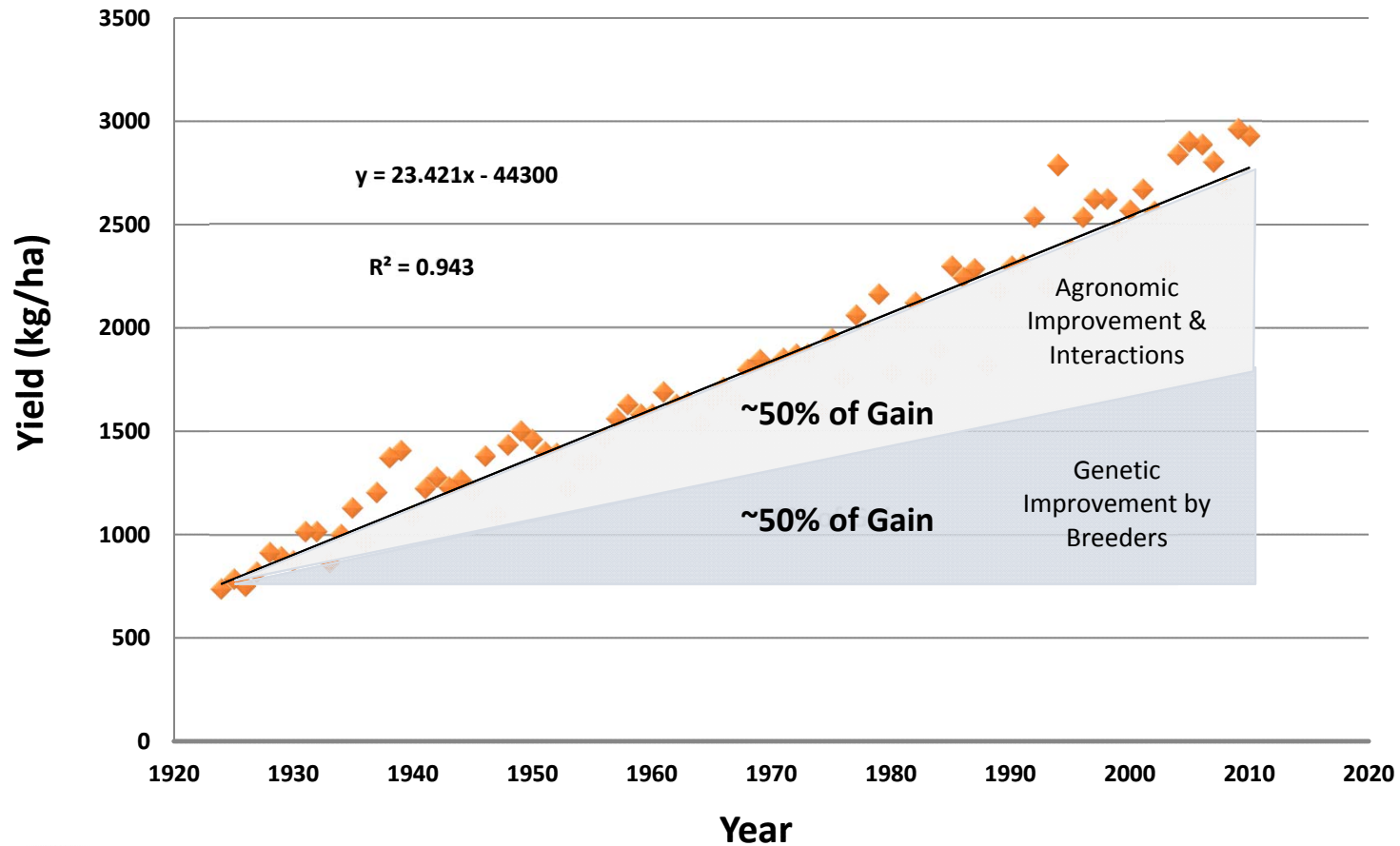




80 Years of B(reeding) x A(gronomy) Interactions in 30 Minutes or Less

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University of Wisconsin, Madison¹, UI², UM³, PU⁴, UNL⁵, EdA⁵

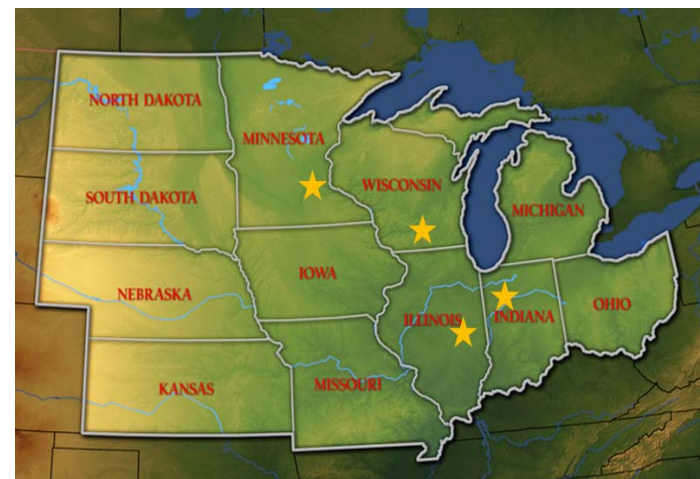
Genetic versus Agronomic On-Farm Yield Gain



Specht, J.E., D.J. Hume, and S.V. Kumudini. 1999. Soybean yield potential—A genetic and physiological perspective. *Crop Sci.* 39:1560–1570.

