Can stress tolerance in corn and soybean keep yields moving up?

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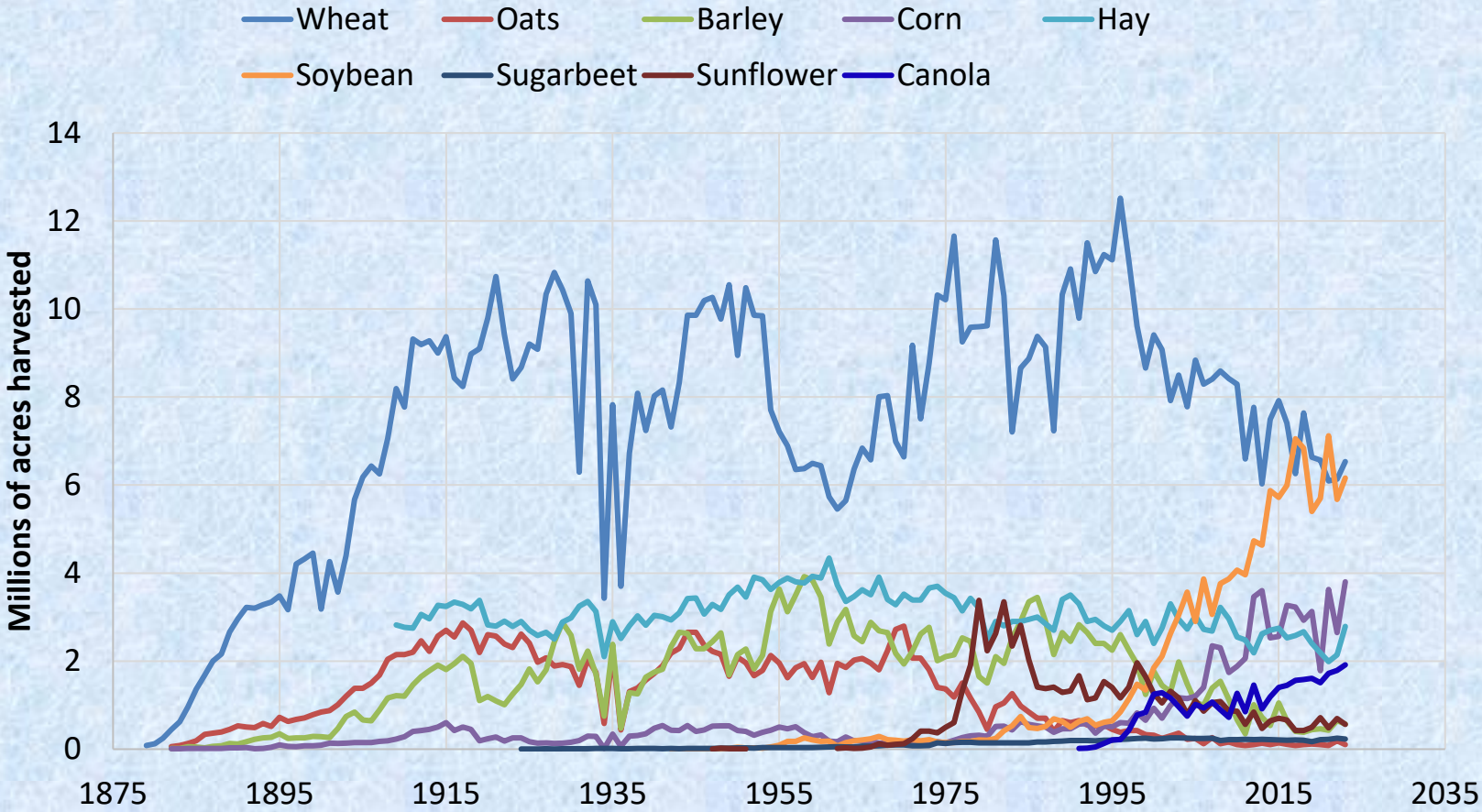
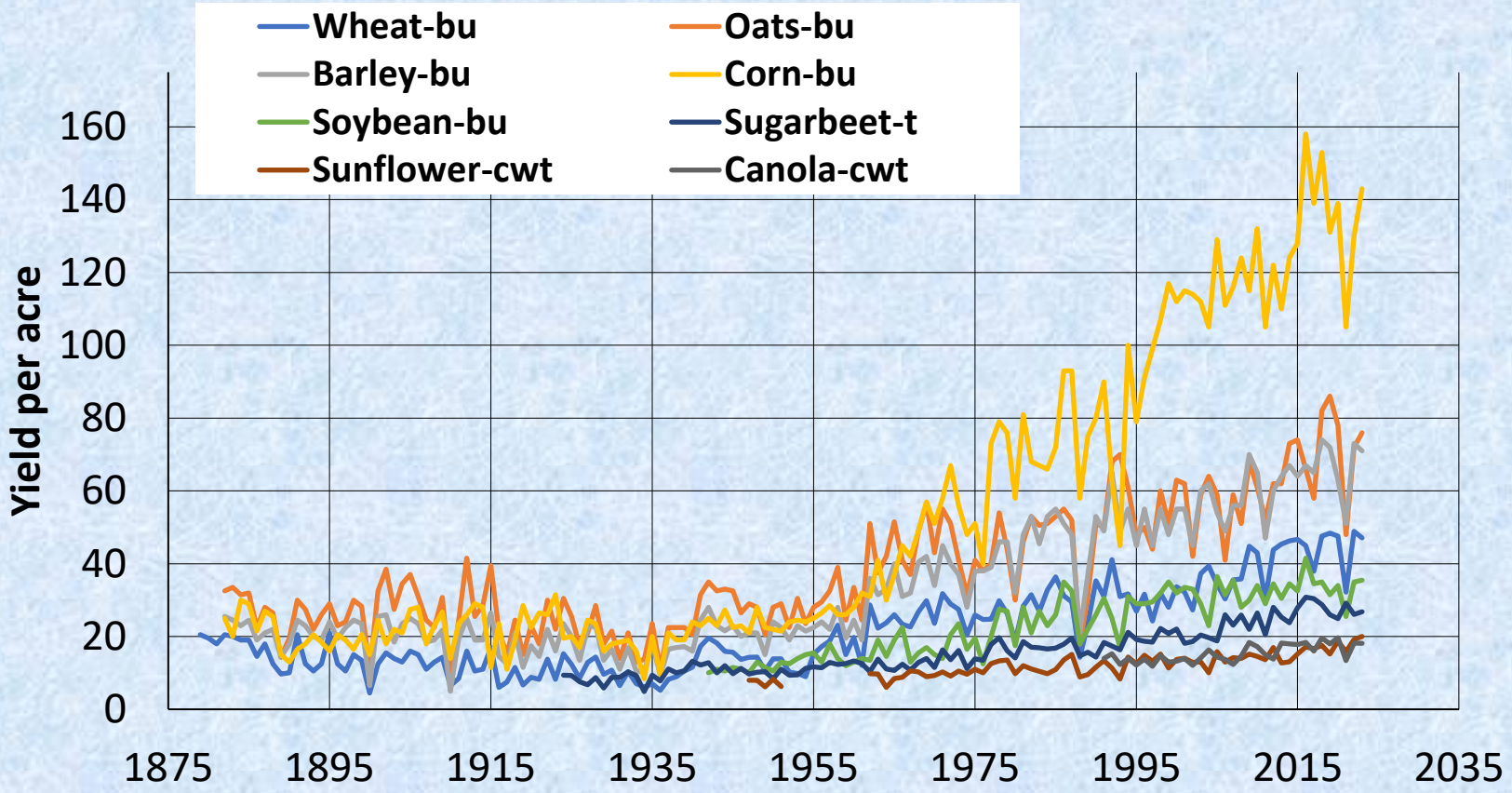
Today's approach

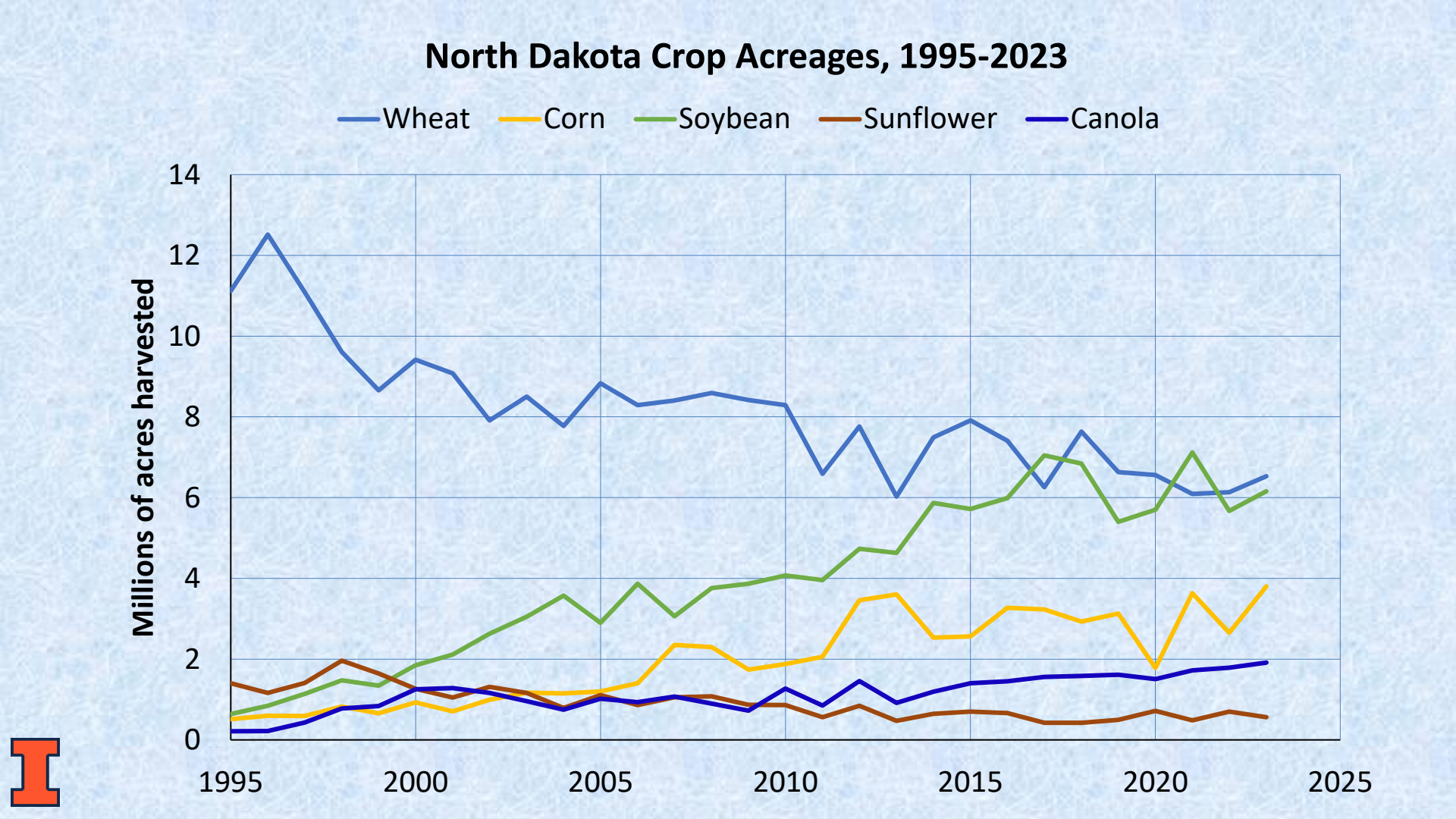
- Will concentrate on soybeans
- Differences between soybean seasons in Illinois and ND: do lower yields result from stress?
- Defining stress: do our old ideas still work?
- Are soybeans being bred for stress?
- Can we manage to avoid or alleviate stress?
  - Rotation
  - Inputs and practices
- Will increasing CO_2 in the air (climate change) mean more stress?

