Nutrient Management of Pulses and Fertilization during and after Drought

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Golden Triangle MSU Extension Cropping Seminar

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Objectives

Provide info on pulse fertility

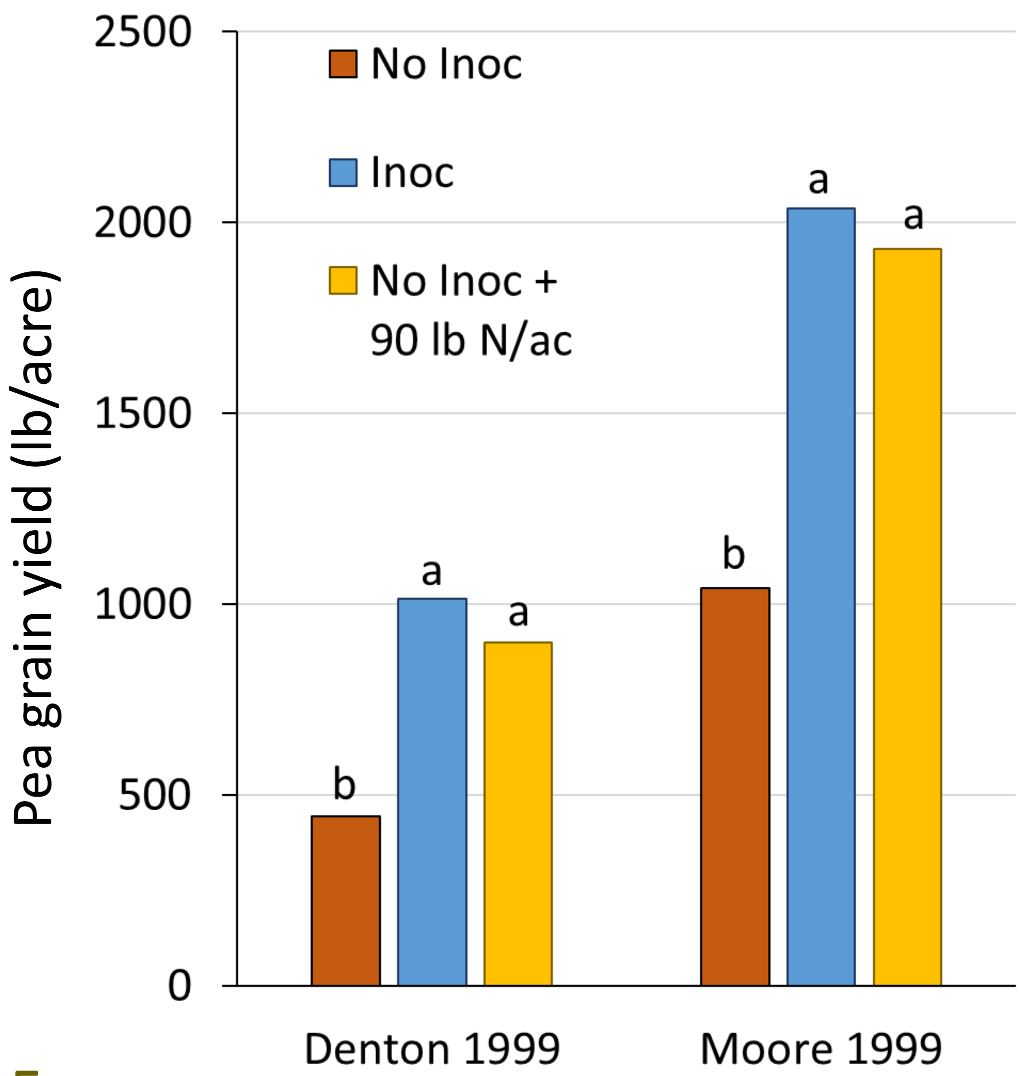
- N fertilization and inoculation effects
- P, K, S needs
- Fertilizer rates, placement, timing

Present special fertilization considerations during and after dry years

- Drought's impact on plant nutrients
- Soil testing
- Drought effect on next year's fertilizer needs

Pulses require N by either:

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



"New" fields:

Granular = more effective

Field with pulse history in ~ 5 yrs :

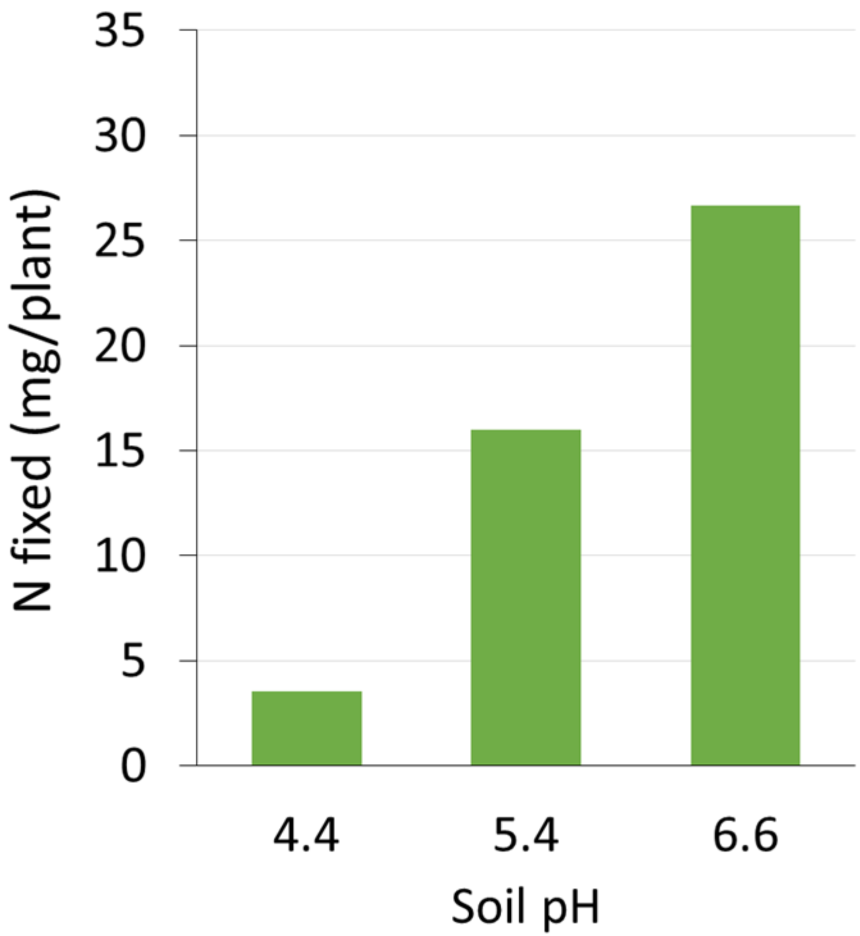
Liquid or peat = less expensive

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

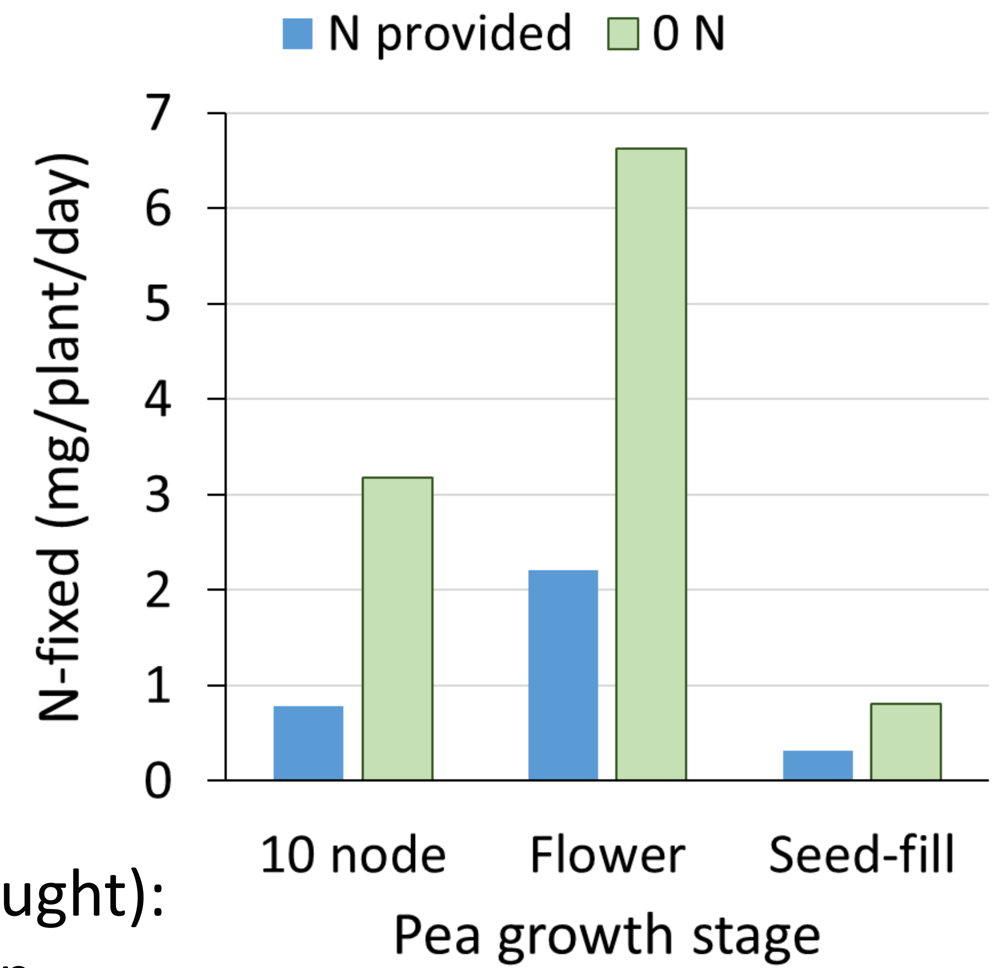
- Extreme soil temps
- Waterlogged or dry soil
- Soil pH < 5.5, > 8
  inoculant strains differ in tolerance
- Saline soils
- Maturing plants



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 as 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

Does granular inoculant (GI) pay off?

