ROI and Soybean Production

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Cropping Systems Agronomy
MICHIGAN STATE UNIVERSITY

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NORTH CENTRAL SARE
Sustainable Agriculture Research & Education

MICHIGAN SOYBEAN COMMITTEE

NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

Project GREEEN

USDA NIFA

Topics for Today

1. Basic concepts for profitable crop production
2. Recent weather trends
3. Planting date impacts on soybean vs corn
4. Other management (& interaction with planting date)
5. Biologicals (Seed treatment in soybean)
6. Resources & Projects needing your help!

Basic Concepts of Grain Crop Production

- Develop uniform and healthy crop canopy (**Source**)- that can maximize light interception
  - Knowledge of crop growth and development
  - Identify field-specific yield limiting factors
  - Make sound agronomic decisions to minimize them

- Optimize components of grain yield (**Sink**)
  - Know what they are and when determined, and limit stress in that period
  - Lost yield potential can not be recovered later in season

Soybean Yield Components

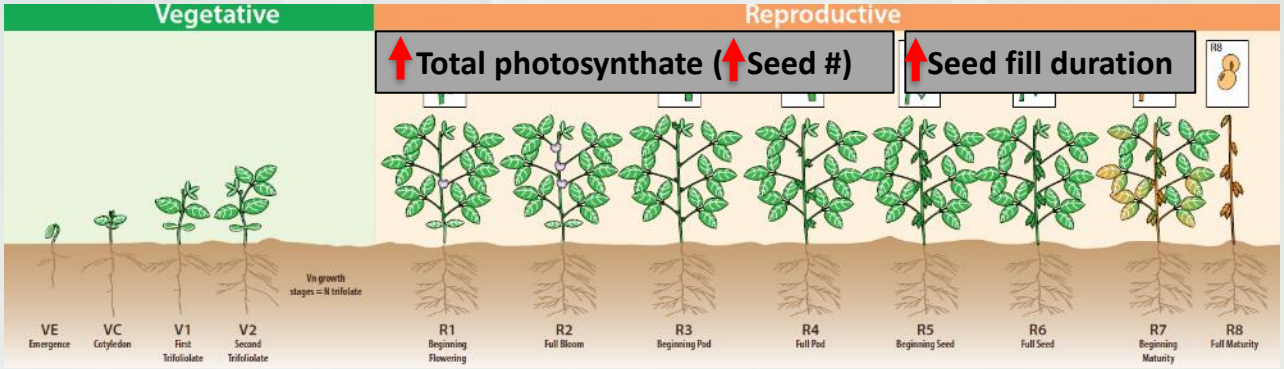
- Establish uniform plant stand (plants/acre)
- Set and retain more pods (pods/plant)
- Increase number of seeds/pod
- Maximize seed weight (seeds/lb)

Pods per acre

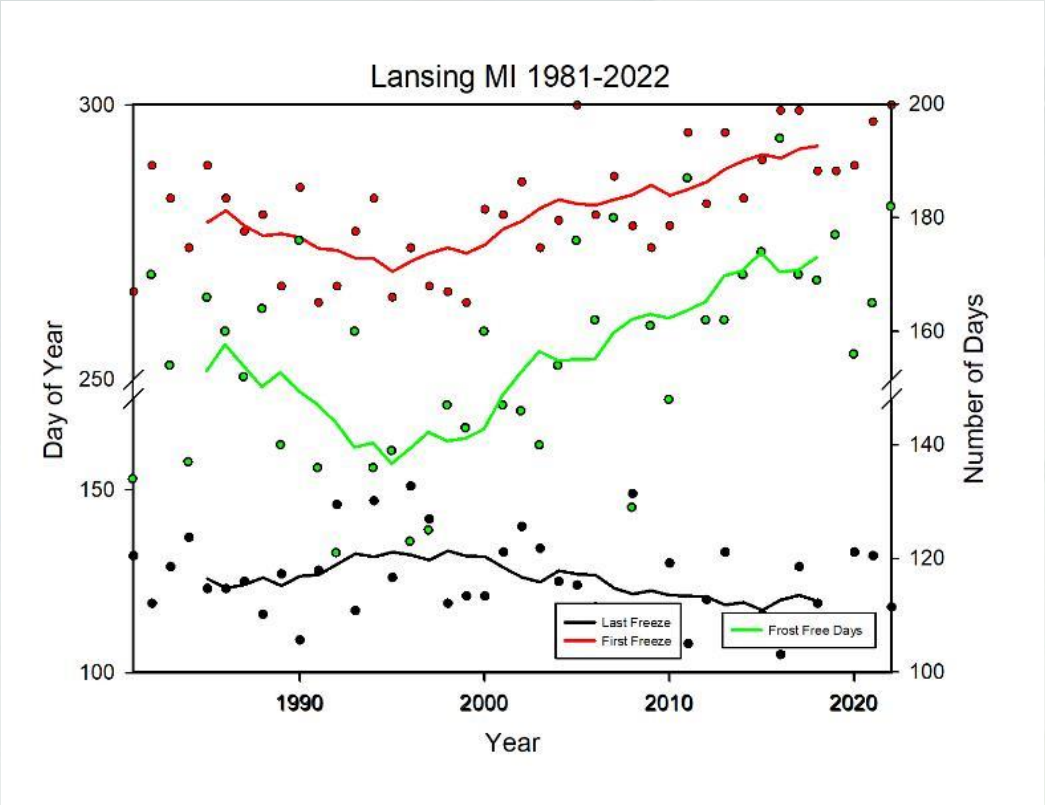
Seeds per acre

Seed weight

What can be done to **POSITIVELY** influence these yield components and **minimize Yield Limiting Factors at field-scale**



Weather Trends: Longer frost-free season



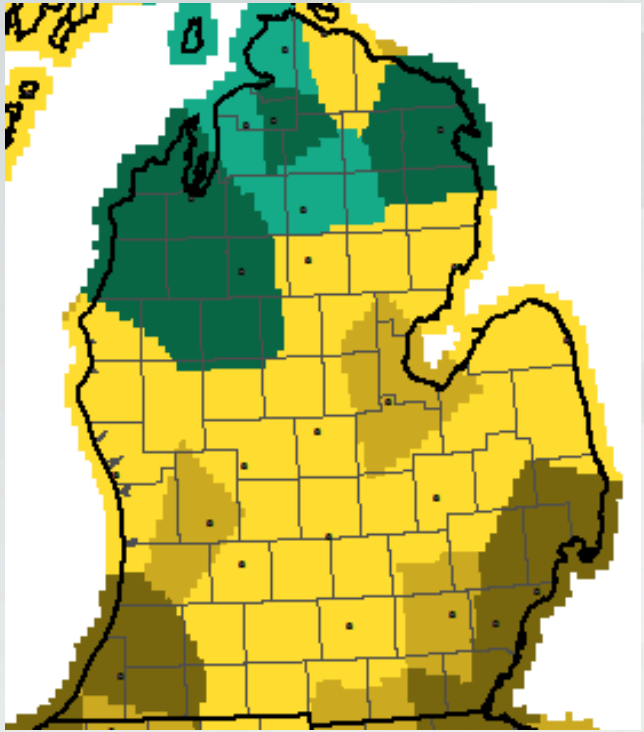
Jeff Andresen, MSU

GLISA, 2019

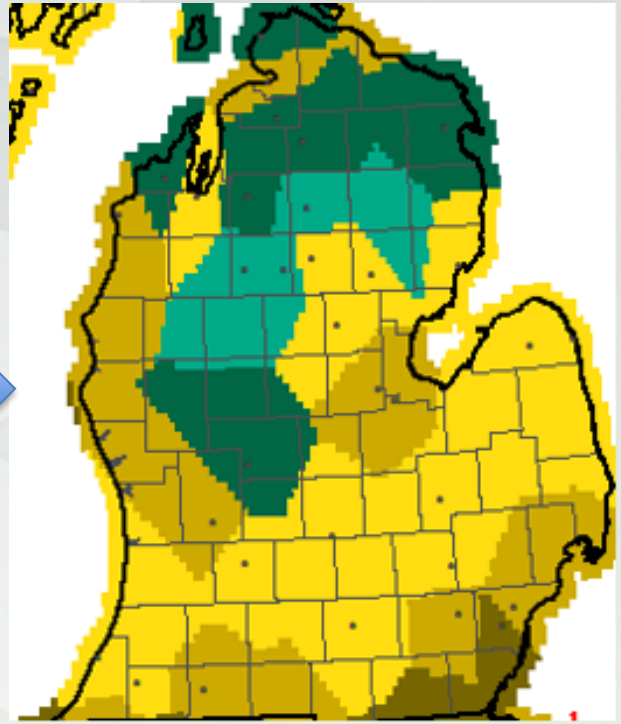
Start of Growing Season for summer crops

Apr 1 - 10
Apr 11 - 20
Apr 21 - 30
May 1 - 10
May 11 - 20
May 21 - 31

Median **Last** Frost (**28 ºF**)



Data from **1981-2010** ONLY



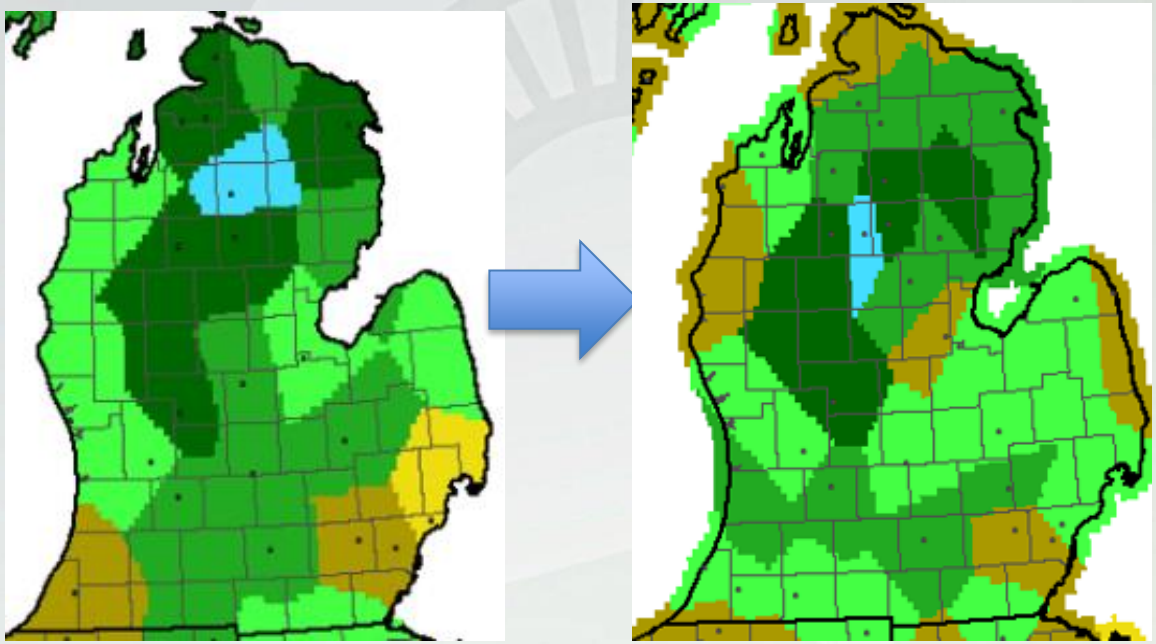
Data from **1991-2020**

https://mrcc.purdue.edu/VIP/frz_maps/freeze_maps.html

End of Growing Season for summer crops

Median **First** Frost
(28 ºF)

50th percentile

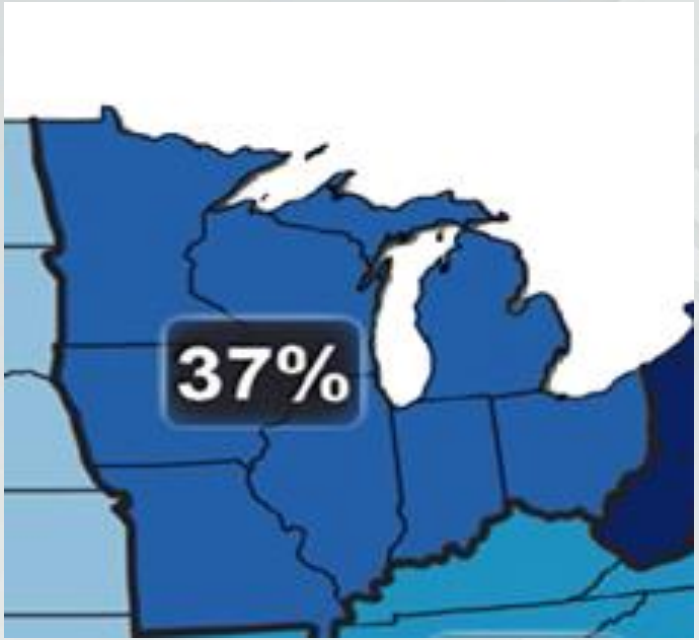


Data from 1981-2010 ONLY

Data from 1991-2020

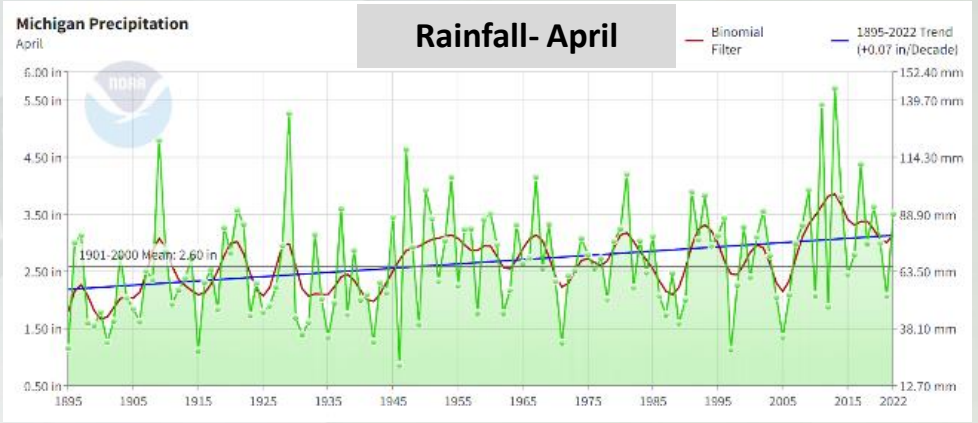
https://mrcc.purdue.edu/VIP/frz_maps/freeze_maps.html

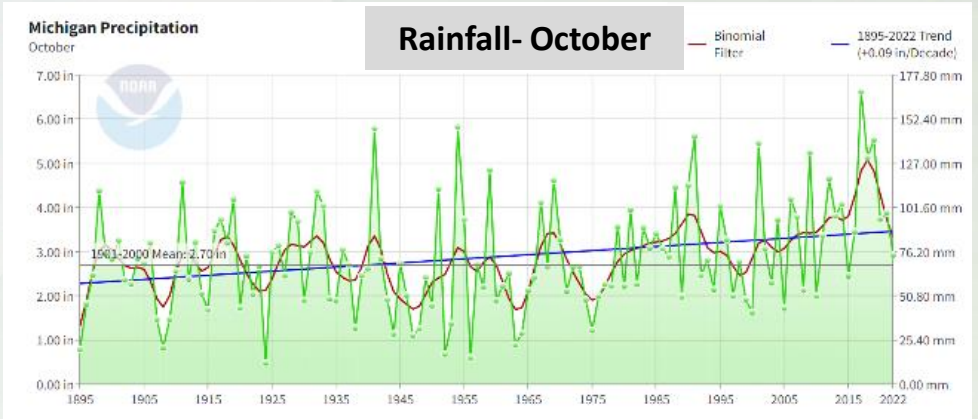
Weather Trends: Wetter in spring/fall



Increase in extreme precipitation
(during top 1% of severe storms)

GLISA, 2019





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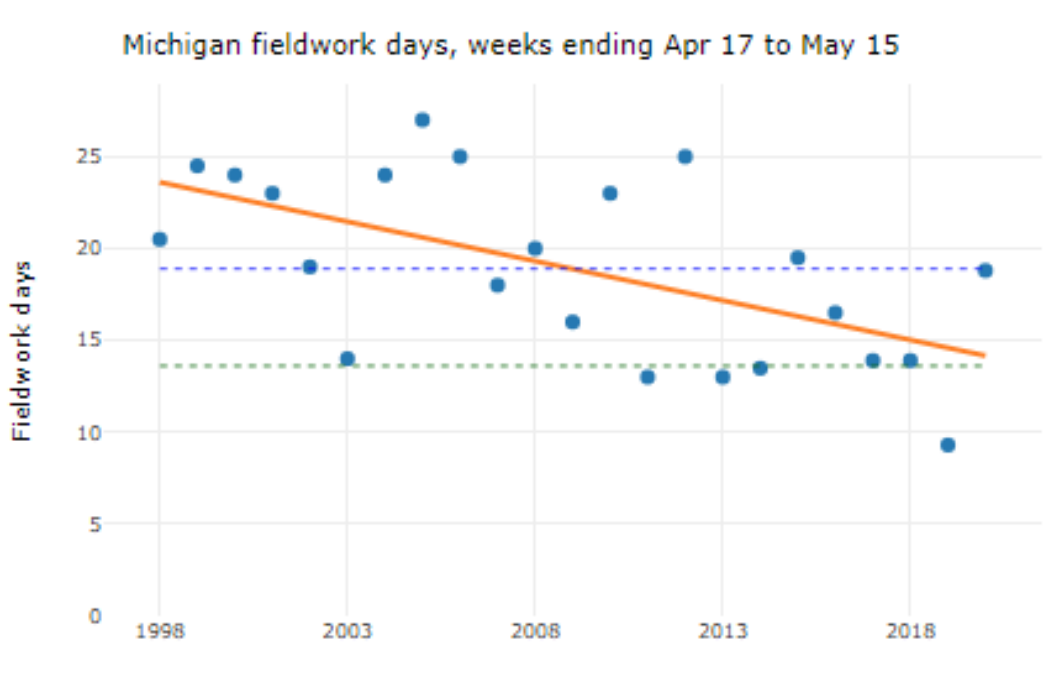
Weather Trends: Less #days for field work in Spring



