The Physiology Behind 100+ Bushel Yields in Arkansas

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Outline

- **Introduction**
  - **Framework for increasing seed number and seed size**
- Research in Mr. Cullers' contest field
- Small plot research at Fayetteville

Framework for determining seed number and seed size

Yield (g m^{-2}) =

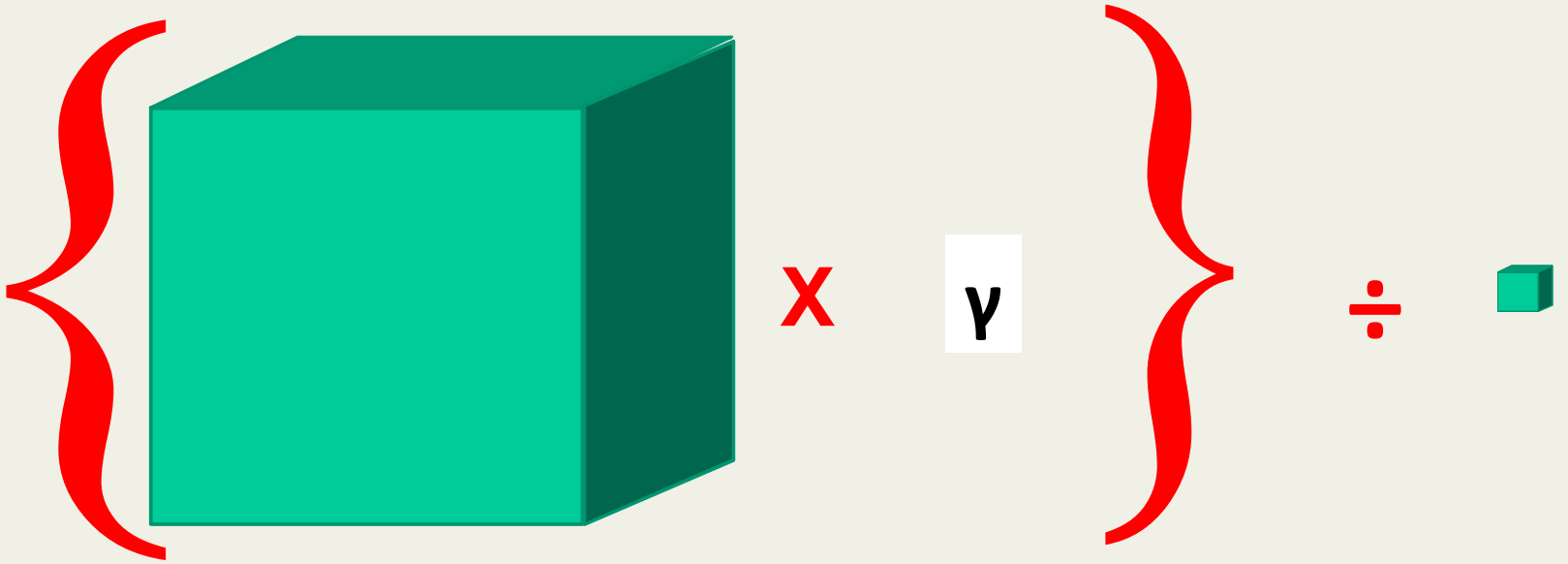
- seed number (seed m^{-2}) x
- average seed mass (g $seed^{-1}$)

Hypothesis:

- seed number is determined during flowering and pod formation and is limited by sugars produced during photosynthesis

- average seed mass is determined by the duration of the seed fill period and is limited by nutrient availability.

Seed number – Charles Edwards model



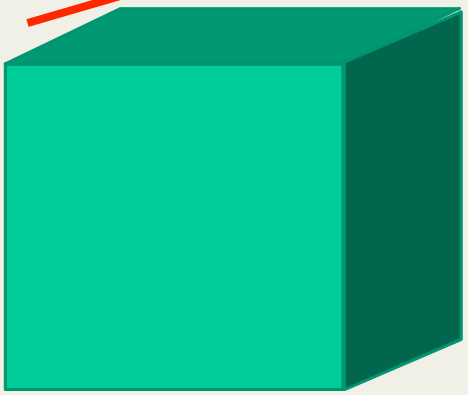
Total crop growth rate during flowering early pod formation (g sugar m^{-2} d^{-1})

Fraction of total sugar partitioned to seed

Minimum amount of sugar per day needed to keep a seed from aborting (g sugar $seed^{-1}$ d^{-1})

