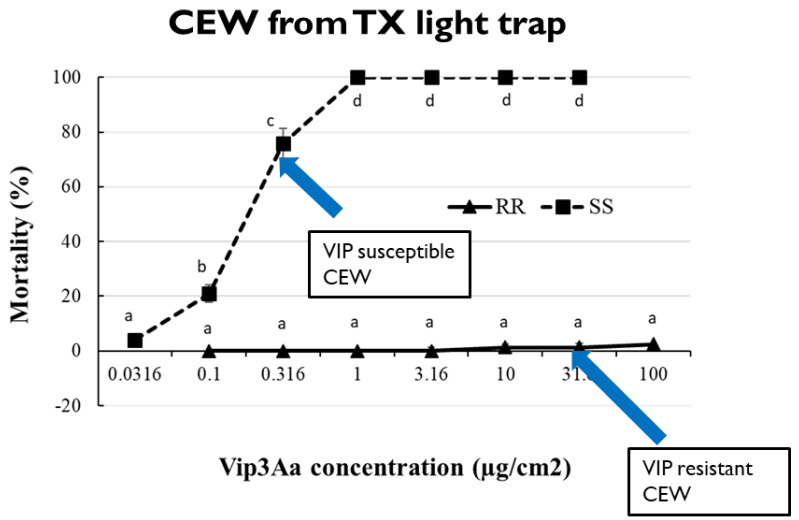


Low level of resistance
(probably minor genes?)



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(major gene controlled)

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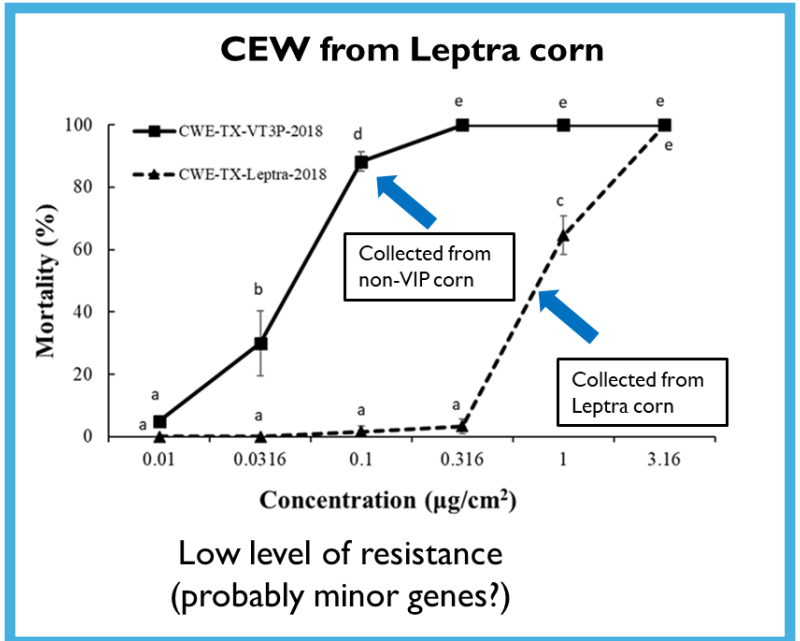

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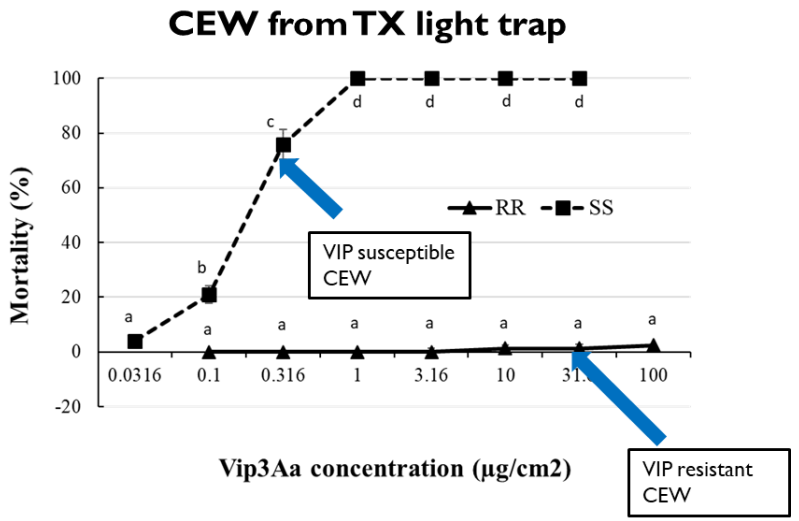

