

Combatting Insecticide Resistance in US Agriculture: Understanding, Evolution, and Solutions

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What's so bad about insecticide resistance?

- Economic
- Environmental
- Cross Resistance

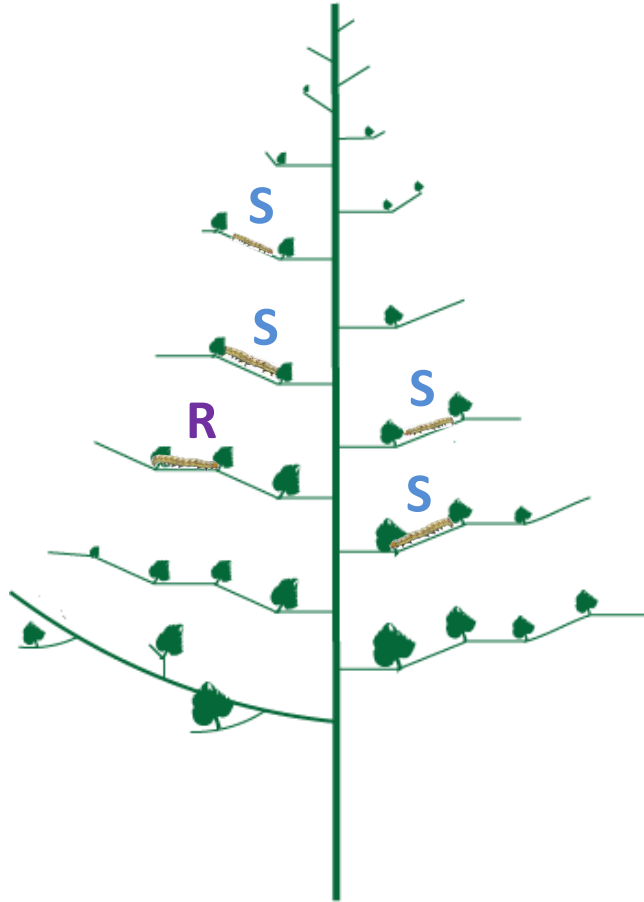


Structure

1. Understanding insecticide resistance
2. Mechanisms of resistance
3. Types of resistance
4. Delivery systems
5. Genetic flow of resistance
6. Strategies for resistance management
7. Future challenges and solutions
8. Conclusion
9. Discussion, Q&A

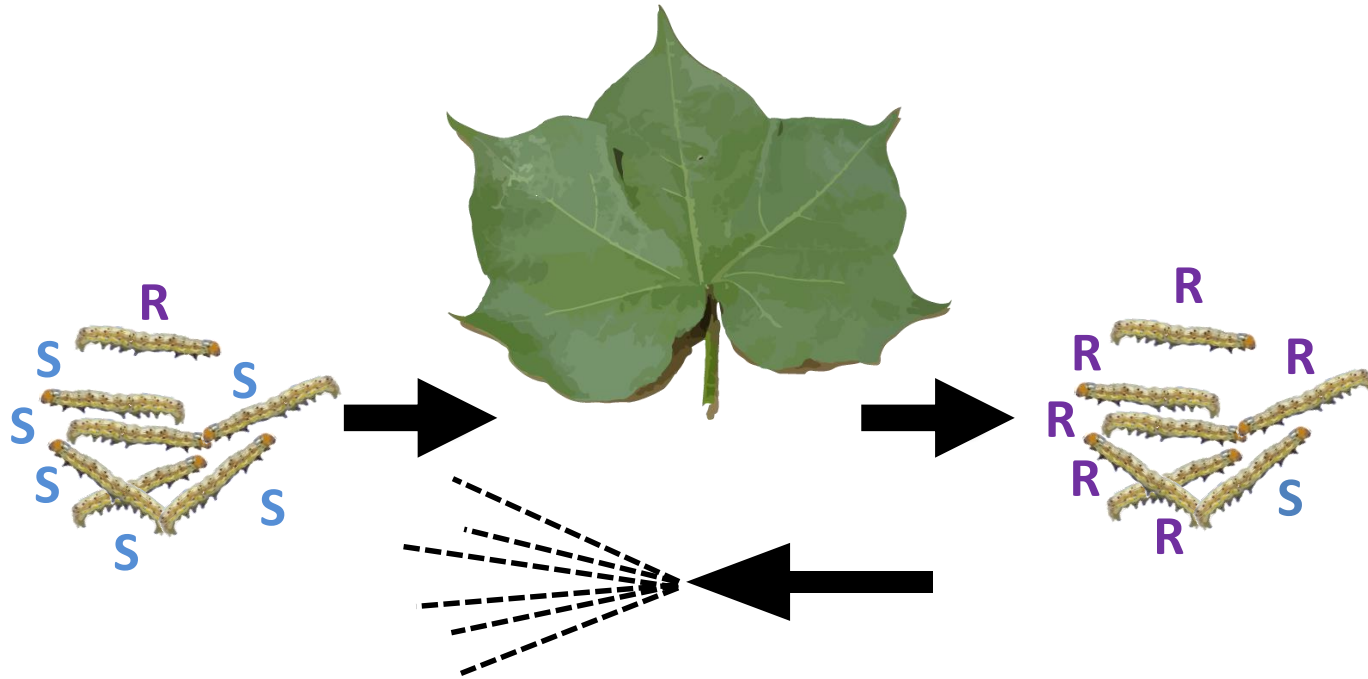
Defining Insecticide Resistance

- Laboratory selected resistance
- Field evolved resistance
- Practical resistance
- Incomplete resistance
- Complete resistance

