Building innovative management plans for challenging soybean pests

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Outline

- Review of Integrated Pest Management (IPM) activities for annual crops
- Varied pest life histories challenge some IPM strategies
- How does pesticide resistance develop?
- Case study: practical management of thrips neonicotinoid resistance
- Looking to the future: managing current and emerging soybean pests

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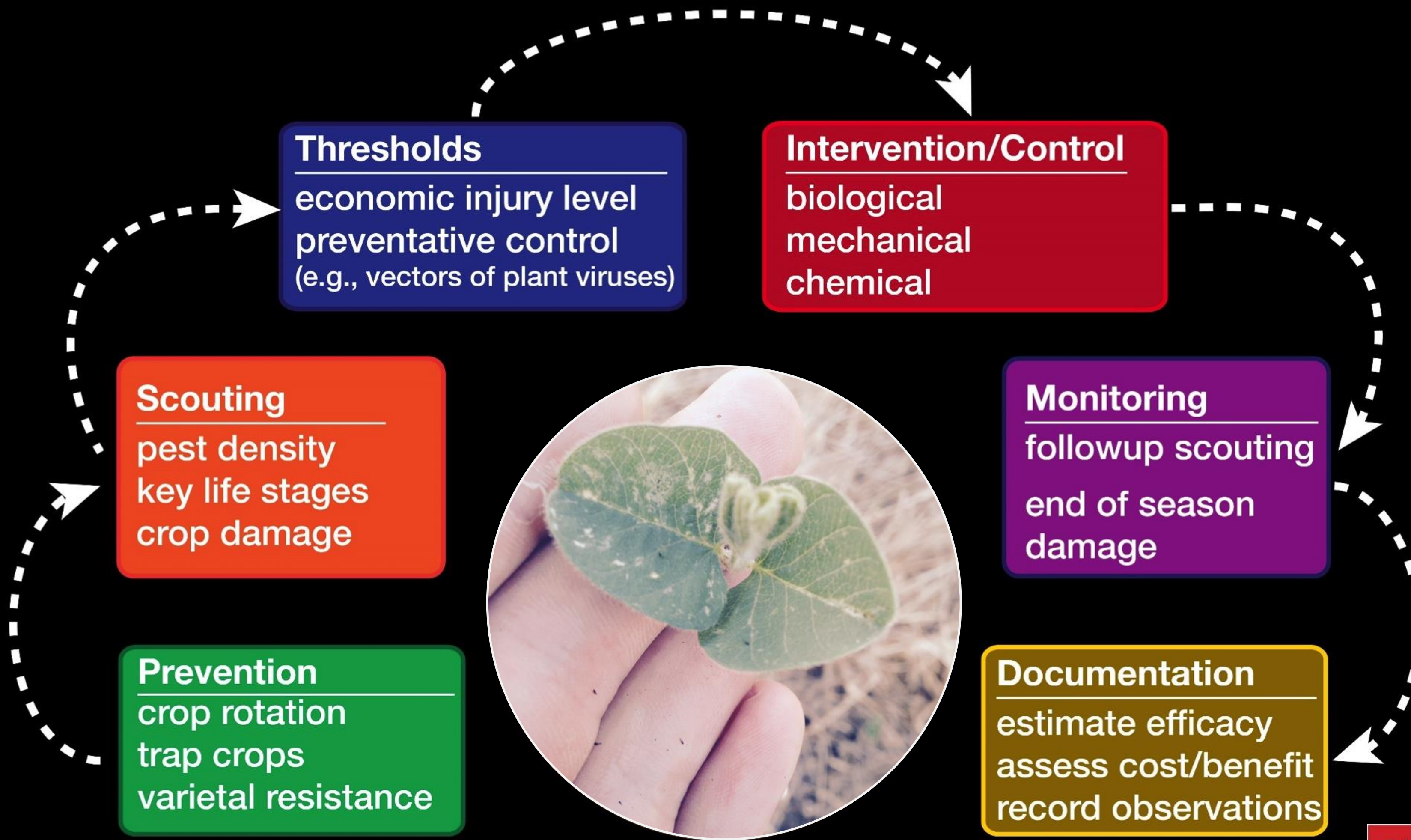
Back to the basics: IPM in a nutshell

Integrated Pest Management (IPM) is a science-based approach to minimize pest damage using a combination of intervention strategies.



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Pest diversity complicates soybean IPM

Bean leaf beetle
(*Cerotoma trifurcata*)

Corn earworm (podworm)
(*Helicoverpa zea*)

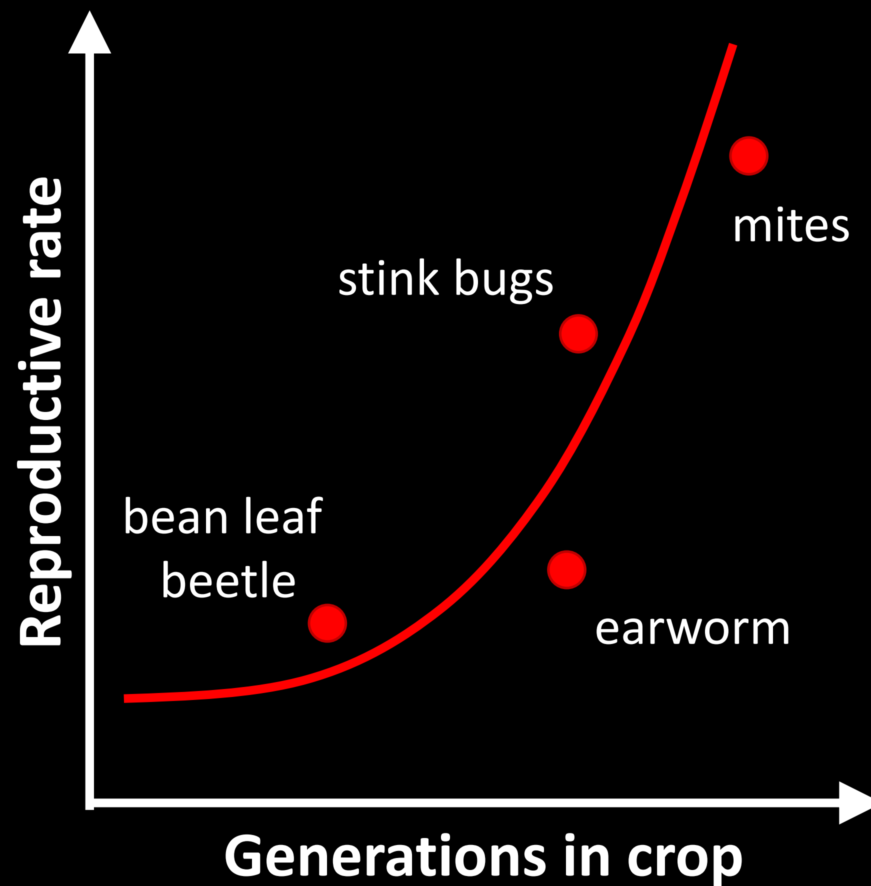
Soybean looper
(*Chysodeixis includens*)

Stink bugs

A diversity of life cycles poses IPM challenges

***A few factors driving pest issues*:**

- Generation time (egg → adult)
- Generations each season
- Pest feeding mode (leaf chewers, piercing sucking pests, root chewers)
- Reproductive rate
- Dispersal potential
- Host plant diversity (monophagous ↔ polyphagous)



