Nutrient Management During and After Drought

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Clain Jones, Extension Soil Fertility Specialist
994-6076, clainj@montana.edu

Questions for you

- What nutrient issues did you see last year?
- Were your nitrate-N levels this last fall any different than last few years?
- How was protein?

Image by Ron Nichols, NRCS

Goals for today

- Explain how drought directly impacts plant nutrients
- Discuss drought effect on next year's fertilizer needs
- Describe soil testing
- Offer suggestions to increase drought resiliency

Drought affects plant uptake and nutrient availability

Plants

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

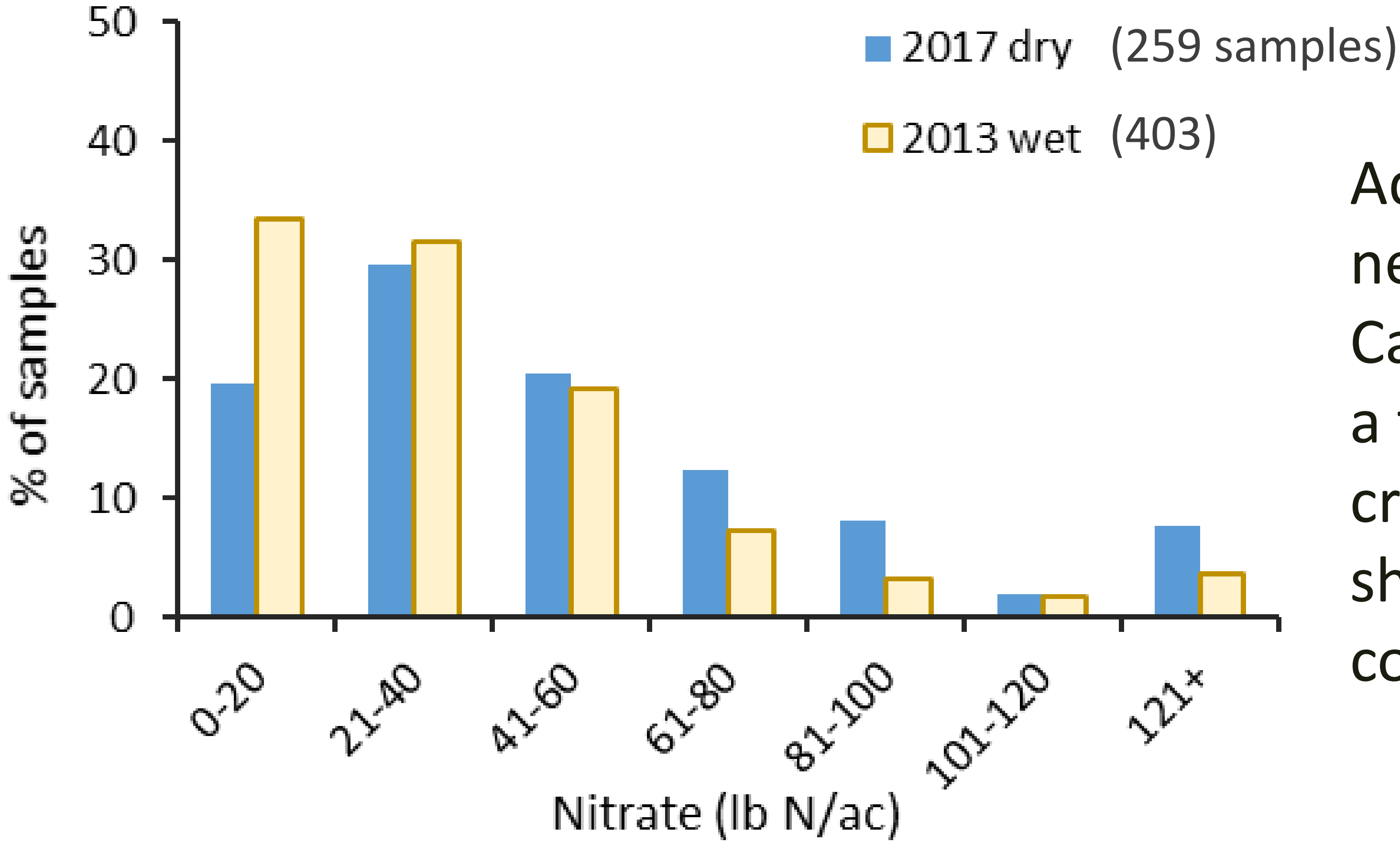
Nutrients

- 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			
Grain	40 bu	50	25	15	3
Hay	2 ton	50	20	76	4
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

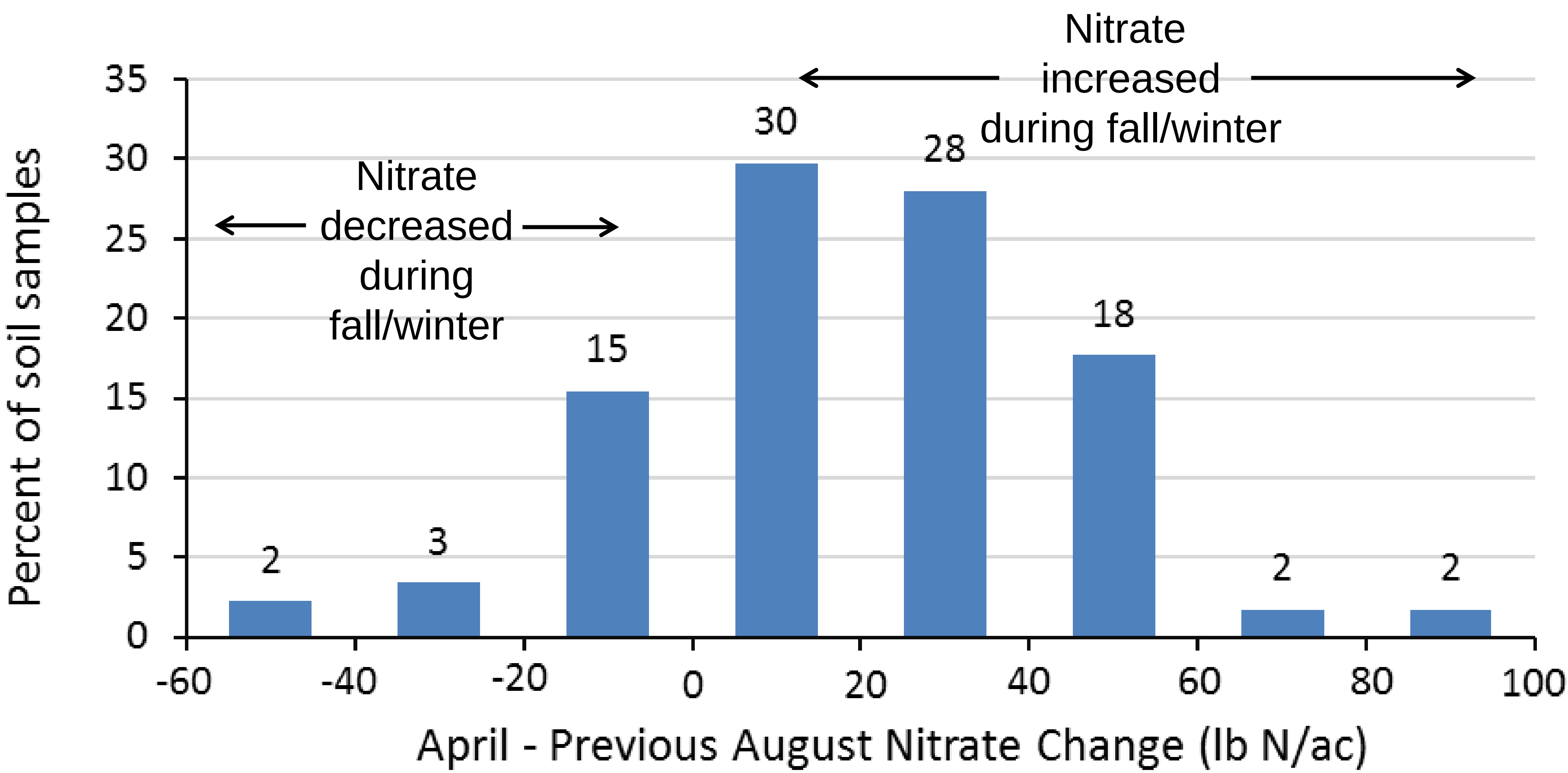
P and K recycling changes depending on fall precip

So with all these unknowns, what should you do?

