Nutrient Management in Reduced Tillage Systems

Crop Pest Management School

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MONTANA STATE UNIVERSITY
EXTENSION

Objectives

- Overview of tillage systems in Montana
- Discuss how minimum tillage (MT), no-tillage (NT), and conventional tillage (T) can affect:
  - Nitrogen (N) mineralization
  - Stratification of phosphorus (P) and potassium (K)
  - Soil erosion, water conservation, and temperature
- Discuss management recommendations among each tillage system

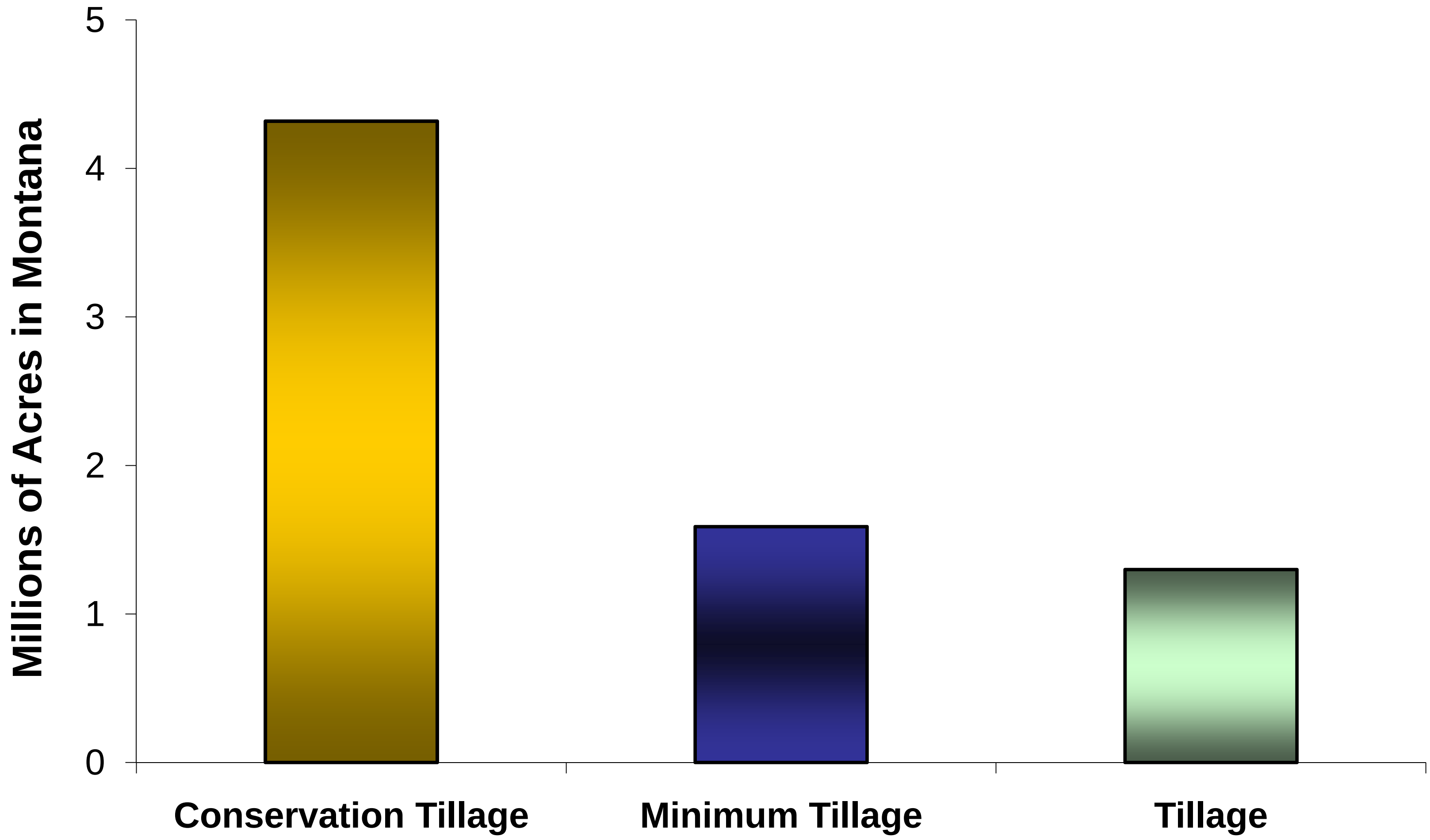
Minimum Tillage Systems

- 15 to 30% of soil surface contains residue
- Minimal soil disturbance
- Examples:
  - Stubble mulching = Tillage that leaves stubble on soil surface
  - Fewer tillage passes
  - Shallow tillage
  - Strip tillage

Conservation Tillage Systems

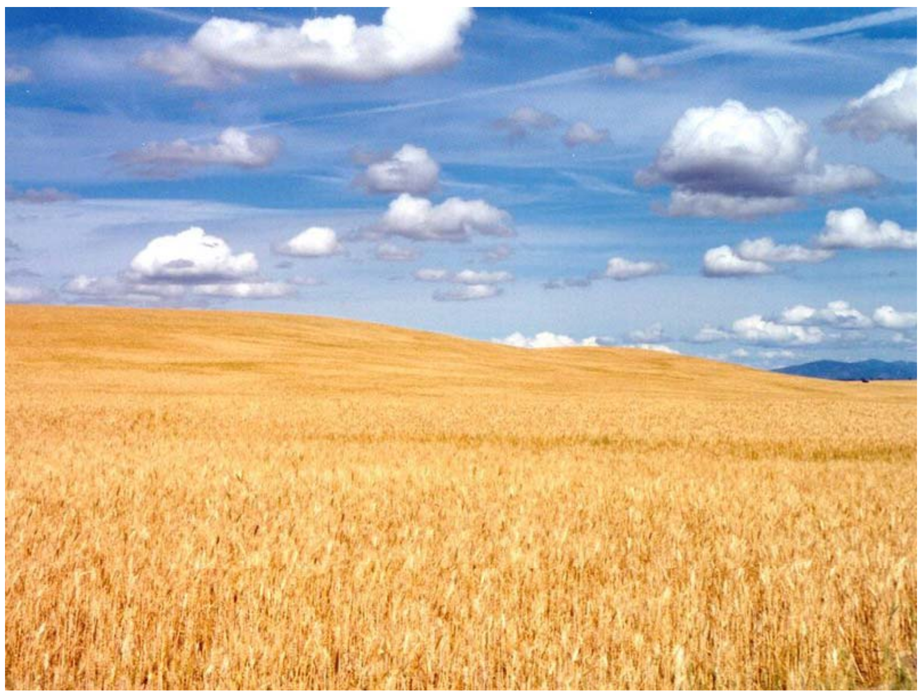
- High levels of crop residue on soil surface
- Minimal to no soil disturbance from harvest to harvest
- Examples:
  - Ridge till
  - Mulch till = Lightly disturbed soil surface prior to planting
  - No-till
    - Most advanced type of conservation tillage

