

COVER CROPS AND SOIL HEALTH

Growers' Workshop
Sheridan and Helena
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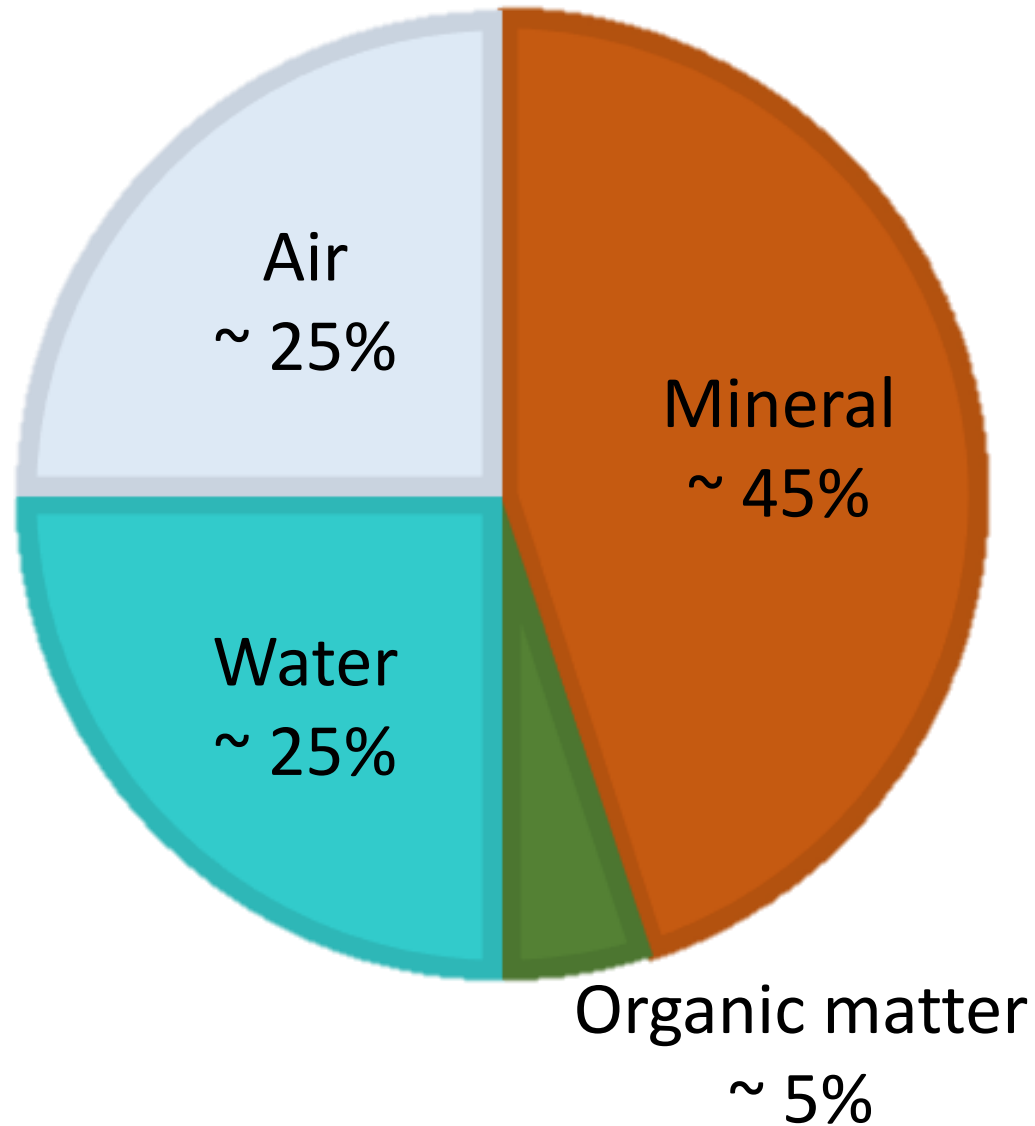


MSU Soil Fertility Extension

Today I plan to present:

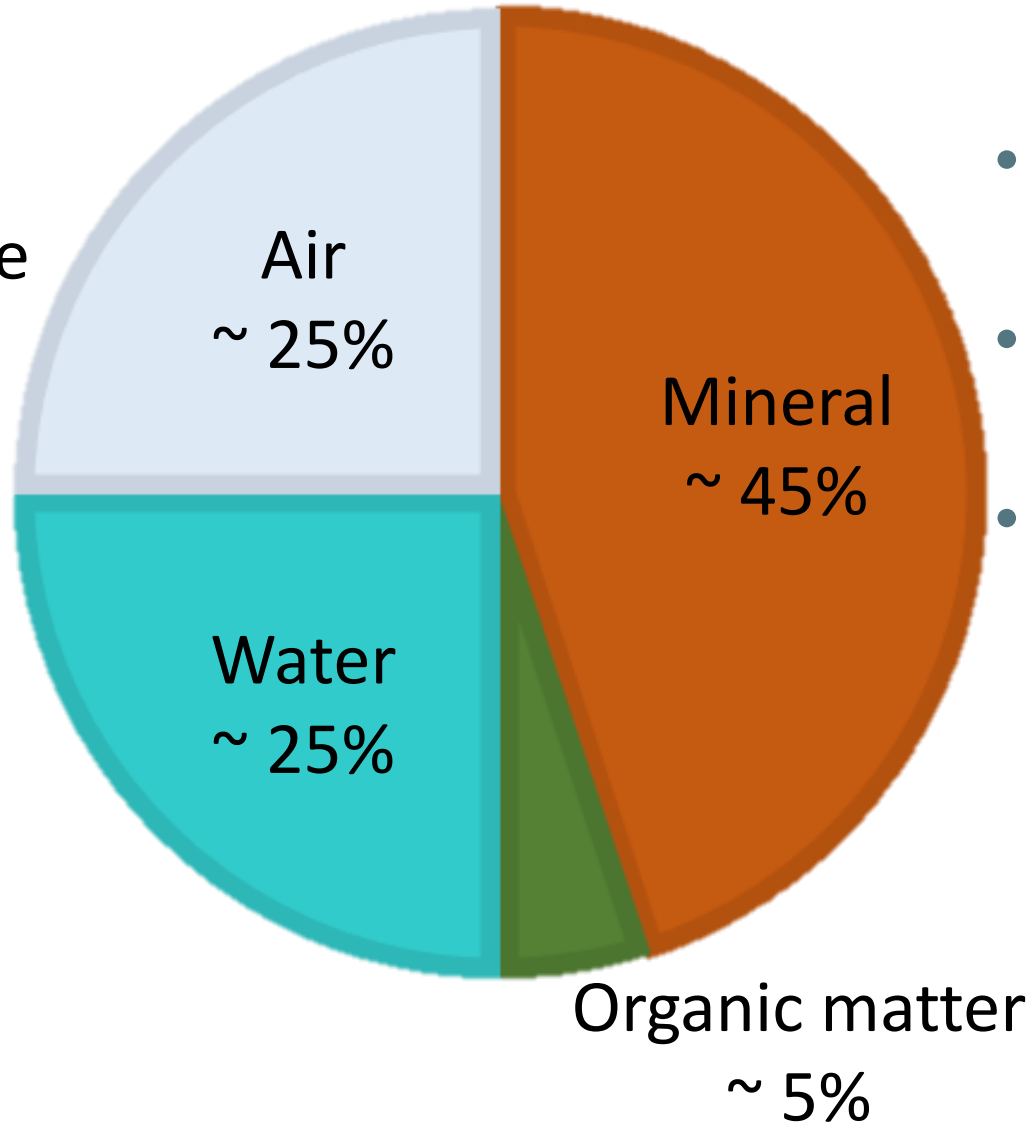
- Management practices to benefit soils
- Potential benefits of cover crops
- Cover crop effects on
 - Nitrogen
 - Soil organic matter
 - Temperature, aggregate stability, microbial activity
 - Following crop yield and protein
 - Economics
- Management considerations with cover crops