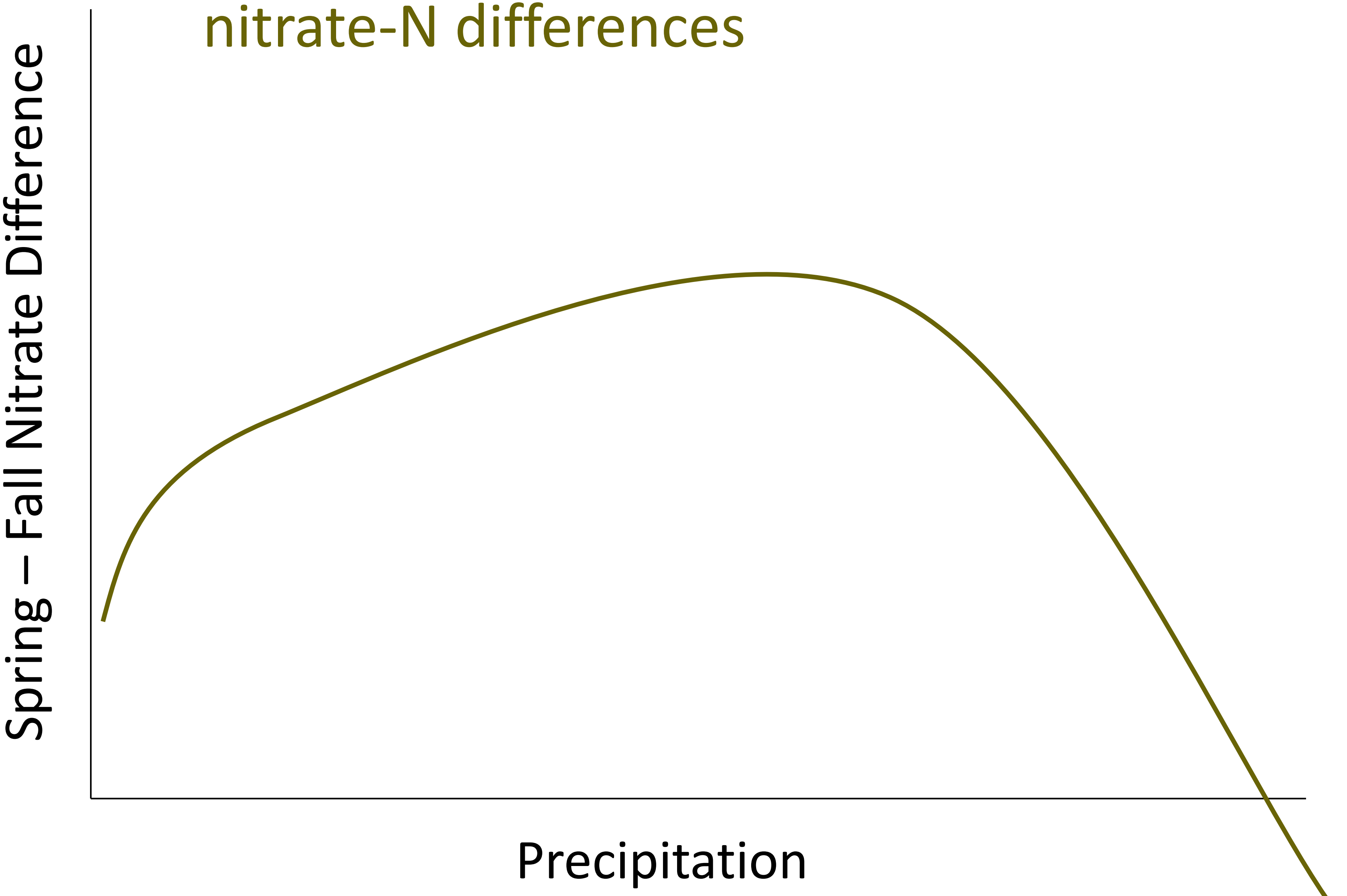
Soil Test!

- 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

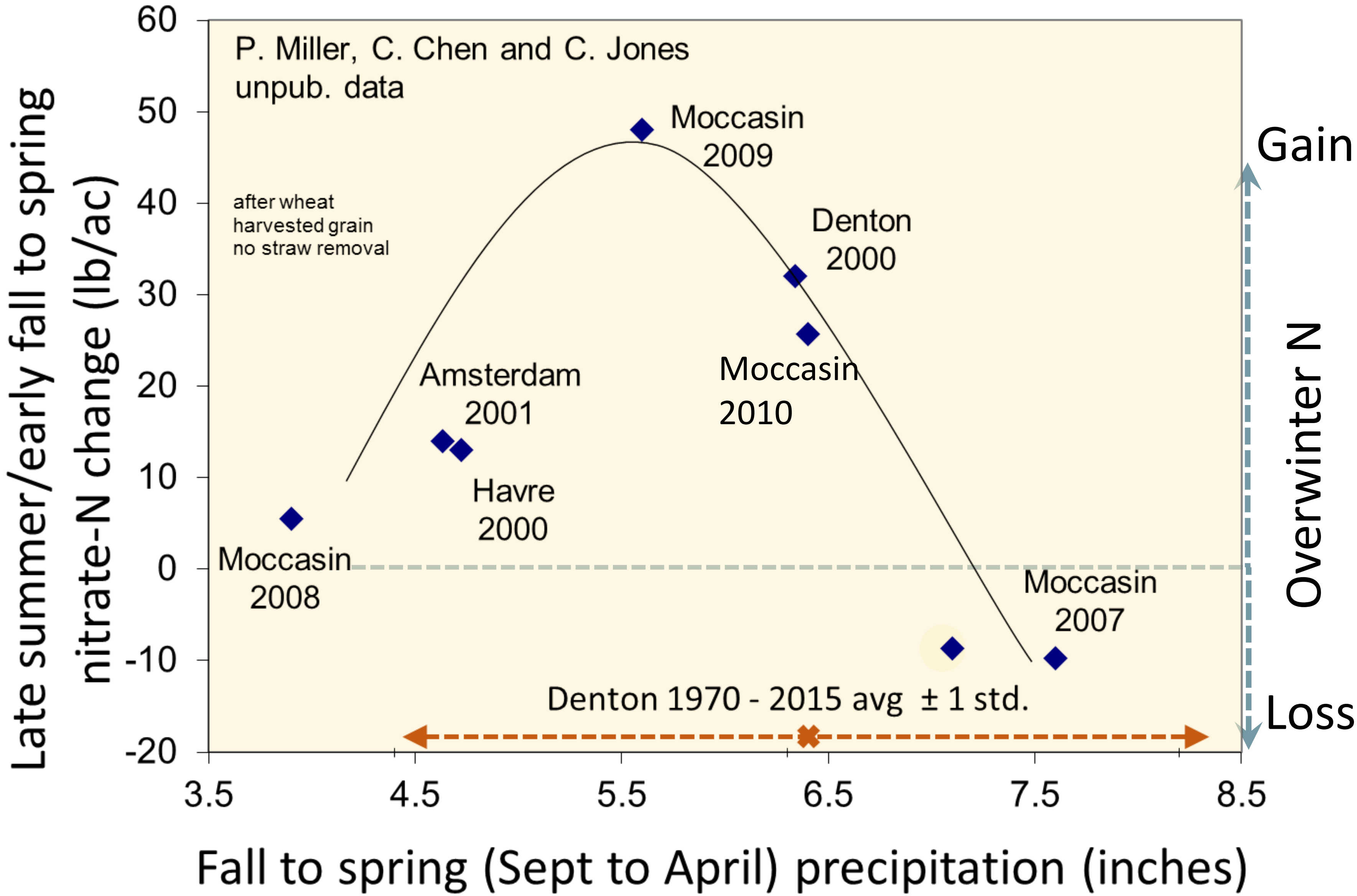
August to April nitrate changes, Montana data based on 175 samples (Jones et al. 2011)



Conceptual spring to fall soil nitrate-N differences



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

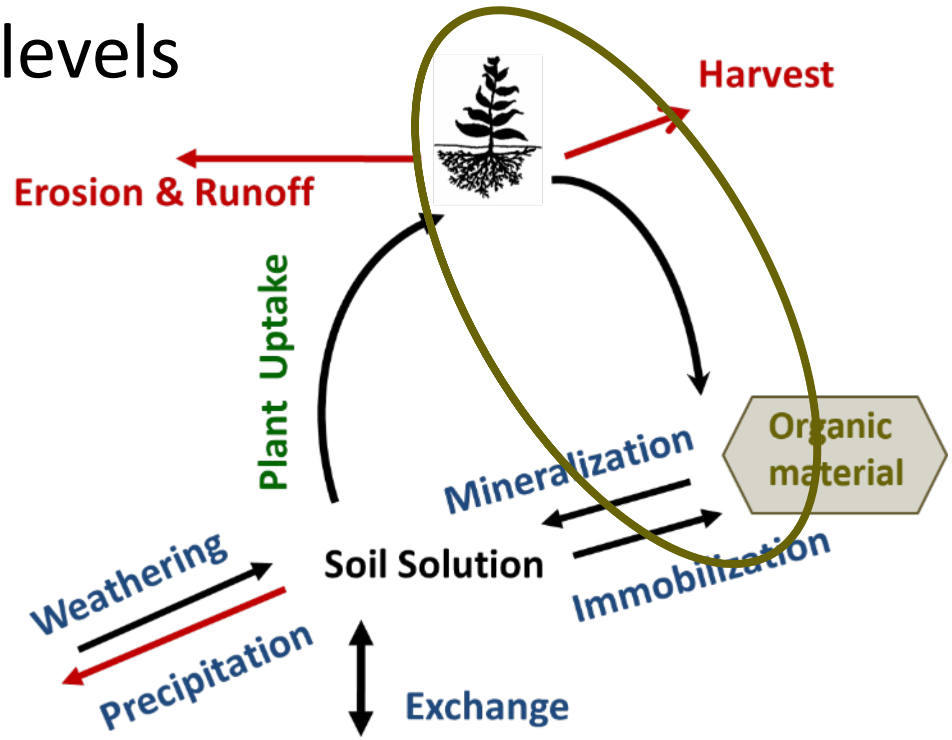
- Ideally, sample in early spring to avoid over- or under fertilization. Late fall if not possible.
- Lower N rate if fall to early spring is dry to average (since high mineralization w/o much leaching).
- Low amounts of early N – allows flexibility for given year's precip, prevents excess vegetative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

Questions?