North Dakota Crop Acreages, 1879-2023

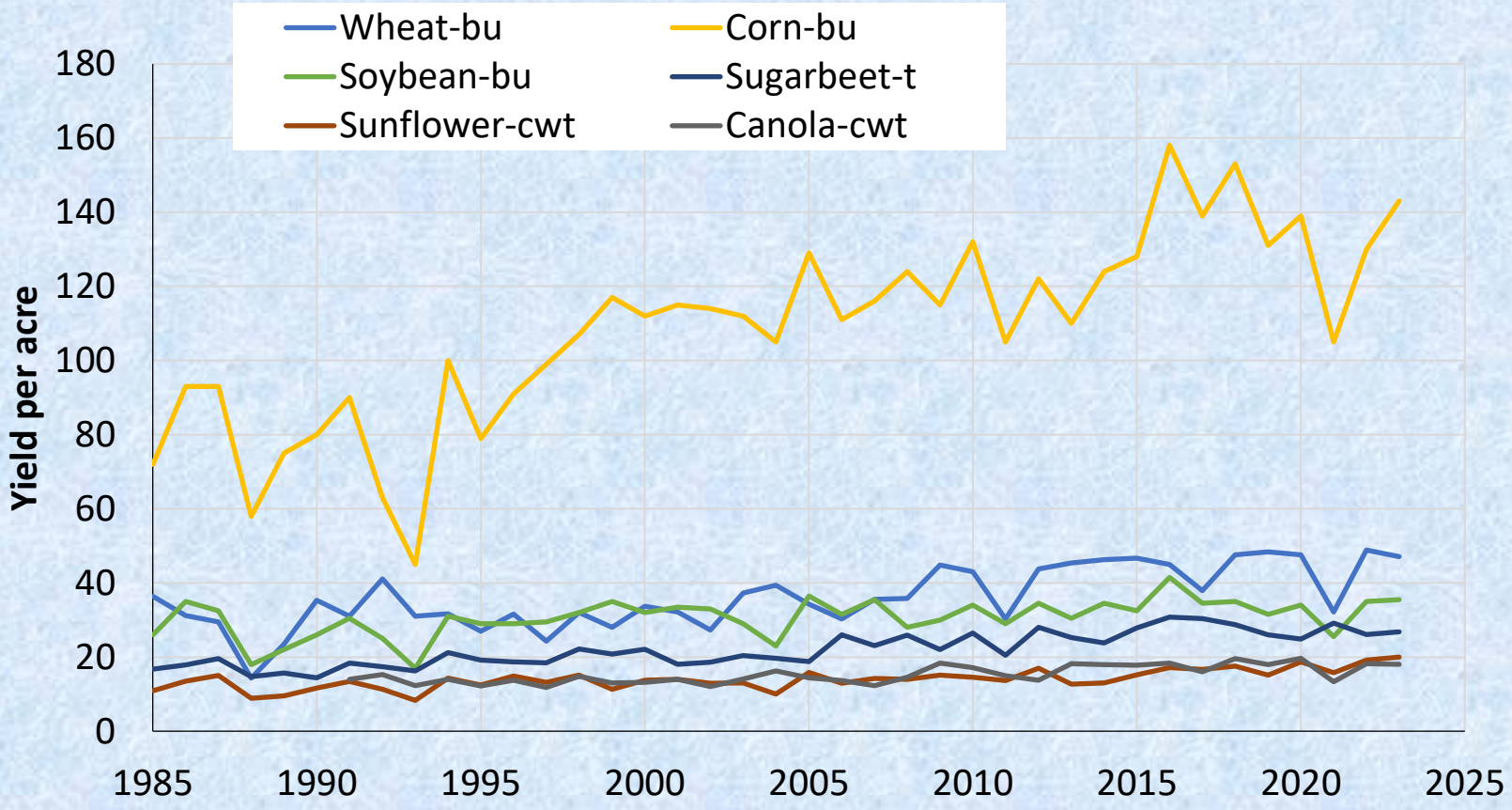


North Dakota Crop Yields, 1879-2023



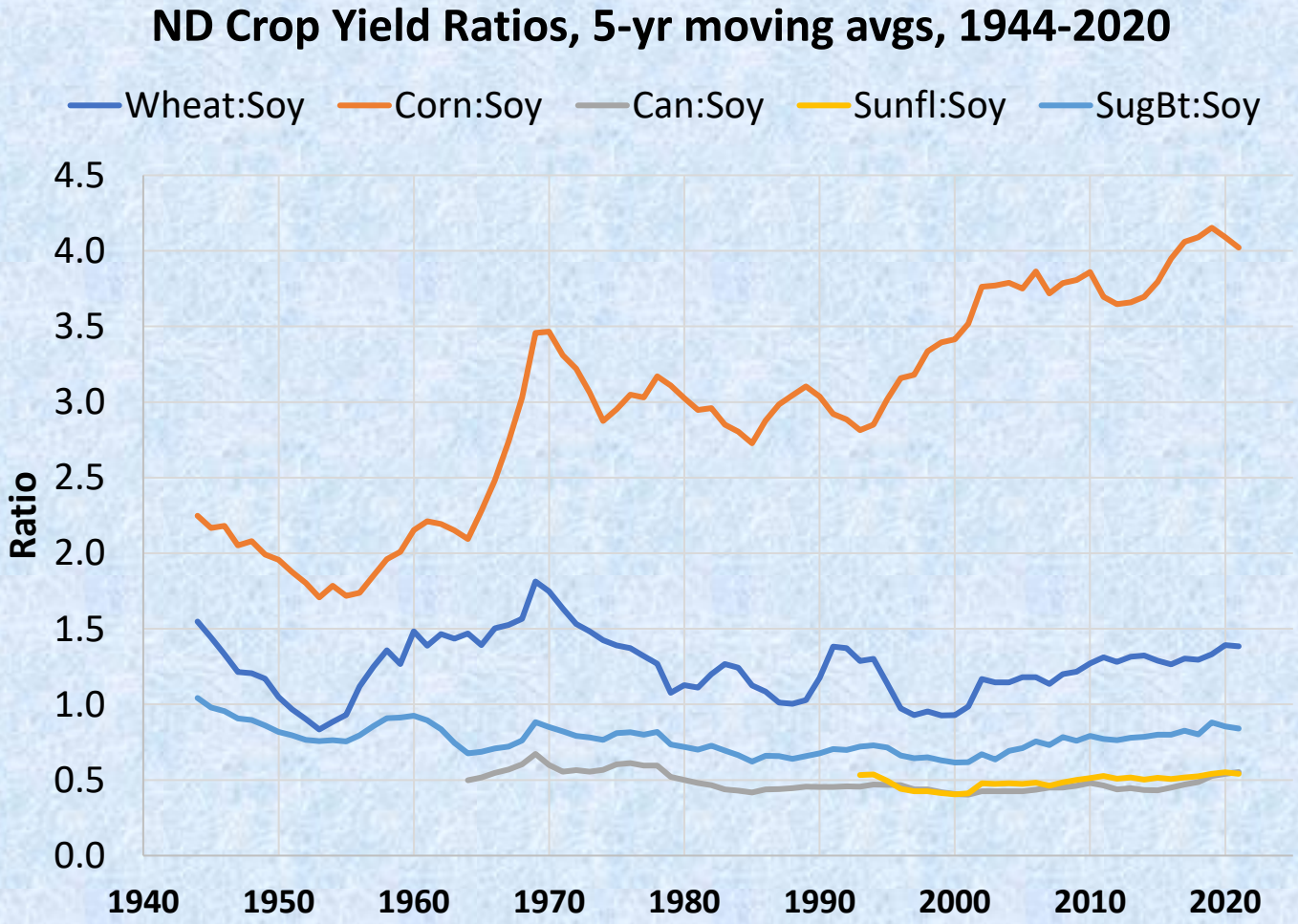

North Dakota Crop Acreages, 1995-2023
Wheat
Corn
Soybean
Sunflower
Canola
Millions of acres harvested
0
2
4
6
8
10
12
14
1995
2000
2005
2010
2015
2020
2025

North Dakota Crop Yields, 1985-2023

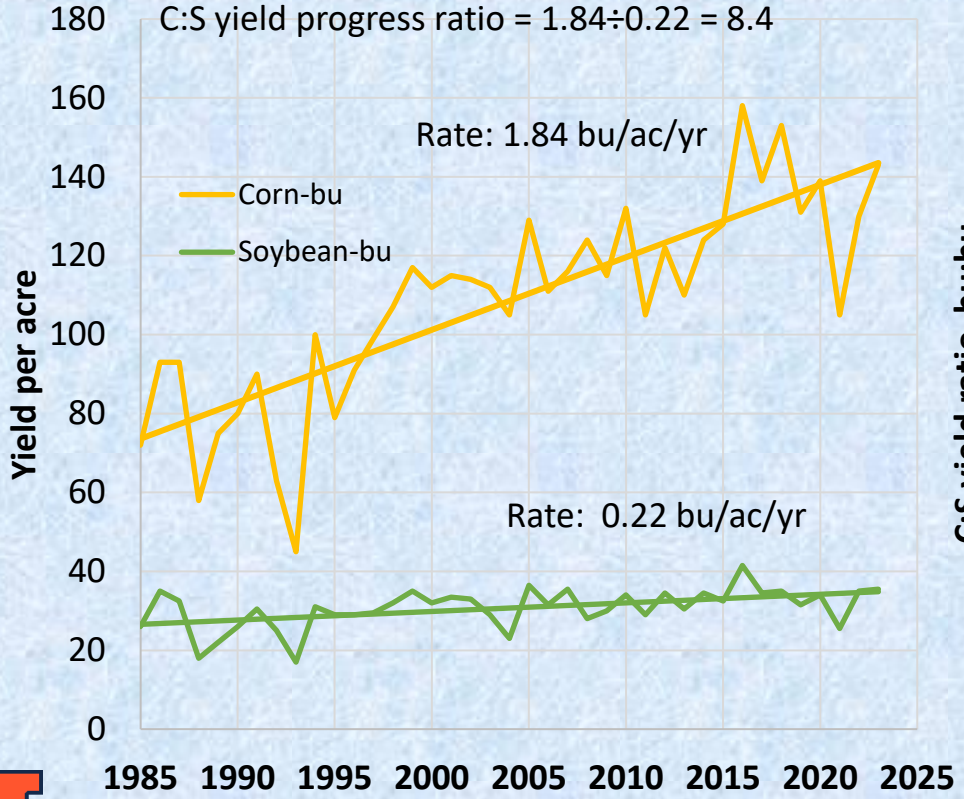


A rising X:Soy yield ratio indicates a lowering of soybean yield compared to yield of X

