Effects of Cropping Systems on Nitrogen and Phosphorus Availability

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MONTANA STATE UNIVERSITY | EXTENSION

Questions for you

- What crops do you grow?
- What crops have you considered growing?
- How many of you primarily recrop?

As diversity of cropping system increases:

Efficiency of fertilizer use increases. Why?

- Different rooting depths scavenge nitrogen and phosphorus at different depths
- Deep rooted crops can bring nutrients from subsurface to surface for use by shallow rooted crops (winter wheat → pea)

Some basics on effects of cropping systems on soil nitrogen (N)

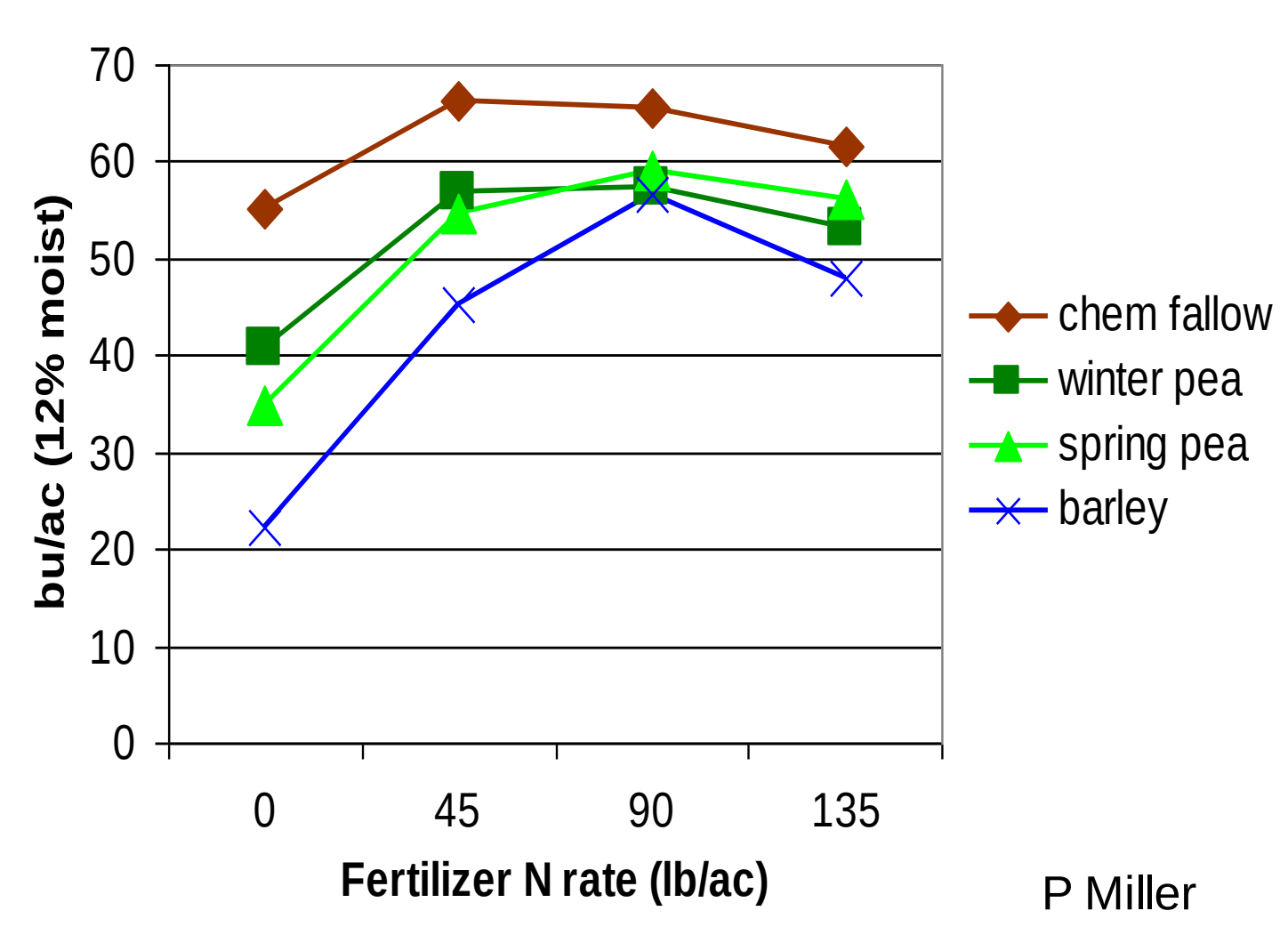
Previous crop affects:

- Amount of N
  - Small grain and oilseed stubble ties up N
  - Legumes release N

- Vertical distribution of N
  - Depends on rooting depth

- Timing of N release
  - Spring vs winter crop
  - Legumes decompose quickly
  - Small grain and oilseed stubble slowly

Effect of Previous Crop on N Needed to Optimize Wheat Yield

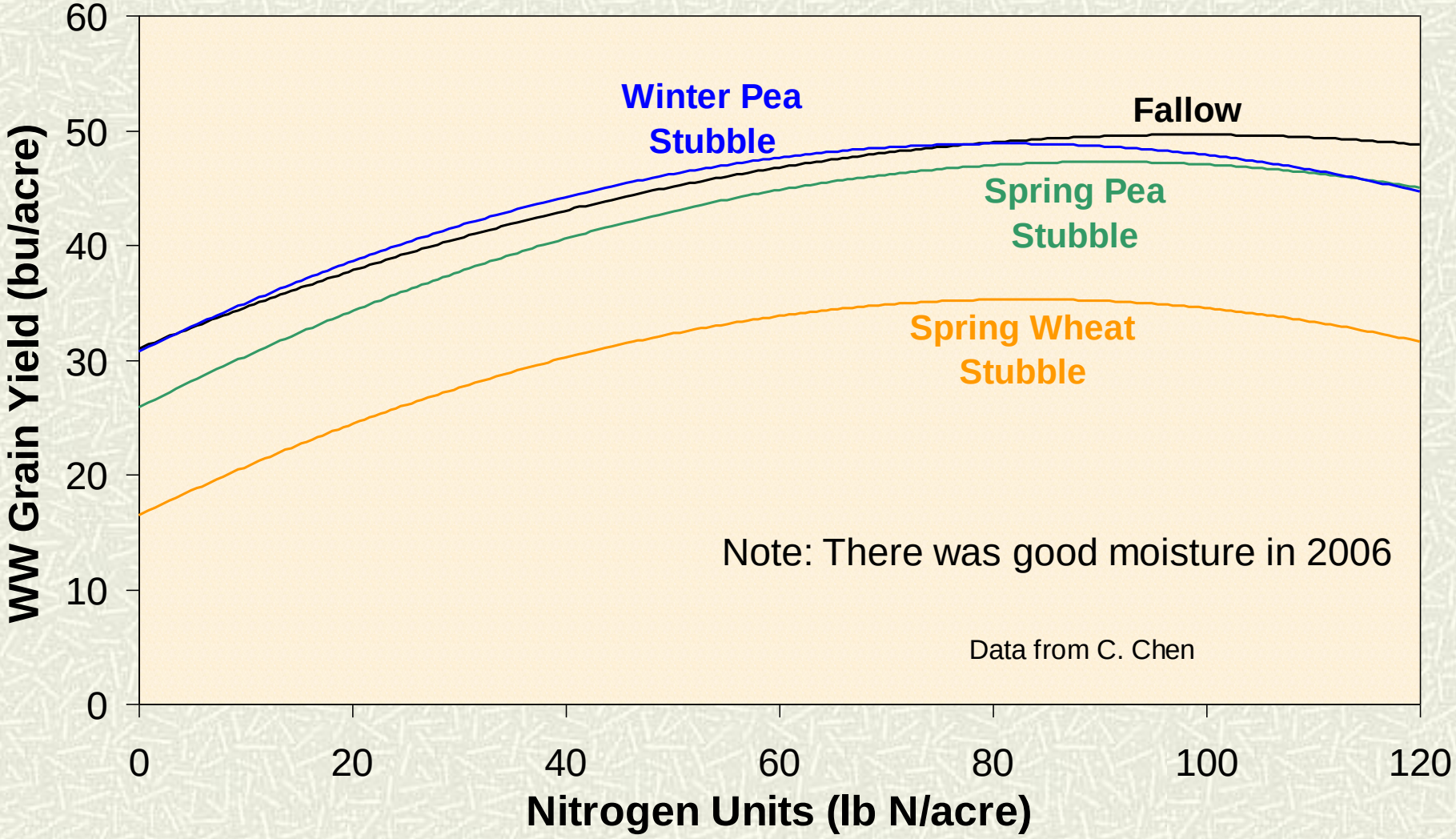


Wheat needs 0 to 45 lb/ac less fertilizer N when grown on fallow or pea than on barley.