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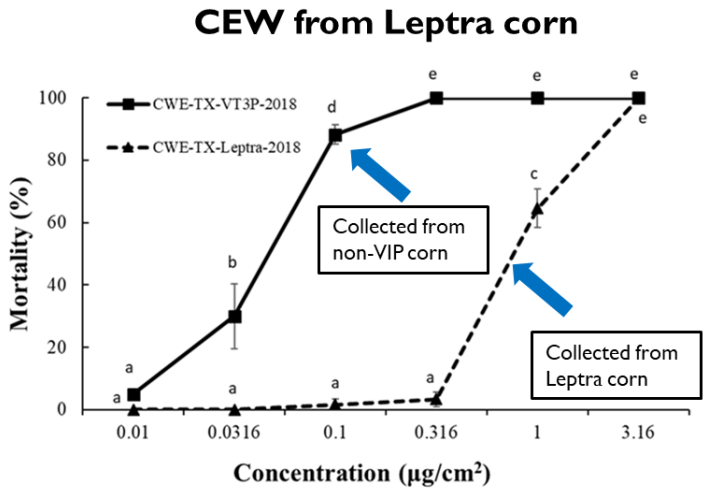

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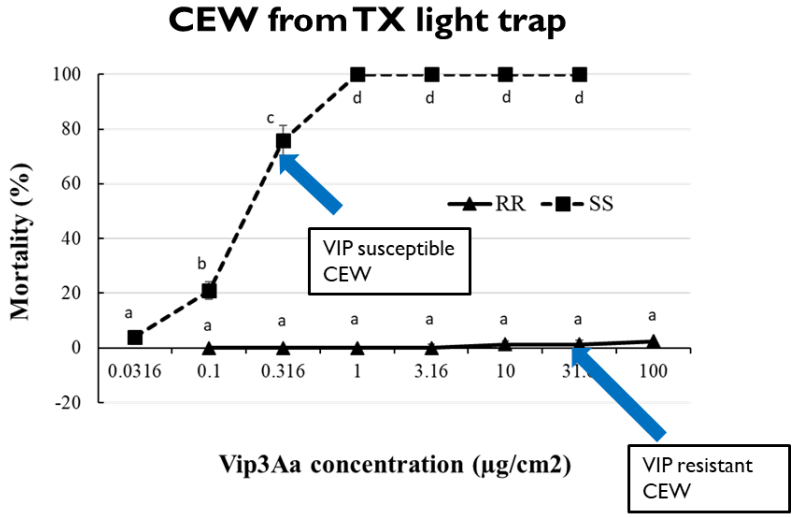

