Cover Crop Research Results

CPMS Bozeman

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MONTANA STATE UNIVERSITY EXTENSION

Today's objectives

- Summarize past cover crop research findings of the MSU Cropping Systems group
- Present results from recent and ongoing MSU cover crop studies

The Summerfallow Challenge

Photo: Susan Tallman

PROS:
Soil moisture recharge
N benefit

CONS:
Loss of organic matter
Increased soil erosion
Decreased soil structure
Decreased water holding capacity
Increased saline seeps
Increased N leaching
Decreased soil biological activity

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 cover crops early (vs late)
3. Terminating at first bloom (vs pod)
4. Tilling cover crop (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)

Plot Study No-till and Till: Three 2-year cycles

- Objective: Determine effects of legume species and tillage on subsequent spring wheat.
- ~14 inch annual precip. (central Gallatin Valley, MT)
- Field had been no-till for several years

Plot Study No-till and Till: Design

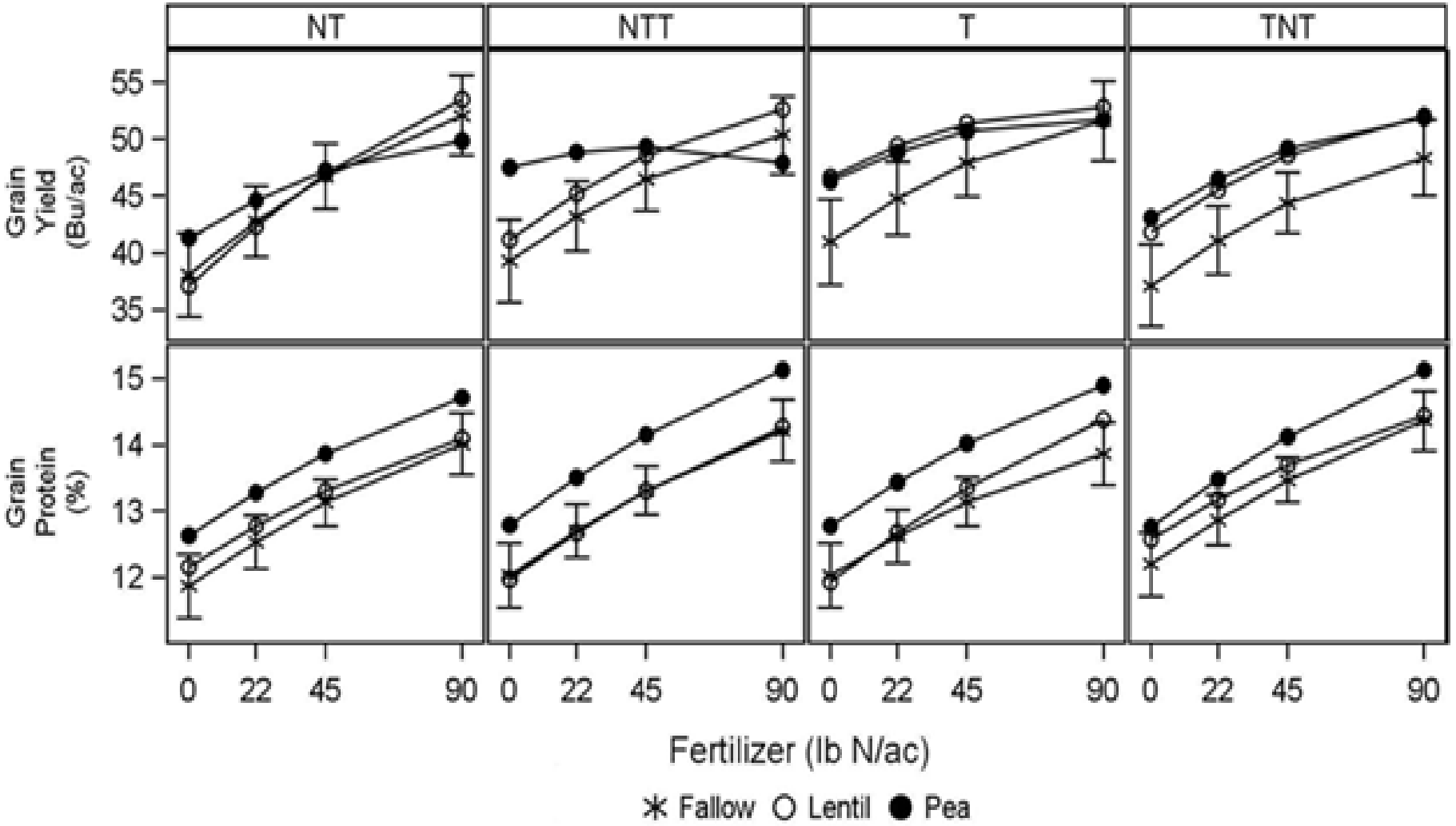
3 Crop Treatments X **4 Tillage Treatments**

- Spring Pea Manure
- Spring Lentil Manure
- Fallow

- No-Till (NT)
- No-Till, Till (NTT)
- Till (T)
- Till, No-Till (TNT)

- Green manures terminated at first flower
- Spring wheat planted at 4 N rates following year

Plot Study No-till and Till: Spring wheat yield & protein



Plot Study No-till and Till: Take home messages

- Early-terminated spring cover crops did not hurt subsequent spring wheat grain yield or protein compared to fallow.
- Higher N fixation by pea often produced higher subsequent spring wheat yield and/or protein.

8-year Plot Study

- Objective: Determine long-term effects of legume-containing rotations vs. fallow on subsequent wheat mainly in no-till.
- ~16 inch annual precip. (4 miles west of Bozeman)

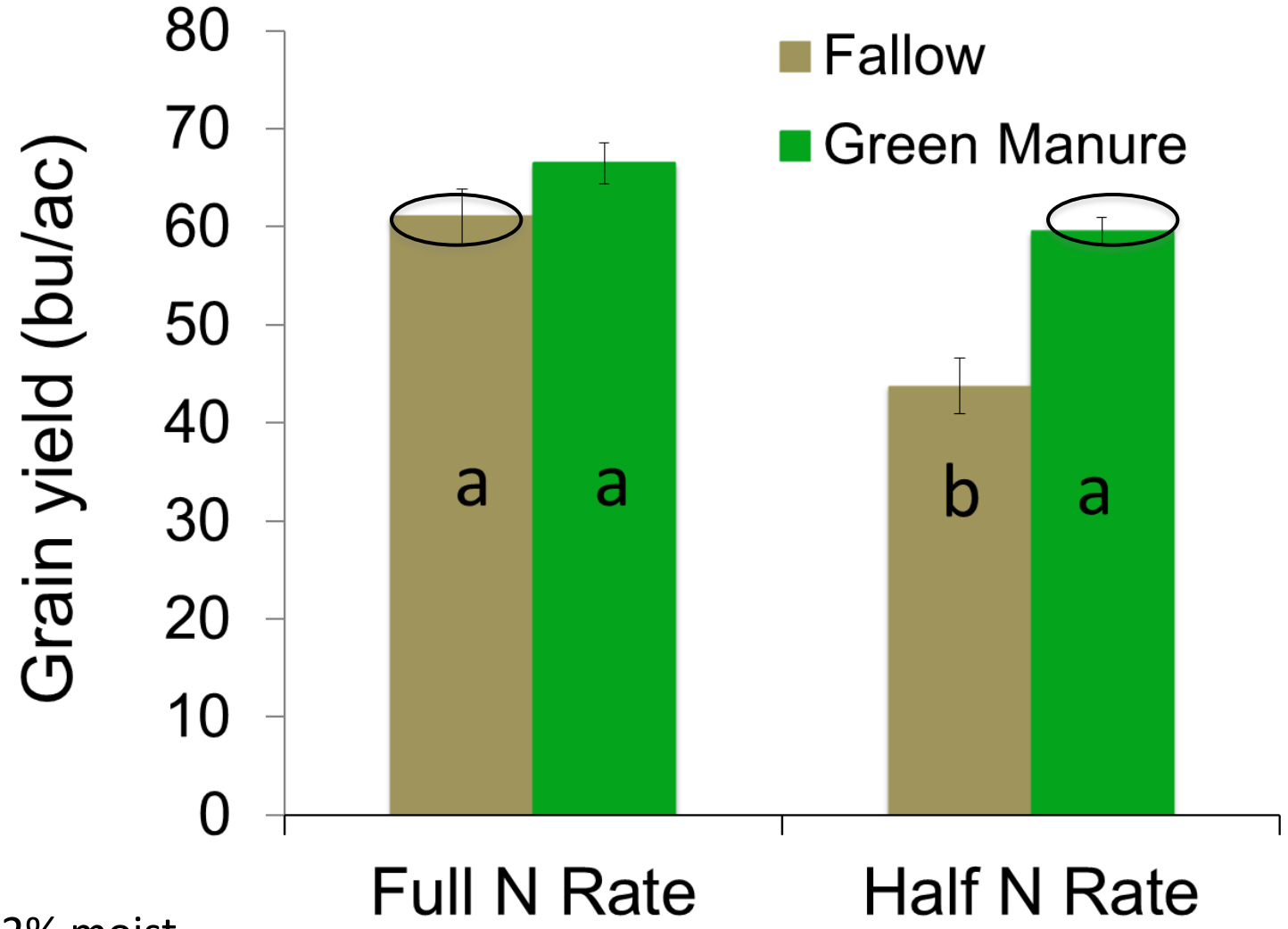
8-year Plot Study: Design

- Unique feature is deep, uniform silt loam soil and relatively abundant winter precip. to recharge soils
- Focus here on no-till pea forage/legume cover crop-wheat vs. fallow-wheat
- Pea forage grown in 2003, 05, 07 and pea CC grown in 2009, terminated at full pod
- Spring or winter wheat planted in even years. 2010 was wettest of wheat years, 2012 record drought.
- 2 N rates: Full (3 lb available N/bu) and ½ N
- NO differences in wheat yield between CC and fallow in 2004, 2006, and 2008.


