Tonight's host and co-host

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N Fertilization by Crop

Winter Soil Fertility Series: Week 3

Jan 20, 2021

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Photo by K. Olson-Rutz

Goals

- Provide N rate guidelines and cautions for specific crop types, and chance for you to practice calculating N rates
  - Oilseeds
  - Wheat
  - Pulse crops
  - Forages will be covered Feb 3
  - Vegetables – see our ‘small acreage’ and ‘garden’ presentations on our website and MSU Master Gardener

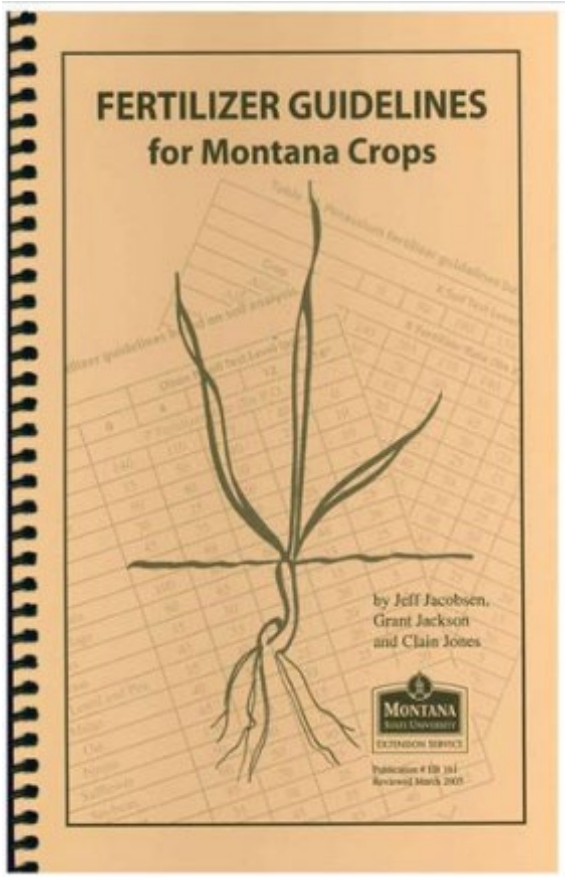
Determining N rates

MT based guidelines for N rates are available in several MSU Extension publications. https://store.msuextension.org/

- EB0161 – most crops

More details:

- MT200703AG – how to do calculations
- EB0197 and 0206 – wheat
- EB0186 – barley
- EB0210 – pulse crops
- EB0224 – canola
- EB0216 and 0217 – forages
- EB0200 – organic production
- MT200705AG – gardens



Abridged versions at Soil Scoops
https://landresources.montana.edu/soilfertility/soilscoop/index.html

N fertilizer rate: the fundamental steps

- Define crop and yield goal
- Look up N required
- Subtract N in soil based on soil test

Corn - grain	
Yield potential (bu/ac)	Available N (lb/ac)
50	60
90	108
130	156
170	204

Example soil test result

Nitrate -N			OM %
ppm	lb/ac	Depth	
10	18	0-24”	0.8

How much fertilizer N?

108 lb available N required
- 18 N in soil
= 90 lb **N** from fertilizer

90 lb **N** ≠ lb fertilizer. Depends on concentration of N in fertilizer. Urea is 46% N, 90/0.46 = 196 lb urea/acre

N rate adjustment: yield goal and SOM

- Realistic yield goal
  - Use variety selection tools (AMBA, MSU-SARC, MSU Dept Plant Sciences and Plant Pathology)
  - Past yields indicative of future performance
- Soil Organic Matter (SOM)
  - <1% SOM, add 15-20 lb N/acre
  - >3% SOM, reduce 15-20 lb N/acre

In corn example:

- 0.8% OM, how to adjust?
- 90 lb N required + 15 lb N = 105 lb N/ac required
- 105/0.46 = 228 lb urea/ac

N rate adjustments: prior crop

- Stubble: small grains stubble high carbon to N (C:N). Adjust fertilizer N up or down?

  10 lb N/1000 lb stubble up to 40 lb N

example calcs in *Developing Fertilizer Recommendations for Ag*

- Fallow: assume ½ of stubble has decomposed over previous year when adjusting

  5 lb N/1000 lb stubble from year before fallow

After legume adjust fert up or down?

- Legume covers release more N more quickly than legume grain (pulse)
- Benefit to yield with less or no fertilizer N, compared to fallow, takes 3 to 4 cycles (several MSU studies with wheat; e.g., Miller et al., 2015)
- A pulse rotation can still increase barley yields planted three years after the pulse crop
- Legume N credit (addition) highly variable among species and agronomic conditions

LEGUME crop	N Credit lb N/acre
Grain 1-2x	~10
Grain ≥ 3x	~20
Cover crop 1-2x	20-30
Cover crop ≥ 3x	30-50
Alfalfa	40

N rate adjustments: tillage and timing of soil sample

- Tillage – No-till may require extra N for 6 to 15 years
- Fall vs. spring soil sample (overwinter loss or gain?)
  - Shallow and sandy soils likely to lose N over winter to leaching. Up to 60 lb N/ac loss
  - Fields with legumes year before likely to increase N from fall to spring. Up to > 80 lb N/ac gain, but averages about 25 lb N/ac.
  - No easy way to predict – early spring ideal if not wet, late fall better than late summer (Jones et al. 2011)

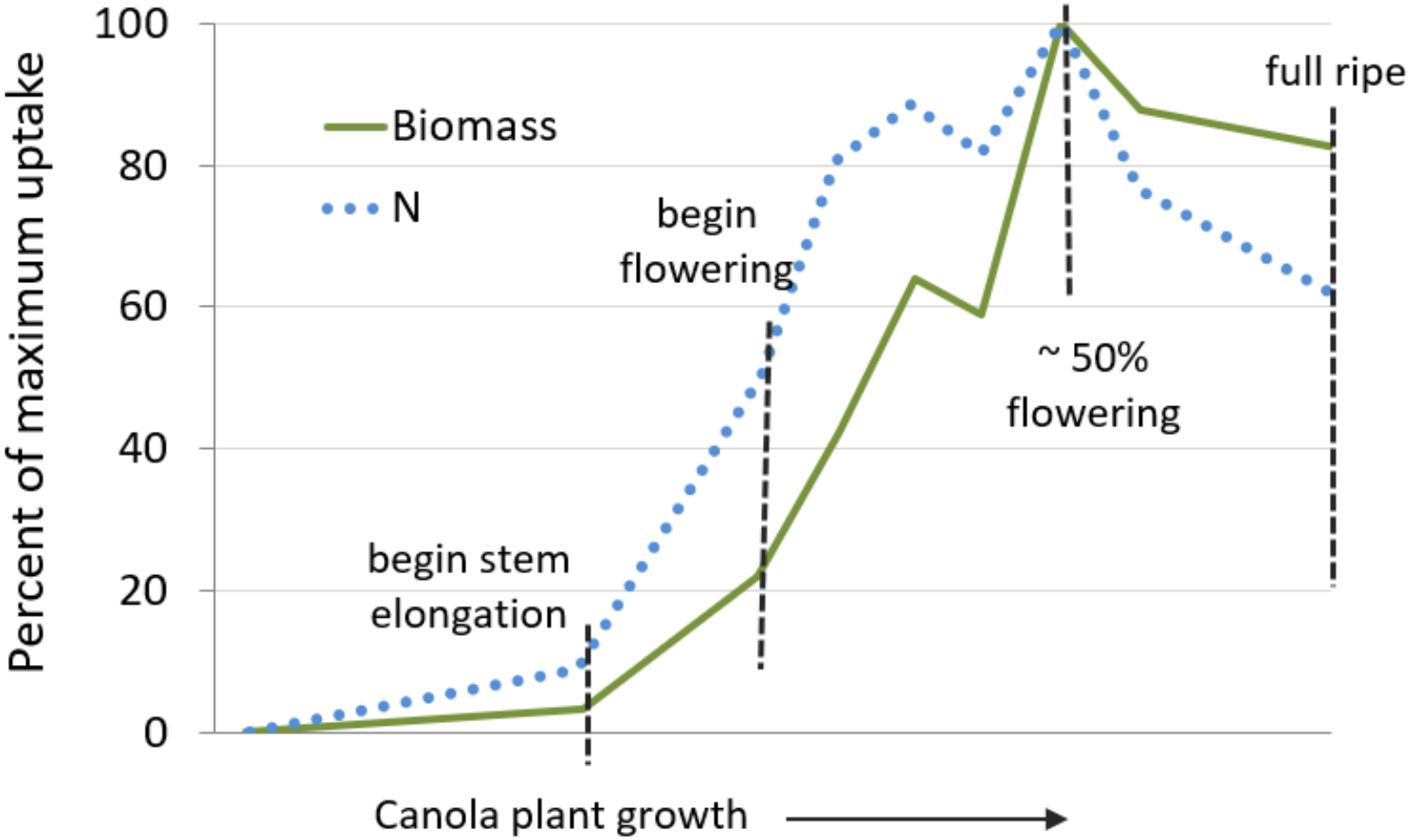
Danger of too much N?

- Nitrates leaching into ground water
- Too much leaf growth, at expense of fruit/seed/grain and root growth
- High barley protein, low beet sugar
- Soil acidification leading to crop losses (see Feb 10 webinar)
- Hairy carrots


Image by K. Olson-Rutz

N needs to be available BEFORE max plant growth

Uptake depends on growth stage NOT calendar day.



Nutrient uptake figures are available at

http://landresources.montana.edu/soilfertility/nutuptake.html

Questions?

