Nutrient Management of Legumes for Grain and Forage

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CCA Training, Huntley

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MONTANA STATE UNIVERSITY EXTENSION

AGRICULTURE

MAKING A DIFFERENCE IN MONTANA COMMUNITIES

Guesses on what's wrong with above peas?

Goals for today

- Identify major nutrient needs for pulse crops and perennial legumes
- Provide rate and placement suggestions
- Describe potential benefits of pulse crops in rotations

Questions for you

- Raise your hand if you or your producers grow peas or lentils
- Raise your hand if you or your producers raise alfalfa or sainfoin hay
- Raise your hand if you haven’t so far and you need a good stretch

Nitrogen: Generally not needed due to N fixation

- Poor N fixation if:
  - Improper inoculant , low temps, drought or excess moisture, > 35 lb total available N/ac
  - Low availability of other nutrients including phosphorus, potassium, sulfur, and iron
- Too much early N can produce excess vegetation and reduce seed yield
- If soil N < 15 lb N/ac, 10-15 lb starter N to the side of the seed or top-dressed may be helpful (takes up to a month for N fixation process to kick in)

Economics of Inoculant

Improper inoculation risks:

- Yield reduction
- Less N credit for next crop

If pulse crop fixes 10 lb N/acre for the following crop

- 10 lb N = 22 lb urea @ $500/ton = $5.40 of N/acre provided by pulse crop
- What's a typical inoculant cost per acre?
- Note: this doesn't include gains in pea yield.

Without healthy nodules, legumes don't fix N

Active nodules are red, rather than white inside

Check for active nodules 3-4 weeks after seeding.

Active nodules are red, rather than white *inside* though sometimes outside too.

If no active nodules then 10-20 lb N/acre top-dress may be justified


Not Fertilized
Fertilized w/ P, K, and S
ORG1 # 308 CDR
Winter Pea, Bozeman, 5/17/07

Phosphorus, Potassium and Sulfur Uptake

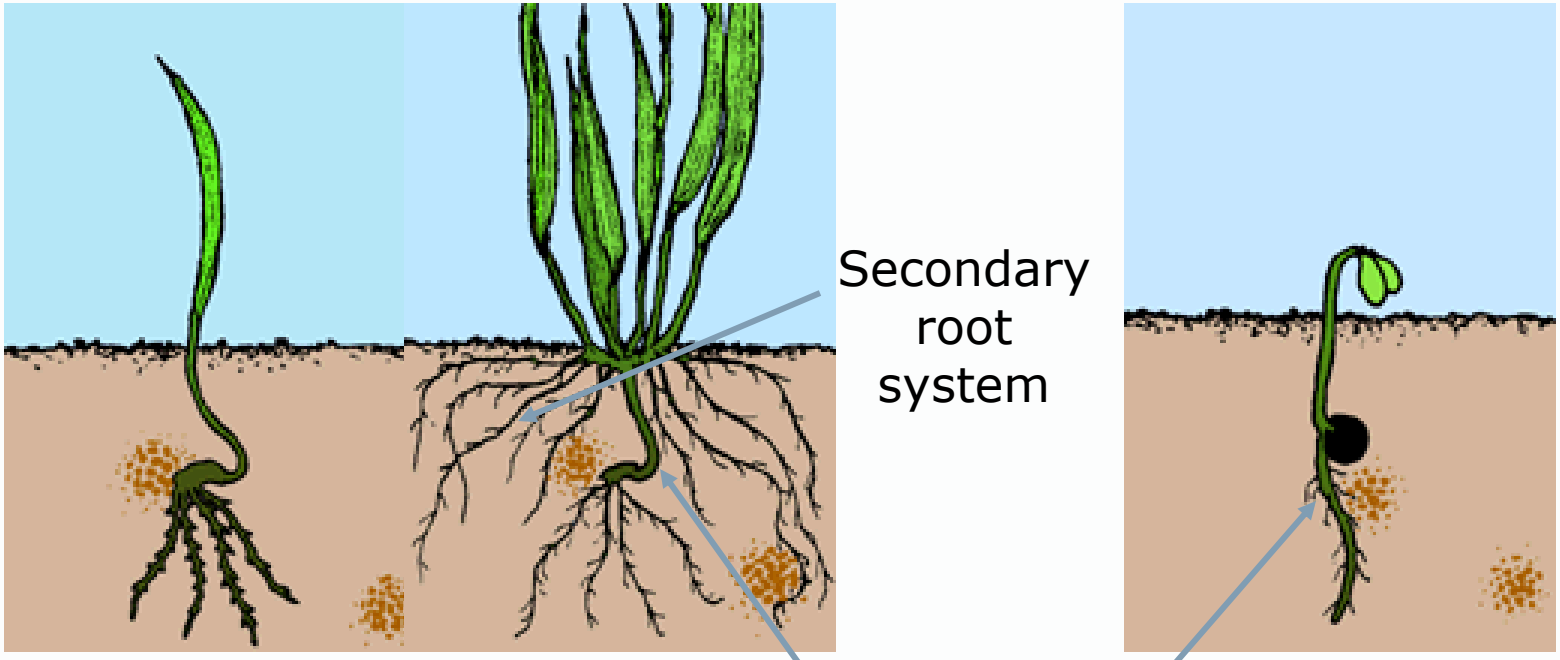
Nutrient	Peas, Lentils, Chickpeas	Wheat
	lb/bu (lb/ton hay)	
Phosphorus	0.67 (11)	0.62
Potassium	0.87 (32)	0.38
Sulfur	0.15	0.08

- P levels are often low in Montana (due to calcareous soils).
- K levels are often moderate to high in Montana. No research located on K and legumes in region.
- BOTH P and K needed for N fixation!
- S is need for efficient use of N

Rooting patterns and starter and deep band fertilizer placement comparing wheat to legumes

Wheat

Legumes



Montana Phosphorus Fertilizer Guidelines for Annual Legumes

Olsen P (ppm) 0 to 6 inches	Application rate (lb P_2O_5/acre)
4	30
8	25
12	20
16	15
Above 16	0 up to crop removal*

* Assume 2/3 lb P_2O_5 per bushel of grain

Why are P needs of annual legumes somewhat less than for small grains and oilseeds?

- Lower yields
- Annual legumes root shallower:

  Better able to take advantage of higher P levels in upper 6 inches
- Legumes lower soil pH, mobilizing P, however this benefit does not appear to carry over to the next crop (Rick et al. 2011)
- Small grains raise pH, lower P availability in MT.