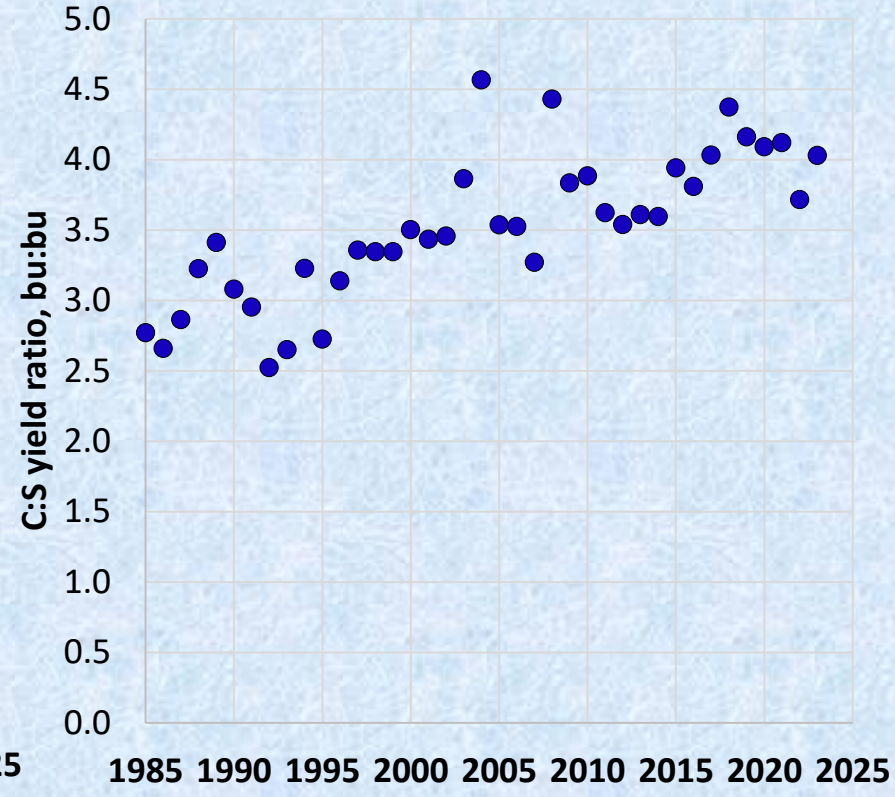
This only applies to yield, not to economic returns



North Dakota Corn & Soybean Yields, 1985-2023

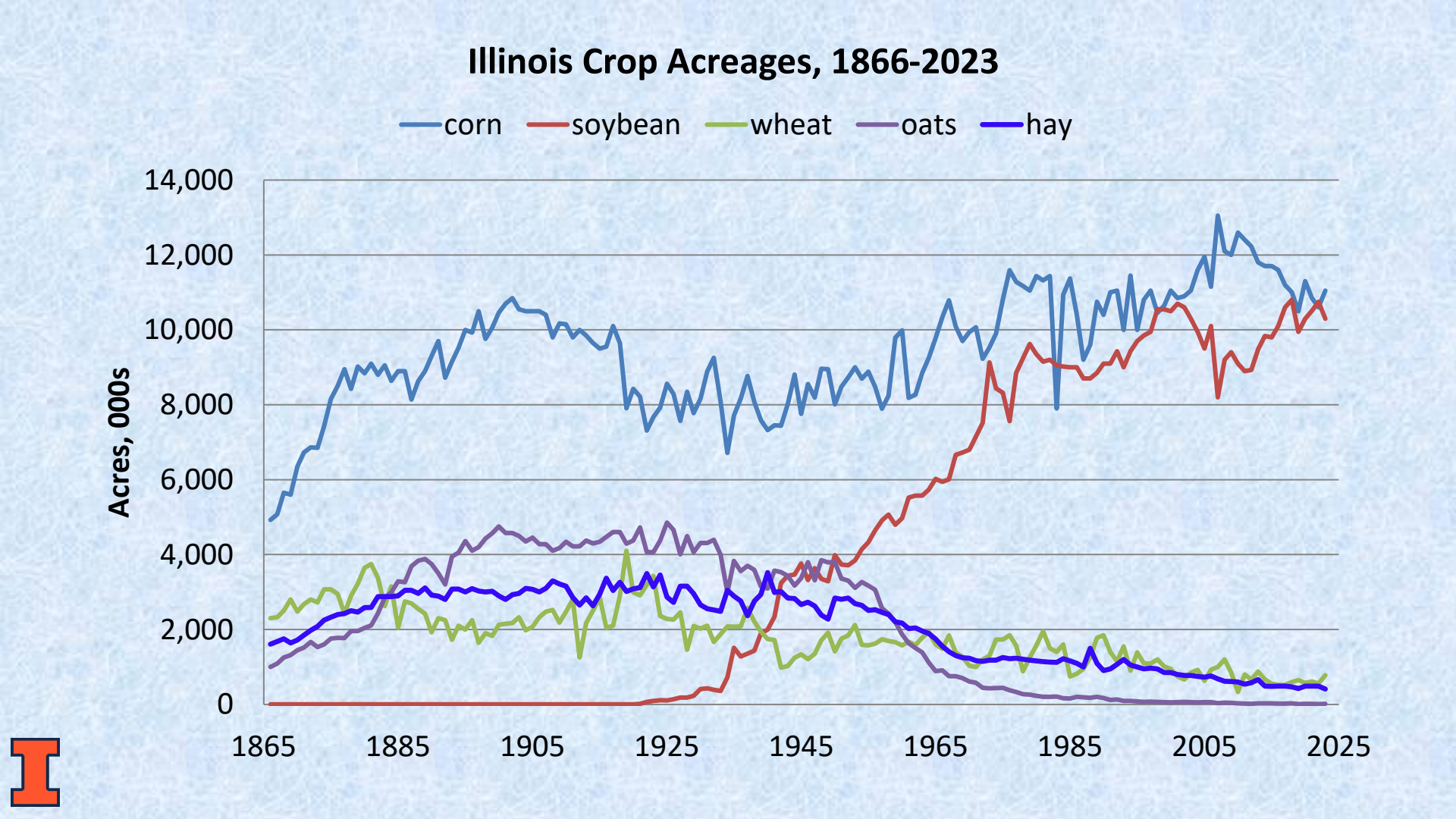


ND Corn:Soybean Yield ratio, 1985-2023

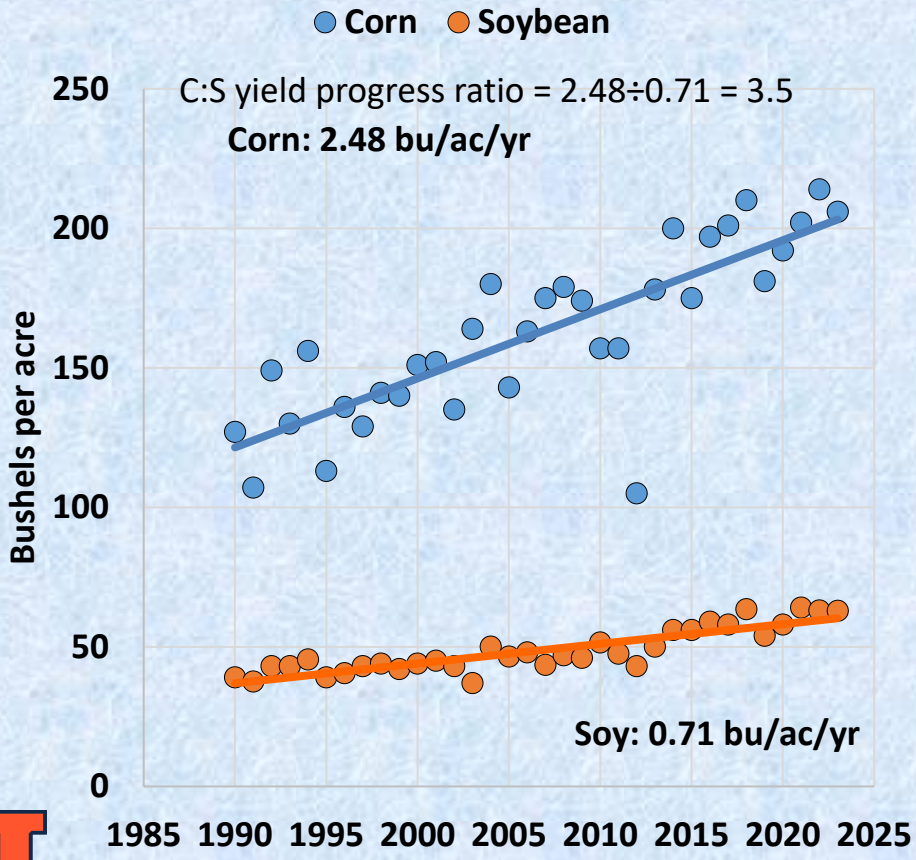


Is the soybean “honeymoon” over with in ND?

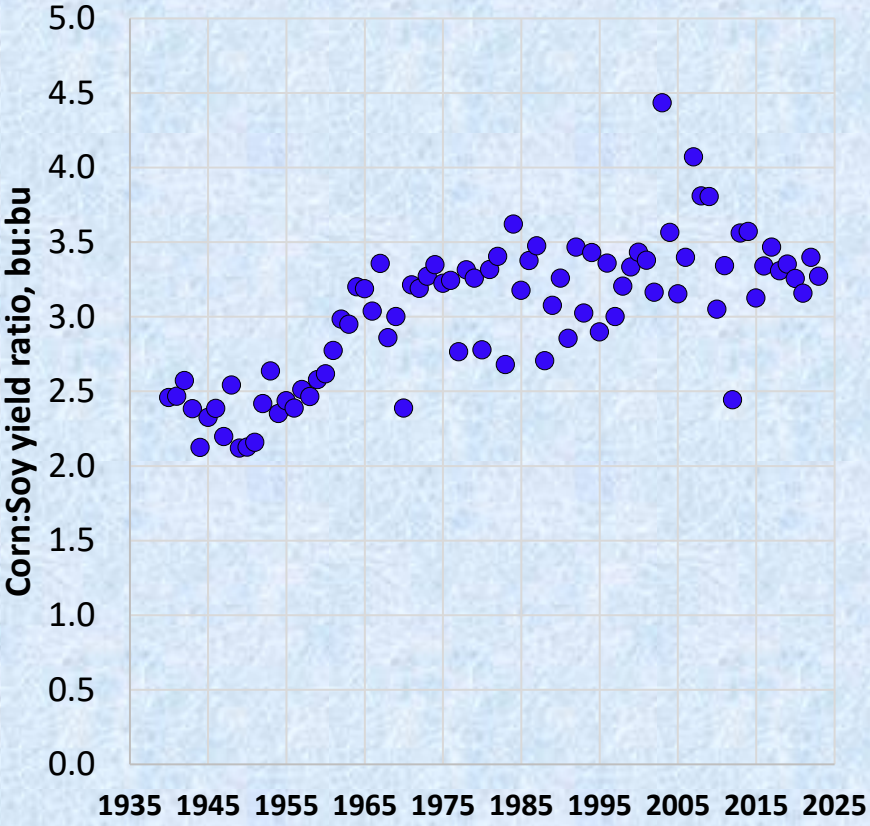
- It may be more accurate to say that there never was one – soybean came in as a “disease solution” to replace wheat
- Soybean mostly replaced wheat, which does not “share seasons” with soybean like corn does
- It is clear that the yield ratio of corn to soybean in ND has been unfavorable to soybean – soybean yield have increased more slowly than corn yields
- But a lot of soybeans in the world grow in areas where they do not yield especially well, because they present an opportunity for more profit or stability than alternative crops – the idea of **“comparative advantage”**