Source: USDA NASS

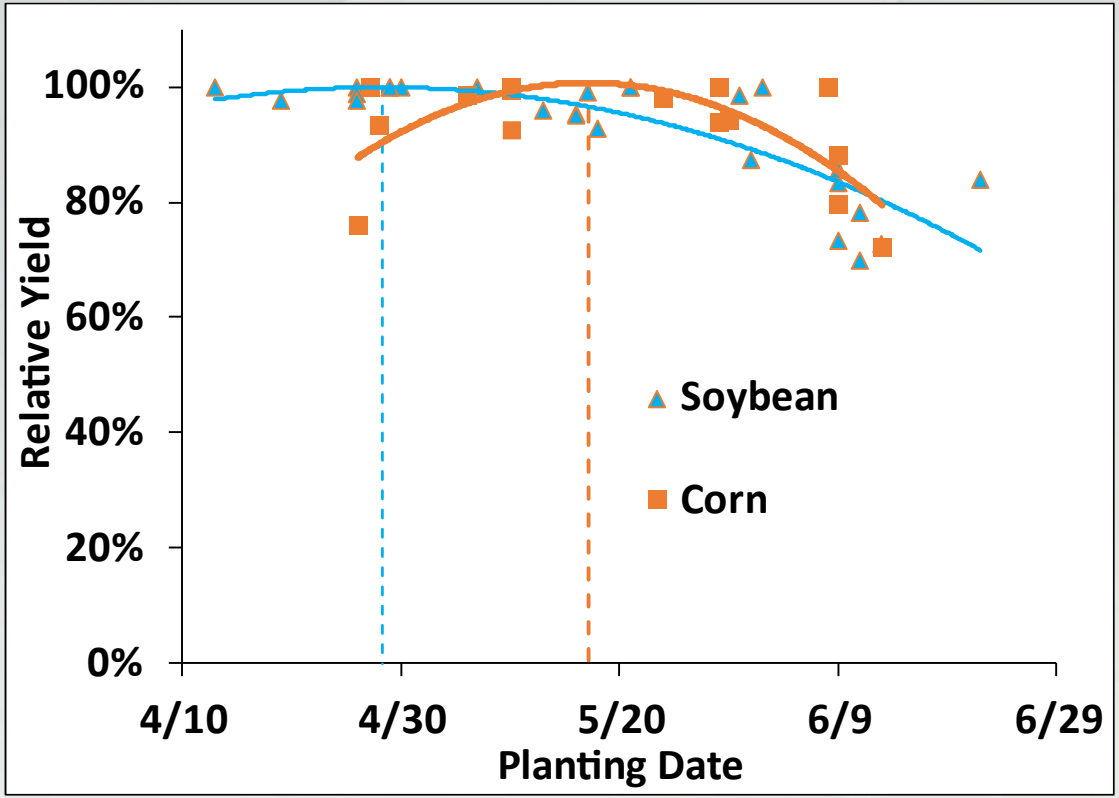
- Michigan: 4 less days per decade for fieldwork (between mid-April to mid-May)

Planting Time Impacts Crop Growth in Michigan

Pictures taken mid-July

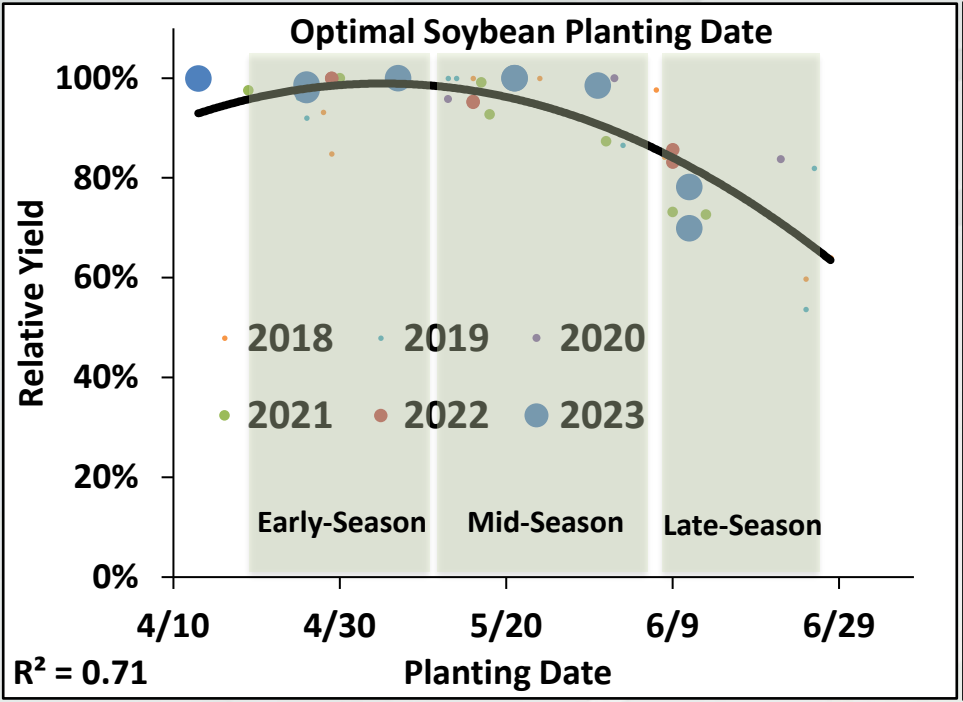
Planting date:	end-April	Mid-May	end May-early June	early-mid June

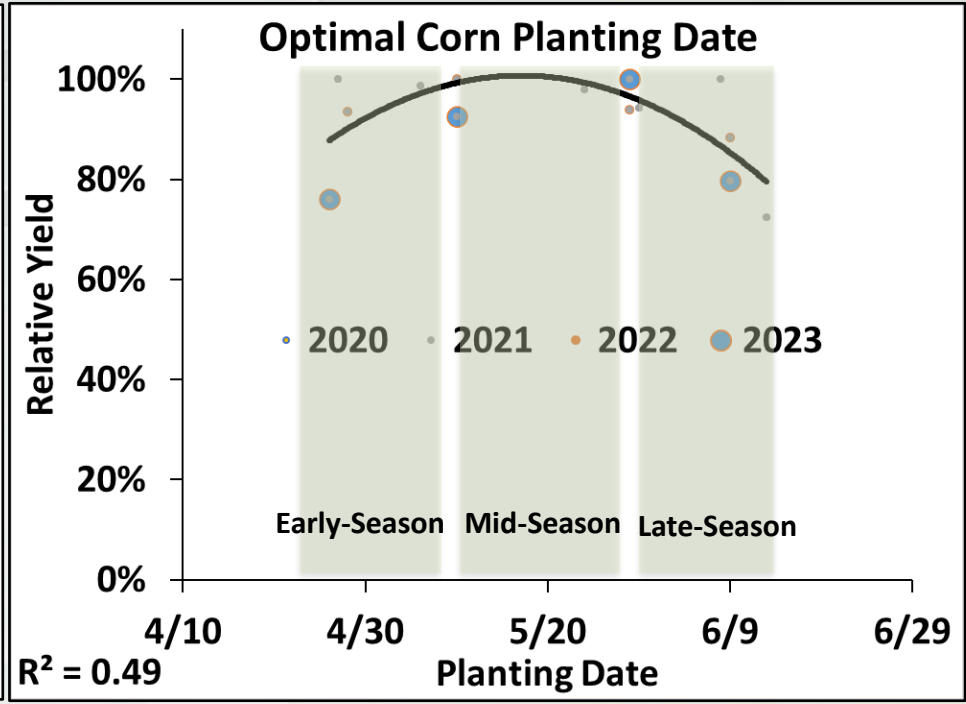
Planting Time Impacts Crop Yield in Michigan



Data from 2018-2023 across multiple trials.
Each data point is average of ≥16 plots.

Planting Time Impacts Crop Yield in Michigan





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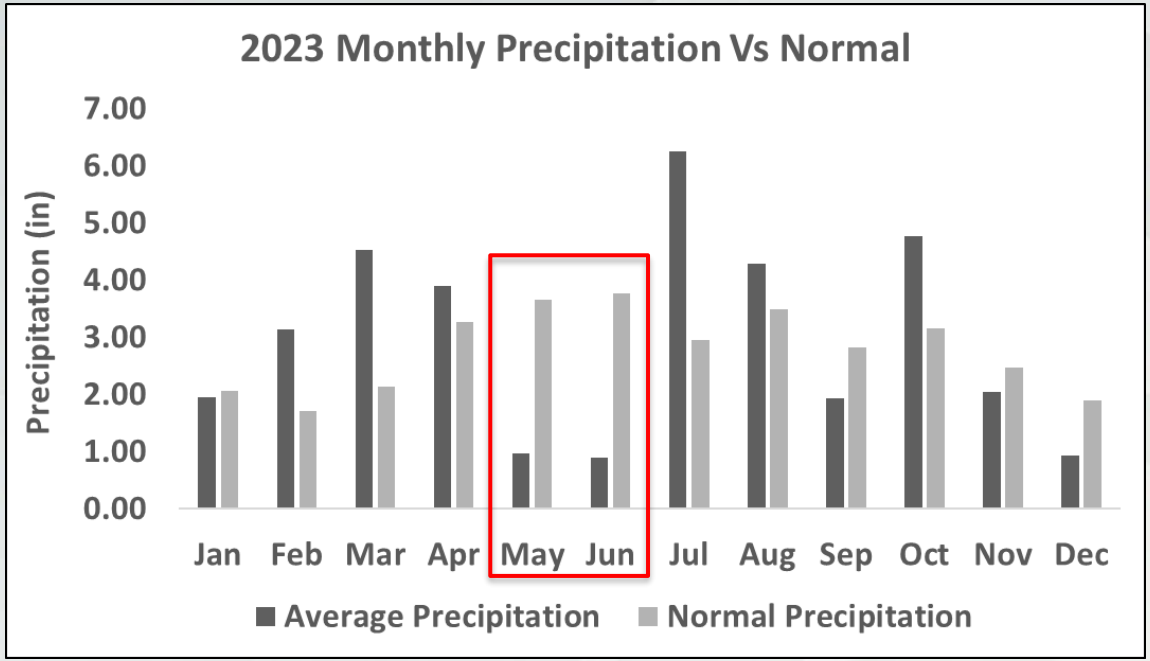
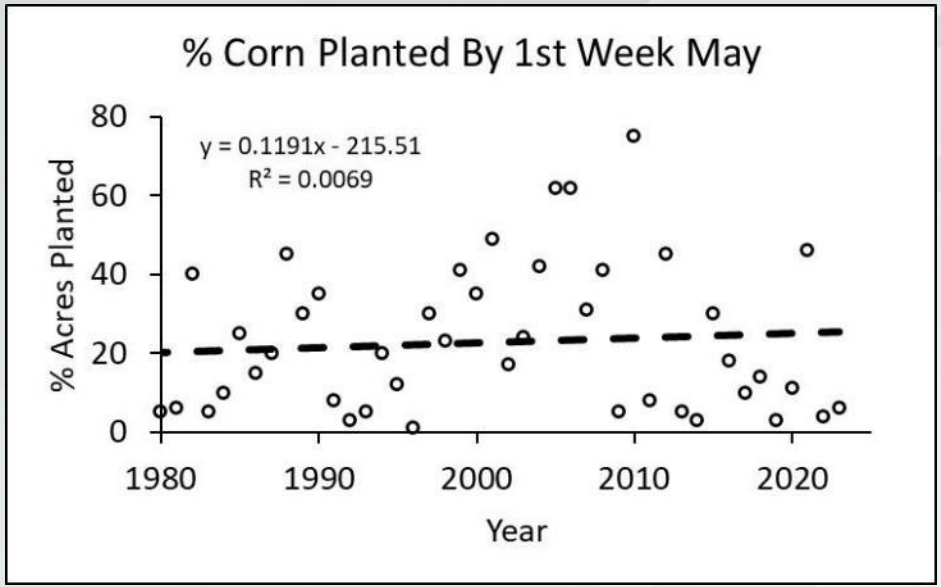
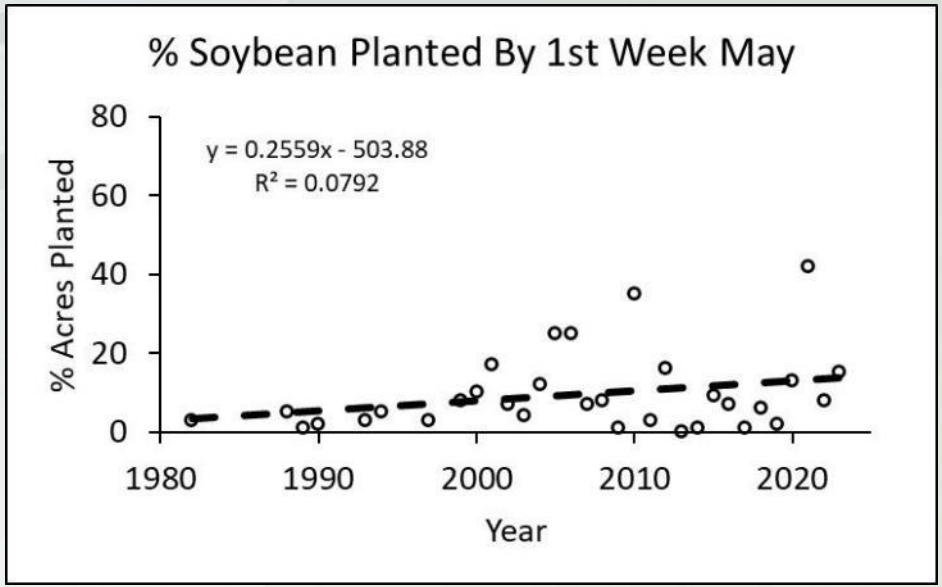
2023 Weather



- **Early-season drought**
  - Delayed emergence
  - Uneven emergence
  - Prolonged vegetative phase
- **Late-season wet conditions**
  - Low dry-down rate
  - Delay in harvest

Planting Progress over years- Corn vs Soybean

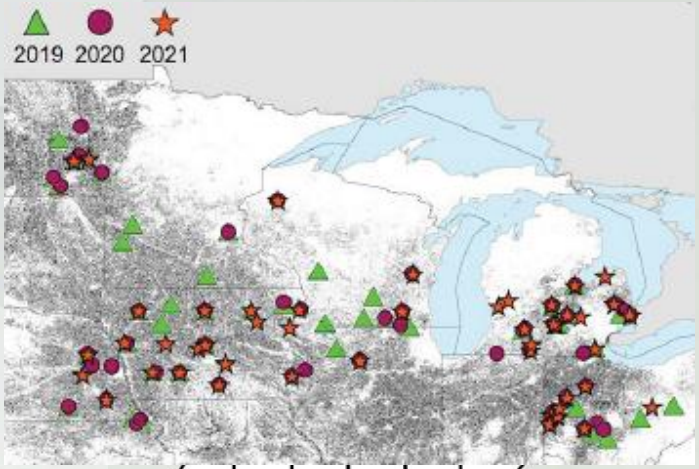


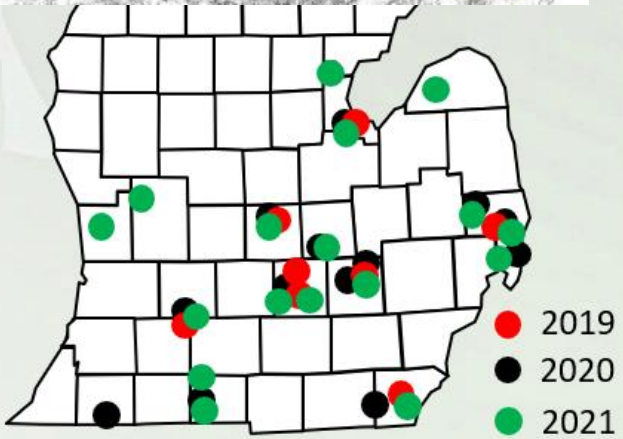


Source: USDA NASS Date from 1982 – 2023, Week 18

Soybean Early-season planting: On-farm Trials

- Conducted 2019 - 2021
- 2 plant dates (**early, typical**), ~3 weeks apart, in strips
  - Fungicide/insecticide at R3 in few fields in 2019 in early planting
- Yield from each strip
- Seed quality samples





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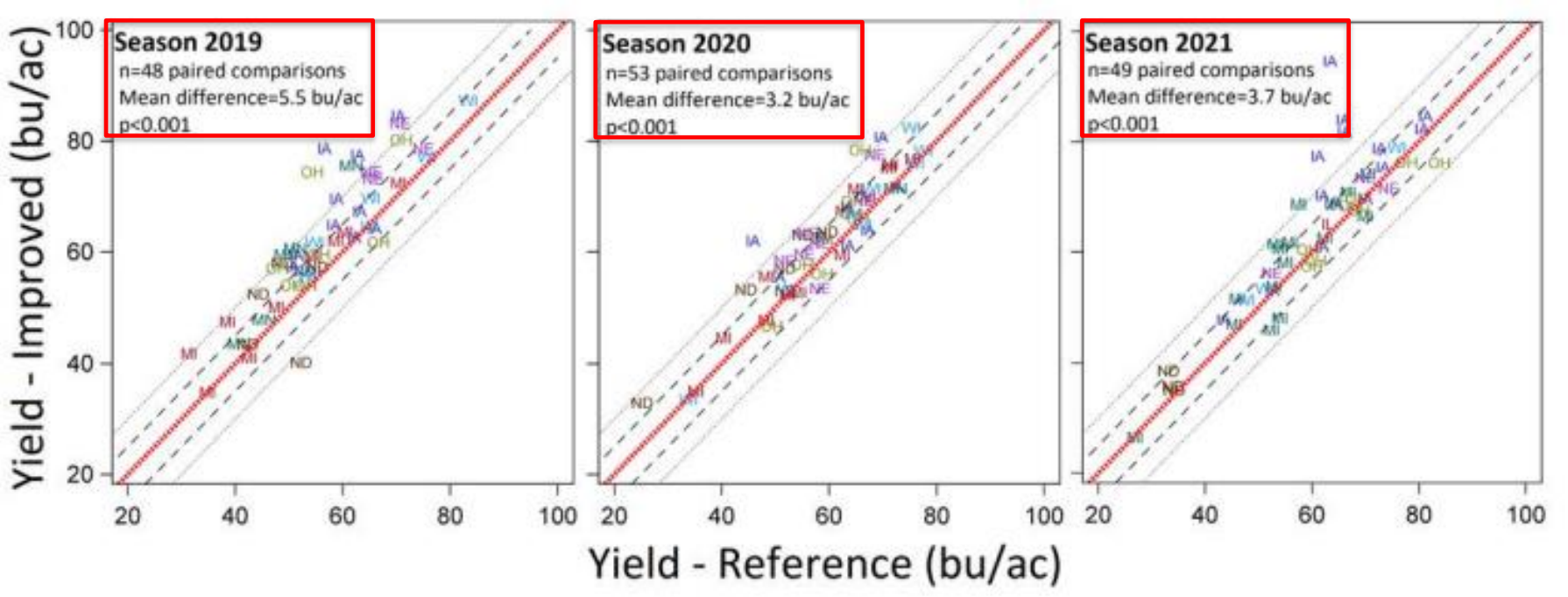
Soybean Yield: Data across states