Tillage Systems in Montana

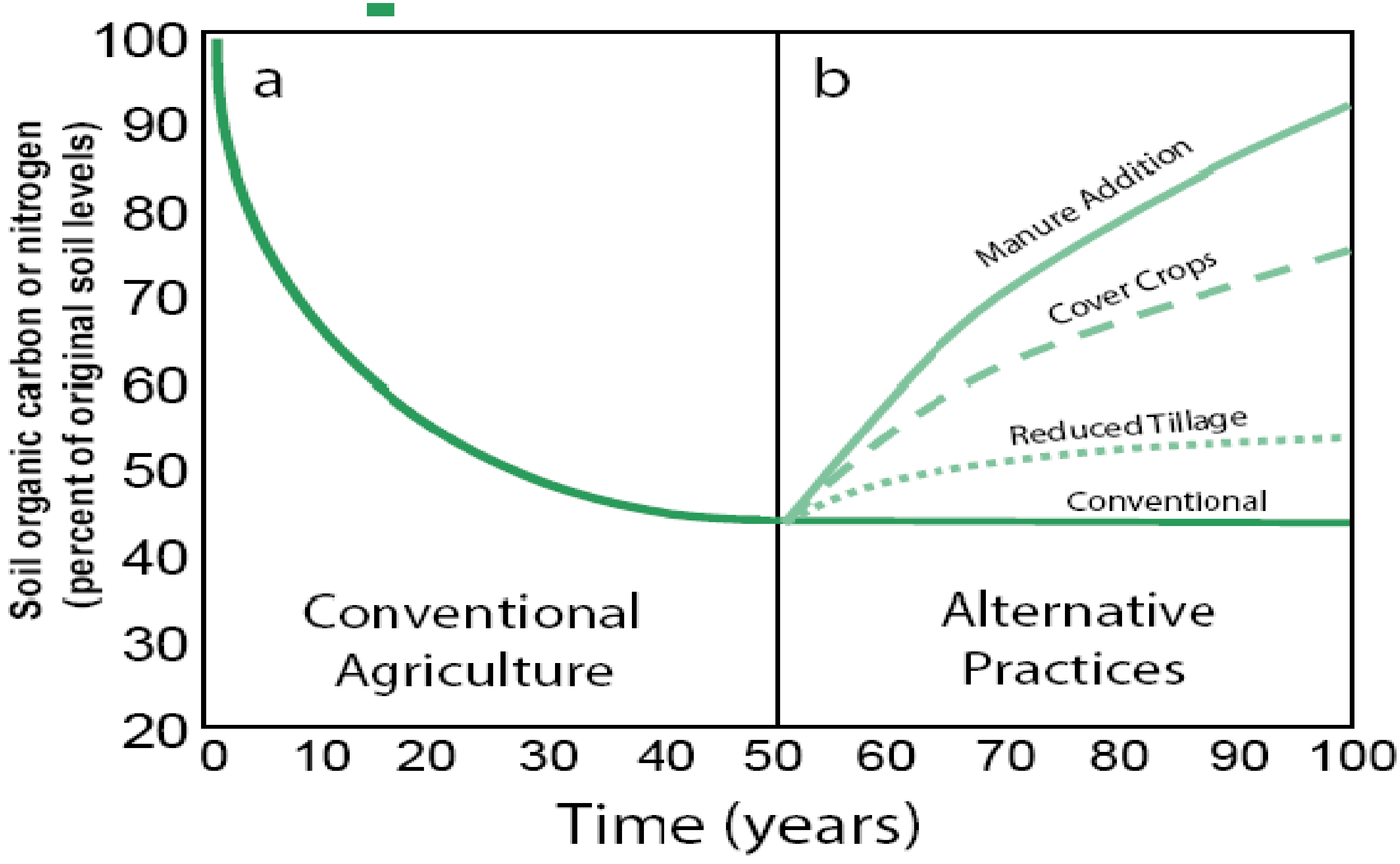


Data from Conservation Technology Information Center

DIFFERENCES IN NITROGEN MINERALIZATION

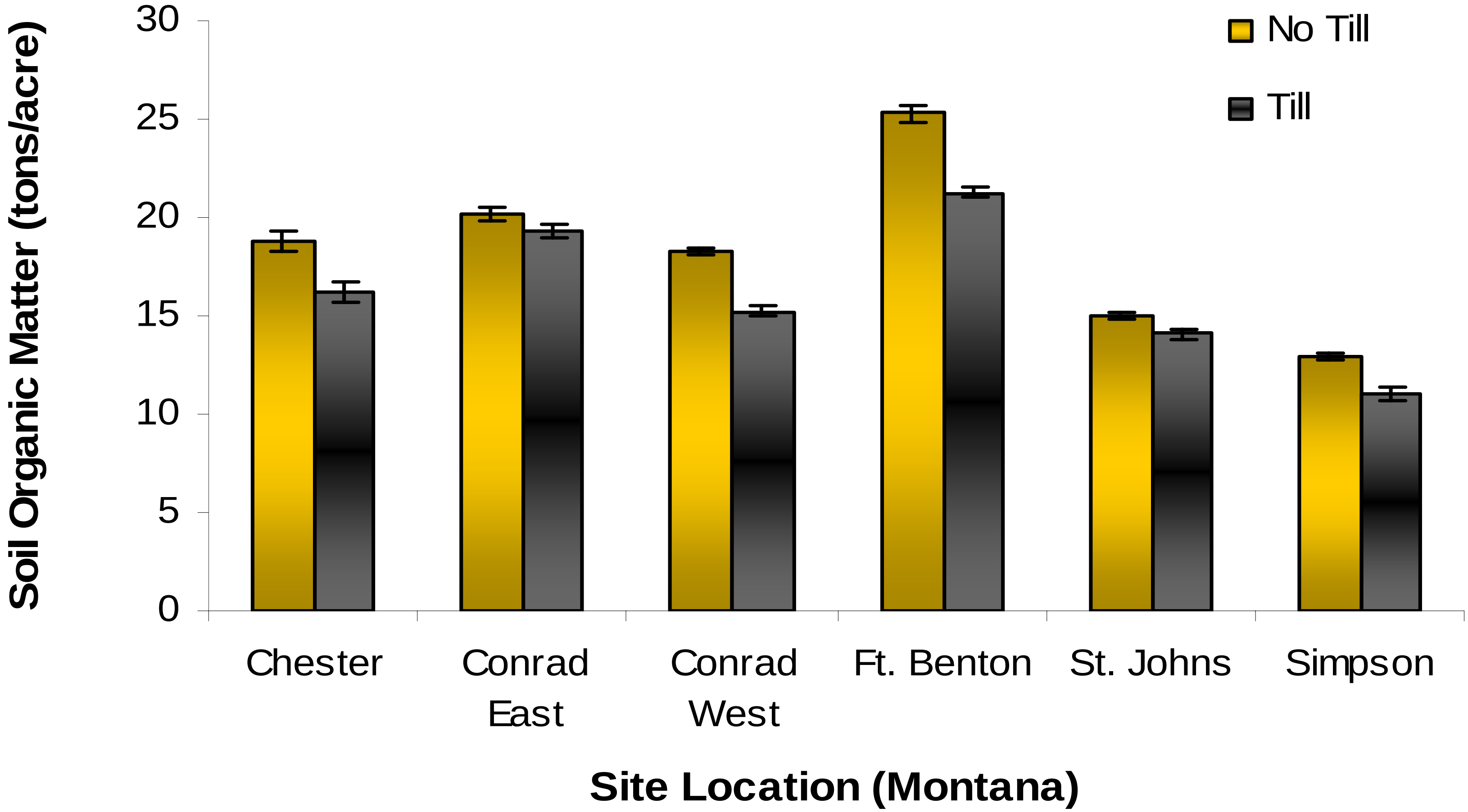


How does management affect soil organic carbon?



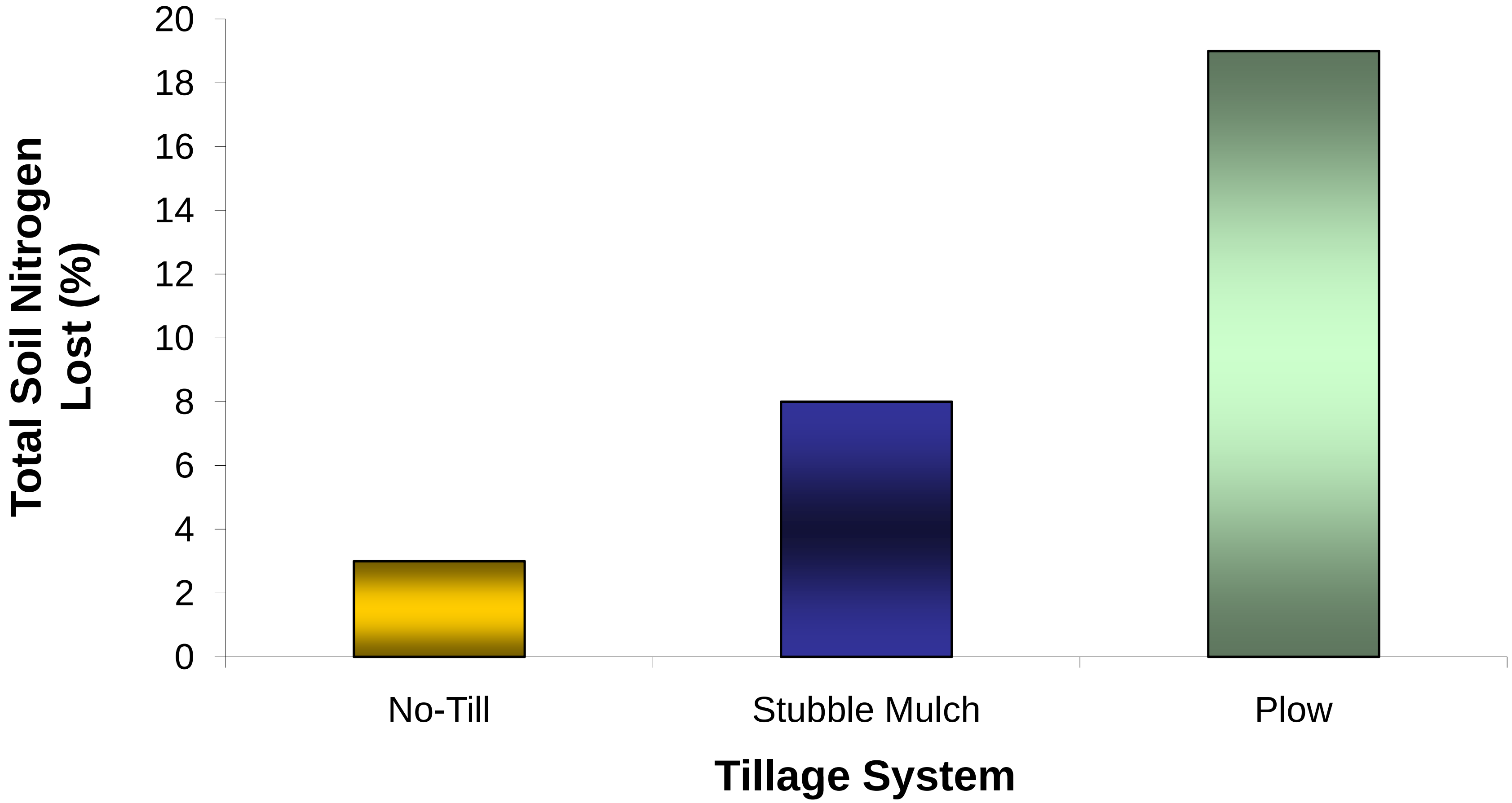
(Modified from Tilman, 1998)

How does tillage affect soil organic matter in Montana?



