Pulse Crop Fertility and Micronutrient Requirements

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MONDAK Pulse Day, Wolf Point

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Objectives

Provide you info on pulse fertility

- N fertilization and inoculation effects

  far more reports of failed nodulation in 2017

- P, K, S, and micronutrient needs
- Fertilizer rates, placement, timing

Pulses require N by either:

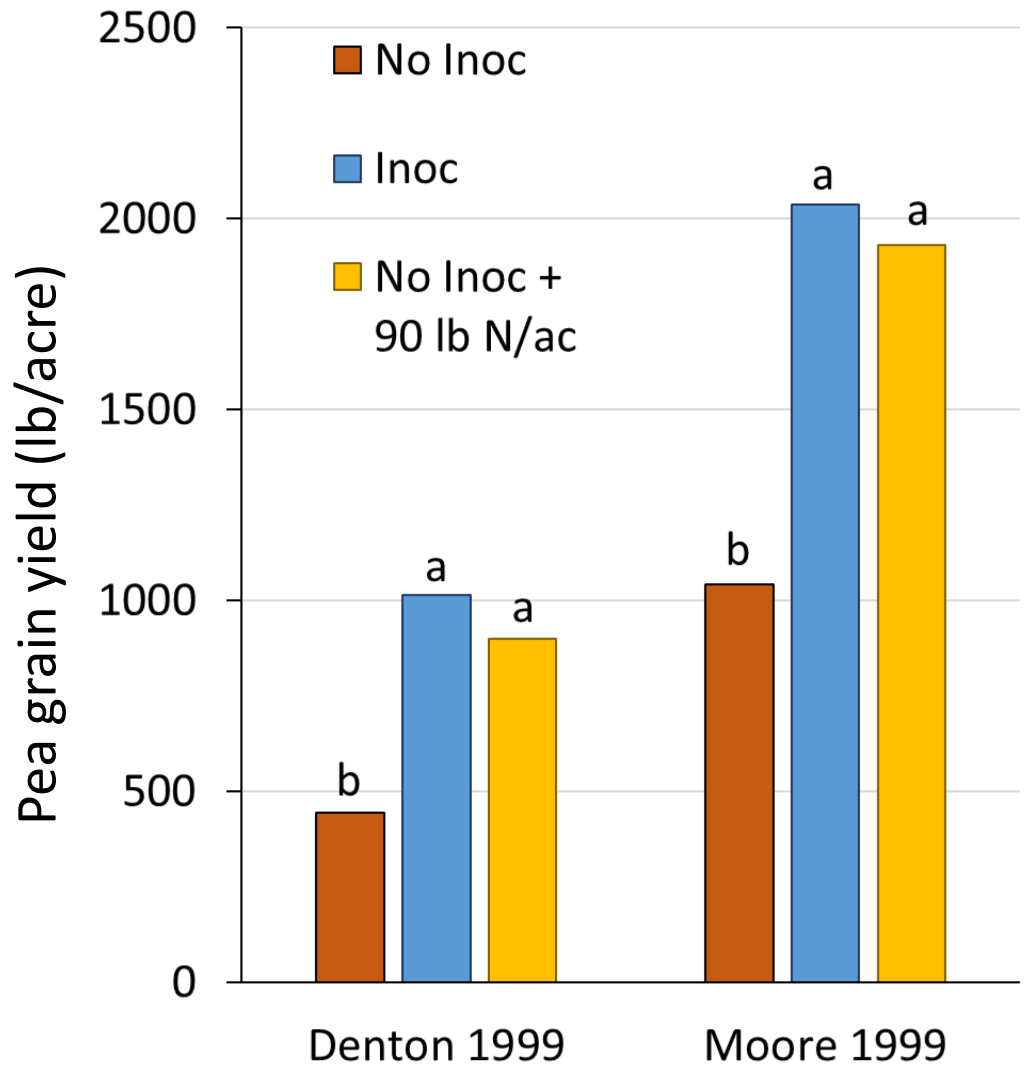
- Inoculation, especially on sites with no recent pulse history
- Fertilizer

"New" fields:

Granular = more effective

Field with pulse history in ~ 5 yrs :