Seed number

Seed size



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X

Duration of seed growth

X

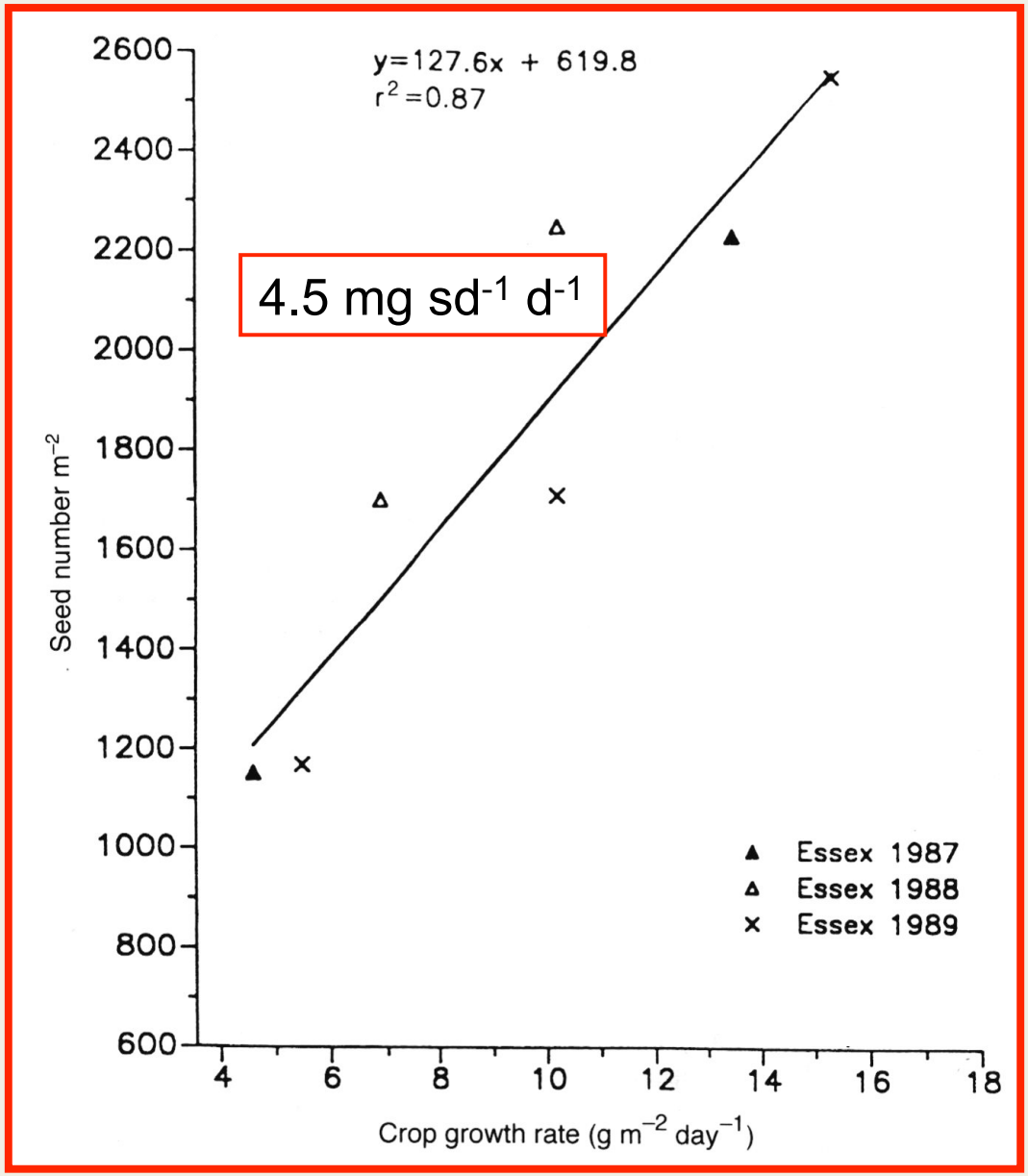
Seed growth rate

=

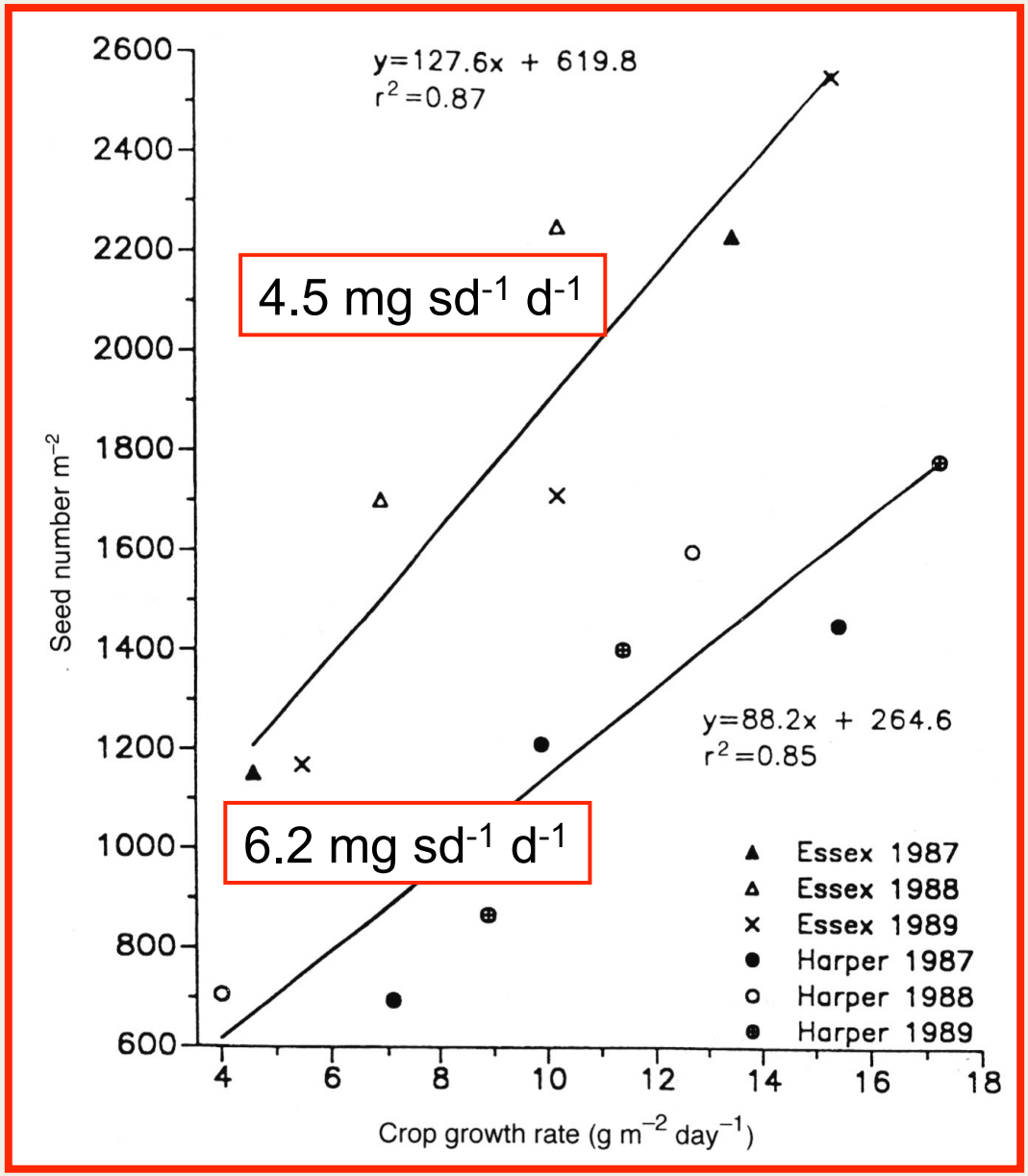
Yield

Total crop growth rate, CGR

Sugar per seed, SGR



Egli and Zhen-wen. 1991. Crop Sci. 31:439



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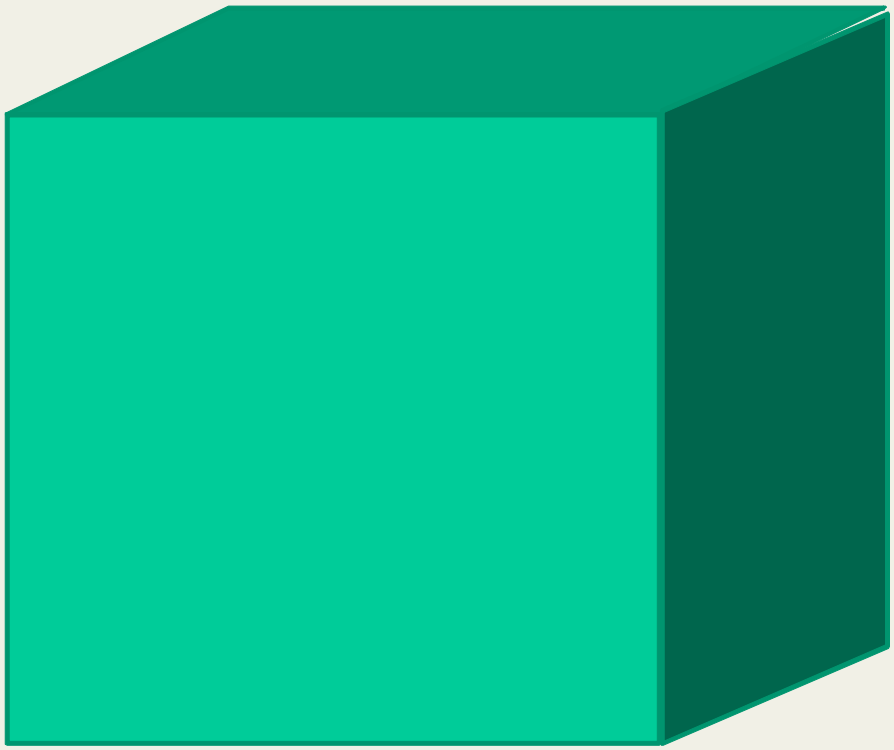
Large seed number:

- high growth rates R1 to R5
- low seed growth rates

Large average seed size:

- low seed growth rates
- long seedfill period
- not limited by nutrition

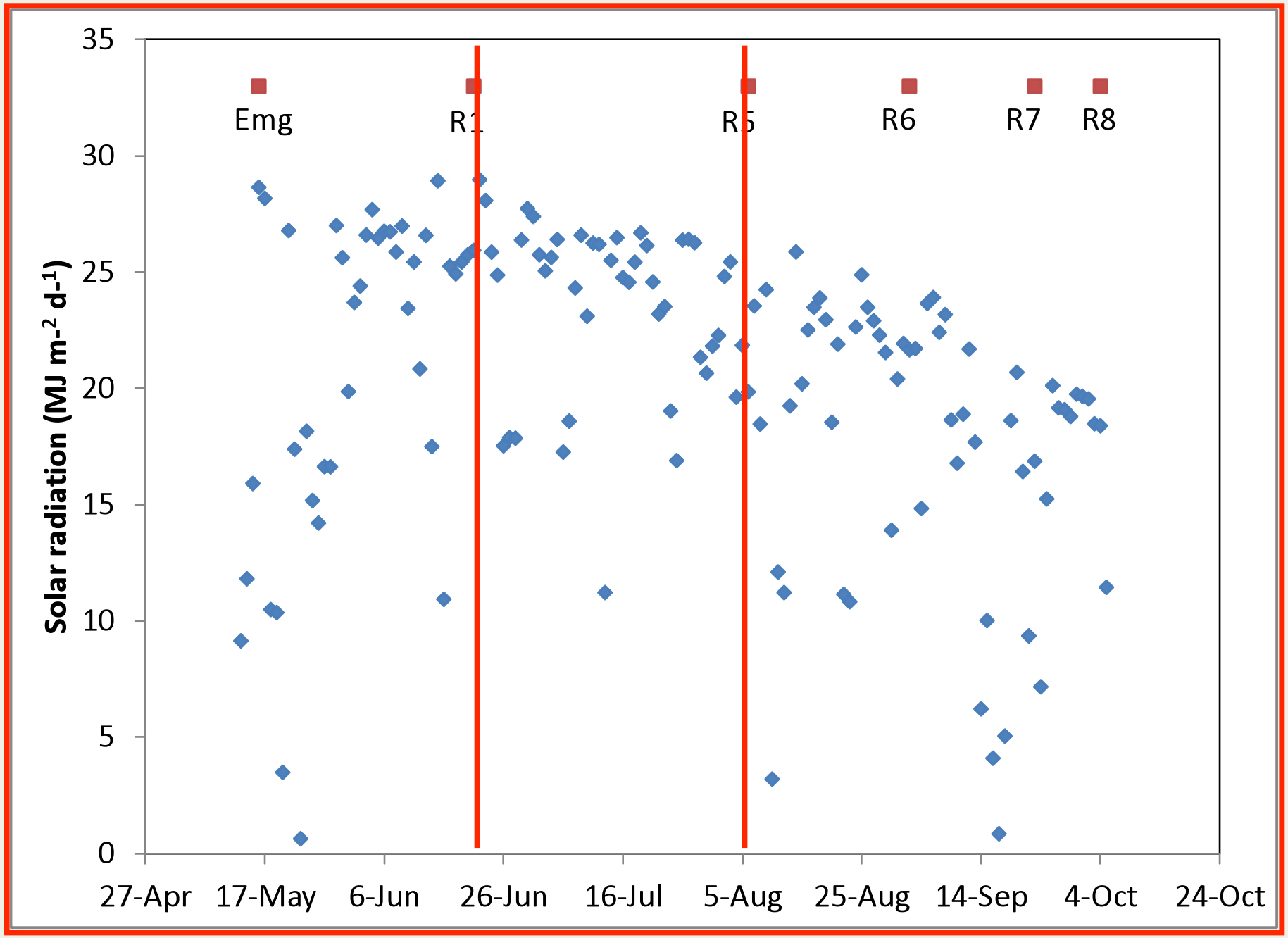


Total crop growth during flowering early seed fill (g sugar m^{-2} d^{-1})

How can we increase the size of this block of sugar?

- Match planting date and variety such that flowering begins before the solstice

- Manage row spacing and population density so that full light interception occurs at beginning flowering


Solar radiation (MJ m-2 d-1)
35
30
25
20
15
10
5
0
Emg
R1
R5
R6
R7
R8
27-Apr
17-May
6-Jun
26-Jun
16-Jul
5-Aug
25-Aug
14-Sep
4-Oct
24-Oct

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Current Yield Record

- Mr. Kip Cullers, Missouri Soybean Association
  - 2006 – **139** bu/ac
  - 2007 – **155** bu/ac
  - 2008 – **118** bu/ac
  - 2009 – N/A
  - 2010 – **161** bu/ac
  - 2011 – **109** bu/ac
  - 2012 – N/A
  - 2013 – **115** bu/ac