Average Soil Components



Practices to benefit soil

- Minimize disturbance
- Keep soil surface covered



- Nutrient mgt (soil test; 4Rs)
- Increase diversity
- Keep living root in soil

Practices to benefit soil

- ✓ Minimize disturbance
- ✓ Keep soil surface covered



Perennial
pasture/forage
production

- Nutrient mgt (soil test; 4Rs)
- Increase diversity
- Keep living root in soil

Perennial >> annual

Practices to benefit soil

- ✓ Minimize disturbance
- ✓ Keep soil surface covered

Fallow or new seeding of forage



- Nutrient mgt (soil test; 4Rs)
- ✓ ? Increase diversity
- ✓ Keep living root in soil

No-till
Recrop >> fallow
Cover crops?

Do you have a place for cover or nurse crops?

What we have found with MT research trials



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

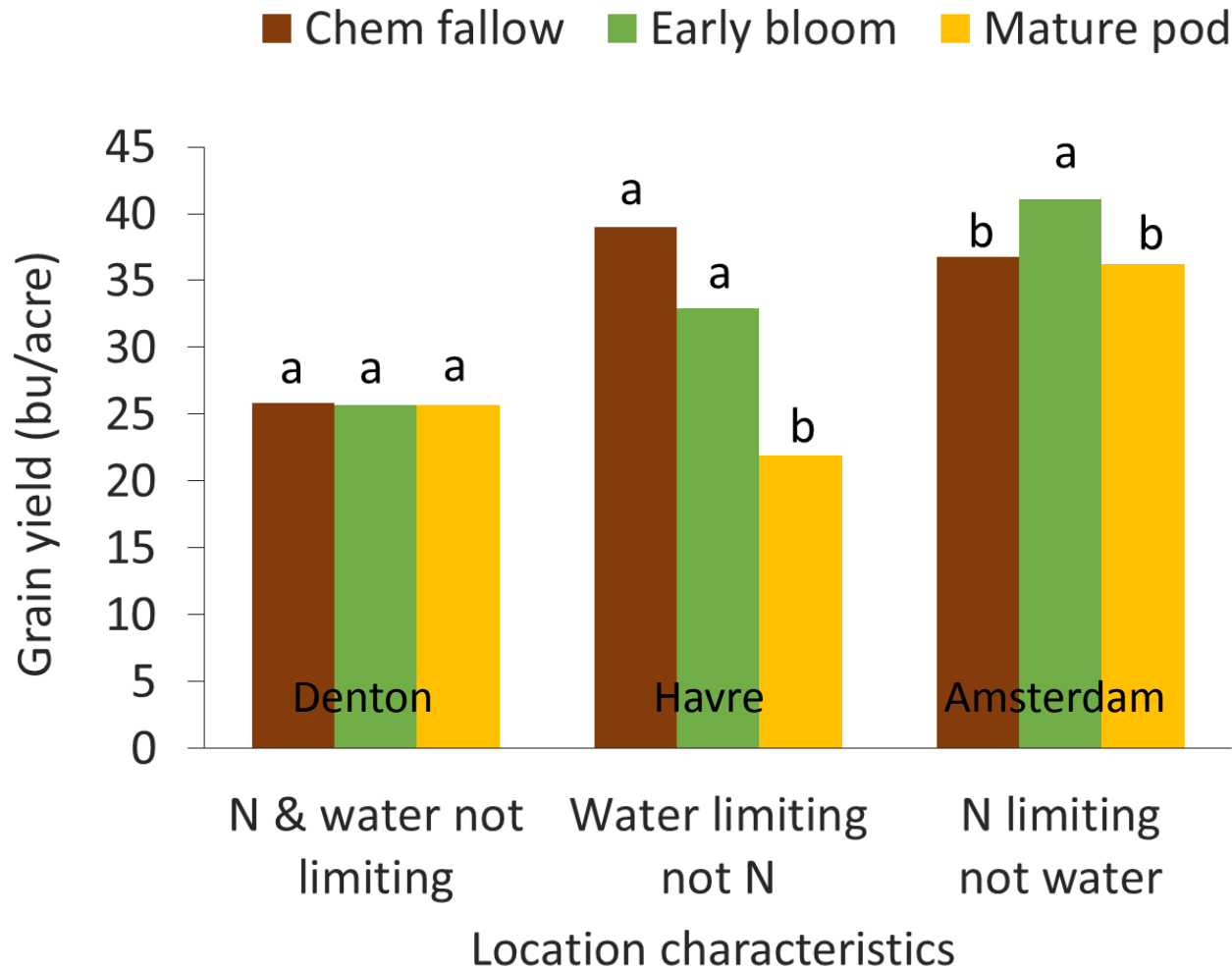


1. Seeding winter legumes (vs spring legumes)
2. Seeding spring cover crops early (vs late)
3. Terminating at first bloom (vs pod)
4. Tilling cover crop (vs spraying)

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)

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



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



Plot Study No-till and Till: Design

3 Crop Treatments

- Spring Pea Manure
 - Spring Lentil Manure
 - Fallow
-
- Green manures terminated at first flower
 - Spring wheat planted at 4 N rates following year
 - Gallatin Valley, ~14 inch annual precip.

