Spring Fertilizer Management

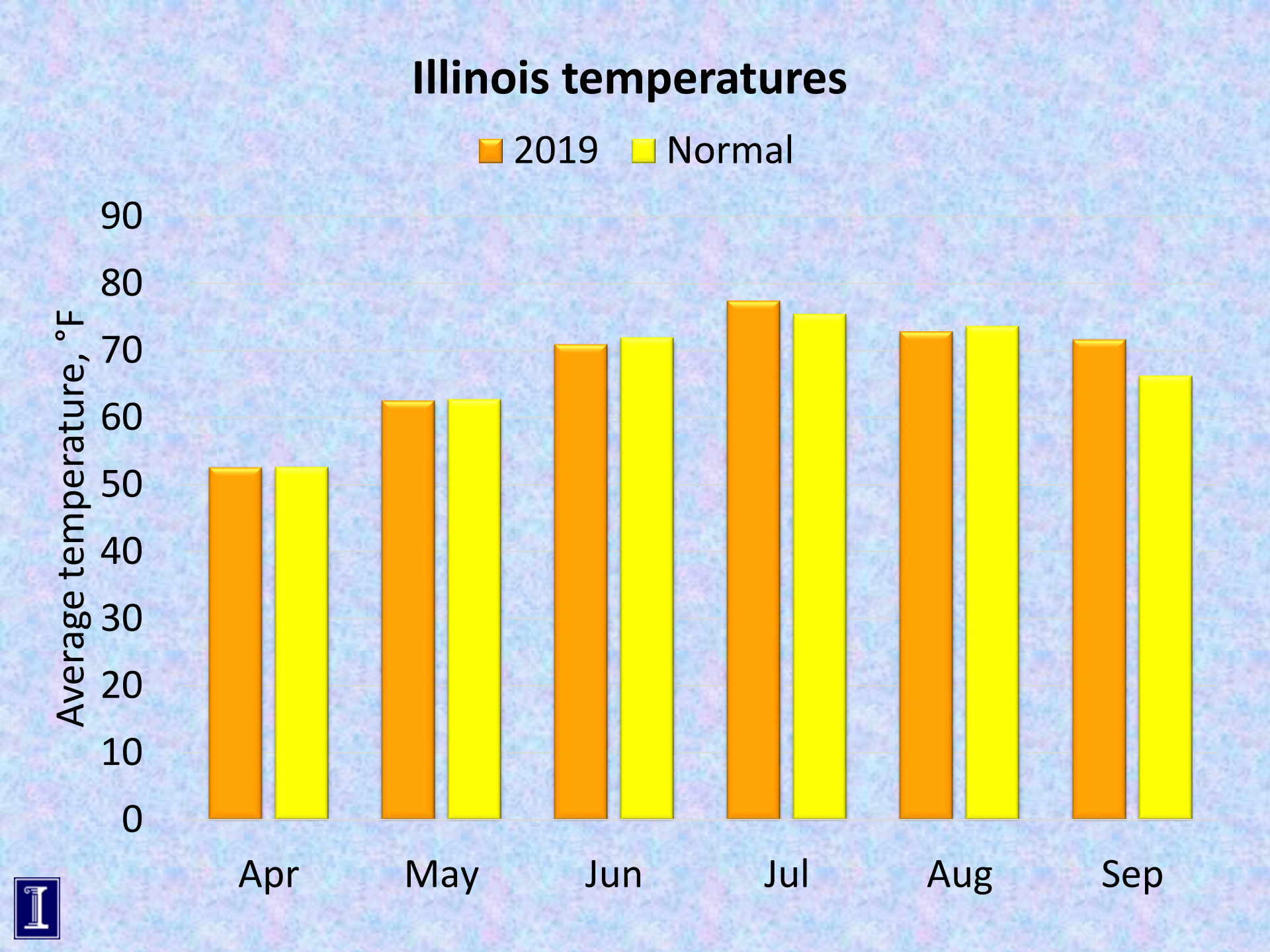
IFCA Webinar
March 20, 2020

ILLINOIS
Crop Sciences
COLLEGE OF AGRICULTURAL, CONSUMER & ENVIRONMENTAL SCIENCES

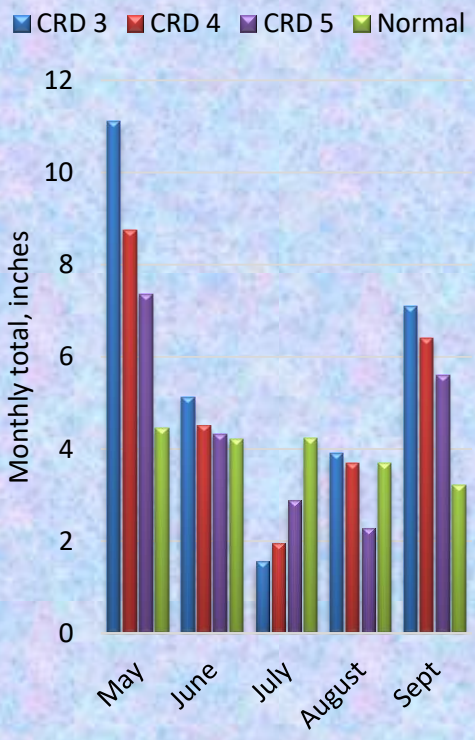
Emerson Nafziger
Crop Sciences
University of Illinois
ednaf@illinois.edu

The 2019 Illinois corn crop

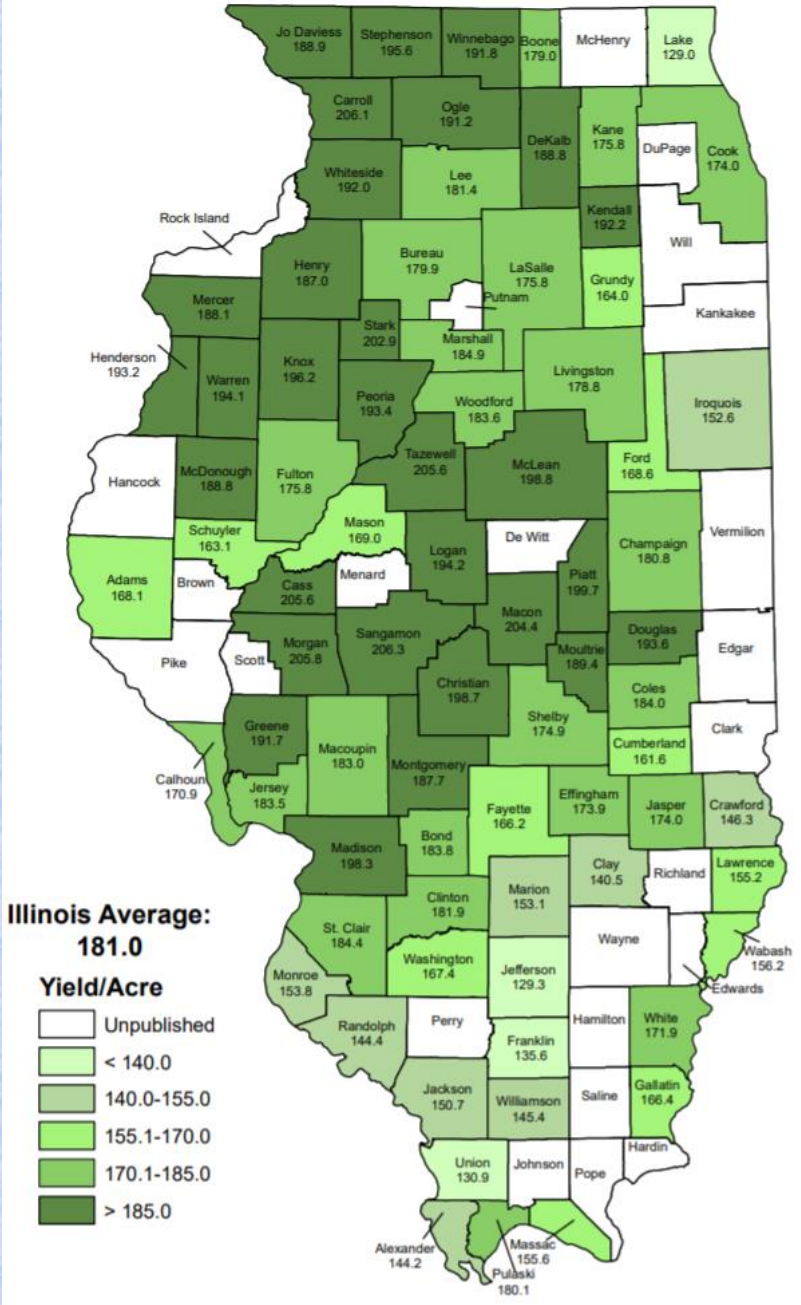
- Was the latest-planted on record due to high rainfall in May
  - ~10% planted in April; 32% in May; 58% in June, mostly in the first half of June
- Crop condition between 40 and 50% good+excellent all season (worst since 2012)
- Loss of GDDs partly made up in September, but harvest was late and grain moisture higher than normal
- Final yield estimate of 181 bushels per acre, 10 bushels below 30-yr trendline yield


Illinois temperatures
2019
Normal
Average temperature, °F
90
80
70
60
50
40
30
20
10
0
Apr
May
Jun
Jul
Aug
Sep