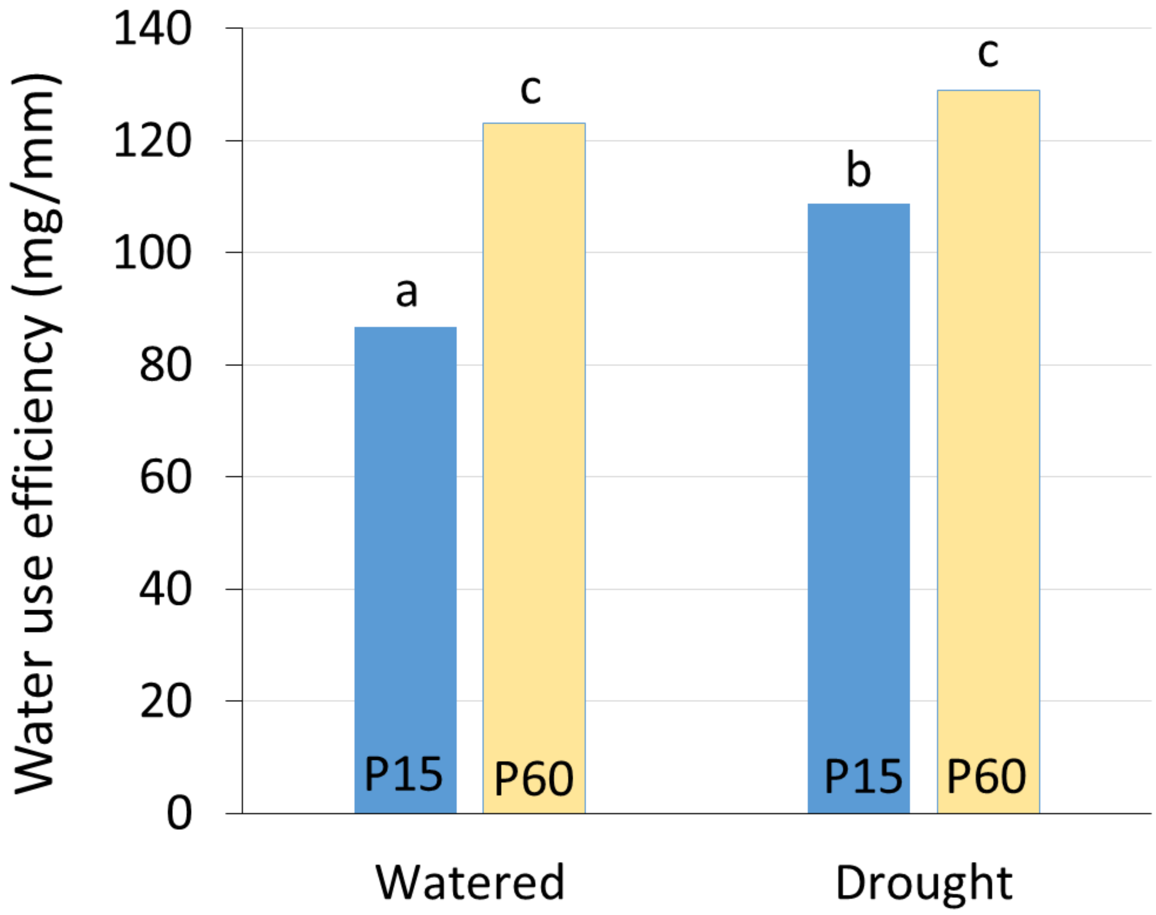
On to P and K

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.



P increased water use efficiency, thus drought tolerance, when initial soil test P was "low"

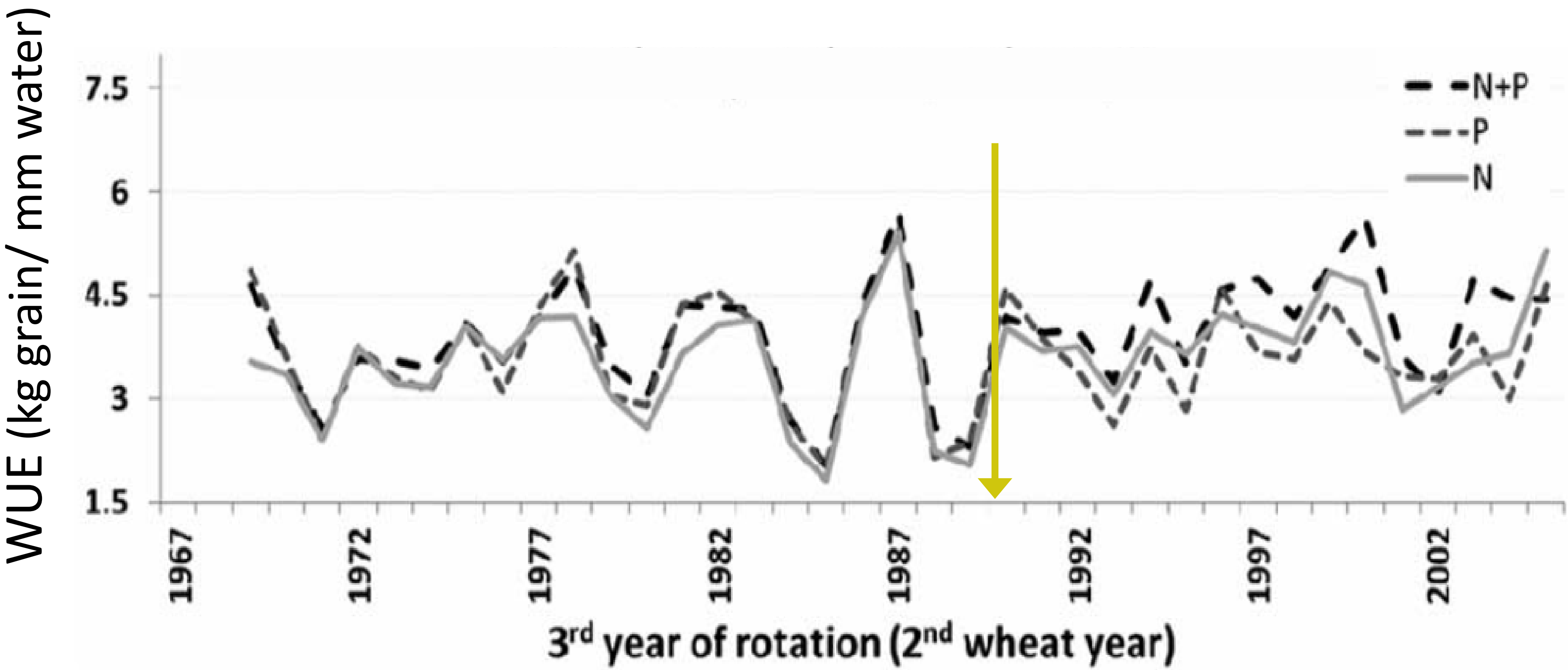


"drought" = no water for 21 days starting at initial flowering

Jin et al., 2015, Australia, field pea grown in buried cylinders under field conditions

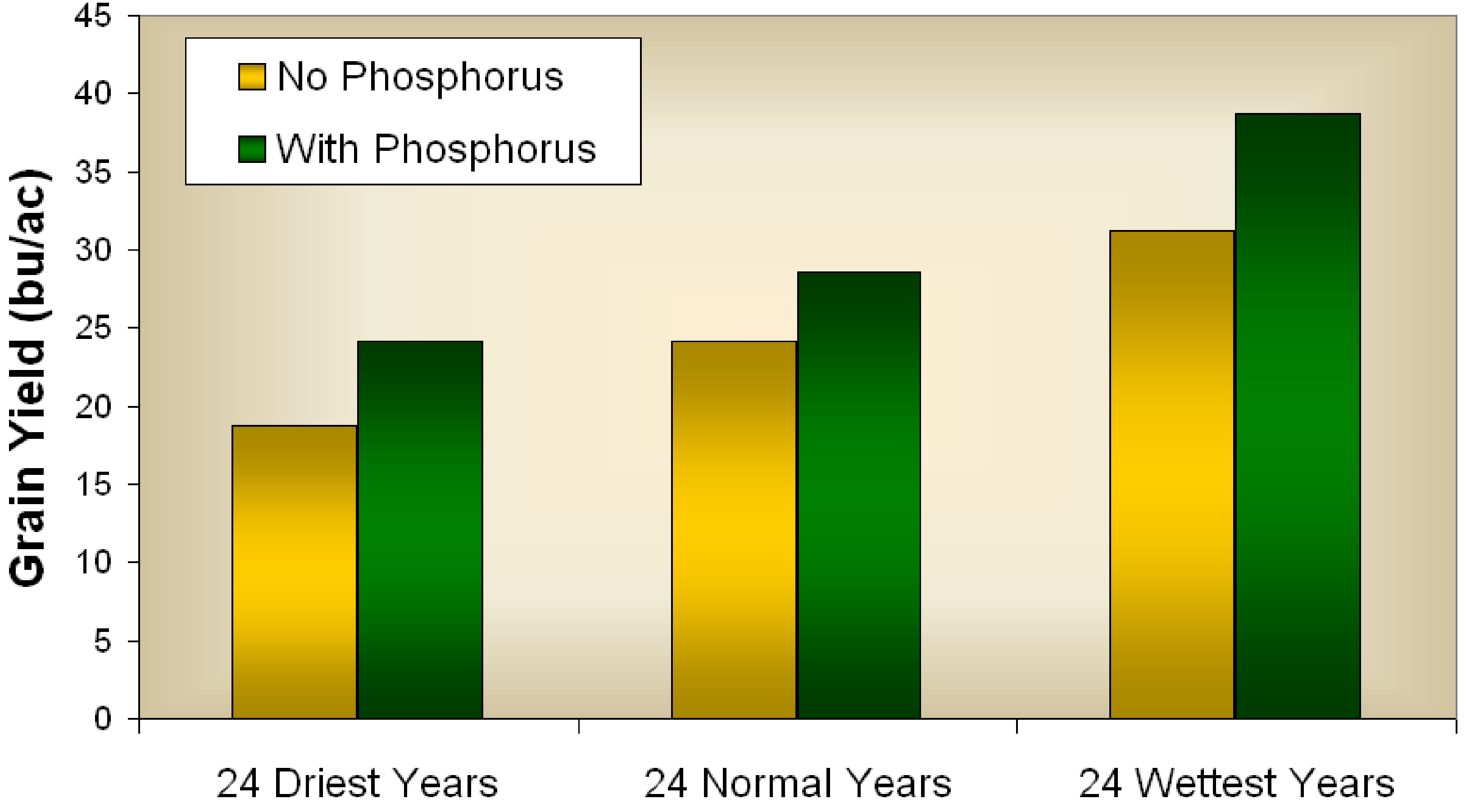
Balanced N and P result in highest water use efficiency

