Tonight's host and co-host

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Cover Crops

Winter Soil Fertility Series: Week 7

Feb 17, 2021

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Photo by K. Olson-Rutz

Today's goals

- Present cover crop management considerations
- Discuss cover crop effects on
  - Following crop yield, protein, and profit
  - Soil quality parameters, including SOM and N availability
- Answer the question: does cover crop diversity matter? (to soil quality, or cash crop yield and protein)

The Summerfallow Challenge


Photo: Susan Tallman

PROS:

Soil moisture recharge

N benefit

More consistent yields

CONS:

Loss of organic matter

Increased

- soil erosion
- saline seeps
- N leaching

Decreased

- soil structure
- water holding capacity
- soil biological activity


Photo: Susan Tallman

Alternatives?

- No-Till
- Cover crops

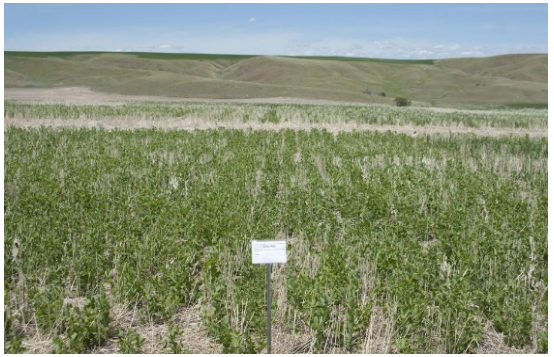


Photo: Steve Spence

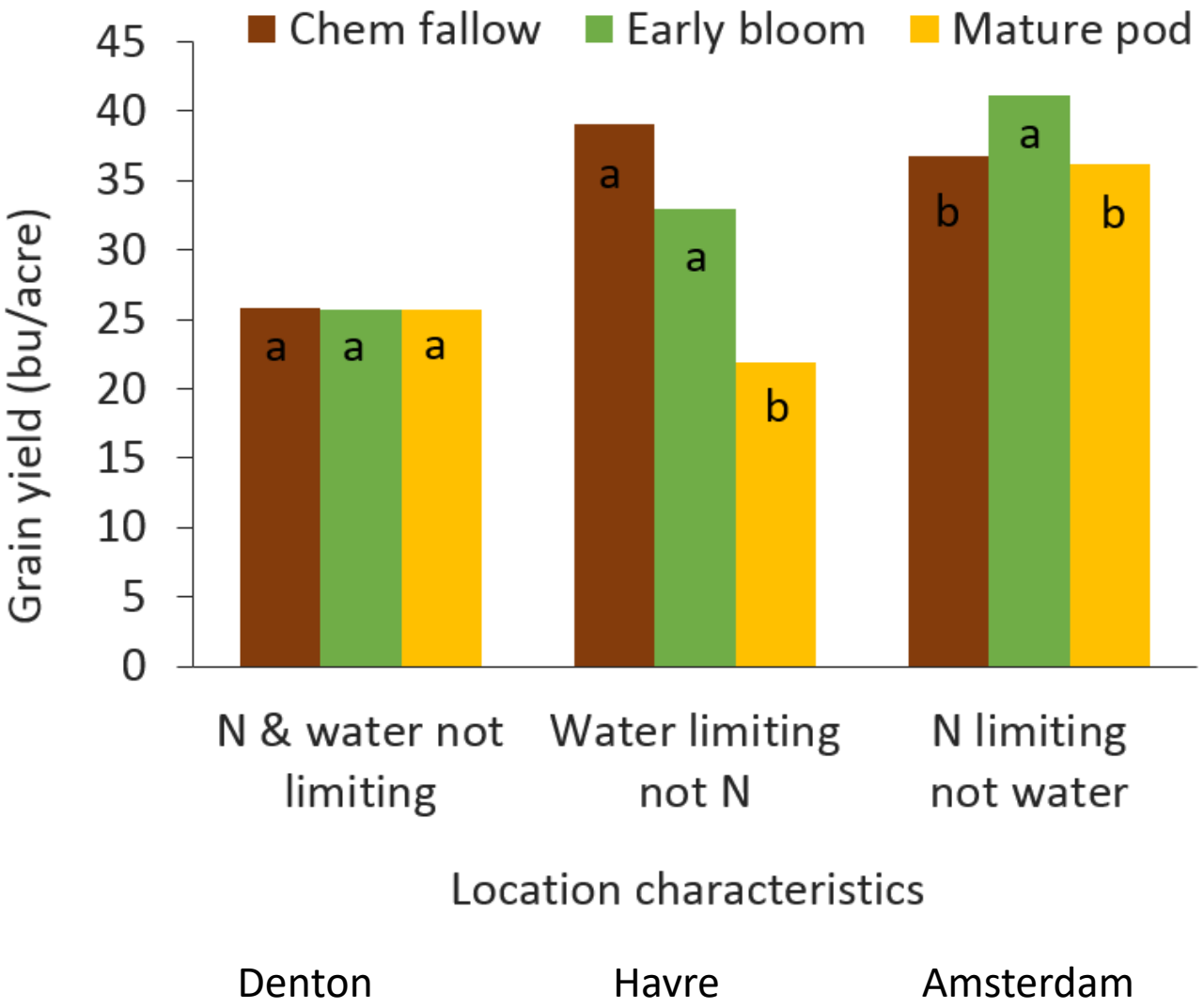
MSU single species cover crop research since 1999 has found higher grain yields and/or protein after cover crops when:

1. Seeding winter legumes (vs spring legumes)
2. Seeding spring covers early (vs late)
3. Terminating at first bloom (vs pod)
4. Tilling covers (vs spraying)

Why?

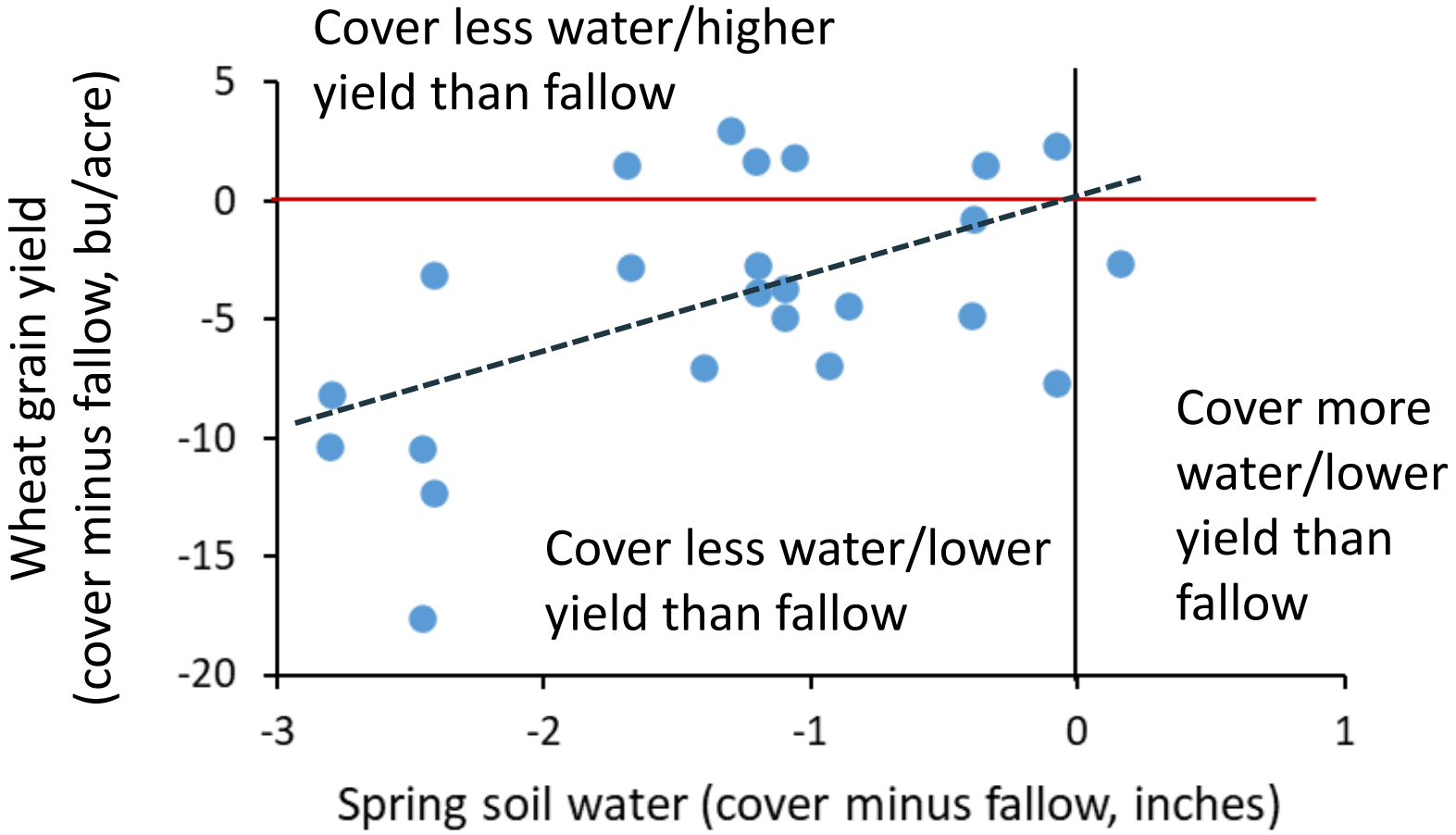
- More N fixed (1)
- More time for soil water to be recharged and N to become released from residue (1, 2, 3)
- Faster N release and fewer N losses (4)

Our MT studies confirmed early Saskatchewan studies that termination timing is key, when water is limiting



Haying covers at early bloom produced higher sp. wheat yields the following year than harvesting pea when water or N limiting (Miller et al 2006)

Generally spring soil water and wheat yields are lower following covers than fallow