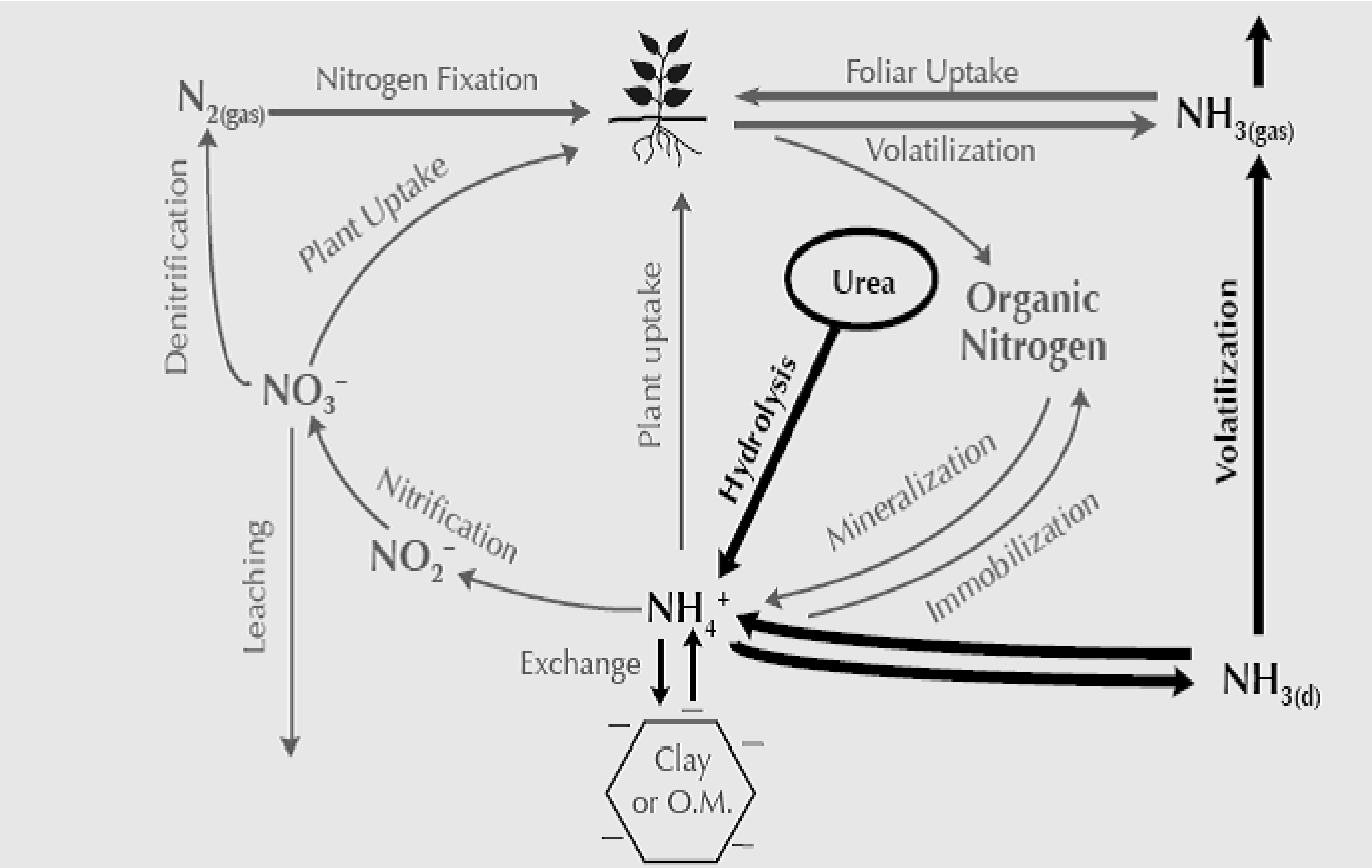
(Bricklemyer, 2003)

How does tillage level affect soil nitrogen lost (over 12 years)?



(Lamb et al., 1985)

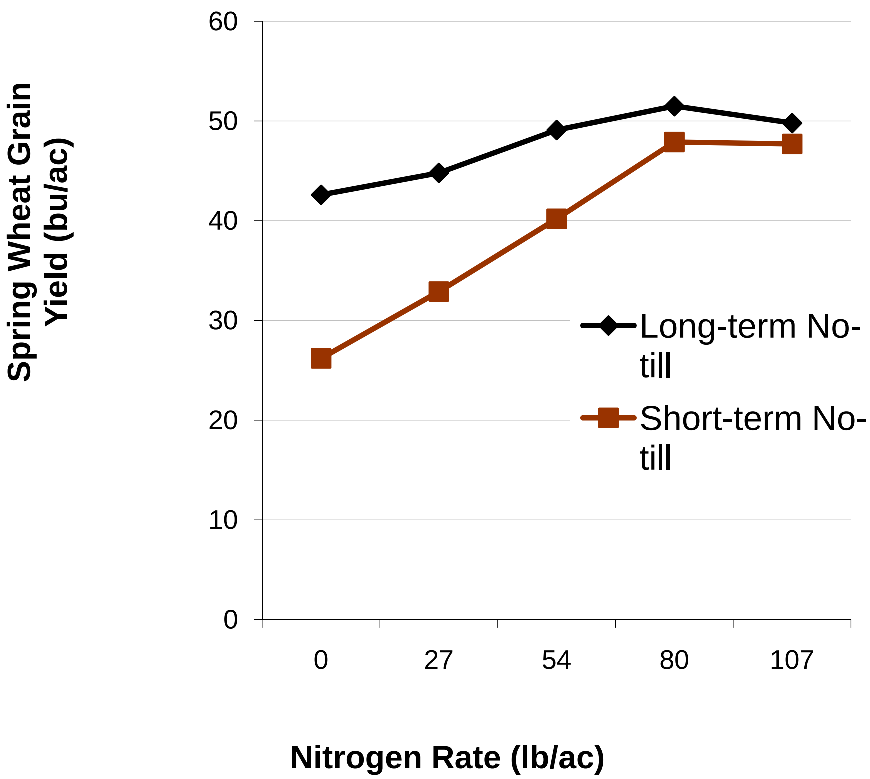
Nitrogen Cycle

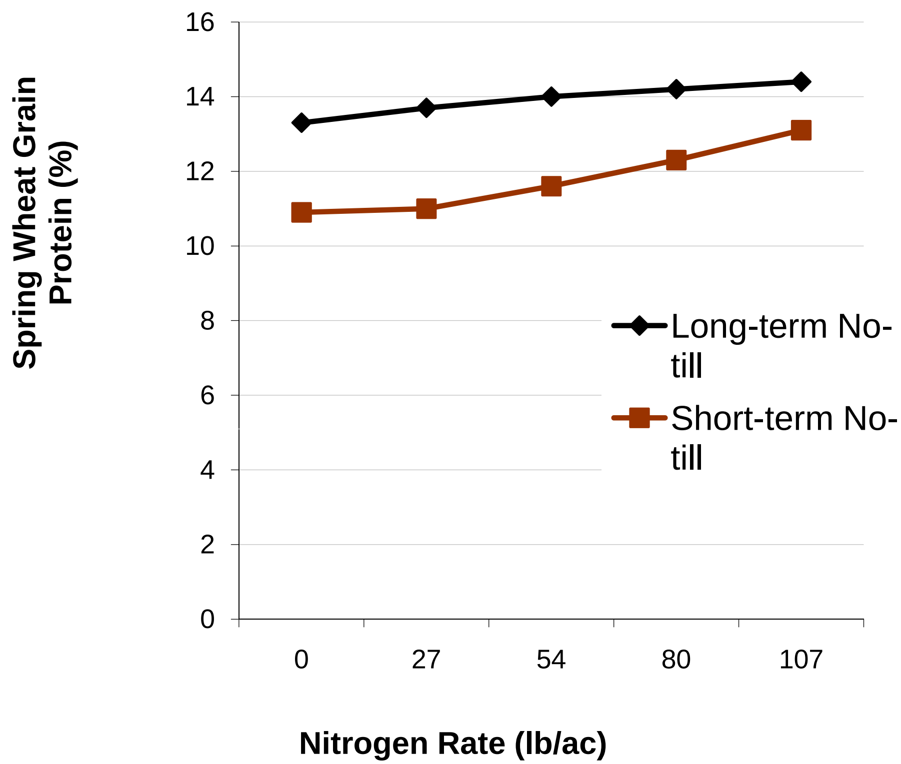


Is growing organic matter free?