On to oilseeds

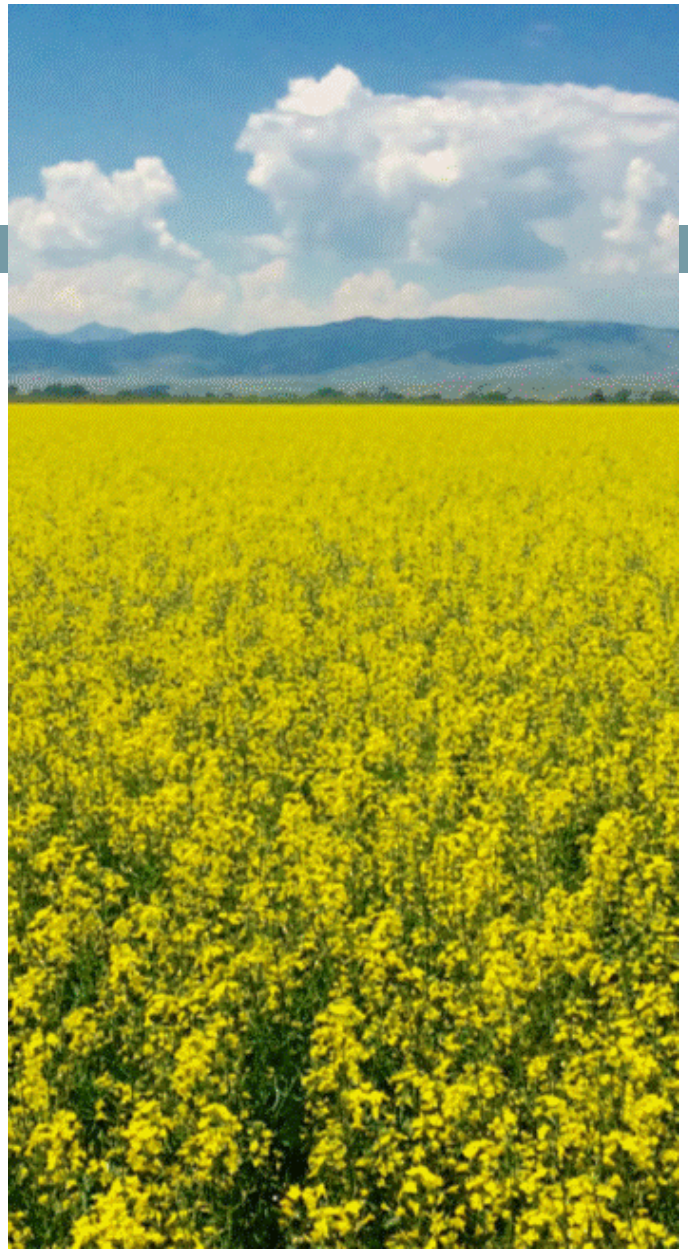
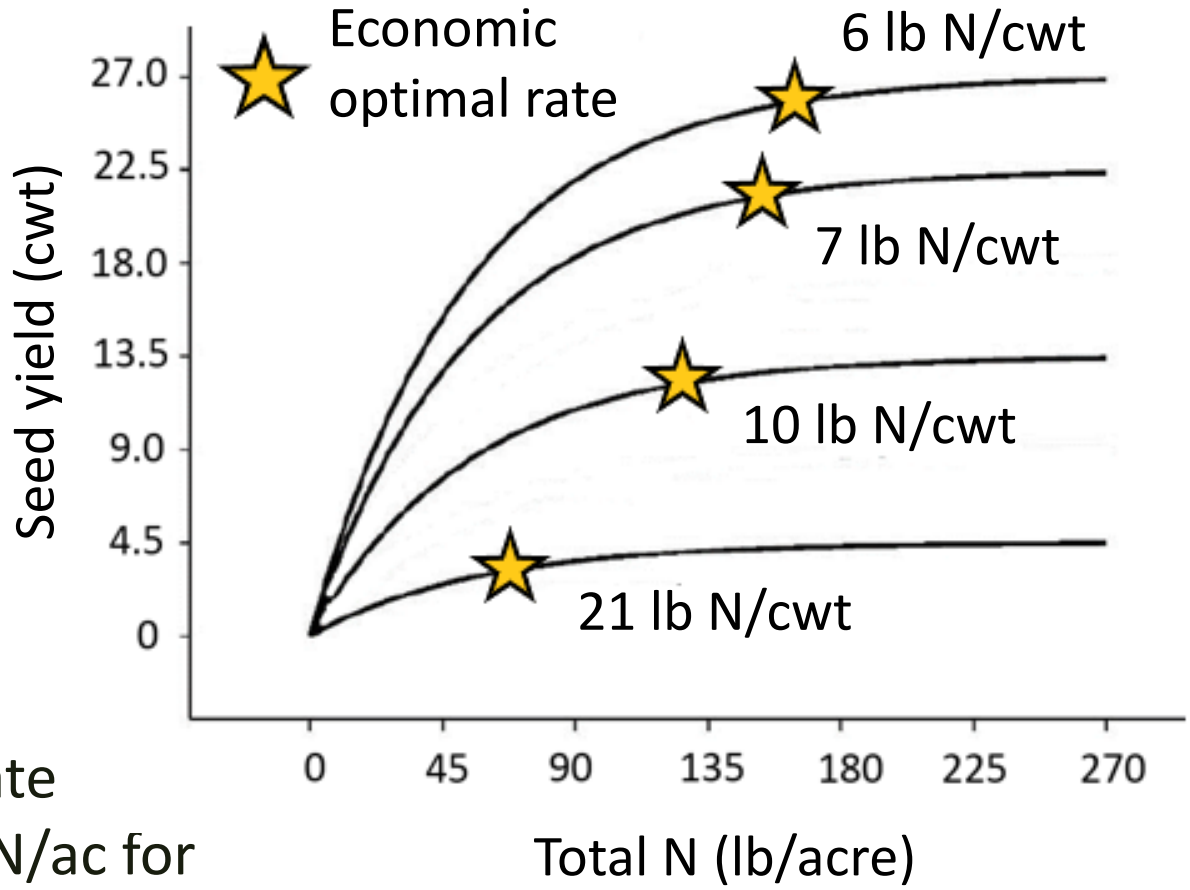


Image by Sophia Flikkema

N, water, and canola yields

- N use and optimum lb N/bu or lb N/cwt depends on yield
- As yields become limited by water, lb avail N/cwt (or lb N/bu) goes up
- Economic optimal rate ~ 120 – 140 lb avail N/ac for typical MT canola yields



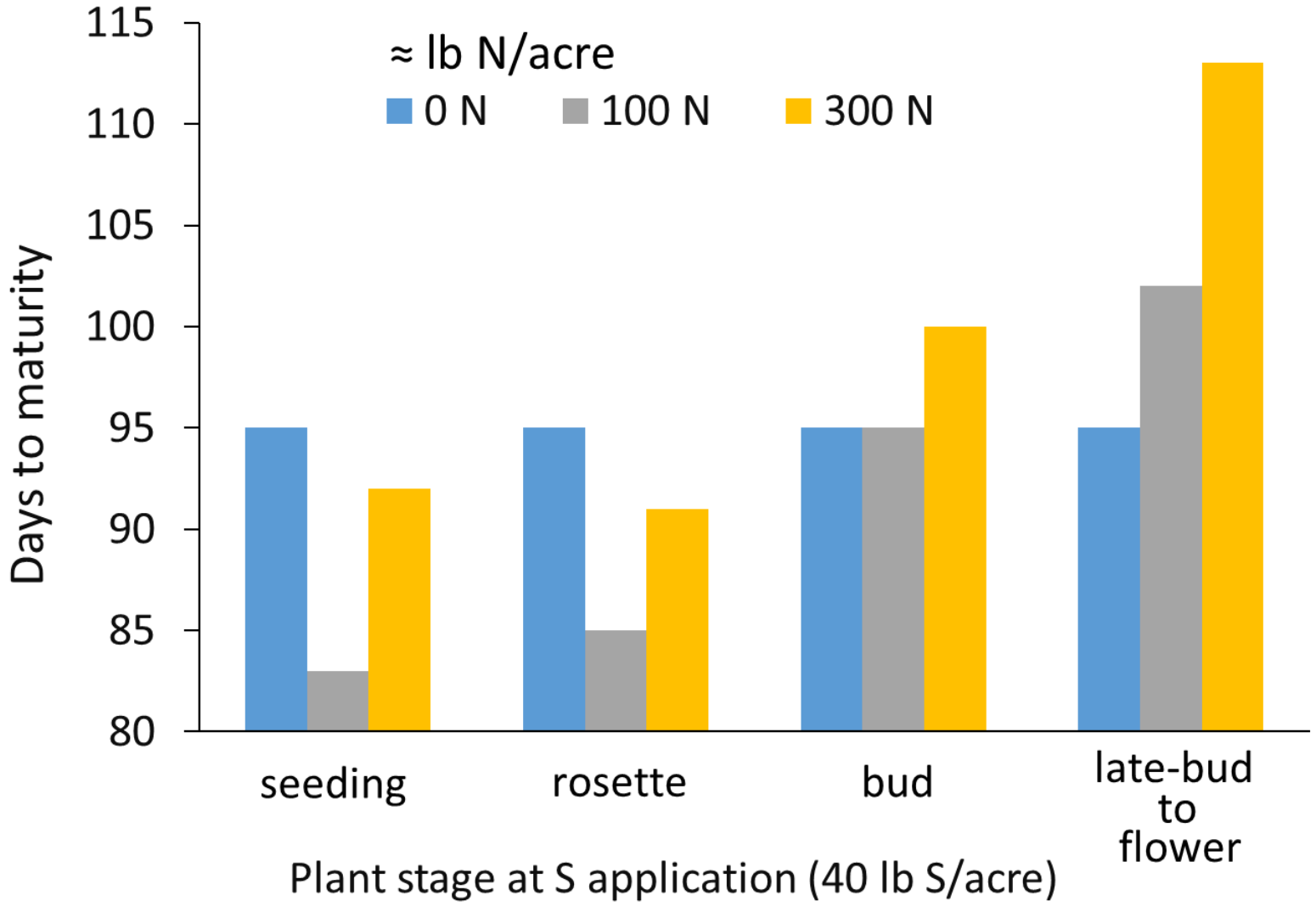
Pan et al., Crops & Soils 2017

Example N rate calculations depending on previous crop

	Spring wheat	Grain pulse grown 1x	Legume cover crop grown 1x
Canola yield goal (bu/ac)	18	20	23
Total soil N recommended (bu/ac x 3.25 lb/bu)	58	65	75
Spring soil N (lb/ac)	-20	-35	-50
N credit (lb/ac)	0	-10	-25
Fertilizer N (lb/ac)	**38**	**20**	**0**

