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80 Years of B(reeding) x A(gronomy) Interactions in 20 Minutes or Less

S. Rowntree[1], J. Suhre[2], N. Weidenbenner[3], E. Wilson[4], V. Davis[1], S. Naeve[3], S. Casteel[4], B Diers[2], K Rinker[2], R Nelson[7], J. Specht[5], P. Esker[5] and S. Conley[1]

UW-M[1], UI[2], UM[3], PU[4], UNL[5], EdA6[5] , ISU6[7]

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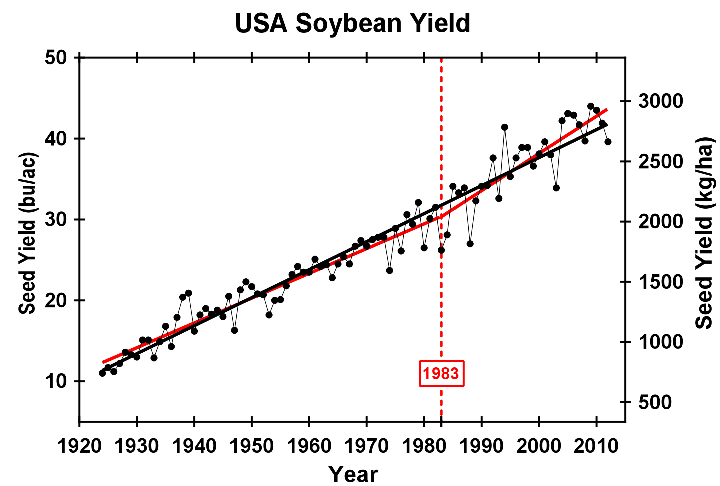
Genetic Gain Study

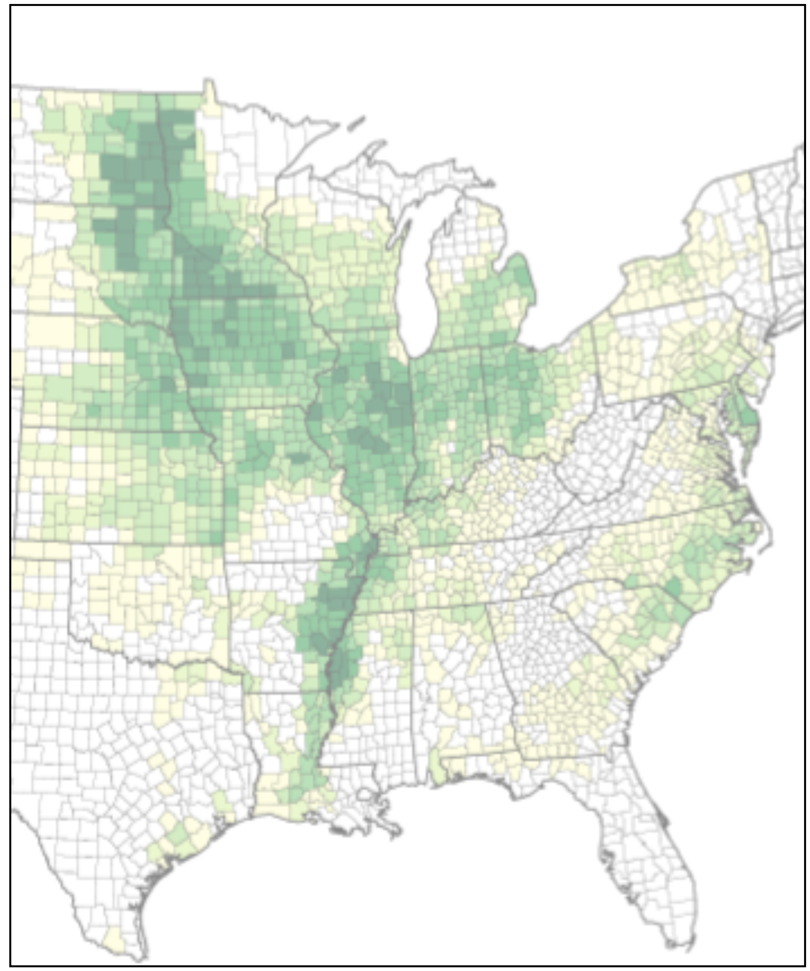
- Yield increases are the result of improved genetics, agronomics, environmental changes, and their interactions.
- How much of this gain is the result in improved genetics?
- How have soybean plants been altered to achieve greater yields?



Rinker et al. Crop Sci. 2014

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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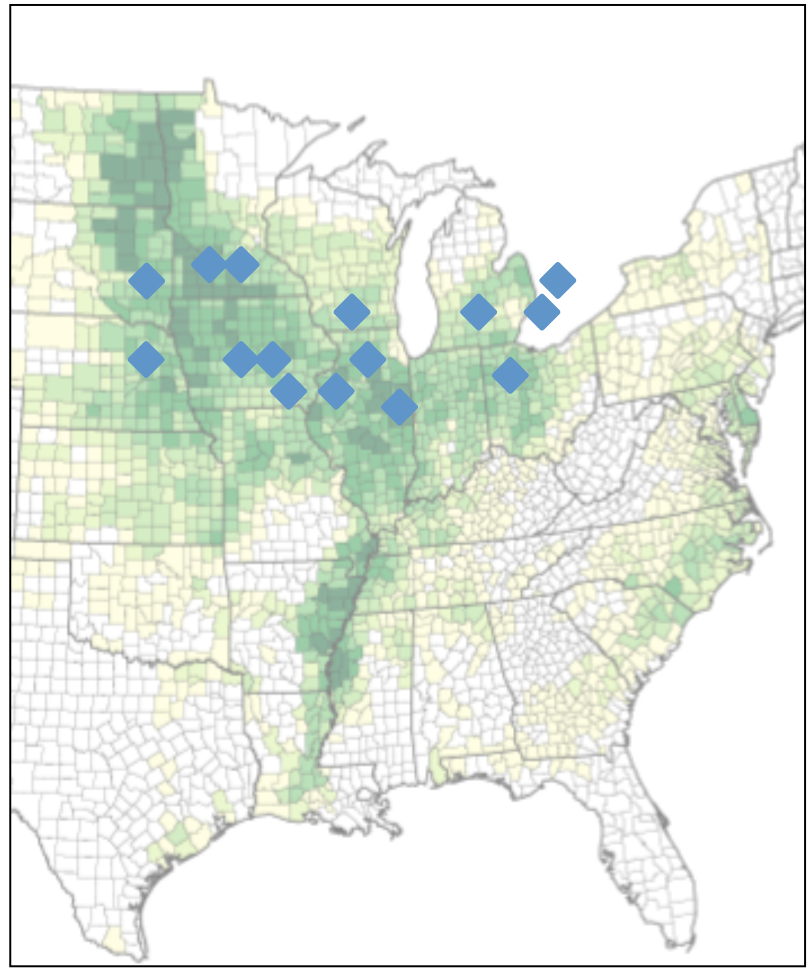

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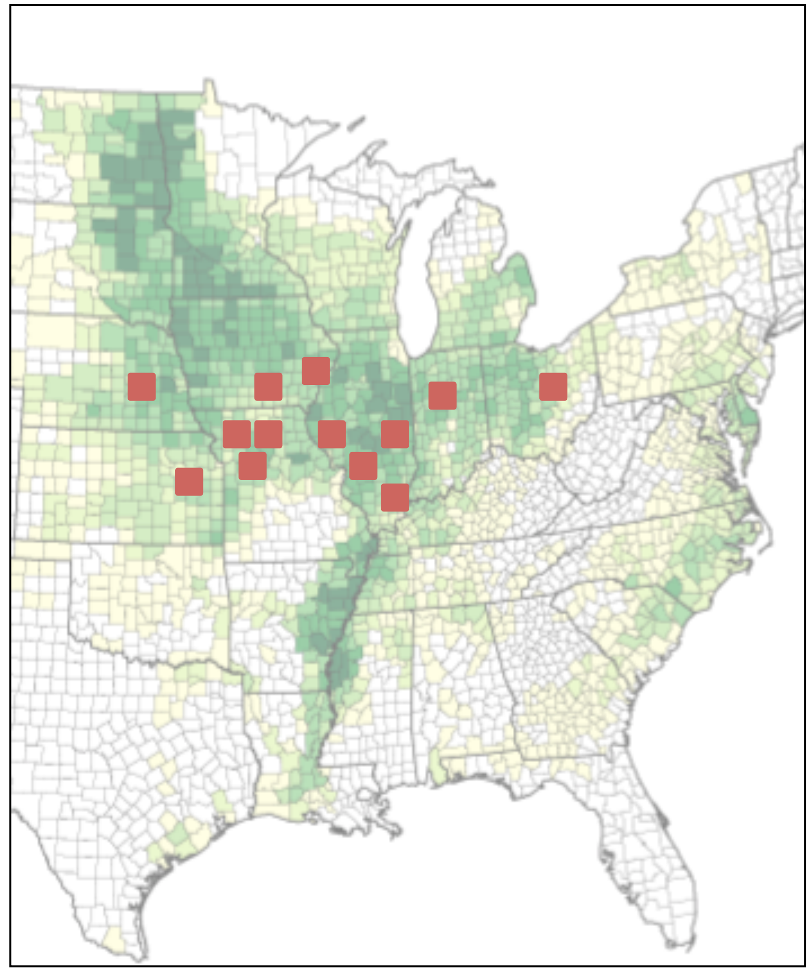