Phosphorus placement

P placement depends on:

- Source

  MAP < 20 lb P_2O_5/acre (9" row spacing, good soil moisture)
  TSP < 26 lb P_2O_5/acre
  DAP use CAUTION = toxic to seedlings

- Soil

  Safe rates higher in heavy clay soils, soils with high SOM
  Safe rates lower in coarse and drier soils

- Equipment

  Use seeding/fertilizer equipment with wide openers if possible to disperse seed and fertilizer granule in the seed bed.

Phosphorus placement

- If P required is higher than safe seed placed – broadcast and incorporate before seeding or sub-surface side band next to seed.
- Consider applying more P with alternate crop to bank P for the pulse crop year.

P response

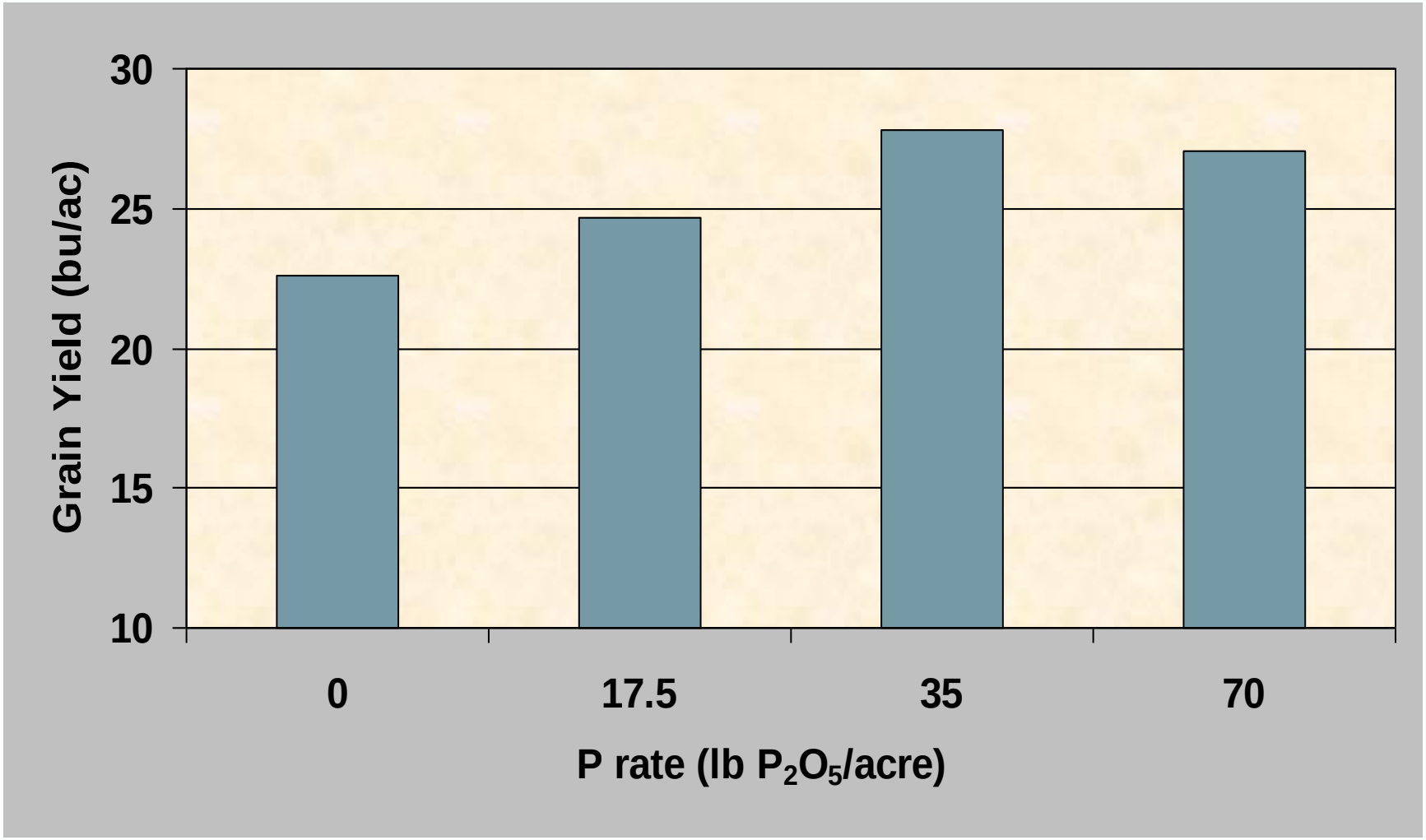
- P response better when soil P is low
- 2 studies in west-central Alberta
  1. Max yield with 40 lb P_2O_5/ac and no response when Olsen P > 9 ppm
  2. Max yield with 26 lb P_2O_5/ac and no response when Olsen P > 13 ppm
- P response was higher on loam than clay loam soils (Karamanos et al. 2003)

P increases N fixation and biomass

Using soil collected near Scobey, MT
(Olsen P = 6 ppm)

- P added at 16 and 32 lb P_2O_5/ac approximately *tripled* N fixation over non P fertilized peas
- P added at 16 and 32 lb P_2O_5/ac increased aboveground pea biomass by 45 and 60%, respectively (likely due to increases in both N and P).

