Nutrient Management of Pulses

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Crop and Pest Management School

Bozeman

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Objectives

Provide you info on pulse fertility so you can better answer your clients' questions

- N-fixation by growth stage
- N fertilization and inoculation effects
- P, K, S needs
- Fertilizer rates, placement, timing

Nitrogen fixation process

- Nodulation begins 2-3 weeks after plant emergence
- Nodules are active 3-4 weeks after plant emergence (≈ 3rd node)
- Active nodules are pink to red inside
- Amount fixed depends on species

  (pea > chickpea > lentil)

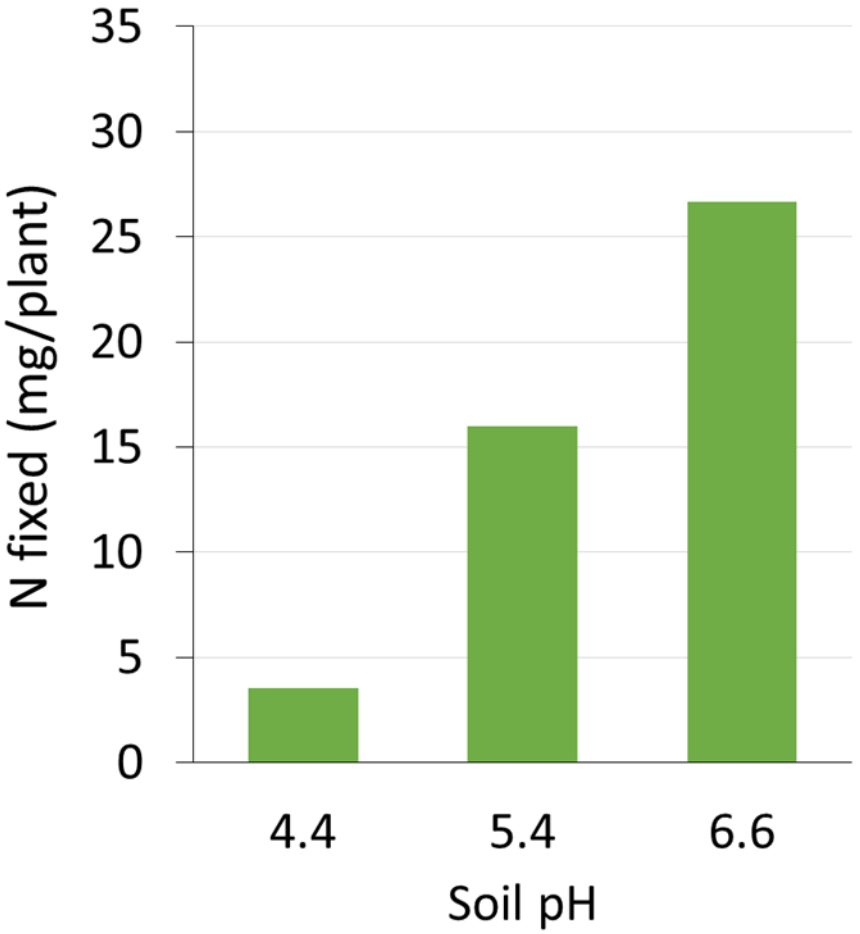
Nodulated pea root
Courtesy A. McCauley

Image: Flicker Pennstatelive

Without healthy nodules legumes don’t fix N

Uncontrollable factors negatively affecting nodulation & N fixation

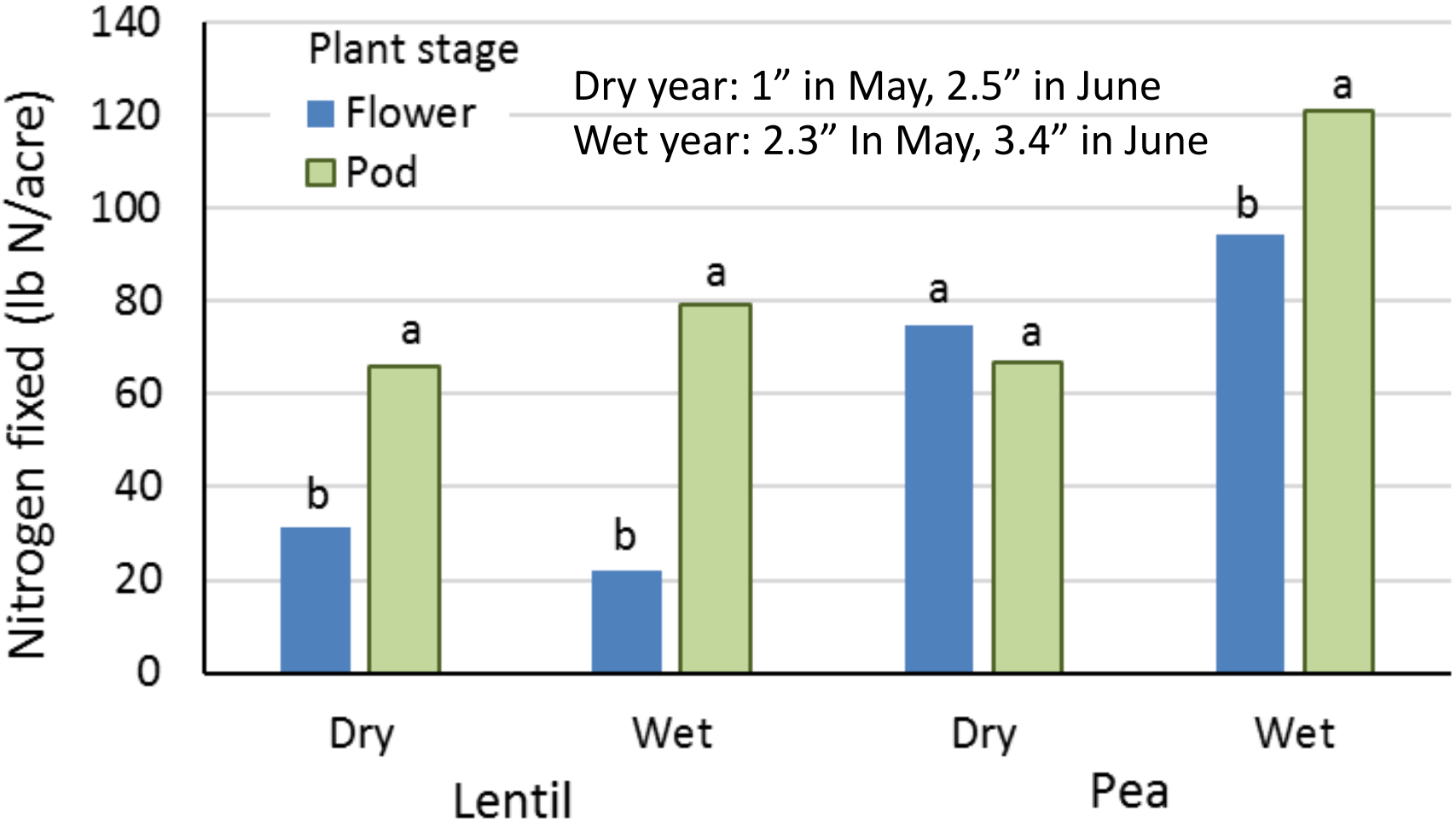
- Extreme soil temps
- Waterlogged or dry soil
- Soil pH < 5.5, > 8 inoculant strains differ in tolerance
- Saline soils