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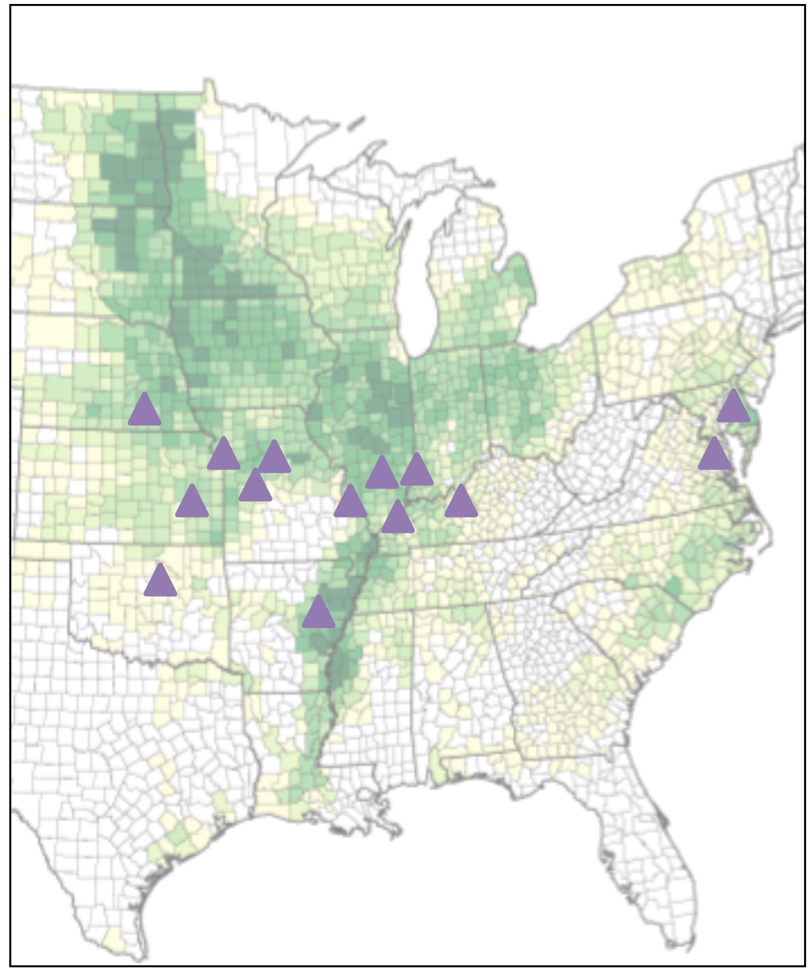
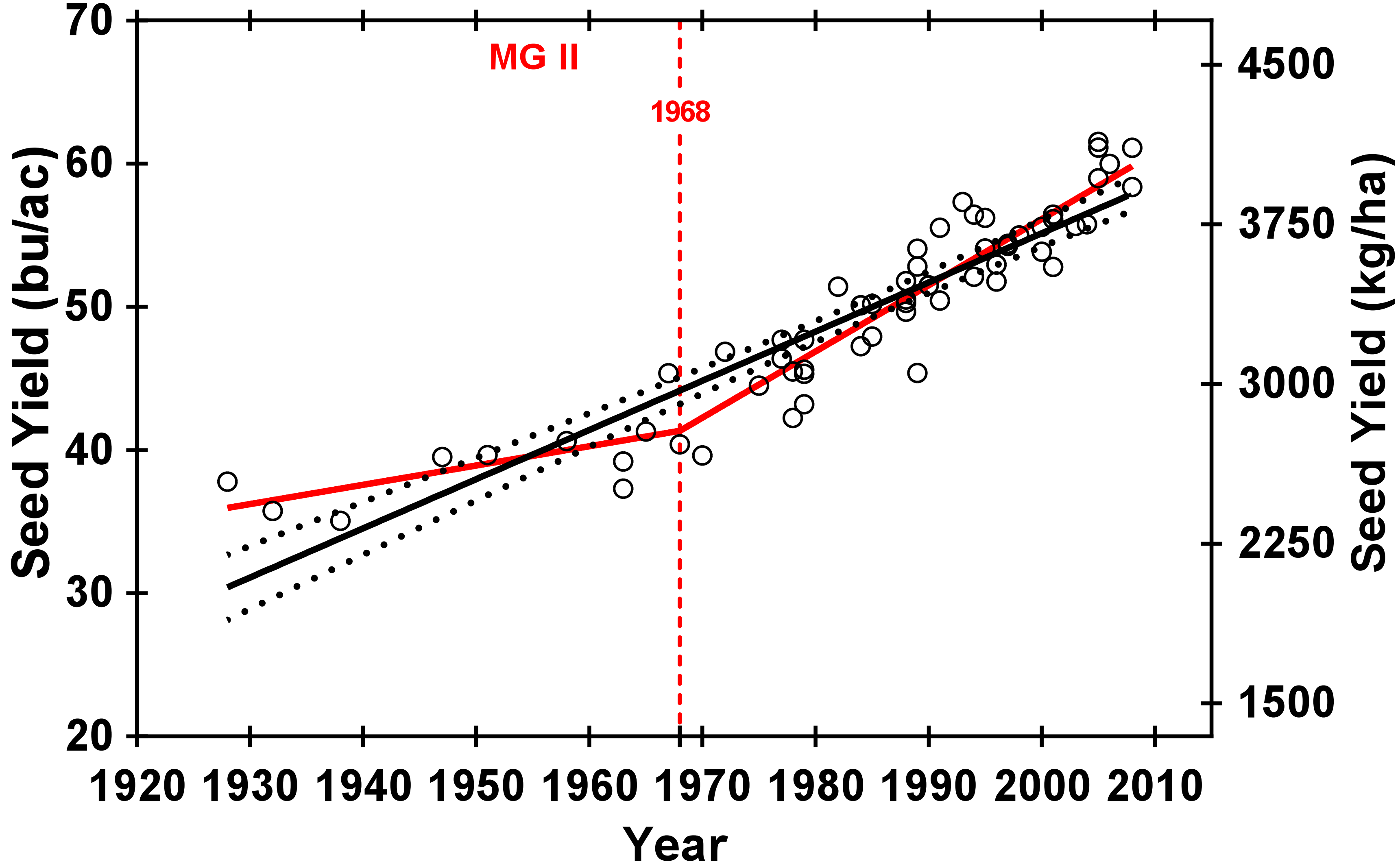


