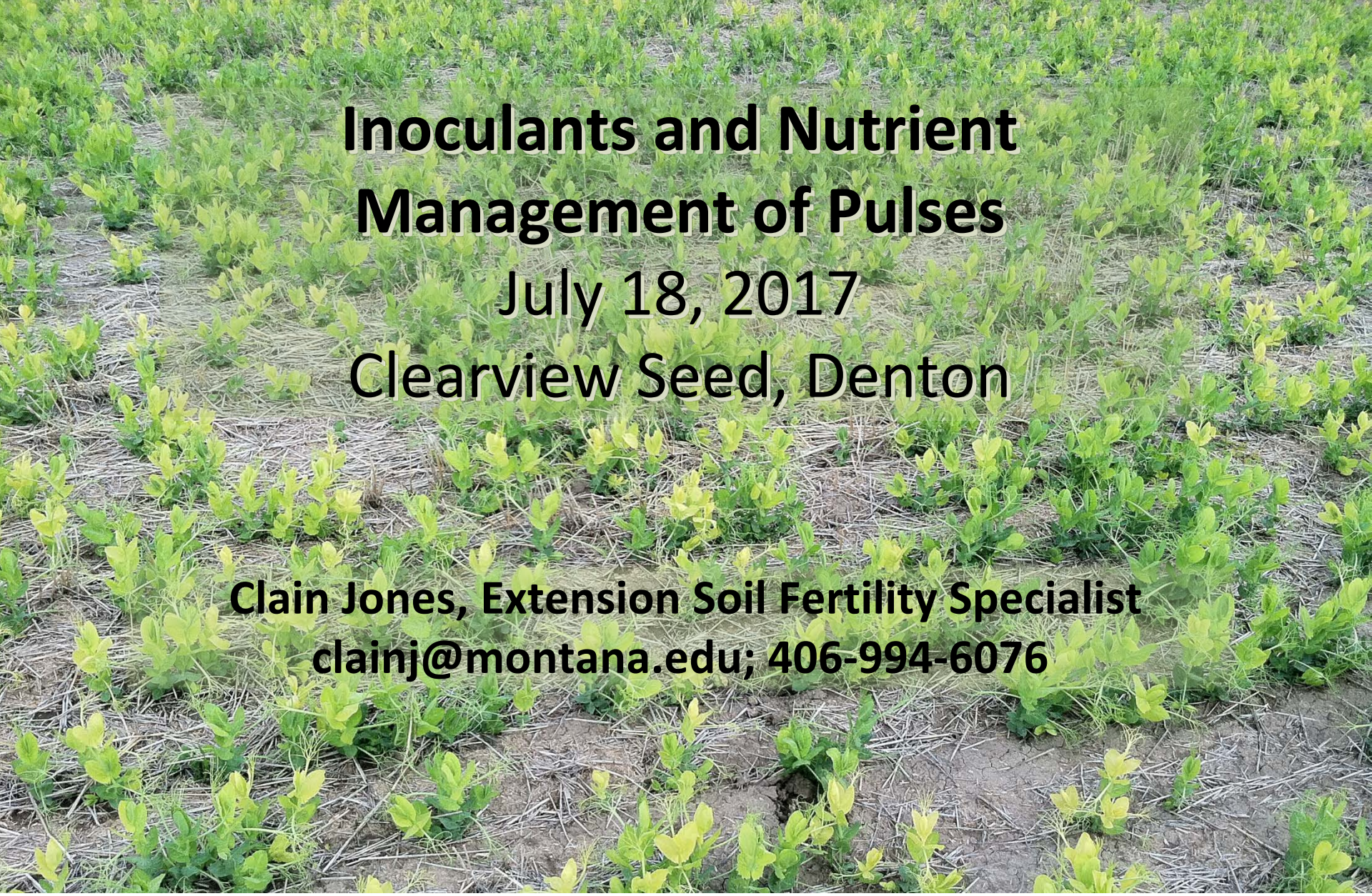

# Inoculants and Nutrient Management of Pulses

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Clearview Seed, Denton

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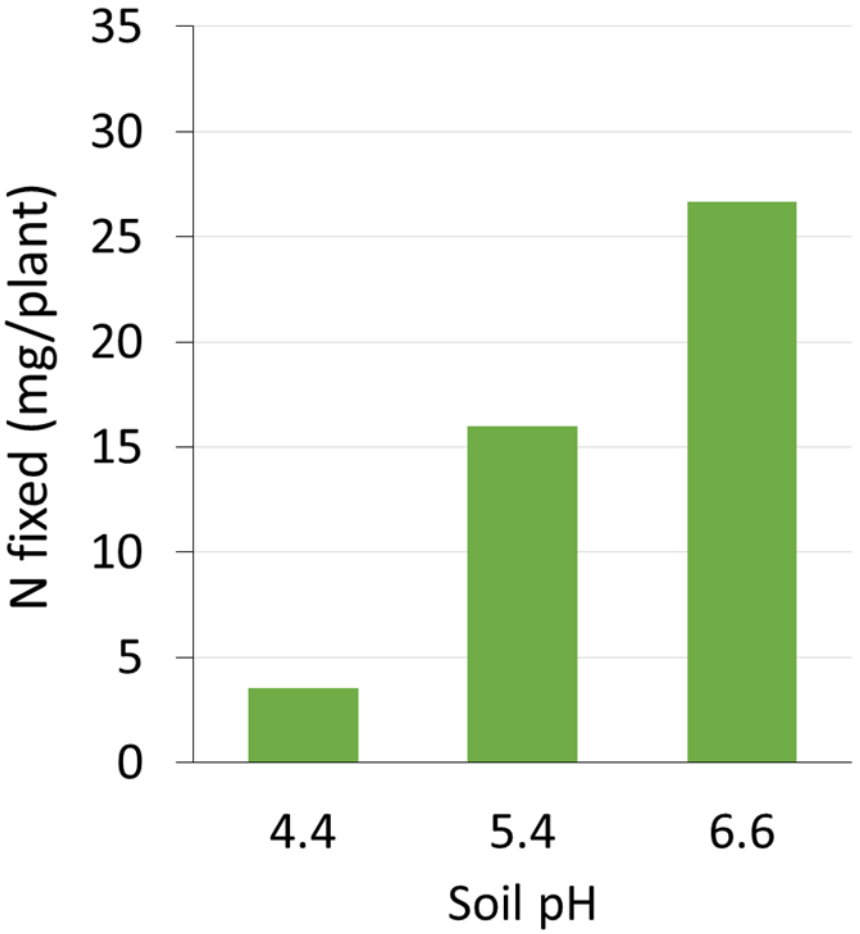
# Objectives

Provide you info on pulse fertility

- Requirements for N-fixation