Profit increase in Improved trt:
$51 (2019), $31 (202), $53 (2021)

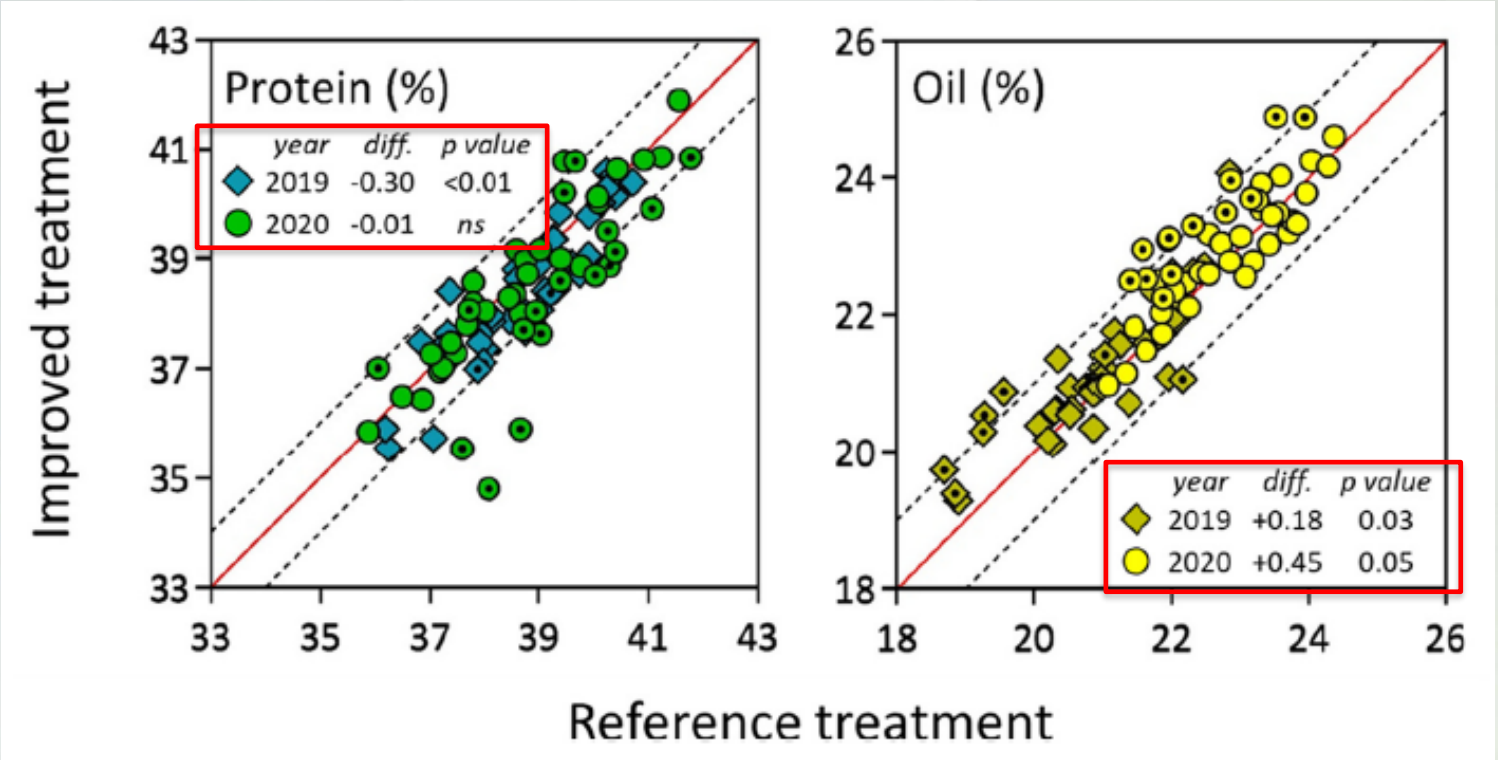


Reference is Typical planting

Improved is Early Planting + other management (e.g., fung./insect. spray, late-MG, lower seed rate)

Available at https://www.canr.msu.edu/agronomy/Extension/soybean

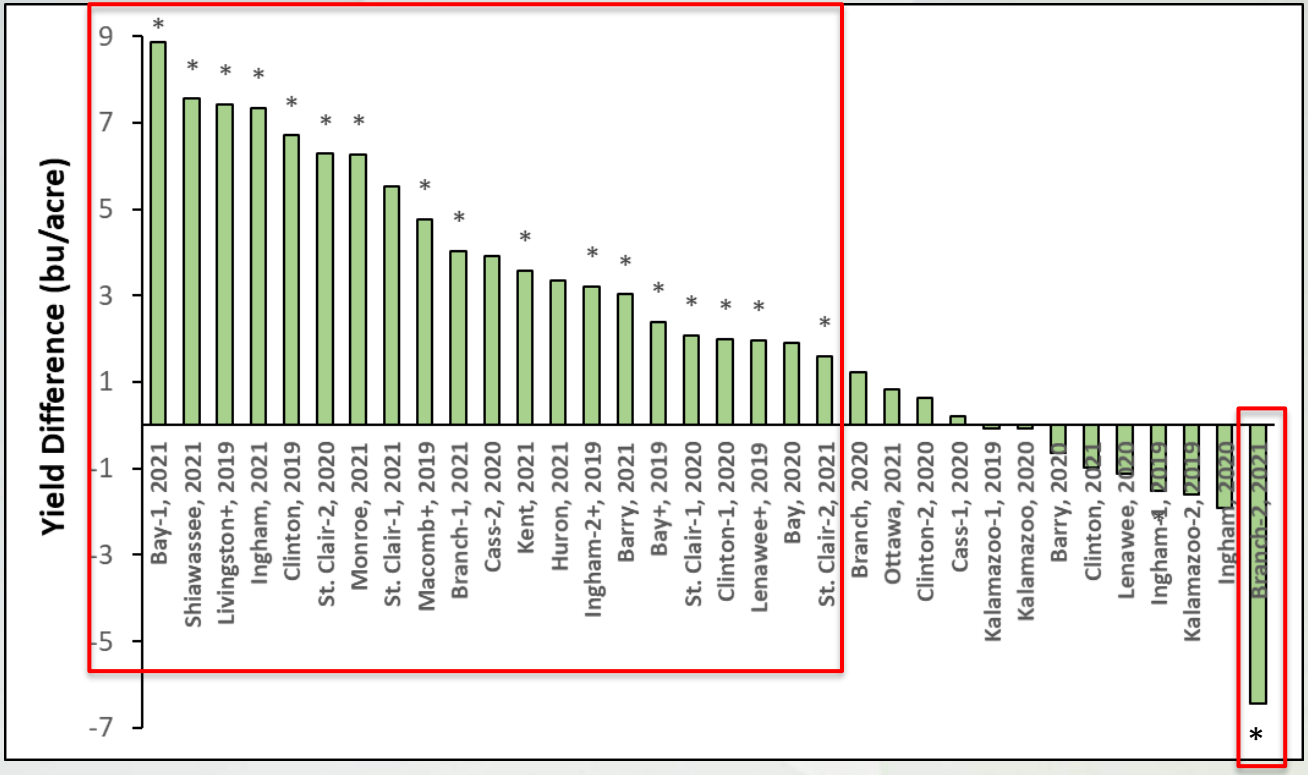
Seed Quality



Andrade et al., 2022

Soybean Yield: Michigan Data

Yield diff. =
Early planting -
Typical planting

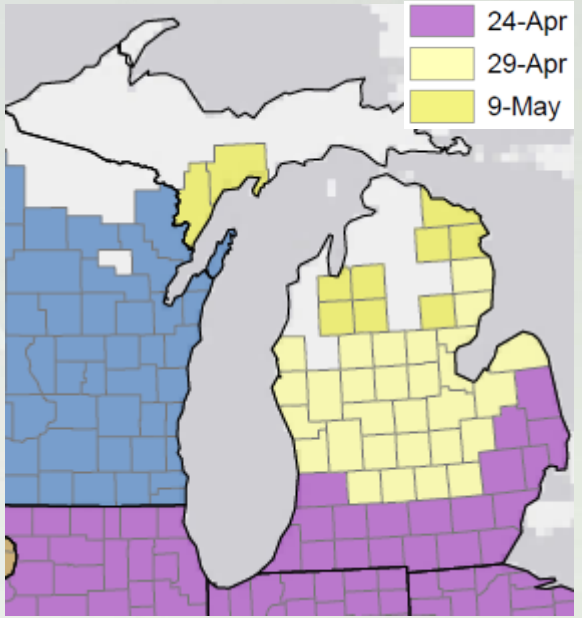


* Denotes significant differences at P <0.10
\+ denotes fung./insect. spray at R3 in early planting in 2019

Available at https://www.canr.msu.edu/agronomy/Extension/soybean

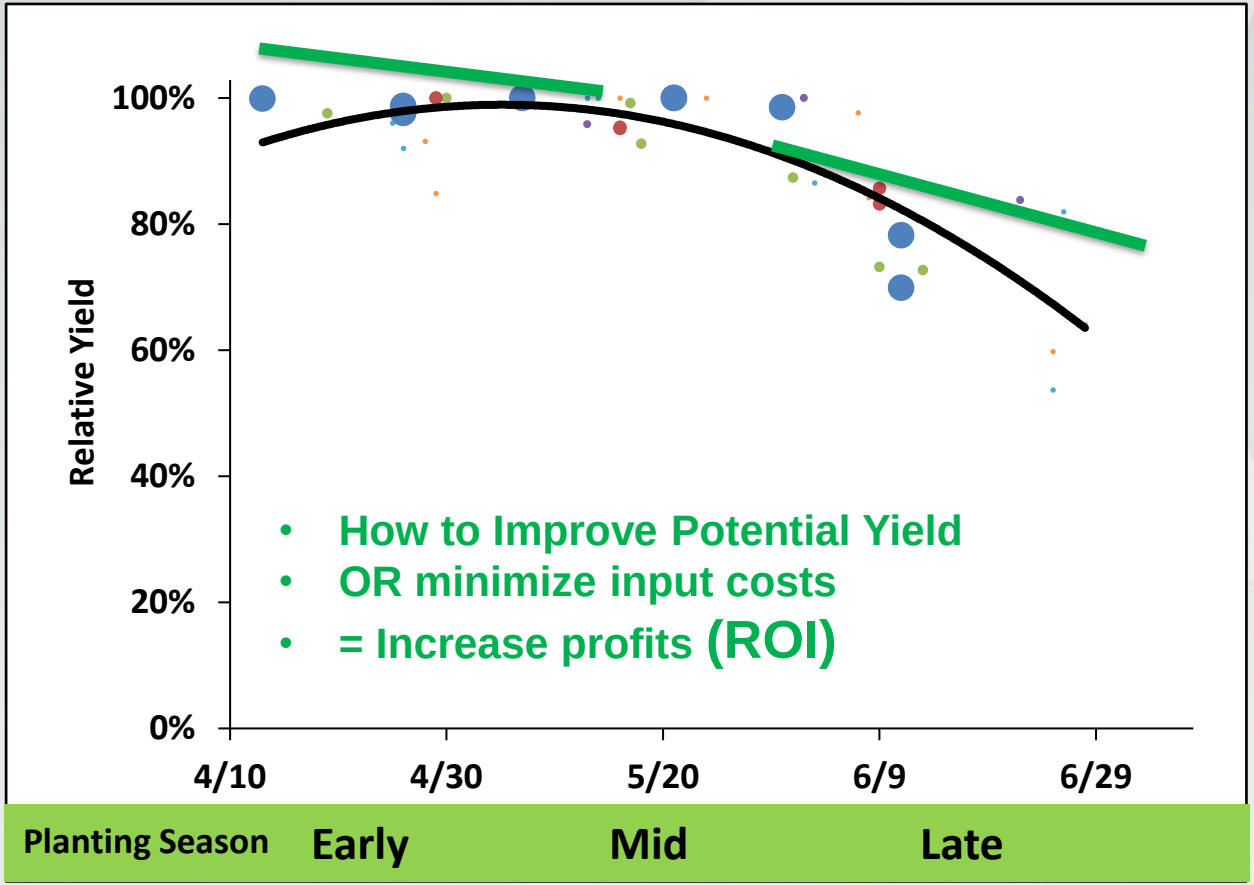
Risk vs Reward of Early Soybean Planting

- Rewards:
  - Increase in yield
  - Extended planting window
  - Minimize yield penalty from late planting
- Risks:
  - Poor germination/emergence, plant stand
    - Imbibitional injury (~45° F), insect/disease, crusting
  - Freeze damage to emerged plants
  - Crop insurance coverage
- Optimal time: typically starts end-April
  - Do NOT plant if forecast of cold rain in 24 hrs
  - Target fields suitable for early planting (vs crop)



https://www.canr.msu.edu/agronomy/Science%20for%20Success-%20Planting%20Date.pdf

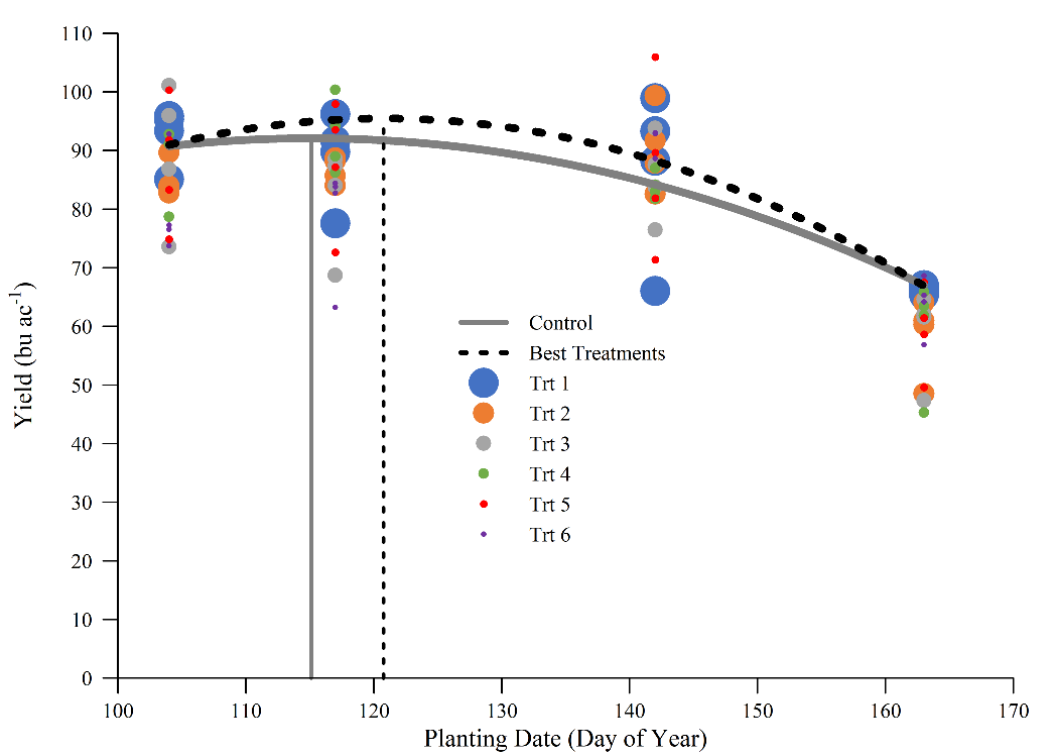
Planting Time: change other management?



