ABSTRACT: 450

PROGRESS FROM 80 YEARS OF BREEDING SOYBEAN IN THE UNITED STATES

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Soybean improvement efforts have been ongoing in the United States since the 1920's. During the period from 1924 to 2011, average national soybean yields have increased at a rate of 23.5 kg hectare^{-1} year^{-1}. Our objective was to determine the role of genetic improvement in the yield increases that have occurred. This was done by growing an experiment of soybean cultivars with release dates from 1923 to 2008 in common tests during 2010 and 2011 in 17 states and one Canadian province. The cultivars were grown in tests organized by their maturities and there were 60 maturity group (MG) II, 59 MG III and 49 MG IV cultivars. Across years and locations, the rate of yield increase in these tests was 22.8 kg hectare^{-1} year^{-1} for both MG II and III, and 20.2 kg hectare^{-1} year^{-1} for MG IV. Other observed changes are that new cultivars matured later, have greater lodging resistance, are shorter, and generally have greater disease resistance than old cultivars. Composition analysis of seed harvested from these trials revealed that over generations of breeding, seed protein concentration has decreased from 0.27 to 0.15 g kg^{-1} year^{-1}, depending on MG, and oil concentration increased from 0.14 to 0.06 g kg^{-1} year^{-1}. These tests support other research which shows that most of the soybean yield advances in the United States are the result of improved genetics and by comparison, agronomic improvements have had a smaller impact.

INVITED SPEAKER

Advances in Soybean Breeding in the USA

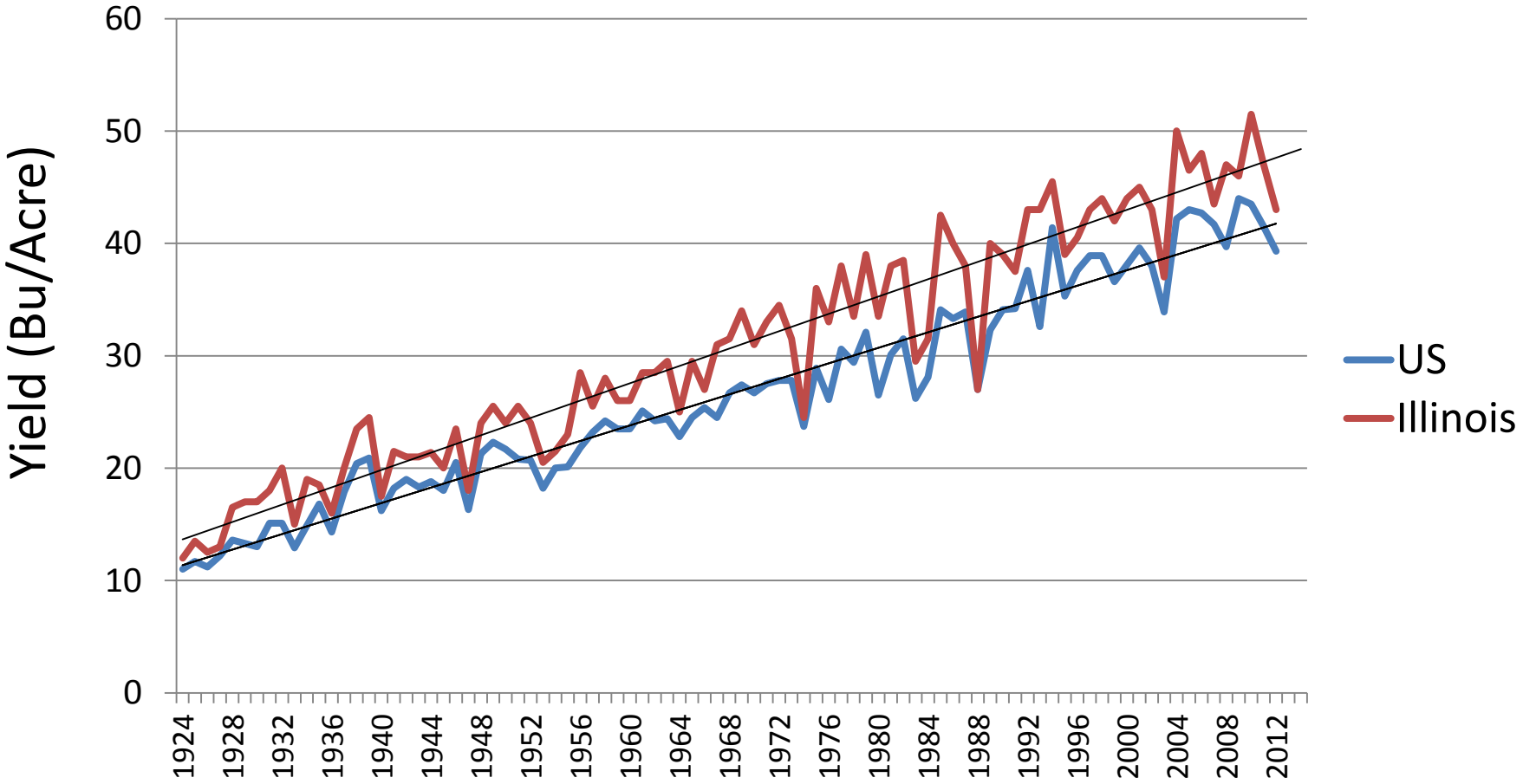
Brian Diers
University of Illinois

Outline

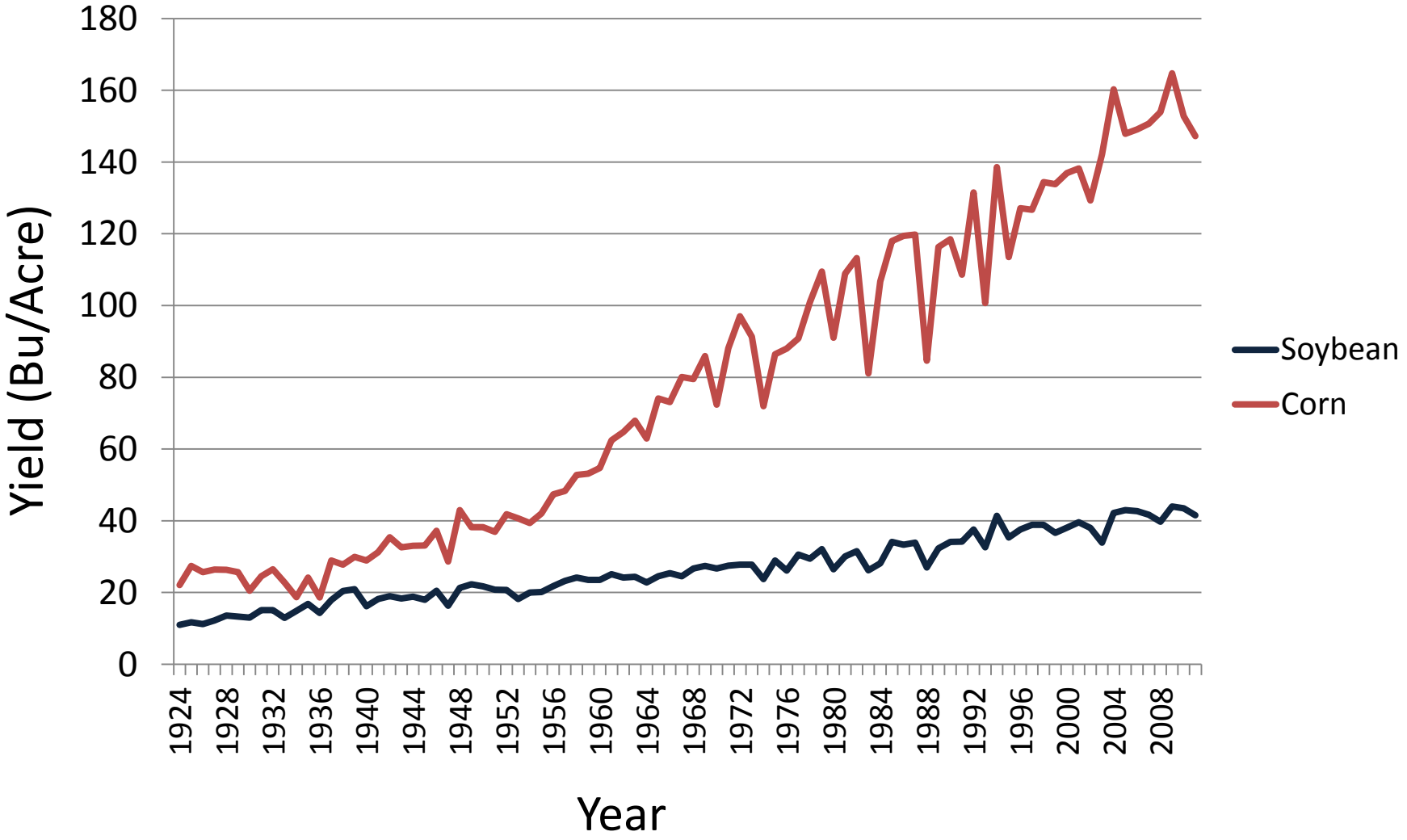
- Soybean yield trends.
- Yield trends for Williams or Williams 82.
- Decade study.
  - Overall trends.
  - Rotation experiment.
  - Planting date experiment.
- Summary.

Soybean Yields are Increasing

- 22.8 kg/ha/yr (0.34 bushels/acre/yr) nationally
- 25.5 kg/ha/yr (0.38 bushels/acre/yr) in Illinois