Especially when start pushing the system with high N
In 1990, N rates started doubling



Kroebel et al., 2012. SK

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



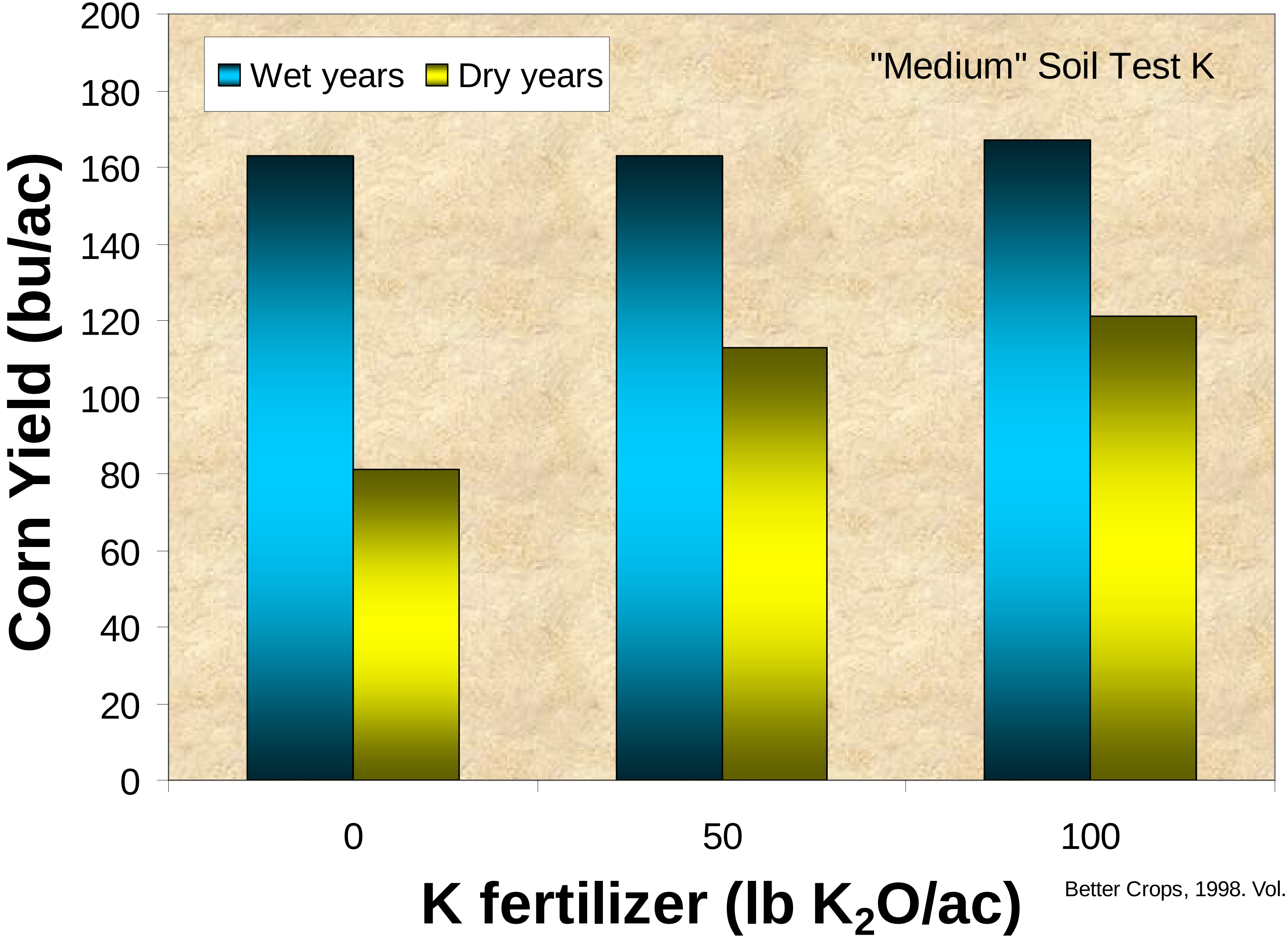
(Olsen P = 16-20 ppm; added 30 lb P_2O_5/ac; Scott, SK)

(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



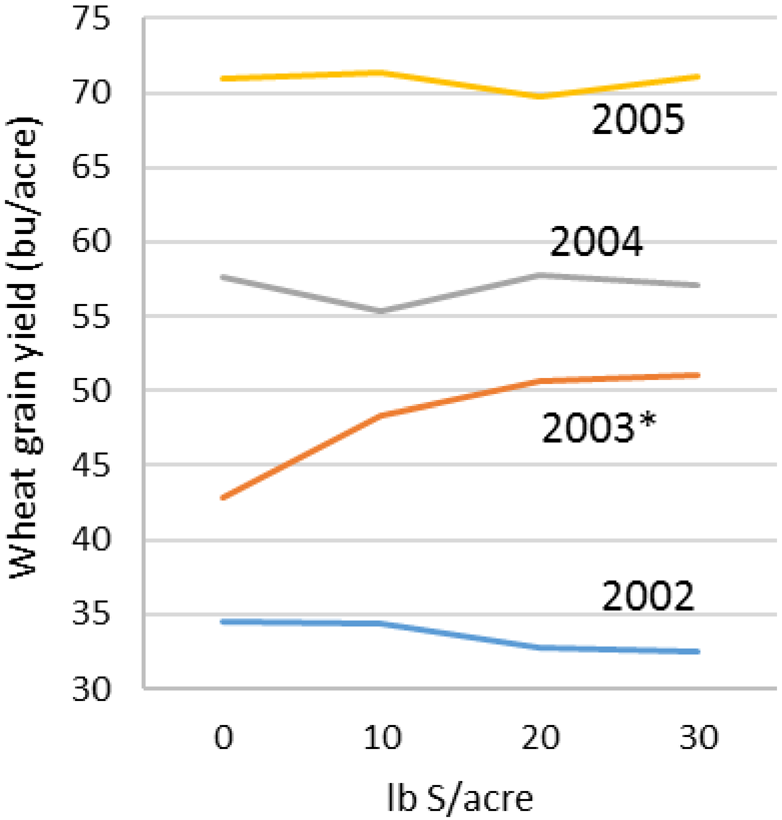
Better Crops, 1998. Vol. 82(3).

Recommendations for P and K

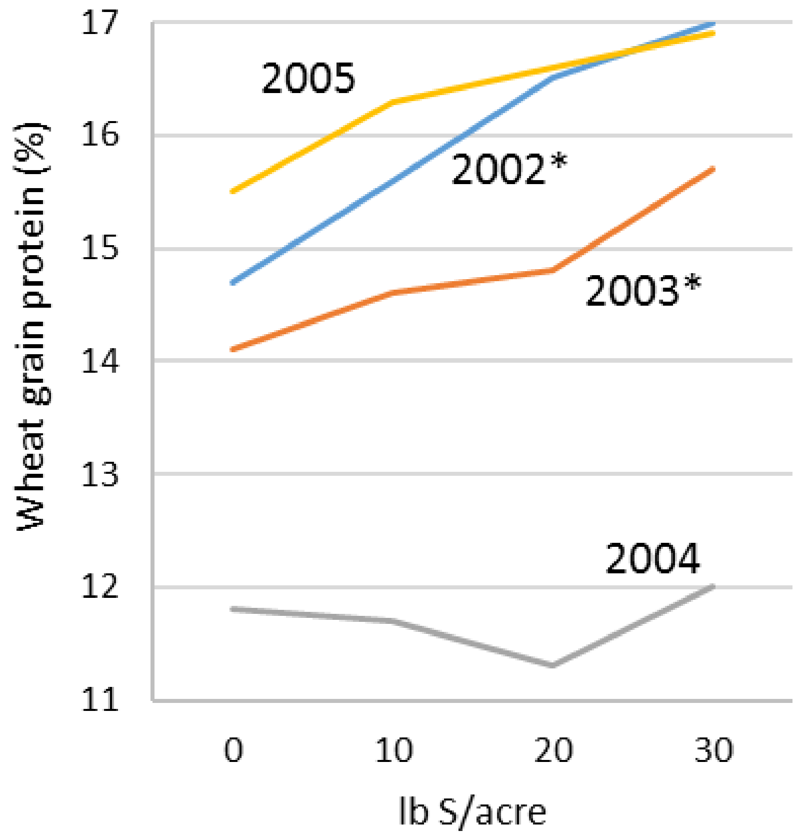
- In dry years, use the same amount of P and K fertilizer as in a "normal" year
- P, K and S important for legume nodulation – don't ignore

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**

Questions?