Illinois Crop Acreages, 1866-2023
corn
soybean
wheat
oats
hay
Acres, 000s
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1865
1885
1905
1925
1945
1965
1985
2005
2025

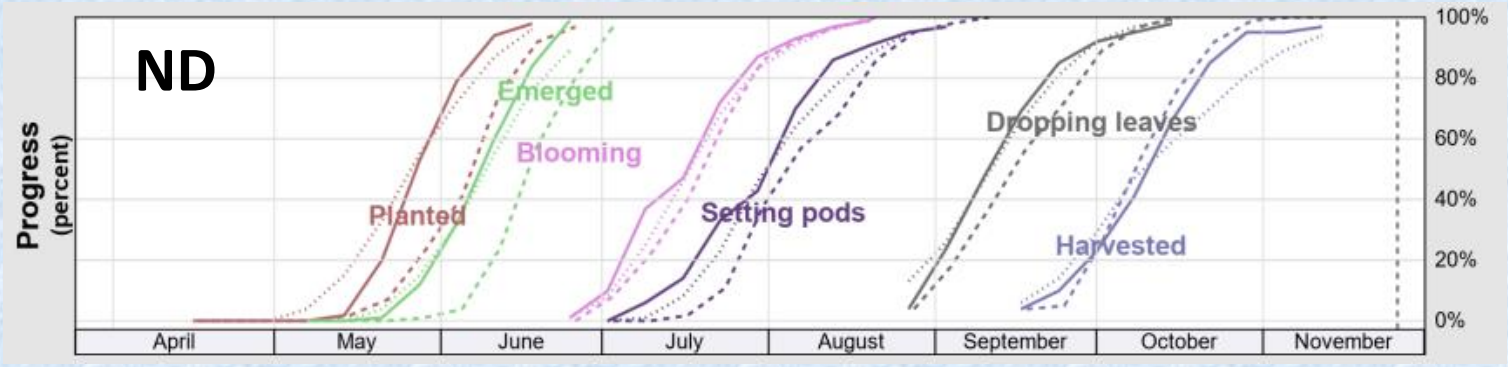
Illinois yields, 1990-2023

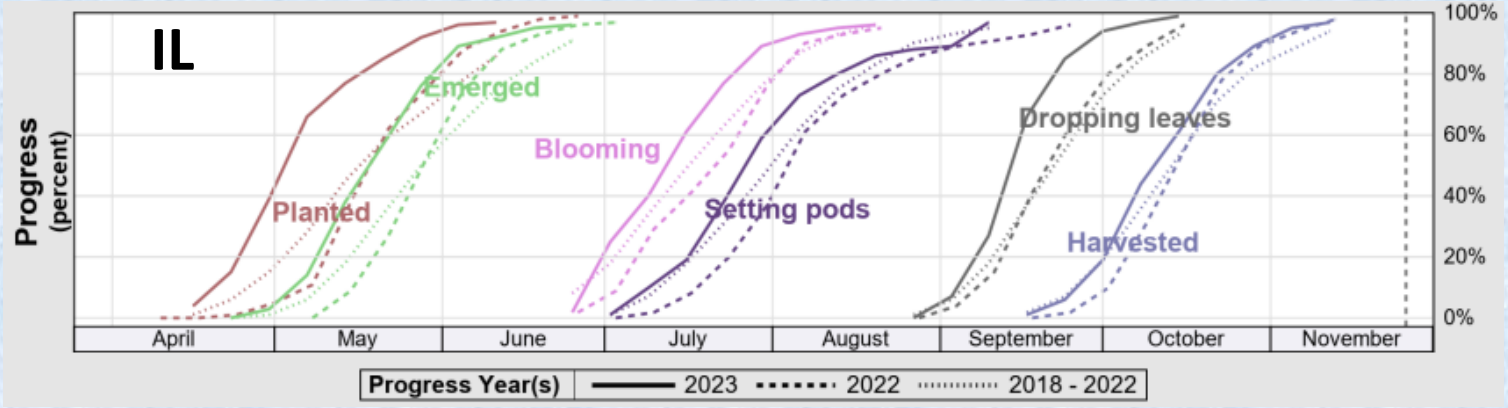


Corn:Soybean Yield Ratio, Illinois, 1940-2023



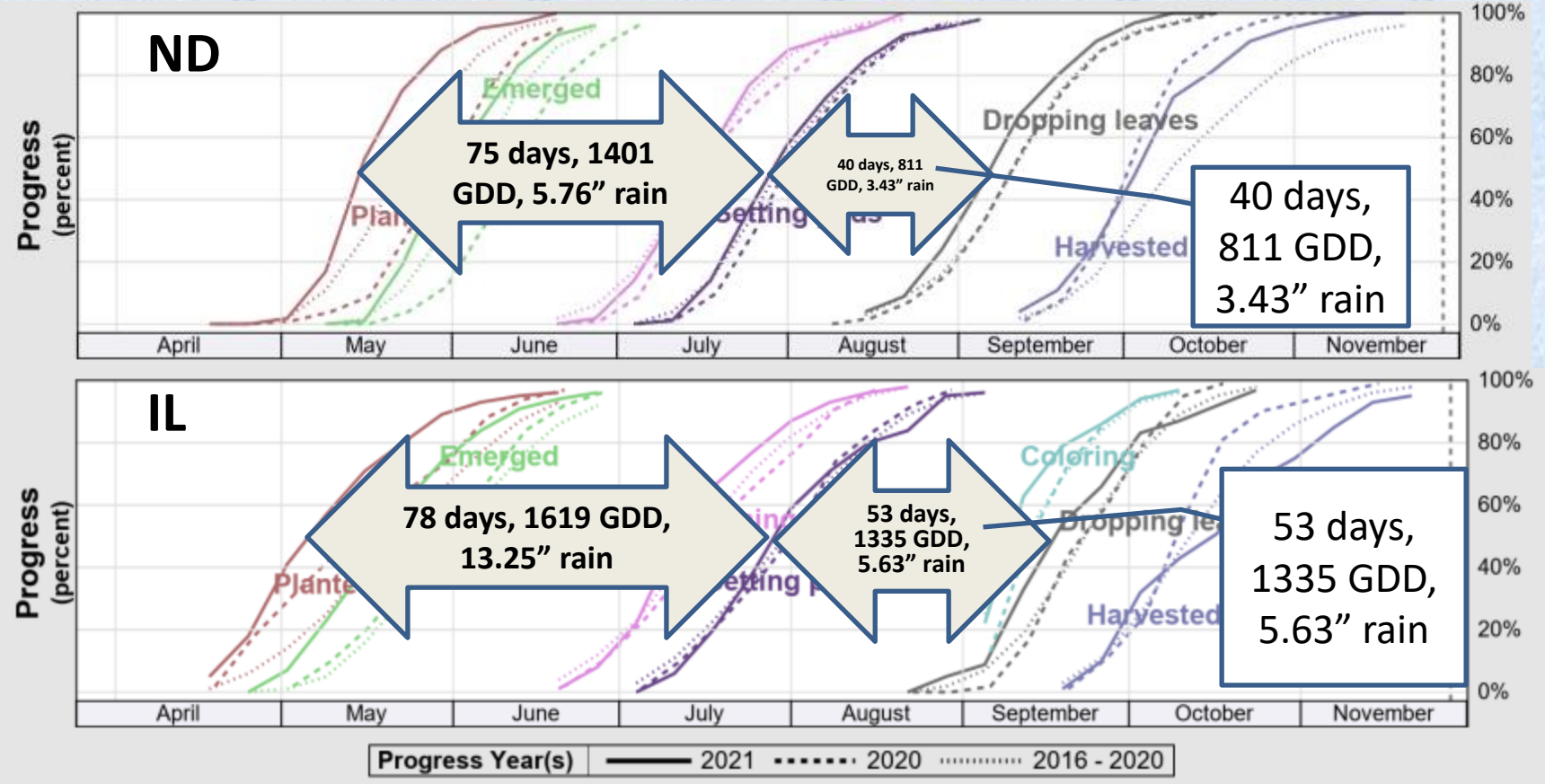
Seasonal differences between N Dakota and Illinois
The following are from NASS Crop Progress reports





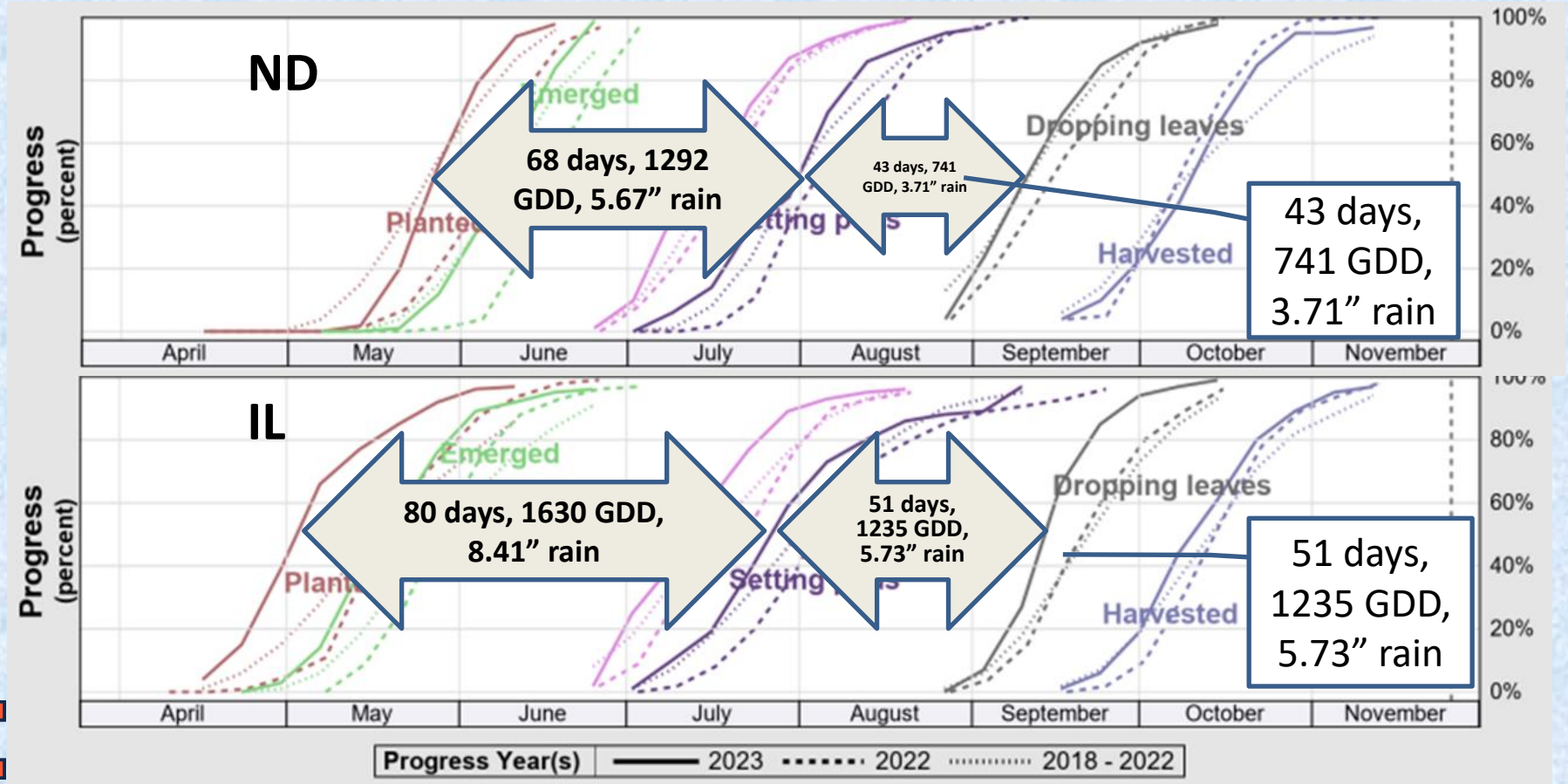
In 2021, ND avg soy yield = 29.2; IL avg soybean yield = 64 bu/ac

