Nitrogen Management for Grain Yield and Protein

Great Falls, Montana

Dry Fork Ag Workshop

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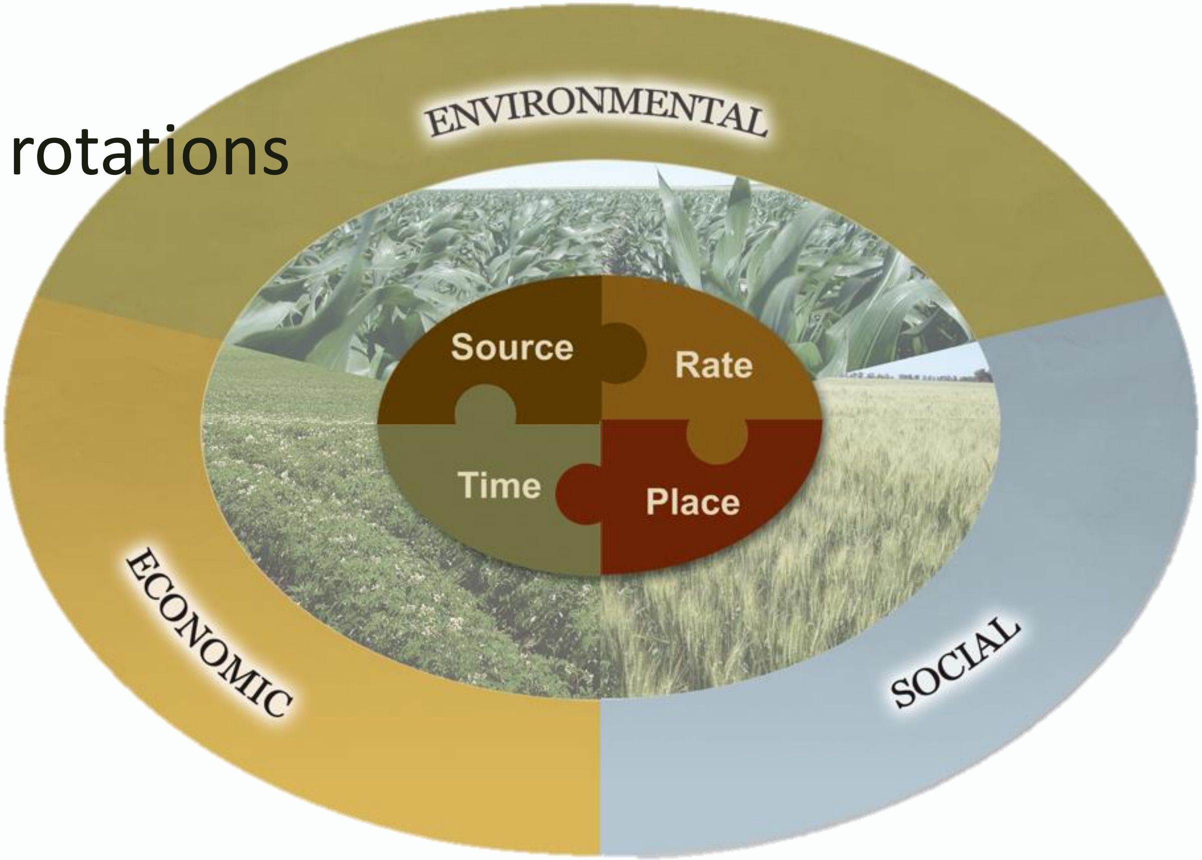
Clain Jones clainj@montana.edu 994-6076

MSU Soil Fertility Extension

Todays objectives – 4Rs of nitrogen

- Steps towards calculating an N rate
- Timing
- Source & legume rotations
- Placement



Realistic yield goal

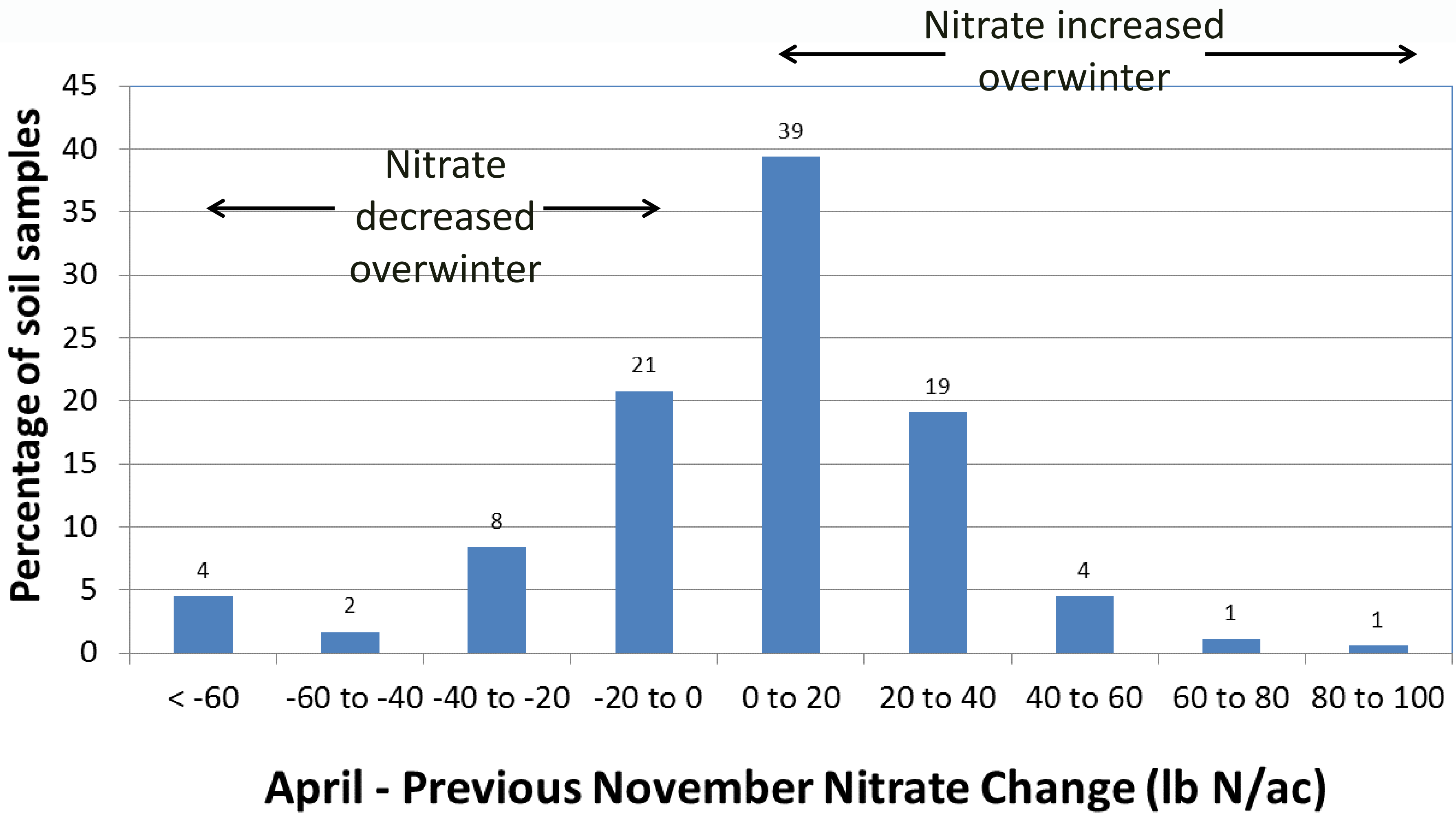
- Use variety selection tools
- Past yields indication of future performance
- Having ability for in-season N application allows conservative yield estimate for pre-plant rate

Residual soil N: Timing of soil sampling

- Nitrogen fertilizer guidelines are based on spring soil samples for nitrate in Montana
- BUT, most sampling in MT occurs from late summer to late fall

Why is this a potential problem?

Soil nitrate can increase or decrease from November to April, Montana data based on 180 samples (Jones et al. 2011)



Fall soil tests can lead to over or under-fertilized fields

High N crop residue and/or high O.M.

Mineralization

Over fertilized

Over winter

High Precip

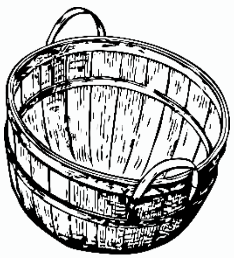
High N on shallow or coarse soil

Under fertilized

N leaching (or N_2 gas losses?)

Compare fall with spring a few times to see patterns of loss or gain for given pastures/rotation

Historical average AVAILABLE N rate guideline: when soil organic matter = 2%



- Dryland winter wheat
  2.6 lb N/bu @ 12.5% protein

- Spring wheat
  3.3 lb N/bu @ 14% protein

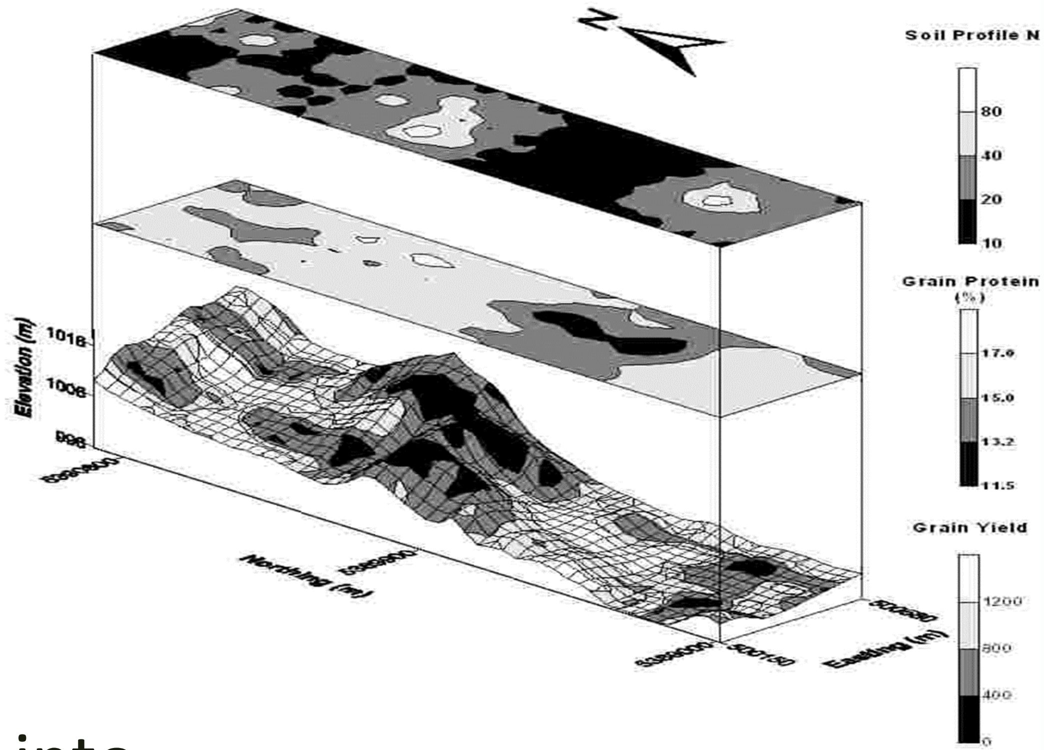
- MSU N rate calculation tool takes into account fertilizer costs, grain prices, and protein discounts to optimize net revenue.
  http://www.msuextension.org/econtools/nitrogen/index.html

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

Variable rate N application
(Zone or site specific farming)

- At this time economic advantage is inconsistent
- At simplest, divide field into zones of low, med, high productivity
- NDSU has bulletin series on Zone farming SF1176 series at [www.ag.ndsu. edu/publications](www.ag.ndsu.edu/publications)