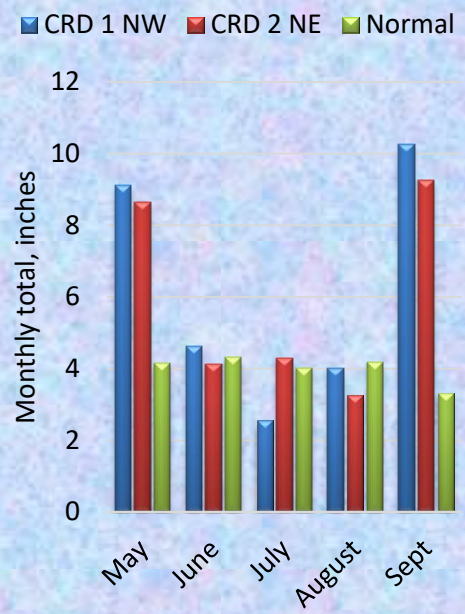
Central Illinois rainfall 2019



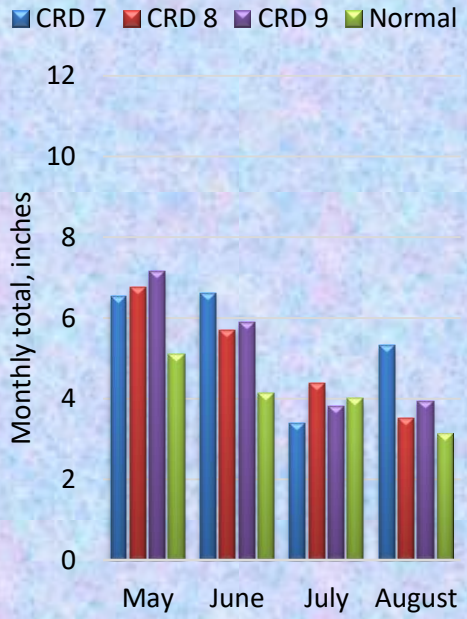
2019 Illinois Corn Yield Estimates



Northern Illinois rainfall 2019



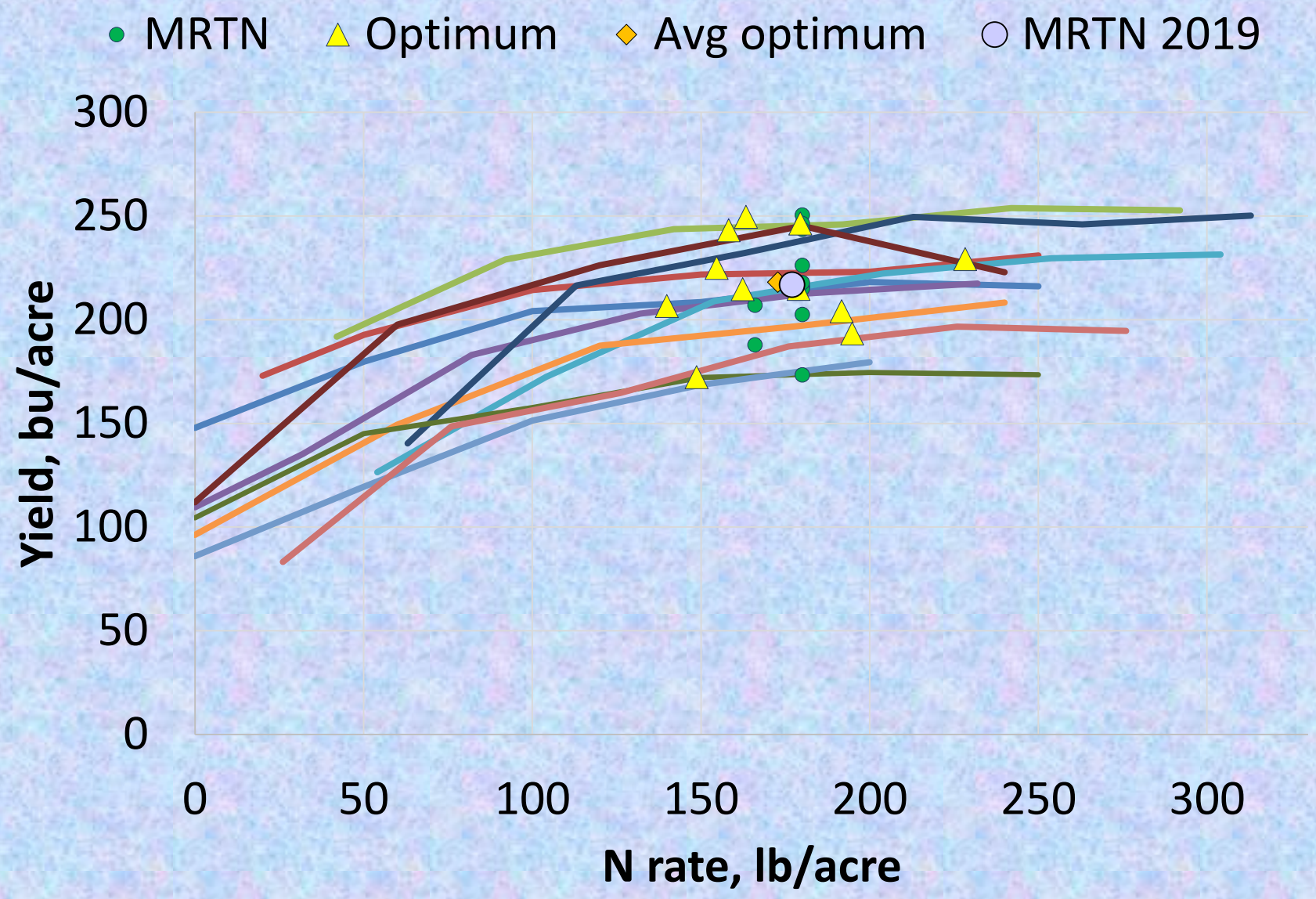
Southern Illinois rainfall 2019



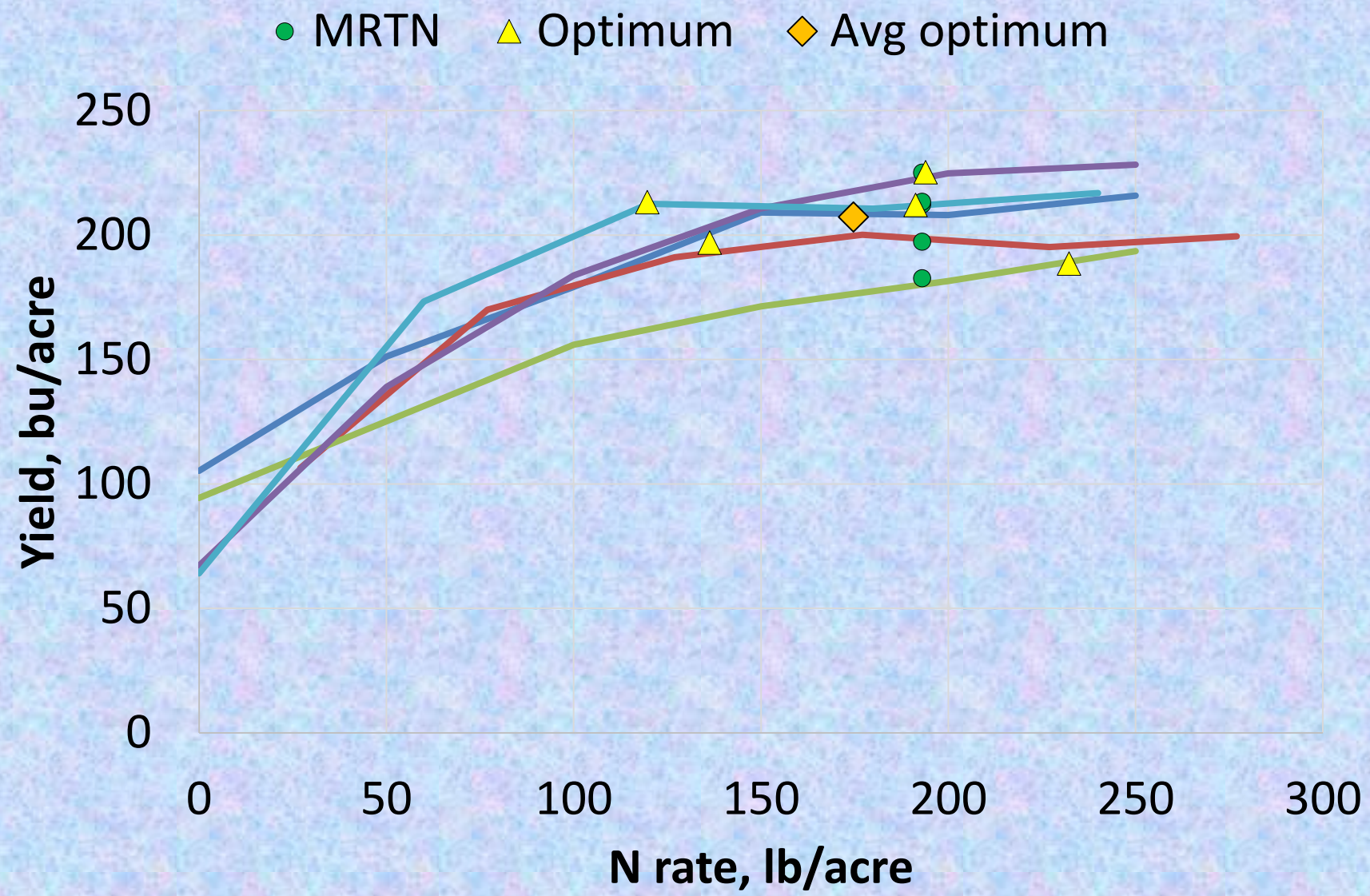
Guiding principles for N management:

- N rate is the first consideration
- The crop needs a good supply of N for early growth, and in lower-OM soils or cool soils, this needs to come mostly from fertilizer
  - If no N can be been applied before planting, some N (at least 40-50 lb, depending on placement) should be applied into the rooting zone at or soon after planting, and the remaining as in-season
- Applying some N up front and the rest in-season is often logistically sound, but:
  - It may not often increase yields compared to all-early N
  - Planning for multiple in-season applications (spoon-feeding) is not likely to be cost-effective