http://agwired.com/2010/10/13/kip-cullers-sets-new-world-record-soybean-yield/

Cullers Management

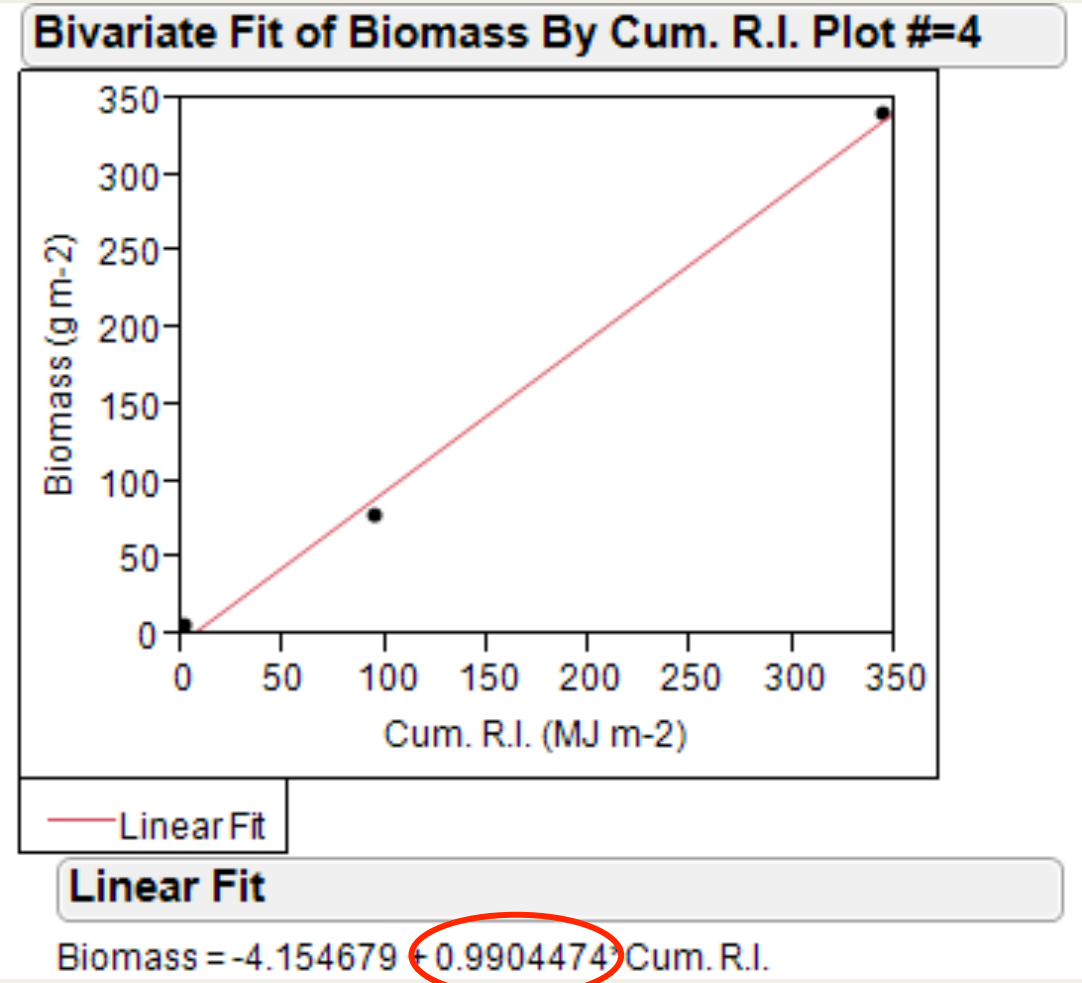
- Rotates between two contest fields of Newtonia silt loam
- Perennial poultry litter applications
- Early planting
- Plant density ~140,000 plants/ac
- 9 inch twin rows on 30 inch centers with a Monosem planter
- Indeterminate Pioneer Hi-Bred varieties from 4.2 – 5.1 RM
- Frequent (daily) overhead irrigation
- Multiple seed treatments, herbicides, insecticides, fungicides, and others…

Research with Cullers

- Establish four plots within each variety
  - Radiation use efficiency
  - N accumulation rate
  - Seed growth rate and seed fill duration

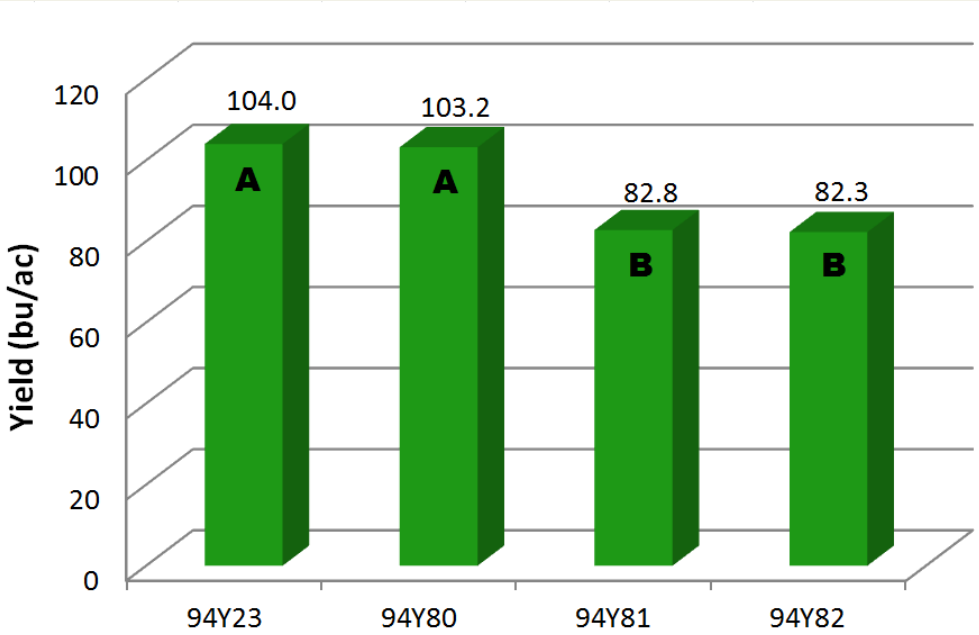
Radiation Use Efficiency

- 3 biomass samples over time
- Weekly light interception
- Solar radiation measured at the field

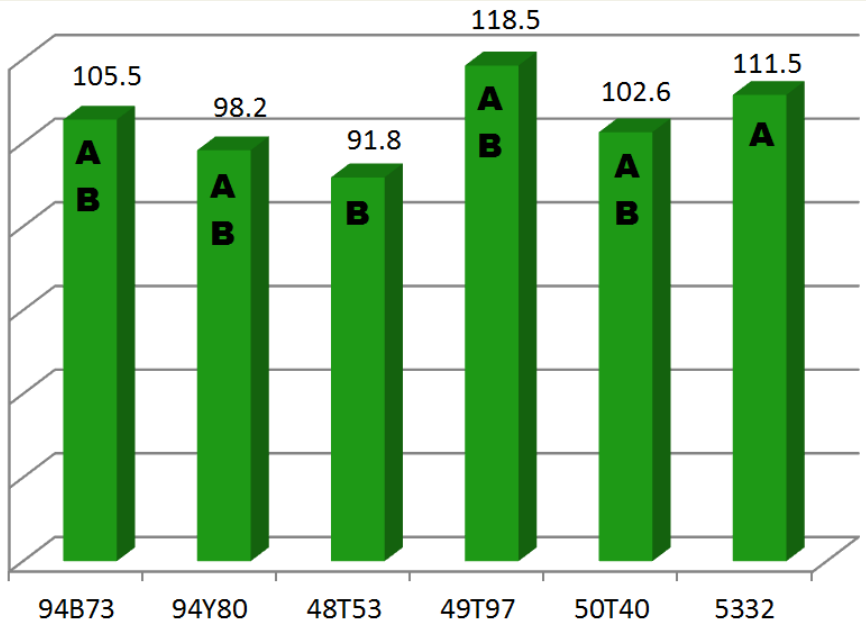


Cullers Yield Results

2012



2013



- Severe heat and drought in 2012
- Late planting (May 27th) in 2013
- No supplemental fertigation