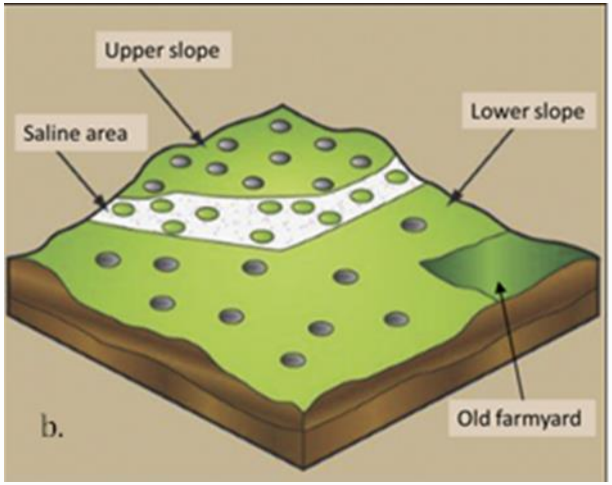


Image adapted from IPNI 2012

N rate adjustments

- 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

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

- After legume rotation: Adjust fert up or down? Legumes credit (add) N

Crop	N credit (lb N/acre)
Alfalfa	40
Annual legume 1 x	~10
Annual legume >3 x	~20

N rate adjustments (cont)

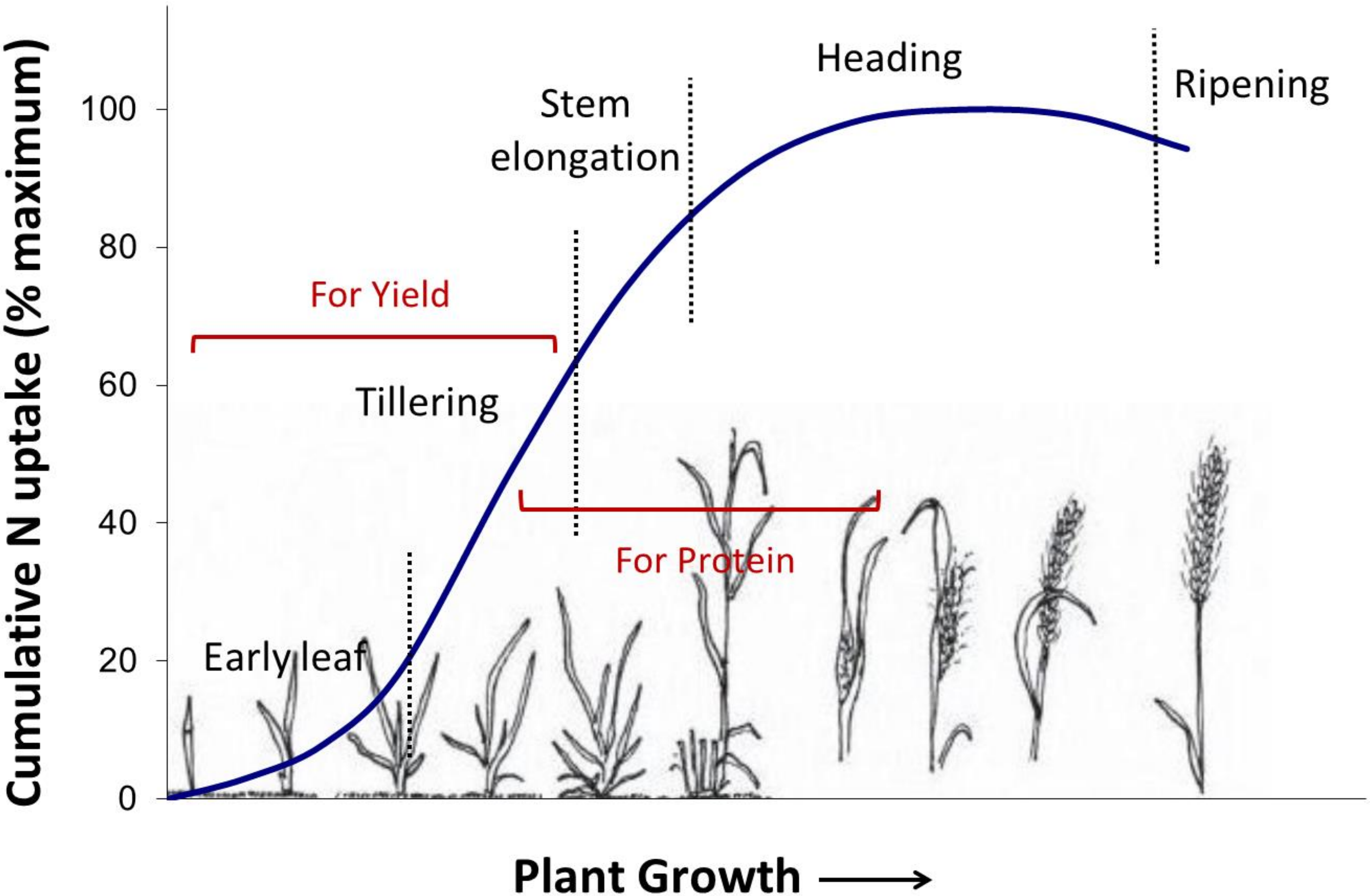
- SOM
  - <1% SOM, add 15-20 lb N/acre
  - >3% SOM, reduce 15-20 lb N/acre

- Tillage – No-till may require extra N for 6 to 15 years. Finer soils require longer end.

Questions?

On to *Timing*

N uptake by wheat for yield and protein



Timing depends on source

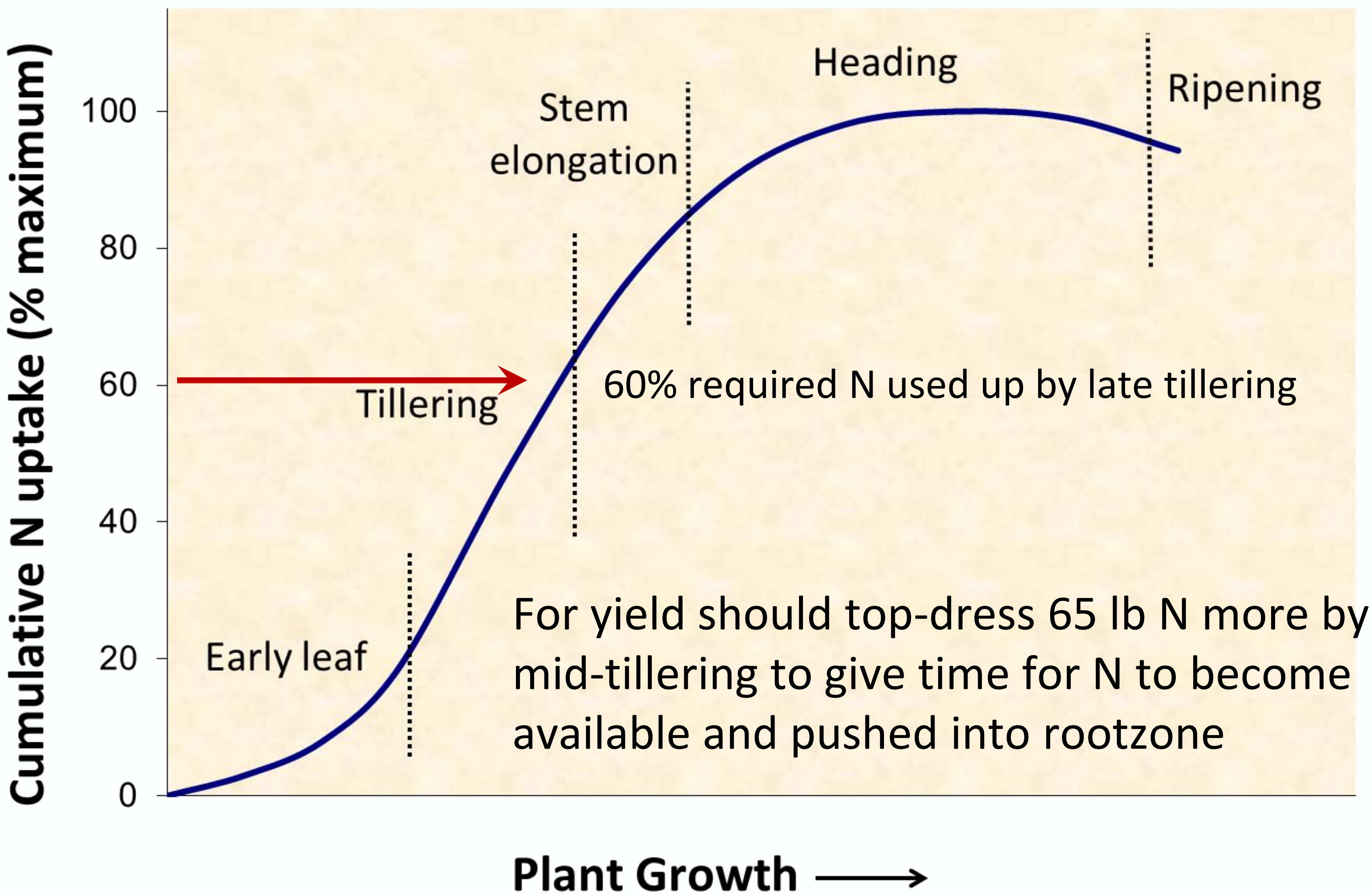
- Readily available [urea (46–0–0), urea ammonium nitrate (28–0–0)]
  - shortly before seeding up to mid-tillering
- Slowly available (manure, slow-release N)
  - take time to become available
  - apply well before needed – e.g. fall

Use Nutrient Uptake figure to time top-dress

Example on per acre basis:

- 165 lb N total need
- 40 lb N in soil + 60 lb preplant N = 100 lb N = **60% total N** required (100/165=0.60)
- (165 – 100) = 65 lb N needed to top-dress

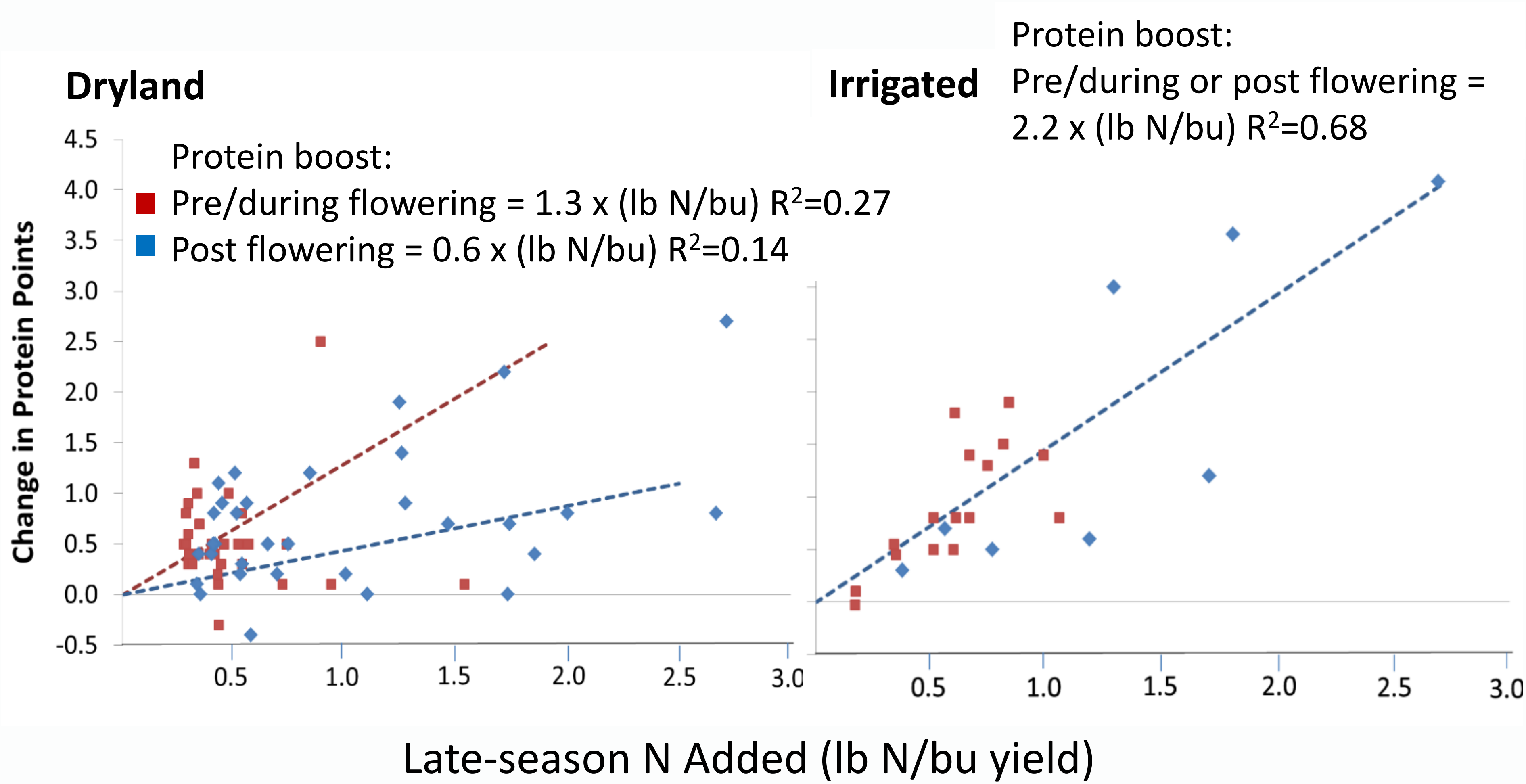
Top-dress amount and timing based on wheat growth stage