Factors to consider:

- Variety Selection:
  - Maturity
  - Traits
- Seed rate
- Seed quality
- Seed treatment
- Seedbed preparation
- Planting method
- Row spacing
- Fertility
- Pest management
- Harvest decisions

Planting Time: System-level approach example

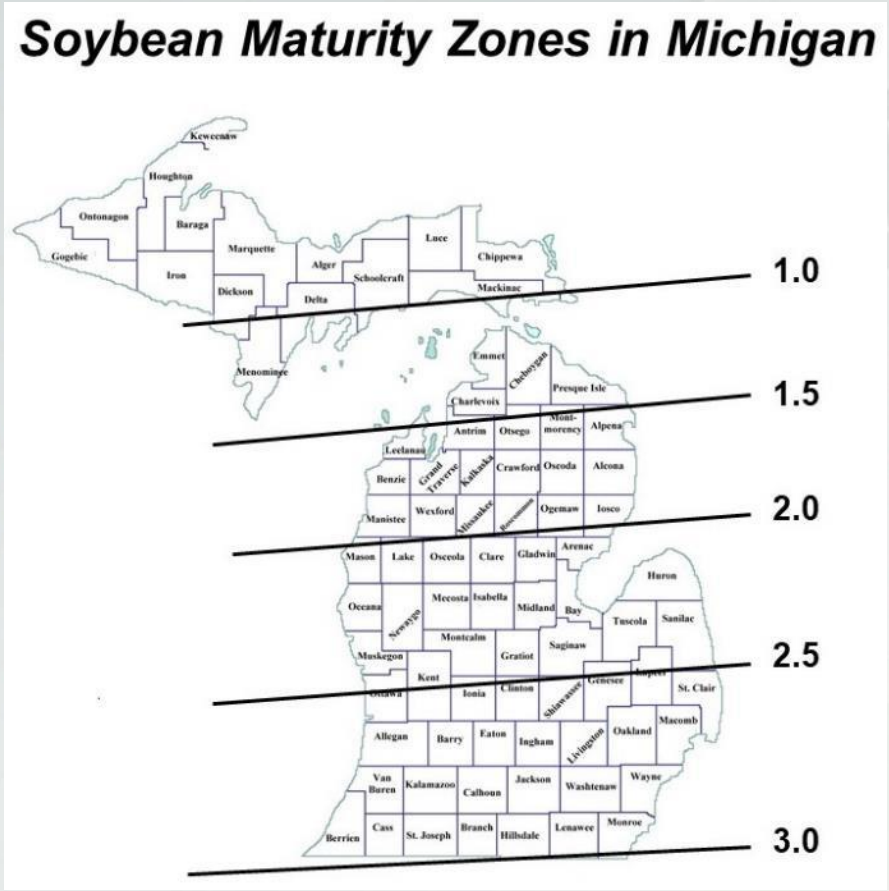


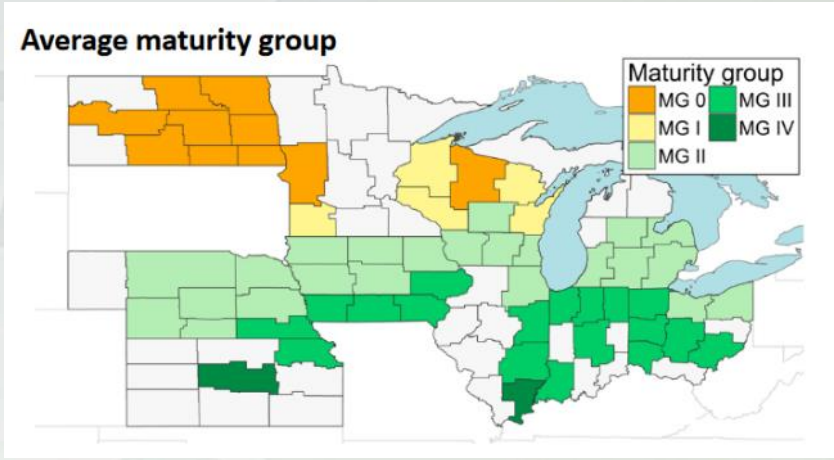
2023 prelim. data (Lansing)

Treatments:

1. Control
2. Maturity (+ or -1 MG)
3. Seeding rate (130k/A vs higher)
4. Fertility (20 lbs @ R1)
5. Fungicide (@R3)
6. Desiccant (@R6.5)

Optimal Maturity Selection: Role of planting date?

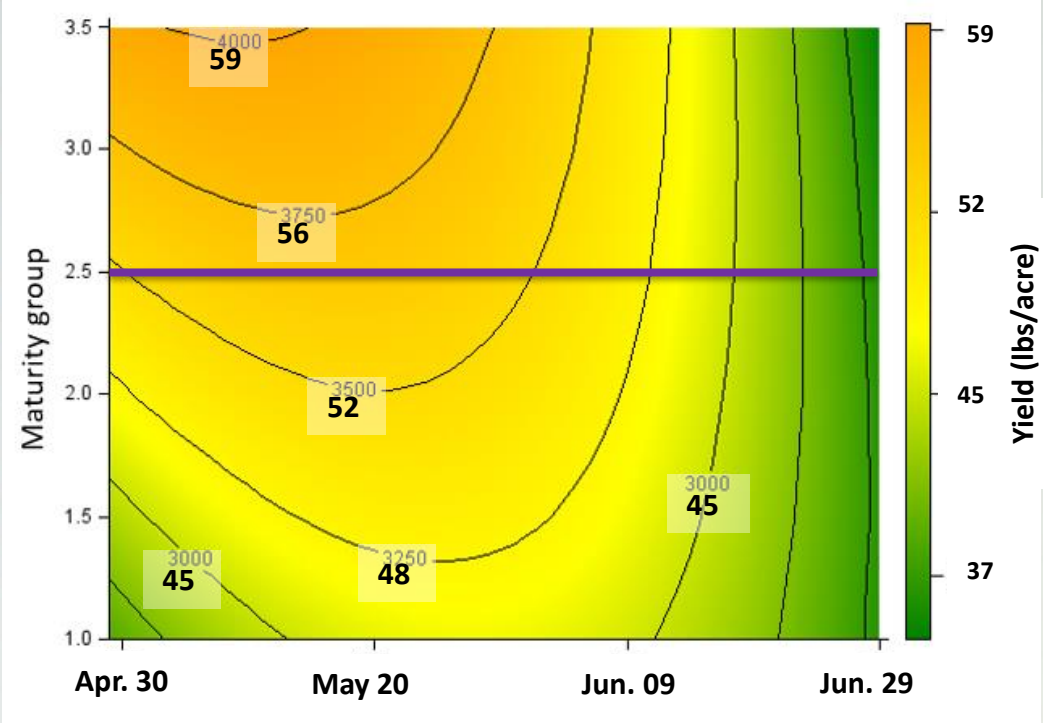




2014-17 survey data

- **Based on one planting date (mid-season)**
- **Does NOT account for early/late planting**

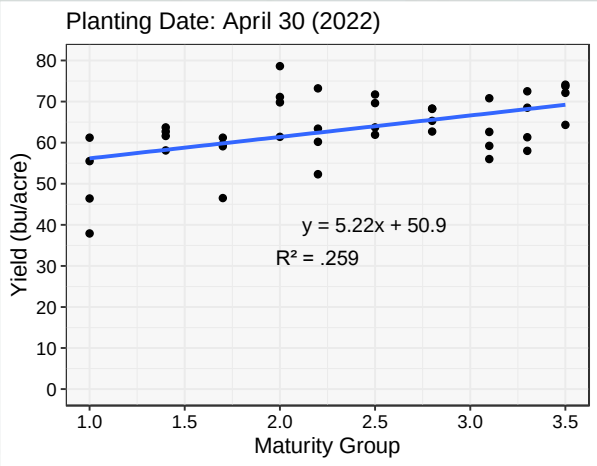
Optimal Maturity Selection: by planting date

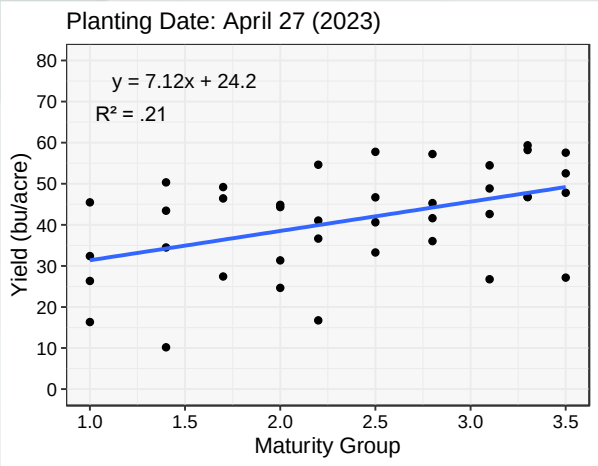


2 Years data (Lansing, MI)
Siler & Singh (2022, Crop Sci.)

- Late maturity variety for early-season planting (till 1st week of May)
- Switch to early maturity with delay in planting (starting early June) OR Double crop soy

Optimal Maturity Selection: by planting date





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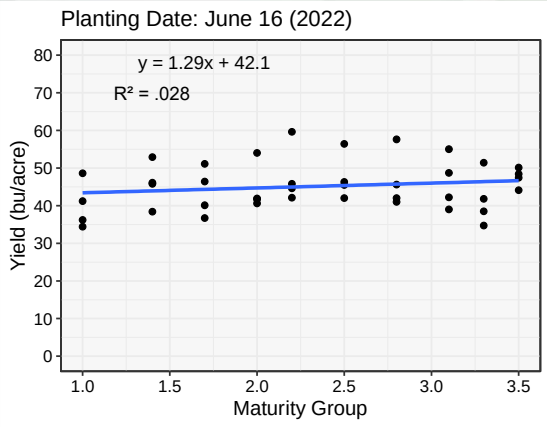
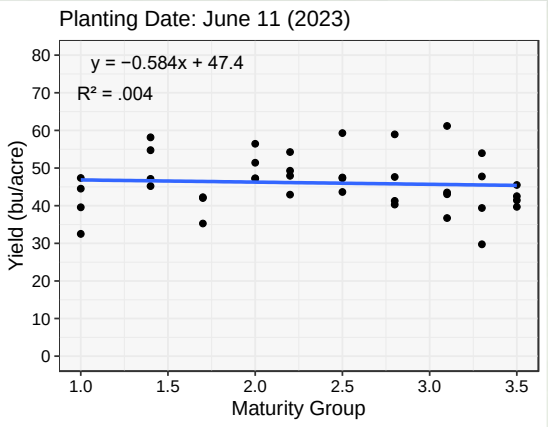
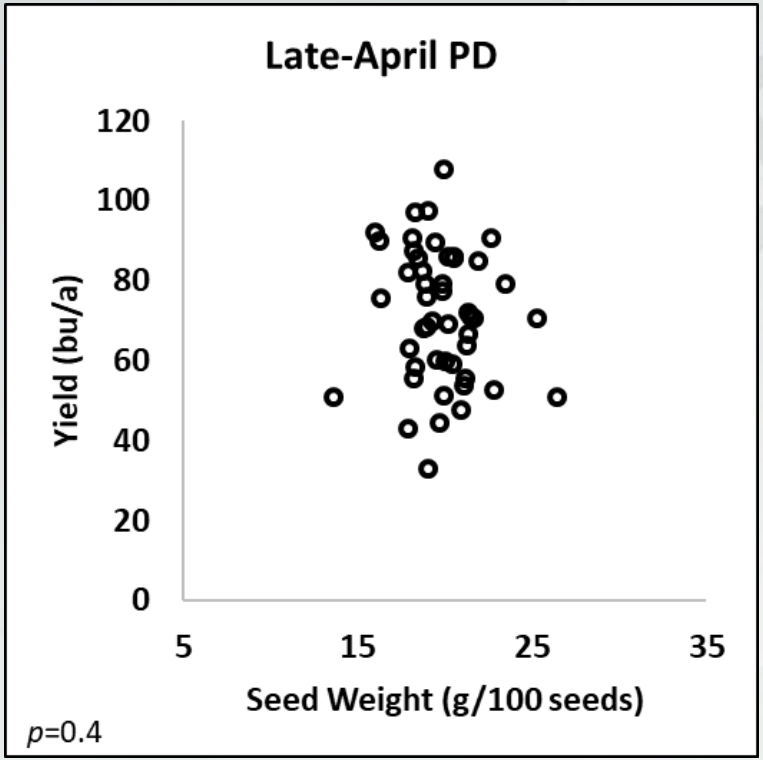


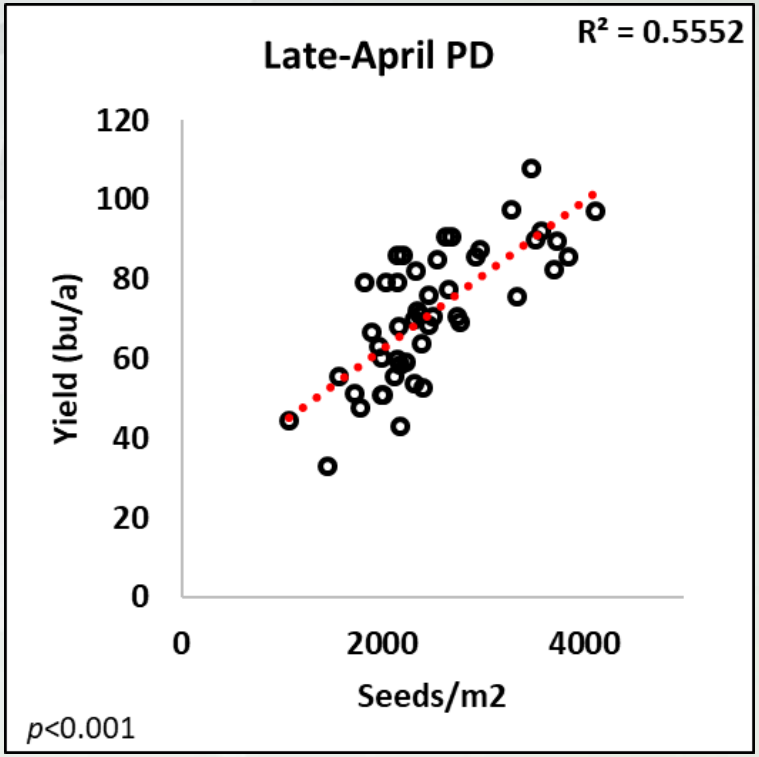


Physiology of Yield Increase

- Adjust planting date and soybean maturity in order to:
  - Harvest more light prior to the onset of reproductive development
  - Maximize number of nodes/pods/seed per acre, longer reproductive phase
  - Minimize the impact of periods of extreme heat and/or moisture stress during flowering and pod set

Yield Components: Seed weight vs Seed Number



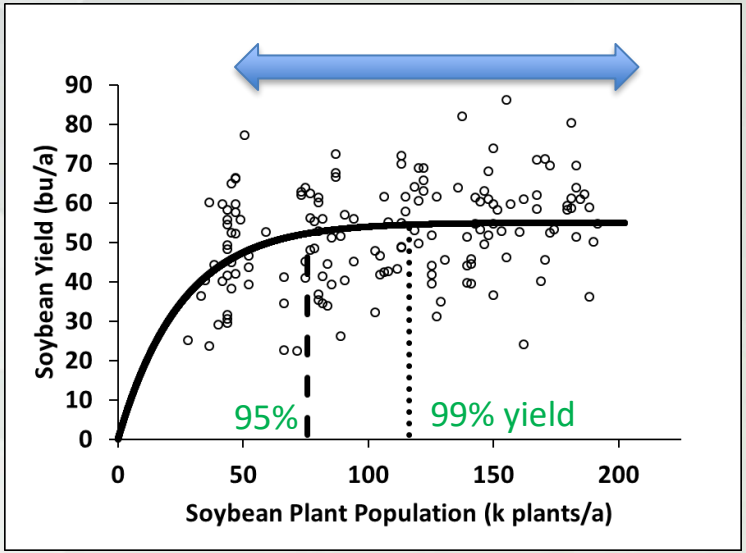


Summary: Plant date & Variety maturity

- Combine early planting with other management for higher yields/profits
- For mid-season planting, mid- and early- maturity varieties have competitive yield, and low moisture
- Benefits of early-season planting can be expanded upon with the use of late-maturity varieties
- Select early-maturity variety to minimize yield loss and other (e.g., high moisture) issues in delayed/replant situations (or double crop soybeans)
- **Portfolio approach** in maturity selection (also provide genetic diversity)
  - Plant late-maturity variety first (30-40% acres)
  - Plant mid- and early-maturity varieties in sequence to “stack” soy flowering/pod set
  - Plant ~20-30% acres to each of mid- and early-maturity variety