- No, it requires nitrogen (N) to 'grow' soil organic matter (SOM)
- To gain 1% SOM in the upper 6 inches of soil, it takes approximately 1,000 lb N/acre above crop needs (assuming a 20:1 SOM:N ratio)
- Need more N in first few years after converting to no-till (NT) and less N in long-term to attain same response as conventional till (T)

Nitrogen response in long- and short-term no-till

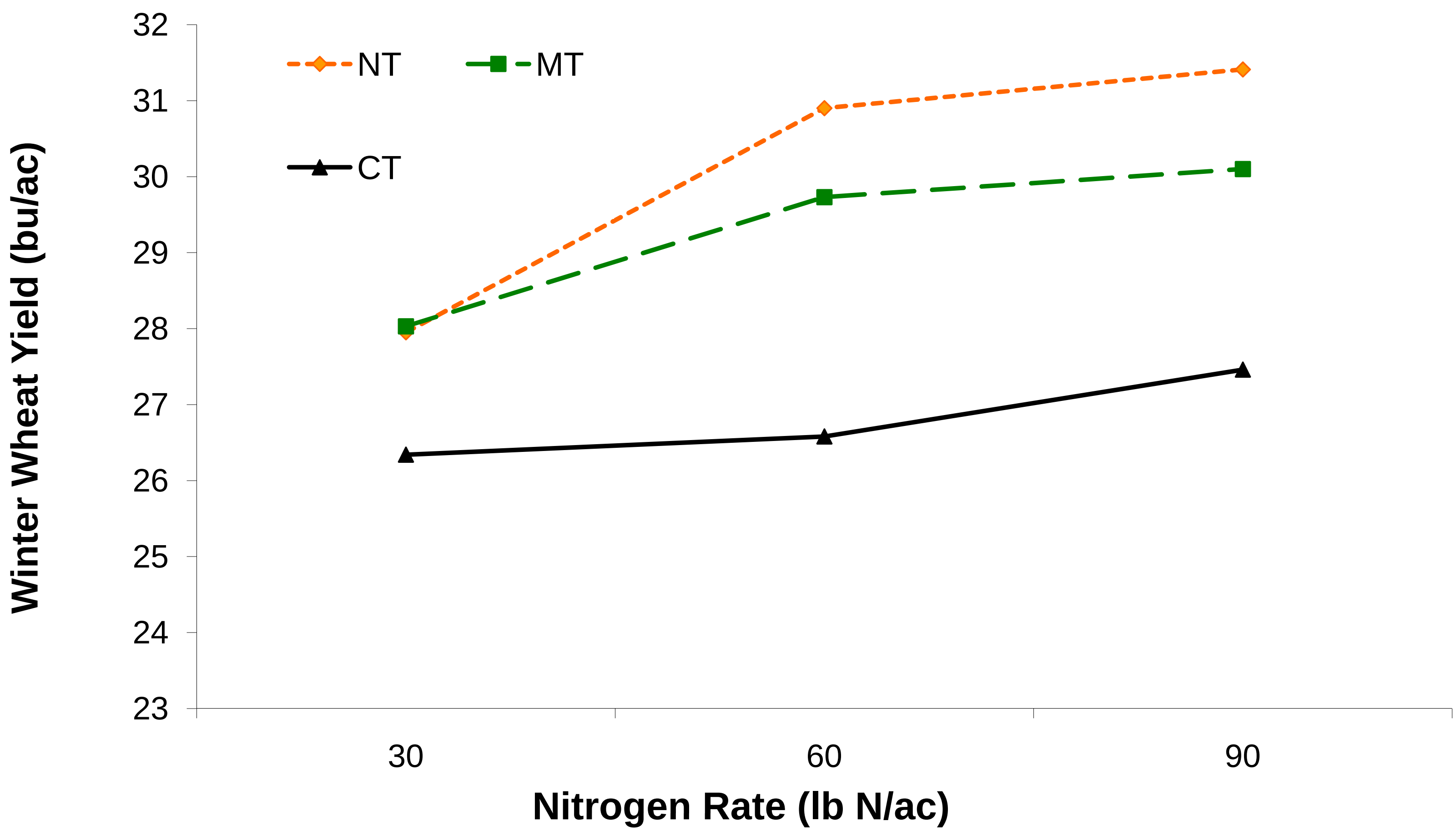




(Miller et al. 2004)

Why is there a larger difference with protein than with yield at high N?

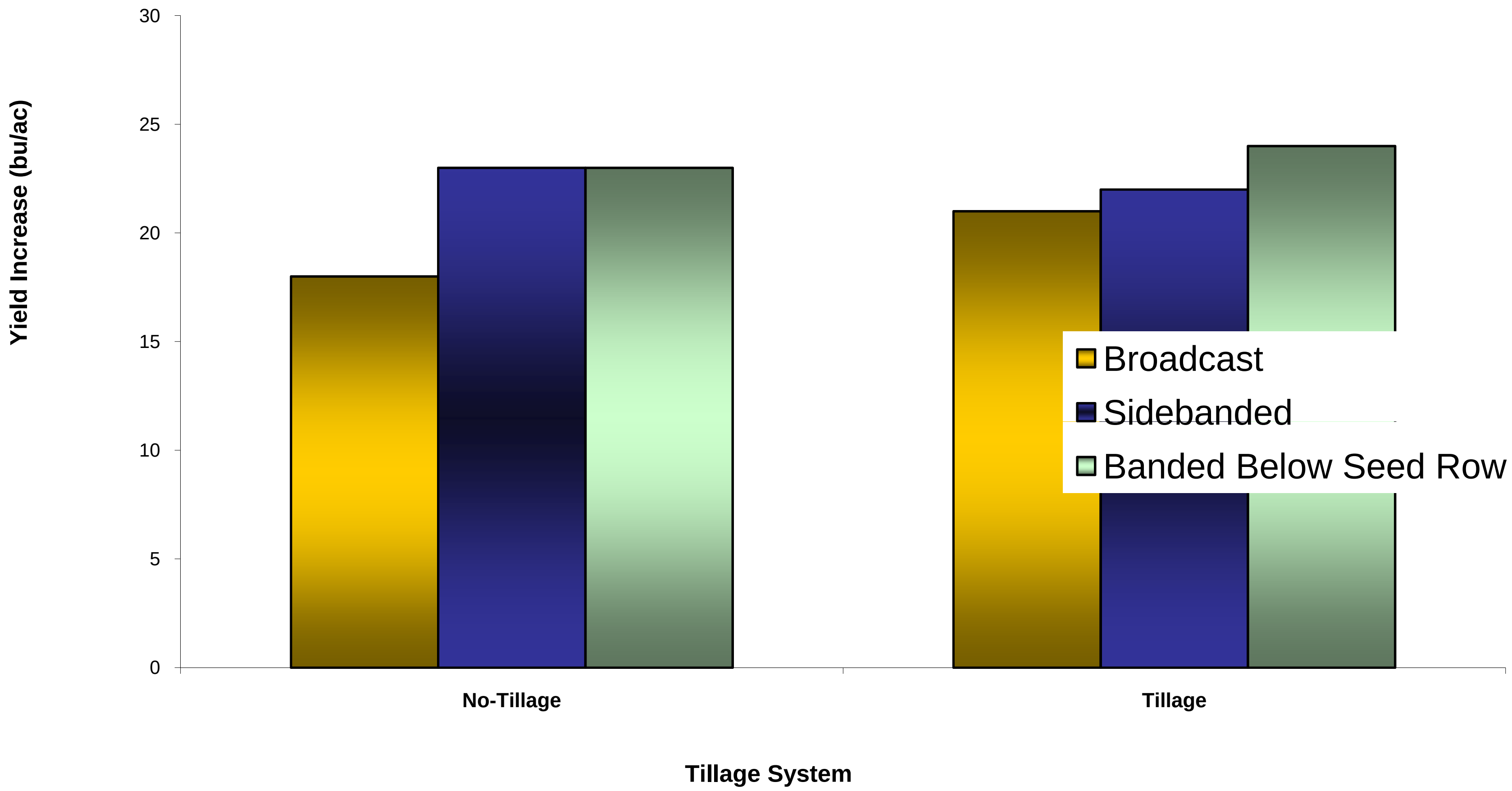
How do tillage management and nitrogen rate affect yield?



Mandan, ND

(Halvorson et al. 1999)

How do tillage management and nitrogen placement methods affect yield?



(Mahli and Nyborg, 1992)

Effect of tillage management on nitrogen fertilizer use

- In Saskatchewan, grain yields and protein were, generally:
  - Less in NT than T in fine- and medium-textured soil
  - Higher in NT than T in coarse soils
- Less N mineralization in finer soils under NT due to:
  - Lower soil temperatures,
  - Protection of SOM within soil aggregates, and/or from
  - Less oxygen movement and N mineralization in finer soils.