The “Decades” or Genetic Gain Study

- 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



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



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).*



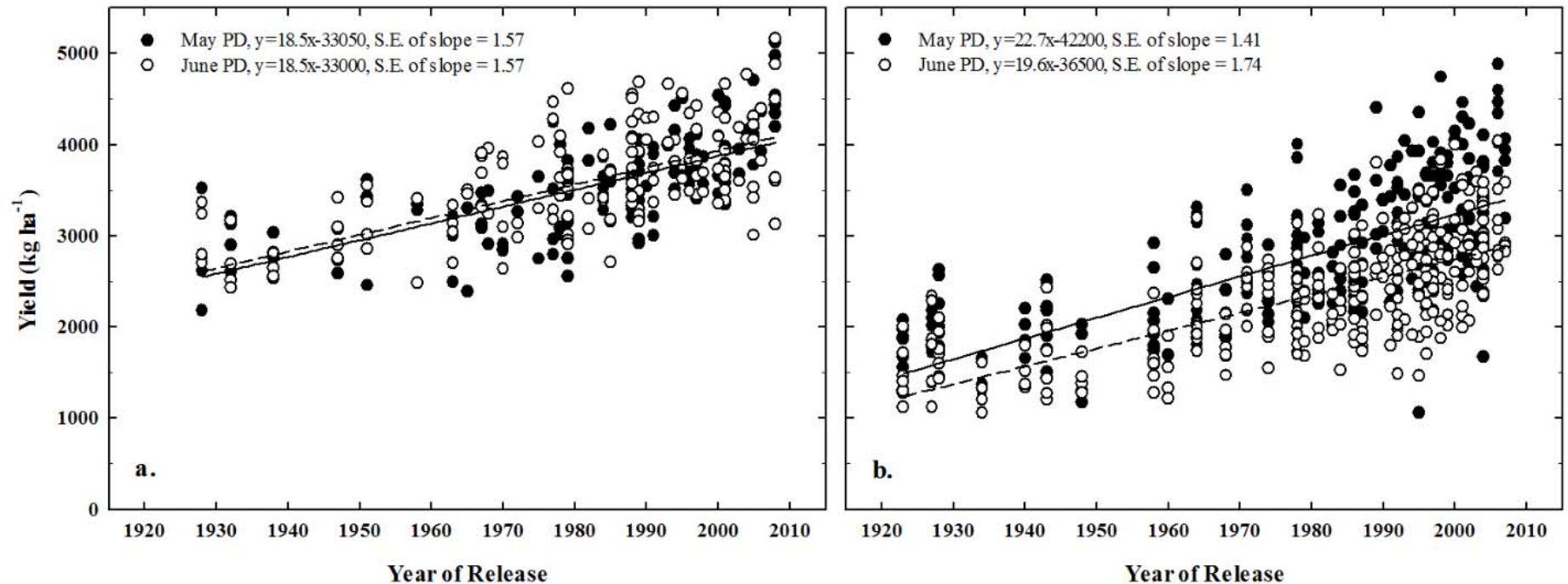
Table 1. Experimental details with respect to test sites, soils, and dates of planting and harvest.

	Arlington, WI		Urbana, IL		Lafayette, IN	
	Arlington Agricultural Research Station		Crop Sciences Research and Education Center		Throckmorton Purdue Agricultural Center	
Location of research site	43°18' N, 89°20' W		40°3' N, 88°14' W		40°17' N, 86°54' W	
Soil series	Plano silt loam		Flanagan silt loam and Drummer silty clay loam		Throckmorton silt loam	
Soil family	Fine-silty, mixed, mesic Typic Argiudoll		Fine-silty, mixed, mesic Typic Endoaquoll and fine, smectitic, mesic Aquic Argiudoll		Fine-silty, mixed, mesic mollic Oxyaquic Hapludalf	
Soil fertility						
Phosphorus (mg kg ⁻¹)	44–56		23–34		39–66	
Potassium (mg kg ⁻¹)	166–173		122		138–146	
pH	6.9–7.1		5.8–6.1		6.0–6.1	
Organic matter (g kg ⁻¹)	3.2		3.6–4.1		2.9–3.0	
Field operations	2010	2011	2010	2011	2010	2011
Planting date (May PD treatment)	4 May	5 May	15 May	12 May	10 May	17 May
Planting date (June PD treatment)	1 June	6 June	14 June	8 June	4 June	12 June
Harvest date (May PD treatment)	8 Oct.	17 Oct.	7 Oct.	11 Oct.	24 Sept.	11 Oct.
Harvest date (June PD treatment)	13 Oct.	17 Oct.	7 Oct.	11 Oct.	4 Oct.	11 Oct.
Planting date difference (d)	28	32	30	27	25	26

From: 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.