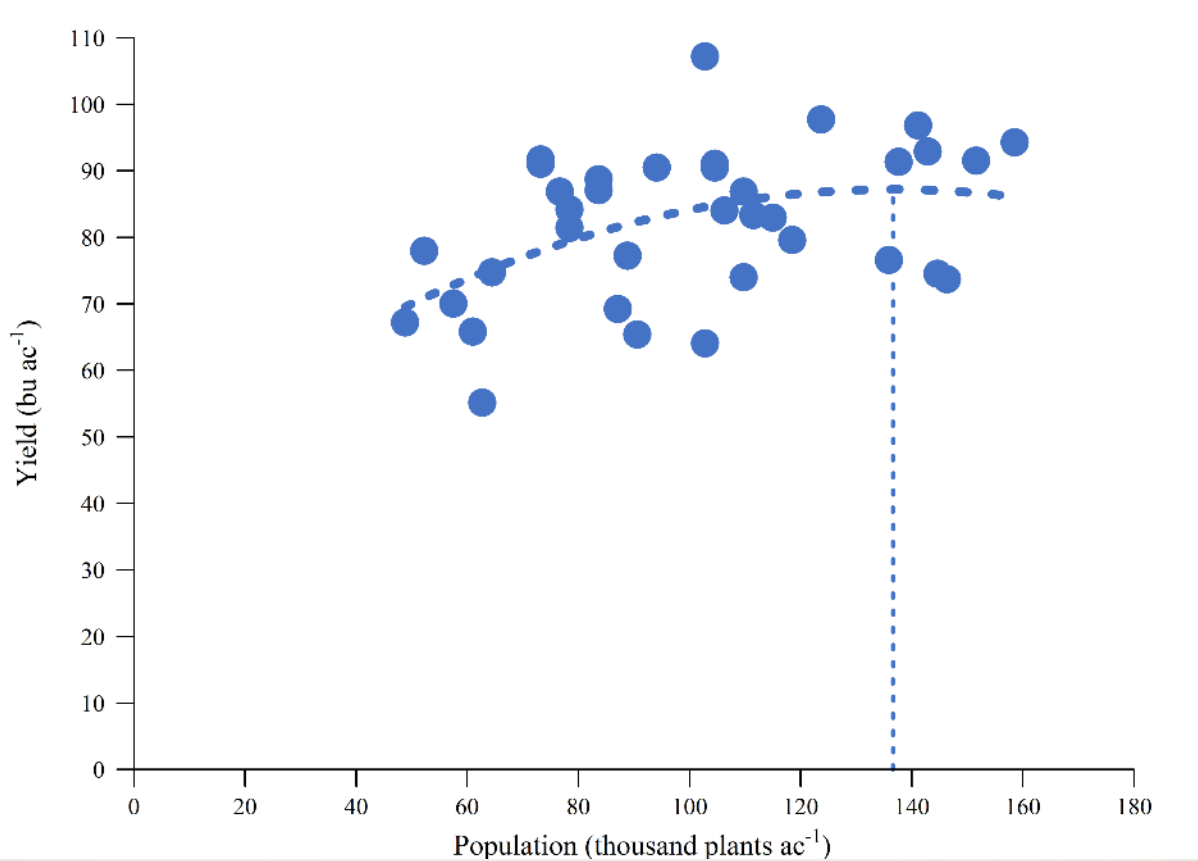
Soybean Seeding Rate

50,000 Seeds/A	90,000 Seeds/A	130,000 Seeds/A	170,000 Seeds/A	210,000 Seeds/A



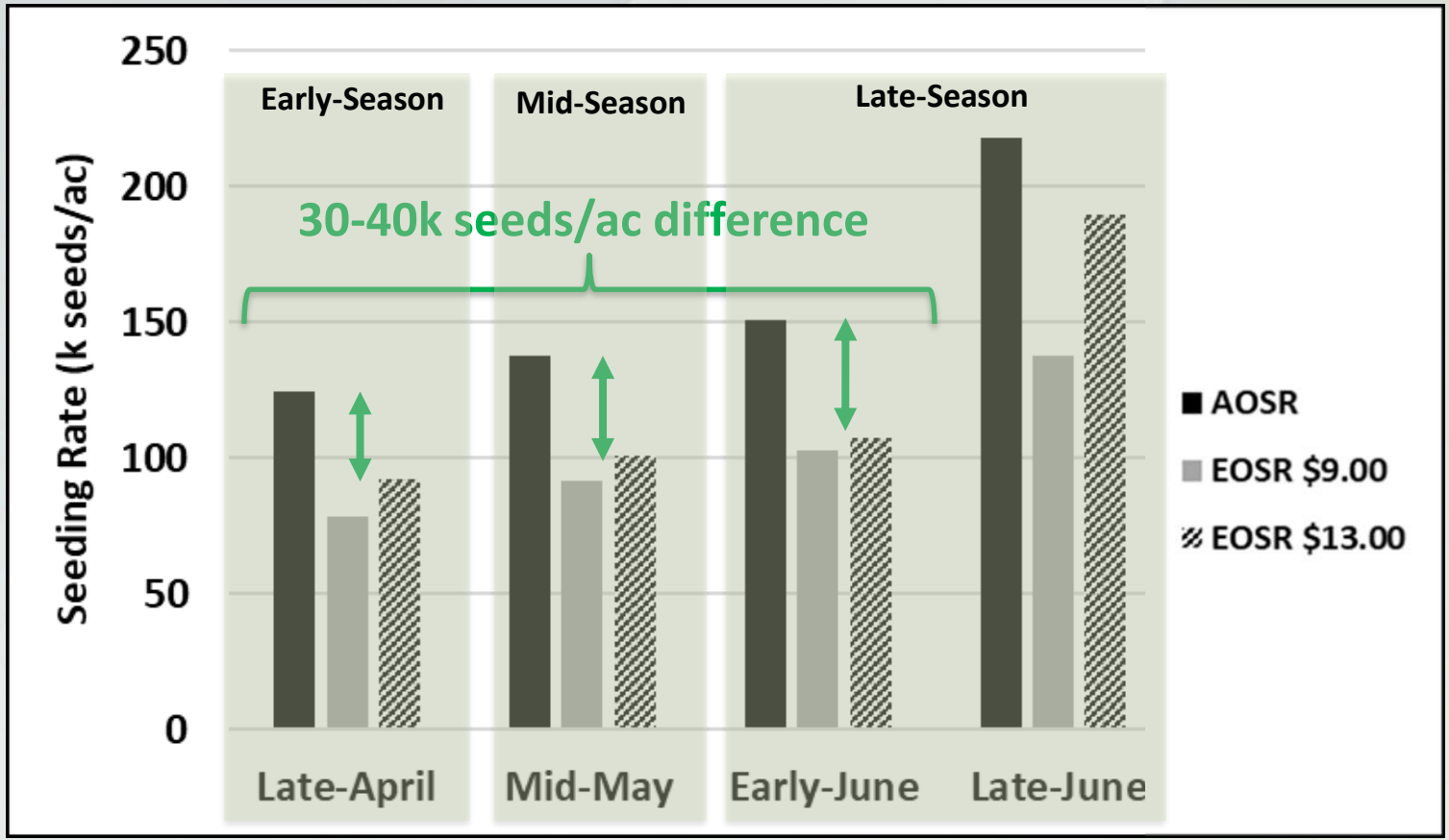
Seed rate: ~20% higher

2023 Seeding rate trial



15-inch rows
Conventional till
40 rates tested

Soybean Seeding Rate- Agronomic vs Economic Optimal



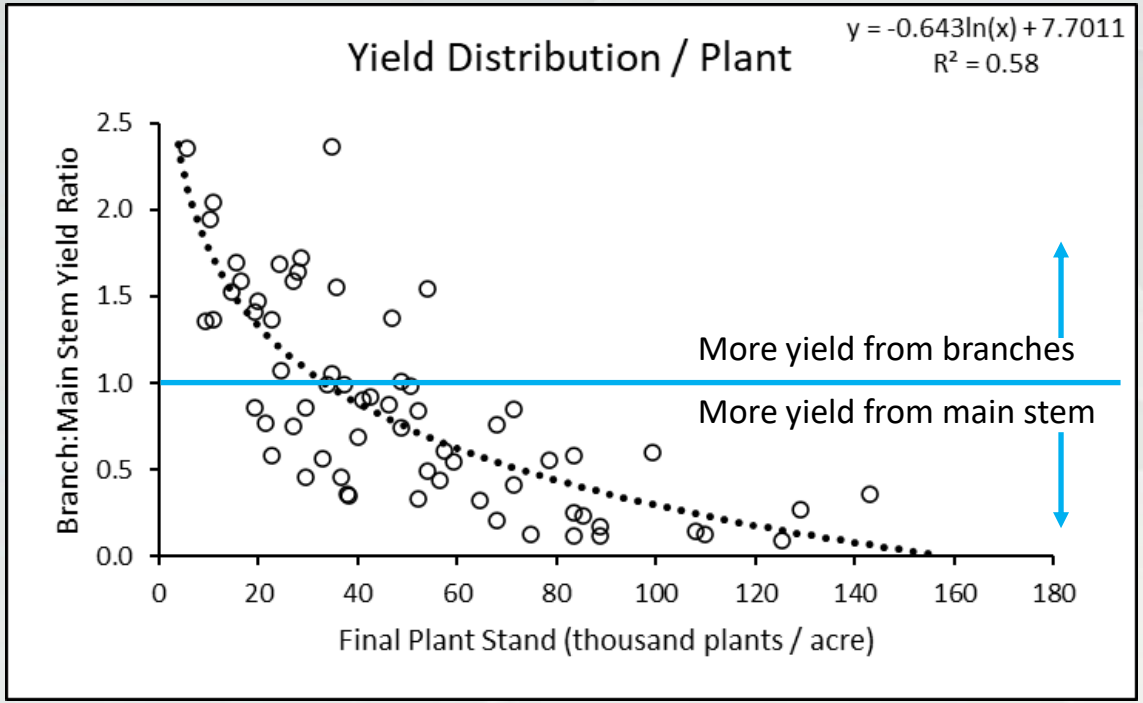
Agronomic Optimal Seed Rate (AOSR)

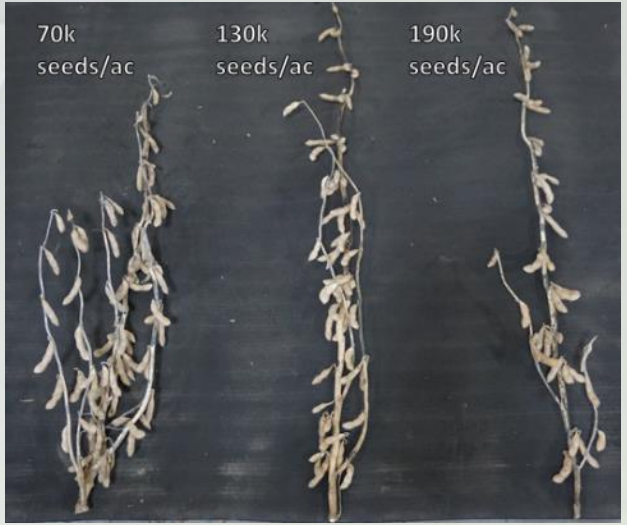
Economic Optimal Seed Rate (EOSR)

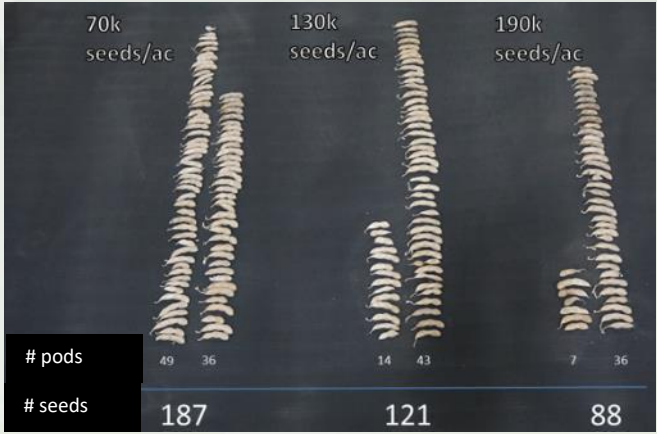
$50 per unit (140k) seed cost, $15 for seed trt

15-inch rows
Conventional till
4 site-years data

Seeding Rate- Plant architecture



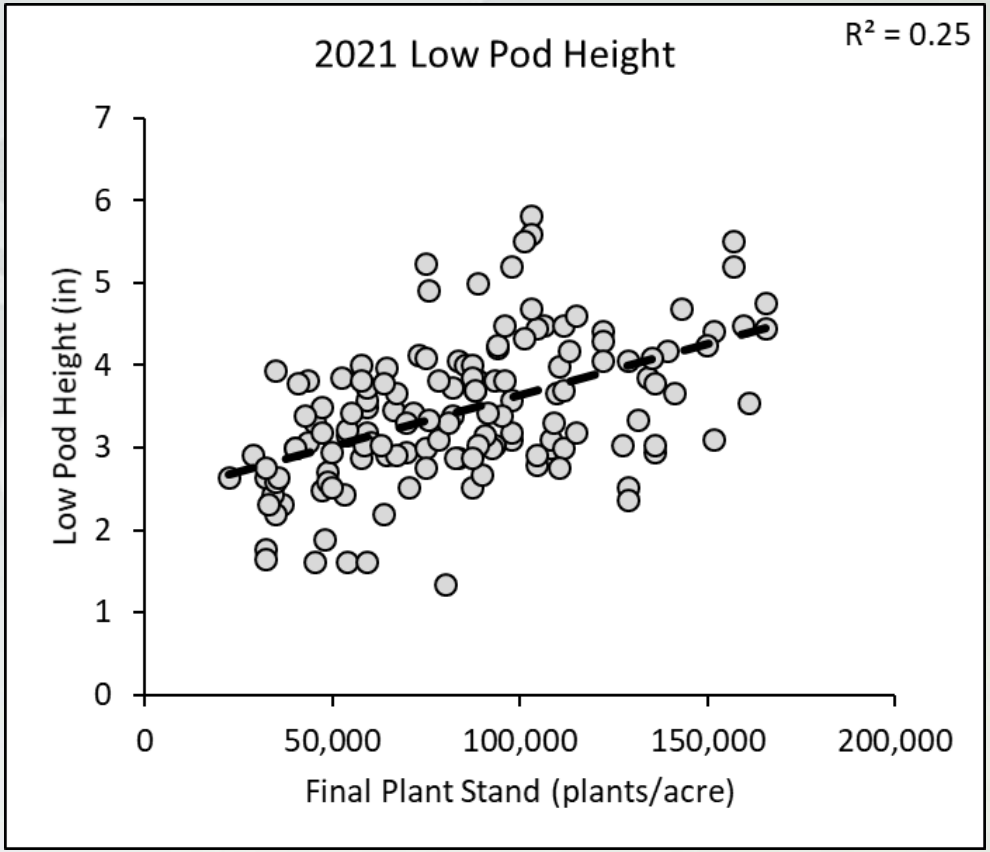




Seeding Rate- harvest loss at low densities

Low Seed Rate

High Seed Rate



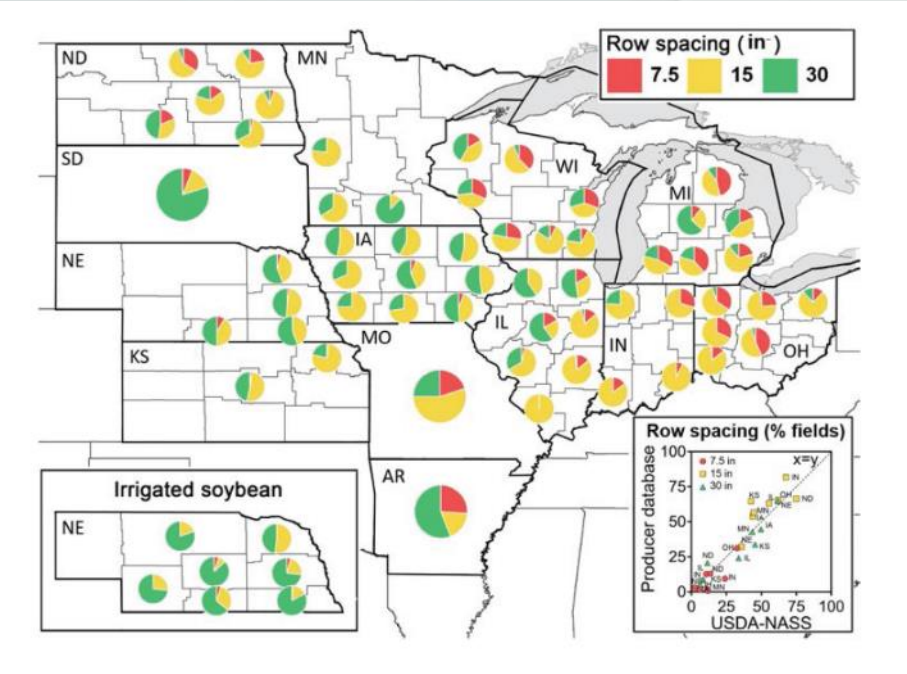
Summary: Seeding Rate

- For max yield: final **plant** stand of 100-120,000/ac for May planting, 120-150,000 plants/ac for June planting. ~20% higher for seeding rate
- Economic optimum rates are lower than agronomic optimum rates
- Lower seeding rate in high yielding areas/fields, higher rate in low yielding areas/fields (application in variable rate seeding)
- Leave a strip in field with lower seeding rate (~20-30%) for field testing
- Early-planted uniform stand of >50k/ac can produce high yield
- Stand count is important for evaluating yield potential

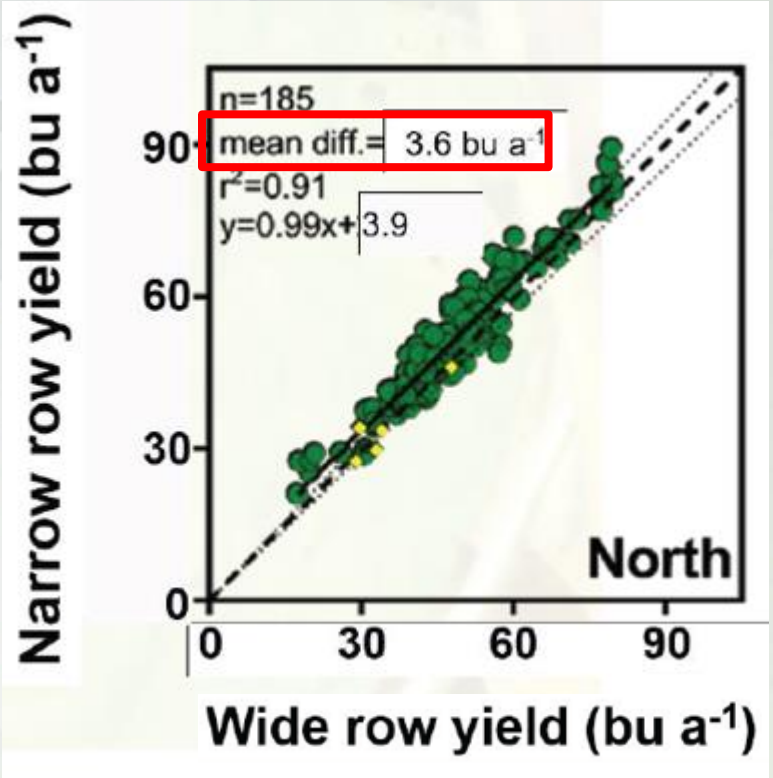
Replant decisions

- Step 1: Assess amount of stand loss and plant health
- Step 2. Assess pattern of loss
- Step 3. What to do? **Re-plant** vs **Repair-plant** vs **do nothing**?
  - What is the importance of uniform stand (soybean vs corn)
  - Plant's ability to recover
  - Calendar date
  - Yield potential of current stand
  - Yield penalty (due to delayed planting)
  - Others- seed availability, cost, insurance, weed management etc.

