Characterizing QoI Resistance in Rhizoctonia

Clayton A. Hollier, PhD

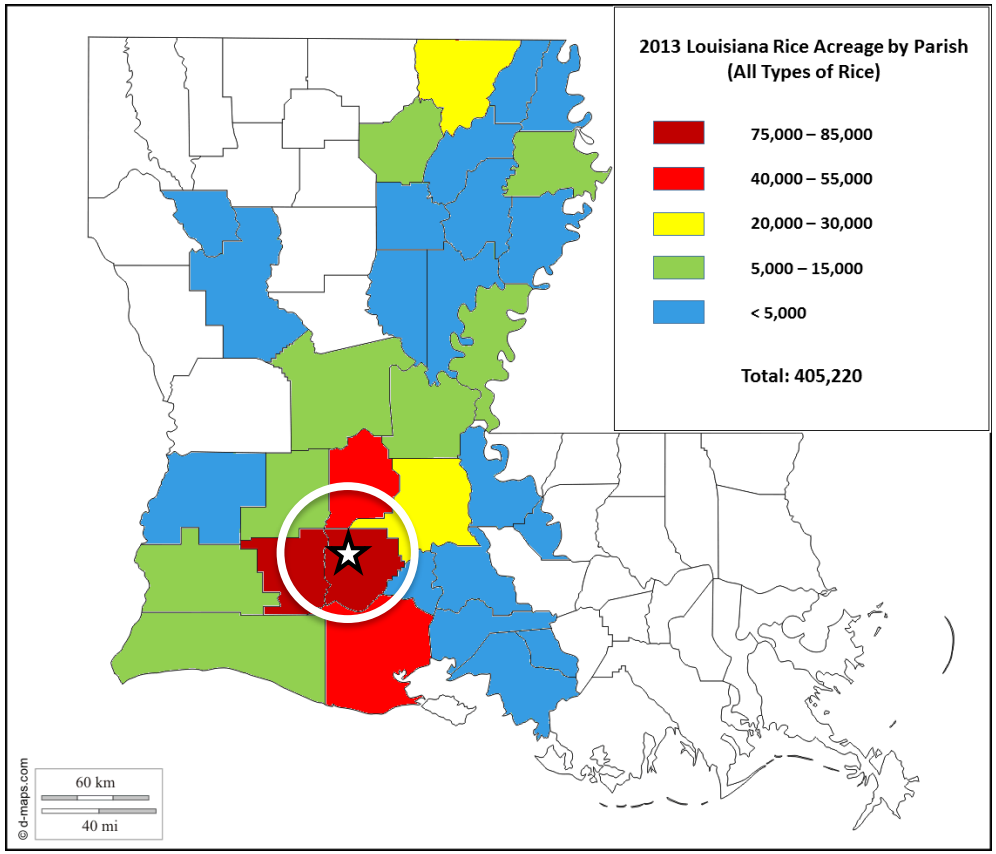
Department of Plant Pathology and Crop Physiology

LSU AgCenter Research · Extension · Teaching

LSU College of Agriculture

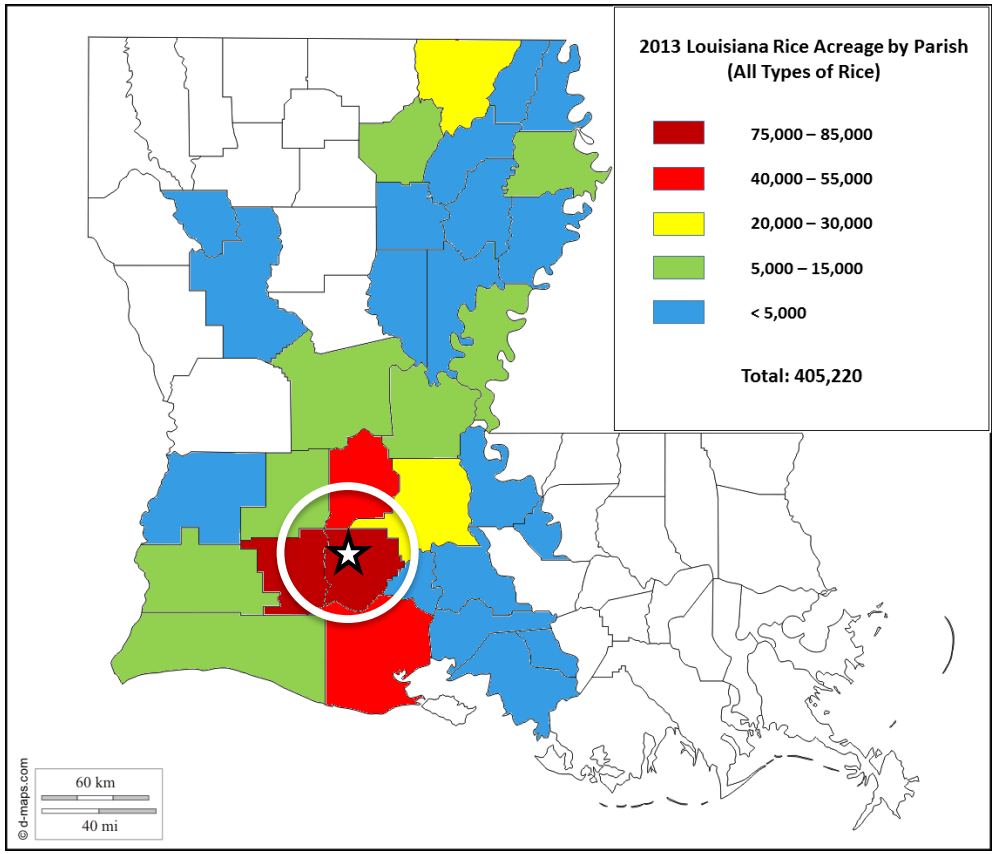
Fungicide Resistance!