Liquid or peat = less expensive

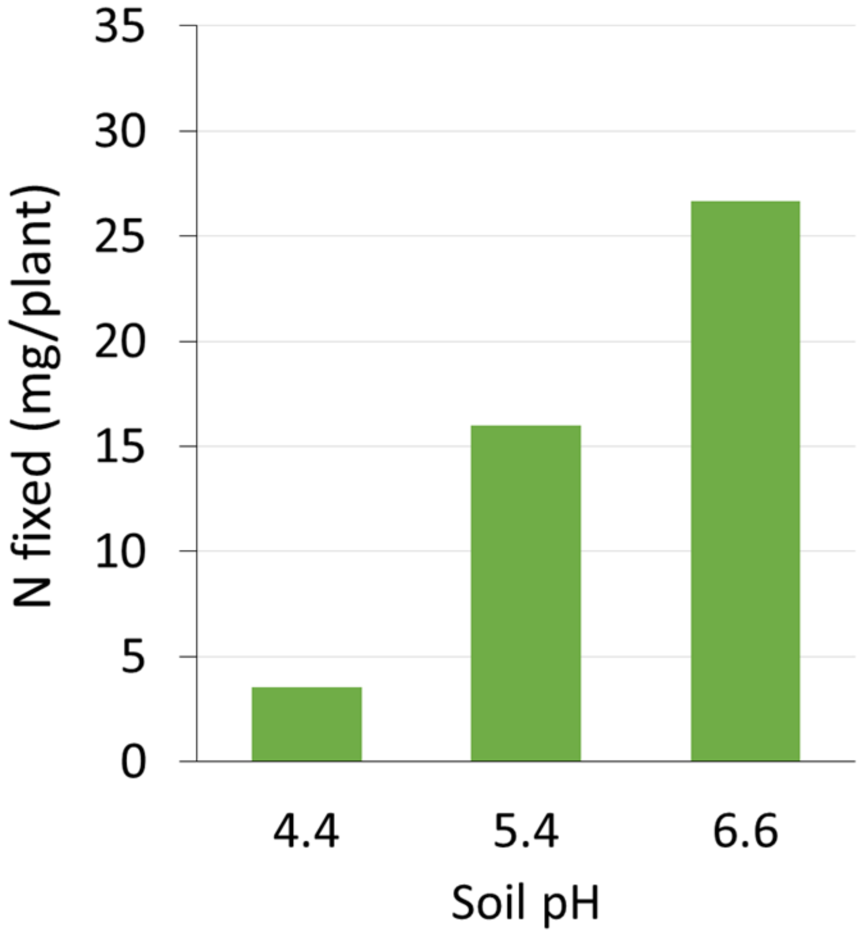


Fields had no recent pulse history

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

Uncontrollable factors negatively affecting nodulation & N fixation

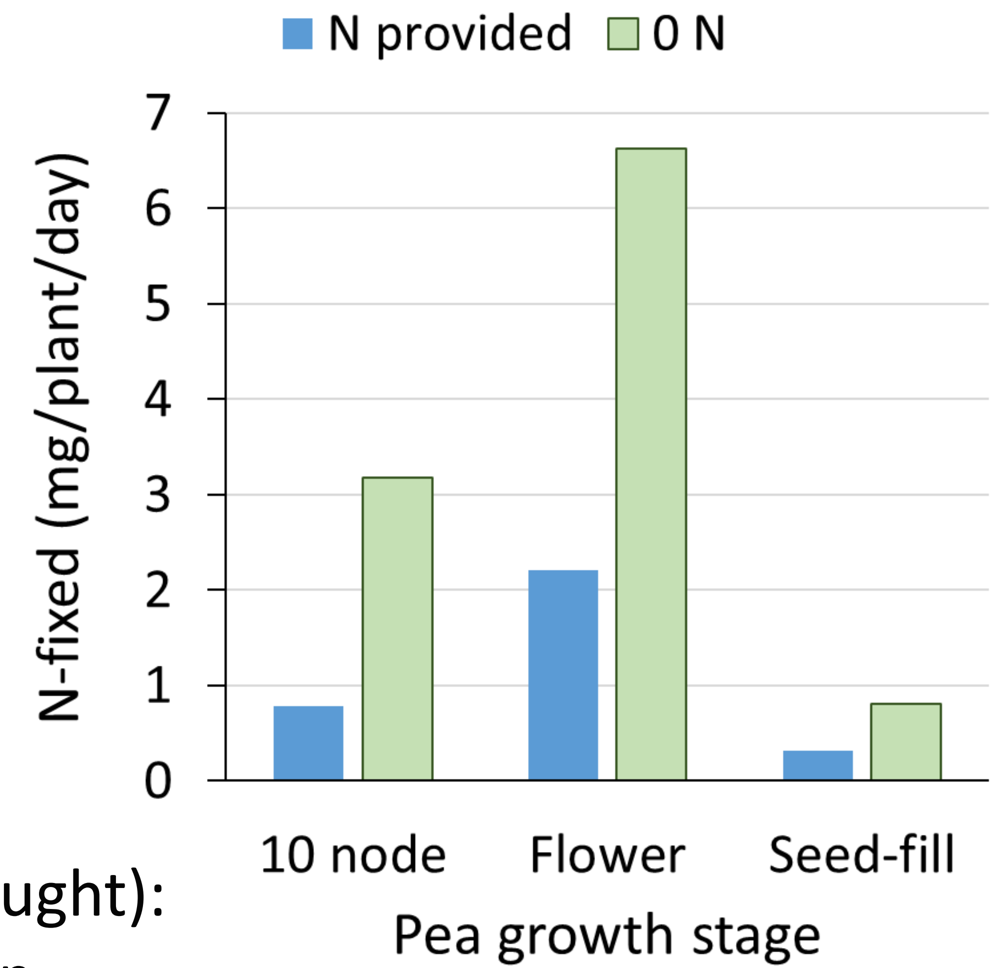
- Extreme soil temps
- Waterlogged or dry soil
- Soil pH < 5.5, > 8
  inoculant strains differ in tolerance
- Saline soils
- Maturing plants



Rice et al., 2003, greenhouse

Practices to improve nodulation & N fixation

- Use species-specific inoc at right rate
- Keep inoc cool, dark
- Granular more reliable than liquid esp as pH <5.4 (Rice et al., 2000)
- Avoid fertilizer salts with inoculant (mixing with fertilizer can kill bacteria)
- Ensure adequate P, K, S
- Watch soil N (esp after drought): too much inhibits N-fixation
- No-till to retain soil moisture



Voison et al., 2003
greenhouse study

Does granular inoculant (GI) pay off?