Seedfilling rates: ND – 0.73 bu/d, 0.036 bu/GDD; IL – 1.21 bu/d, 0.048 bu/GDD



In 2023, ND avg soy yield = 35.5; IL avg yield 63 bu/acre

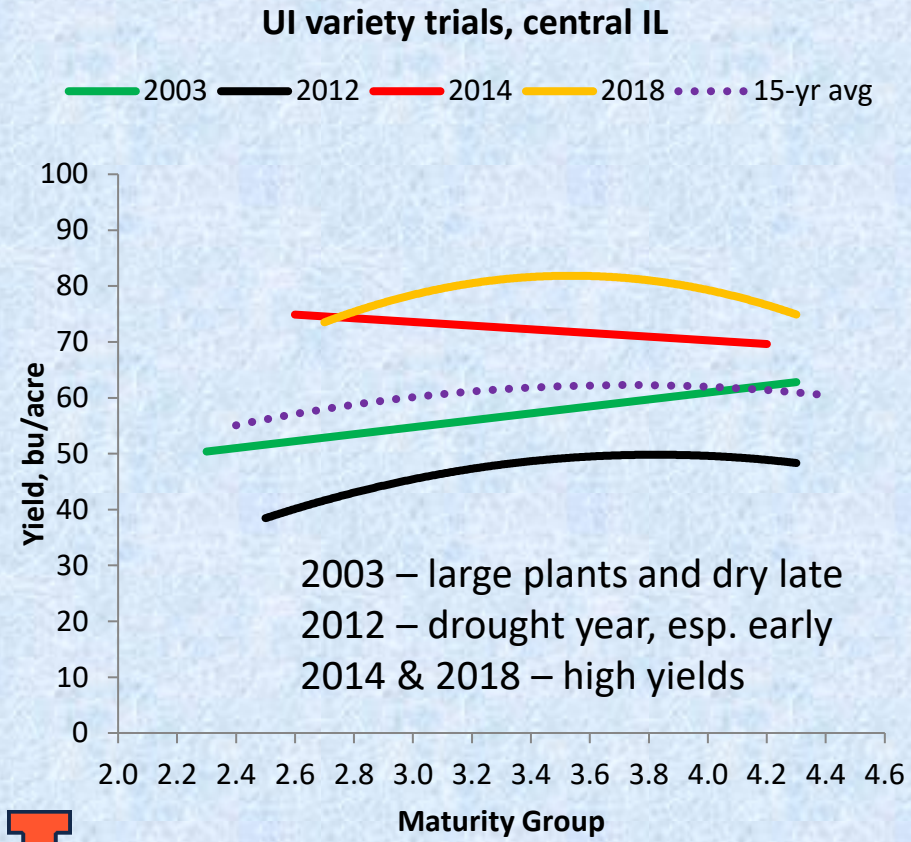
Seedfilling rates: ND – 0.83 bu/d, 0.048 bu/GDD; IL – 1.24 bu/d, 0.051 bu/GDD



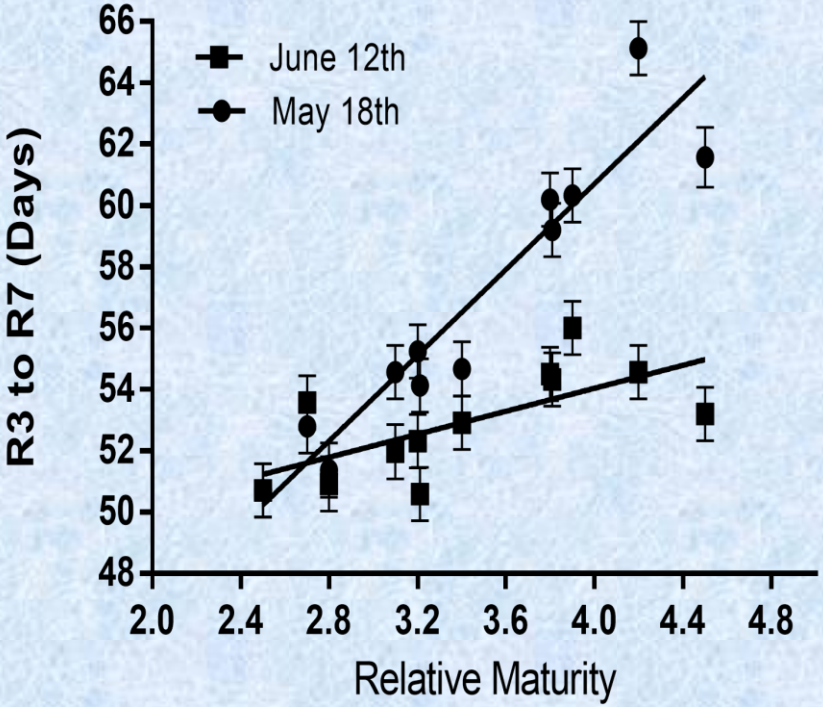
Seasonal differences between ND and IL

- Soybean planting is typically (but not always) several weeks earlier in IL than in ND
- May 1-Sept 15 avg temperature is 63.6 in ND and 70.9 in IL
- May 1-Sept 15 normal rainfall is 11.2” in ND(about 1 inch higher than this in eastern ND) and 17.3” in IL
- The contrast between 2021 and 2023 does not identify clear weather-related reasons for yield differences among seasons in ND, although rainfall pattern may have differed
- The contrast between Illinois and ND shows higher yield accumulation rates during seedfilling in IL, and a shorter seedfilling period in ND (20% fewer days, 40% fewer GDDs)

Can varietal maturity help with stress?

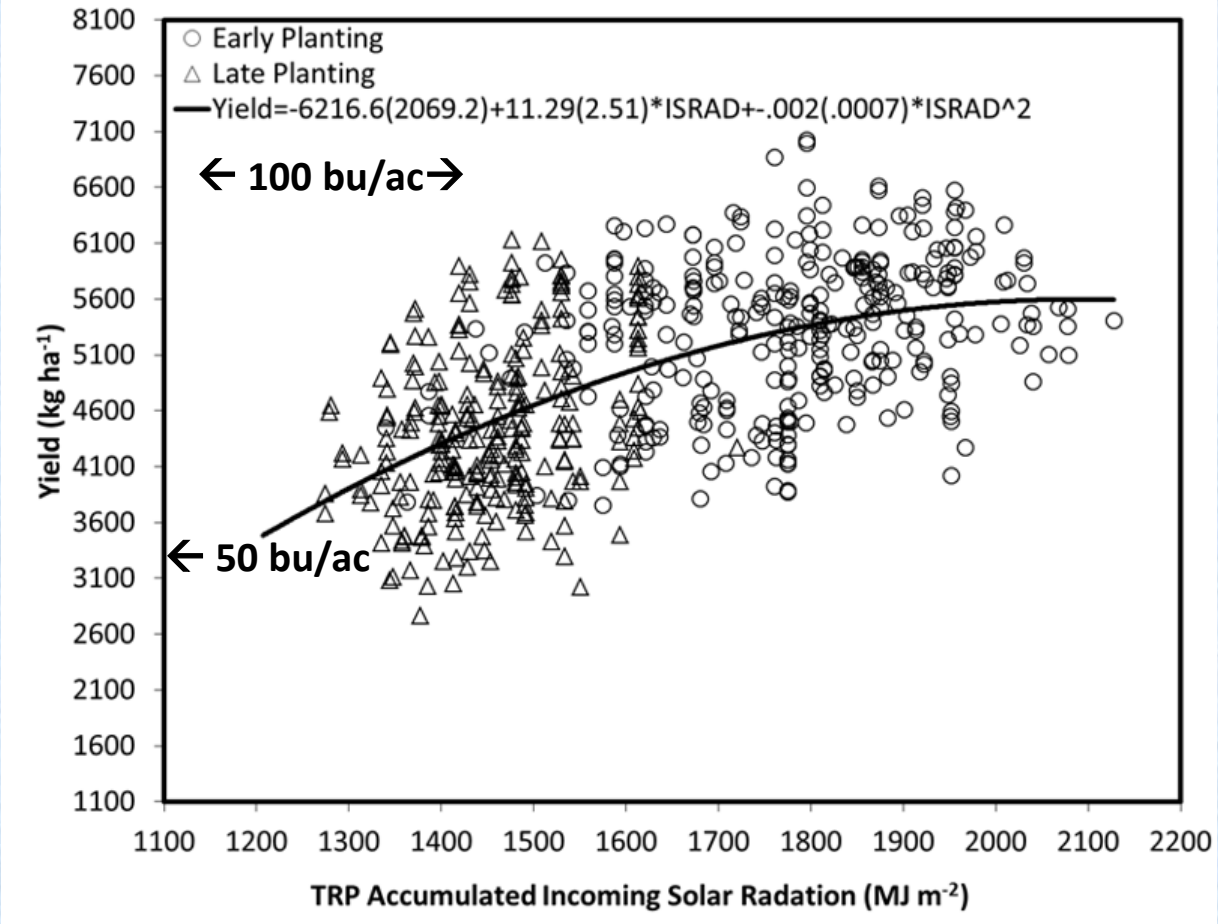


We have evidence that lengthening seed-filling period can boost yield:
planting longer-maturity soys early sometimes helps



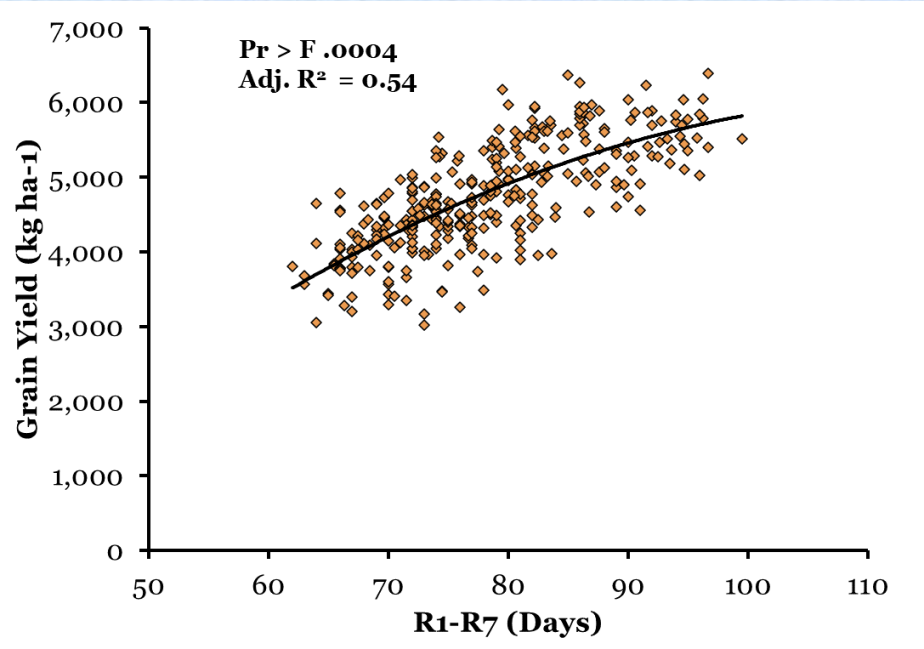
From a large MG x planting date study in IL and IA