Van Roekel and Purcell. 2014. Crop Sci. (in press)

N Accum Rate & RUE

- N accumulation rate (NAR) with a full canopy
- Radiation use efficiency (RUE) during vegetative growth
- **Both NAR and RUE are highest ever reported for soybean**

2013

Variety	NAR	RUE
	g N m^{-2} d^{-1}	g MJ^{-1}
94B73	1.88 AB	508 lbs/ac/day
94Y80	1.66 AB	1.73 A
48T53	1.43 B	1.46 B
49T97	18 lbs N/ac/day	1.89 A
50T40	2.07 A	1.80 A
5332	1.51 B	1.83 A

Van Roekel and Purcell. 2014. Crop Sci. (in press)

Seed Fill Duration

- Rate HI increase typically ≈ 0.013
- Typical seed fill for 30 to 35 days

Lower rates and longer durations:

- Prevent seed/pod abortion
- Minimizes demand on leaf proteins (N)

Planted April 11, 2012

Variety	DMAC	Seed Fill Duration (days)
94Y82	0.0088 B	56.9 A
94Y81	0.0100 AB	45.3 B
94Y92	0.0108 AB	39.7 B
94Y91	0.0111 A	40.9 B
95Y10	0.0111 A	40.6 B

Seed Fill Duration

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Lower rates and longer durations:

- Prevent seed/pod abortion
- Minimizes demand on leaf proteins (N)

Planted May 27, 2013

Variety	Rate HI Increase	Seed Fill Duration
	HI d^{-1}	d
94B73	0.0082 D	45.8 A
94Y80	0.0138 A	34.0 C
48T53	0.0105 C	31.2 CD
49T97	0.0132 AB	28.8 D
50T40	0.0103 C	39.8 BC
5332	0.0111 BC	36.4 BC

Conclusions

- Early flowering and full light interception maximizes amount of photosynthate produced
- High N accumulation rate creates large pool of available N
- Long seed fill duration lessens photosynthate and N demand for each individual seed
  - All work together to increase seed (pod) number and seed weight

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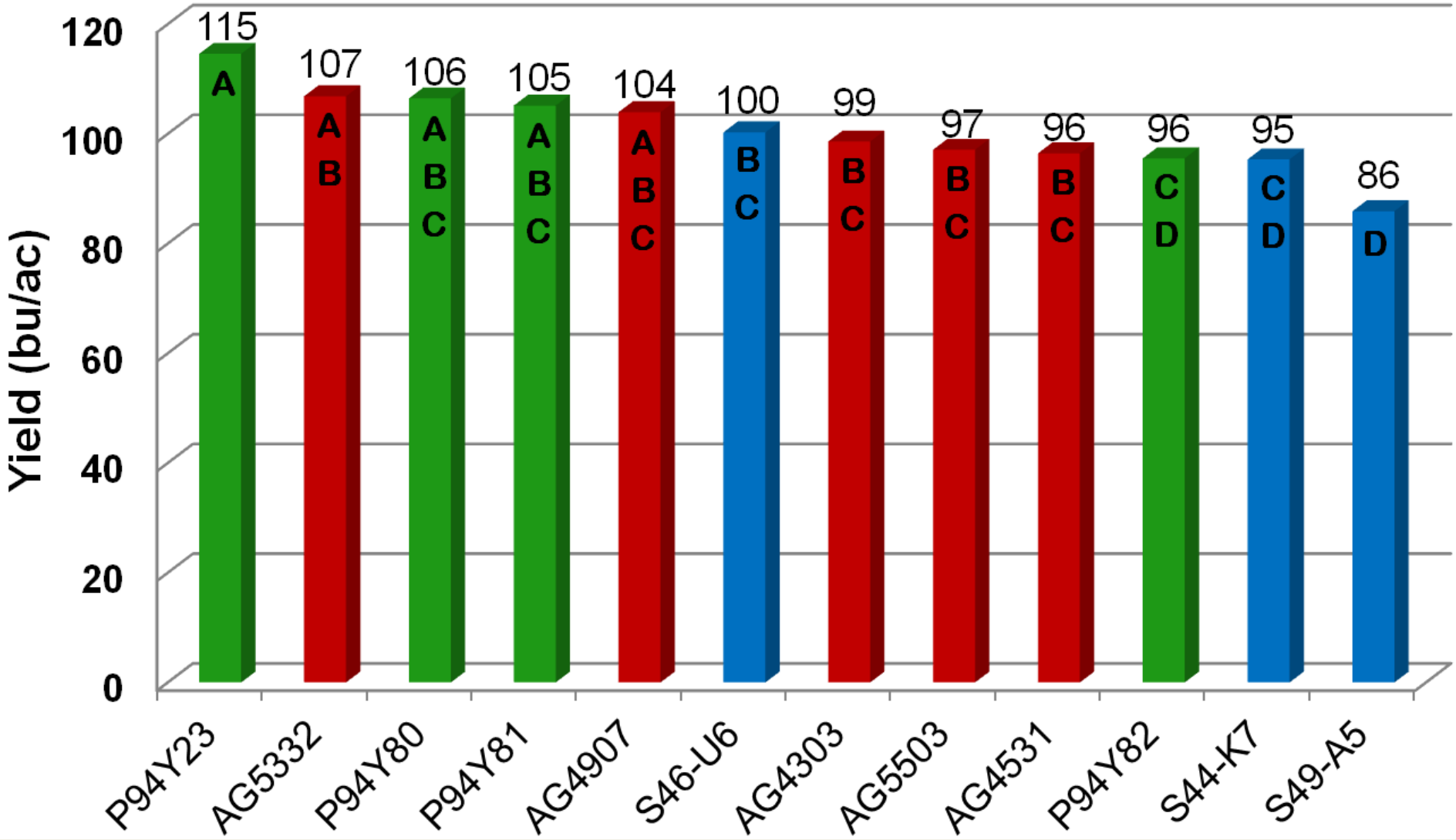
Max Yield Management

- Deep tillage ≥ 14 in.
- Early planting
- 18 inch rows
- 140,000 plants/ac
- N, K, & S fertigation
- Preventative fungicides
- Strict pest control