X

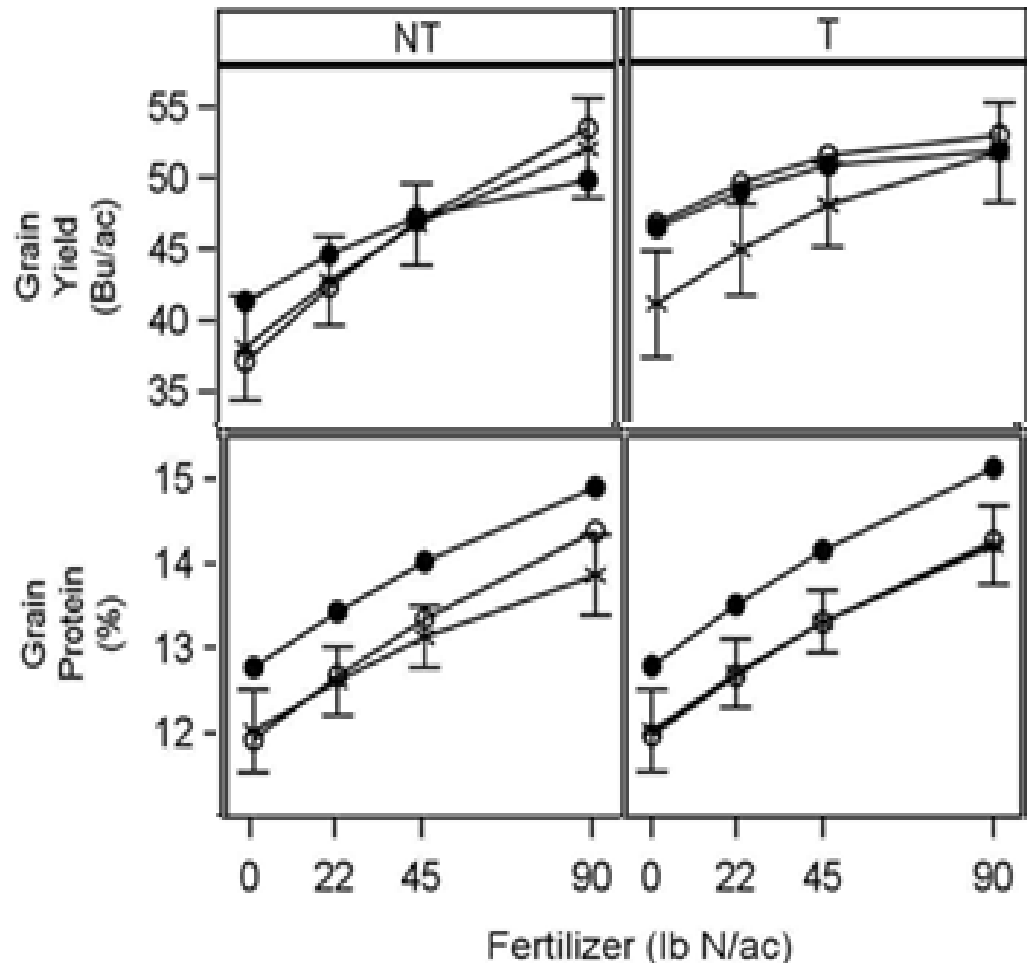
Tillage Treatments

- No-Till (NT)
- Till (T)





Effect of lentil and pea cover crop on spring wheat yield & protein



* Fallow ○ Lentil ● Pea

Take home:

- Early-terminated spring cover crop did not hurt wheat yield or protein.
- Pea cover crop only increased yield at low N rates when tilled.
- Pea increased grain protein at all N rates for both NT and T.
- Lentil cover crop did not benefit yield or protein (likely N contribution too low)



Questions?

Cover Crop Cocktails Plot Study

1. Compare crop and soil response to fallow, single species pea CC, and multi-species mixtures
 - Cover crop and wheat: Biomass, biomass quality, yield
 - Soil:
 - Microbial biomass
 - Soil enzyme activity
 - Soil temperature
 - Aggregate stability
 - Compaction
 - Soil water, nitrate, and Olsen P
 - Mycorrhizal colonization
 - Potentially mineralizable nitrogen
2. Determine the specific effects of 4 plant functional groups
3. 2 sites in Triangle, 2 in Gallatin Valley



Species diversity: does it increase benefits?