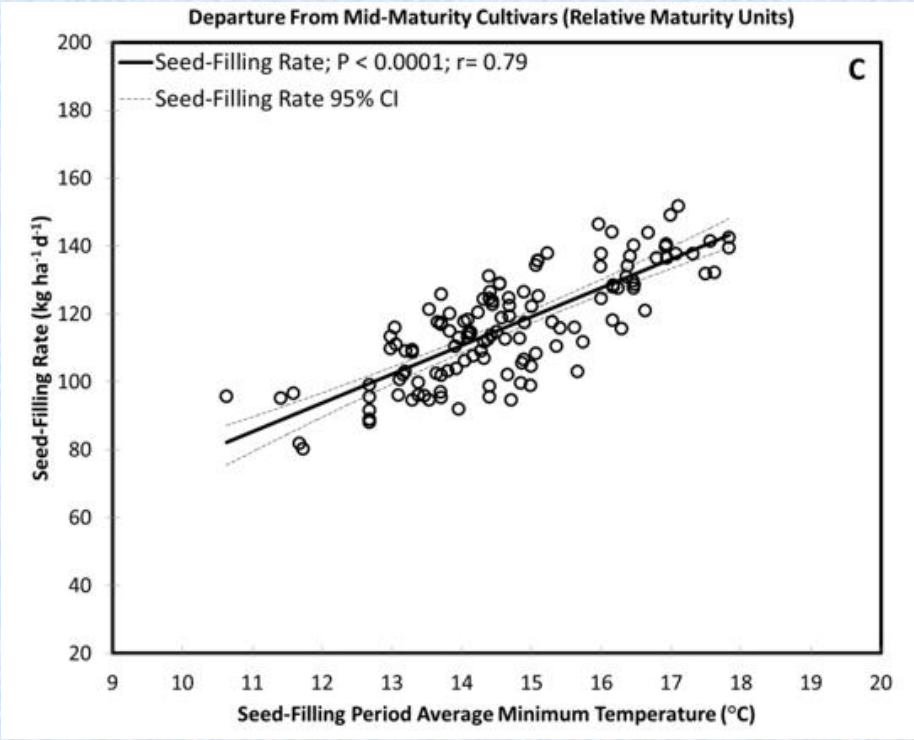
More light intercepted by the canopy meant more yield, up to a certain point. Reaching that point required early planting in this set of trials



More from the same study

More days from flower to maturity can help yields, if they are “good” days



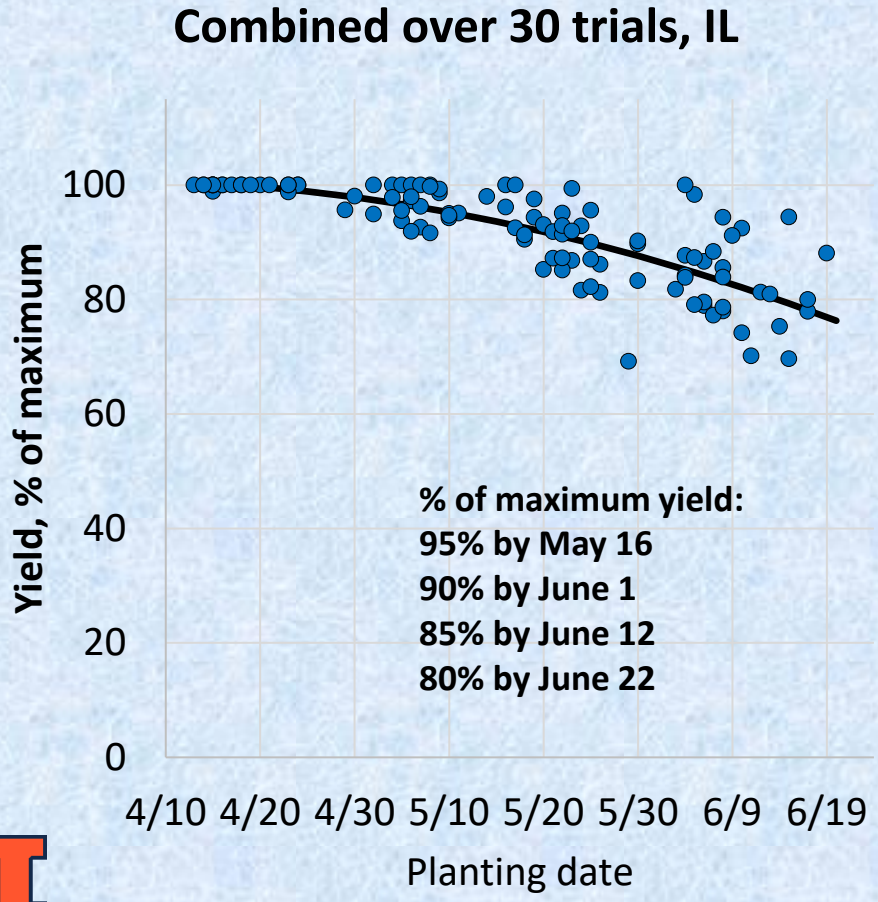


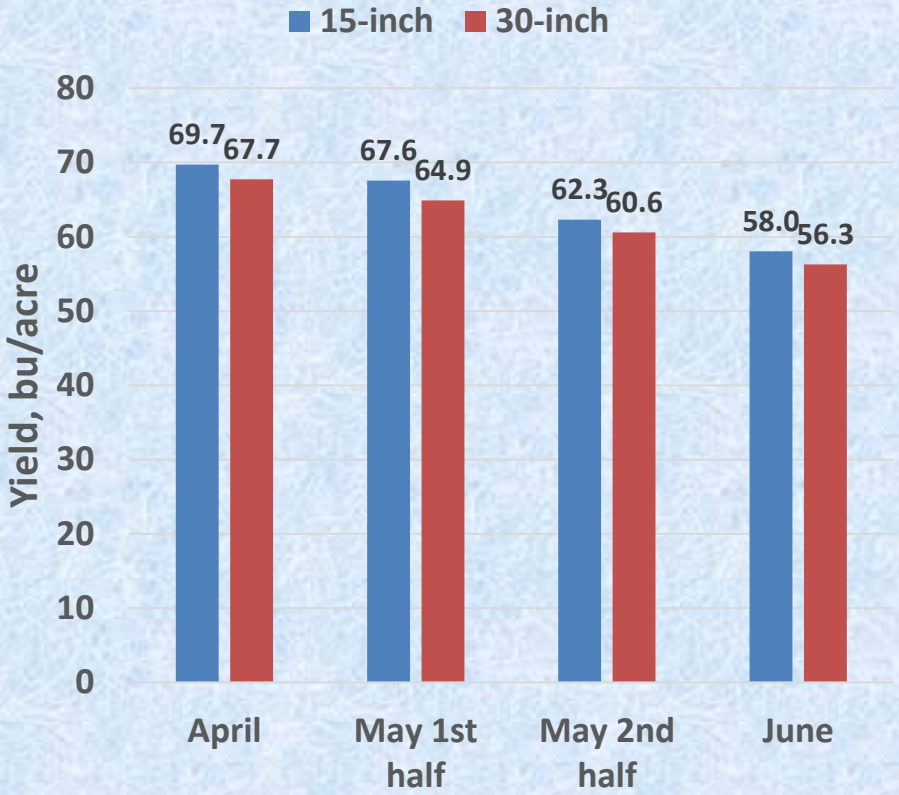
Low nighttime temperature during seedfill can be stressful (lower seedfilling rate)

Soybean varieties in ND

- NDSU variety trial data are hard to access, but some impressions:
  - Trial average yields vary widely, from 50 to 150% of state average yields
  - Among entries in some trials, the highest yield is as much as double the lowest yield
  - Sites with irrigated trials tend to have good yields in rainfed trials as well (at least in good years)
  - There seems to be little correlation between MG and yield in most trials; this may be because only a narrow range of maturities makes sense in the region
  - Is it hard for producers to choose “best” varieties; do any end up with “dogs”?

Planting date and row spacing



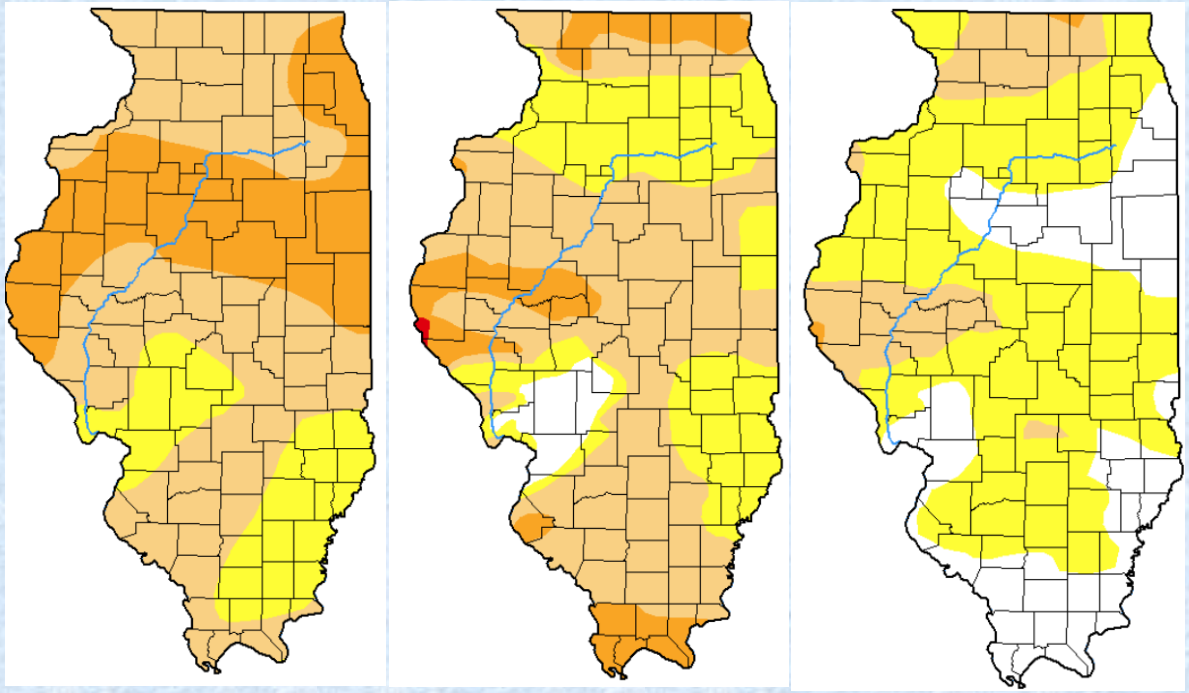


Average response to 15” rows: + 2.0 bu/ac

No effect of planting date on response to narrow rows

Dry weather and soybeans in 2023

June 27 | July 18 | August 15



Soybeans added nodes and pods in August, then filled them.