On to grain and forage quality

Grain protein and drought

N goes to yield and protein

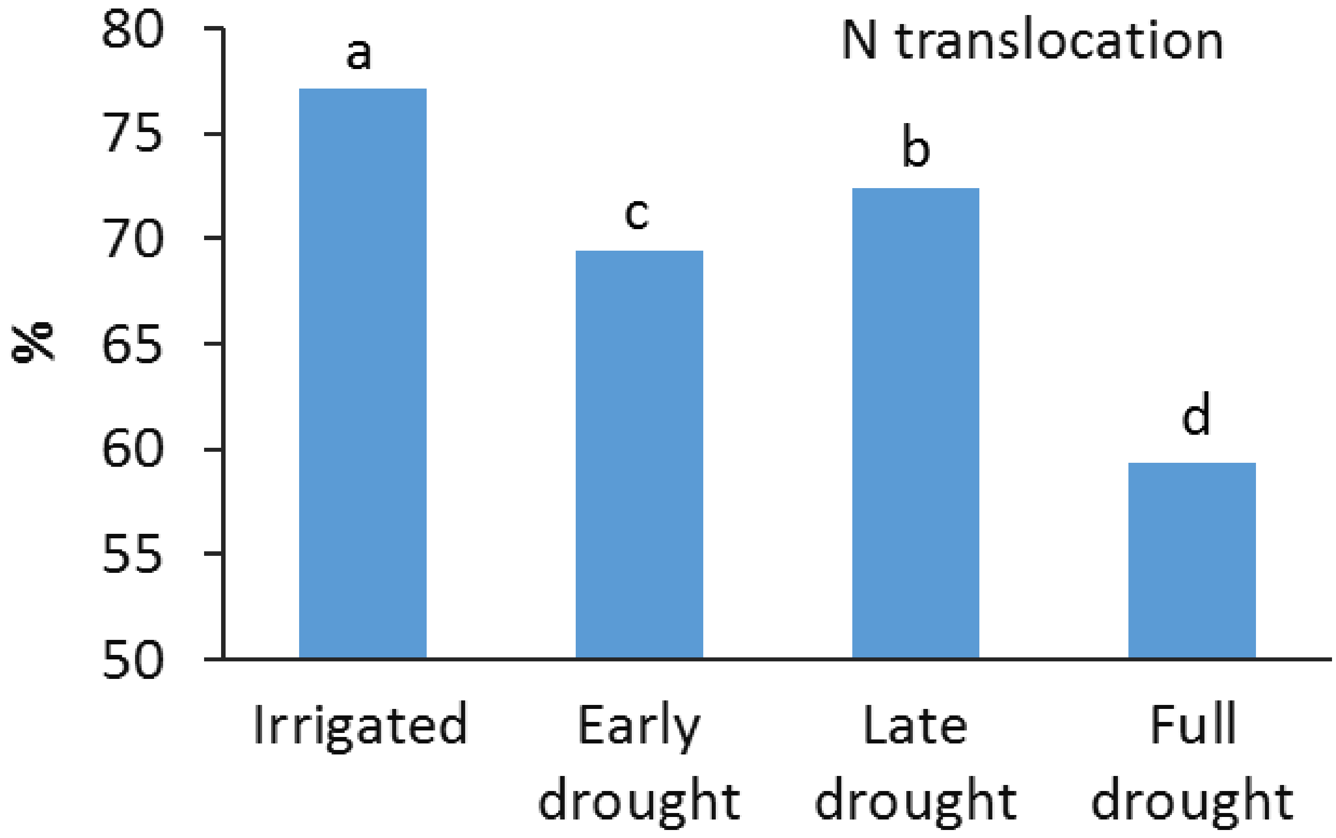
N goes to protein

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.
- Manage towards increased resiliency

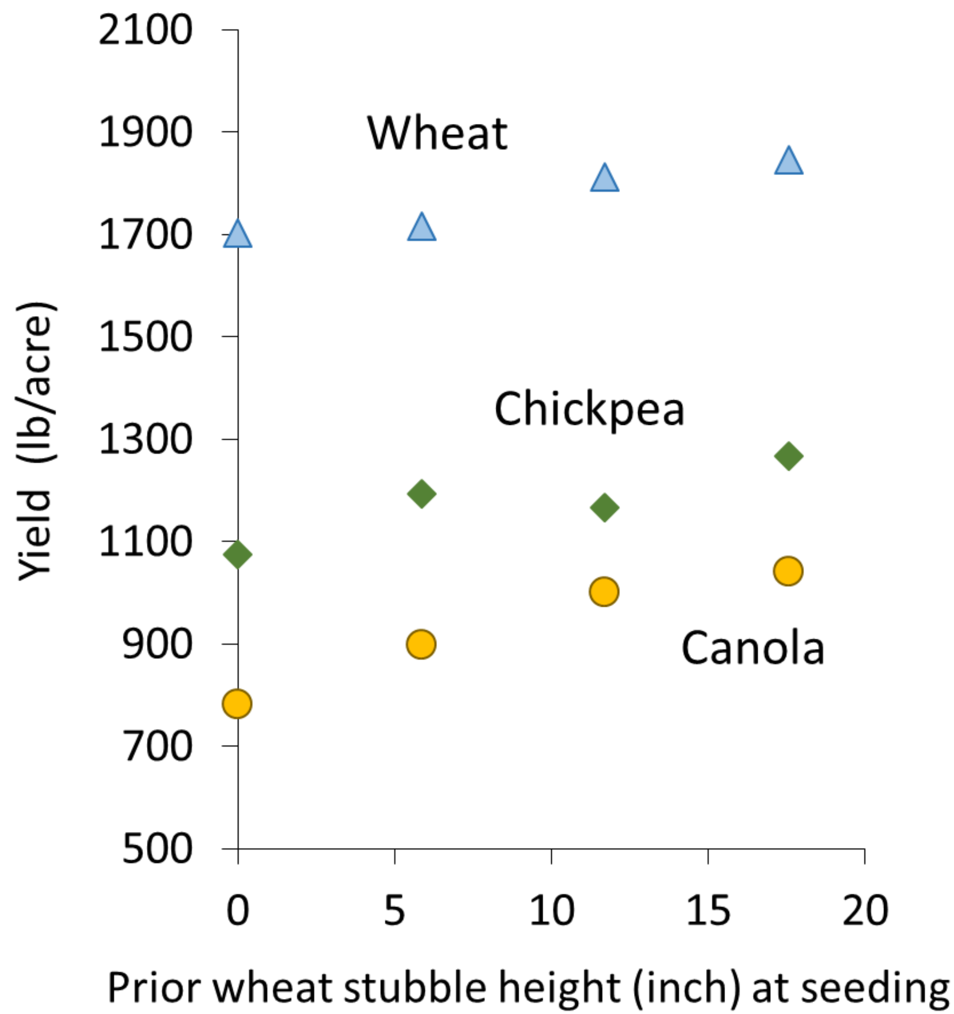
Questions?

On to resiliency

Agronomic practices to improve soil water

Reduce tillage, increase residue and stubble to:

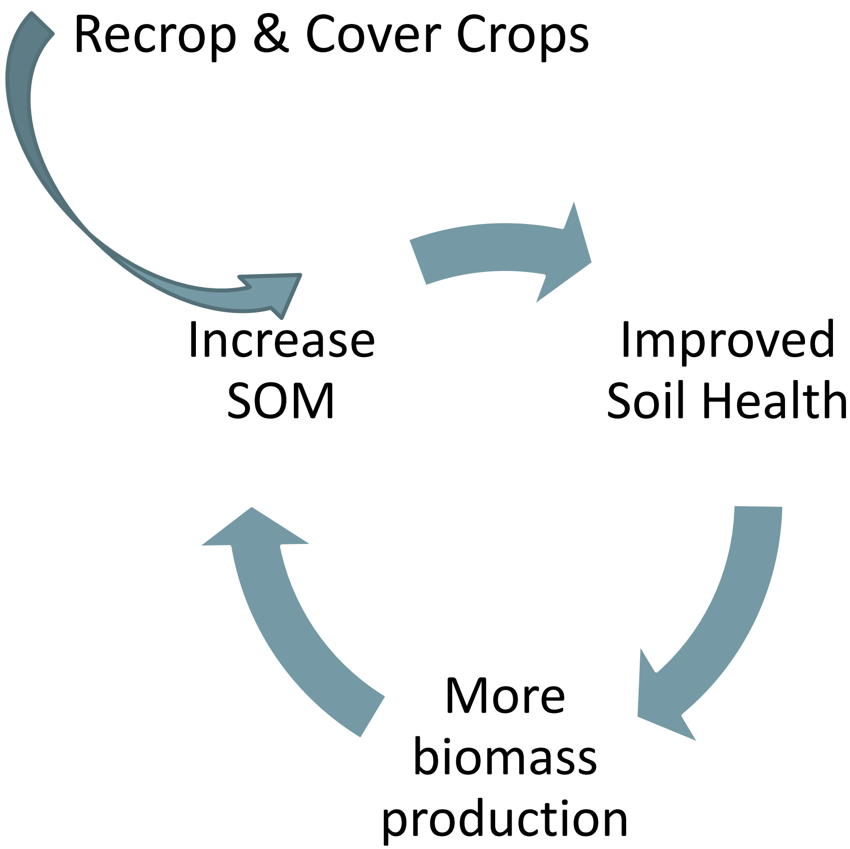
- Trap snow
- Reduce wind stress
- Reduce evaporation loss
- Reduce soil temperature
- Increase water infiltration and storage