11 trials, Soy-Corn, Cent./No. IL, 2019



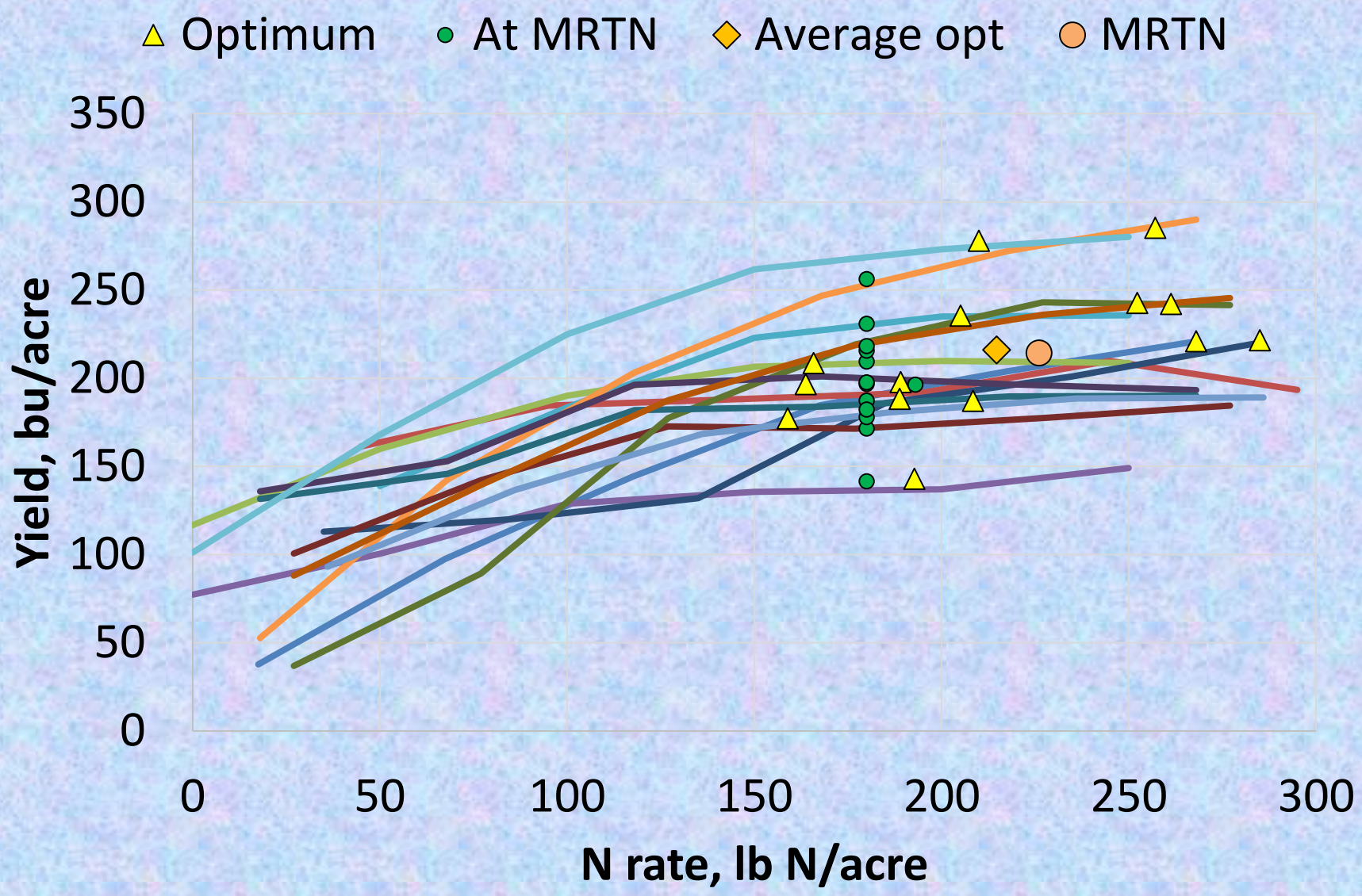
5 N trials, Central IL, Corn-Corn 2019



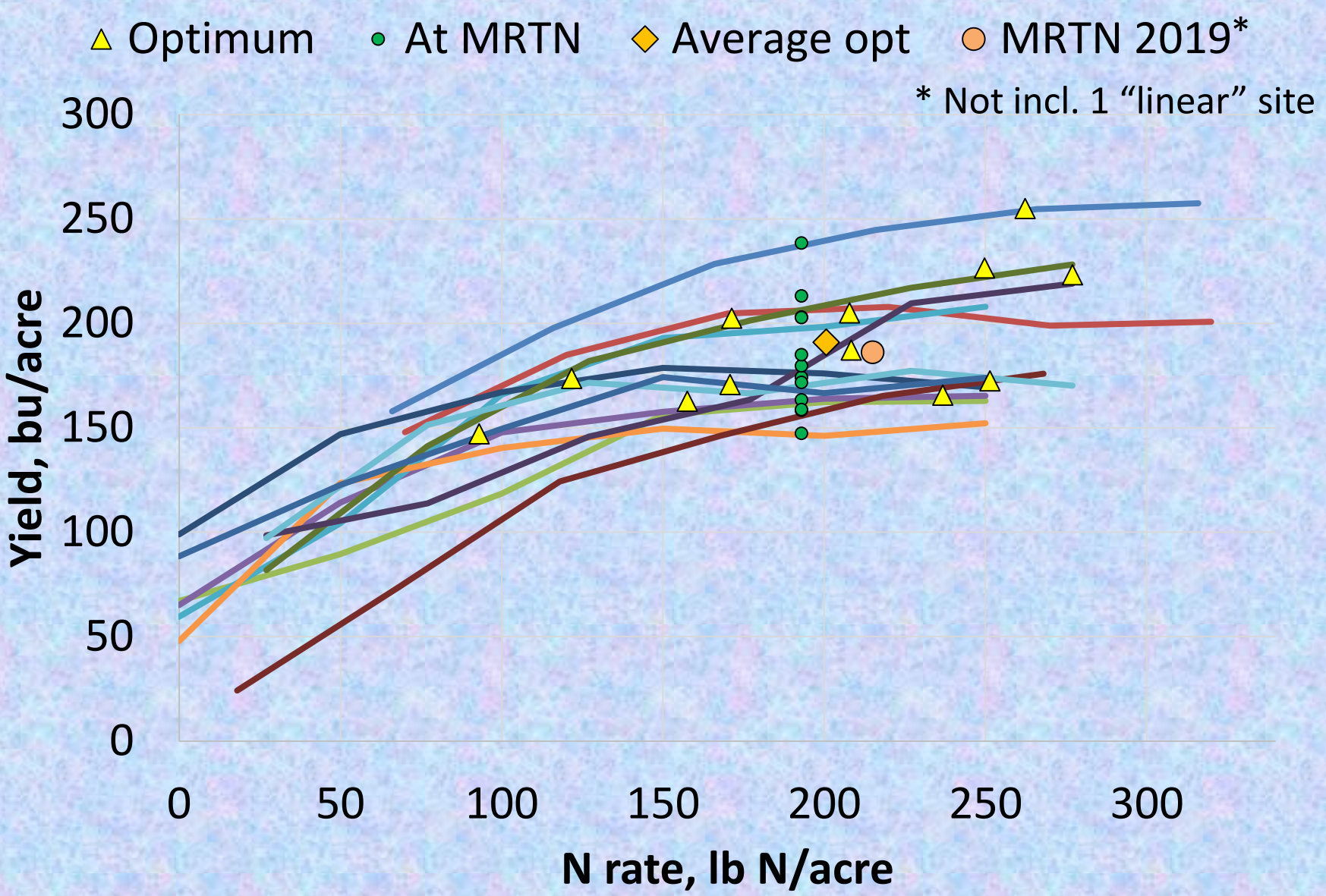
N responses, central/northern Illinois, 2019

- Despite the wet spring and much-delayed planting, soy-corn trials that were established showed N responses that were more or less normal
  - This, along with the smaller number of trials, means that the MRTN values from the calculator will change little
- Adding in 2019 N responses in corn following corn will also leave MRTN values relatively unchanged

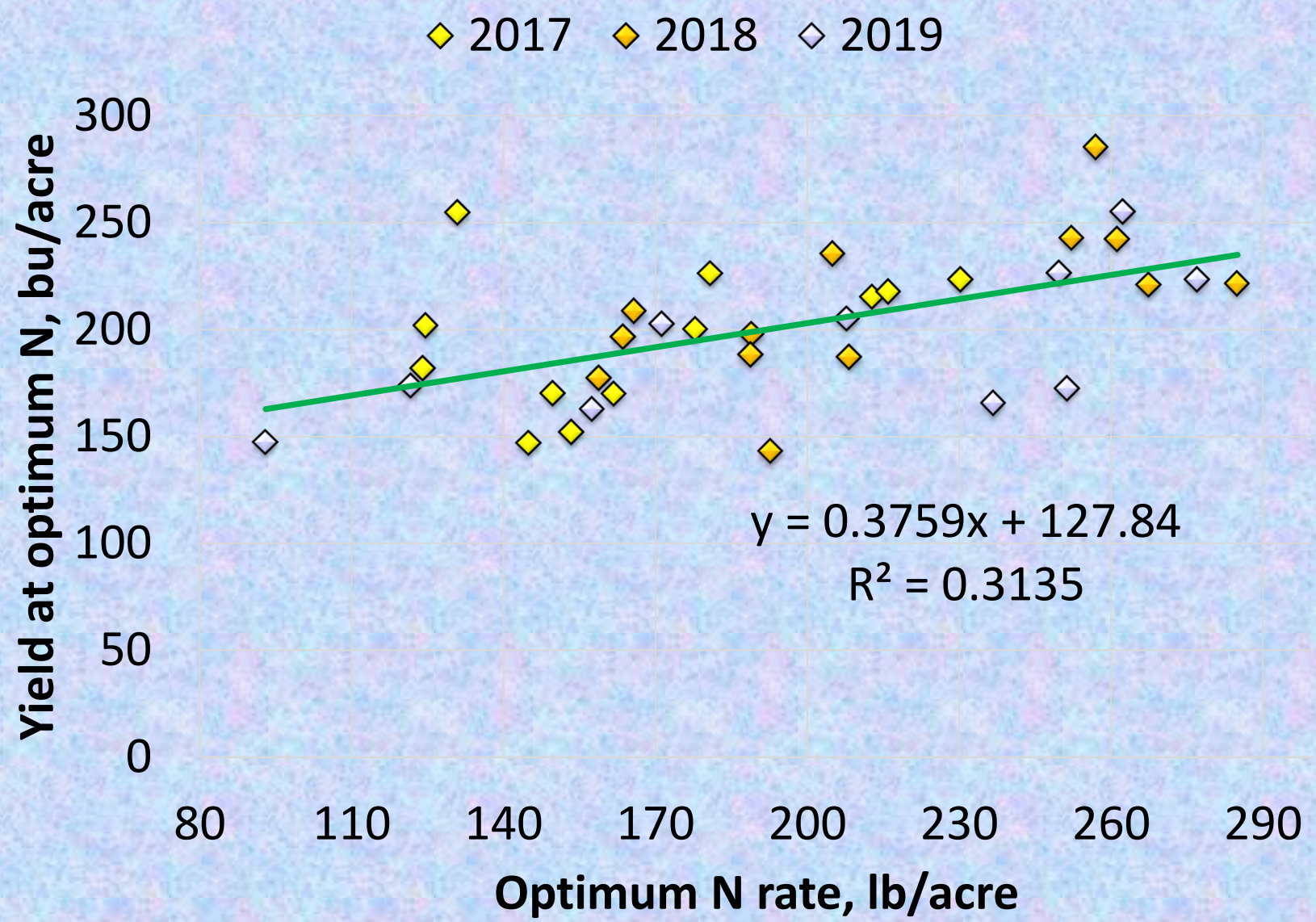
14 So. IL on-farm N trials, soy-corn, 2018