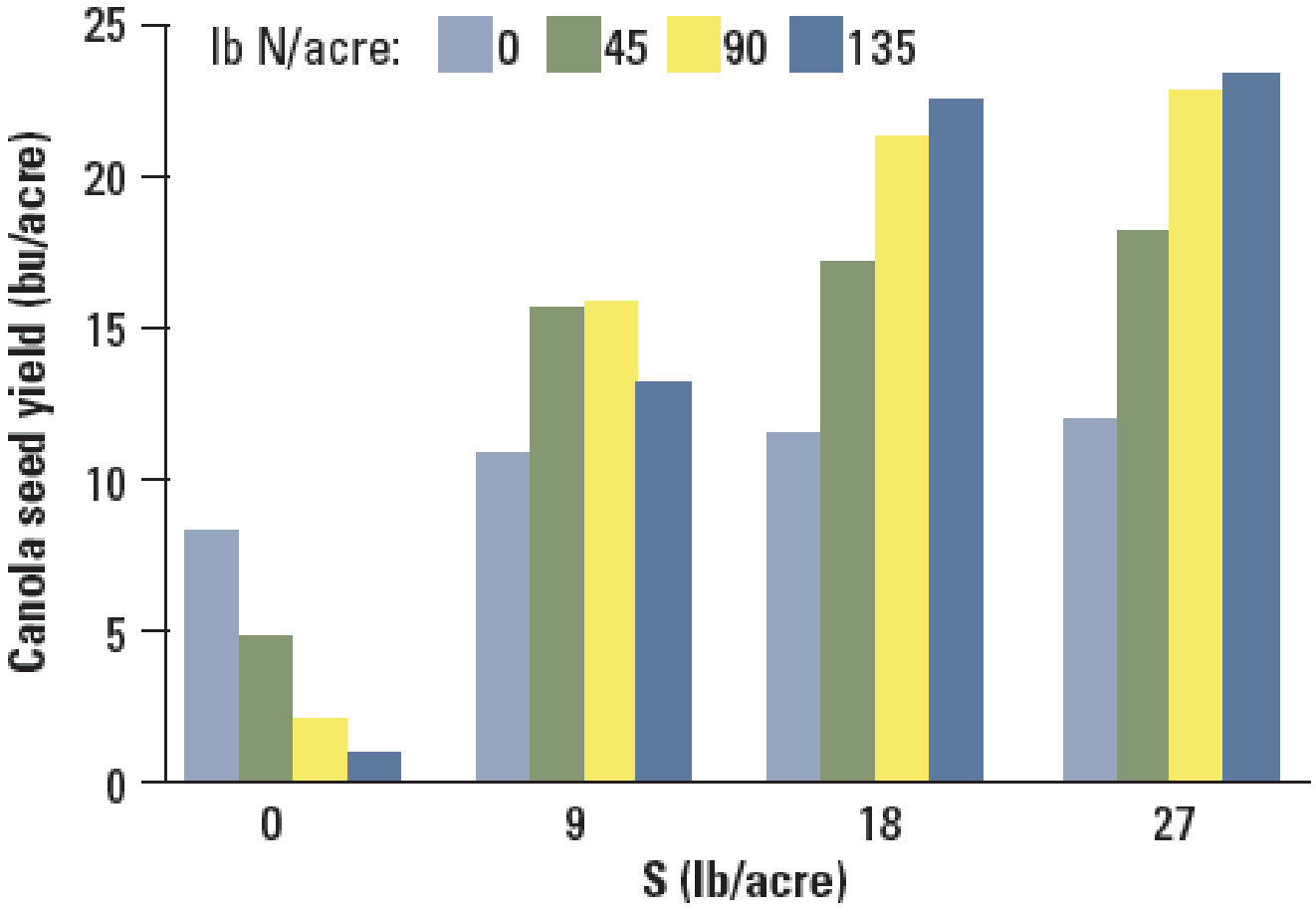
Excess N and late S slows canola maturity

Especially in dry years or with delayed seeding



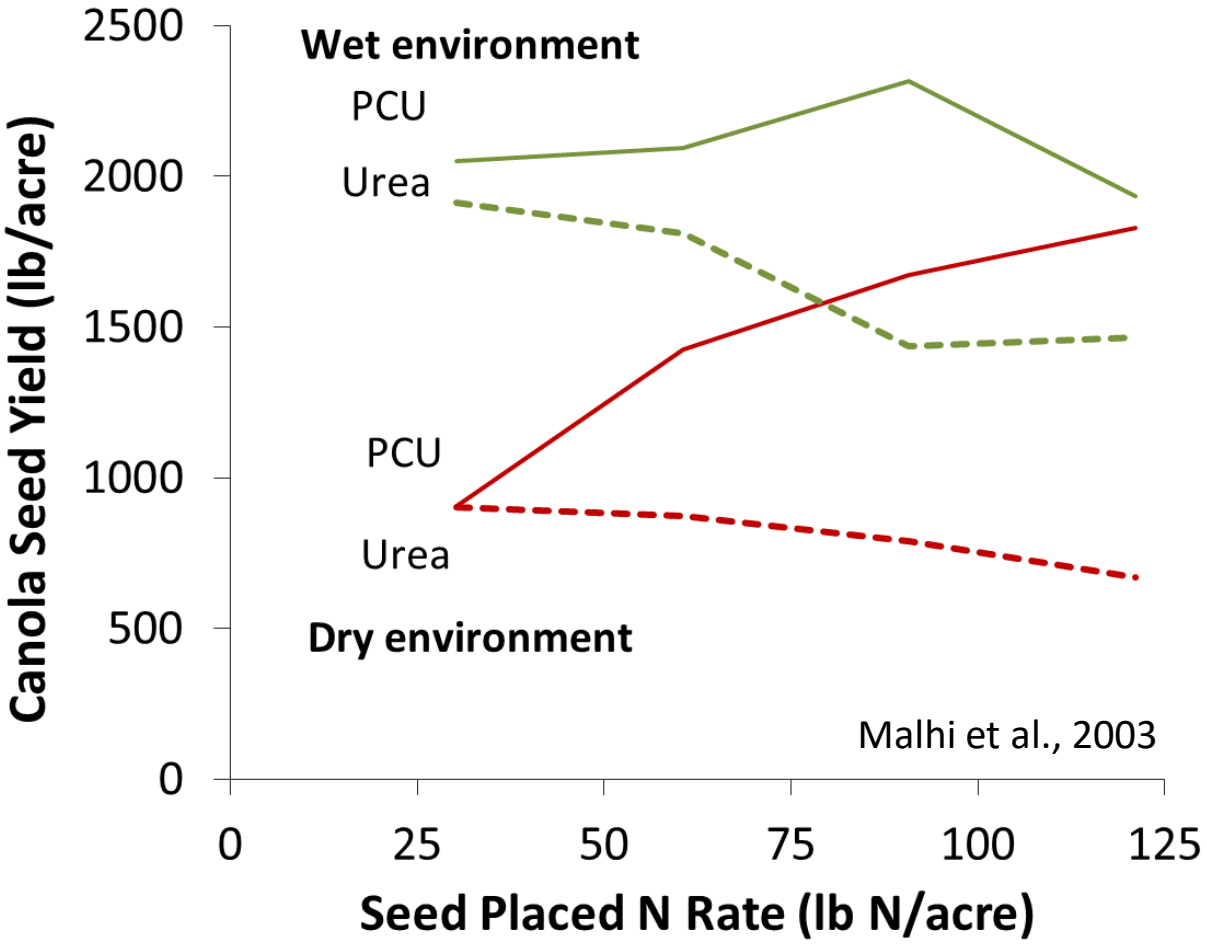
(Janzen & Bettany, 1984, greenhouse study)

Canola and other crops can only respond to N if S is not limiting; S helps most when N is sufficient



The 'ideal' N:S of 7:1 only helpful if both are deficient, otherwise irrelevant (Karamanos et al., 2007)

Open pollinated variety, N and S broadcast and incorporated just prior to seeding. Malhi et al., 2007



Other N sources

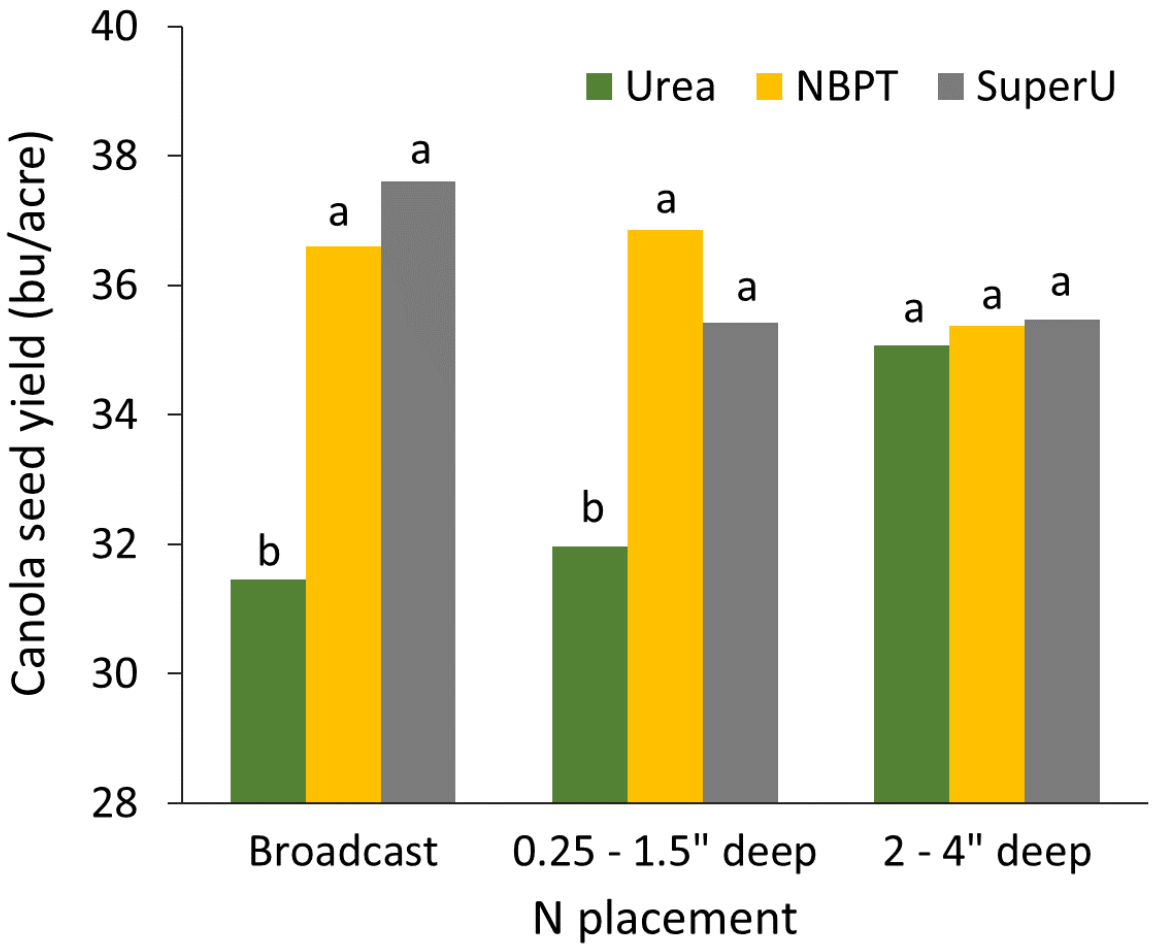
- Polymer coated urea
- Legumes

- Polymer coated are safer seed-placed than urea
- PCU release is often too slow in cool, dry conditions to provide enough N early on – consider blending