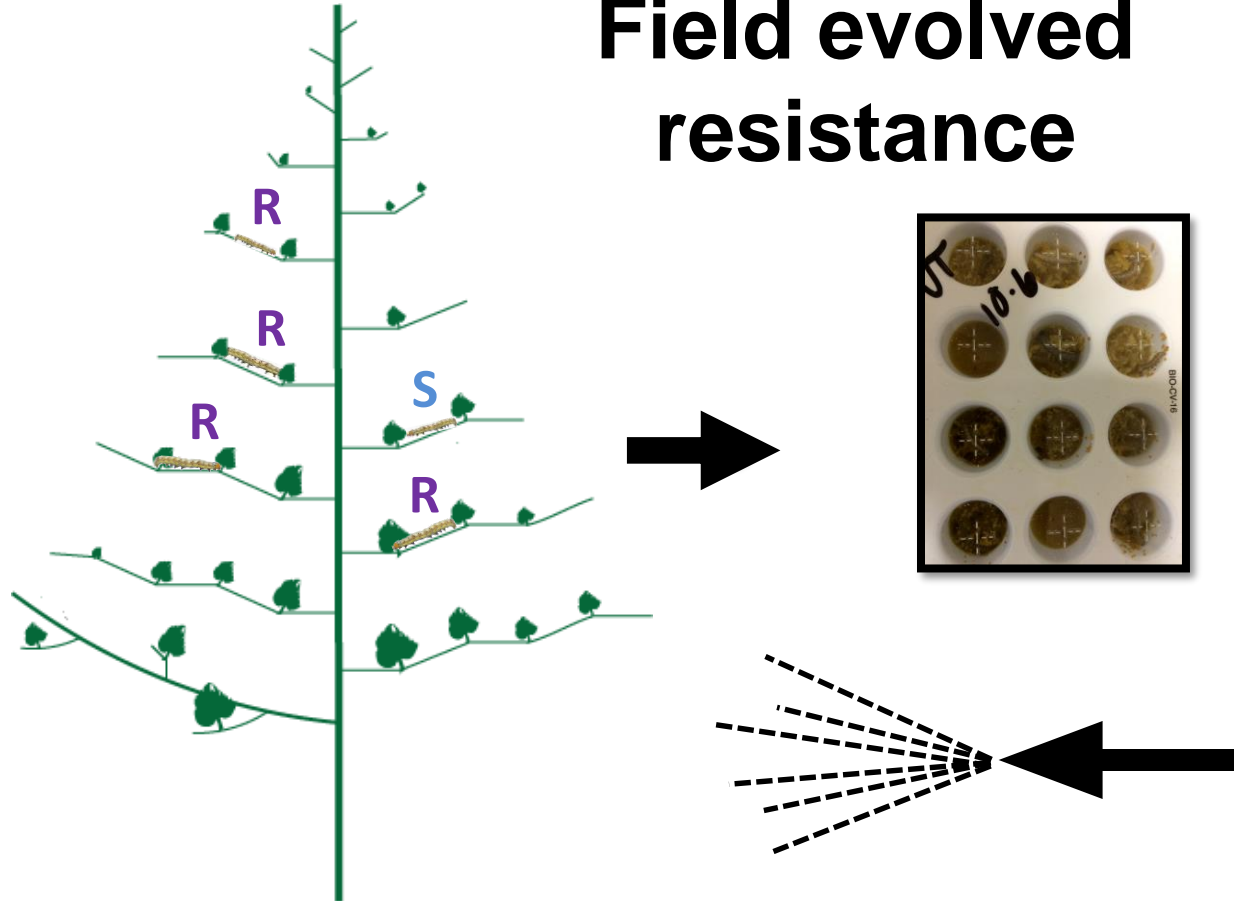


**Baseline
susceptibility**

Laboratory selected resistance



Field evolved resistance

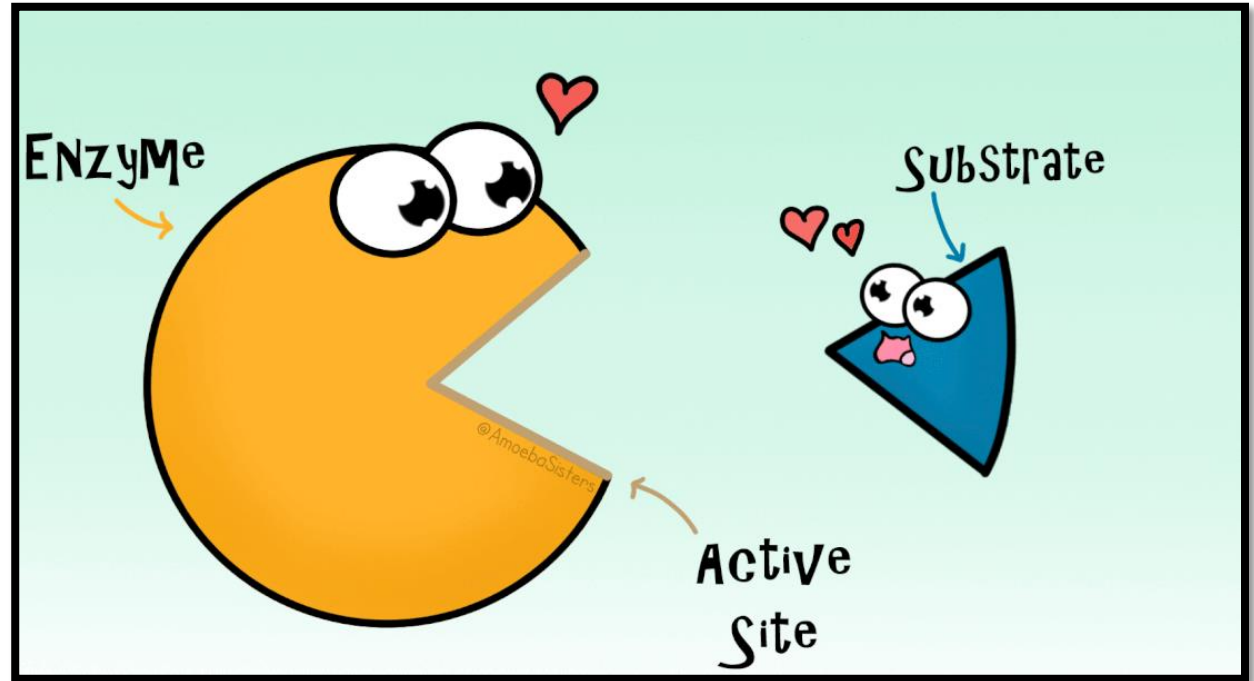


Defining Resistance

- Laboratory selected resistance
- Field evolved / field selected resistance
- Practical / field resistance
- **Incomplete resistance**
- **Complete resistance**

Mechanisms of resistance

- Metabolic



Mechanisms of resistance

- Metabolic
- Target-site



Mechanisms of resistance

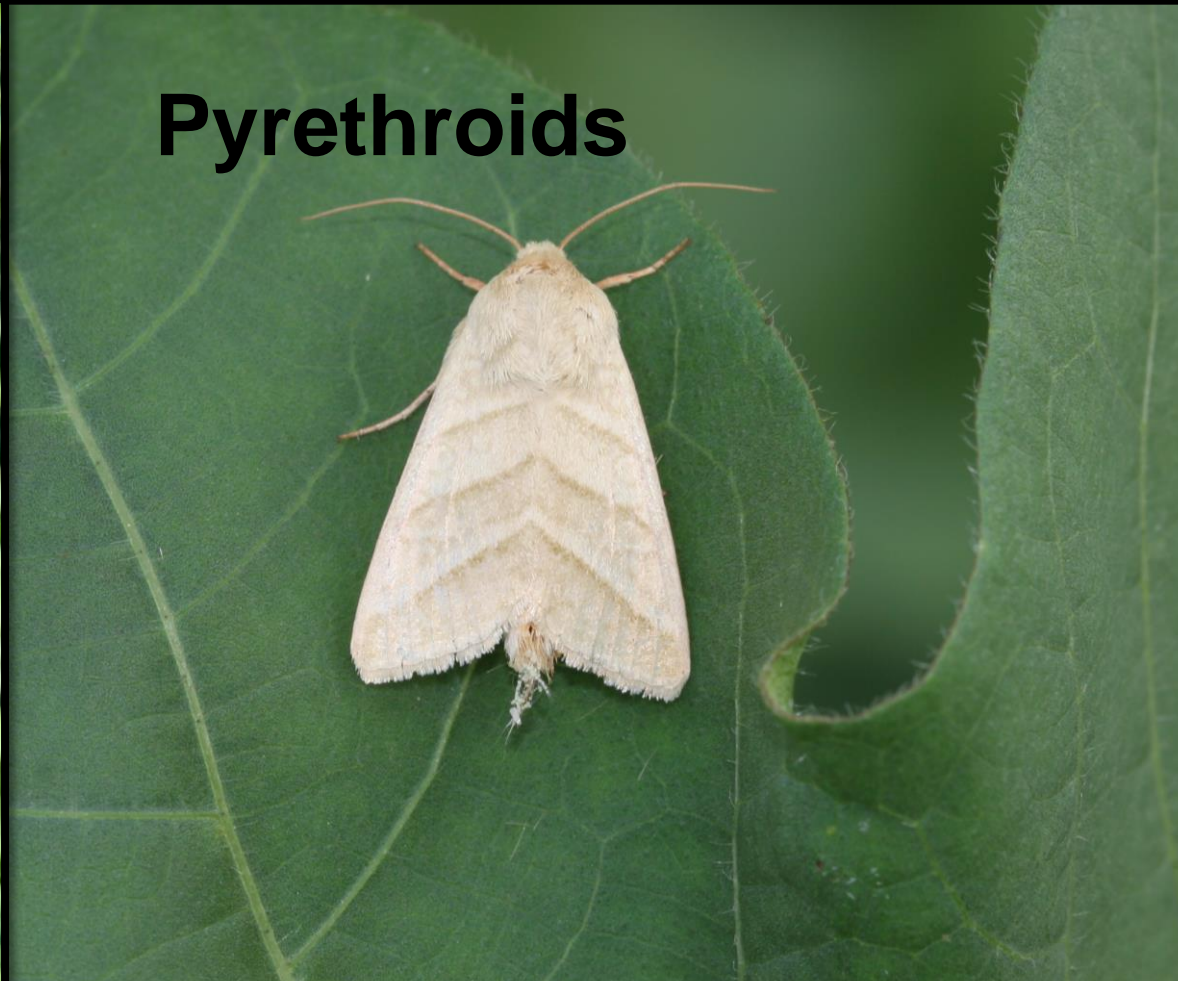
- Metabolic
- Target-site
- Penetration
- Behavioral

Types of insecticide resistance

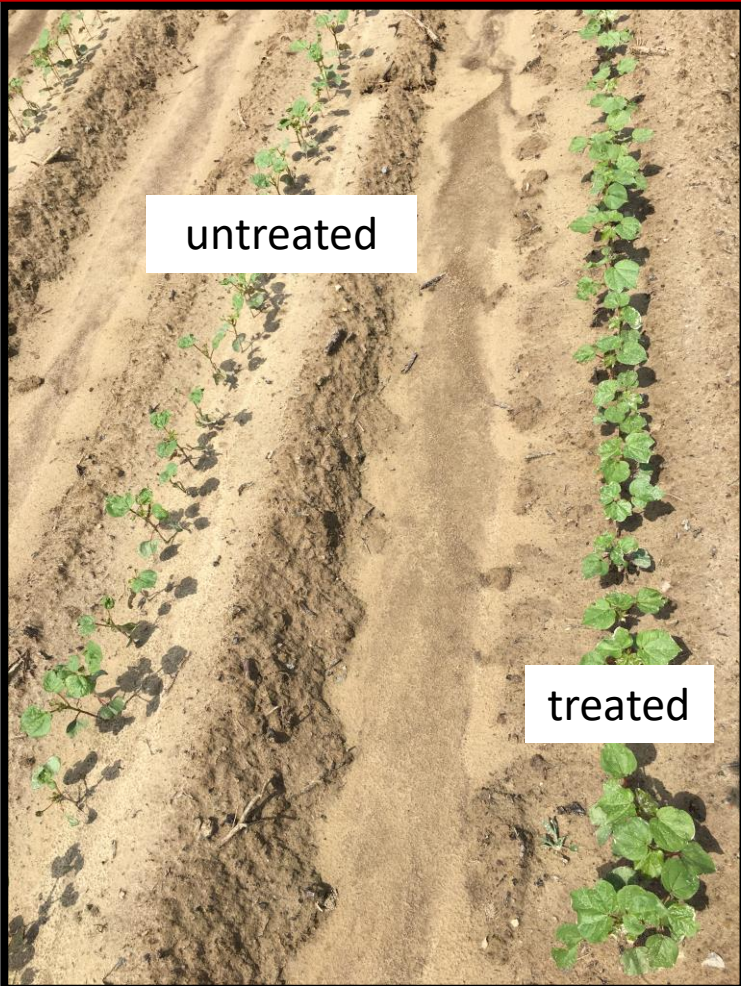
- Organophosphates
- Pyrethroids
- Neonicotinoids
- Diamides

