

Bollworm (and Fall Armyworm) Issues in Bt Cotton

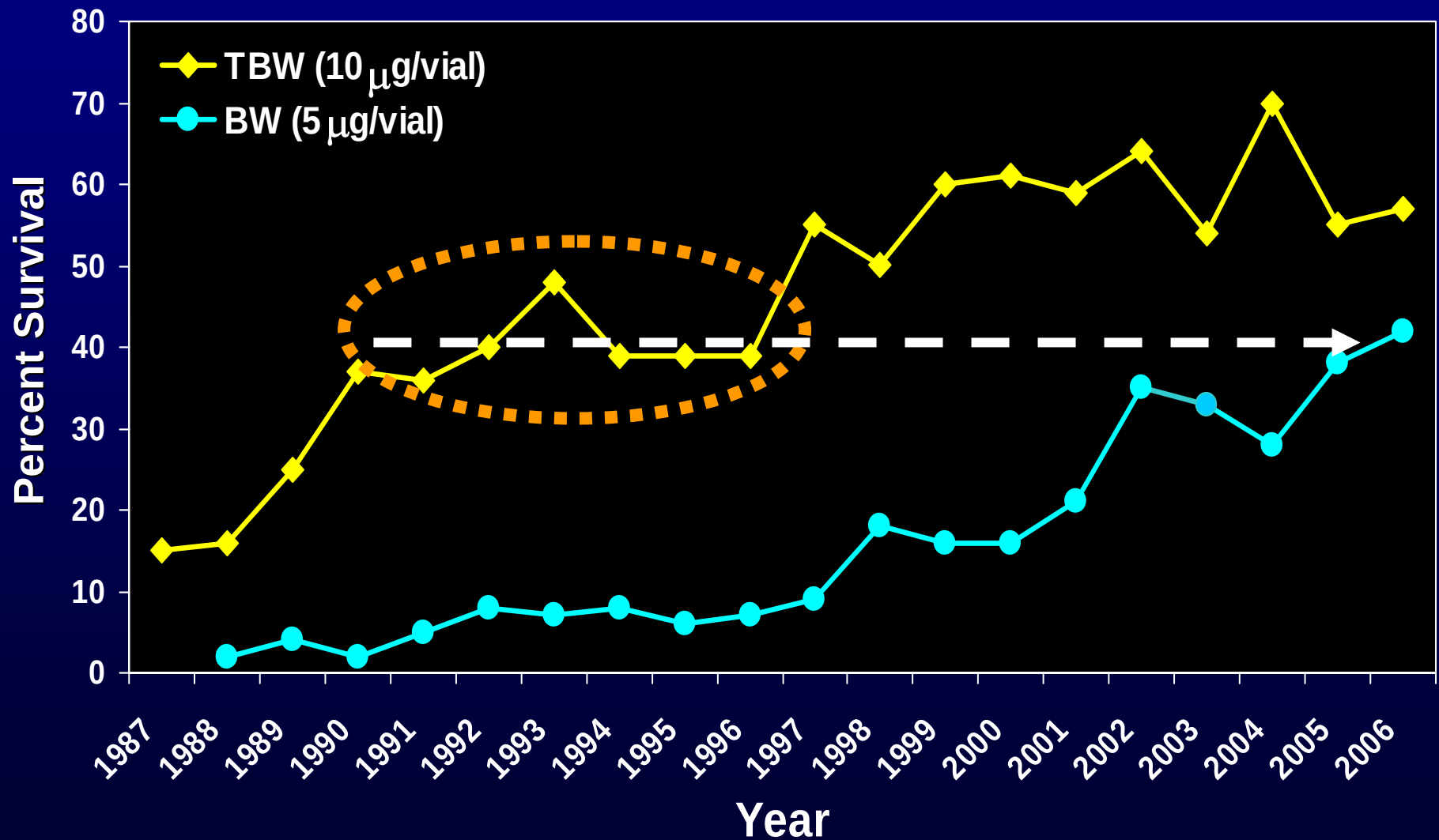
Walt Mullins
Monsanto Company

Bollworm/Fall Armyworm Issues with Bt Cotton

- Pyrethroid resistance
- Variability in Natural Tolerance to Bt
- Varietal Influence on Expression/Control
- Other Influences on Expression/Control
- Field to Field Variation

Resistance Monitoring Survey

Cypermethrin (May-Sep Mean Survival)



Toxicity of Cry1Ac

(susceptible LAB colonies)

Insect	LC50	Bollgard® Plant Protein Expression Level*
Tobacco budworm	0.013	1.0
Pink bollworm	0.012	1.0
Beet Armyworm	>100	1.0
Bollworm	0.87	1.0
Fall Armyworm	>100	1.0

***Expression levels vary considerably due to many factors. Number represents an estimate of average fresh weight expression across tissue types and times.**