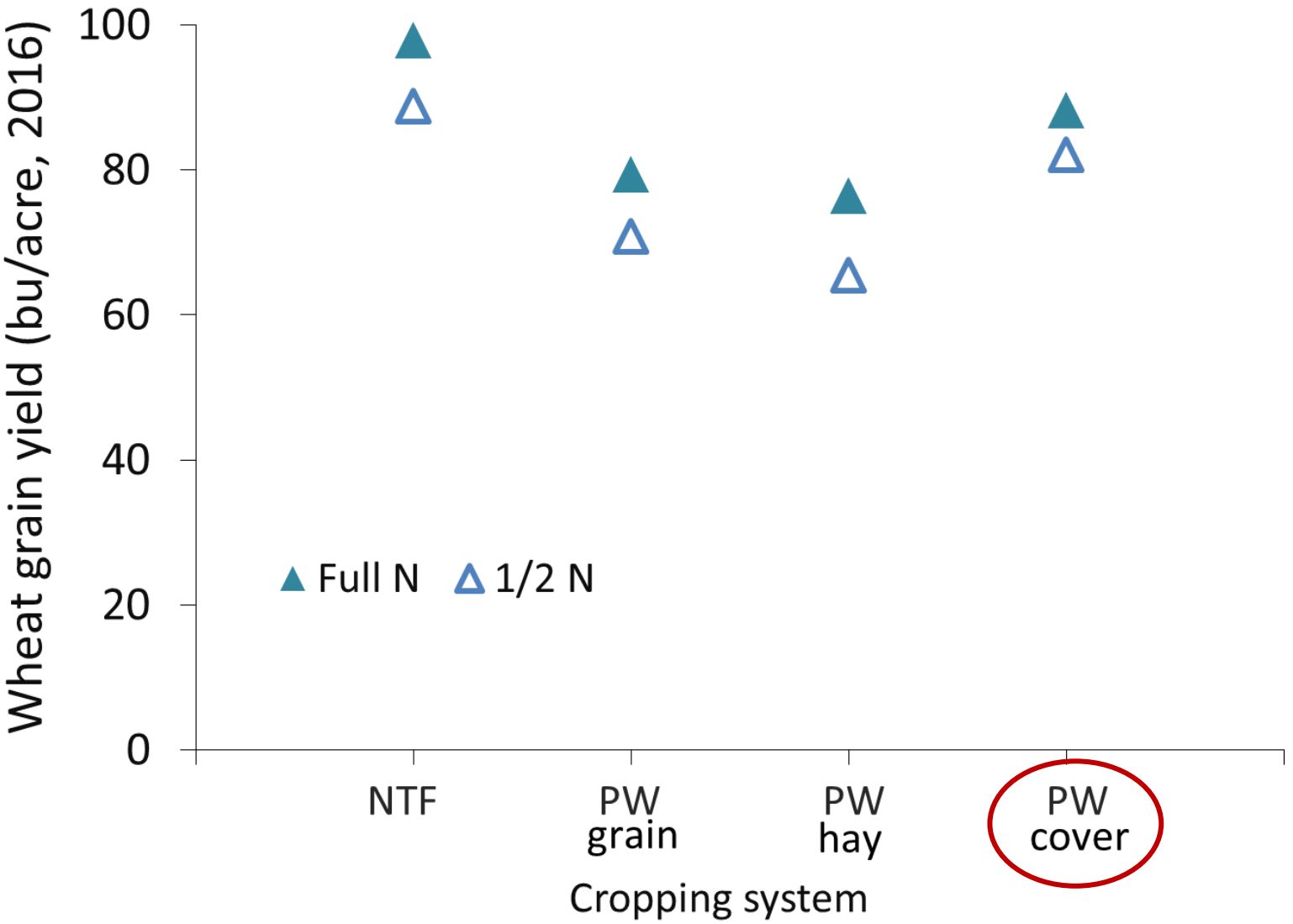
Soil water to 3' depth; covers terminated at first flower, full-bloom, or pod stage.

Burgess 2012, Burgess et al. 2014, Miller unpub data, O'Dea et al. 2013, all MT, Zentner et al. 2004, SK

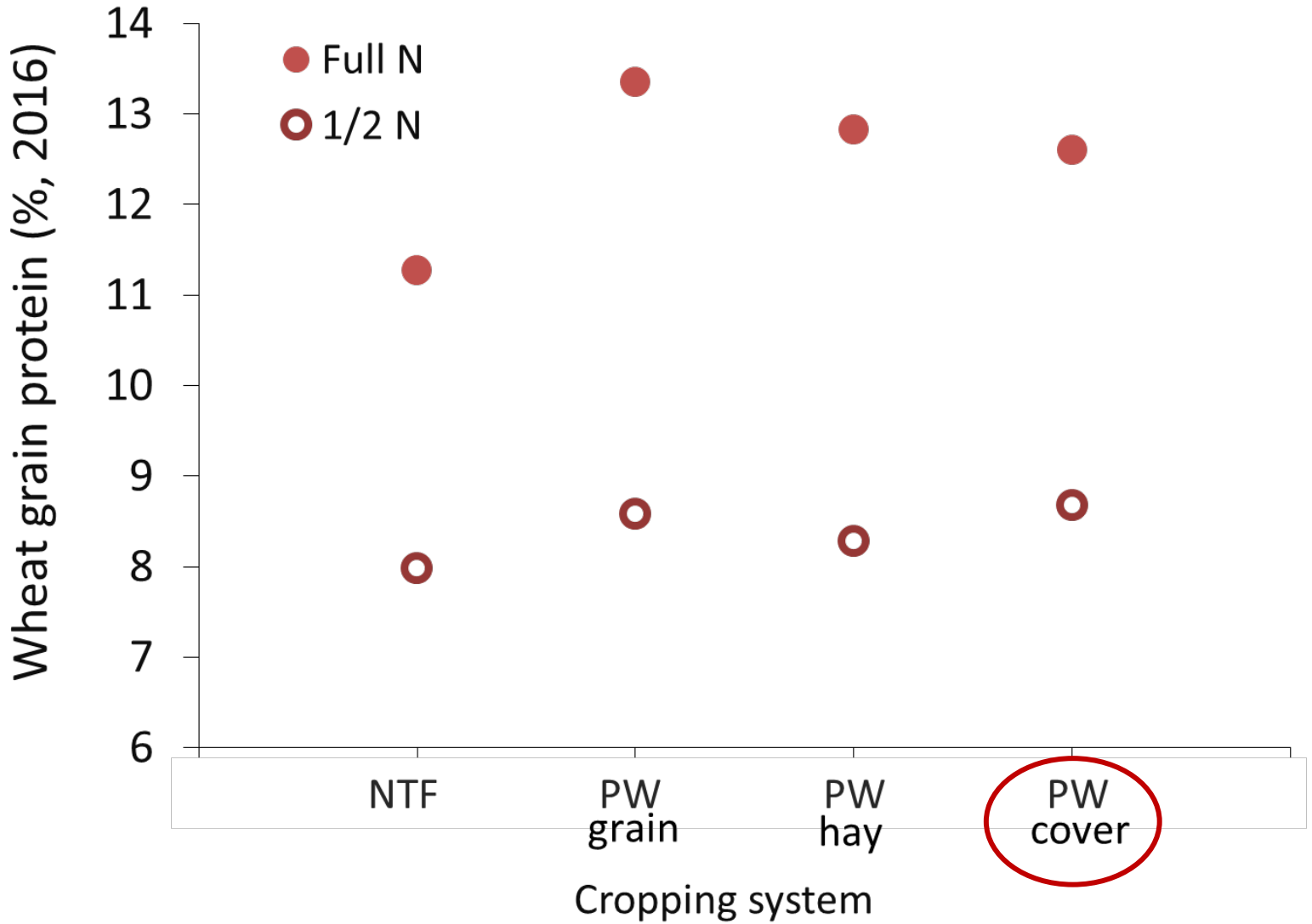
14-year Plot Study: east of Bozeman

- Long-term effects of no-till pea grain, forage, or cover crop-wheat vs. fallow-wheat
- ~16” annual precip on deep soils & ability to recharge soils
- Pea terminated at full pod
- 2 N rates: Full (3 lb available N/bu) and ½ N

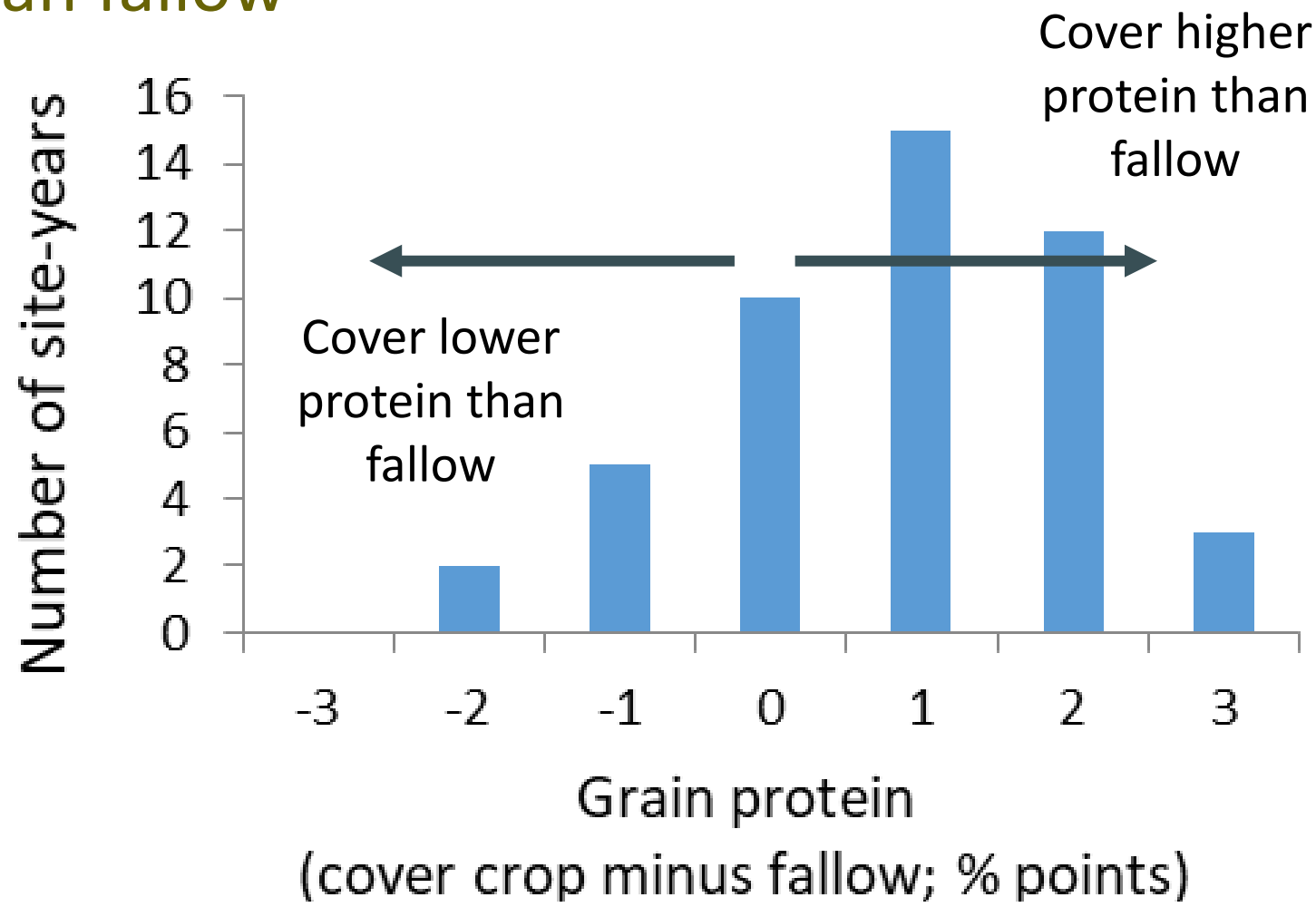
14-Year Plot Study:
Winter wheat grain yield in 14th year



14-Year Plot Study: Grain protein in 14th year (2016)