Yields usually go up, but not always enough to offset the cost of inoculant. Questions to ask:

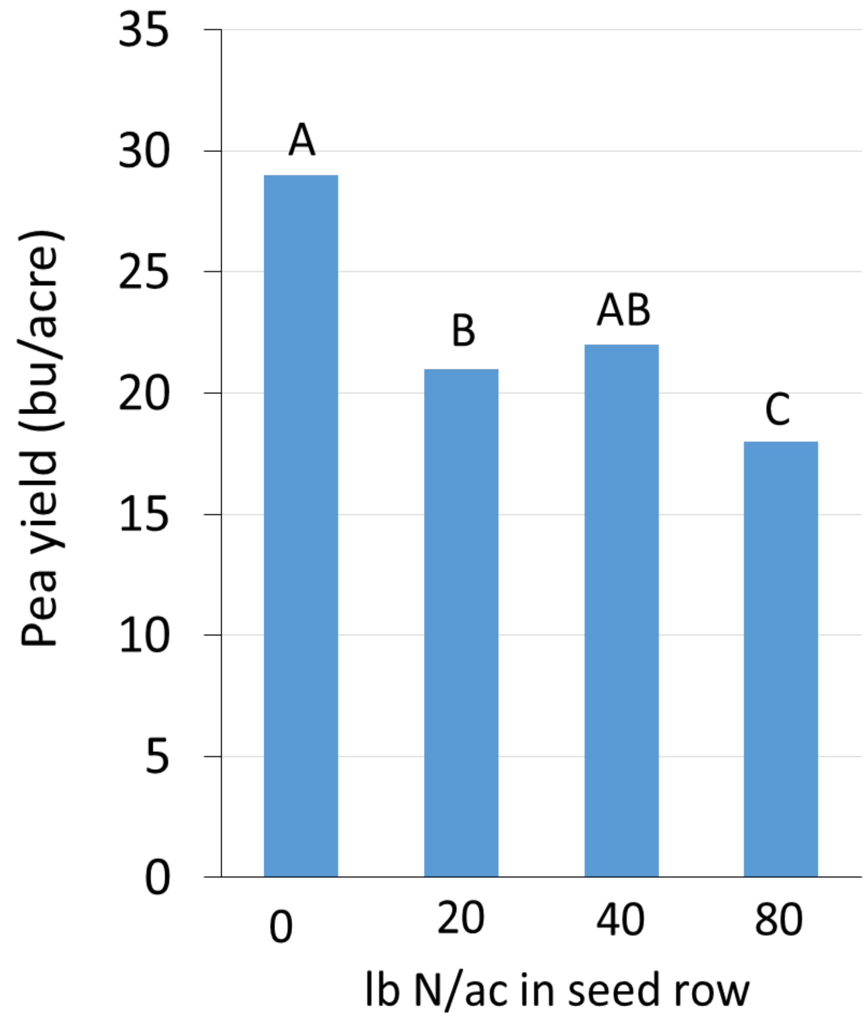
- Are soils high in N (McKenzie et al., 2006)?
- Do fields have a long or recent history of inoculation?
- Might insufficient water limit yield or cause rhizobia to die (McKenzie et al., 2006)?
- Is a premium paid for protein? GI tends to increase protein in “new” or low soil N or drought conditions (McKenzie et al., 2006; Clayton et al., 2004; Bestwick et al., 2018). One MT buyer is already paying $0.25 to 0.75/bu for protein > 22%.

If legumes fix N, why might add fertilizer N?

- Nodulation requires healthy plants
- Little N contributed by nodules until 3rd node, early N 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

Seed row N

- Too much N
  - inhibits nodulation
  - produces excess vegetation
  - reduces yield
- Aim for 10-15 lb total available N/ac (soil + fertilizer) in top 12” in spring
- Place to side of seed row
- With lentil and chickpea, starter N reduces time to maturity, improves harvestability (Gan et al. 2003)



Huang et al., 2017, Moccasin

Questions on N?

On to S, P and K

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 pea (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 spring wheat

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

* Assume 2/3 lb P_2O_5 per bushel of grain

Crit P level for N-fixation ≈ Olsen P 10 ppm
(producer in Judith Basin, 2016)