Nitrogen Fixers

- Spring Pea
- Common Vetch
- Lentil

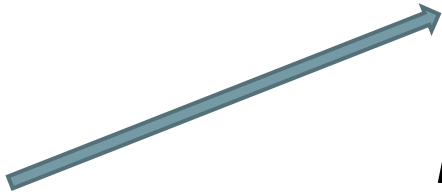


Increase nitrogen

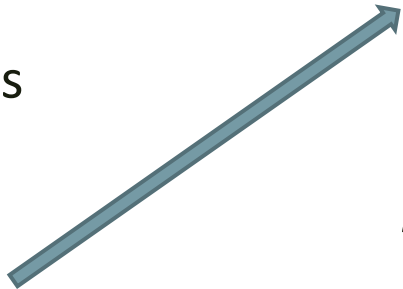


Fibrous Root

- Oats
- Italian ryegrass
- Proso millet



Add soil carbon



Reduce compaction, move nutrients upward



Tap Root

- Purple top turnip
- Safflower



Potential disease control



Brassica

- Daikon radish
- Winter canola
- Camelina

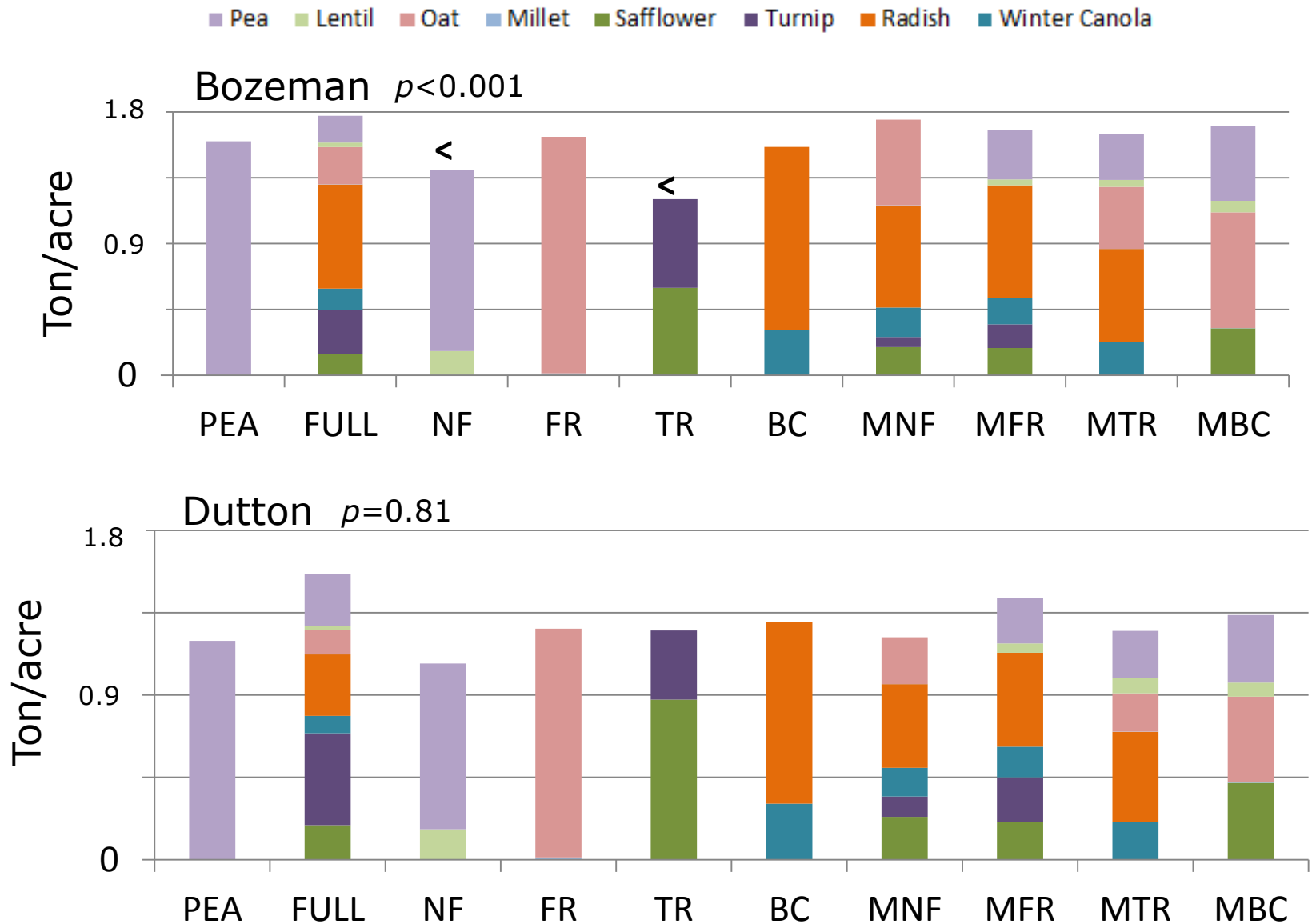
Lessons learned about plantings



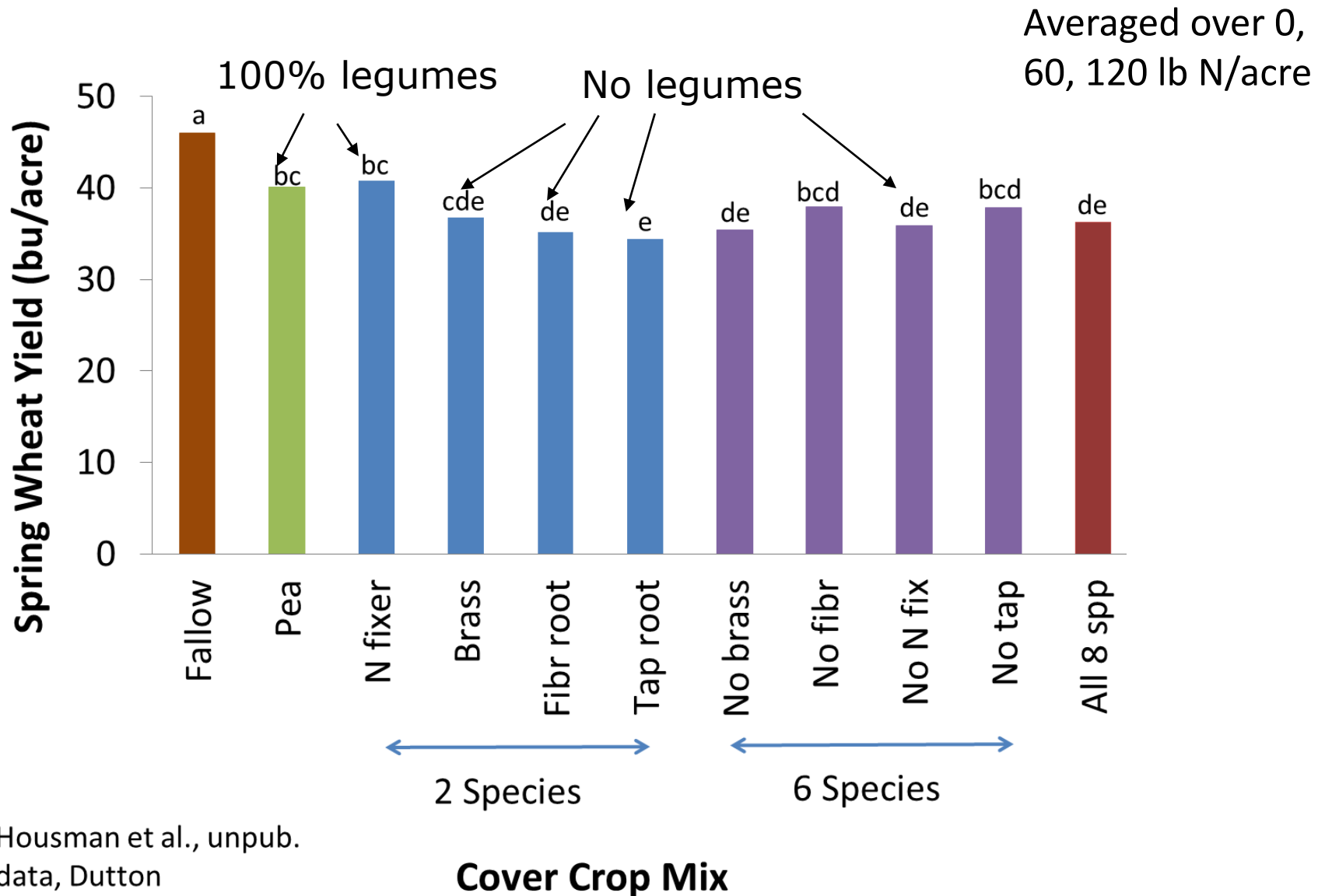
- Early weed control essential
- Common vetch difficult to terminate w/ glyphosate
- Camelina, Italian ryegrass, and lentil not competitive
- Millet not competitive in mid-spring mix
- Possible biological control benefits of wheat-stem sawfly with oat and radish