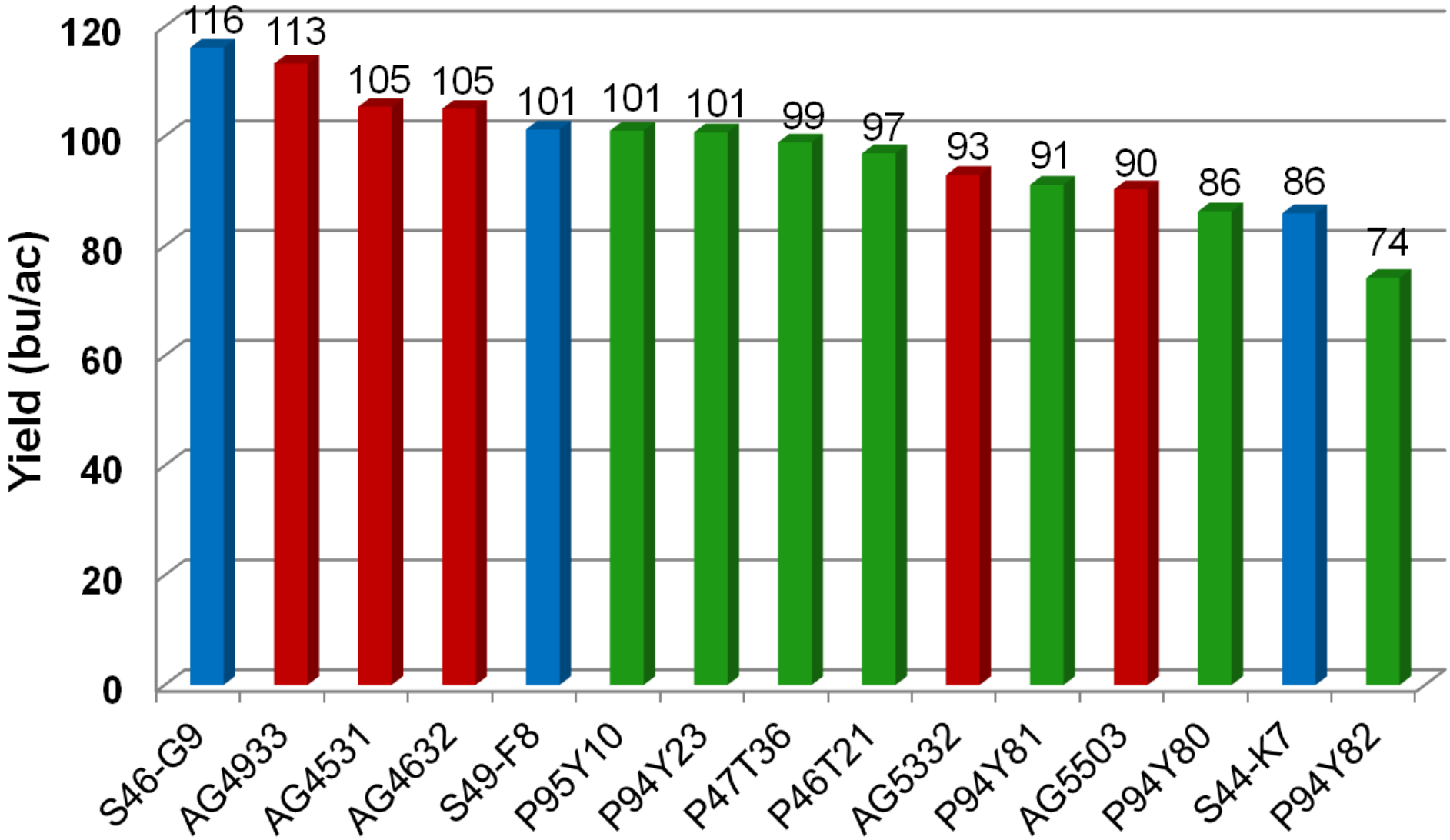
Max Yield Management - 2013

- Season before:
  - 11.1 Mg ha^{-1} poultry litter
- Prior to planting
  - 11.4 Mg ha^{-1} poultry litter
  - 392 kg ha^{-1} KCl
  - 280 kg ha^{-1} $K_2Mg(SO_4)_2$
  - 112 kg ha^{-1} $NH_4(SO_4)_2$
- During Season
  - Irrigated 25x, 496 mm
  - 178 kg ha^{-1} N
  - 40 kg ha^{-1} K
  - 11 kg ha^{-1} S

Fayetteville 2012



Fayetteville 2013



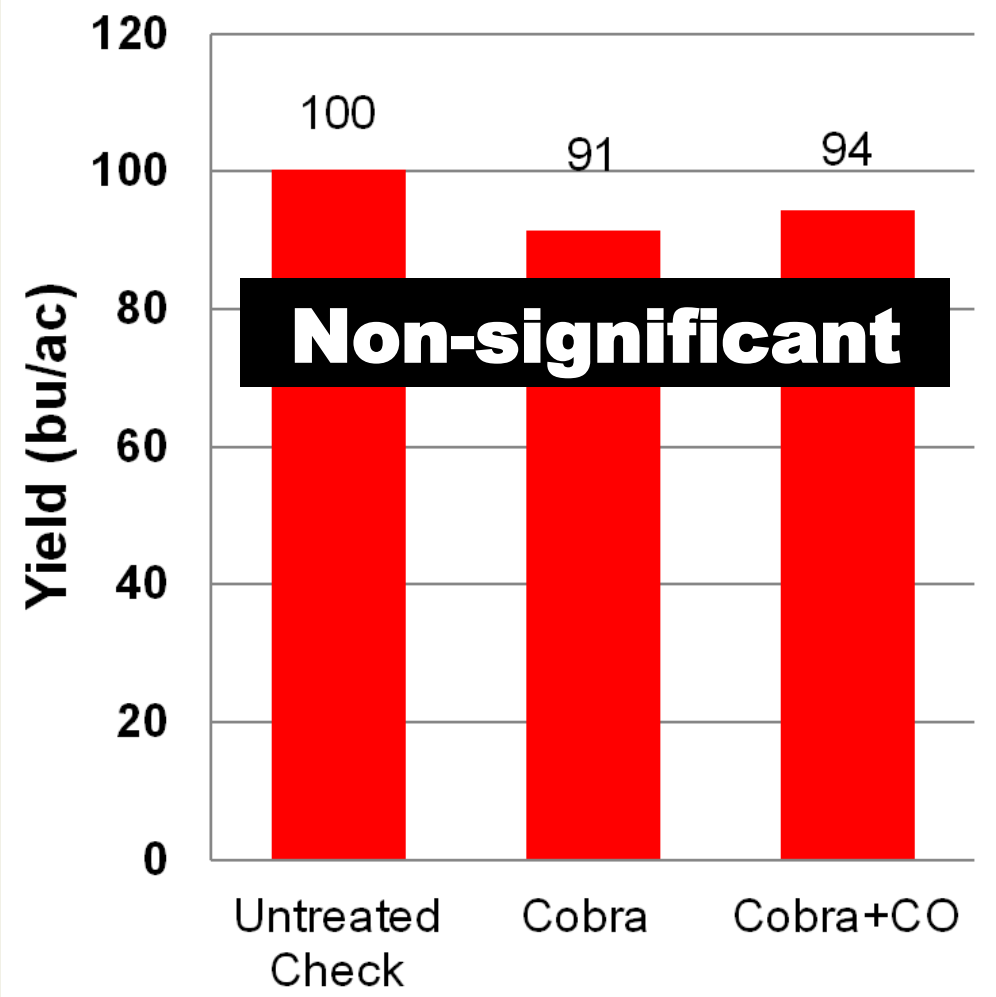
Planted May 14th, 125,000 plants per acre