- N fertilization and inoculation effects
- P, K, S needs
- Fertilizer rates, placement, timing

# Uncontrollable factors negatively affecting nodulation & N fixation

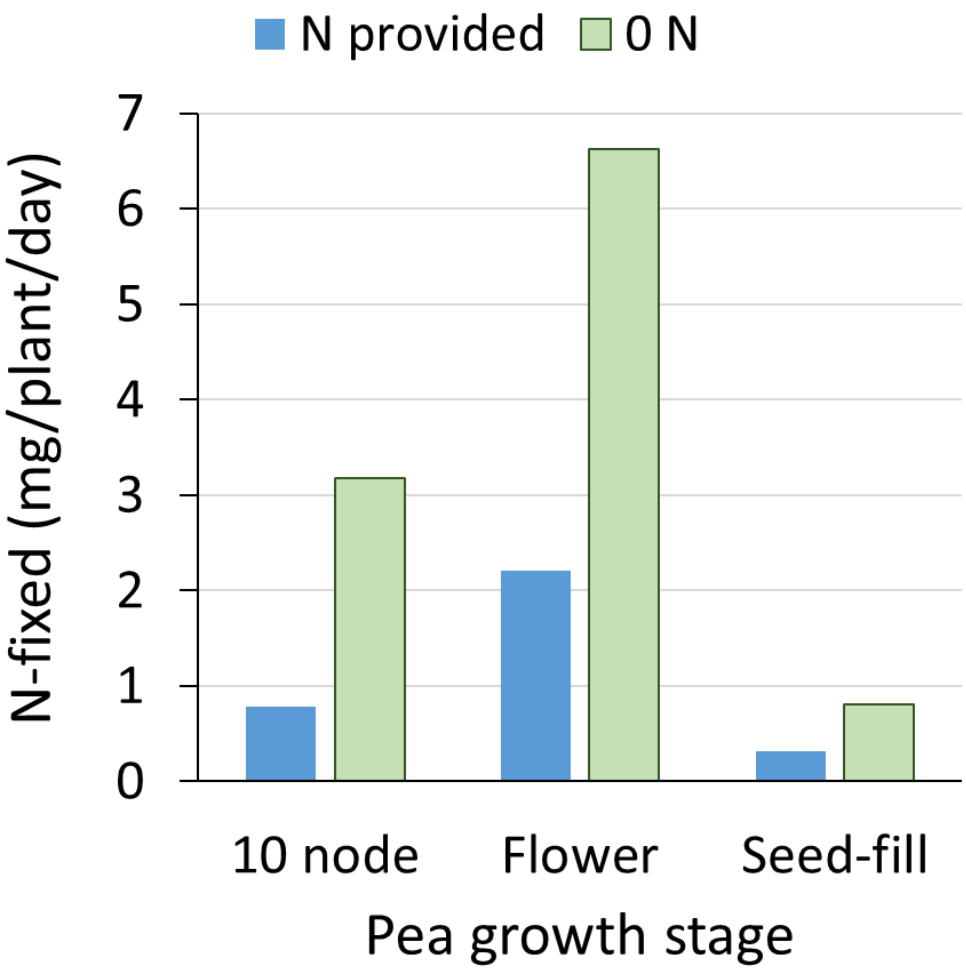
- Extreme soil temps
- Waterlogged or dry soil
- Soil pH < 5.5, > 8 inoculant strains differ in tolerance
- Saline soils
- Maturing plants