Split/In-season N Applications

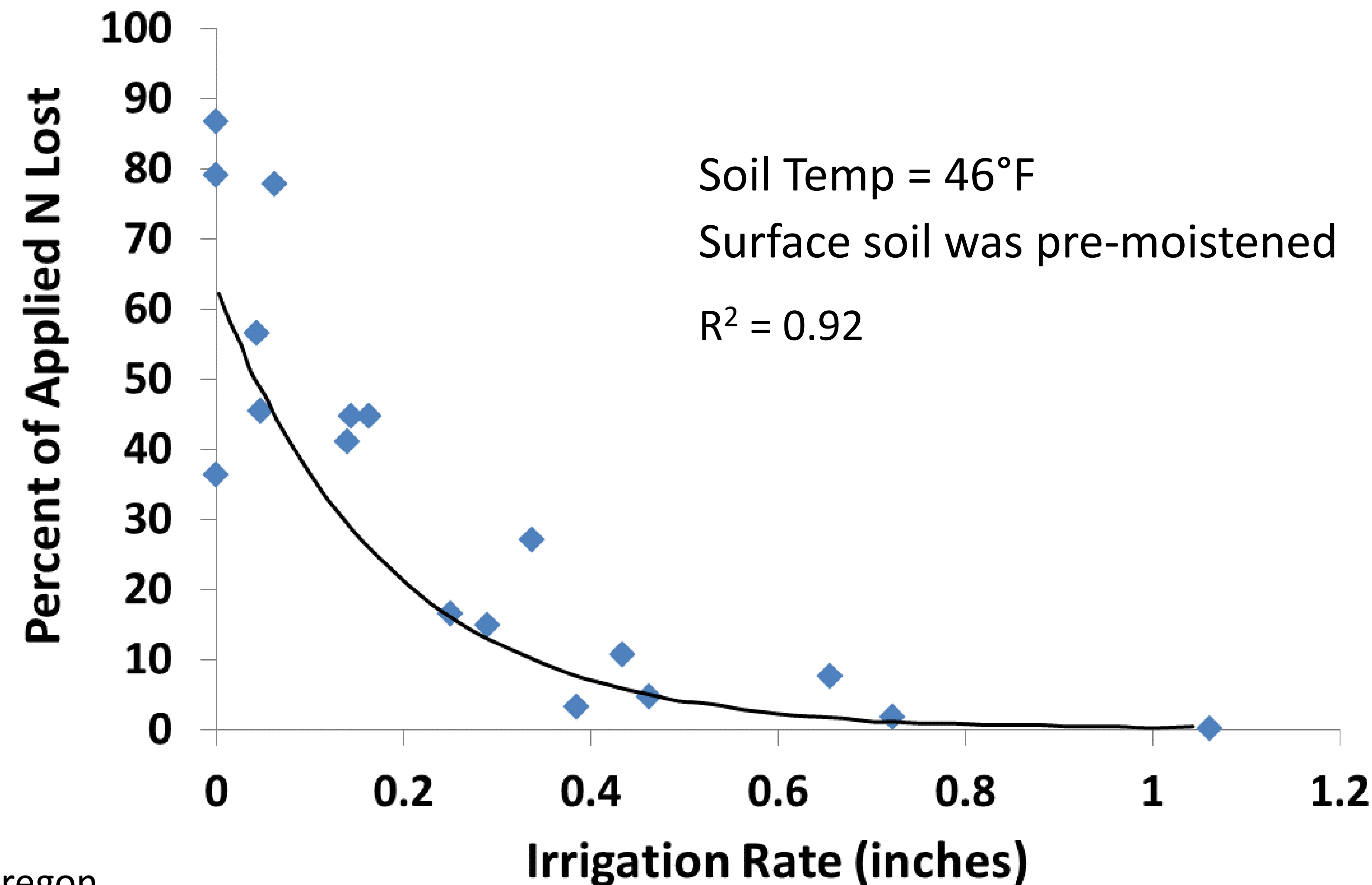
- Fall broadcast supplies early growth needs
- In-season adjustment for estimated yield potential based on precip to date
  - Don’t apply 2nd application if dry or substantial disease
  - Apply large 2nd application if wet
  - Use chlorophyll meters (e.g., SPAD, GreenSeeker, and Crop Circle) and remote-sensing technologies to guide in-season N adjustments
- Later applications:
  - Potential to increase protein rather than yield

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

Broadcast before rain or irrigation (to minimize volatilization loss)



Echo, Oregon
Holcomb et al. 2011

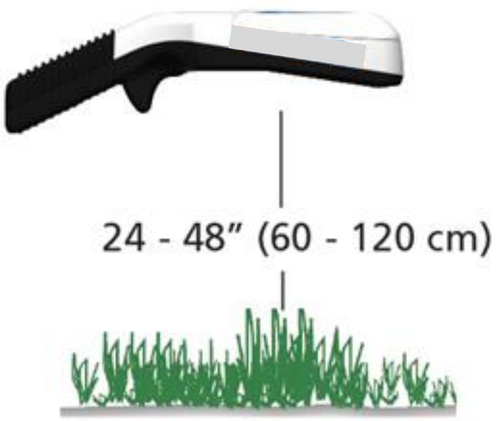
Late season N cautions

- High late season N on irrigated wheat – lodging
- After stem elongation less chance of lodging
- If risk of scab, avoid application within 5 days of flowering if irrigated or expected rainfall

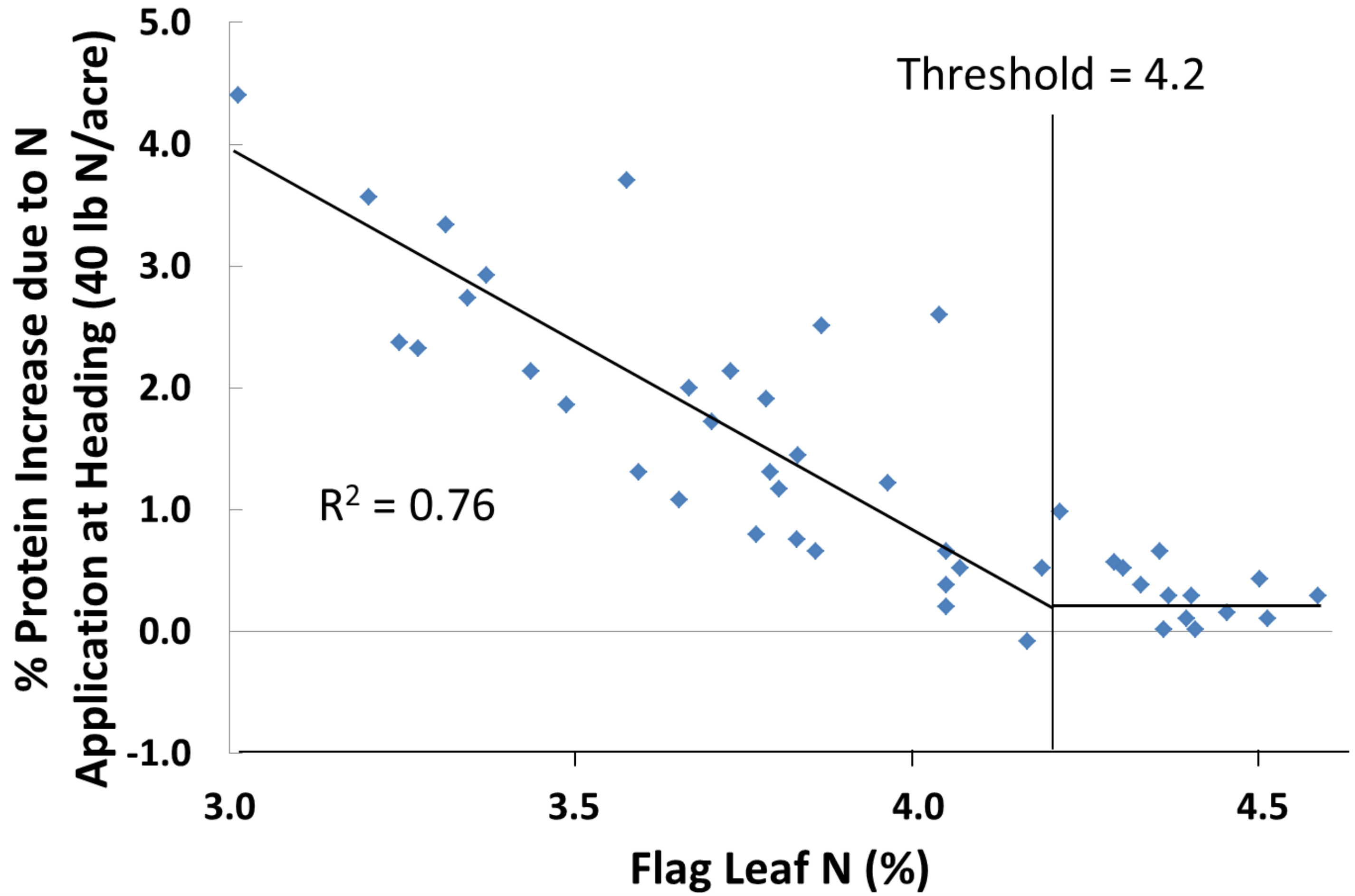
Image from MT200806

To apply late season or not?

- Flag leaf N concentration (sampled at heading) < 4.2%
- 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



Protein increase gained by top-dressing 40 lb N/acre at heading on SW increases at lower flag leaf N



Relationship between protein response to N topdressed and flag leaf N in irrigated sw. Fertilizer Fact 12

Flag leaf sampling

- When?
  Collect at first sign of flowering
- Numbers?
  Randomly select 50-75 flag leaves per field
- How and where send?
  Overnight to a lab w/ fast turnaround (e.g., 1 day turn-around)
- Is this a common way to determine whether to topdress or is it Clain's hair brain idea?
  Agvise analyzed ~15,000 flag leaf samples in 2009 and ~30,000 in 2010 (Dietrich, pers. comm.)