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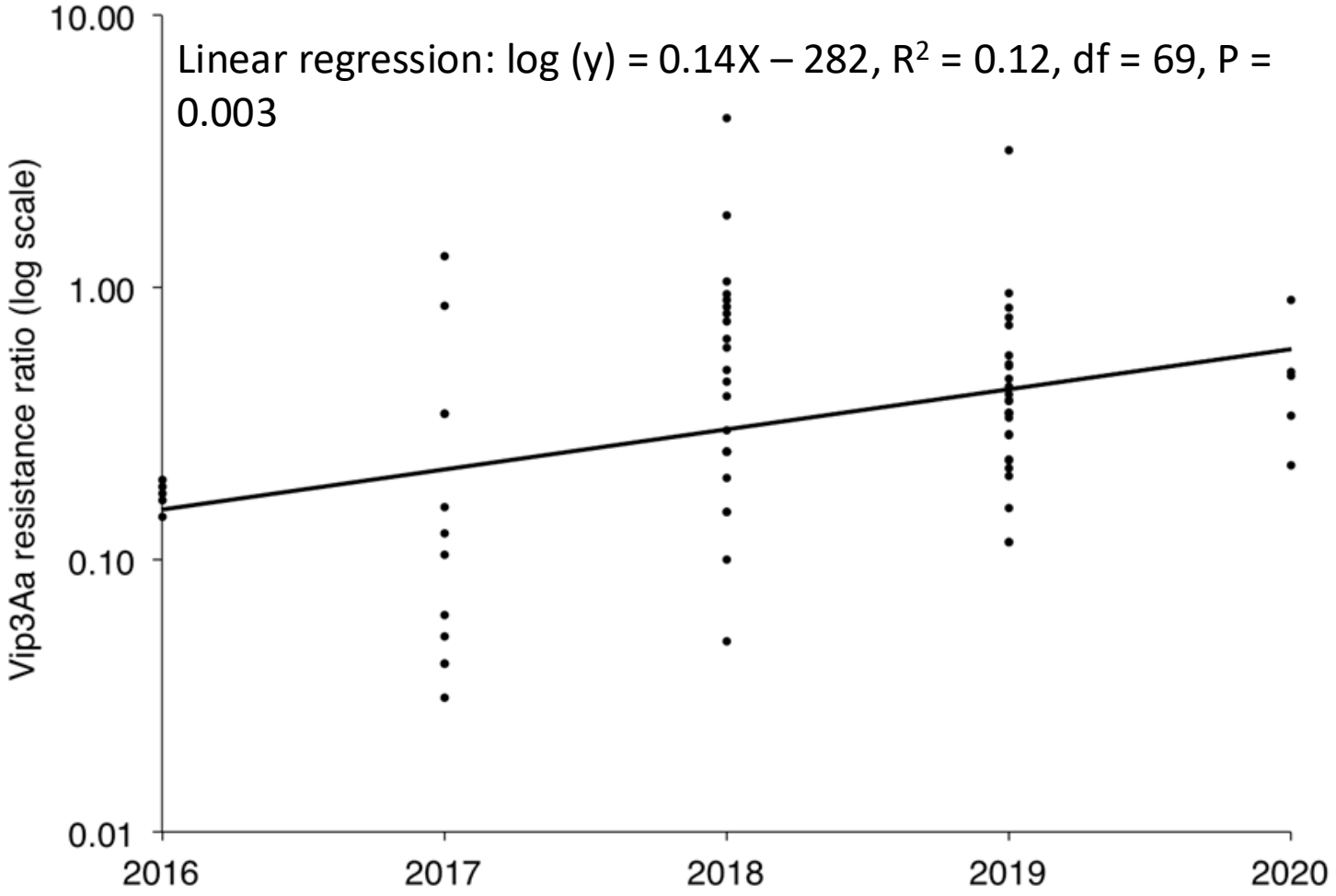
Vip3Aa early warning of resistance



Open Access Article

Early Warning of Resistance to Bt Toxin Vip3Aa in *Helicoverpa zea*

by Fei Yang [1,*], David L. Kerns [1], Nathan S. Little [2], José C. Santiago González [1] and Bruce E. Tabashnik [3,*]

[1] Department of Entomology, Texas A&M University, College Station, TX 77843, USA
[2] USDA Agricultural Research Service, Stoneville, MS 38776, USA
[3] Department of Entomology, University of Arizona, Tucson, AZ 85721, USA
* Authors to whom correspondence should be addressed.

Toxins **2021**, *13*(9), 618; https://doi.org/10.3390/toxins13090618

Categories of Bt resistance to crops

Susceptible – No significant decrease in susceptibility.

Early Warning – Field-evolved resistance where monitoring data show a statistically significant decrease in susceptibility, yet reduced efficacy of the Bt crop has not been reported.

Vip3Aa

Practical Resistance – Where > 50% of individuals in a population are resistant and efficacy of the Bt crop is reduced.

Cry1Ac, Cry1F, Cry2Ab

Where are we on Cry Resistance Management?

- Assumptions
  - Resistance is recessive ✗
  - Resistance resides on a single locus ✗
  - Rare resistance allele frequency ✗
  - Sufficient near-by source of non-Bt corn to serve as a reservoir ✗
  - No cross resistance among Bt proteins ✓
  - High dose ✗

Where are we on Vip3Aa Resistance Management?