Rice et al., 2003, greenhouse

# Practices to improve nodulation & N fixation

- Use species-specific inoc
- Keep inoc cool, dark; granular more reliable than liquid
- Apply proper inoc rate
- Avoid fertilizer salts (mixing with fertilizer can kill bacteria)
- Adequate P, K, S
- Too much soil N inhibits
- No-till = retained soil moisture




Voison et al., 2003
greenhouse study

## Pulses require N by either:

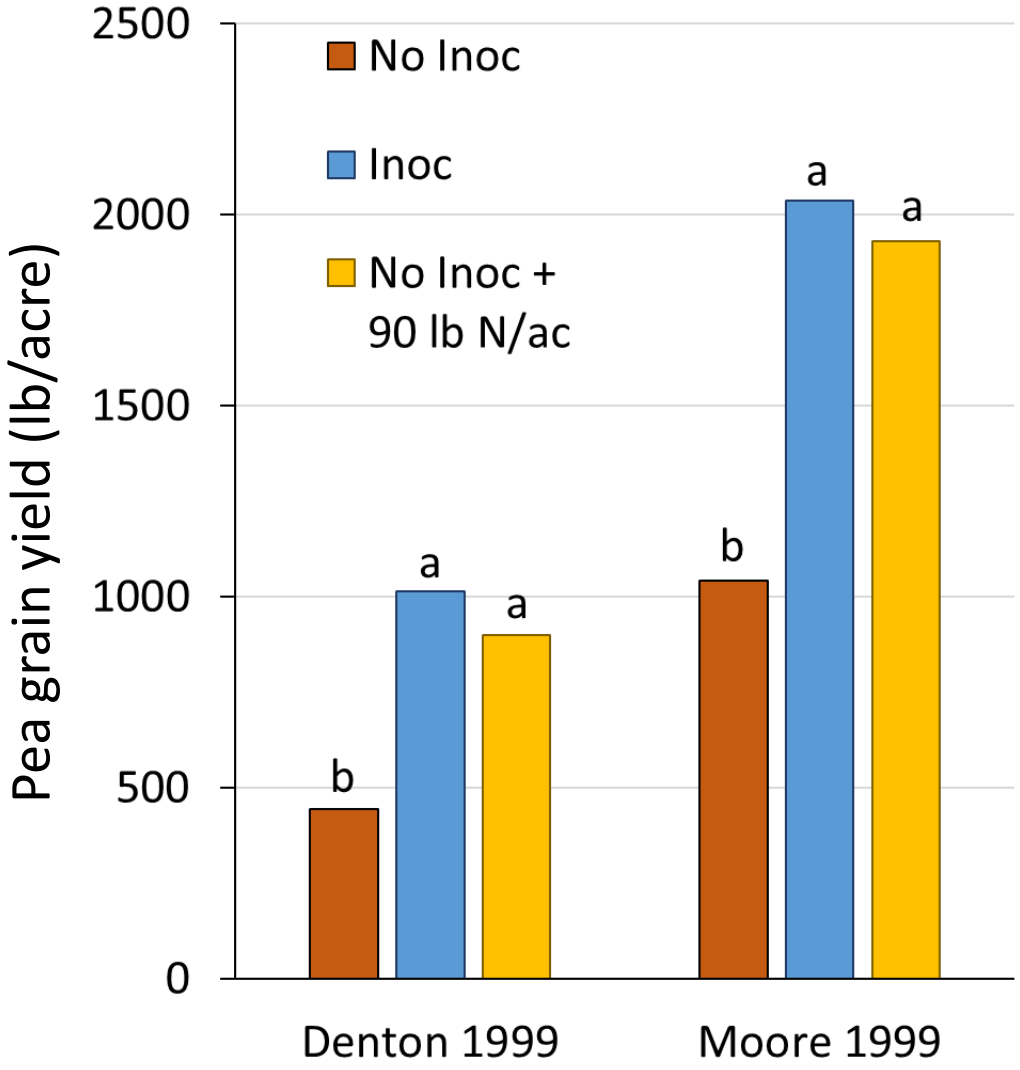
- Inoculation, especially on sites with no recent pulse history
- Fertilizer