12 Southern IL on-farm N trials, soy-corn, 2019



On-farm N trials southern Illinois



N responses in southern Illinois, 2019

- Over 30 trials in S. IL 2017-2019 optimum N rates tended to be higher than we had found previously,
  - MRTN values calculated using 2018 data were ~40 lb >$MRTN_{2018}$; and using 2019 data were about 20 lb >$MRTN_{2019}$
  - Adding the 2019 data increased the MRTN by a few more lb
- It makes sense that high yields in soils with lower OM increases the need for fertilizer N in Southern Illinois
- Correlation between yield and optimum N rate across trials suggests adding a “high-yield supplement” to N rates in lower-OM soils (<2% OM) when yield potential is predicted (by V10-12) to be above 200 bu/acre in southern Illinois:
  - Use MRTN rate (now 195 lb/acre) up to 200 bu/acre, and 1 lb/bu (total) for yields above 200 bu/acre
  - Later-season drought may mean this extra N is wasted: but crop decline during grainfill is not as common with today’s hybrids; and fertilizer N requirements (per bushel) can be high when yields are lower due to dryness

Illinois corn N rate calculator output for 2020

- Numbers below at N:corn price ratio of 1:10

Updated calculator: http://cnrc.agron.iastate.edu/nRate.aspx

IL Region	Rotation	Trials	2020 calculator, range		
		#	Low	**MRTN**	High
North	Soy-C	65	153	**169**	185
	Corn-C	69	186	**200**	216
Central	Soy-C	274	166	**180**	193
	Corn-C	151	183	**193**	209
South	Soy-C	122	182	**195**	210
	Corn-C	30	183	**198**	216

Lake Springfield MRTN values similar to those in Central IL

Illinois corn N rate calculator output for 2020

- Corn at $3.50; N price as indicated
- The ratio sets the rate: $0.30/$2.63 = **$0.40/$3.50** = $0.50/$4.38
  (these would all calculate the same MRTN rate)

IL Region	Rotation	MRTN at N price, $/lb		
		$0.30	$0.40	$0.50
North	Soy-C	177	162	152
	Corn-C	208	196	183
Central	Soy-C	185	175	166
	Corn-C	202	193	182
South	Soy-C	200	191	179
	Corn-C	208	191	181

If using more than one source, use the price of the source used for the last (rate-finishing) application to set total rate

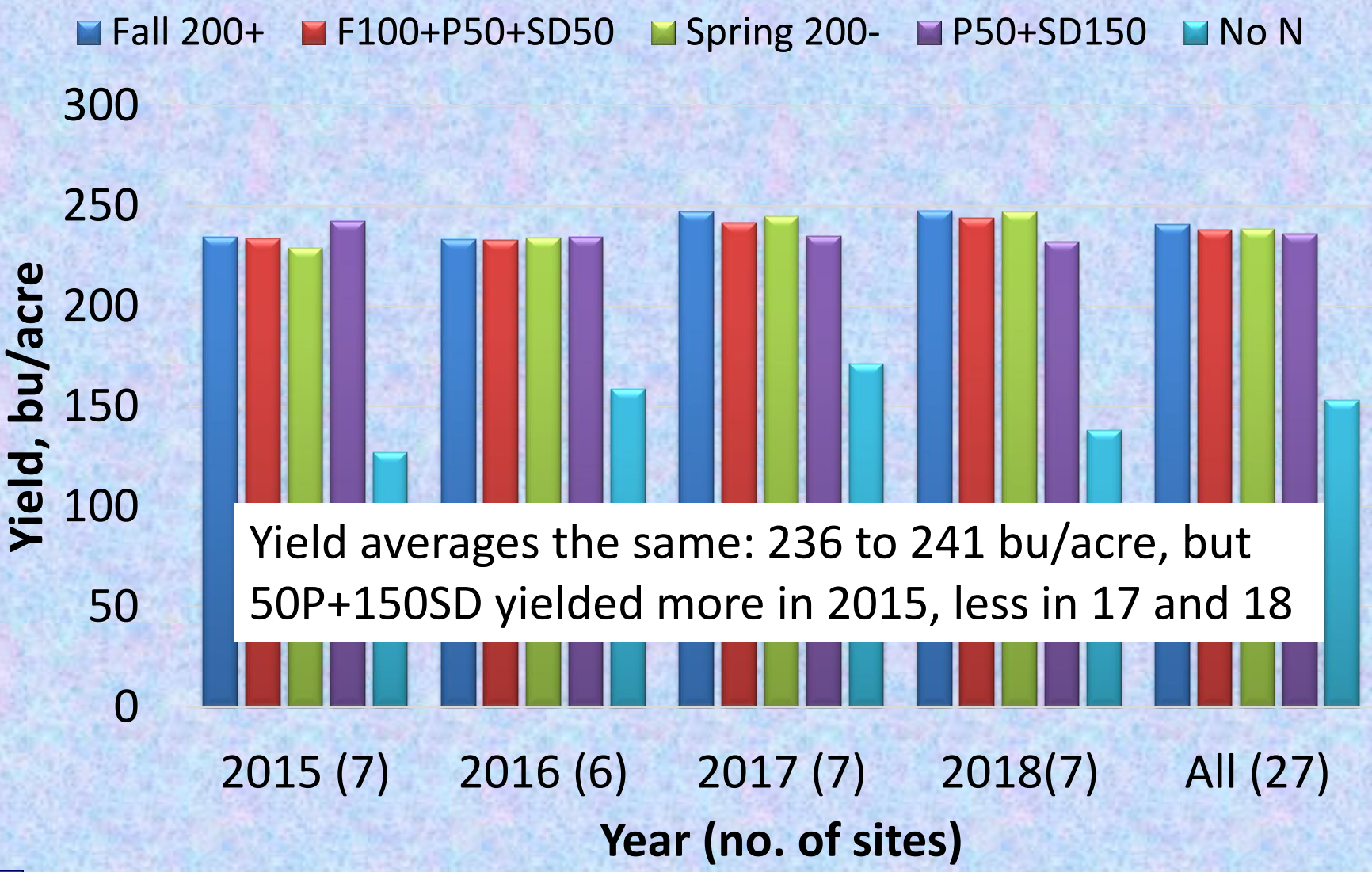
N management issues for 2020

- Harvest was late to very late in 2019
- Fall ammonia application began in late October after early cooldown, but the application window in fall 2019 was not very wide
  - Fall NH_3 application in 2019 was ahead of that in fall 2018, but not ahead of normal
- There have ben a few chances to apply ammonia since November, but a lot remains to be done
- Most soils in Illinois are wet at present
- The current price of NH_3 is about $500 per ton ($0.30 per lb of N); UAN32 $280/ton ($0.43/lb N); urea $390/ton ($0.42/lb N)
- New corn cash price for fall about $3.50 (or less)

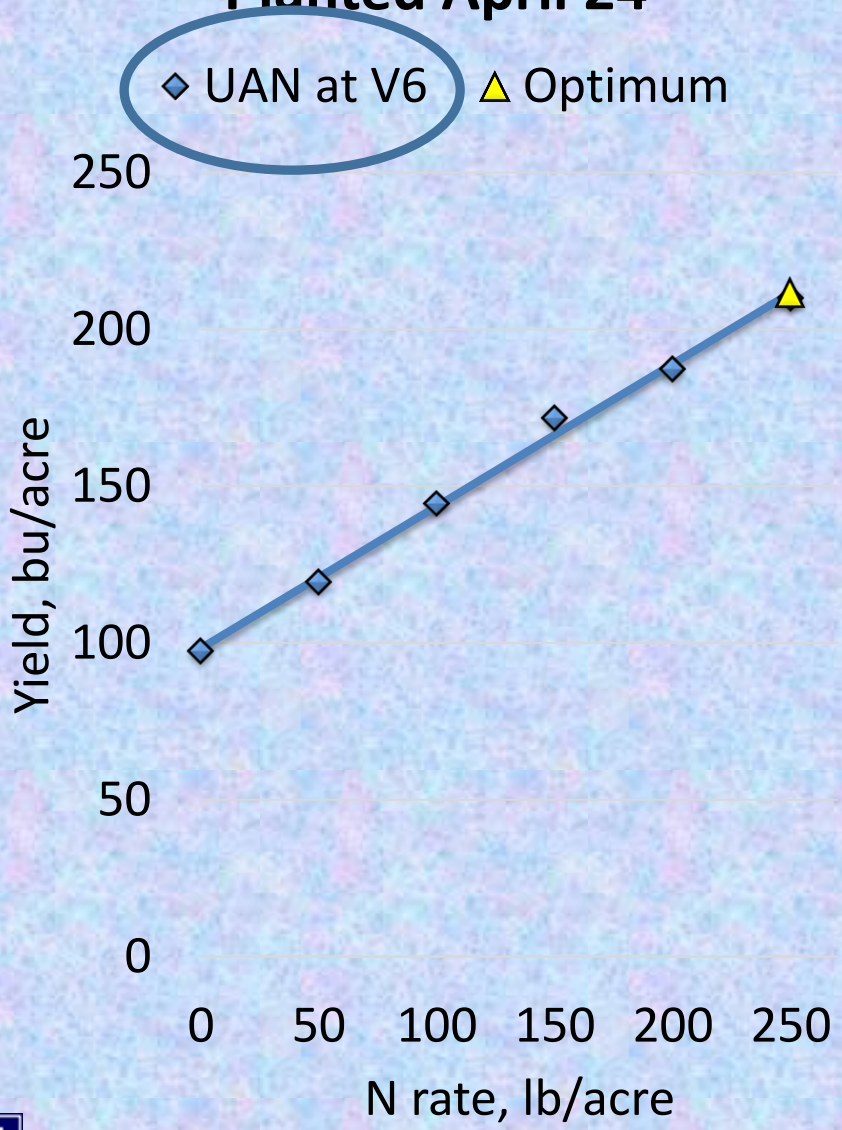
N timing: a major issue in 2019

- A lot of previous research showed that not having (enough) N in the soil near the seed as nodal roots begin to develop can result in yield loss
  - A major issue with cereal rye cover crop, which does a good job of removing N from the soil
- May rainfall likely moved NO_3^- downward out of the rooting zone quickly, adding to the problem
- With so little N applied early in 2019, then long delays in spring planting, this problem was widespread
  - Suggestion was to find a way to get some N applied in time to prevent/correct N depletion before stage V1-V2