Rice et al., 2003, greenhouse

Nodules are very sensitive to drought stress

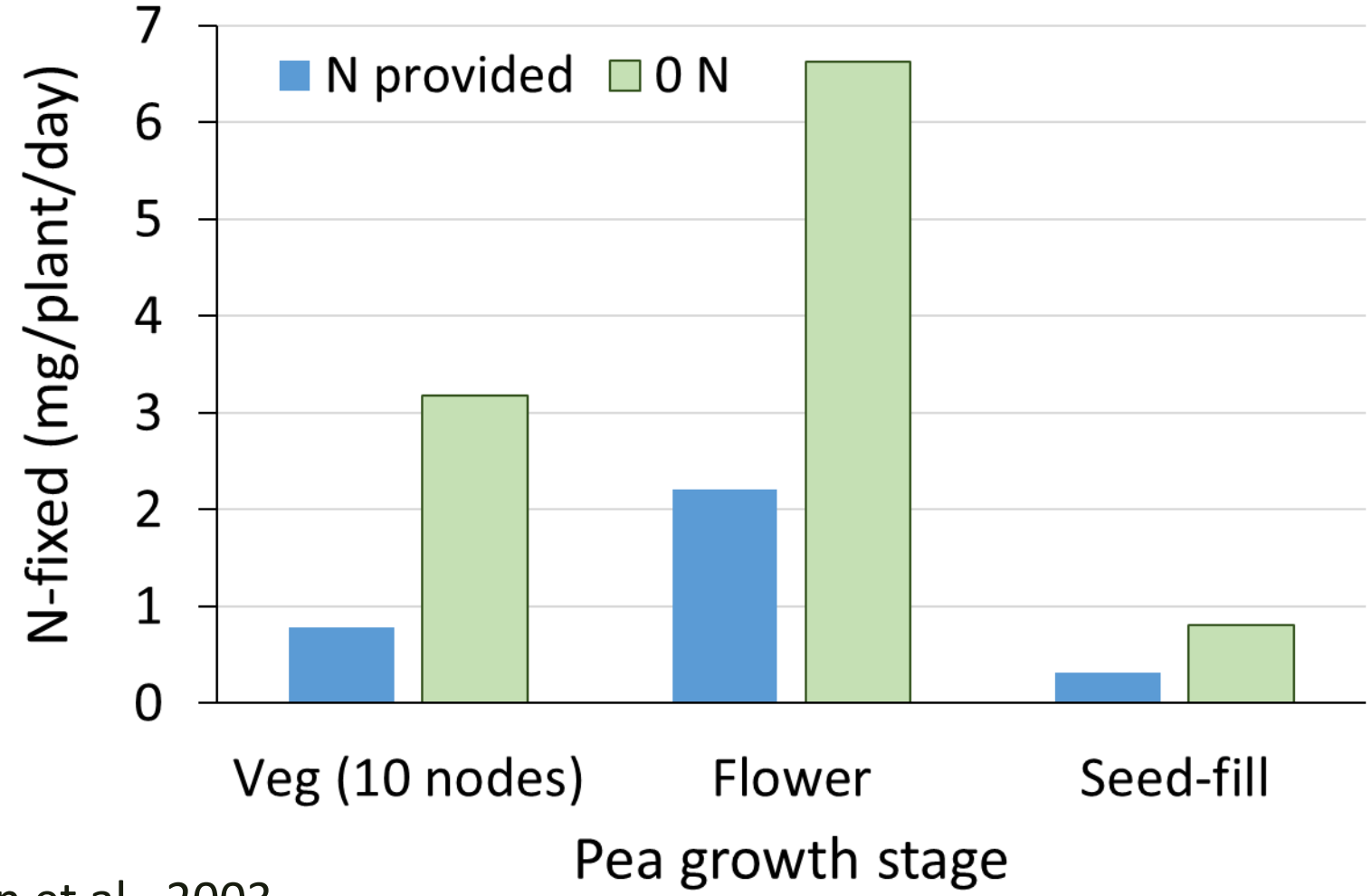
N fixation by lentil and pea in wet and dry years



McCauley, 2011
Gallatin Valley, spring planted
Determined by N difference method

N fixation can stop by flower stage at least in pea

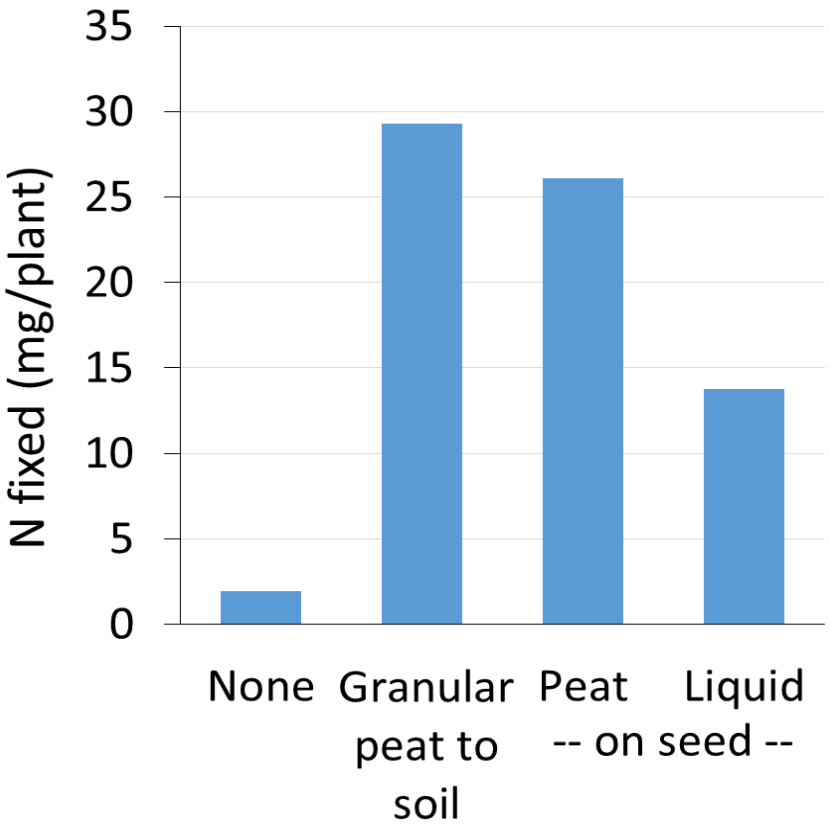
N-fixation declines as plant matures; is reduced if fertilized with N