Row Spacing



2014-17 survey data

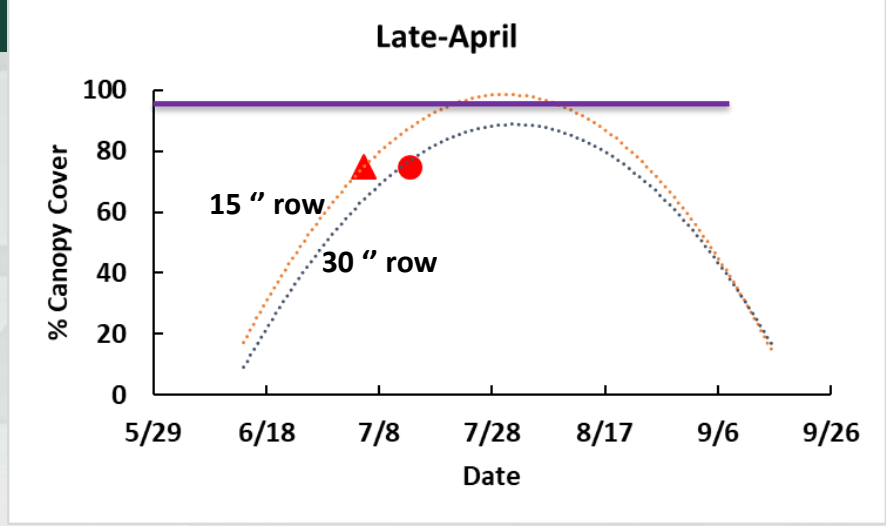


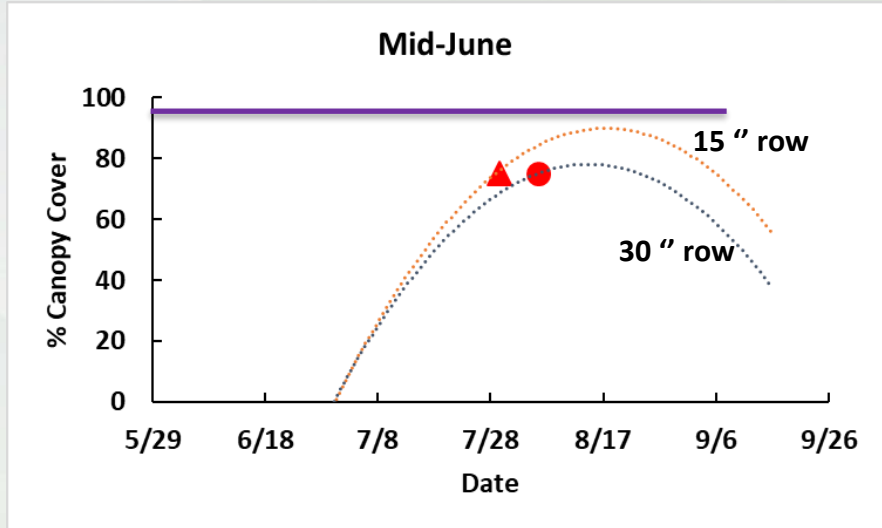
Andrade et al., 2019

Soybean Row Spacing

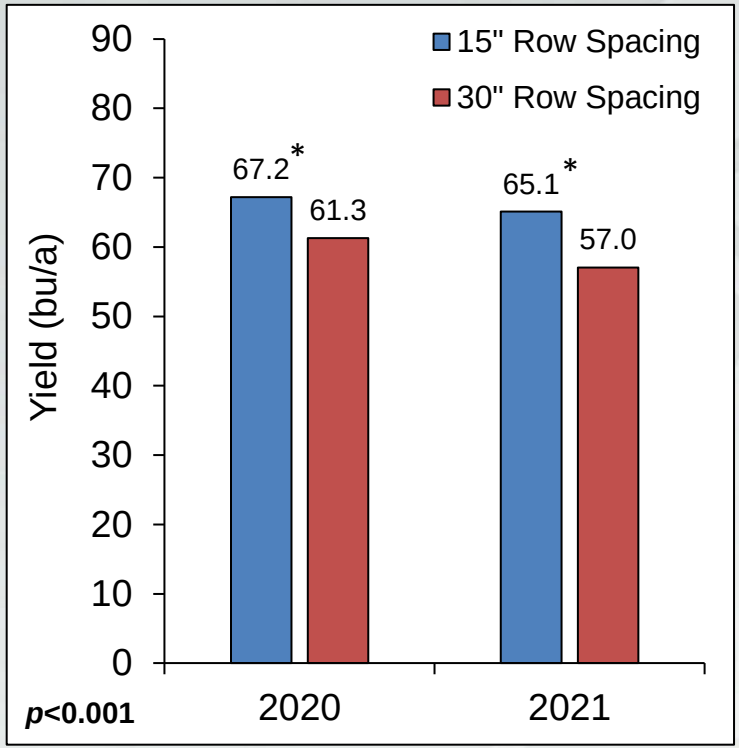
30’’ spacing

15’’ spacing



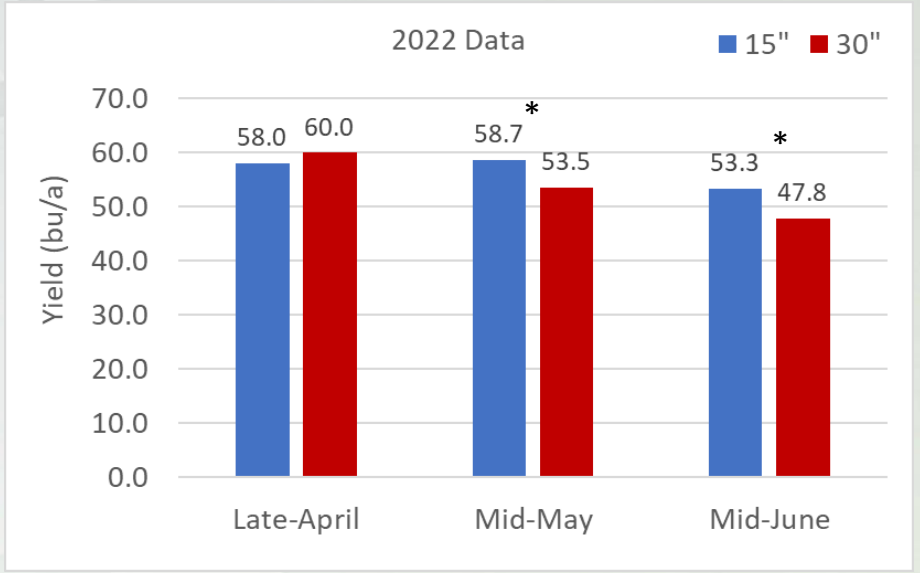


Soybean Row Spacing



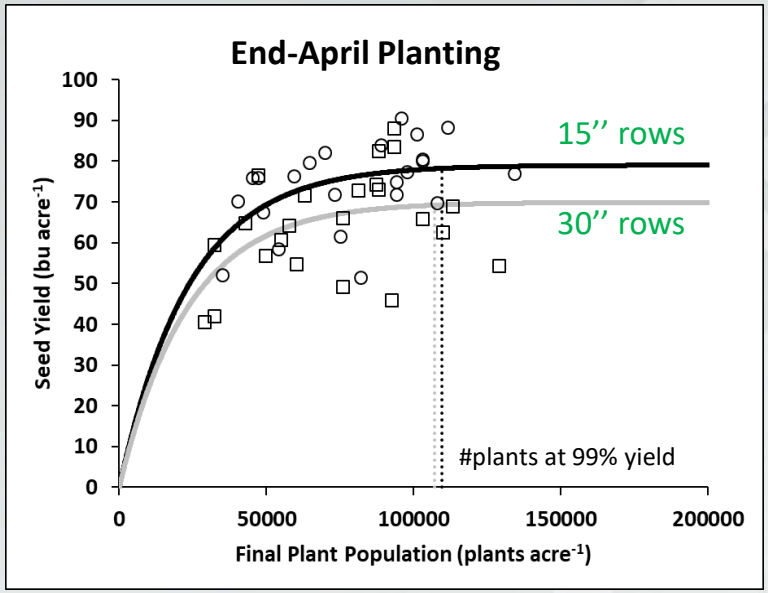
Rows	2023 Yield	
15"	65.2	a
30"	57.9	b

* Denotes significant differences at P <0.10

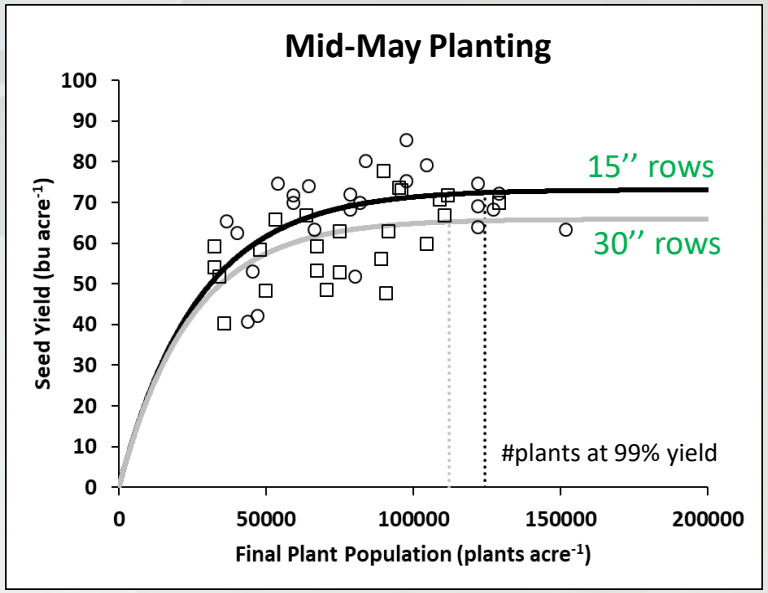


- Narrow rows (15'') had yield advantage over 30'' rows across all years (6-14%)
- Yield increase in 15'' over 30'' was similar across plant dates in 2020, 21, 23 (NOT in 2022)

Soybean Row Spacing



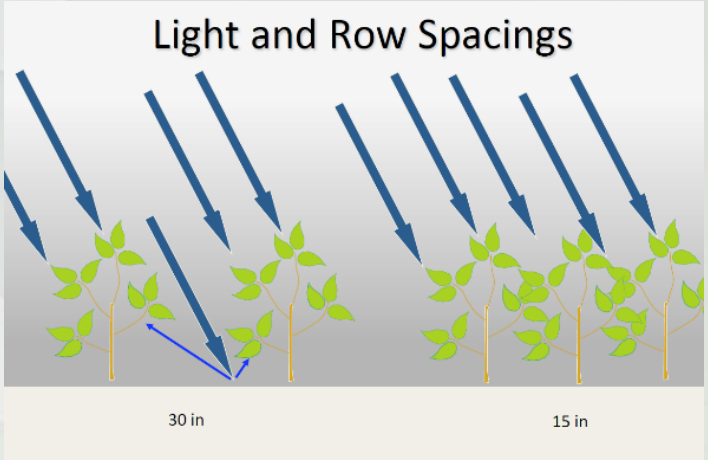
Seed rate: ~20% higher



- Optimal plant density: minimal differences between 30" and 15" (except late planting situations where narrow row benefit more from increase in seed rate)

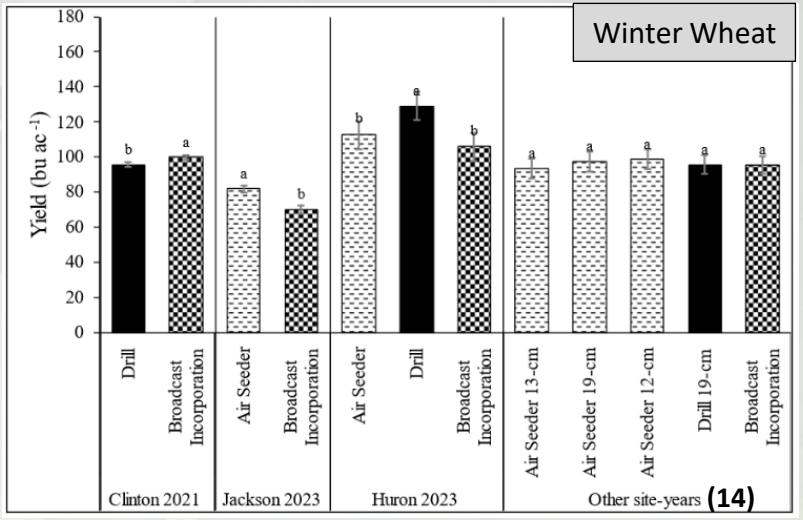
Summary: Row Spacing

- **Narrow rows**: faster canopy closure, >95% light interception, moisture conservation, weed control
- **Yield benefit** under narrow rows: Limited time for vegetative growth before flowering
  - Northern production regions
  - Delayed planting/ Double crop
  - Early-maturing varieties
- **Yield loss**: Disease pressure- white mold

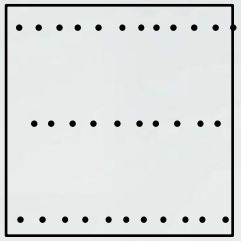


Soybean: Importance of Precise Seed Placement?

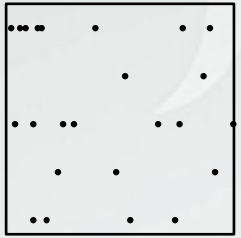
- Precise seed placement may be less important in soybean than in other crops such as corn
- Research in wheat showing potential for using broadcast incorporation to achieve earlier planting without yield penalty



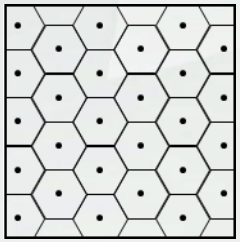
Precision Planter
15-in Row Spacing



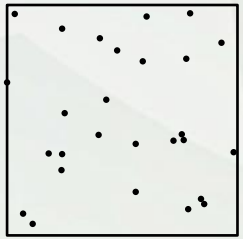
Seed drill
7.5-in Row Spacing



Ideal

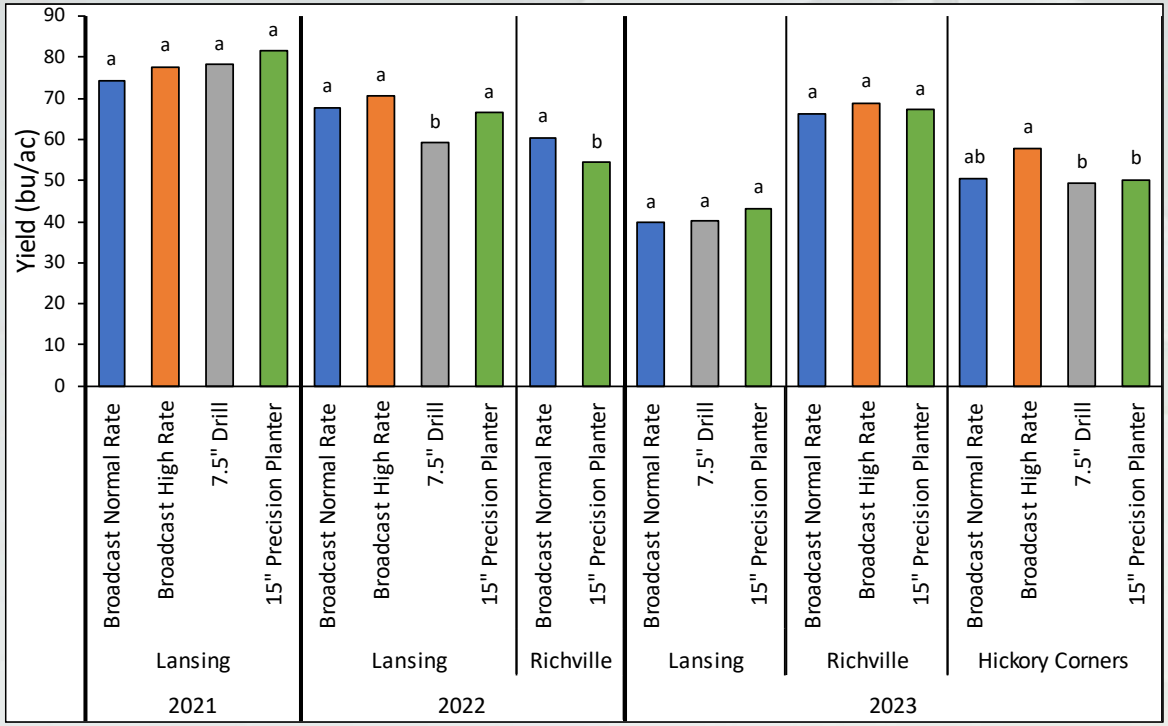


Broadcast Incorp.



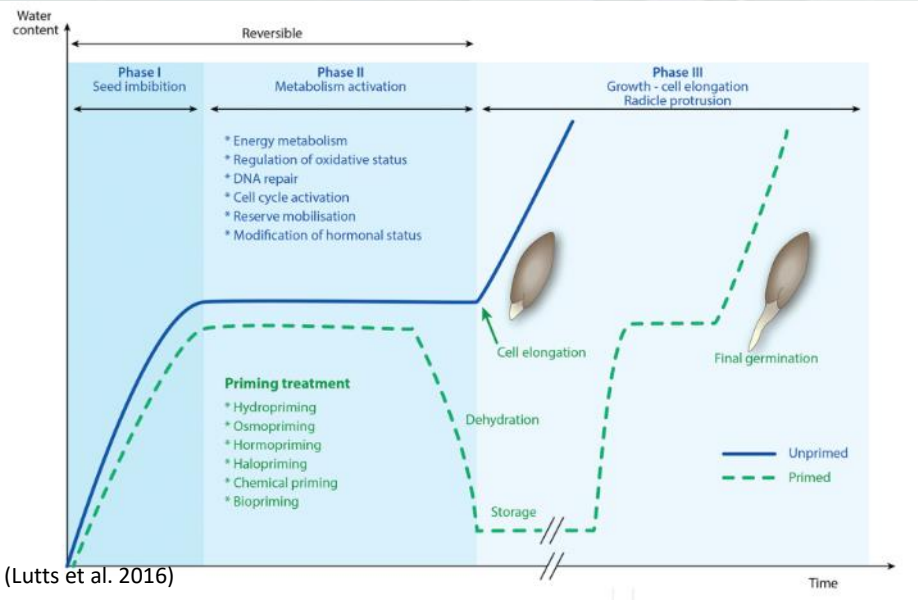
Soybean: Planting Methods

- **Minimum yield penalty** in soybean from less-precise seed placement across 5 site-years.