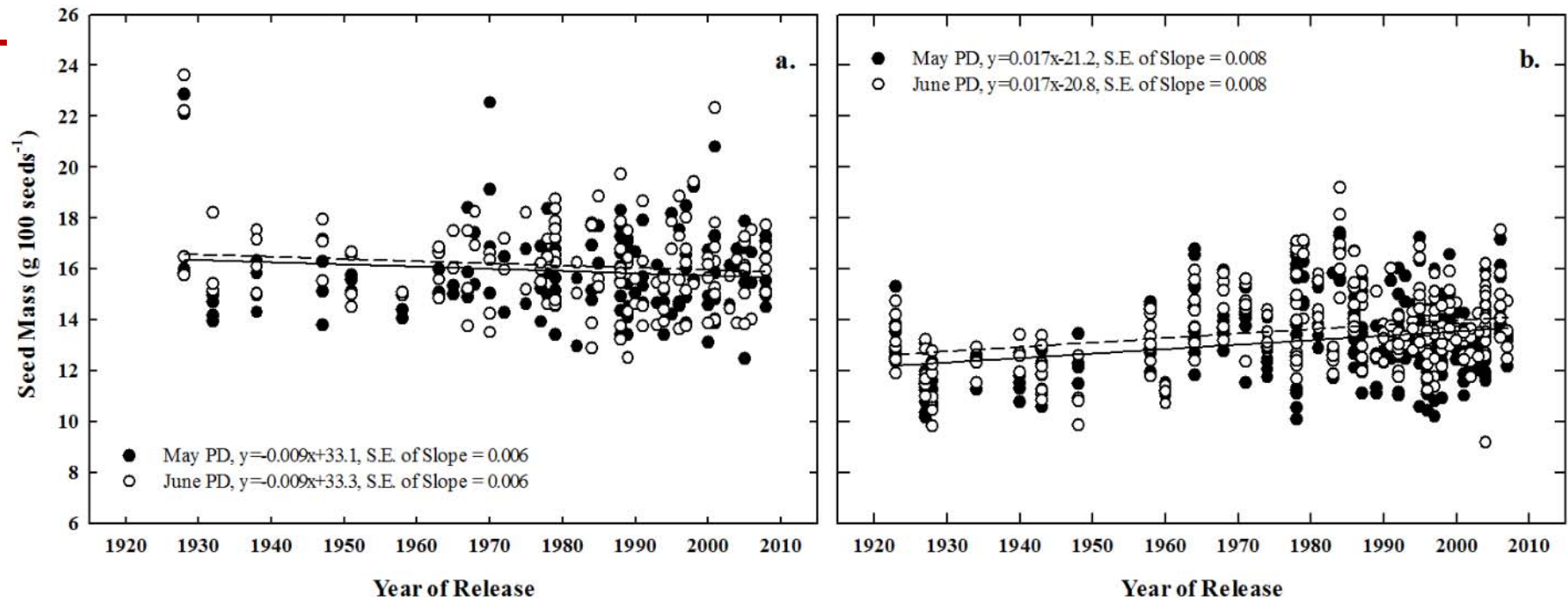


Seed Yield of MG II(a) & MG III(b) cultivars at early and late planting (2010-2011)



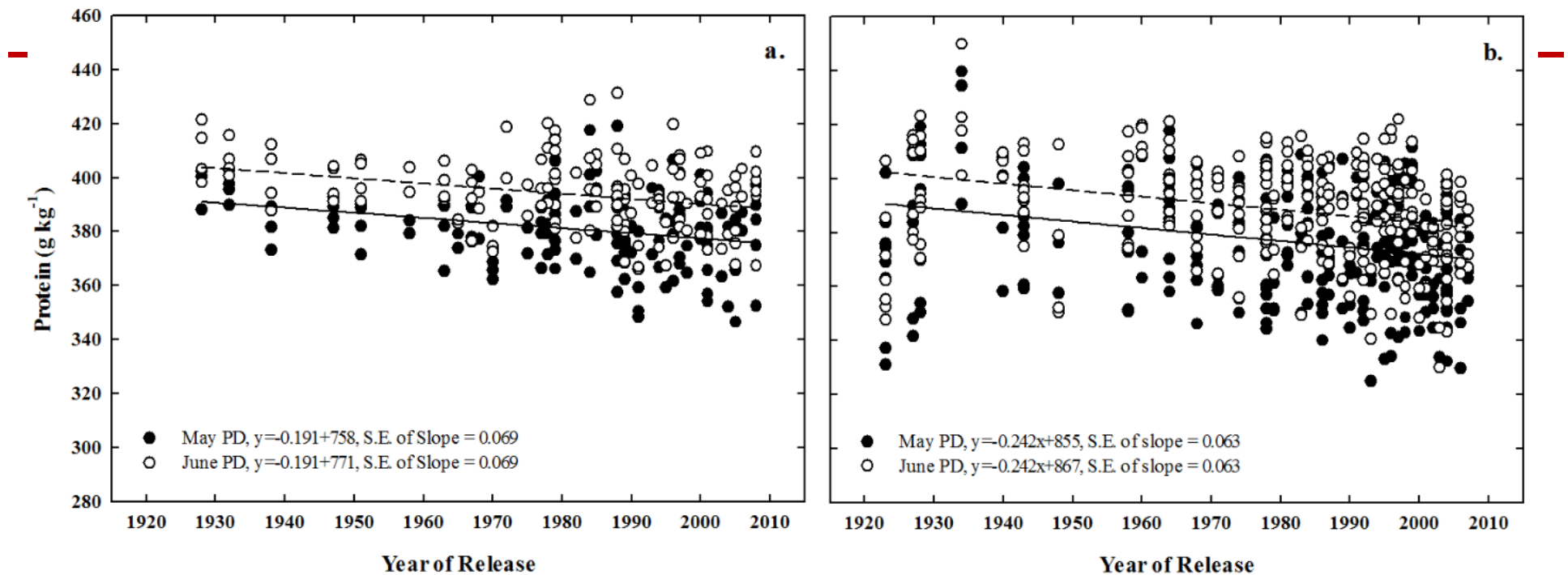
- Within MGs, yields have improved over cultivar year of release ($P < 0.001$). Represents the successful efforts made by breeders to improve soybean yield over time.
- Within MG IIIs, there was a difference ($P < 0.05$) in the rate of yield improvement over time between early and late plantings. A synergistic interaction!