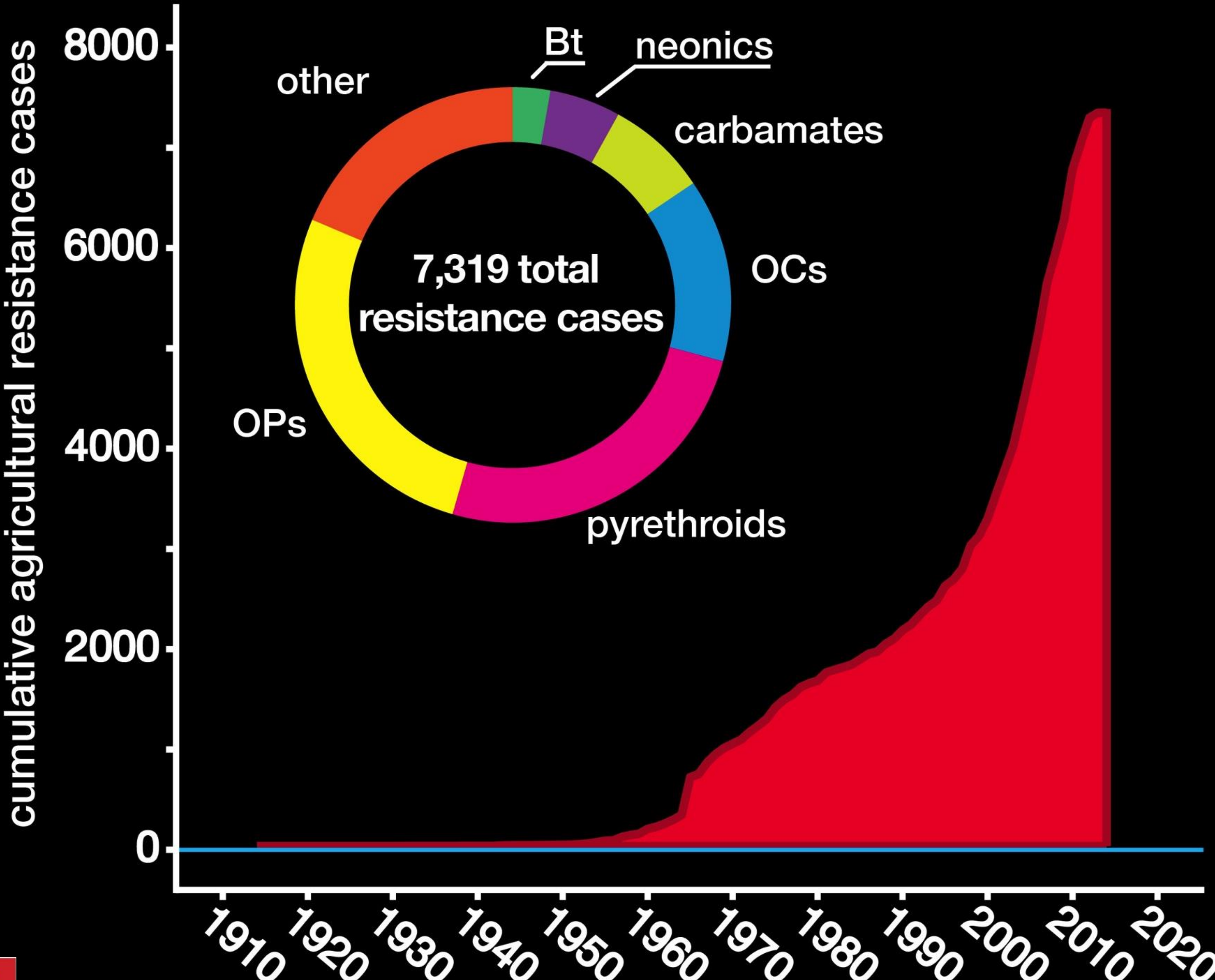
How do these factors affect the likelihood for resistance development?

Insecticide resistance is a global problem

- More than 11,000 cases of resistance reported since 1914
- Agricultural and medical (mosquito) pests

Which pests tend to become resistant and why?

Trends in global resistance



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Key factors favor resistance development

***<u>Insecticide resistance</u>*:** genetically based decrease in susceptibility to a pesticide

Pesticide use drives resistance

<u>Factors influencing selection rate</u>

- Population structure and migration
- Frequency & intensity of pesticide exposure
- Selection for resistance mechanisms (physiological targets)
- Fitness advantages of resistant pests in treated fields
- Pest behavior in fields

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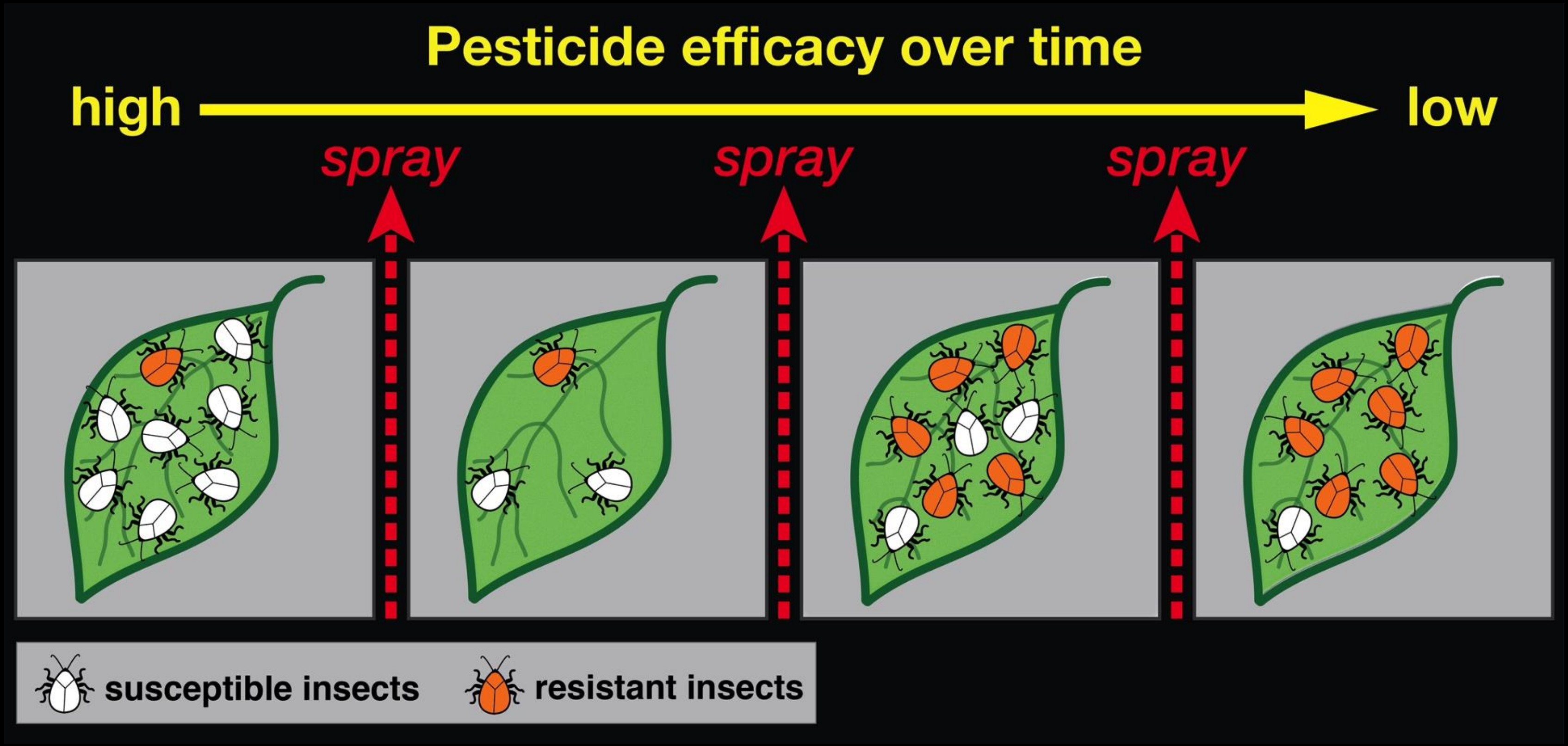
Insecticide resistance development