Yields usually go up, but not always enough to offset the cost of inoculant. Questions to ask:

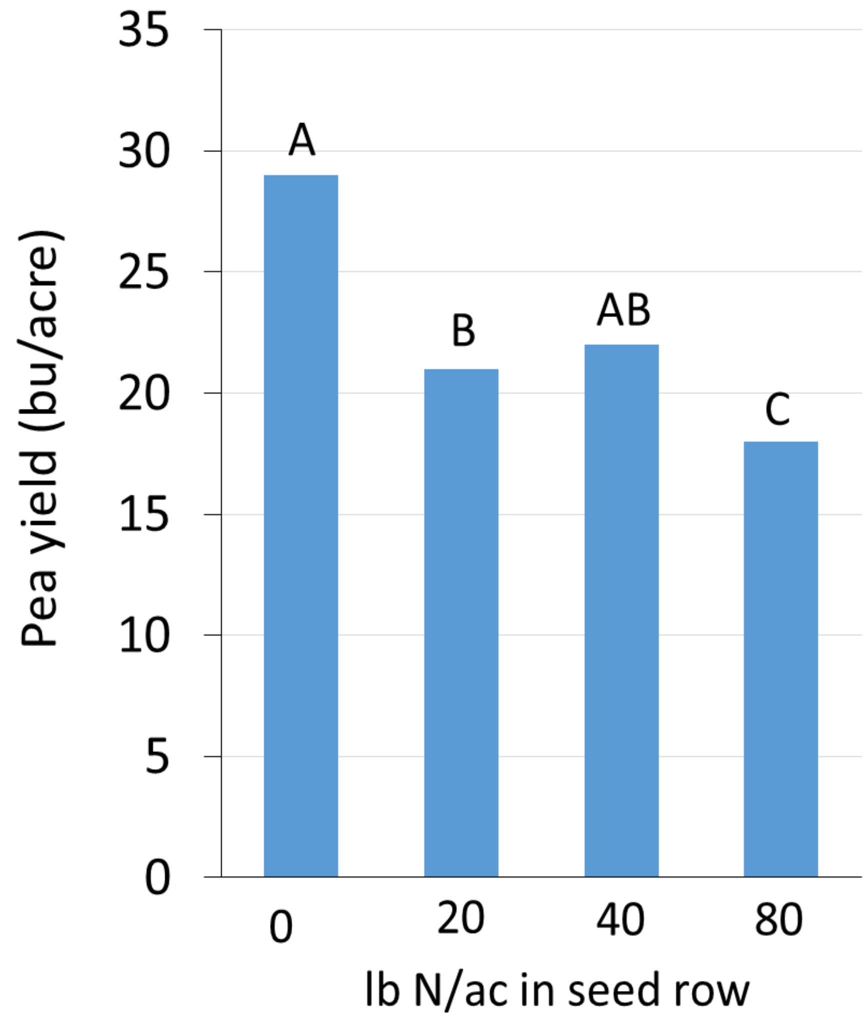
- Are soils high in N (McKenzie et al., 2006)?
- Do fields have a long or recent history of inoculation?
- Might insufficient water limit yield or cause rhizobia to die (McKenzie et al., 2006)?
- Is a premium paid for protein? GI tends to increase protein in “new” or low soil N or drought conditions (McKenzie et al., 2006; Clayton et al., 2004; Bestwick et al., 2018). One MT buyer is already paying $0.25 to 0.75/bu for protein > 22%.

If legumes fix N, why might add fertilizer N?

- Nodulation requires healthy plants
- Little N contributed by nodules until 3^{rd} node, early N must come from top 12” of soil
- Rhizobial fed plants take 2-3 weeks longer to get going
- If insufficient N, plants get ‘stuck’ – can’t grow to feed nodules, nodules aren’t actively providing N for growth
- Insurance against nodule loss to pea leaf weevil
- N-fixation stops if soil nodule dries up, but growth optimized if there is soil N

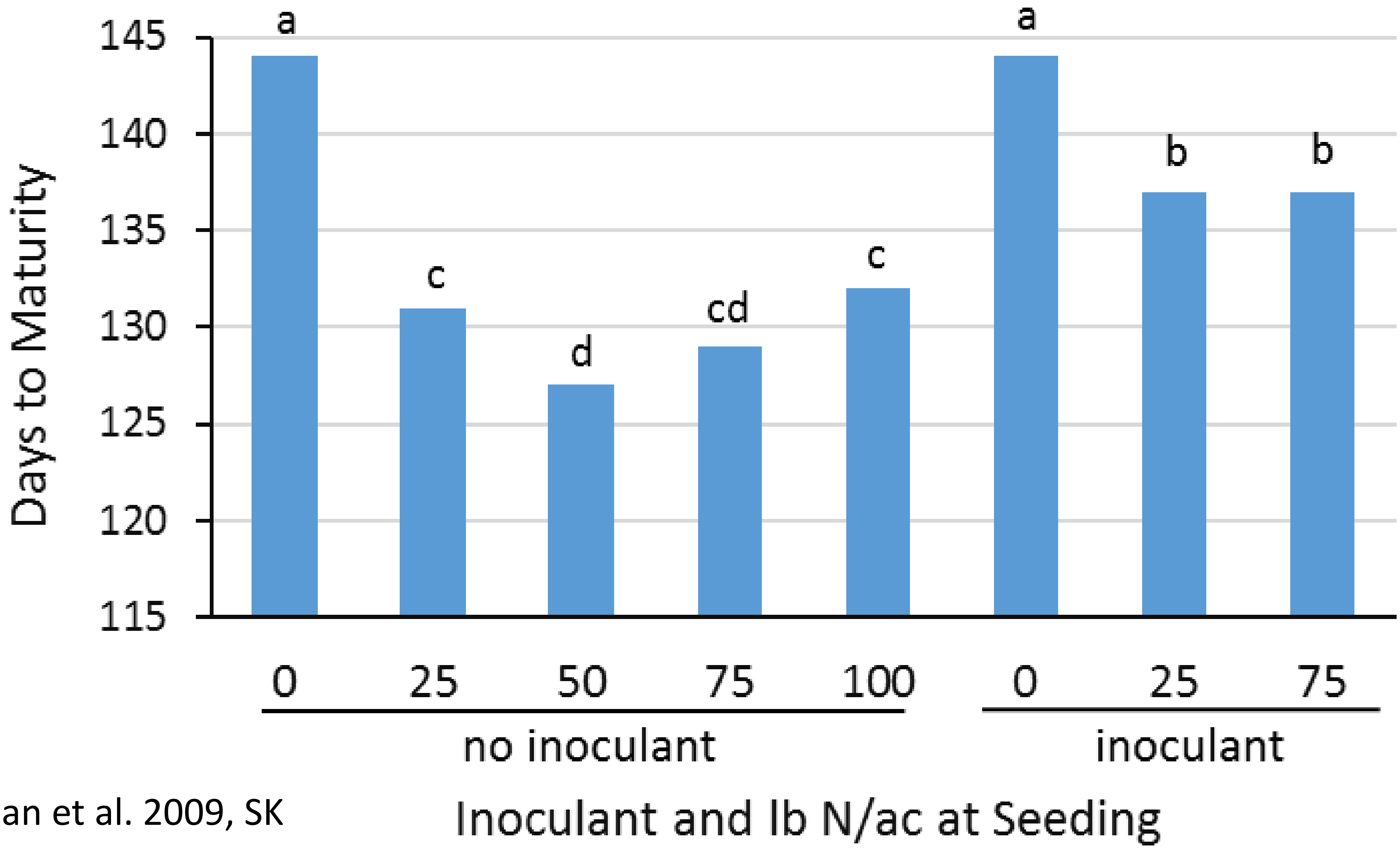
Seed row N

- 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

Starter N helps reduces chickpea days to maturity, especially under moist, long, growing seasons



Gan et al. 2009, SK

In 90 – 107 days-to-maturity years, N reduced days to maturity by 4-5 days

Questions on N?