- In 2011, Syngenta confirmed *R. solani* isolates resistant to azoxystrobin (☆, resistance origin)
- Resistance found only within 40 km of resistance origin



Fungicide Resistance!

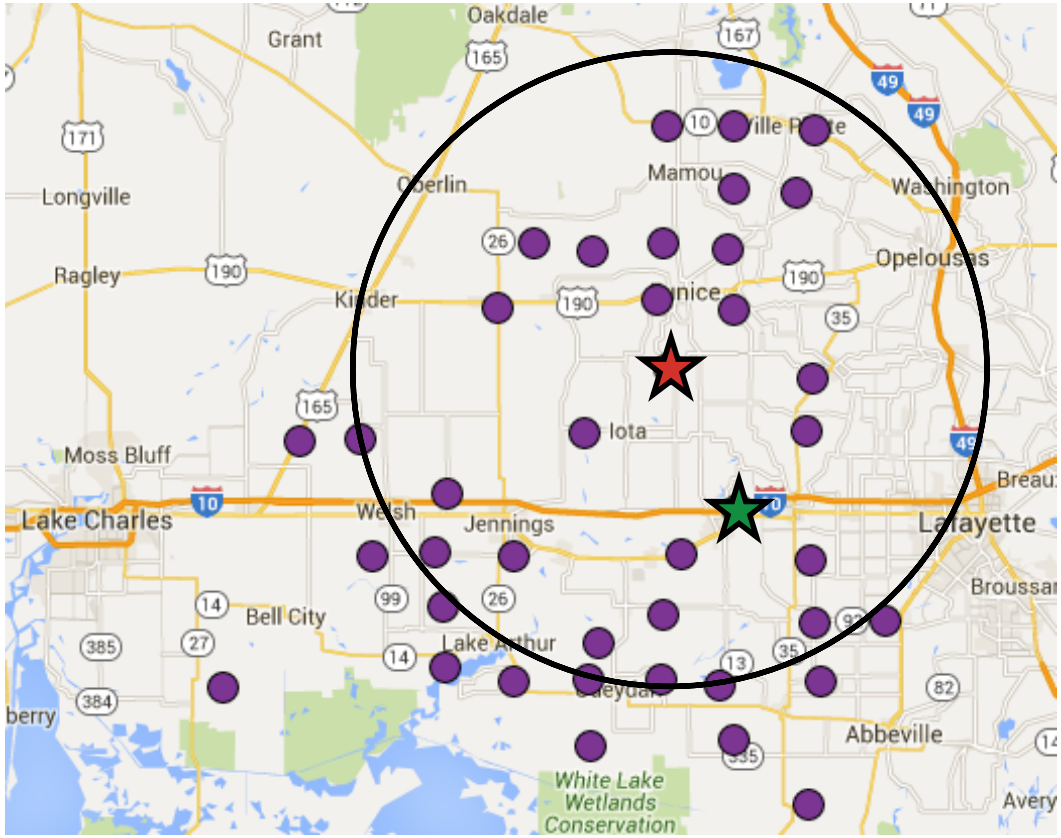
- Loss of disease management
- Wasting resources
- Resistance beyond 40 km from resistance origin?
- Other strobilurin fungicides?



LSU AgCenter
Research · Extension · Teaching

Sample Collection

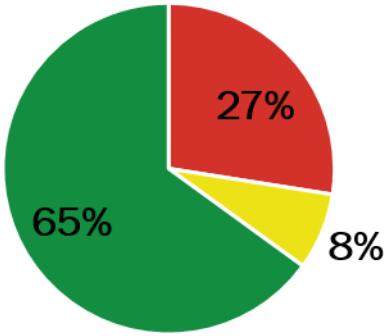
- 5 mile grid for field selection
- 40 sites including resistance origin and sensitive control



Azoxystrobin Results

Legend

- Resistant
- Intermediate
- Sensitive
- * More sensitive than sensitive control



Azoxystrobin EC_{50} Means

Error bars represent standard deviation.