Voison et al., 2003
greenhouse study

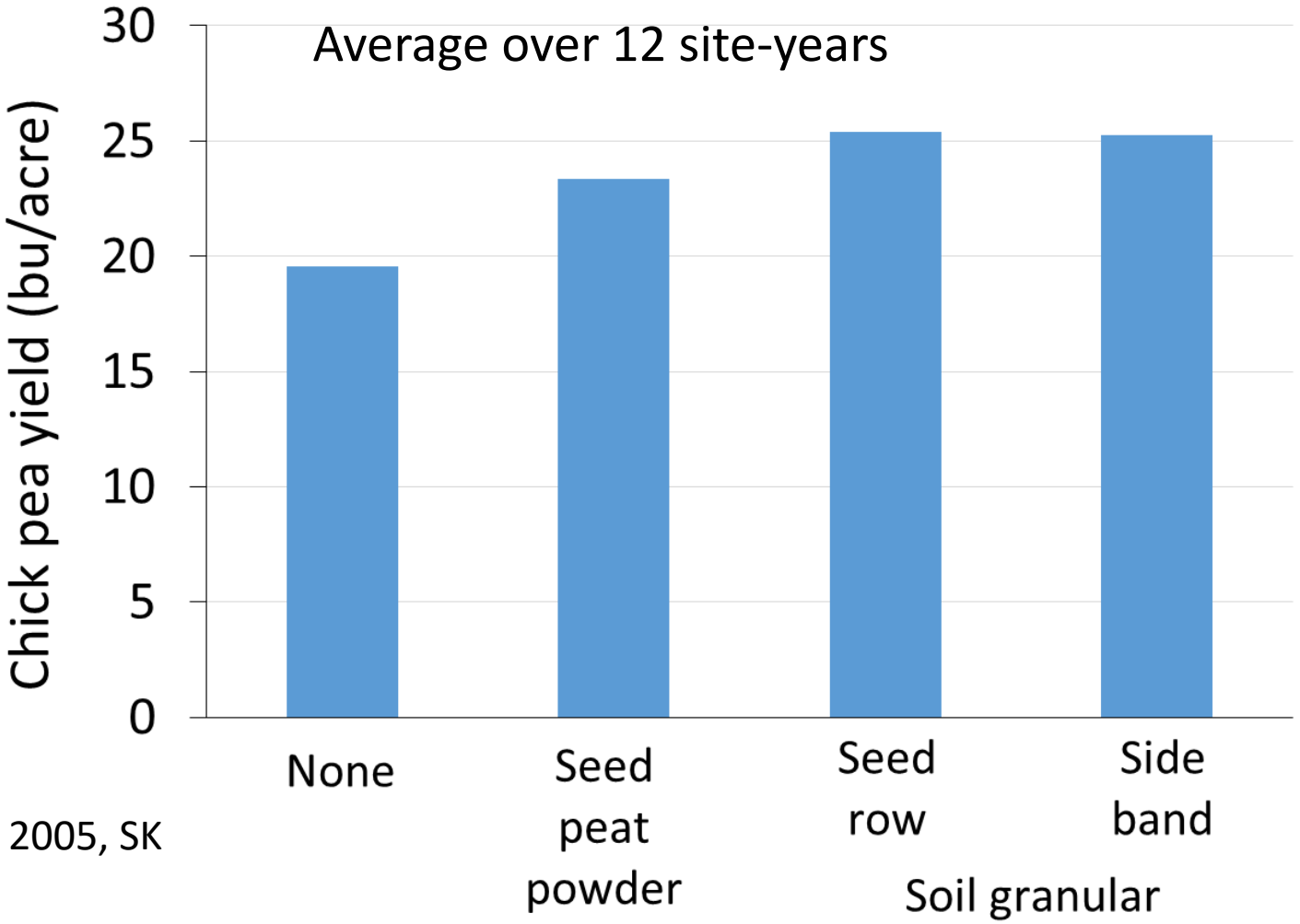
Practices to improve nodulation & N fixation

- Keep inoculant cool, dark
- Granular more reliable than liquid esp. as pH <5.4, only source providing nodules at pH 4.4 (Rice et al., 2000)
- Use species-specific inoculant
- Apply proper inoculant rate
- Avoid fertilizer salts (mixing with fertilizer can kill bacteria)
- Ensure adequate P, K, S
- Watch soil N (**high in northeast in 2017!):** too much inhibits N-fixation
- No-till to retain soil moisture



Rice et al., 2003, greenhouse

Soil granular seed placed and side-band increased yields 8/12 yrs compared to seed peat powder or no inoculant on “new” fields