N placement

To minimize volatilization loss:

- side or pre-plant band >2” deep prior to packing
- early-spring broadcast with incorporation
- if seeder can’t place N deep, consider NBPT (e.g., Agrotain®)
- 28-0-0, 32-0-0 better subsurface than surface band

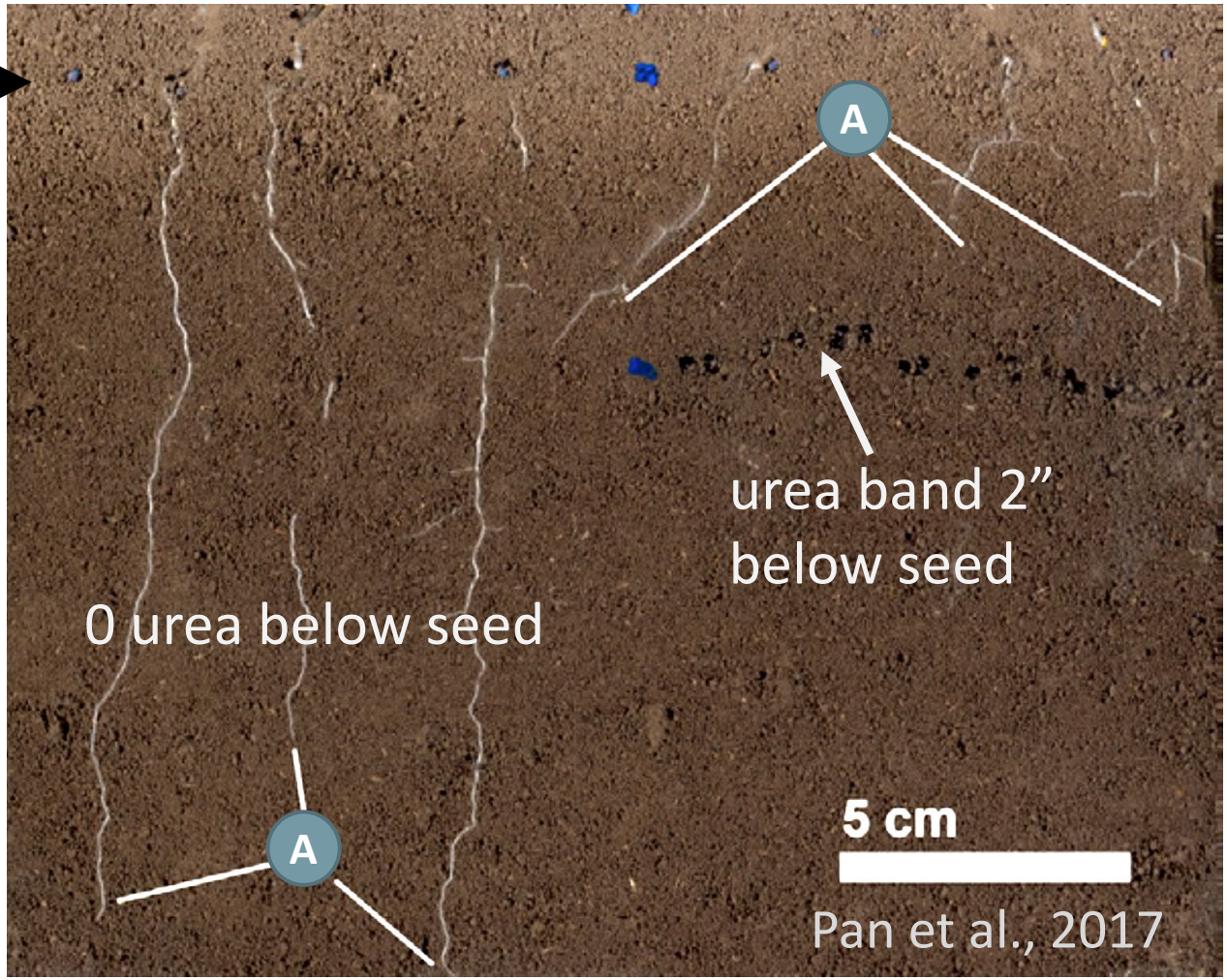


Dick, Nebo, Holzapfel, Tenuta, unpub data, western prairie provinces courtesy Karamanos

To avoid toxicity to root growth, avoid seed row or directly below seed row See Crops & Soils Magazine, May-June 2017

canola seed row

A points to end of canola roots



Wheat's early lateral roots avoid fertilizer band so less sensitive than canola

SDSU and IPNI online safe seed-placed fertilizer rate calculator: http://seed-damage-calculator.herokuapp.com/

Questions?

On to wheat

Image by K Olson-Rutz

MSU N Econ calculator for small grains

The best way to maximize profit is to adjust N rates based on costs, prices, and discounts

Inputs

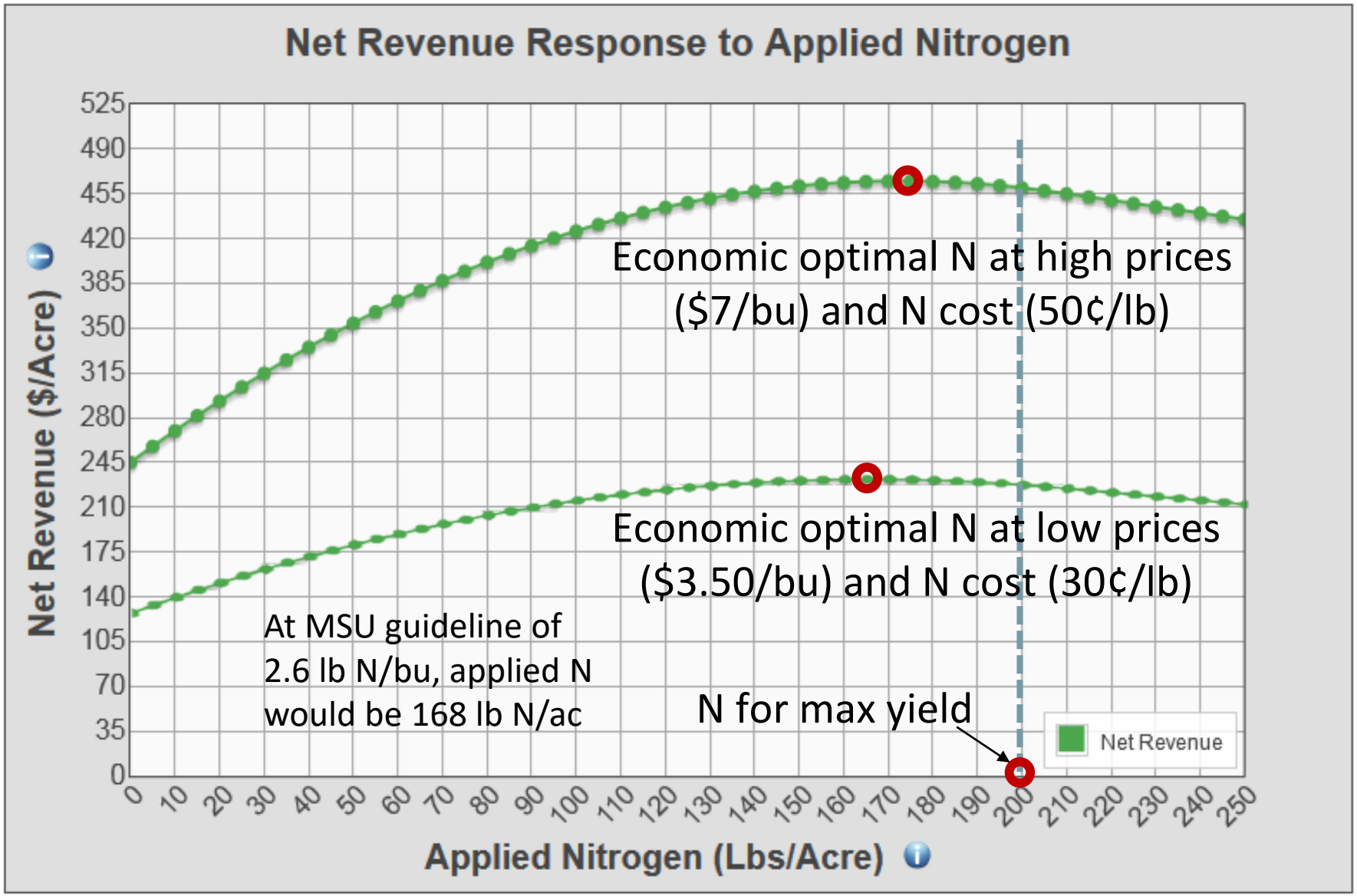
- N fertilizer cost, grain price, protein discount/premiums
- Yield goal – details on how to determine discussed later
- Residual soil nitrate-N from soil test
- Soil organic matter (SOM) from soil test

These calculate **FERTILIZER** N for max net return

Then adjust for prior crop, SOM, stubble, etc.