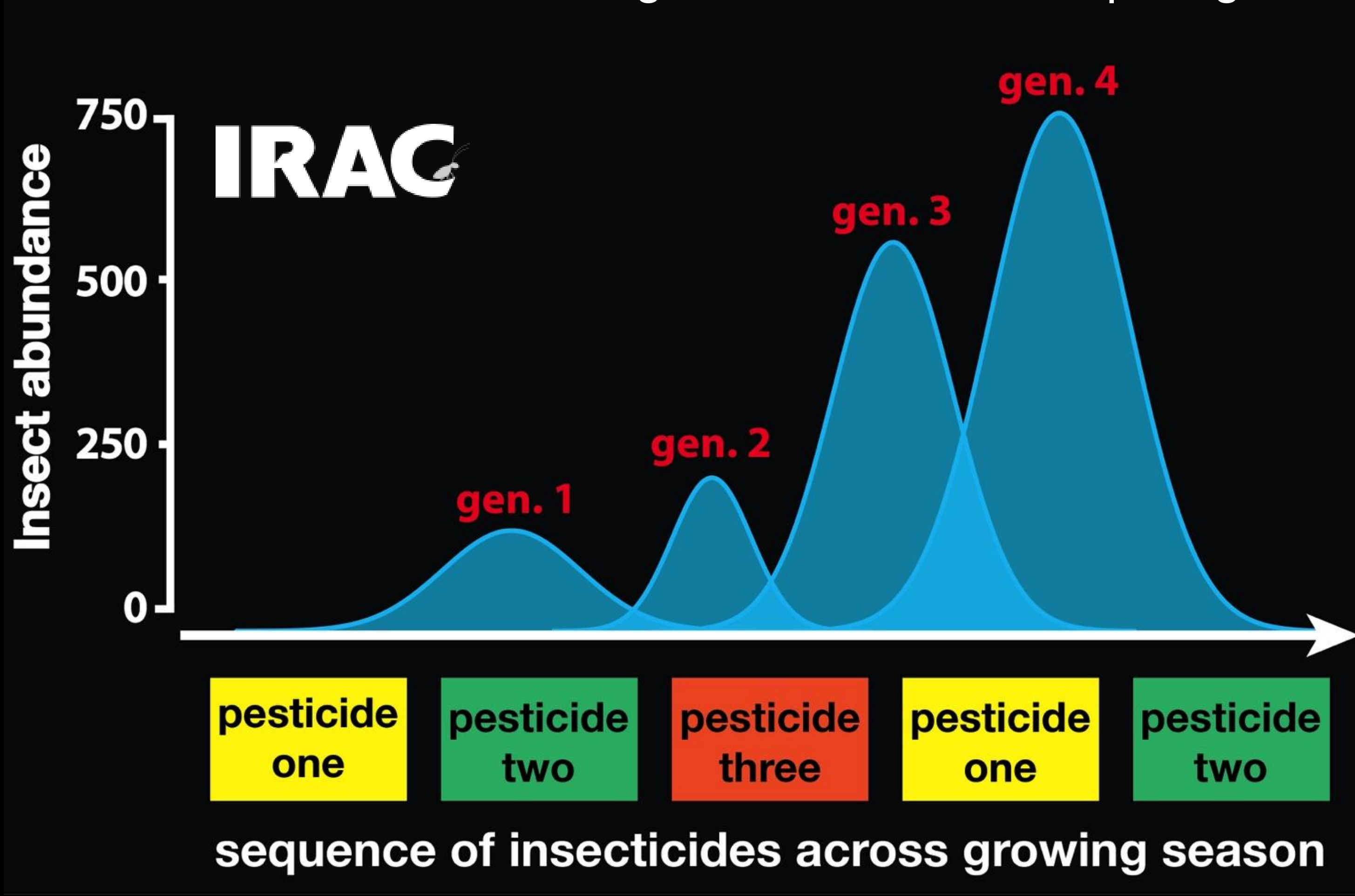
- Repeated exposure to the same types of pesticides favors selection for resistant individuals in an insect population.
- Reduced pesticide efficacy is costly and results in more sprays over time



Insecticide resistance management (IRM)

- Effective insecticide resistance management (IRM) reduces selection pressure on pest populations.

- Insecticide Resistance Action Committee (IRAC) helps farmers focus on different insecticides or alternating insecticides across pest generations.



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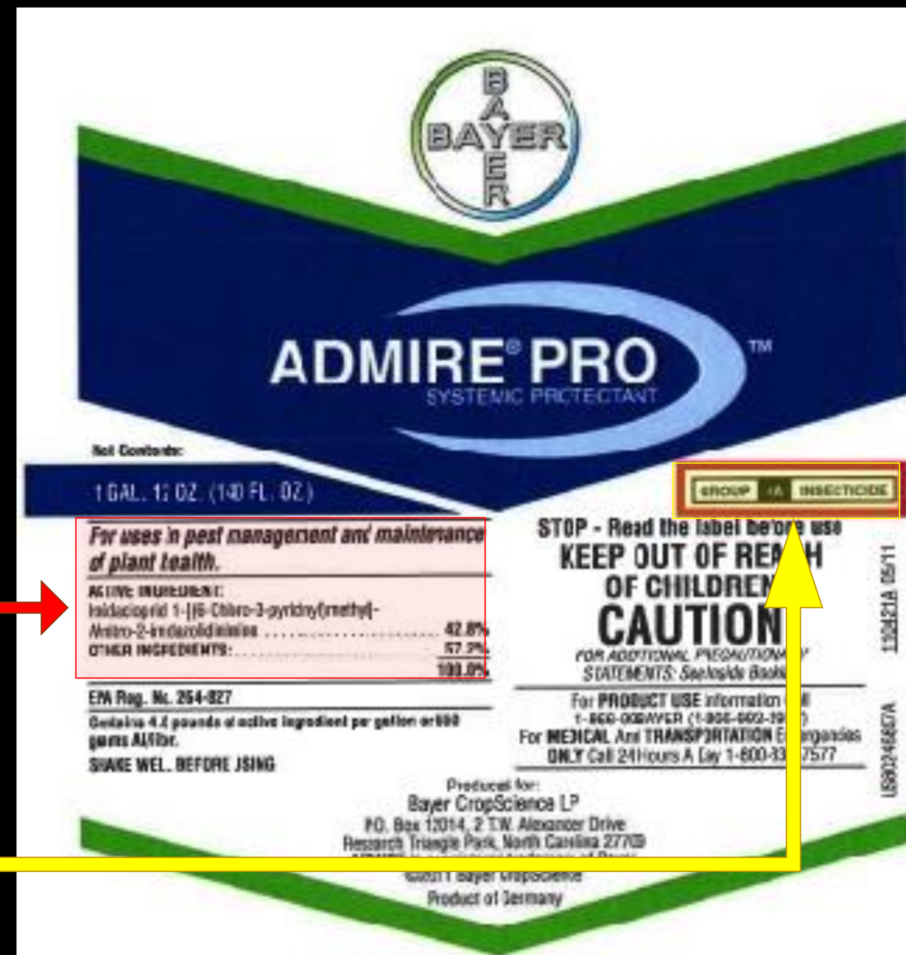
Pesticide labels provide critical IRM information

- Maintaining pest susceptibility requires insecticide rotation.
- All insecticides are grouped by physiological target site called a mode of action group (MoA).
- Pesticide labels tell growers what MoA(s) each product has.
- Insecticide MoA groups can be arranged into an effective resistance management rotation.