Effect of P on Spring Pea Yield (2004-2005) Sidney, MT



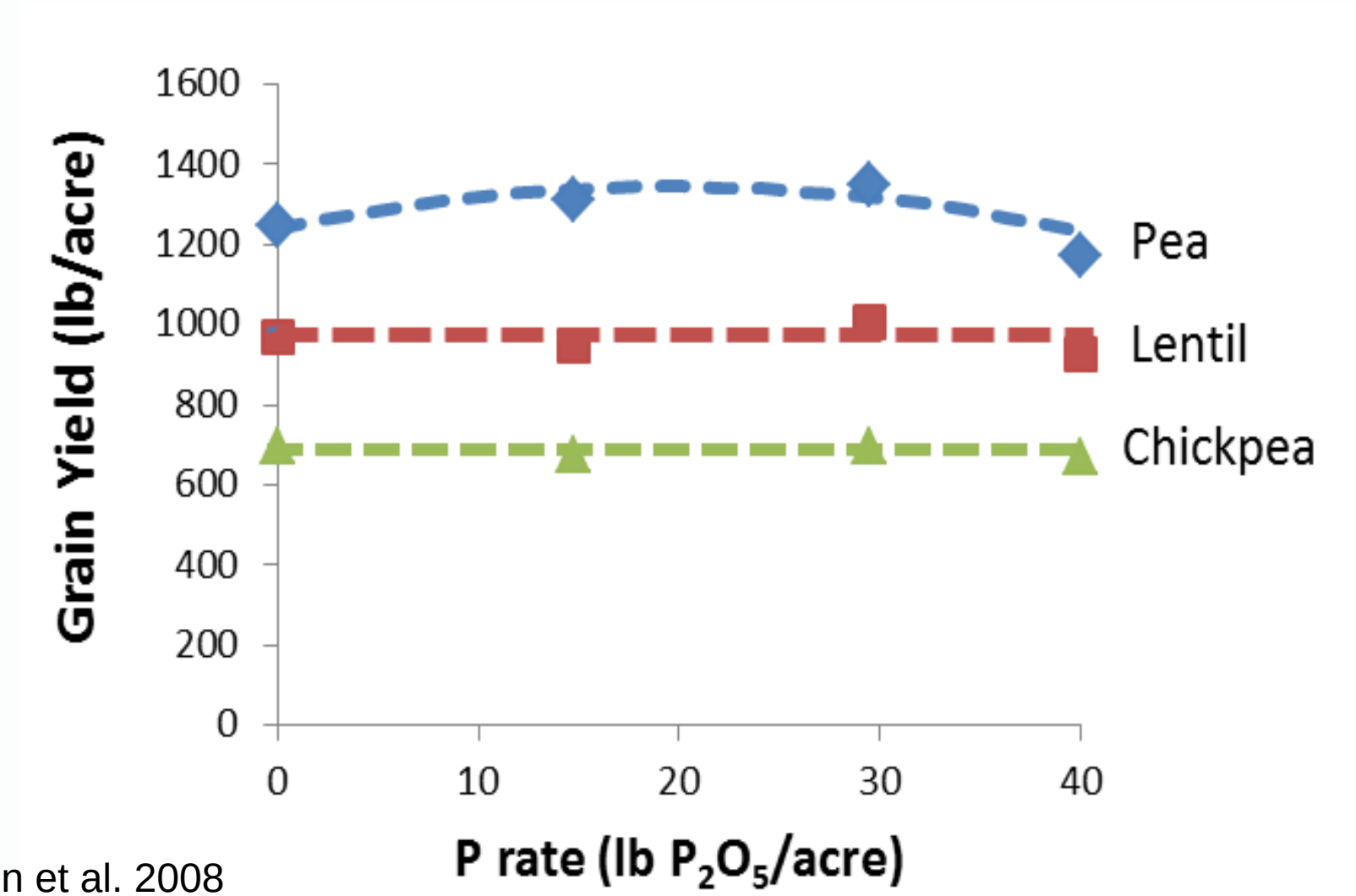
Olsen P = 10-14 ppm

Data from J. Waddell

Increasing pea yield increases soil nitrate

Adding 35 lb P_2O_5/ac at Sidney increased soil nitrate-N the following spring by 50% over peas with no added P, possibly due to N fixation differences.

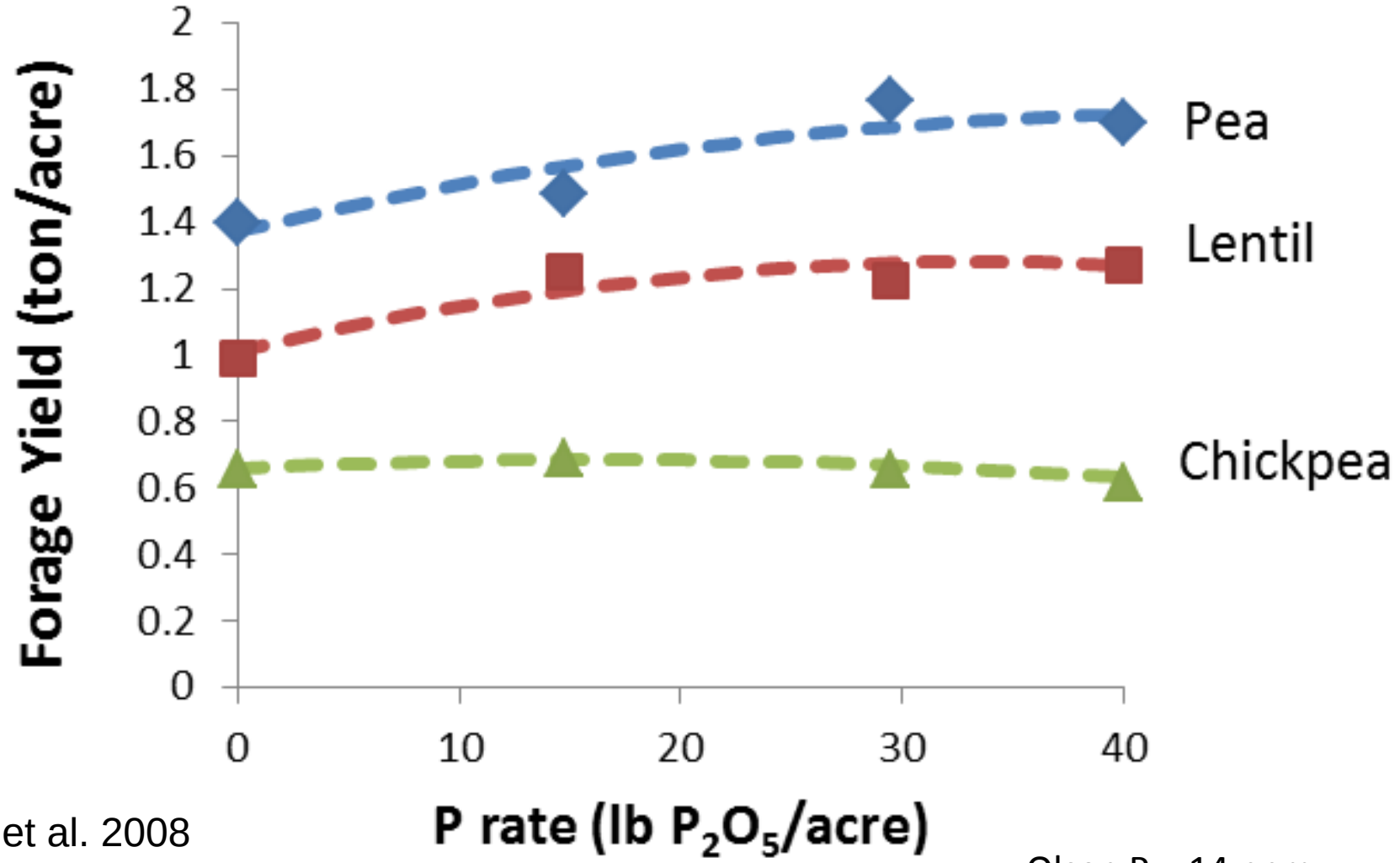
Effect of P on Dryland Pulse Crop Grain Yield



Wen et al. 2008
Moccasin, MT

Olsen P = 14 ppm

Effect of P on Dryland Pulse Crop Forage Yield



Wen et al. 2008
Moccasin, MT

Olsen P = 14 ppm

Take home messages on P

- Annual legumes need similar amounts of P PER bu than wheat.
- P is necessary for N fixation.
- Legumes are better able to access soil and fertilizer P than small grains.