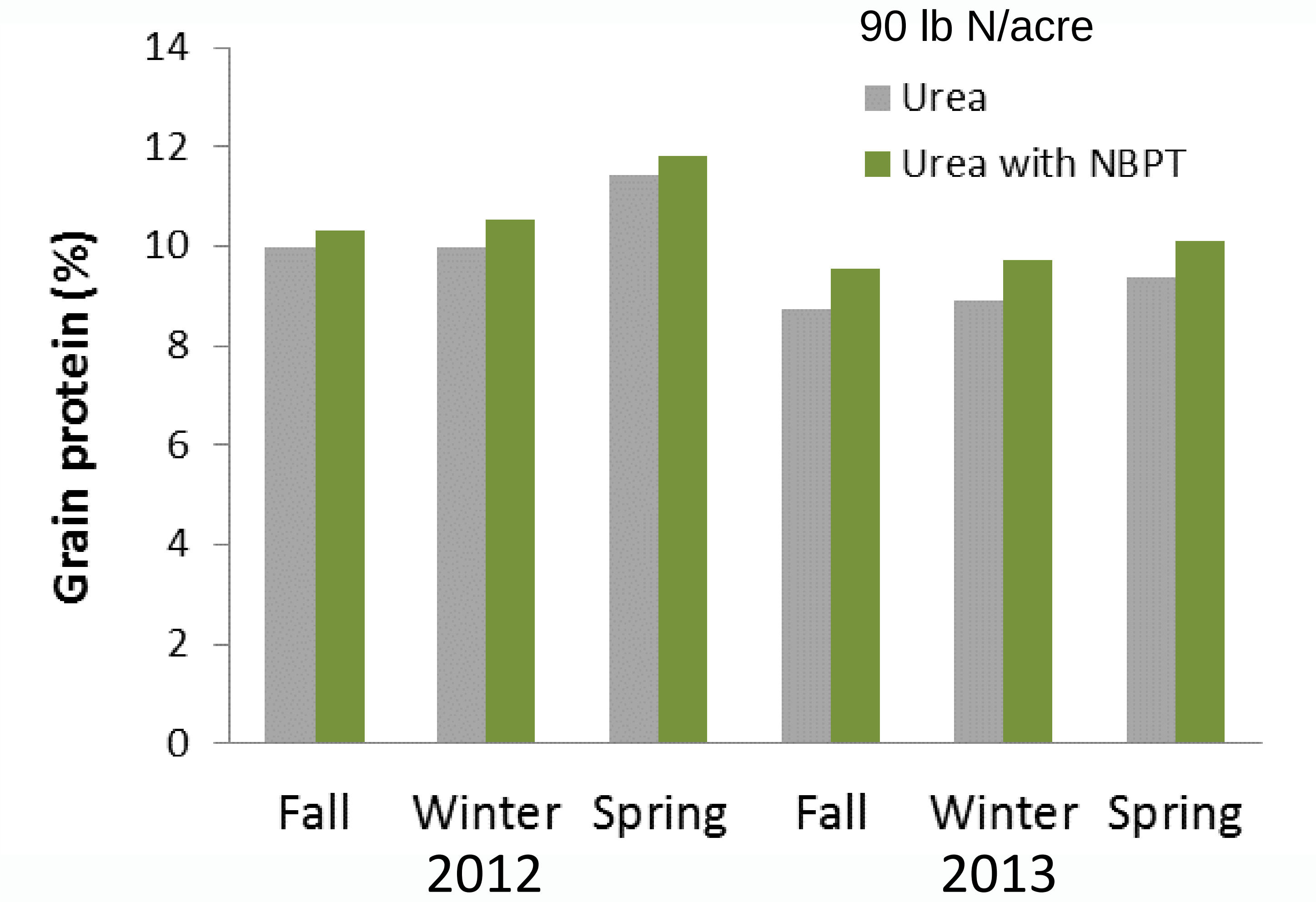
Questions?

On to *Source and Placement*

Different N sources have different volatilization and leaching loss potential

	***POTENTIAL* loss compared to urea**	
Source	Volatilization	Leaching
Conventional		
Ammonium nitrate, CAN, ammonium sulfate	less	≈
UAN (solution 28 or 32)	less	≈
Enhanced Efficiency Fertilizers (EEFs)		
Urease inhibitors (NBPT: Agrotain, ContaiN)	less	≈
Nitrification inhibitors (DCD: Guardian DF; nitrapyrin: N-Serve, Instinct)	≈	less
Combinations (SuperU)	less	less
Controlled release polymer coated (ESN)	less	less
Slow release (Nitamin, N-Sure, N-Demand)	≈	less?

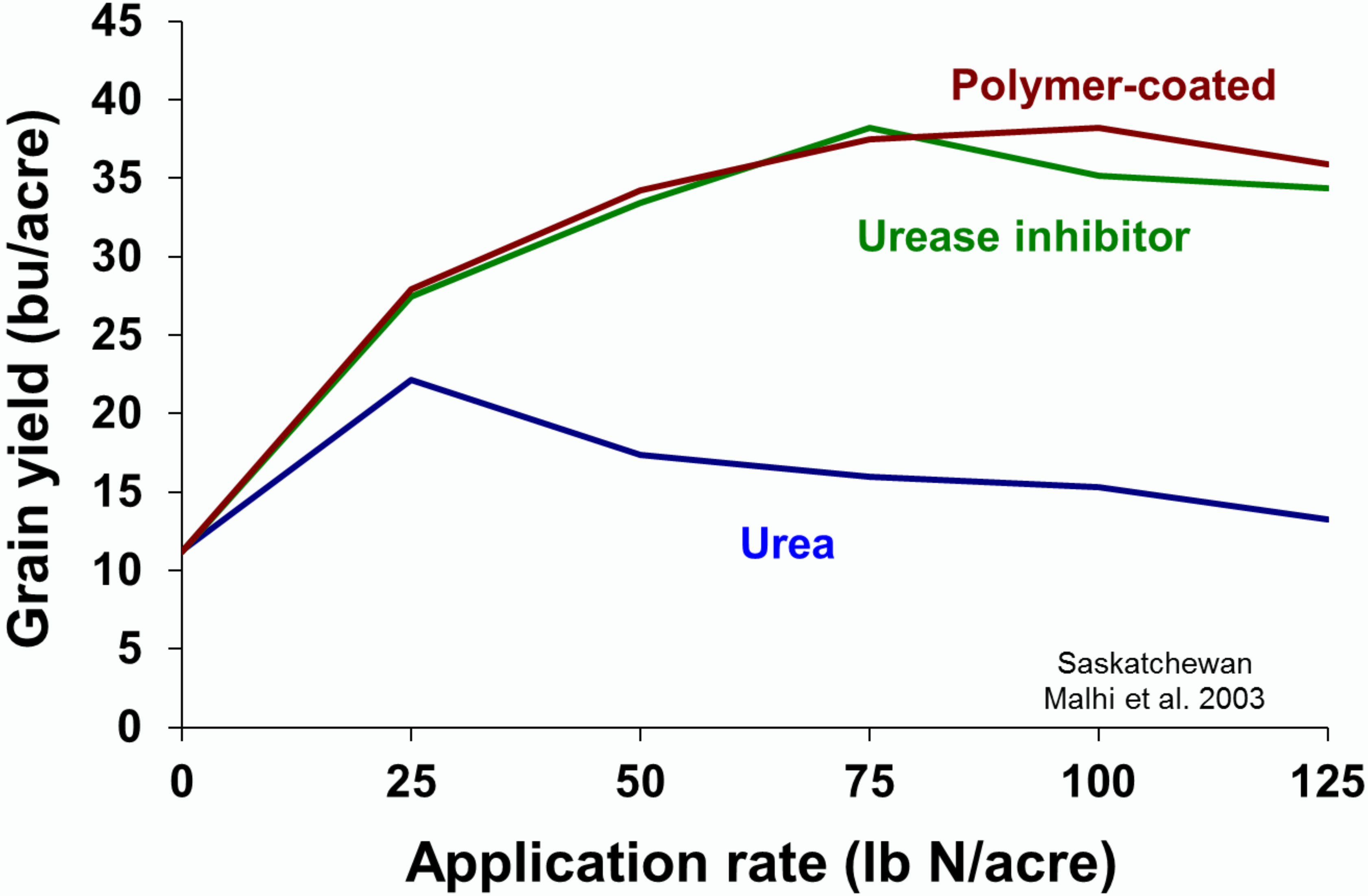
NBPT with broadcast urea can increase WW grain protein



NBPT sig increased protein by about 0.4 to 0.8% points for both years. NBPT only increased yield in Fall 2012.

Coffee Creek, MT
Engel unpub data

EEFs increase safe rate with seed

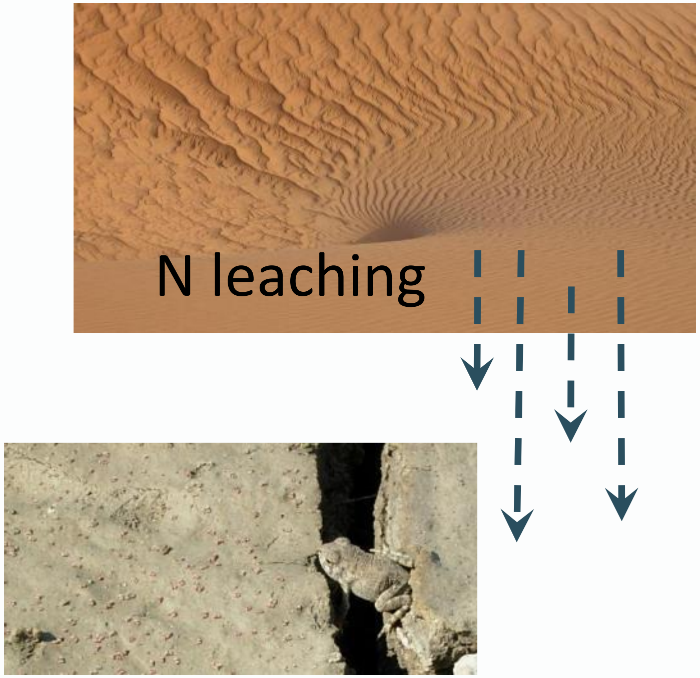


Slow- and controlled-release for the northern Great Plains

- No consistent benefit shown
- Fall broadcast controlled release may increase yield over broadcast urea, especially in a wet year when urea may leach overwinter
- If fall application to reduce spring workload is important, then extra cost might be worth it
- Release tends to be too slow with late winter to early-spring application (McKenzie et al., 2007)
- Consider blending with urea

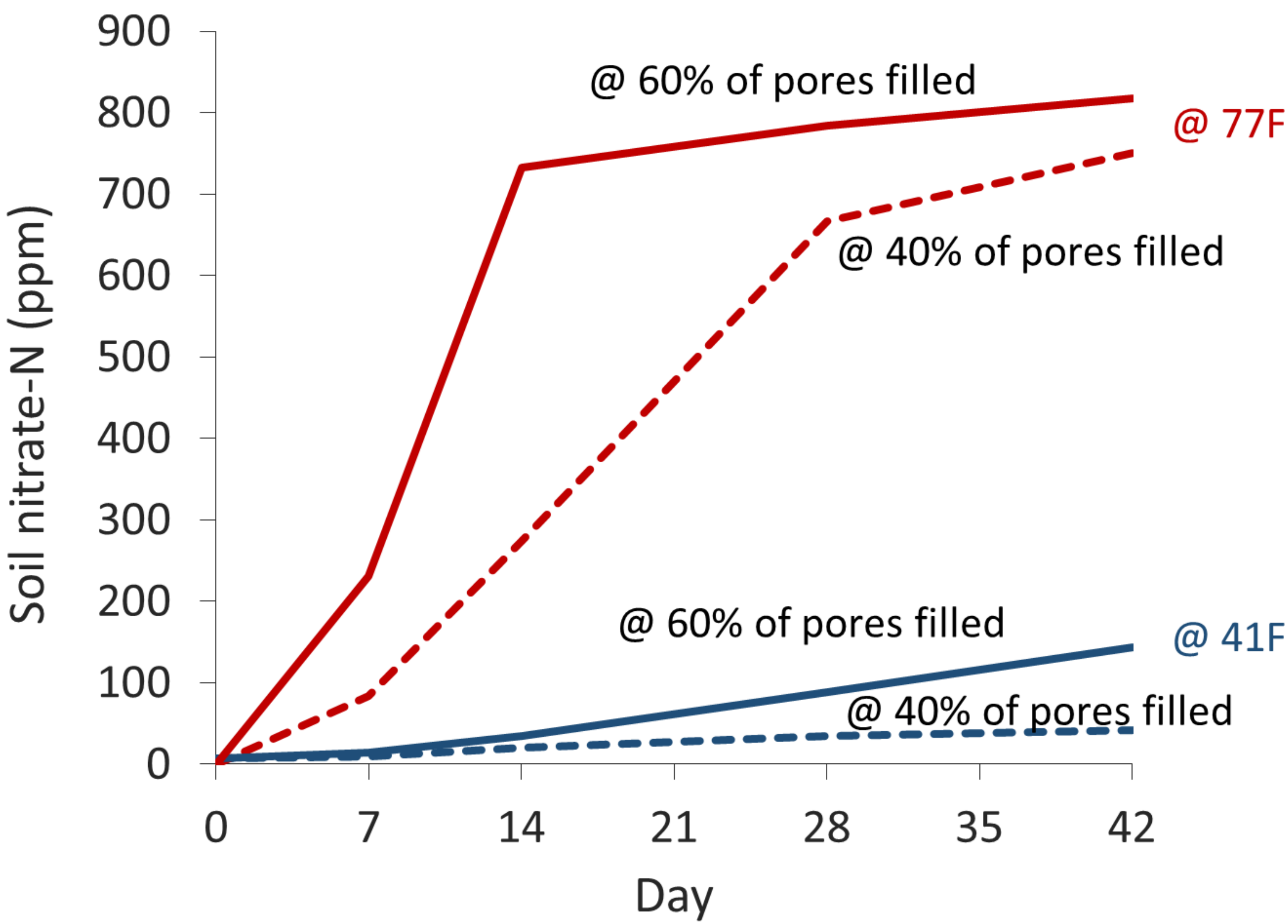
Nitrification inhibitors

- Potential benefit with fall-banded urea where:
  - high precip with leaching in sandy soils
  - denitrification (nitrate → N_2 gas) in water logged/clay soils