Active Ingredient

Mode of Action (MoA)



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Pesticides kill insects in different ways

IRAC - Insecticide Mode of Action Classification

Insecticide Resistance Action Committee www.irac-online.org

Nerve & Muscle Targets

Group 1 Acetylcholinesterase (AChE) inhibitors
- *1A* **Carbamates** (e.g. methomyl)
- *1B* **Organophosphates** (e.g. chlorpyrifos)

Group 2 GABA-gated chloride channel antagonists
- *2A* **Cyclodiene Organochlorines** (e.g. endosulfan)
- *2B* **Phenylpyrazoles** (e.g. fipronil)

Group 3 Sodium channel modulators
- *3A* **Pyrethrins, Pyrethroids** (e.g. λ-cyhalothrin)

Group 4 Acetylcholine receptor (nAChR) agonists
- *4A* **Neonicotinoids** (e.g. imidacloprid)
- *4C* **Sulfloximines** (e.g. sufloxaflor)

Group 5 Nicotinic acetylcholine receptor channel agonists (allosteric)
- *5* **Spinosyns** (e.g. spinetoram)

Group 6 Chloride channel activators
- *6* **Avermectins** (e.g. abamectin)

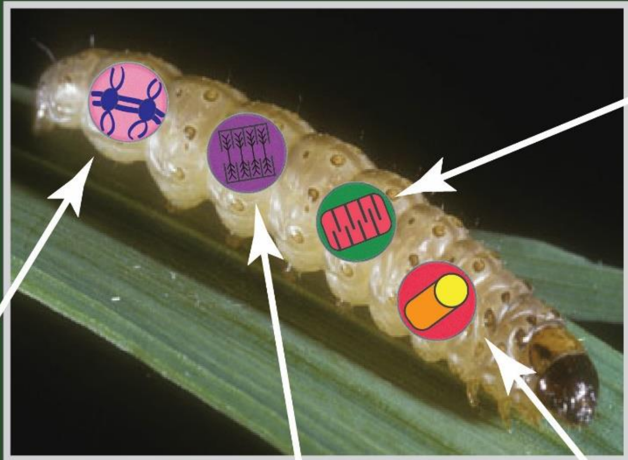
Group 9 Non-specific mode of action (feeding blockers)
- *9B* **Pymetrozine**
- *9C* **Flonicamid**

Group 14 Nicotinic acetylcholine receptor channel blockers
- *14* **Nereistoxin analogs** (e.g. Cartap)

Group 19 Octopamine receptor agonists
- *19* **Amitraz**

Group 22 Voltage dependend sodium channel blockers
- *22A* **Indoxacarb**
- *22B* **Metaflumizone**

Group 28 Ryanodine receptor modulators
- *28* **Diamides** (e.g. cyantraniliprole)



Growth & Development Targets

Group 7 Juvenile hormone mimics
- *7A* **Juvenile hormone analogues** (e.g. methoprene)
- *7B* **Fenoxycarb**
- *7C* **Pyriproxyfen**

Group 10 Mite growth inhibitors
- *10A* **Clofentezine**
- *10B* **Etoxazole**

Group 15 Inhibitors of chitin biosynthesis, type 0
- *15* **Benzoylureas** (e.g. Novaluron)

Group 16 Inibitors of chitin biosynthesis, type 1
- *16* **Buprofezin**

Group 18 Ecdysone agonists/moulting disruptors
- *18* **Diacylhydrazines** (e.g. tebufenozide)

Respiration Targets

Group 12 Inhibitors of mitochondrial ATP synthesis
- *12A* **Difenthiuron**
- *12B* **Organotin miticides (e.g. cyhexatin)**
- *12C* **Propargite**
- *12D* **Tetraifon**

Group 13 Uncouplers of oxdative phosphorylation via disruption of H proton gradient
- *13* **Chlorfenapyr**

Group 20 Mitochondrial complex III electron transport inhibitors
- *20A* **Hydramethylnon**
- *20B* **Acequinocyl**
- *20C* **Fluacyrpyrim**

Group 21 Mitochondrial complex I electron transport inhibitors
- *21A* **METI acaricides (e.g. tebufenpyrad)**

Group 23 Inhibitors of acetyl CoA carboxylase
- *23* **Tectonic & Tetramic acid derivatives** (e.g. spirodiclofen)

Group 25 Mitochondrial complex II electron transport inhibitors
- *25* **Cyenopyrafen**

Midgut Targets

Group 11 Microbial disruptors of insect midgut membranes
- *11A* ***Bacillus thuringiensis***
- *11B* ***Bacillus sphaericus***

Unknown

UN compounds of unknown or uncertain mode of action
- *UN* **Azadiractin**
- *UN* **Bifenazate**
- *UN* **Pyridalyl**
- *UN* **Pyrifluquinazon**

Adapted from IRAC General MoA Poster 2012 Photo John Capinera

Finding pesticides that fit: life stages are key

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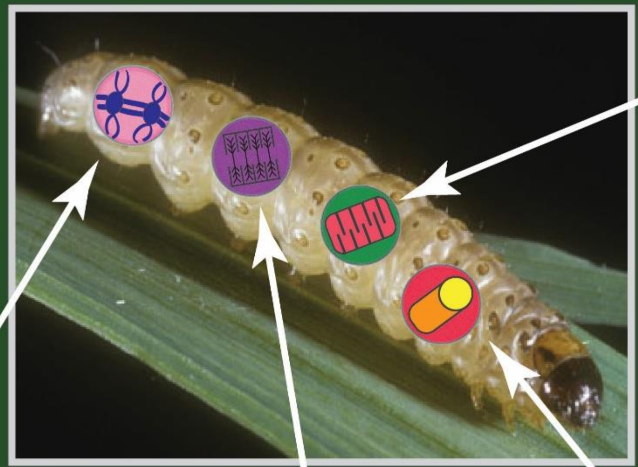