Legume or
fallow year

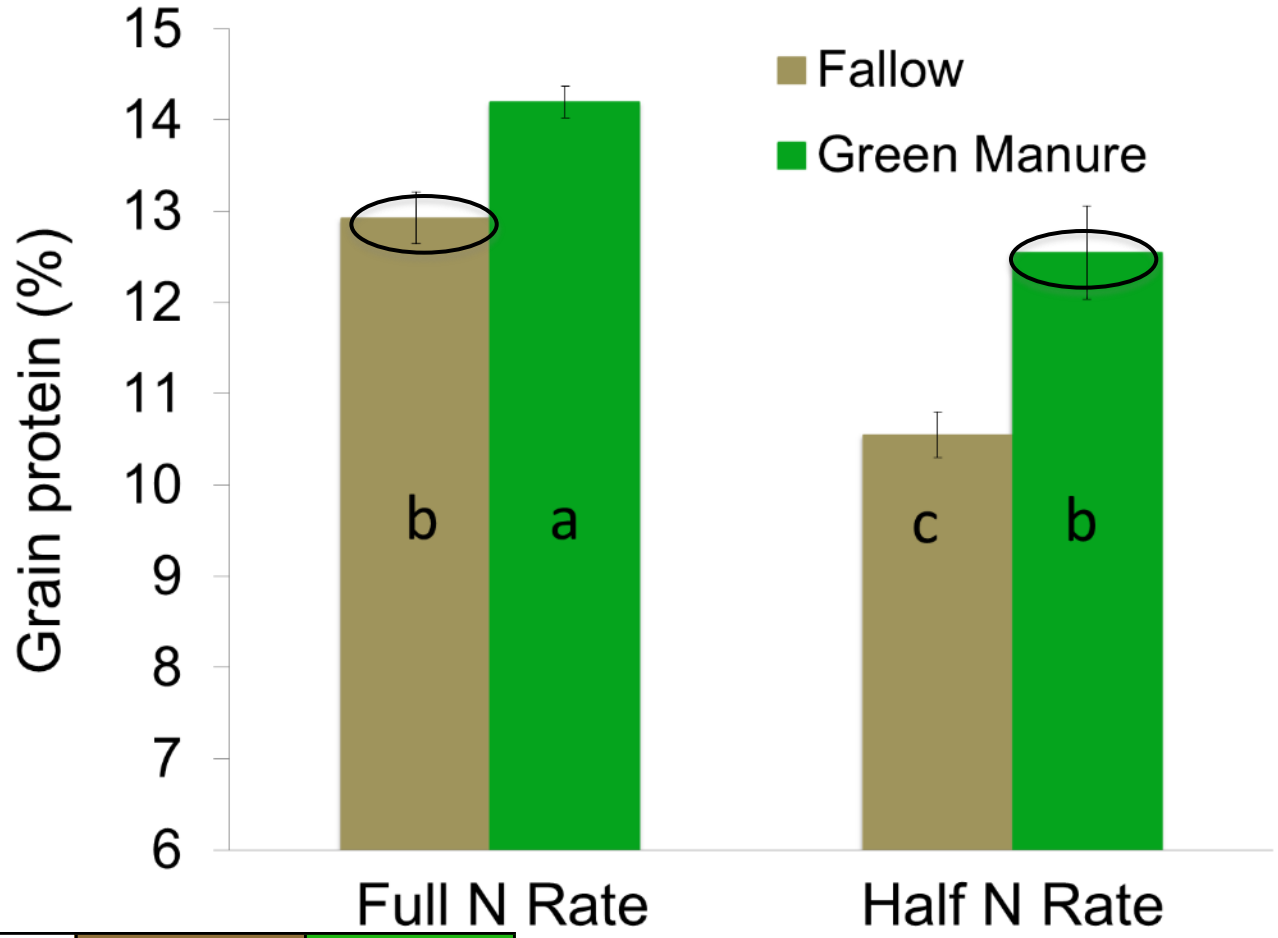

Wheat year

8 Year Plot Study: Grain yield in 8th year (2010)



@ 12% moist

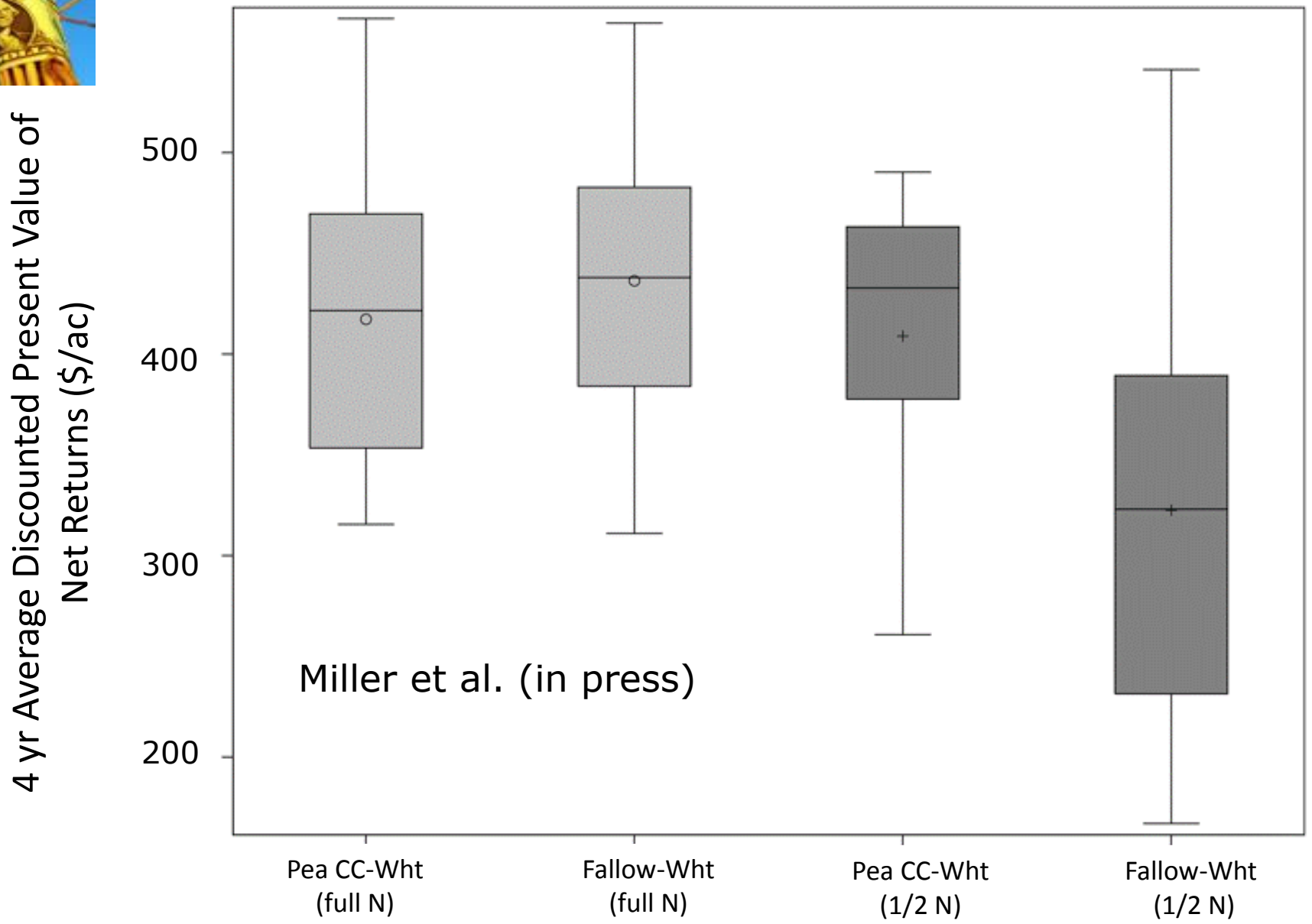
8 Year Plot Study: Grain protein in 8th year



* N fertilizer rates	*Fallow-Wheat*	*LGM-Wheat*
Full N rate (lbs/ac)	124.00	83.00
Half N rate (lbs/ac)	39.00	0.00

Pea cover crop after 4 CC-wheat rotations saved **124 lb N/ac** compared to fallow.