### "New" fields:

Granular = more effective

### Field with pulse history:

Liquid or peat = less expensive




McConnell et al., 2002, stat letters (a, b) are w/in location-year

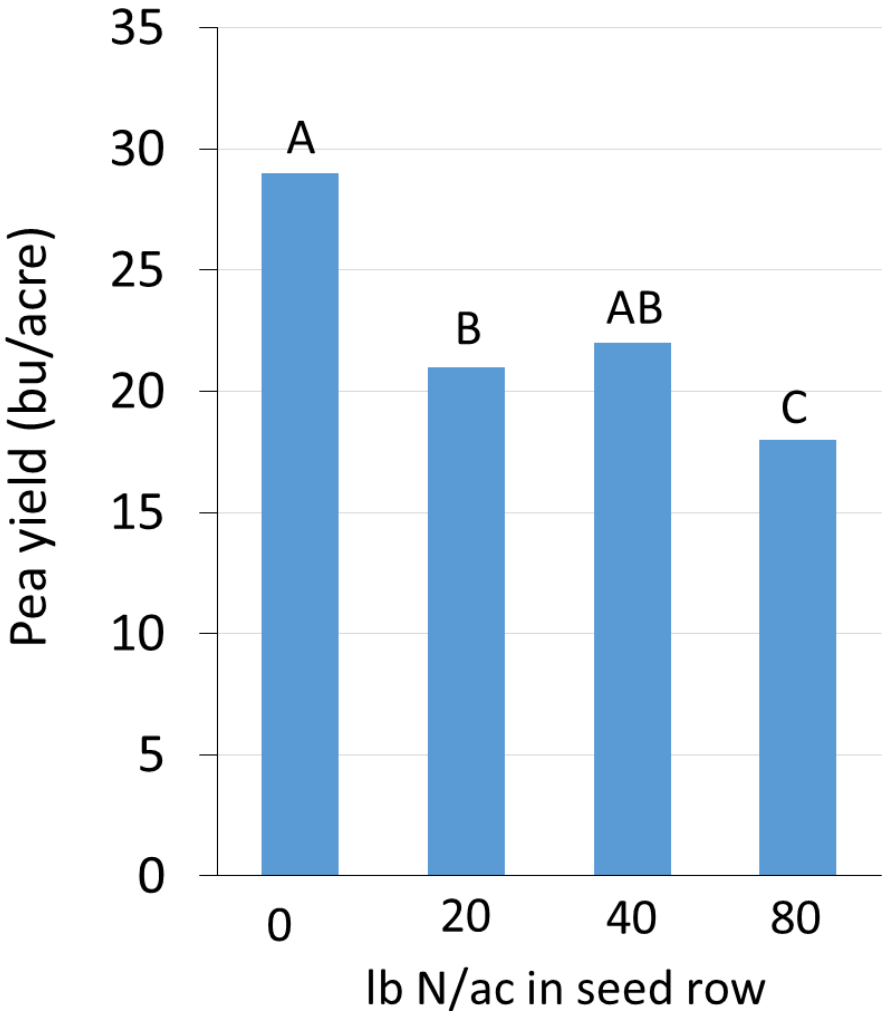
**Fields had no recent pulse history**

# If legumes fix N, why add fertilizer N?

- Nodulation is carbon expensive, requires healthy plants
- Little N contributed by nodules until 3rd node, must come from top 12” of soil
- Rhizobial fed plants take 2-3 weeks longer to get going
- If insufficient N, plants get ‘stuck’ – can’t grow to feed nodules, nodules aren’t actively providing N for growth
- Insurance against nodule loss to pea leaf weevil
- N-fixation stops if soil nodule dries up, but growth optimized if there is soil N

# How much seed row N?

- Too much N
  - inhibits nodulation
  - get excess vegetation
  - reduced yield
- Aim for 10-15 lb total available N/ac (soil + fertilizer) in top 12” in spring
- Place to side of seed row




Huang et al., 2017 in press, Moccasin

# Does granular inoculant (GI) pay off?

Yields usually go up, but not always enough to offset the cost of inoculant. Considerations?