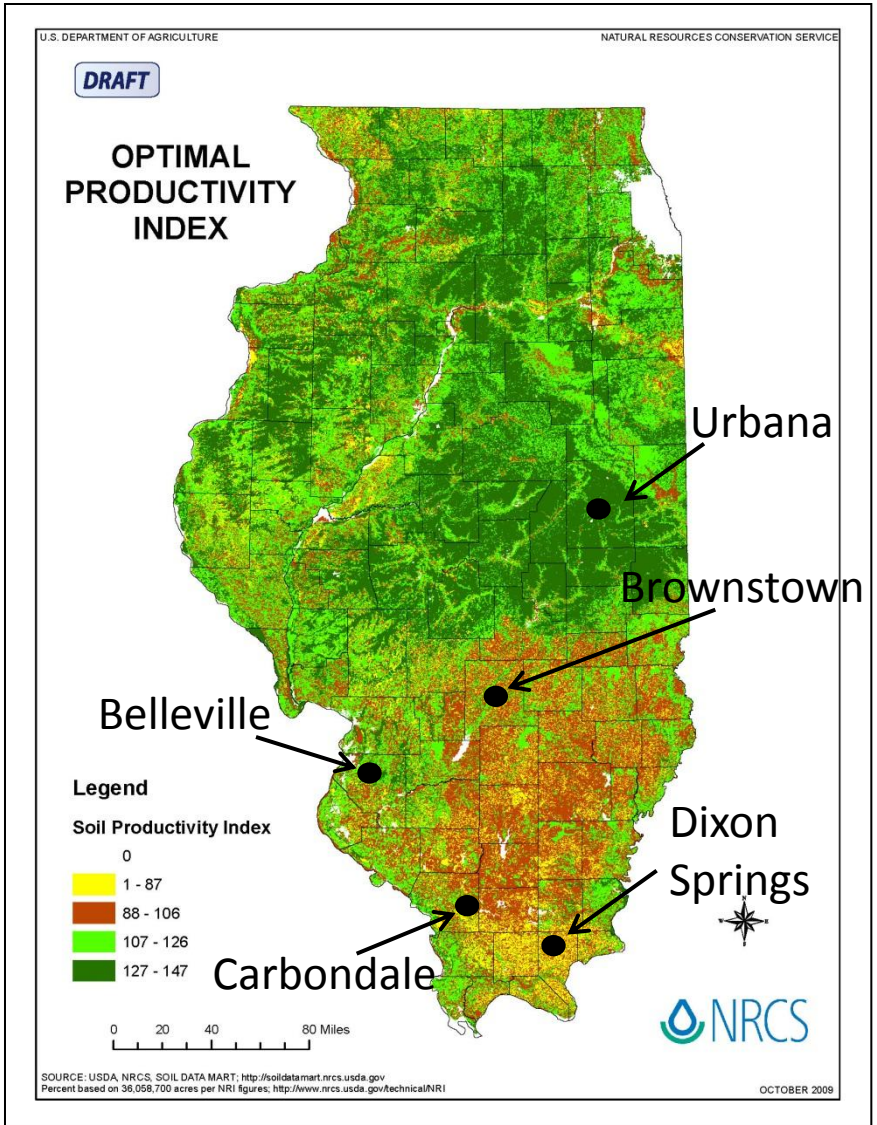


U.S. Average Corn and Soybean Yields

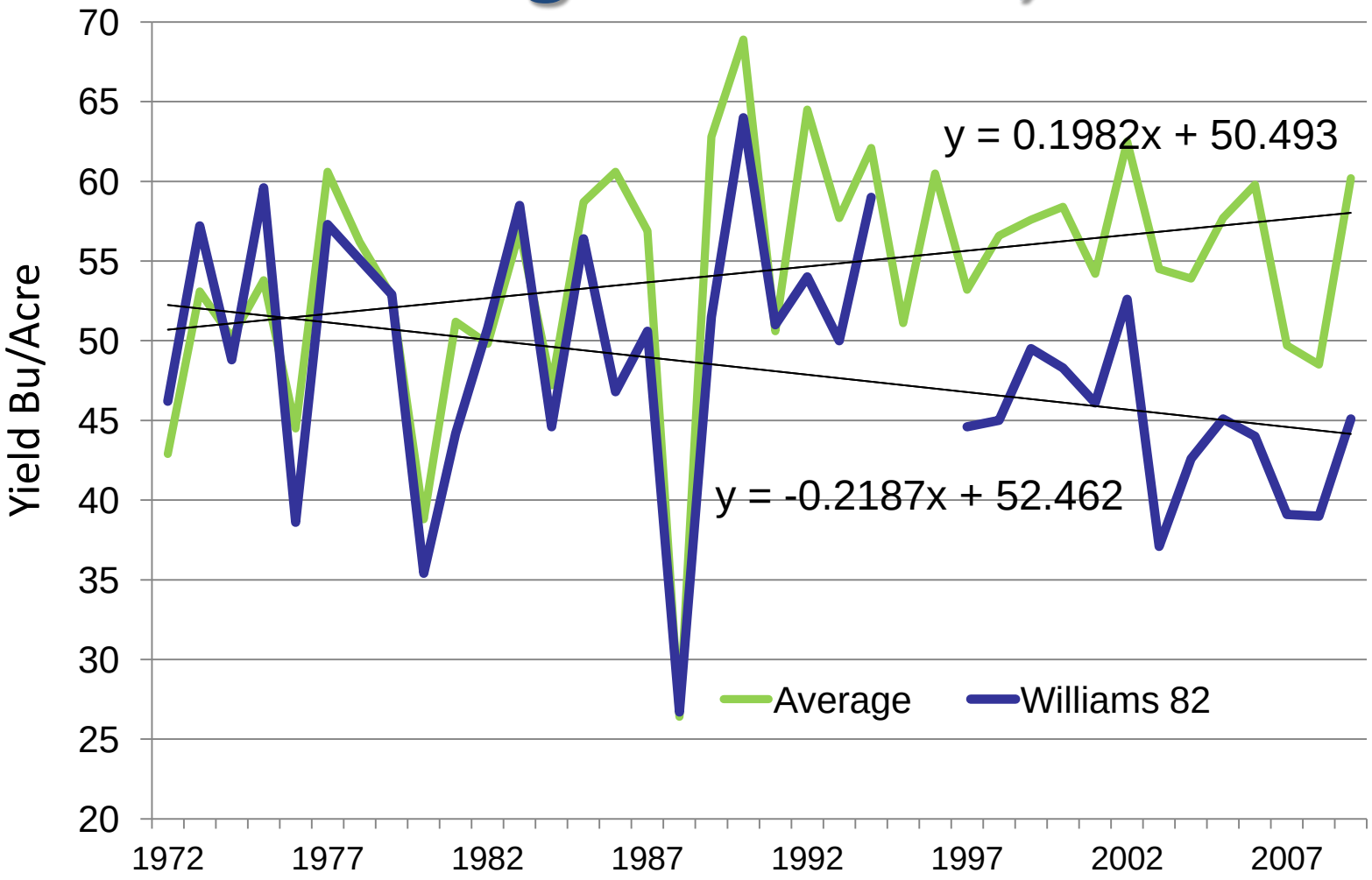


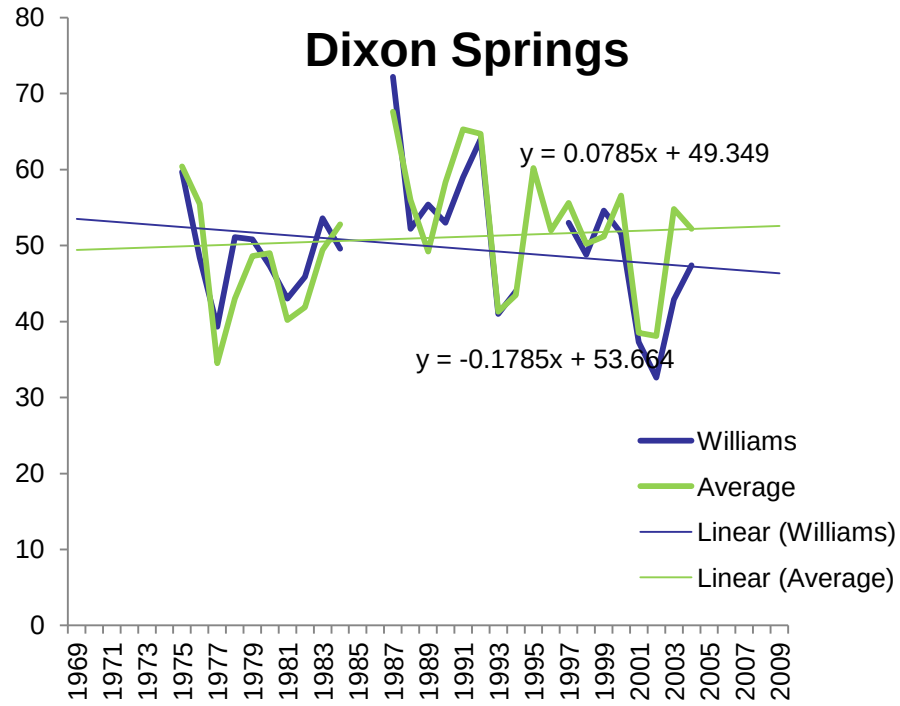
Genetic Gains in Soybean

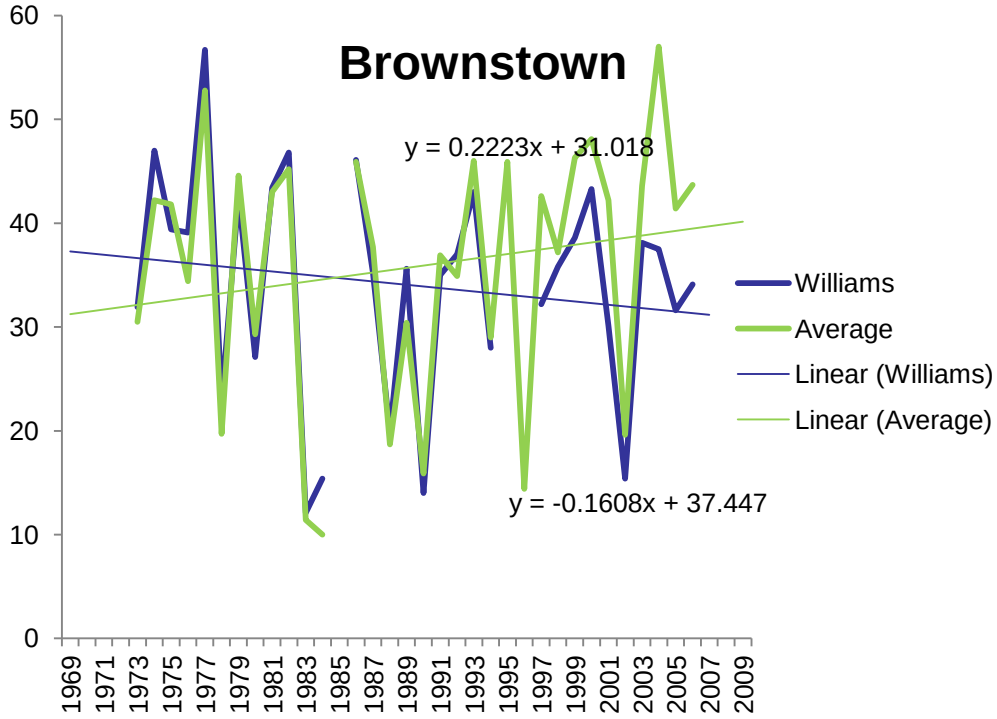
- Soybean breeders not as focused on yield as maize breeders
- More emphasis on disease and pest resistance.
- What is the value of resistance?
- Historic performance of Williams or Williams 82.