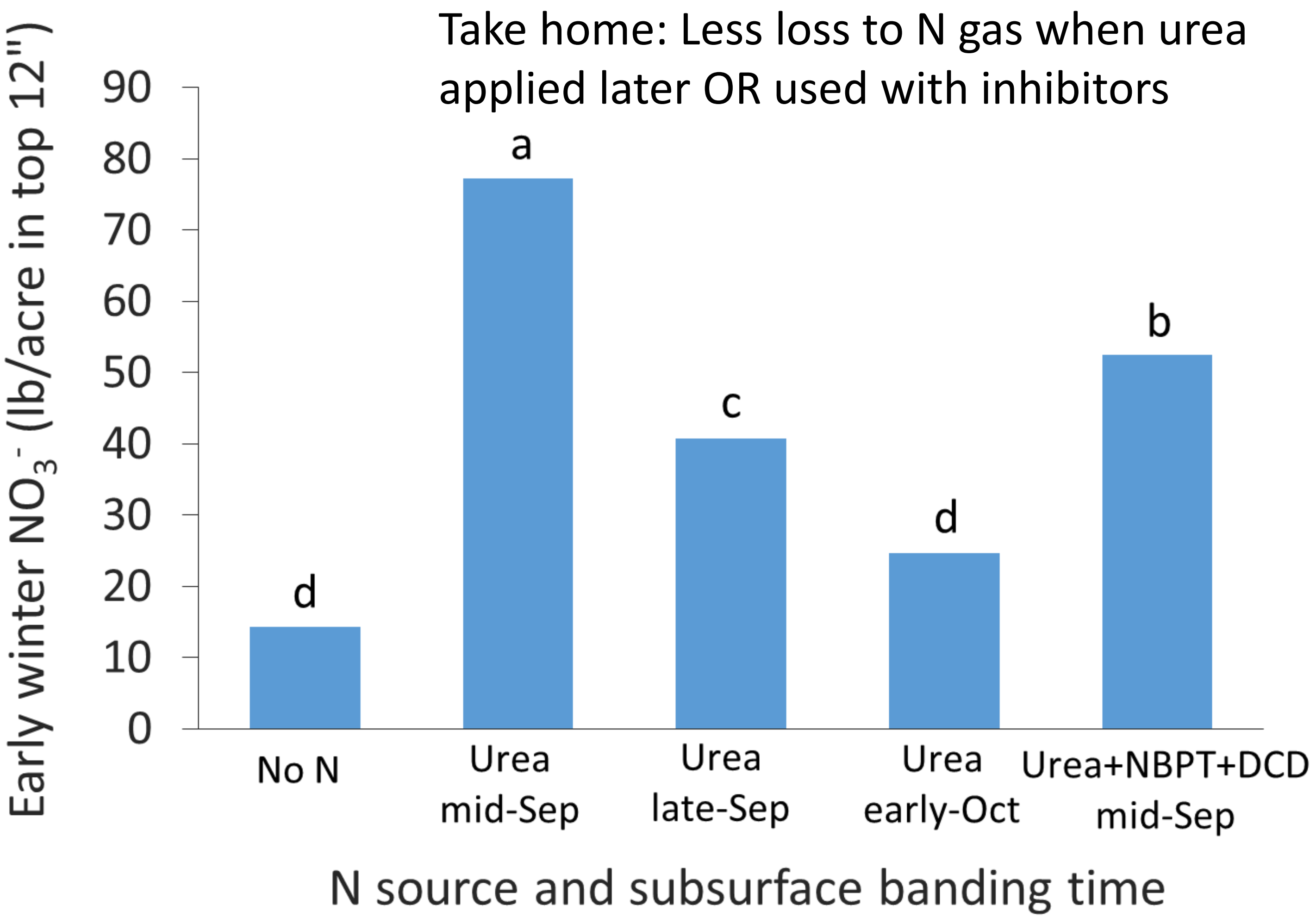
- Benefits less likely in dry or well drained soils
- An alternative is fall subsurface large urea granules

Urea conversion to nitrate is faster when soil is wet and warm



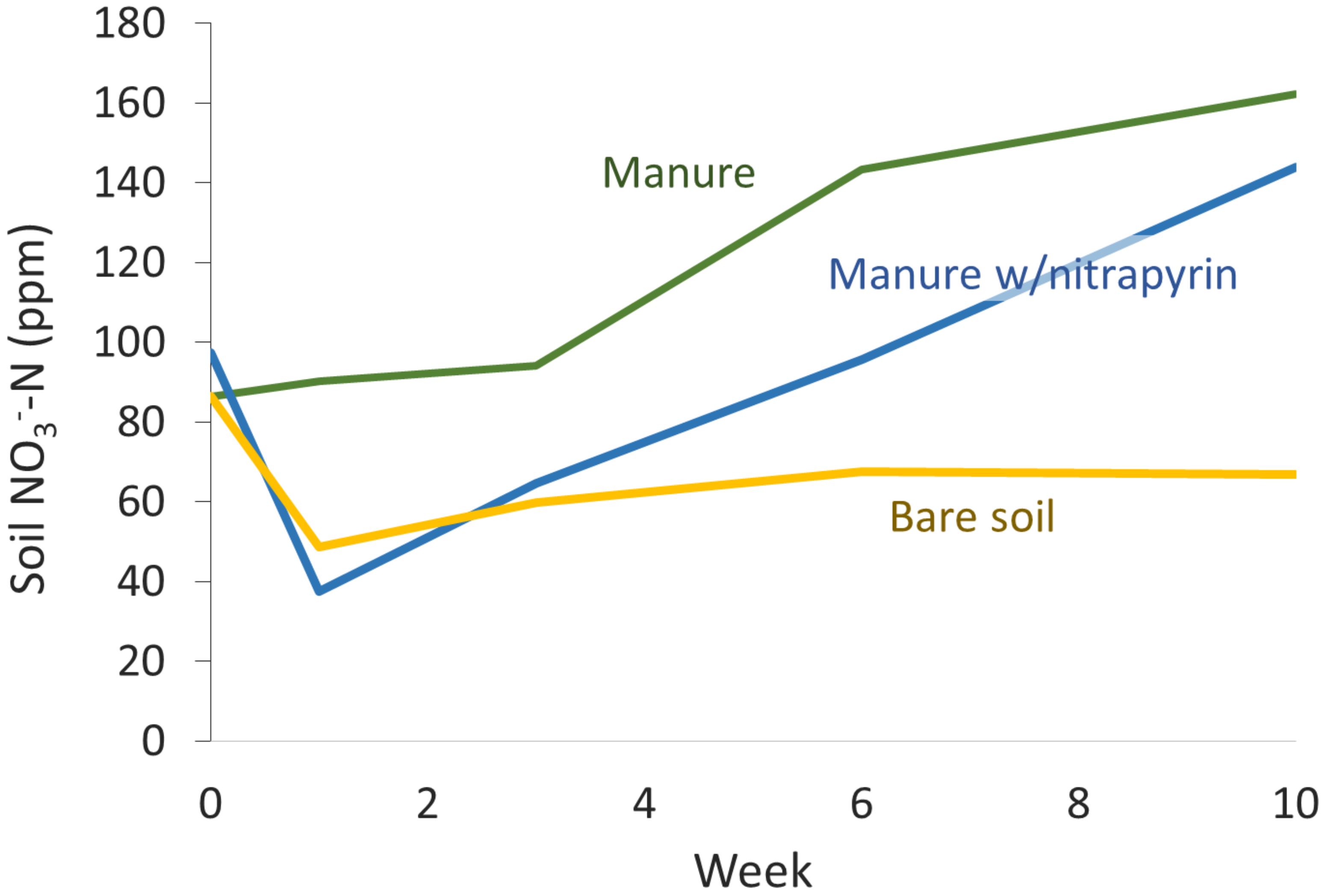
Chen et al. 2010, clay-loam pH 8.3

Inhibitors can delay denitrification (nitrate→ N_2 gas)



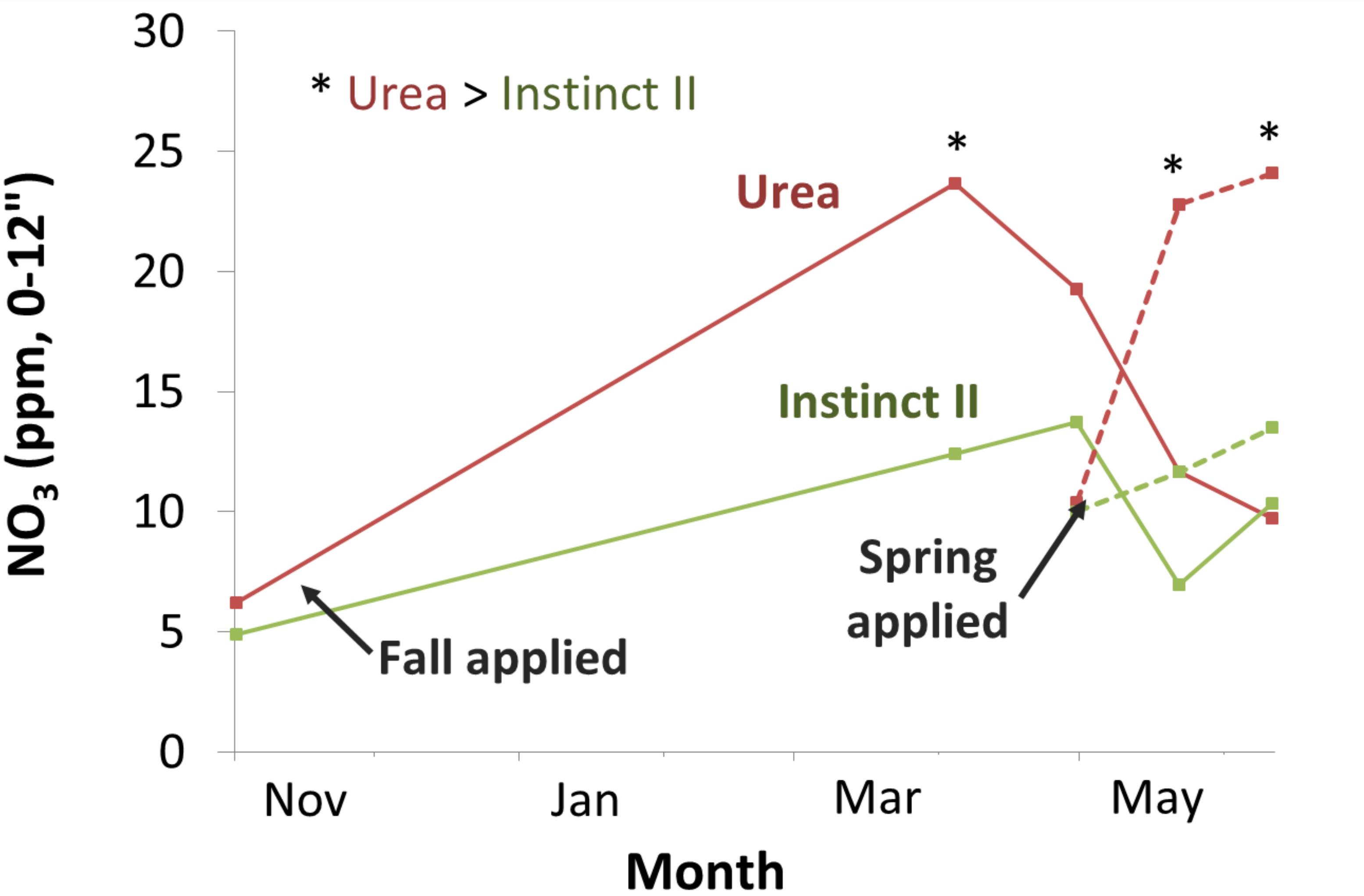
Tiessen et al. 2006, Manitoba, clay-loam