Questions?

Potassium

- Use soil test or crop removal rate
- Best broadcast and incorporated pre-plant or banded at planting.
- Seed placed N+K_2O should be < 15 lb/ac

  E.g. 50 lb 11-52-0 as starter = 5.5 lb N/ac

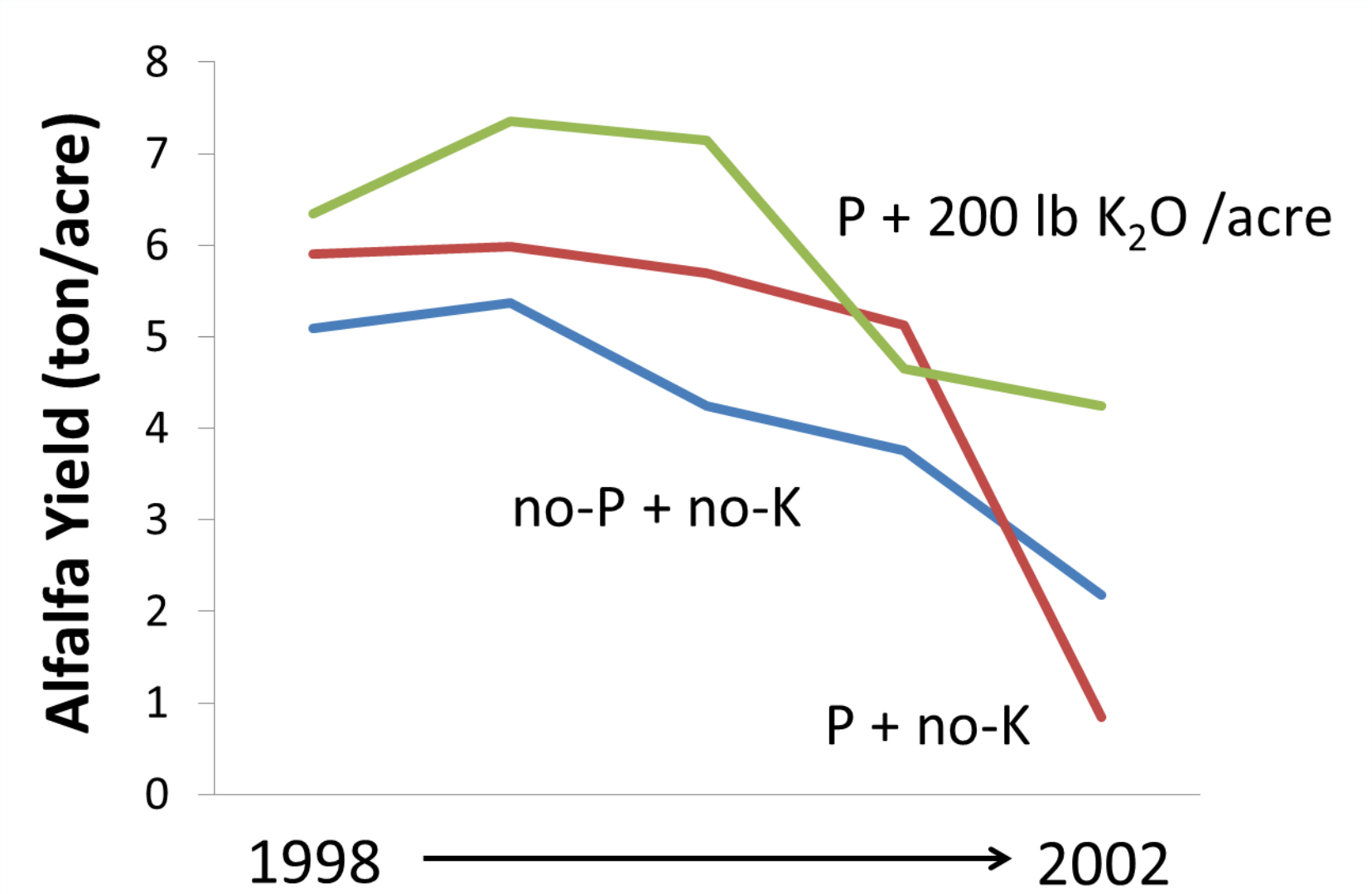
  15-5.5 = 9.5 lb/ac limit on K_2O if applied with seed (9” row spacing with good soil moisture)

Montana Potassium Fertilizer Guidelines for Annual Legumes

Soil Test K (ppm) 0 to 6 inches	Application rate (lb K_2O/acre)
100	35
150	30
200	25
250	20
Above 250	0 up to crop removal*

* Assume 0.87 lb K_2O/bu of grain

P and K balance is important in long term



Indiana, Berg et al. 2003

Average of annual P at 50, 100, and 150 lb P_2O_5/acre

Sulfur (deficiency common this year)

- Soil tests are not reliable for S
- Base S on prior crop performance, S removal rate (0.15 lb S/bu seed) or tissue concentration (varies by crop)
- Elemental S can be used to bank S. About 70 lb S/ac before canola in canola, barley, pea system provided enough for the pea rotation 3 years later (sulfate fertilizer did not)
- Sulfate S rates
  - 15-20 lb/ac at planting if often see S deficiencies
  - 3-5 lb S/ac as granular or liquid as rescue treatment

Plant tissue S concentrations

Leaf S concentration at which 90% of maximum yields were obtained.	
Crop	**Plant tissue S concentration (%)**
Chickpea	0.18
Lentil	0.29
Field pea	0.12
Sampling 2nd to 4th mature leaf at 7th leaf stage, 4 weeks after seeding. Huang et al. 1992 and Gupta and MacLeod 1984	

Conclusions on nutrient management of pulses

- Inoculation and adequate nutrients maximize N fixation. N benefits from legumes will be higher when soil N is low, seed is inoculated, and P, K, and S are adequate.
- Phosphorus has been shown to have both positive and neutral results on pea and lentil yields, but response should be higher on low P soils, and on pea forage.