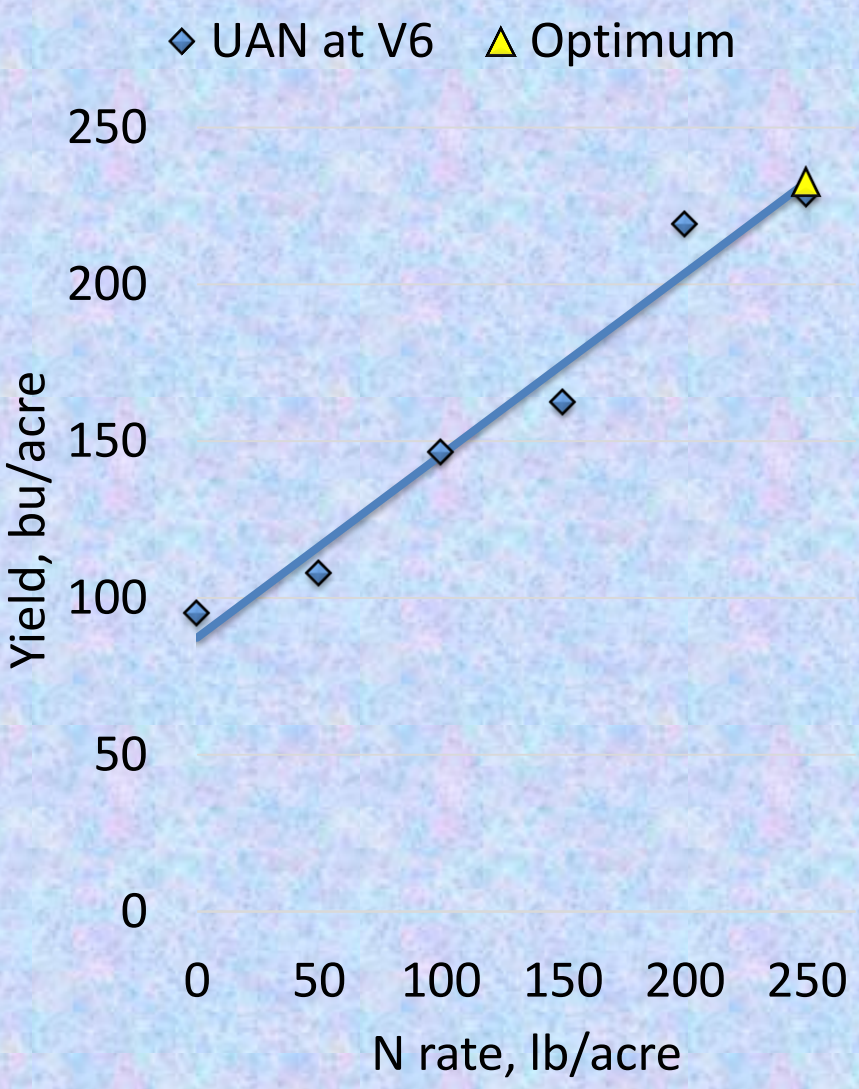
N form/timing by year



Monmouth, soy-corn 2019
Planted April 24



Monmouth strip trial, corn-corn 2019



N timing lessons from 2019

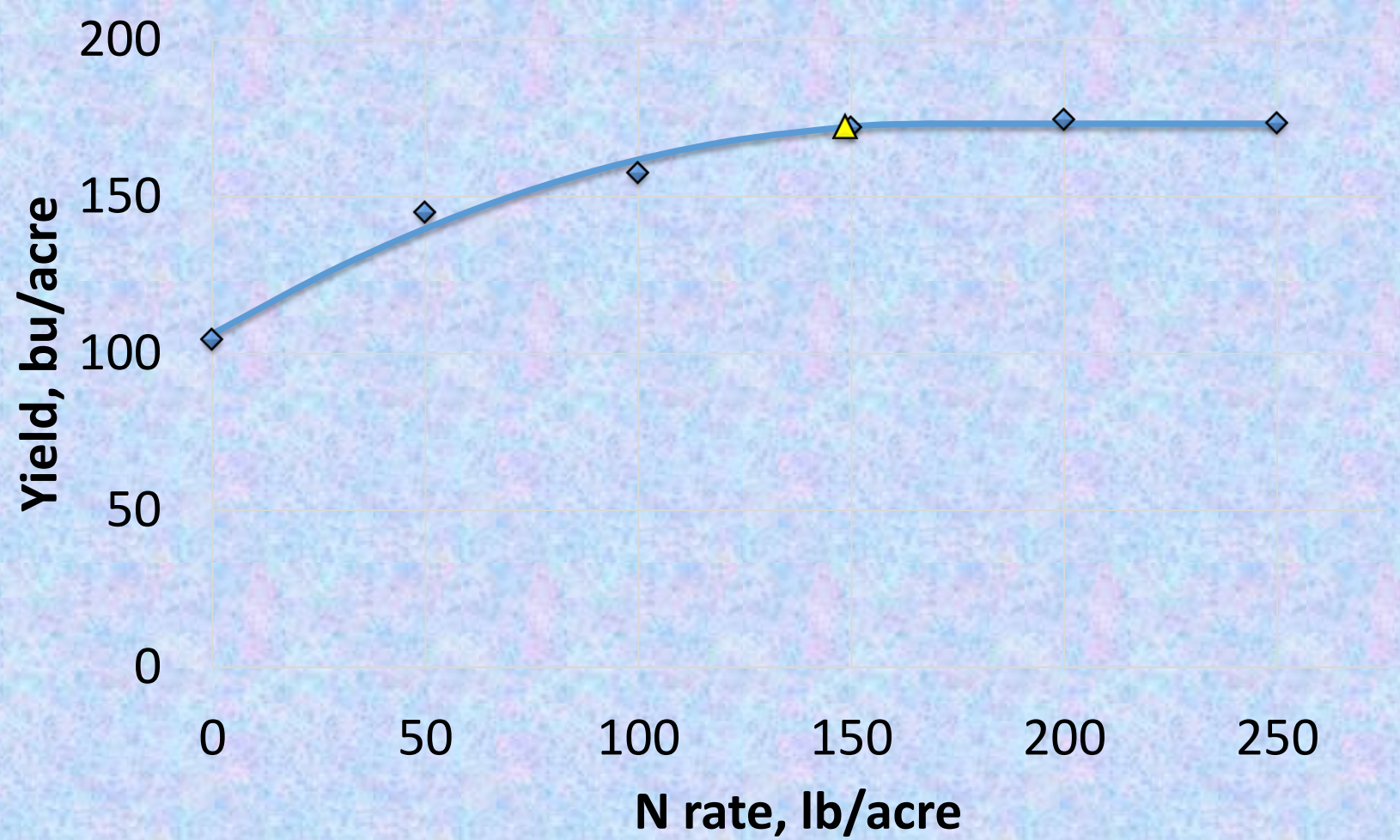
- Data and anecdotes confirmed the need to have enough N in the soil near the row early
- Planting in April and having 6 weeks of (wet) weather before N application cost serious yield
- We don't have a good idea of how much N (and how close to the seed) is "enough" but mineralized N contributes, so the amount of fertilizer N needed depends on soil temperatures at planting, soil organic matter, and rainfall between planting and V2-V3

The arithmetic on early N

- An acre of soil about 7 inches deep weighs about 2 million lb: 1 ppm = 2 lb
- 20 lb. of N mixed uniformly into this layer is 10 ppm N
- If we consider 40 ppm near the seed at emergence to be a safe amount, we need:
  - 40 lb. N broadcast and distributed uniformly to 3.5” deep
  - For a zone 7.5” wide and 3.5” deep (= 1/8th of the soil volume), 40 ppm requires only 10 lb N <u>if</u> it’s uniformly distributed and <u>if</u> the N stays in that zone for at least 3 weeks (300 GDD) after planting
  - 30 to 50 lb N placed 2 x 2” or dropped over atop the row is safer than 10-15 lb N in-furrow or Y-dropped using seed firmers, but in-furrow N (<15 lb) is better than no N

N study, soy-corn, Urbana 2019

Planted May 31
UAN injected
June 7



150-lb N UAN timing, Urbana, 2019

	Yield	
150 injected mid-row (imr) at V1	172	cd
50 imr V1 + 100 imr V6 (3.2” rain V1-V6)	184	ab
50 imr V1 + 100 dribbled in-row (dir) V6	176	bc
50 imr V1 + 50 imr/50 dir V6	178	bc
50 imr V1 + 50 imr V6 + 50 dir V10 (+2.9”)	173	bcd
50 imr V1 + 50 dir V6 + 50 dir V10	162	d
50 imr V1 + 100 dir V10	172	bcd
75 imr V1/75 dir V1	169	cd
150 dir V1	195	a

NREC-funded study over 15 site-years in central and northern Illinois, 2015-2018

Treatment (all 150 lb N/acre)	Yield	Rank	Sep.
All N applied at planting:	bu/acre	1 to 19	p = 0.1
UAN injected mid-row (check)	**224**	**10**	bcde
UAN dribbled mid-row	**222**	**15**	cde
Urea/Agrotain broadcast	**224**	**12**	bcde
SuperU broadcast	**229**	**1**	a
ESN broadcast	**225**	**7**	abcd
UAN/Agrotain broadcast	**221**	**16**	def
NH_3 injected mid-row	**223**	**13**	bcde
NH_3/N-Serve injected mid-row	**223**	**14**	bcde
UAN/Instinct II injected	**221**	**17**	def
Average all-early	**223**		
Split N application (1st at planting):			
UAN 50 broadcast+UAN 100 injected V5	**220**	**18**	ef
UAN 100 inj+UAN 50 injected V5	**224**	**9**	bcde
UAN 100 inj+Urea/AT 50 broadcast V5	**227**	**2**	ab
UAN 100 inj+UAN 50 dribbled in-row V9	**227**	**3**	ab
UAN 100 inj+Urea/AT 50 broadcast V9	**227**	**4**	ab
UAN 100 inj+UAN 50 dribble in-row V5	**226**	**5**	ab
UAN 100 inj+UAN 50 dribble mid-row VT	**225**	**8**	bcd
UAN 100 inj+UAN 50 dribble in-row VT	**226**	**6**	abc
Average split-N	**225**		
All N sidedressed:			
UAN injected mid-row V5	**224**	**11**	bcde
UAN dribbled mid-row V9	**217**	**19**	f

N timing and form summary

- The “check” of 150 lb N as injected UAN (between rows) at planting produced average yield
- 0 or 50 lb (broadcast UAN) at planting with the rest applied later did not perform very well – corn needs more N early than it got this way
- With the exception of SuperU and (sometimes) ESN, applying all of the N at planting produced below-average yields
  - BUT, this was more of a timing-of-availability issue than one of loss of N
- Applying UAN on the surface is generally not very good, but it works OK for sidedressing (after early N) if dribbled in-row, closer to roots

More on timing and form

- While split N/sidedressing often yielded a little more than most all-early applications at this (low) rate, the added yield wasn't enough to make the economics work for most of these treatments
  - At normal N rates, yields would have differed even less
- In two nitrification inhibitor (N-Serve, Instinct II) comparisons included, inhibitor did not add yield; but SuperU (NI + UI) performed better than urea with Agrotain (UI) when surface-applied
- Lower-OM soils may benefit more from splitting N, by allowing us to wait to assess yield/demand and rainfall amounts before the last application

So, split N or not?