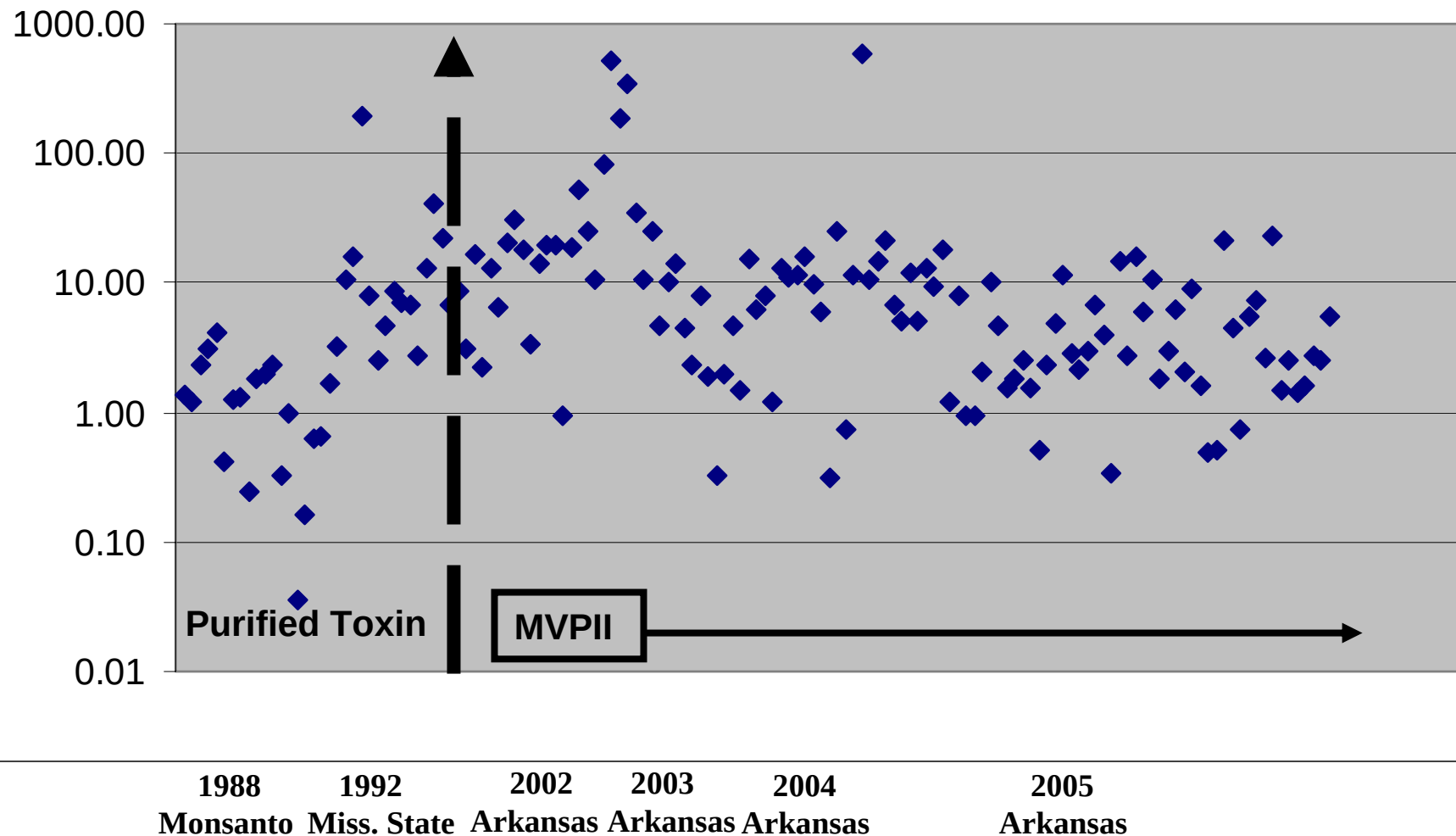
Toxicity of Cry2Ab2

(susceptible LAB colonies)

Insect	LC50	Bollgard® II Plant Protein Expression Level*
Tobacco budworm	0.549	180
Pink bollworm	0.036	180
Beet Armyworm	16.72	180
Bollworm	17.48	180
Fall Armyworm	82	180