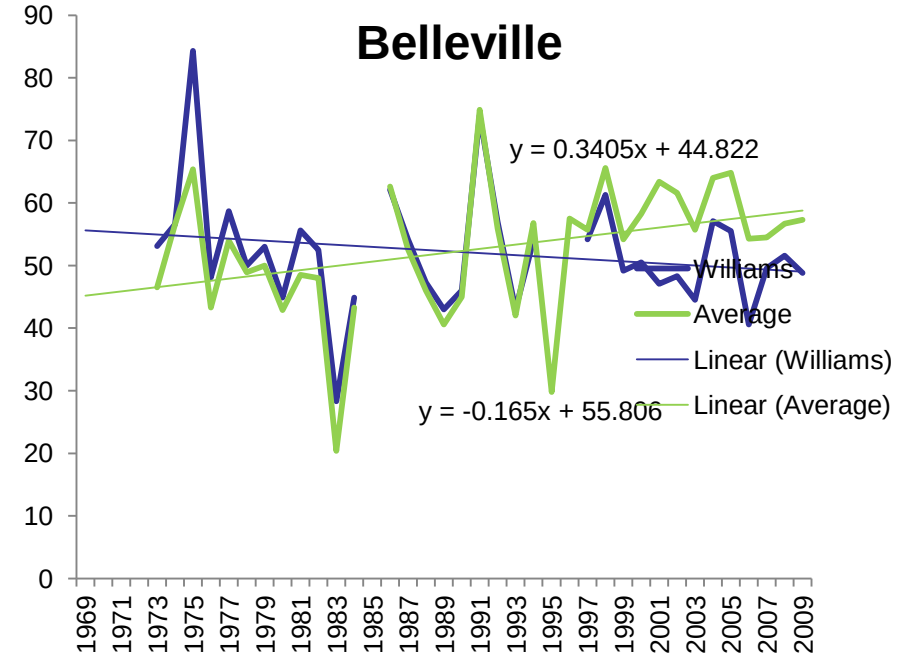


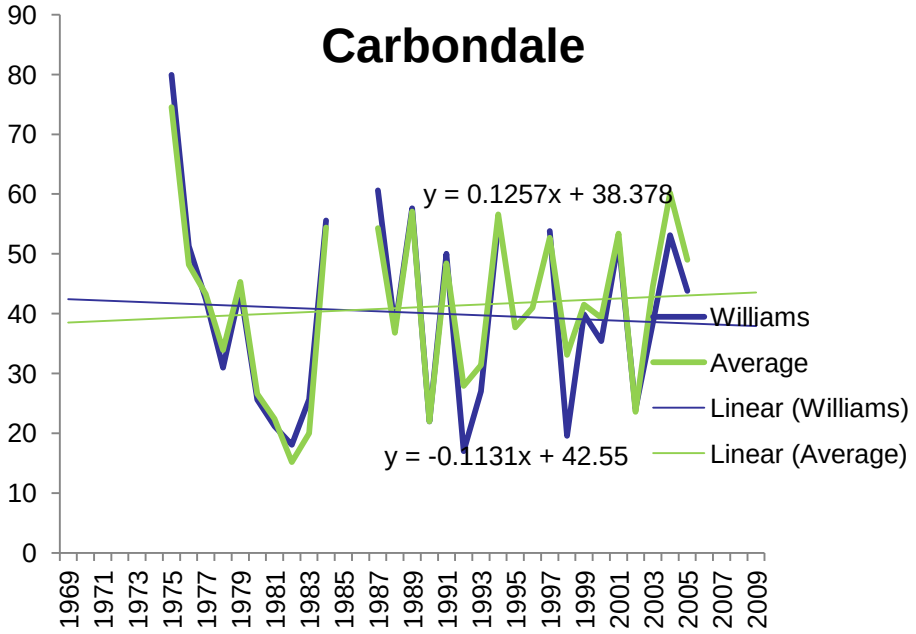
Yields of Williams or Williams 82 Compared to Test Average in Urbana, IL




Dixon Springs
y = 0.0785x + 49.349
y = -0.1785x + 53.664
Williams
Average
Linear (Williams)
Linear (Average)

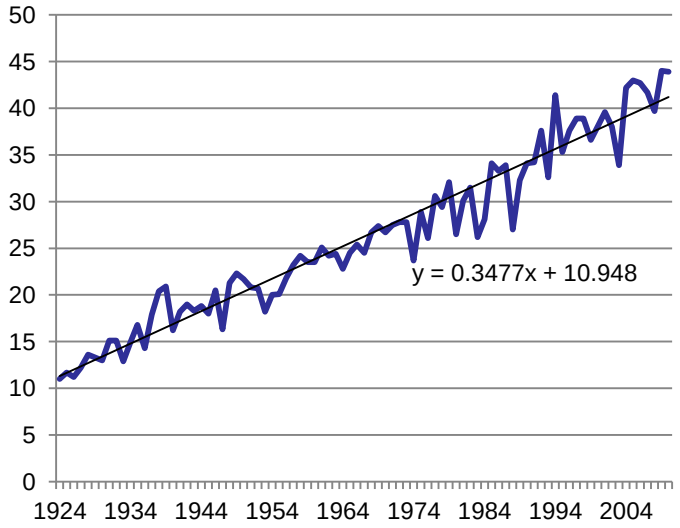

Brownstown
y = 0.2223x + 31.018
y = -0.1608x + 37.447
Williams
Average
Linear (Williams)
Linear (Average)


Belleville
y = 0.3405x + 44.822
y = -0.165x + 55.806
Williams
Average
Linear (Williams)
Linear (Average)


Carbondale
y = 0.1257x + 38.378
y = -0.1131x + 42.55
Williams
Average
Linear (Williams)
Linear (Average)

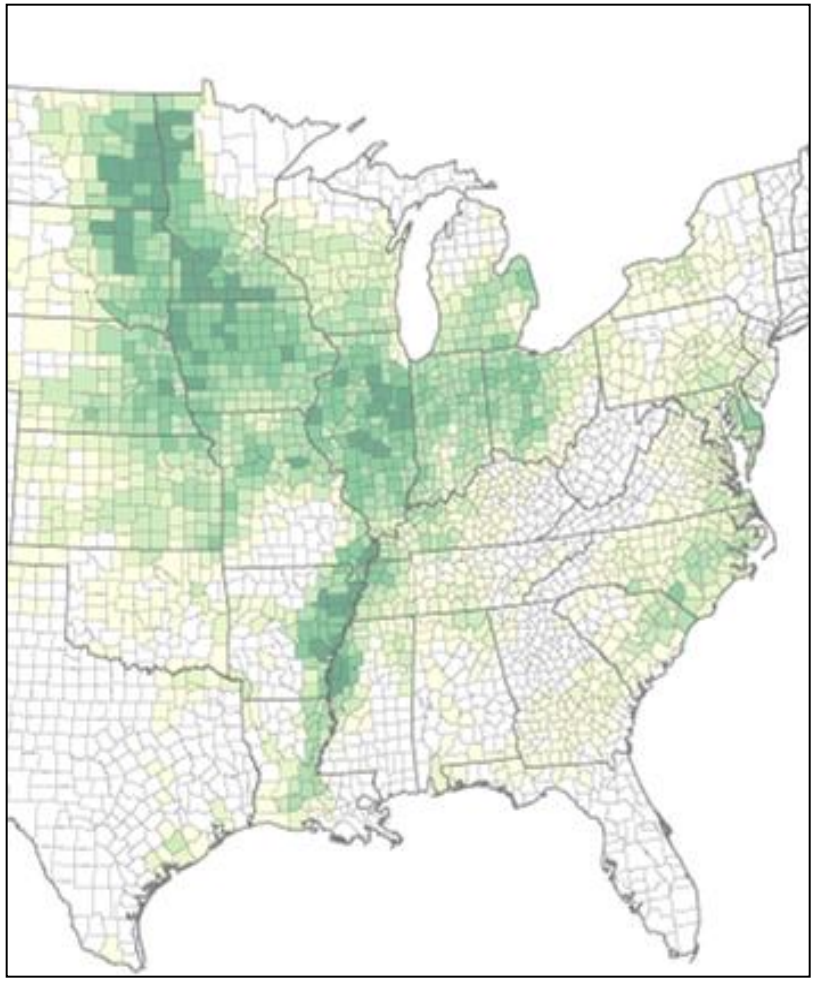
Genetic Gains

- Yield increases are the result of improved genetics, agronomics and growing conditions.
- How much of this gain is the result in improved genetics?
- How have soybean plants been altered to achieve greater yields?



Genetic Gain Study

- Collected sets of MG II, III and IV soybean cultivars from the 1920's to present day.
  - Included modern commercial cultivars from Syngenta, Monsanto and Pioneer.
- In 2010-2011 cultivars grown:
  - 15 MG II locations
  - 13 MG III locations
  - 14 MG IV locations



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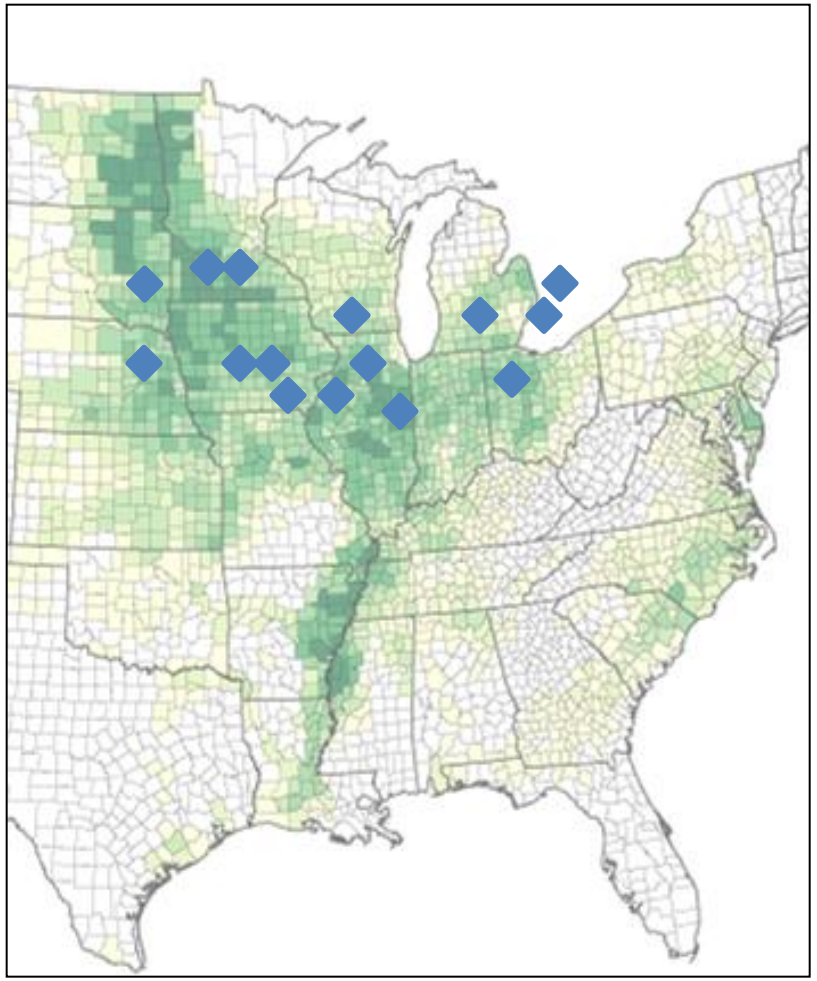