Wheat protein is generally higher after cover than fallow



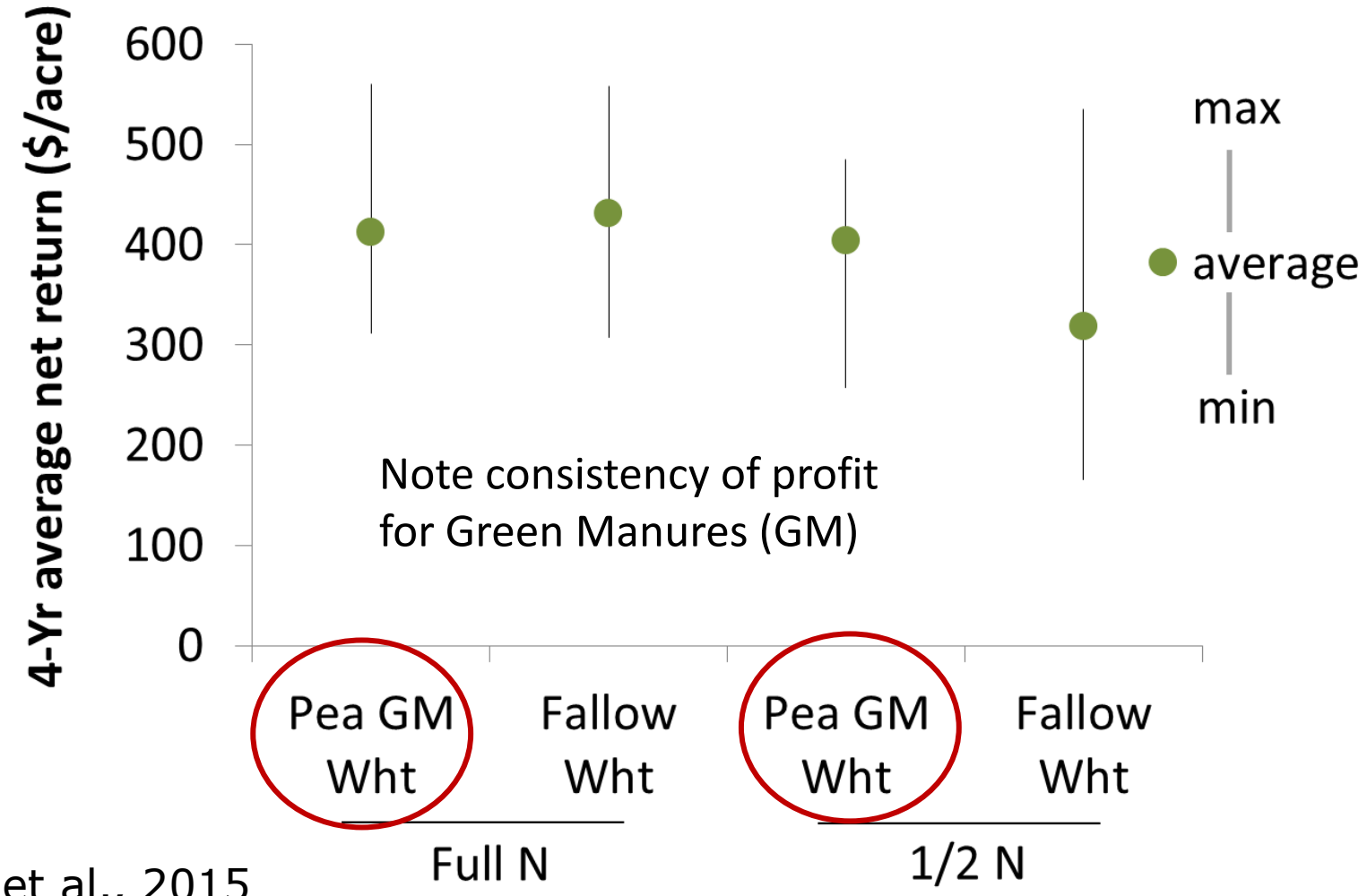
47 site-years. Positive protein means cover crop produced higher protein than fallow. Allen et al. 2011, Burgess 2012, Housman 2016, Miller et al. 2016, Miller unpub. data, O'Dea et al. 2013, Tallman 2014, all MT; Zentner et al. 2004, SK

Questions?

On to economics of single species covers

Economics: 14-year Plot Study (**2009-2012**)

2010 was a wheat year, and had very wet spring

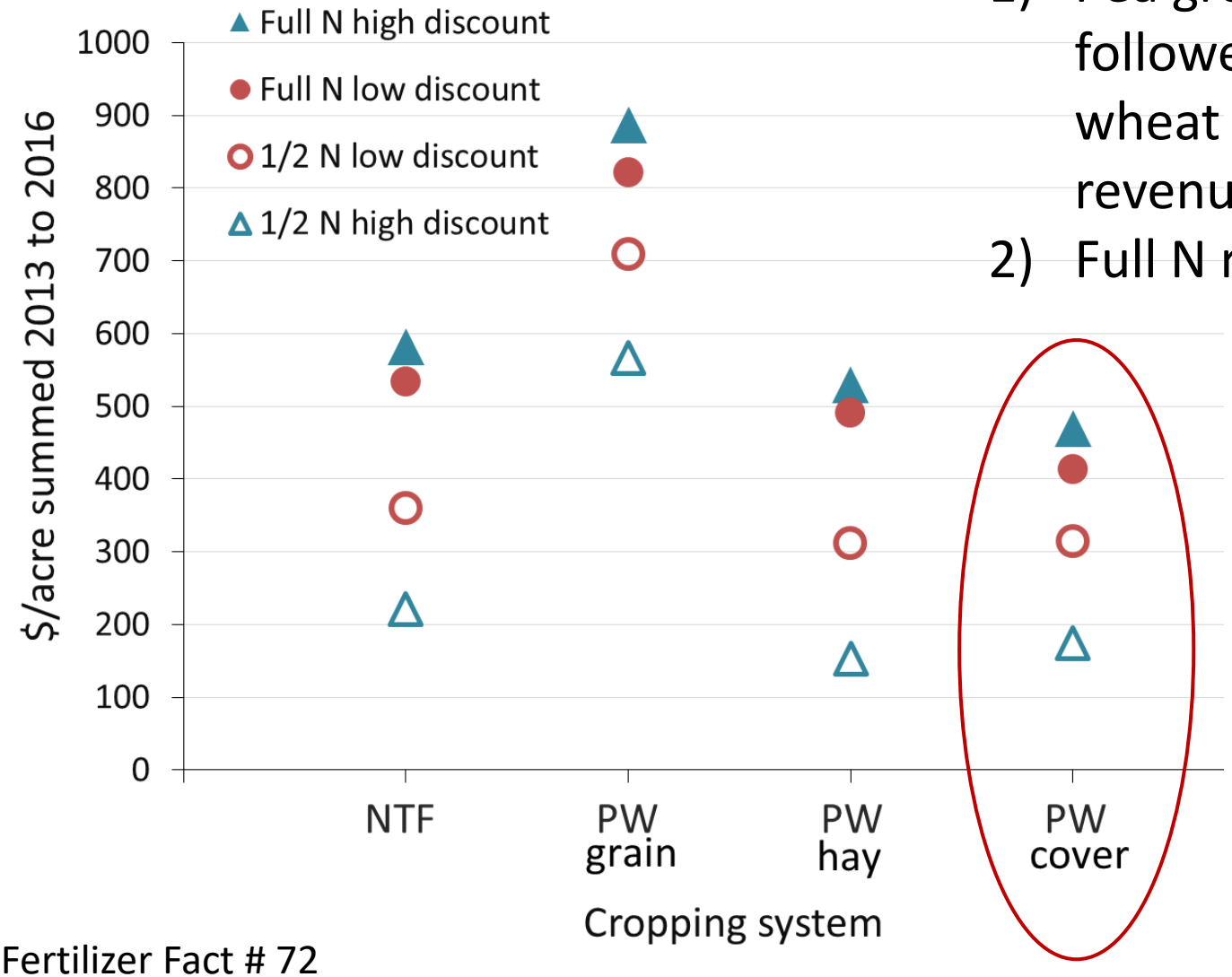


Miller et al., 2015

Economics: 14-year Plot Study (**2013-2016**) dry years

Take home:

1) Pea grown for grain followed by winter wheat was big net revenue winner.
2) Full N rate best choice

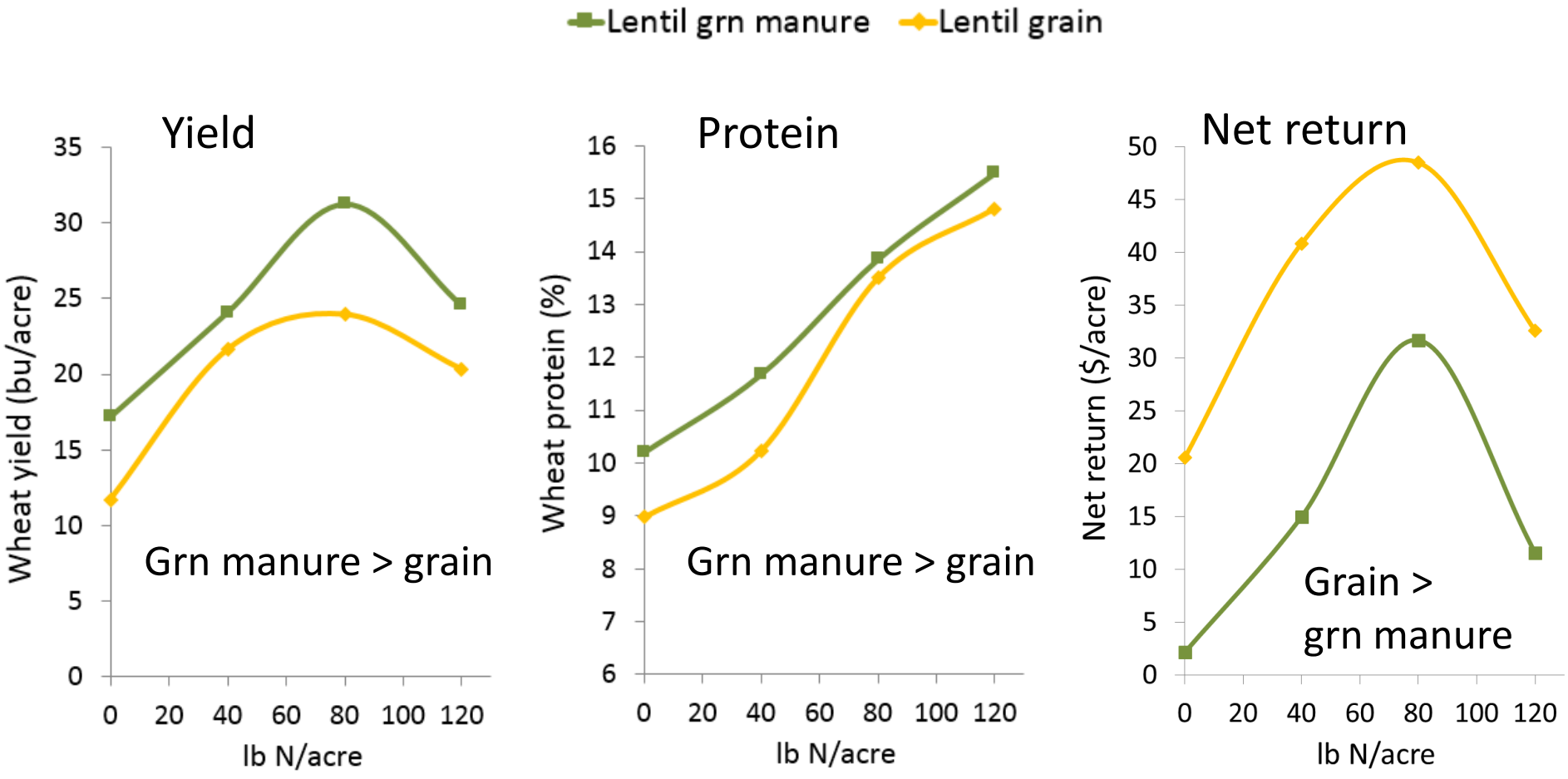


Fertilizer Fact # 72

14-year Plot Study: Take home messages

- Wheat grain yield and protein benefits take time
  - 3 - 4 CC cycles in high moisture years
  - 6 CC cycles with dry years
- Economic returns were more stable with cover crop (less dependent on N rate) and much higher with pea-grain than cover crop
- How do results compare in locations outside Gallatin Valley?