Treatments Evaluated

- P94Y81 and AG4907 in 2011-12
- P47T36 and AG4632 in 2013
  - Herbicide burn at V3
  - Kip's seed treatments
  - Thinned to even spacing or emergence

Burn Treatments, 2011-13

- Applied at V3
- Early morning with dew to increase injury
- Products & rates:
  - 0.5 oz/ac Aim + NIS
  - 0.9 oz/ac Cadet + NIS
  - 12.5 oz/ac Cobra + NIS
  - 12.5 oz/ac Cobra + 2% crop oil
  - 12.5 oz/ac Cobra + 0.5 oz/ac Aim + 2% crop oil

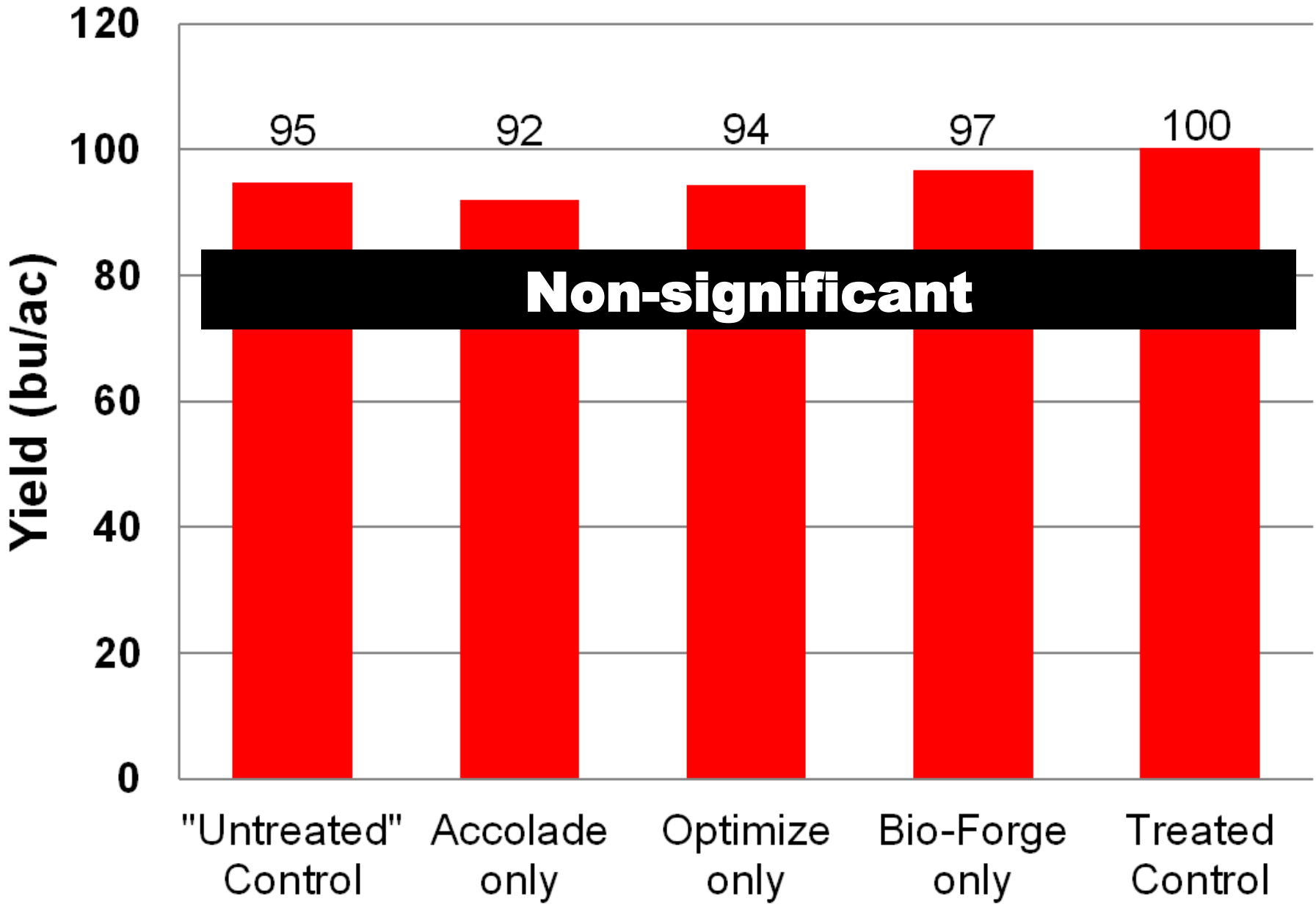


Seed Treatments

- "Untreated" (came with fungicide/insecticide)
- Optimize 400 (2x rate)
  - Novozymes, Bradyrhizobium +

  lipo-chitooligosaccharide (LCO), "biological molecule stimulates cell division & growth"
- Bio-Forge
  - Stoller, N,N'-diformyl urea, "upregulate anti-oxidative pathways, reduce plant stress"
- Accolade-(P)
  - INTX Microbials, Azospitillum brasilense, free-living N_2 fixing bacteria
- Treated control – all of the above