Photo: Susan Tallman

2013 Cover Crop Biomass – wet year

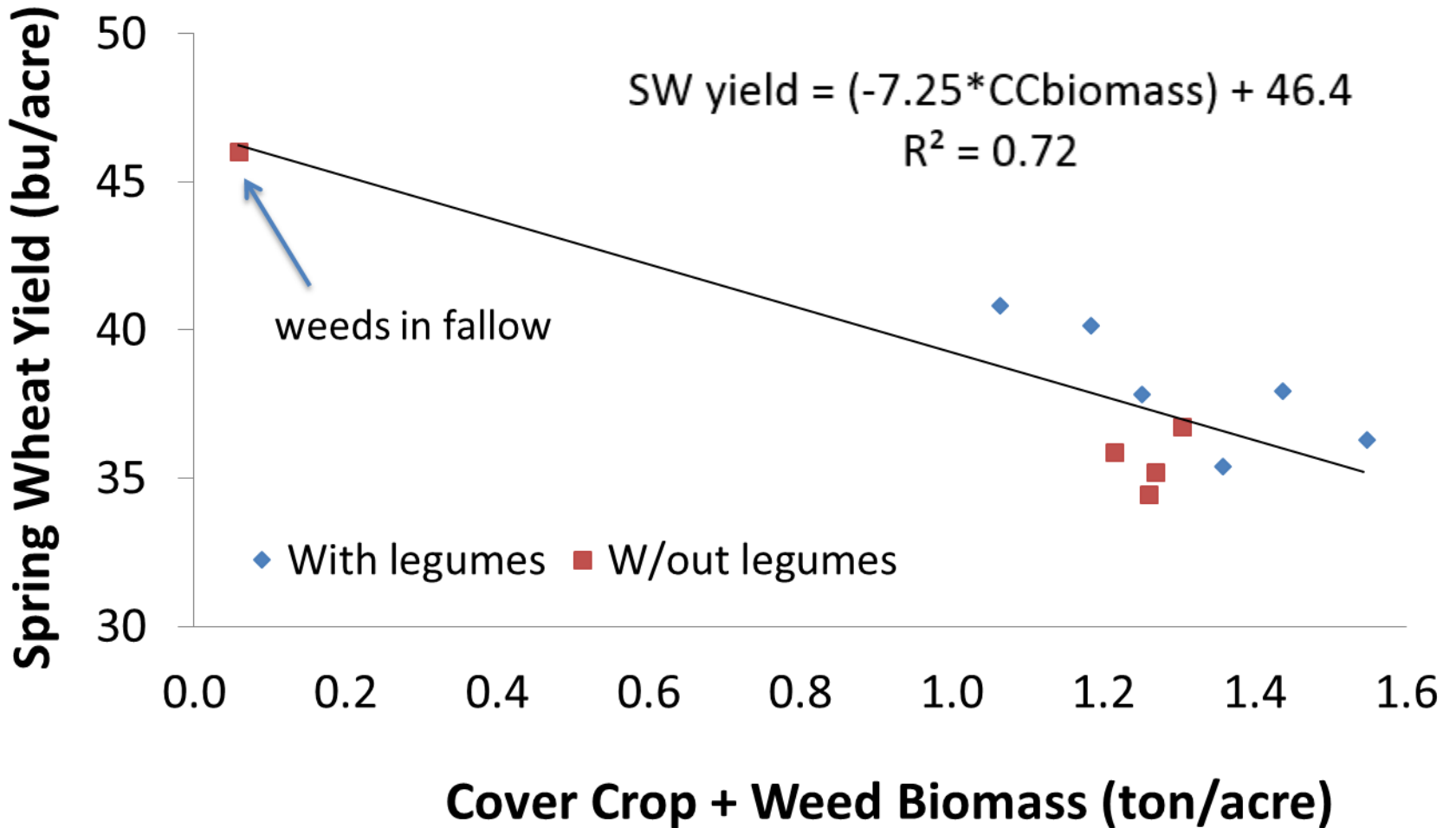


Effect of cover crop treatment on spring wheat grain yield at Dutton (2014)



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?

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	CC>fallow	CC>fallow
PMN	CC>fallow	Pea>6 spec	CC>fallow	ns
Olsen P	ns	ns	ns	ns
Temp at 2"	--	--	CC<fallow	CC<fallow
Aggregate stability	ns	ns	ns	ns

ns – no significant difference (95% confidence) among treatments

* - penetration resistance less for fallow than CCs at Dutton and Conrad, likely due to higher water content, not less compaction so only CCs compared.

Summary after SECOND full rotation

	Amsterdam	Conrad
Cover crop biomass	but 6 spp. > 2 spp.	ns
Microbial Biomass	CC>fallow	ns
Microbial Enzymes (5)	CC>fallow	ns
PMN	CC>fallow	ns
Olsen P	ns	ns
Temp at 2"	CC<fallow	CC<fallow
Aggregate stability	ns	ns