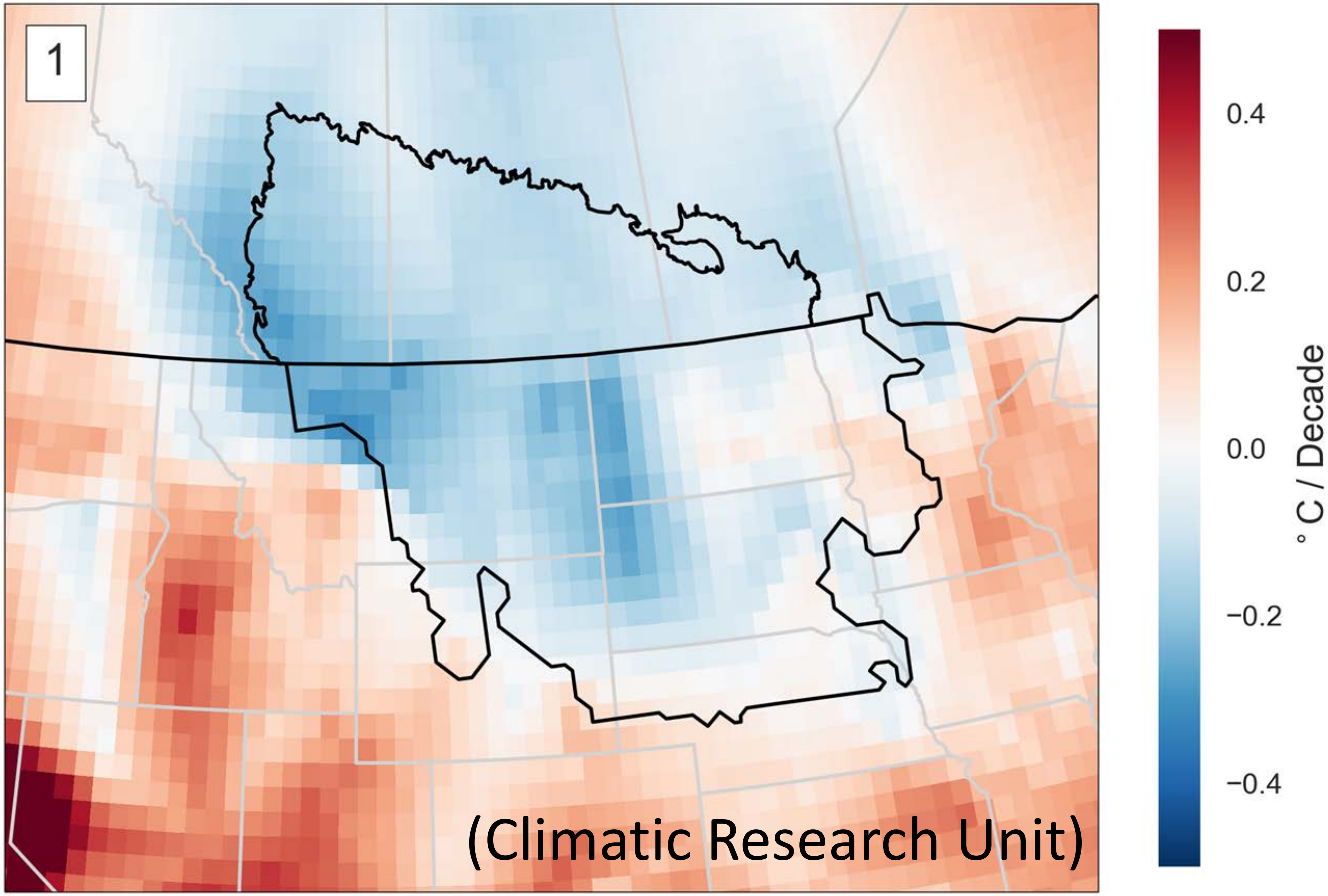
Cutforth et al., 2011, SK, All started with same soil moisture at seeding

Cropping intensity – recrop or cover crop

- Increases SOM
  - Takes time
  - Increases water holding capacity
  - Provides nutrients for crop and soil microbes
  - Improves soil health
- Increases and retains active root in soil for longer
- Legume residue *releases more N when wet which is when you need more.*
- Reduces soil temperature AND regional temperature



Reduced fallow has apparently reduced regional spring and summer air temperature

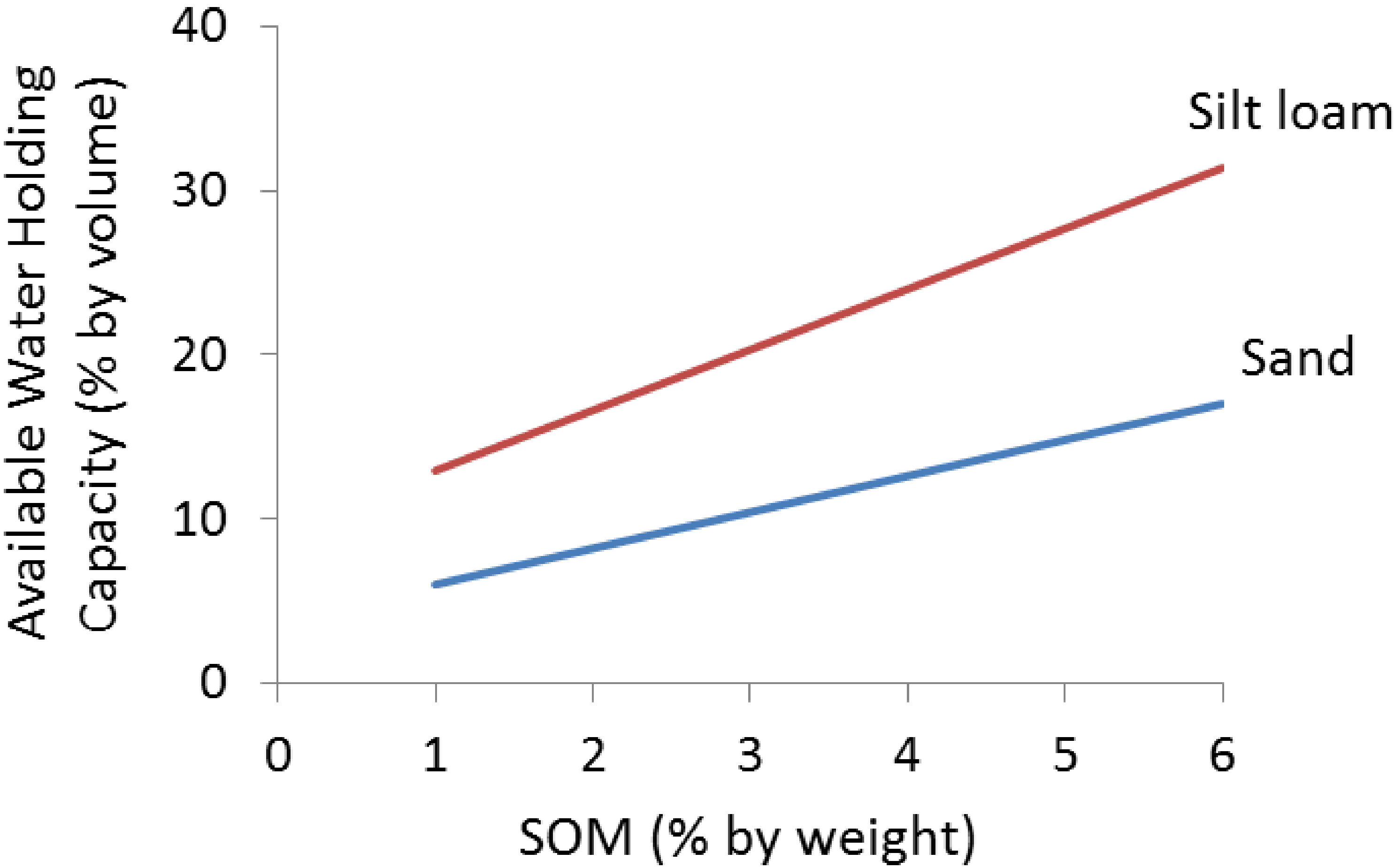


April - June average temperature trends

1970-2015

June 15 to July 15 maximum temps (1976-2000) have DROPPED almost <u>3°F/decade</u> in parts of Canadian Prairies likely due to large decrease in fallow acres (Gameda et al., 2007)

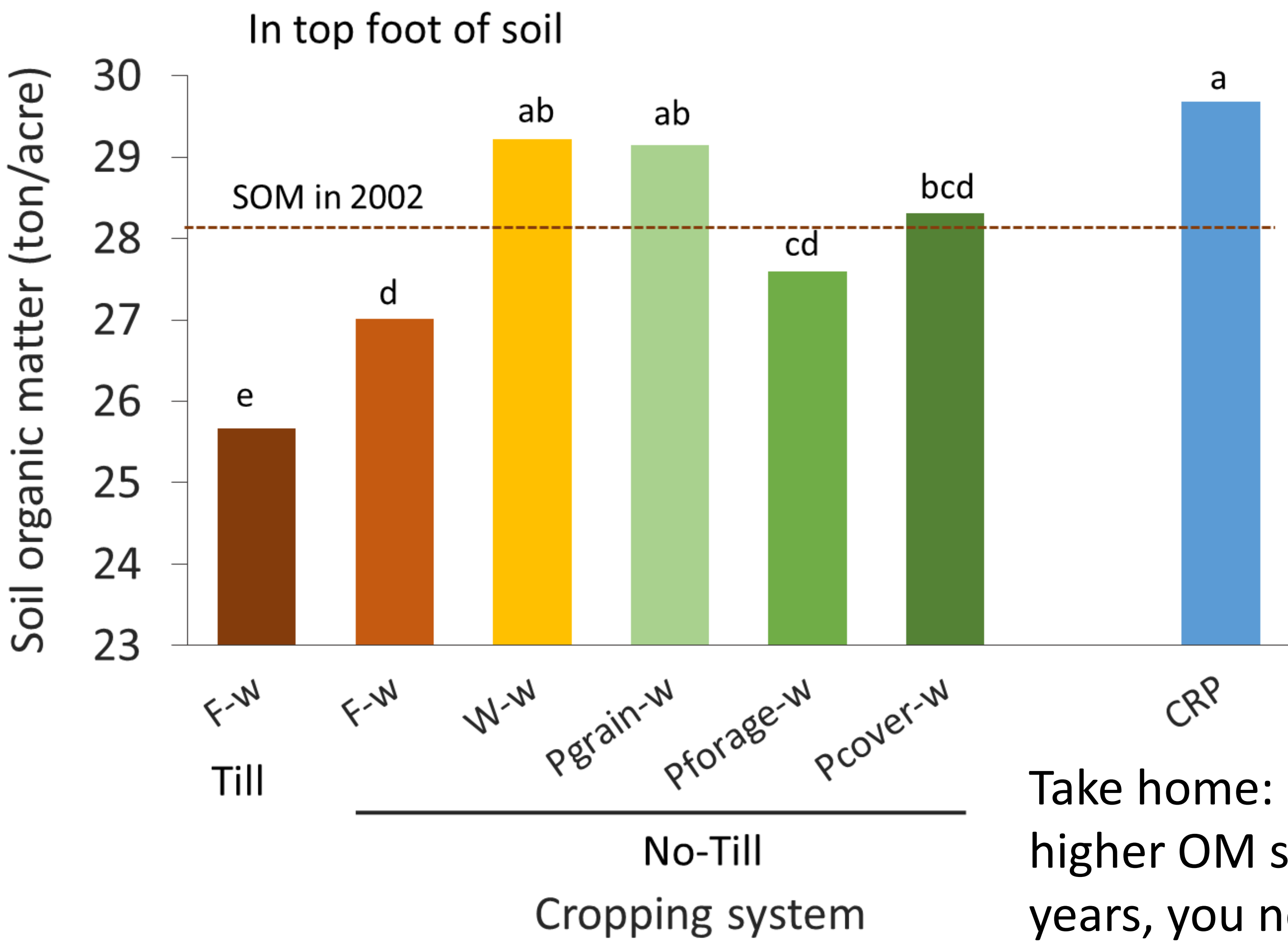
SOM increases available water holding capacity



Hudson 1994

Guesses on how long to increase SOM from 2.0 to 2.2% (meaning by 10%)?