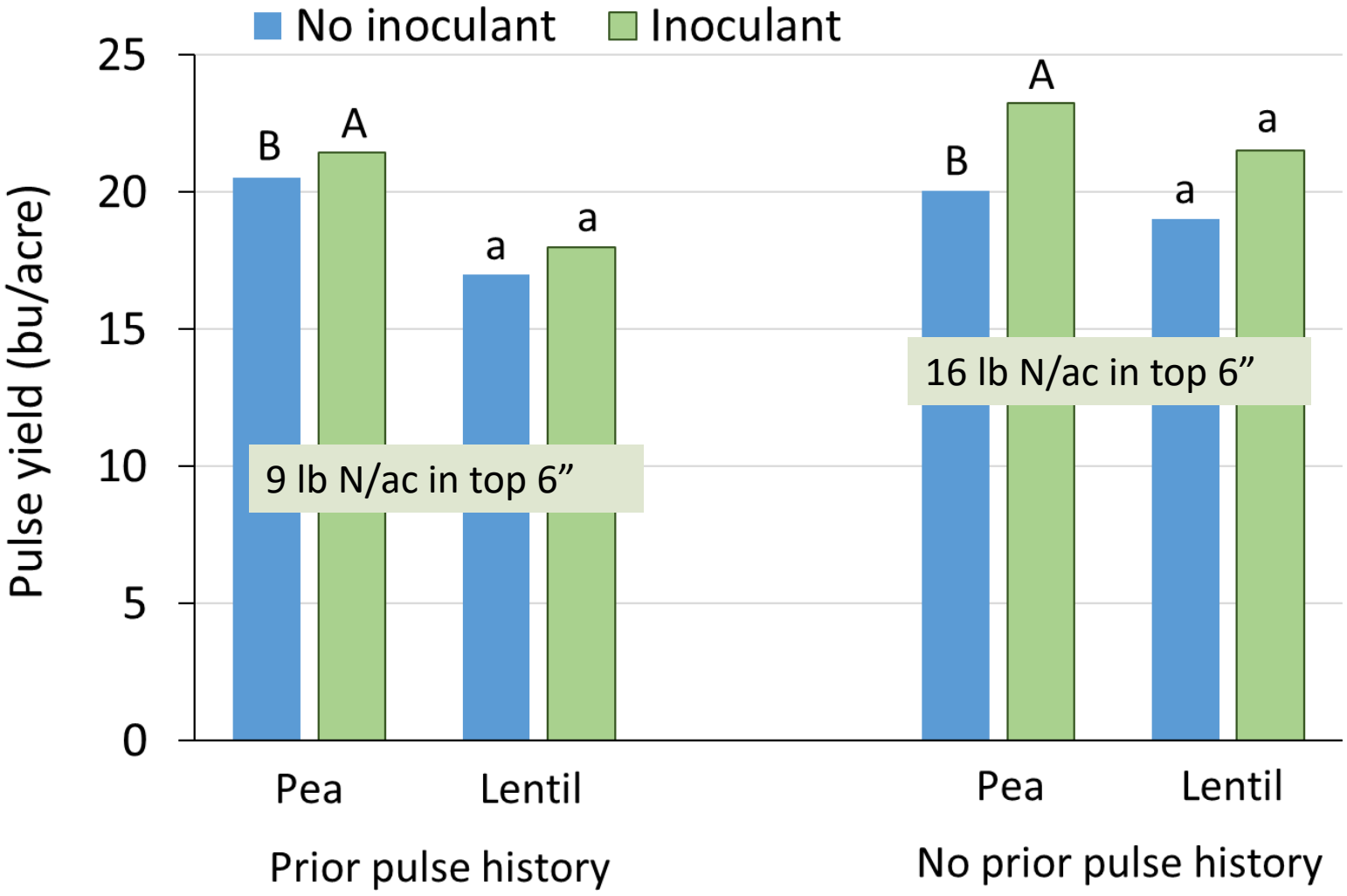


Gan et al., 2005, SK

“New” fields: Granular = more effective

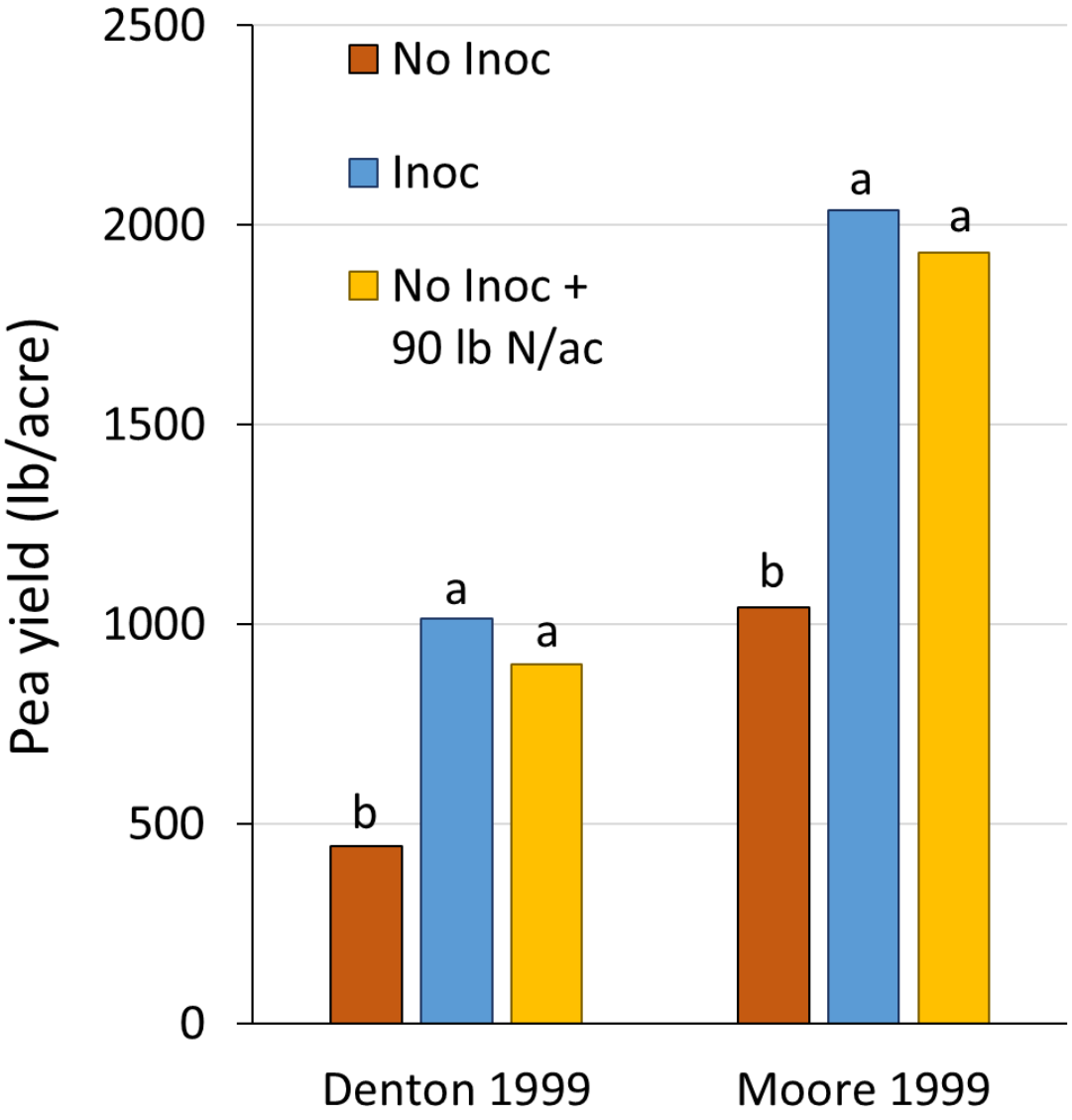
Field with pulse history: Liquid or peat = less expensive

Inoculation more important in ‘new’ fields



Huang et al., 2017, Moccasin

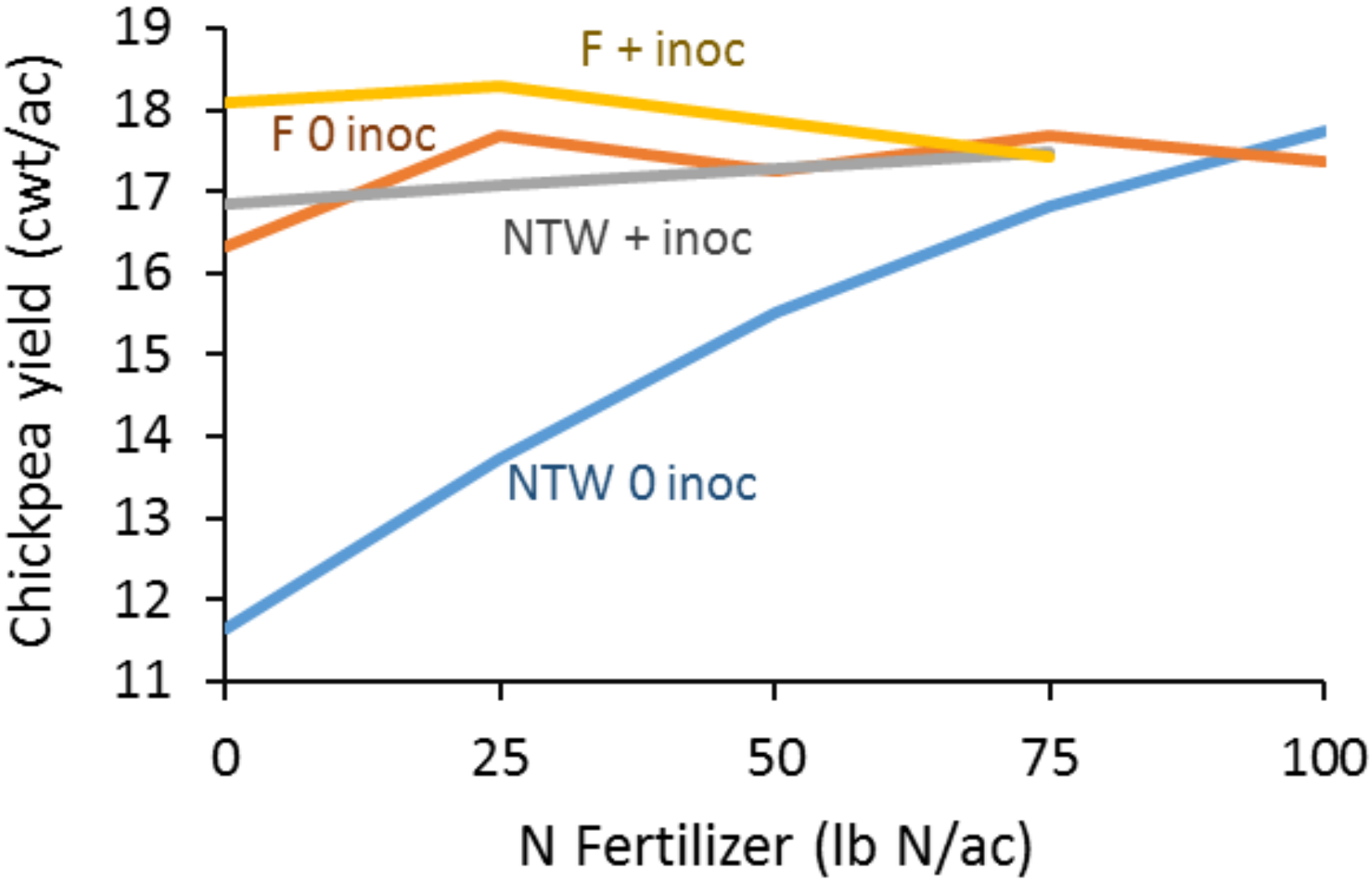
Peas benefit from N either from fertilizer or through inoculation, especially on sites with no recent pulse history.