Soybean Genetic Yield Improvement

Linear 23 kg ha^{-1} $year^{-1}$ / 0.34 bu ac^{-1} $year^{-1}$

Pre-breakpoint 9 kg ha^{-1} $year^{-1}$ / 0.14 bu ac^{-1} $year^{-1}$

Post-breakpoint 31 kg ha^{-1} $year^{-1}$ / 0.46 bu ac^{-1} $year^{-1}$

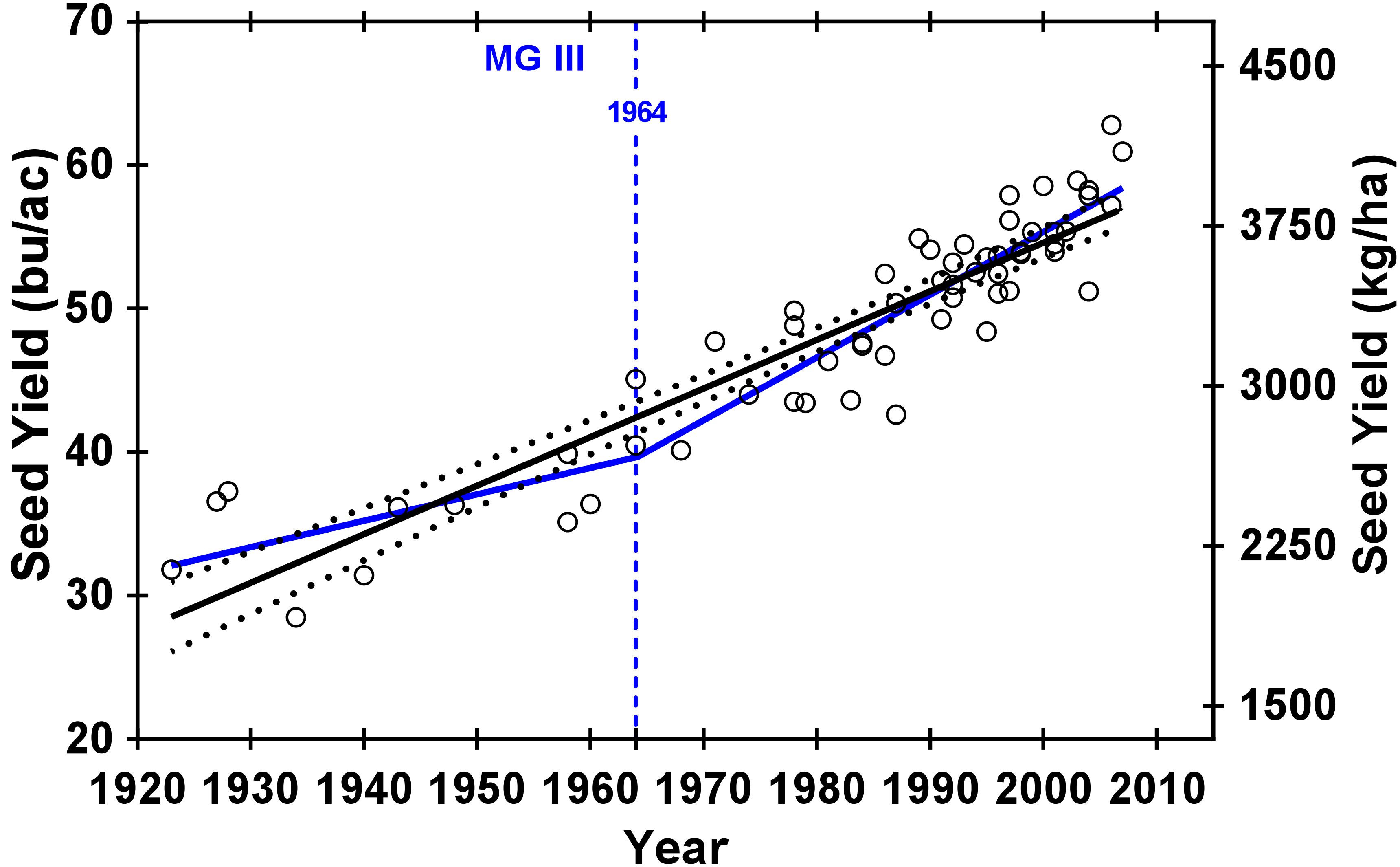


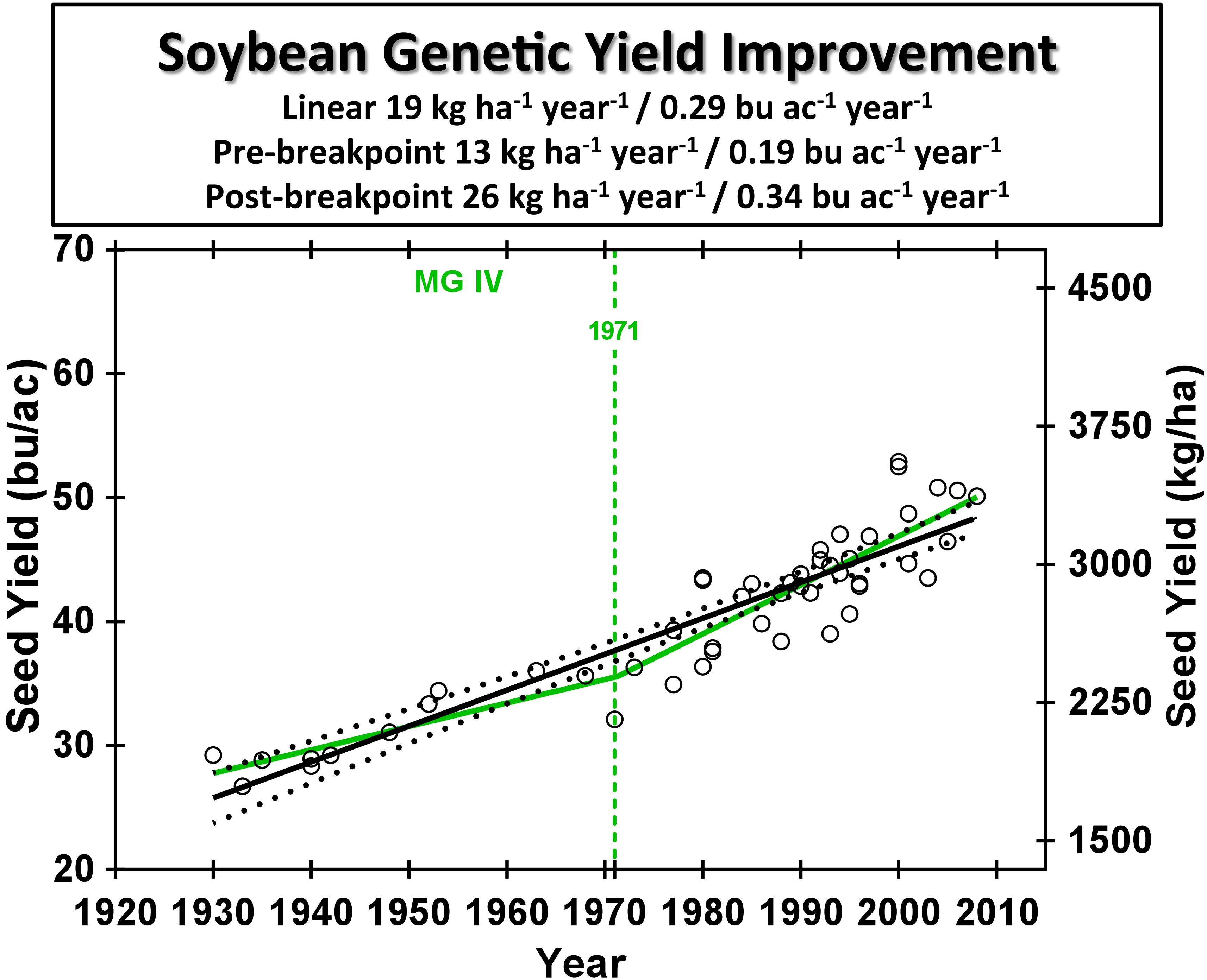
Soybean Genetic Yield Improvement

Linear 23 kg ha^{-1} $year^{-1}$ / 0.34 bu ac^{-1} $year^{-1}$

Pre-breakpoint 12 kg ha^{-1} $year^{-1}$ / 0.18 bu ac^{-1} $year^{-1}$

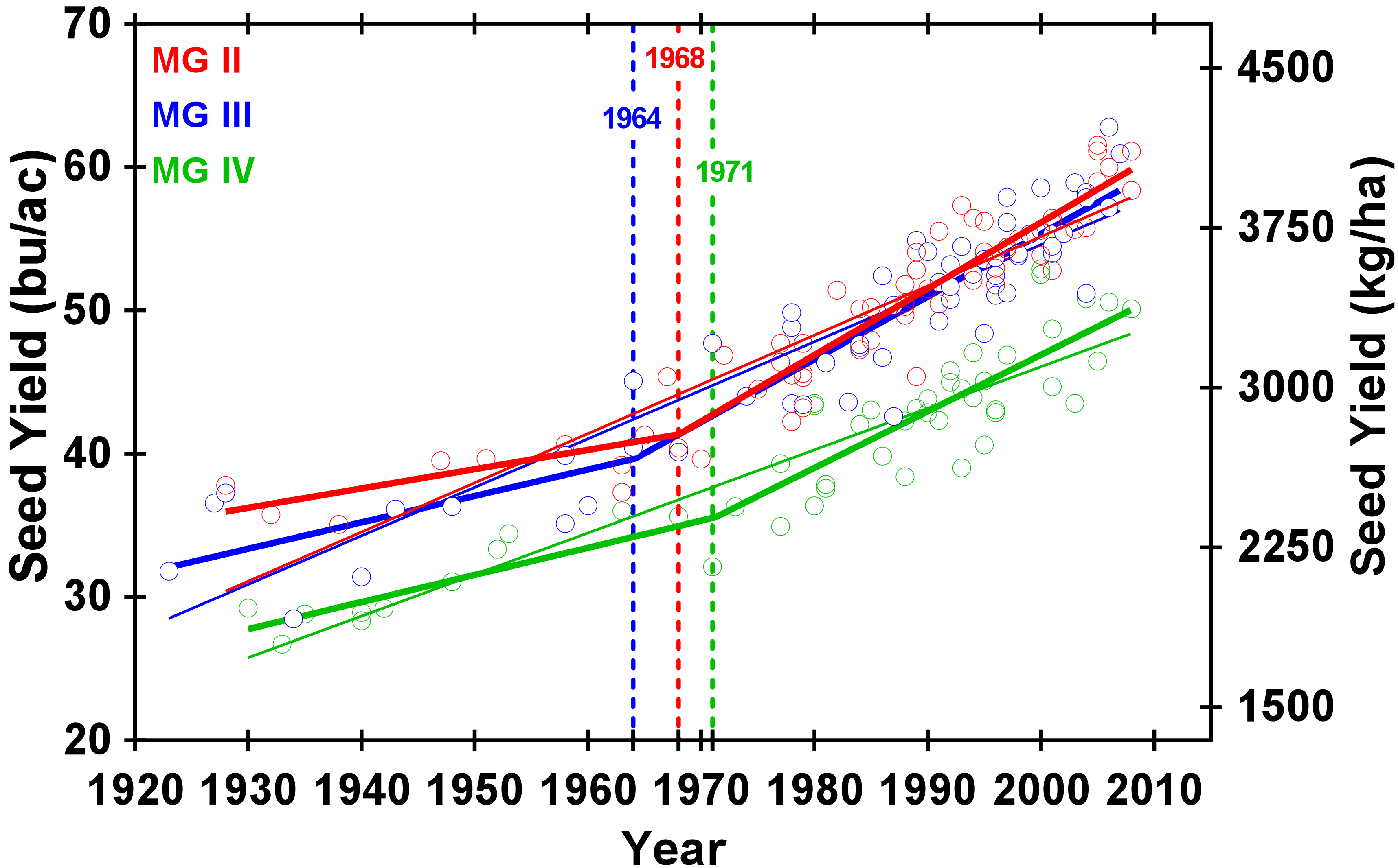
Post-breakpoint 29 kg ha^{-1} $year^{-1}$ / 0.44 bu ac^{-1} $year^{-1}$





Soybean Genetic Yield Improvement
Linear 19 kg ha-1 year-1 / 0.29 bu ac-1 year-1
Pre-breakpoint 13 kg ha-1 year-1 / 0.19 bu ac-1 year-1
Post-breakpoint 26 kg ha-1 year-1 / 0.34 bu ac-1 year-1
MG IV
1971
Seed Yield (bu/ac)
Seed Yield (kg/ha)
Year
70
60
50
40
30
20
4500
3750
3000
2250
1500
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

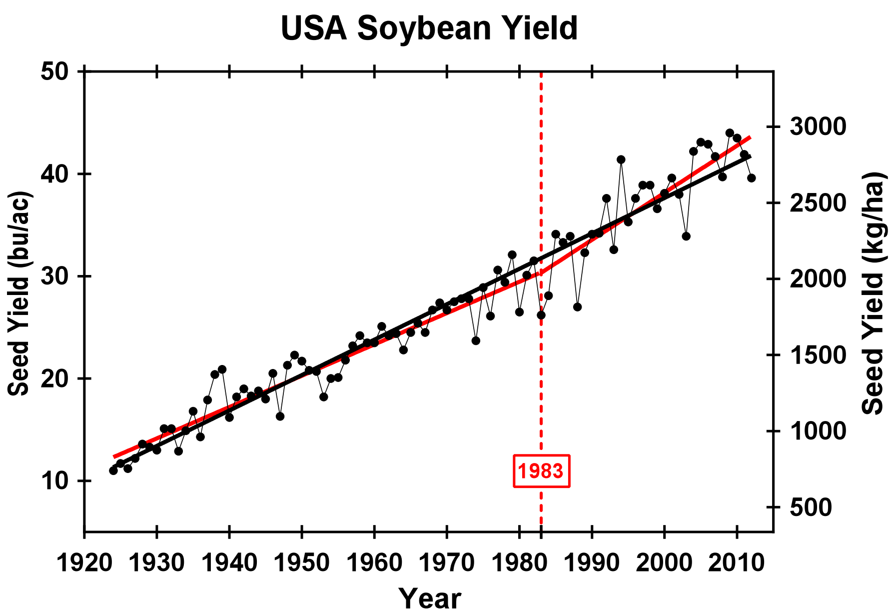
Soybean Genetic Yield Improvement

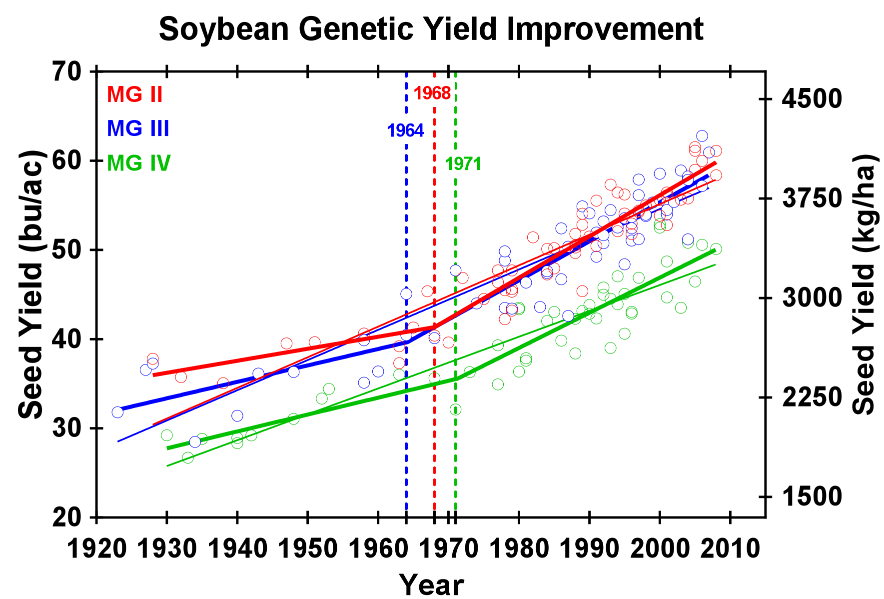


Soybean Genetic Yield Improvement

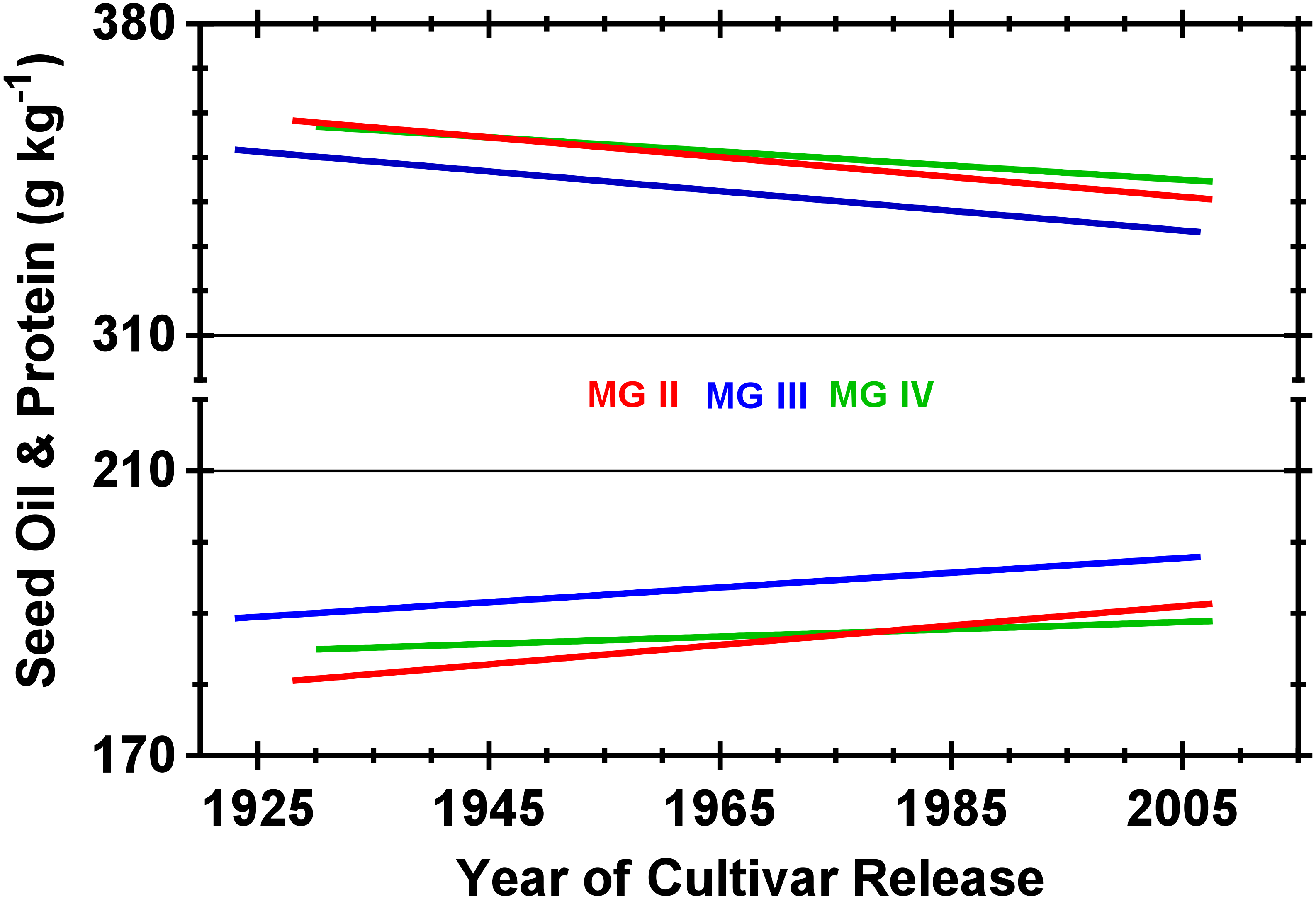
On-farm improvement **23** kg ha^{-1} yr^{-1}