- Soils high in N (McKenzie et al., 2006)
- Fields with long or recent history of inoculation
- Dry soils – rhizobia die and water is limiting yield (McKenzie et al., 2006)
- Premium for protein? GI tends to consistently increase protein (data not shown). Protein may become a factor in price paid for pulse grains.

# Rescue N

- If have yellow lower leaves (N deficiency) dig and look for rosy red nodules
- SK suggests 40-50 lb N/ac topdress
- Yield gain may not offset N cost
- Need water/rain to move N into soil

Image: C. Jones

Image: Flicker  Pennstatelive

Questions on N?

*On to S, P and K*


Not Fertilized
Fertilized w/ P, K, and S
ORG1 # 308 CDR
Winter Pea, Bozeman, 5/17/07
Image by T. Rick

# Is this plant N deficient?

- Sulfur (S) deficiency is yellow upper (new) leaves
- S is necessary to take up N and make protein
- Soil tests are not reliable for S
- Base S on prior crop performance, S removal rate (0.15 lb S/bu) or tissue concentration (varies by crop; see *MT Cool Season Pulse Production Guide* or The Soil Scoop: *Soil Fertility for Pulse Crops*)

# Sulfur fertilization

## Preventive

- Bank elemental S. 71 lb S/acre before canola in canola, barley, pea system provided enough for the pea rotation 3 years later (Wen et al., 2003, SK)
- Sulfate S: 15-20 lb/acre at planting (<18 lb/acre in seed row)
- Liquid S: to the side of seed row at <18 lb/acre (Ahmed et al., 2017, SK)
- Save the seed row for P