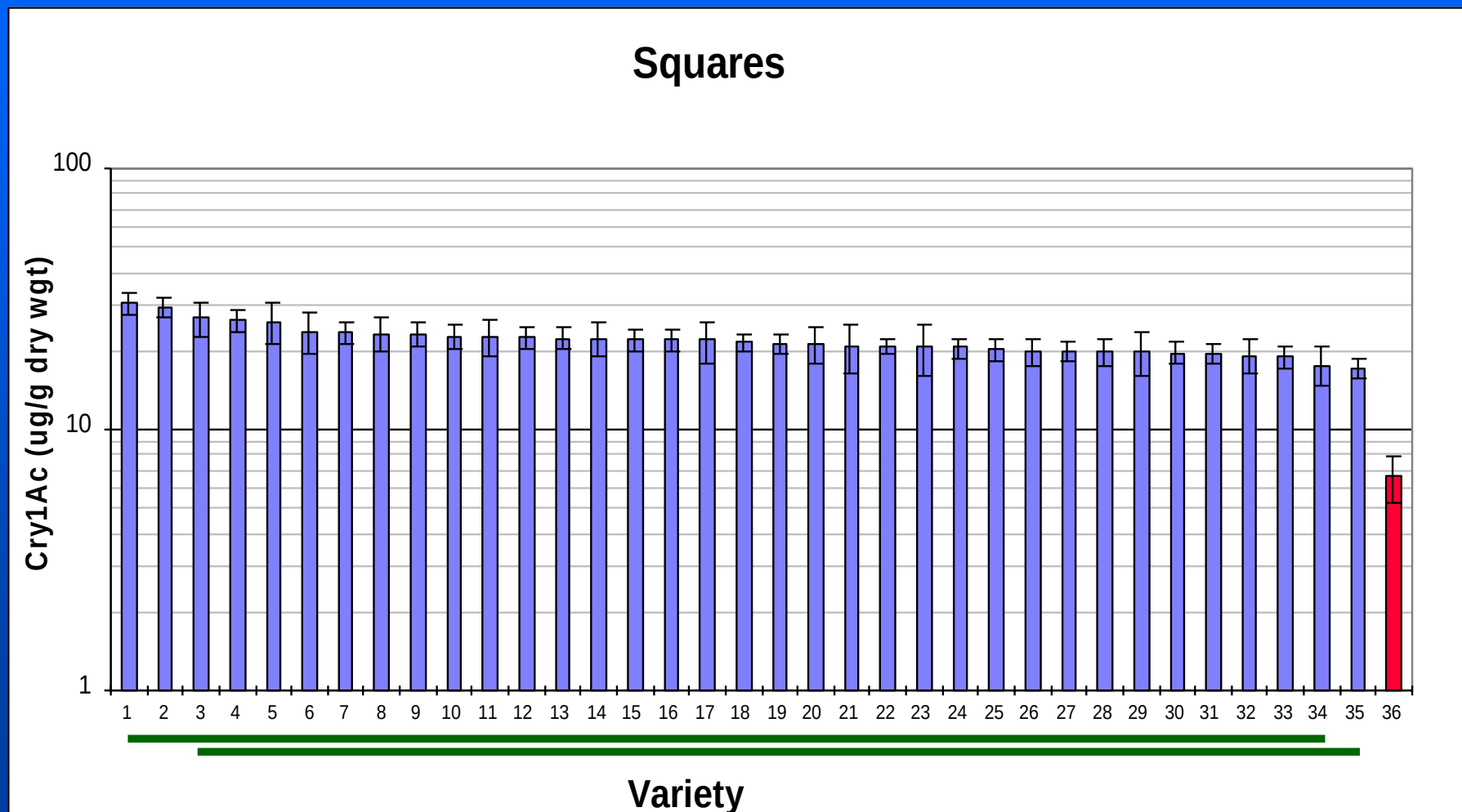
***Expression levels vary considerably due to many factors. Number represents an estimate of average fresh weight expression across tissue types and times.**

Variation in LC50s (LC50 / LC50 Lab) for *H. zea* Exposed to Cry1Ac in Diet Incorporation Assays



Varietal Influence on Expression? 1999 GE Expression Results

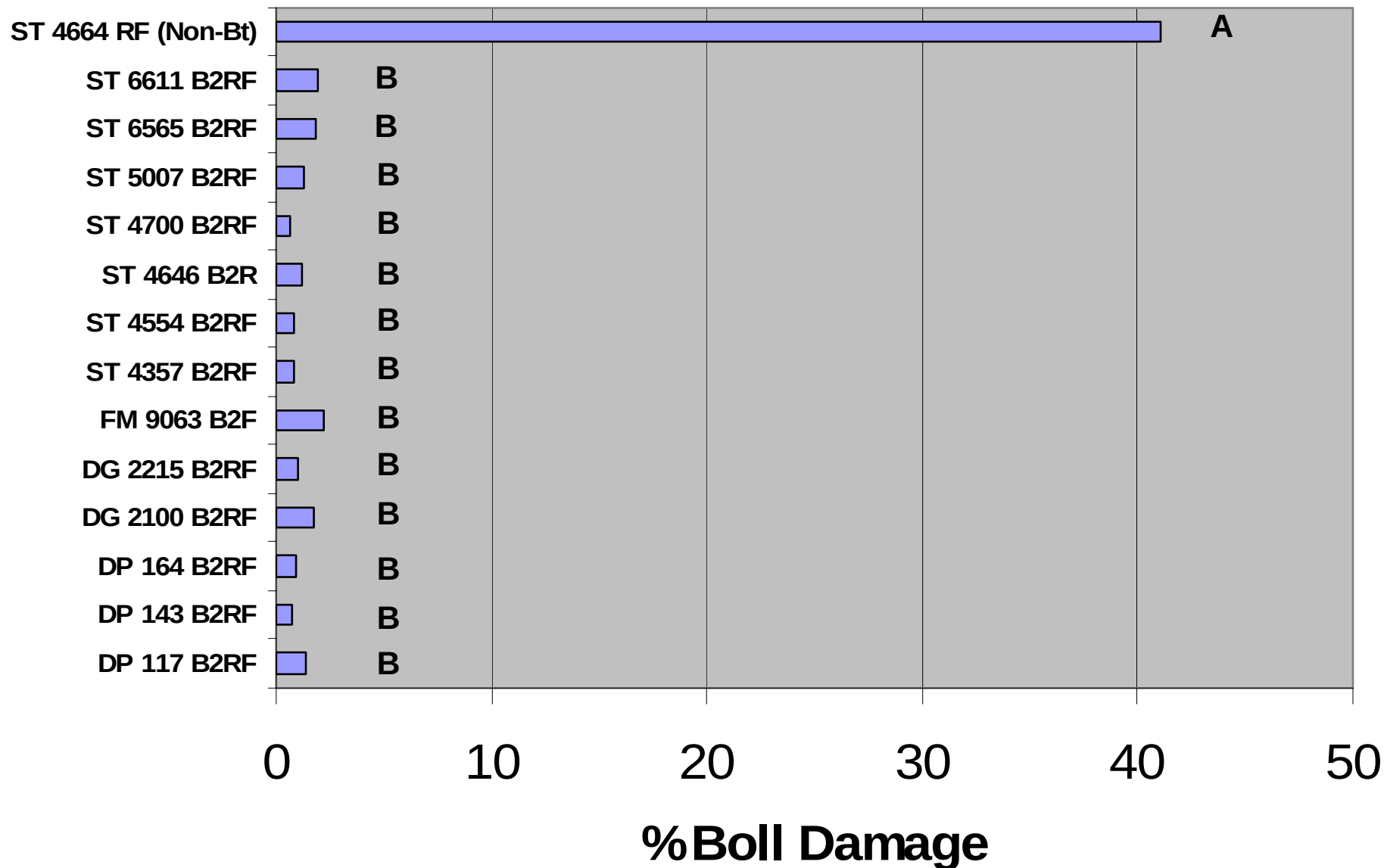
(— GE Requirement Level)