Genetic improvement **MG II 23** kg ha^{-1} yr^{-1}, **MG III 23** kg ha^{-1} yr^{-1}, **MG IV 19** kg ha^{-1} yr^{-1}





Changes in Seed Protein and Oil



Genetic Gain Acknowledgments

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Daren Mueller – Iowa State
Shaun Casteel – Purdue University
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Grover Shannon – University of Missouri
Dechun Wang – Michigan State
Pengyin Chen – University of Arkansas
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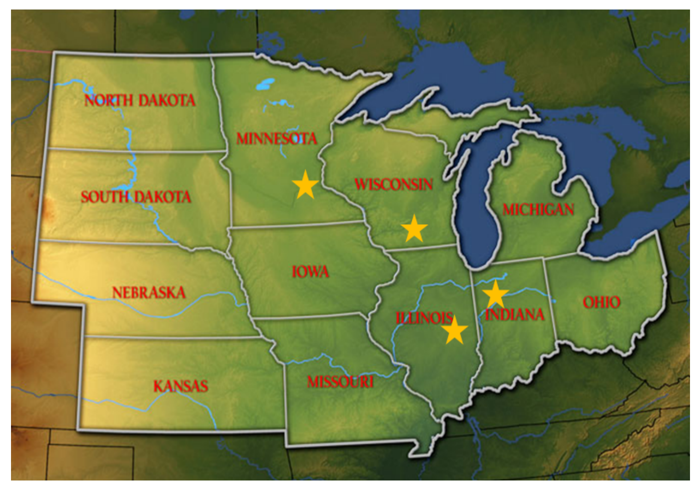
Anne Dorrance – Ohio State University
Terry Niblack – Ohio State University
Guo-Liang Jiang – South Dakota State

Characterizing Genetic by Agronomic Interactions

- **Collaboration between the University of Minnesota, University of Wisconsin, University of Illinois, and Purdue University**

- **Goals of identifying agronomic advancements contributing to yield improvement and the interactions of agronomic advancements with genetic yield improvement**

- **4 Agronomic Variables of Interest:**
  - Planting Date
  - Seeding Rate
  - Nitrogen Use Efficiency
  - Fungicide Use



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Experimental Design

- 59 MG II cultivars (released 1928-2008) and 57 MG III cultivars (released 1923-2007)
- 13 MG II & 15 MG III cultivars replicated twice for a total of 72 plots per planting date
  - Plot size: 20 ft x 15 ft (8 rows – 4 destructive & 4 non-destructive)
  - Row spacing: 30 -in rows
  - Seeding rate: 150,000 seeds a^{-1}
- Replicated across years (2010 & 2011) and locations (WI, IN, MN and IL)
- All data were regressed over cultivar year of release using a linear-mixed model in SAS v.9.2
- Data collected: seed yield, crop phenology, seed mass, and seed protein and oil concentration

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Genetic Gain x Management Interactions in Soybean: I. Planting Date

Rowntree, S., Suhre, J.J., Weidenbenner, N., Wilson, E., Davis, V., Naeve, S., Casteel, S., Diers, B., Esker, P., Specht, J., and Conley, S.P. 2013. Genetic Gain x Management Interactions In Soybean: I. Planting Date. Crop Sci. 53:1128-1138. Open Access.

Rowntree, S., Suhre, J.J., Wilson, E., Davis, V., Casteel, S., Diers, B., Esker, P., and Conley, S.P. 2014. Physiological and Phenological Responses of Historical Soybean Cultivar Releases to Earlier Planting. Accepted Crop Science.

Hypothesis:

- **Earlier soybean planting provides a production system environment more optimal for the expression of genetic yield potential in newer cultivars.**
  - ***If so, then the estimated rate of genetic yield gain would be expected to be greater with earlier planting than with later planting (i.e. a synergistic interaction).***

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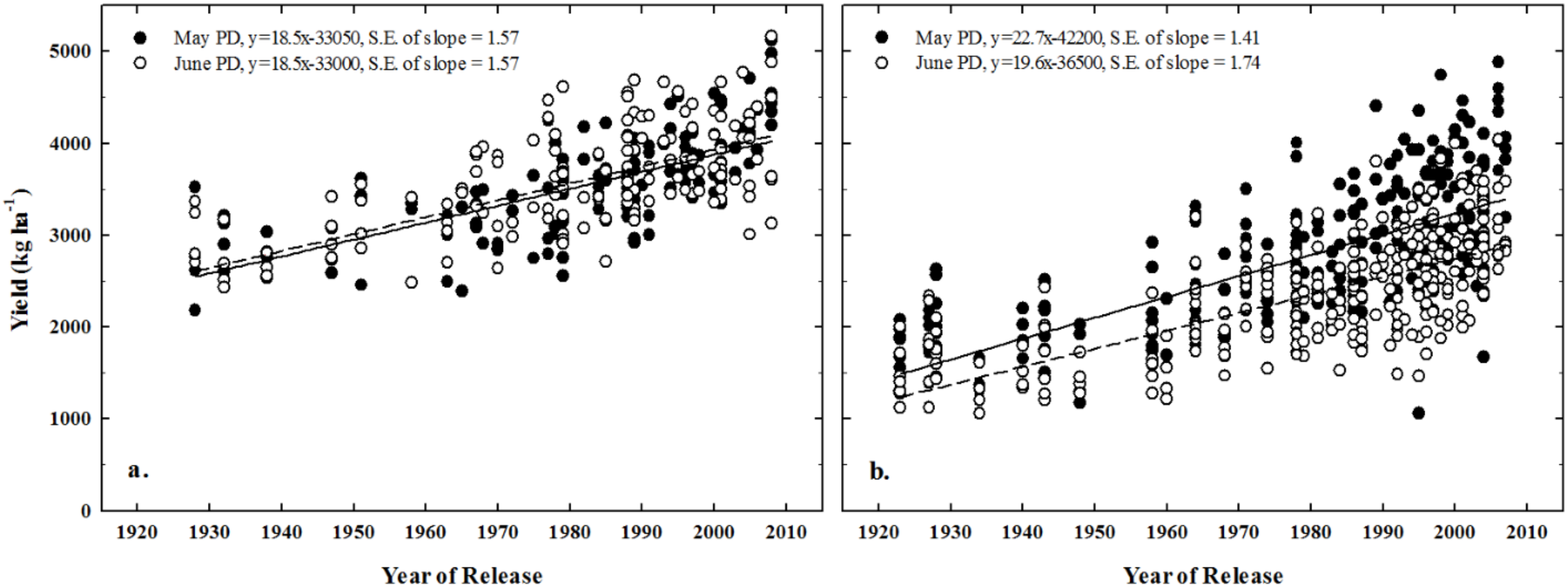
Seed Yield of MG II(a) & MG III(b) cultivars at early and late planting (2010-2011)



- Within MGs, yields have improved over cultivar year of release (P<0.001). Represents the successful efforts made by breeders to improve soybean yield over time.

- Within MG IIIs, there was a difference (P<0.05) in the rate of yield improvement over time between early and late plantings. <u>*A synergistic interaction!*</u>

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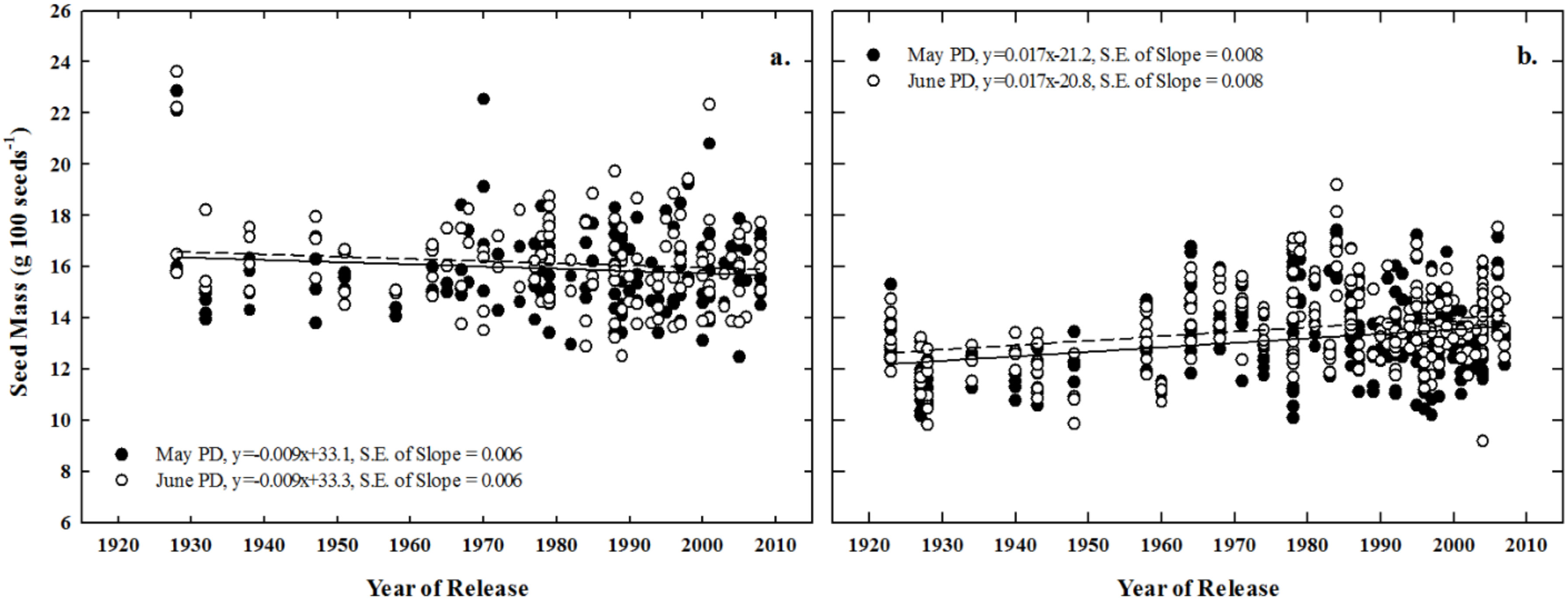
Seed Mass of MG II(a) & MG III(b) cultivars at early and late planting (2010-2011)



- Within MG, there was no effect (P>0.05) of cultivar year of release or planting date on seed mass.