## Rescue

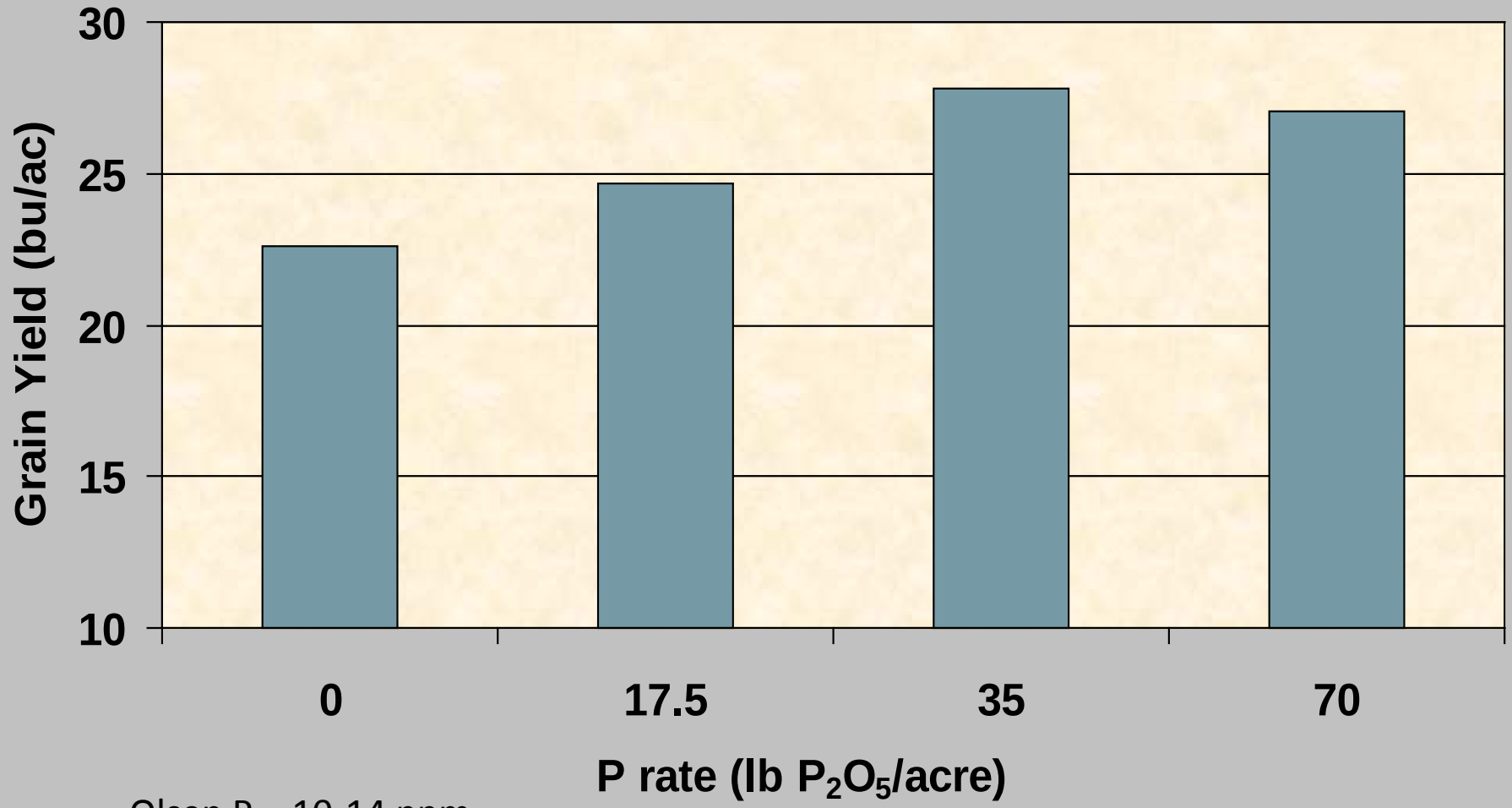
- 3-5 lb S/acre as granular or liquid

# Montana phosphorus fertilizer guidelines for annual legumes vs winter wheat

| Olsen P (ppm) 0 to 6” | Annual legume application rate (lb $P_2O_5$/acre) | W wheat application rate (lb $P_2O_5$/acre) |
|---|---|---|
| 4 | 30 | 50 |
| 8 | 25 | 45 |
| 12 | 20 | 40 |
| 16 | 15 | 35 |
| Above 16 | 0 up to crop removal* | |

* Assume 2/3 lb $P_2O_5$ per bushel of grain

# Effect of P on spring pea yield (2004-2005)




Olsen P = 10-14 ppm

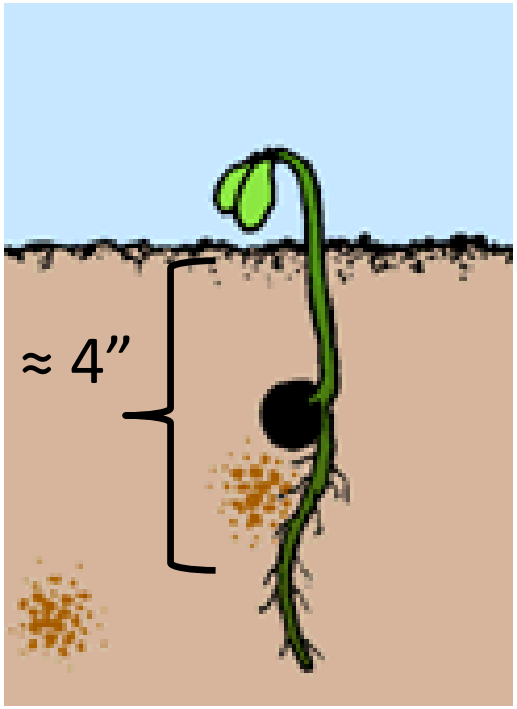
Data from J. Waddell, Sidney, MT

# P response – depends on species and variety

- P response better when soil P < 9 ppm, add 30-40 lb $P_2O_5$/acre (Ffact No. 38; McKenzie et al., 2001; Karamanos et al., 2003)
- At soil P > 13 ppm, up to 15 lb $P_2O_5$/acre as maintenance amount ≈ max safe seed placed rate.
- P is more likely to pay off with pulse forage than grain when soil P is near adequate (Wen et al., 2008)
- P response loam >> than clay loam soils (Karamanos et al., 2003)
- Starter P may increase harvestability rather than pod production in lentil (Gan unpub. 2003).

# Phosphorus source for seed row placement

- MAP < 5-20 lb $P_2O_5$/acre seed placed
- DAP use CAUTION = toxic to seedlings
- Liquids – equally potent as MAP, but close proximity of band to seed = higher risk to seed (Grenkow et al., 2013).




If more P required – sub-surface side band, broadcast incorporate before seeding, build with prior crop

# Take home messages on P

- Annual legumes need and remove similar amounts of P PER bu as wheat.
- P is necessary for N fixation.
- Legumes are better able to access soil and fertilizer P than small grains.
- Be cautious with seed placed, but don’t let that limit amount provided.