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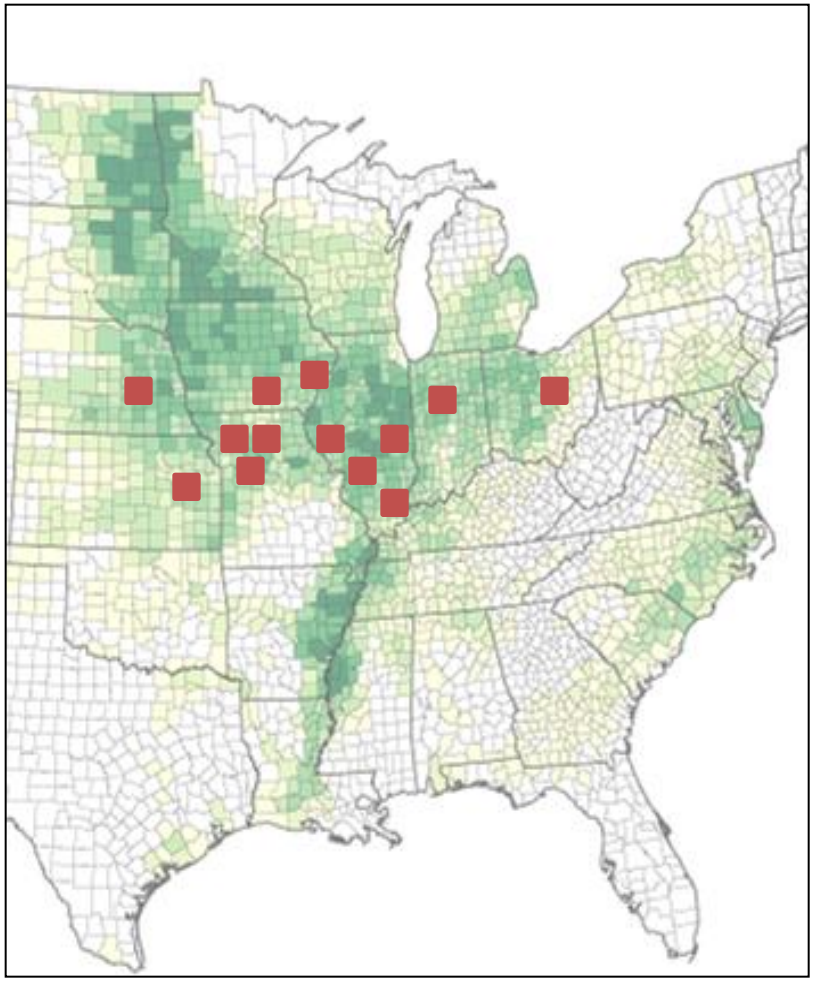

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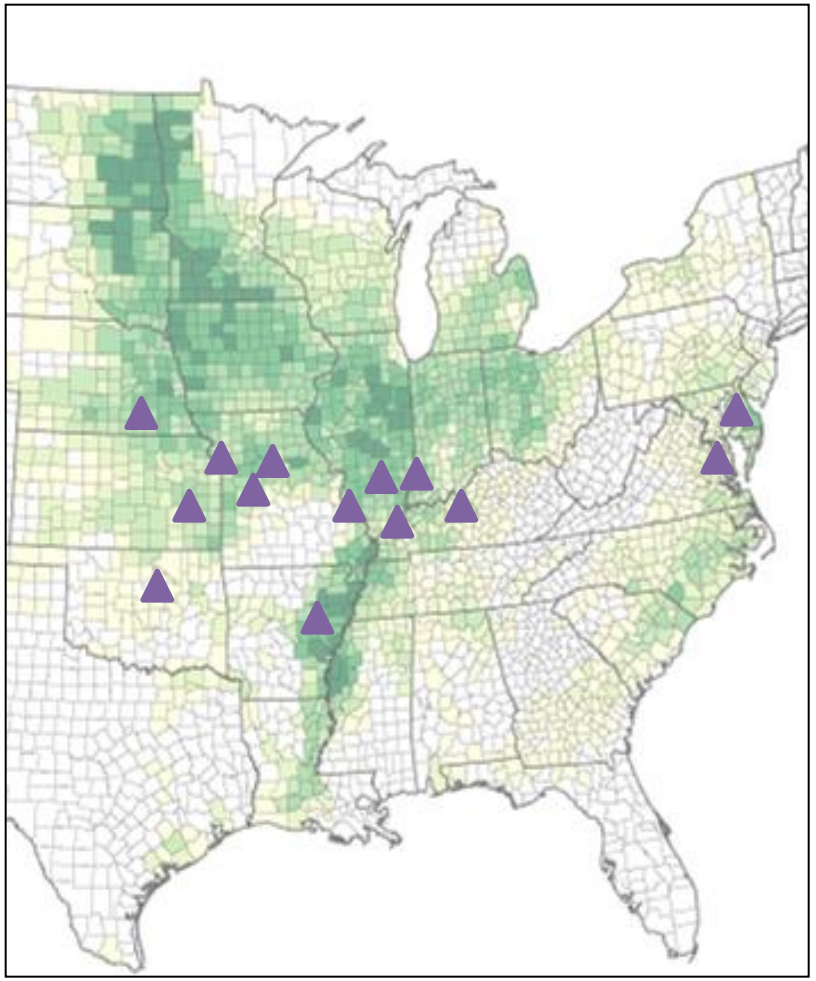
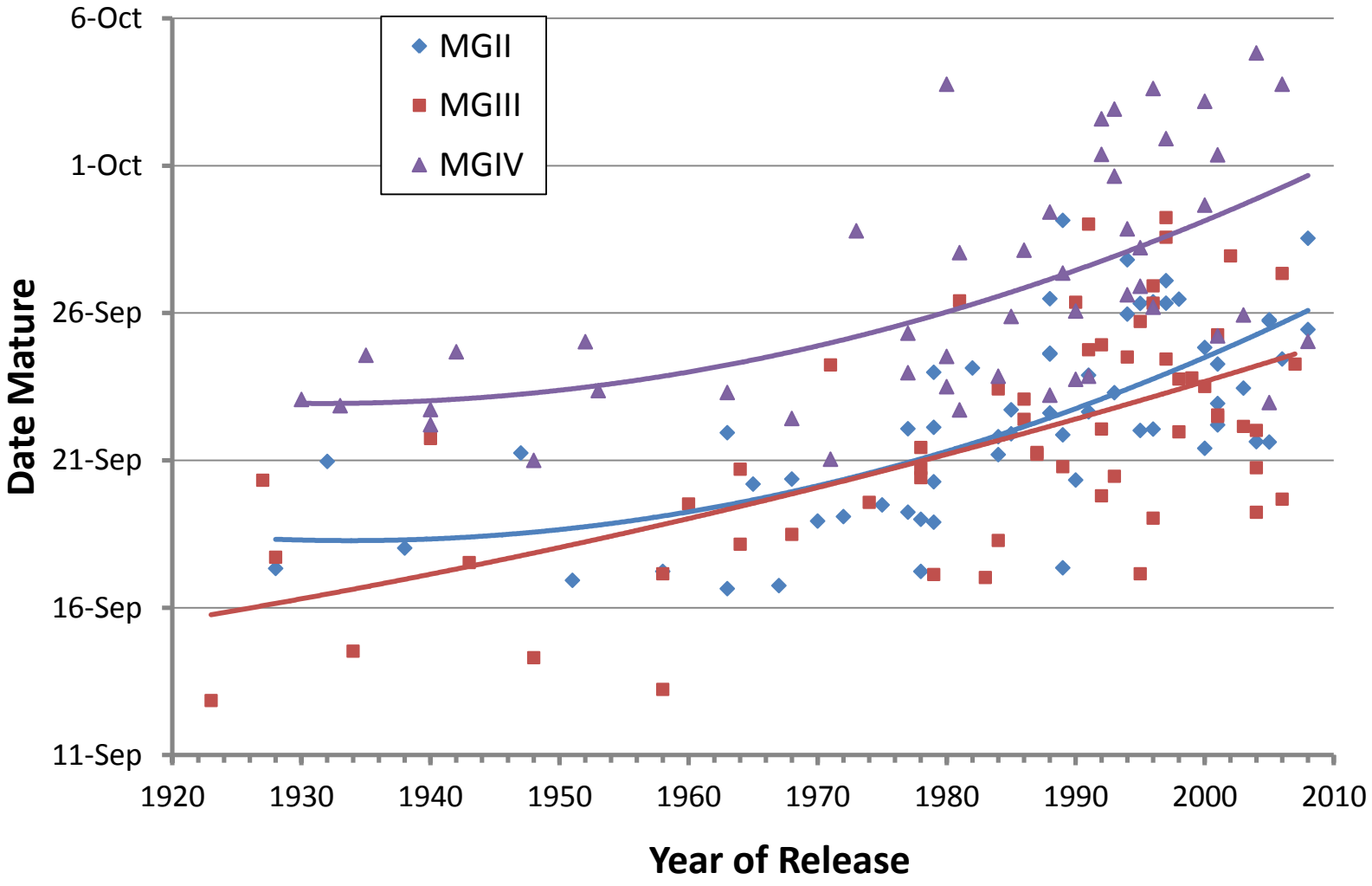


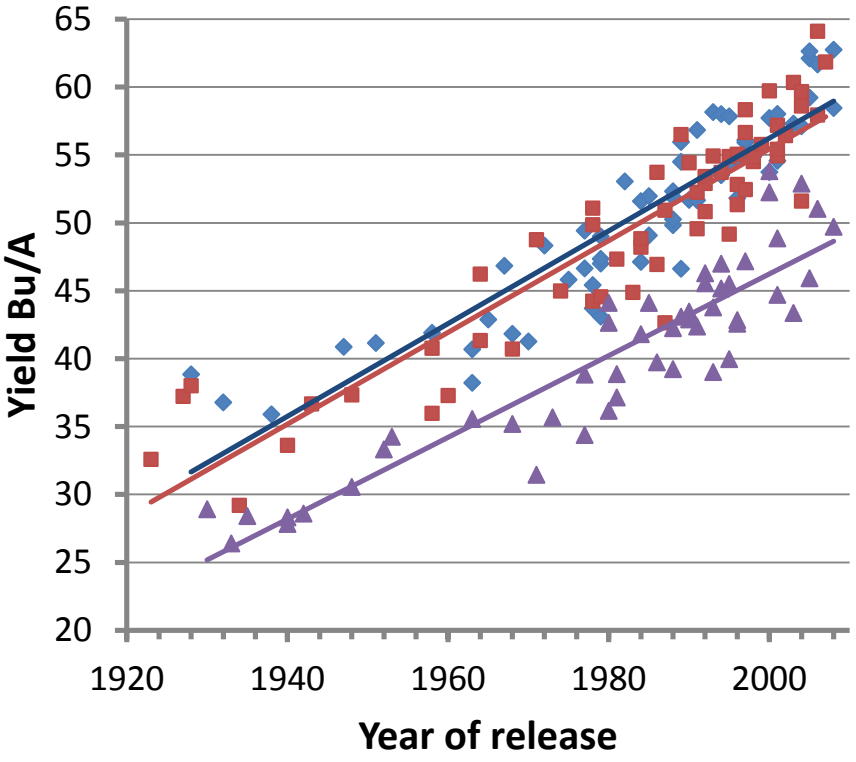
New Varieties Mature Later Than Old Varieties