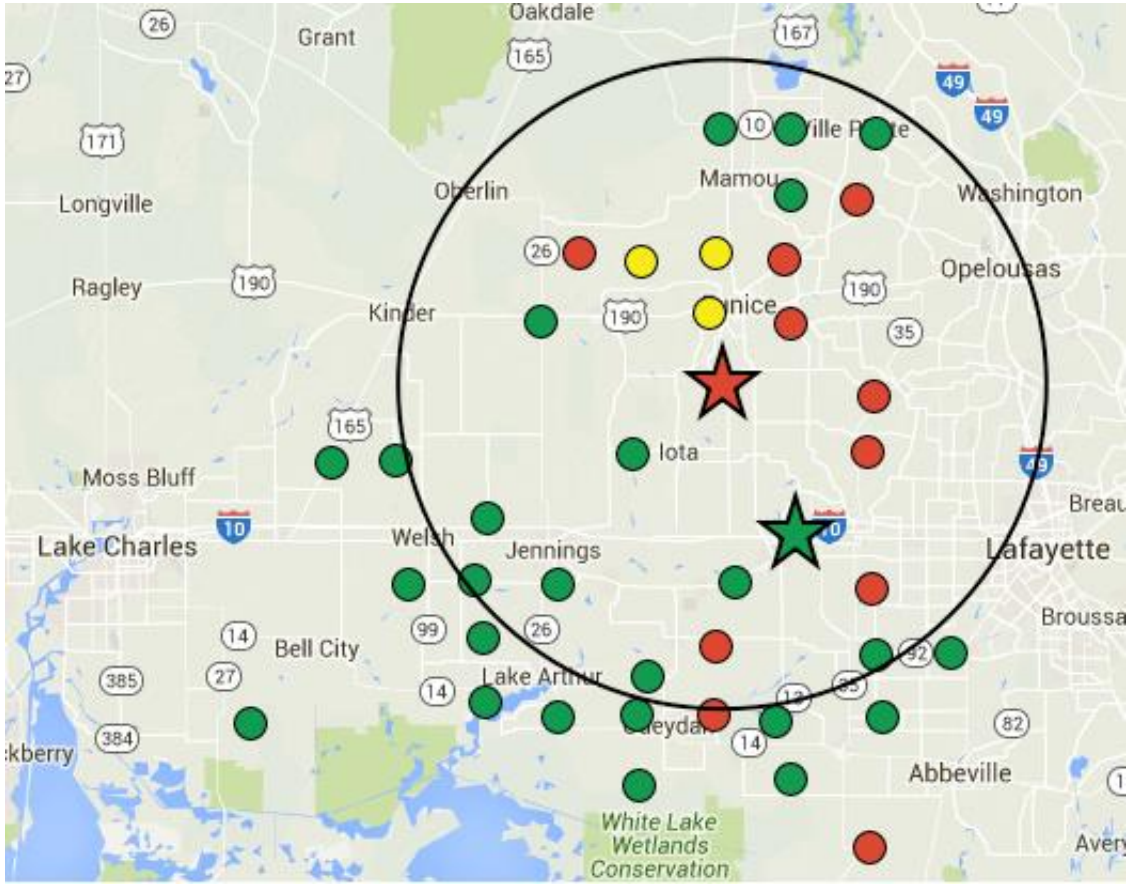
$Log_{10}EC_{50}$ [log_{10}(µg ml^{-1})]