Organophosphates





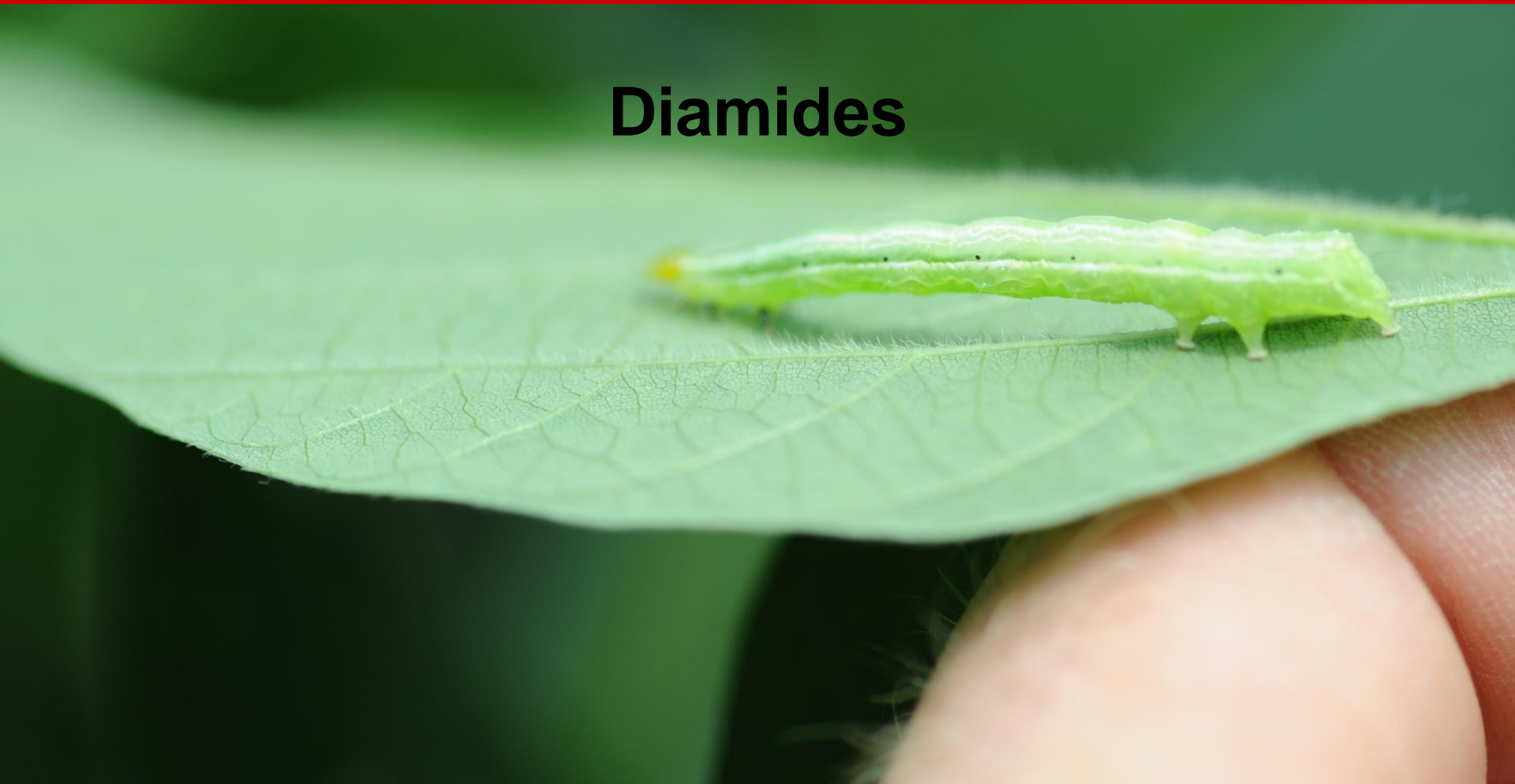
Pyrethroids



Neonicotinoids



Diamides



Delivery systems relative to resistance

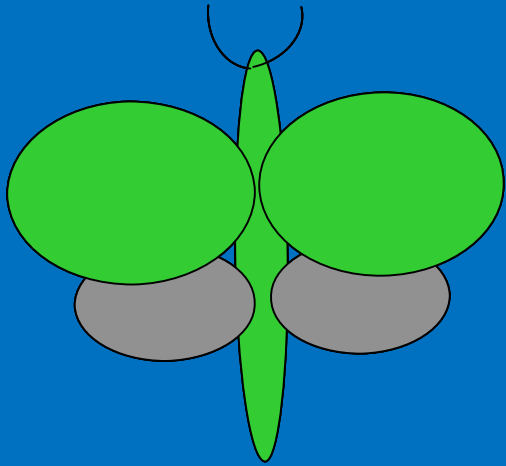
- Foliar sprays
- Seed treatments
- Soil applications
- Biological control agents
- Trap and kill
- Transgenic crops
- Chemigation

Delivery systems relative to resistance

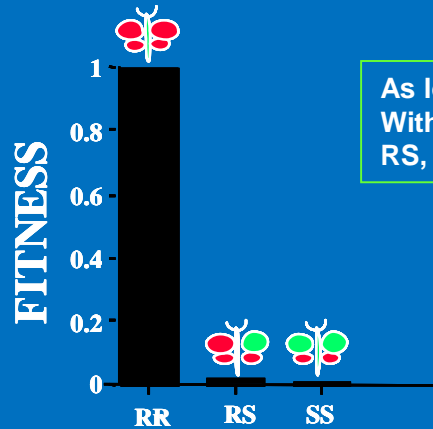
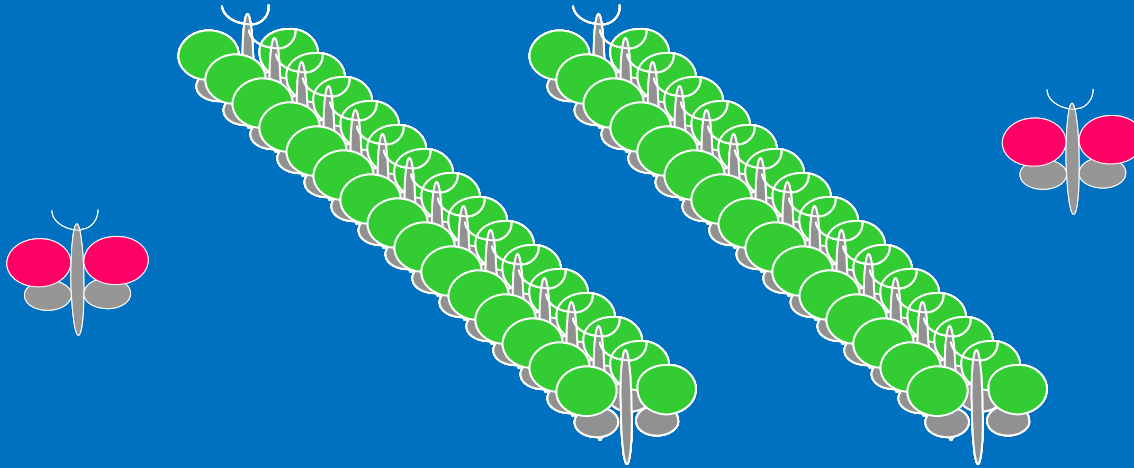
- Foliar sprays
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- Transgenic crops
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Genetic flow of resistance

- Genetic basis of resistance
- Fitness

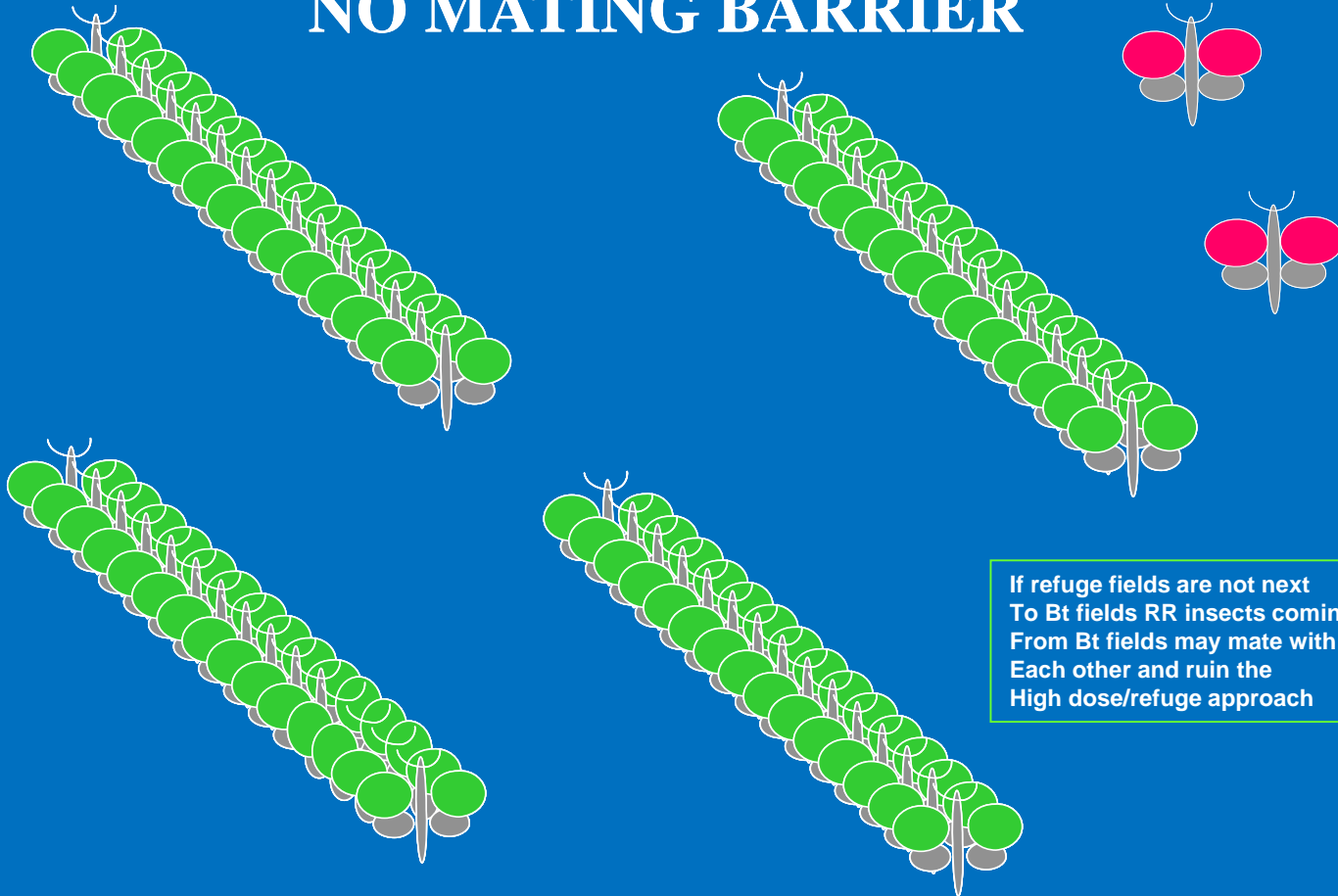


A BARRIER TO MATING



As long as all RR insects mate
With SS insects all offspring are
RS, and these have low fitness