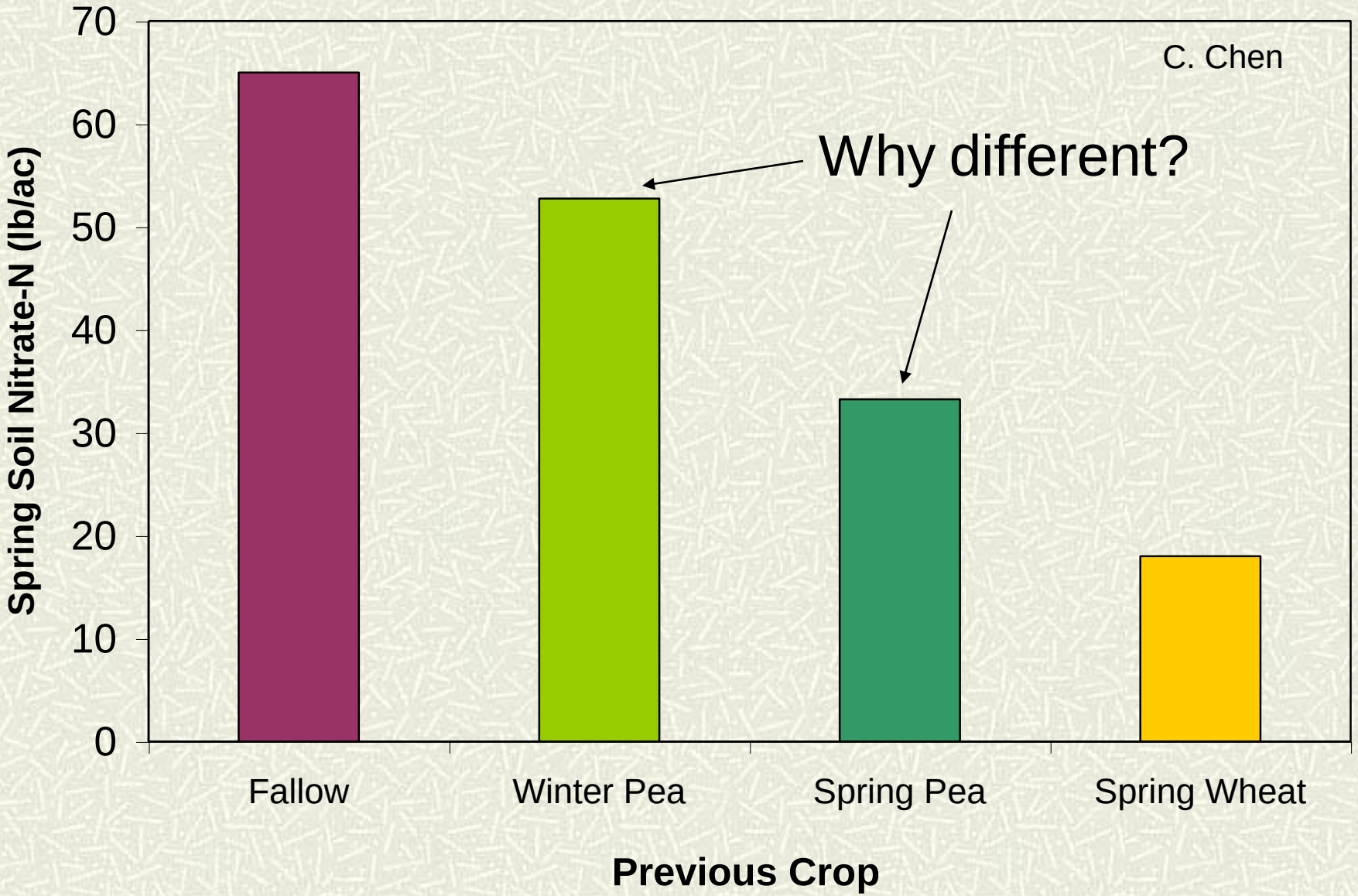
Moccasin Cropping System/Tillage Study

Effect of Previous Crop and N on 2006 Winter Wheat Grain Yield (NT)

Moccasin, MT



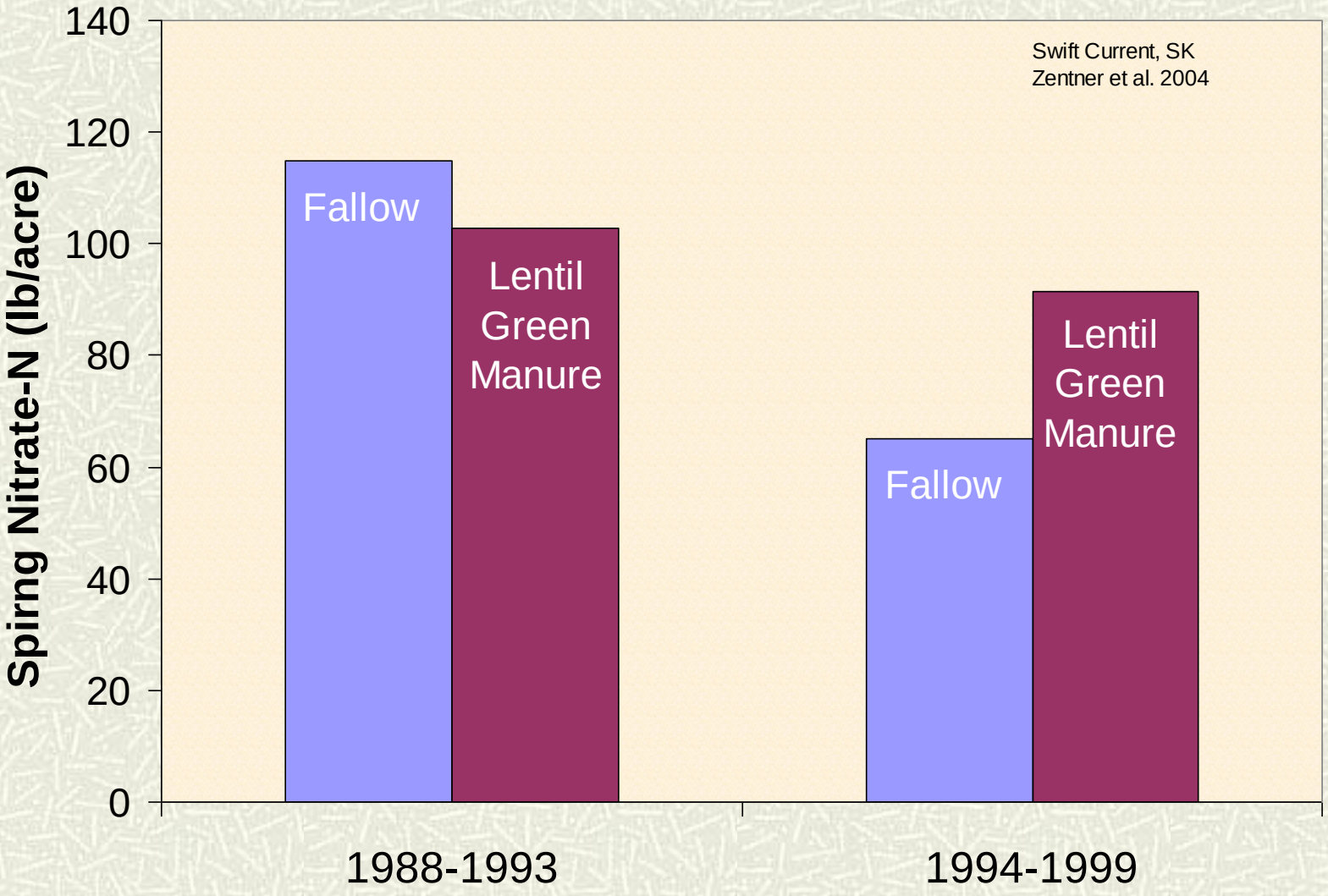
Effect of Previous Crop on Residual Nitrate-N



Nitrogen Benefits from Legumes

- 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.
- Benefit 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.

Effect of Lentil Green Manure on Spring Soil Nitrate-N Levels



Some basics on effects of cropping systems on soil phosphorus (P)

- Previous crop affects:

  -Soil moisture. Dry soil decreases available P.