On to S, P and K

Is this plant N deficient?

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

- Soil tests are not reliable for S
- Base S on prior crop performance, S removal rate (0.15 lb S/bu) or tissue concentration (varies by crop; see *MT Cool Season Pulse Production Guide* or The Soil Scoop: *Soil Fertility for Pulse Crops*)

Sulfur fertilization

Preventive

- Bank elemental S: 71 lb S/acre before canola in canola, barley, pea system provided enough for pea (Wen et al., 2003, SK)
- Sulfate S: 15-20 lb/acre at planting (<18 lb/acre in seed row)
- Liquid S: to the side of seed row at <18 lb/acre (Ahmed et al., 2017, SK)
- Save the seed row for P

Rescue

- 3-5 lb S/acre as granular or liquid

Montana phosphorus fertilizer guidelines for annual legumes vs winter wheat

Olsen P (ppm) 0 to 6”	Annual legume application rate (lb P_2O_5/acre)	W wheat application rate (lb P_2O_5/acre)
4	30	50
8	25	45
12	20	40
16	15	35
Above 16	0 up to crop removal*	

* Assume 2/3 lb P_2O_5 per bushel of grain

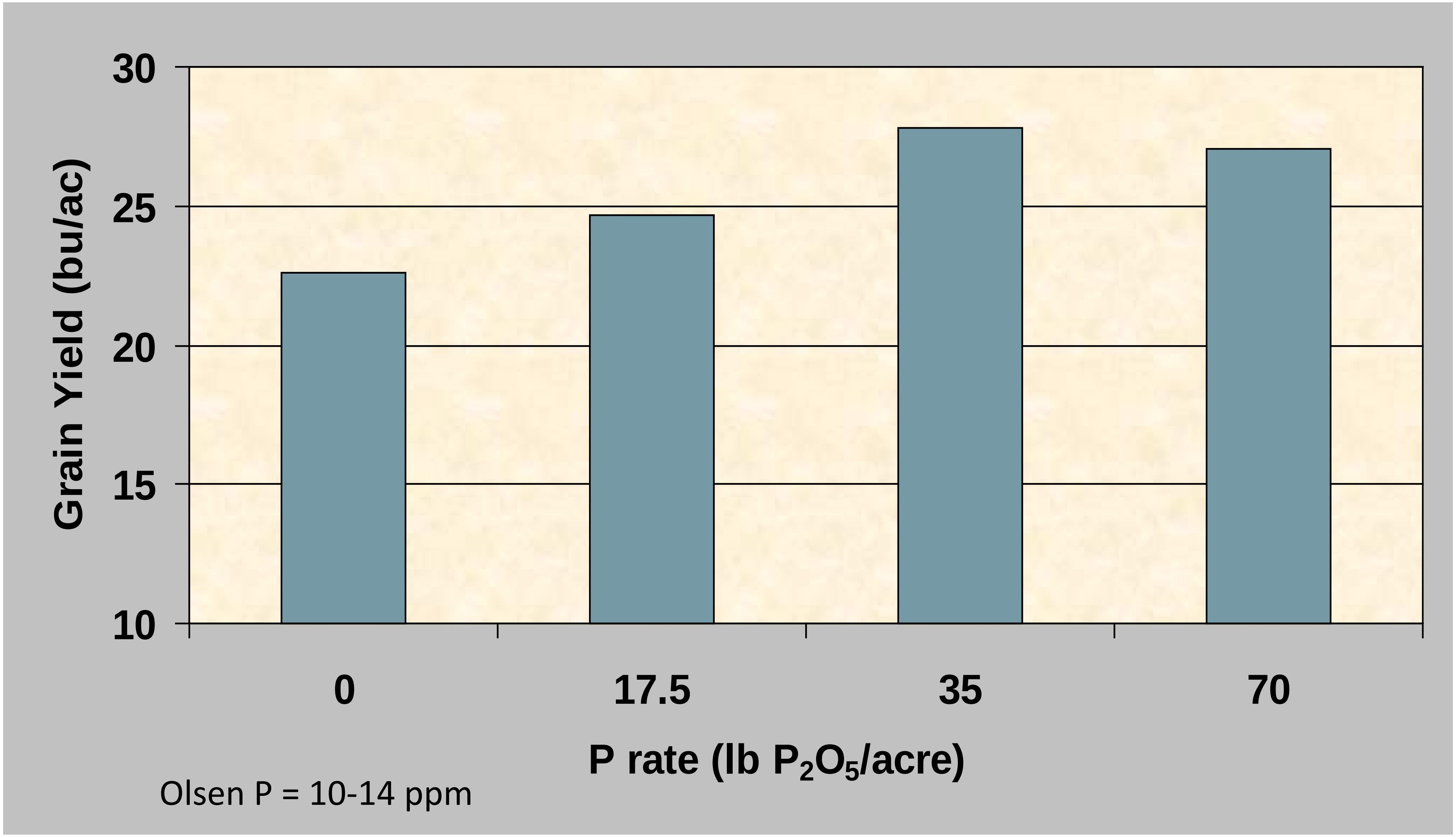
Crit P level for N-fixation ≈ Olsen P 10 ppm

(producer in Judith Basin, 2016)

Winter Pea, Bozeman, 5/17/07

Image by T. Rick

Effect of P on spring pea yield (2004-2005)



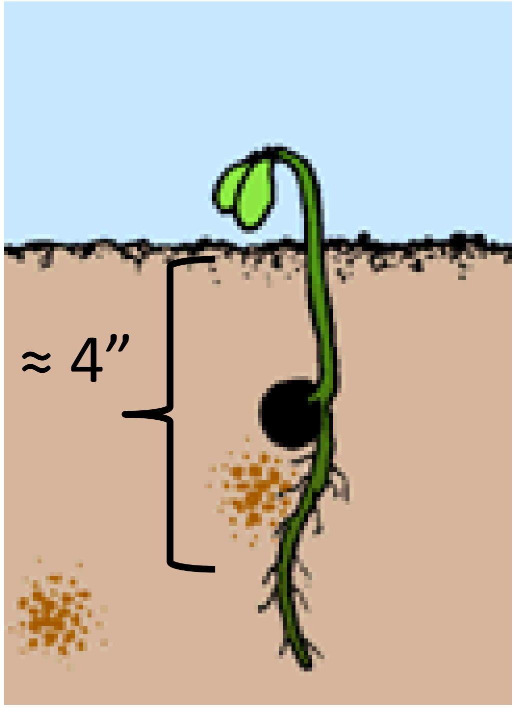
Data from J. Waddell, Sidney, MT

P response

- P response better when soil P < 9 ppm (Ffact No. 38)
- At soil P > 13 ppm, up to 15 lb P_2O_5/acre as maintenance amount ≈ max safe seed placed rate.
- P response loam >> than clay loam soils (Karamanos et al., 2003)
- Starter P may increase yield and harvestability in lentil and chickpea (Gan unpub. 2003).

Phosphorus source for seed row placement

- MAP < 5-20 lb P_2O_5/acre seed placed
- DAP use CAUTION = toxic to seedlings
- Liquids – equally potent as MAP, but close proximity of band to seed = higher risk to seed (Grenkow et al., 2013).



If more P required – sub-surface side band, broadcast incorporate before seeding, build with prior crop

Take home messages on P

- Annual legumes need and remove similar amounts of P PER bu as wheat.
- P is necessary for N fixation.
- Legumes are better able to access soil and fertilizer P than small grains.
- Be cautious with seed placed, but don't let that limit amount provided.

Potassium (K)

- K required for N-fixation
- K levels often moderate to high in Montana, generally not limiting
- Guidelines for MT pulse crops