- High soil productivity means less benefit, but less early-season N from mineralization in lower-OM soils may make it more risky to delay a lot of the N in such soils
- Corn grown in very well-drained, very poorly drained, or root-restricting soils is more likely to benefit from splitting N
- If N is split, apply half or more at/before planting
- Near-row dribbling works well, if done well
- Risks of splitting N:
  - Inability to apply due to wet periods
  - Delay in N availability to plants due to dry soils
  - Cost, and yield increase needed to cover it

Late-split N

- Across 15 trials in 2016-17, we found no advantage—higher yield or lower N rate—from keeping 50 lb N back to apply as in-row "Y-drop" at tassel
  - At current MRTN N rates (180± for SC/200 for CC) applied all early or early + 50 lb late would have produced identical yields at every site
- Subtracting the cost of late application would have made late-split N unprofitable
- A very wet June (like 2015) might mean a yield boost from late-split N, as an additional amount above the MRTN
  - Cost and timing of aerial or ground application an issue

Cover crops and N timing: an issue in 2019

Cover crop rye and N supply

- Allowing grass (crop or weed) roots to grow into the corn rooting zone and stay active up to corn planting is a near-certain way to reduce corn yield potential
- Killing CCR early enough (dead by 2-3 weeks before planting) can help, but soil N supply needs to recover (from mineralization or fertilizer) before corn emergence
- Keeping rye roots out of the corn rooting zone (planting rye 6+ inches away; strip-tilling) will help, but may not prevent this problem
- Applying 75-100 lb N (less if N is directed into the corn rooting zone) to make N available to corn roots by V1-V2 will usually prevent this problem
- Late planting (warm soils) and dry conditions after planting help by increasing mineralized N supply near the corn roots

Corn can follow cover crop rye if managed properly

Photo by Dan Schaefer

Refreshing strips before planting corn (following corn) on June 4, 2019, near Champaign. Yields in this study were in the 185-bushel range:

- There was not a lot of cover crop cereal rye growth; and no effect of cover crop treatments (no cover; rye CC with three kill dates)
- Yields were affected by N management: 50 lb UAN injected at planting + 150 sidedressed yielded ~ 5 bushels less than 200 at planting or split 100 planting+100 SD

Lessons we keep learning:

- Soils, especially productive soils with good OM levels, medium texture, and no major drainage problems, are an excellent **reservoir and source** for plant nutrients including N
- This, coupled with highly productive corn hybrids with "extractive" root systems, means we can have a lot of confidence that a crop properly supplied with N (and green at pollination) won't "run out of N" during the season
- Almost every field thought to "run out of N" due to firing during grainfill has actually run out of water, sometimes due to damage to roots earlier
  - Adding more N will not fix this

Inhibitors – keeping them straight

- Nitrification inhibitors slow the conversion of ammonium to nitrate:
  - Nitrapyrin: N-Serve® and Instinct II®, Corteva
  - Pronitridine: Centuro®, Koch Agronomic Services
  - Dicyandiamide (DCD) – many products and sellers
- Urease inhibitors slow the conversion of urea to ammonia and water:
  - NBPT: Agrotain®, Koch AS and other products
  - NBPT + duromide: ANVOL®, Koch AS
  - NBPT + NPPT: Limus®, BASF
  - PPD/PPDA, thiosulfate(?), many others
- Mixtures of these two inhibitors:
  - Agrotain® PLUS SC, Koch AS (UAN or manure)
  - SuperU®, Koch AS, dry urea with inhibitors added
- Slow-release products such as ESN are not chemical inhibitors, but slowing the release of N into the soil slows loss processes

Using inhibitors

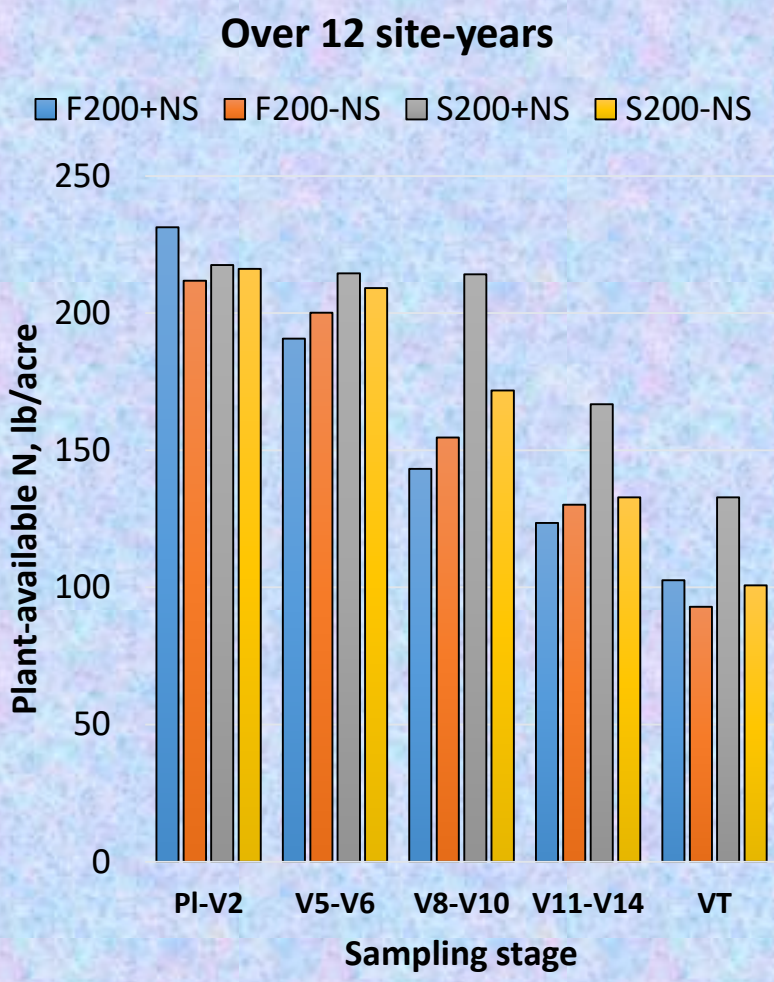
- As a general rule, the longer before plant uptake begins (June 1) we apply N, the more likely it is that some of that N will become unavailable to the crop, due to:
  - Volatilization (loss to the atmosphere as a gas)
  - Leaching (movement to groundwater/tile flow)
  - Immobilization (for some length of time) by microbes in the as they decompose crop residues, especially those with high C:N
- The cooler the soil, the slower the rate of conversion of fertilizer N (urea, ammonium) to "losable" N (NO_3^-)
- The wetter the soil, the more likely N loss
- Inhibitors are biologically active, and so do little in cool soils, a lot in warm soils with N and microbes present
- N application timing and form interact with conditions to affect the need for inhibitor: we can't know this need before application, so need to play the odds

Nitrification inhibitors for spring N?

- Yields averaged over 12 soy-corn site-years from 2016-2018, at 200 lb N as NH_3:

Application time	Without N-Serve	With N-Serve
Fall	228.4	229.3
Early spring	228.0	229.5

- Spring-applied NH_3 had more soil N in May and early June, but did not yield more than fall-applied N
- Adding N-Serve with fall-applied NH_3 did not affect May-June soil N levels
- Adding N-Serve to spring-applied NH_3 increased soil N through vegetative growth stages, but not yield



Inhibitors

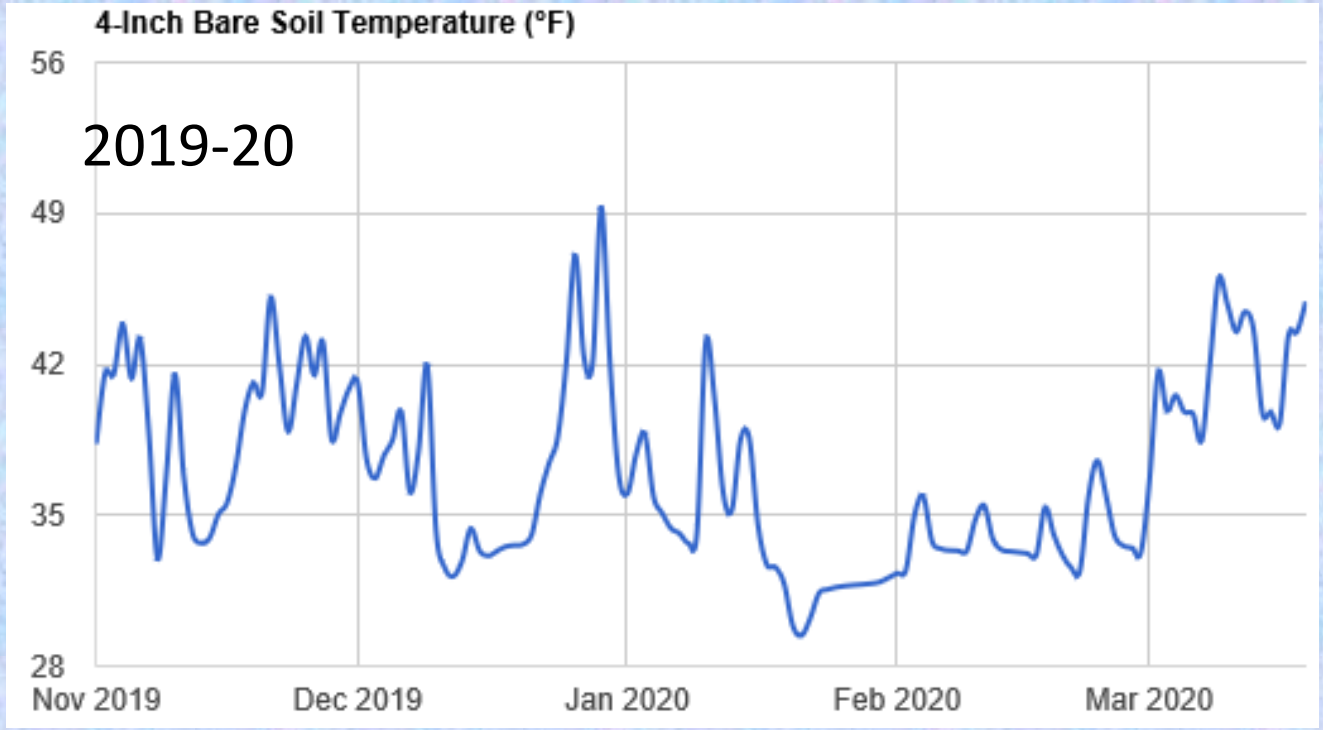
- As a general rule, the earlier (longer before plant uptake begins) we apply N, the more likely it is that some of that N will become unavailable to the crop, due to:
  - Volatilization (loss to the atmosphere as a gas)
  - Leaching (movement to groundwater/tile flow)
  - Immobilization (for some length of time) by microbes in the as they decompose crop residues, especially those with high C:N
- The cooler the soil, the slower the rate of conversion of fertilizer N (urea, ammonium) to losable forms of N
- The wetter the soil, the more likely N loss
- Inhibitors are biologically active, and so do little when it's cool, a lot when it's warm and N and microbes are present
- N application timing and form interact with conditions to affect the need for inhibitor: we can't know this need before application, so need to play the odds