Bollgard® II Varietal Effect on Bollworm Control?

- Tested in 6 high risk bollworm areas in 2006: 2-NC, 2-SC, SW GA, SE TX
- Disruptive sprays applied to remove beneficials
- Very High *H. zea* pressure at all sites except GA (moderate mid-season)
- Rated for % boll damage by examining harvestable bolls during peak infestation periods

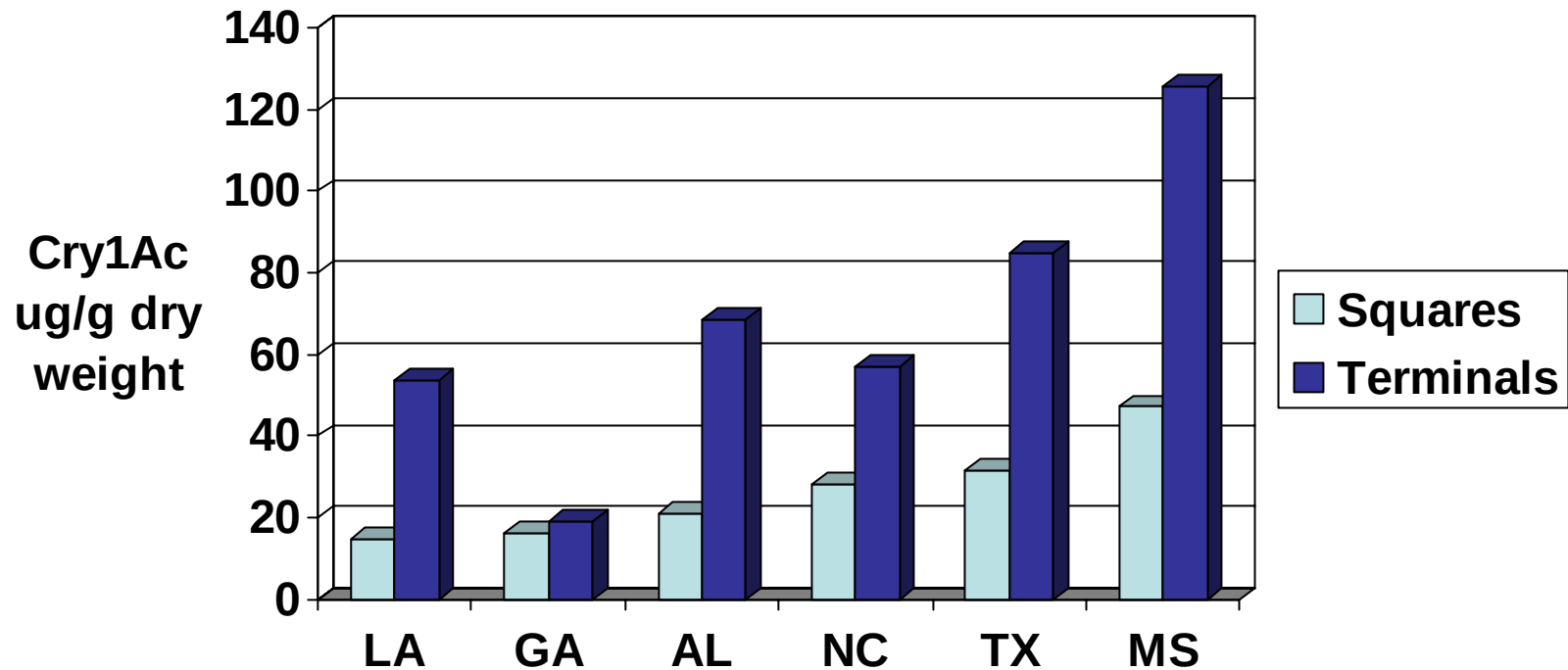
Percent Boll Damage due to Bollworms



Variety Comparison Conclusions

- No Statistically Significant Effect of Variety on Boll Damage across all sites/all rating dates
- No Statistically Significant Effect of Variety on Boll Damage across all sites at latest rating dates