# Potassium (K)

- K required for N-fixation
- K levels often moderate to high in Montana, generally not limiting
- Guidelines for MT pulse crops

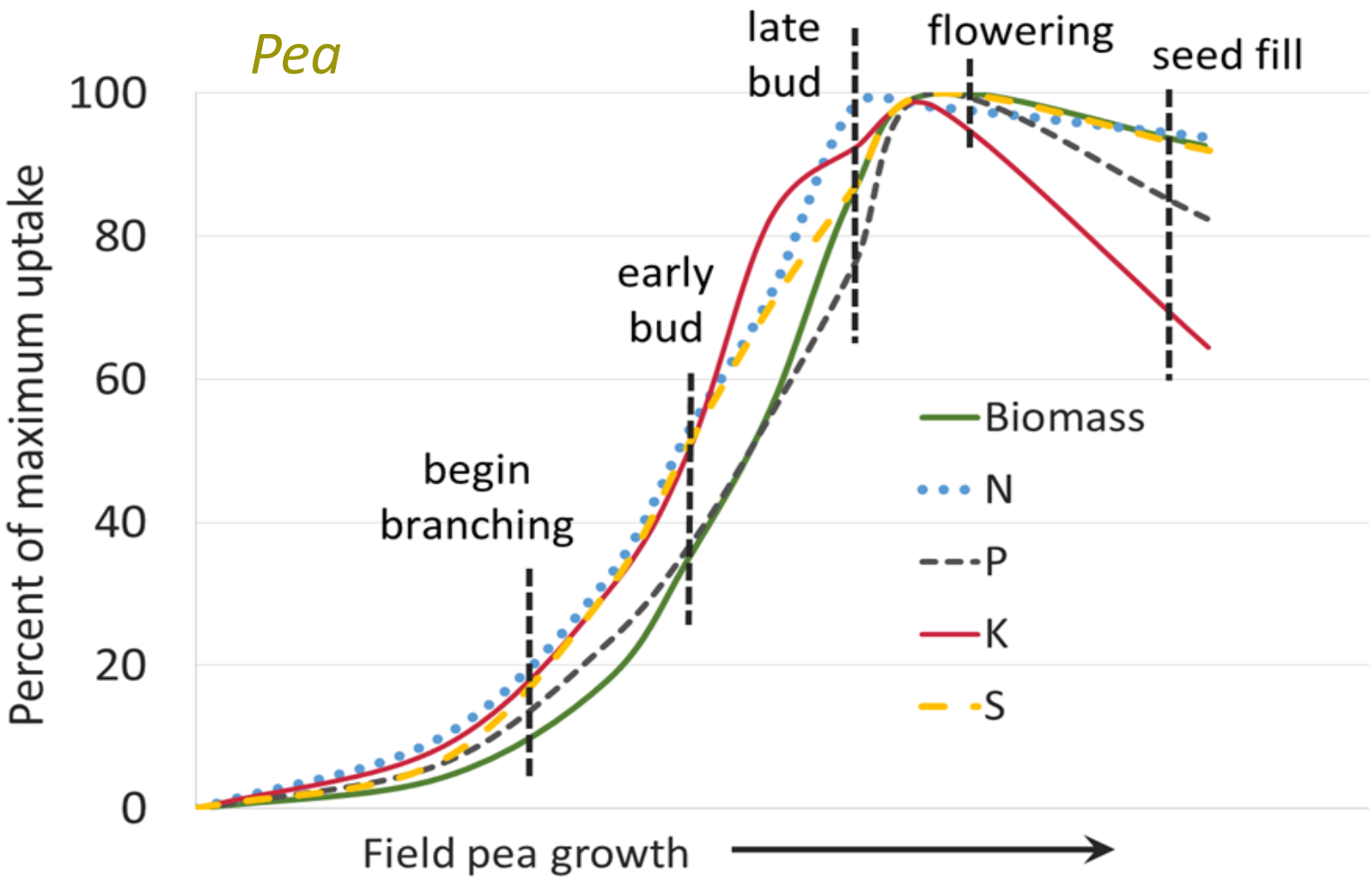
| Soil K (ppm) 0 to 6 inches | Application rate (lb $K_2O$/acre) |
|---|---|
| 0 | 45 |
| 50 | 40 |
| 100 | 35 |
| 150 | 30 |
| 200 | 25 |
| 250 | 20 |
| Above 250 | 0 up to crop removal (0.9 lb/bu) |

Questions?