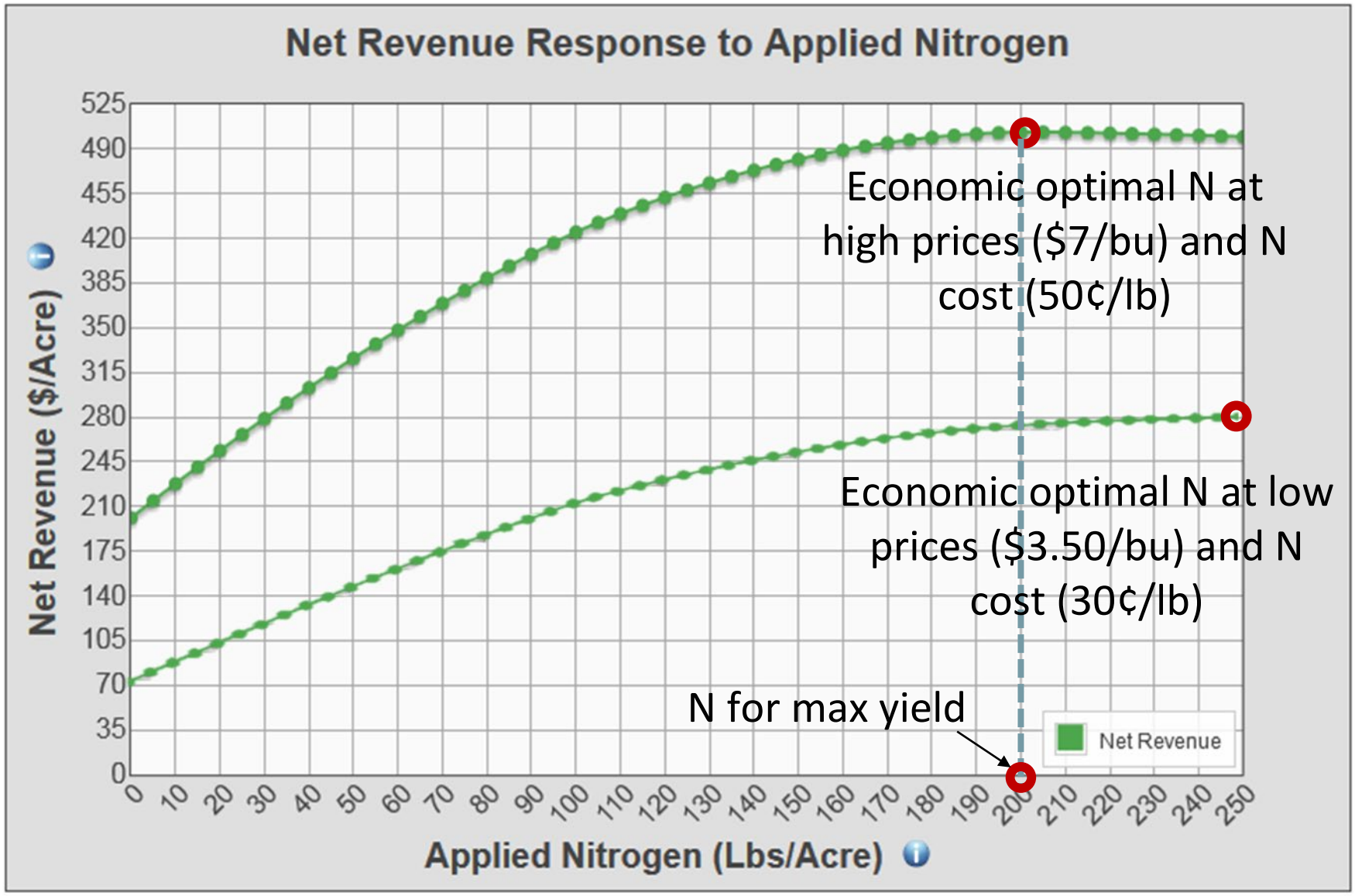
Calculators online for barley, SW, and WW after fallow
http://econtools.msuextension.org/nitrogen/index.html

Economically optimal N (e.g. WW with 0 discounts/premiums)



Soil N = 40 lb/acre, SOM = 2%

Economically optimal N when discounts are high: protein discounts (15¢/0.25%) & premiums (10¢/0.25%)



Soil N = 40 lb/acre, SOM = 2%

Total available N (lb N/bu) for maximum $ return: Winter wheat following fallow

Protein discount (¢/0.25%)	$/ton urea		
	$275	$460	$740
5	2.9	2.6	2.3
10	3.2	3.0	2.5

Based on $5/bu, 80 bu/ac, 2% O.M.

Best way to maximize profit (and stay in business?) is to adjust N rates based on costs, prices, and discounts. Use the MSU calculator.

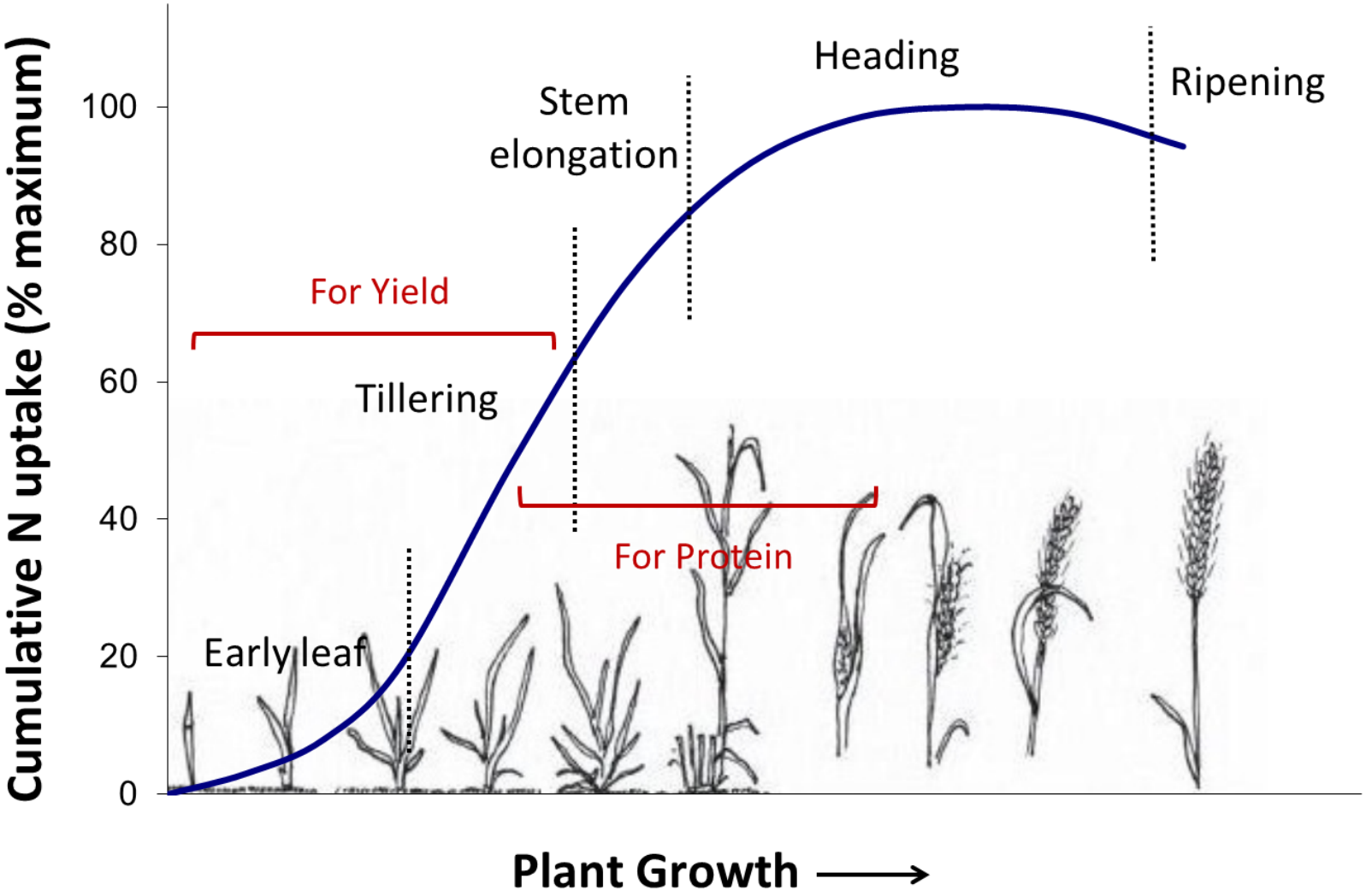
How to apply the Right amount of N

- Use conservative pre-plant/fall broadcast for early growth needs
- In-season adjustment for estimated yield potential based on precip to date
  - Don't apply 2nd application if dry or substantial disease
  - Apply large 2nd application if wet
  - Use chlorophyll meters (e.g., SPAD, GreenSeeker, and Crop Circle) and remote-sensing tech to guide in-season N adjustments
- Later applications:
  - Likely increase protein rather than yield
  - Less chance of lodging


Image by K. Olson-Rutz

N available before stem elongation → wheat yield

N after → grain protein



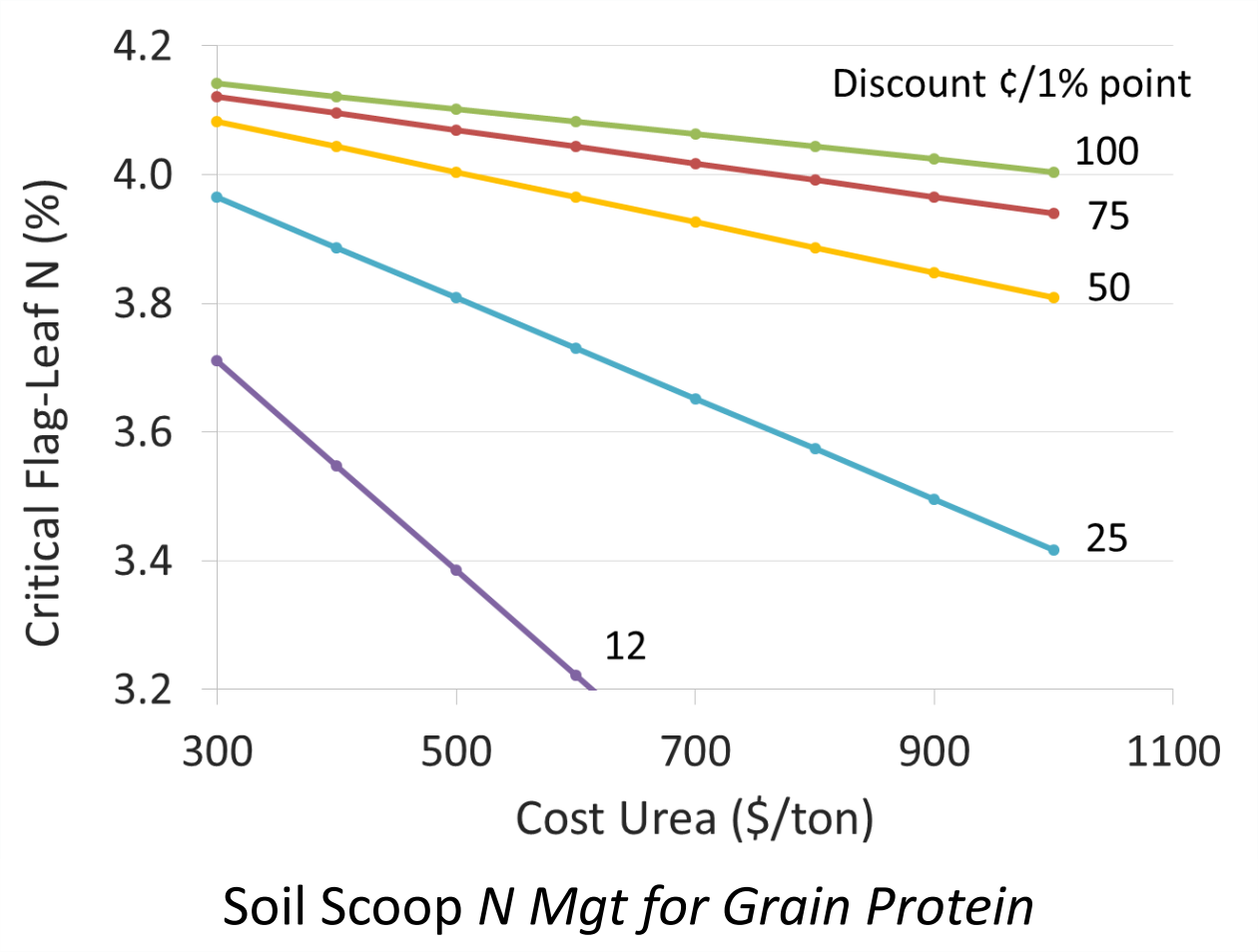
To calculate top-dress N see *The Soil Scoop N Management for Grain Yield*

https://landresources.montana.edu/soilfertility/soilscoop/index.html

To apply late season or not?