NO MATING BARRIER

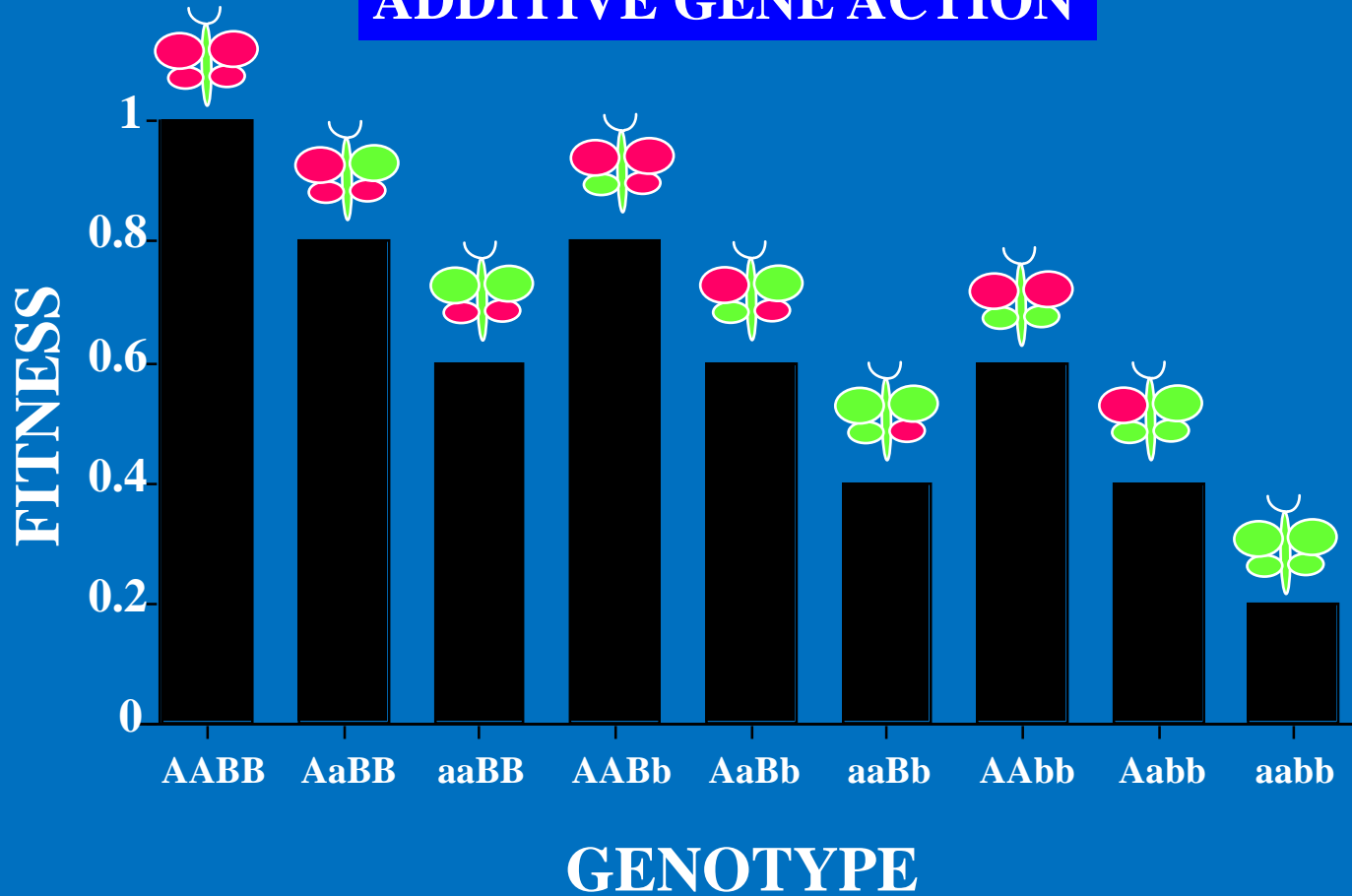


If refuge fields are not next
To Bt fields RR insects coming
From Bt fields may mate with
Each other and ruin the
High dose/refuge approach