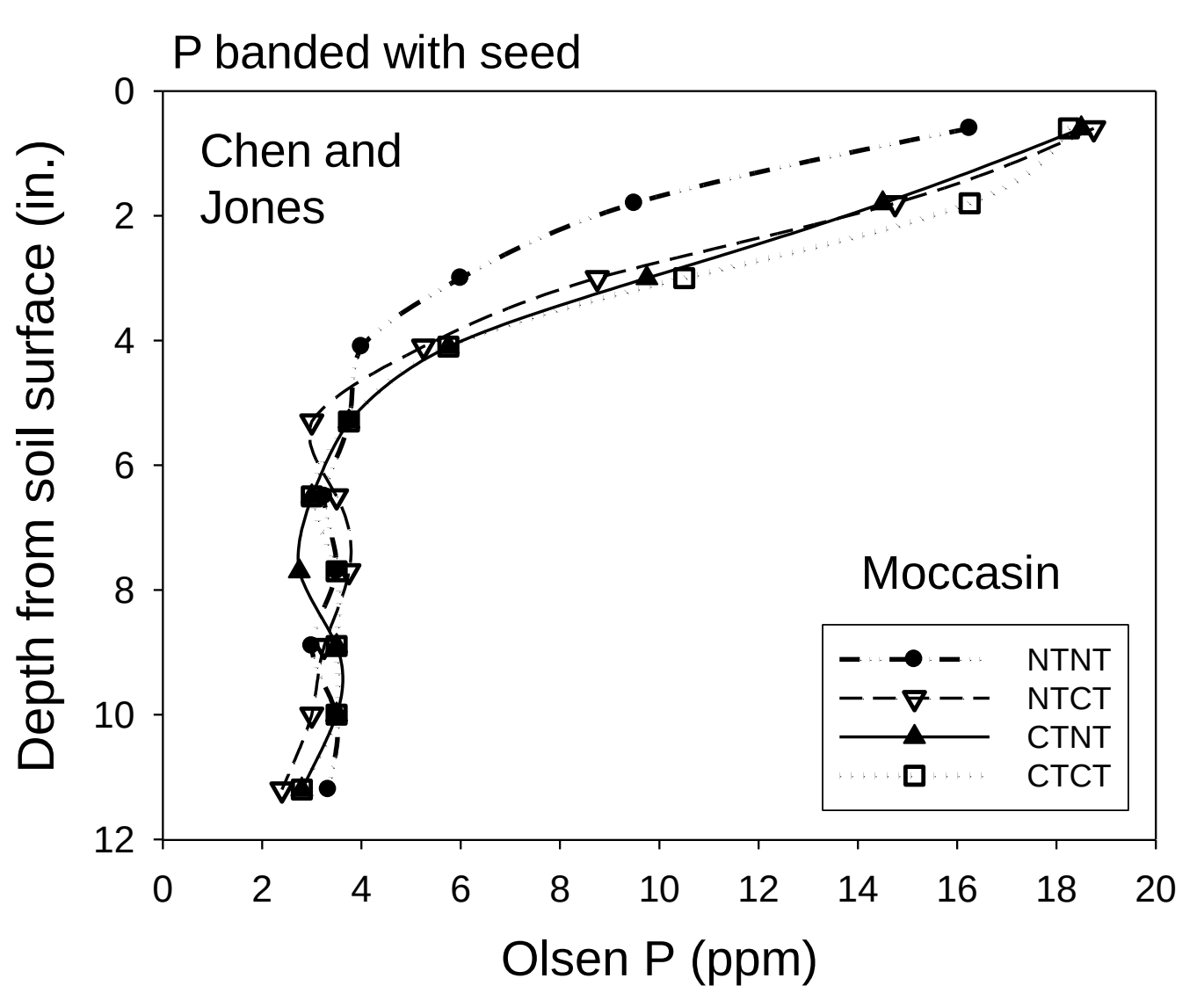
  Sunflowers, safflower, corn, wheat, barley can use substantial amounts of water

  Legumes use similar amounts of water at shallow depth, but very little at deeper depth

  -Available P can possibly be increased by:

  Legumes, buckwheat, and some mustards through root zone acidification

P can accumulate near surface in both no-till and tilled systems



Why important?

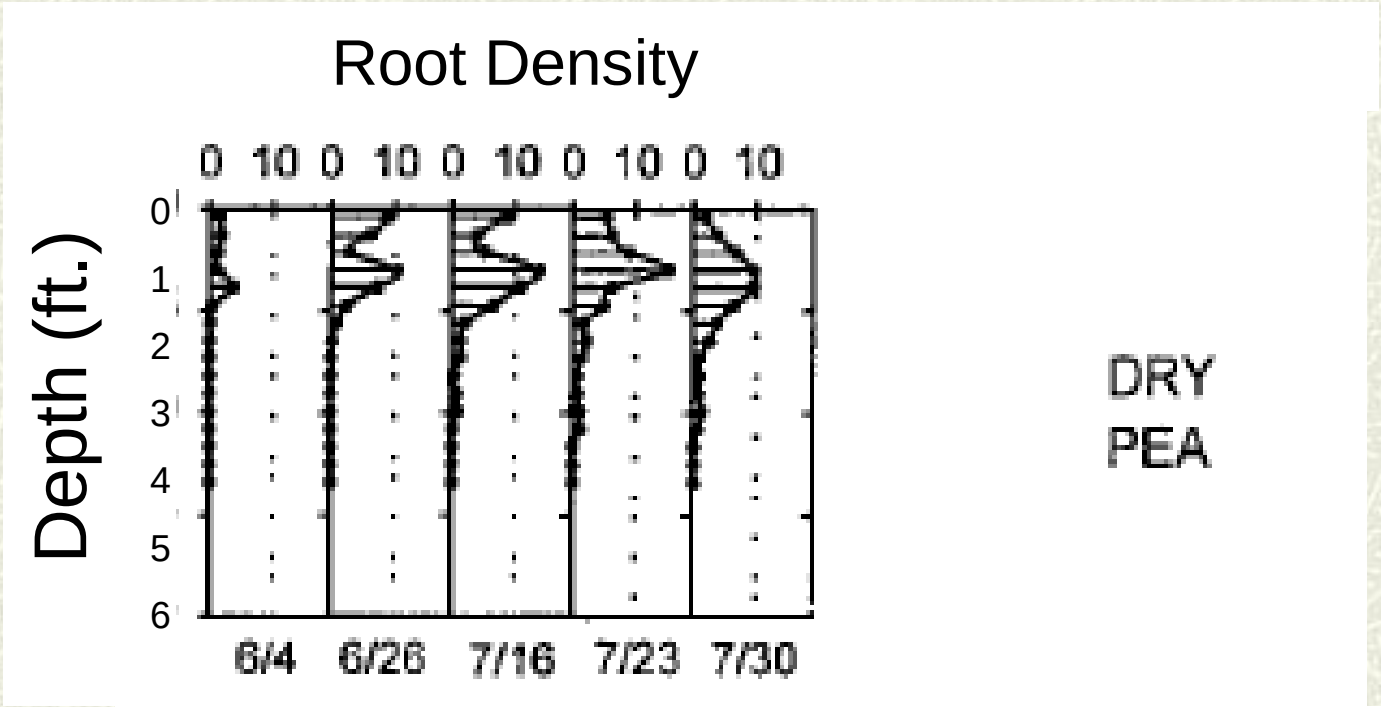
Shallow rooted crops can scavenge P from near surface, increasing efficiency of P fertilizer.

Maximum Rooting Depths (Mandan, North Dakota)

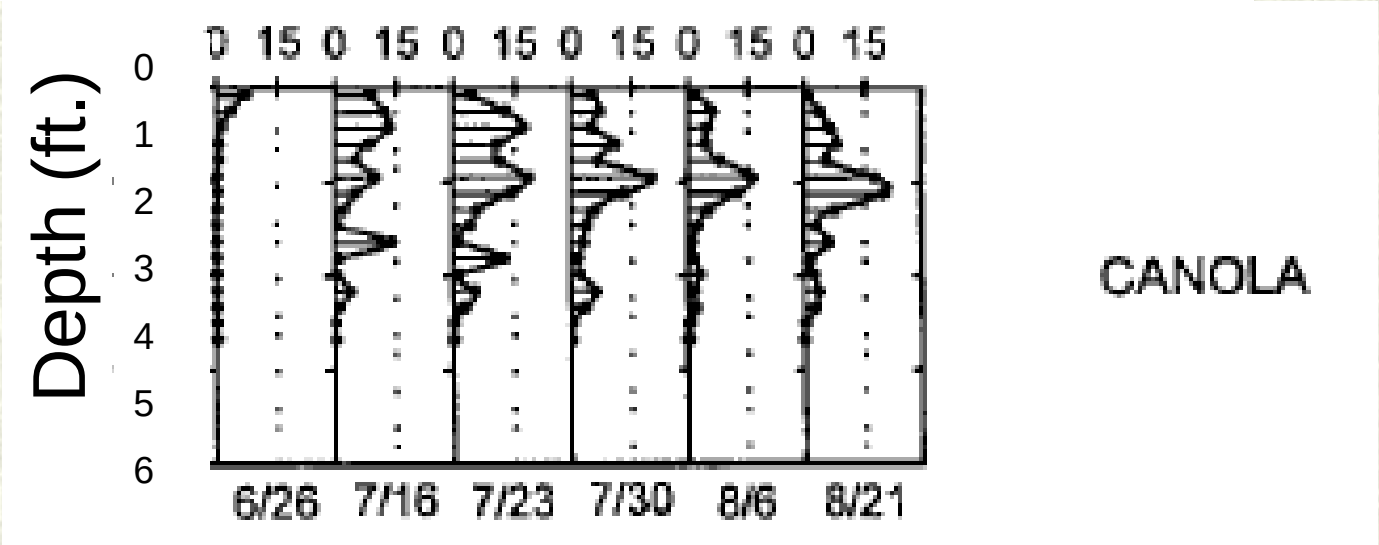
Crop	Maximum rooting depth (ft.)
Dry Pea	3.0
Canola	3.5
Spring Wheat	4.0
Sunflower	4.5

Merrill et al. 2002

What is More Important than Max. Root Length for Nutrient Uptake?