- No Statistically Significant Effect of Variety at any one site or rating date when measuring % boll damage

Impact of Location on Expression Square and Terminal Tissue (Bollgard®)



Greenplate, JEE, 1999

Factors Influencing Expression

(Greenplate, JEE, 1999)

- **LOCATION (Environment)**
- Sampling time
- Tissue type or plant part
- Tissue location on the plant
- Plant to Plant variation

Environmental Influences on Expression

- Waterlogging
- Drought
- Nitrogen Levels
- Shading
- In furrow Insecticides
- Heat
- Insect Attack
- Soil Type
- Foliar Treatments

BUT, not necessarily in predictable ways!!

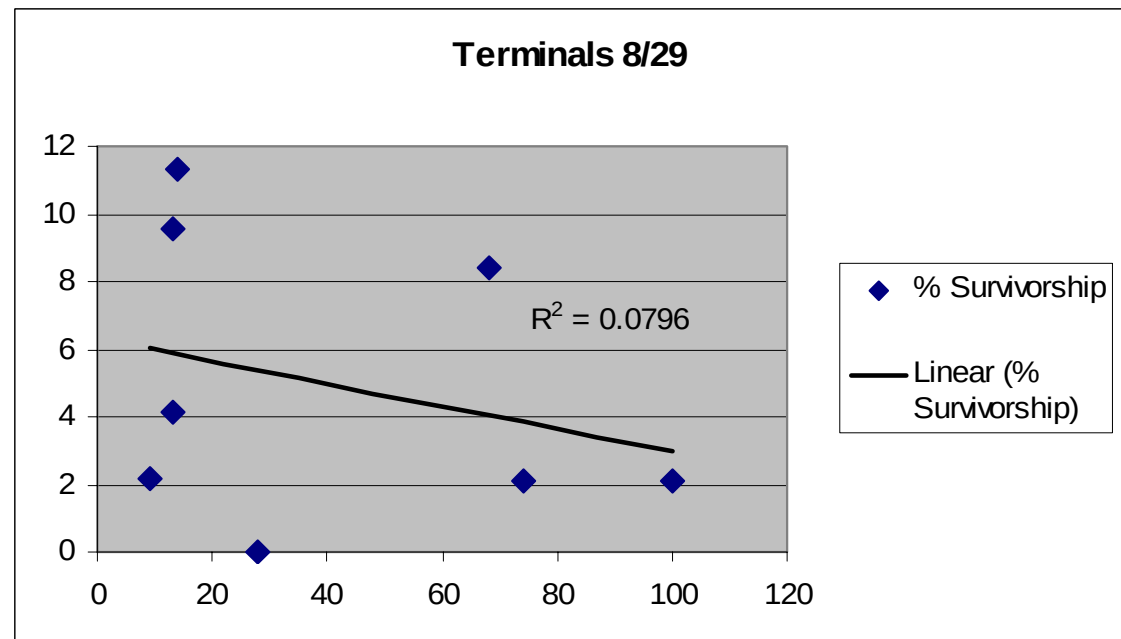
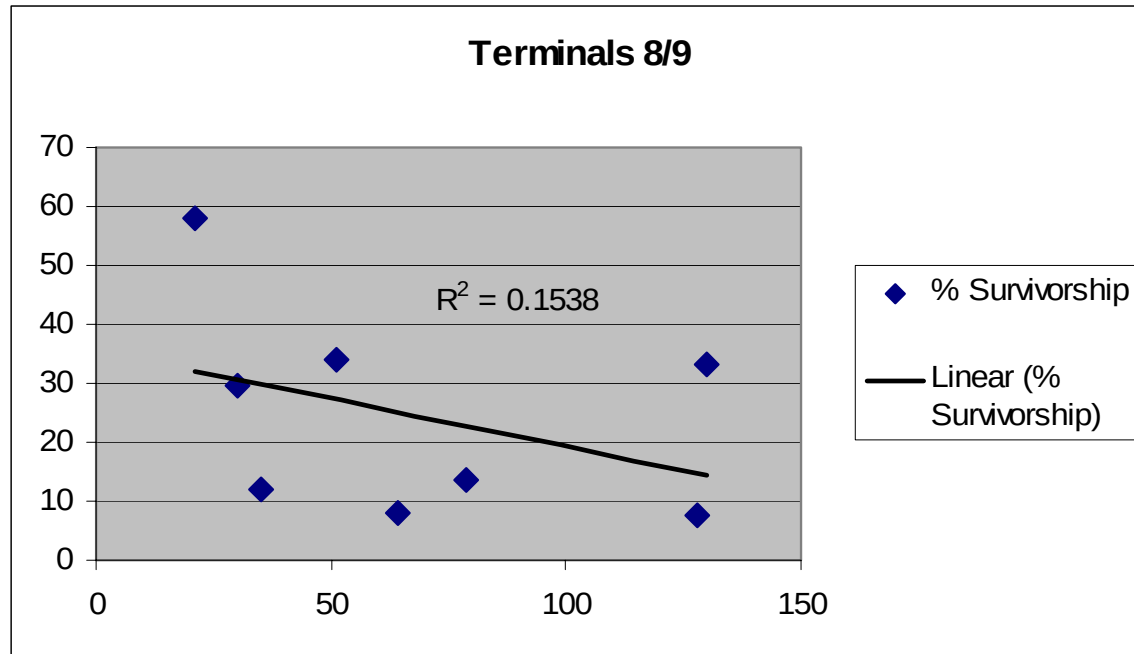
Correlating Bollworm Survival to Expression