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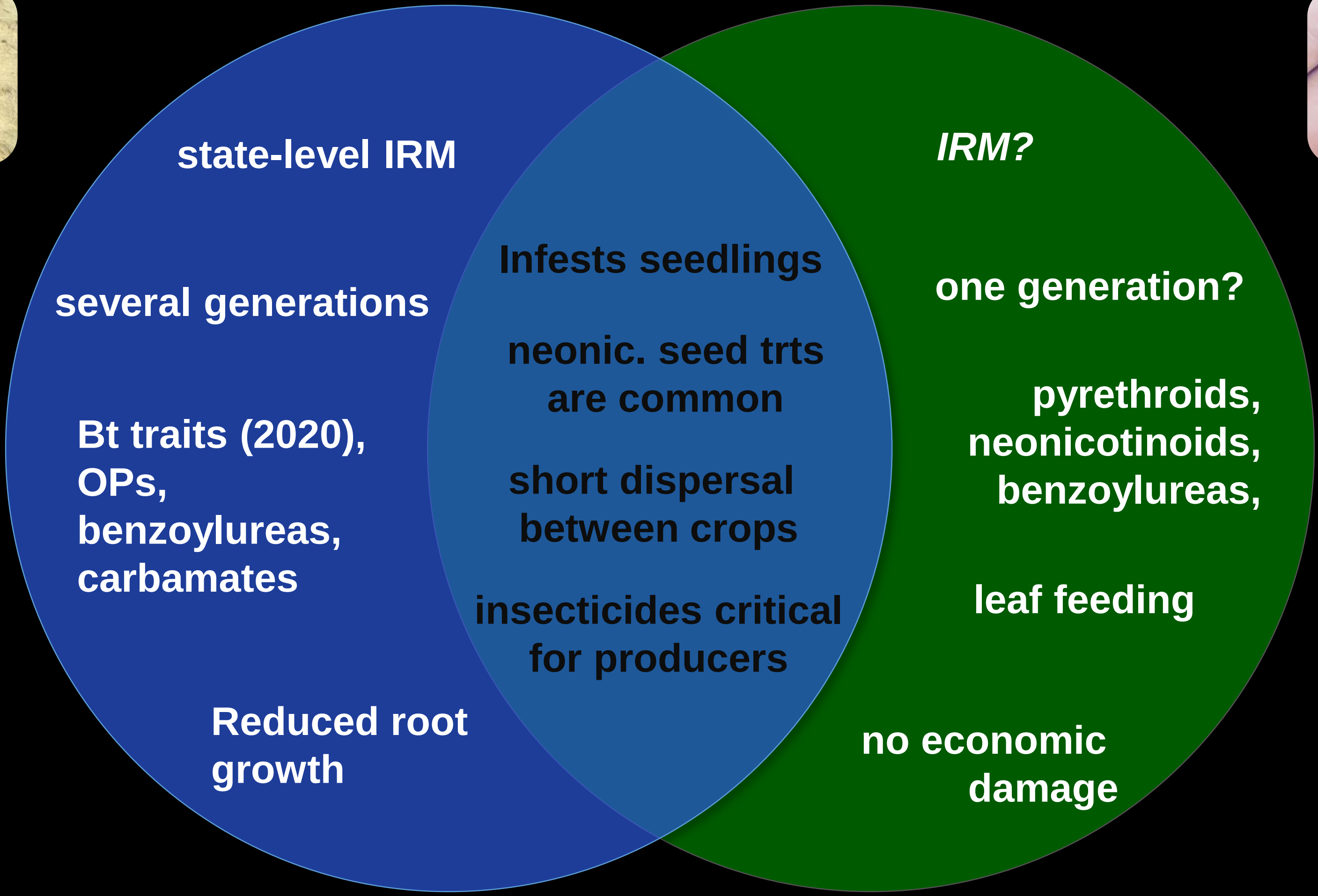
Understanding resistance: a thrips case study

- Tobacco thrips (*Frankliniella fusca*) are a common cotton pest in the Southeast & Mid-South.
- Overuse of neonicotinoids in cotton and soybean drives resistance.

Cotton

Soybean



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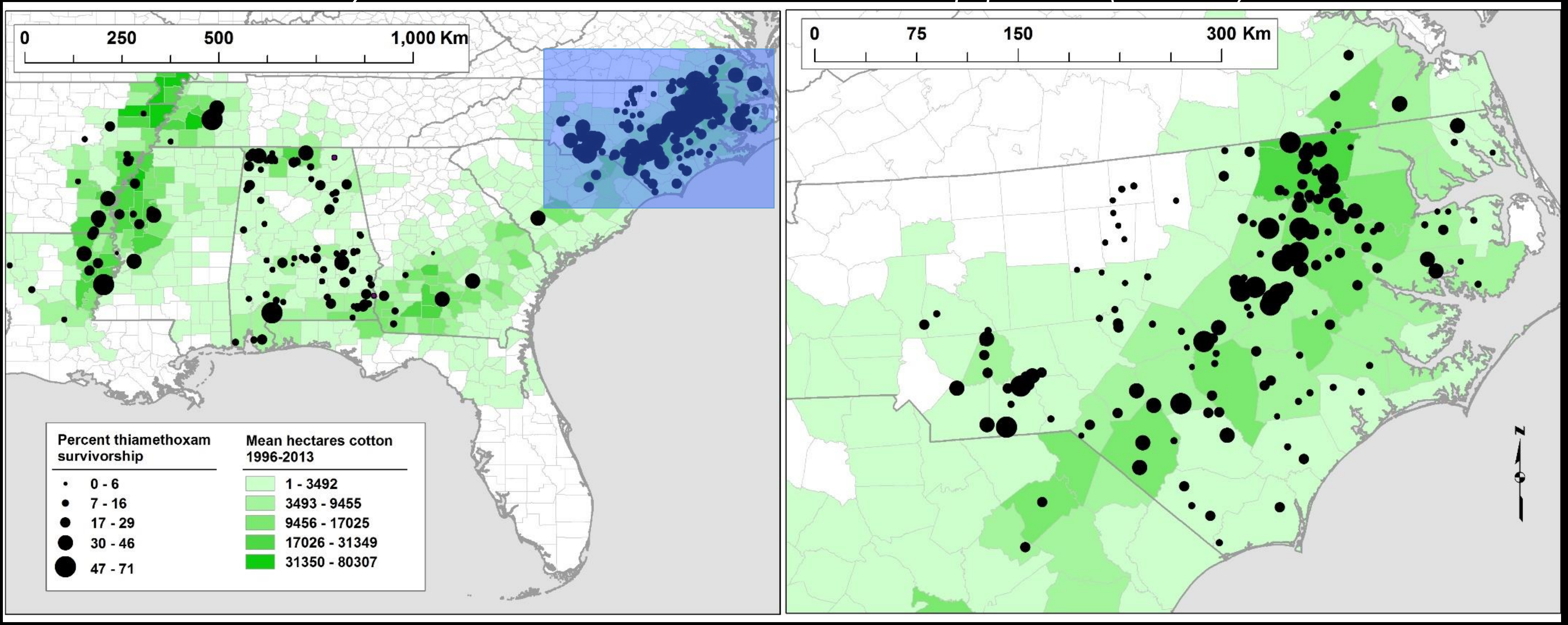
Where do we find neonicotinoid resistance?

- Tobacco thrips resistance is common in NC cotton producing counties (dark green).
- Movement of thrips between treated cotton and soybean is one explanation for emerging resistance.