New Varieties Yield More Than Old Varieties

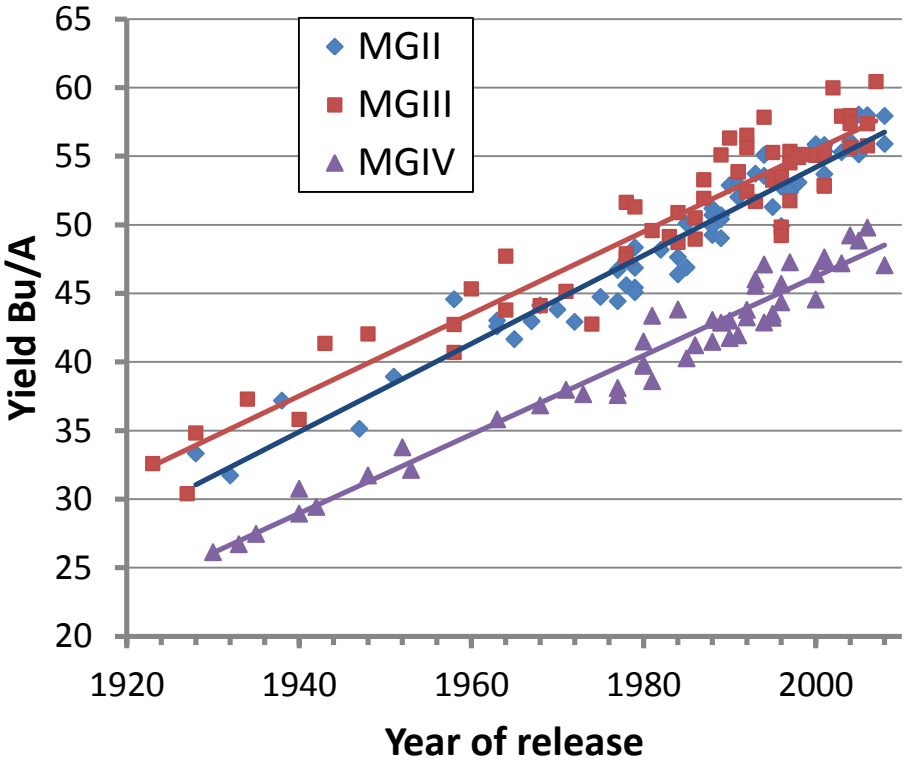
Non-Adjusted Genetic Gain

MGII change 22.8 kg/ha/yr
MGIII change 22.8 kg/ha/yr
MGIV change 20.1 kg/ha/yr



Maturity Adjusted Genetic Gain

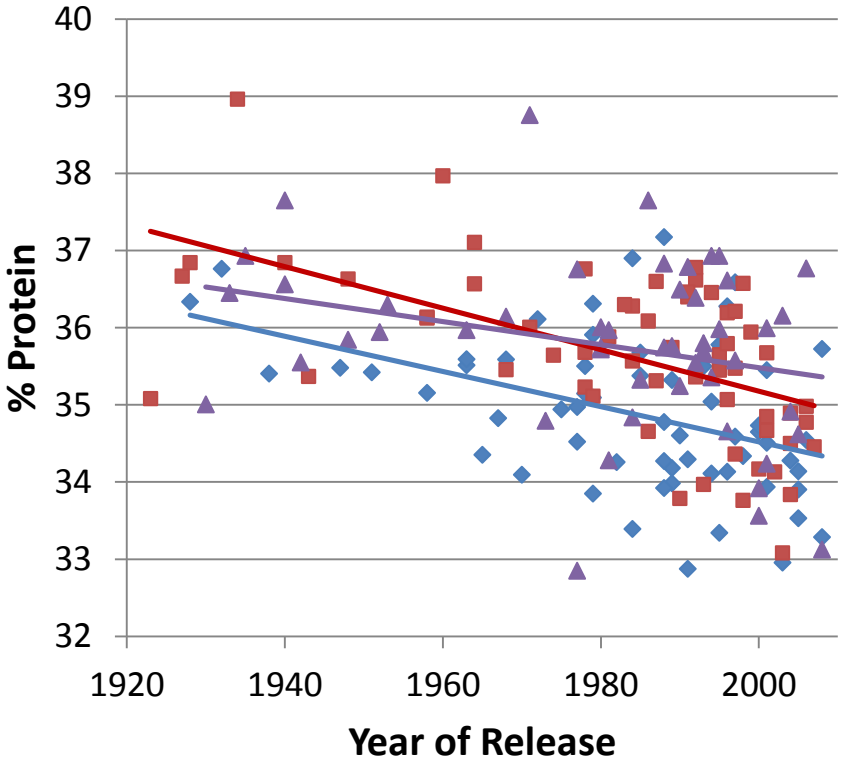
MGII change 20.1 kg/ha/yr
MGIII change 18.8 kg/ha/yr
MGIV change 17.4 kg/ha/yr



Seed Protein Concentration Is Decreasing, Oil Is Increasing

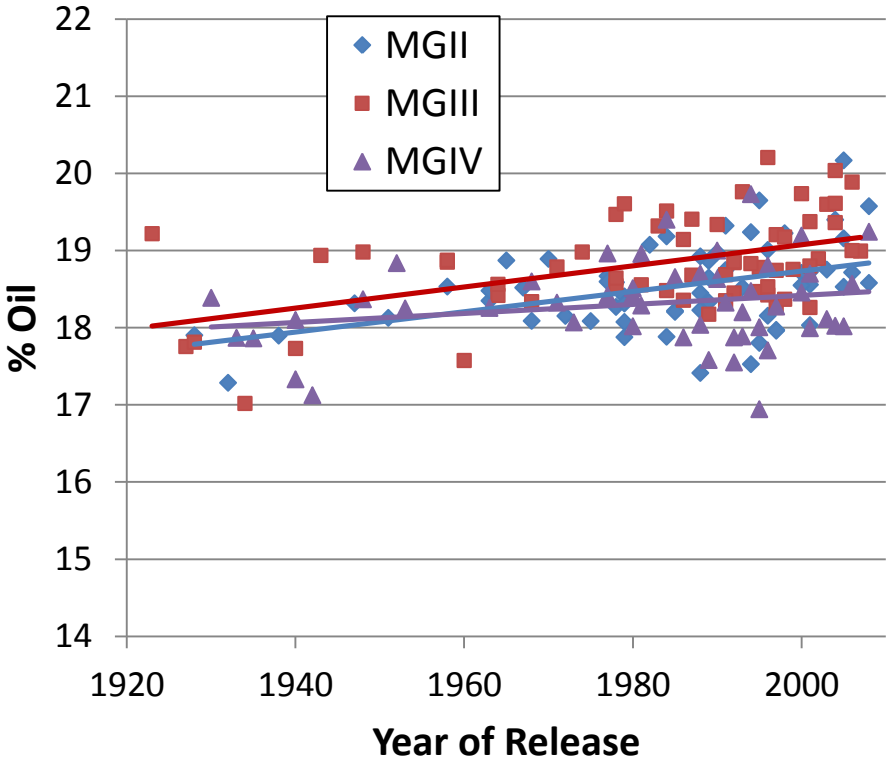
Protein

MGII change -0.023%/year
MGIII change -0.027%/year
MGIV change -0.015%/year



Oil

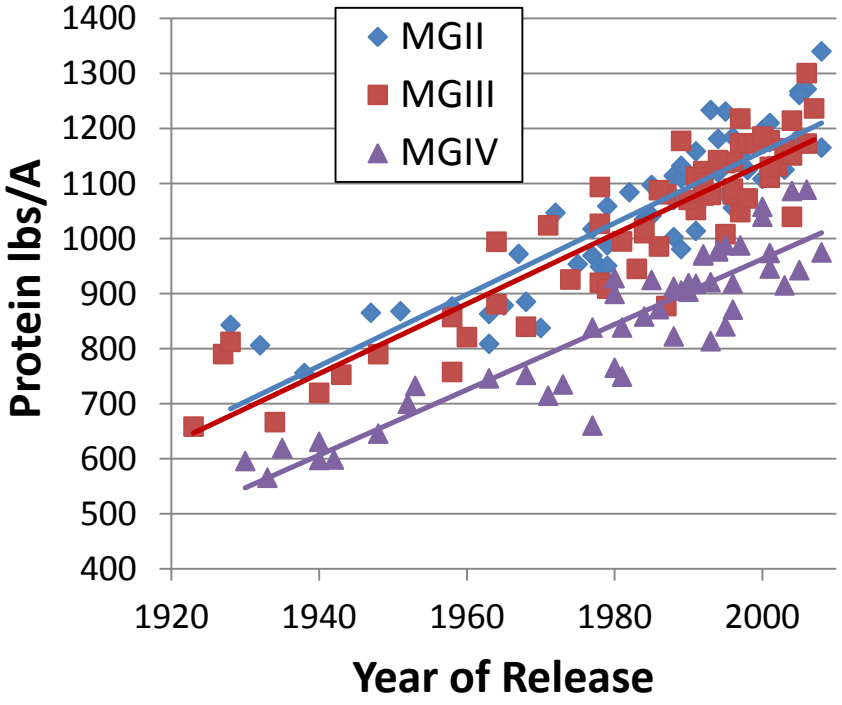
MGII change 0.014%/year
MGIII change 0.014%/year
MGIV change 0.006%/year