(Cry1Ac equivalents
Measured by Quantitative
Bioassay)

Conducted at Leland
Agronomy Center, 2001

- *Lab bioassay
- *Excised tissue
- *Neonate bollworms
- *48 hour survivorship

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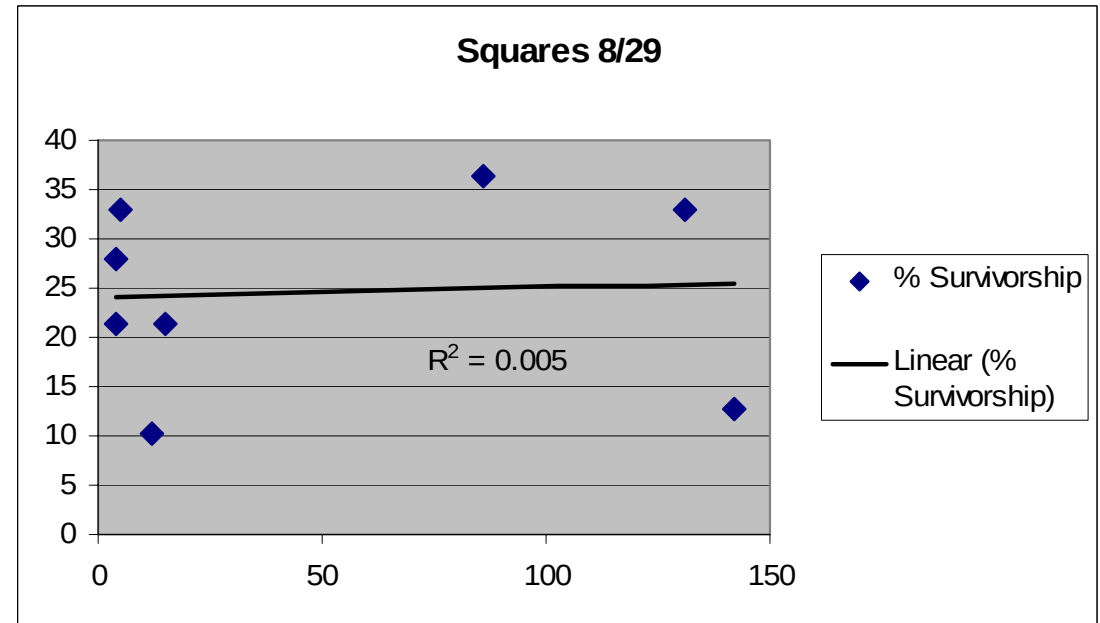