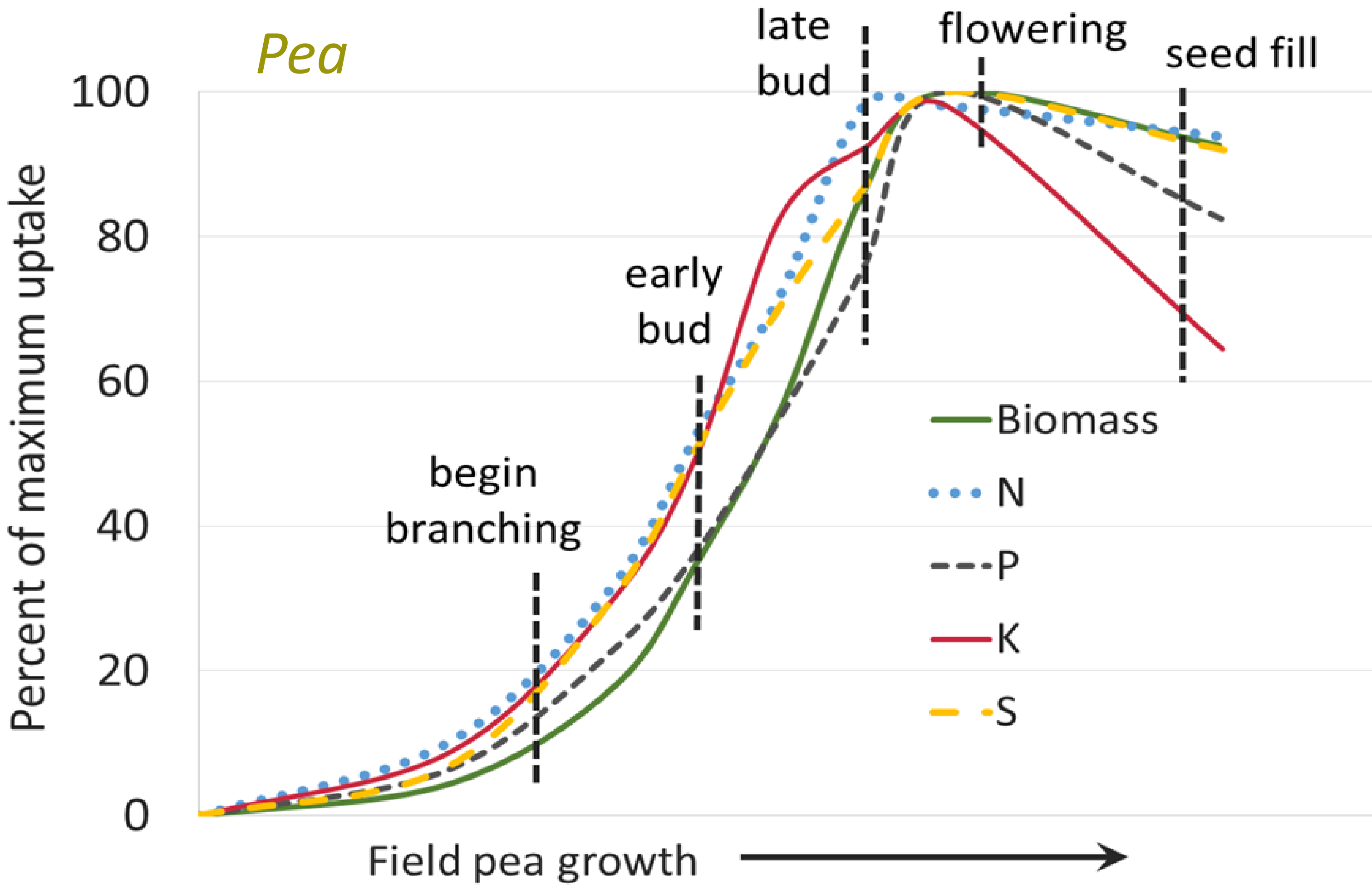
Soil K (ppm) 0 to 6 inches	Application rate (lb K_2O/acre)
0	45
50	40
100	35
150	30
200	25
250	20
Above 250	0 up to crop removal (0.9 lb/bu)

Questions?

On to timing

Nutrient uptake

- Nutrient uptake precedes biomass
- Rapid demands once branching



Source: Malhi et al., 2007, Saskatchewan

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

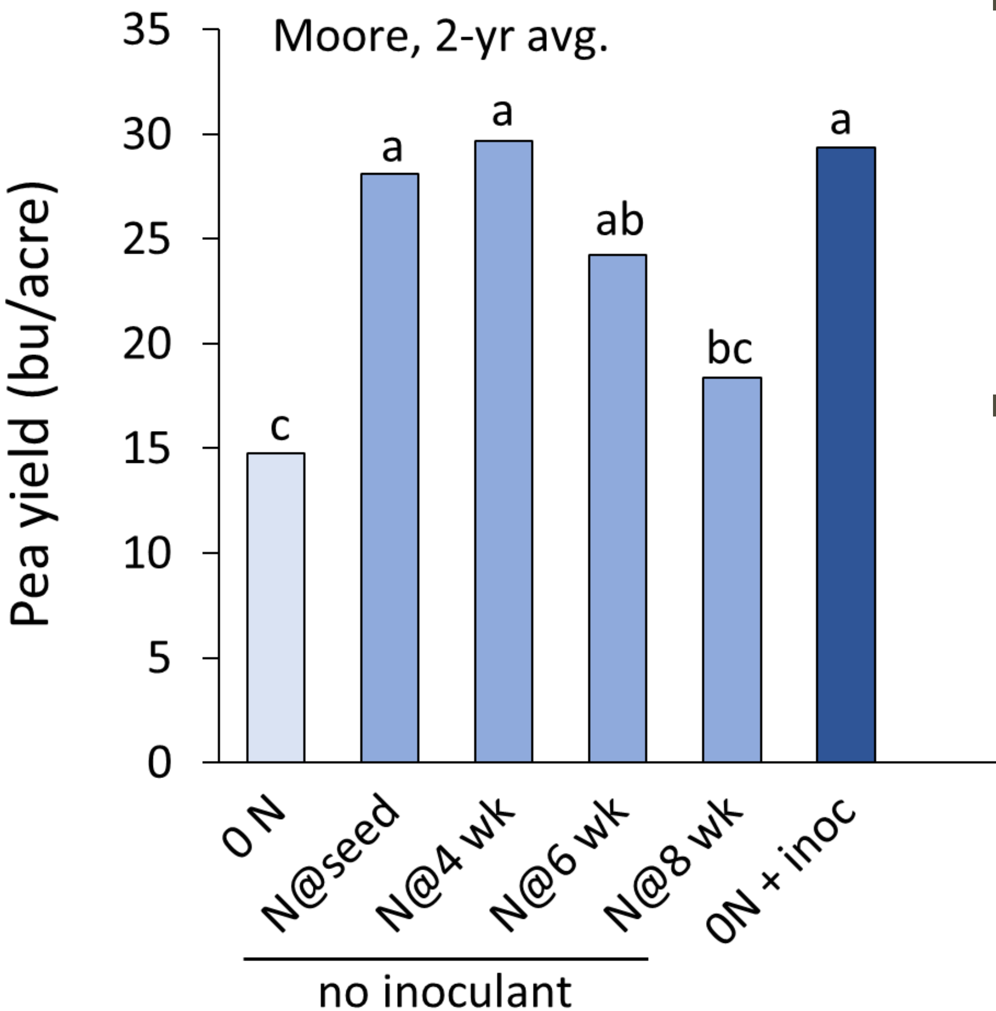
Rescue N

- If have yellow lower leaves (N deficiency) dig and look for rosy red nodules
- SK suggests 40-50 lb N/ac topdress
- Yield gain may not offset N cost
- Need water/rain to move N into soil

Image: C. Jones

Image: Flicker Pennstatelive

Rescue N timing: when is it too late?



- Up to 6 weeks after seeding
  - Pea: 9-12 node stage
  - Chickpea: 10-13 node
- If later
  - too much vegetative growth
  - poor pod set
  - delayed maturity
  - more plant damage?

Question for you: How would you apply N 6 wk after seeding?

(McConnell et al., 2002, Moore, MT, 90 lb N/ac)

Take home messages on Timing

- N: at seeding, or as rescue, but no later than 6 weeks after seeding
- P: build up with prior crop, in very small amount with seed, or side band at seeding
- K: build up with prior crop, side band below the seed, not seed-placed
- S: elemental with prior crop, sulfate at seeding or as liquid for rescue

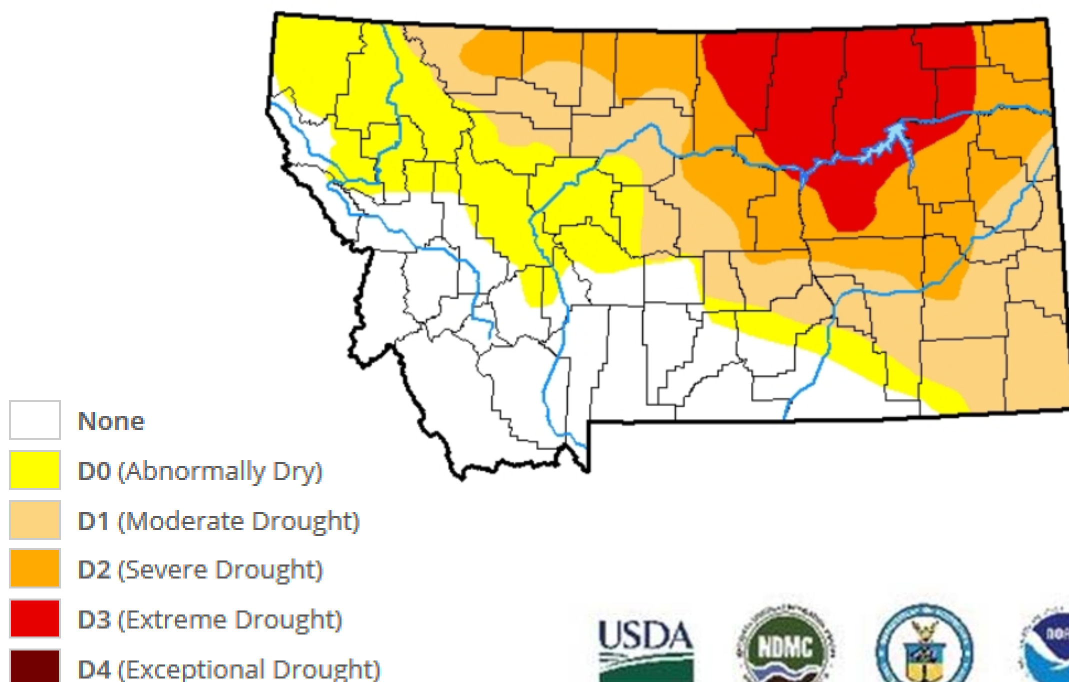
Summary on fertilization of pulses

- A little starter N might pay
- P response likely higher on low P soils, low amounts of seed-placed may pay off
- K needs are high for legumes, but little research on pea or lentil
- Elemental S can last for several years
- Pulses are very sensitive to N, P, K and S in the seed row
- When pulse prices are high, fertilization can pay for itself, if water isn’t limiting

Questions on fertilizing pulses?