8-year Plot Study: Economics (2009-2012)



8-year Plot Study: Take home messages

- In the first 3 cycles, wheat grain yield was not higher after legume than after fallow.
- After 4 two-year cycles, wheat grain yield and protein were higher after legume CC than after fallow.
- Higher than normal precipitation in 2010 likely 1) increased release of available N from an increased organic N pool, and 2) made N limiting to growth.
- Over 100 lb N/ac was saved in 2010 following legume cover crop compared to fallow!
- Economic returns were more stable with cover crop (less dependent on N rate)

Questions still to be answered

- Do cover crop mixtures improve yield, protein, and soil health more than single species?
- Do certain types of species increase soil health more than others?
- Do yield and soil health benefits increase with number of cover crop cycles?

Cover Crop Cocktails Plot Study: One to two 2-year cycles, four site years

- Objective: Determine effects of "functional groups" within mixed cover crops on yield and soil health (microbial respiration, soil enzyme activity, soil temperature, potentially mineralizable N, mycorrhizal colonization)
- 2 sites in Triangle (Dutton and Conrad), 2 sites in Gallatin Valley (Amsterdam and Bozeman)
- 2nd cc cycle at Conrad and Amsterdam was completed in 2014 (preliminary soil data only to date)
- Full field component as well

Cover Crop Cocktails Plot Study: Study sites

3 on-farm conventional
1 university land

3-yr minimum no-till

Year	Amsterdam, Conrad	Bozeman, Dutton
2012	cover crop	--
2013	wheat	cover crop
2014	cover crop	wheat
2015	wheat	cover crop

Susan Tallman

Meg Housman

Plant functional groups & species

Nitrogen Fixers

Spring Pea
Pisum sativum

Common Vetch
Vicia sativa

Lentil
Lens culinaris

Fibrous Root

Oats
Avena sativa

Italian Ryegrass
Lolium multiflorum

Proso millet
Panicum miliaceum

Tap Root

Safflower
Carthamus tinctorius

Purple Top Turnip
Brassica rapa

Brassica

Daikon radish
Raphanus sativus

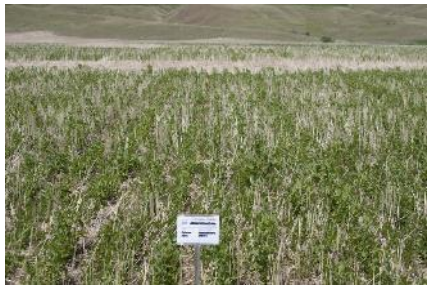
Camelina
Camelina sativa

Winter Canola
Brassica napus

Fallow

Pea

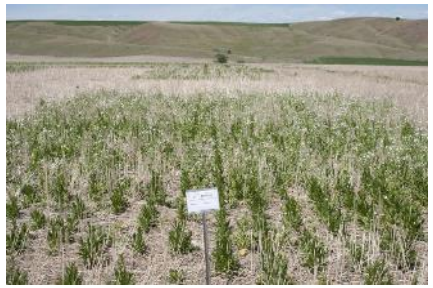
Full (8 species)



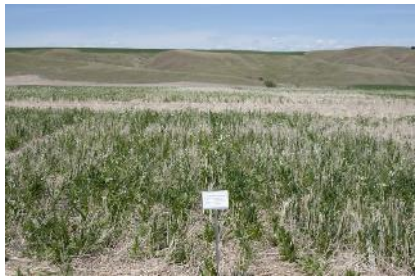
Nitrogen Fixers

Fibrous Roots

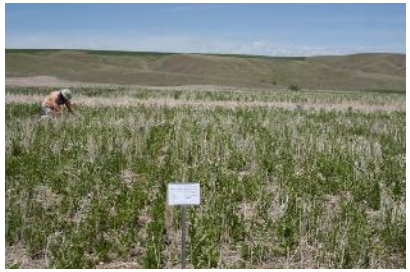
Tap Roots



Brassicas



Minus Nitrogen Fixers



Minus Fibrous Roots

Minus Tap Roots

Minus Brassicas
(no turnip)