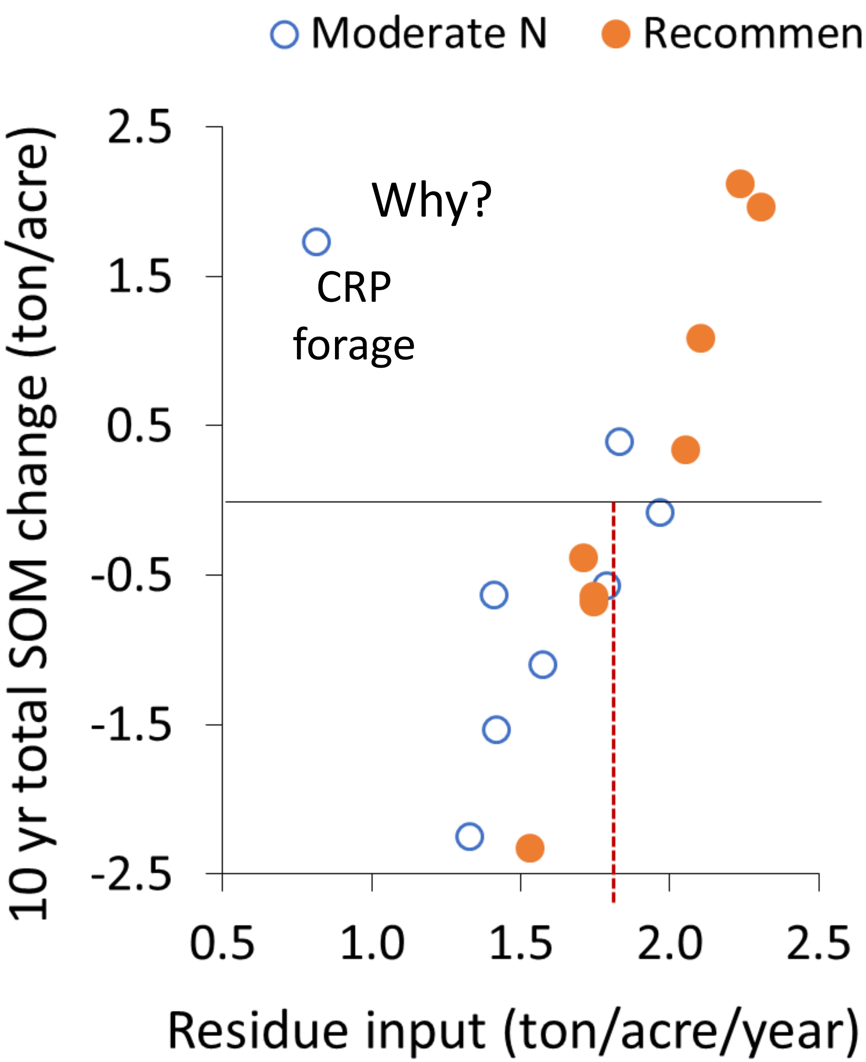
SOM after 10 years of cropping systems (2012)



Take home: If want to have higher OM soil in say 20 years, you need to start NOW.

Engel, in press, MSU Post Farm, 4 miles west of Bozeman

SOM change depends on residue returned, which depends partly on inputs



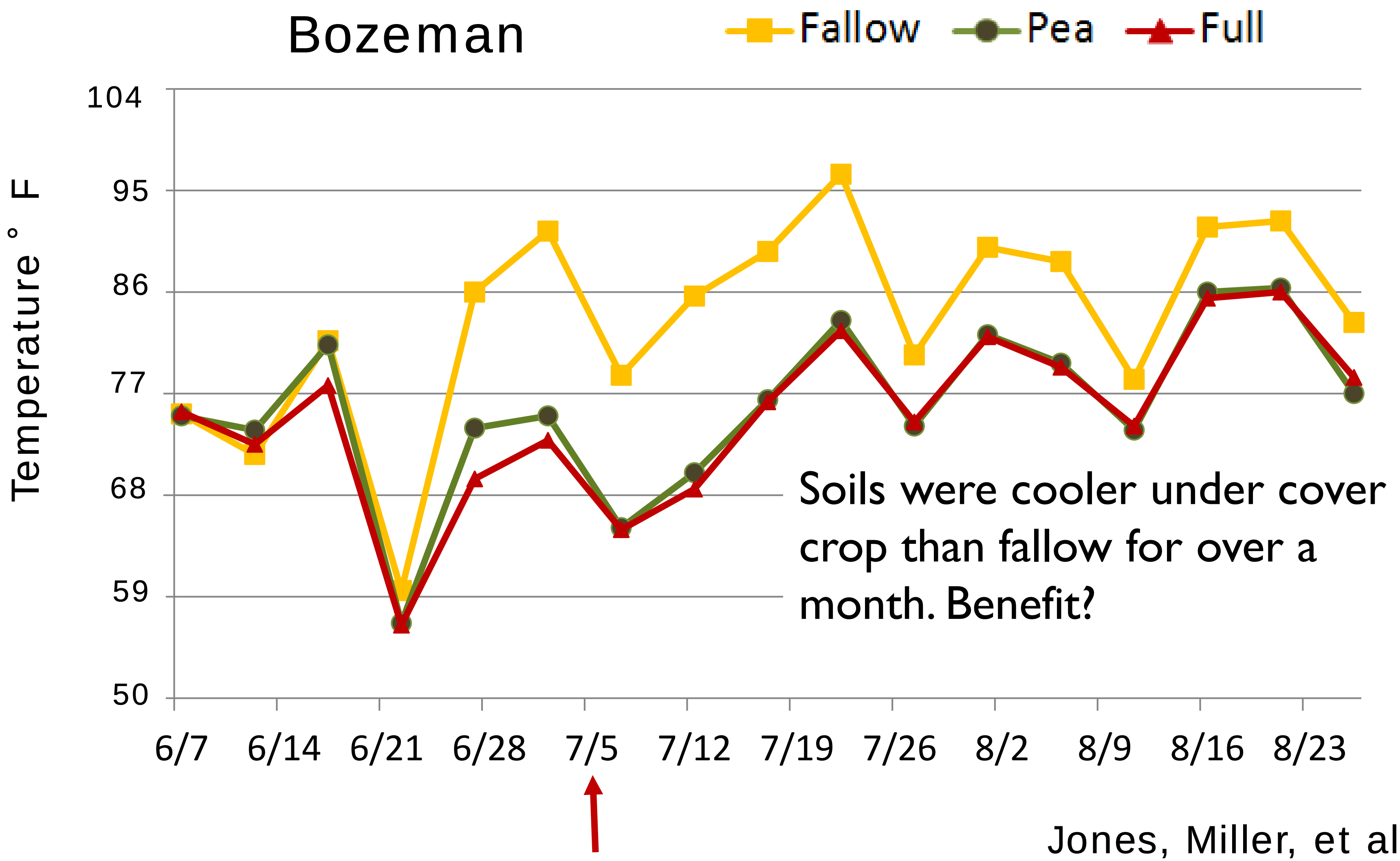
- Residue
- Active roots
- Organic material with high N,P, and S

(Wuest and Reardon, 2016, OR)

Take home: Best way to increase SOC is to increase amount of residue returned. Need about 1.8 ton residue/acre per year from annual crops to break even. Best way: recrop and apply recommended fertilizer rates, or grow perennials.

Engel et al., 2017, Bozeman

4 pm daily soil temperature at 2” deep higher under fallow than cover crops (but no differences between pea and full)



Cover crops terminated on 5 July

Jones, Miller, et al. unpublished

Encourage mycorrhizal association for N and P uptake

Mycorrhiza reach places roots can’t.

Plants with better nutrient status can manage drought stress better.

Mycorrhiza do not thrive in fallow.

However, there is not a lot of evidence that mycorrhizae improve response to drought, where nutrients are not limiting.