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

Not Fertilized

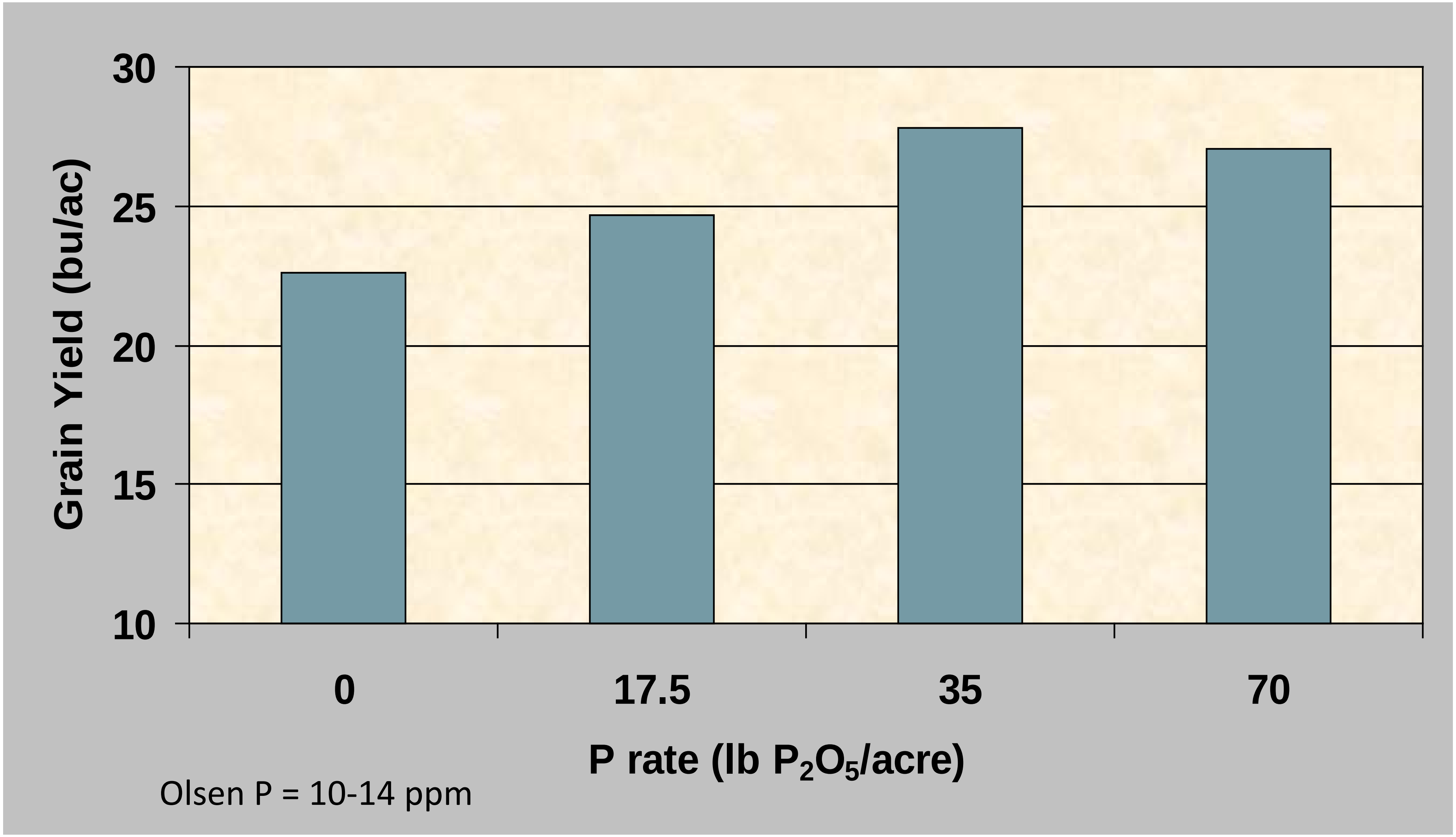
Fertilized with P, K, and S

Winter pea roots, Bozeman, 5/17/07

What looks different?

photo by Terry Rick

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



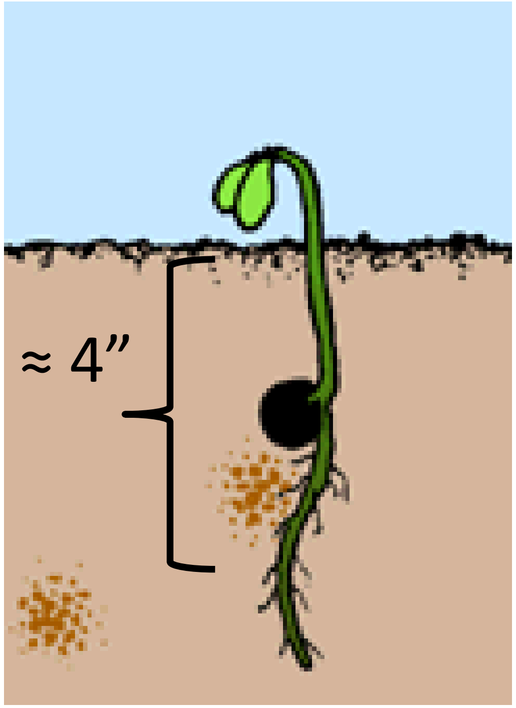
Data from J. Waddell, Sidney, MT

P response

- P response better when soil P < 9 ppm (Ffact No. 38)
- At soil P > 13 ppm, up to 15 lb P_2O_5/acre as maintenance amount ≈ max safe seed placed rate.
- P response loam >> than clay loam soils (Karamanos et al., 2003)
- Starter P may increase yield and harvestability in lentil and chickpea (Gan unpub. 2003).