Nitrapyrin slows dairy manure nitrification



Calderon et al. 2005, silt-loam, pH 6.1, soil water content 68% pores filled, incubated at 72F

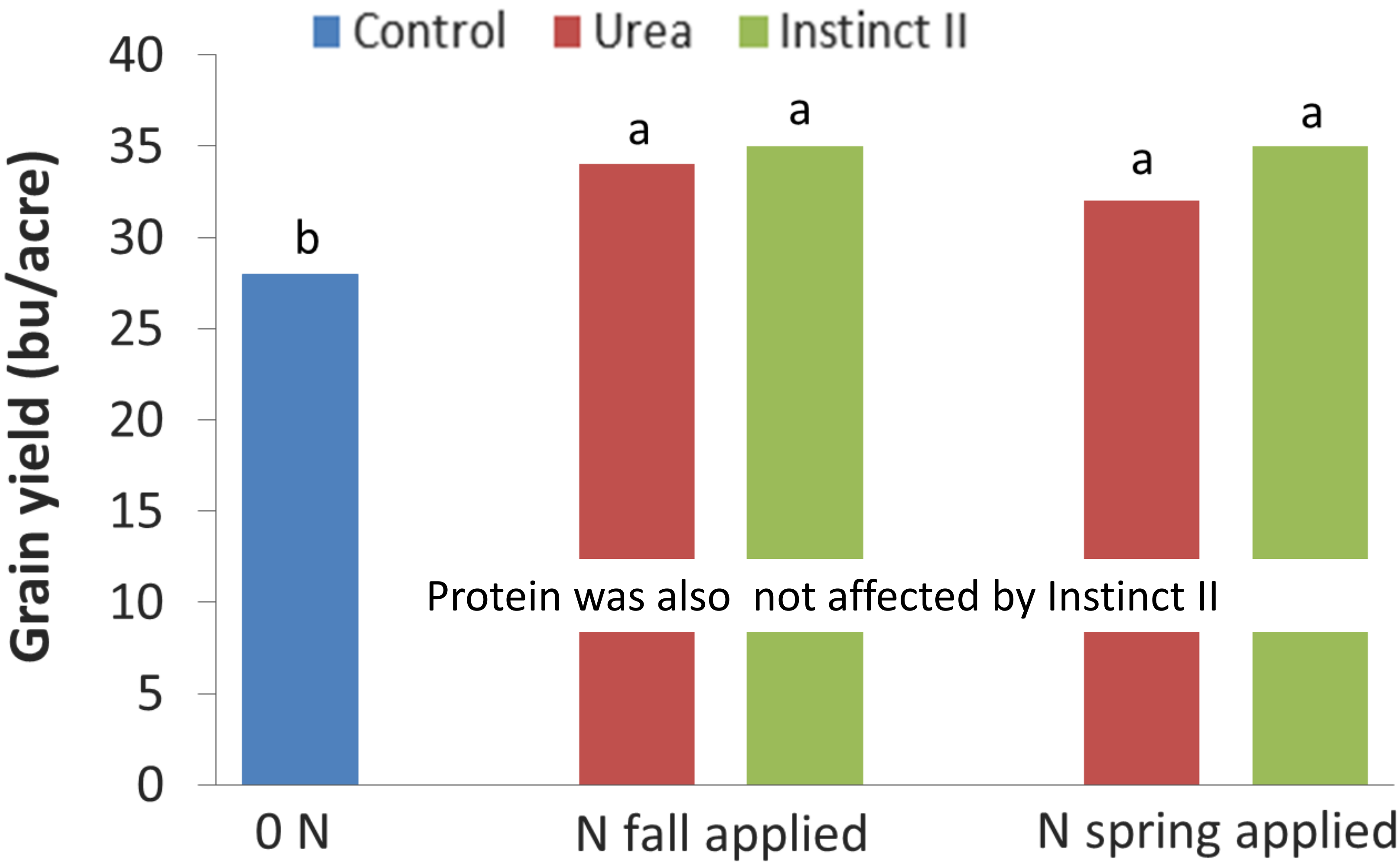
Instinct II reduces fertilizer conversion in soil to nitrate (nitrification inhibitor)