Seed Protein and Oil Production on a Per Acre Basis is Increasing

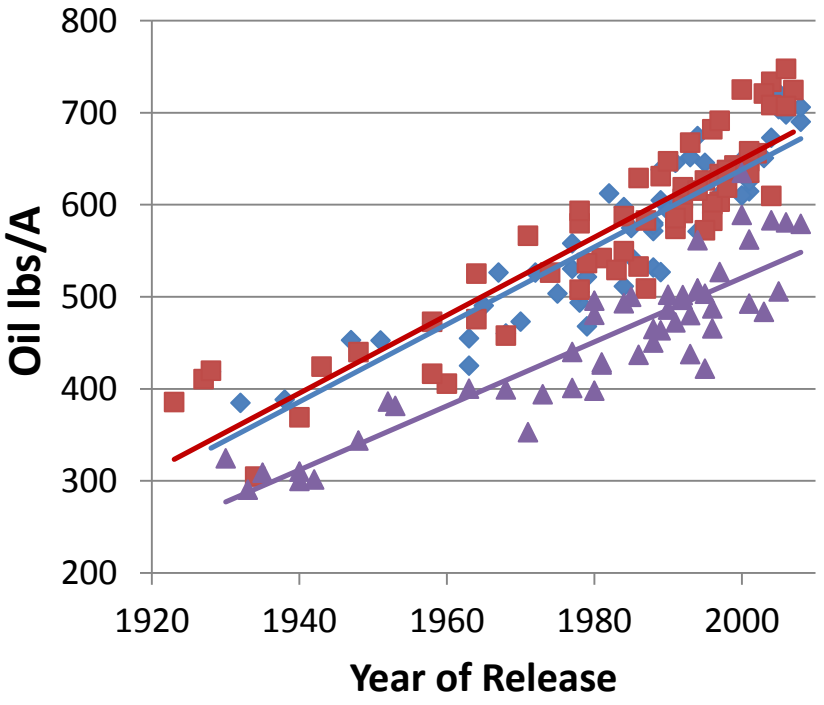
Protein

MGII change 7.2 kg/ha/yr
MGIII change 7.1 kg/ha/yr
MGIV change 6.6 kg/ha/yr



Oil

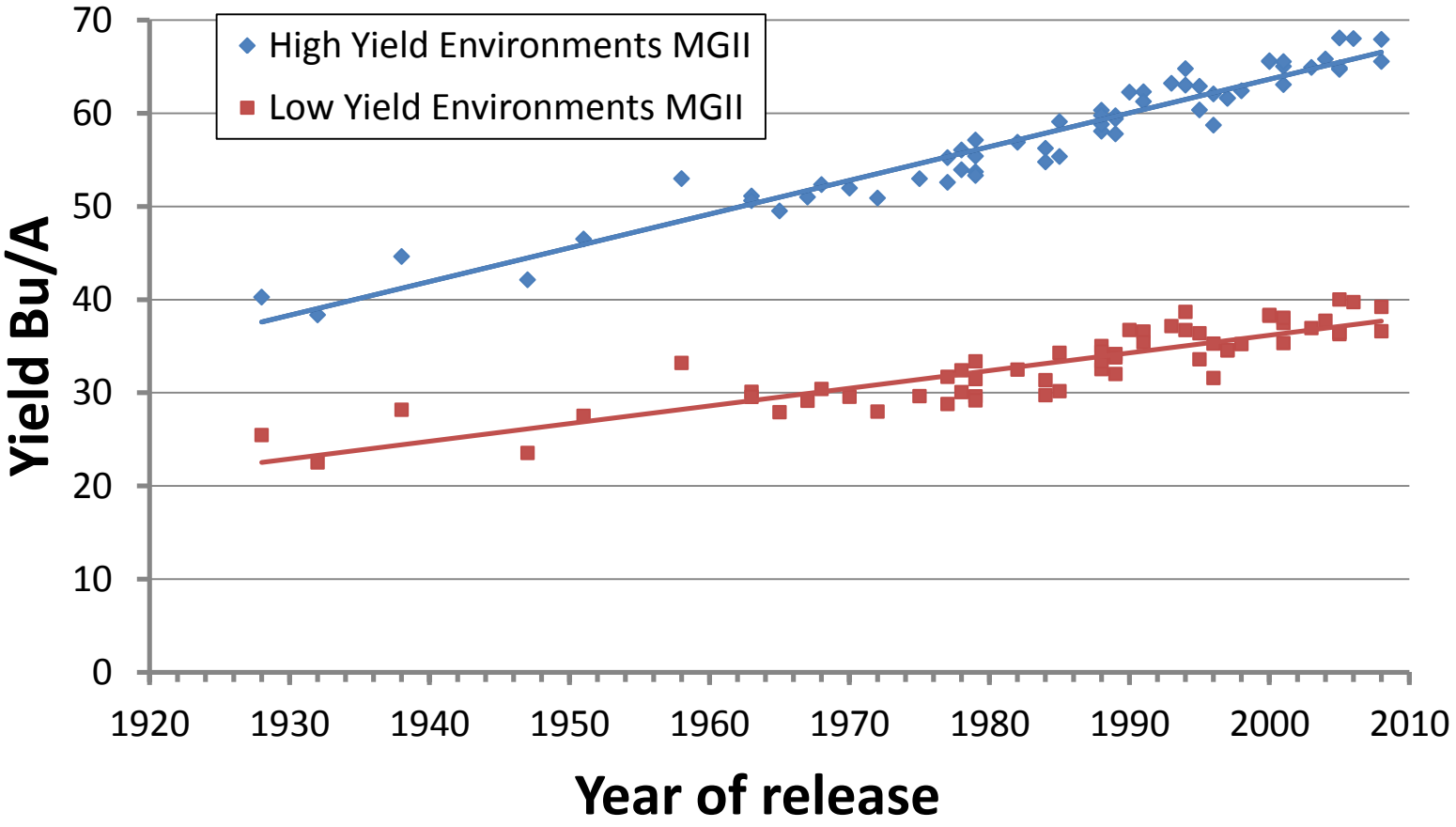
MGII change 4.7 kg/ha/yr
MGIII change 4.7 kg/ha/yr
MGIV change 3.9 kg/ha/yr



Gain is Less in Low Yield Environments than High Yield Environments

High yield environment
Adjusted change 22.8 kg/ha/yr

Low yield environment
Adjusted change 10.7 kg/ha/yr



Disease Resistance Improving Glen Hartman

		Overall	
	Disease/Pest	r	p-value
Foliar observation, R1	Japanese beetle	-0.22	<.0001
	Brown spot	-0.04	0.42
	Bacterial blight	-0.31	<.0001
	Downy mildew	0.1	0.08
	Bacterial pustule	-0.23	<.0001
	General virus	0.04	0.51
Foliar observation, R6	Brown spot	-0.3	<.0001
	Insect damage	0.49	<.0001
	Bacterial disease	-0.69	<.0001
	Downy mildew	0.38	<.0001
	Sudden death	0.02	0.66
	Frogeye leaf spot	0.08	0.13
	Green stem	-0.32	<.0001
	Cercospora	0.06	0.3
	Stem canker	-0.12	0.04
Stem and root samples, maturity	Root appearance	-0.43	<.0001
	Stem anthracnose	-0.34	<.0001
	Pod and stem blight	-0.29	<.0001
	Stem cercospora	-0.09	0.12
	Charcoal rot (%)	-0.18	0.001
	Green stem (%)	0.3	<.0001

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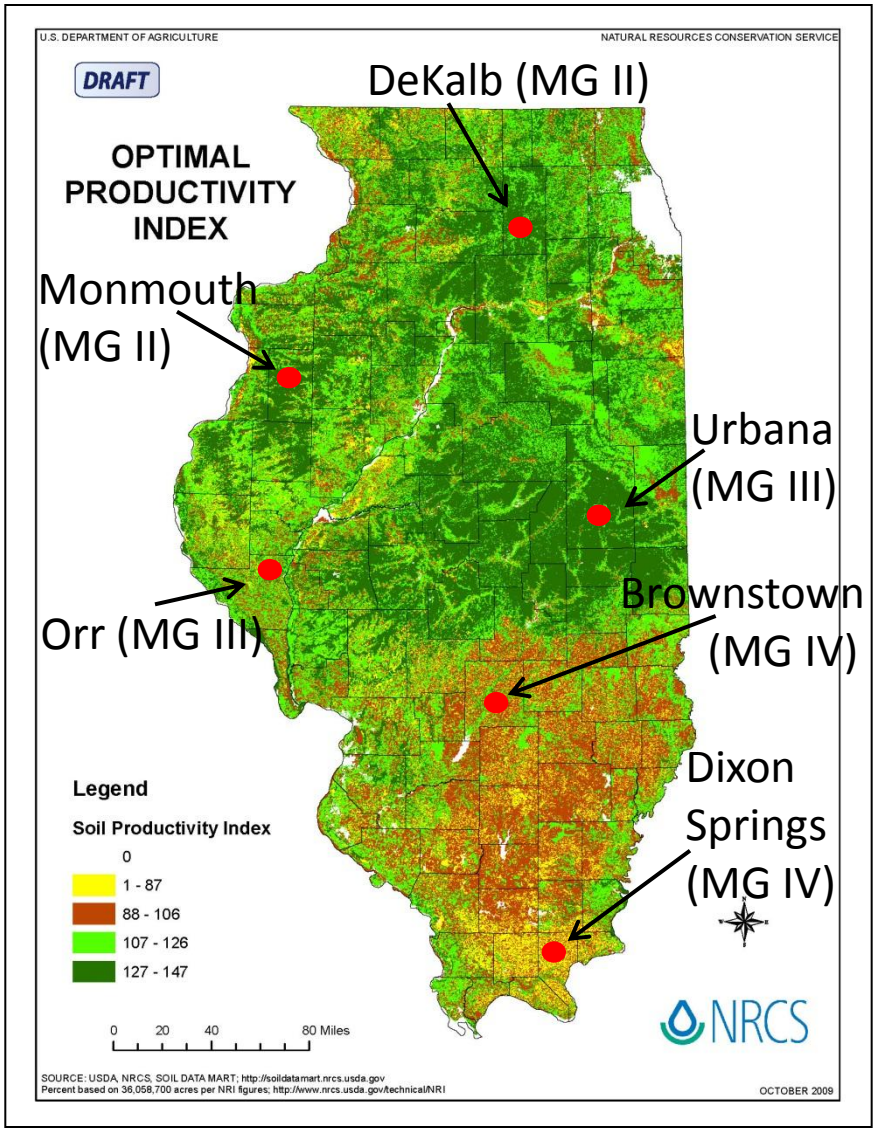
	Charcoal rot (%)	-0.18	0.001
	Green stem (%)	0.3	<.0001

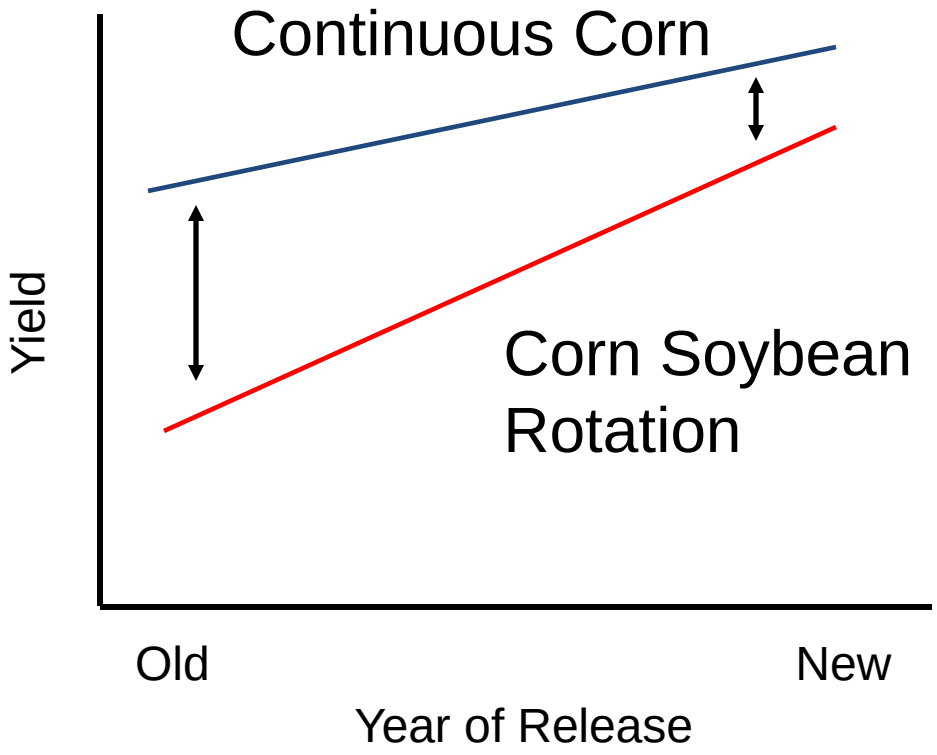
IL Rotation Study in 2010

- Lines in each MG were grown in two locations, with four reps of each rotation treatment.
- Rotations are 11 years of continuous corn or corn-soybean rotation.
  - Rotations from a long term study of Emerson Nafziger.