Calculation Box. Continuous winter wheat nitrogen adjustments for remaining stubble

Grain Weight = Last Year's Yield (bu/ac) x Test Weight (lb grain/bu)
= 50 bu/ac x 60 lb/bu
= **3000 lb grain/ac**

Stubble Weight = Grain Weight (lb grain/ac) x Stubble/Grain Ratio (lb stubble/lb grain)
= 3000 lb grain/ac x 1.67 lb stubble/lb grain
= **5000 lb stubble/ac**

Stubble Remaining = Stubble Weight (lb stubble/ac) - Stubble Removed (lb stubble/ac)
= 5000 lb/acre – 2000 lb/acre
= **3000 lb/acre**

Nitrogen adjustment for Stubble Remaining = 10 lb N/1000 lb Stubble x Stubble Remaining (lb/ac) (add this to N rate, up to 40 lb N/ac)
= 0.01 lb N/lb x 3000 lb/ac
= **30 lb N/ac**

Calculation Box. *Fallow-barley* nitrogen adjustments for remaining stubble WORKSHEET

Grain Weight = Last Year's Yield x Test Weight = <u> 4800 </u> lb grain/ac

Stubble Weight = Grain Weight (lb grain/ac) x Stubble/Grain Ratio (lb stubble/lb grain)

= _____lb grain/ac x 1.13 lb stubble/lb grain

= ______ lb stubble/ac

Stubble Remaining = Stubble Weight (lb stubble/ac) - Stubble Removed (lb stubble/ac)

= _____lb/acre – 2000 lb/acre

= ______ lb/acre

Nitrogen adjustment for Stubble Remaining = 10 lb N/1000 lb Stubble x Stubble Remaining (lb/ac) (add this to N rate, up to 40 lb N/ac)

= 0.01 lb N/lb x _____lb/ac

= ______ lb N/ac

Nitrogen Adjustment for Stubble Decomposition in Crop-Fallow Systems = 0.5 x Nitrogen adjustment for stubble remaining (lb N/ac)

= 0.5 x _____lb N/ac

= ______ lb N/ac

Calculation Box. *Fallow-barley* nitrogen adjustments for remaining stubble ANSWERS

Stubble Weight = Grain Weight (lb grain/ac) x Stubble/Grain Ratio (lb stubble/lb grain)

= 4800 lb grain/ac x 1.13 lb stubble/lb grain

= 5424 lb stubble/ac

Stubble Remaining = Stubble Weight (lb stubble/ac) - Stubble Removed (lb stubble/ac)

= 5424 lb/acre – 2000 lb/acre

= 3424 lb/acre

Nitrogen adjustment for Stubble Remaining = 10 lb N/1000 lb Stubble x Stubble Remaining (lb/ac) (add this to N rate, up to 40 lb N/ac)

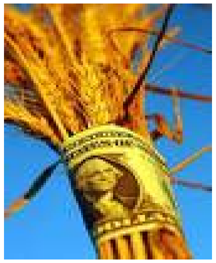
= 0.01 lb N/lb x 3424 lb/ac

= 34.24 lb N/ac

Nitrogen Adjustment for Stubble Decomposition in Crop-Fallow Systems = 0.5 x Nitrogen adjustment for stubble remaining (lb N/ac)

= 0.5 x 34.24 lb N/ac

= 17.12 lb N/ac



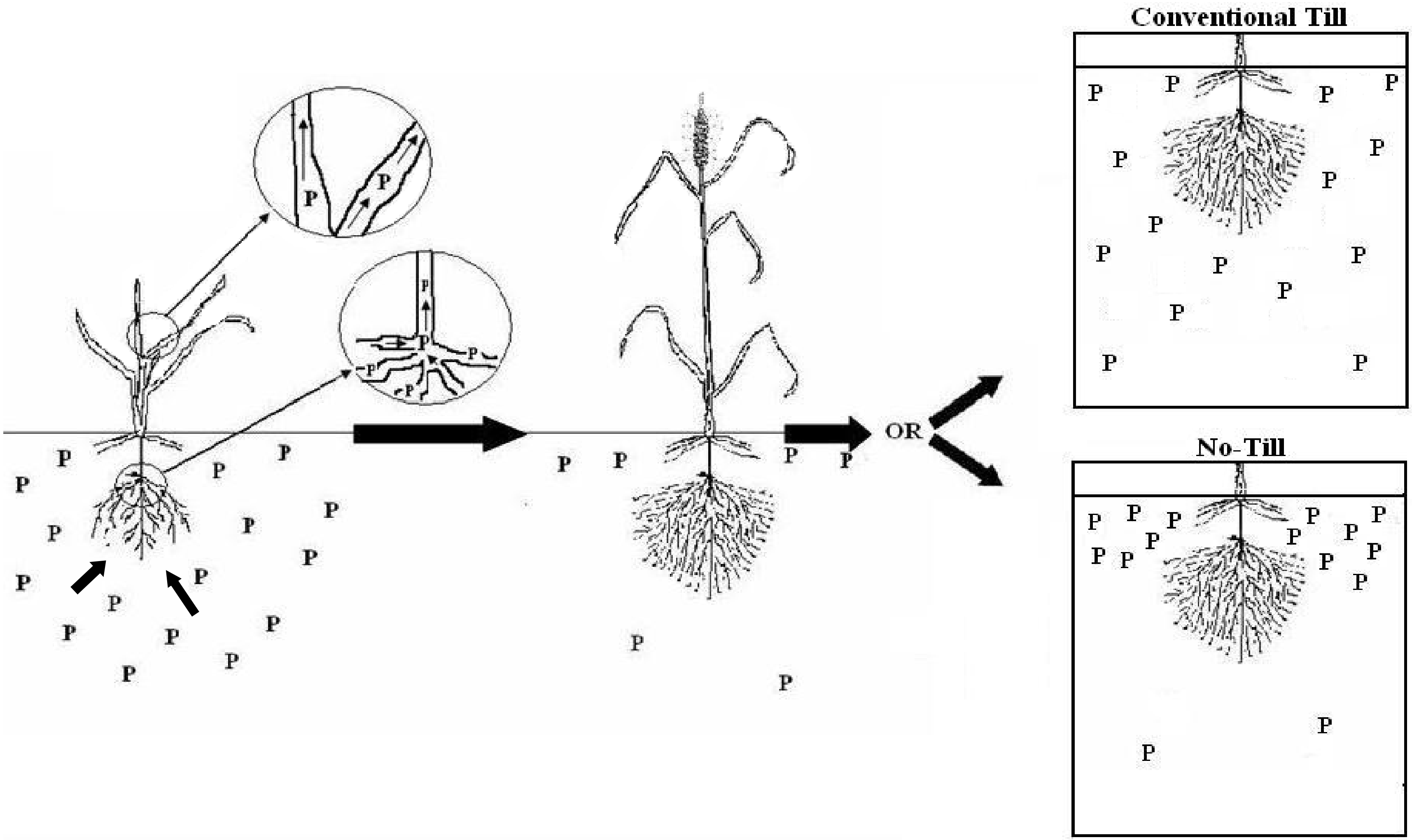
Nitrogen Management Recommendations in Reduced Tillage Systems

- When banding, place N about 2 inches beside and/or below the seed row, when possible
- Consider:
  - Injecting N based liquid solutions
  - Incorporating granular fertilizer with irrigation/rain when possible
  - Applying urea during cool periods
- In long-term, less N will be needed to maximize yield and protein, especially when more N was added in short-term
- Somewhat more N is recommended for the first 5 to 15 years after conversion to NT and MT, particularly:
  - In fine- and medium-textured soils
  - When N is surface broadcast on stubble

Questions so far?