All photos: Steve Spence; Amsterdam, 14 June 2012

2012 Cover Crop Biomass

Photo: Steve Spence

Amsterdam
2012
0.4 ton/acre

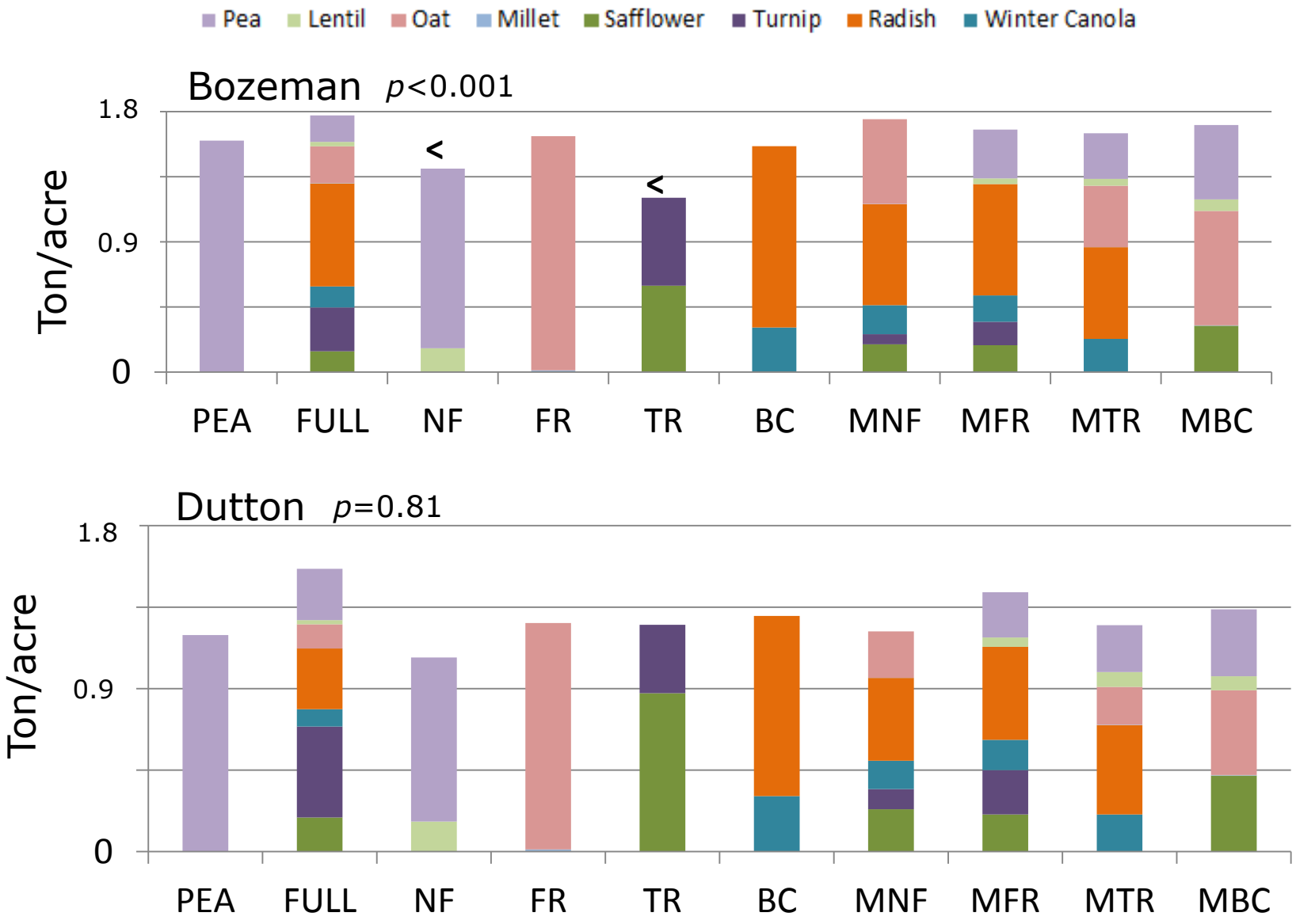
Photo: Evette Allison

Conrad 2012
0.2 ton/acre

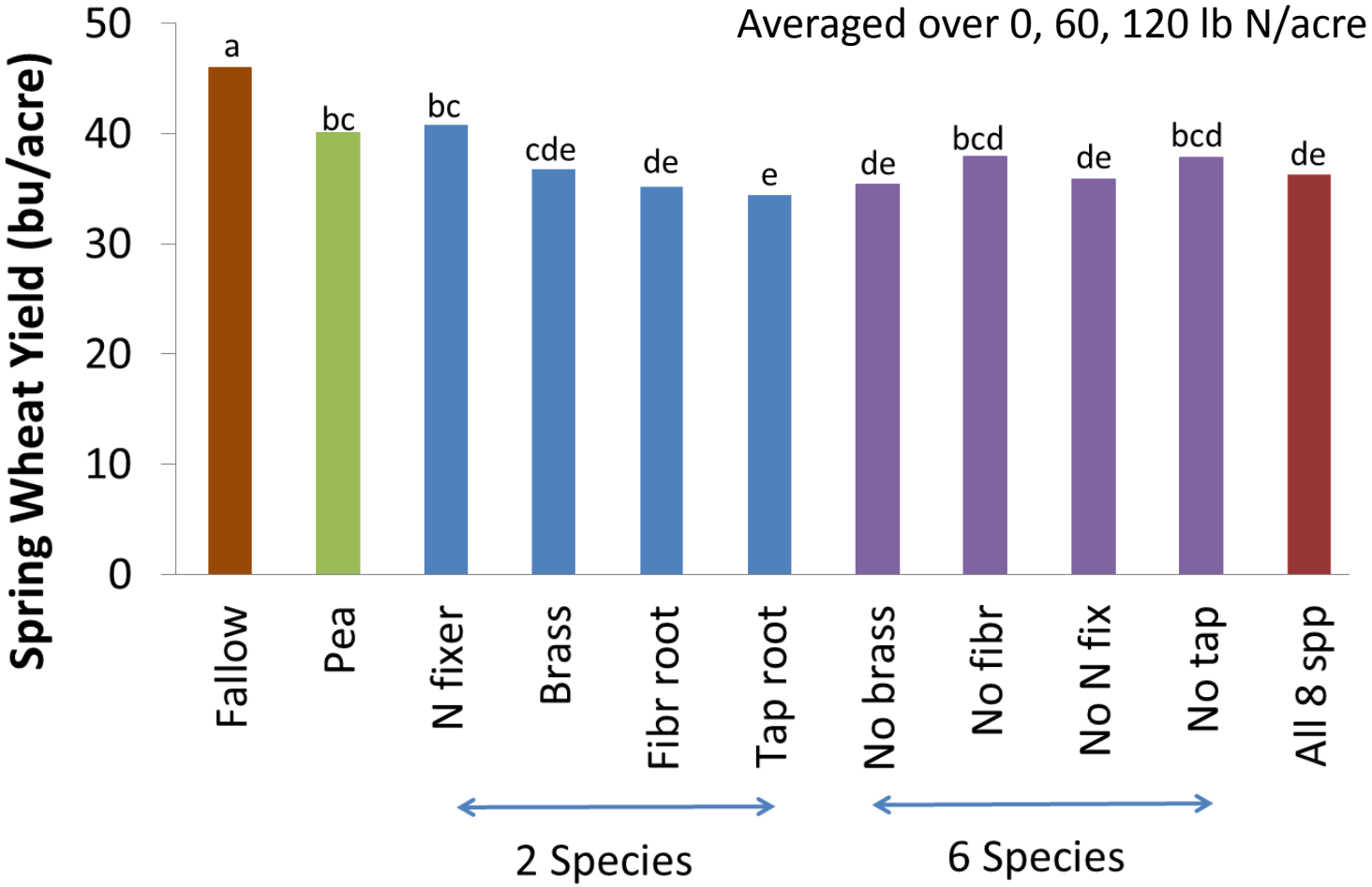
Photo: Steve Spence

2013 Cover Crop Biomass

2013 Cover Crop Biomass

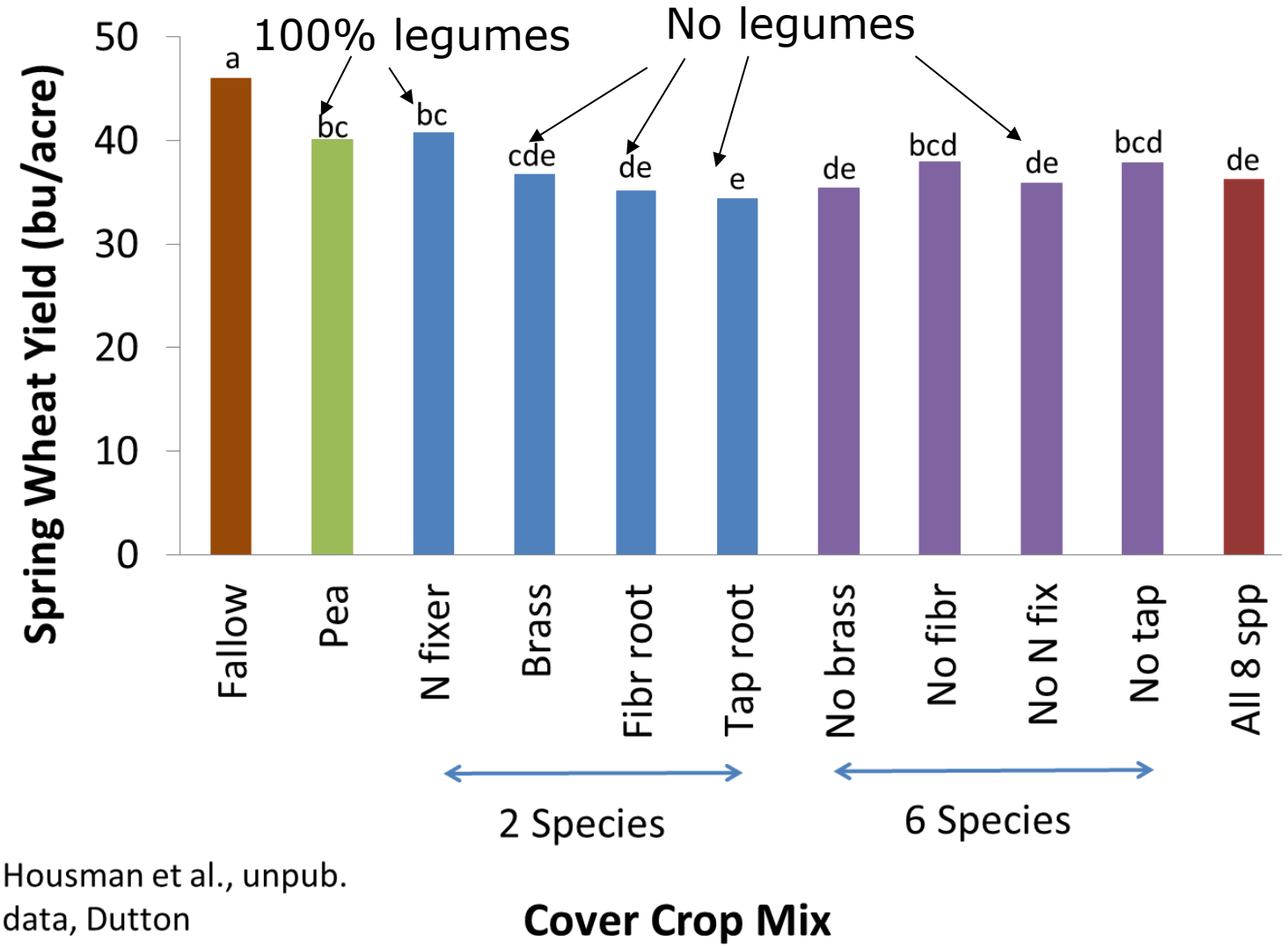


Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)