ns – no significant difference (95% confidence) among treatments



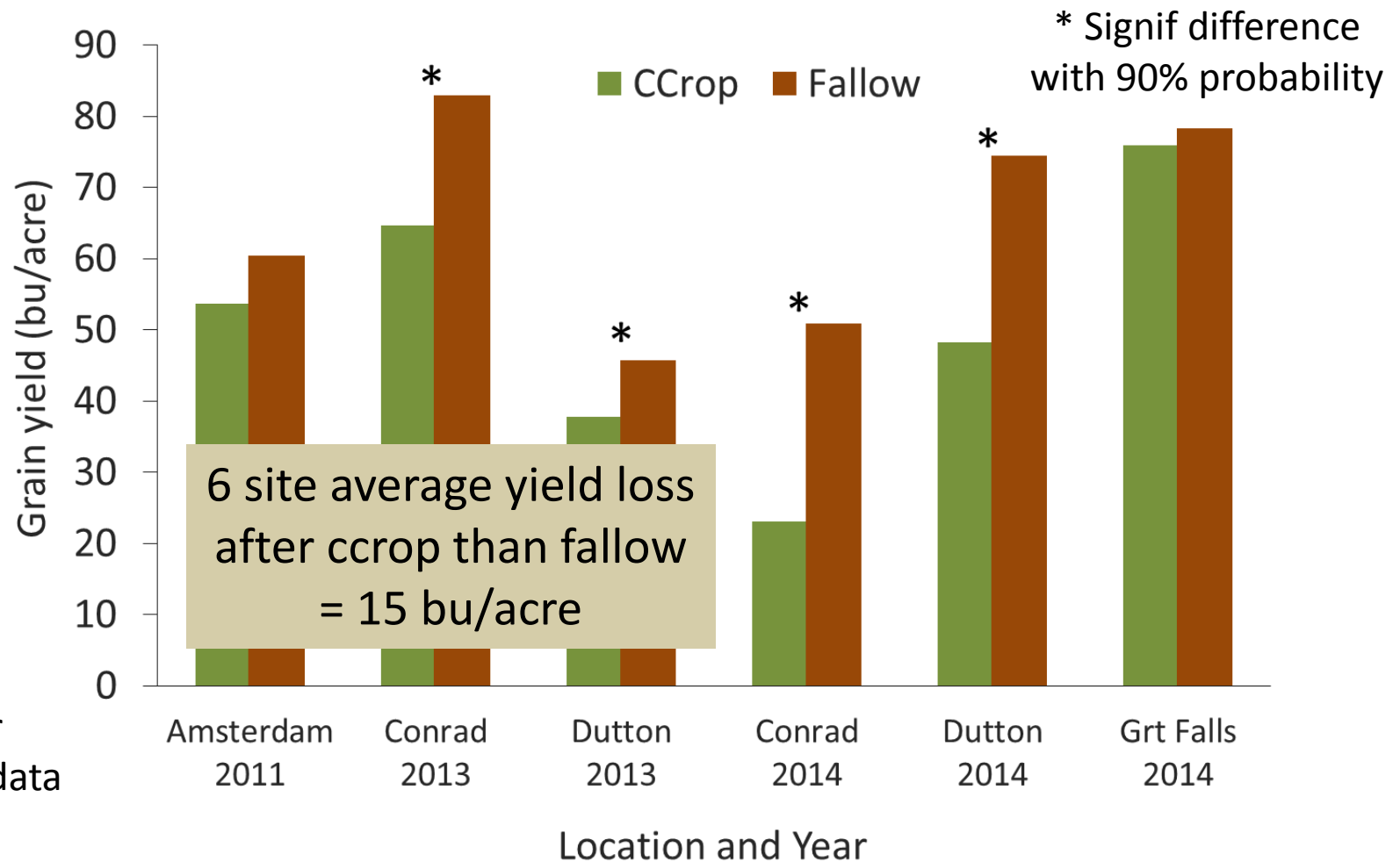
Cover Crop Cocktails Plot Study: Take home messages on yield and soil quality

- 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 between pea and 8-species mix after one cycle; not unexpected.
- After two cycles, no soil health differences between pea and 8-species mix, but CCs increased microbial activity.



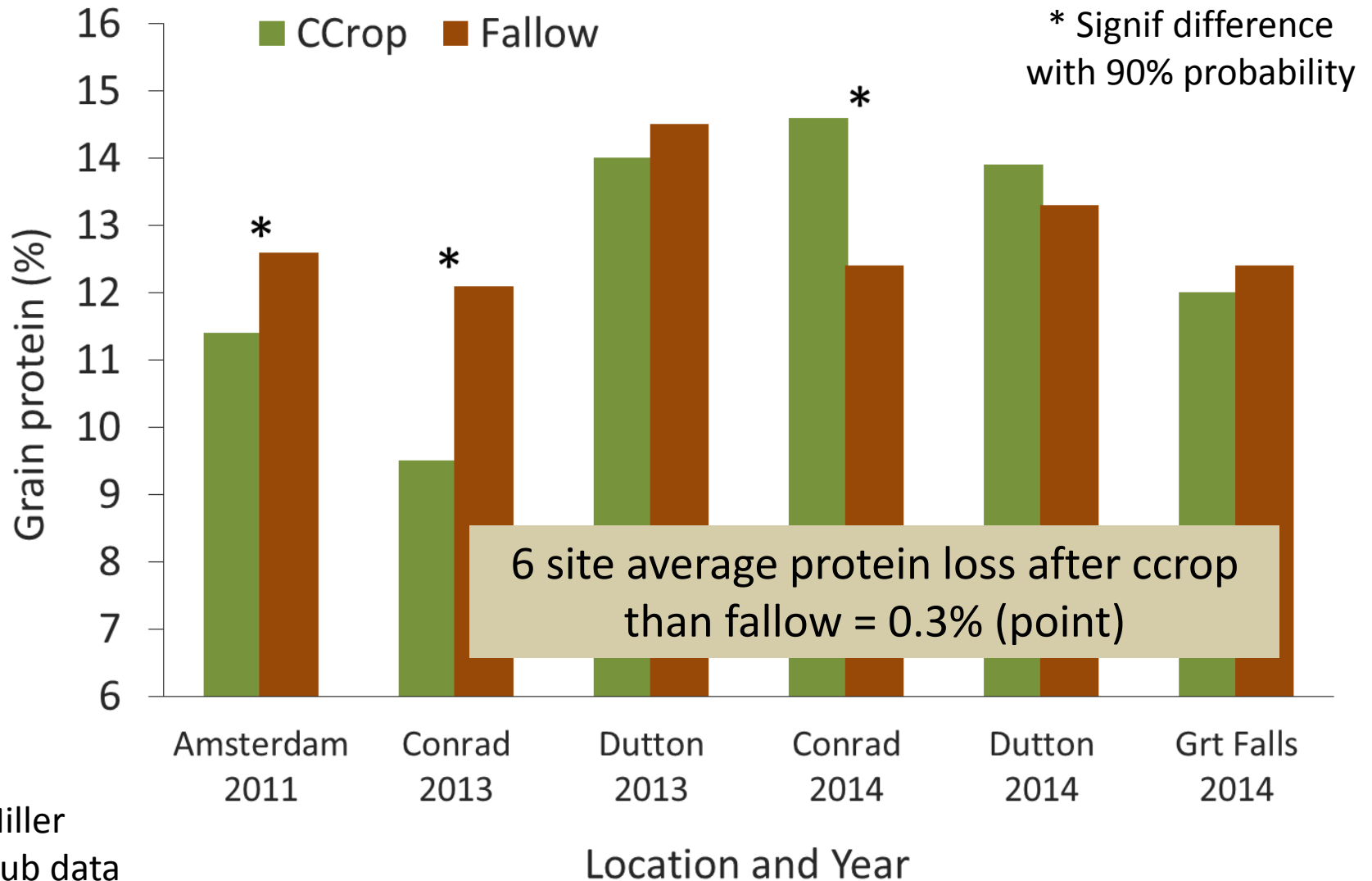
Questions?