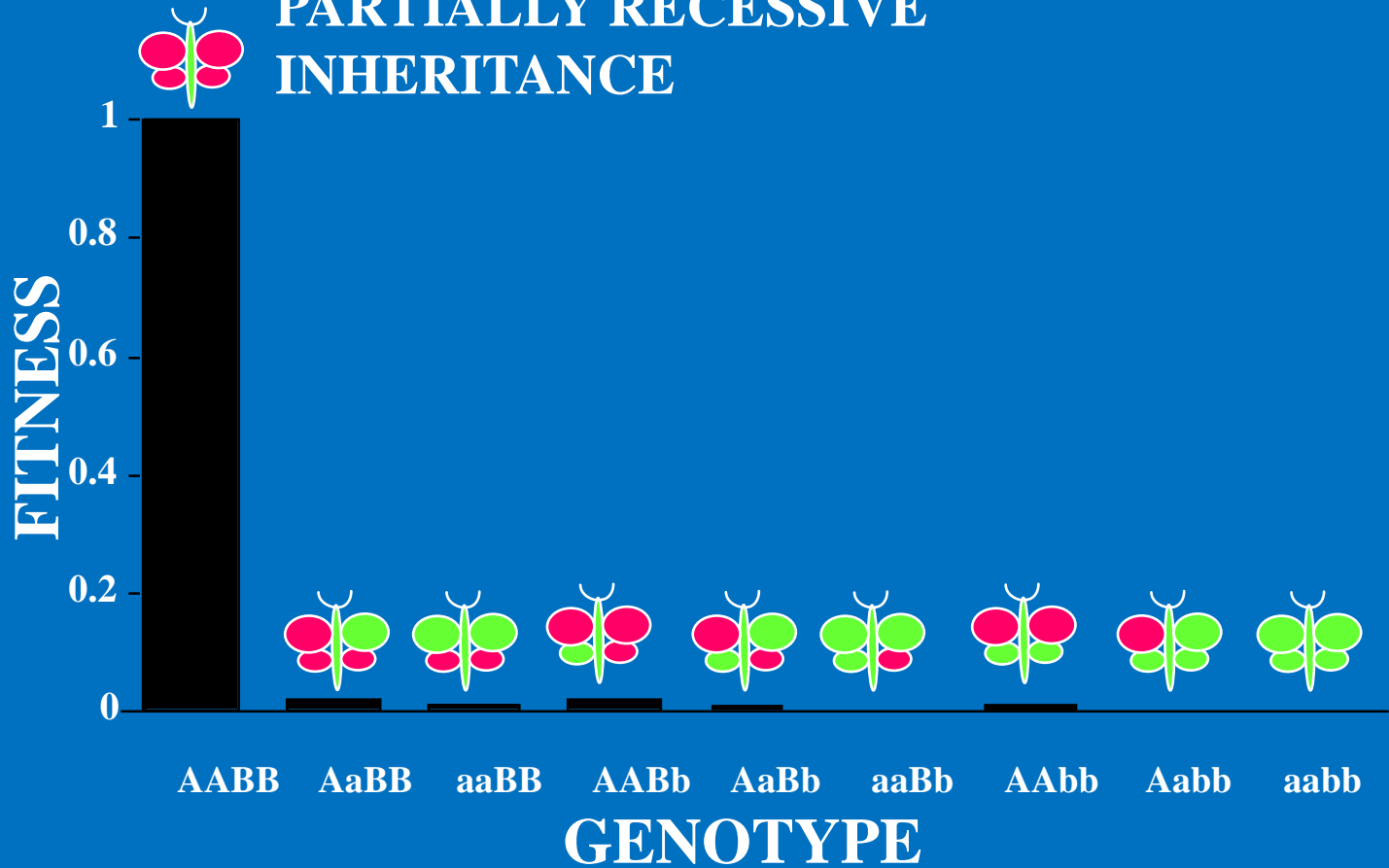
NINE GENOTYPES

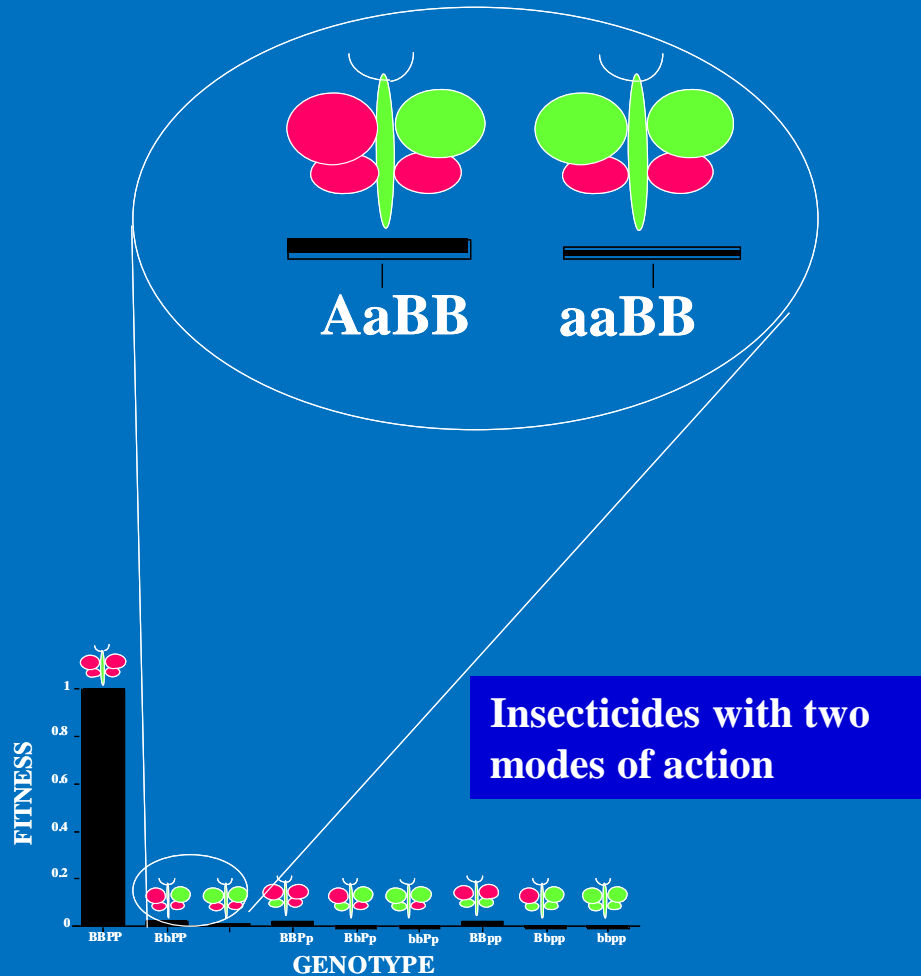


ADDITIVE GENE ACTION



PARTIALLY RECESSIVE INHERITANCE





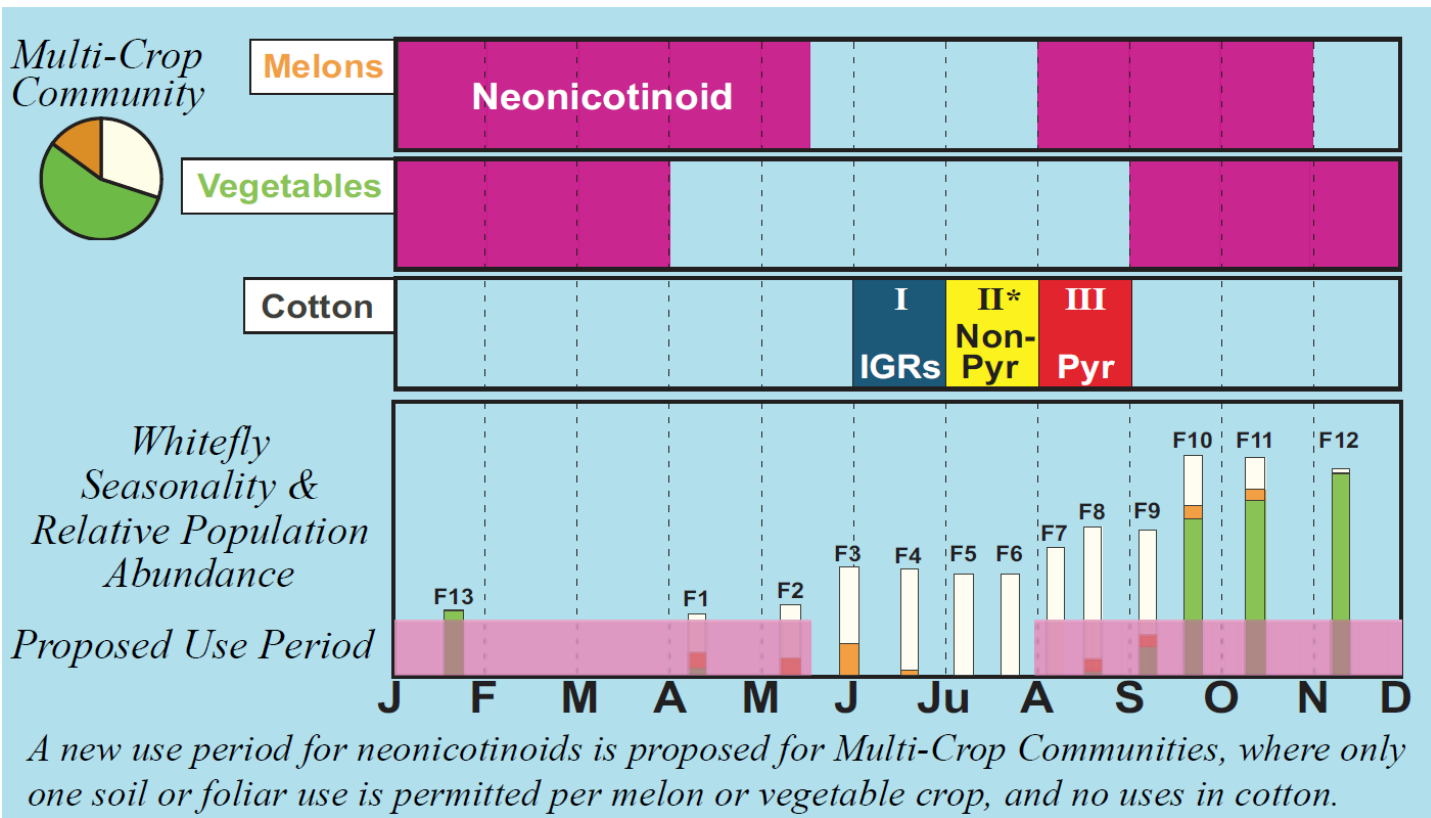
Strategies for resistance management

- Use insecticides only when needed
- IPM
- Rotate modes of action

Keys to whitefly management in AZ cotton

- Good sampling methods and thresholds
- Timing and rotation of insecticides through the year
 - Preserves natural enemies
- Good available suite of effective modes of action

Stage & Timing of Use	Insecticides (MOA Group No.)	Rate	Safety to Beneficials	Control Interval ¹	Strategic Fit ²
Stage I Chemistry (Full Selectivity) Timing: 40% disks infested with ≥1 large nymph and 40% leaves infested with ≥3 adults	<i>buprofezin</i> , Courier 40SC (Group 16)	12.5 oz	Excellent	14–30 days	<ul style="list-style-type: none"> no more than 1 use per season; 1st spray for long-term control and bioresidual; safe on beneficials; appropriate up to 30 days before green-leaf drop; molting inhibitor, effective against nymphs.
	<i>pyriproxyfen</i> , Knack Insect Growth Regulator (Group 7C)	8–10 oz	Excellent	14–30 days	<ul style="list-style-type: none"> no more than 1 use per season; 1st spray for long-term control and bioresidual; safe on beneficials; appropriate up to 30 days before green-leaf drop; juvénoid, effective against eggs and mature nymphs.
	<i>spiromesifen</i> , Oberon 2SC (Group 23)	8–10 oz	Excellent at these rates*	14–30 days	<ul style="list-style-type: none"> no more than two, non-consecutive uses per season; 1st spray for long-term control and bioresidual; safe on beneficials at this rate range*; appropriate up to 21 days before green-leaf drop; lipid synthesis inhibitor, effective primarily against nymphs.
Stage II Chemistry (Partial Selectivity) Timing: 57% leaves infested with ≥3 adults	<i>spiromesifen</i> , Oberon 2SC (Group 23)	12–16 oz	Good at these rates	14–30 days	<ul style="list-style-type: none"> no more than two, non-consecutive uses per season; follow-up spray for long-term control; good, but partial, safety for beneficials; lipid synthesis inhibitor, effective primarily against nymphs.
	<i>acetamiprid</i> , Intruder WSP (Group 4A)	1.7–2.3 oz	Moderate	14–30 days	<ul style="list-style-type: none"> no more than two, non-consecutive uses per season**; follow-up spray for moderate to long-term control, or; before Stage I, late season or to control mass migrations; partial safety for beneficials; neonicotinoid, effective against all stages.
	<i>dinotefuran</i> , Venom 20SG (Group 4A)	10.7 oz	Moderate	7–14 days	<ul style="list-style-type: none"> no more than two, non-consecutive uses per season**; short-term control; partial safety for beneficials; neonicotinoid, effective against all stages.
	<i>thiamethoxam</i> , Centric 40WG (Group 4A)	2 oz	Moderate	7–14 days	<ul style="list-style-type: none"> no more than two, non-consecutive uses per season**; short-term control; partial safety for beneficials; neonicotinoid, effective against all stages.
	<i>Other Non-Pyrethroids</i>	various	Poor to Fair	5–10 days	<ul style="list-style-type: none"> broad spectrum, short-term control only, late season; primarily adulticidal; only limited control of other stages.
Stage III Synergized Pyrethroids <i>(see Stage II timing)</i>	<i>Pyrethroid combinations</i> (Group 3)	various	Poor	7–14 days	<ul style="list-style-type: none"> no more than two pyrethroids per season; broad spectrum, short-term control only, late season; primarily adulticidal; only limited control of other stages.