On to drought

December 26, 2017



http://droughtmonitor.unl.edu/

Drought affects plant uptake and nut avail

Plants

- Roots don’t reach nutrients or deep water
- Lacking transpiration to “suck up” nutrients
- Poor N-fixation

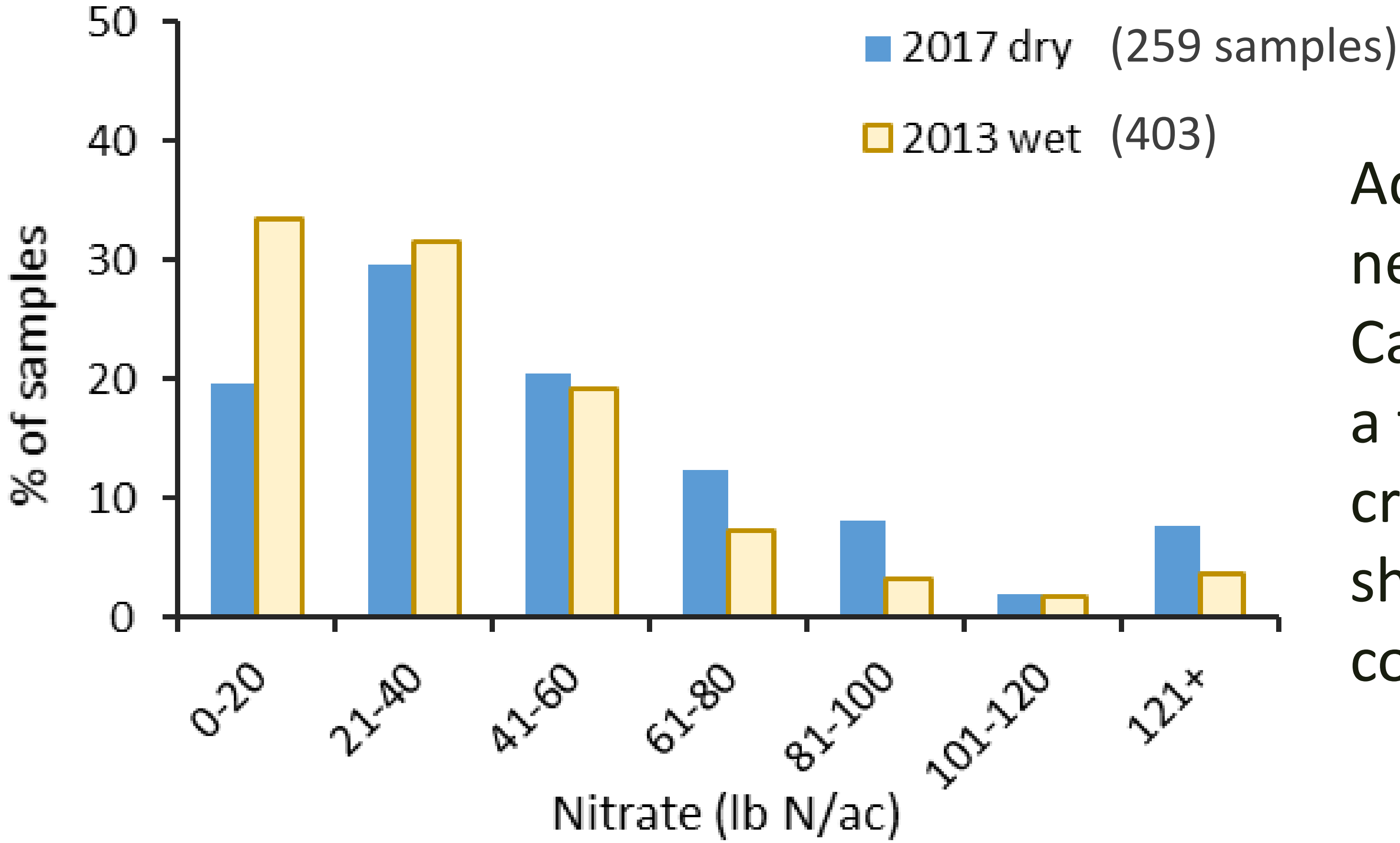
Nutrients

- Low organic matter decomposition
- Low nutrient availability from soil
- Nutrients don’t move easily in dry soil to reach roots

Drought on the following year fertilizer needs

Lower yields = higher residual soil N, as long as not leached

Fall soil nitrate in a wet vs dry year in central and north-central MT



Adjust N for next season
Capture with a fall planted crop or a shoulder cover crop

Data from AgVise

Drought on the following year's fertilizer needs

Lower yields = less nutrients removed by harvest

Change in material harvested (grazed or salvaged hay vs grain) changes nutrients removed

Approximate N, P, K and S removed by harvest of wheat grain, straw and hay (from *Fertilizer Guidelines for Montana Crops*)					
	Amount/acre	N	P_2O_5	K_2O	S
		.... lbs			
Hay	2 ton	50	20	76	4
Grain	40 bu	50	25	15	3
Straw	1.8 ton	26	7	45	7

Change in decomposition of residue

- immature residue decomposes faster than mature residue
- decomposition is slower in dry soils

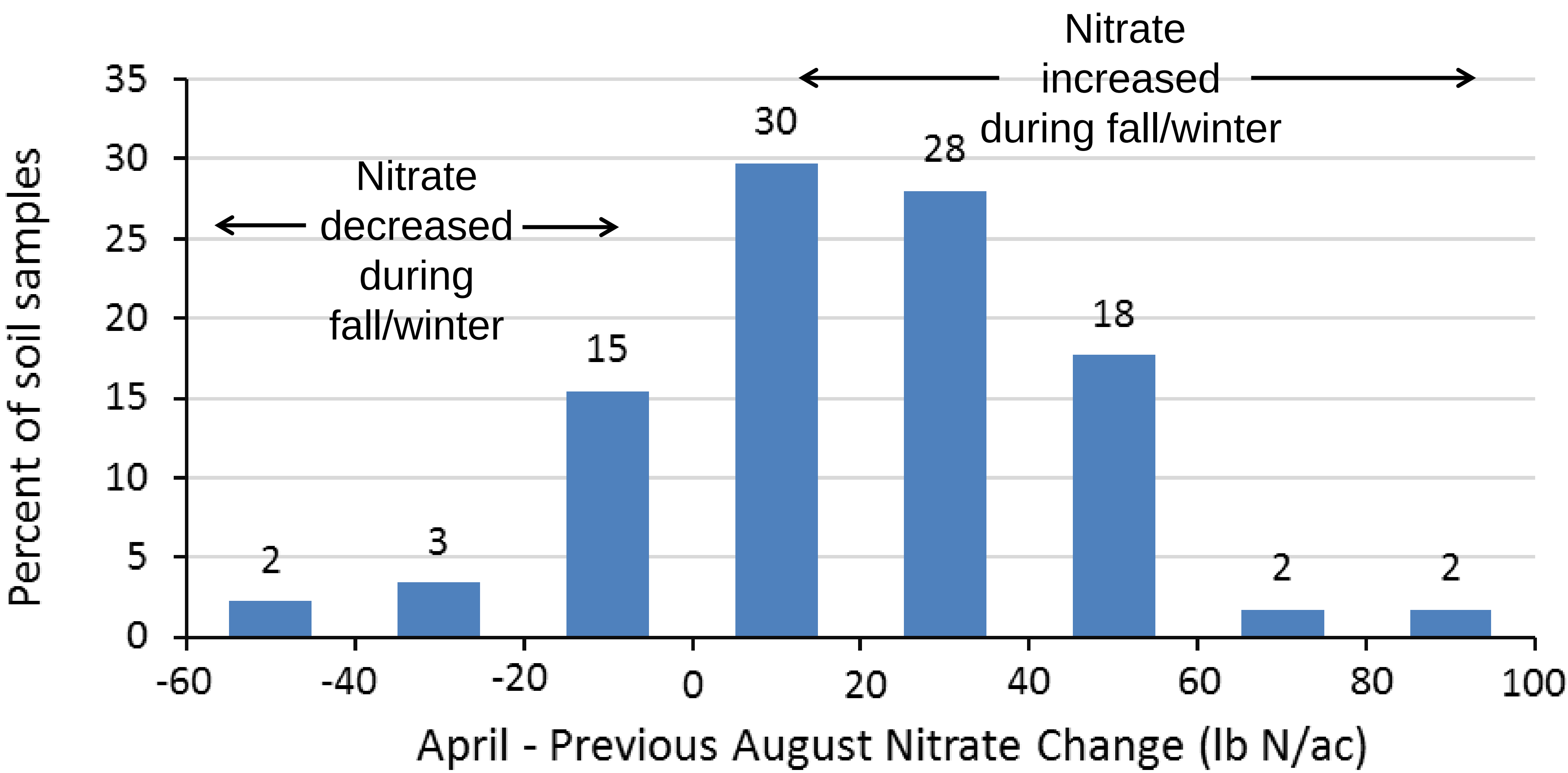
P and K recycling changes depending on fall precip

So with all these unknowns, what should you do?