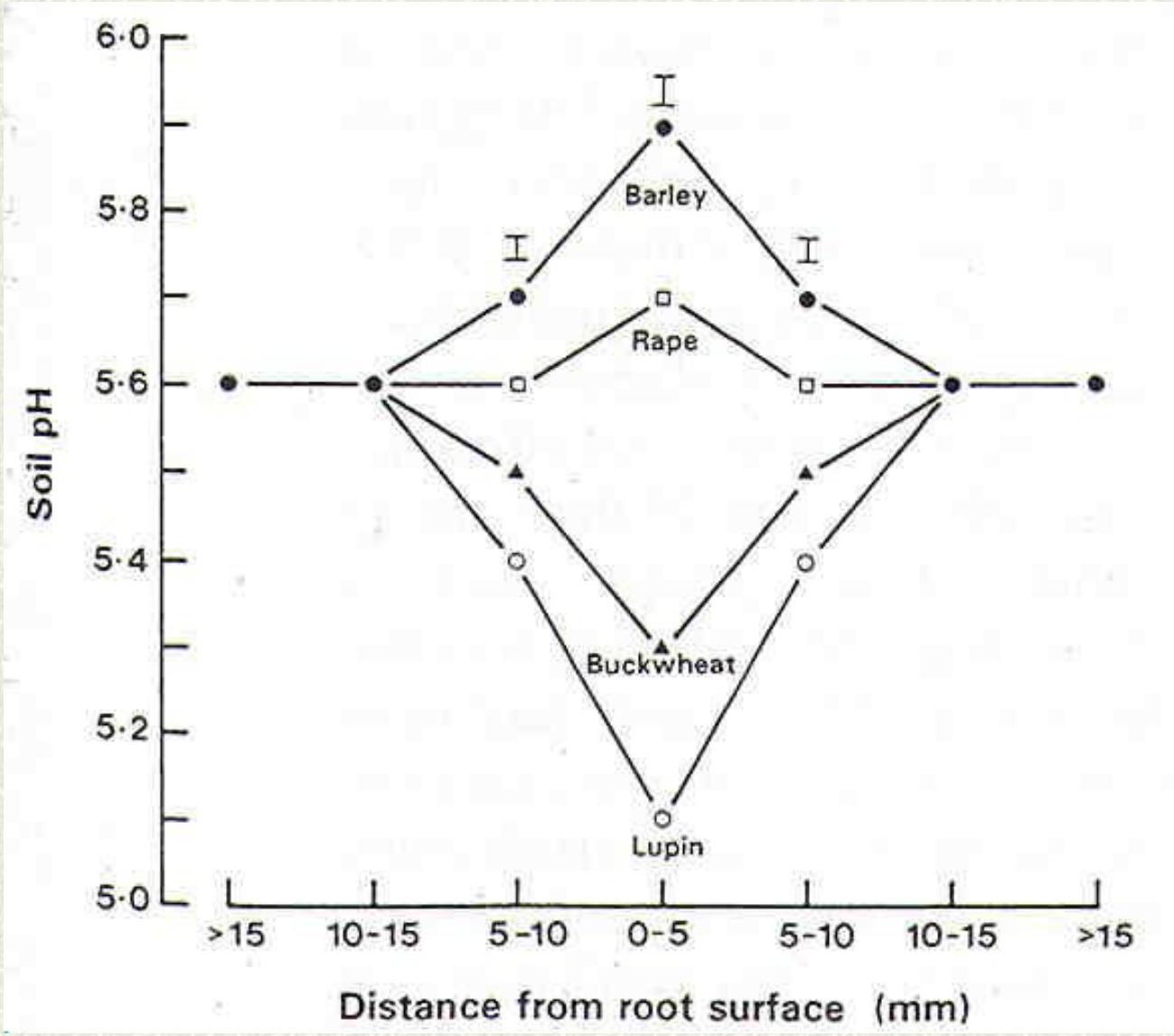
Dry pea will use more nutrients from surface; canola will use more from depth