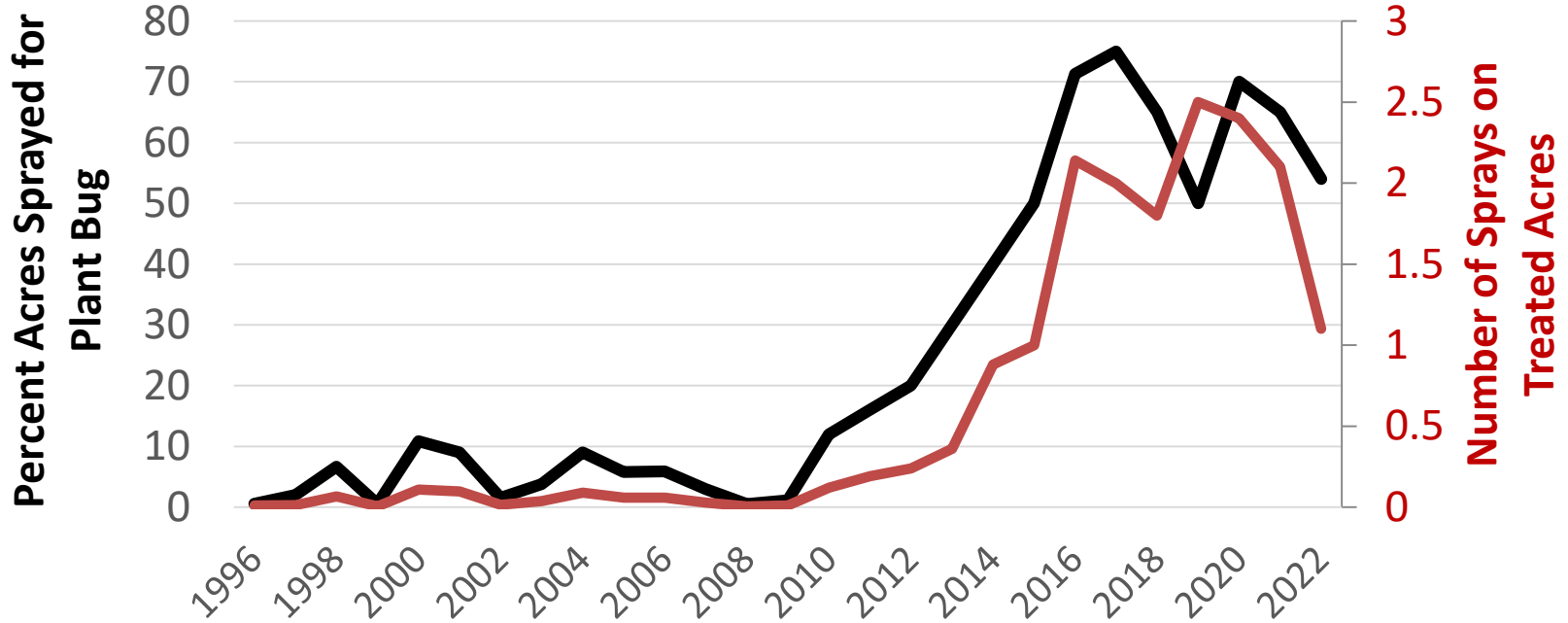




Tarnished plant bug

- Sampling methods and thresholds
- Timing and rotation of insecticides
- Available suite of effective modes of action
- Multi-crop collaboration

North Carolina Tarnished Plant Bug Sprays



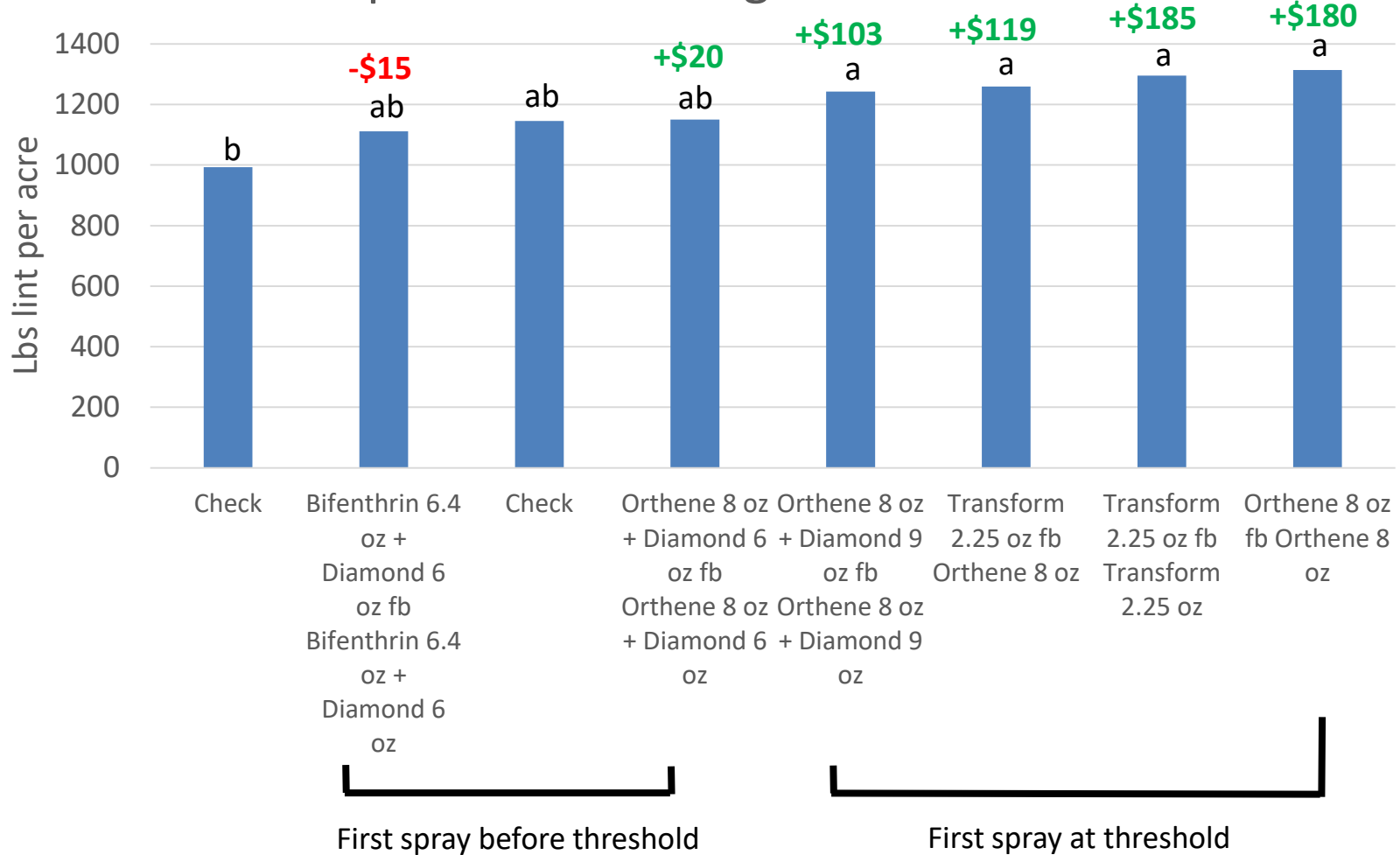
Treating plant bugs in cotton







Net profit over average of two checks



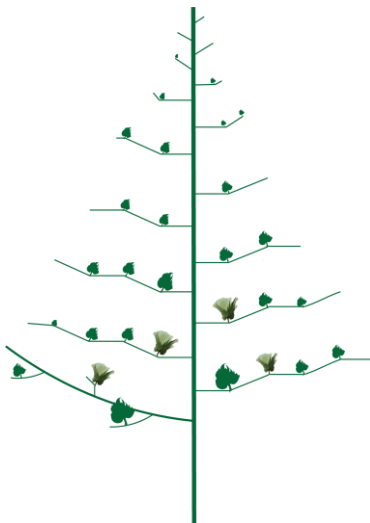
One spray

Centric



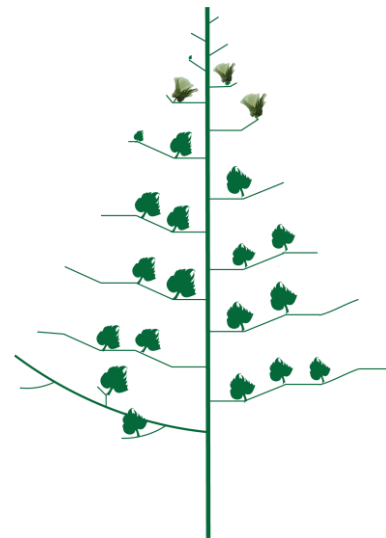
June

Transform
> 2oz



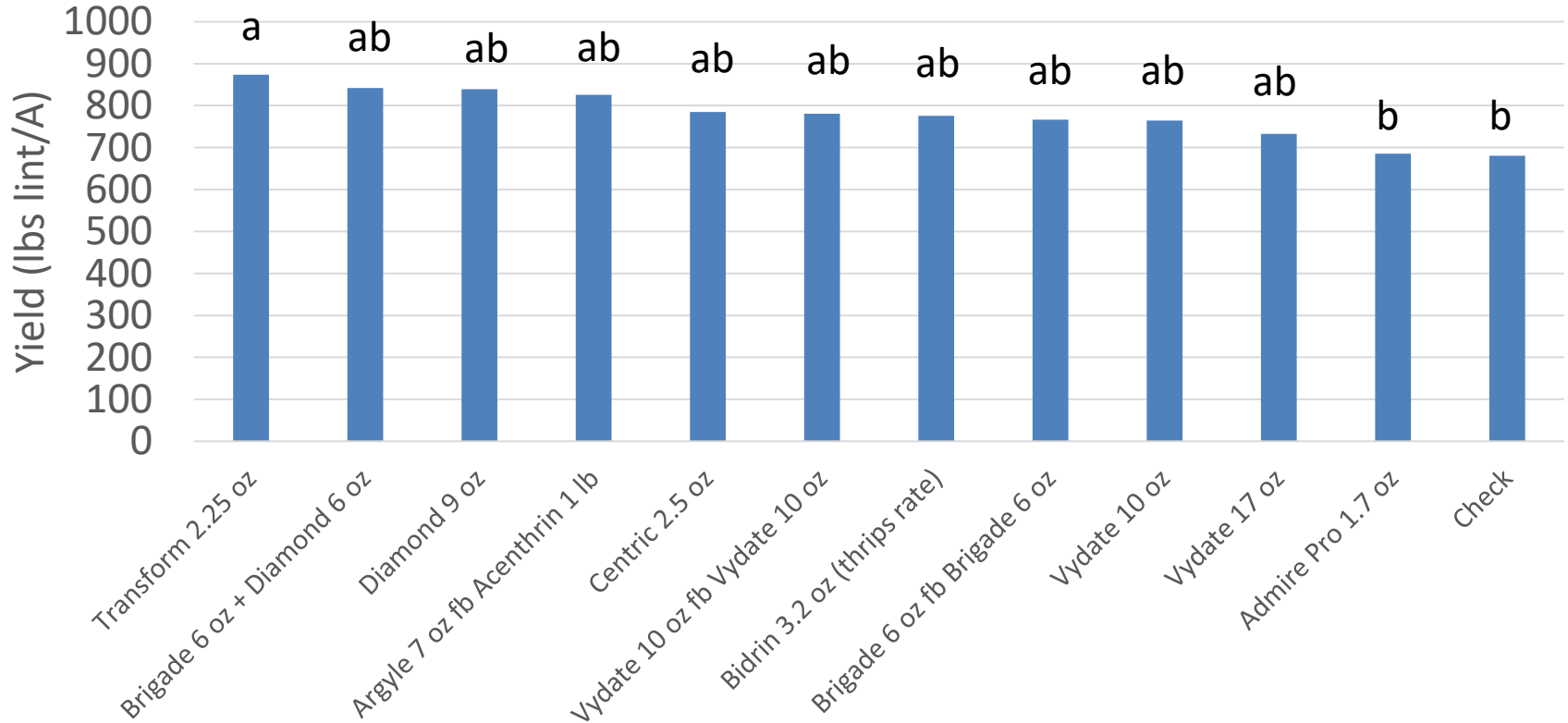
July-early August

Pyrethroid + Orthene
OR
Bidrin
OR
Transform >2oz



mid August- September

Yield- tarnished plant bug spray trial, Plymouth, NC, 2018



Three sprays

Centric

Transform > 2oz (no nymphs)