IL Rotation Study

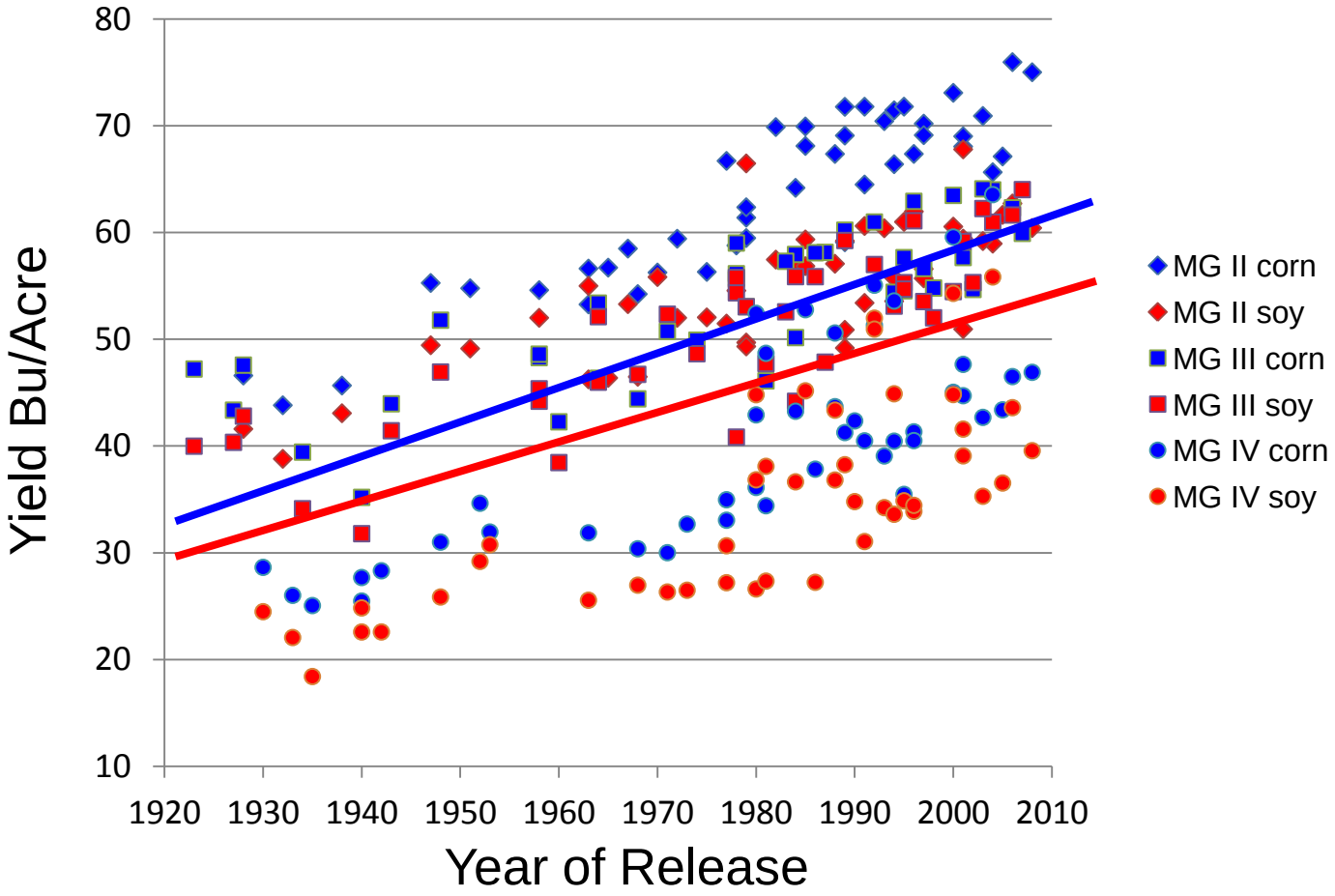
- Hypothesis: Old varieties would perform better relative to new varieties under low pathogen pressure (after continuous corn).



Adjusted Yield Gain Across Environments

Continue Corn 21.4 kg/ha/yr

Corn-Soybean 18.8 kg/ha/yr

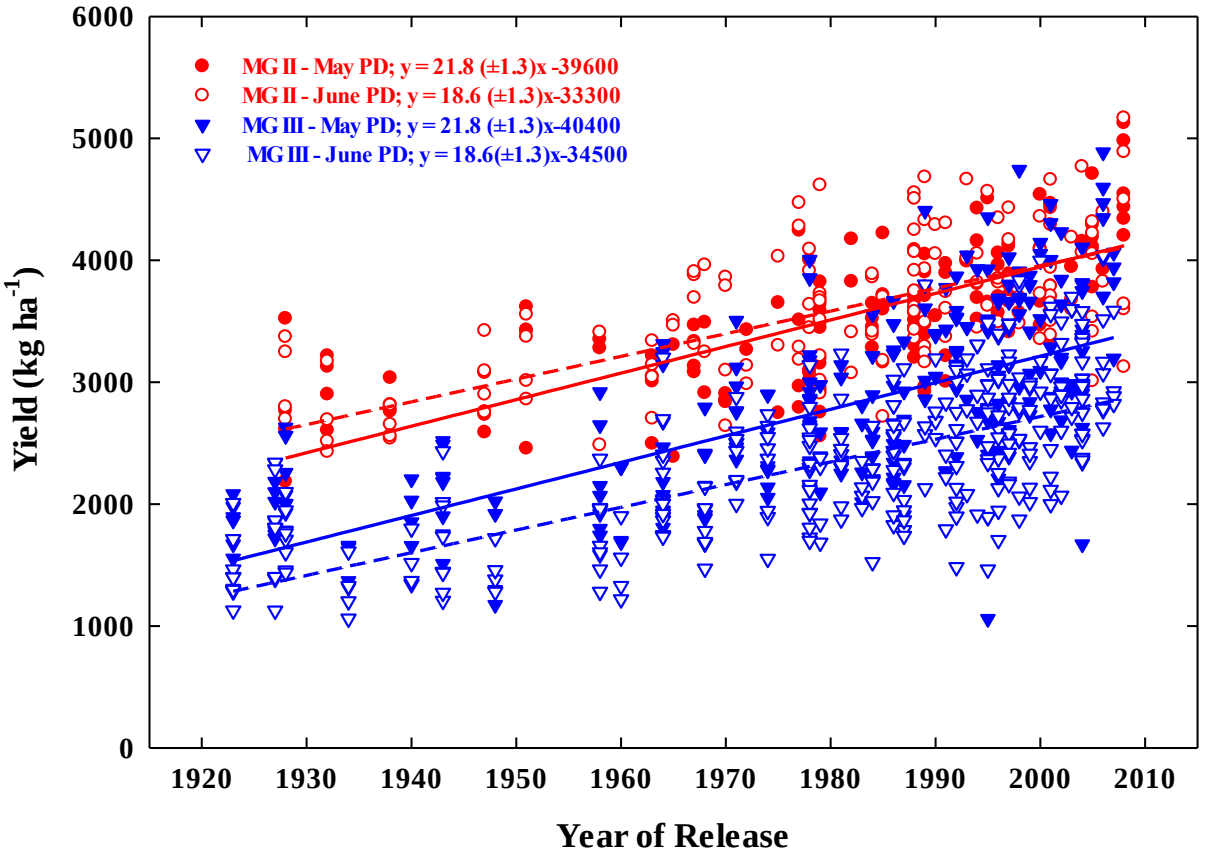


Agronomy Experiments

- Agronomists conducted a series of experiments in 2010 and 2011.
- MG II - Shawn Conley (UW) and Seth Naeve (UM).
- MG III - Vince Davis (UI and UW) and Shaun Casteel (Purdue).
  - Early and late planting (May 1 and June 1 targets).
  - High and low seeding rate (445,000 and 148,000 seed ha^{-1}).
  - High and low fertility.
  - Fungicide treated and not treated.

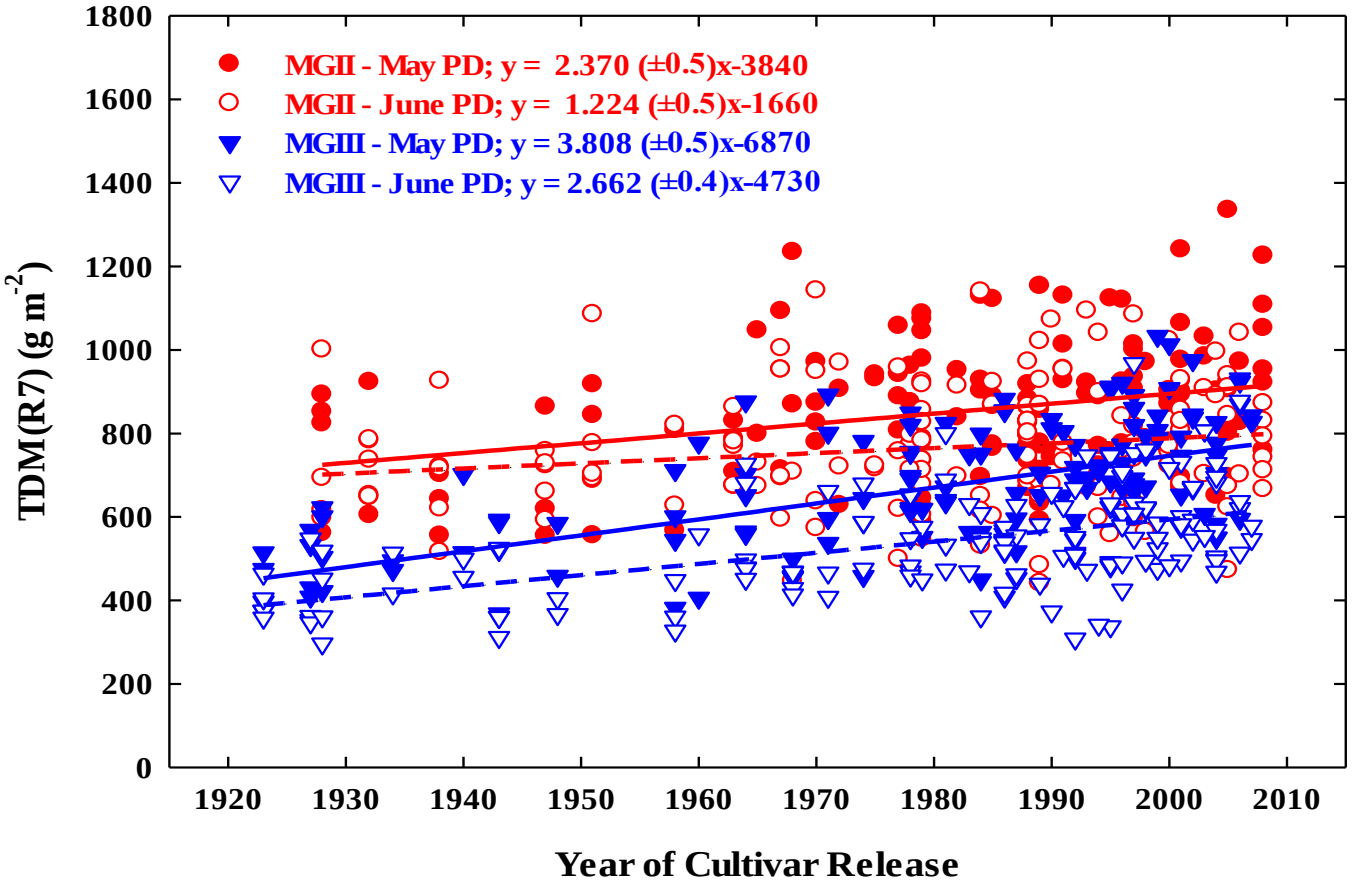
Seed Yield with Early and Late Planting

- Significant planting date effect.
- Significant year of release effect.
- Significant planting date by year of release interaction.