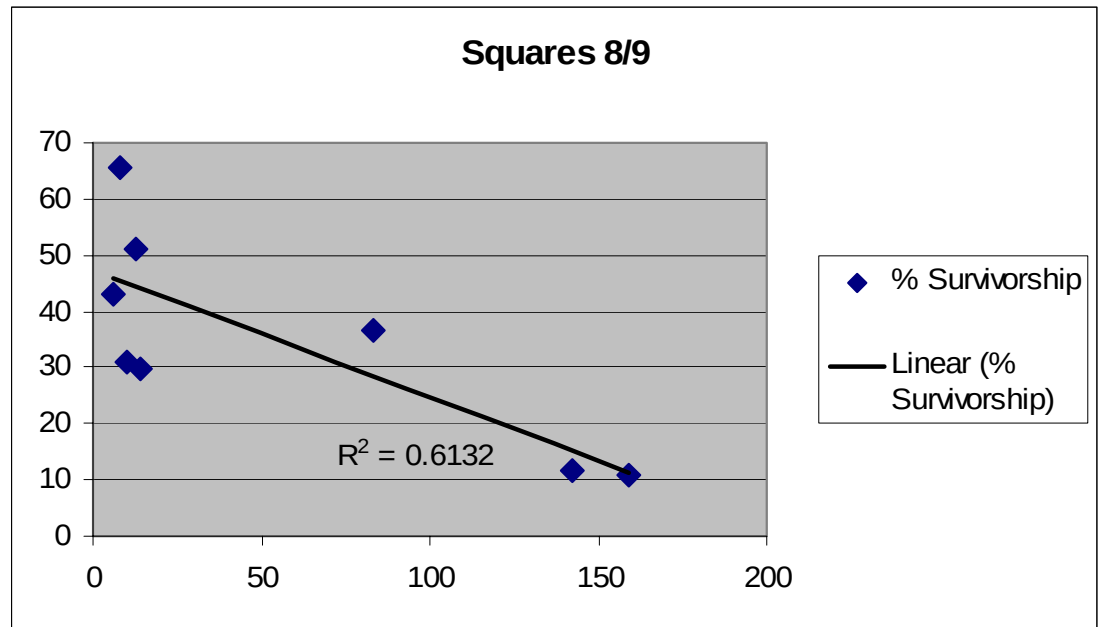
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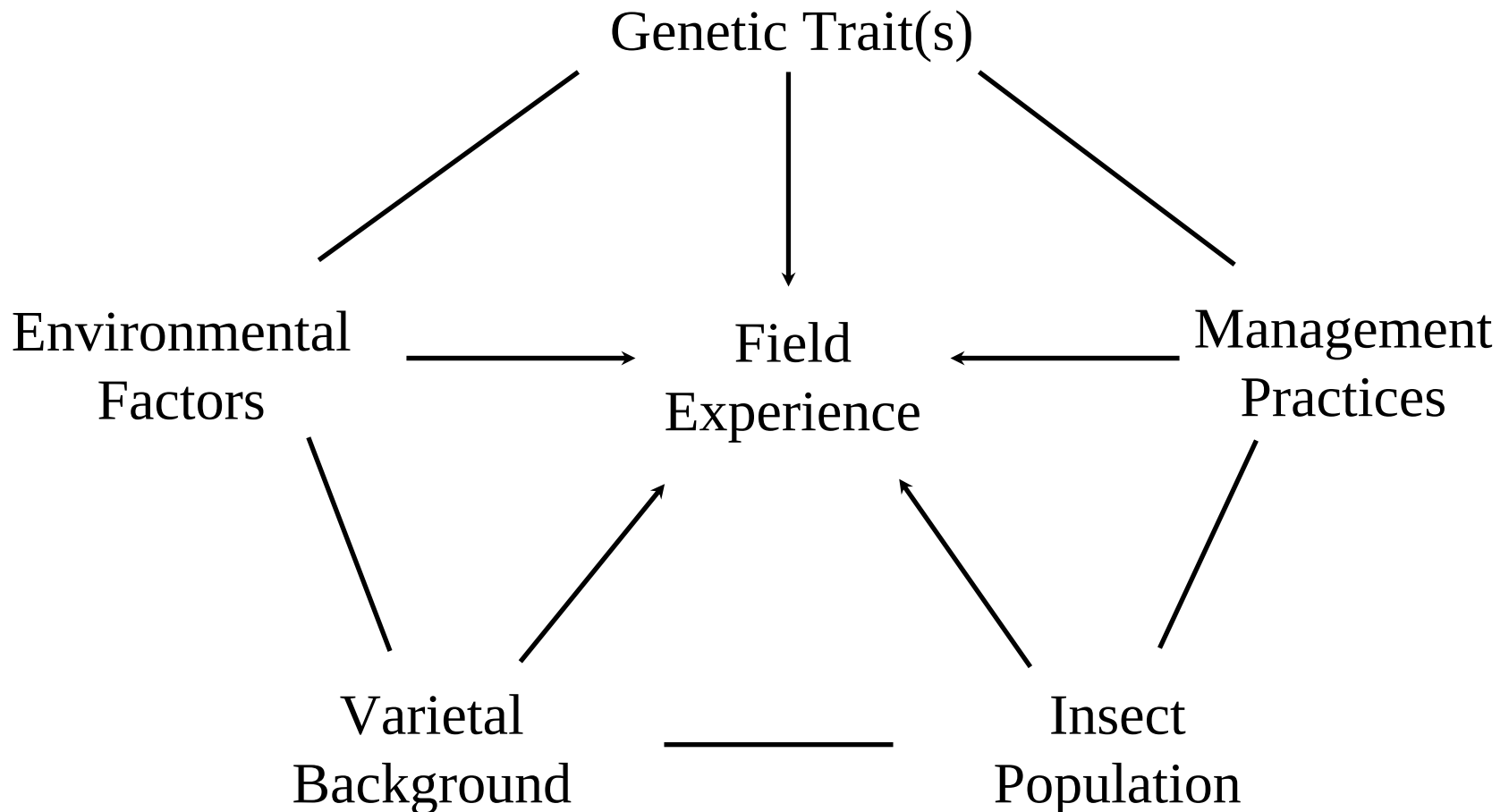
**Plant-Toxin Interactions in Transgenic Bt Cotton
and their Effect on
Mortality of *Helicoverpa armigera* (Lepidoptera:
Noctuidae)**