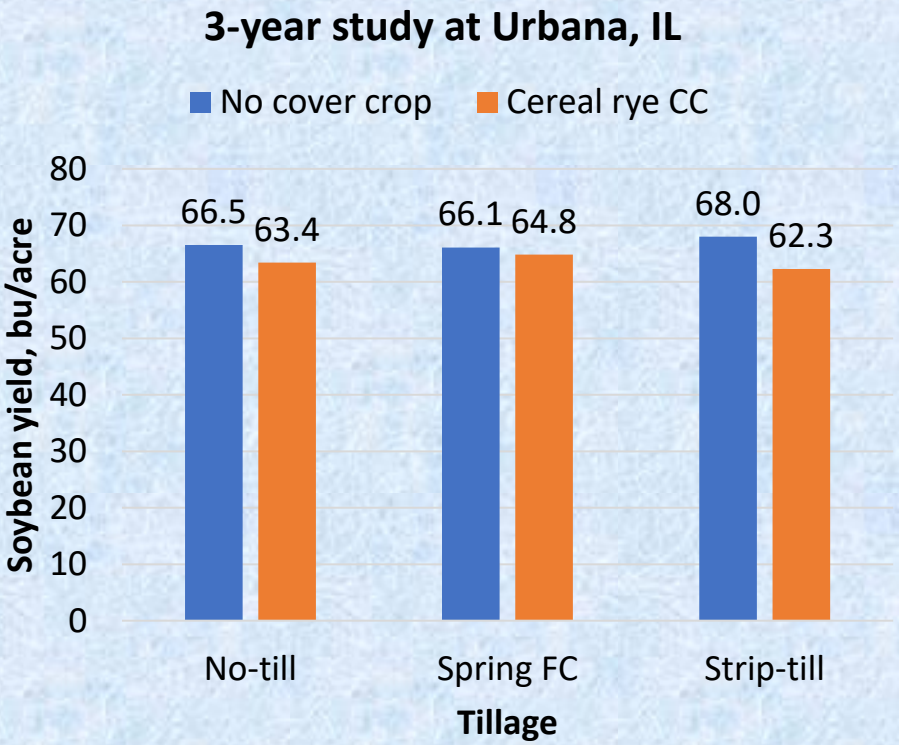
Stress and soybeans today

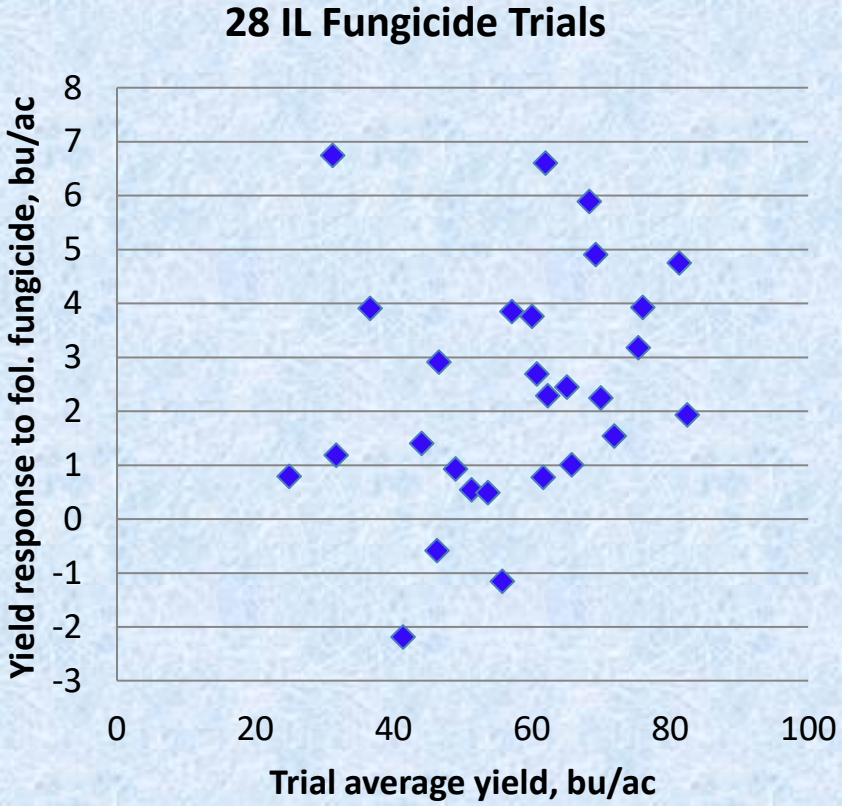
- We still define “stress” as anything that lowers soybean photosynthesis on a given day, but how stress affect yield may have changed
  - We can get good yields without planting super-early
  - Soybeans that get nowhere near to having a “complete canopy by the time flowering begins” can still yield very well
  - Moderately dry weather during vegetative development helps roots develop and may lower seedling and foliar diseases
- Most importantly, “relentless breeding for yield” has resulted in higher photosynthetic rate and faster growth:
  - Better roots (nutrient uptake), active nodules, and ability to persist even if vegetative development is delayed
  - Larger plants means more N storage in leaves by the start of podfill (R5) and higher yield potential
  - Good ability to retain pods and fill seeds

Stress and soybeans today

- STILL, there are no miracles in the soybean field: dry periods need to be relieved by rain in order for soybeans to reach their full potential
- We did find that “dinging soybeans on purpose” (with herbicide) is more likely to lower than to increase yield
- Due to their indeterminate growth habit (flowering and adding nodes at pods at the same time), soybeans are inherently more tolerant to periods of drought than corn, but dry soil and high temperatures can still lower yields a lot
- There are not a lot of management practices that effectively and consistently lower stress effects

Stress relievers?