0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0

11 Resistant | 3 I. | 26 Sensitive

Field Sampled

Azoxystrobin Results

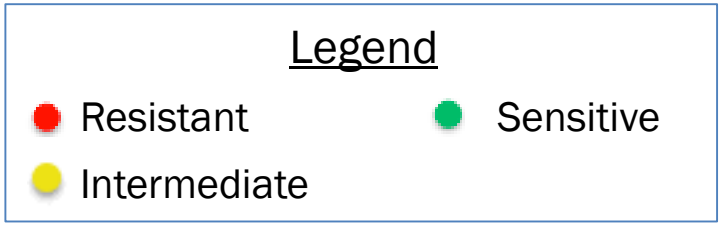


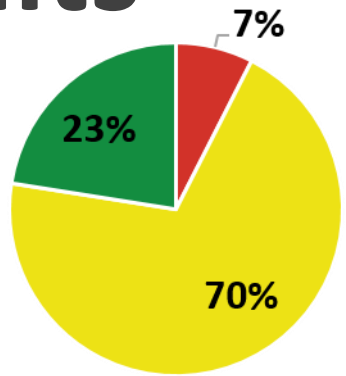
Legend

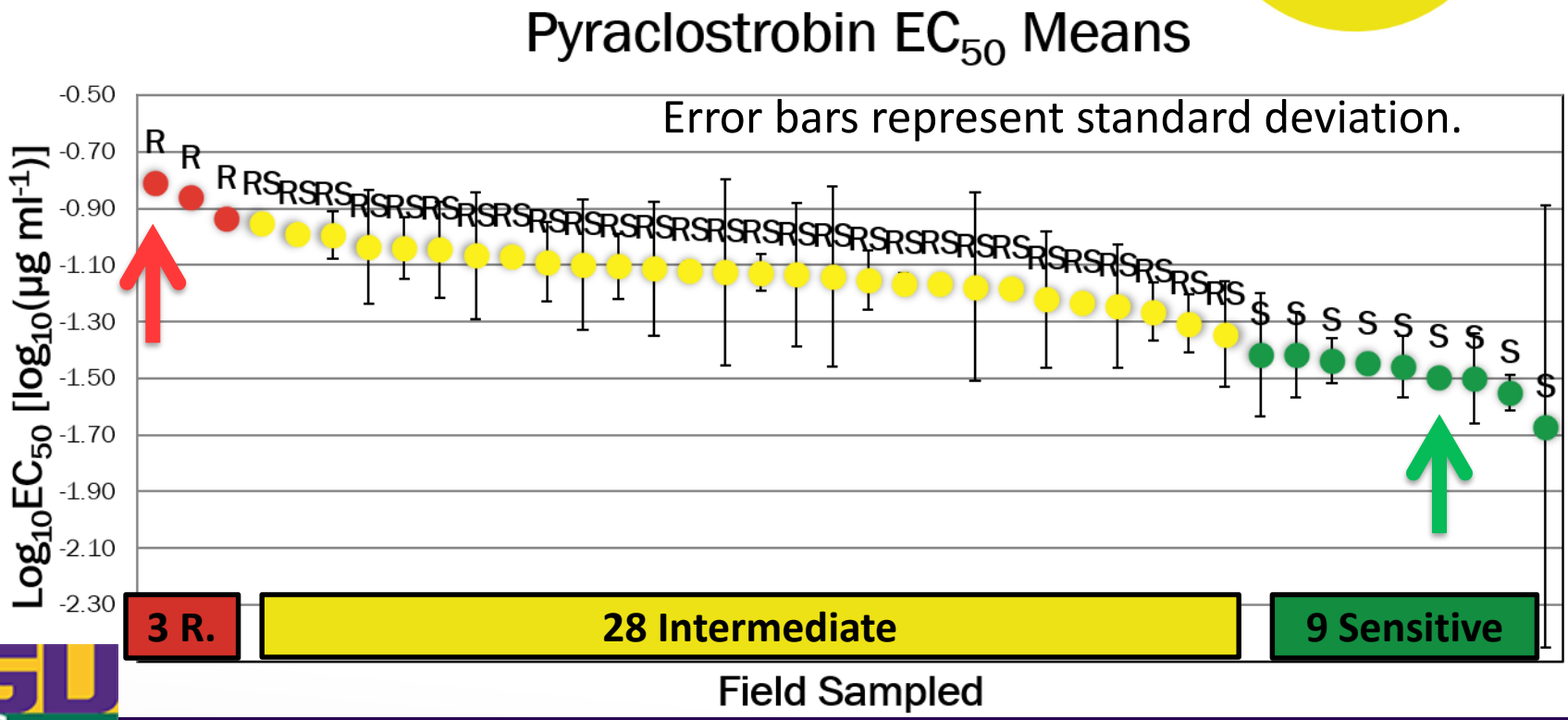
- resistant
- intermediate
- sensitive
- resistance origin
- sensitive control