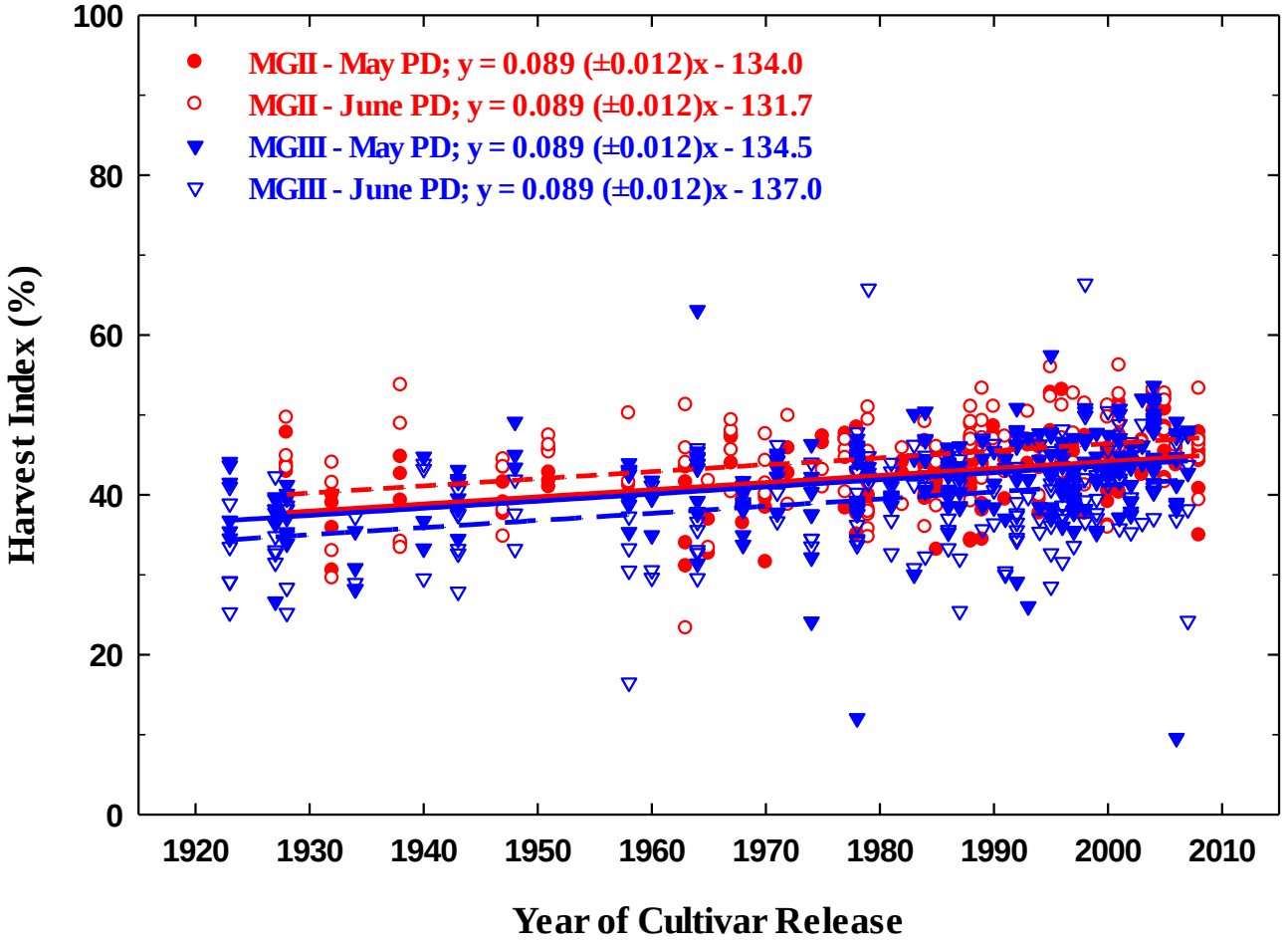
Total Dry Matter Production at R7 with Early and Late Planting

- Significant planting date effect.
- Significant year of release effect.
- Significant planting date by year of release interaction.



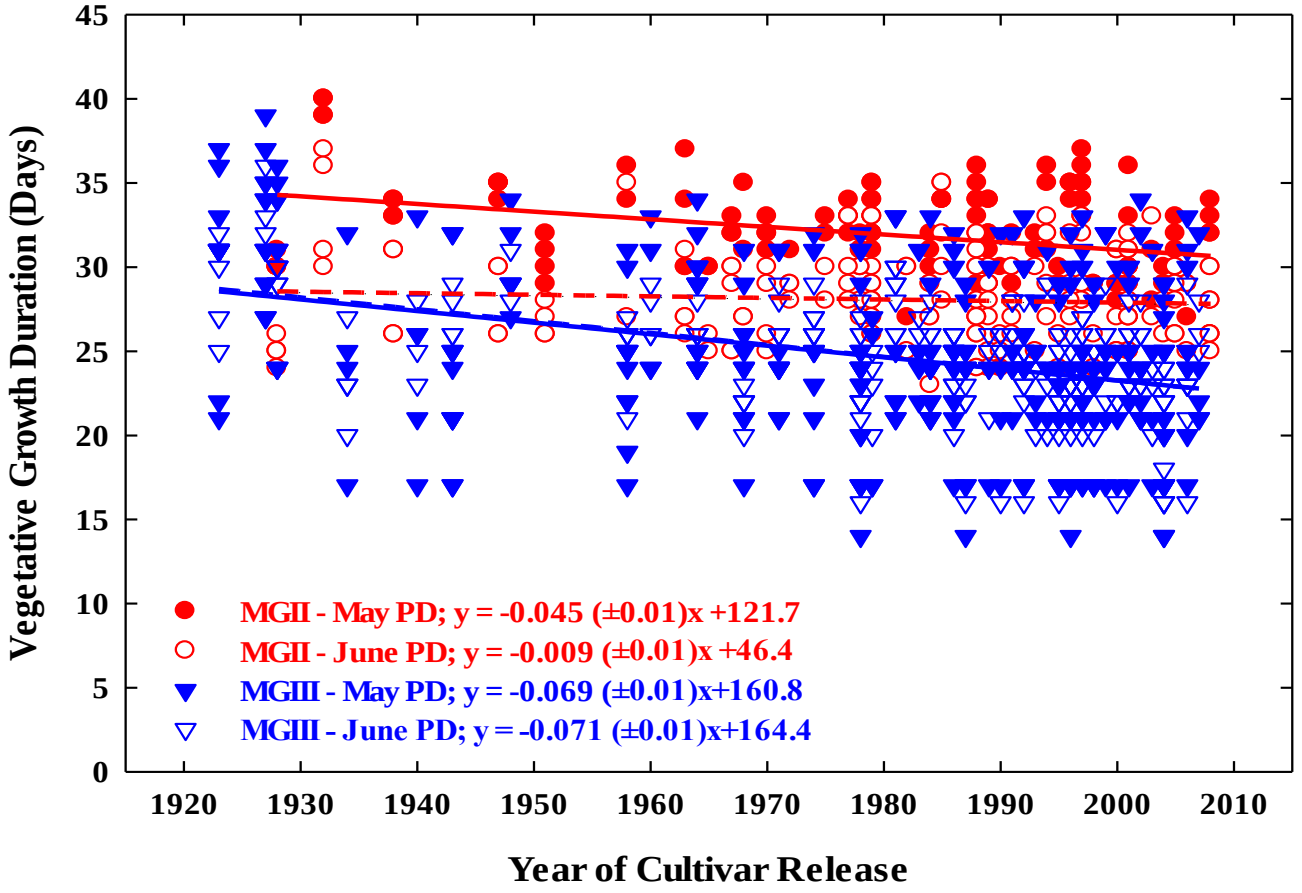
Harvest Index with Early and Late Planting

- No planting date effect.
- Significant year of release effect.



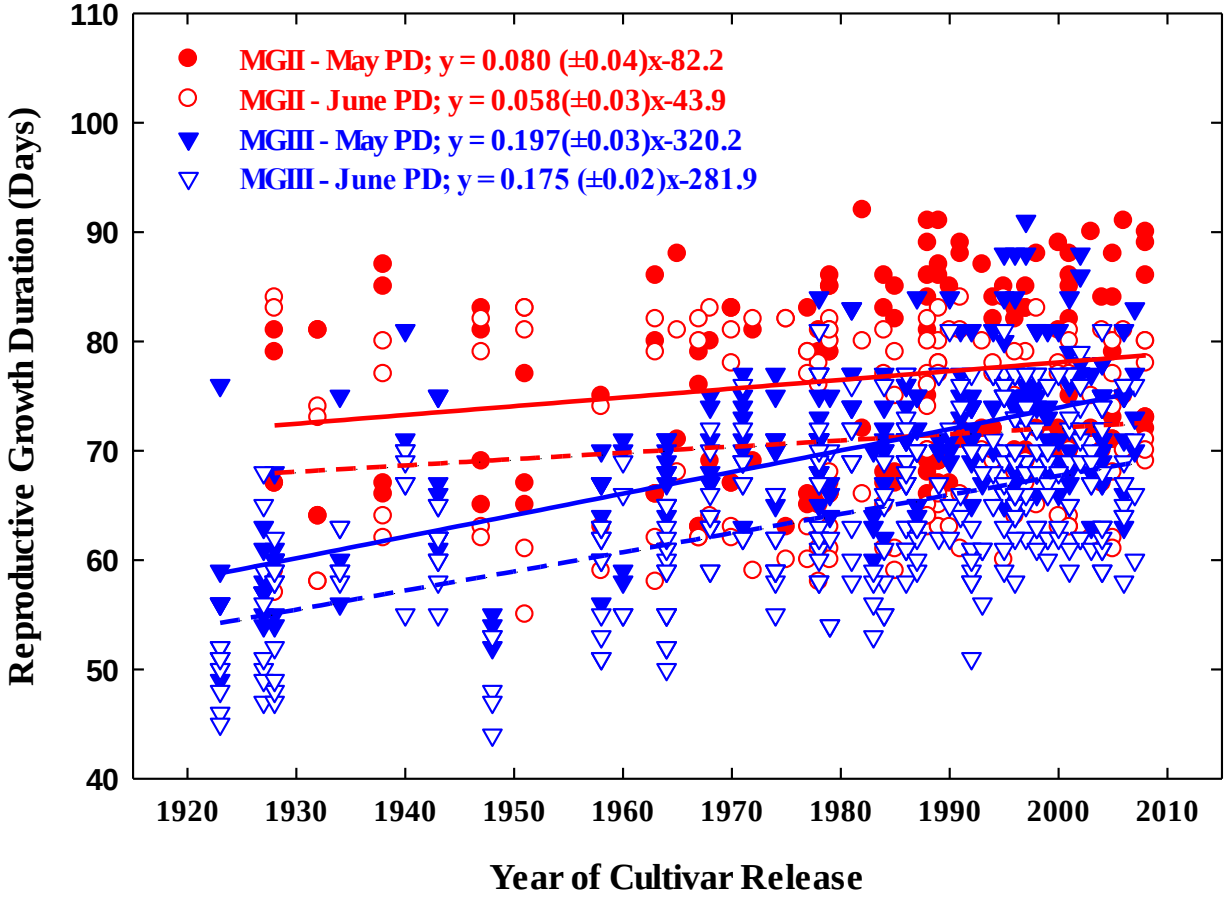
Vegetative Growth Duration (Days from V1 to R1) with Early and Late Planting

- Significant planting date effect.
- Significant year of release effect.



Reproductive Growth Duration (Days from R1 to R7) with Early and Late Planting

- Significant planting date effect.
- Significant year of release effect.



Genetic Gain Study Conclusions

- Majority of the yield advances are the result of improved genetics.
- Compared to old cultivars, new cultivars have:
  - Greater yield.
  - Later maturity.
  - Shorter vegetative period and longer reproductive period.
  - Less protein, greater oil concentration.
  - Greater disease resistance.
  - Greater total biomass production and harvest index.

Genetic Gain Study Conclusions

- Rotation effect the same in new and old cultivars.
  - Can we close that rotation effect?
- Modern cultivars are better adapted to early planting than old cultivars.

Genetic Gain Acknowledgments

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Glen Hartman
Carol Bonin

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