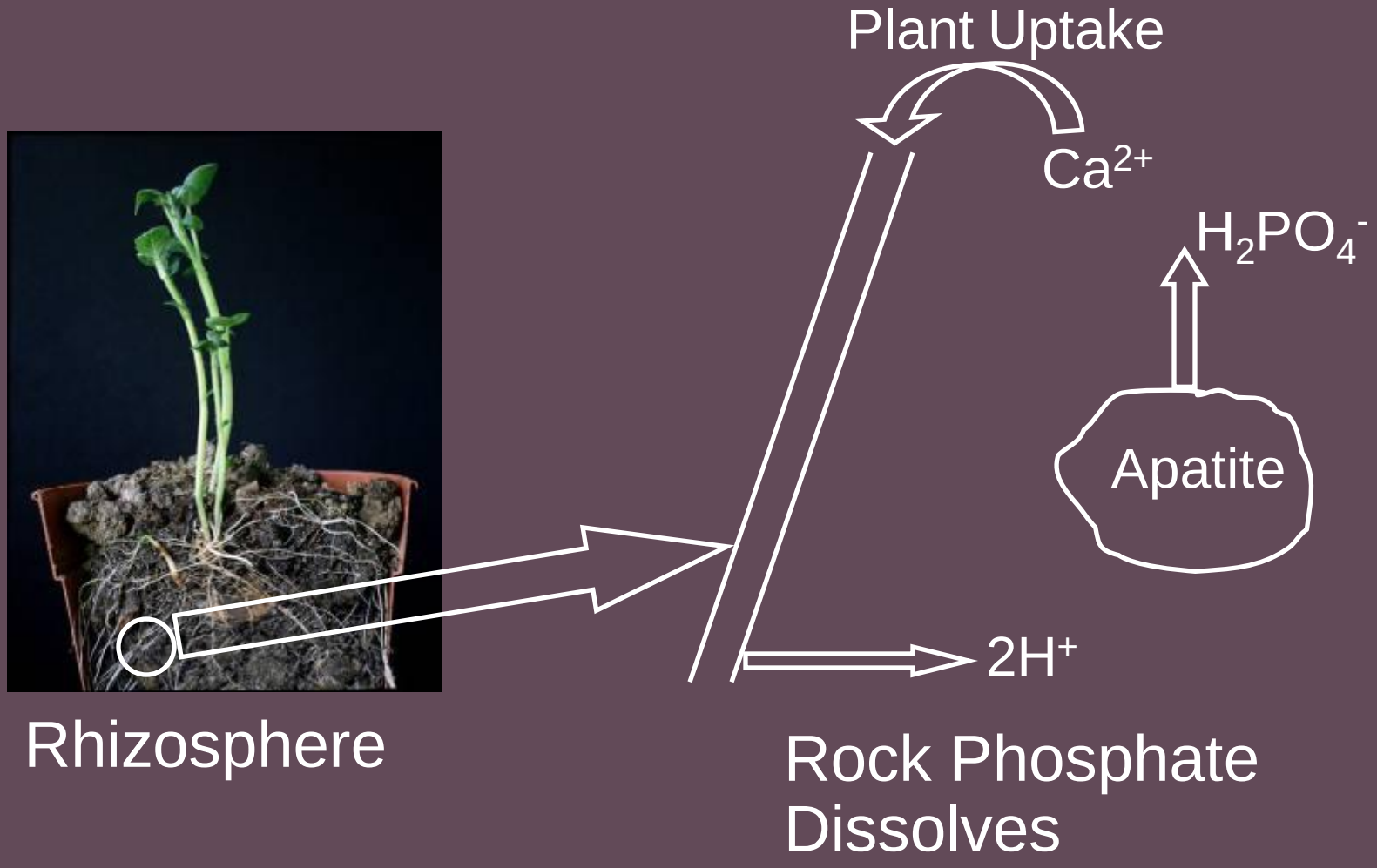
Crop Species that Acidify Rootzone

Buckwheat Legumes Some Mustards

Rootzone pH of four crops



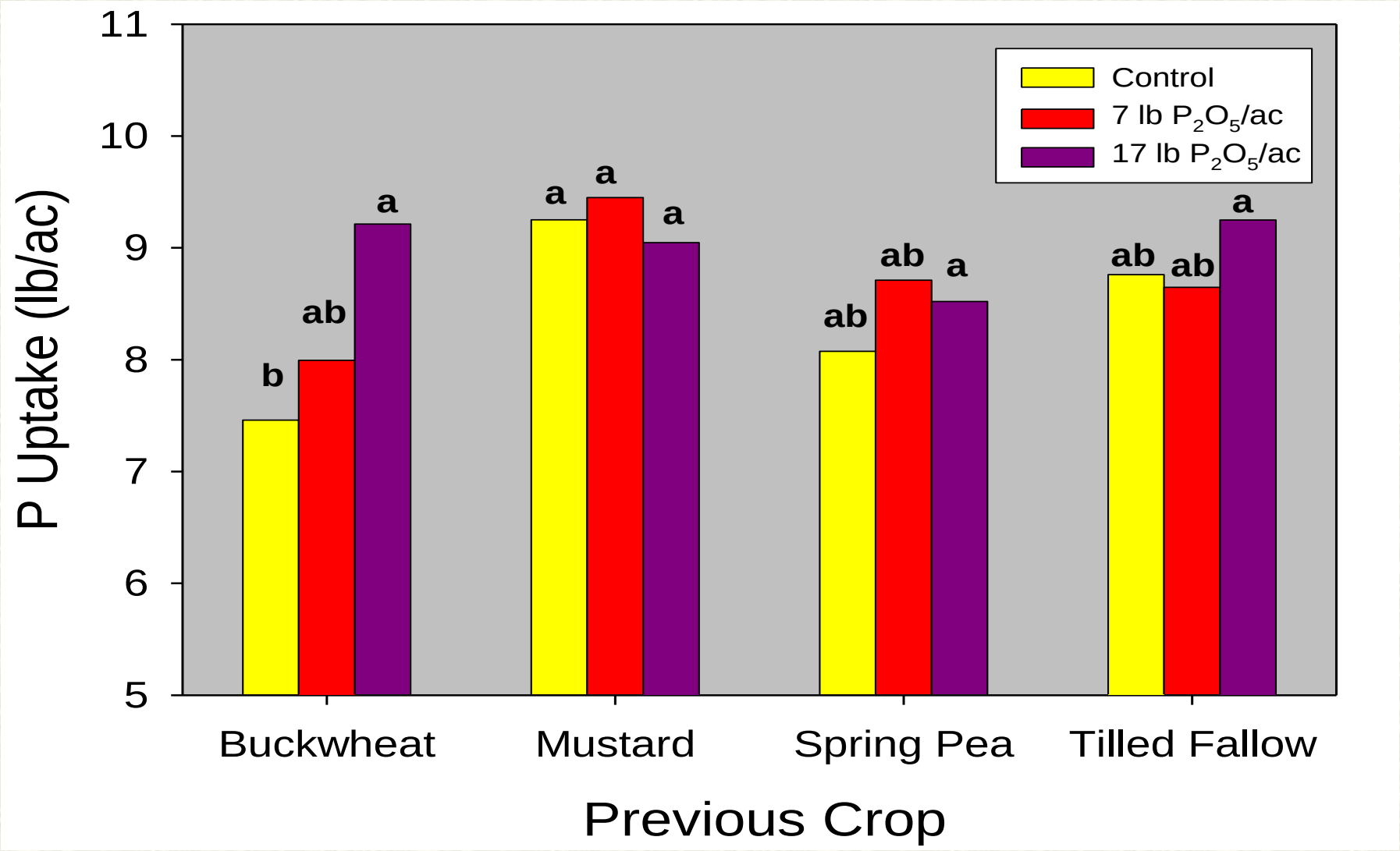
Mechanism for Acidification of the Rhizosphere



Effect of previous crop and rock phosphate on P uptake

- Big Sandy, Montana
- Organic farm

Effect of previous crop on winter wheat phosphorus uptake



Long-term Effect of Cropping System on Soil Fertility

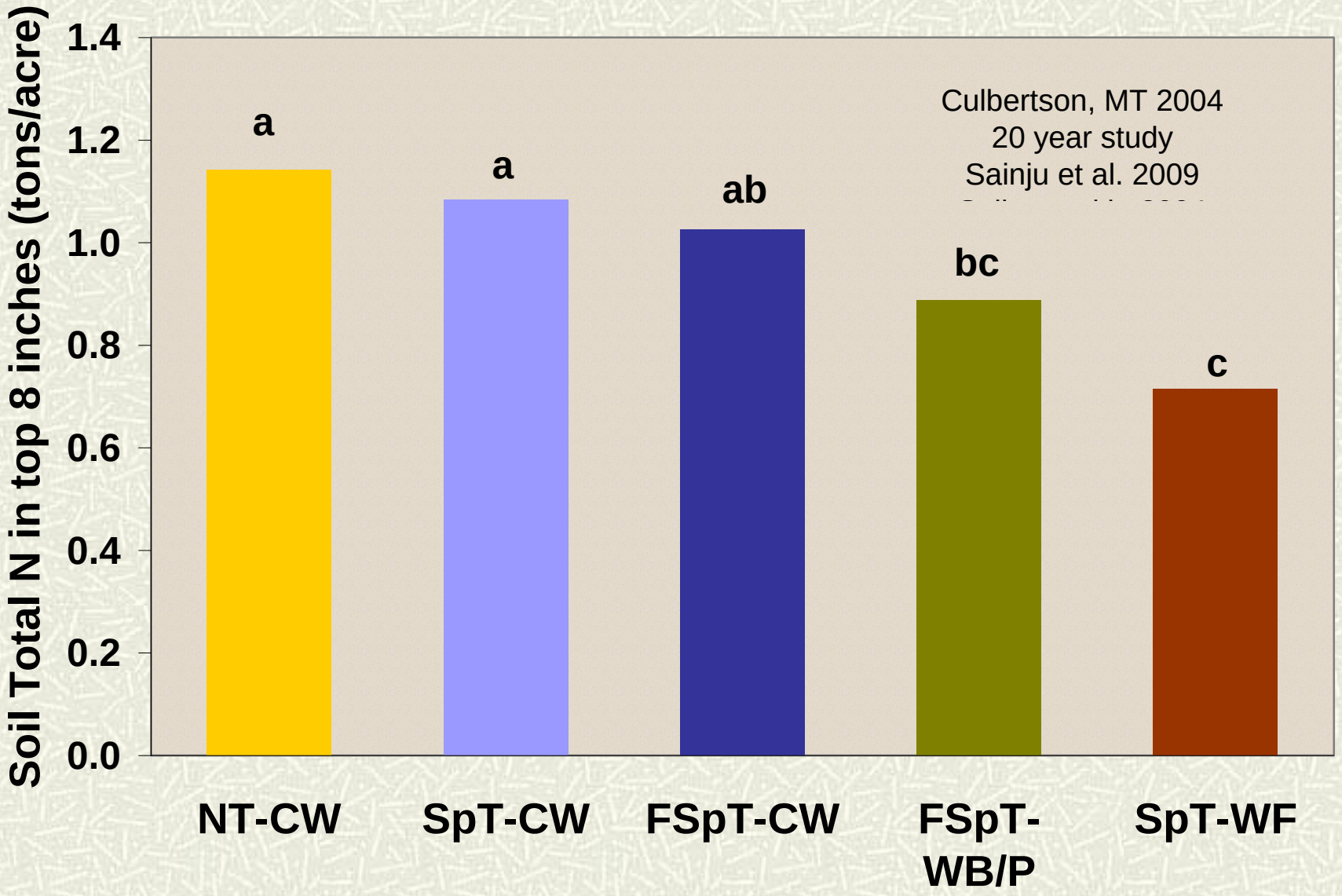
- 1983 to 2004 near Culbertson, MT
- Comparing tillage and crop
- Small-plot field trial
- Soil samples:
  - Collected in October 2004, 4-6 weeks after fall tillage
  - Taken to 8 inch depth

Tillage and Crop Combinations

- NT-CW : No Till-Continuous Spring Wheat
- SpT-CW: Spring Till-Continuous Sp. Wheat
- FSpT-CW:
  Fall & Spring Till – Continuous Sp. Wheat
- FSpT-WB/P: Fall & Spring Till – Wheat/Barley (17 years), Wheat/Pea (4 years)
- SpT-WF: Spring Till – Sp. Wheat/Fallow