Average winter wheat yield, protein, annual net return after lentil green manure or grain (2005-2010)



Chen et al., 2012, Moccasin, MT, dryland, notill, shallow soil (18”), plot study

Take home: In short to long term studies, in different regions in Montana, pulse - wheat returns more profit than pulse cover crop - wheat, when cover crop sprayed out.

Questions?

On to covers

and soil health

Soil Quality vs Soil Health

Soil Quality = properties that change little, if at all, with land use management practices

- Texture
- pH
- Cation Exchange Capacity

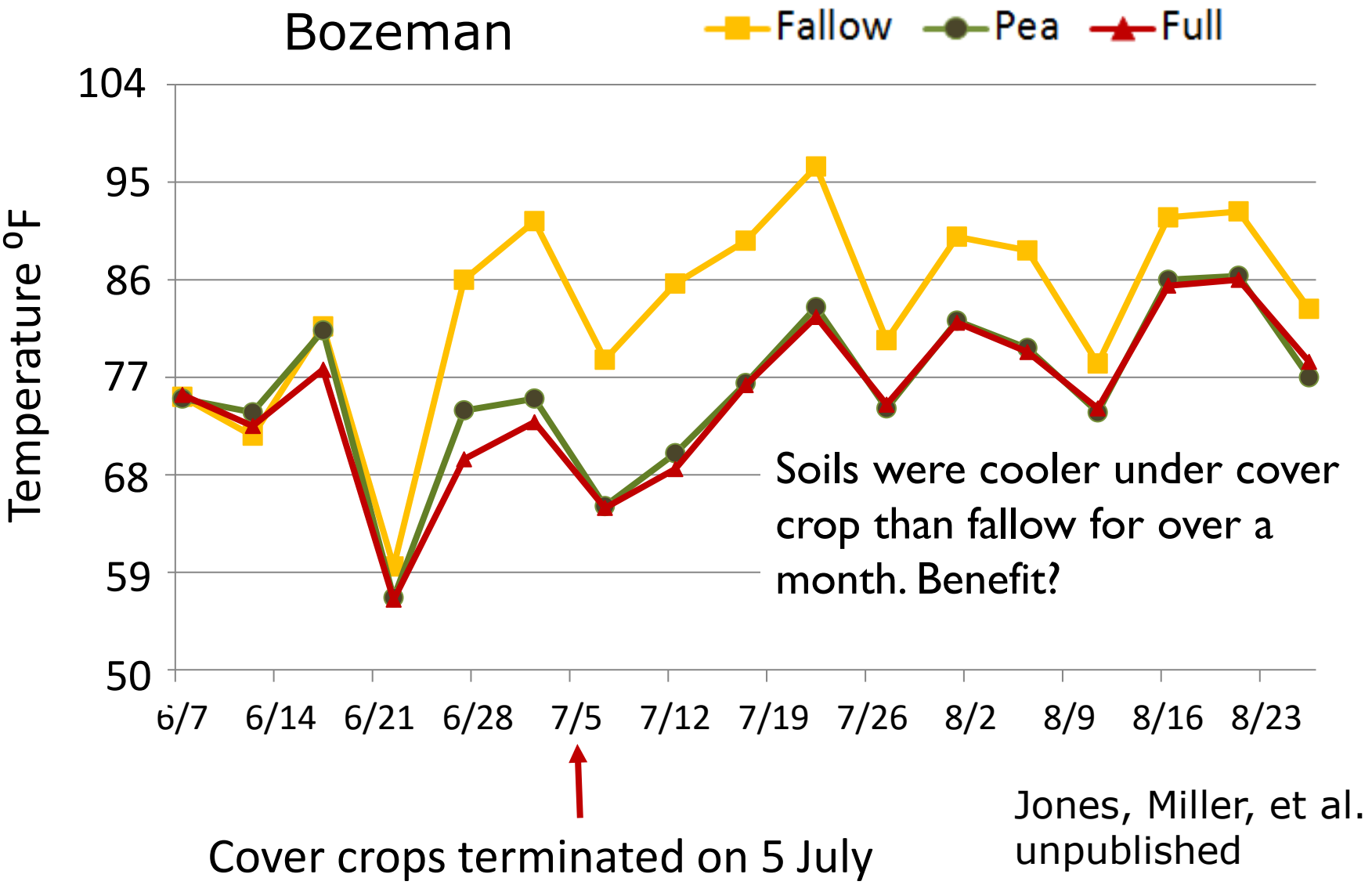
Which is more likely to be influenced by cover crops?

Soil Health = dynamic properties which may be subjective to measure

- Aggregation
- Microbial activity
- Tilth
- Nutrient availability
- Water holding capacity
- Compaction

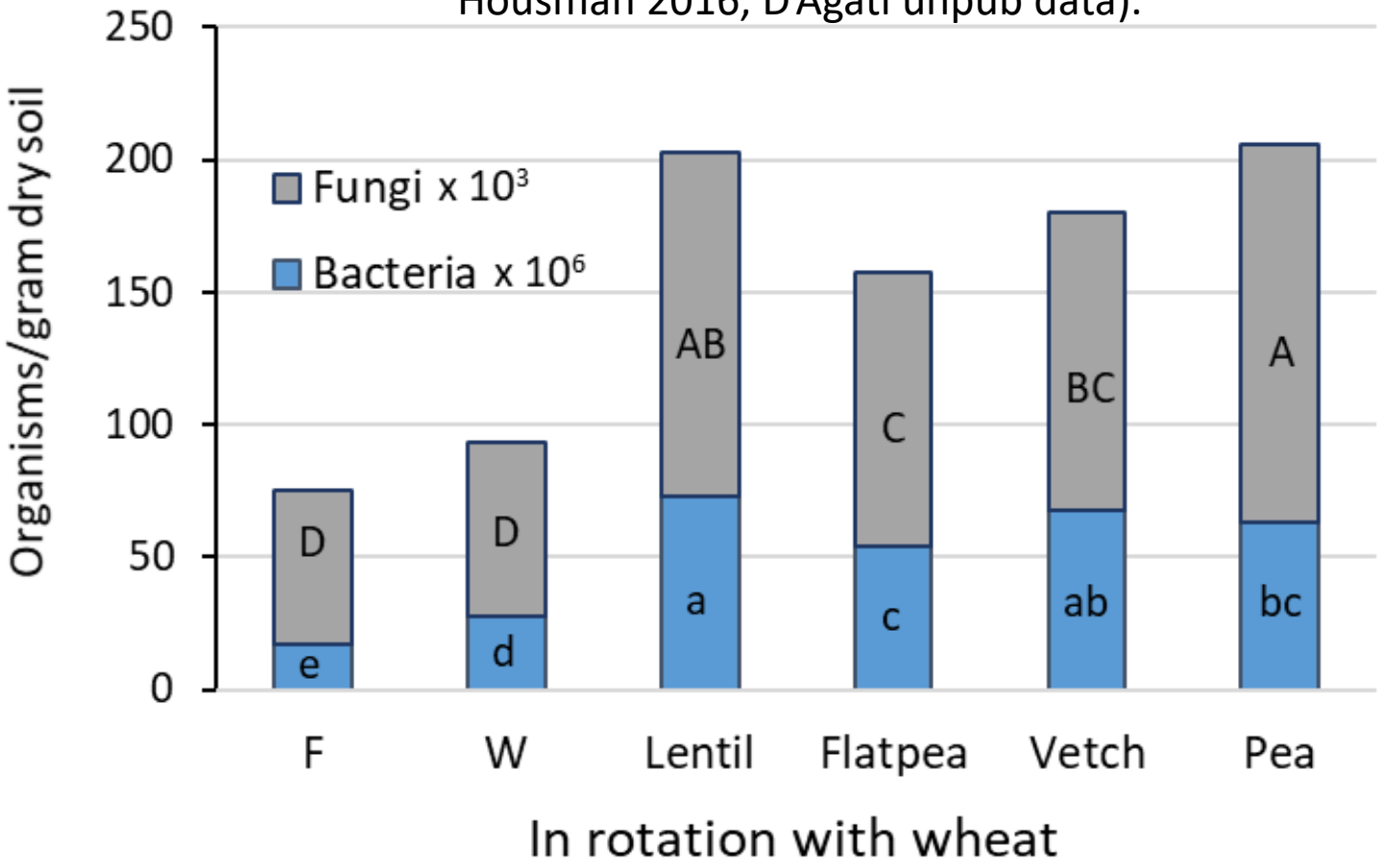
SON and SOM often included in both lists

Covers lower daily soil temperature (4 pm at 2” deep), which should benefit microbes (and more)



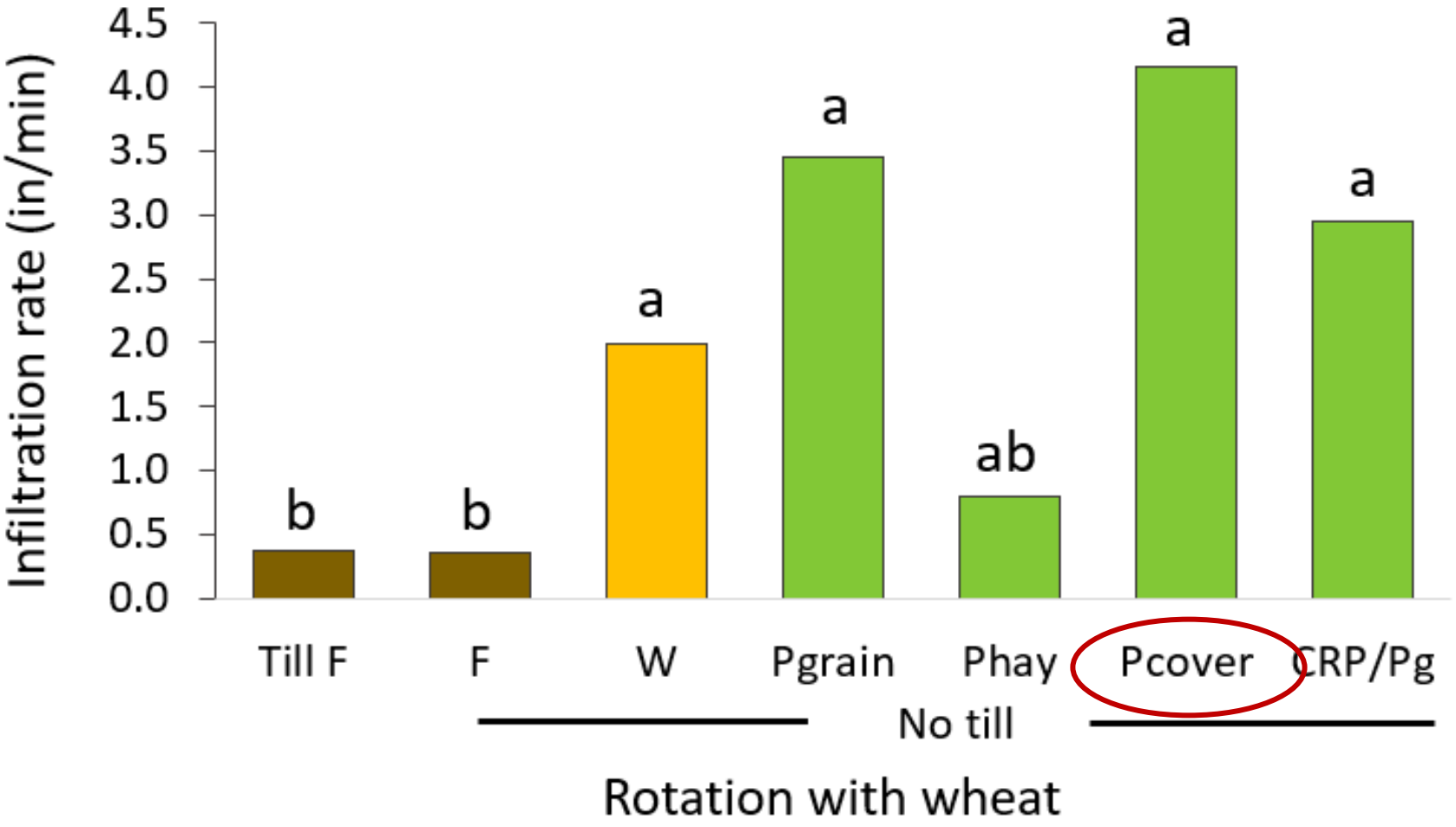
Legume covers increase microbial populations

Agrees with MT study: pea or mixed cover generally greater microbial biomass than fallow (Tallman 2014, Housman 2016, D'Agati unpub data).