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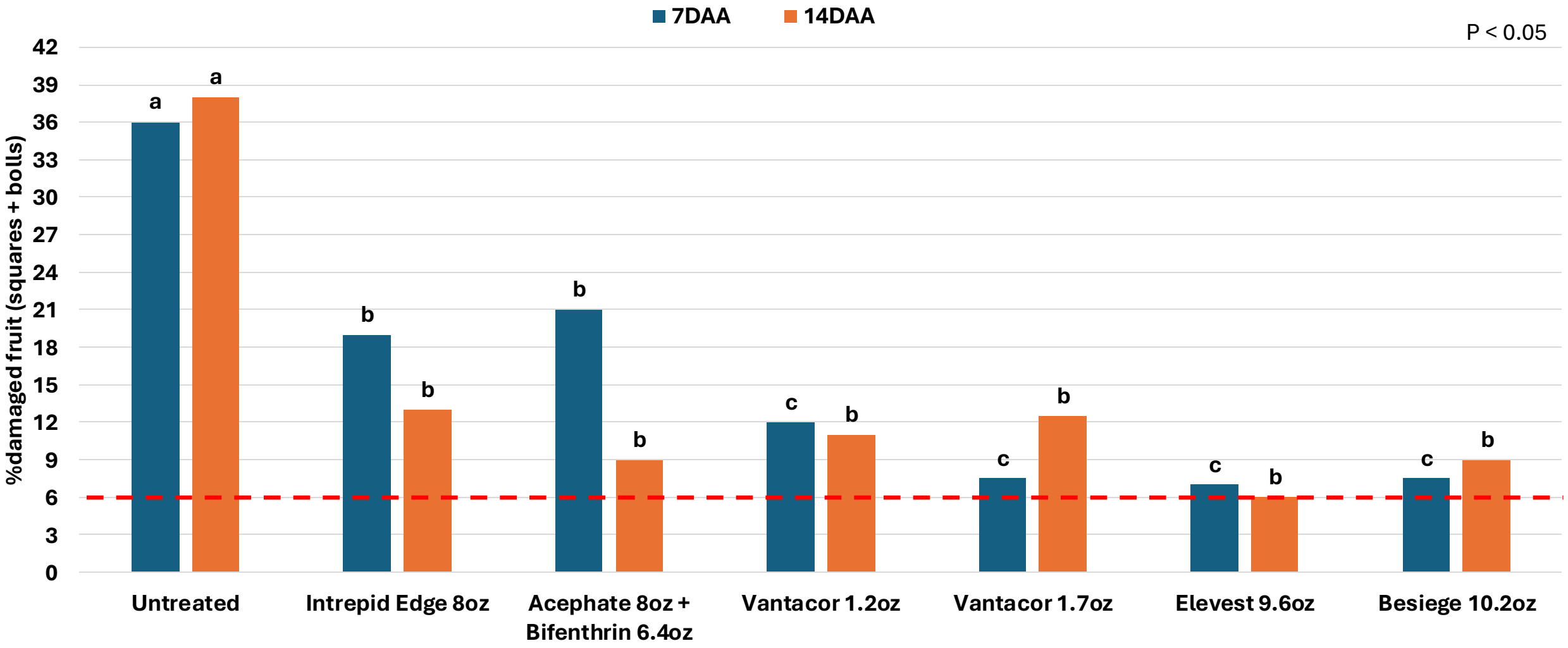
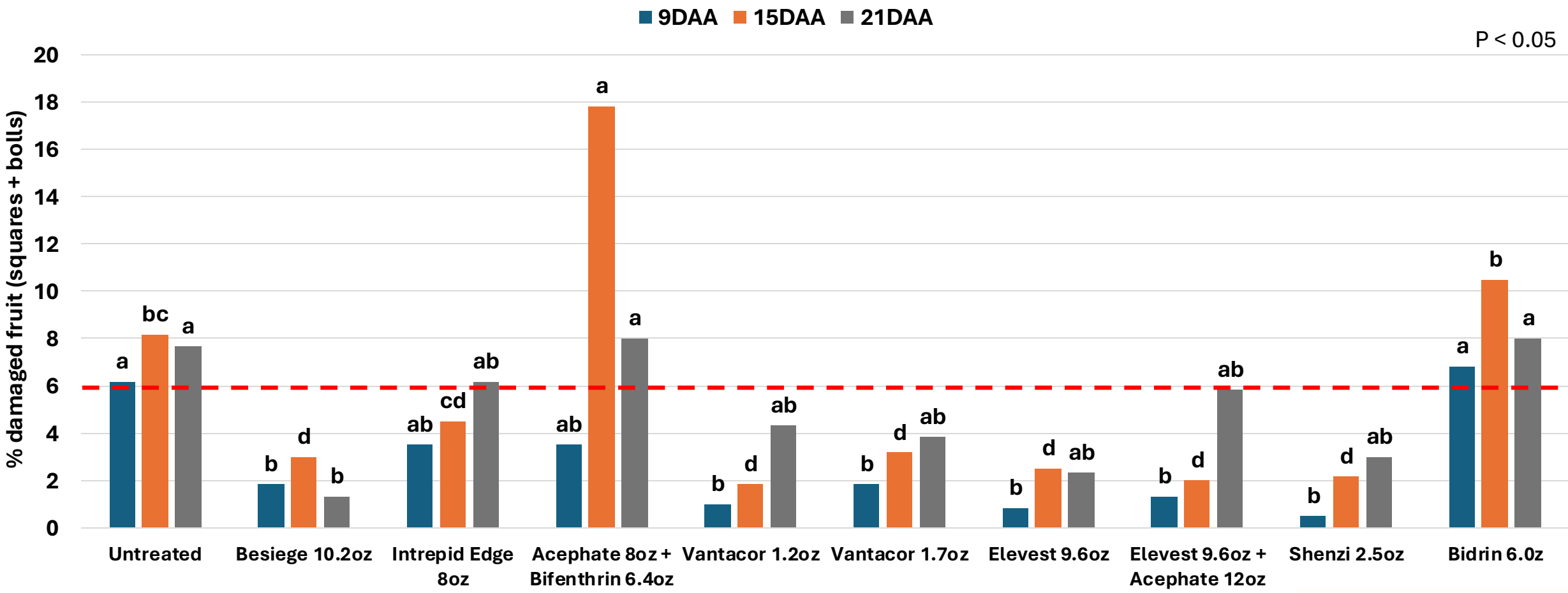
Foliar Insecticide Performance – Bollworms in Cotton 2023: AR, LA, TN, MS, TX