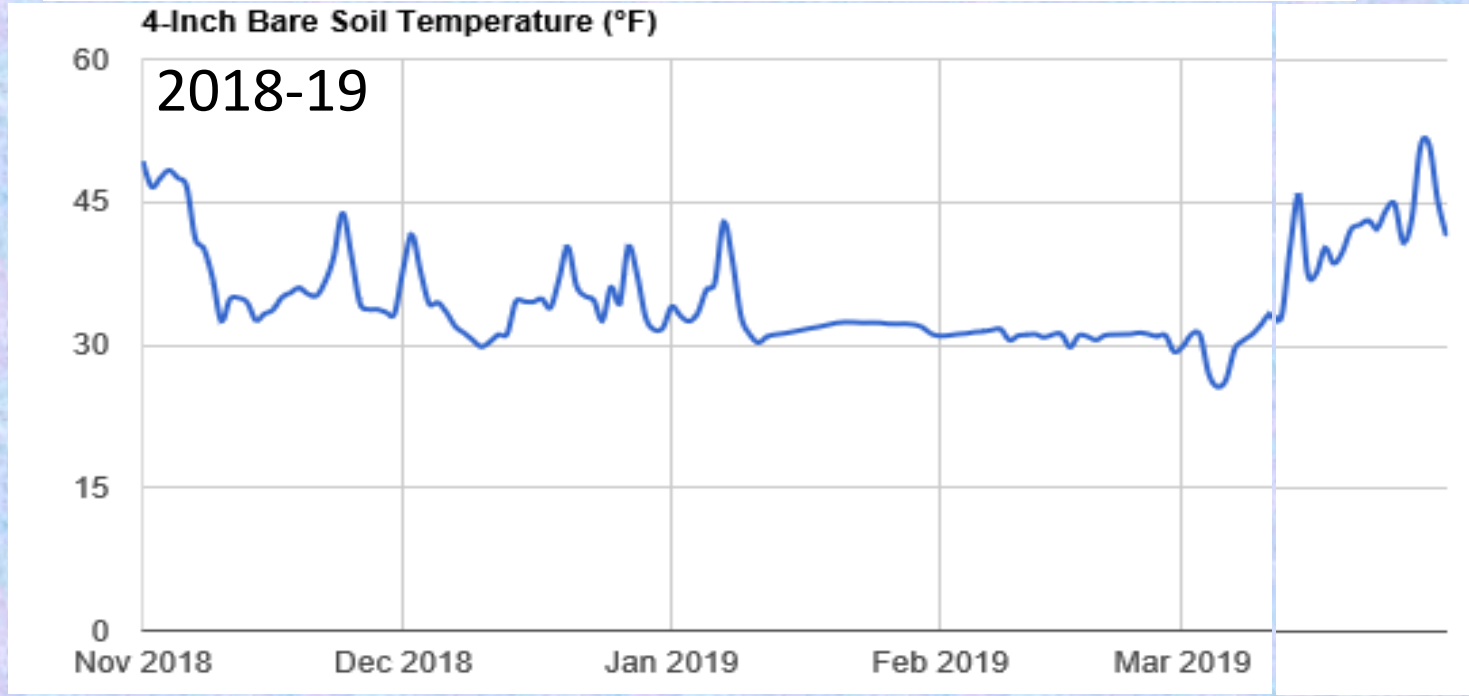
Inhibitors – use or not?

- YES: NI with fall applications after soil temperatures drop to 50°F, with no application on fields with very light or very heavy soils, and fields south of IL Route 16
- YES: NI depending on timing of spring-applied NH_3: if application is more than a month before planting or before mid-April, and when soil temperatures are increasing and/or wet weather is forecasted
- NO: with injected UAN, urea worked in, or for broadcast fertilizer applications* made at or after planting when rain is likely to fall soon
- YES: UI for surface-applied UAN and urea when it's warm and dry for more than a week after application
  - Using a urease inhibitor with in-row surface-banded (Y-dropped) UAN is unlikely to provide much benefit, unless the forecast is for an extended period of dry weather
- *SuperU has worked better in trials than urea with Agrotain, so the nitrification inhibitor may sometimes provide some benefit