Phosphorus source for seed row placement

- MAP < 5-20 lb P_2O_5/acre seed placed
- Liquids – equally potent as MAP if applied at same P_2O_5 rate, 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

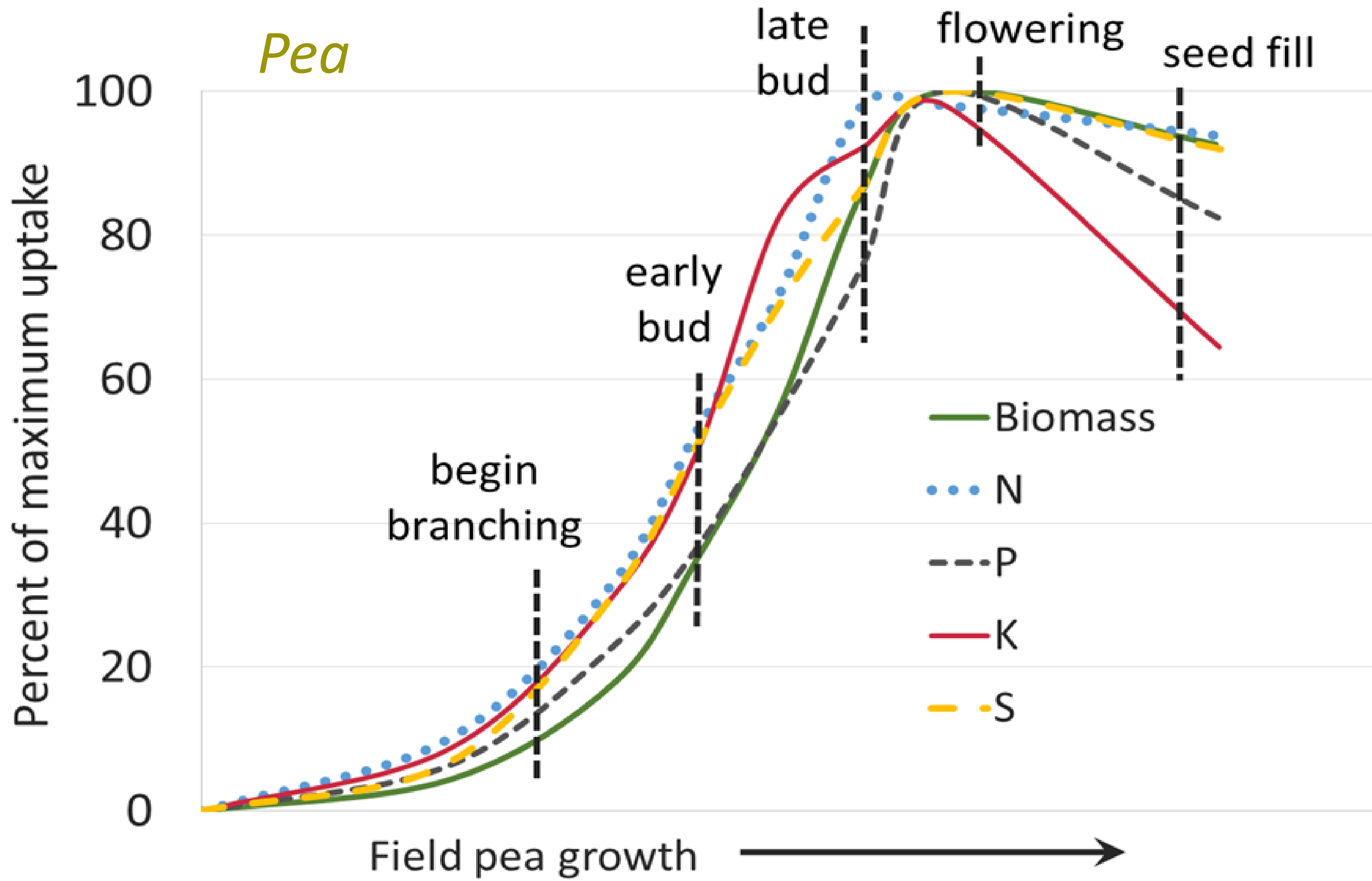
Soil K (ppm) 0 to 6 inches	Application rate (lb K_2O/acre)
0	45
50	40
100	35
150	30
200	25
250	20
Above 250	0 up to crop removal (0.9 lb/bu)

Questions?