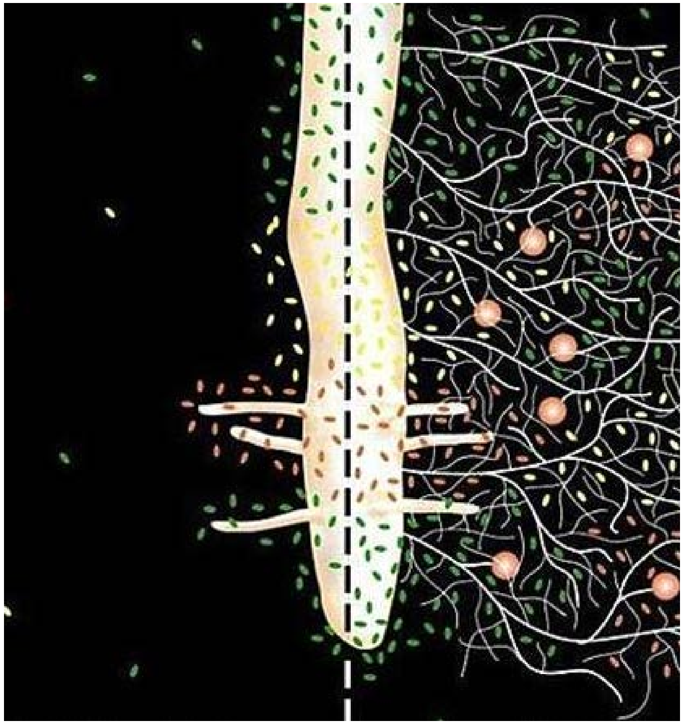


Image by Earth’s Internet & Natural Networking

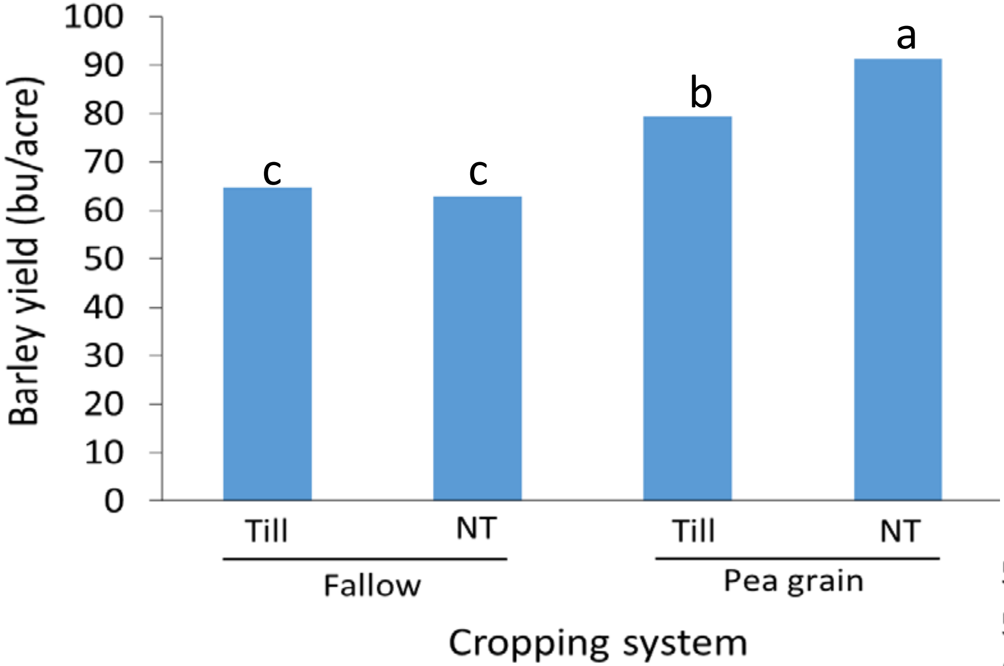
Diversify – how could you & how would it help?

- Structural diversity in field, e.g., stubble strips
- Genetic diversity
- Intersperse fields with non-crop vegetation
- Polycultures – mix species w/in field
- Mix of winter and spring crops

- Interrupt pest/disease cycles
- Buffer microclimate extremes
- Increase production
- Increase yield stability, reduce risk

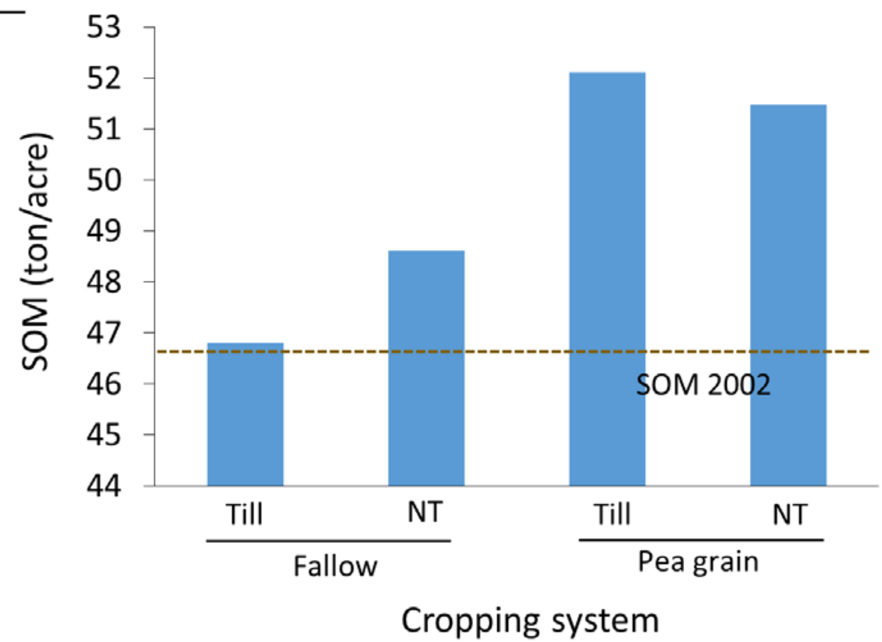
Would you consider using pulse or cover crops to diversify?

Crop rotation and tillage system effects

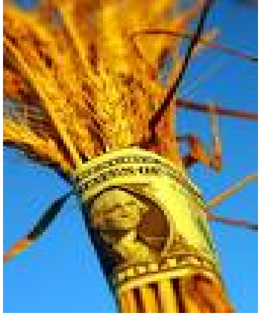


After 10 years of cropping system. Barley yield in 2012 after fallow for both systems.

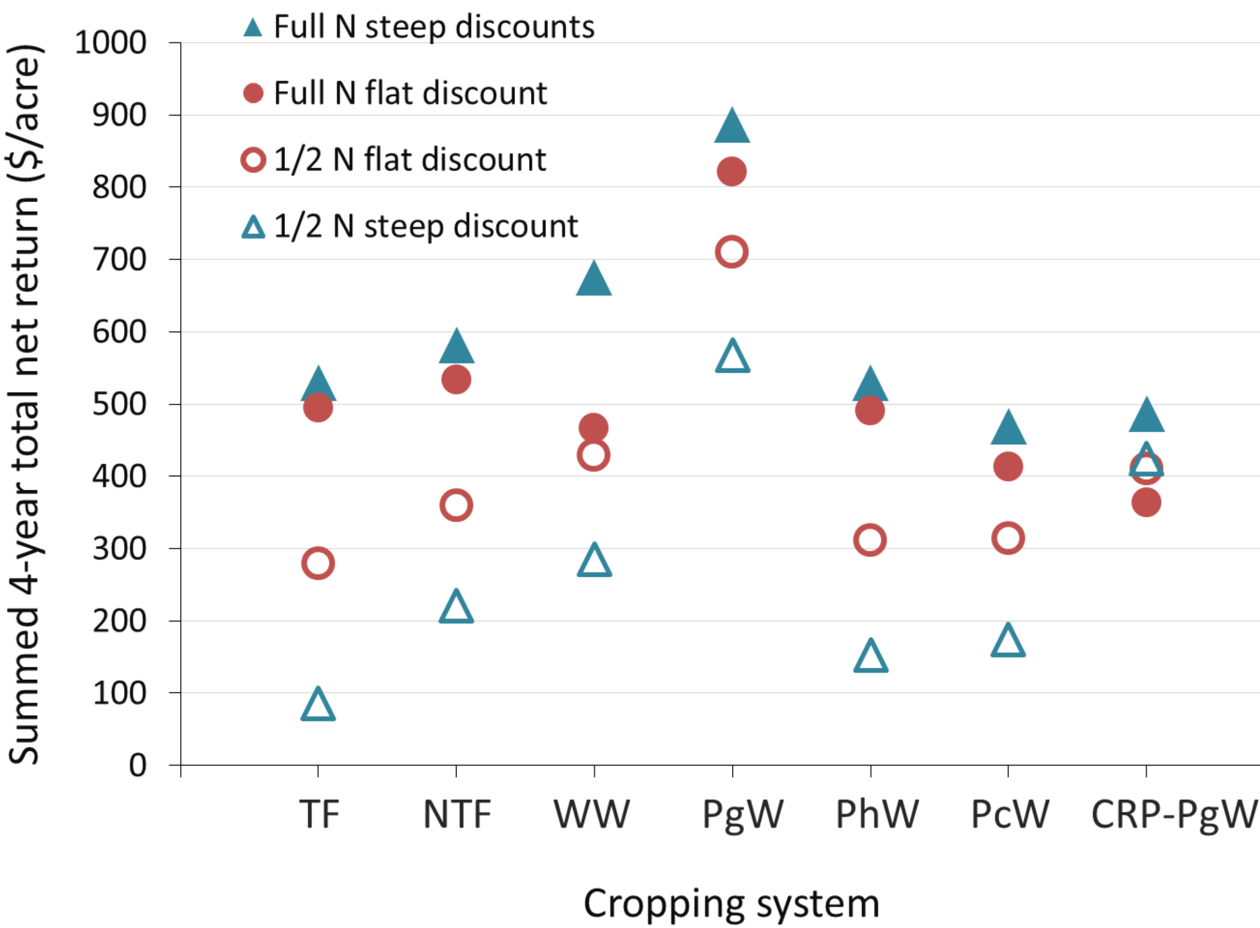
and SOM



P. Miller and R. Engel, unpub. data, Fife, MT



Cropping systems and economic resilience



Take home:

- Pea-grain big revenue winner
- Pea hay or cover crop similar revenue to fallow or continuous W
- Pea-grain at ½ N = revenue of fallow at full N.
- <u>Biggest economic winner also built SOM</u>

14-yr plot study, 2013-2016 = dry years
MSU Fertilizer Fact # 72 by Miller et al. (2017)

How do results compare to locations outside Gallatin Valley?

Summary on adapting to drought and increasing resiliency

Tools to cope with the challenges of drought & climate change:

Adaptations

- Develop and use tolerant varieties
- Use diverse cropping associations, rotations, and sequences
- Manage for efficient water capture, retention, use

Resiliency

- Build and maintain healthy soils now with adequate fertilization
- Enhance and capitalize on natural biological processes
- Reduce reliance on non-renewable external inputs if possible

QUESTIONS?

For more info and this presentation, go to:
http://landresources.montana.edu/soilfertility