*On to timing*

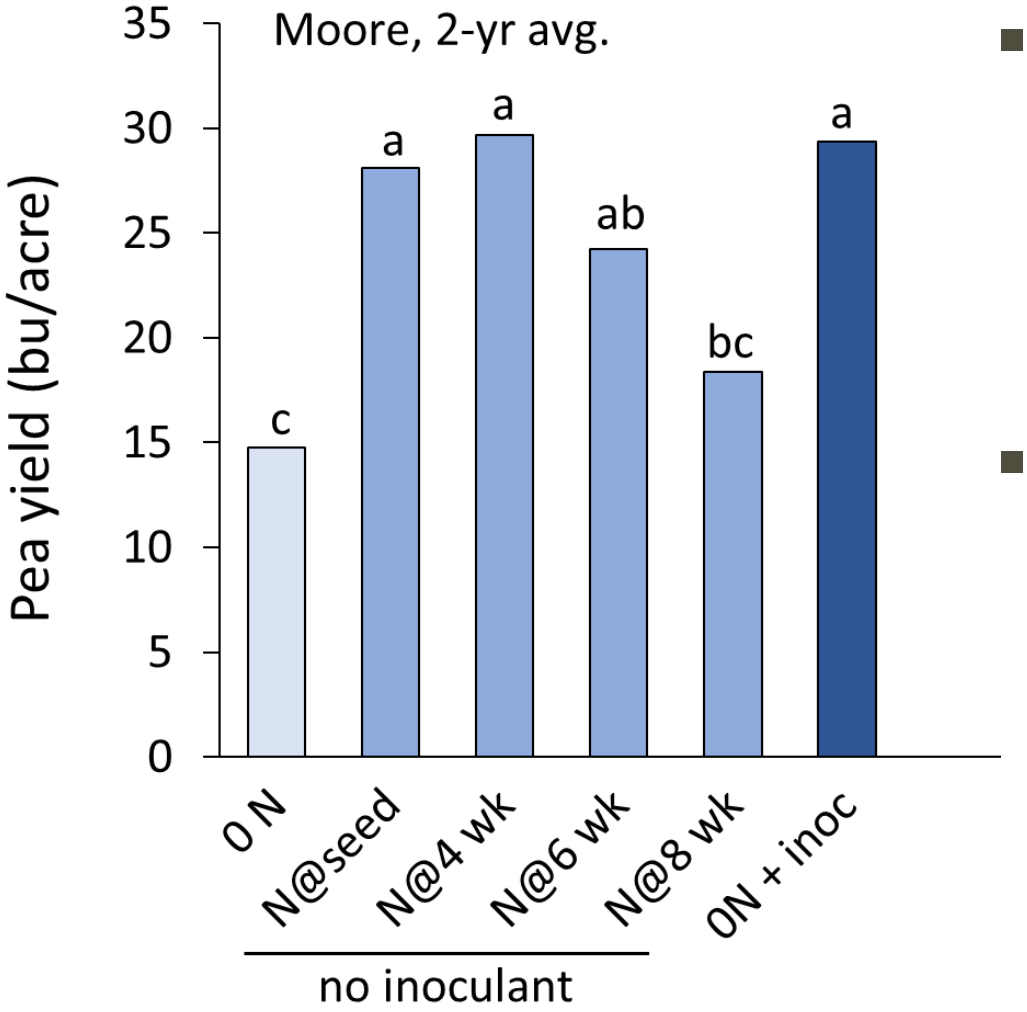
# Nutrient uptake

- Nutrient uptake precedes biomass
- Rapid demands once branching




Source: Malhi et al., 2007, Saskatchewan

# Rescue N timing




- Up to 6 weeks after seeding
  - Pea: 9-12 node stage
  - Chickpea: 10-13 node
- If later
  - too much vegetative growth
  - poor pod set
  - delayed maturity

(McConnell et al., 2002, Moore, MT, 90 lb N/ac)

# Take home messages on Timing

- N: at seeding, or as rescue
- P: build up with prior crop, in very small amount with seed, or side band at seeding
- K: build up with prior crop, side band below the seed, not seed-placed
- S: elemental with prior crop, sulfate at seeding or as liquid for rescue

# Conclusions on fertilization of pulses

- Encourage N-fixation
- P response likely higher on low P soils, low amounts of seed-placed may pay off
- K needs are high for legumes, but little research on pea or lentil
- Elemental S can last for several years
- With high pulse prices, fertilization can pay for itself, if water isn't limiting

# 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.

SK Pulse Growers' Nodulation and N-Fixation Field Assessment Guide
http://proof.saskpulse.com/files/general/150521_Nodulation_and_Nitrogen_Fixation_Field_Assessment_Guide.pdf

IPNI Seed Damage Calculator
http://seed-damage-calculator.herokuapp.com/

# With good soil fertility you can grow big pods

?

Remember Extension guides