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



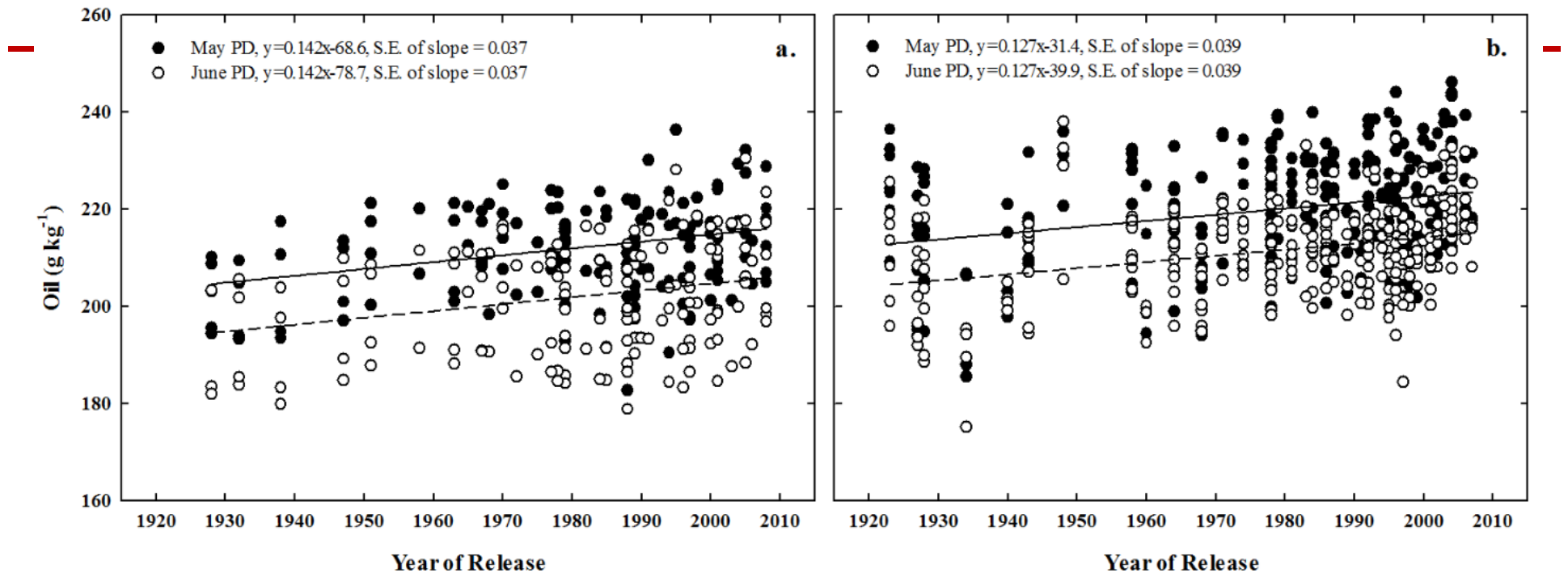
- Within MG, there was no effect ($P > 0.05$) of cultivar year of release or planting date on seed mass.

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



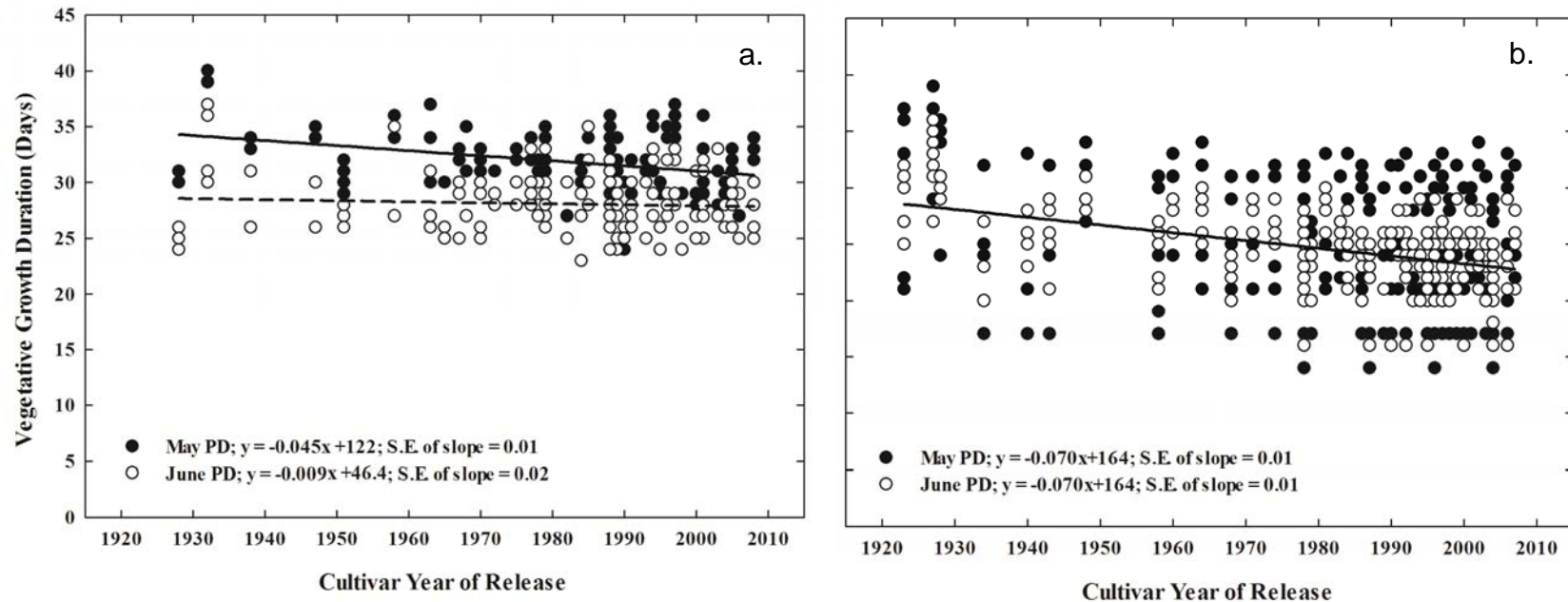
- Within MG, seed protein levels declined ($P < 0.001$) over cultivar year of release.
- Within MG, seed protein levels increased ($P < 0.05$) as planting was delayed by approx. 30 days.