On to timing

Nutrient uptake

- Nutrient uptake precedes biomass
- Rapid demands once branching



Source: Malhi et al., 2007, Saskatchewan

Online: http://landresources.montana.edu/soilfertility/nutuptake.html

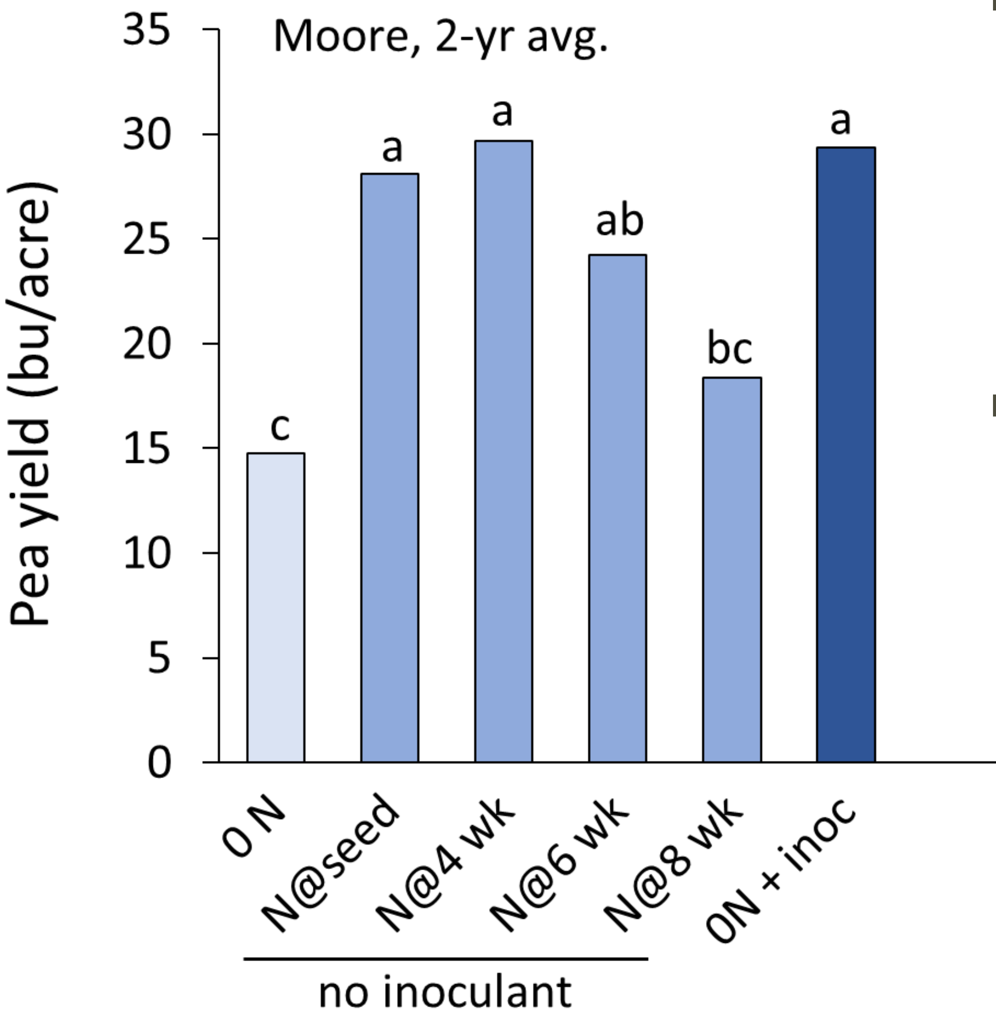
Rescue N

- 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

Rescue N timing: when is it too late?



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

- 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
  - more plant damage?

Question for you: How would you apply N 6 wk after seeding?

Take home messages on Timing

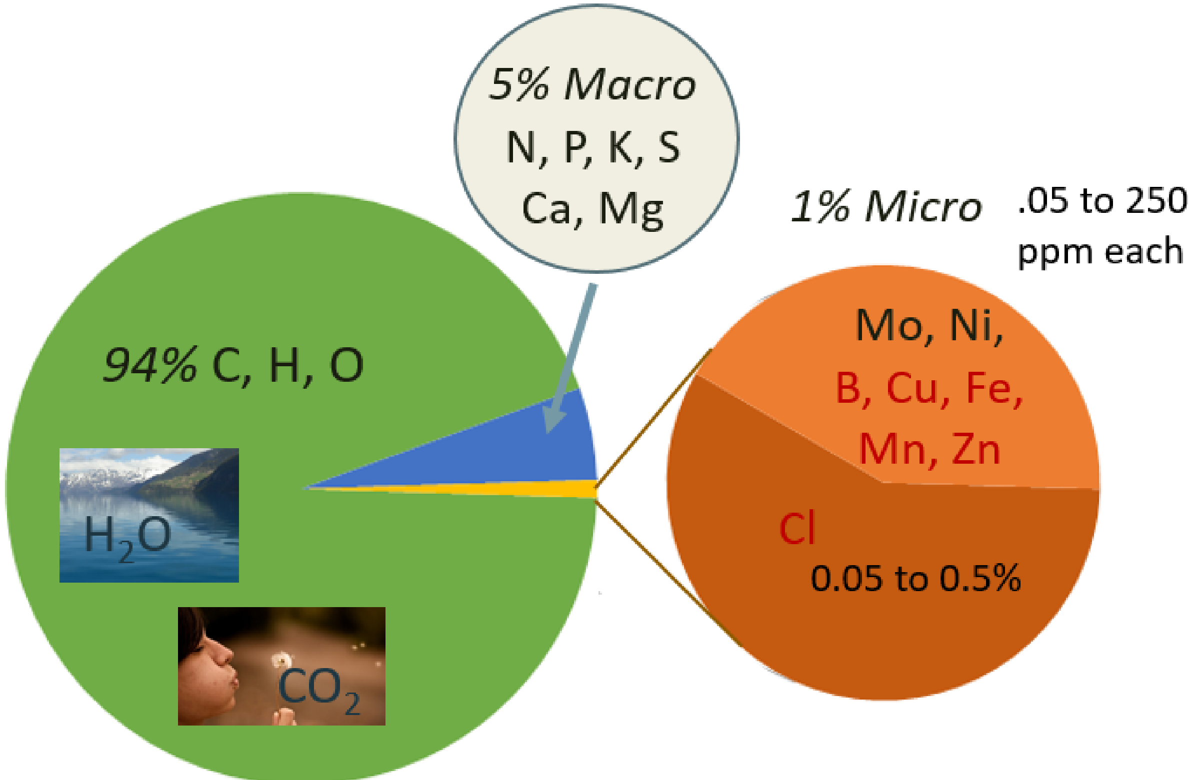
- N: at seeding, or as rescue, but no later than 6 weeks after seeding
- P: build up with prior crop, in very small amount with seed, or side band at seeding
- K: build up with prior crop, side band below the seed, not seed-placed
- S: elemental with prior crop, sulfate at seeding or as liquid for rescue