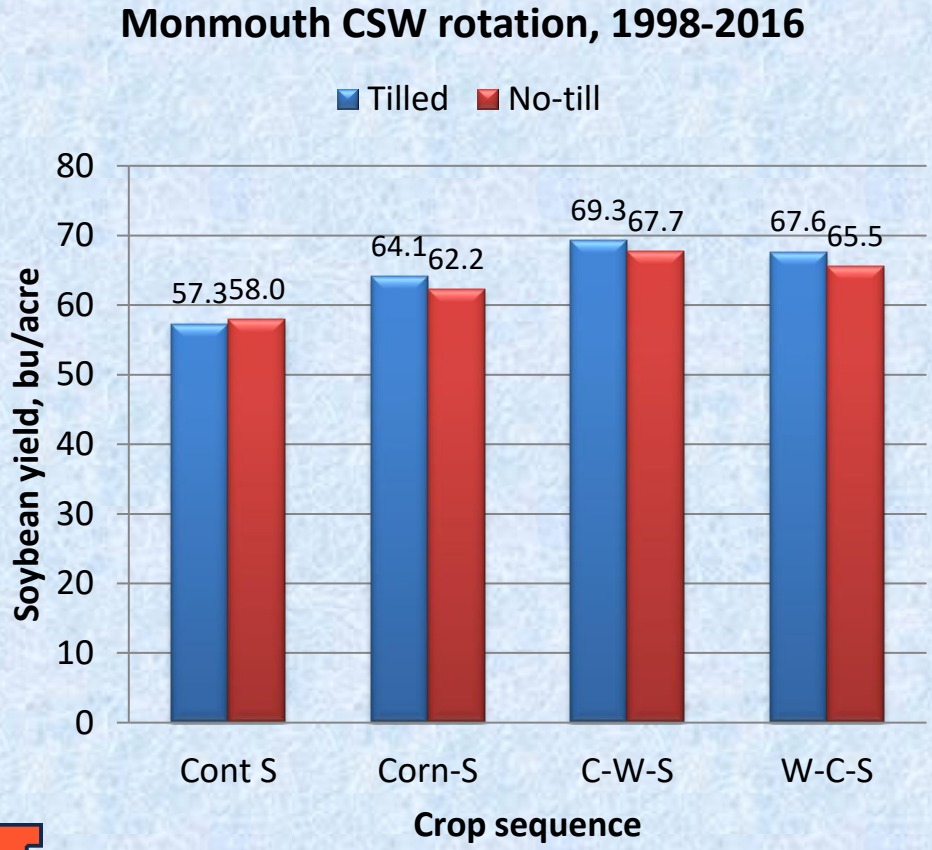


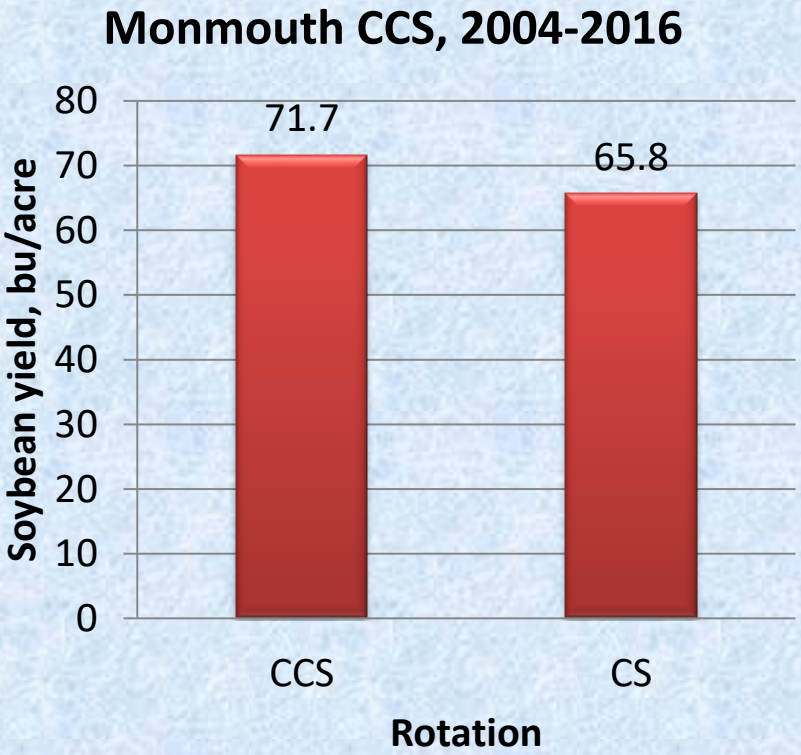


More loss form CC in NT and with dry soil

Significant response at 11 of 28 sites
Average response 2.4 bushels

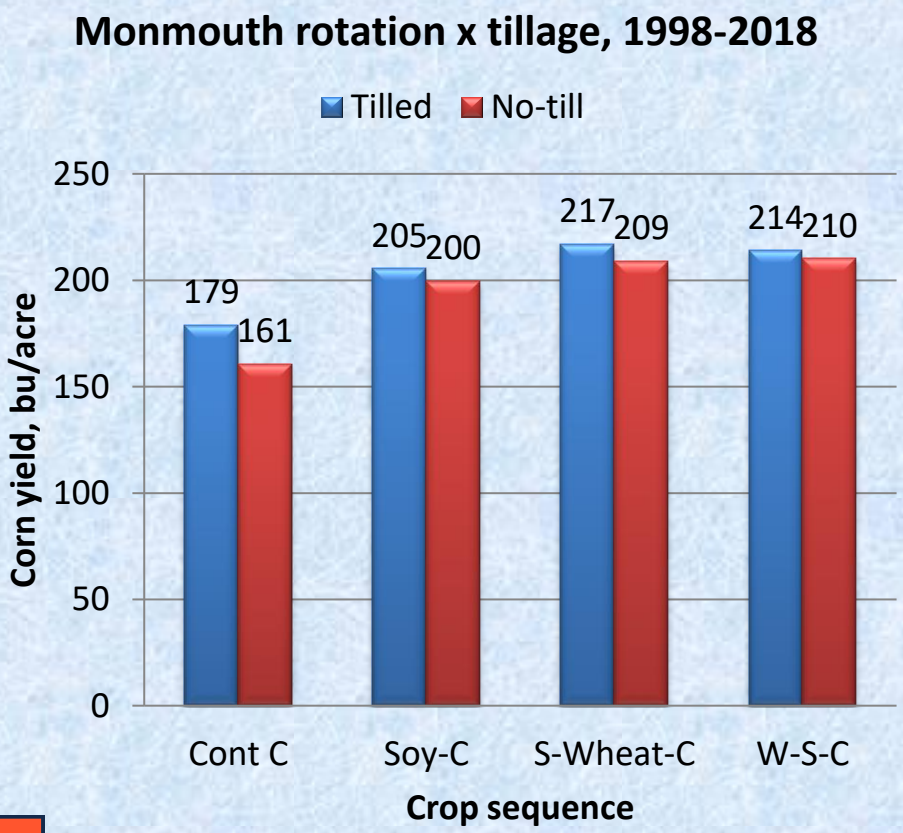
Rotation

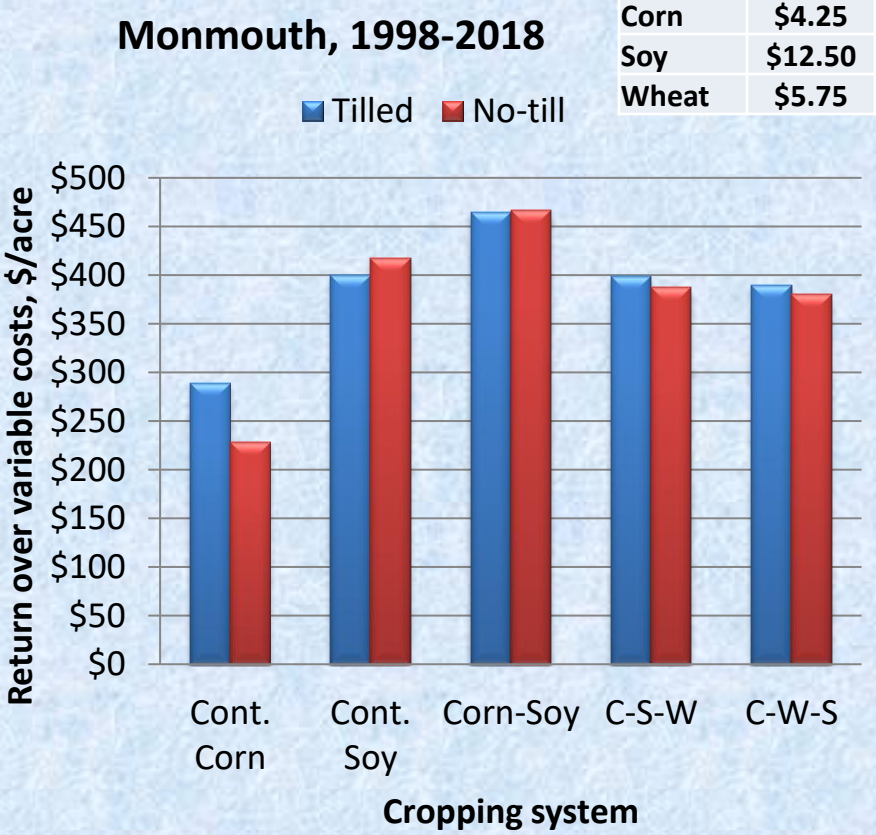

Monmouth CSW rotation, 1998-2016
Tilled
No-till
Soybean yield, bu/acre
80
70
60
50
40
30
20
10
0
57.3
58.0
64.1
62.2
69.3
67.7
67.6
65.5
Cont S
Corn-S
C-W-S
W-C-S
Crop sequence


Monmouth CCS, 2004-2016
Soybean yield, bu/acre
80
70
60
50
40
30
20
10
0
71.7
65.8
CCS
CS
Rotation

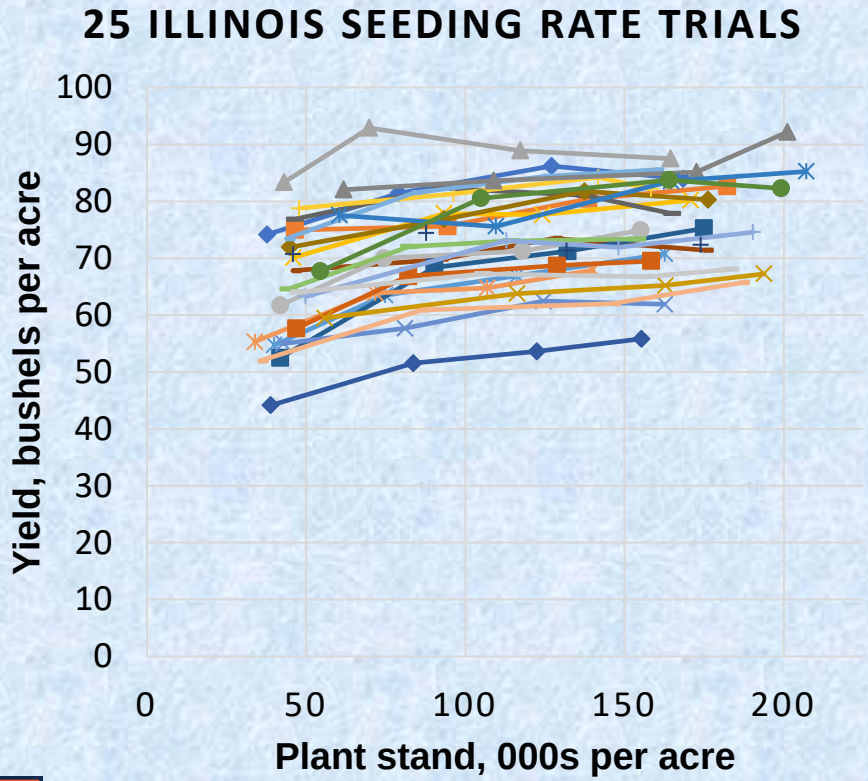
Rotation – a corn-soybean rotation is beneficial for both crop

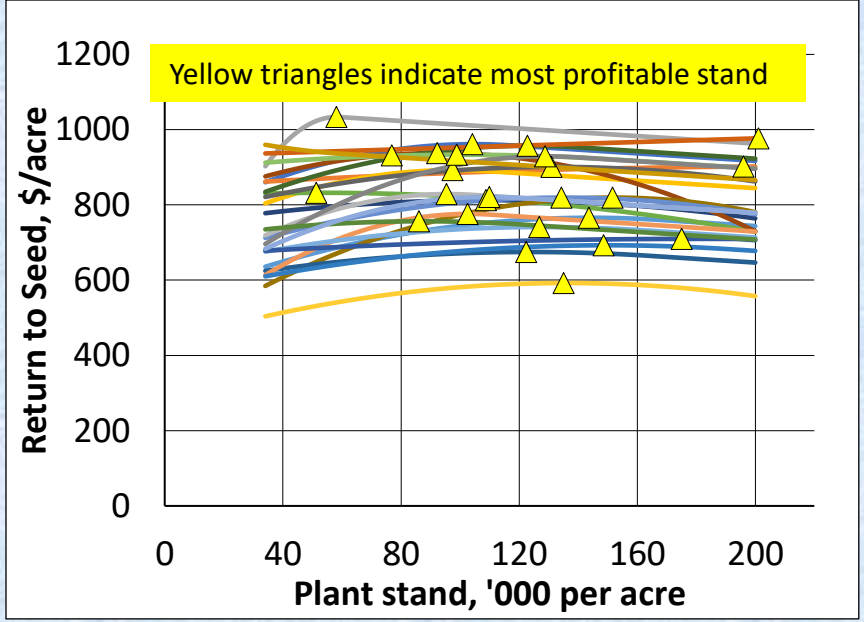
Price	$/bu
Corn	$4.25
Soy	$12.50
Wheat	$5.75

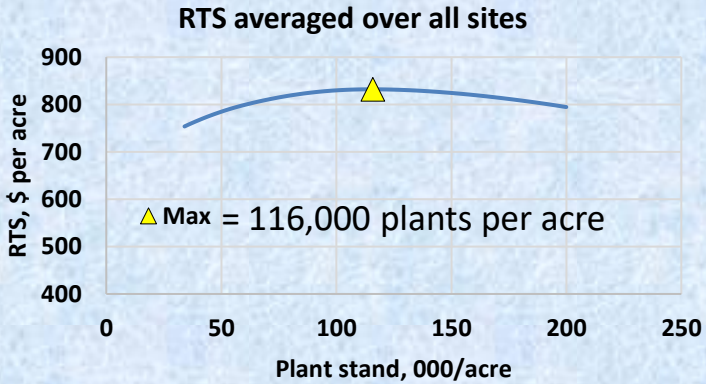




Do we need lower soybean seeding rates?







2023 Budgets, NDSU — East Central ($70 land charge)

	HRSW	Corn	Soybean	Canola
Yield	54	141	34	1660
Price	$ 8.08	$ 5.25	$12.25	$ 0.26
Revenue	$436	$740	$417	$433
Direct costs	$265	$436	$191	$279
Fixed costs (incl land)	$118	$148	$117	$118
Total costs	$383	$584	$308	$398
Return to labor & mgt	$53	$156	$109	$36

2023 Budgets, NDSU — South Valley ($132 land chg

	HRSW	Corn	Soybean
Yield	63	168	40
Price	$ 8.17	$ 5.25	$12.37
Revenue	$515	$882	$495
Direct costs	$294	$488	$200
Fixed costs (incl land)	$184	$211	$180
Total costs	$478	$699	$380
Return to labor & mgt	$37	$183	$115

2023 Budgets, NDSU — South East ($100 land charge)

	HRSW	Corn	Soybean	Canola
Yield	58	163	40	1660
Price	$ 8.15	$ 5.25	$12.33	$ 0.26
Revenue	$473	$856	$493	$423
Direct costs	$266	$469	$198	$273
Fixed costs (incl land)	$148	$177	$146	$148
Total costs	$414	$646	$344	$422
Return to labor & mgt	$59	$210	$149	$1

Illinois - FBFM — Central IL HP

	Corn	Soybean
Yield	222	69
Price	$ 5.00	$13.30
Revenue	$1,120	$918
Direct costs	$579	$295
Power & overhead	$259	$245
Total non-land costs	$808	$540
Operator & land return	$263	$378
Land cost (cash rent)	$363	$363
Operator return	-$100	$15

Back to comparative advantage

- Based on ND crop budgets, soybeans have maintained their potential as a profitable crop, even though yields are lower than in other places
- Global climate change is projected to be beneficial for soybeans north of 45° N latitude, and not beneficial for subtropical soybeans
- Assuming that corn will continue to occupy many of the fields that would be most productive to soybean, minimizing per-bushel costs for soybean will be critical to helping maintain this crop as an important one in ND

Thank you for your attention

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