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

Fields had no recent pulse history

Inoculation is more important in recrop than fallow due to soil nitrate differences



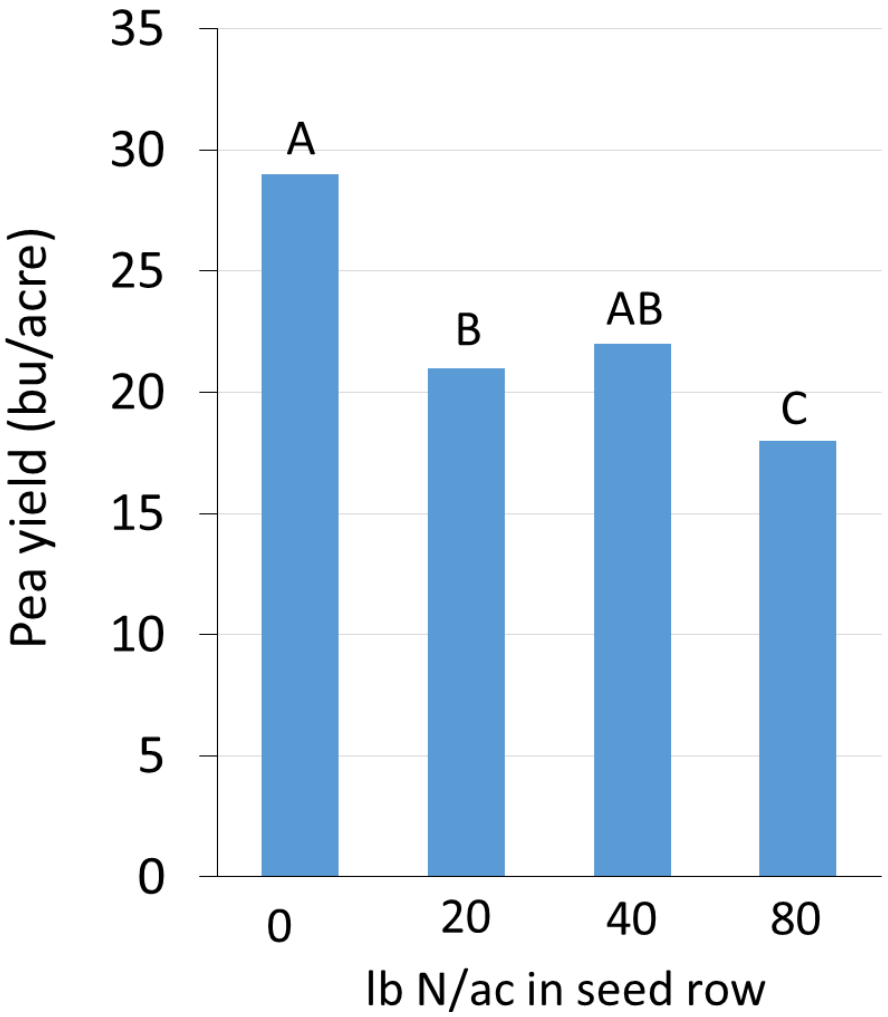
Gan et al. 2009, SK

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 the plant can keep producing, if there is soil N