LSU AgCenter
Research · Extension · Teaching

Pyraclostrobin Results

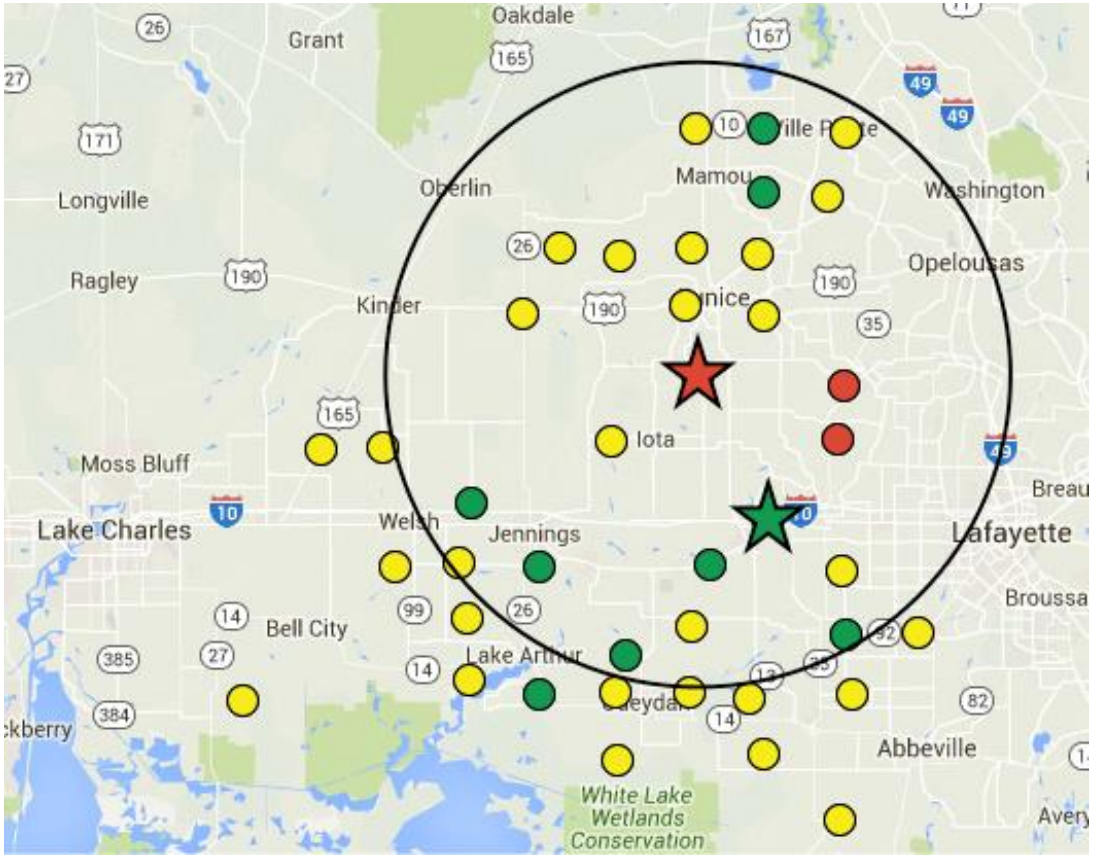






LSU AgCenter
Research · Extension · Teaching

Pyraclostrobin Results



Legend

- resistant
- intermediate
- sensitive
- resistance origin
- sensitive control

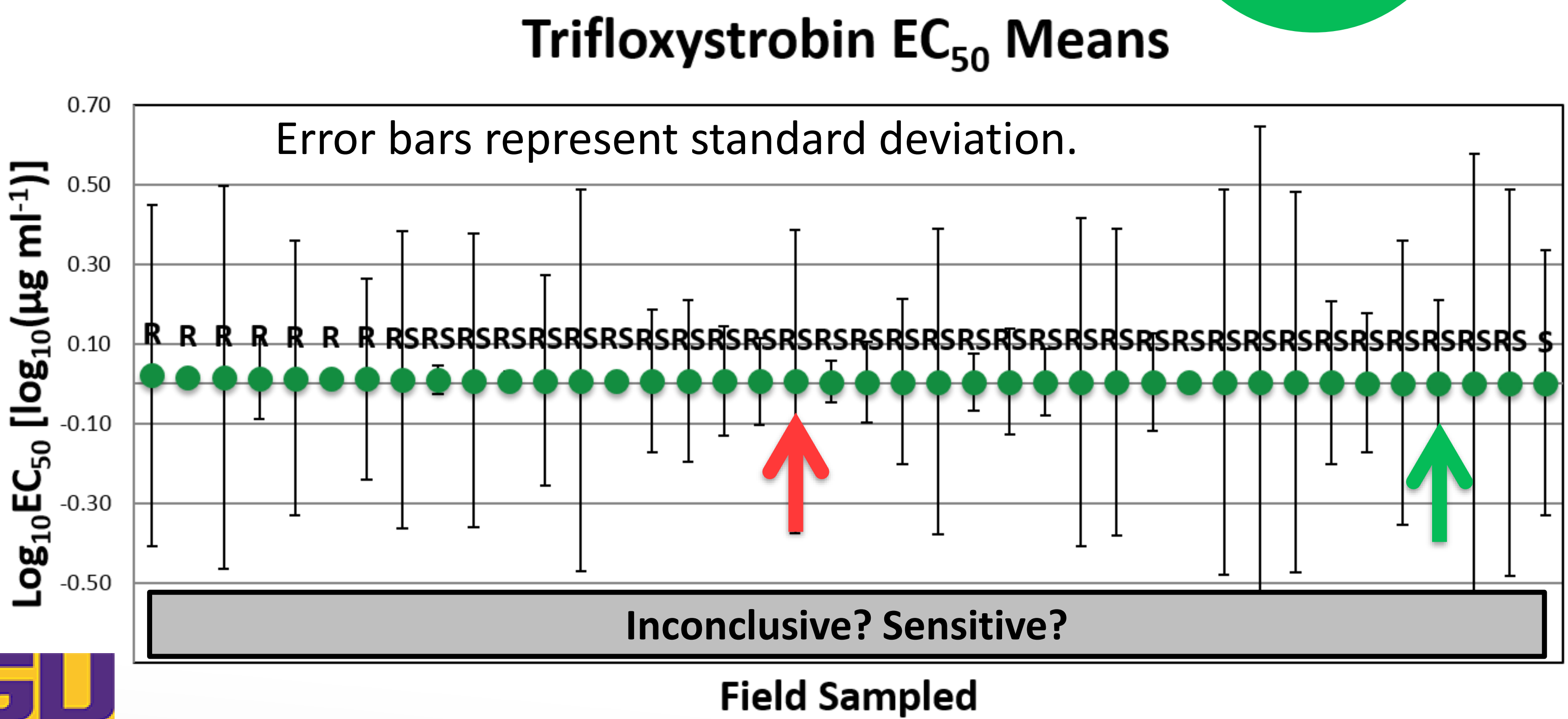
LSU AgCenter
Research · Extension · Teaching