Summary of pulse NPKS fertilization

- A little starter N might pay
- 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
- Pulses are very sensitive to N, P, K and S in the seed row
- When pulse prices are high, fertilization can pay for itself, if water isn't limiting

Questions?

On to micronutrients which are simply needed in lower amount than NPKS



0.05 ppm ≈ 1 ounce in 625 tons

Challenges with micronutrients

- Micronutrients are limited by:
  - Low SOM and pH > 7.5. Most Montana soils are generally pH > 7
  - Cold and dry or very wet soils. Common MT early growing season conditions.
- Many are not mobile or very soluble in soil
- They are needed in very small amounts

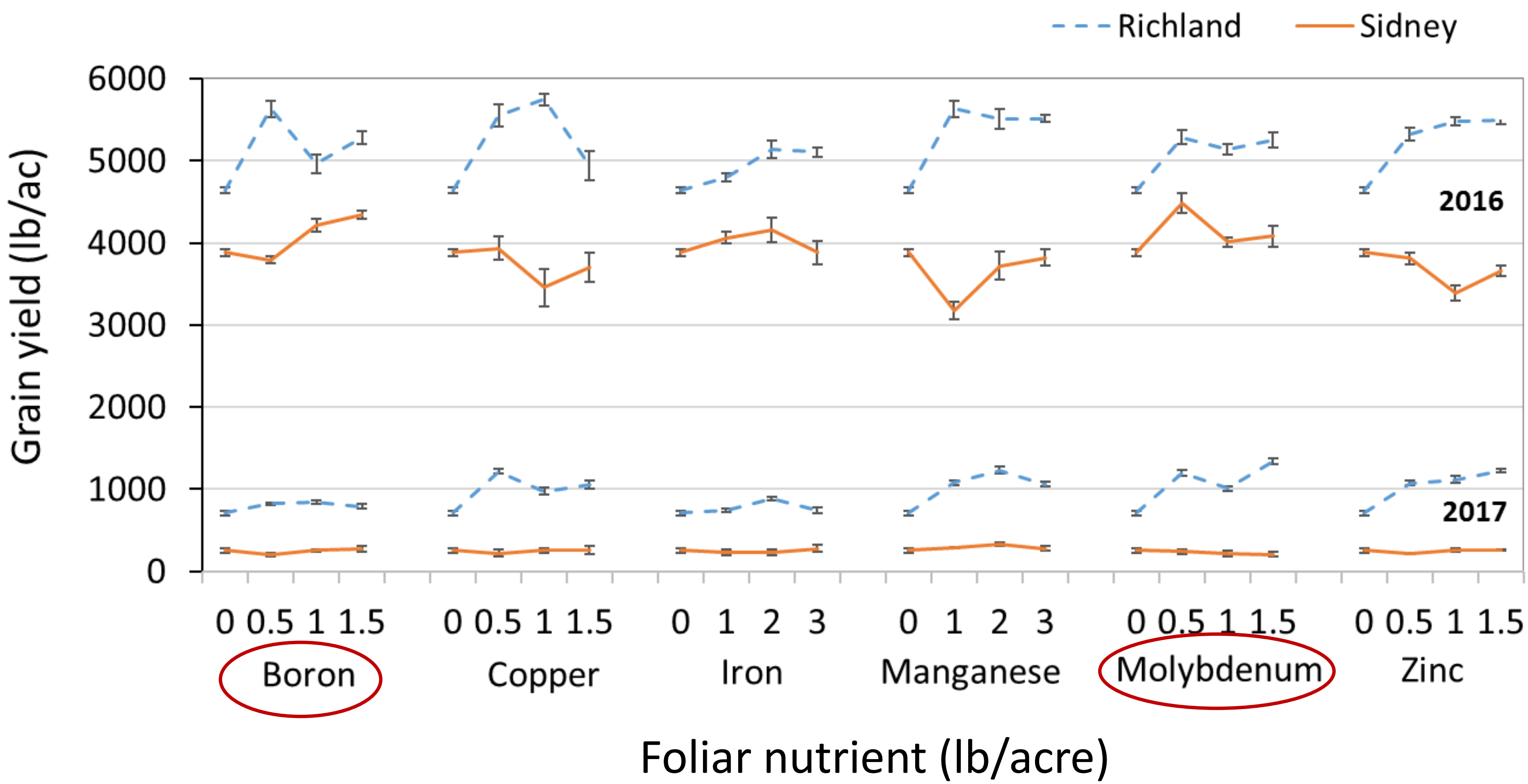
Amount removed by a bushel of seed						
	K_2O	Fe	Zn	Mn	Cu	B
	------------------------- lb/bu -------------------------					
Chickpea[1]	0.87	0.0035	0.0031	0.001[2]	0.0005	--
Wheat grain[3]	0.38	--	0.0035	0.002	0.0008	0.001