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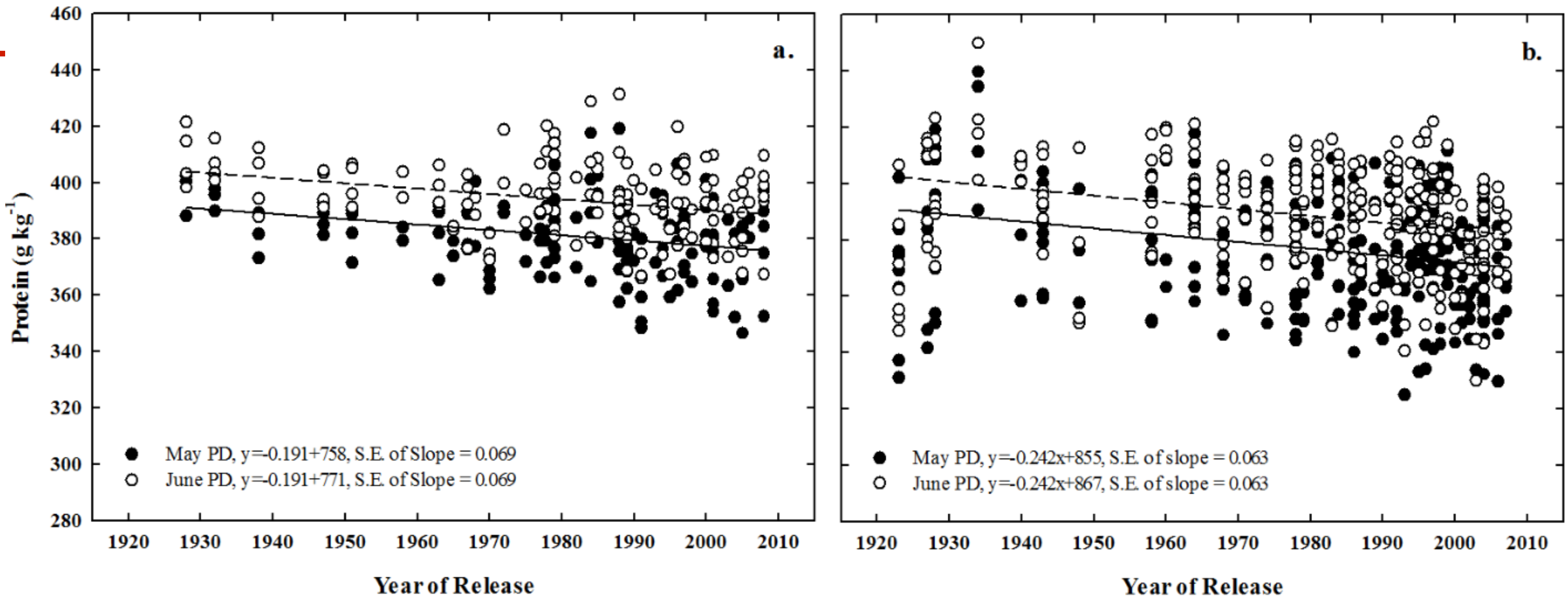
Seed Protein Content of MG II(a) & MG III(b) cultivars at early and late planting (2010-2011)



- Within MG, seed protein levels declined (*P*<0.001) over cultivar year of release.
- Within MG, seed protein levels increased (*P*<0.05) as planting was delayed by approx. 30 days.

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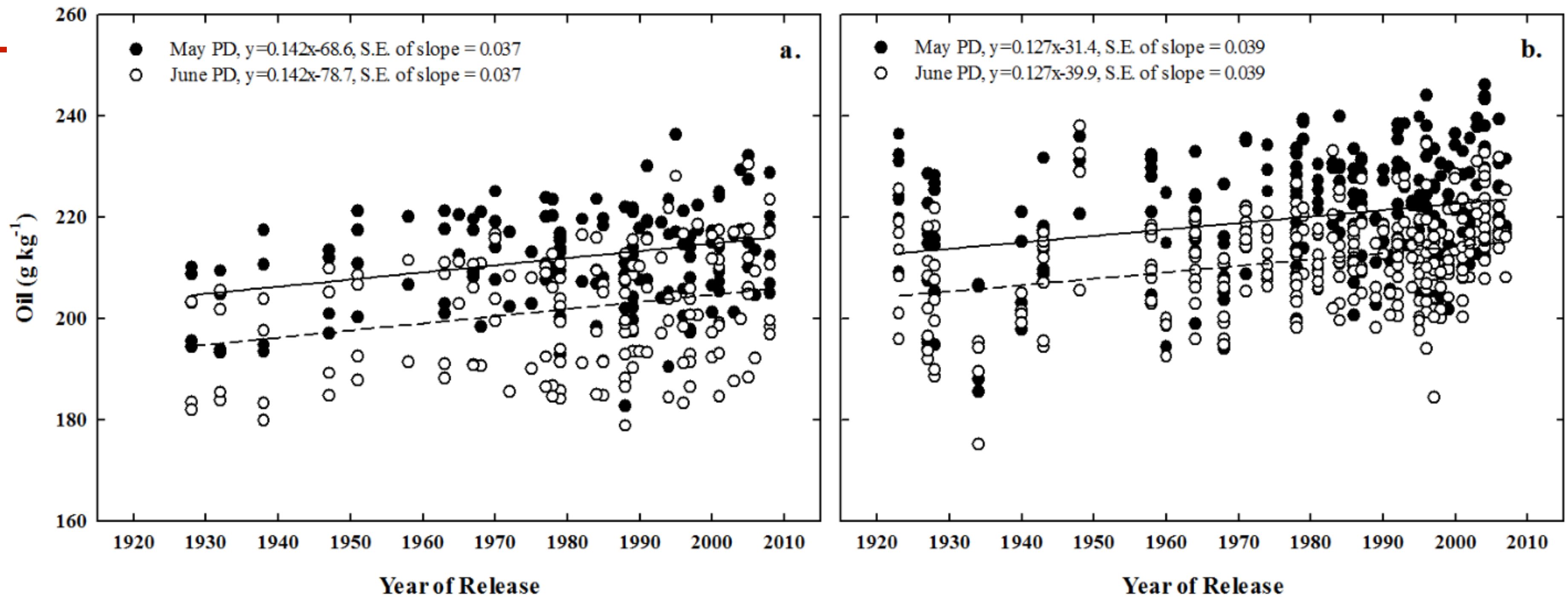
Seed Oil Content of MG II(a) & MG III(b) cultivars at early and late planting (2010-2011)



- Within MG, seed oil levels increased (*P*<0.001) over cultivar year of release.
- Within MG, seed oil levels decreased (*P*<0.01) as planting was delayed by approx. 30 days.

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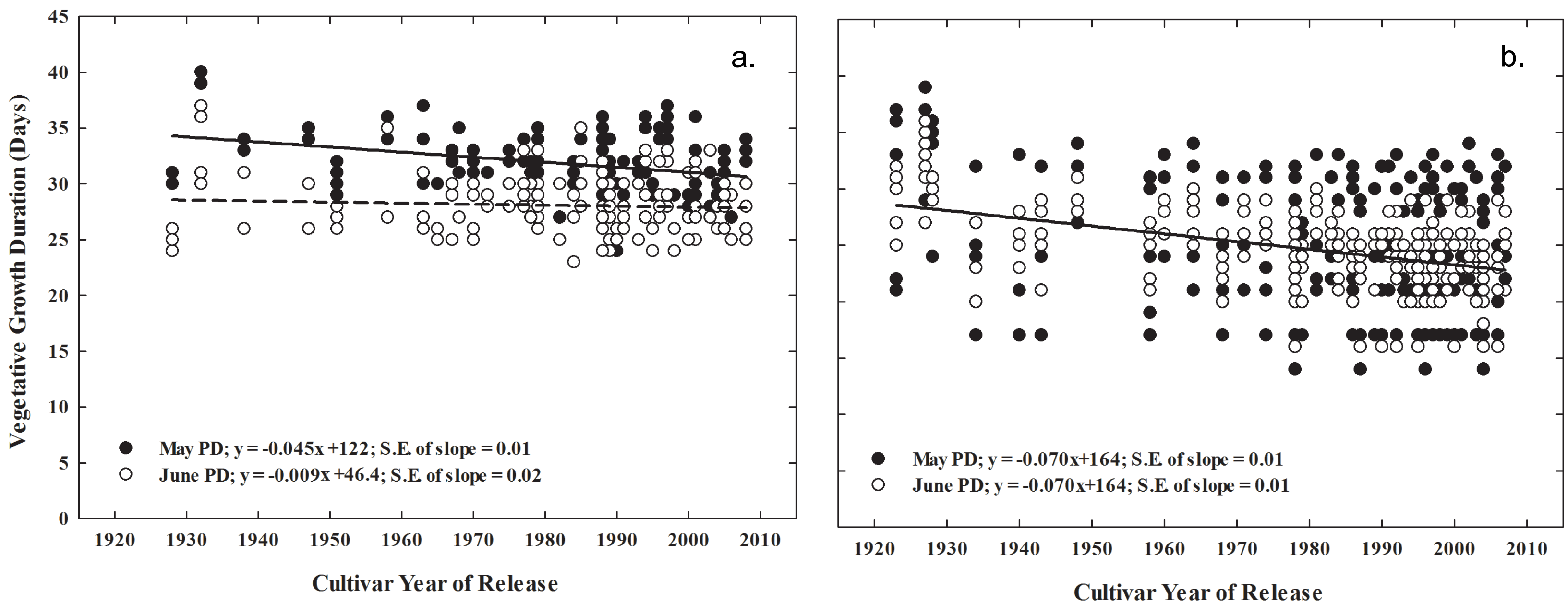
Total Number of Vegetative Growth Days of MG II(a) & MG III(b) cultivars at early and late planting (2010-2011)



- Within MG II, total days of vegetative growth decreased in early planted soybean (P<0.001) over cultivar year of release.
- Within MG III, total days of vegetative growth decreased (P<0.001) over cultivar year of release.