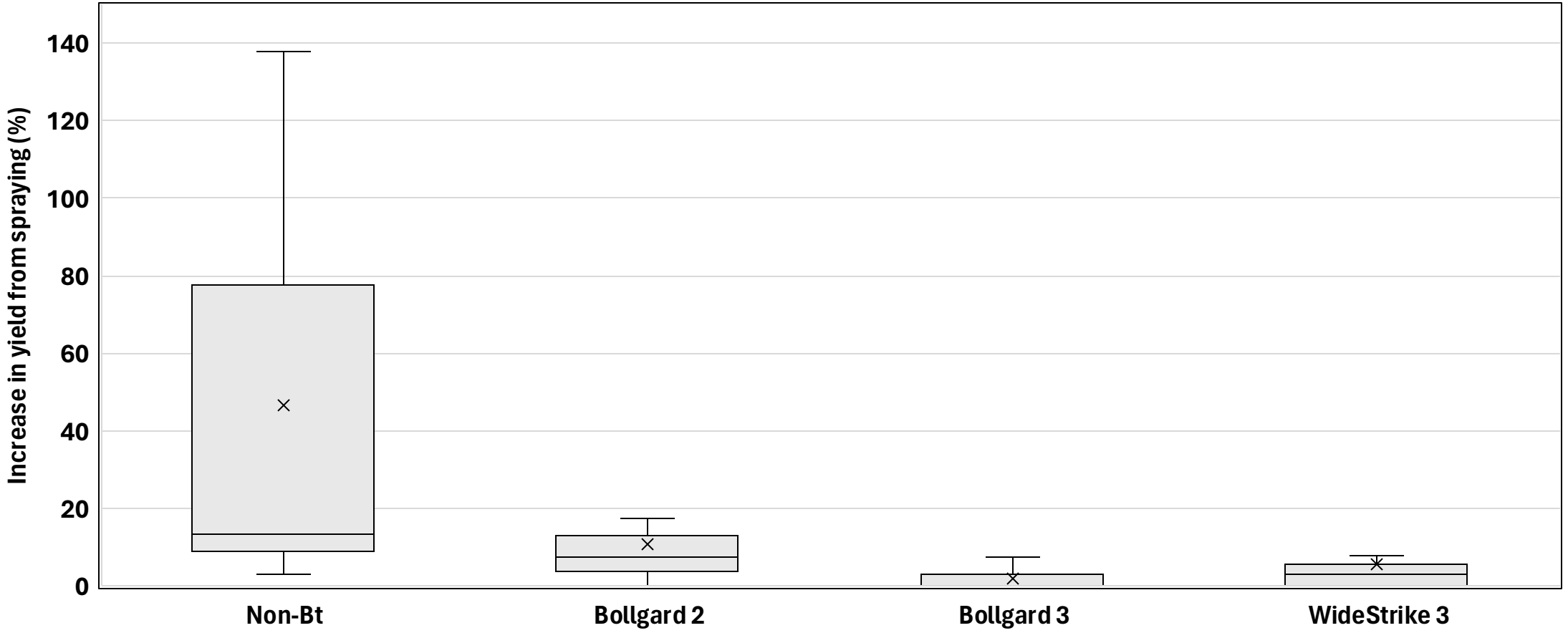


Foliar Insecticide Performance – Bollworms in Cotton 2024: Texas

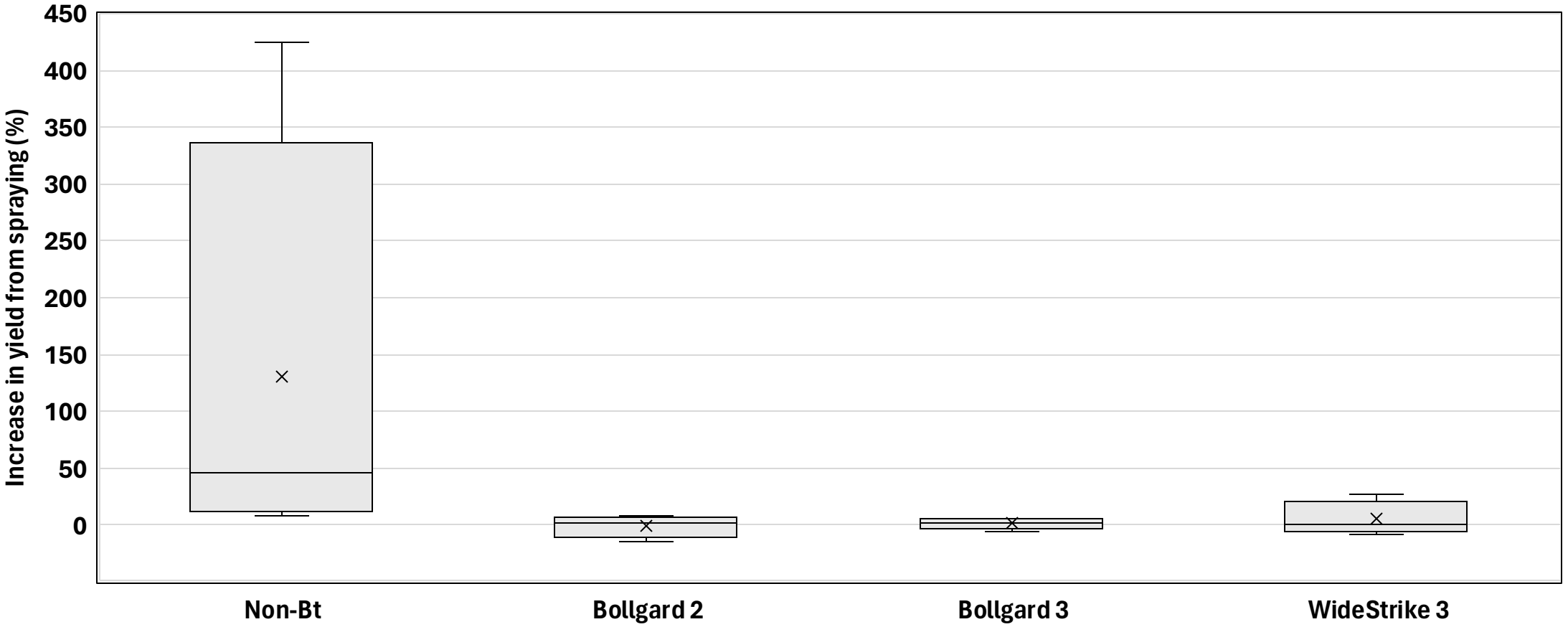


TEXAS A&M AGRILIFE EXTENSION

Diamide application affect on cotton yield- 2022: AR, LA, MS, TN, TX (7 locations)



Diamide application affect on cotton yield- 2023: AR, MS, TN, TX (4 locations)



Recommendations

- Plant Non-Bt or Non-Vip corn and use a refuge with Bt corn (not RIB)

- Treatment thresholds:
  - Dual-gene cotton
    - Treat at 20% egg lay
  - Triple-gene cotton
    - Treat at 6% injury (bolls+squares) or 4% larvae (1/4 or larger)
    - Notify extension personnel if damage is observed (damage unexpected)

- Be wary of pyrethroids
  - resistance is prevalent
  - flare spider mites/aphids

- Vantacor, Besiege, Elevest:
  - residual control needed
    - Use Vantacor 1.7 fl-oz, Besiege at 9-10 fl-oz, or Elevest at 9.6 fl-oz/ac
  - residual control not needed
    - Use Vantacor at 1.2 fl-oz, Besiege at 7-8 fl-oz, or Elevest at 6.8 fl-oz/ac
  - Timing is most important!

Acknowledgements

Contact Information

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ddkerns@agcenter.lsu.edu

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