K. M. OLSEN AND J. C. DALY

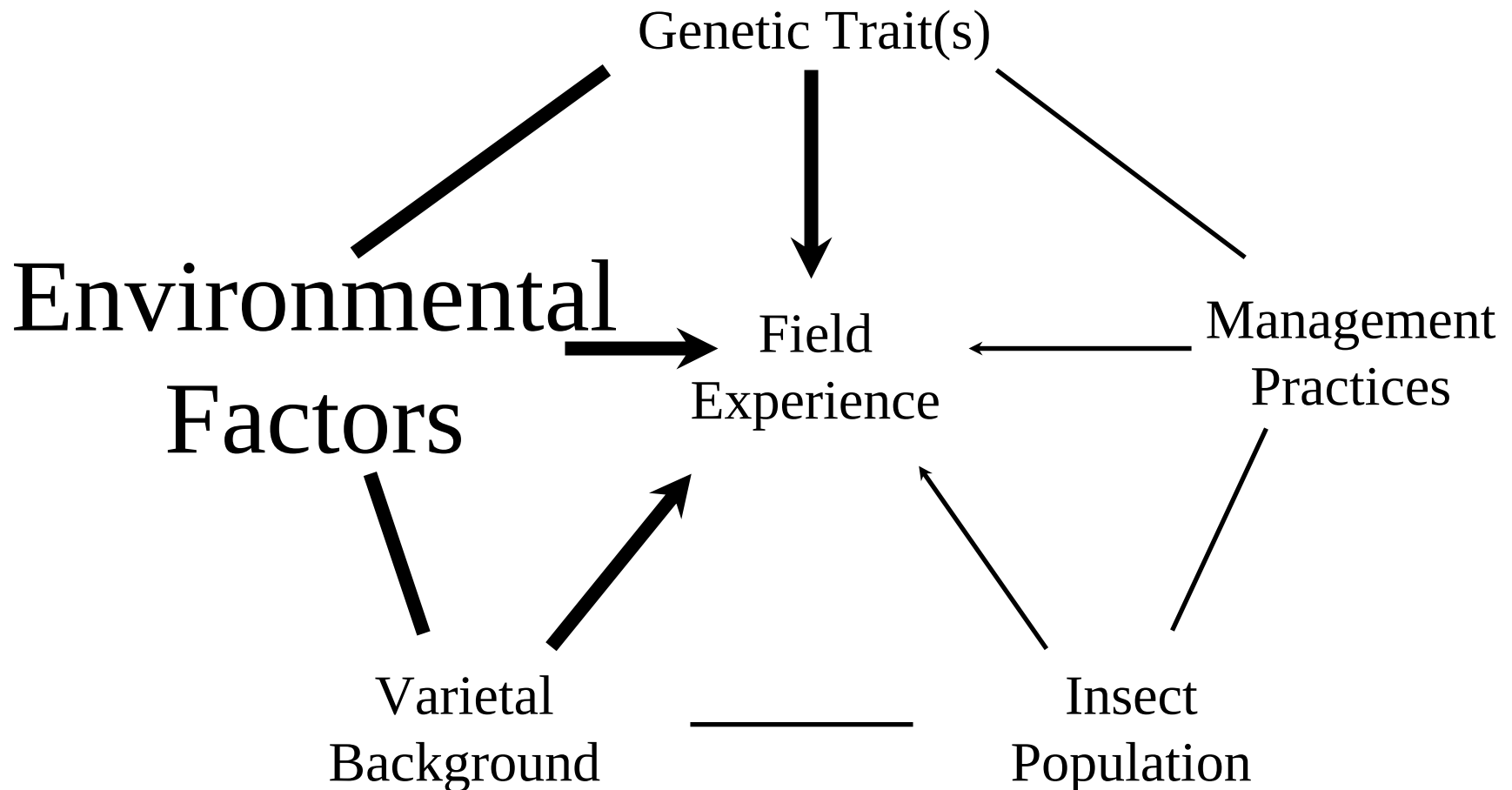
**Commonwealth Scientific and Industrial Research
Organisation, Entomology and Australian Cotton CRC, GPO
Box 1700,
Canberra, ACT 2601, Australia
J. Econ. Entomol. 93(4): 1293-1299 (2000)**

**“Changes in plant physiology,
associated with the maturation of
the cotton plant, were observed to
contribute to changes in the efficacy
of the Bt toxin.”**

Why Field to Field Variations Occur With Transgenic Traits (1999)



Why Field to Field Variations Occur With Transgenic Traits (2006)



Ramifications of Biological Variation for Bollworm and Fall Armyworm Control in Bt Cotton

- Understanding a particular technology's range of effects requires multiple experiences across multiple environments, varietal backgrounds and pest populations
- Damage in one field rarely dictates or predicts that damage will occur in other adjacent fields, even given the same Bt technology in the same variety
- Every field of Bt cotton must be monitored for bollworm/fall armyworm damage and treated accordingly