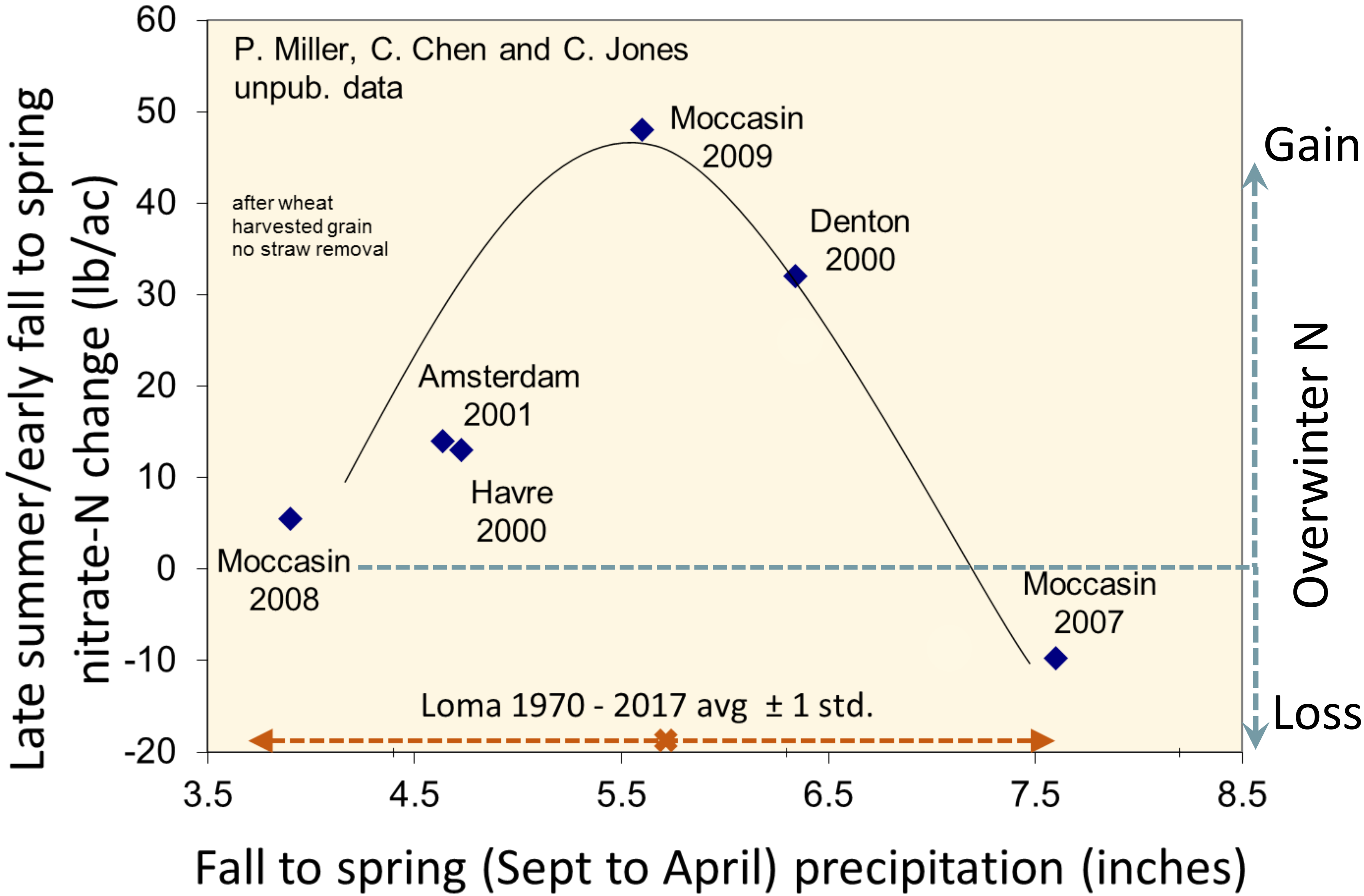
Soil Test!

- Take to 2 ft depth for N, 6” for P and K
- Consider sampling N to 3 ft if didn’t reach yield goal on previous crop or two
- Ideally taken in spring for N to adjust for overwinter changes, avoid under- or over-fertilization

August to April nitrate changes, Montana data based on 175 samples (Jones et al. 2011)



Overwinter precip effect on soil N



What else will affect overwinter soil nitrate differences?

- Organic matter
- Temp
- Soil texture
- Previous crop
- Initial soil nitrate and moisture
- Coarse and shallow soils (< 2 ft) and soils with > 60 lb N/acre in the fall are most likely to have lost N overwinter

Recommendations for Nitrogen

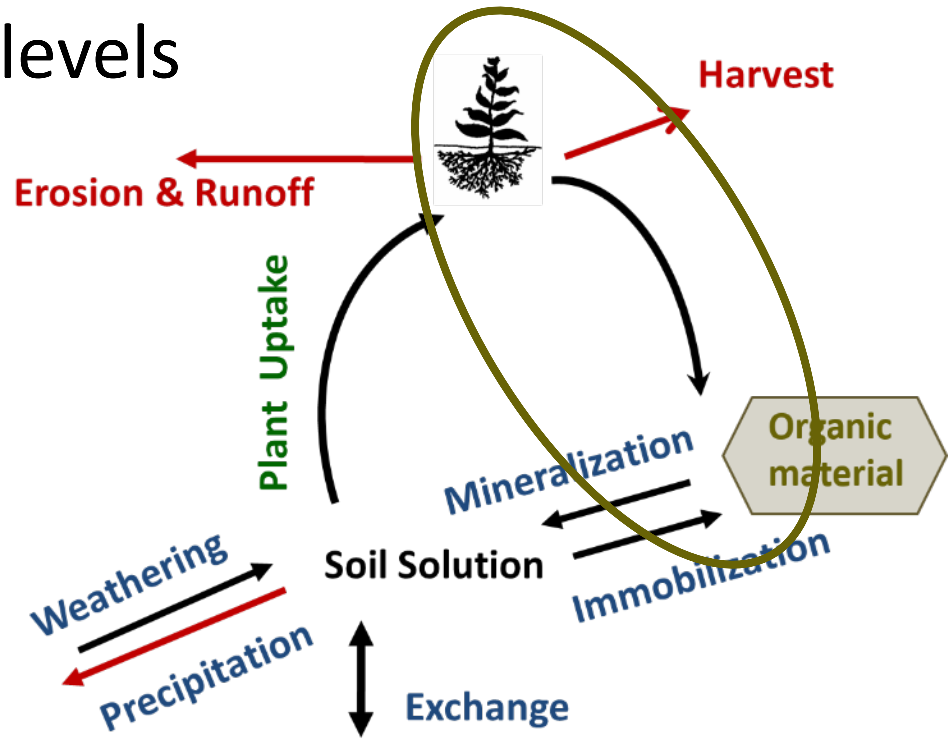
- Ideally, sample in early spring to avoid over- or under fertilization. Late fall if not possible.
- Lower N rate if fall to early spring is dry to average (since high mineralization w/o much leaching).
- Low amounts of early N – allows flexibility for given year’s precip, prevents excess vegetative growth
- N credits will be lower than ‘usual’ after drought because they are partially biomass dependent

Questions?