Trifloxystrobin Results

Legend

- Resistant
- Sensitive
- Intermediate

100% Sensitive



Conclusions

- Geographic distribution of azoxystrobin-resistant isolates of *R. solani* is larger than previously known
- Imperfect or weak strobilurin cross-resistance in this pathosystem

LSU AgCenter
Research · Extension · Teaching

Fungicide Resistance

Plant Disease Management Constraints

LSU AgCenter
Research · Extension · Teaching

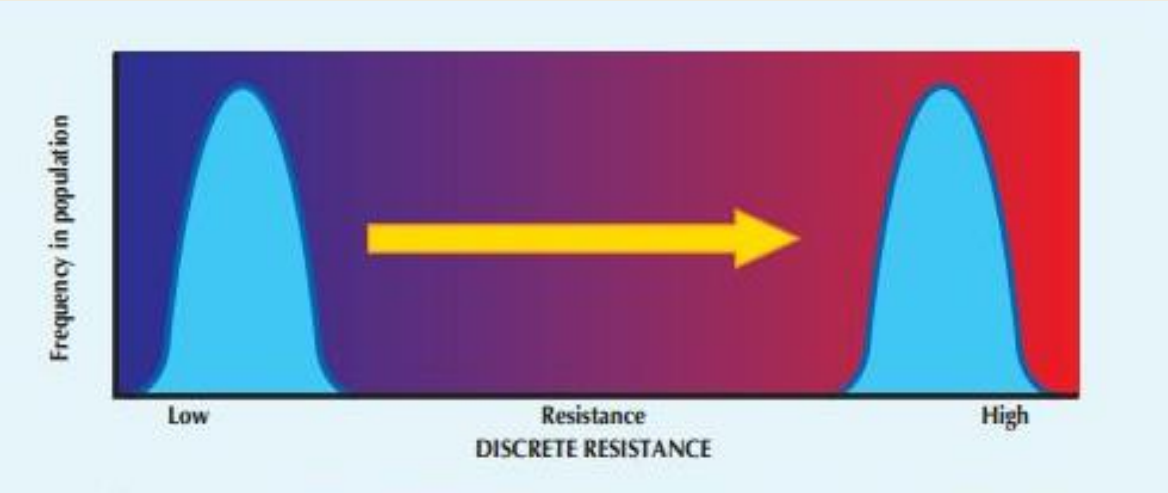
Table 1
Occurrence of Practical Fungicide Resistance in Crops