Conclusions on nutrient management of pulses (cont.)

- Potassium needs are high for legumes, partly b/c needed for N fixation, but little research has been conducted on pea or lentil responses to K.
- Elemental S can be applied to last for several years or in-season
- With high pulse prices, maximizing yield with fertilization can easily pay for itself.

Questions so far?

Potential benefits of pulse crops and legume green manures in rotations

Pulse crops replacing fallow could:

- Reduce the need for N fertilizer
- Increase subsequent wheat protein
- Improve soil health
- Provide higher economic return

However, water use by legume crop may reduce yield of following crop in some years.

Potential N fixation under irrigated conditions

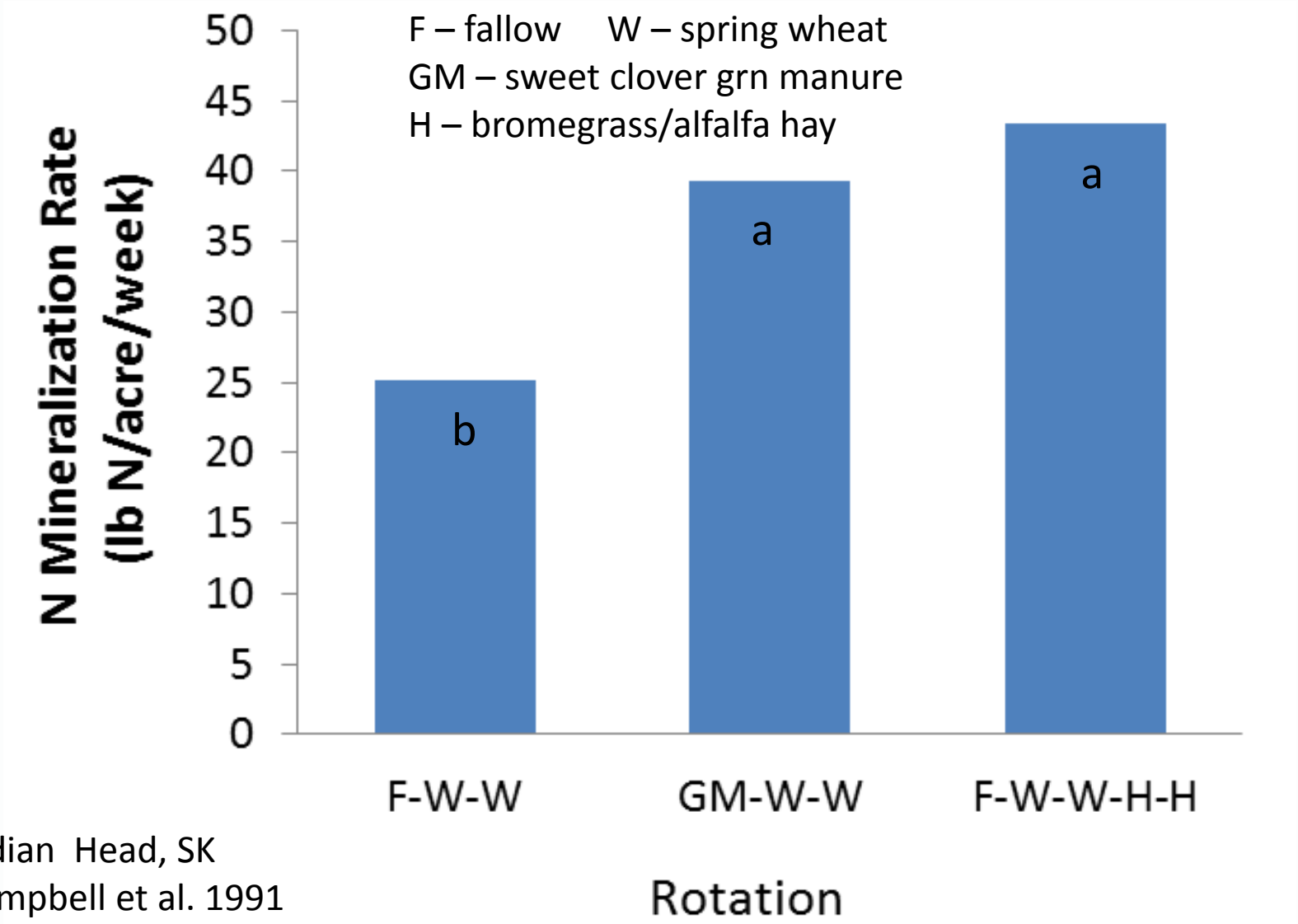
N fixed in inoculated irrigated legumes in Southern Alberta		
Legume	Plant-N from Atmosphere (%)	N Fixed (lb/acre)
Alfalfa	80	267
Sweetclover	90	223
Field pea	80	178
Lentil	80	134
Chickpea	70	108
Dry bean	50	62