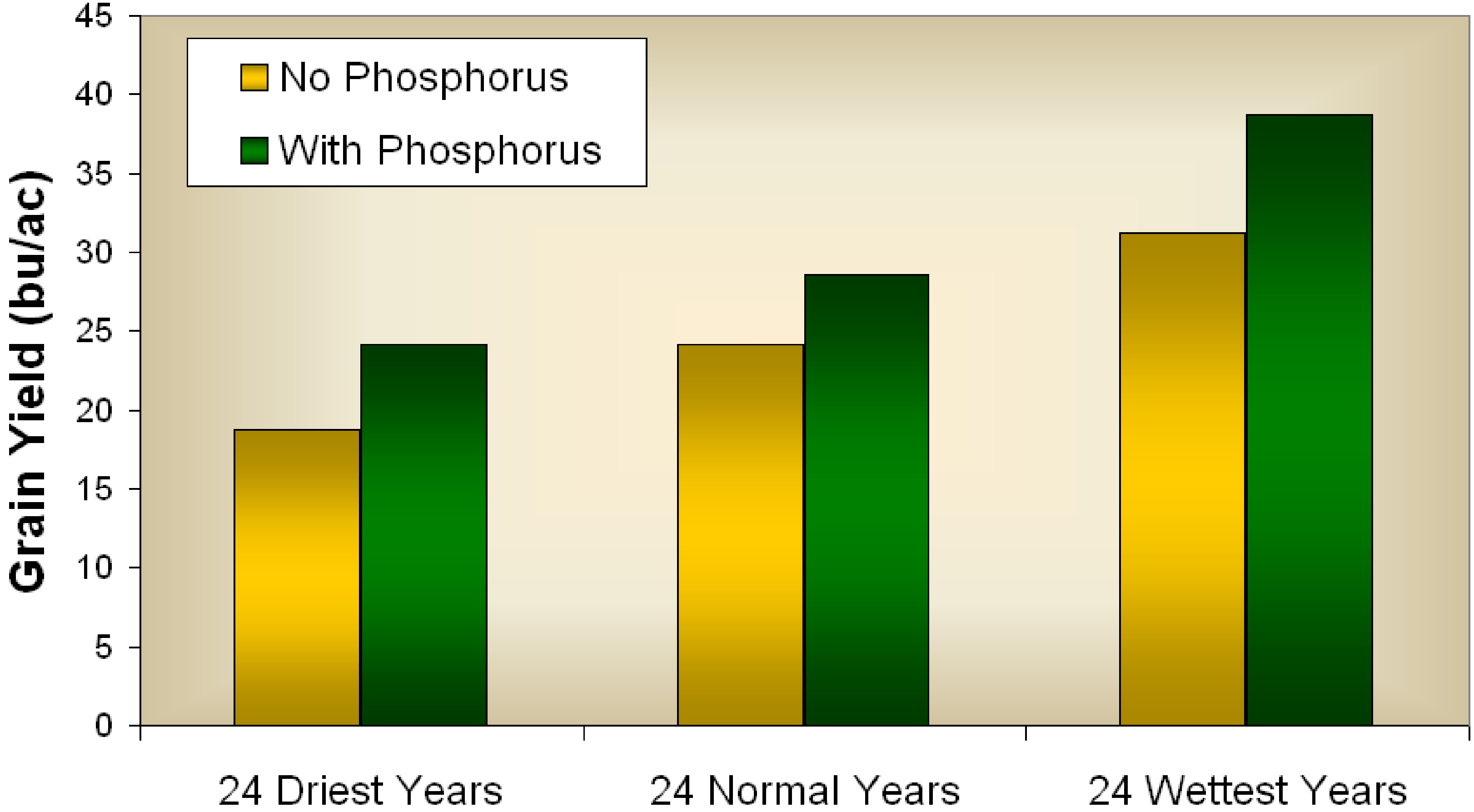
On to P and K

Drought on soil P and K

- P and K soil levels may be higher than average
- Long wet fall conducive to more decomposition of residue, increasing K levels
- Dry fall would lead to less P and K recycling from residue to soil.



In dry years, it's tempting to back off on all fertilizer, including P and K. Is this the best choice?



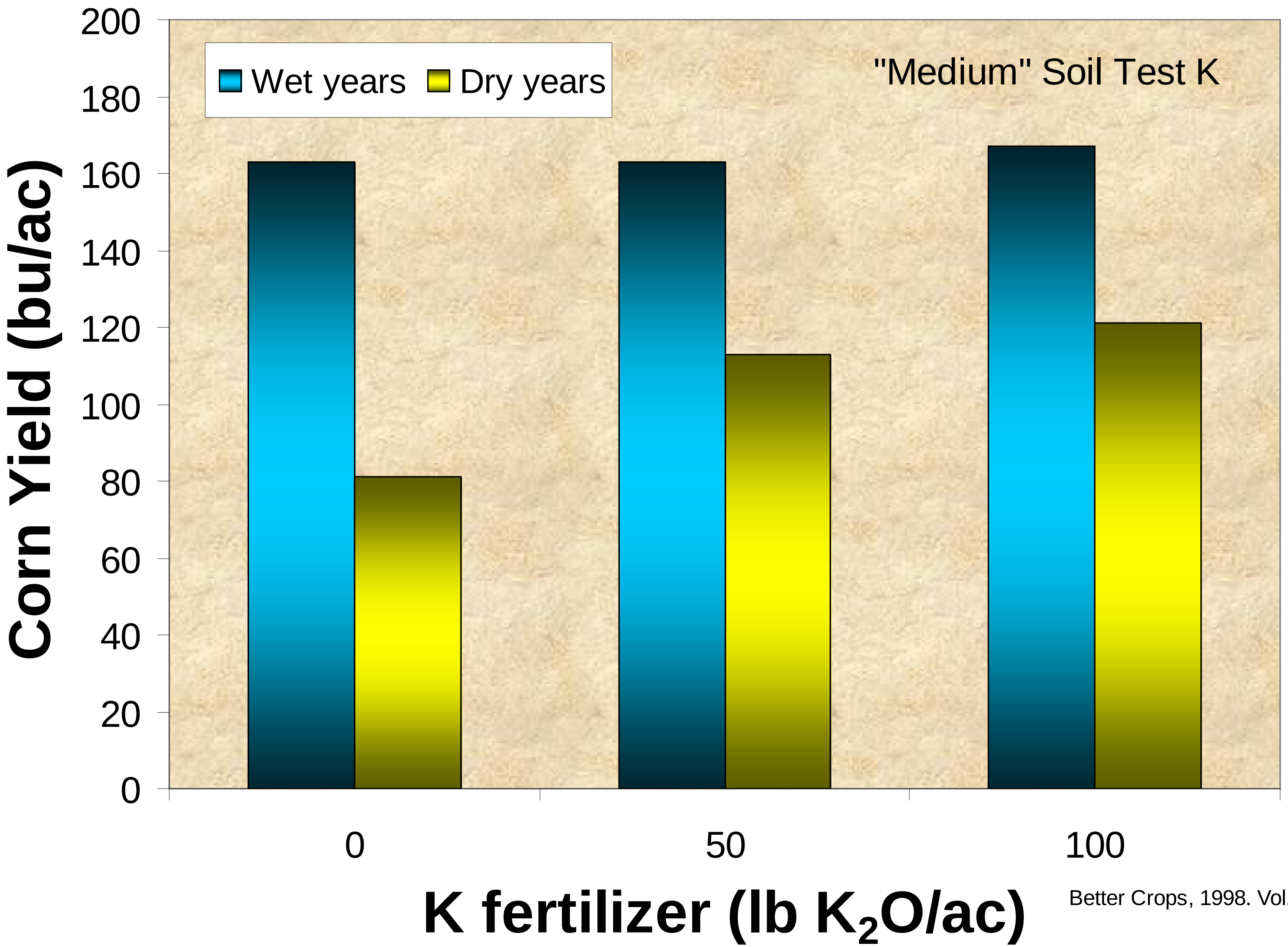
(Olsen P = 16-20 ppm; added 30 lb P_2O_5/ac; Scott, SK)

(Brandt, S. 2007. Phosphorus fertilization boosts yields in fallow wheat production. Better Crops with Plant Food. 91:15.)

Environmental stress and K

- Higher K for drought, cold, heat, high light, salinity tolerance (Wang et al., 2013)
- Stressed plants may actually need more K
- "Luxury consumption" may be insurance against environmental stress (Kafikafi, 1990)
- Foliar K between 2 weeks before anthesis to grain fill can improve yield in drought stress (Shabbir et al., 2016, Pakistan; Raza et al., 2013, Pakistan)

Effect of K on Corn Grain Yield



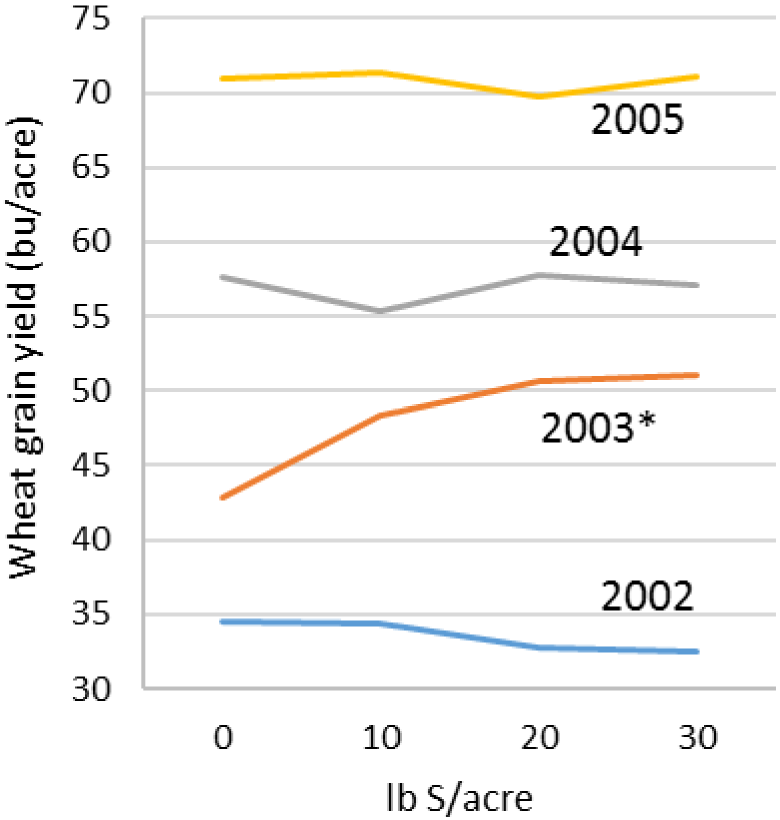
Better Crops, 1998. Vol. 82(3).