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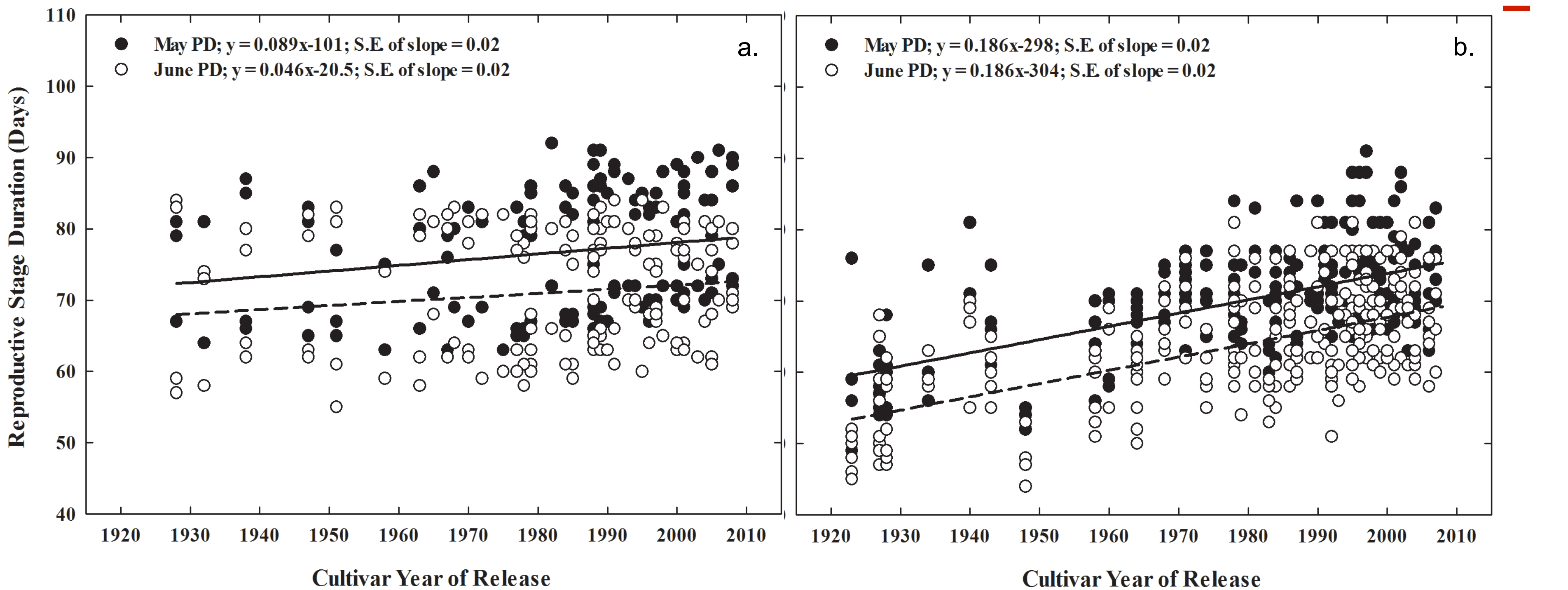
Total Number of Reproductive Growth Days of MG II(a) & MG III(b) cultivars at early and late planting (2010-2011)



- Within MG, total days of reproductive growth increased (*P*<0.001) over cultivar year of release.
- Within MG, total days of reproductive growth have increased (*P*<0.10) in May plantings

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Conclusions for I. Planting Date: Seed Yield, Composition and Phenology

- Earlier planting increased cultivar mean yields in MG IIIs.
- An inverse effect on seed protein (decreased) and seed oil (increased) concentrations was documented.
- An inverse effect on vegetative growth (decreased) and reproductive growth (increased) was documented.
- Trend toward earlier planting is one of the agronomic improvements that, when coupled with genetic improvement (MG III's), has provided a <u>synergistic increase</u> in on-farm soybean yields in the Midwestern U.S.

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Genetic Gain x Management Interactions in Soybean: II. Seeding Rate

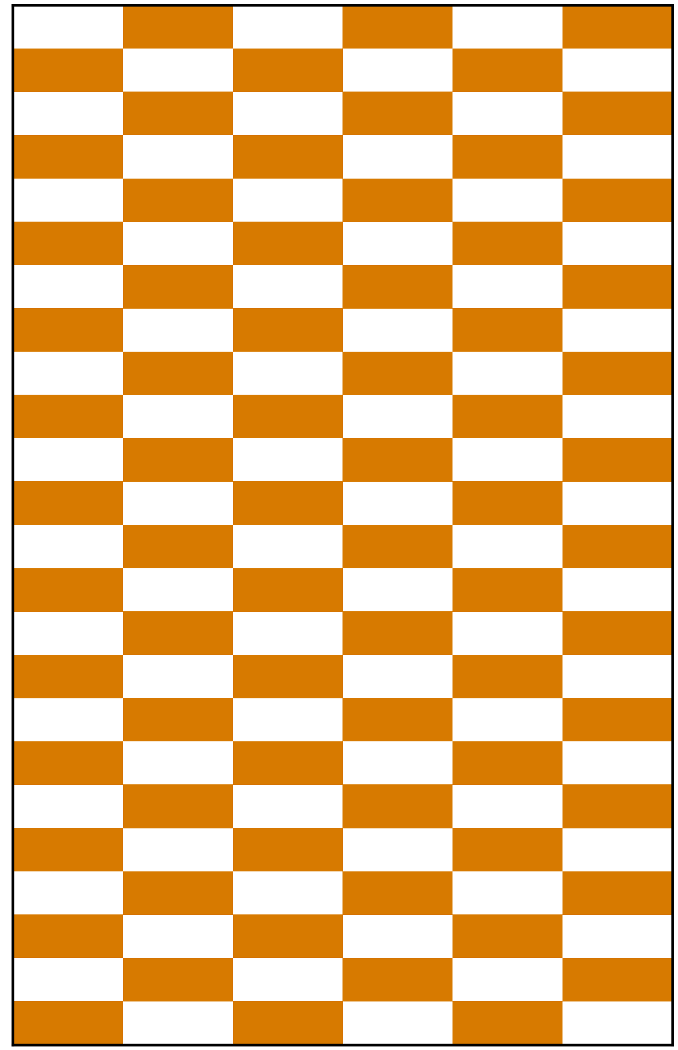
Justin J. Suhre,* Nicholas H. Weidenbenner, Scott C. Rowntree, Eric W. Wilson, Seth L. Naeve, Shawn P. Conley, Shaun N. Casteel, Brian W. Diers, Paul D. Esker, James E. Specht and Vince M. Davis. Agronomy J. (*in review*).

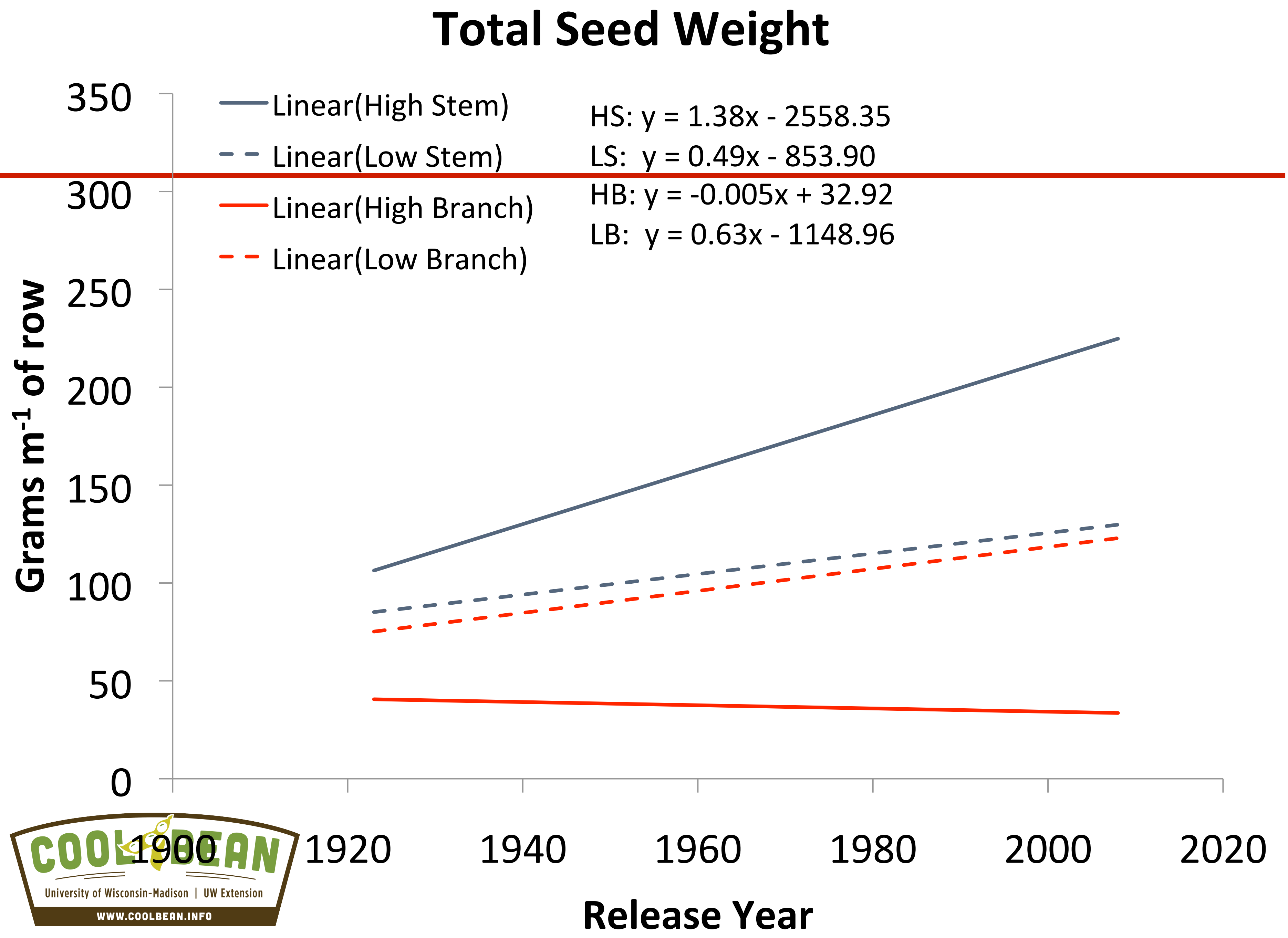
Hypothesis:

- **Newer cultivars will express higher yield potential than older cultivars when grown in higher plant densities showing a greater ability to withstand interplant competition**
  - ***If so, then the estimated rate of genetic yield gain would be expected to be greater with higher seeding rates (i.e. a synergistic interaction).***
- **Newer cultivars will express greater seed yield from plant branches than older cultivars when grown in lower plant densities.**

Materials and Methods

- 4 locations over 2 years
- Randomized Incomplete Block Design – PROC MIXED in SAS
- 59 MG II cultivars with 13 replicates/ 57 MG III cultivars with 15 replicates
- Two seeding rates
  - 180,000 seeds a^{-1} (High)
  - 60,000 seeds a^{-1} (Low)
- 4 row plots
  - 30 in spacing
  - 15 ft length





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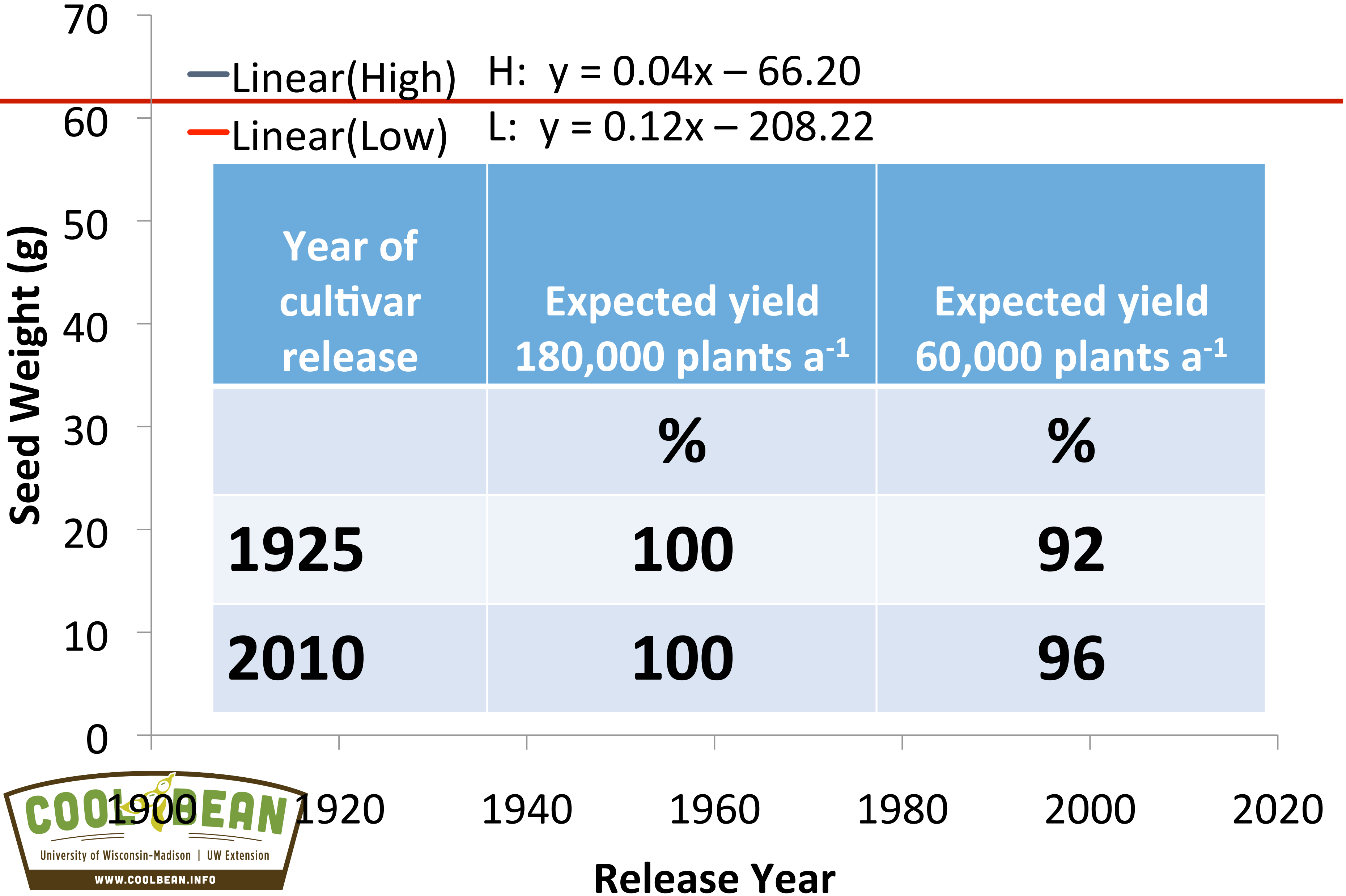
Yield per Plant