Adapted from RJ Rennie, Ag. Canada Research Station, Lethbridge, Alberta

Nitrogen Benefits

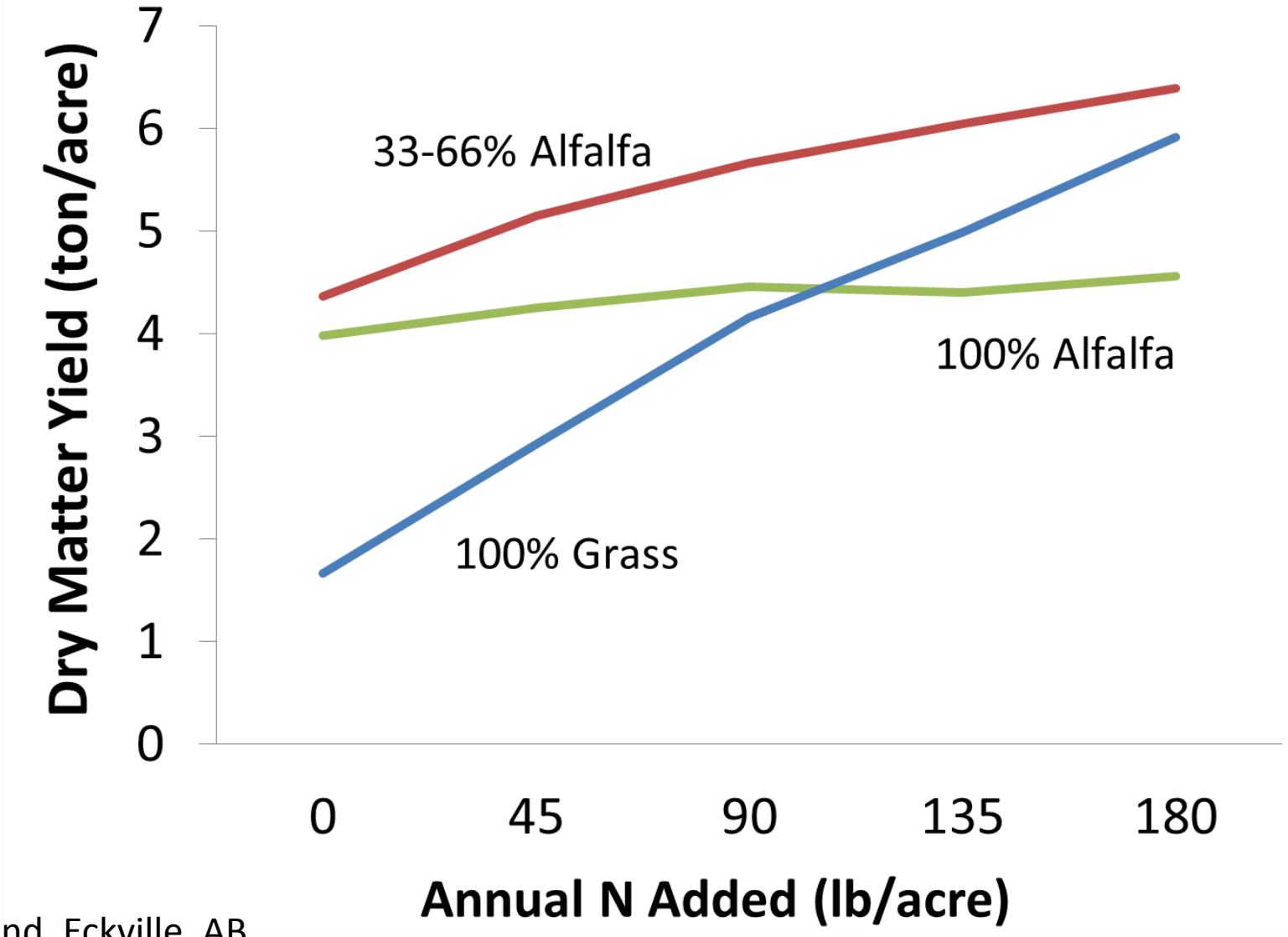
- Peas and lentils CAN ‘fix’ about 2-4 lb N/bu.
  Ex: 50-100 lb N/acre for 25 bu crop.
- Over 1/2 of this is removed at harvest.
- Credit TO NEXT CROP is between 0 and 20 lb N/acre.
  Where did rest go?
- If replacing a small grain or oilseed with a legume, bigger N savings will be in legume year.
- If replacing fallow with legume, bigger N savings will be in long-term.

Soil N added with perennial legumes in rotation for 30 yrs compared to F-W-W



Indian Head, SK
Campbell et al. 1991

Alfalfa-grass mix benefits total yield at all N rates and more N needed on straight grass