- Do you have a way to apply N without crop damage? (e.g. fertigation, high clearance weed sprayer, aerial)
- Are protein discounts sufficiently high to justify cost? (depends on expected % protein boost)
- Use chlorophyll readings
  - Irrigated spring wheat at heading < 93 to 95% of well-fertilized reference plot
  - Not a reliable tool in dryland winter wheat in our region
- What is the flag leaf N concentration?

Flag leaf N concentration (sampled at heading)



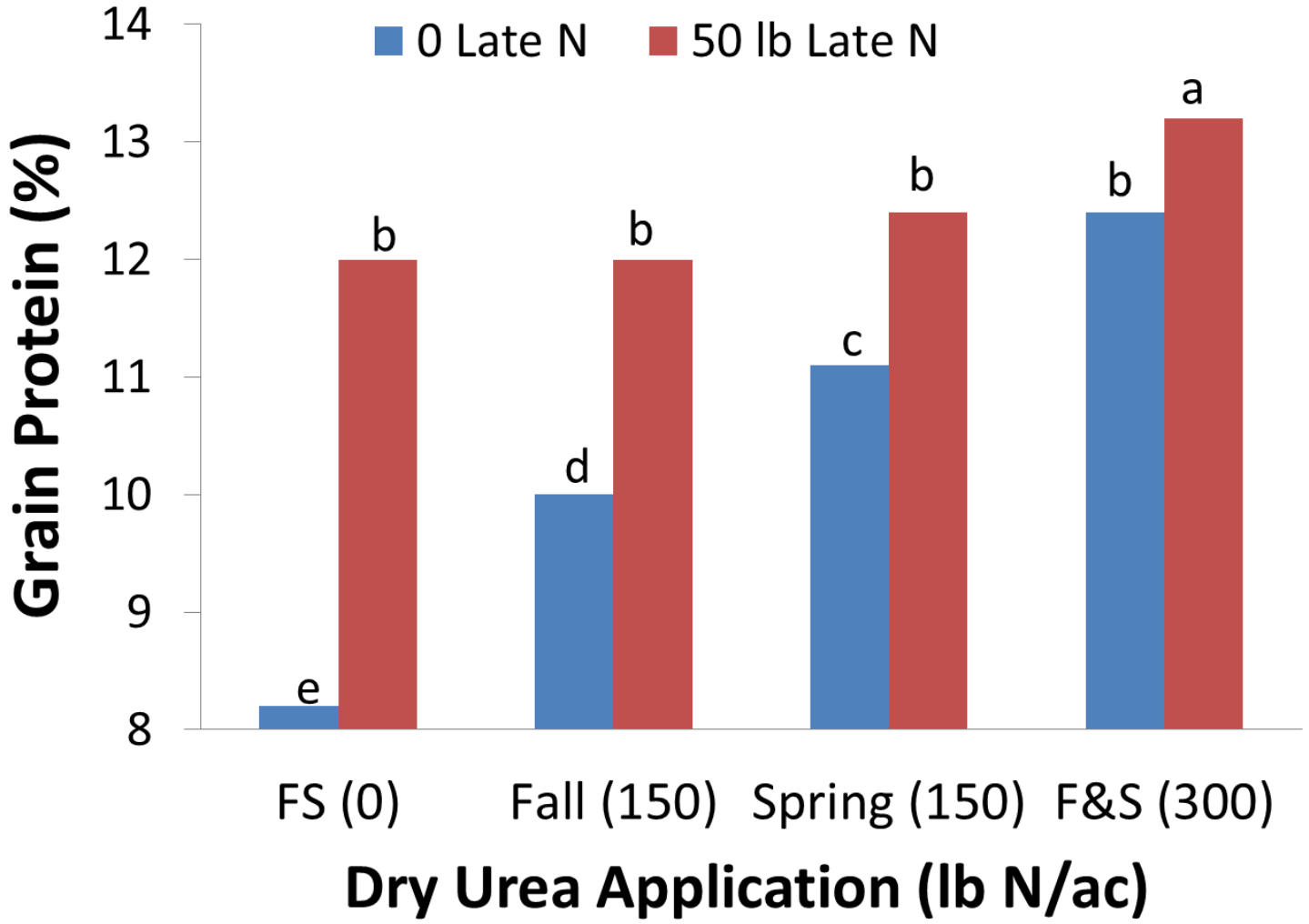
Soil Scoop *N Mgt for Grain Protein*

Critical FLN = FLN below which should top-dress N to max profit (and above which should result in a loss)

Critical FLN =

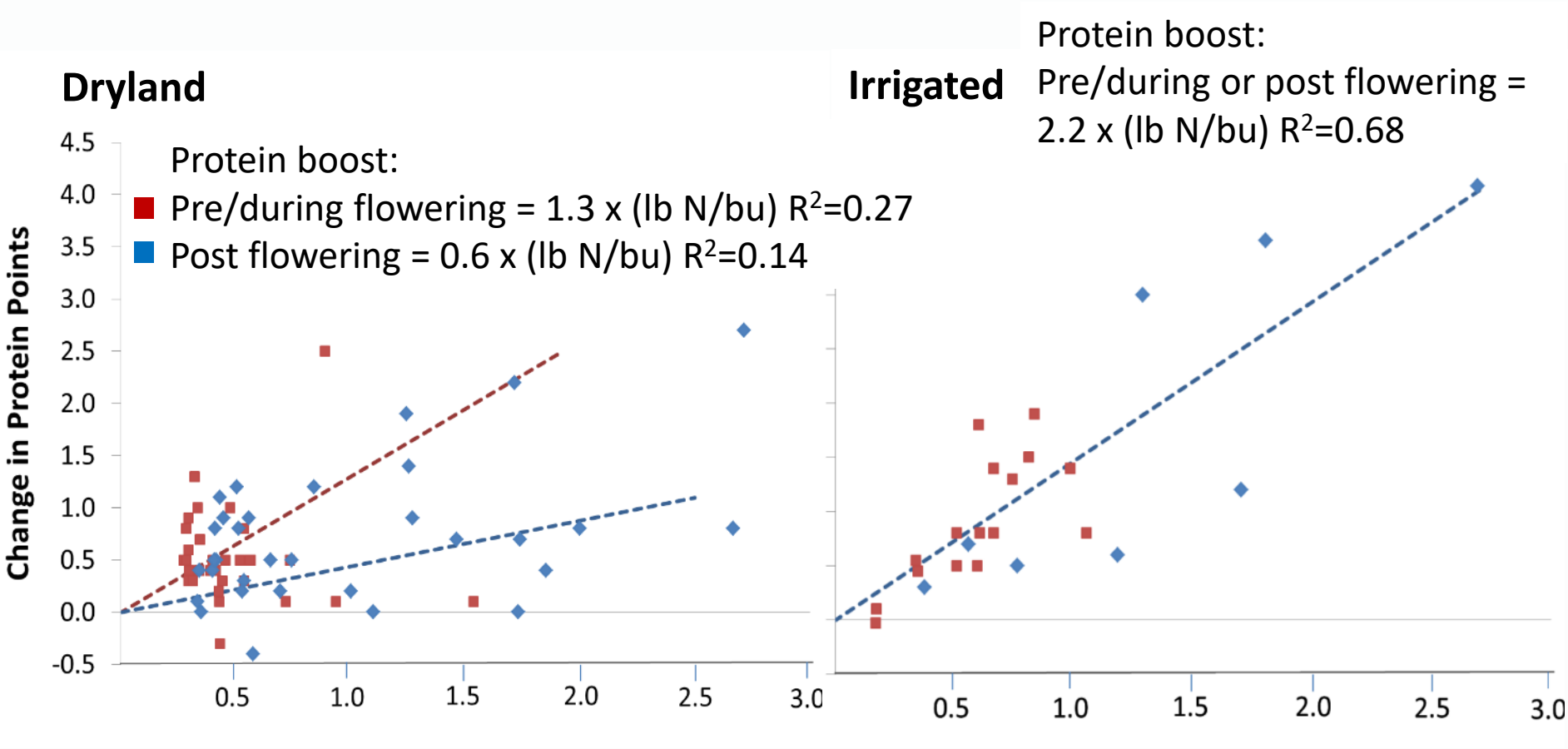
4.2 – 13.3(N cost in $/lb N)/((protein discount per point)(expected yield))

Urea applied between heading and flowering (Feekes 10.2 - 10.5) increases protein in irrigated winter wheat



Brown & Petrie 2006
Idaho, fall pre-plant incorporated, late N incorporated with irrigation

In-season N rate, timing, and dryland vs. irrigation affects protein boost



Ability to incorporate with rain or irrigation more important than exact timing at flowering

Evaluate N management

- If winter wheat protein < 12.5%, likely yield limited by lack of N
- To gain 1 protein point (%) in winter wheat:
  - + 22 lb N/ac with < 6” growing season precip
  - + 33 lb N/ac with > 12” growing season precip
- If spring wheat protein < 13.2%, likely yield limited by lack of N
- See *Practices to increase wheat grain protein* EB0206, and 2 *Soil Scoops* on N for wheat