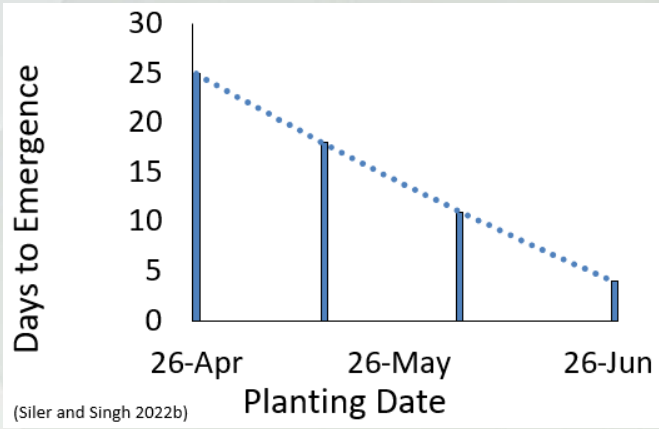


Soybean Seed Priming

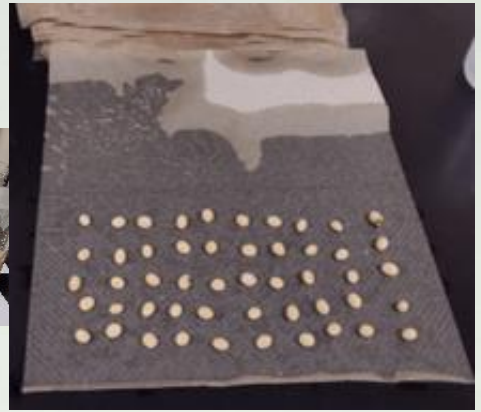
- Early planting: more time to emerge
- Concerns of frost damage
- Seed priming can minimize these issues



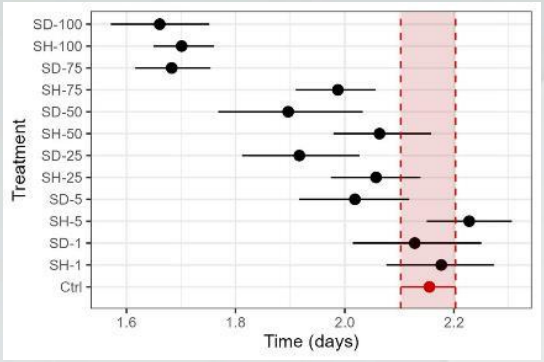
(Lutts et al. 2016)



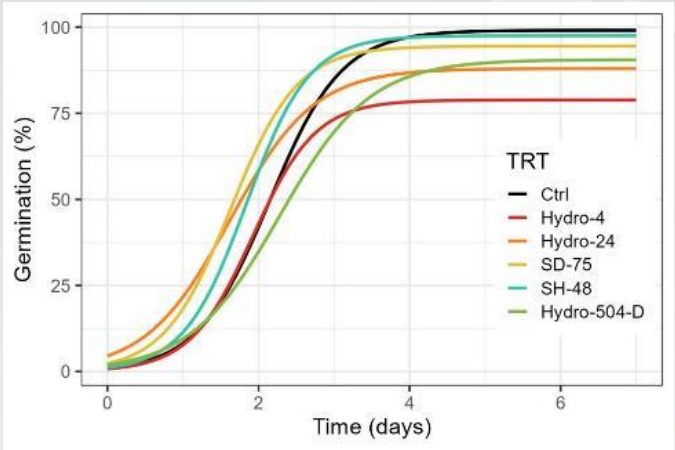
(Siler and Singh 2022b)



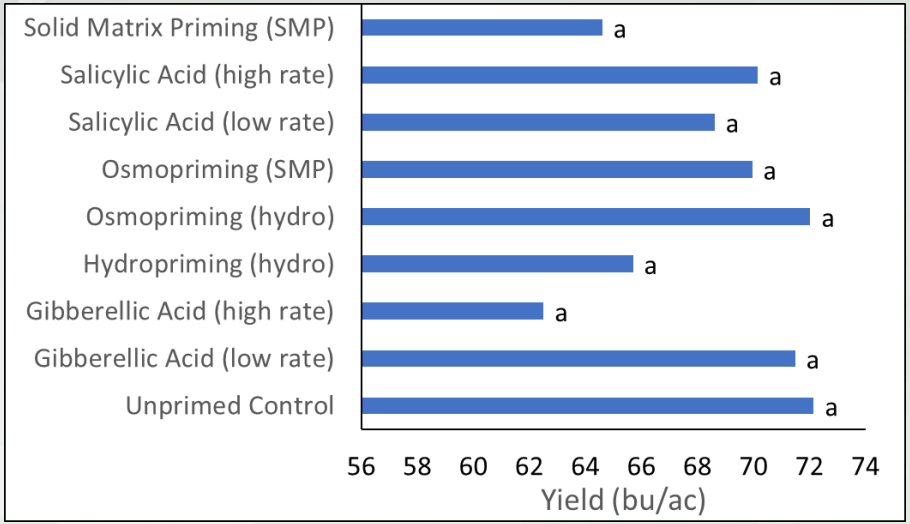
Soybean Seed Priming- 2023 prelim. data



Lab trials



Field Trials



- Can pre-hydration of seed be more beneficial/practical?

Optimal soybean management

- Crop rotation (diversity of crops is good)
- **Planting time** (early, in good field conditions)
- **Planting method**- need for precise seed placement, stand uniformity (yes for corn, soybean- maybe not)
- Change other management based on planting date (e.g., **variety maturity**, seed rate, harvest aids)
- **Seeding rates** for max yield vs profits. **Narrow rows** do help.
- Fertility management (based on soil test, yield goals)
- Pest management (based on scouting)
- **Harvest decisions**

National Screen of Commercially Available Biological Seed Treatments for **Soybean**

Trade show at 2022 Commodity Classic

- 22 Companies
- 40 Different products
- Multiple active ingredients
  - *Bradyrhizobium*
  - *Azospirillum*
  - *Bacillus*
  - *Pseudomonas*
  - … and more!

Some of the products claim that they:

- Improve N fixation
- Assimilate P from organic and inorganic sources
- Increase nutrient use efficiency and uptake
- Stimulate growth of efficient roots and expand root absorption
- Control of diseases and nematodes

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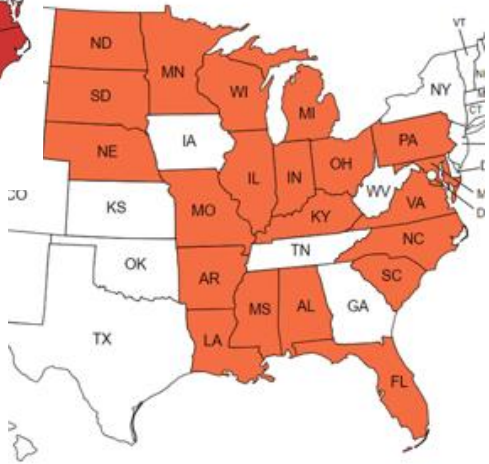
Field Trials (2022-2023)

2022 States

2023 States



Michigan Sites

- 2022: 17 states, 49 locations
  2023: 21 states, 55 locations
- **104** site-years (6 in MI) total

- Small plot trials
- Randomized complete block design with 6-8 reps at all sites.

Lead: Laura Lindsey (OSU)

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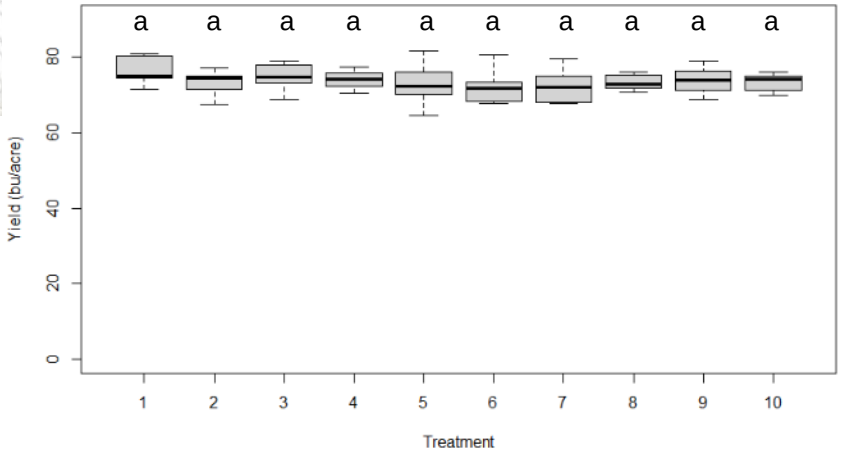
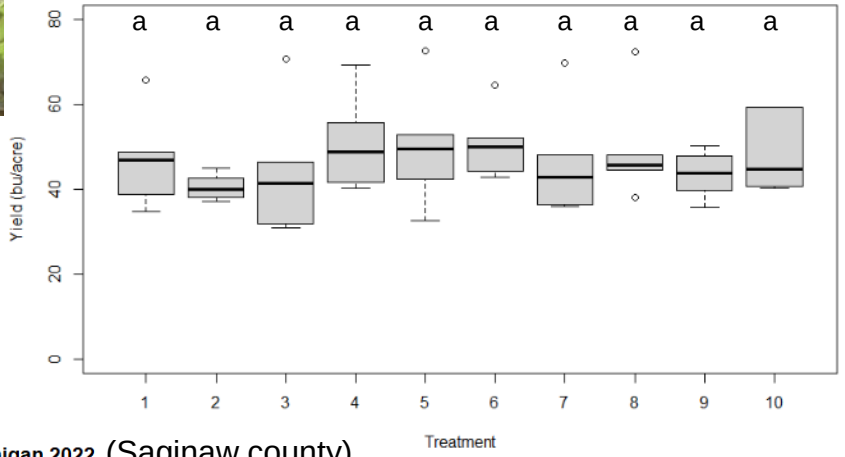
Table 1. List of treatments (products) and active ingredients in each biological product.

Treatment (product)	**Active ingredients** (purple text: replaced in 2023)
1	*Azospirillum brasilense, Bacillus licheniformis, Bacillus amyloliquefaciens, Bacillus subtillis, Pseudomonas fluorescens, Rhizobium*
2	*Trichoderma virens (2023: Kosakonia cowanii* strain SYM00028*)*
3	*Bradyrhizobium spp.*
4	*Bacillus subtillis, Bacillus amyloliquefaciens, Bradyrhizobium japonicum* *2023: Bacillus subtillis + Bradyrhizobium japonicum*
5	*Pantoea agglomerans (2023: Bacillus amyloliquevaciens* strain PTA-4838*)*
6	*Pseudomonas brassicacearum (2023: Methylobacterium hispanicum)*
7	*Bradyrhizobium elkanii, Delftia acidovorans + Bacillus velezensis*
8	*Bacillus velezensis*
9	*Glomus intraradices, Glomus mosseae, Glomus aggregatum, Glomus etunicatum*
10	Untreated Control (seed treated with fungicide + insecticide only)

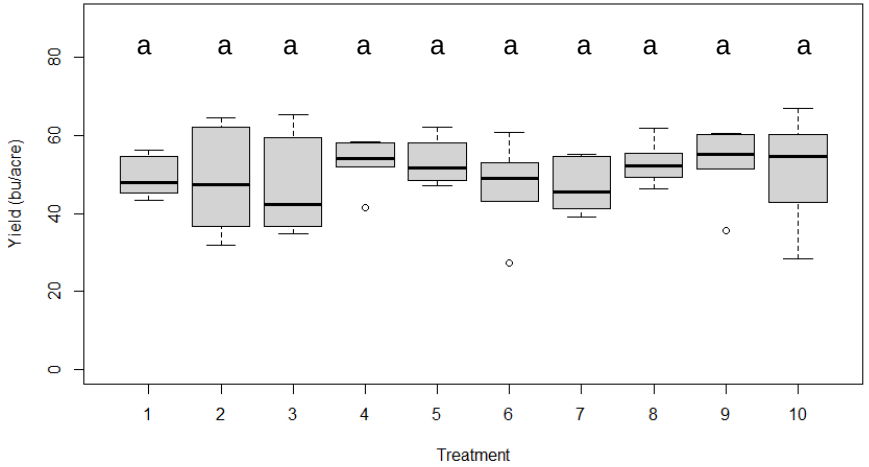
Britton, Michigan 2022 (Lenawee county)

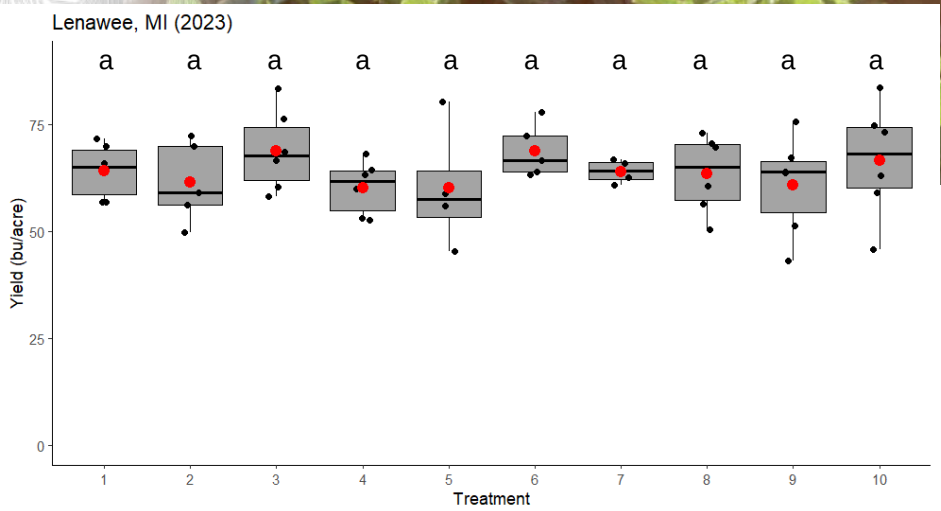


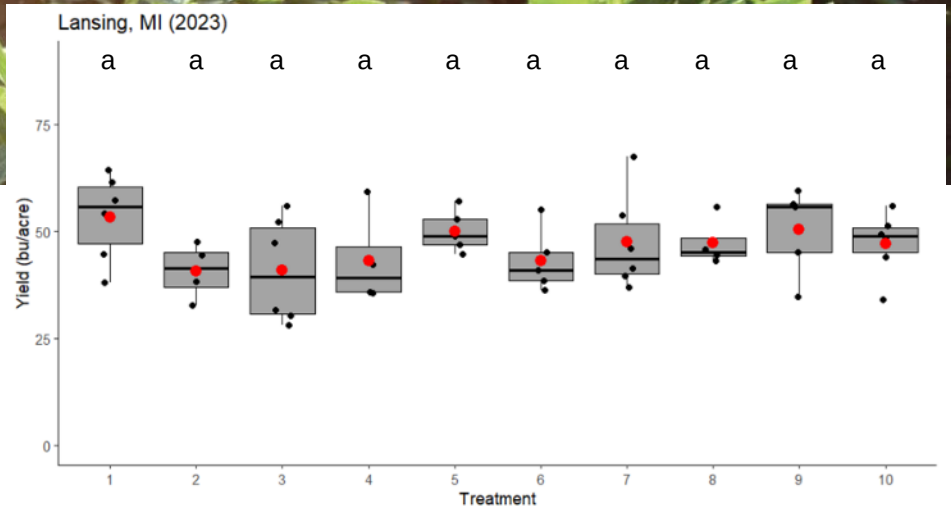
Mason, Michigan 2022 (Ingham county)

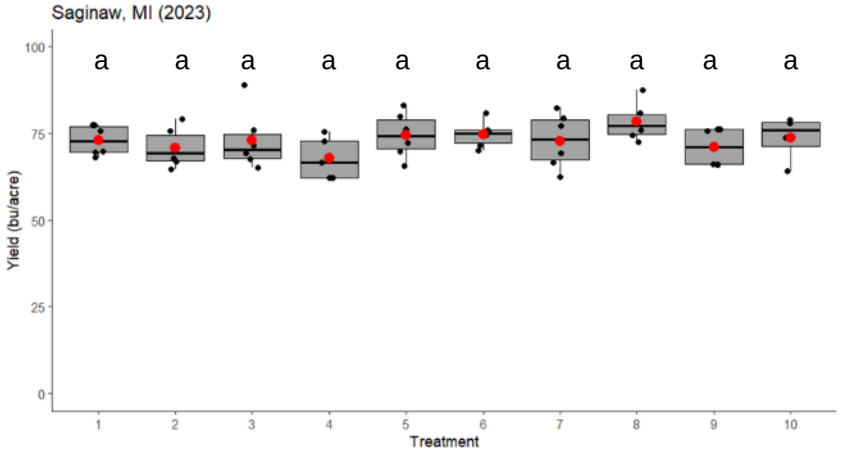


Saginaw, Michigan 2022 (Saginaw county)









- Michigan: no response at any location in 2022 or 2023

2023- prelim. data

Red circles: average for each treatment

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Locations with significant treatment differences in 2022

Site	Control	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5	Trt 6	Trt 7	Trt 8	Trt 9
Arlington, Wisconsin	77.4 dc (2.2)	73.1 d (2.2)	80.2 abc (2.2)	84.7 a (2.2)	78.1 bcd (2.2)	78.8 bc (2.2)	77.0 cd (2.2)	78.3 bcd (2.2)	83.2 ab (2.2)	76.8 cd (2.2)
Clinton, Wisconsin	55.2 e (2.4)	61.6 cd (2.4)	68.9 ab (2.4)	69.0 a (2.4)	68.2 ab (2.4)	62.7 bcd (2.4)	64.6 bcd (2.4)	66.9 abc (2.4)	59.9 de (2.4)	61.0 cde (2.4)
Eau Galle, Wisconsin	45.3 a (1.8)	39.5 bc (1.6)	44.3 a (1.6)	39.3 c (1.6)	37.4 c (1.6)	39.0 c (1.6)	44.0 ab (1.6)	37.9 c (1.6)	39.4 bc (1.6)	39.4 bc (1.6)
Renner, South Dakota	53.1 a (1.2)	50.5 c (1.2)	50.1 bc (1.2)	51.6 ab (1.2)	54.2 ab (1.2)	55.0 a (1.2)	53.7 ab (1.2)	51.6 bc (1.2)	55.4 a (1.2)	51.6 bc (1.2)

- 2022: Only 2 of 49 sites across US showed positive response
- Detailed analyses ongoing

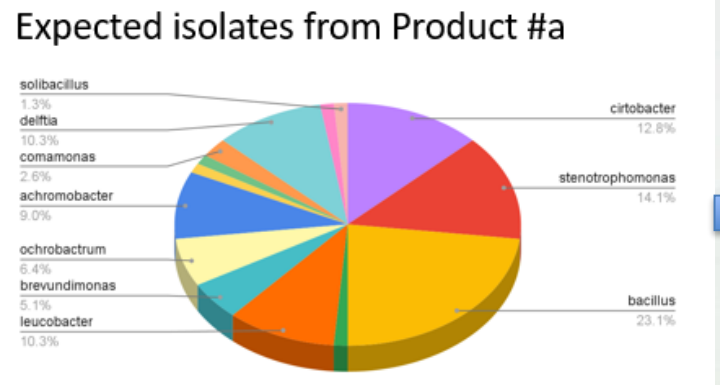
Locations with significant treatment differences in 2023 (prelim. data)

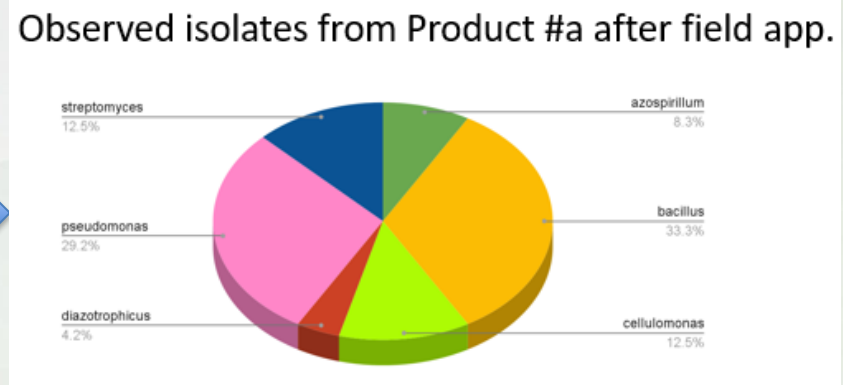
Site	Control	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5	Trt 6	Trt 7	Trt 8	Trt 9
Suffolk, Virginia	56.1 BC	54.9 C	54.9 C	57.6 ABC	57.0 ABC	56.5 ABC	61.7 AB	56.0 BC	62.1 A	61.8 A
Clinton, Wisconsin	59.1 B	76.3 A	72.3 A	75.3 A	71.5 A	76.1 A	72.7 A	74.4 A	74.5 A	63.6 B
Fond Du Lac, Wisconsin	74.8 AB	77.1 AB	73.0 AB	77.4 A	70.9 B	73.5 AB	77.3 A	64.0 C	71.7 AB	73.1 AB

- 2023: 2 out of 25 sites (that reported yield so far) showed positive response
- Detailed analyses ongoing

Biologicals: Key reminders

- Biology is more challenging than chemistry!
- Ongoing work is looking into unique situations (e.g., pH, CEC, texture, tillage, yield potential etc.) where these products can provide ROI
- Challenges and upcoming research:
  - Seed treatments need to survive, reproduce and colonize roots
  - Delivery technology, application method and timing
  - Not customized for unique field limitations, **long-term impacts** (e.g. soil health)





Biologicals: Phenotype in controlled Environment!