All residue was left on the field

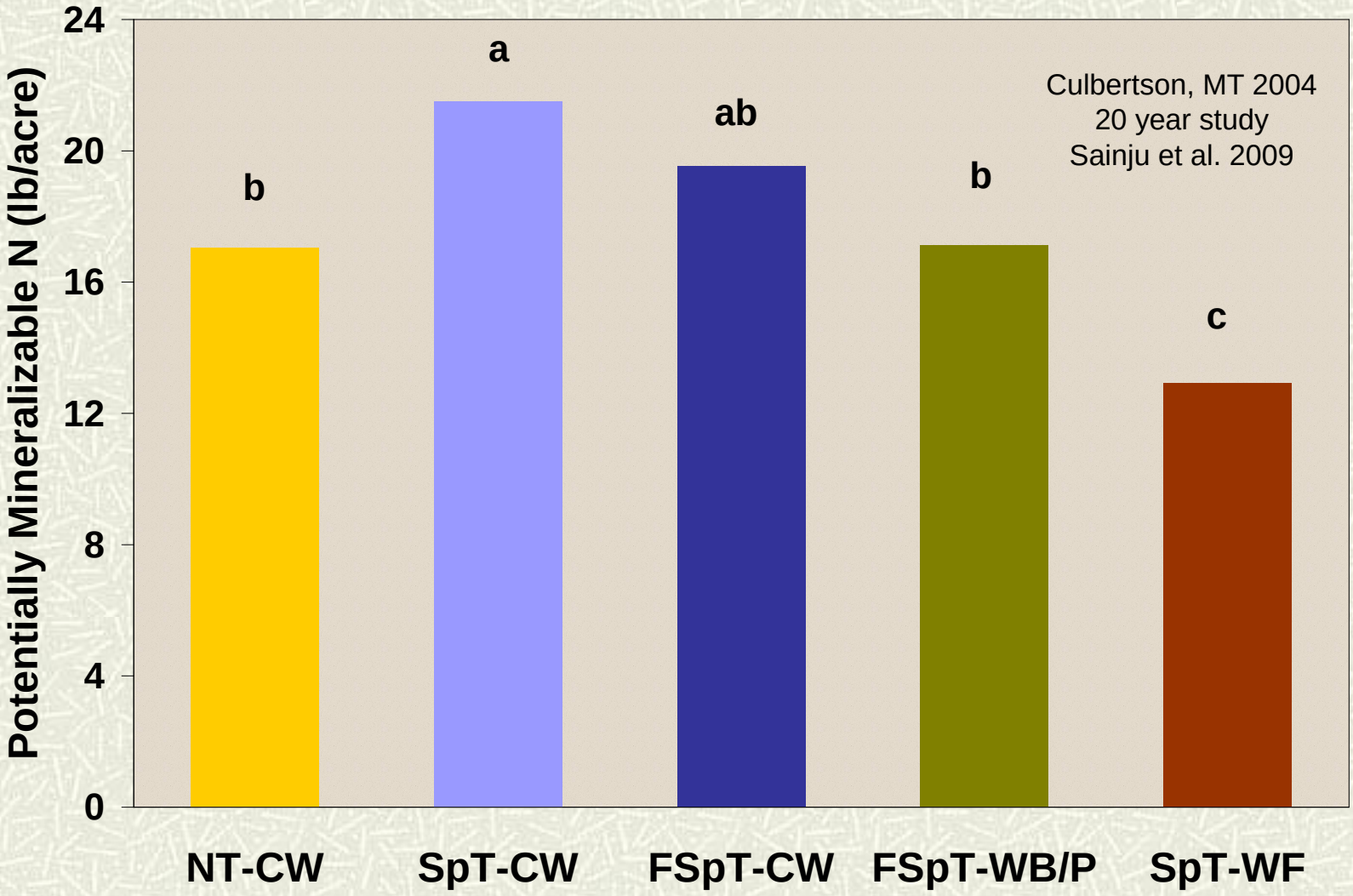
Soil Total N


Soil Total N in top 8 inches (tons/acre)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
a
a
ab
bc
c
Culbertson, MT 2004
20 year study
Sainju et al. 2009
NT-CW
SpT-CW
FSpT-CW
FSpT-WB/P
SpT-WF

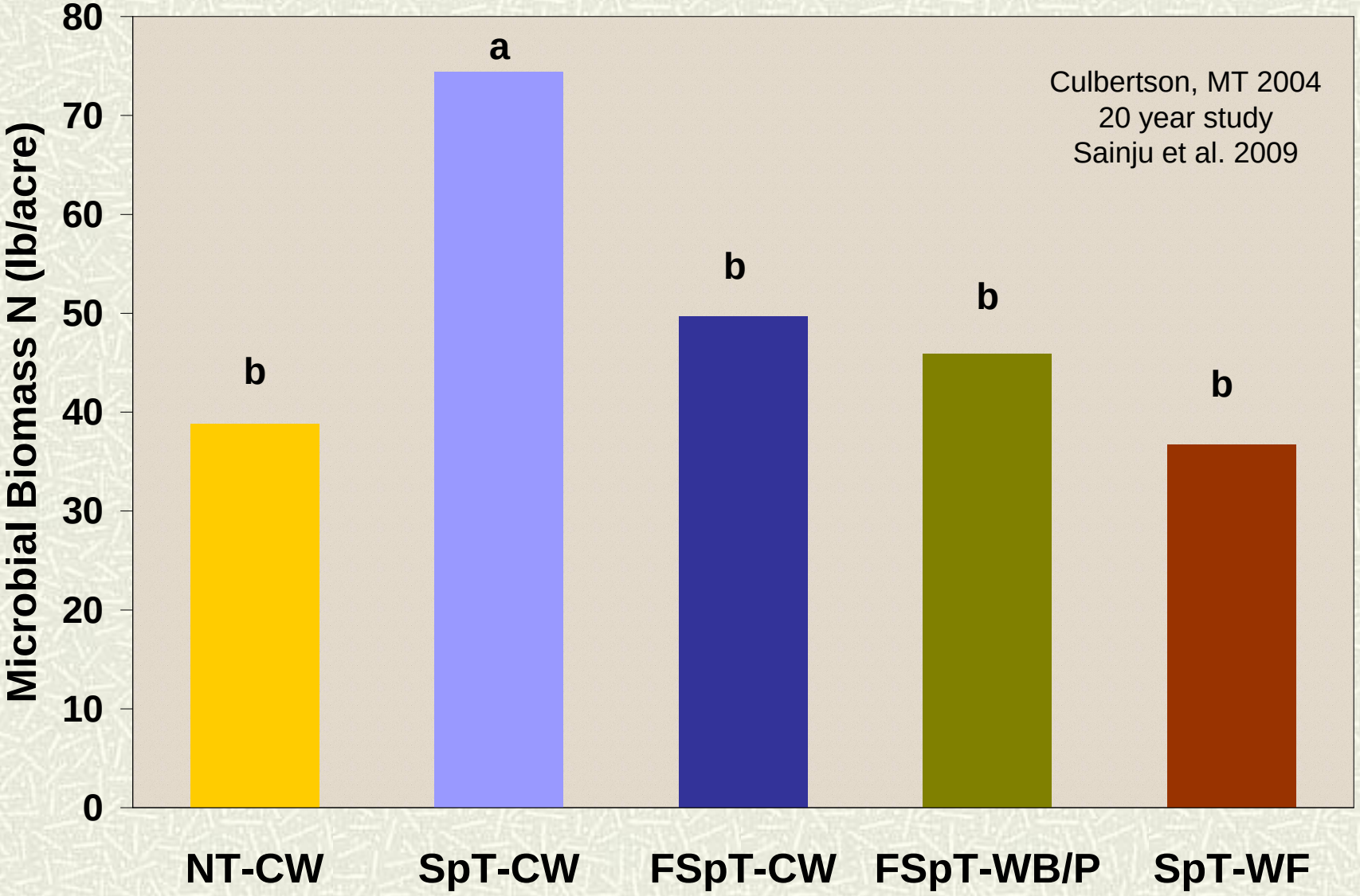
Why does fallow have less soil total N than recrop?