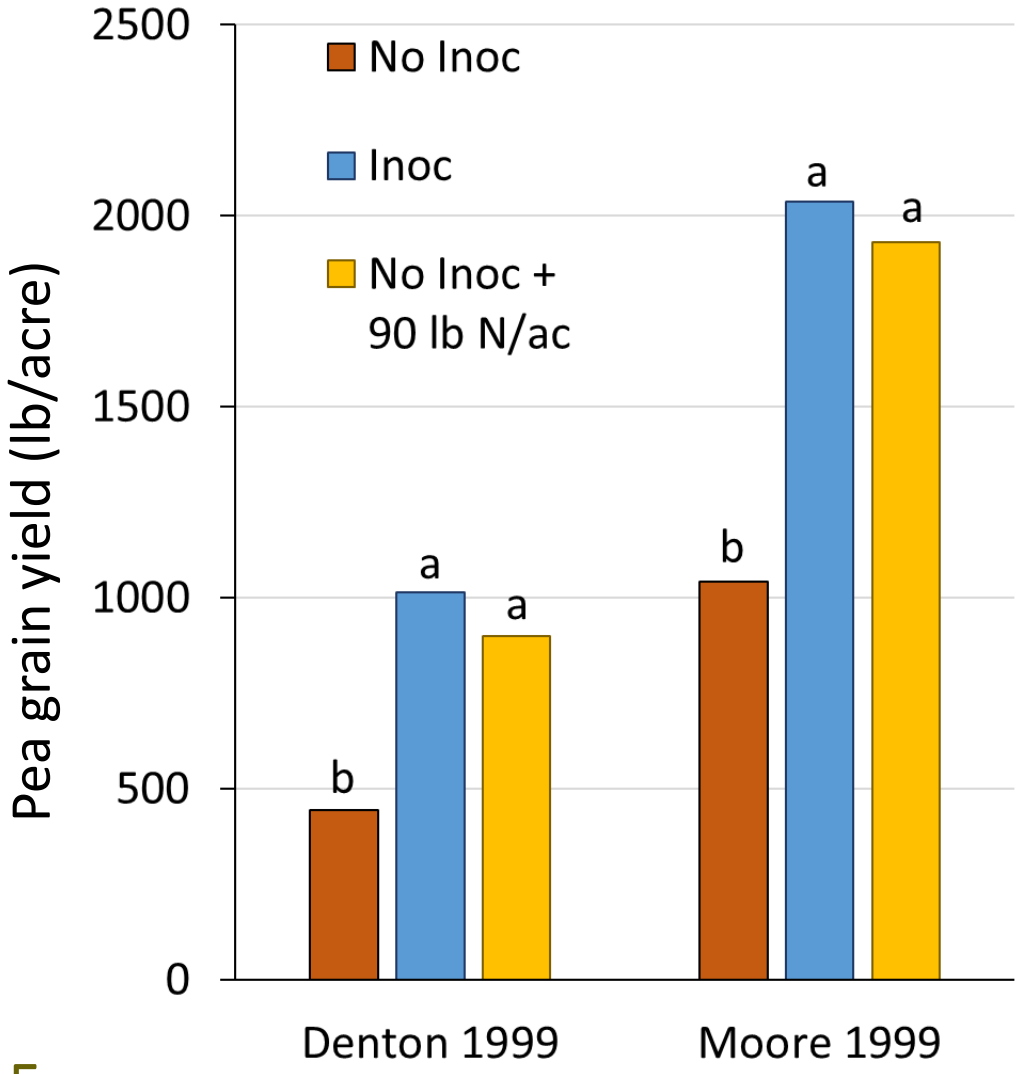
Questions?

On to pulse crops

Image by K Olson-Rutz

Pulses require N by either:

- Inoculation, especially on sites with no recent pulse history
- Fertilizer (rarely)



"New" fields:

Granular = more effective

Field with pulse history in ~ 5 yrs :

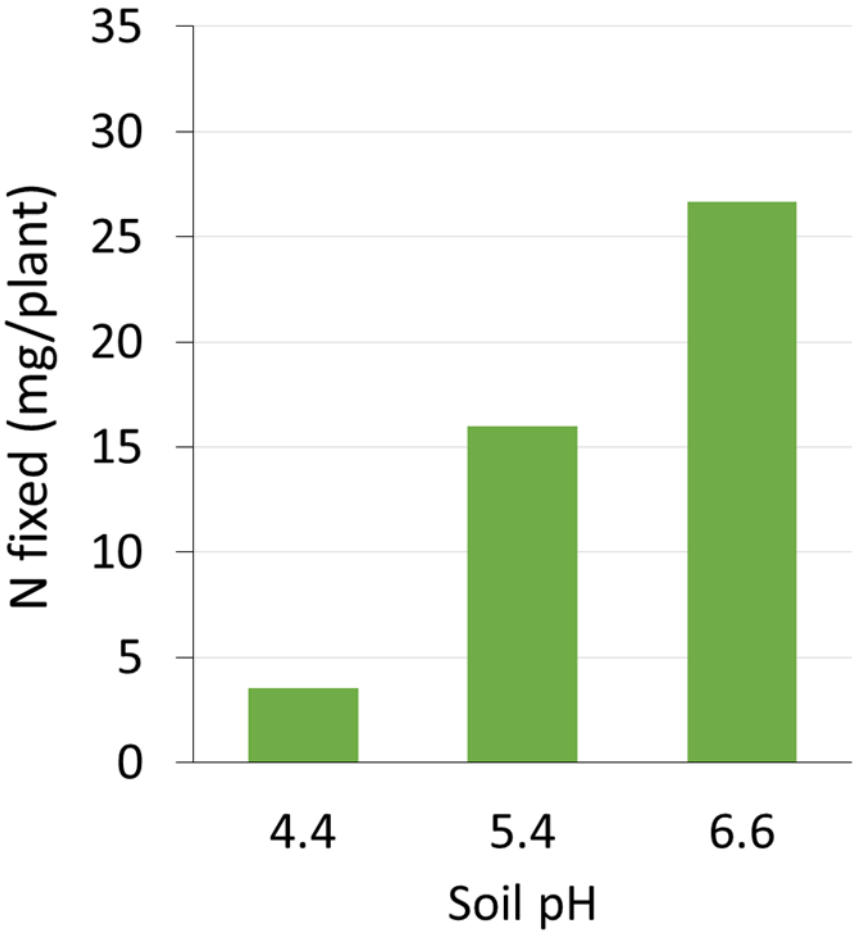
Liquid or peat = less expensive

Fields had no recent pulse history

McConnell et al., 2002, stat letters (a, b) are w/in location-year

Uncontrollable factors negatively affecting nodulation & N fixation

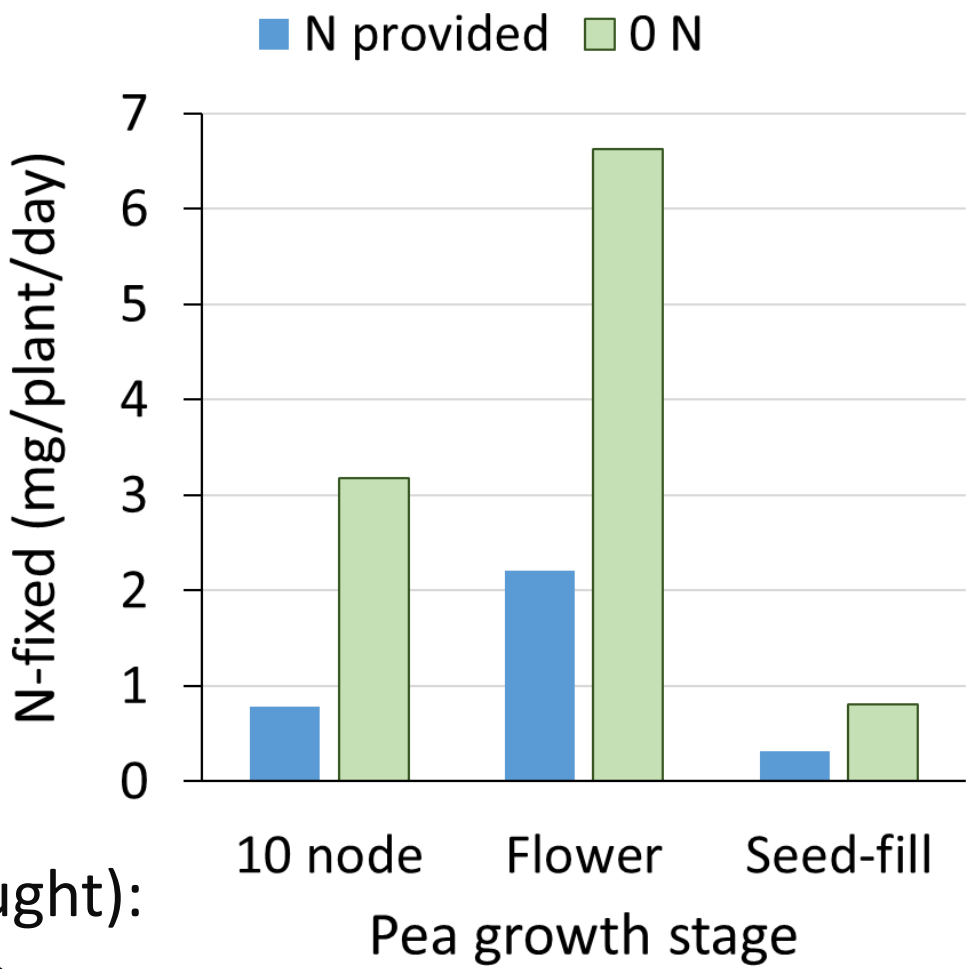
- Extreme soil temps
- Waterlogged or dry soil
- Soil pH < 5.5, > 8 inoculant strains differ in tolerance
- Saline soils
- Maturing plants