DIFFERENCES IN NUTRIENT STRATIFICATION AND UPTAKE

Stratification Cycle

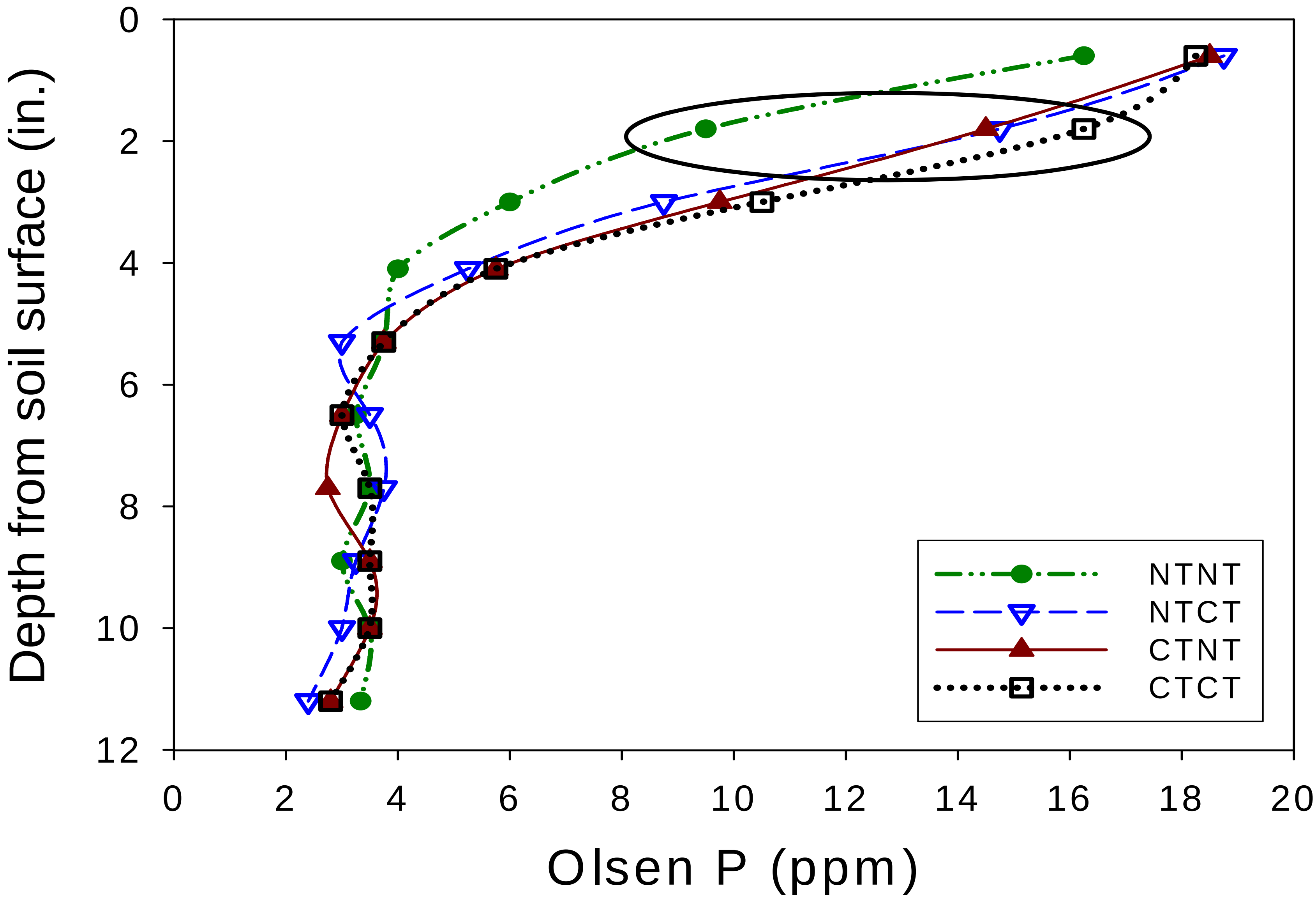


Nutrient Stratification

- Stratification, both vertical and horizontal, is expected to occur more in NT and MT systems due to less soil mixing by tillage

- In fact, in western Canada:
  - No-till and MT systems resulted in greater stratification of soil nutrients than T systems

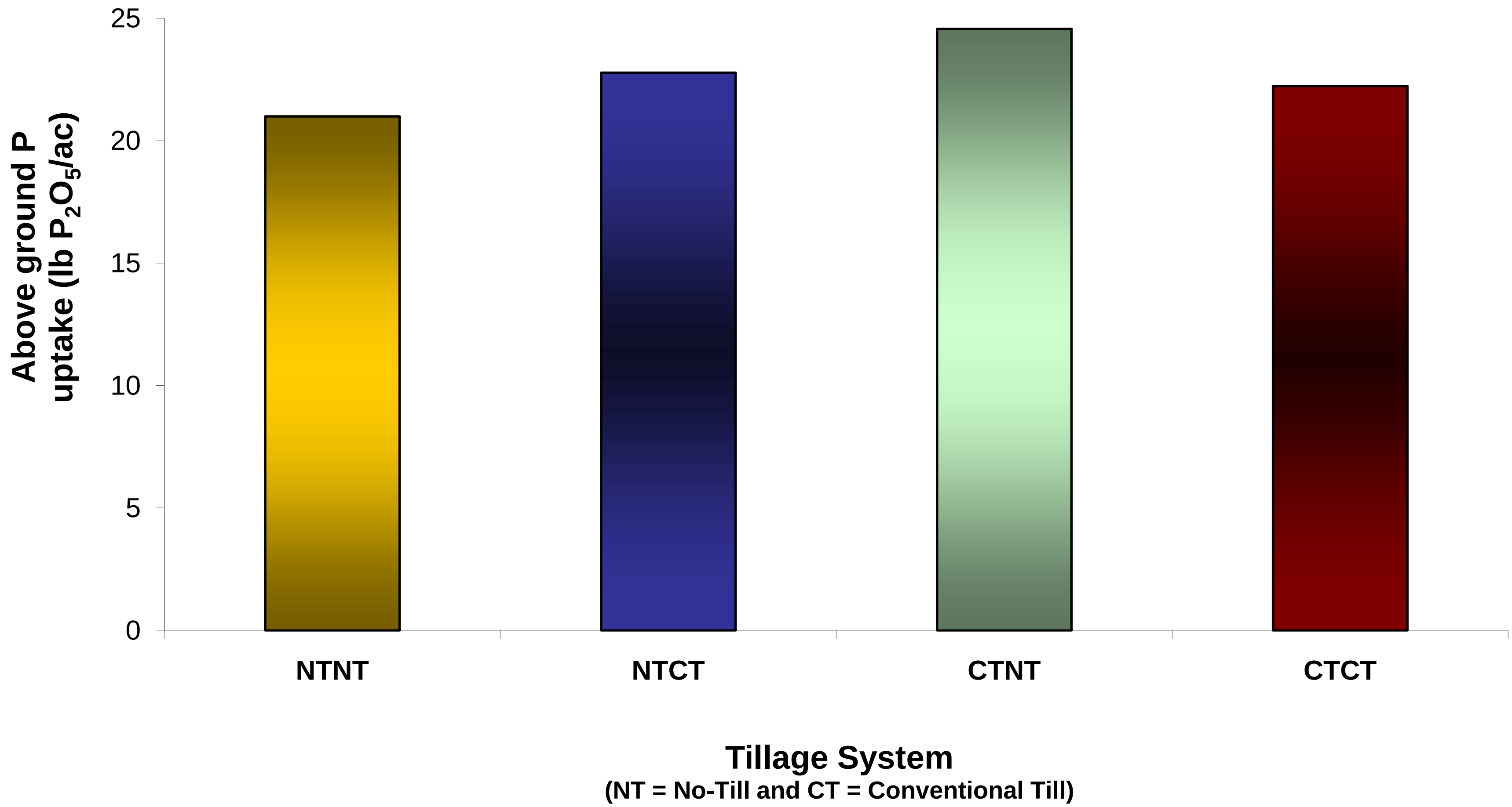
Olsen P Distribution at Moccasin



Phosphorus Stratification

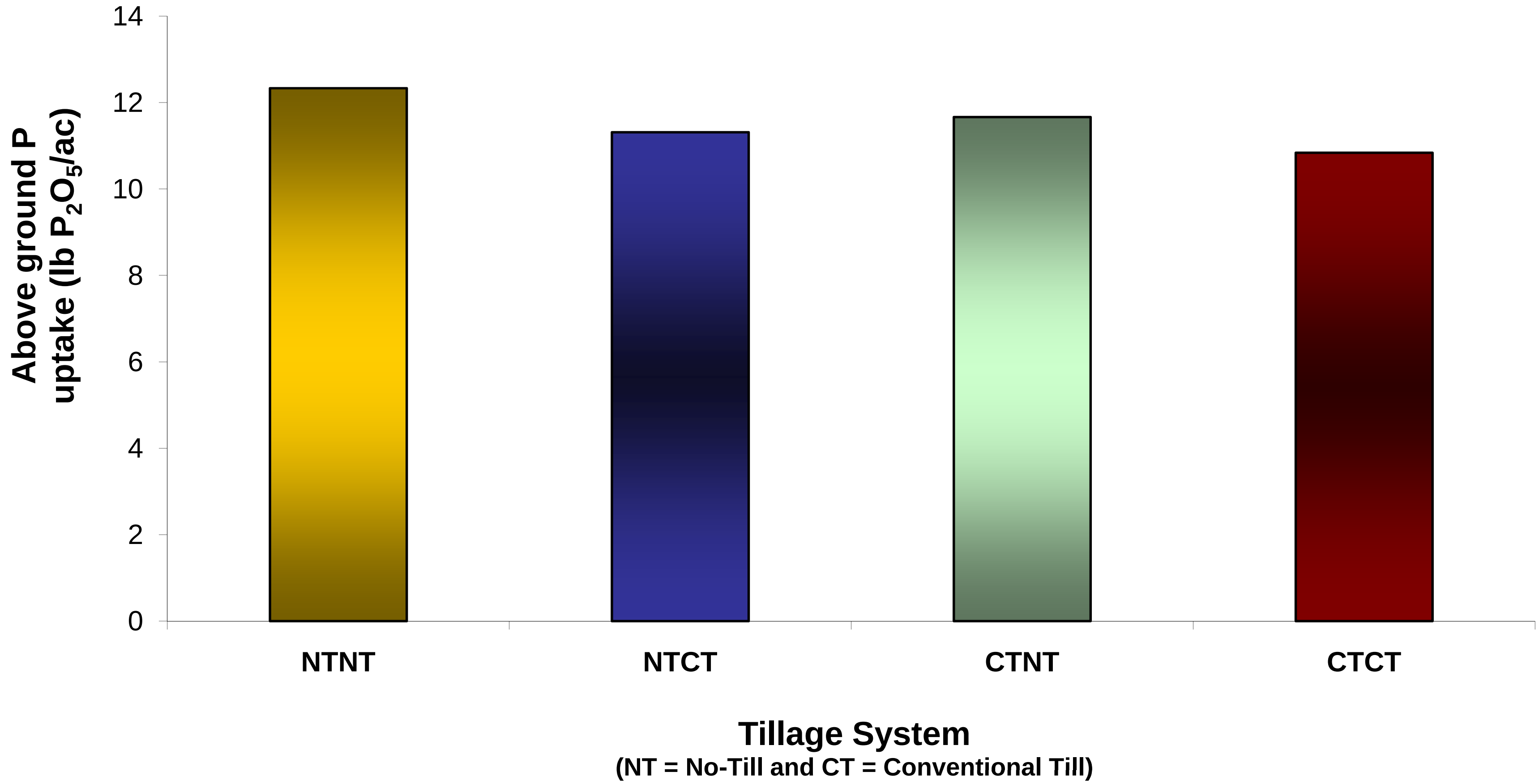
- Seed-placed P fertilizer applications:
  - Led to the accumulation of available P in the surface
  - Depletion of available P deeper in the soil profile
- BUT, did P uptake by wheat or pea differ between NT and CT?