- Little to no plant N uptake in fallow year
- More rapid decomposition of residue
- Leading to greater potential for N loss to leaching

Potential N from Organic Matter



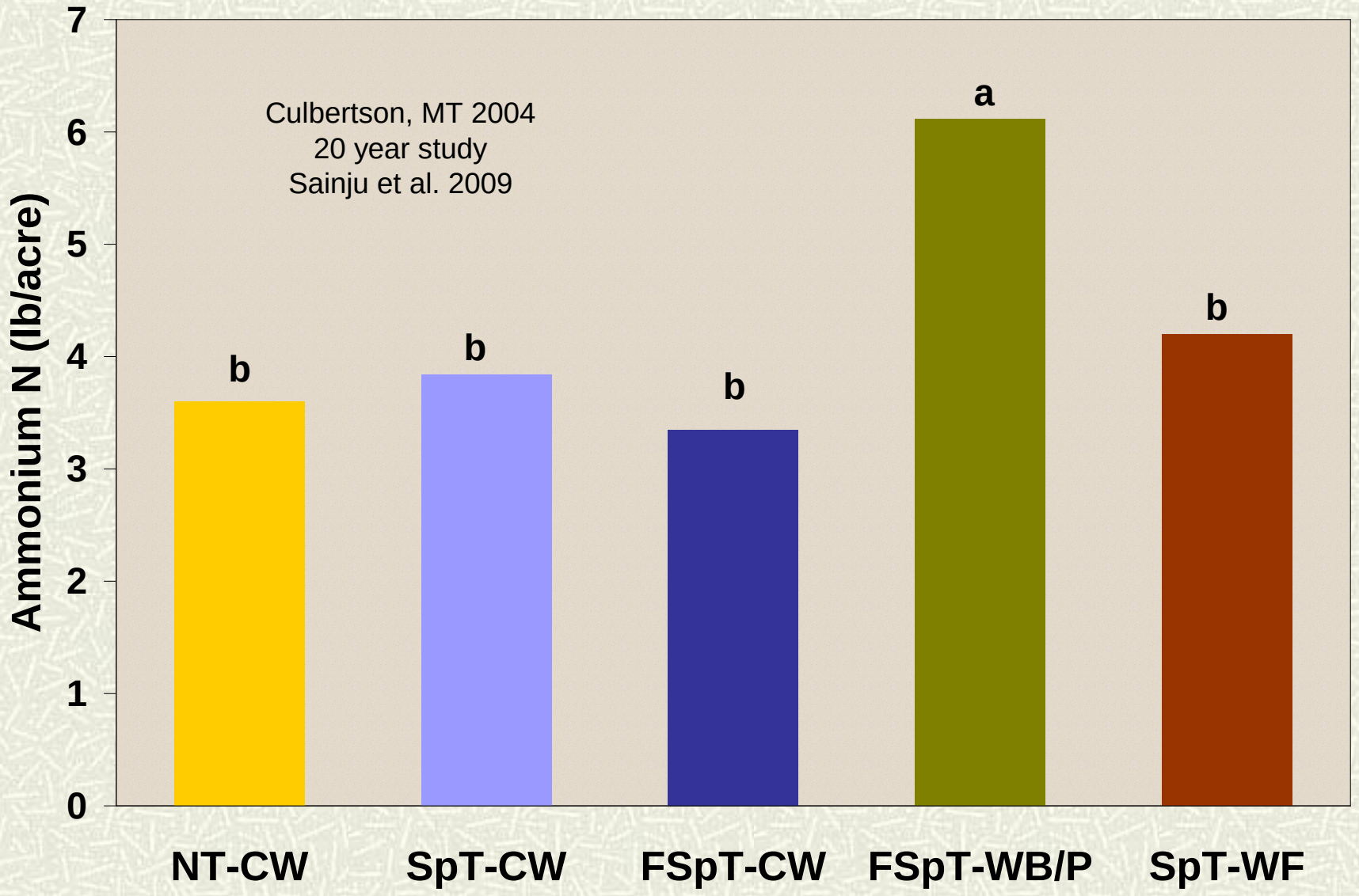
Microbial Biomass N



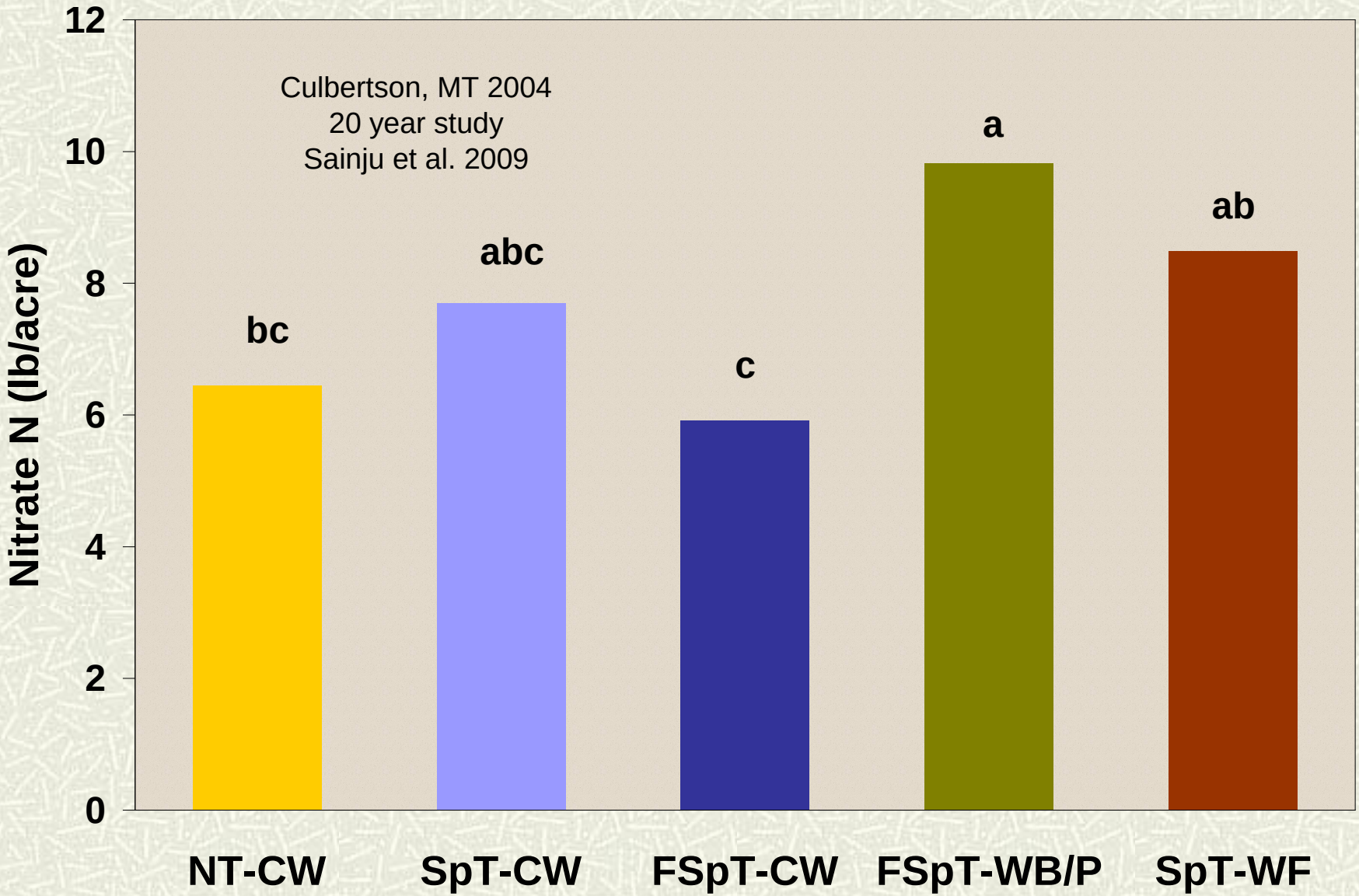
Potential N from organic matter (PMN) and microbial biomass N (MBN) are highest in SpT-CW. Why?

- In NT the residue may sit on the soil surface with minimal decomposition potential.
- In twice tilled systems, adding fall-tillage to spring tillage increases the decomposition of residue to plant available N sources – PMN and MBN are reduced more quickly.