Cover Crop Cocktail Farm Study: 1 rotation of mixed CC reduced grain yield in 4 of 6 production years



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

Cover Crop Cocktail Farm Study: 1 rotation of mixed CC produced varied grain protein results





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

- Spring wheat grain yield was lower after CC than fallow in four of six field-scale studies, and protein results were mixed.
- High water use from late termination was likely cause of yield differences.

Not a stellar outlook for cover crops in short term, what about long term? 8-year plot study



Legume or fallow year



Wheat year

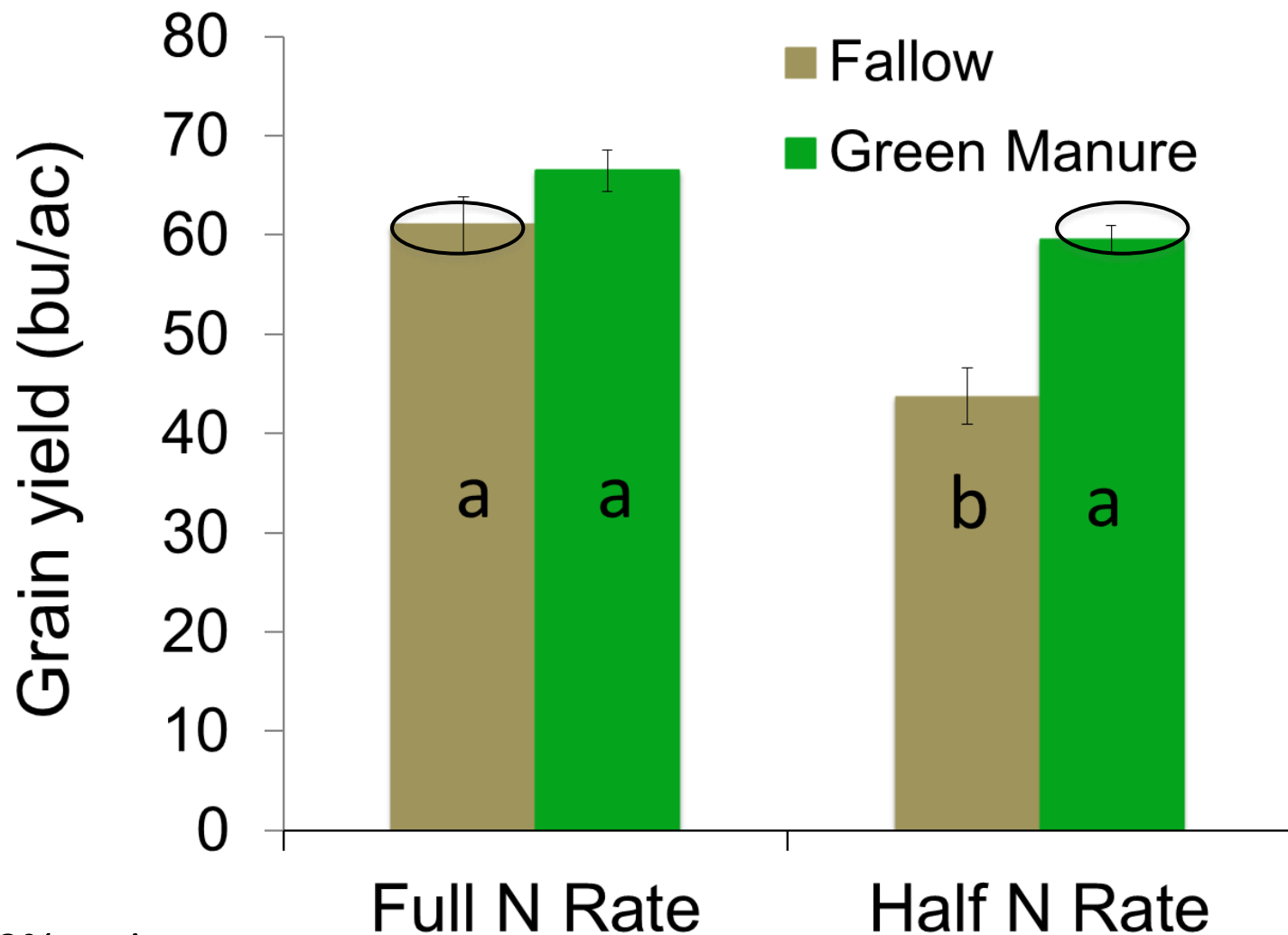


8-year Plot Study

- Long-term effects of no-till pea forage/legume cover crop-wheat vs. fallow-wheat
- ~16" annual precip on deep soils & ability to recharge soils
- 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 following CC and following fallow in 2004, 2006, 2008, and 2012, and large benefit of CC in 2010*