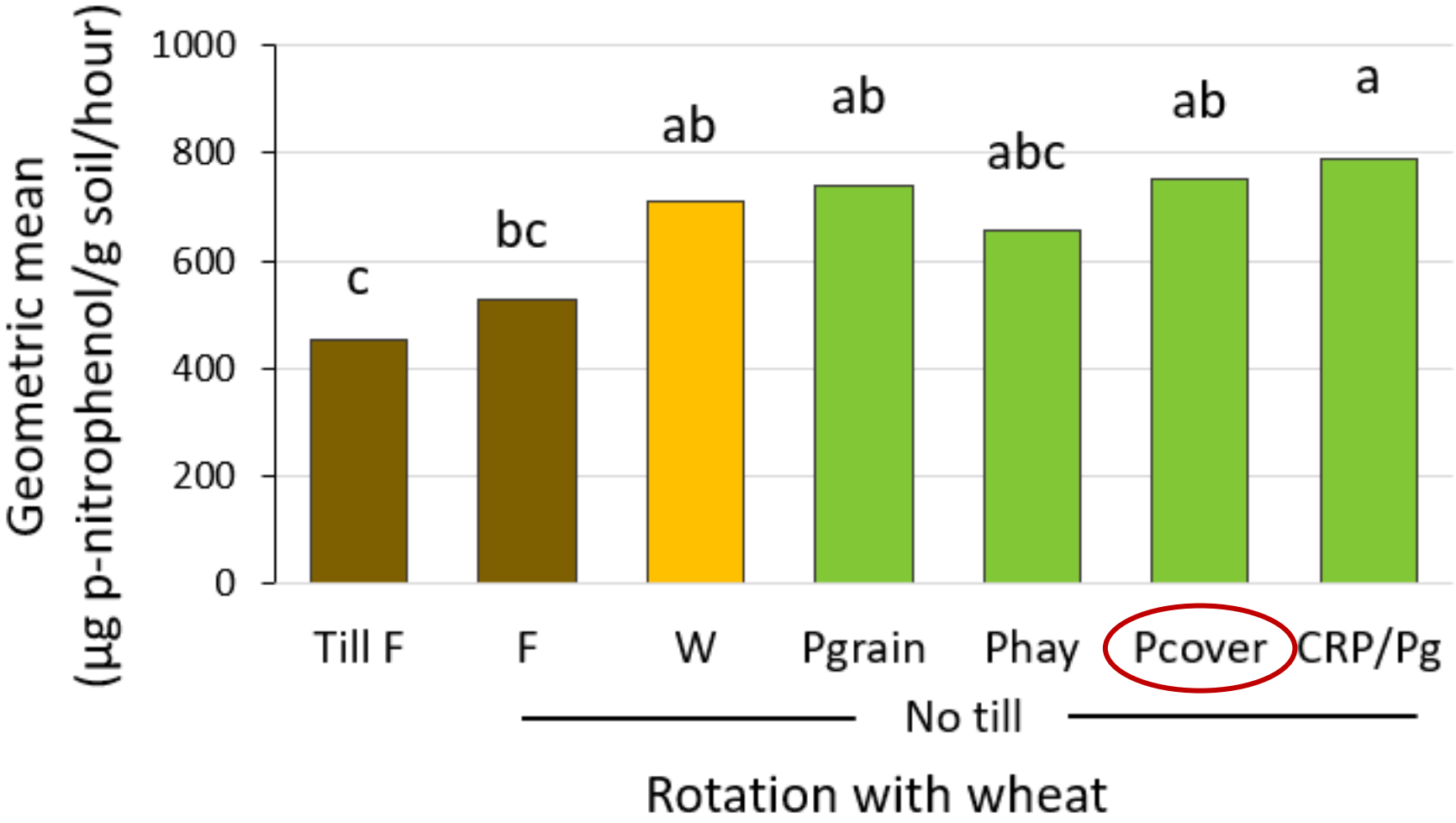
Biederbeck et al. 2005, 6 yrs of rotations, SK. Organisms in top 4", sampled after wheat phase in Oct, 15 months after cover crop termination.

Infiltration rates were 7-FOLD higher after 18 years of recrop than after fallow at Bozeman (2020)



Fouts and Jones unpub data

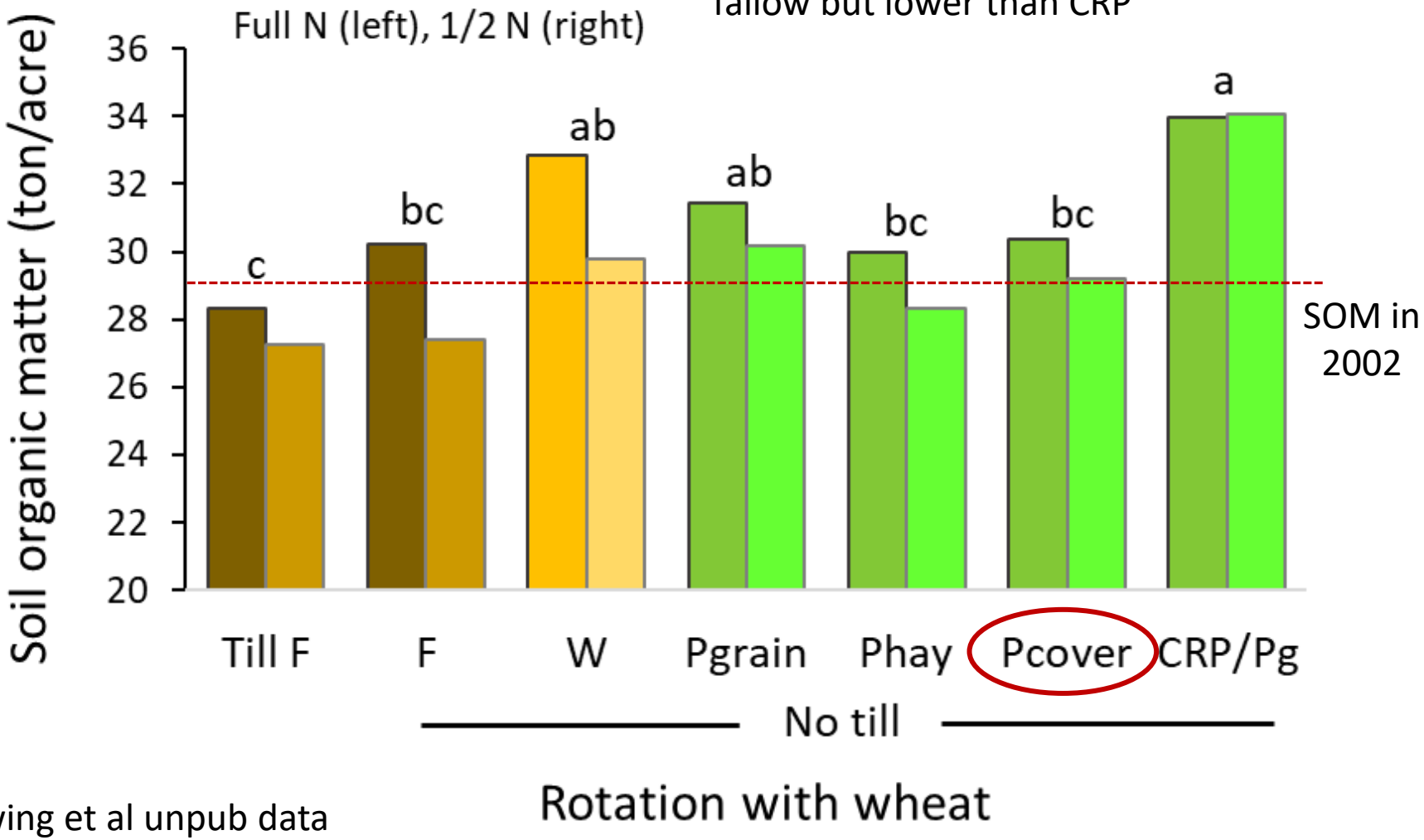
Soil enzyme activity greater after 18 years of recrop than after fallow at Bozeman (2020)



Fouts and Zabinski, unpub data

SOM in top foot after 14 years of cropping systems at 2 N rates near Bozeman, MT (2016)

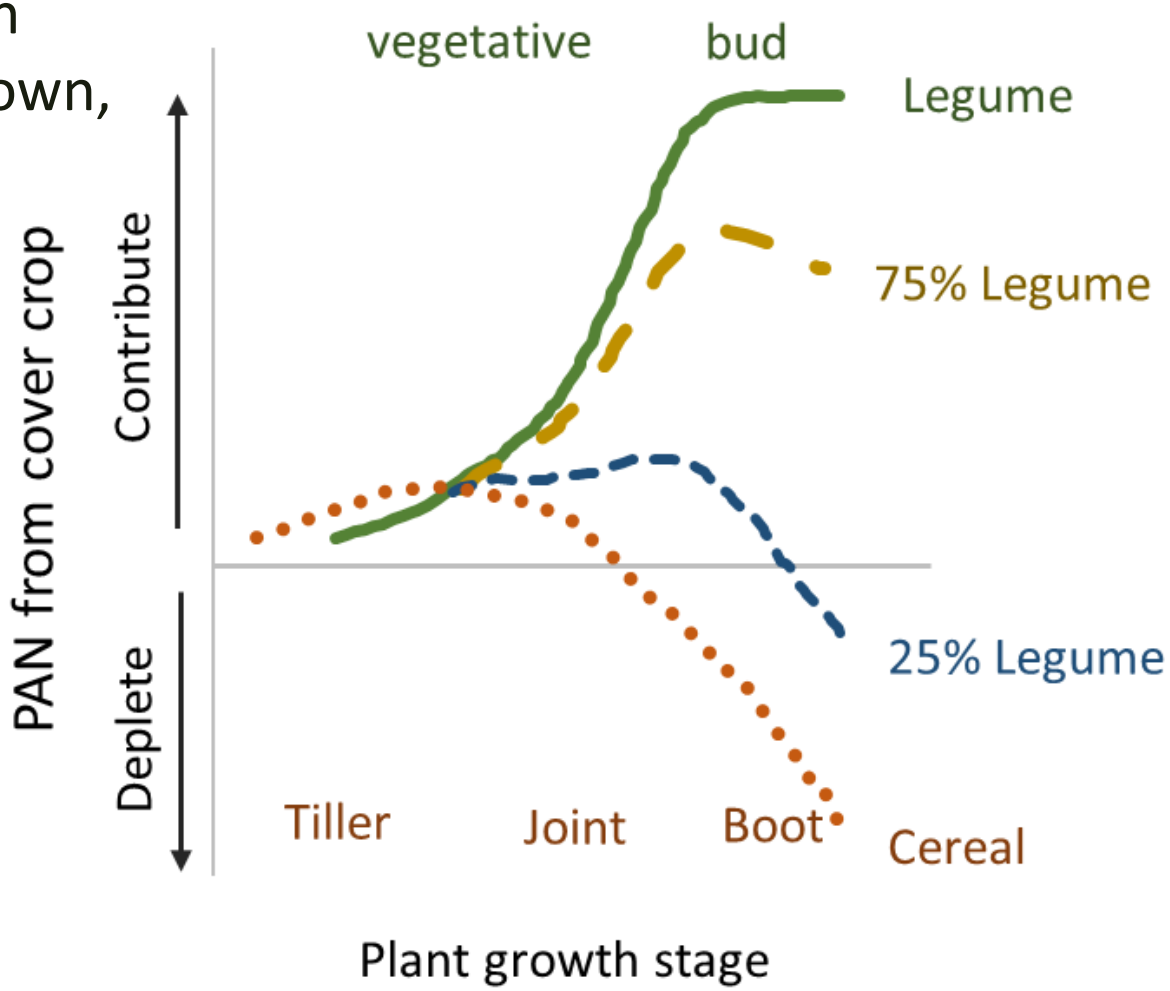
Pea cover produced higher SOM than tilled fallow but lower than CRP