Resources: agronomy.msu.edu

Cropping Systems Agronomy

Team | Research | Extension | Michigan Corn Hybrid Trials | Resources | Prospective Students | Contact

/ Extension /

Extension

The ultimate goal of our extension program is to provide current, unbiased, and scientifically sound agronomic management information to clientele in Michigan and elsewhere. Our program focuses on current and emerging issues faced by farmers with an overall goal to help farmers increase their profit within the constraints of available resources while minimizing potential adverse environmental consequences. We also focus on factors that could limit the quality of the crop in addition to yield to maximize farmer profit in the current and future marketplace.

Extension

- Soybean
- Corn Grain
- Corn Silage
- Small Grains
- Multi-Crop Systems

Soybean

Across the US, soybean Extension Specialists are working together on a 'Science for Success' initiative. Please check out this tab for exciting information on soybean

Science for Success Articles

Articles

SOYBEAN PLANTING CONSIDERATIONS: PLANTING DATE, SEEDING RATE AND ROW SPACING IMPLICATIONS

PUBLISHED ON APRIL 28, 2022

Presentations

Soybean planting decisions to maximize ROI, Manni Singh - **Updated with latest research !!!**

Adjusting Management Practices to Adjust for Variable Soybean Planting Times

Reports

2022

Boots on the Ground - Trial Report

Profitable Soybean Planting Practices

Using Data Science for Profitable Soybean Systems

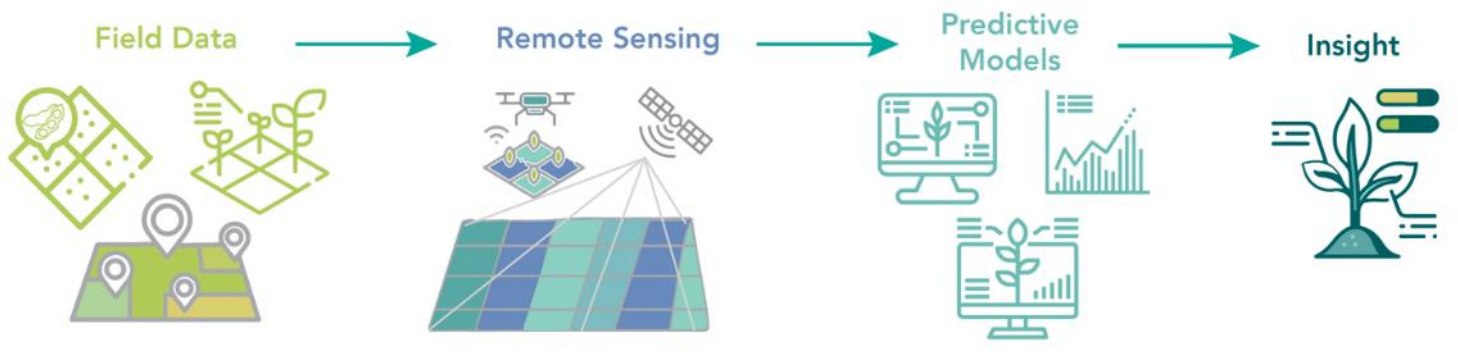
- **Goal**: Develop a new APP (online tool) for field-specific management guidelines
- More data from real world = Better predictions from tool
- **Data from your fields** will help usability of this tool for you
- We will add weather, soil, and satellite data to field data
- Data will stay confidential
- **Receive a coupon** to access the tool in development for 2024 (https://agroptimizer.com/)

- Fill out the survey ONLINE (**https://arcg.is/1anP4r)**
- OR ask us for a Paper copy

Lead: Shawn Conley

Mapping Soybean Protein/Oil at Field Scale

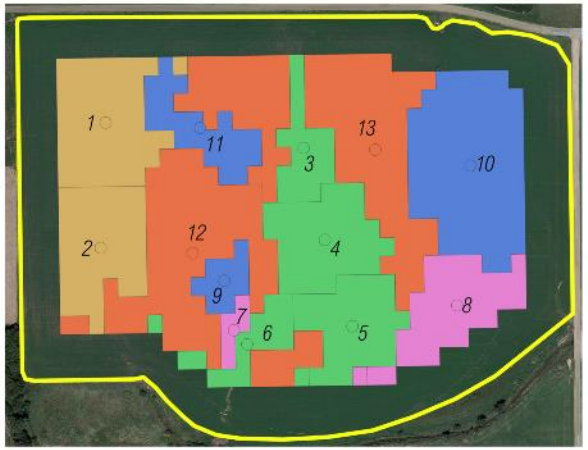
NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM



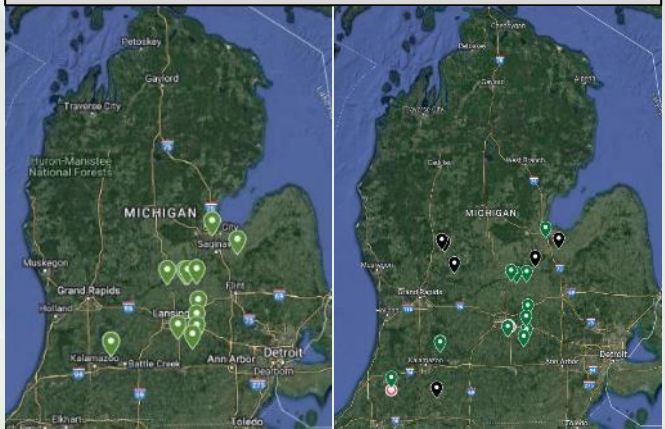
Example Field

Zone 1	2 samples
Zone 2	4 samples
Zone 3	2 samples
Zone 4	3 samples
Zone 5	2 samples

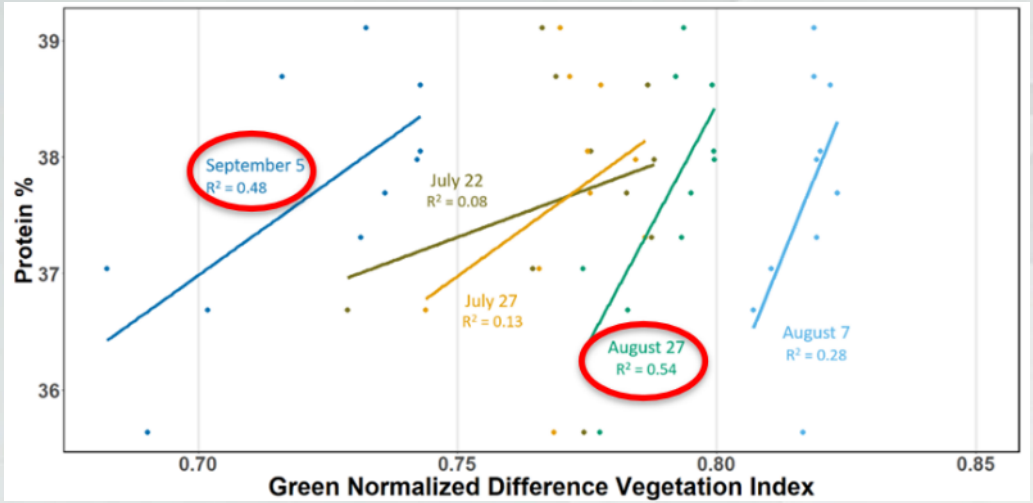
TOTAL = 13 samples



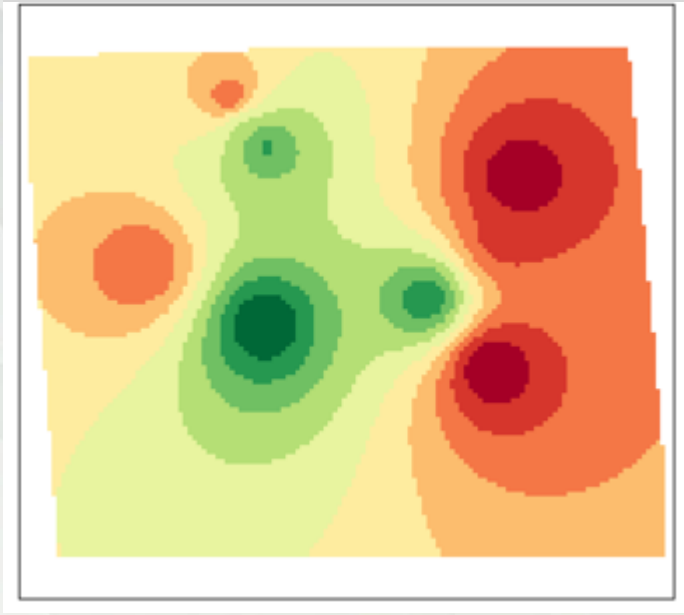
2022: 14 Fields **2023: 18 Fields**

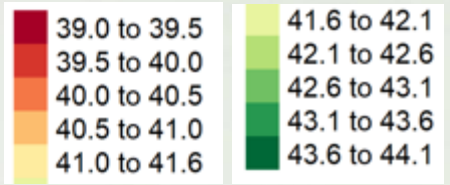


Mapping Soybean Protein/Oil at Field Scale

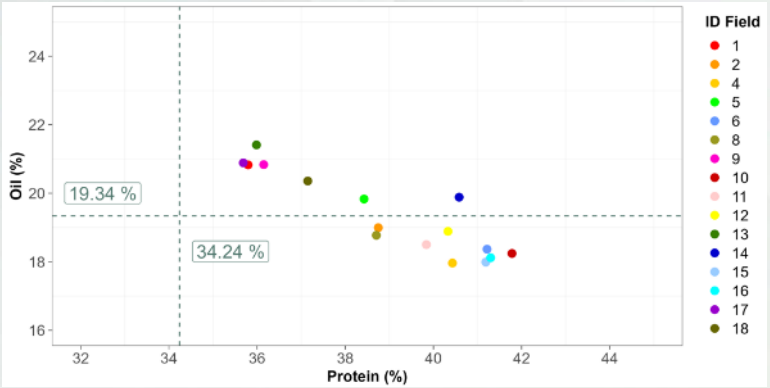


Field #6 (40 acre), 2023





2023 MI Fields:



- **Technicians**:
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- **Graduate Students**
  - Harkirat Kaur
  - Benjamin Agyei
  - Paulo Arias
- **Undergrad/Intern students**
- **Past students**
- Mike Particka
- Paul Horny
- **Farmer cooperators**

- Dr. Jeff Andresen
- Dr. Laura Lindsey (OSU)
- Dr. Ignacio Ciampitti (KSU)
- Dr. Shawn Conley (UW)
- Dr. Chris Difonzo
- Dr. Marty Chilvers
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- Dr. Kurt Steinke
- Dr. Sarah Lebeis
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Thanks!

MICHIGAN SOYBEAN COMMITTEE

NCSRP NORTH CENTRAL SOYBEAN RESEARCH PROGRAM

Project GREEEN

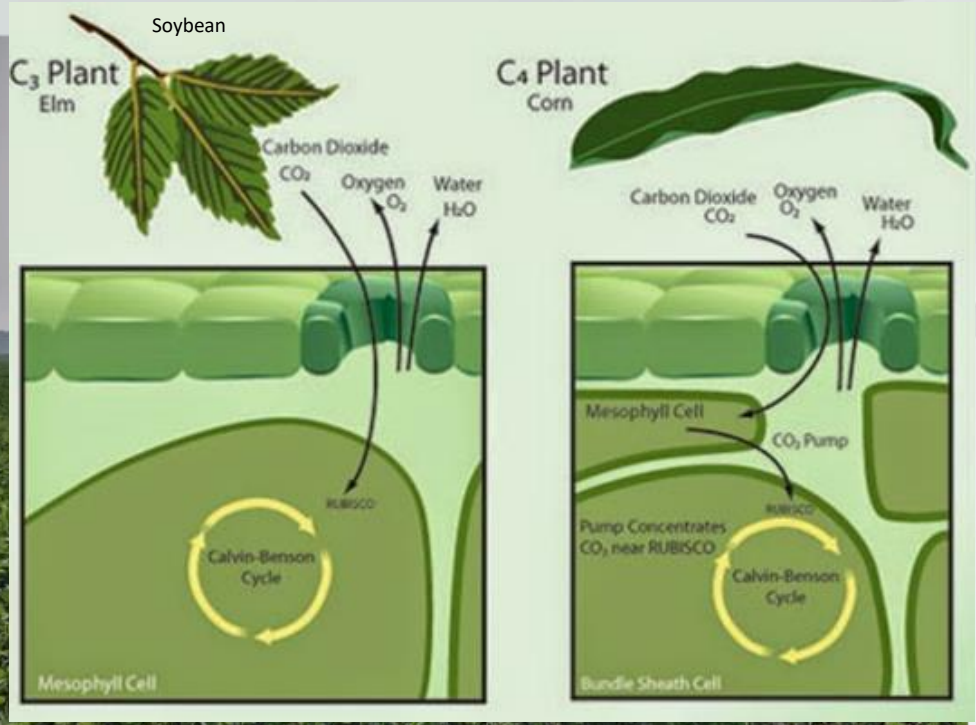
Cropping Systems Agronomy
MICHIGAN STATE UNIVERSITY

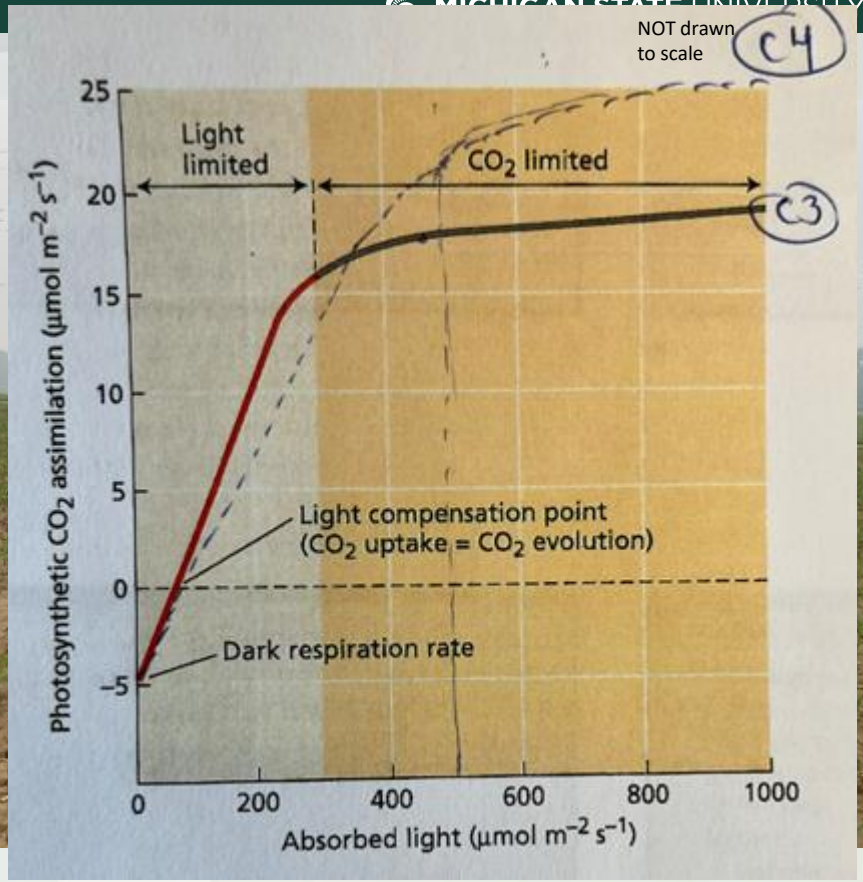
MICHIGAN STATE UNIVERSITY | Extension

Seed companies

NORTH CENTRAL SARE Sustainable Agriculture Research & Education

USDA NIFA





Smoke can affect light levels. **Soybean is a C3 plant** that tends to have CO_2 be most limiting factor affecting productivity, whereas **corn is a C4 plant** and tends to have light be the most limiting factor affecting productivity.

https://agcrops.osu.edu/newsletter/corn-newsletter/2023-21/how-could-haze-wildfires-affect-crop-growth