P. Miller, unpub data, 2015
MSU Post Farm, 16” rainfall zone

N banded 2” below surface

Instinct II: dryland spring wheat grain yield

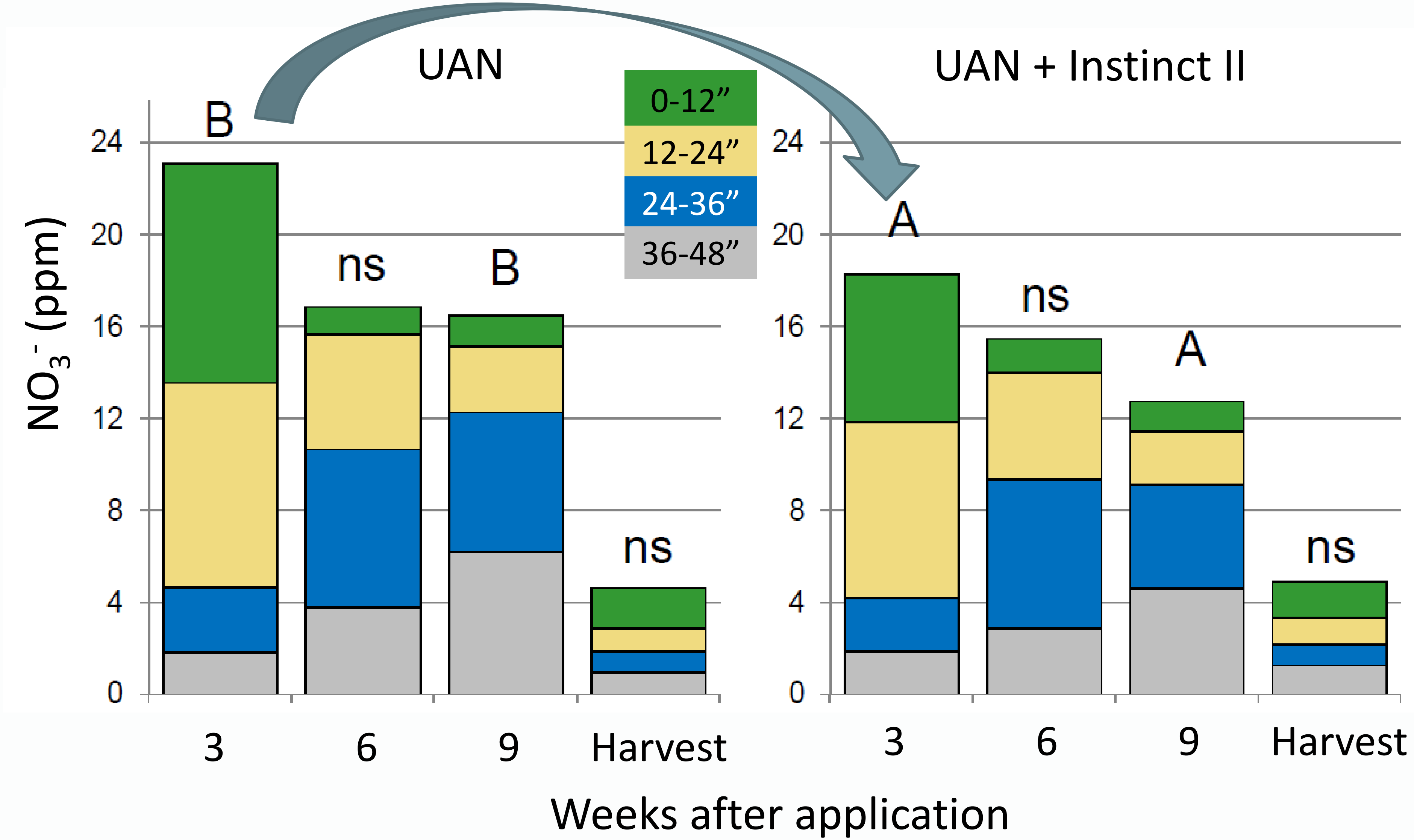


Protein was also not affected by Instinct II

P. Miller, unpub data, MSU Post Farm, 16” rainfall zone. 2015 was drier than average.

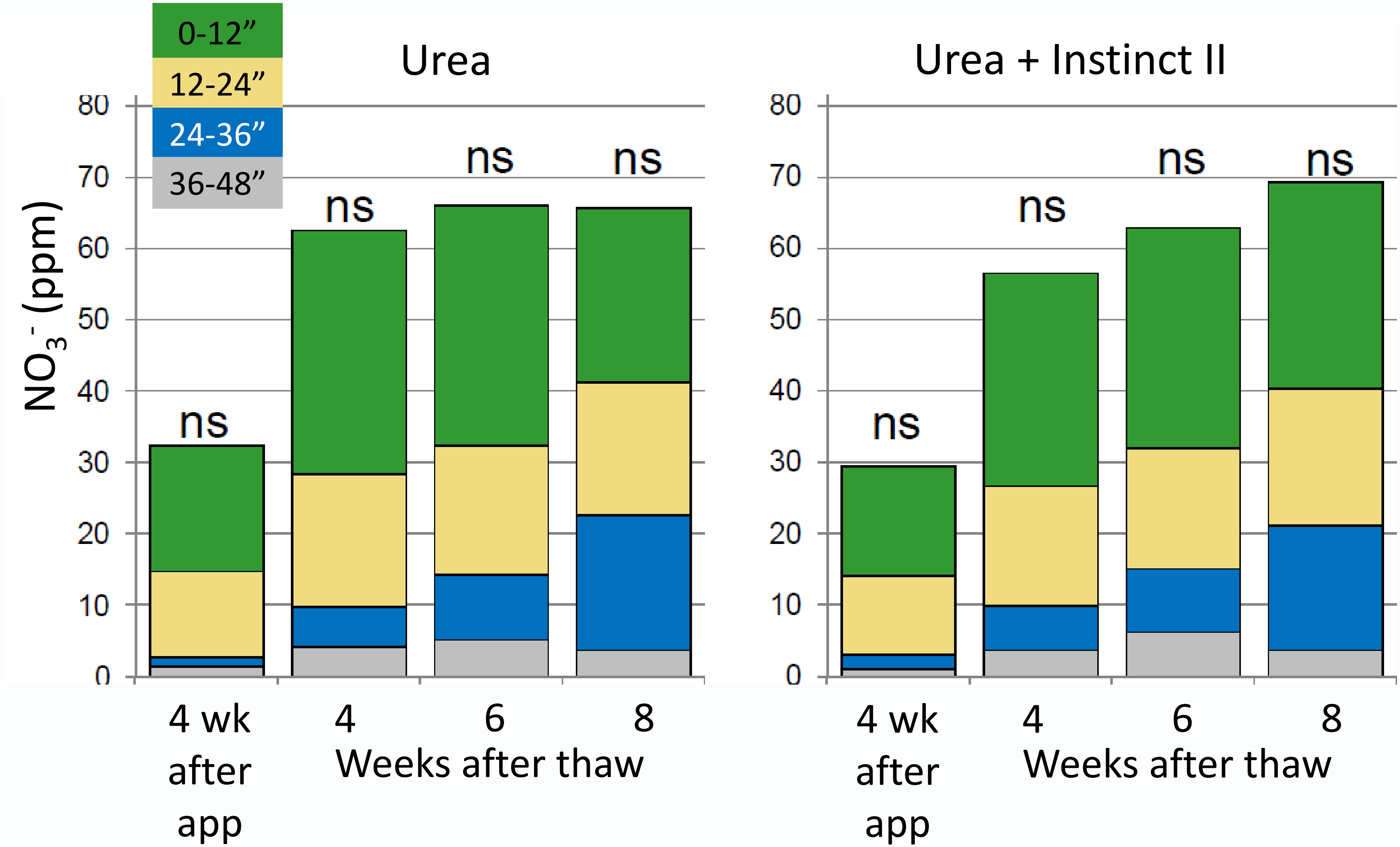
N banded 2” below surface

Under irrigation, Instinct II reduced NO_3^- available in the soil



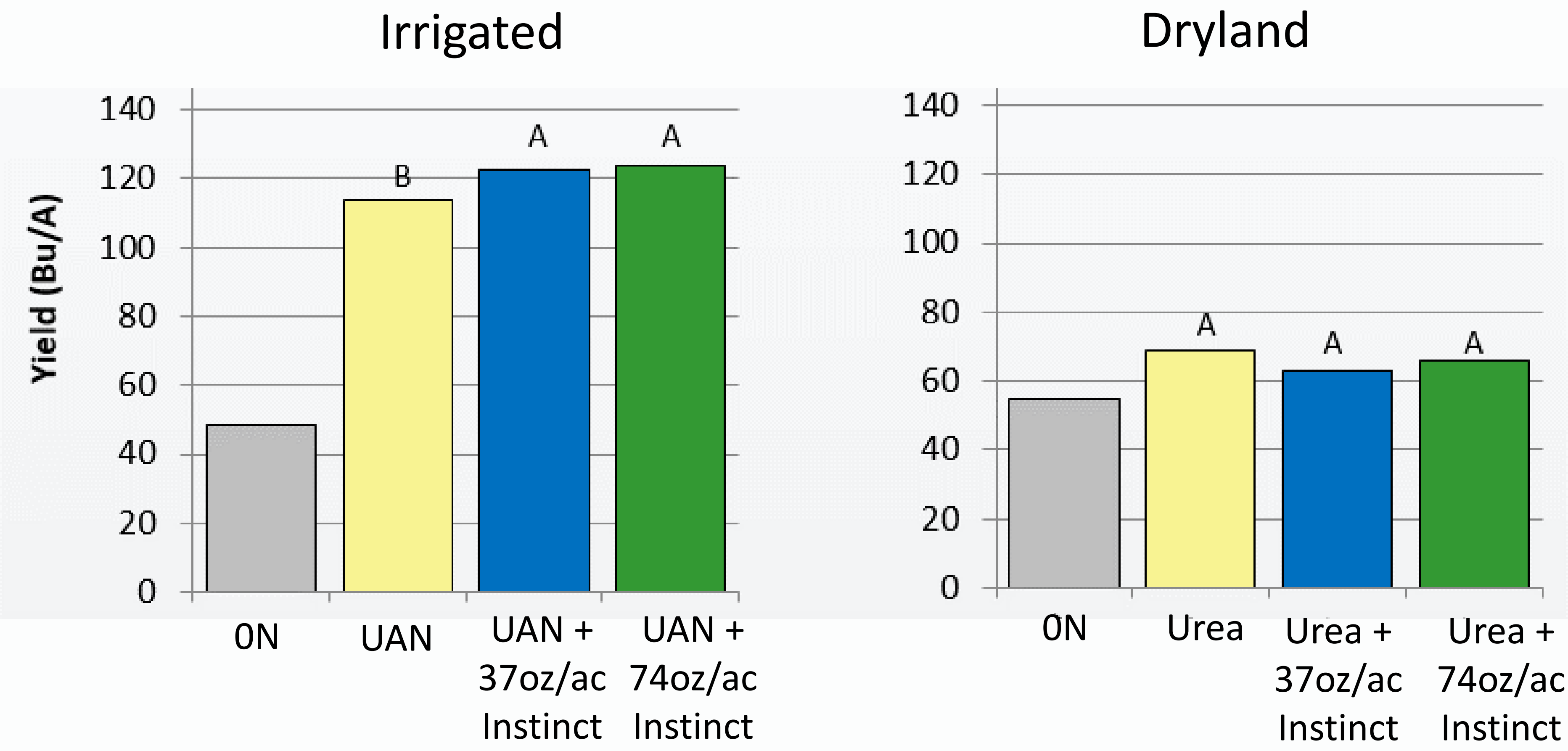
Scherder et al., 2015, Ephrata, WA, 7.4”, UAN sidedress dribble stream bar

In dryland, Instinct II had no influence on NO_3^- available in the soil



Scherder et al., 2015, Plaza, WA, 16” precip., urea preplant incorporated

Winter wheat grain yield increased with Instinct II® under irrigation (but not dryland)

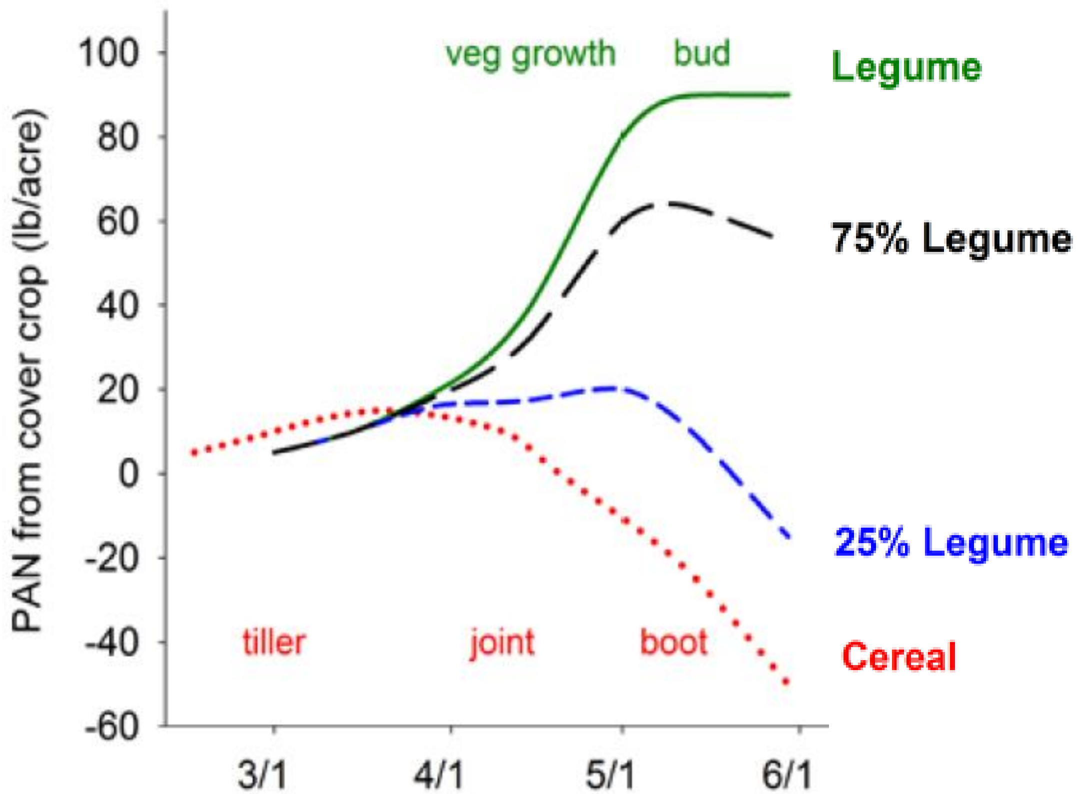


Scherder et al., 2015, inland Pacific NW

UAN sidedress dribble stream bar, urea preplant incorporated

Legume cover crops

- Terminate by first bloom

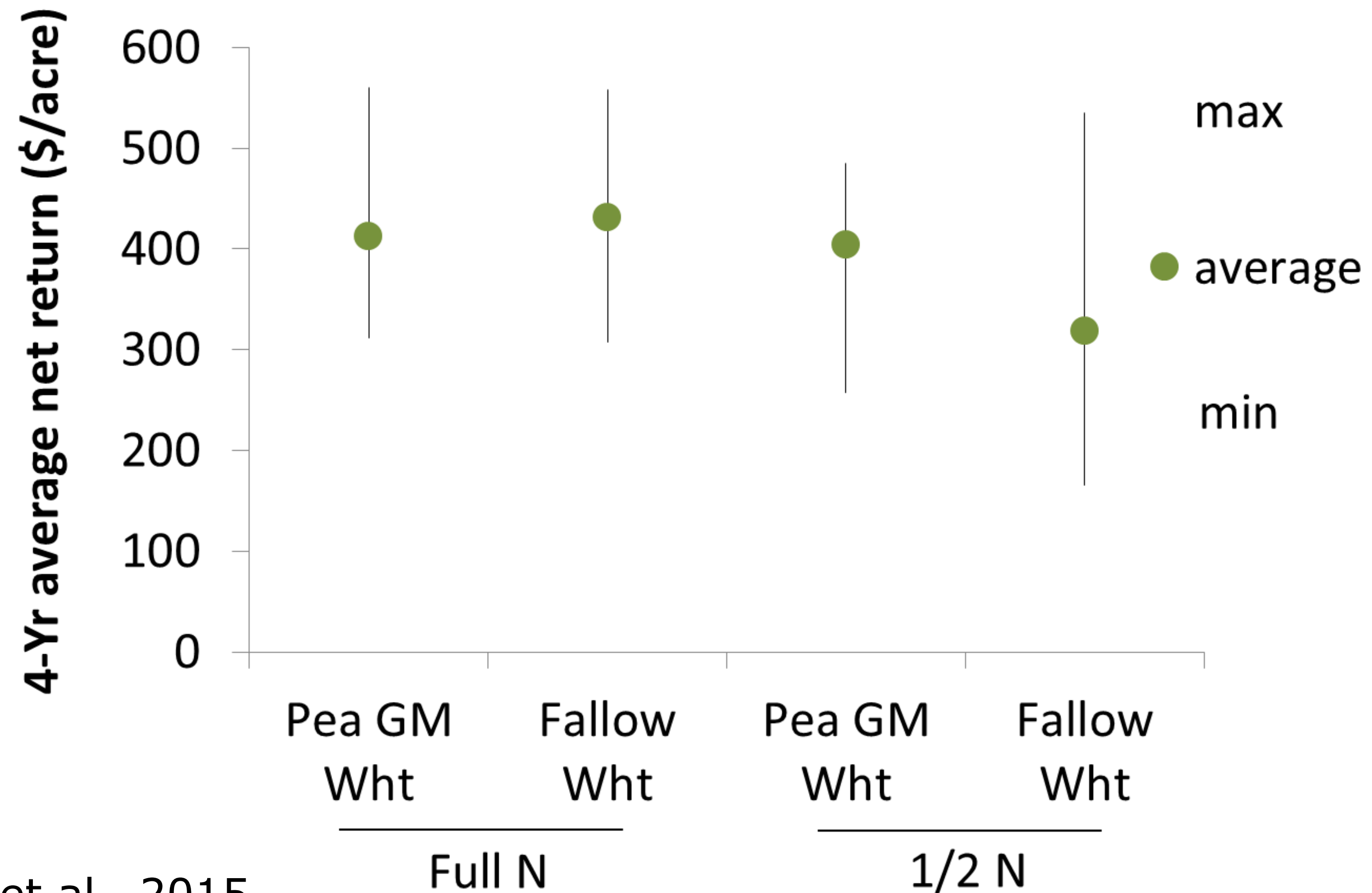


Termination timing

- Comprise 50% of ccrop to provide plant available N (PAN)