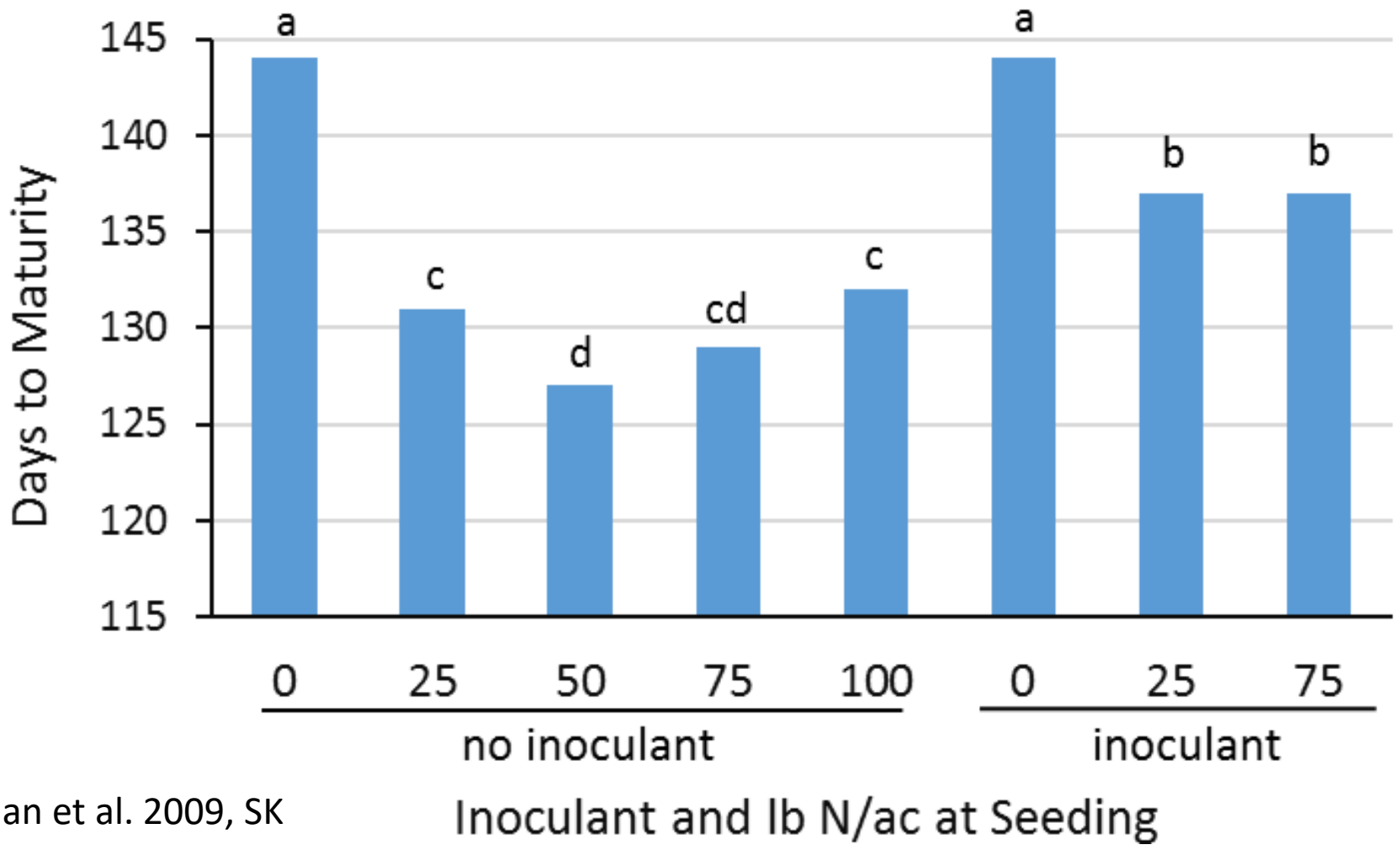
Seed row N

- 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

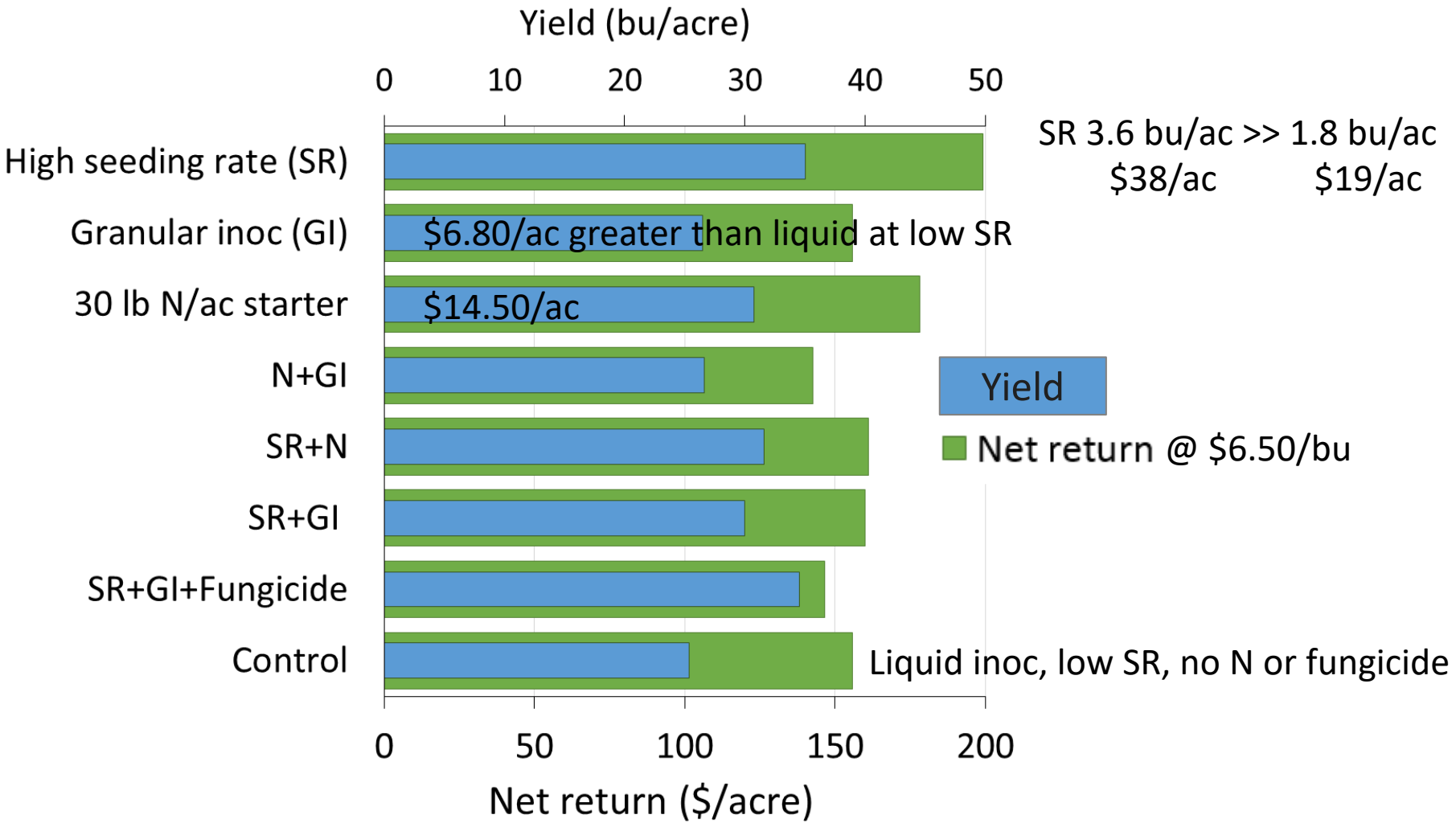
Starter N helps reduces chickpea days to maturity, especially under moist, long, growing seasons



Gan et al. 2009, SK

In 90 – 107 days-to-maturity years, N reduced days to maturity by 4-5 days

Input effects on pea on 'low yielding' (<45 bu/ac) sites



Grenkow et al., 2014, Saskatchewan

Why might granular inoculant (GI) not always pay?

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 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%.

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)

Plant tissue S concentrations

Leaf S concentration at which 90% of maximum yields were obtained.	
Crop	Plant tissue S concentration (%)
Chickpea[1]	0.18
Field pea[2]	0.20
Lentil[1]	0.29

[1]Sampling 2nd to 4th mature leaf at 7th leaf stage, 4 weeks after seeding. Huang et al. 1992.

[2]Sampling top half of shoot. Gov. W. Australia, Ag & Food

Sulfur

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

BOTH P and K needed for N fixation and yield!

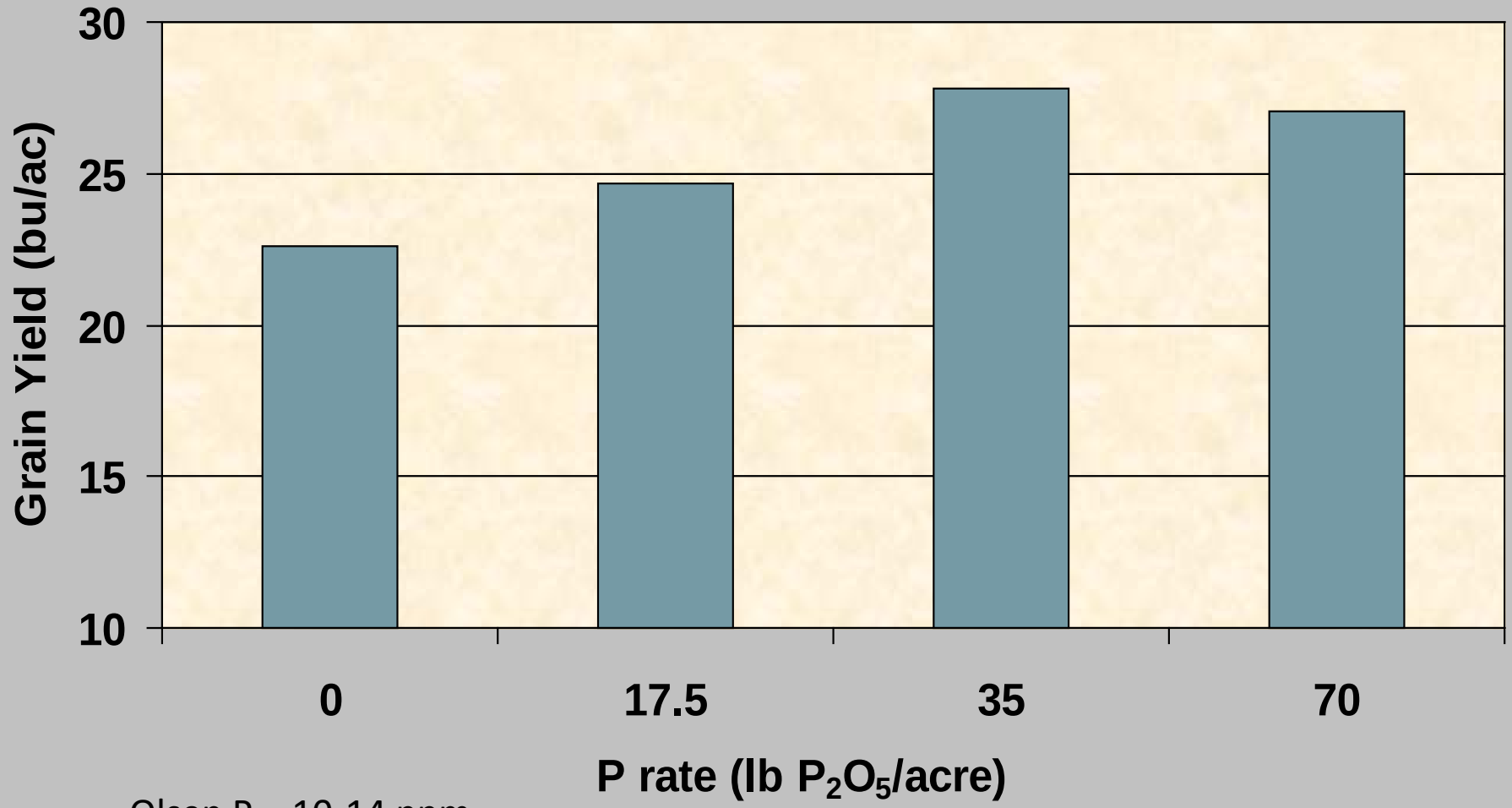
Phosphorus and Potassium removal by harvest		
Nutrient	Peas, lentils, chickpeas	Wheat grain (barley hay)
	lb/bu (lb/ton hay)	
P_2O_5	0.67 (11)	0.62 (13[1.])
K_2O	0.87 (32)	0.38 (38[1.])
[1.] Shewmaker 2012, Univ Idaho.		

P levels often low in Montana (due to calcareous soils)

K levels often moderate to high in Montana
No research located on K and legumes in region

Image by T. Rick

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



Olsen P = 10-14 ppm

Data from J. Waddell, Sidney, MT

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

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

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)

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).