Recommendations for P and K

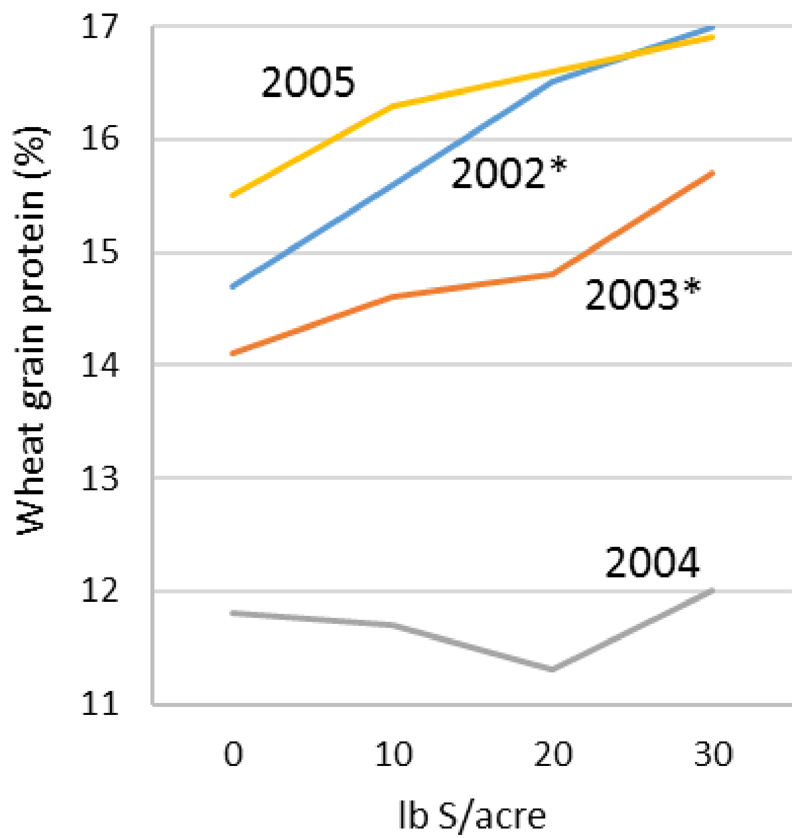
- In dry years, use the same amount of P and K fertilizer as in a "normal" year
- P, K and S important for legume nodulation – don't ignore

Nodulated pea root
Courtesy A. McCauley

Sulfur can increase WW yield in drought years



And protein in both wet and dry years



In severe drought (2002), water, not S, limited yield. In moderate drought (2003), perhaps less gypsum dissolved and less SOM mineralized to provide S

Ffact No. 41, **Knees, MT**

Grain protein and drought

N goes to yield and protein

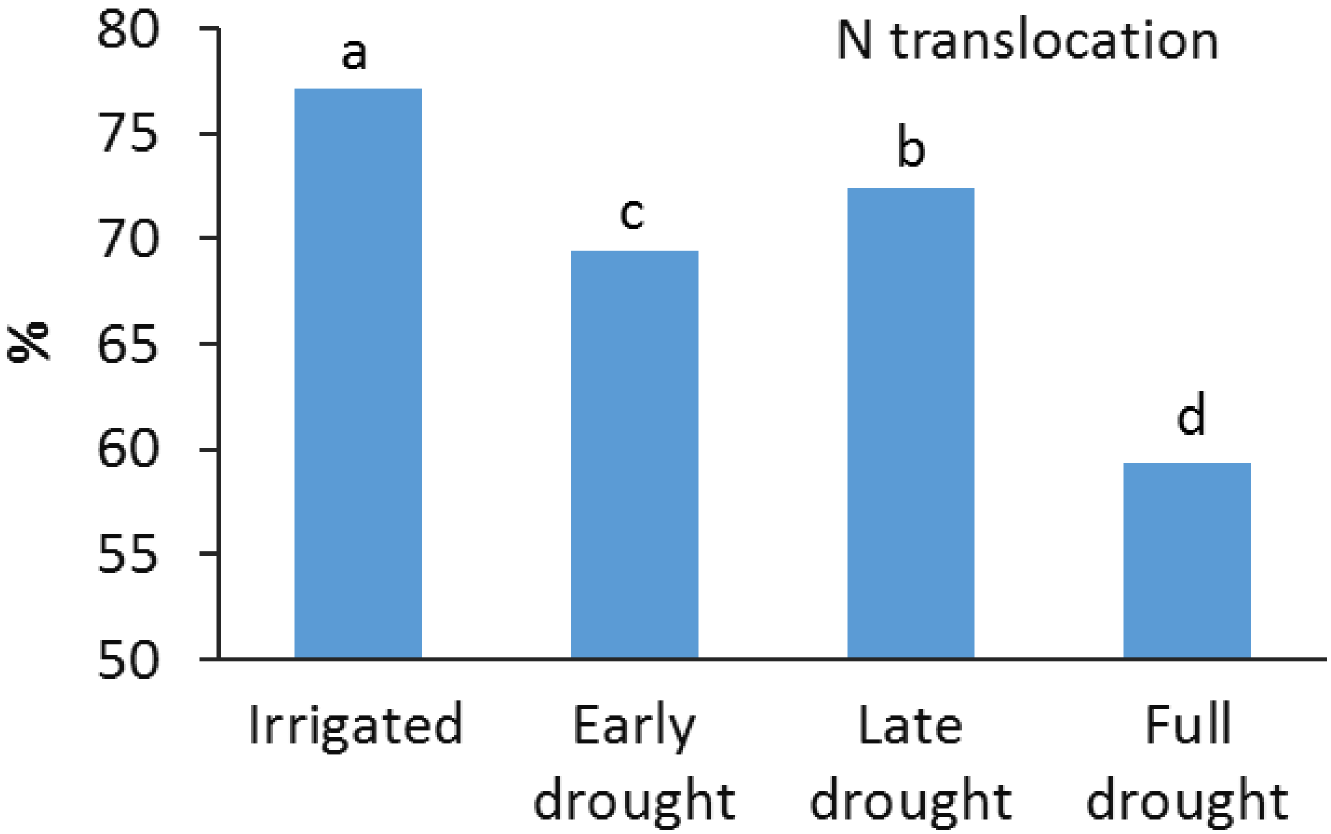
N goes to protein

Drought limits N and S uptake, and nitrate to amino acids to protein conversion

Simplistically, drought:

- before stem elongation, yield and protein = low
- around flowering, yield = adequate, protein = low
- during grain fill, yield = low, protein = high

Drought limits translocation of plant N to grain to form protein



Early = 2nd node to milky ripe, Late = milky ripe to maturity.

Ozturk and Caglar 1999, Turkey

Forage nitrate and drought

Image by Rachel Long, UC Extension

- Plants grown under stress (drought) don’t convert nitrate to amino acids to protein. Nitrate levels can become toxic.
- Test before cutting with free Nitrate QuikTest through MSU Extension
- See *Nitrate Toxicity of MT Forages* (MT200205AG) for details

Minimize nitrate toxicity risk

- Ensure adequate P, K, S
- Base N rates on soil tests
- Back off on N for yield if there is risk, N for max yield may be too high
- Split N applications with 2nd application based on current growing season yield potential
- Plant cool season forages to harvest earlier than warm season forages, before drought stress
- Wait a week before harvesting or grazing after ‘drought-ending’ moisture

Summary on post-drought fertility

- Account for nutrient removal by harvest, plant part harvested, maturity of residue
- Fall conditions influence decomposition rate, N availability, P and K recycling
- N, P and K likely higher than average
- Soil test in the spring and adjust fertilizer rates
- Catch residual N with a fall planted cover or cash crop.

For additional information

Soil Fertility Website:

http://landresources.montana.edu/soilfertility

Contains links to my presentations including this one, the bulletin *Montana Cool Season Pulse Production Guide*, and more.

SK Pulse Growers' Nodulation and N-Fixation Field Assessment Guide

http://proof.saskpulse.com/files/general/150521_Nodulation_and_Nitrogen_Fixation_Field_Assessment_Guide.pdf

With good soil fertility you can grow big pods,

and drought affects fertilization decisions

?

Remember Extension guides