#### **Soybean Stress and Yield Accrual**

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## Outline

- Highlights of the physiology of yield accrual
- Water stress effects on soybean
- Importance of seed number and seed size
- The Critical Period for soybean yield
- Q&A and discussion about stress and soybean



## Why waste an hour on stress?

- We need to have an objective view of crop growth, yield accrual, and stress impacts to
  - Better understand yield limitations
  - Attempt to control controllable factors

# What can farmers do to increase soybean yields?

- My short list to increase yields
  - Variety Selection (including MG [work in progress])
  - Good Soil Fertility
  - Narrow Rows
  - Early Planting
  - Soil Management (tillage, drainage, increased OM)
- Yield Preservation
  - Effective pest management IPM, preferred



# A short aside about management for increased yields in soybean



## **Extreme Beans:**

#### **Increasing Yields - Decreasing Costs**



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University of Arkansas System

#### Kitchen Sink Study – aka "SOYA"

- SEED TREATMENTS (ST):
  - None vs F vs F+I+Biologicals vs F+I+Bio+LCO's
- FOLIAR OR OTHER TREATMENTS:
  - Nitrogen, 150 lbs/a → Urea (75 lb/a) w/ Agrotain (3 qt/ton) + ESN®(75 lb/a) @ V4
  - Defoliant → Cobra® (12 fl oz/a) @ V4
  - Foliar fertilizer → Task Force®2 (64 fl oz/a) @ R1
  - Antioxidant → Bio-Forge® (16 fl oz/a) @ R3
  - Foliar fungicide → Headline® (6 fl oz/a) @ R3
  - Foliar insecticide → Warrior II® (1.92 fl oz/a) @ R3
    - F and I Priaxor and Endigo in 2013 and 2014



#### Summary

- 60 total site years
  - 28 site-years showed significant yield increases
    - 2012- 5 locations
    - 2013- 11 locations
    - 2014- 12 locations
  - North: 15 out of 21 (71%) responsive site-years
  - Central: 5 out of 18 (28%) responsive site-years
  - South: 8 out of 22 (36%) responsive site-years



#### **Conclusions SOYA**

- Seed treatment and early season products show little value in increasing soybean yield (some in North)
- Benefit from foliar insecticide and fungicide were greater in the North
- There did not appear to be a yield level x management interaction
  - Higher yielding environments may not see additional benefit from intensive management

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#### Conclusions

- Only products with true pesticidal modes of action had any impact on yield
  - These are yield protectors
  - "Yield Enhancers" did not improve yields
- We found relatively little support for the universal use of prophylactic applications of pesticides or the use of the yield promoting products tested
- Simple calendar sprays are no replacement for in-field scouting and on-time decisions.

## To kick this horse, again...

- Farmers' primary job is to set their crop up for success.
  - Lay the groundwork for maximum yields
- POTECT yield by reducing stress
  - Biological stresses through IPM principles
  - Abiotic stresses are difficult to predict or manage
- Yield ENHCING products are a fallacy (so far)

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## What is yield?

- Yield = amount of a crop grown, per unit area of land
- Yield = ADM x HI
  - Aboveground Dry Matter (ADM) is the foundation for final yield
    - Vegetative biomass is the engine that produces yield
    - Is a storage reserve that is mobilized to the seed
    - Is affected by stress
  - Maximizing Harvest Index (HI) is critical for high yields
    - % of the aboveground dry matter in grain
    - Stress during seed fill can reduce seed set and limit HI and yield

## A brief aside on ADM and HI

Suhre et al., 2014
Soybean Yield
Partitioning Changes
Revealed by Genetic
Gain and Seeding
Rate Interactions



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 de Felipe, 2022 -Physiological processes associated with soybean genetic progress in Argentina



## Crop Growth Rate – Determines ADM

- Crop Growth Rate (CGR) is simply the daily rate of biomass accrual
- CGR = PAR x % Intercepted PAR x RUE
  - PAR = photosynthetically active radiation (~ 'light')
  - RUE = Radiation Use Efficiency
- CGR x Time = biomass



## Maximum yield requires

- Maximum CGR
  - CGR = PAR x % Int. PAR x RUE
  - Integrated over time
  - Each piece must be maximized
- Maximum HI
  - Full seed-set
  - Efficient mobilization
- Caveat concurrent photosynthesis

# Stresses can reduce each factor of yield accrual

- Drought stress as an example
- This #1 most important stress for soybean in the Midwest
- Water stress is incredibly deceptive





• Boyer 1970. Leaf enlargement and metabolic rates in corn, soybean, and sunflower at various leaf water potentials

#### **Water Stress**





Leaf expansión +

Branching +++

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 Monzon et al, 2021 - Critical period for seed number determination in soybean as determined by crop growth rate, duration, and dry matter accumulation

## Sensitivity to current photosynthesis



 Borras et al 2003 – Seed dry weight response to source–sink manipulations in wheat, maize and soybean: a quantitative reappraisal

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#### Seed size response



 Borras et al 2003 – Seed dry weight response to source–sink manipulations in wheat, maize and soybean: a quantitative reappraisal

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## Is there a Critical Period in soybean?



## Critical Period: What do we know?





#### What drives seed number?



Days after emergence

 Monzon et al, 2021 - Critical period for seed number determination in soybean as determined by crop growth rate, duration, and dry matter accumulation

#### Timing of stress



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## **Redefining Soybean's Critical Period**

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## **Our objective**

• Generate a detailed dynamic description of the effect of stress timing on yield components and yield for soybean



### Experimental details



- Field St Paul MN 2022 and 2023
- Trt: Ten 80%-Shade short intervals + Control
- Shade duration: remove 150MJ/m2 PAR (8-11 day
- No other stress



Rand. comp. blocks, 3 (2022) or 4 (2023) replications.



2023

#### **Grain Number**



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## Weight per Grain



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#### Understanding Green Stem in Soybeans

Green stem: delayed or abnormal senescense or maturation in soybean plants





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#### Conclusions

Most Critical Period
R4 – R6



Most Critical
R5
Stage

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#### **Next Steps**

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• 2023 trials: more data, more varieties, more cycles

Critical period for grain composition

• Differentiate Direct (C supply) and Indirect (N fixation) effects



stage in which stress occurred



Xield (gm 400 400

300

200







# Thank You



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