Year of cultivar release	Expected yield 180,000 plants a^{-1}	Expected yield 60,000 plants a^{-1}
	%	%
1925	100	92
2010	100	96

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Conclusions for II. Seeding Rate: Branch and Stem Seed Yield

- Newer cultivars have increased yield under BOTH high and low densities
  - However, newer cultivars have improved branching ability to compensate for lower plant stands
  - Therefore, the penalty for lower seeding rates has decreased by HALF and effectively reduced seeding rate by yield effects

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Genetic Gain x Management Interactions in Soybean: III. Nitrogen Utilization

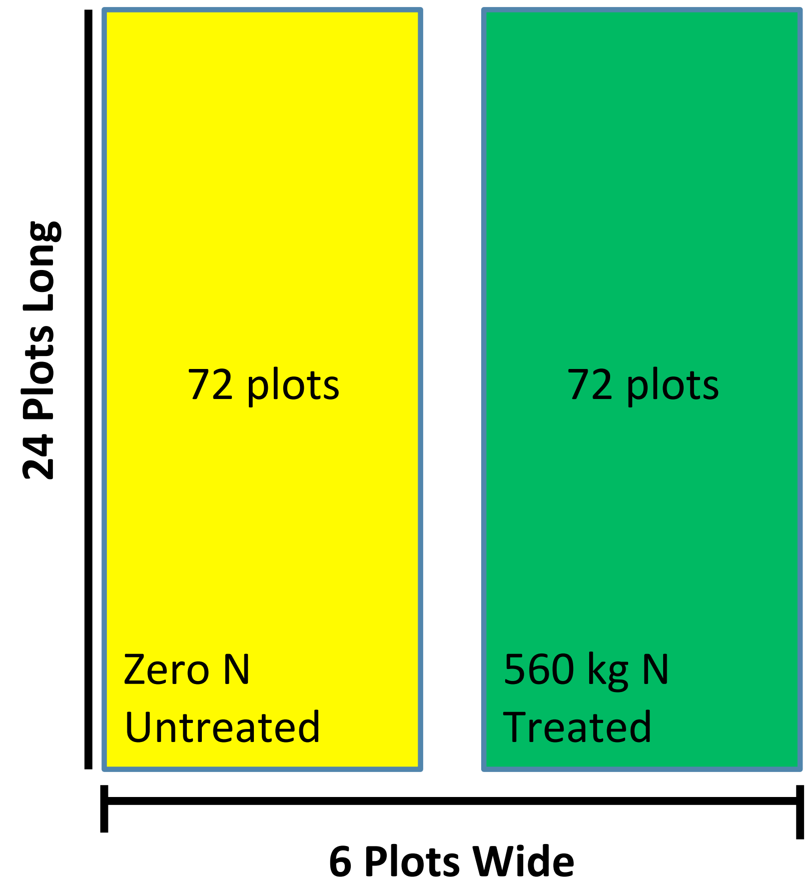
Eric W. Wilson, Scott C. Rowntree, Justin J. Suhre, Nicholas H. Weidenbenner, Vince M. Davis, Seth L. Naeve, Shawn P. Conley, Brian W. Diers, Paul D. Esker, and Shaun N. Casteel*. 2014. Crop Science 54. 1:340-348. Open Access.

Hypothesis:

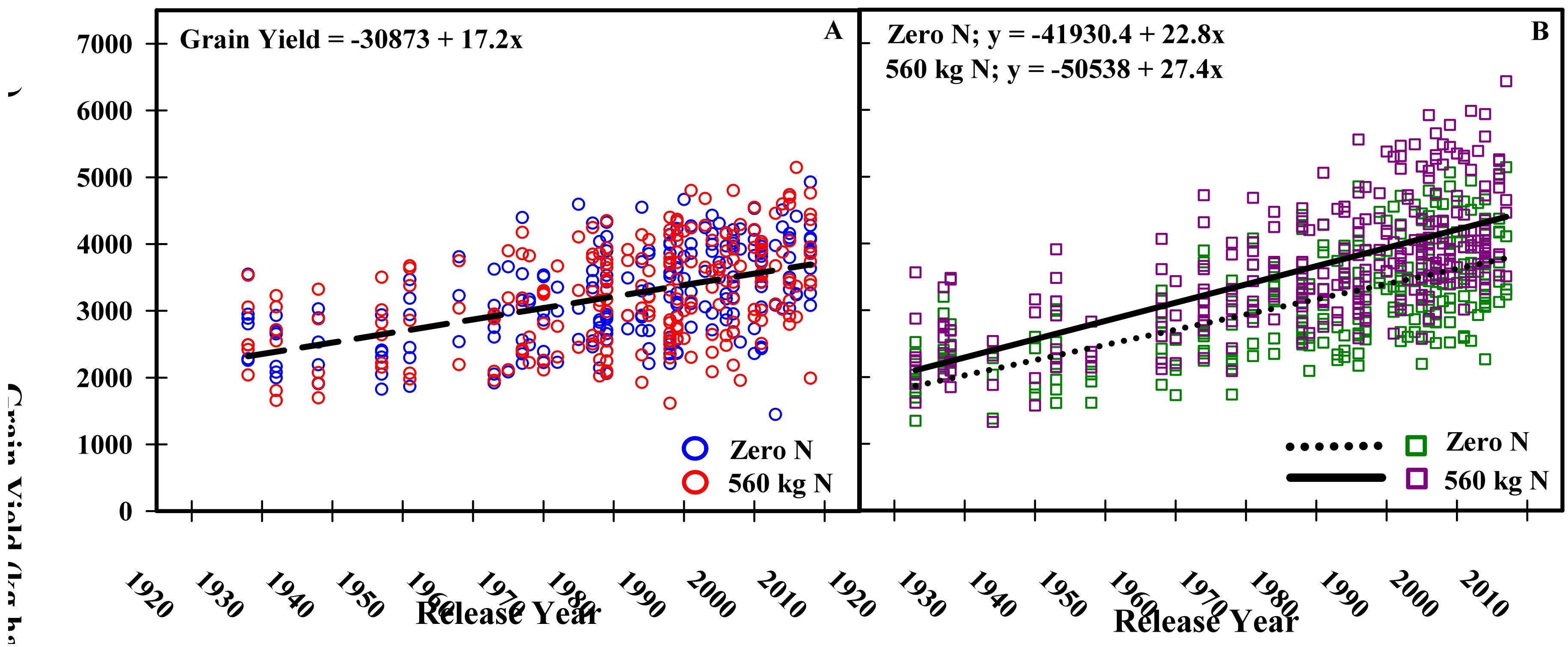
- **Newer soybean cultivar N requirements for yield are not being satisfied by soil and biological N sources.**
  - ***If so, then the estimated rate of genetic yield gain would be expected to be greater with the addition of fertilizer N.***

N Fertilization Treatments

- Zero N
- Total N 560 (500) kg N ha^{-1}
  - 224 (200) kg N ha^{-1} at broadcast at planting (½ urea, ½ polymer coated urea)
  - 336 (300) kg N ha^{-1} broadcast at V5 –V6 (½ urea coated with urease inhibitor, ½ polymer coated urea)



Seed Yield of MG II(a) & MG III(b) cultivars treated with zero nitrogen or 560 kg N ha^{-1} in 2010 (MN, WI, IL, and IN) and 2011 (WI, IL, and IN).



- Within MGs, yields have improved over cultivar year of release (*P*<0.001).
- Within MG IIIs, there was a difference (P<0.0001) in the rate of yield improvement over time between N treatments. Current cultivars were more responsive to additional N than older cultivars.

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Conclusions for III. Nitrogen Utilization: Seed Yield

- Nitrogen application did not affect grain yield of MG II cultivars.
- Fertilizer N increased overall yield and rate of yield gain in MG III cultivars released from sources between 1923 and 2007.
- The mechanisms in which these two groups (MG's) of cultivars utilized greater N supply differed suggesting that further exploration of the effects of increased N availability on photosynthetic activity, yield components, seed-fill period, and grain constituent partitioning is needed.

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Genetic Gain x Management Interactions in Soybean: IV. Disease Effects

Nicholas H. Weidenbenner, Scott C. Rowntree, Eric W. Wilson, Justin J. Suhre, Shawn P. Conley, Shaun N. Casteel, Vince M. Davis, Seth L. Naeve, Brian W. Diers, and Seth L. Naeve. 2013. Crop Science: In review.