OR

Transform + Diamond 6 oz (nymphs)

fb (if needed)

Admire OR Centric + Transform

Pyrethroid + Orthene

OR

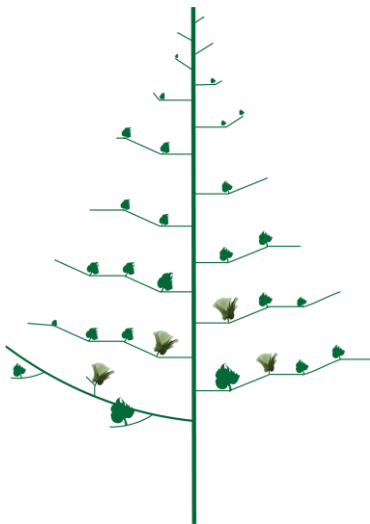
Bidrin

OR

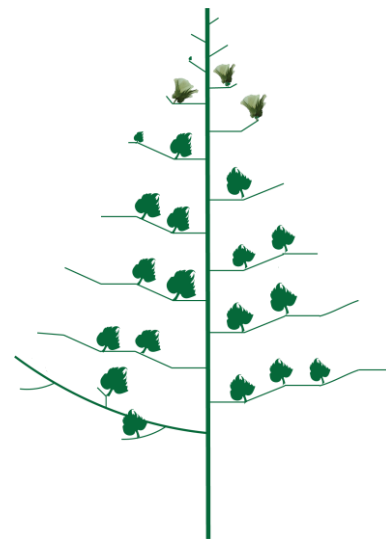
Transform >2oz



June



July-early August

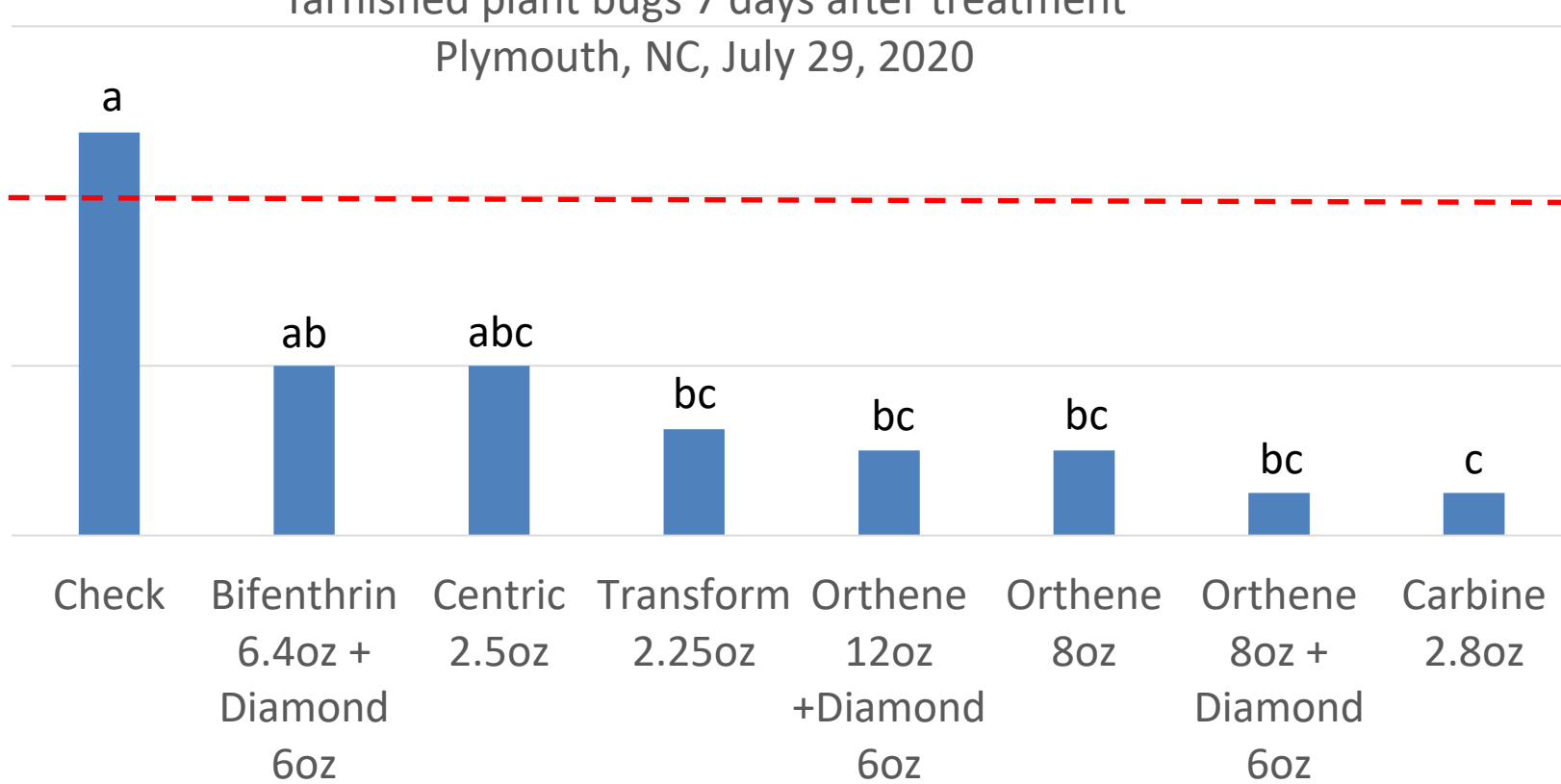


mid August- September

Tarnished plant bugs 7 days after treatment

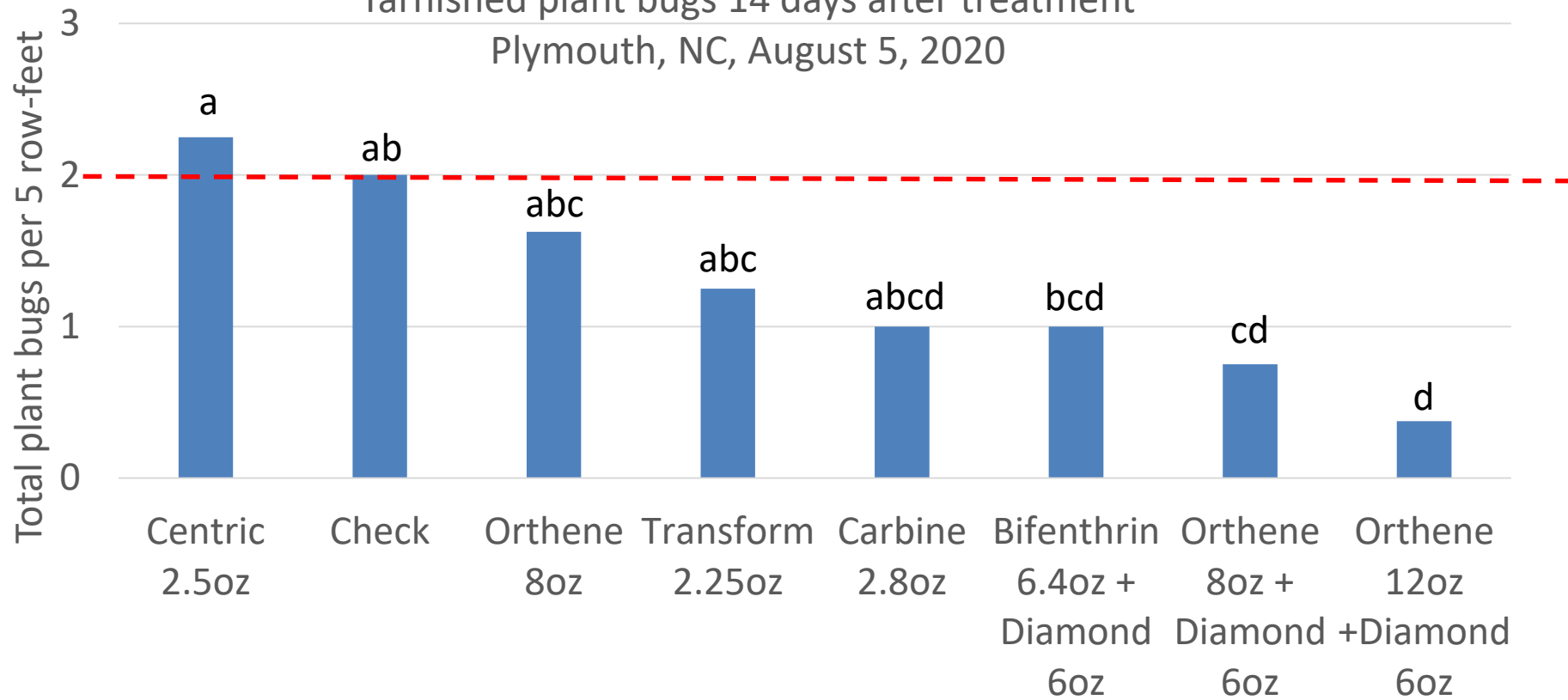
Plymouth, NC, July 29, 2020

Total plant bugs per 5 row-feet



Tarnished plant bugs 14 days after treatment

Plymouth, NC, August 5, 2020



Four + sprays

Transform > 2oz (no nymphs)