Date first observed (approx.)	Fungicide or fungicide class	Years of commercial use before resistance observed (approx.)	Main crop diseases and pathogens affected	Ref*
1960	Aromatic hydrocarbons	20	Citrus storage rots, *Penicillium* spp.	1
1964	Organo-mercurials	40	Cereal leaf spot and stripe, *Pyrenophora* spp.	2
1969	Dodine	10	Apple scab, *Venturia inaequalis*	3
1970	Benzimidazoles	2	Many target pathogens,	4
1971	2-Amino-pyrimidines	2	Cucumber and barley, powdery mildews *Sphaerotheca fuliginea & Blumeria graminis*	5
1971	Kasugamycin	6	Rice blast, *Magnaporthe grisea*	6
1976	Phosphorothiolates	9	Rice blast, *Magnaporthe grisea*	6
1977	Triphenyltins	13	Sugar beet leaf spot, *Cercospora betae*	7
1980	Phenylamides	2	Potato blight and grape downy mildew, *Phytophthora infestans & Plasmopara viticola*	8
1982	Dicarboximides	5	Grape grey mould, *Botrytis cinerea*	9
1982	Sterol Demethylation inhibitors (DMIs)	7	Cucurbit and barley powdery mildews, *S. fuliginea & Blumeria graminis*	10
1985	Carboxanilides	15	Barley loose smut, *Ustilago nuda*	11
1998	Quinone outside Inhibitors (QoIs; Strobilurins)	2	Many target diseases and pathogens	12
2002	Melanin Biosynthesis Inhibitors (Dehydratase) (MBI-D)	2	Rice blast, *Magnaporthe grisea*	13

*References: 1. Eckert, 1982; 2. Noble *et al.* 1966; 3. Gilpatrick, 1982; 4. Smith, 1988; 5. Brent, 1982; 6. Kato, 1988; 7 Giannopolitis, 1978; 8 Staub, 1994; 9. Lorenz, 1988; 10. De Waard, 1994: 11. Locke, 1986; 12. Heaney *et al.* 2000; 13. Kaku *et al.* 2003.

Qualitative Resistance

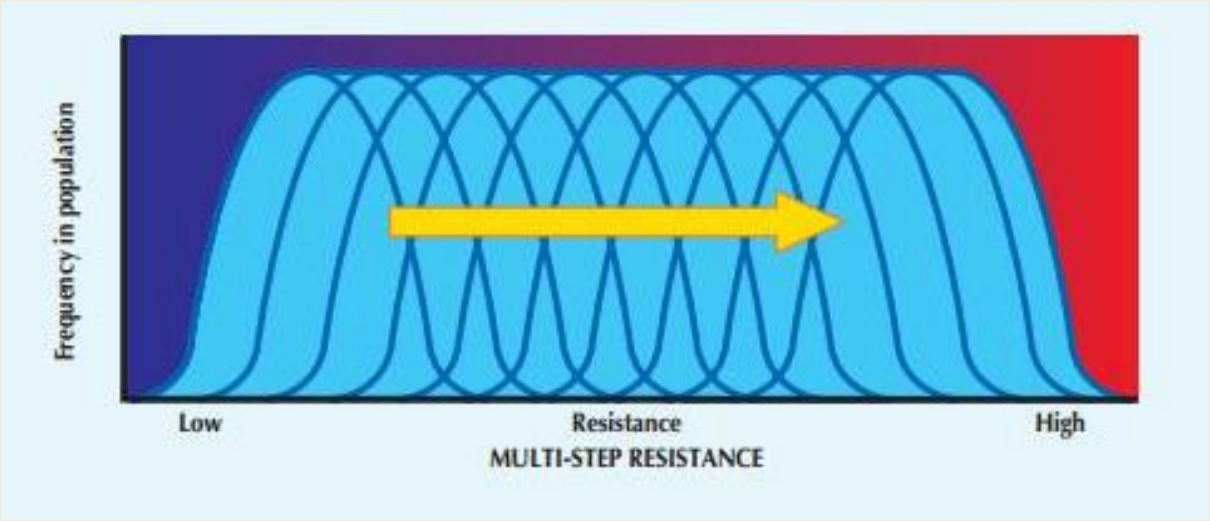
- One-step or discrete resistance
- Generally results from the mutation of a single major gene
- Results in sudden shift in the population from very sensitive to highly resistant
- Leads to total failure of the fungicide
- Examples:
  - benzimidazoles
  - phenylamides



LSU AgCenter
Research · Extension · Teaching

Quantitative Resistance

- Multi-step resistance results from mutation of many genes that contribute to resistance
- Results is a gradual shift in the population to more resistant
- Seldom leads to total failure of the fungicide
- Example:
  - DMI fungicides