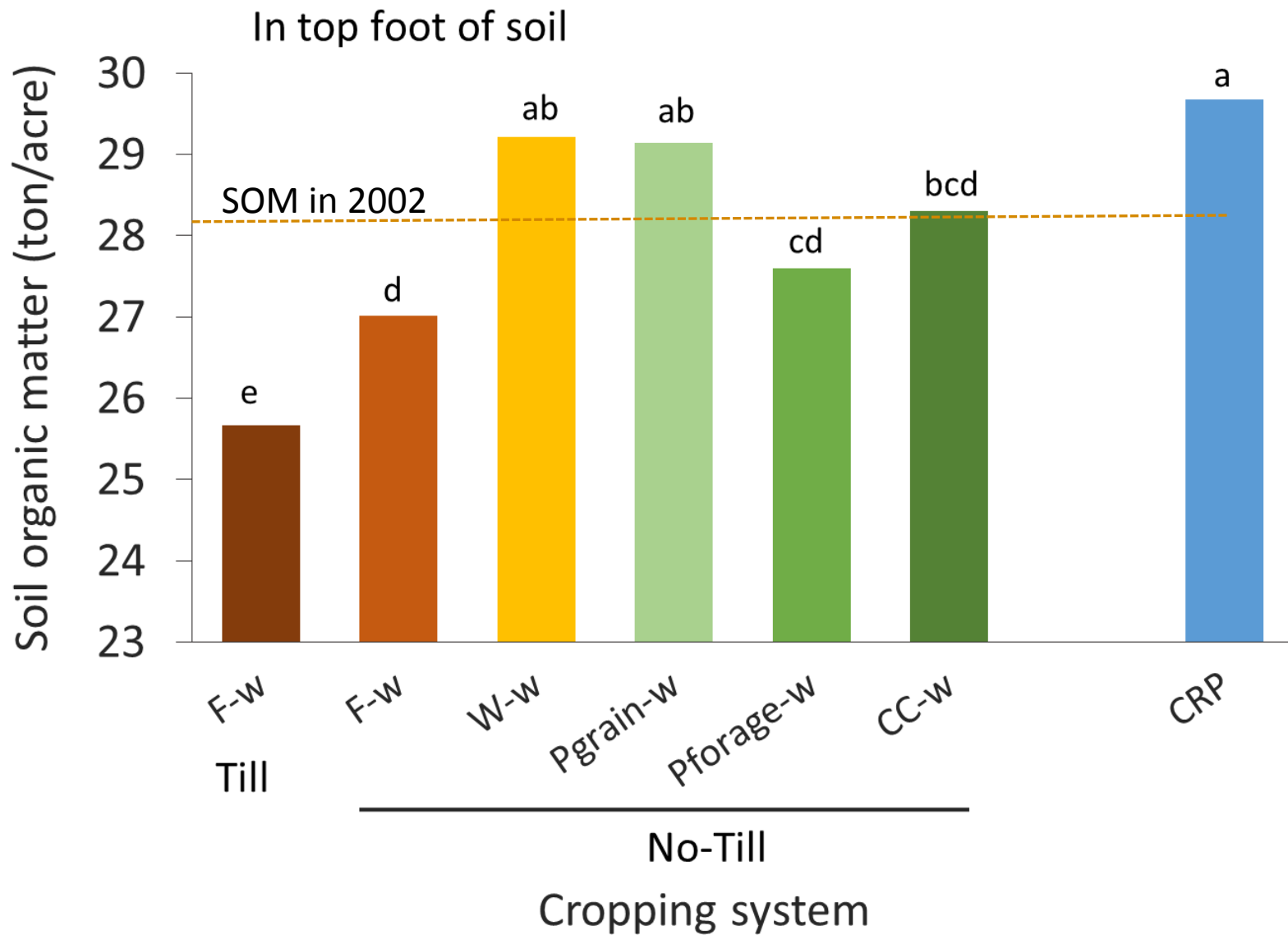


8 Year Plot Study: Grain yield in 8th year (2010)



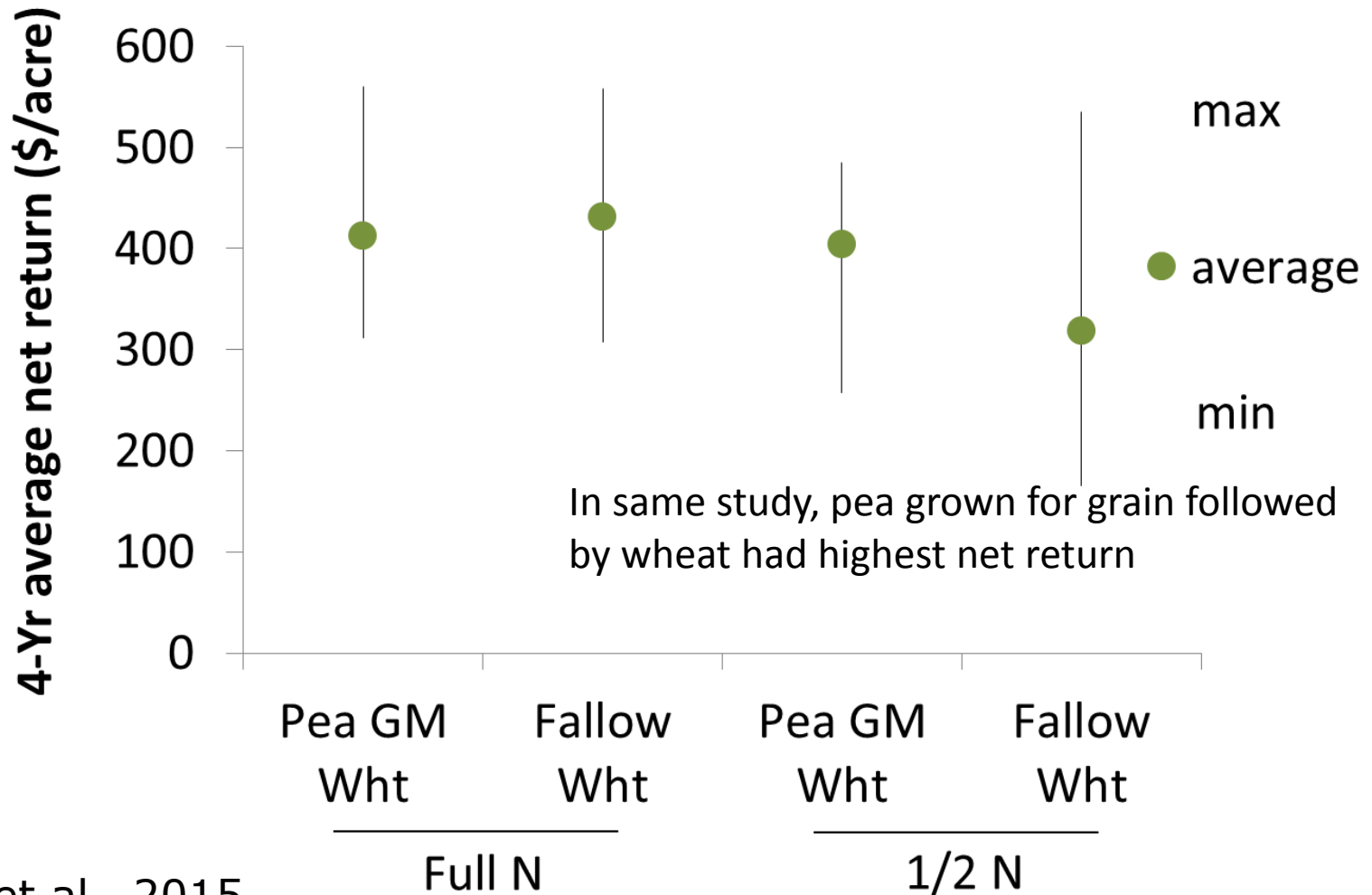
@ 12% moist

SOM can be built with recrop and CRP





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





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?

Economic options

- Grazing may provide more immediate economic return and increase the rate of change in soil health.

Currently under study at MSU-Northern and Bozeman (next talk).



- NRCS provides incentives for growing cover crops



Conclusions

- In short term (1 CC-cycle studies), grain yield is 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 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 crops provide resilience to uncontrollable factors such as weather and markets
- Cover crop value to soil health, subsequent crops, and possibly land value is expected to increase over time.

QUESTIONS?

For additional information on soil fertility topics including information on cover crops, and results from a MT survey on cover crops, see <http://landresources.montana.edu/soilfertility>