Phosphorus placement

Seed row safe rates depend on soil and moisture

- heavy clay soil >> coarse
- high SOM >> low SOM
- high moisture >> dry soils

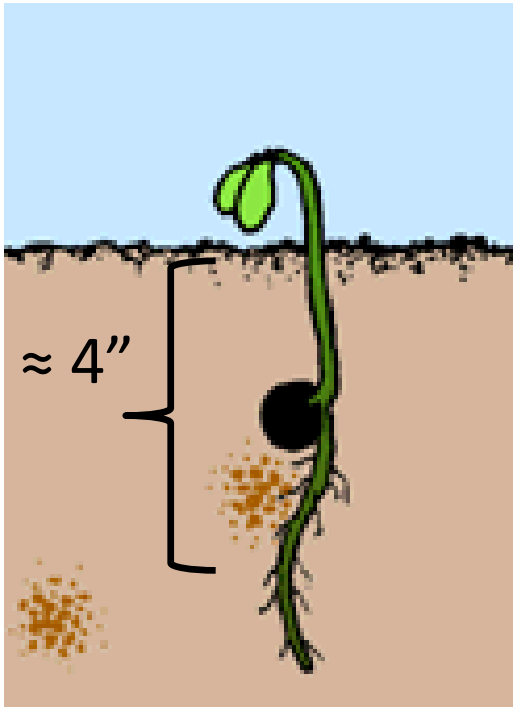


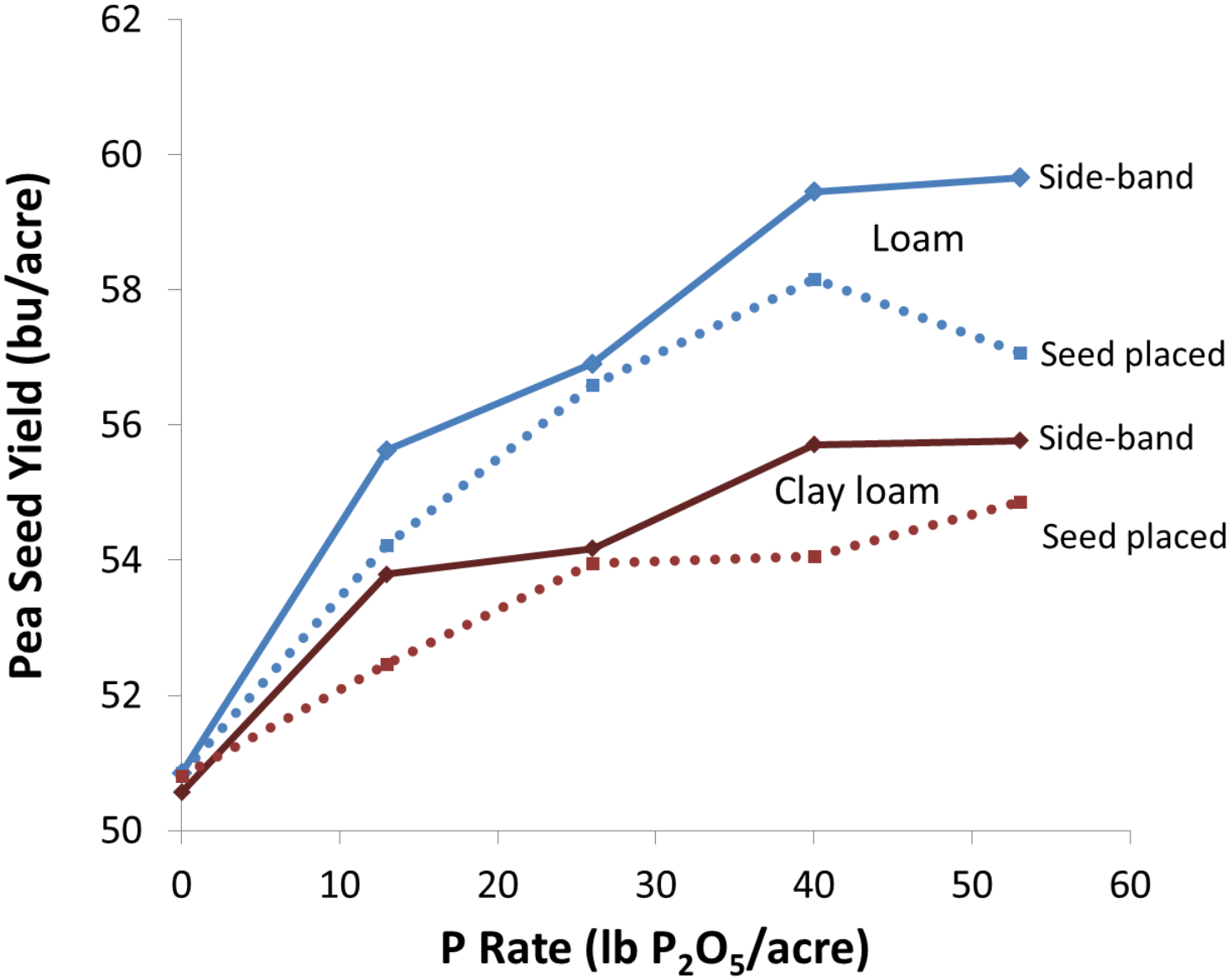
Image:Koenig, WSU

Equipment

Use wide openers, or put P in knife and seed in fertilizer slot

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

Safe rates of seed placed P depend on soil conditions



Karamanos et al. 2003, Alberta

Take home messages on P

- Annual legumes need 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

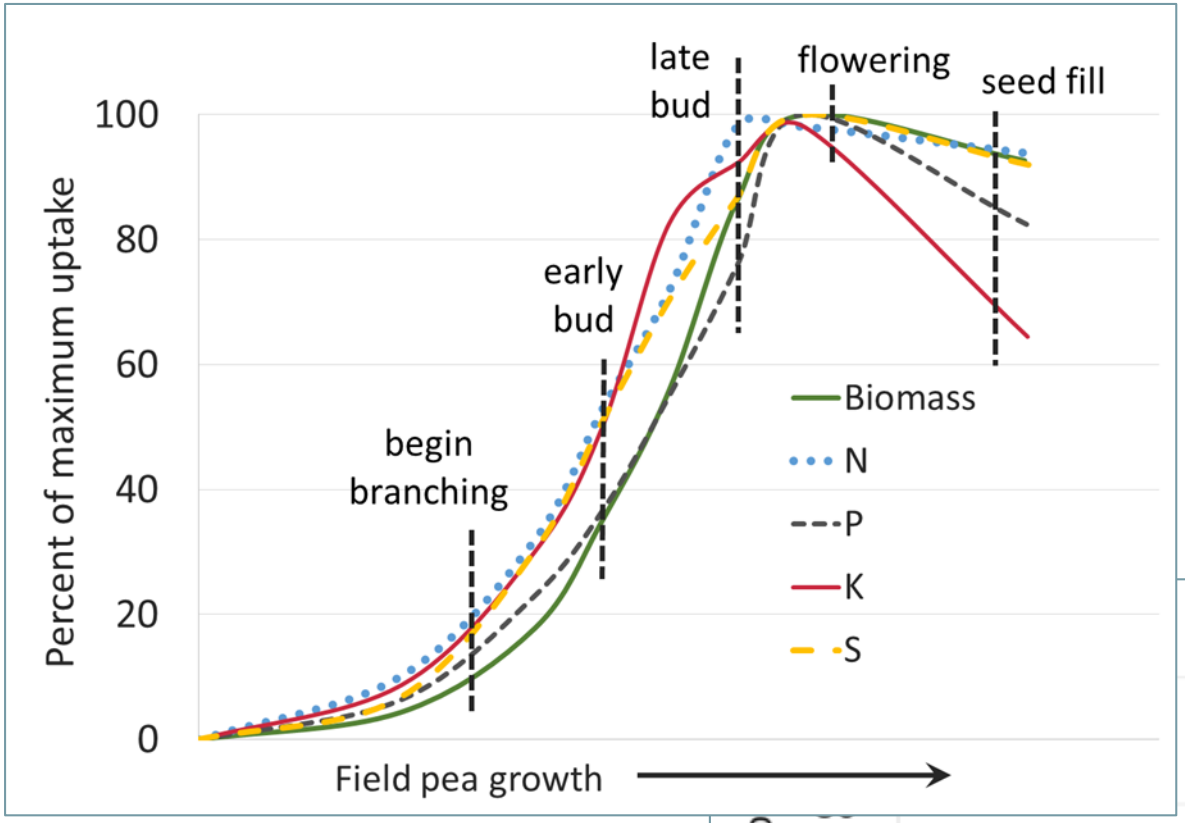
Soil K (ppm) 0 to 6 inches	Application rate (lb K_2O/acre)
0	45
50	40
100	35
150	30
200	25
250	20
Above 250	0 up to crop removal (0.9 lb/bu)

Questions?