[1] Thavarajah & Thavarjah 2012; [2] North Carolina Extension; [3] Fertilizer Guidelines for MT Crops

Soil testing for micronutrient

- Use in combination with other tools
- Tests are not highly accurate, precise, or consistent among labs
- Based on 18,000 MT soil tests in 2013 and 2015 combined, by AgVise, Cl, Mn and Zn appear deficient most often
- Although published
  - Critical soil levels are not well established. Dry pea response to Fe and Mn when soil test > crit level (Fertilizer eFact No. 77); alfalfa did not respond to B on 'low' B soils (Fertilizer eFact No. 75).
  - Correlations between soil (& tissue test) levels and fertilizer rate guidelines are not well established

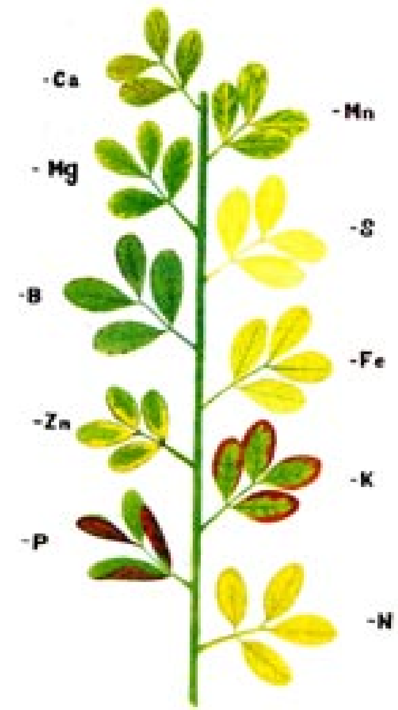
Pea responded even when soil tests > critical levels and in dry years



soil test < crit level

Fertilizer eFact No. 77

Tissue analysis for in-season micronutrient adjustments



- Visual tissue assessment for potential deficiency See *Plant Nutrient Functions and Deficiency and Toxicity Symptoms (NMM 9):* http://landresources.montana.edu/nm
- Tissue concentrations
  - Critical tissue concentrations are hard to find
  - Other than for Cl, there are no MT guidelines for micros based on tissue tests. In 87 corn fields, there was a positive correlation between tissue test concentrations and yield only for Cu (Stewart 2016), not for B, Fe, Mn, Mg or Zn.
- Once deficiency observed, potential yield may already be reduced

Micronutrient source affects application timing and method

Timing

- Borate, chelated, sulfate, or high solubility (>40%) oxysulfate forms: Spring
- Oxide and low solubility (<40%) oxysulfate forms: Fall

Method

- Broadcast and incorporated is ideal, but challenging to get even distribution of a very small quantity
- Seed-placed and subsurface band is generally not recommended (due to toxicity)
- Foliar applications use less than ½ the suggested rate. Can be done with borate, and chelated Cu, Fe, Mn, Zn

Karamanos 2000, Gerwing and Gelderman 2005

Foliar fertilizer sources and rates

Element	Fertilizer source	Rate (lb/ac) [1]
Boron	sodium borate	0.3-0.5[1,2]
Copper	chelated	0.2-0.25[1]
	sulfate	0.5[2]
Iron	chelated	0.15[1]
	sulfate	2[2]
Manganese	chelated	0.5-1.0[1]
Molybdenum	sulfate	0.5[2]
Zinc	chelated	0.3-0.4[1]
	sulfate	0.5[2]

1. Karamanos 2000, doesn't suggest sulfate and oxysulfate foliar
2. Mohammed et al., Fert eFact 77, measured response at these rates

Conclusions: micronutrients

- A combination of deficiency symptoms, soil testing, and tissue testing may be best approach at identifying deficiencies. This is NOT an exact science.
- Micronutrient deficiencies are the exception, not the rule
- Cool wet conditions cause deficiency – will generally disappear when weather warms
- Too much micronutrient may hurt yield more than not enough

Conclusions: micronutrients, cont.

- The main challenge is even distribution of a very small quantity – consider foliar options
- Read product label: look for ‘available’ micronutrients and watch for heavy metal contamination
- “Micronutrients should be used when there is an economic benefit to the farmer ….” – R. Karamanos, Ph.D. soil scientist
- *Most conclusive test is growth responses from field strip trials*

For additional information

Soil Fertility Website:

http://landresources.montana.edu/soilfertility

my presentations

the bulletin *Montana Cool Season Pulse Production Guide*

Nutrient Management Module #7 on micronutrient

Nutrient Management Module #9 on deficiency symptoms

Nutrient Management Module #11 on fertilizer placement
http://landresources.montana.edu/nm

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