Ewing et al unpub data

N from legumes

- Legume covers release more N more quickly than legume grain (pulse)
- N benefit depends on species, how long grown, how often grown, growing and decomposing conditions
- Legumes should be >40% of cover to provide plant available N (PAN), especially if terminated late

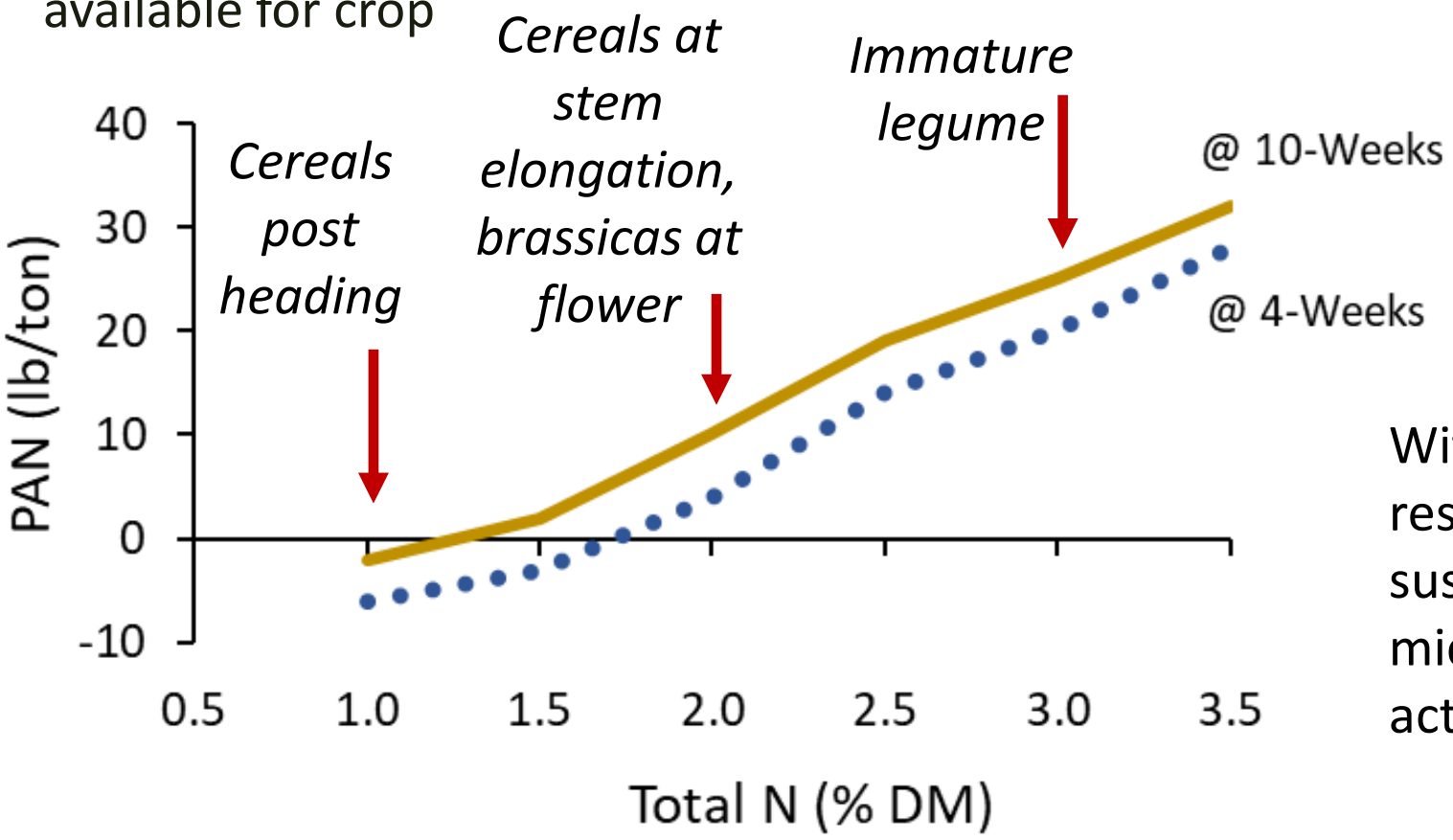


Sullivan and Andrews 2016, OR

Plant available N **AMOUNT** from plant residue

Depends on residue N concentration

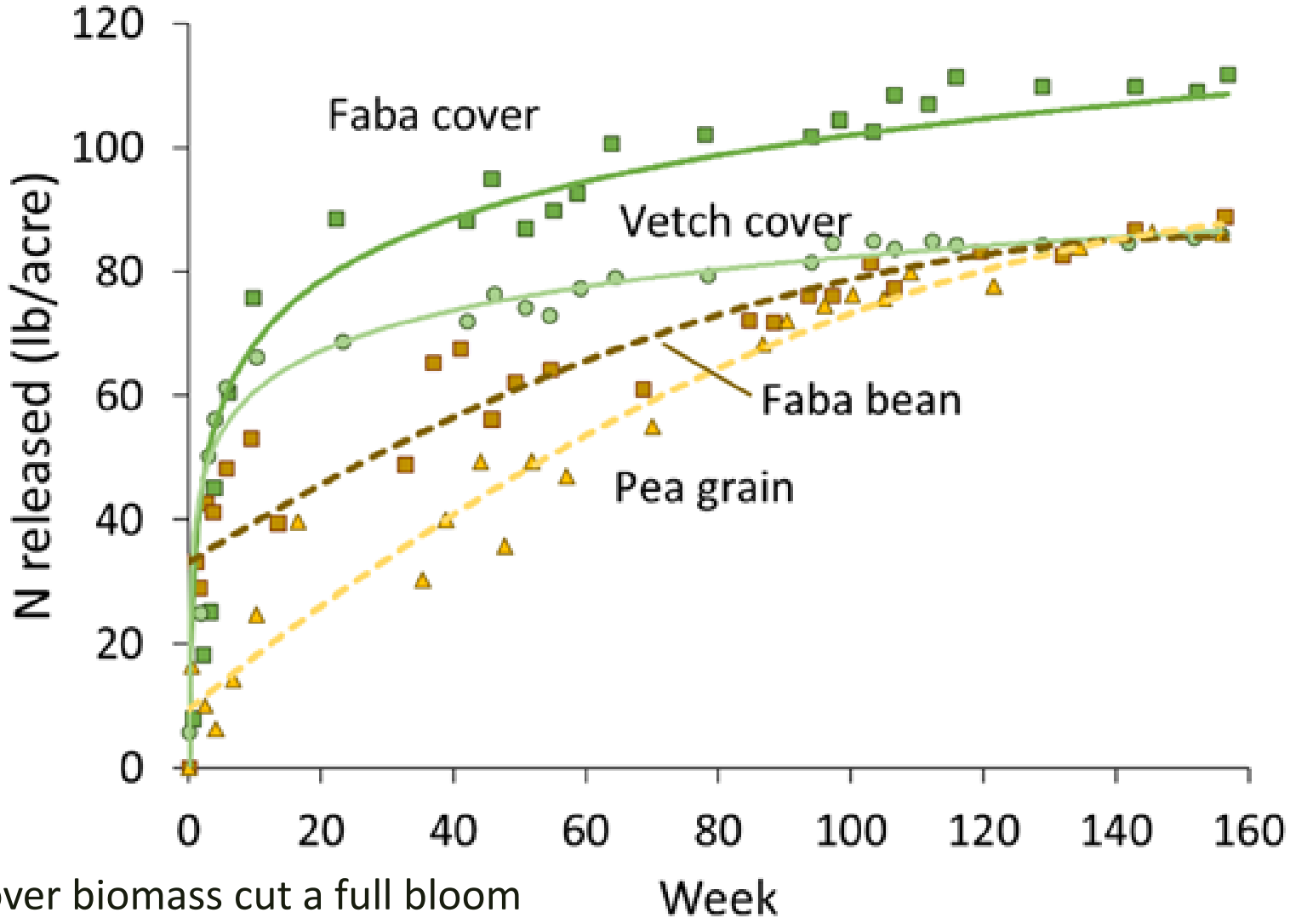
- Leafy green: high N concentration = more PAN
- Mature plant: lower N concentration, N used by microbes and not available for crop



With tilled residue and sustained microbial activity

Oregon State University Extension Predicting Plant Available N EM9235
Estimating Plant-available Nitrogen Release from Cover Crops PNW636