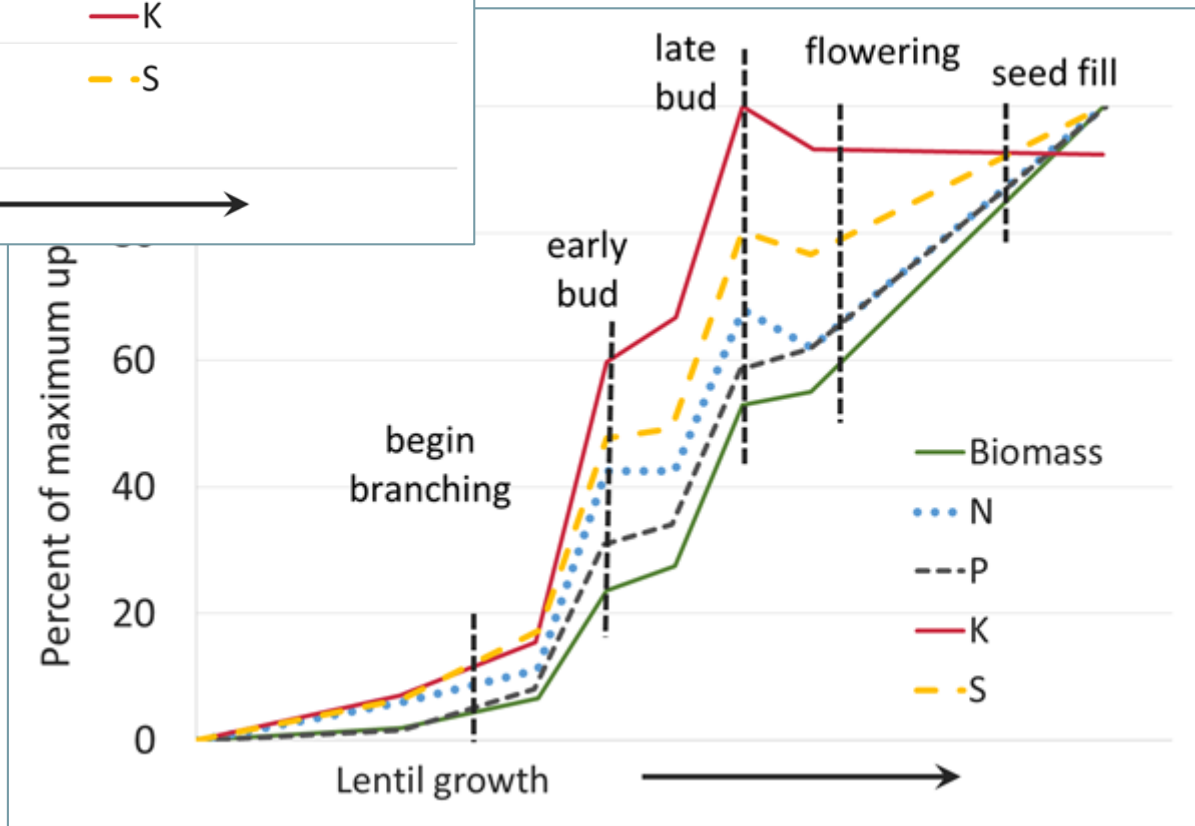
On to timing

Nutrient uptake

- Nutrient uptake precedes biomass
- Rapid demands once branching
- Indeterminates just keep growing



Pea



Source: Malhi et al., 2007, Saskatchewan

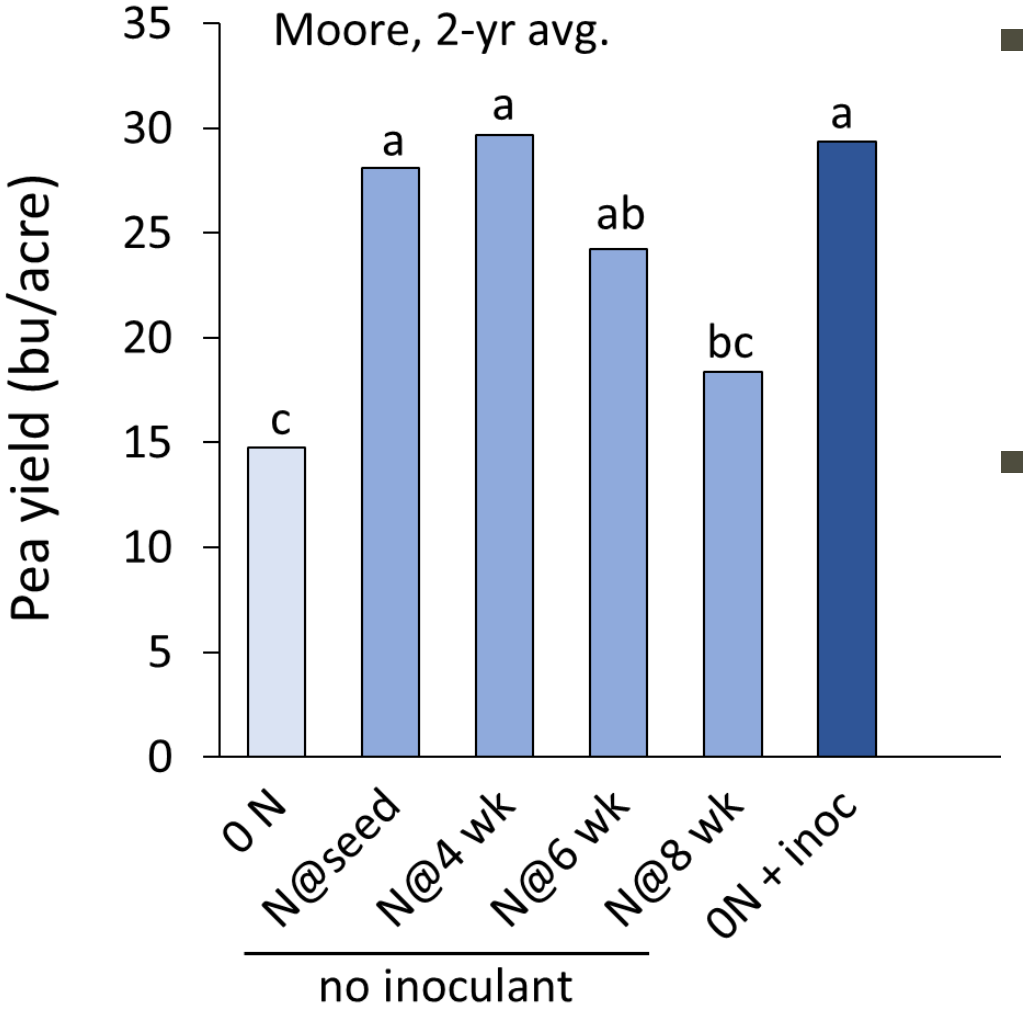
Lentil

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

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

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

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

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

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
- Pulses are sensitive to too much N, P, K and S in the seed row
- 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