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



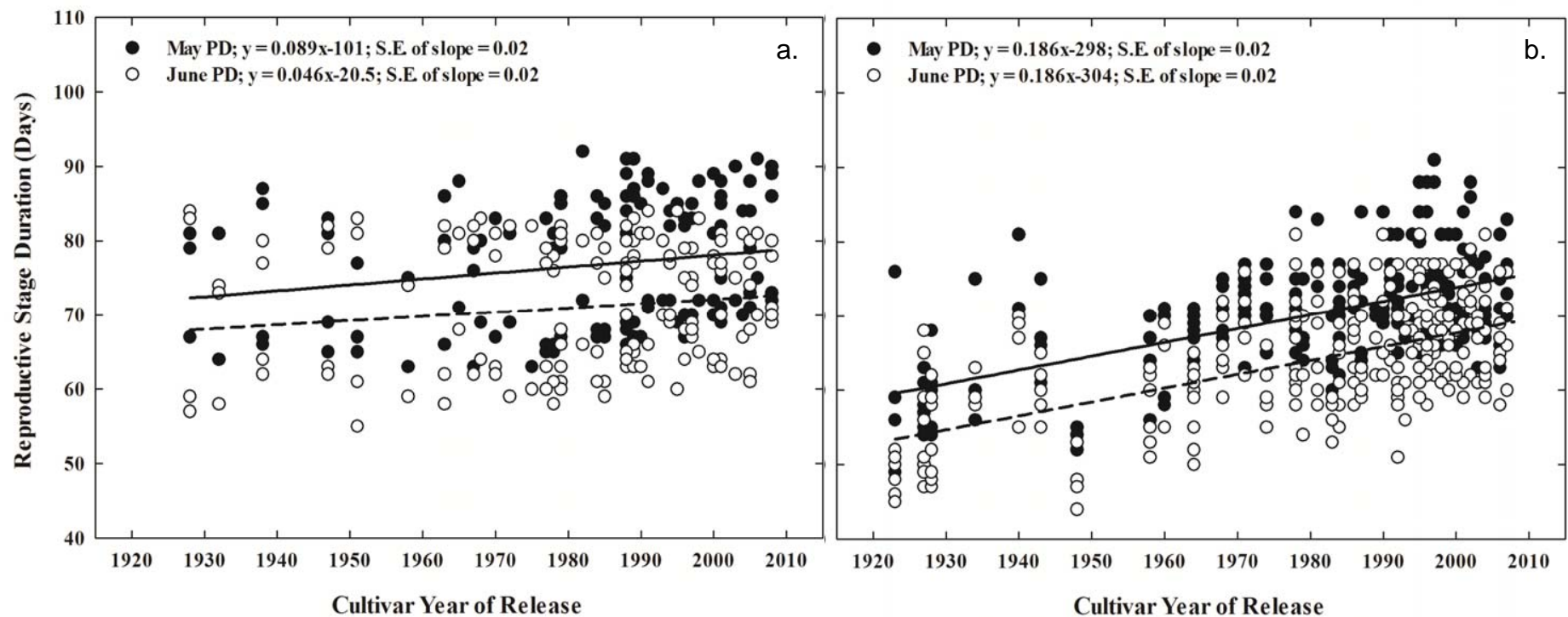
- Within MG, seed oil levels increased ($P<0.001$) over cultivar year of release.
- Within MG, seed oil levels decreased ($P<0.01$) as planting was delayed by approx. 30 days.

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.

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

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

- Earlier planting increased cultivar mean yields in MG III's.
- 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 synergistic increase in on-farm soybean yields in the Midwestern U.S.



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).

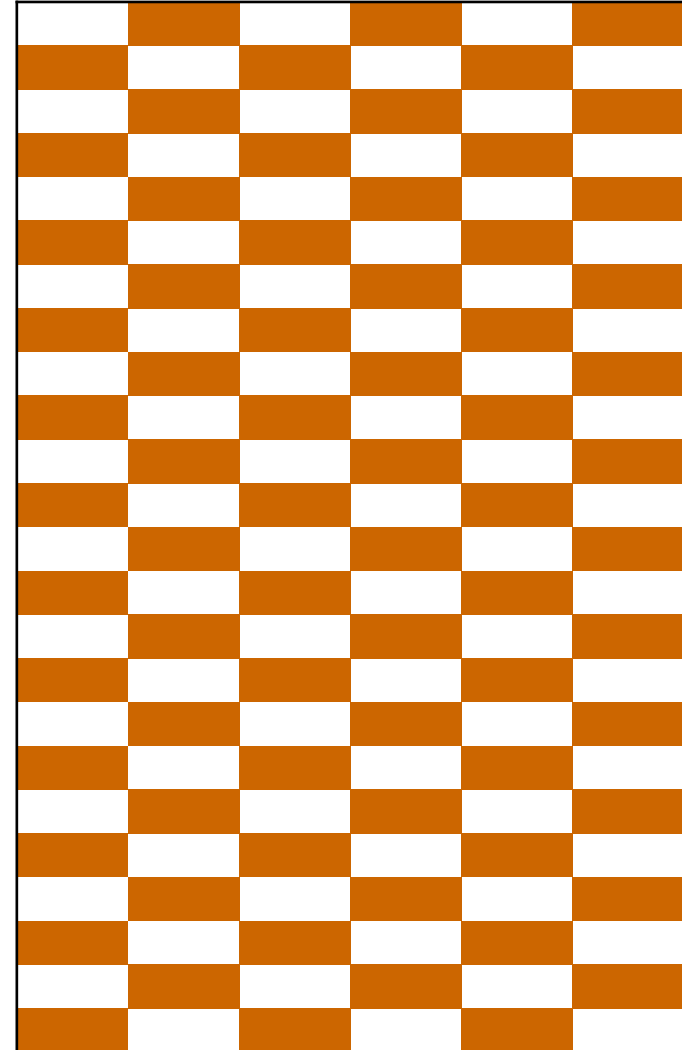
Hypothesis:

