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.
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

![Graph showing the yield of corn and soybeans over time from 1924 to 2008. The yield for corn is represented by a red line, and the yield for soybeans is represented by a blue line. The yield for corn increases significantly over the years, while the yield for soybeans shows a more moderate increase.]
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

\[ y = 0.1982x + 50.493 \]

\[ y = -0.2187x + 52.462 \]
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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New Varieties Mature Later Than Old Varieties

Date Mature vs Year of Release for MGII, MGIII, and MGIV varieties. The graph shows a trend where newer varieties mature later than older 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
<table>
<thead>
<tr>
<th>Disease/Pest</th>
<th>Foliar observation, R1</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p-value</td>
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# Disease Resistance Improving

**Glen Hartman**

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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.
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.

![Graph showing yield with year of release and planting date 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.

![Graph showing dry matter production with different planting strategies and years of cultivar release.](image)
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

University of Illinois
Brian Diers  Vince Davis
Troy Cary  Glen Hartman
John Meharry  Carol Bonin
Keith Rincker

Collaborators:
Randy Nelson – USDA-ARS, Univ. of Illinois
Jim Specht – University of Nebraska
David Sleper – University of Missouri
Silvia Cianzio – Iowa State
Daren Mueller – Iowa State
Shaun Casteel – Purdue University
Shawn Conley – University of Wisconsin
Grover Shannon – University of Missouri
Dechun Wang – Michigan State
Pengyin Chen – University of Arkansas
David Holshouser – Virginia Tech
Vaino Poysa – Agriculture & Agri-Food Canada

Bob Uniatowski – University of Delaware
James Orf – University of Minnesota
Seth Naeve – University of Minnesota
Stella Kantartzi – Southern Illinois University
Chad Godsey – Oklahoma State
William Kenworthy – University of Maryland
Robert Kratochvil – University of Maryland
William Schapaugh – Kansas State
Chad Lee – Kentucky State
Rouf Mian – USDA-ARS Ohio State University
Leah McHeal – Ohio State University
Anne Dorrance – Ohio State University
Terry Niblack – Ohio State University
Guo-Liang Jiang – South Dakota State