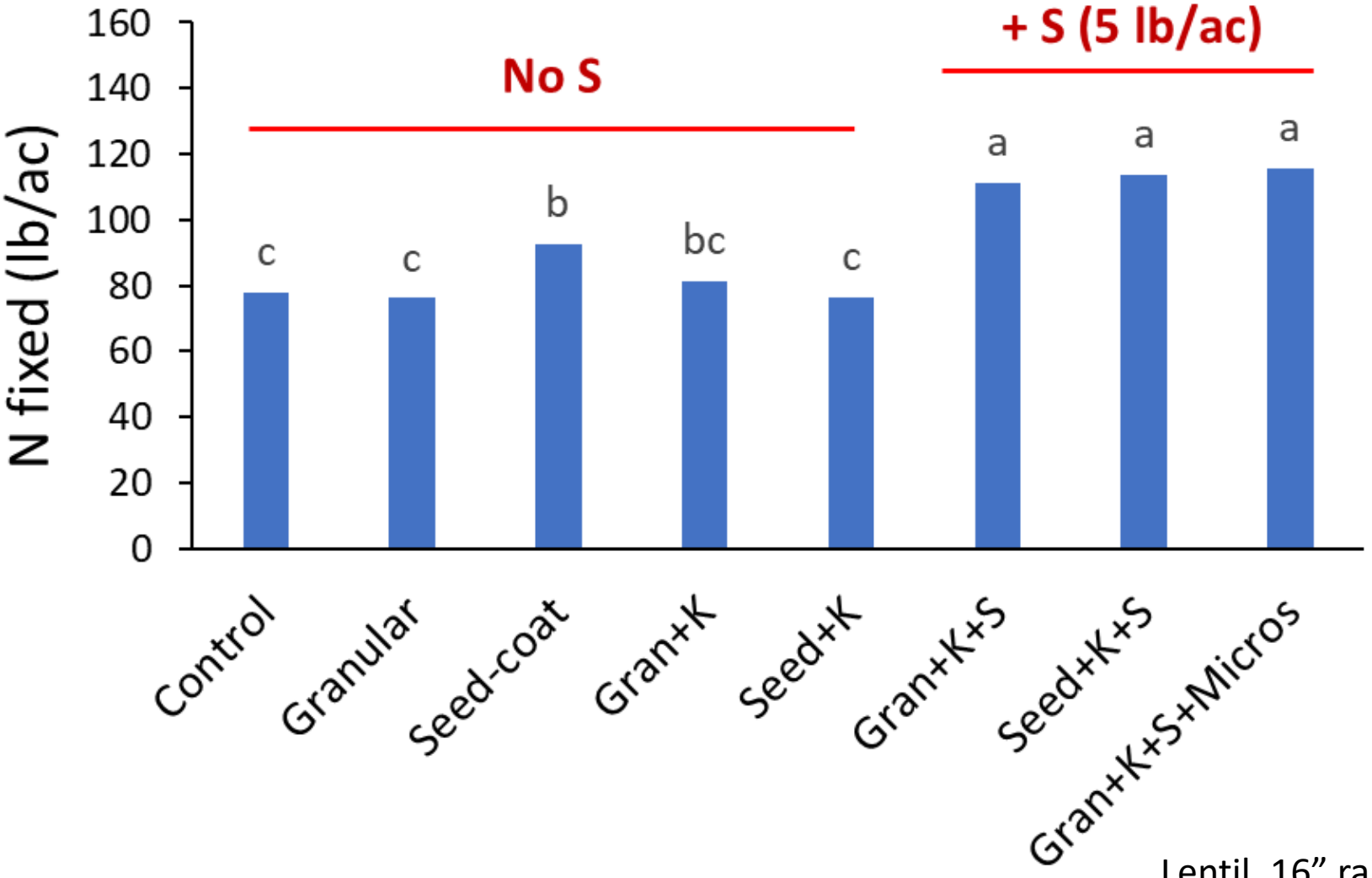
N release from above ground plant material for many years



Cover biomass cut a full bloom

Lupwayi and Soon 2016, AB

If want to maximize N fixation in pulse cover crops, need adequate S (and P and K)



Higher N fix = less N fertilizer = reduced risk of soil acidification. See Feb 10 session

Lentil, 16" rainfall zone
N budget method
Jones unpub data 2020

Questions?

On to mixed species cover crops

Cover Crop Cocktails Study

1. Does increased crop diversity improve soil health?
   - Microbial biomass
   - **Soil enzyme activity**
   - Soil temperature
   - Aggregate stability
   - Compaction
   - Soil water, nitrate, and Olsen P
   - Mycorrhizal colonization
   - **Potentially mineralizable nitrogen**
   - **Soil organic matter**
2. Does increased diversity increase subsequent grain yield?

Plant functional groups – planted individually and in groups

Nitrogen fixers

Spring Pea

Lentil

- *Increase N*

Fibrous Root

Oats

Proso millet

- *Add soil carbon*

Tap Root

Purple top turnip

Safflower

- *Reduce compaction, move nutrients upward*

Brassicas

Daikon radish

Winter canola

- *Rapid ground cover, high biomass, potential disease control*

Study design: 2 sites, 12 and 14” rainfall zones

11 treatments

The big three

- Summer Fallow (SF)
- Pea-only Legume Green Manure (PEA)
- Cover Crop Mixture -8-spp/4-functional group (CCM)

Single functional group treatments (2-species)

- Nitrogen Fixers (NF)
- Fibrous Roots (FR)
- Taproots (TR)
- Brassicas (BC)

Three functional group treatments (6-species)

- FR, TR, BC (Minus NF)
- NF, TR, BC (Minus FR)
- NF, FR, BC (Minus TR)
- NF, FR, TR (Minus BR)

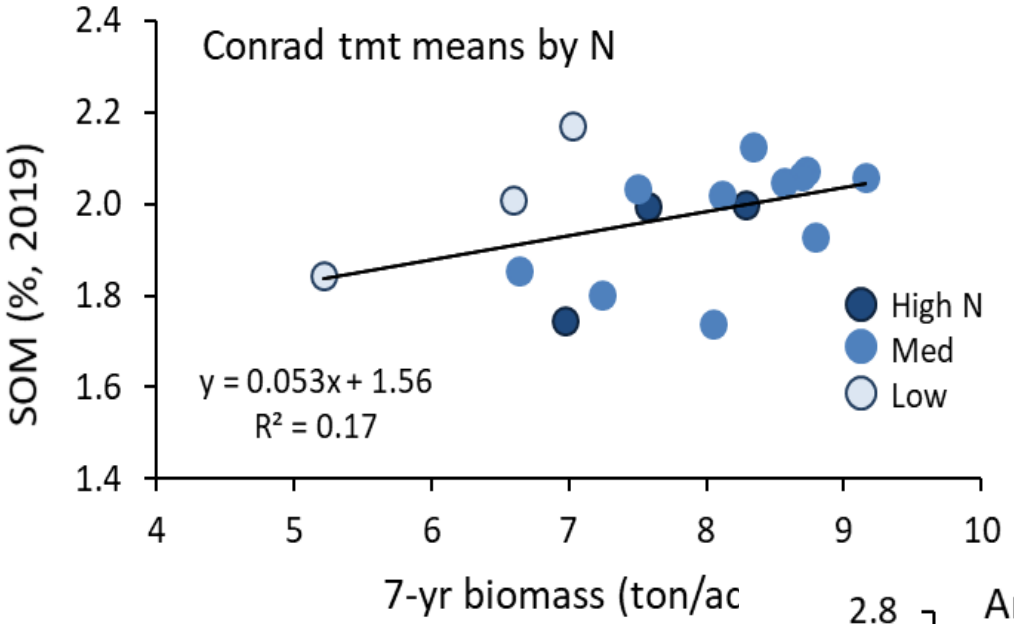
Cover Crop Biomass – depends on moisture

Photo: Steve Spence

Biomass was not strongly related to # of species

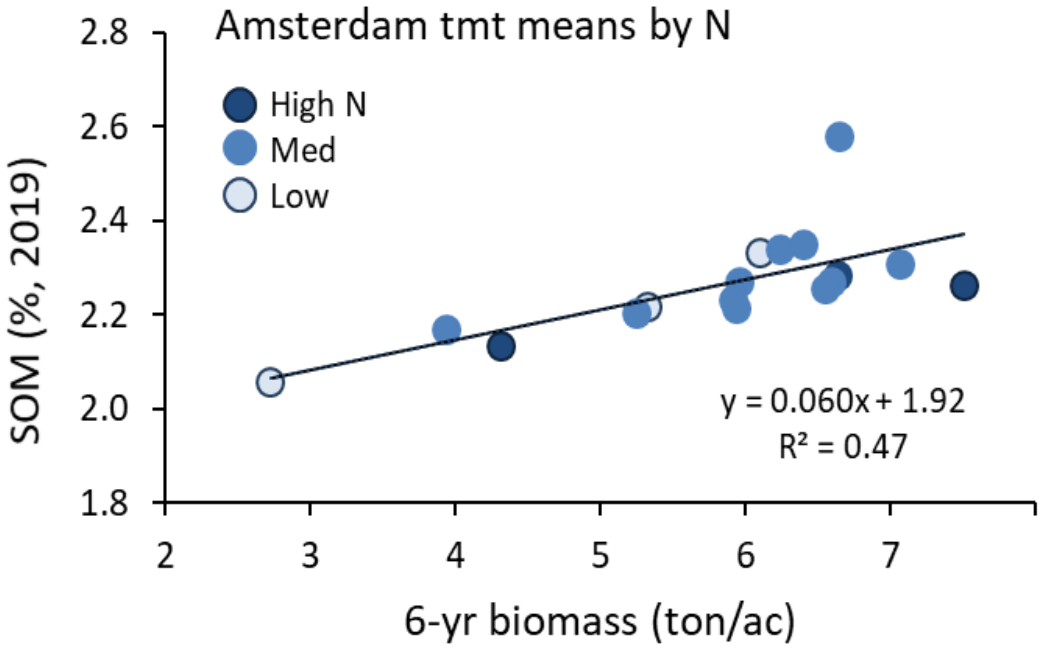
Photo: Meg Housman

Soil organic matter vs biomass

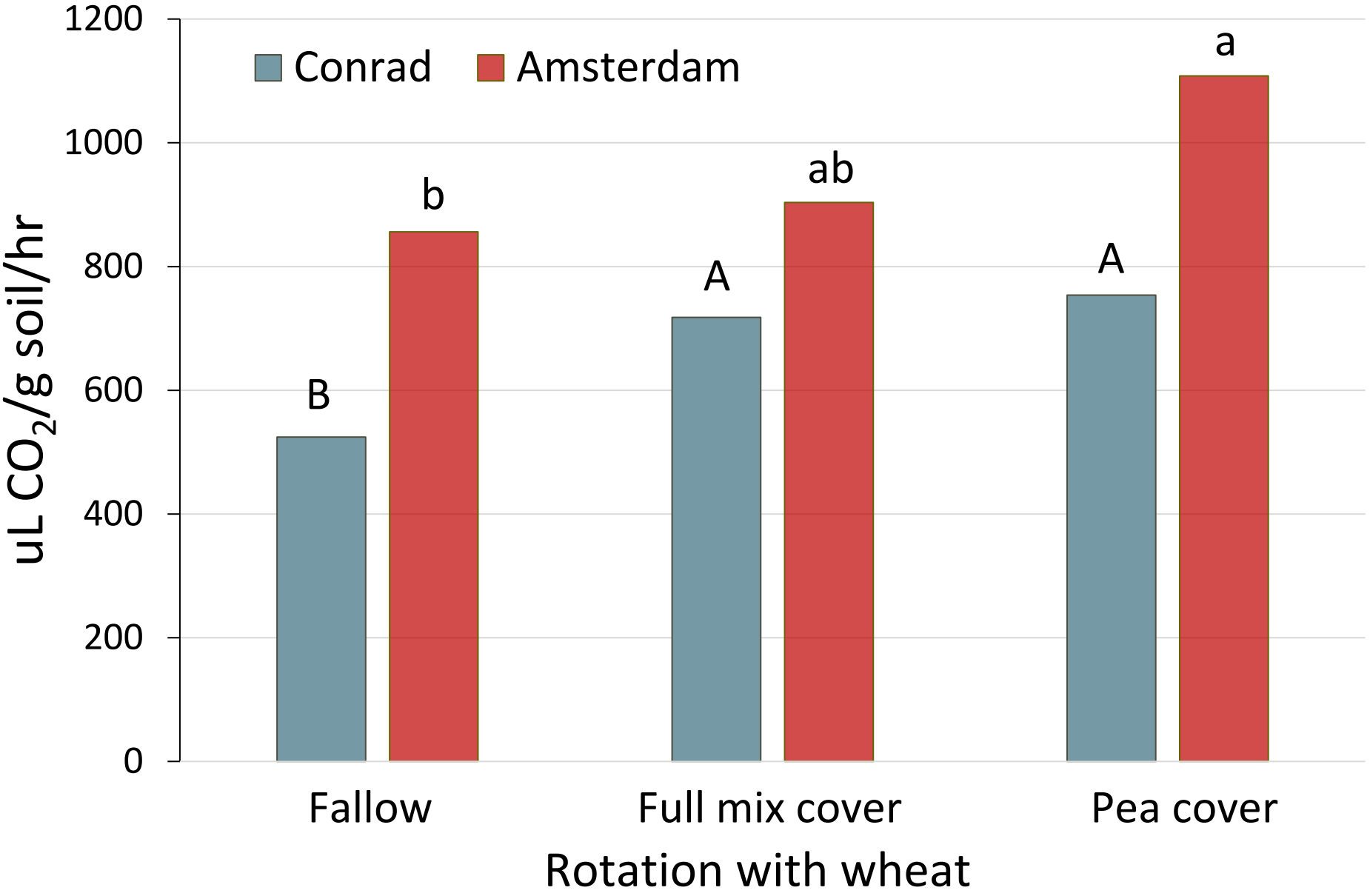


N rate did not affect SOM in top 4" at either site

Take home: Select covers that produce high biomass OVER THE ROTATION if want to build SOM.