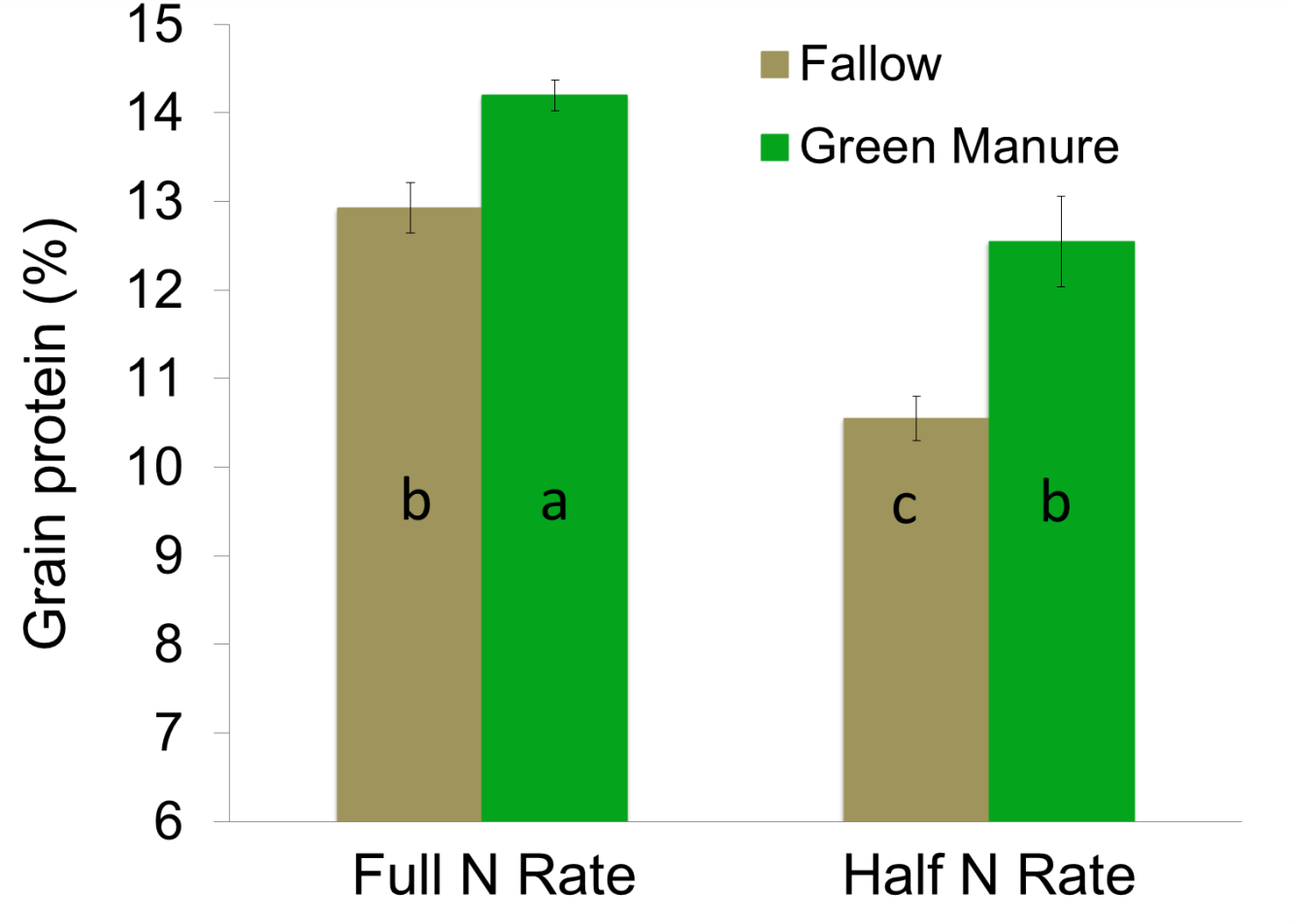


Dryland, Eckville, AB
Malhi et al. 2004

Legume green manure (LGM) study near Bozeman

- No-till pea forage/legume green manure-wheat vs. fallow-wheat
- Pea forage grown in 2003, 2005, 2007 and pea green manure grown in 2009, terminated at full pod
- Spring or winter wheat planted in even years. 2010 was wettest of wheat years.
- 2 N rates: Full (3 lb available N/bu) and ½
- *No wheat yield or protein differences between after fallow and pea forage/pea manure in first 6 years of study (3 pea cycles)*

Spring wheat grain protein in 8th year



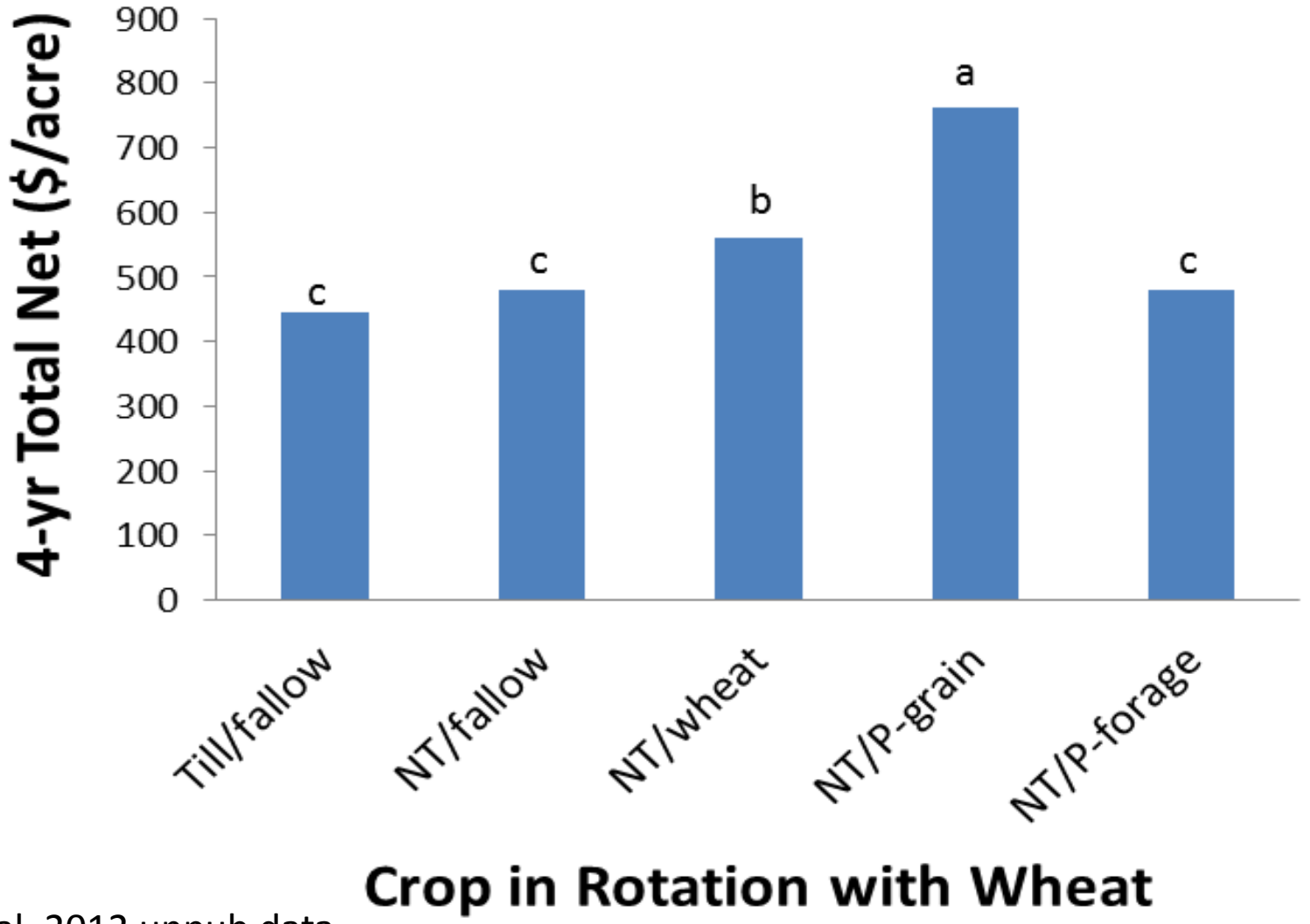
* N fertilizer rates	*Fallow-Wheat*	*LGM-Wheat*
Full N rate (lbs/ac)	124.00	83.00
Half N rate (lbs/ac)	39.00	0.00

Pea green manure after 4 LGM-wheat rotations saved **124 lb N/ac** compared to fallow.