OR

Transform + Diamond 6 oz (nymphs)

fb (if needed)

Admire OR Centric + Transform

fb (if needed)

Pyrethroid + Orthene

OR

Bidrin

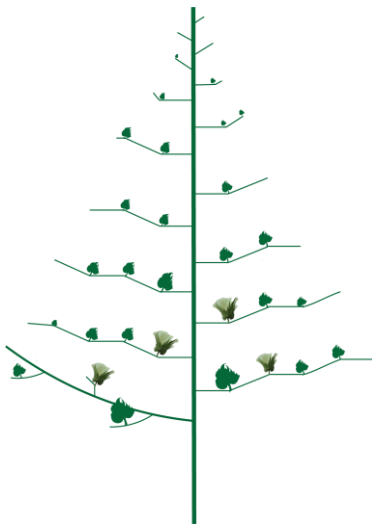
OR

Transform >2oz

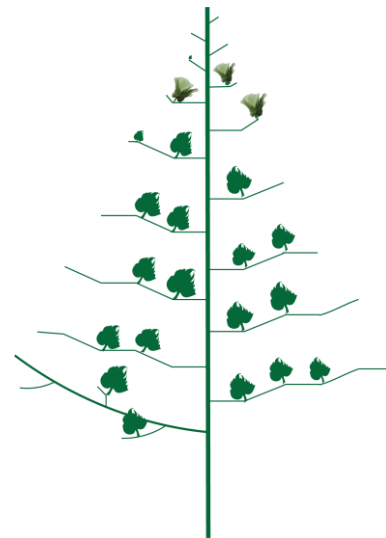
Centric
fb (if needed)
Transform > 2oz



June



July-early August

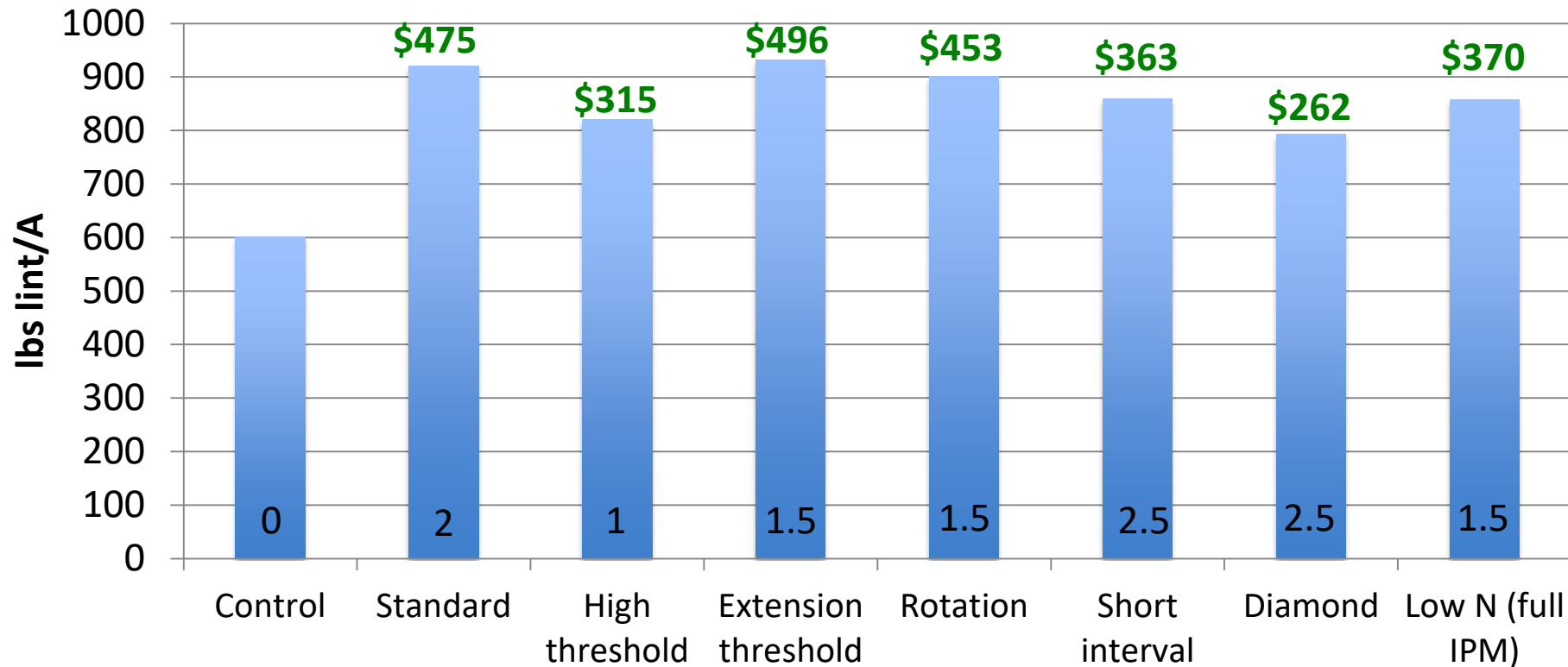


mid August- September

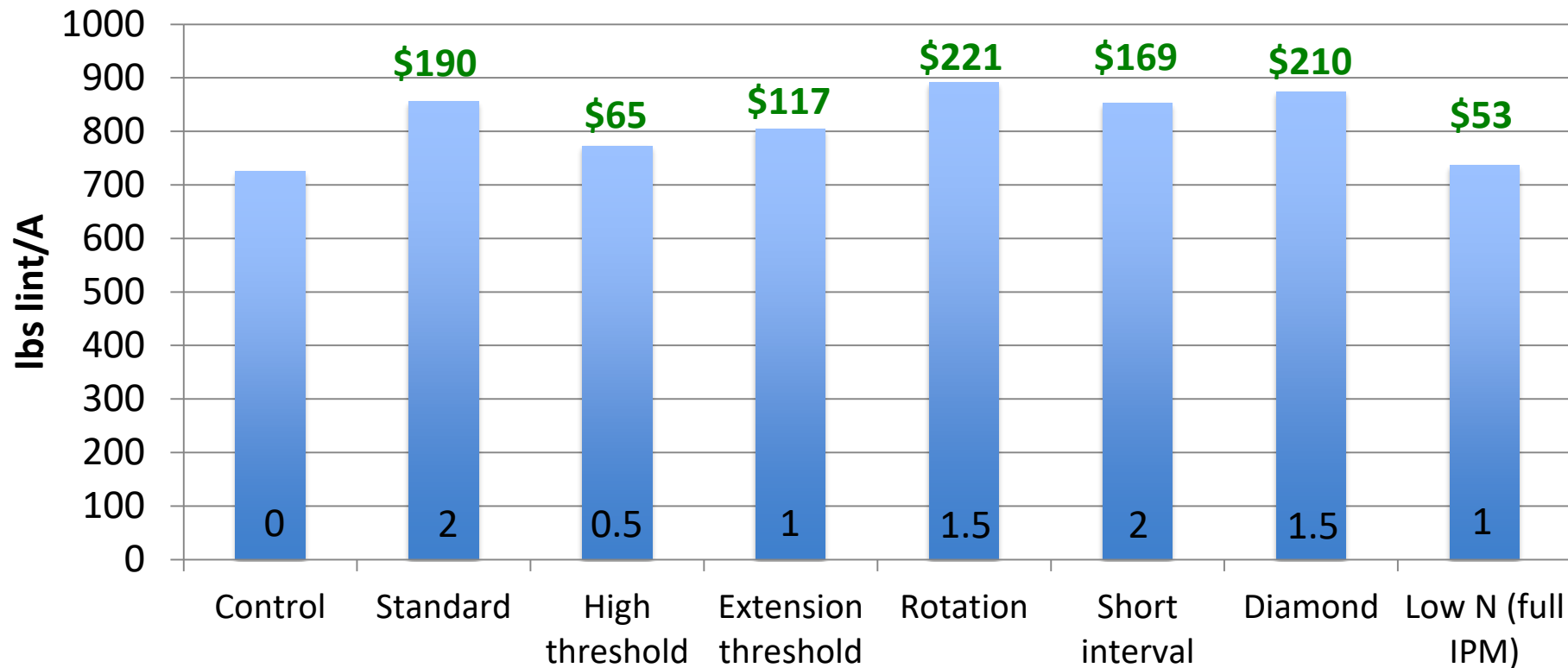
Putting it all together

Treatment	Threshold	Rotation	Interval	Diamond	Nitrogen
Control	No	No	No	No	120 lbs/A
Standard	No	No	7 days	No	120 lbs/A
High Threshold	Yes	No	7 days	No	120 lbs/A
Extension Threshold	Yes	No	7 days	No	120 lbs/A
Rotation	Yes	Yes	7 days	No	120 lbs/A
Interval	Yes	Yes	3-4 days	No	120 lbs/A
Diamond	Yes	Yes	3-4 days	Yes	120 lbs/A
Low N (full IPM)	Yes	Yes	3-4 days	Yes	80 lbs/A

Best Management Practices- DP1835 (semi-smooth)



Best Management Practices- DP1840 (smooth)



Future challenges

Challenges

- Multiple pests
- Pests that infest multiple crops





- Future solutions
- Negative cross-resistance

Future challenges

Challenges

- Multiple pests
- Pests that infest multiple crops

- Future solutions

	Genotype	
	One	Two
Toxin A		
Toxin B		

Future challenges

Challenges

- Multiple pests
- Pests that infest multiple crops

- Future solutions
- Negative cross-resistance
- Biologicals

Conclusion

- You will continue to contend with insecticide resistance
- Consultants are KEY