Seed Treatments, 2011-13



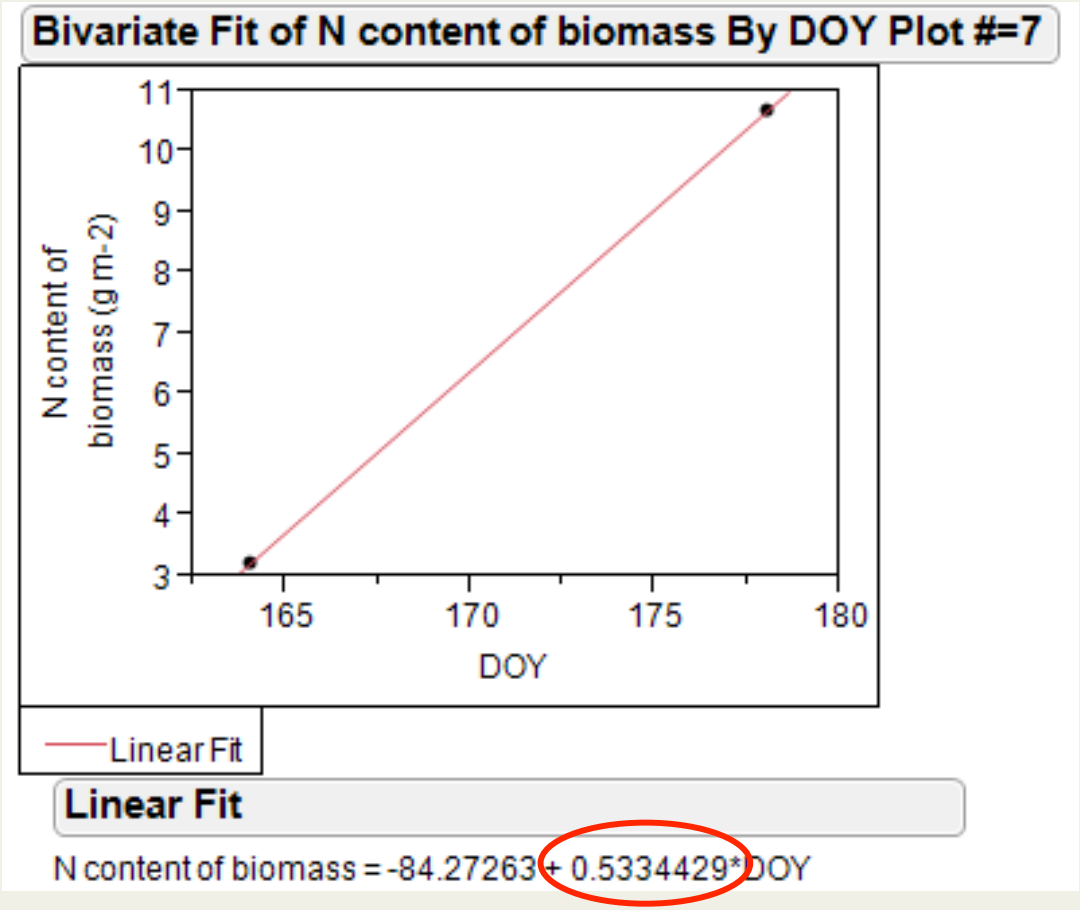
Conclusions

- **Early planting & narrow rows** to set pods
- **Irrigation, fertility** & **pest control** to keep pods
- **Agronomy 101**(variety, compaction, pH…)
- **N_2 fixation** most profitable
- **Attention to detail** & **timing** of everyday agronomics capable of 80 bu/ac (100+ with weather & luck)

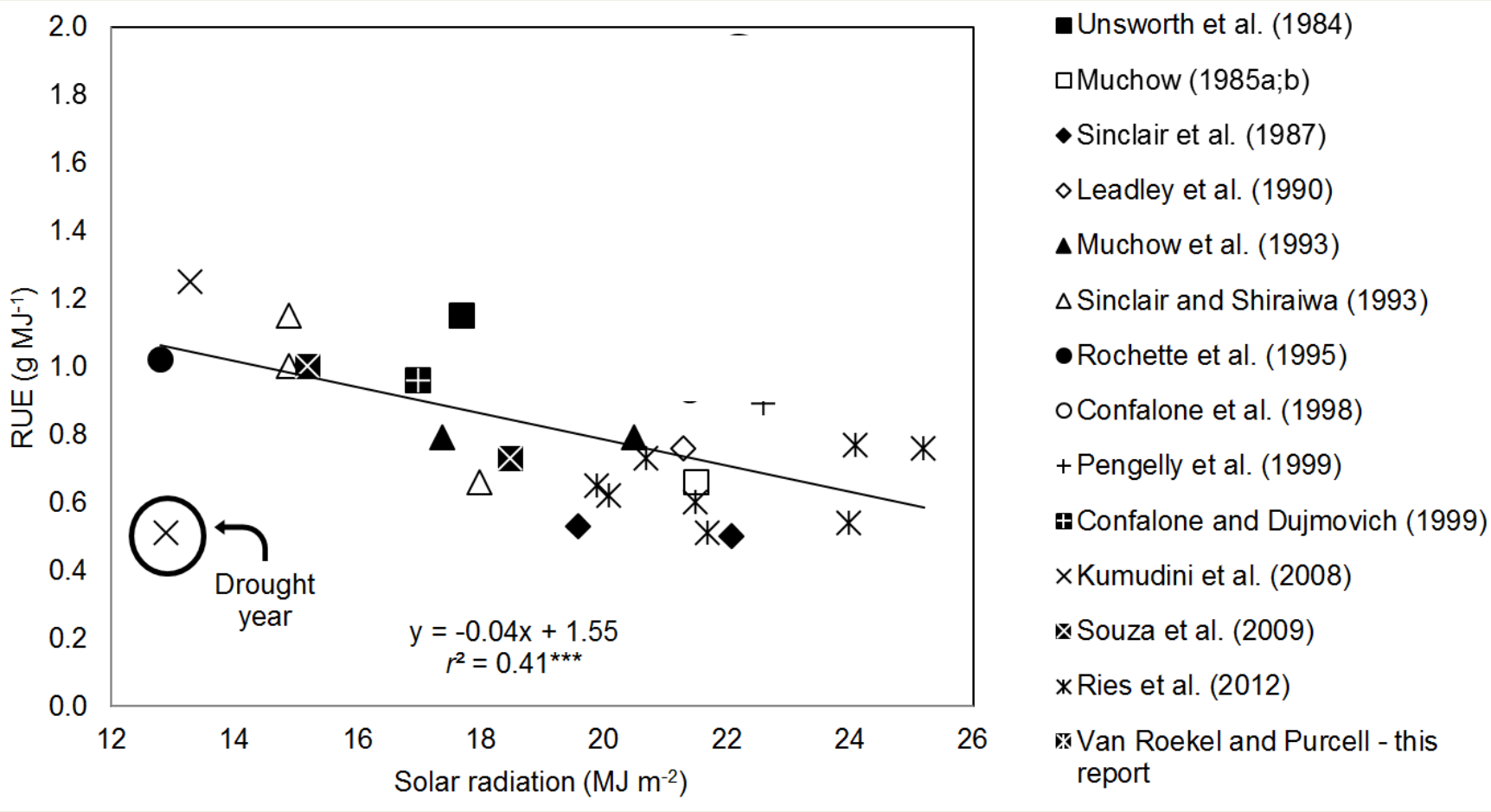
Thank You

N Accumulation Rate

- Crop growth rate from biomass samples
- Analyzed for N concentration
- N content of biomass over time



RUE*Solar Radiation



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