Rice et al., 2003, greenhouse

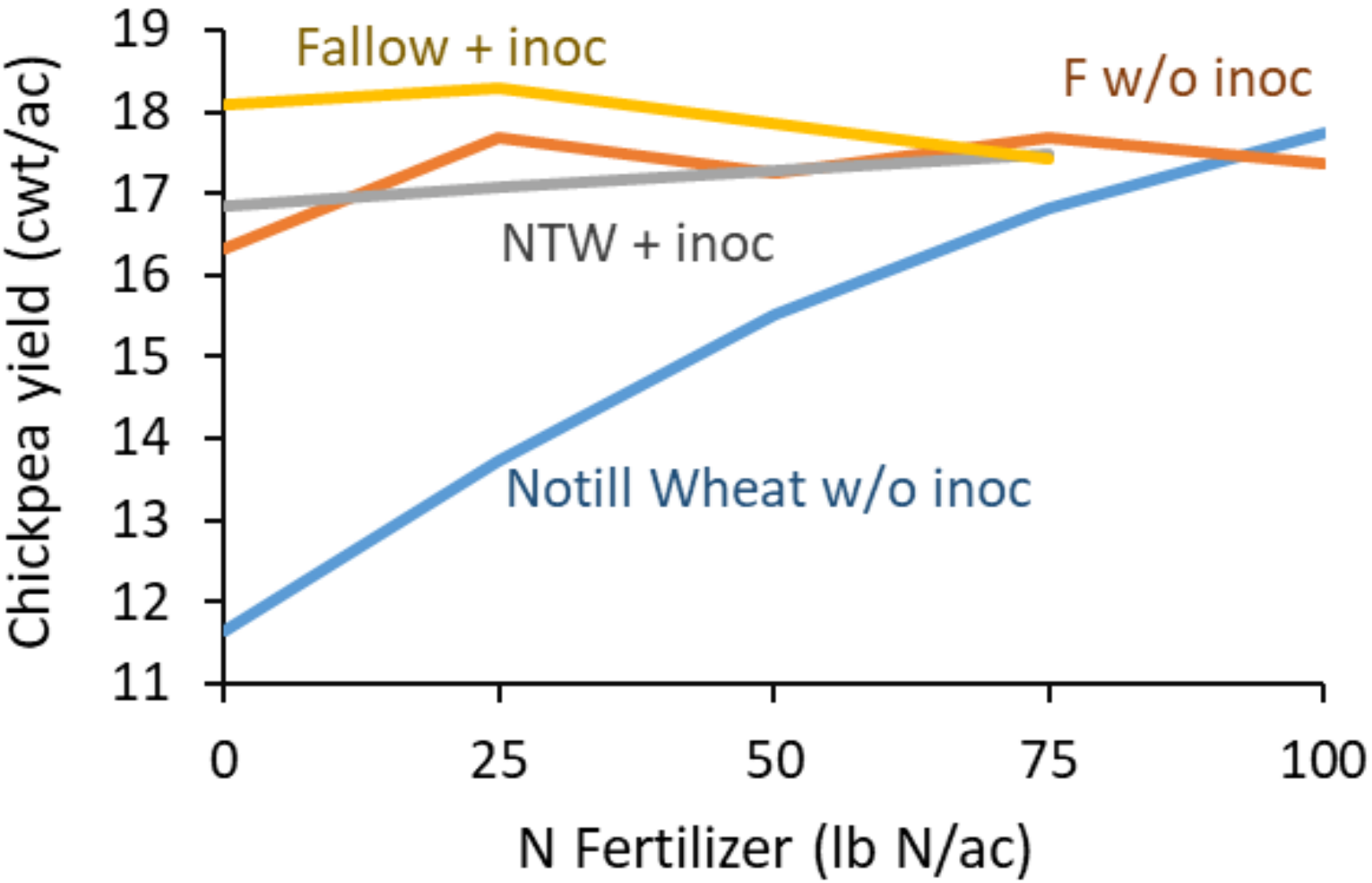
Practices to improve nodulation & N fixation

- Use species-specific inoc at right rate
- Keep inoc cool, dark
- Granular more reliable than liquid esp at pH <5.4 (Rice et al., 2000)
- Avoid fertilizer salts with inoculant (mixing with fertilizer can kill bacteria)
- Ensure adequate P, K, S
- Watch soil N (esp after drought): too much inhibits N-fixation
- No-till to retain soil moisture



Voison et al., 2003 greenhouse study

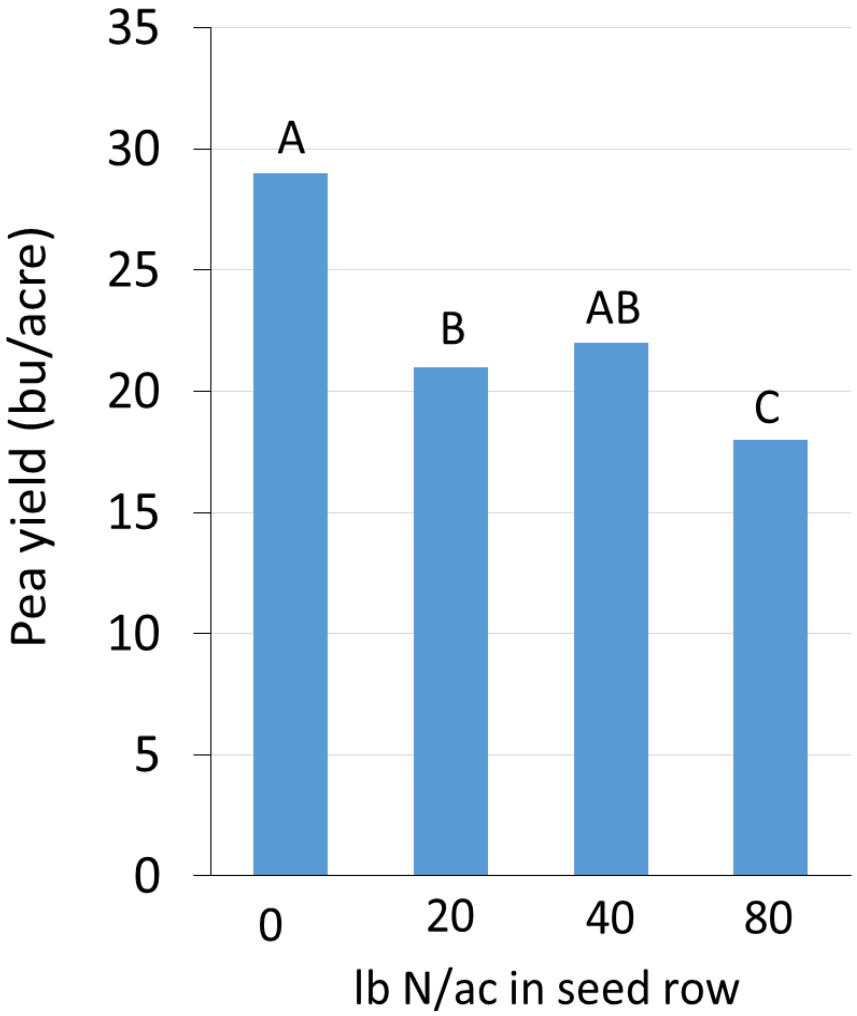
Inoculation is more important in recrop than fallow due to lower nitrate after recrop



Gan et al. 2009, SK

Seed row N

- Too much N
  - inhibits nodulation
  - produces excess vegetation
  - reduces yield
- Aim for 10-15 lb total available N/ac (soil + fertilizer) in top 12” in spring
- Place to side of seed row
- With lentil and chickpea, starter N reduces time to maturity, improves harvestability (Gan et al. 2003)



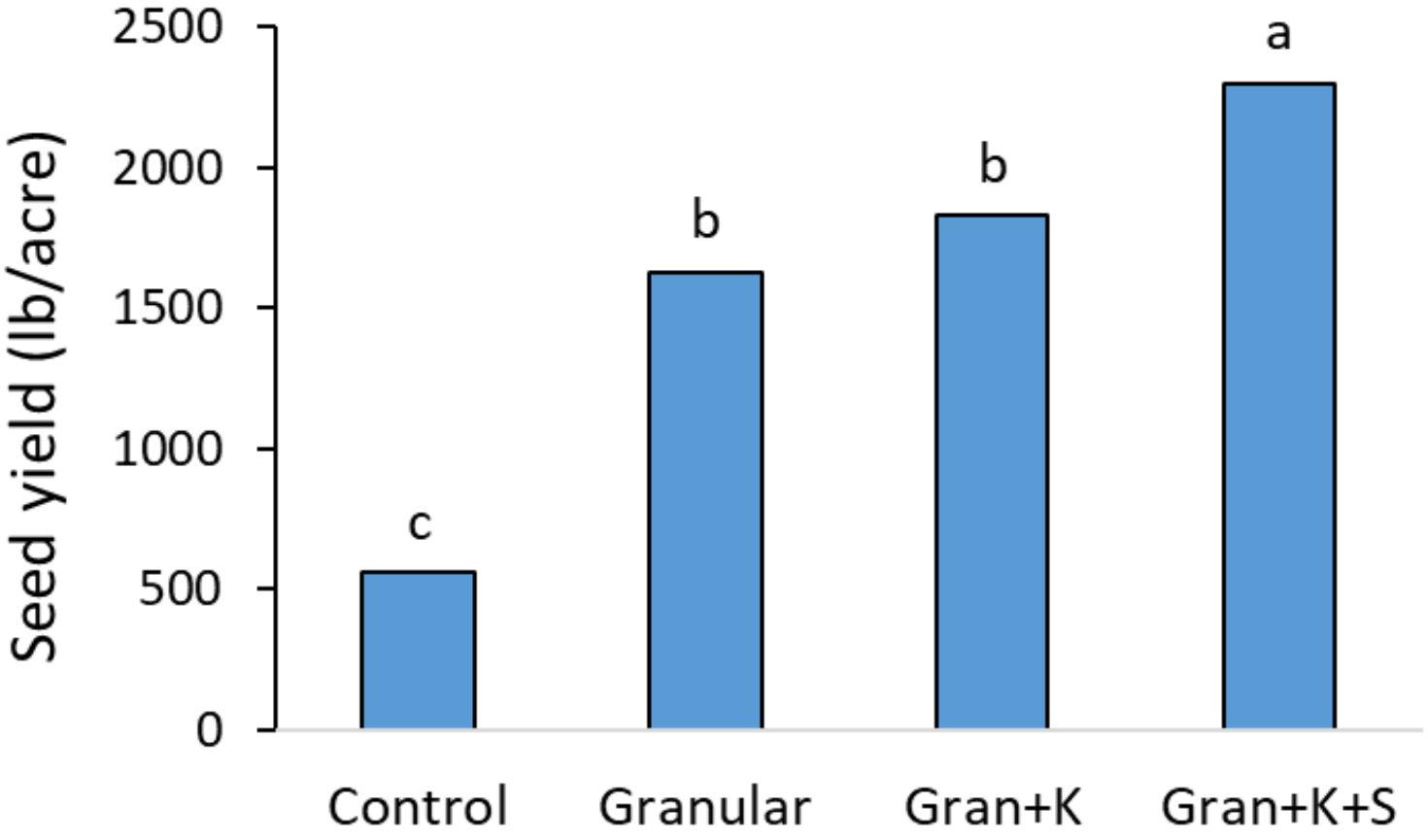
Huang et al., 2017, Moccasin

Is this plant N deficient?

Image by Clain Jones

- Sulfur (S) deficiency is yellow upper (new) leaves
- S is necessary to take up N and make protein

S and inoculation increased lentil yields at Sidney in 2019



Chen et al. unpub. data, 5 lb S/ac, 15 lb K_2O/ac

S increased lentil N fixation by 30 lb N/ac in Gallatin Cty in 2020 (Jones unpub. data)

Summary

- Soil test for residual N in soil
- Base rate on yield goal and adjust for SOM, prior crop
- Ensure nutrients are available before rapid growth
- Ideally 50 to 65% of N based on reasonable yield goal at seeding, remainder adjusted to current production potential, applied broadcast or foliar.
- Need adequate S to ensure N response
- Beware of seed-placed fertilizer toxicity
- More is not necessarily better

Photo by Ann Ronning

Thank you!
Questions?

Future sessions
Jan 27: Micronutrients
Feb 3: Forage Nutrient Mgt
Feb 10: Sustainable Nutrient Mgt
Feb 13: Cover crops

This presentation and more information on soil fertility is available at http://landresources.montana.edu/soilfertility