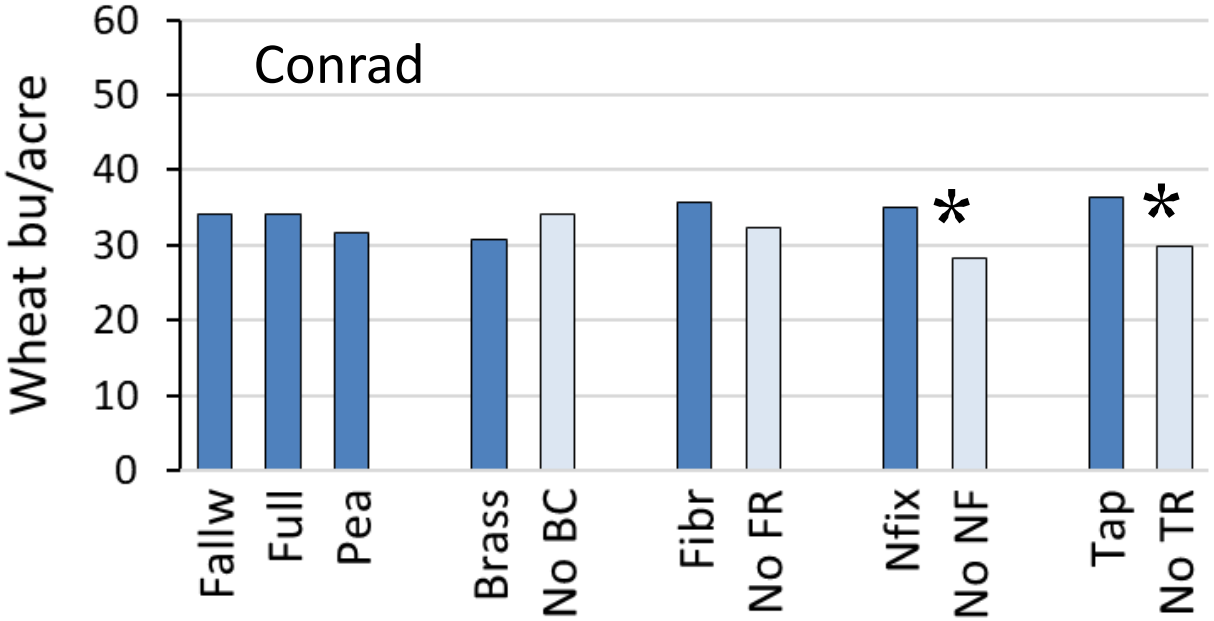
Microbial biomass (SIR):

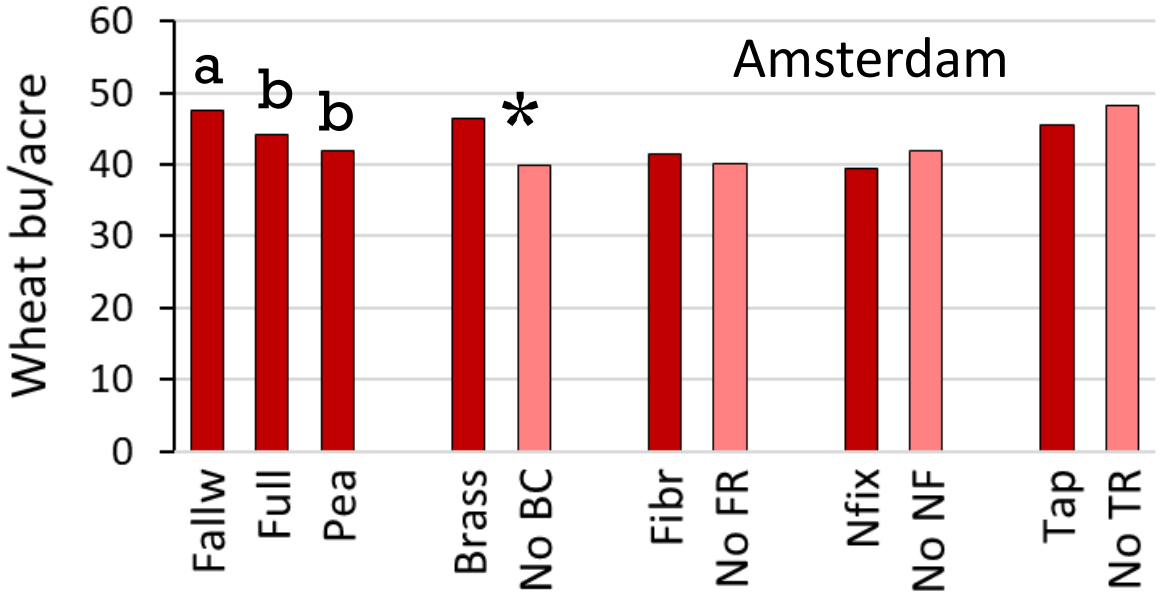


Questions?

On to wheat yield and protein after mixed species cover crops

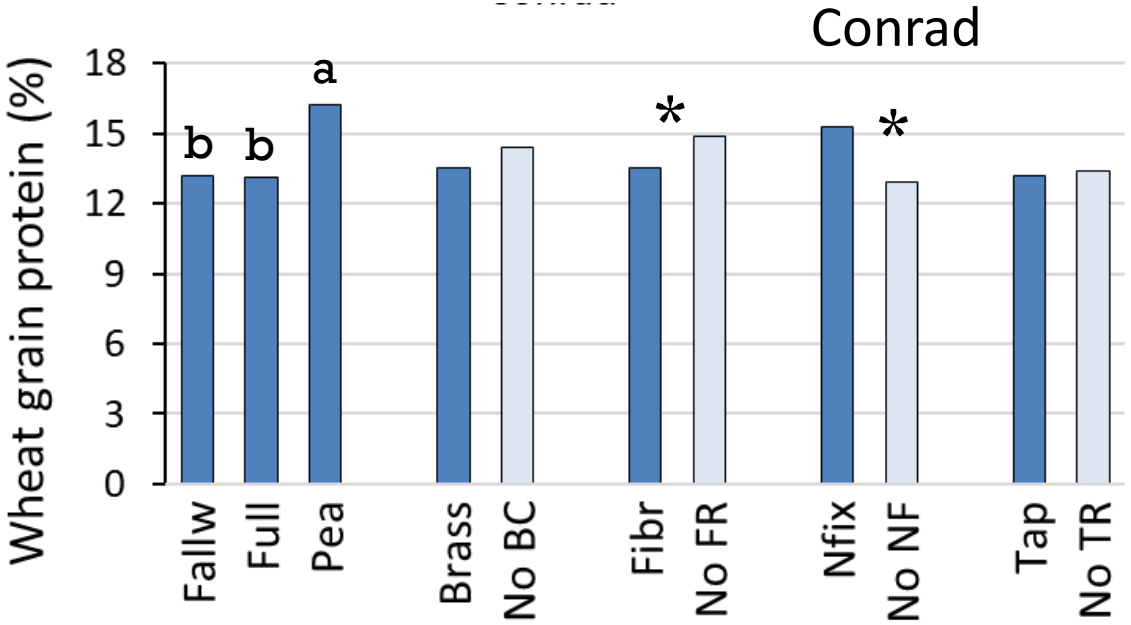
Spring wheat yield after 4 rotations (2019)

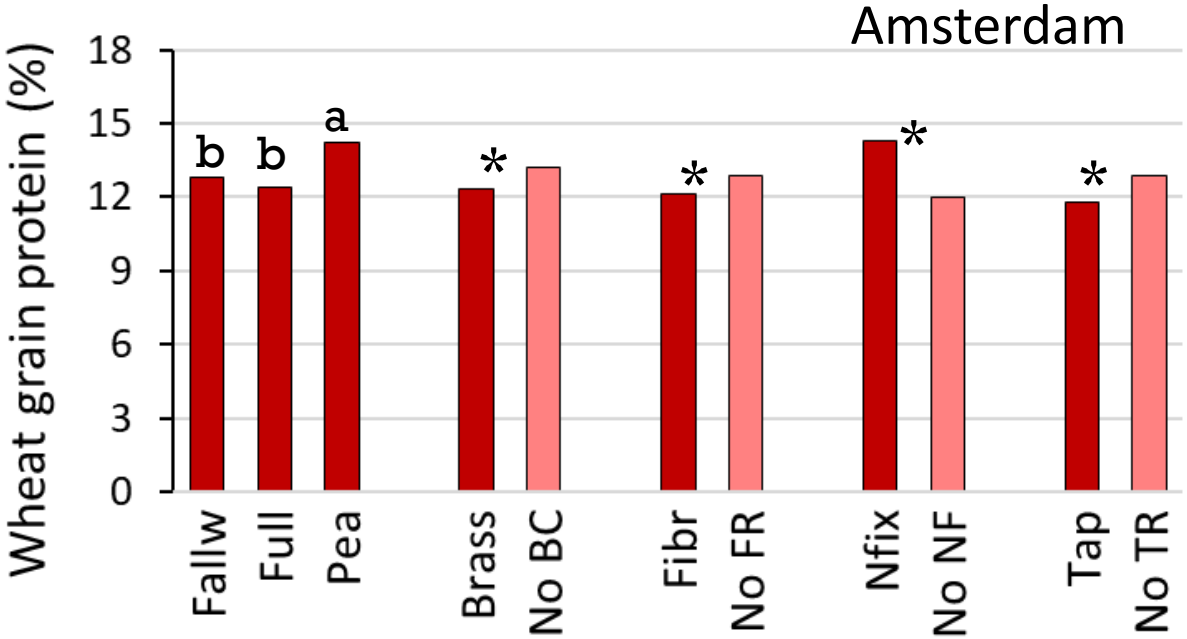




D'Agati et al. 2019

Spring wheat protein after 4 rotations (2019)





D'Agati et al. 2020

Summary

- Cover crops can't compete economically with pea grain-wheat (unless perhaps covers are grazed)
- It takes time to change soil quality
- Higher number of species in mix doesn't consistently improve yield, protein, or soil quality. Good result – allows flexibility. Base selection on seed cost, biomass produced, specific soil health goals, etc.
- To maximize N and water availability following covers:
  - Early termination (by first pea bloom)
  - >50% legume in seed mix

Photo by Ann Ronning

Thank you!
Questions?

Please take a few minutes to evaluate this seminar series by completing the short survey; link provided in chat box soon.

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