2014-2016 resistance survey *NC resistant populations (Blue inset)*



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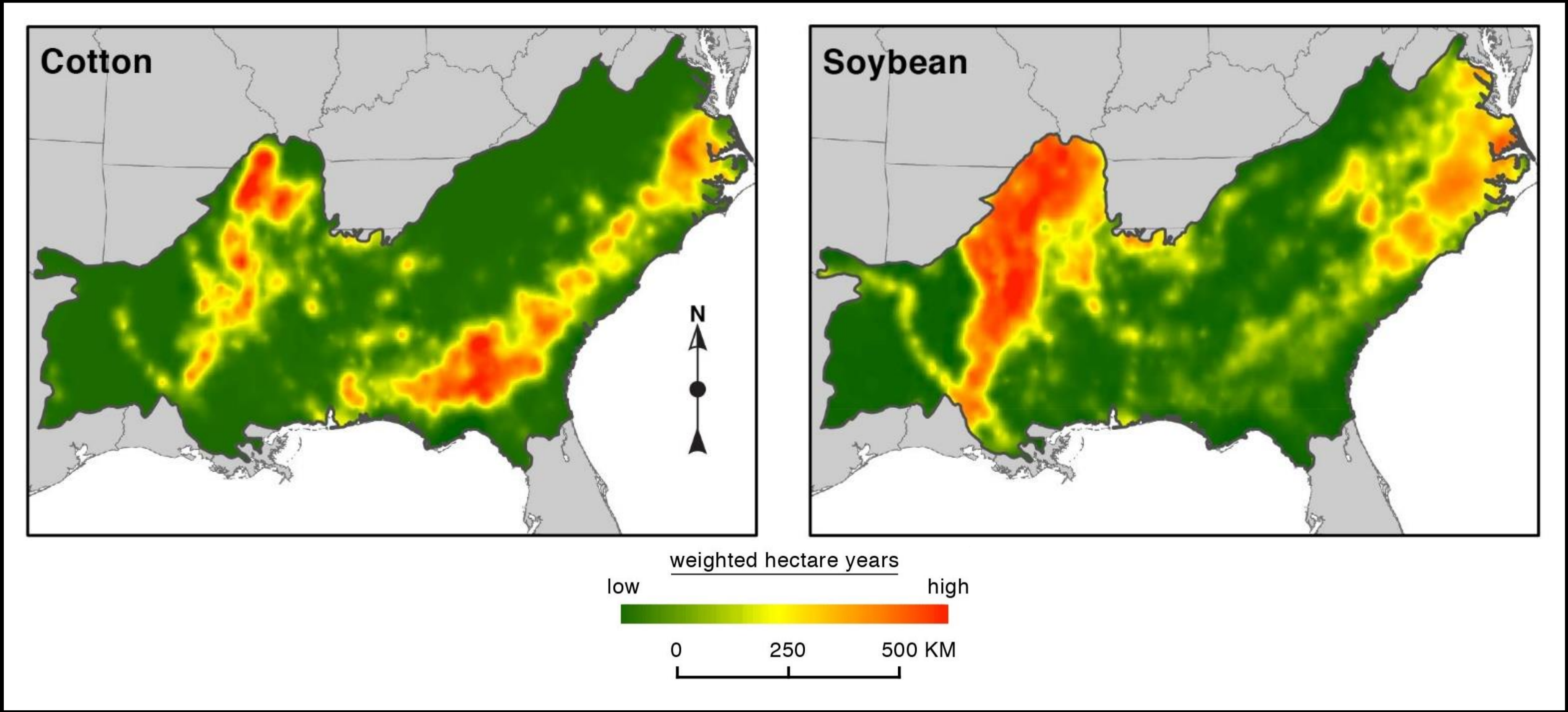
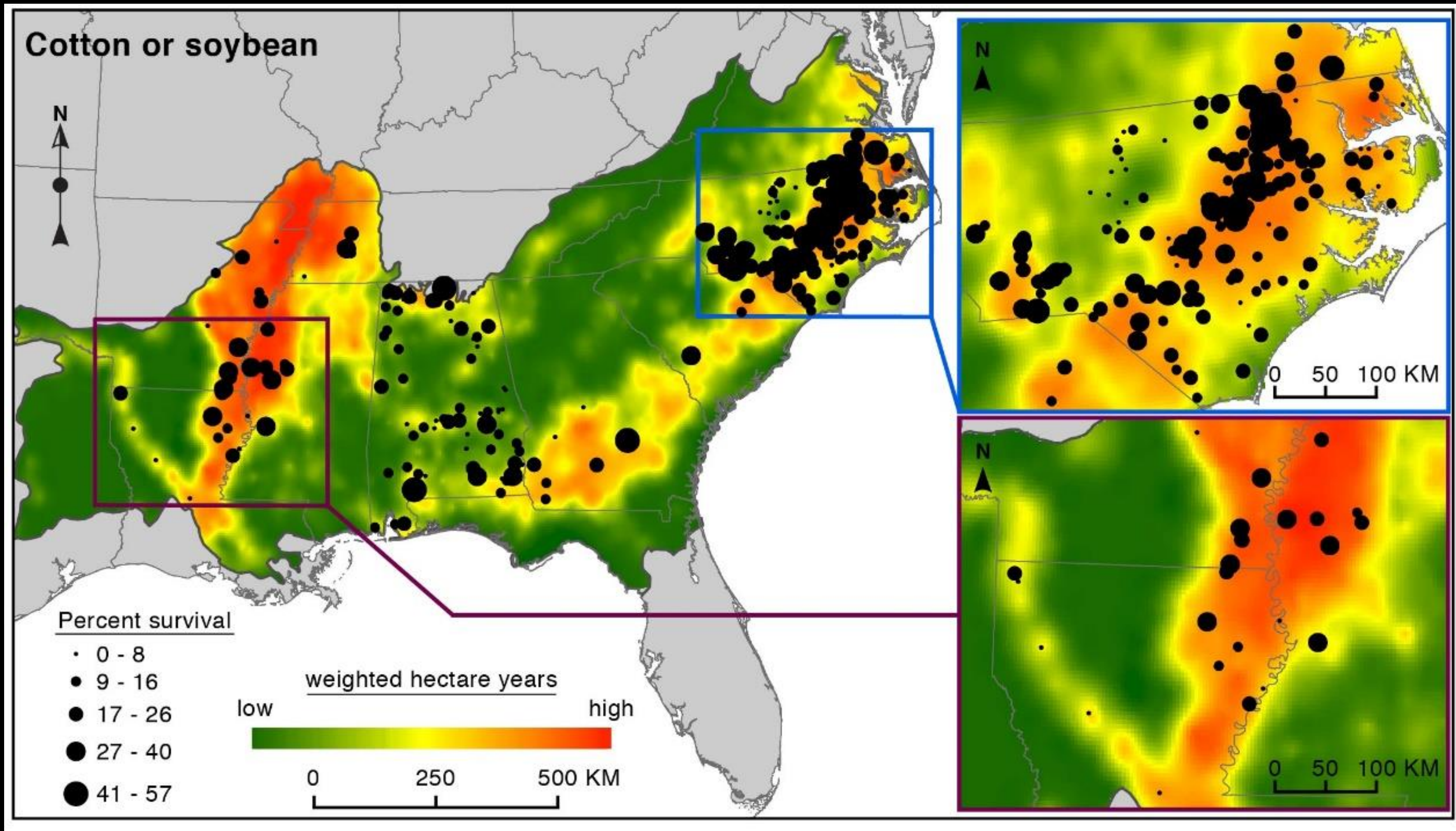
Intensity of cotton and soybean production



Cotton and soy production linked to resistance



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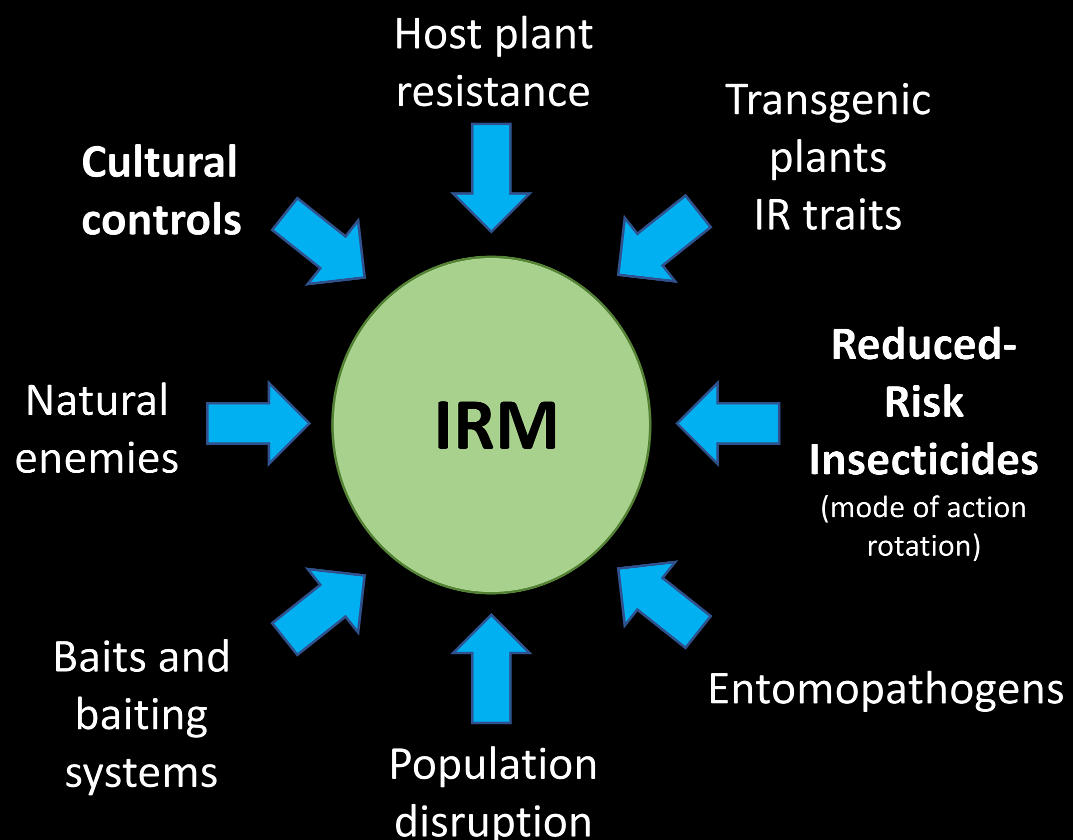
IRM take home message