- **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.**

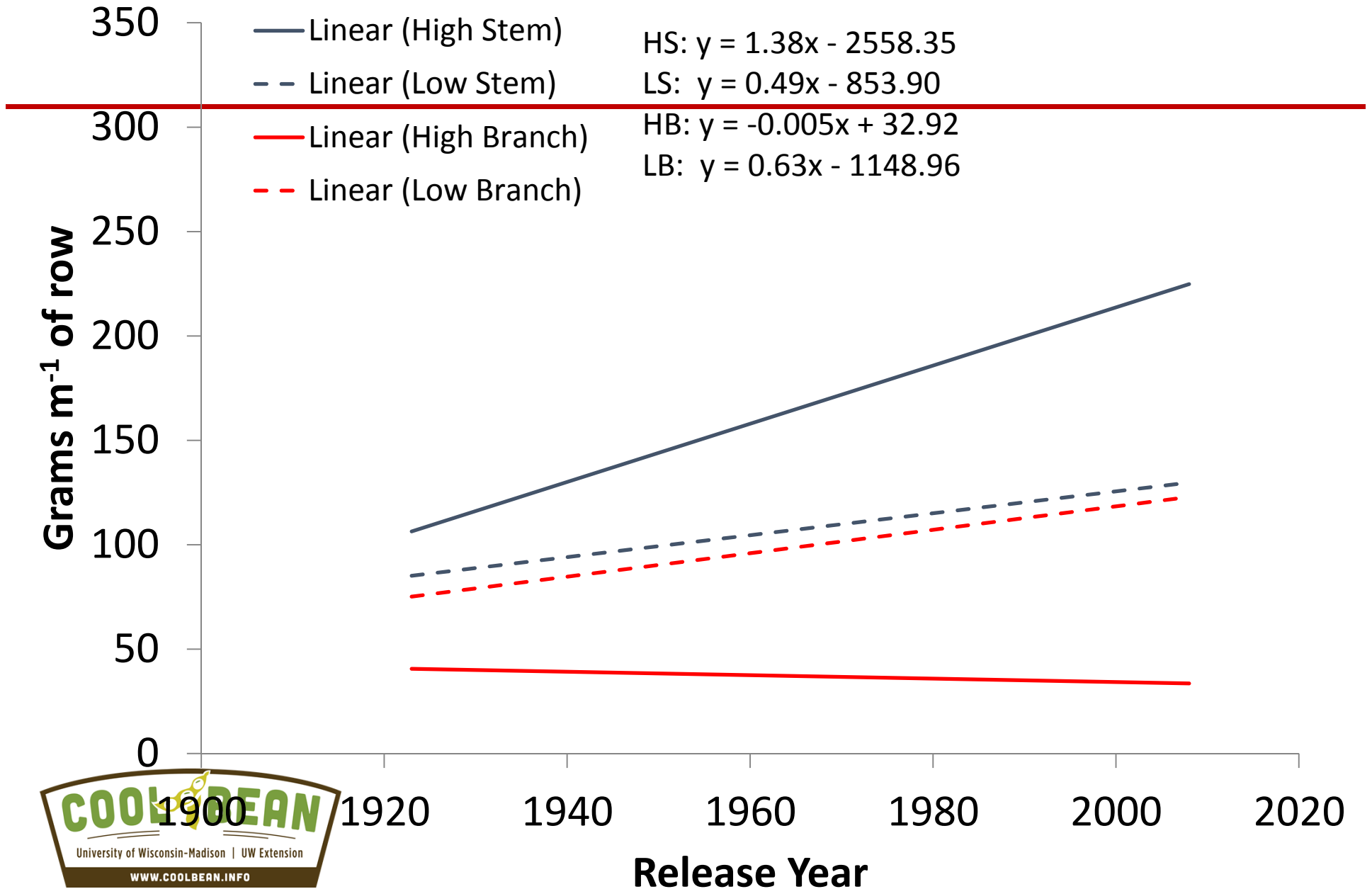


Materials and Methods

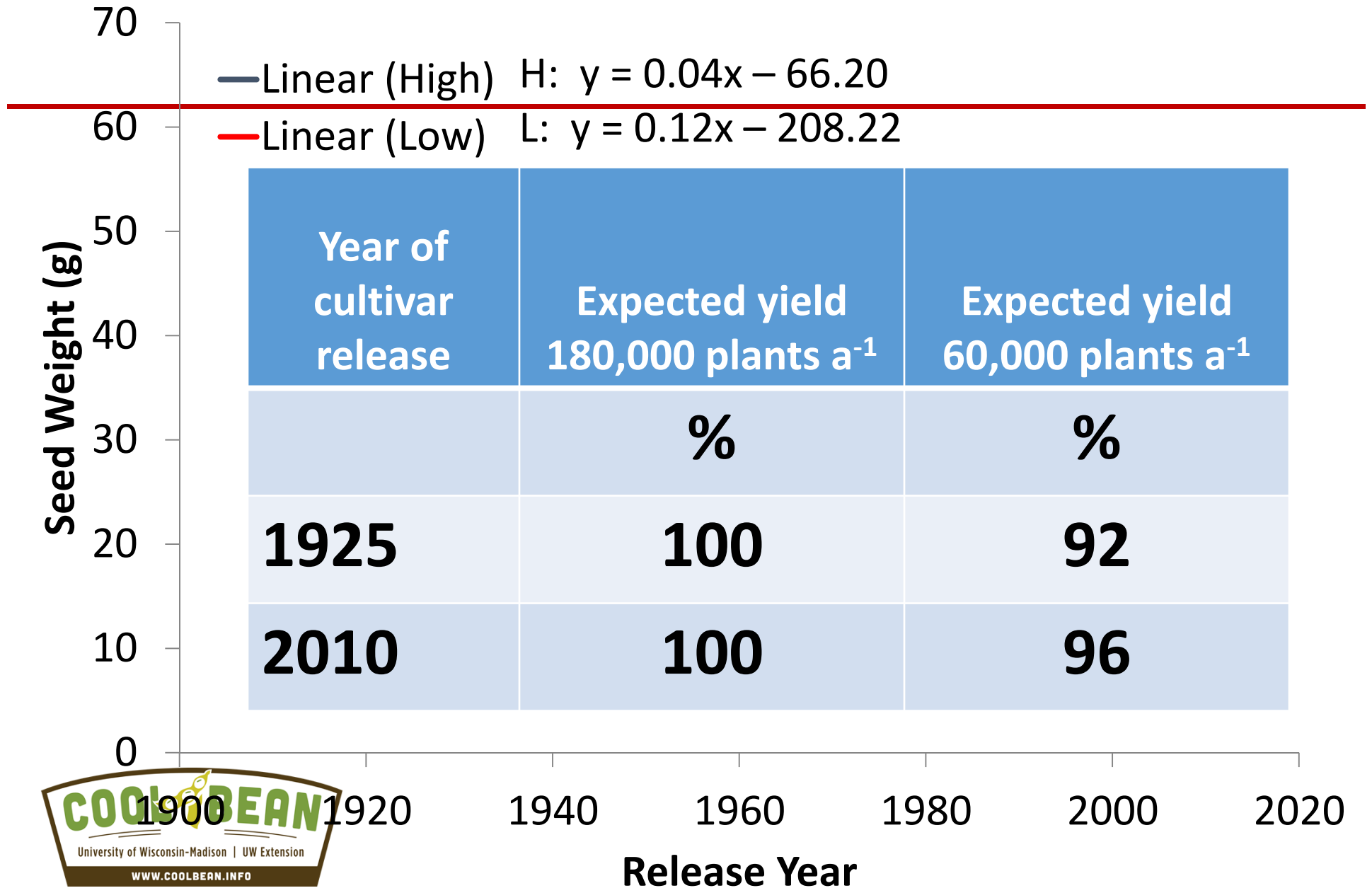
- 4 locations over 2 years
- Randomized Incomplete Block Design – PROC MIXED in SAS
- 59 MG II cultivars with 13 replicates/ 57 MG III cultivars with 15 replicates
- Two seeding rates
 - 180,000 seeds a^{-1} (High)
 - 60,000 seeds a^{-1} (Low)
- 4 row plots
 - 30 in spacing
 - 15 ft length



Total Seed Weight



Yield per Plant



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