Take home messages

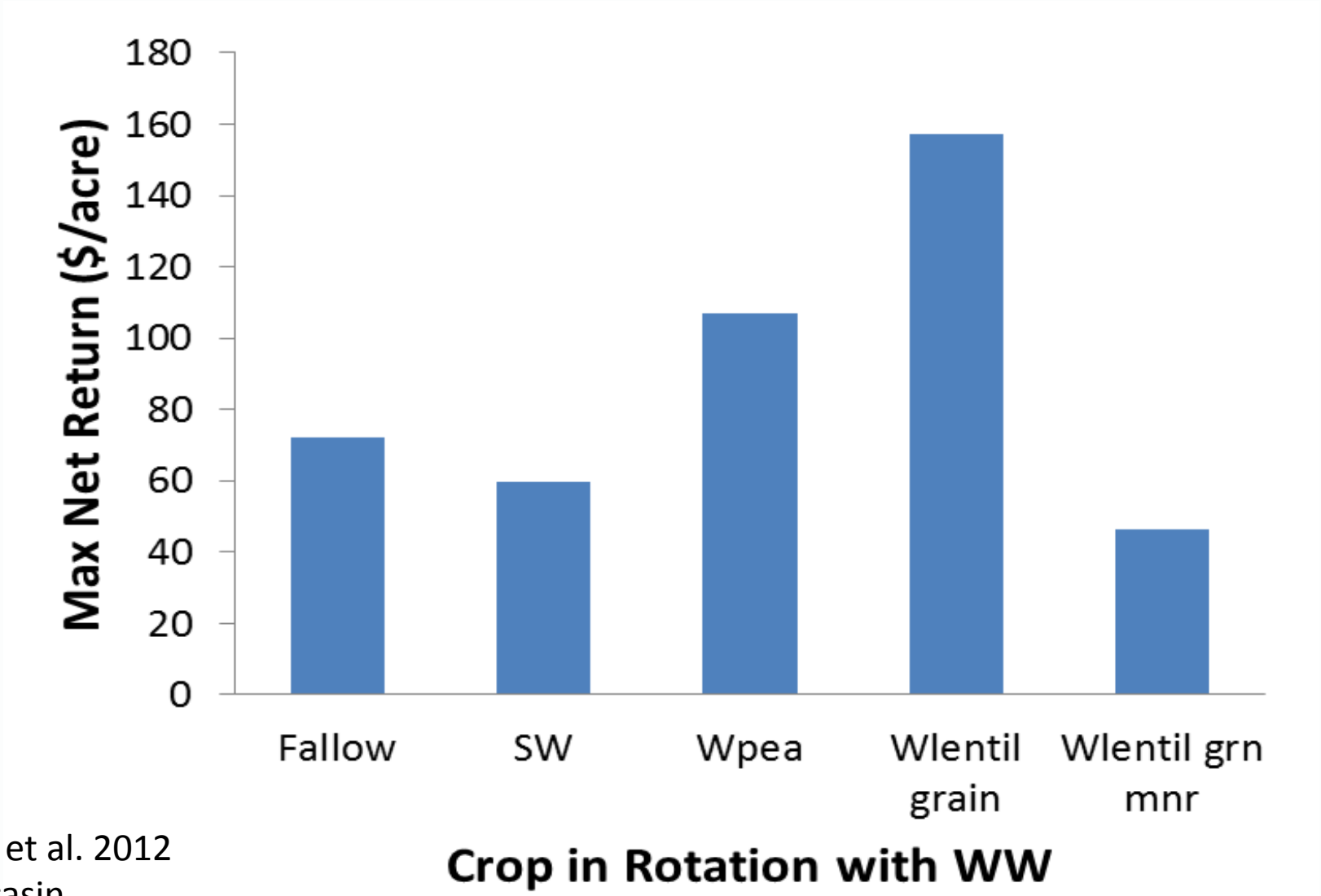
- After 4 two-year cycles, wheat grain yield and protein were higher after LGM than after fallow.
- Over 100 lb N/ac was saved in the fourth cycle of LGM-wheat compared to fallow-wheat.

Economics of integrating pulse crops into wheat systems



Bozeman
Miller et al. 2012 unpub data

Economics of integrating pulse crops into wheat systems



Chen et al. 2012
Moccasin

How do I maximize N benefit?

- Seed legume into soil with low available N
- Inoculate, especially if field never had legumes
- Provide sufficient phosphorus (P) and potassium (K)

Summary

Over the long term:

- Including pulse crop rotations, especially as green manure, in small grain systems can increase small grain yields, protein and reduce the amount of N fertilizer required.
- Adding alfalfa to perennial grass increases yields and reduces N fertilizer required.
- Adding a perennial forage rotation increases soil N and reduces potential leaching loss.

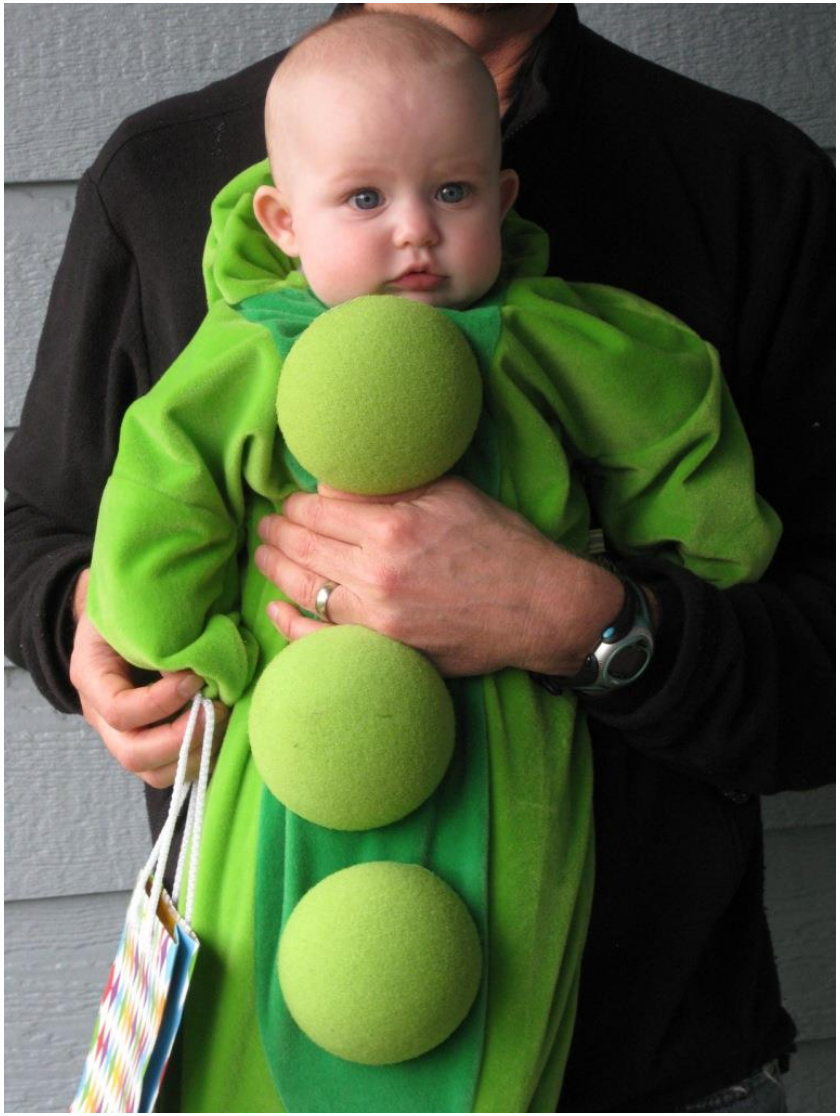
For additional information

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.

With good soil fertility you can grow big pods



Questions?