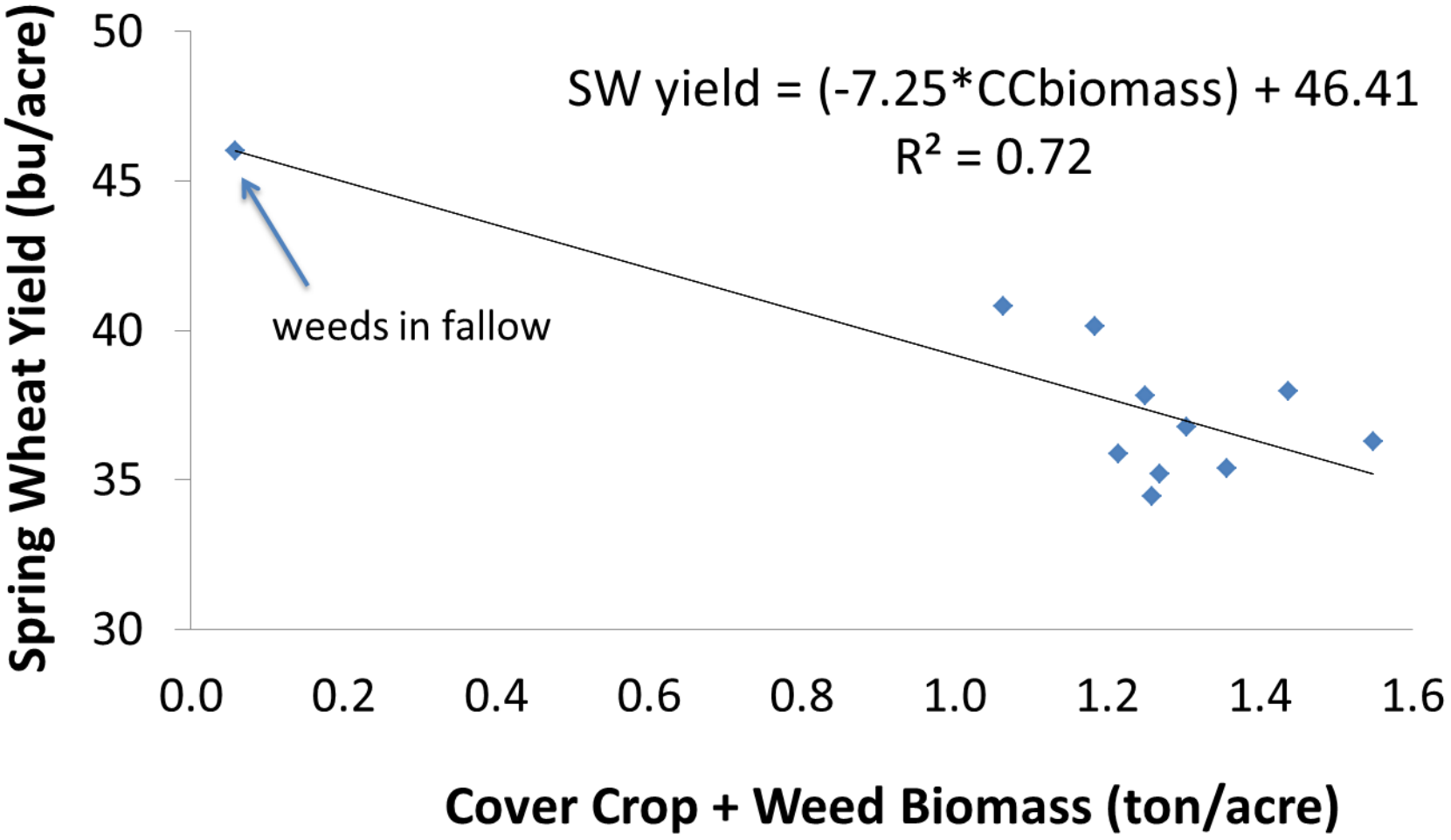
Housman et al., unpub. data, Dutton

Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)



Housman et al., unpub. data, Dutton

Spring wheat yield at Dutton vs previous year total biomass (cc + weed)