LSU AgCenter
Research · Extension · Teaching

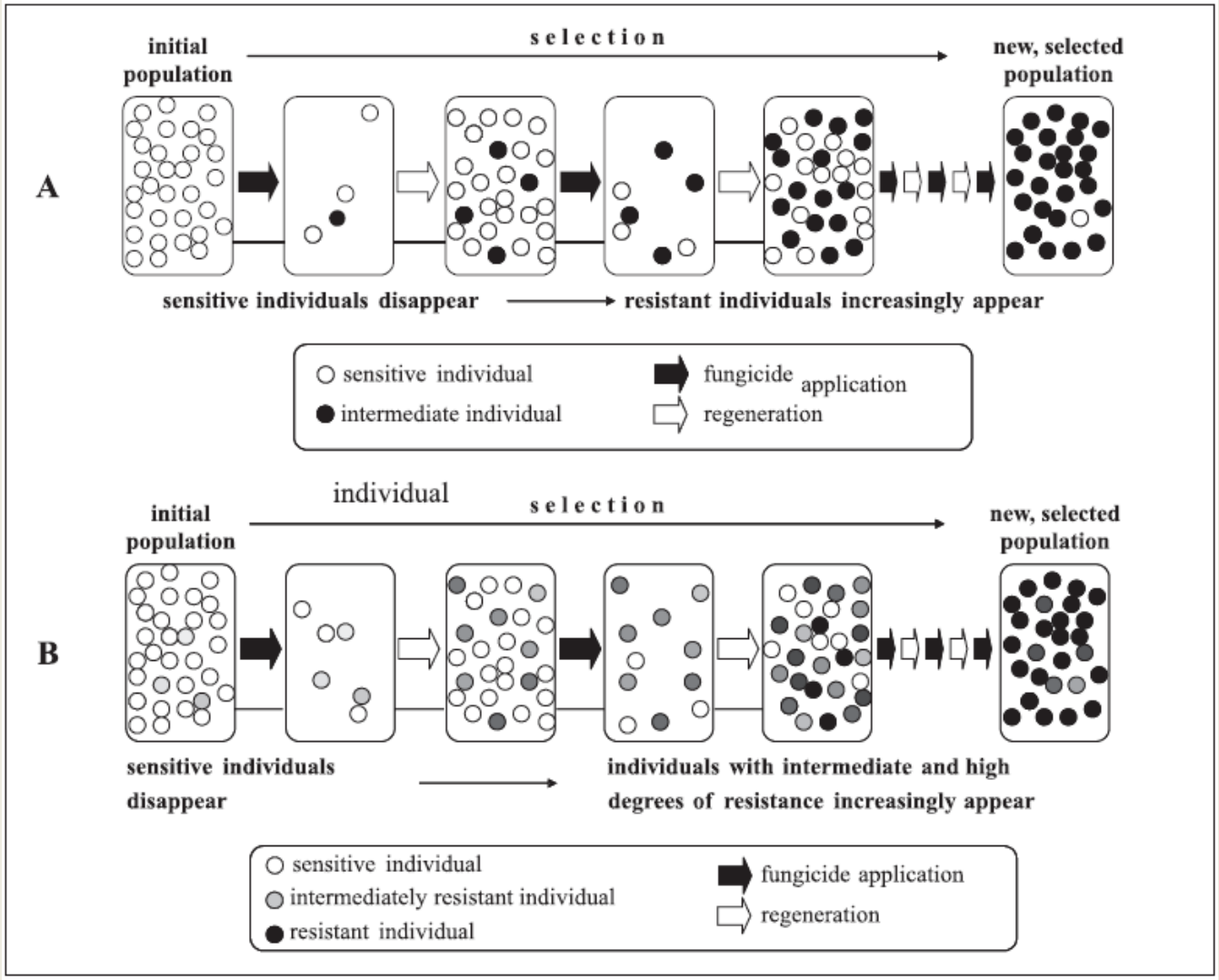


Figure 2: Development of fungicide resistance is a selection process, with the fungicide as the selecting agent. In qualitative resistance (Fig. 2a), mutation-based insensitive mutants are selected, and strains are either sensitive or resistant to the drug. In quantitative resistance (Fig. 2b) individuals that express genes leading to reduced fungicide sensitivity, are more likely to survive a drug treatment. Sub-lethal fungicide stress leads to further induction of genes that help resisting subsequent drug treatments. As a consequence the population is shifted to increasing resistance, and increasing numbers of individuals with higher degrees of resistance are found. For details, see text. After Hewitt (22), modified.

Cross-Resistance

- Resistance to a fungicide with a specific mode of action is expressed to other fungicides with the same mode of action

LSU AgCenter
Research · Extension · Teaching

Resistance Risk Factors

FUNGICIDE

- Site-specific mode of action
- Fungicide use pattern
  - Frequent or sole use
  - Improper timing
  - Poor coverage
  - Low rates
  - Use as a curative

PATHOGEN

- High reproductive rate
- Short latent period
- Fitness of resistant strains

LSU AgCenter
Research · Extension · Teaching

Managing fungicide resistance

1. Do not use the product exclusively (i.e., mixtures)
2. Restrict the number of applications per season, and apply only when necessary. Use other fungicides before and after
3. Use manufacturers' recommended dose
4. Avoid using as an eradicant
5. Integrated disease management
6. Chemical diversity

LSU AgCenter
Research · Extension · Teaching

Questions? Comments?

LSU AgCenter
Research · Extension · Teaching