Willamette Valley, Oregon
Sullivan and Andrews, 2012

After 4 rotations pea GM provides same net return as fallow, with less N

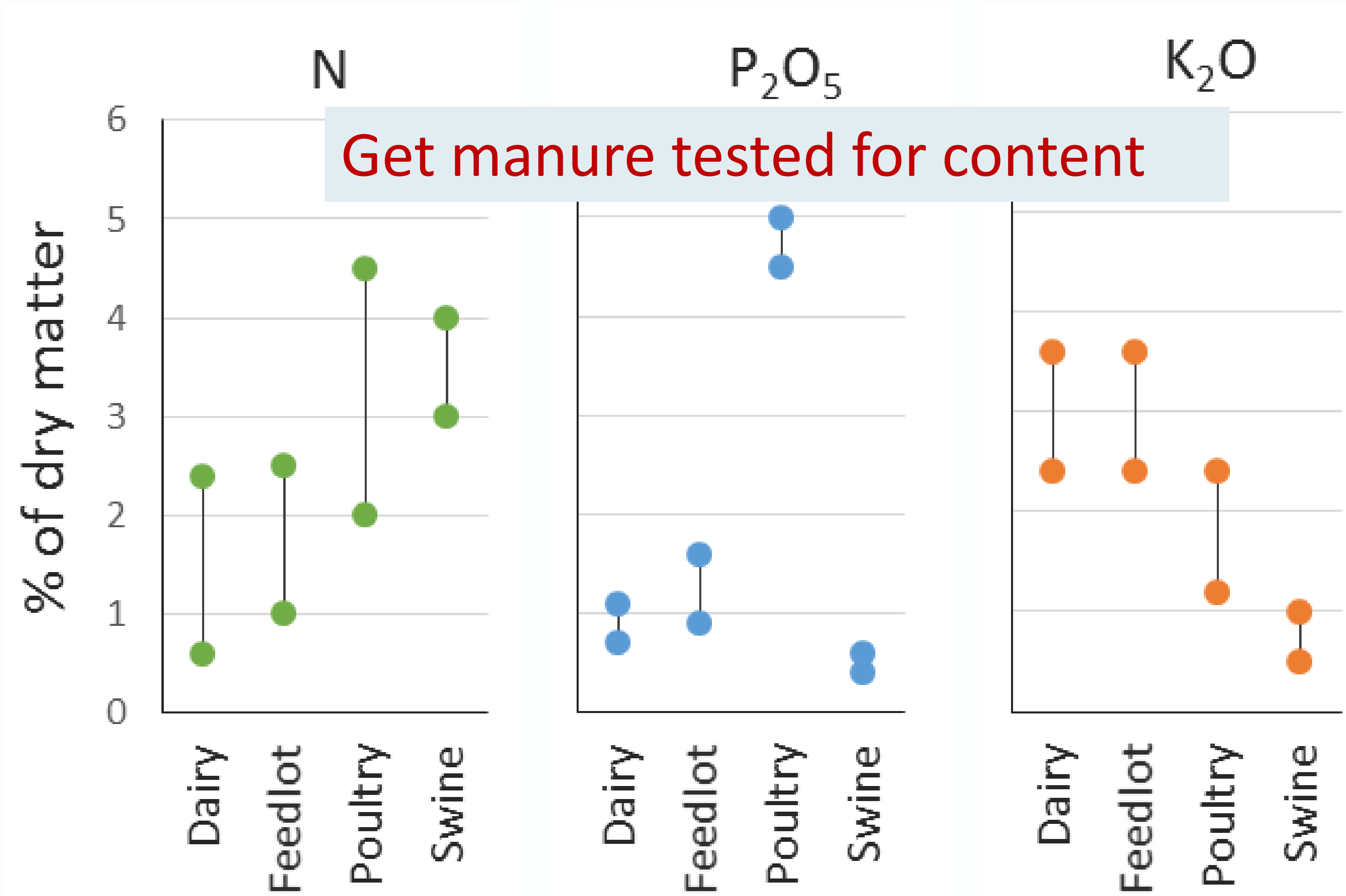


Miller et al., 2015

Considerations when fertilizing with manure

- Nutrient content is highly variable
- May provide more P and K than needed
- High N can reduce N-fixation by legumes
- Takes time to release nutrients
- Nutrients can be easily leached through the soil profile or volatilized if left on the surface
- May introduce weed seeds and contain residual herbicide
- Weight and bulk of transporting and applying wet manures to fields

Nutrient content of manure is variable



Knott's Handbook for Vegetable Growers 1997

Approximately how much total N, P, and K does 1/2” of manure compost supply?

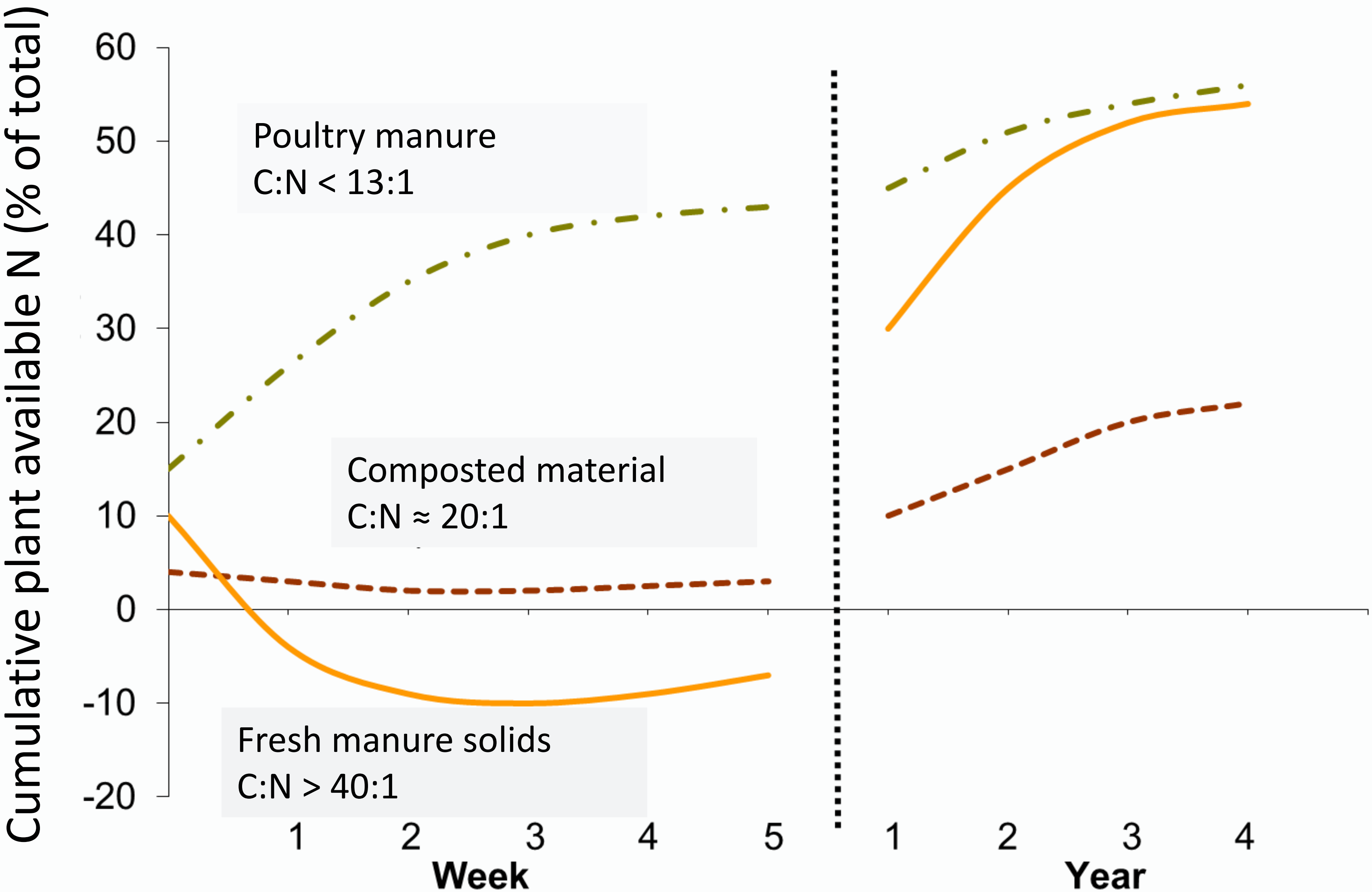
	N	P_2O_5	K_2O
Removed by:	lbs/acre		
1 season vegetables/acre	150	15	140
40 bu/acre wheat grain (dryland)	50	25	15
90 bu/acre wheat grain (irrigated)	113	56	34
1. Added by 1/2” manure	875	325	875
2. Added by 1/2” manure	150	20	150

Nutrients removed by one season's harvest (irrigated)

Crop	N	P_2O_5	K_2O	N:P:K ratio	N:P:K if meet N w/ manure
	lbs/acre				
Vegetable (edible portion)	150	15	140	*23:1:18*	*23:3.5:19*
Wheat grain (90 bu/acre)	113	56	34	*4.5:1:1*	*4.5:0.7:4*
Pea (70 bu/acre)	153	47	61	*7:1:2.5*	*7:1.2:6*
Alfalfa (3 ton/acre)	144	33	159	*10:1:9*	*10:1.5:8*
Manure (1/2")	875	325	875		*6:1:5*

- If feed to N needs, watch P and K

Manure takes time to provide nutrients and available N from manure depends on source



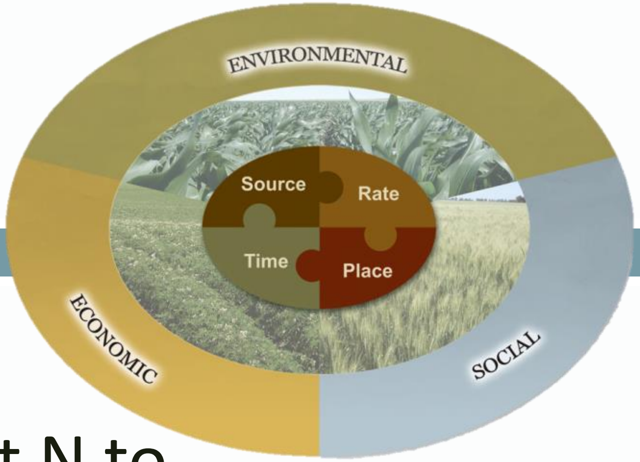
MSU EB0200

Placement

- Urea and ammonium based fertilizers – best subsurface placed
- Safe rates for seed placed
  - On-line resources to calculate
  - 50% higher with NBPT
  - 2-4 x higher with polymer coated

- Foliar application
  - Use practices to min leaf burn
  - < 30 lb N/ac of UAN
  - < 45 lb N/ac of liquid urea
  - Use less with herbicide, surfactant, sulfur, NBPT

Summary



- Use realistic yield goals and soil test N to calculate pre-plant N rate
- Adjust in-season for given year
- Apply early for yield, later for protein
- Select the source appropriate for conditions
- Use on-line tools for variety selection, optimal N rate, safe seed-placed rates, manure rates

Resources

- Variety selection tool www.sarc.montana.edu/php/varieties/
- N rate calculation tool http://www.msuextension.org/econtools/nitrogen/index.html
- On soil fertility website http://landresources.montana.edu/soilfertility/
    - Safe rates for seed-placed – under *Agriculture Links*
    - Manure rate calculators – under *Agriculture Links*
- Under *Extension Publications*
    - *Nutrient Management in No-Till* (EB0182)
    - *Enhanced Efficiency Fertilizers* (EB0188)
    - *Nutrient Uptake and Timing by Crops* (EB0191)
    - *Practices to Increase Wheat Grain Protein* (EB0206)

QUESTIONS?

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

Photo by Andrew John