Ammonium N


Culbertson, MT 2004
20 year study
Sainju et al. 2009
Ammonium N (lb/acre)
0
1
2
3
4
5
6
7
b
b
b
a
b
NT-CW
SpT-CW
FSpT-CW
FSpT-WB/P
SpT-WF

Nitrate N

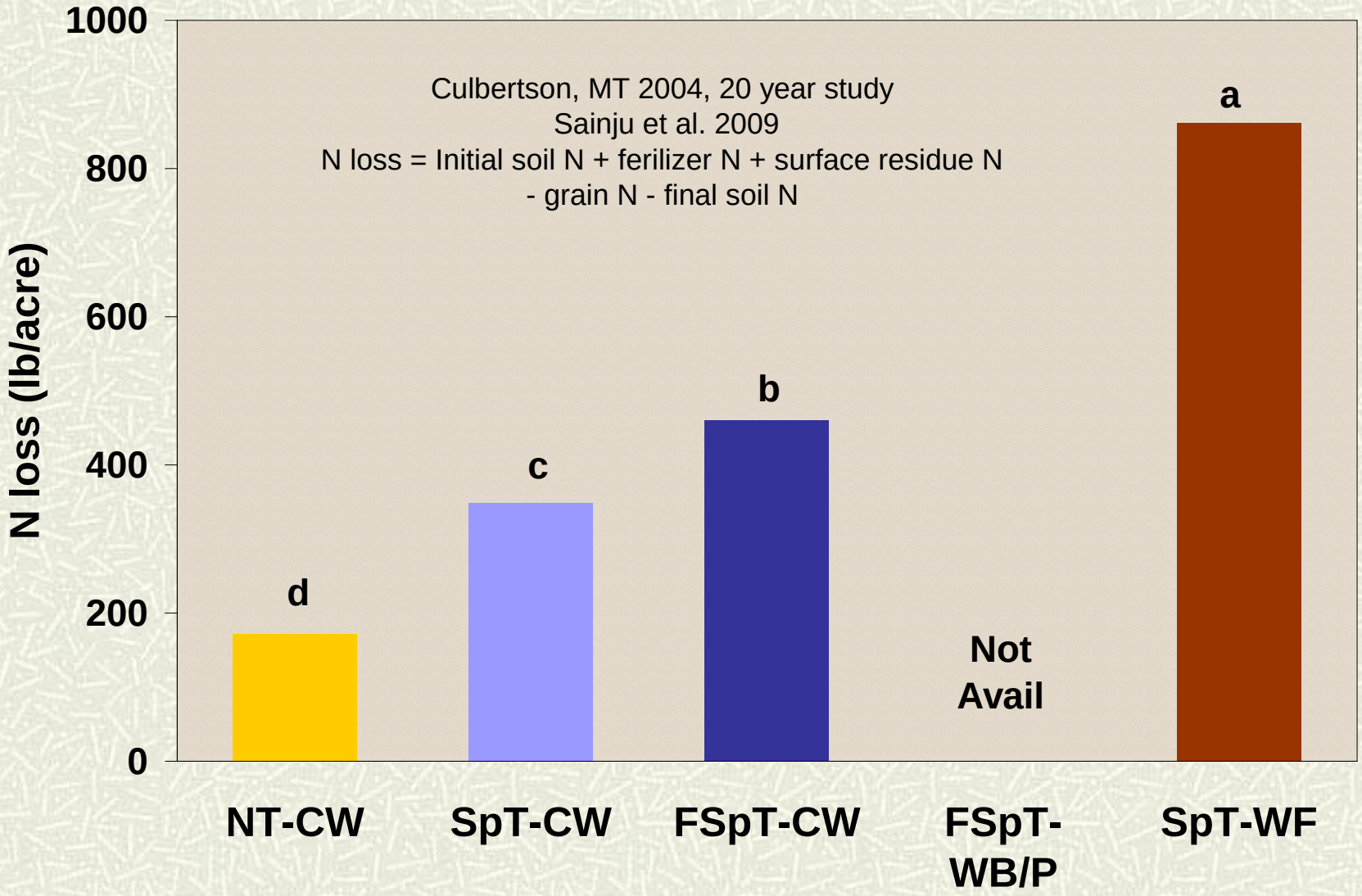

Culbertson, MT 2004
20 year study
Sainju et al. 2009
Nitrate N (lb/acre)
12
10
8
6
4
2
0
bc
abc
c
a
ab
NT-CW
SpT-CW
FSpT-CW
FSpT-WB/P
SpT-WF

Why does FSpT-WB/P have higher ammonium N than all the other treatments?

- Pea residue decomposes more rapidly than wheat and has higher N than wheat
- Incorporation by fall tillage enhances residue decomposition

Estimated N loss

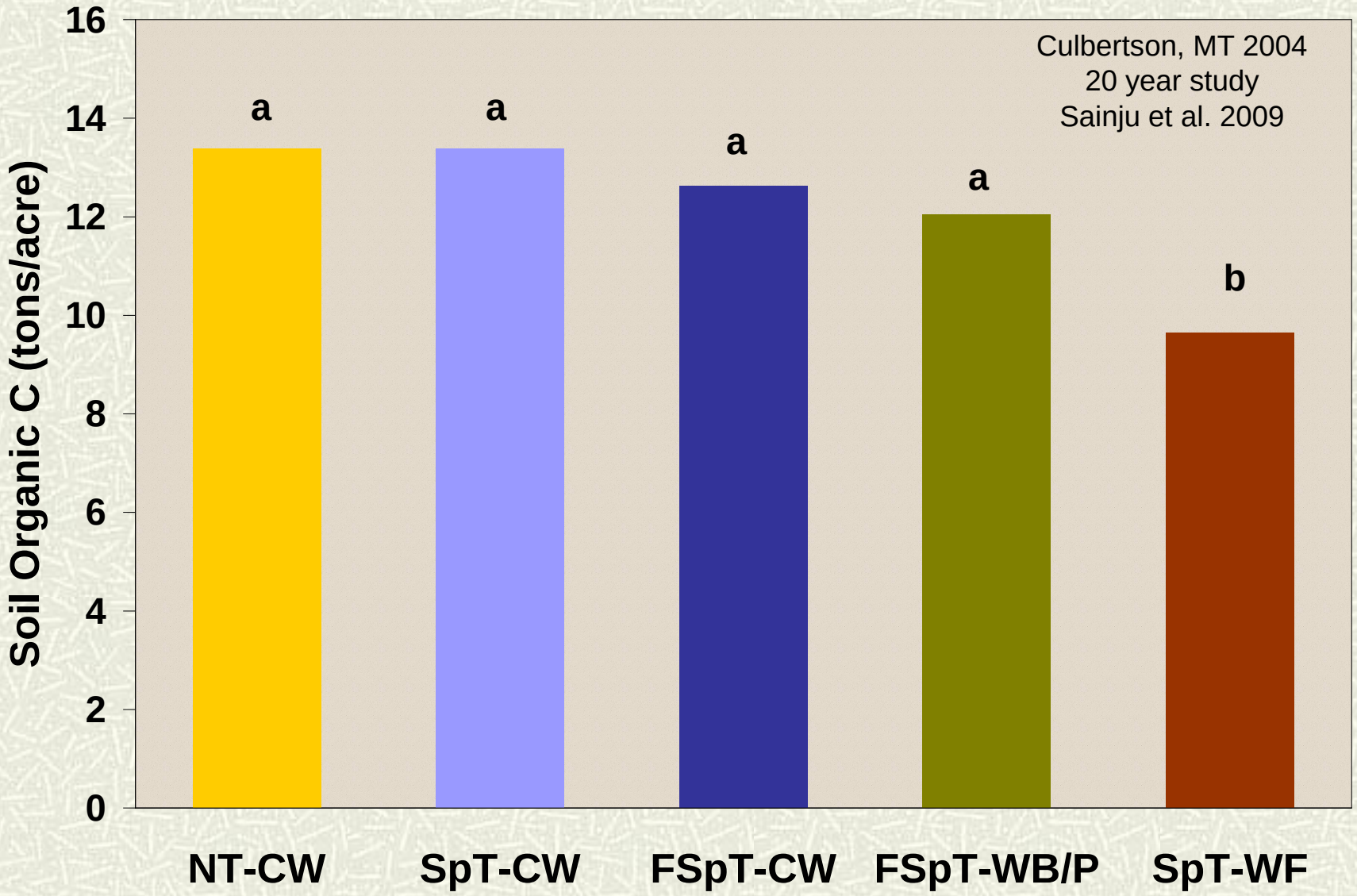
Spring 1983 to Fall 2004



Why does fallow lose much more soil N than the other systems?

- No N uptake in fallow year
- Residue decomposition is more rapid because of higher soil moisture and perhaps soil temperatures
- N is not retained on site in plant residue

Soil Organic Carbon



Effect of Straw Removal

- If you bale and remove 3/4 ton residue per acre as straw
- Per acre this removes:

  750 lb C (value?)

  11 lb N = $11

  3 lb P_2O_5 = $3

  19 lb K_2O = $13 Total = $27/ac

  Using 2008 fertilizer prices

  Oct. 2009 straw sold for $45/ton or ~$34 for ¾ t

Conclusions

- Adding legumes to rotation increases plant available soil N and may reduce fertilizer needs.
- Continuous cropping and reduced tillage increase stored soil N.
- Minimum till may increase plant available N, compared to NT.
- Fallow has high potential soil N loss to leaching, volatilization and N_2O emission. NT-CW stored 40 lb N/acre/year more than ST-WF by reducing N losses.
- Fallow reduces organic matter; organic matter increases with residue.

Other Resources

- Soil Fertility information: http://landresources.montana.edu/soilfertility

  Ex: Nitrogen Rate Economic Calculator

- MSU-Bozeman Cropping Systems: http://scarab.msu.montana.edu/CropSystems/

Questions?