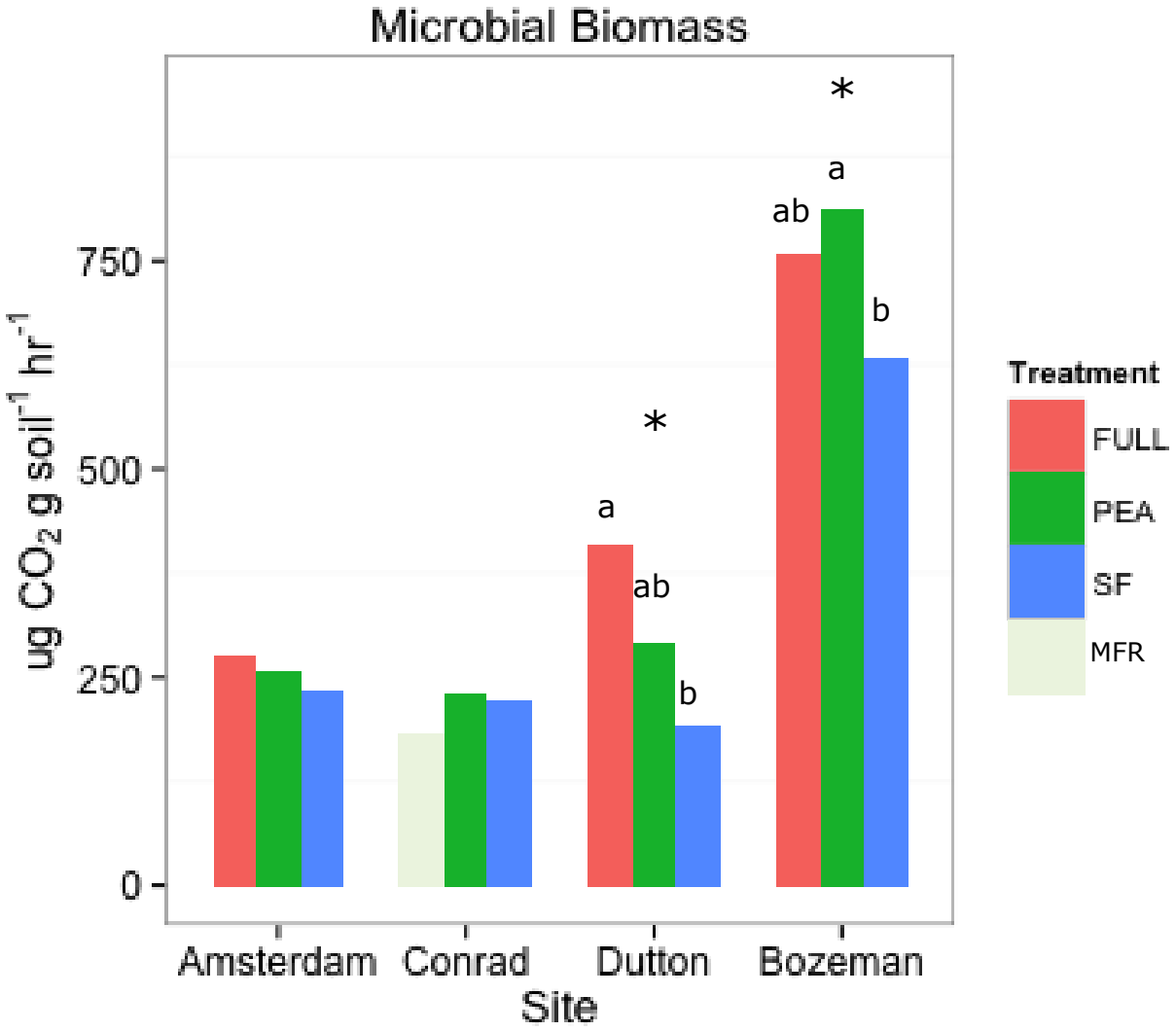


Housman, Tallman, et al., unpub data, Dutton

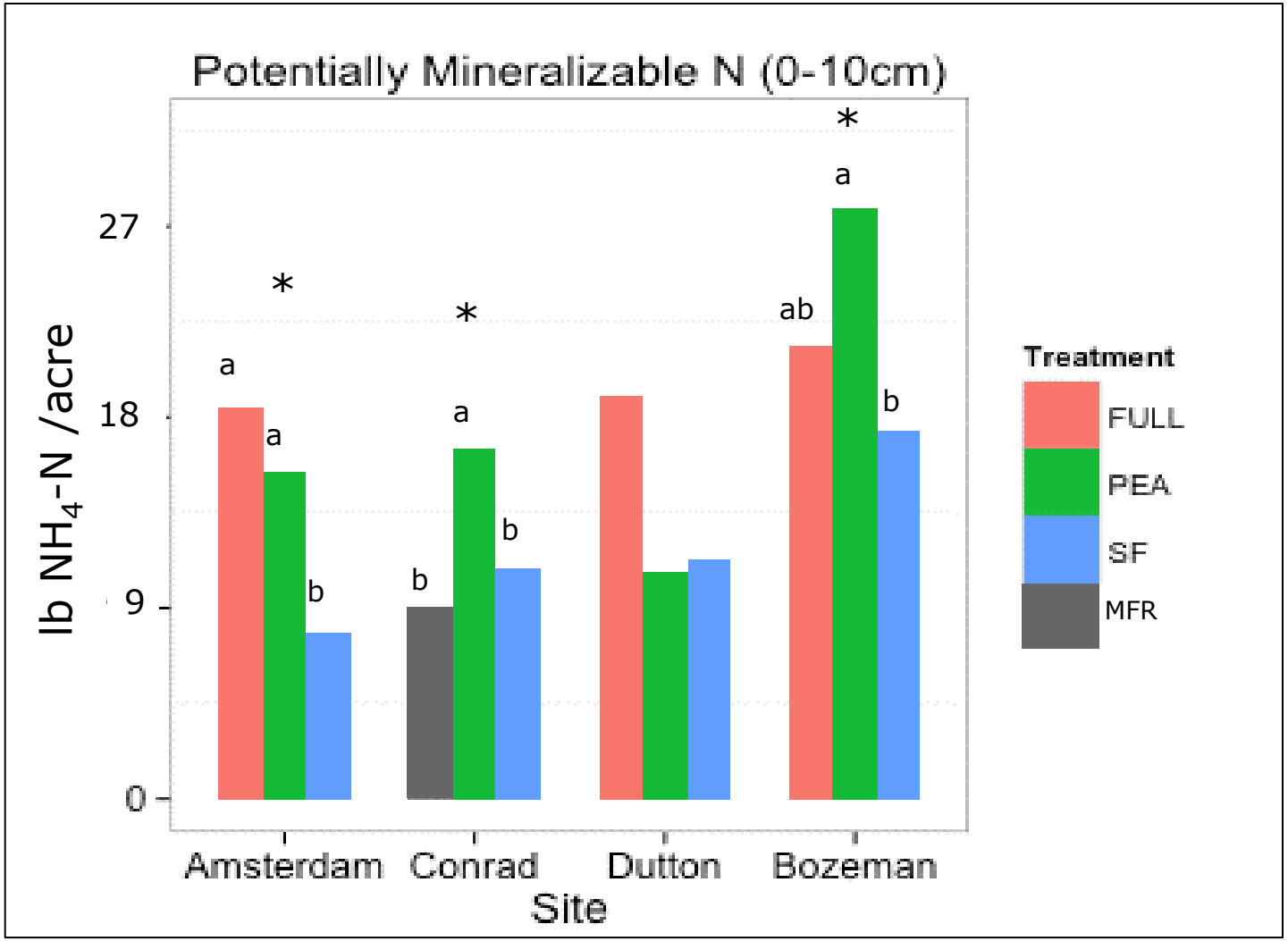
What about soil health?

Preliminary Results

Microbial Biomass

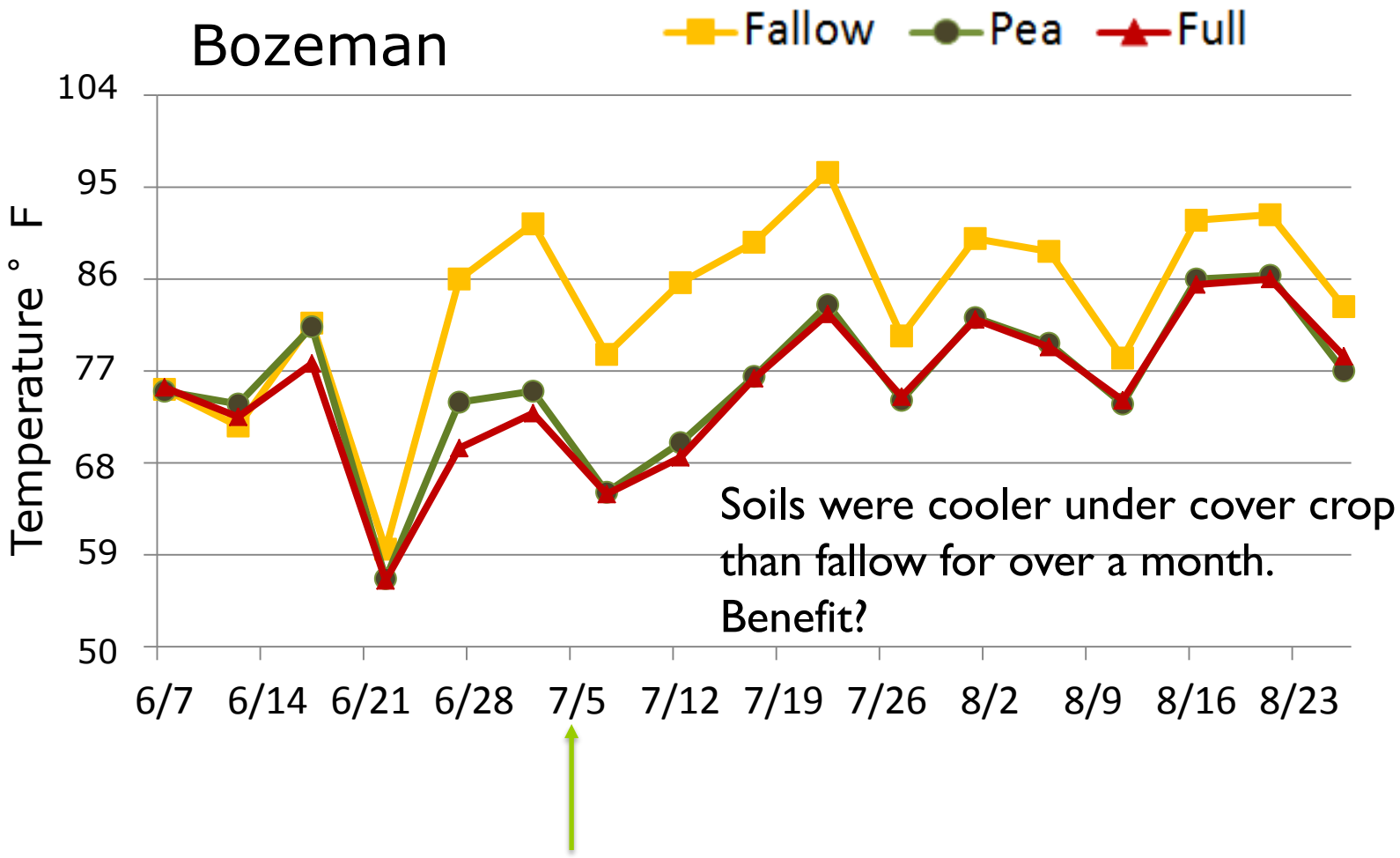


Potentially Mineralizable Nitrogen



Tallman, Housman, et al., 2014

Soil temperature at 2” deep much higher under fallow than cover crops



Jones, Miller, et al. unpublished

Summary after first full rotation

	Amsterdam	Conrad	Dutton	Bozeman
CC Biomass	**ns**	**ns**	**ns**	**ns**
Biomass C:N	**8 spec>Pea**	**ns**	**8 spec>Pea**	**ns**
Microbial Biomass	**ns**	**ns**	**CCrop>fallow**	**CCrop>fallow**
PMN	**CCrop>fallow**	**Pea>MFR**	**CCrop>fallow**	**ns**
Olsen P	**ns**	**ns**	**Not analyzed**	**Not analyzed**
Max daily temp	**--**	**--**	**fallow>CCrop**	**fallow>CCrop**
Penetration resistance*	**ns**	**Pea>MFR**	**ns**	**ns**

ns – no significant difference between 8 species (full mix) and pea
* - penetration resistance less for fallow than CCs at Dutton and Conrad, likely due to higher water content, not less compaction so only CCs compared.

Cover Crop Cocktails Plot Study: Take home messages on yield and soil quality

- After one cycle, spring wheat grain yields higher after pea and N fixers than most other mixes.
- Higher cover crop biomass correlated with lower spring wheat yield, likely b/c of more water and N use.
- Relatively few soil health differences; not unexpected given only one cycle.

Cover Crop Cocktail Farm Study (2012 – 2013)