Winter Wheat Aboveground Phosphorus Uptake



Note: Winter wheat fertilized with 20 lb P_2O_5/ac

Winter Pea Aboveground Phosphorus Uptake



Note: WP was not fertilized

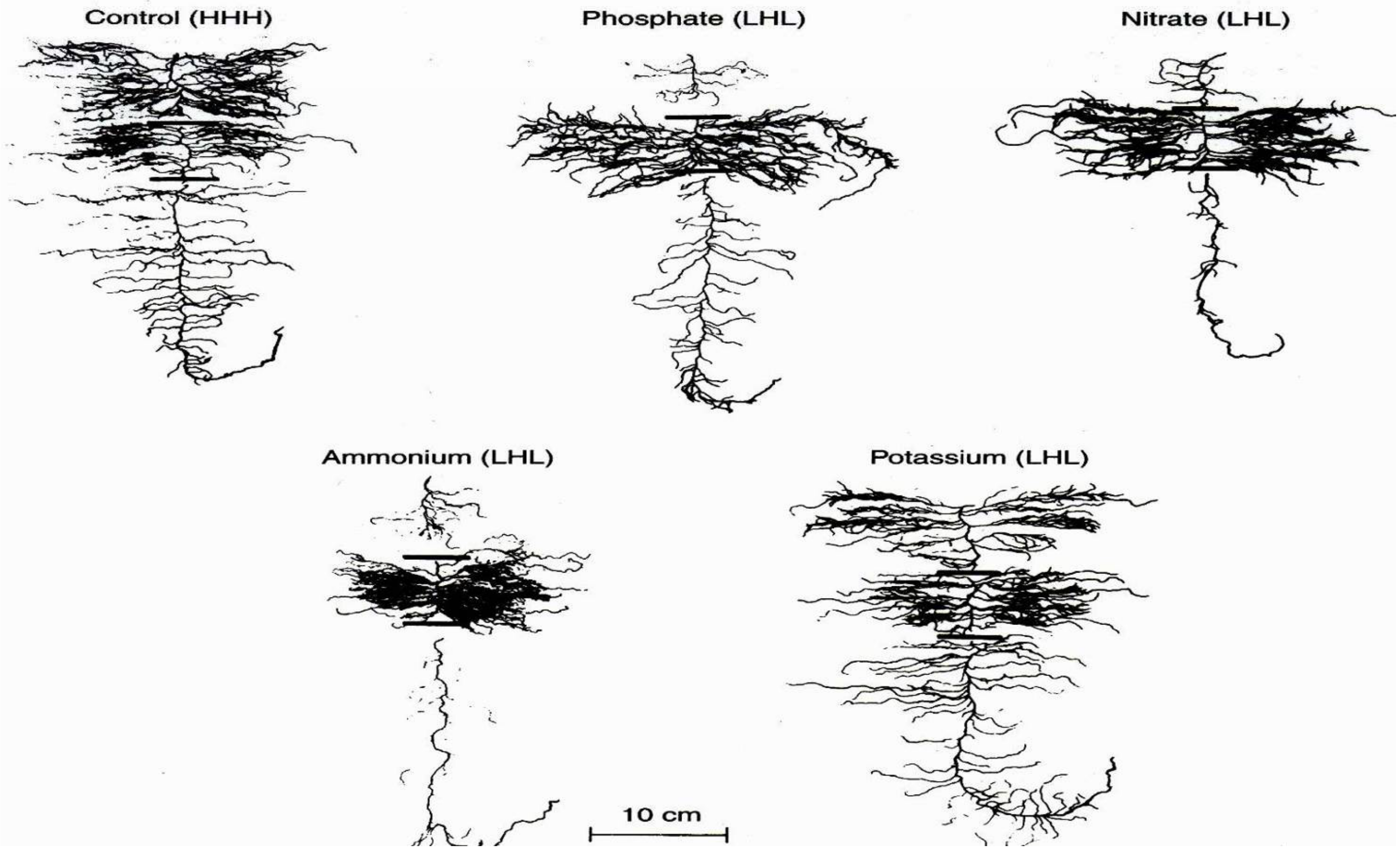
Nitrogen and Potassium Stratification

- In the 0 – 2” soil layer, soil N and K levels:
  - Were greater under NT than T
  - Gradually decreased to similar levels as T below 2”

  (Grant and Bailey, 1994; Lupwayi et al., 2006)

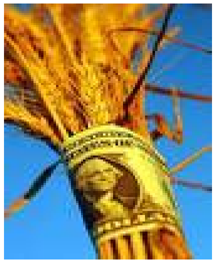
- Despite stratification of K, tillage type was not found to affect K uptake by wheat (Lupwayi et al., 2006)

How do localized concentrations of nutrients affect root distribution?



(Drew, 1975)

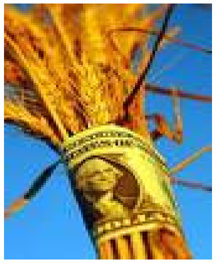
Why does this matter?



Management to Counter Stratification

- Sub-surface band P and K with the seed or ~ 2” below the seed to (Grant and Bailey, 1994; Randall and Hoeft, 1988):
  - Promote deep root growth
  - Avoid stranding these nutrients near the soil surface
  - Slow the conversion of fertilizer P to less soluble compounds
  - Induce a higher yield response as broadcast applications

- Fairly high levels of P can be banded directly with the seed, but:
  - Apply only 10 – 30 lb/ac of K_2O + N (Jacobsen et al., 2005)
  - No more than 30 lb/ac of K_2O + N for barley and 25 lb/ac of K_2O+N for wheat



Management to Counter Stratification

- Due to horizontal stratification, more soil samples are needed in NT and MT systems to accurately represent a field.
  - Twice as many samples per composite were found to be needed in NT than T to be 95% confident in the average nitrate level (0-2’) when the data were averaged for $\frac{2}{3}$”, $1\frac{1}{3}$” and 2” diameter cores (Kanwar et al., 1998)
- Bands may persist at higher concentrations for 5 - 7 yrs (Stecker and Brown, 2001)
- Regardless of tillage system measure Olsen P to 6” (Jones and Chen, 2007)

Questions so far?

SOIL EROSION, WATER CONSERVATION AND TEMPERATURE DIFFERENCES

Soil Erosion

- In natural systems:
  - Overland flow of water rarely occurs
  - Water coming from precipitation generally infiltrates the soil where it falls
- In cropped systems:
  - If the soil is tilled and exposed to rainfall, the surface can seal from as little as ¼ inch of rainfall
  - Precipitation received thereafter tends to run along the soil surface, moving downslope
- For subsequent crops, water moving along the soil surface can decrease:
  - Topsoil
  - Soil water
  - Available nutrients

Table 1. Wind erosion rates estimated with the RWEQ model (Merrill et al., 1999) and estimated nitrogen and phosphorus losses for conventional-, minimum- and no-till in wet and dry years.