- Resistance can be avoided with good stewardship
- Rotation of insecticides can be an effective means to reduce resistance selection pressure.
- IRM is a component of IPM. Reducing pest exposure is important to maintain pesticide efficacy over time



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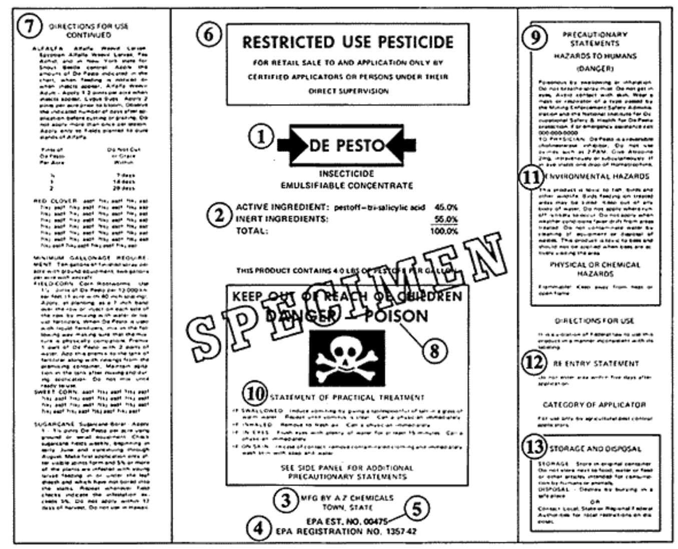
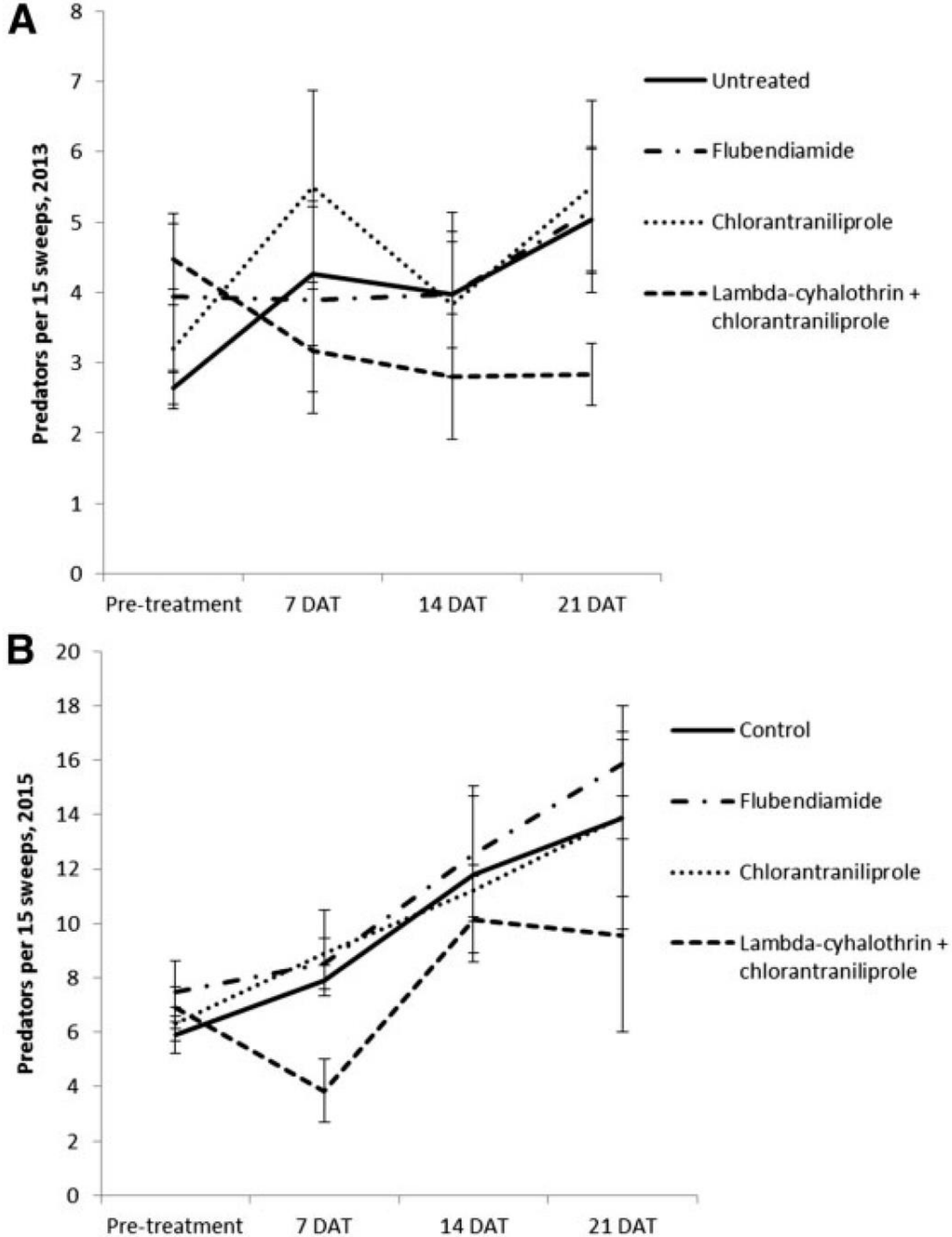
Selecting an Insecticide

1. Efficacy
2. Resistance Management
3. Persistence
4. Application
    1. Environmental restrictions
    2. Timing
    3. Method
    4. Harvest interval
    5. Re-entry period
    6. Human concerns- HAZARDS!!!
5. Cost



Selecting an Insecticide

- Ease of use and compatibility with other materials
- Impacts on beneficials


A
Predators per 15 sweeps, 2013
8
7
6
5
4
3
2
1
0
Pre-treatment
7 DAT
14 DAT
21 DAT
Untreated
Flubendiamide
Chlorantraniliprole
Lambda-cyhalothrin +
chlorantraniliprole
B
Predators per 15 sweeps, 2015
20
18
16
14
12
10
8
6
4
2
0
Pre-treatment
7 DAT
14 DAT
21 DAT
Control
Flubendiamide
Chlorantraniliprole
Lambda-cyhalothrin +
chlorantraniliprole

Choosing Rate

- Label has range
- Higher rate
  - May reduce need for retreatment
  - Hormesis reduced
  - May reduce resistance potential
- Lower rate
  - Environment and IPM concerns
  - Cost savings

Choosing Timing

- Base on threshold/tolerance levels
- Immature insects easier to kill
- Weather
- Time of day
  - Insect activity varies