A close-up photograph of a woman with a surprised or playful expression. She is wearing large, round, black-rimmed glasses. Her hair is covered by a pink lace headscarf decorated with small orange and teal floral ornaments. She is wearing a purple top with a white floral pattern. The background is dark and indistinct.

¡Hola I
hear you
missed me
last year!

Disclaimer: Not an actual picture of my mother-in-law.

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.

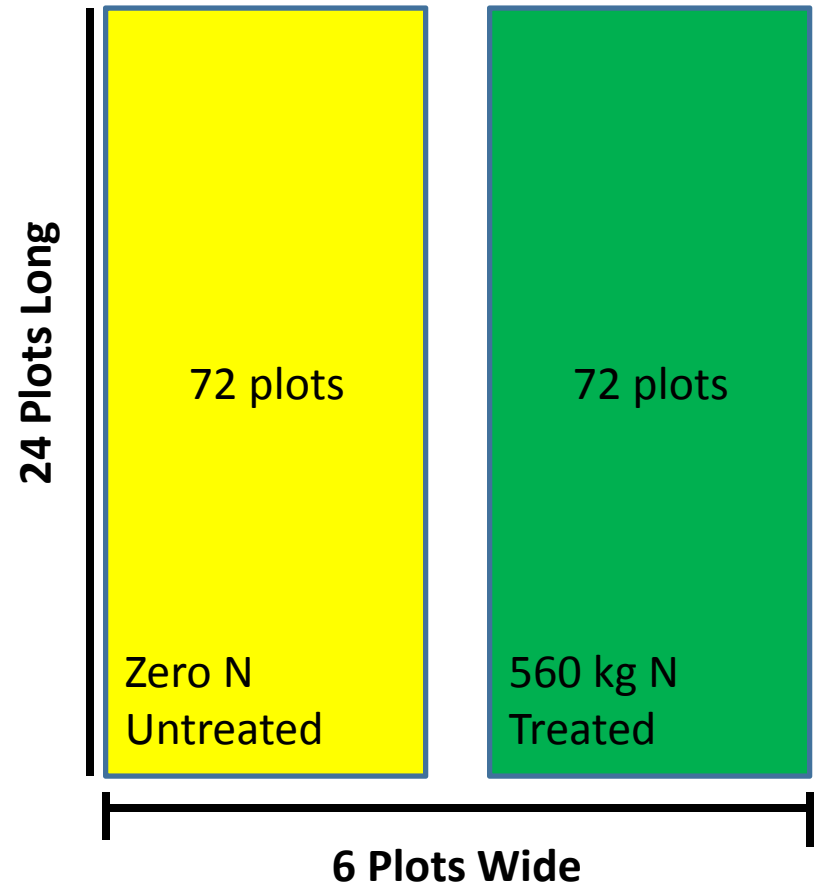
Hypothesis:

- **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.*

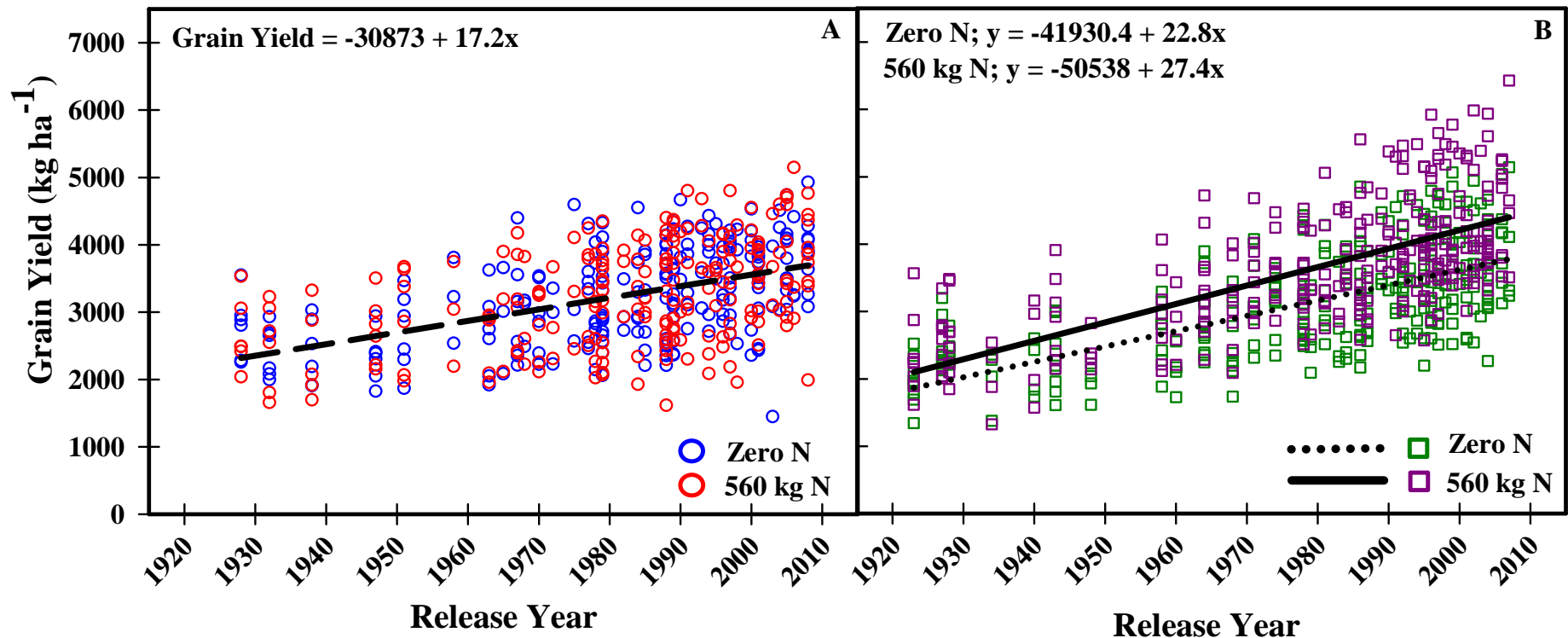


N Fertilization Treatments

- 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.



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.



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.**



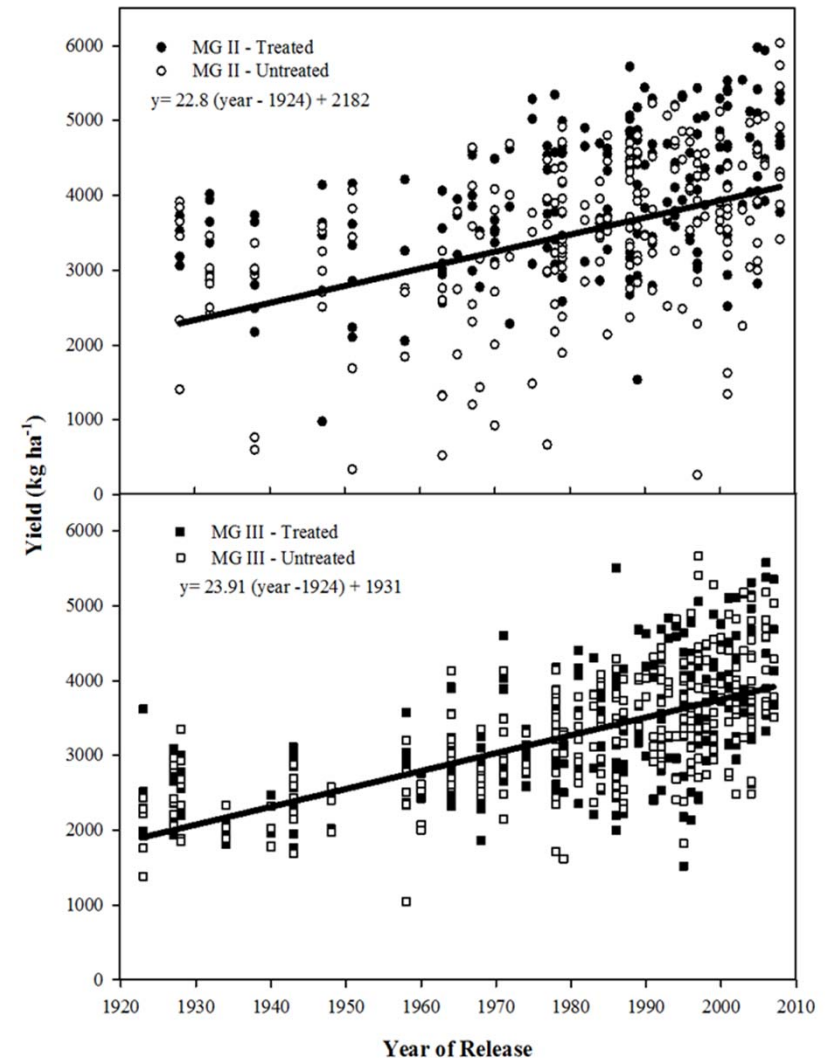
Treatments: (No Fungicides vs. Fungicides)

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



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



Acknowledgments



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