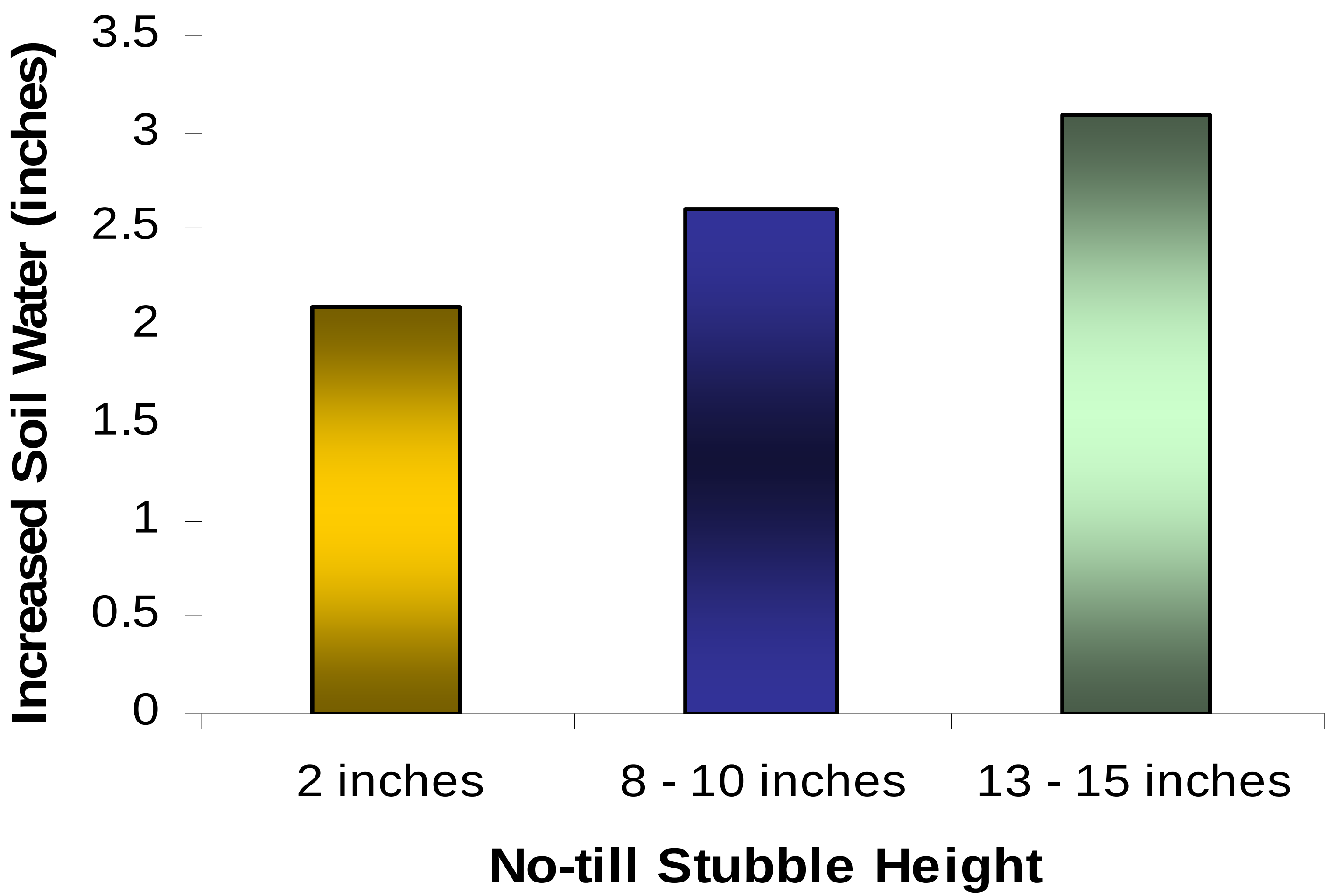
	Soil Loss		Nitrogen Loss[a]		P_2O_5 Loss[a]	
Tillage System	tons/ac		lb/ac			
	Wet	*Dry*	*Wet*	*Dry*	*Wet*	*Dry*
Conventional Till	0.062	10	0.15	25	0.08	28
Minimum Till	0.068	7	0.16	17	0.08	19
No-Till	0.002	5	< 0.01	11	< 0.01	13

[a]Assumes soil contains 0.12% N and 0.06% P

Water Conservation

- Maintaining crop residue is important for harvesting precipitation due largely to:
  - Greater snow catch
  - Lower evaporation rates
- In dryland production regions, any reduction in stored water typically results in yield loss

How do stubble height changes affect fall to spring soil water?



(Bauer and Tanaka, 1986)

Water Conservation from Stubble Height Changes

- Stubble height significantly increased spring wheat grain yield and water use efficiency (WUE) (Cutforth and McConkey, 1997)
  - WUE = crop yield per unit of water

- Both yield and WUE results were attributed to:
  - Favorable microclimate growing conditions
  - Lower surface soil temperatures
  - Reduced evapotranspiration losses

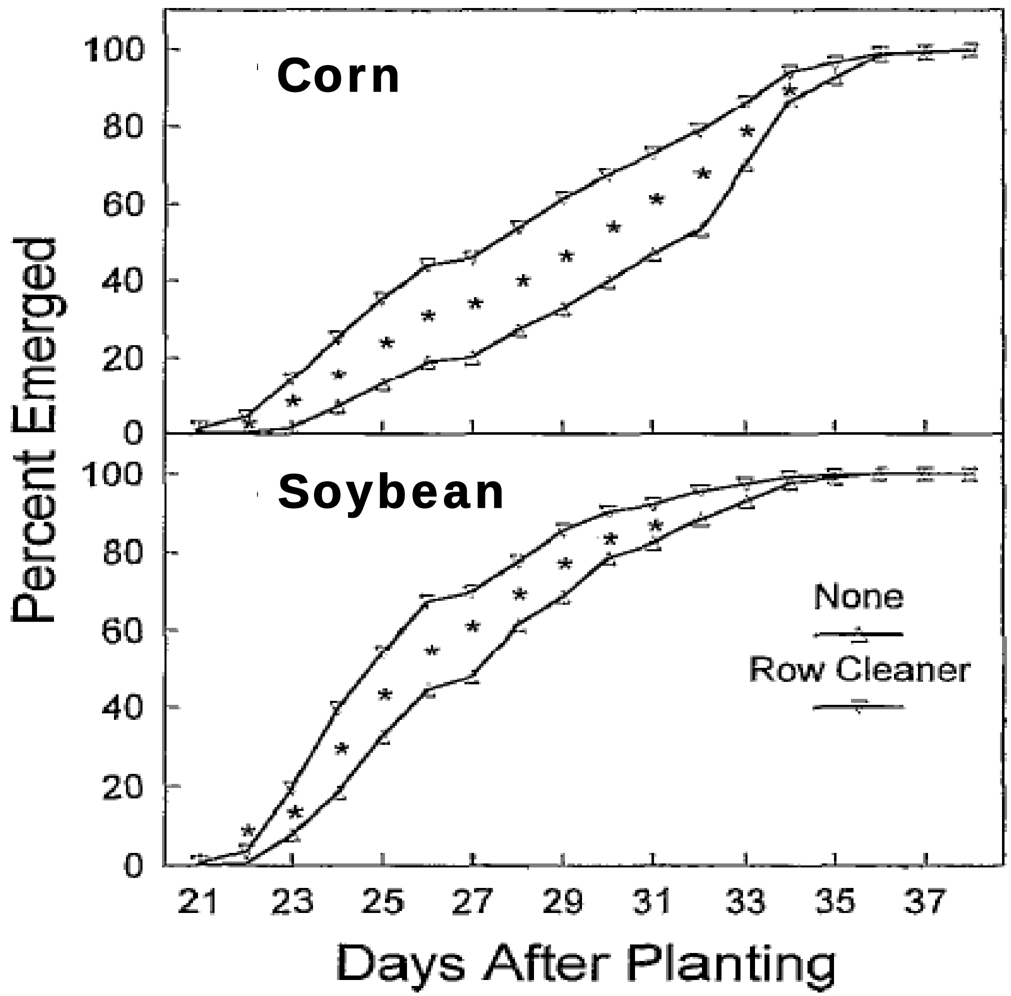
Water Infiltration

- After 7 years, improved soil physical and chemical conditions in NT annual cropping treatments resulted in higher infiltration rates in both dry and wet soil (Pikul and Aase, 1995)
- Increased water infiltration, generally, increases:
  - Nutrient movement through the soil, reducing the chance nutrients will be limiting
  - Yield potential
  - N availability due to increased N mineralization

Effect of Crop Residue on Soil Temperature

- Cooler spring soil temperatures may delay early spring planting in NT or MT fields compared to T fields because of delays in soil warm-up
- In the Midwest, residue managers are commonly used on planters to clear a path where corn or soybeans are planted

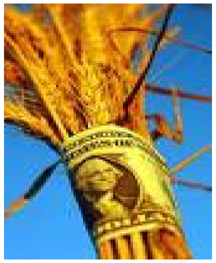
How does crop residue affect crop emergence?



(Vetsch and Randall, 2000)

Effect of Crop Residue on Soil Temperature

- Unlike corn and soybeans, wheat residue management has been less of an issue because:
  - Cool season crops, i.e. wheat and barley, do not respond like warm season crops, i.e. corn, soybeans and grain sorghum
  - Wheat and barley normally compensate for poor stands or slow early growth by increasing tiller numbers



Residue Management

- Within a MT system, there are still management changes that can be made to better conserve these resources

- Keep stubble height as tall as possible to:
  - Maximize yield
  - Maximize available water
  - Maximize WUE
  - Decrease soil erosion
  - Increase snow catch
  - Increase shading

- Again, when possible, place fertilizers below surface residue to minimize immobilization

Questions so far?

SUMMARY

Summary

- Overall, there are only slight differences in recommended fertilizer rates, placement and timing among tillage systems
- In NT and MT systems, N rates need to be slightly increased in the short-term to maximize yield and build SOM to save on N in the long-term
- In general, P and K rates do not need to be adjusted based on tillage system
- Sub-surface application of these nutrients is recommended in NT and MT systems

Summary

- When feasible, build soil test levels to high levels before converting to continuous NT or MT
- Finally, a top-notch soil testing program is necessary in any NT or MT system to accurately determine fertilizer rates

Questions?

For more Information:

Soil Fertility Website:

http://landresources.montana.edu/soilfertility

Cropping Systems Website:

http://scarab.msu.montana.edu/CropSystems