Peoria

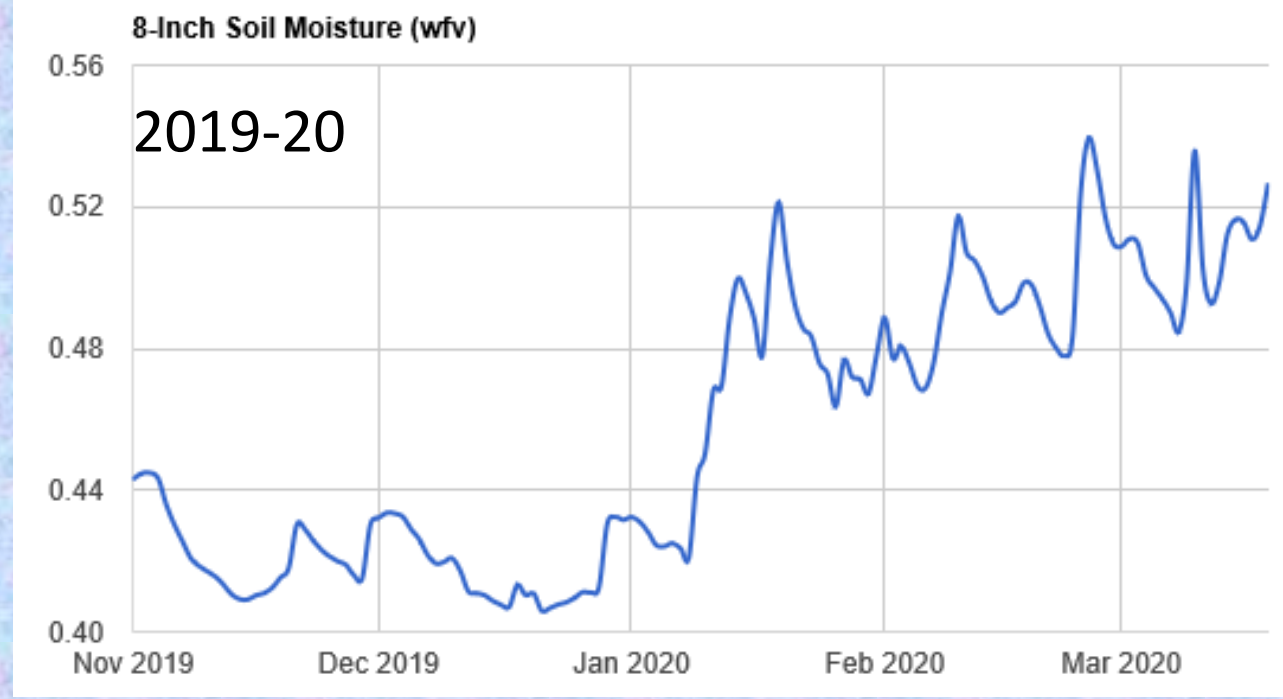
From IL State water Survey

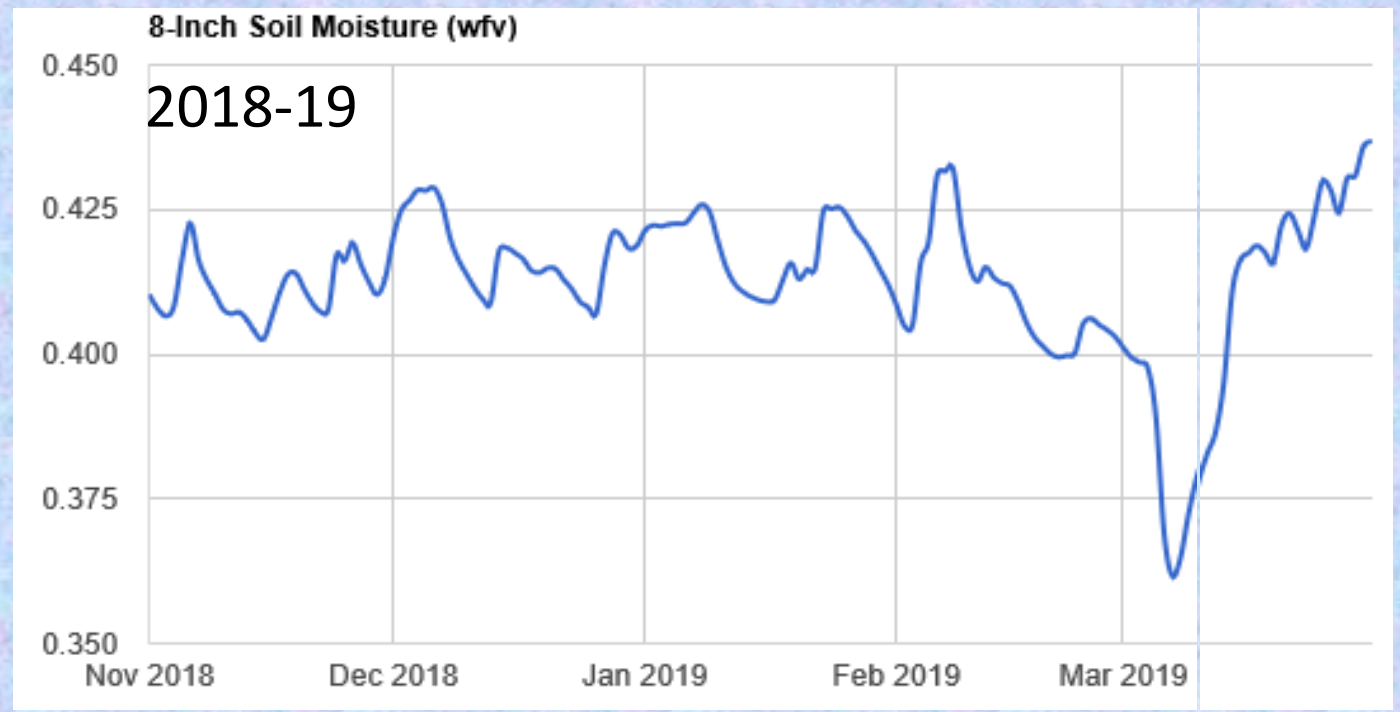




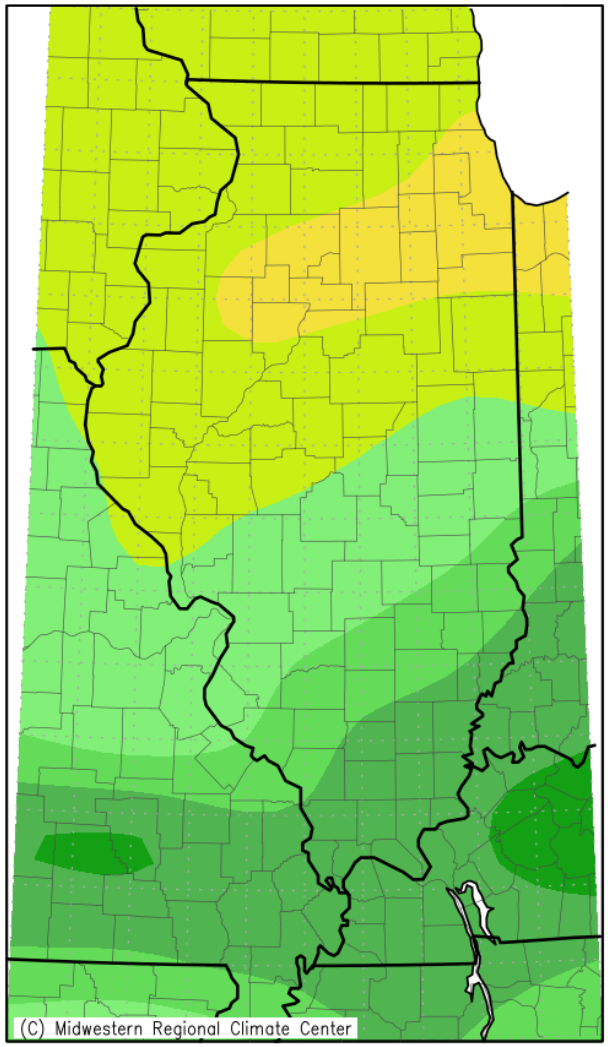
Peoria

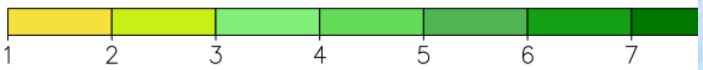
From IL State water Survey





Accumulated Precipitation (in)
March 1, 2020 to March 20, 2020

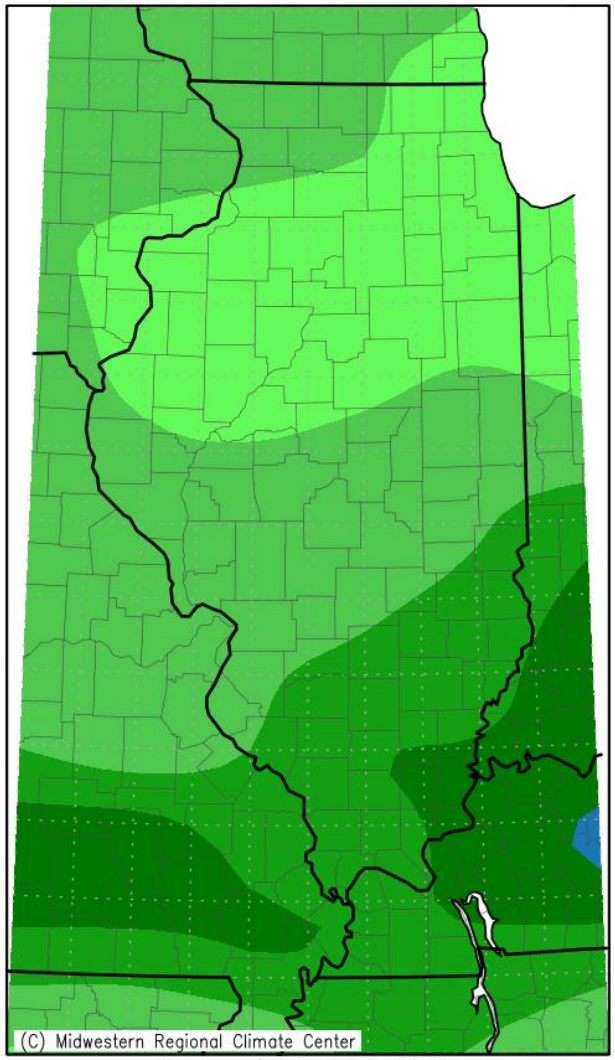




Midwestern Regional Climate Center

cli–MATE: MRCC Application Tools Environment

Accumulated Precipitation (in): Departure from Mean
March 1, 2020 to March 20, 2020



Mean period is 1981–2010.

Midwestern Regional Climate Center

cli–MATE: MRCC Application Tools Environment

February-March 2020

- Soils are wet now, and at 45° or less, will not dry quickly
- Late March is not ”prime time” for getting NH_3 applied: we could get a lucky break and drying soils, but chances are low
- If we aren’t able to apply NH_3 soon and are considering switching to a different form, a switch means delaying application until closer to planting: no other N source approaches NH_3 in terms of safety from loss

Is NH_3 into wet soils a problem?

- More NH_3 dissolves in cold soil than in warm soils, so retention in soil isn't a problem, as long as soil isn't too wet or too "chunky" to close the knife track
- If the soil at knife depth is too wet to shatter, the NH_3 will move only a short distance from its release point:
  - 220 lb NH_3 (180 lb N) dissolves in 4.12 cubic ft (257 lb) of water at 50°; in moderately wet soil (40% water) that would make a (uniform) band about 1/2 inch in diameter
- Is this lack of spread a problem?
  - Highly concentrated NH_3 can leave solution and move up, but only if soil dries out
  - N in a small band is a little less accessible to roots
  - Tillage later will probably help, but if soil is inverted and then dries out, some NH_3 could escape into the air
- Don't plant directly on top of the band, just in case soils dry and some NH_3 moves
  - rainfall before planting will make this safer

N management if the spring is “normal”

- Weather and soil conditions allow NH_3 application in late March or early April:
  - Apply deep enough to get good cover
  - Nitrapyrin or pronitridine may be helpful if warm and wet conditions are forecast between application and planting
  - Applying at an angle more than 2-3 weeks before planting is usually safe, but using RTK to apply off the row might be better
    - To keep the N near the corn roots (to come), might move application band 6-8” from the (new) row rather than 15” (midway between rows)
- Adjust (lower) the preplant N rate to account for planting-time and/or sidedress N

If it's wet well into April

- If soils stay too wet to apply NH_3 until past mid-April, and then dry quickly so they're ready to plant by late April:
  - Could apply NH_3 off-row, before or right after planting
  - Unless NH_3 is applied near-row and soils are warming, consider 10-12 gallons 28 or 32% as herbicide carrier broadcast pre, and decreasing the (sidedress) NH_3 rate by that amount
  - Instead of UAN pre, could apply 30-40 lb N in a 2 x 2 band; in-furrow only will not allow that much N
  - If NH_3 is out, could apply all or most N as UAN broadcast, probably better before last tillage pass, or wait to apply some at sidedress
- Could also consider using urea (worked in or with Agrotain) or SuperU broadcast before or after planting; do not delay all N for more than a week after planting

N management if it stays wet up to May

- Soils too wet to apply NH_3 until late April, and planting starts only in early May:
  - Apply all or most N as UAN broadcast, best if worked in (applied before last tillage pass)
  - Use urea (worked in or possibly with Agrotain) or SuperU broadcast before or after planting
    - Need to apply some early N if dry N is delayed >1 week
  - Apply 40-60 lb N as UAN starter + broadcast with herbicide, then apply the rest as:
    - Broadcast urea/SuperU as soon as possible after planting
    - UAN (injected 6-8 inches off row if possible)
    - NH_3 by stage V1-V2 (a little later if soils are warming fast) – inject 6-8 inches from row if possible

N management if 2020 is a rerun of 2019

- Soils wet into mid- or late May, and planting takes priority over N application
  - The need for upfront N decreases some as mineralization kicks in, but we can't skip it entirely
  - Broadcast N as UAN or urea (with Agrotain if not tilled in) or SuperU right before or right after planting
  - Apply at least 40-50 lb N at planting – 2 x 2 or atop row – then sidedress with NH_3 or UAN (injected or dribbled in-row), or topdress with protected urea, anytime up to V6-V8
  - If wet weather delays in-season application past V8:
    - Do in-row dribble of UAN with planting, or find a way to drop urea with UI or SuperU atop the row to supply 40-50 lb N at/after planting
    - Broadcast urea, with Agrotain if it's drying; slow-release N (ESN) may not release as fast as needed
- Do not plant corn into green or not-yet-dead cover crop rye, especially if no early N has been applied

For those who applied NH_3 last fall:

AGRI-VIEW

Fall fertilizer may not help crops

Richard Mulvaney University of Illinois Jan 2, 2020

1 of 3

University of Illinois researchers use a stable isotope of nitrogen, 15N, in formulating tagged ammonia. They applied it at a typical rate of 200 pounds per acre in mid- to late-November in 2016 and 2017 in six Illinois fields.

University of Illinois

Mulvaney's (U of I) group reported:

- 200 lb N as ^{15}N-labeled fall-applied NH_3, with and without N-Serve, 2 soy-corn and 1 corn-corn site each year, 2017 and 2018:
  - In corn following soybean, 10 to 43% (average of 23%) of grain N came from fertilizer
  - In corn following corn, 14 to 27% (average of 22%) of grain N came from fertilizer
- From the news release:
  - "Farmers apply ammonia in the fall thinking they've supplied nitrogen to their corn crop for the coming year. But based on our results, most of the fertilizer nitrogen will not be taken up by the crop." and
  - "Considering the low uptake efficiencies observed in our study, farmers should think twice before putting their nitrogen on in the fall," Griesheim said.

Does fall-applied N supply the crop?

- YES: Over 16 site-years with 200 lb N in corn following soybean, yield was never lower from fall NH_3 + N-Serve than from spring NH_3 without N-Serve; the average was +1 bu for spring-applied
- In these trials, the optimum N rate averaged 12 lb higher for fall-applied than for spring-applied NH_3
  - The average optimum N rate for fall-applied N was the same as the MRTN; for spring-applied N, it was less than the MRTN
- The net return to N (at opt N rate) averaged $9/acre more for spring-applied N, but realizing that have required knowing when to lower N rates
- Fertilizer N recovery in corn plants is typically less than 50%; the rest of the N comes from SOM in that season
- The Mulvaney study had no spring-applied treatment, so no way to support the contention that recovery or yield from it would have been higher

Thank you

Have a Safe Spring Season in 2020

ILLINOIS
Crop Sciences
COLLEGE OF AGRICULTURAL, CONSUMER
& ENVIRONMENTAL SCIENCES