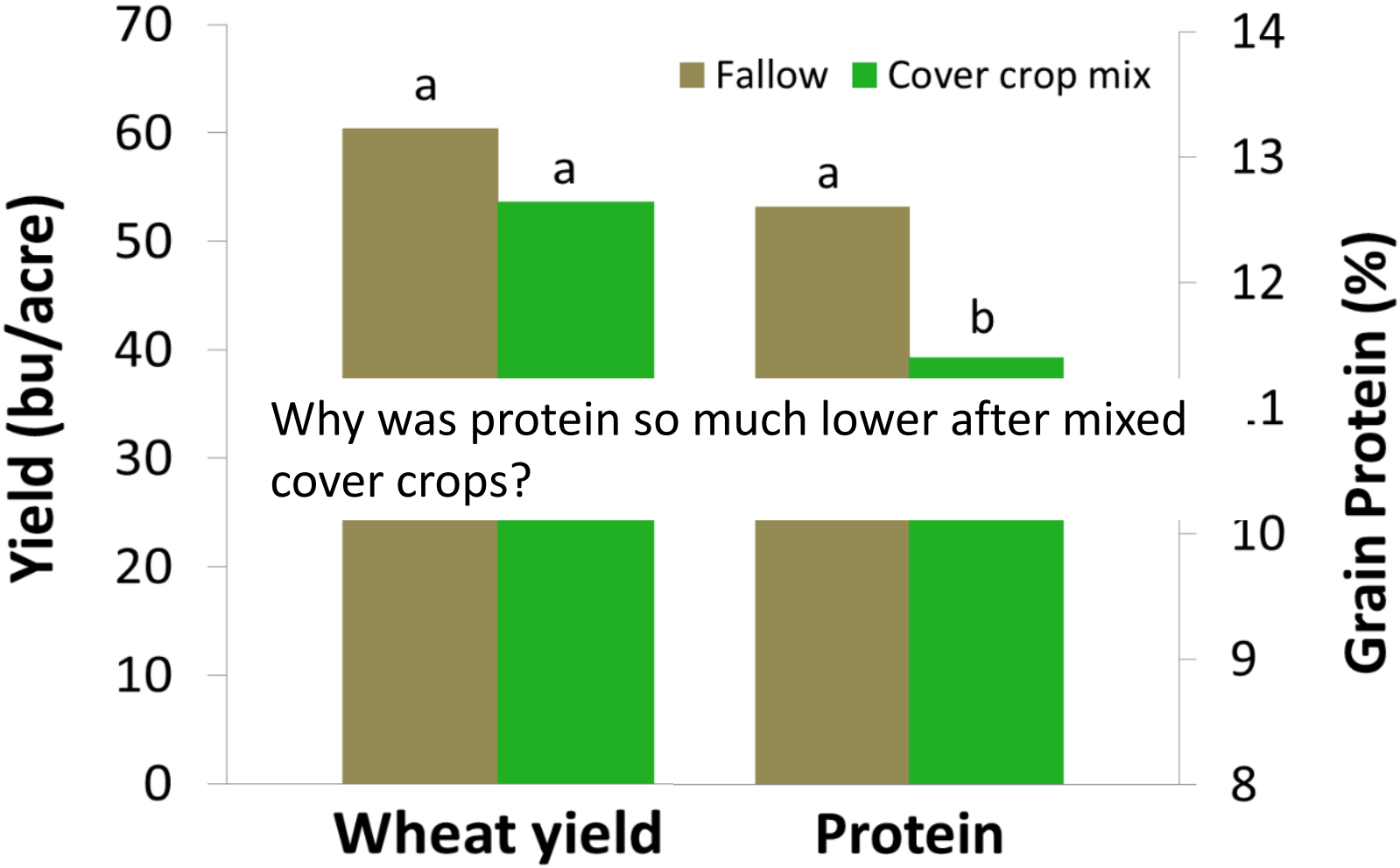
- 3 sites (Gallatin Valley and two in Triangle)
- Cover crops selected by growers and/or NRCS
- Growing season length somewhat on long side:

  Site 1 (Gallatin Valley): May 29 – Aug 29

  Site 2 (Triangle): Apr 12 – July 1

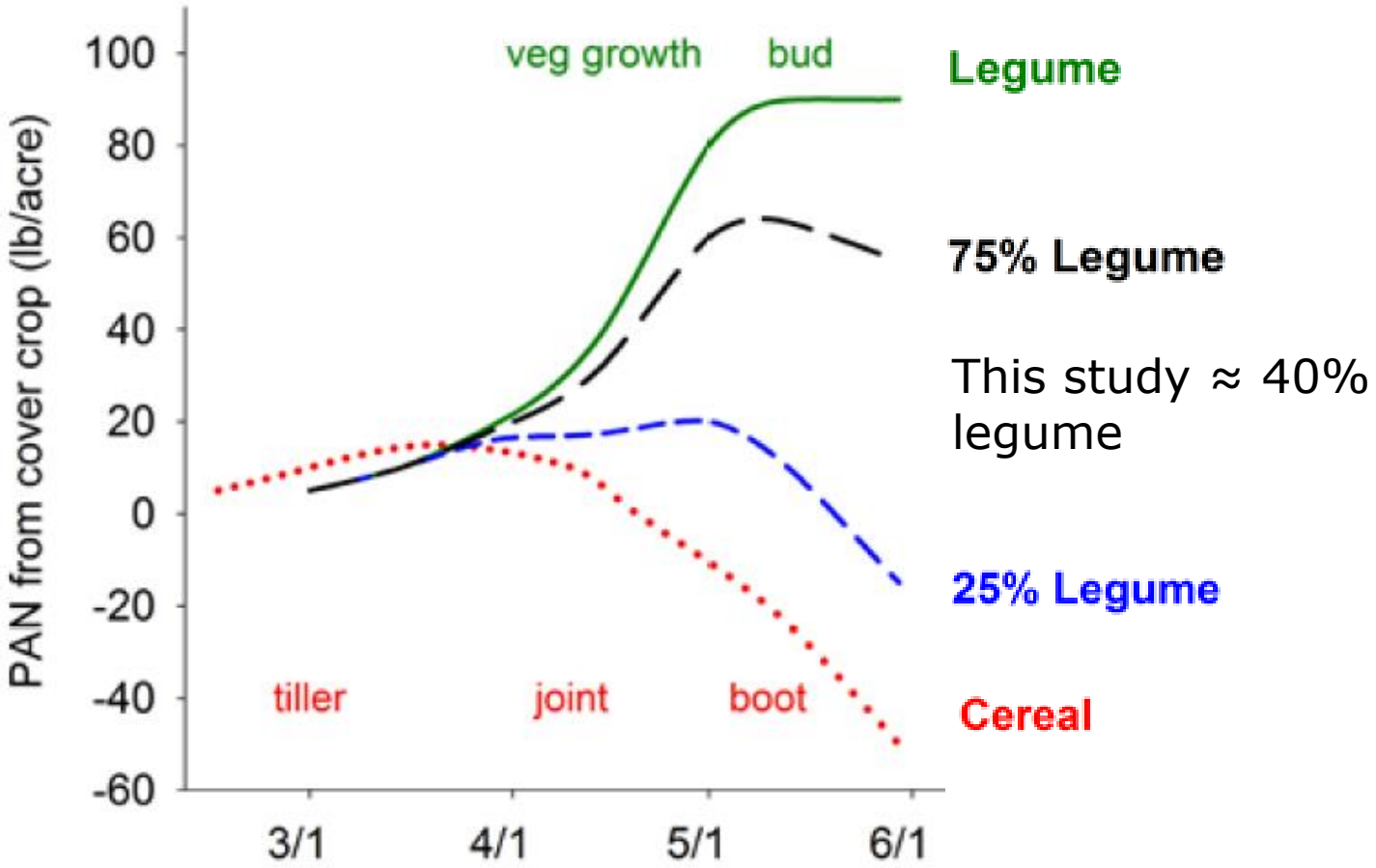
  Site 3 (Triangle): May 5 – July 20

Cover Crop Cocktails Farm Study: Spring wheat yield after mixed CC, Gallatin Valley



Why was protein so much lower after mixed cover crops?

Percent legume and termination timing affects plant available N (PAN)