Prevathon (chlorantraniliprole)

Advantages

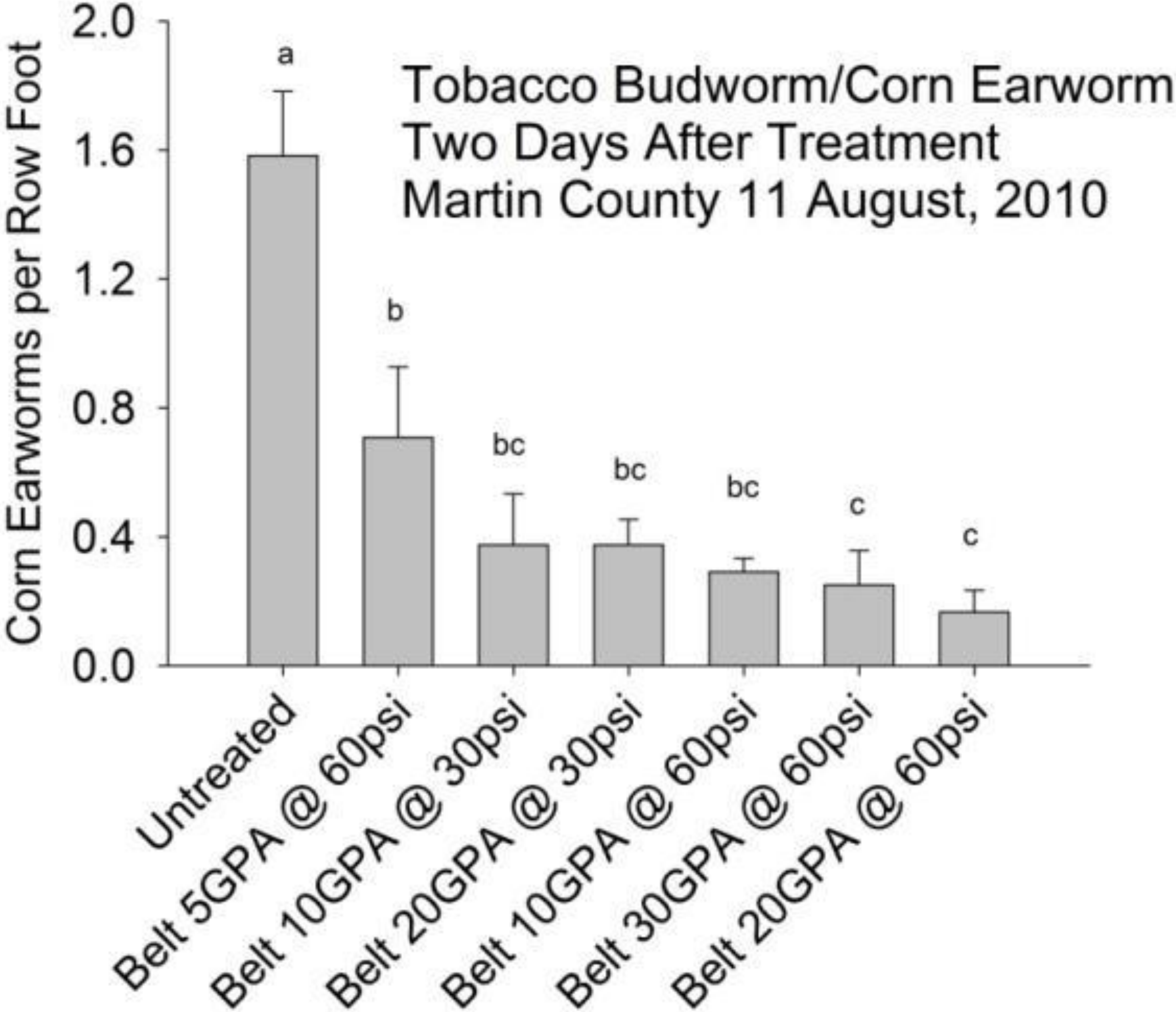
- Specific to caterpillars
- Long residual
- Preserves some beneficials
- Arguably the most effective caterpillar material available

Disadvantages

- Pricey

Notes

- Does not appear to be as effective against corn earworm in NC compared to Midsouth



Tobacco Budworm/Corn Earworm
Two Days After Treatment
Martin County 11 August, 2010
Corn Earworms per Row Foot
2.0
1.6
1.2
0.8
0.4
0.0
a
b
bc
bc
bc
c
c
Untreated
Belt 5GPA @ 60psi
Belt 10GPA @ 30psi
Belt 20GPA @ 30psi
Belt 10GPA @ 60psi
Belt 30GPA @ 60psi
Belt 20GPA @ 60psi

Dimilin (diflubenzuron)

Advantages

- Mainly for caterpillars
- Very long residual for green cloverworm and velvetbean caterpillar

Disadvantages

- Green cloverworm and velvetbean caterpillar are rarely pests in NC soybeans

Notes

- Marketed with "yield enhancement" properties

Intrepid (methoxyfenozide)

Advantages

- Specific to caterpillars
- Very effective against soybean looper and armyworms (including fall and beet)
- Rainfast when dry

Disadvantages

- Ineffective against our main caterpillar- corn earworm
- Takes 5-7 days to work
  - Needs to be ingested
  - Molt accelerator

Notes

- One step under dimides (Prevathon and Belt)
- “Dead worms walking” around 3 days after treatment

Blackhawk (spinosad)

Advantages

- Preserves many beneficials

Disadvantages

- Short residual
- Pricey

Steward (indoxacarb)

Advantages

- Specific to caterpillars
- Very effective against soybean looper and armyworms (including fall and beet)
- Most effective against corn earworm in recent screening trials

Disadvantages

- Pricey

Orthene (acephate)

Advantages

- Broad spectrum
- Most effective chemical for brown stink bugs in soybean

Disadvantages

- Eliminates beneficial insects
- Broad spectrum
- Short residual
- Need to spray 8 hours minimum before a rain

Baythroid, Capture, Karate, Mustang Max, etc.
(beta-cyfluthrin, bifenthrin, lambda-cyhalothrin, zeta-cypermethrin, etc.)

Advantages

- Broad spectrum
- Some residual

Disadvantages

- Eliminates beneficial insects
- Broad spectrum
- Widely used

Notes

- All are pyrethroid-class insecticides
- Work best when applied morning/evening

Corn Earworm

- Prevathon (14 oz) product of choice
- Exceptions
  - Second spray
  - Spray failure
- Alternatives
  - Steward (8 oz), Blackhawk, Intrepid Edge

Yellowstriped armyworm

- Pyrethroid or Orthene
- Good alternatives
  - Steward, Prevathon, Belt, Blackhawk

Bean Leaf Beetle

- Rotate away from what was sprayed previously (year before or within season)
- Pyrethroid or Orthene

Stink Bug

- Green stink bug
  - Pyrethroid or Orthene
- Brown stink bug
  - Bifenthrin or Orthene

Looper (cabbage and soybean)

- Intrepid Edge

Beet Armyworm

- Prevathon, Steward, Blackhawk

Extra Fit for Premixes?

Insecticide	Pest(s) controlled above the insecticide doing the heavy lifting
Besiege – Karate + Prevathon	Caterpillars + stink bugs/bean leaf beetle
Cobalt Advanced – Karate + Lorsban	Brown stink bug
Endigo – Karate + Centric	Don’t see a fit for neonics. in soybeans
Hero/Steed – Mustang + Capture	???
Leverage 360 – Beta-cyfluthrin + Trimax	Don’t see a fit for neonics. in soybeans
Stallion – Mustang + Lorsban	Brown stink bug
Swagger – Capture + Trimax	???

Questions