Hypothesis:

- **Fungicide applications reduce the rate of genetic gain over time, by increasing yield of older cultivars, and modern soybean management practices have helped to improve yield.**

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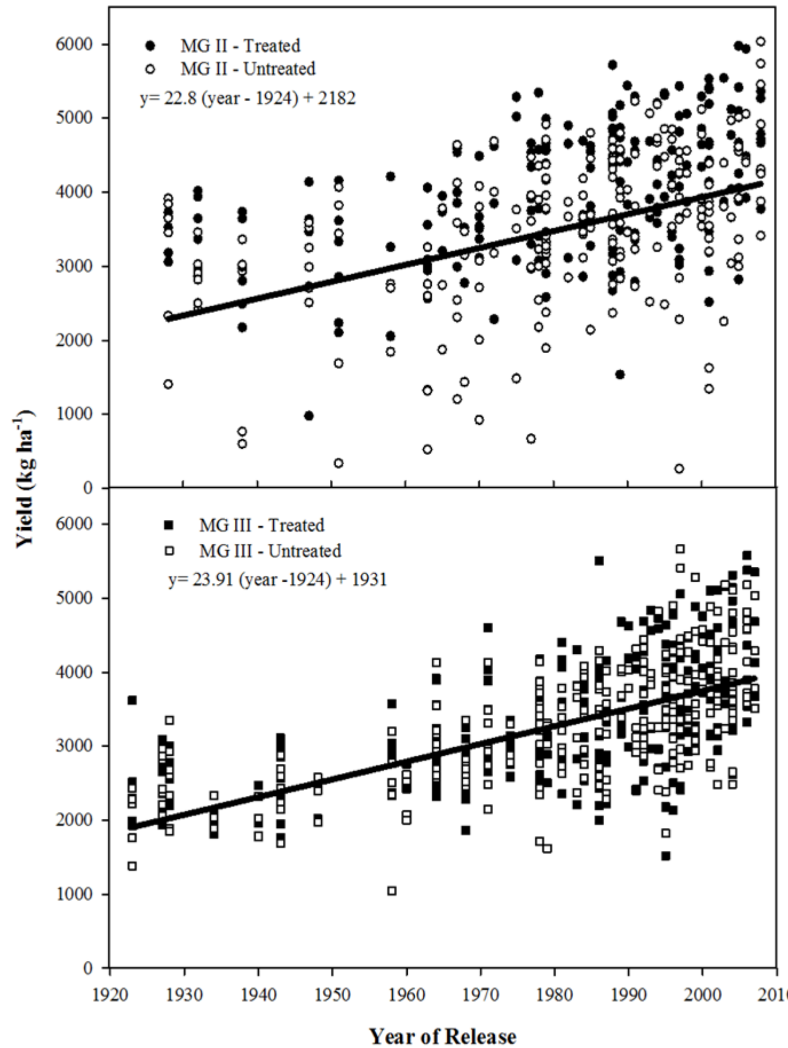
Treatments: (No Fungicides vs. Fungicides)

- Seed treatment:
  - Fludioxonil (group 12)
  - Mefenoxam (group 4)
- Foliar treatment:
  - R1
    - Boscalid (group 7)
  - R3
    - Boscalid (group 7)
    - Pyraclostrobin (group 11)
  - R5
    - Propiconazole (group 3)
    - Trifloxystrobin (group 11)

Conclusions for IV. Disease Effects: Seed Yield

- Soybean yield increased 22.8 kg ha^{-1} yr^{-1} in MG II and 23.9 kg ha^{-1} yr^{-1} in MG III
- National average yield of 23.4 kg ha^{-1} yr^{-1}
- No effect of fungicide treatment or interactions across maturity groups



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Looking Forward:
Implications of (B) x (A) Interactions

- **Employ strategies in breeding programs to exploit synergistic genetic gain by agronomic interactions.**

1. Yield evaluation and selection under early planting conditions.
2. Should breeders focus on increasing branch or stem yield? (e.g. should selection be made at lower populations or narrower rows?)
3. Further exploration of the effects of increased N availability on photosynthetic activity, yield components, seed-fill period, and grain constituent partitioning is needed.
4. Continued focus on disease management practices in soybean

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Acknowledgments

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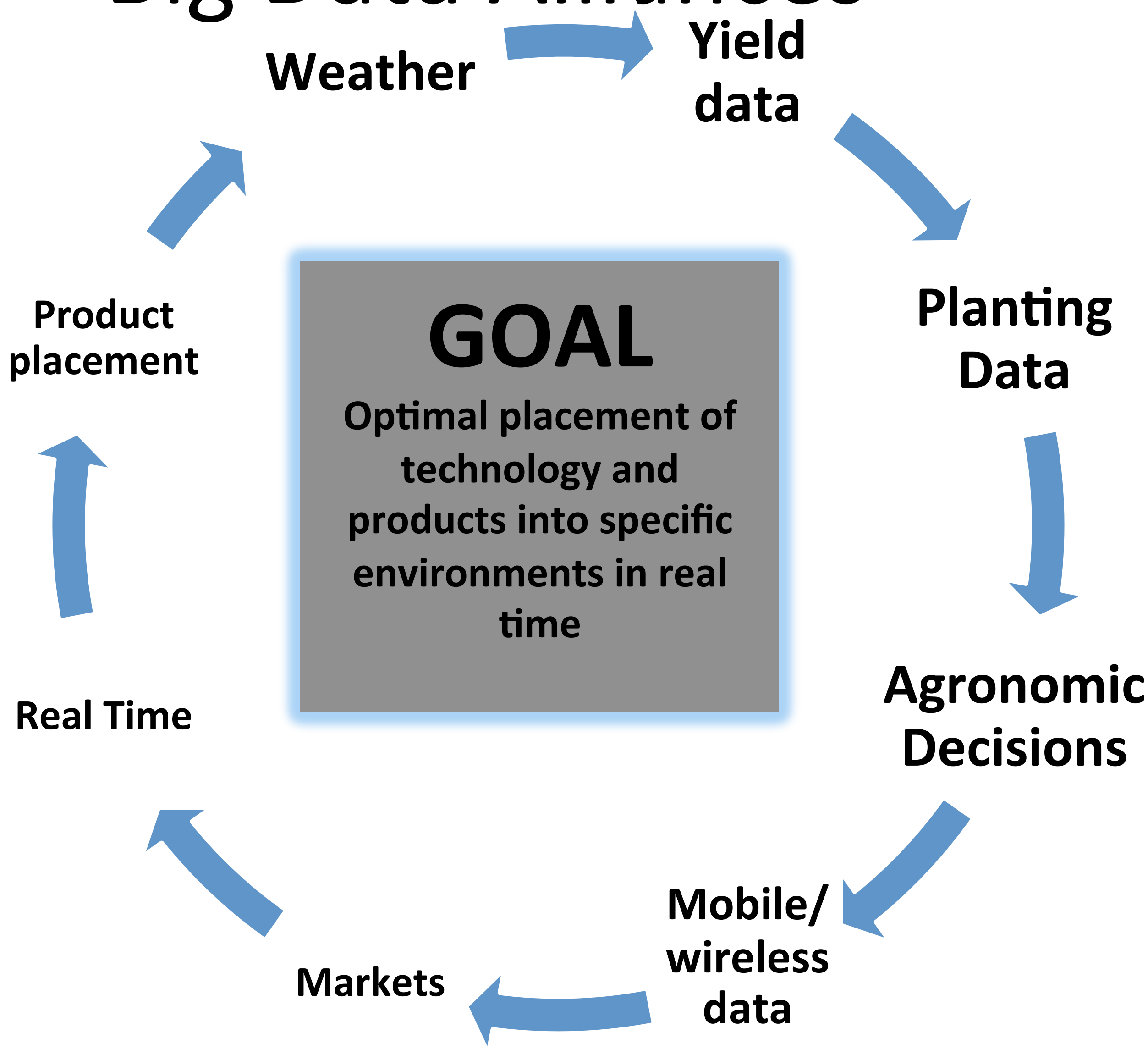

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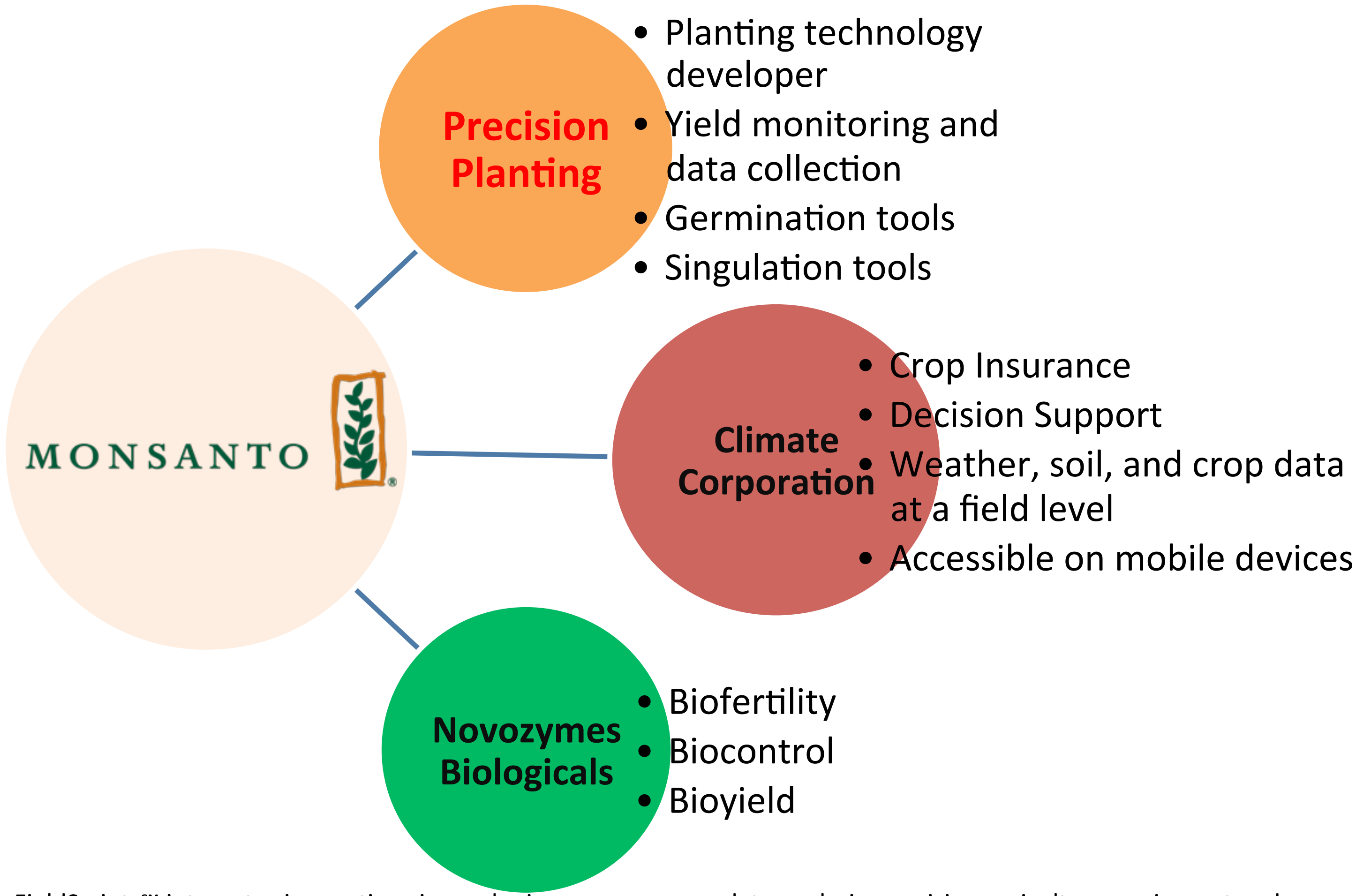

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- **Links Pioneer Field 360 with JD wireless transfer, JD link, and My John Deere**
- **Transferring data from planters and harvesters to the cloud**

DTN

- Real time weather
- Market Information
- Exclusive network of weather stations
- Forecasts and crop models

Other Alliances

- **John Deere and Dow AgroSciences**
  - Precision ag data
  - Similar to Dupont Pioneer agreement
  - field data via the portal MyJohnDeere.com
- **John Deere and BASF**
  - Plans to develop precision farming and farm management tools
  - Enhance field-scouting services and tailor agronomic advice for farmers
  - Turn data into management decisions
  - BASF will offer field scouting and agronomic decision support
  - John Deere will provide a new application for sprayer setup
  - Integration of field data via the portal MyJohnDeere.com
- **John Deere Ag Management Solutions (AMS) and Raven Industries**
  - Agreement to supply customers with a broad suite of application control solutions in the precision agricultural market
- **CNH and Trimble**
  - Automated Steering Technology Partnership for New Holland and Case IH Agriculture Equipment