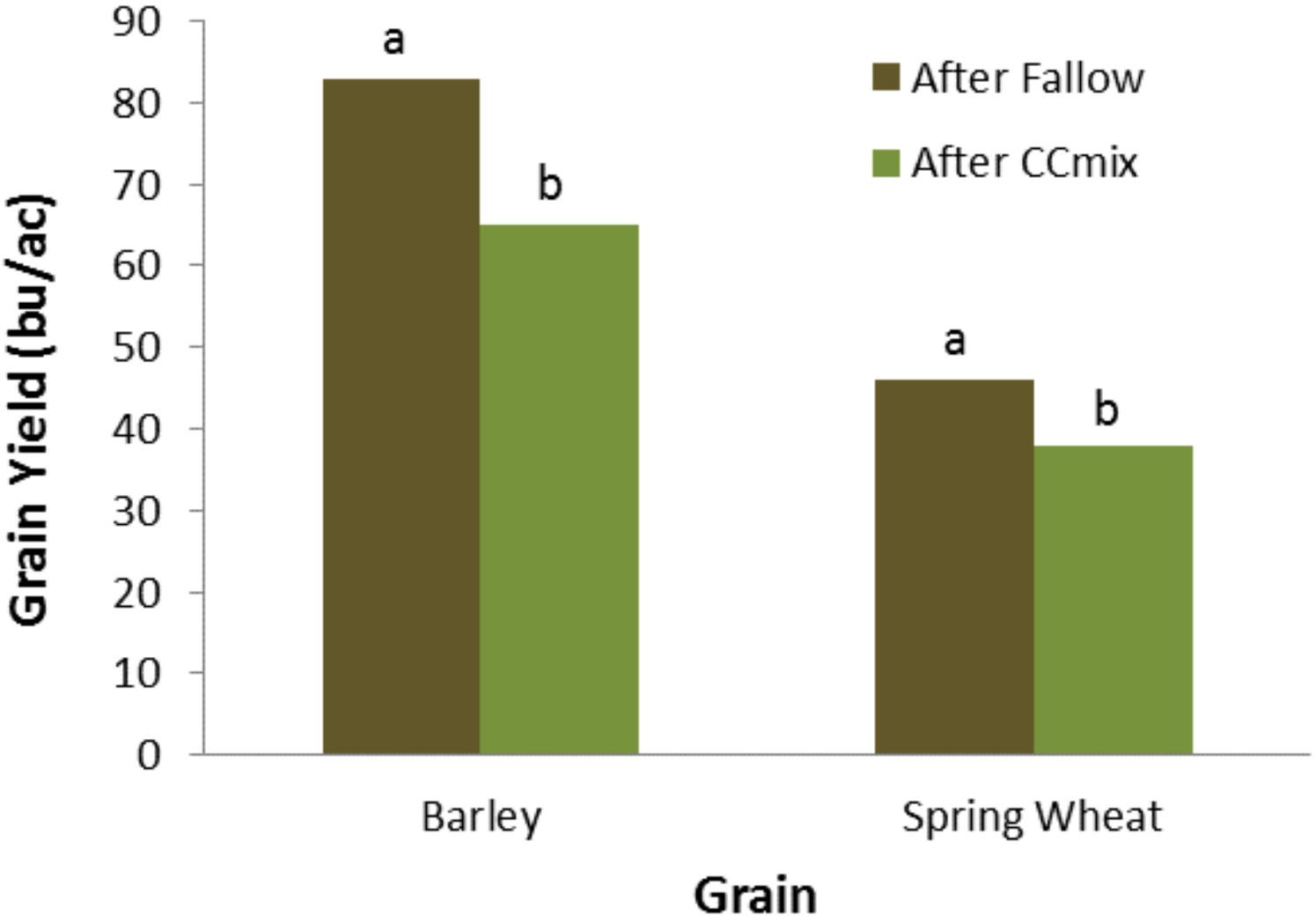


This study ≈ 40% legume

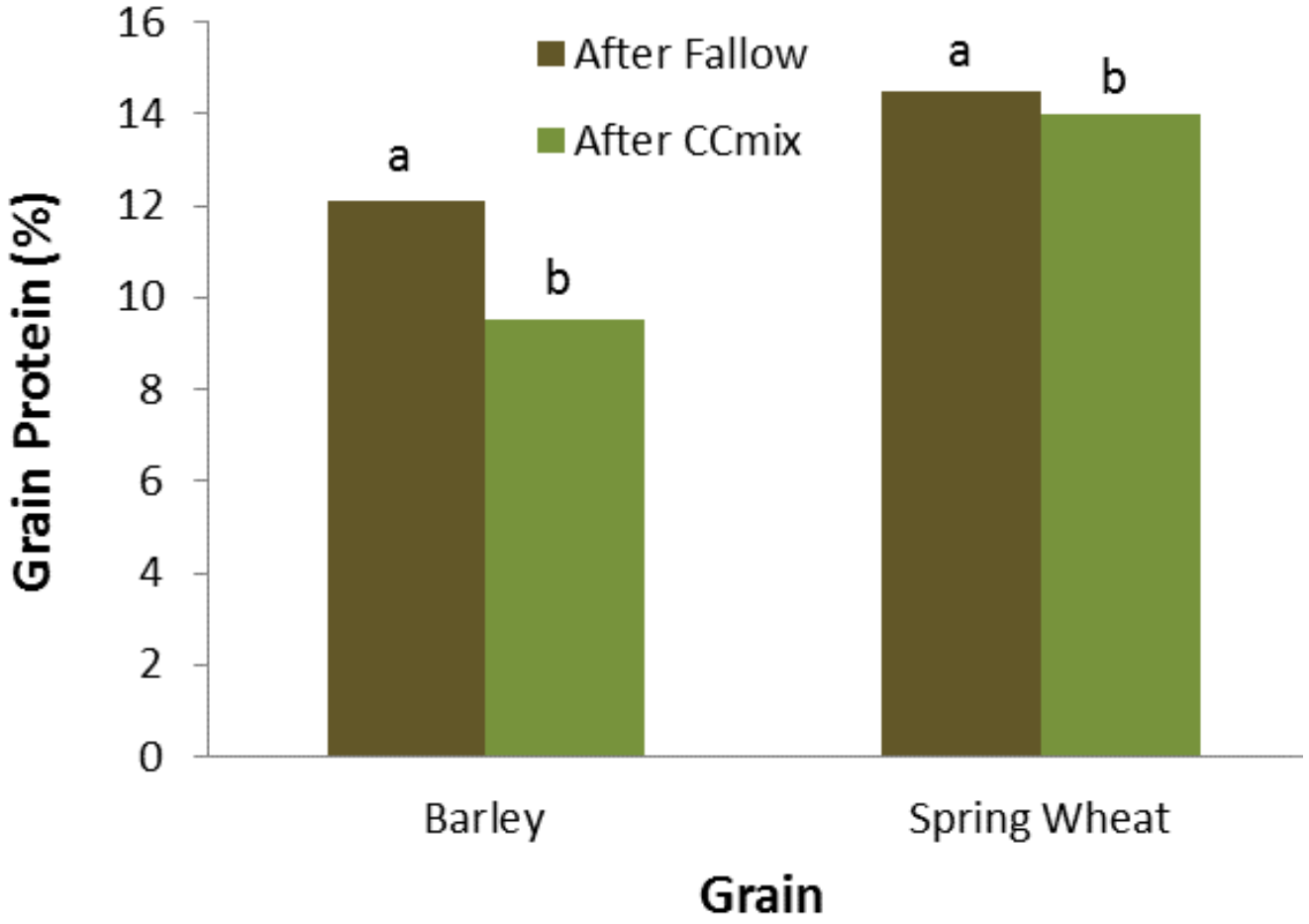
Take home: Legume % less than 50 can result in low available N esp if terminated late

Willamette Valley, Oregon
Sullivan and Andrews, 2012

Cover Crop Cocktail Farm Study: Spring wheat yield after mixed CC, Golden Triangle



Cover Crop Cocktail Farm Study: Spring wheat grain protein after mixed CC, Golden Triangle



Yield and protein less after mixed cover crops on farmers' fields, likely due to late termination and high water & N use

Cover Crop Cocktails Farm Study: Take home messages on yield and protein

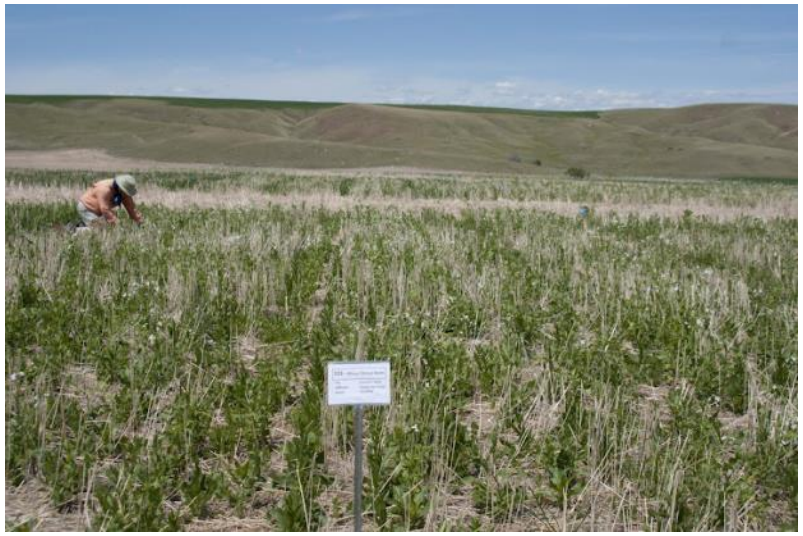
- Spring wheat grain yield was lower after CC than fallow in two of three field-scale studies
- Spring wheat grain protein was lower after CC than after fallow in all 3 studies.
- High water use from late termination was likely cause of yield differences.
- Low N availability from late termination & low legume % was likely cause of protein differences.

Conclusions

- In short term (1 CC-cycle studies), grain yield and protein are generally equal or less than after fallow.
- Early termination (by ~ first pea bloom) is key to preventing yield and protein losses.
- In short term studies, there does not appear to be yield or soil quality advantages of multiple species mixes over pea.
- In long term (4+ cycles), yield, protein, and net revenue can be higher after cover crops than fallow, especially at low N rates, likely from more available N.
- Cover crop value to soil health, subsequent crops, and possibly land value is expected to increase over time.

Acknowledgments

- USDA – AFRI
- USDA – WSARE
- NRCS – CIG
- Montana Fertilizer Advisory Committee
- Montana Wheat and Barley Committee
- Numerous landowners
- Ann McCauley
- Jeff Holmes
- Anton Bekkerman
- Mac Burgess



Questions?

For additional information on soil fertility topics including information on cover crops, see http://landresources.montana.edu/soilfertility