Effects of Tillage System on Nutrient Availability and Management

Prepared for 2007 MABA Convention

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No-till Relevance

Winter Wheat, 2004

Data from Conservation Technology Information Center
Conservation Tillage

Winter Wheat, 2004

Cons. Tillage Acreage (% of total)

Mt  70%
Id  30%
Co  20%
Ne  15%
Wy  25%
Ut  30%
West 50%
Us  20%
Questions for you

• Is the majority of all of your clients’ acreage in no-till? Yes, No?
• Who recommends different N fertilizer rates for no-till than for till?
Objectives today

• Discuss how tillage, reduced tillage, or no till can affect nutrient availability
• Show the effects of tillage system on yield and protein responses to nitrogen (N)
• Show the effects of tillage system on vertical ‘stratification’ of phosphorus (P) and P availability
Basics

Tillage ‘mineralizes’ more N than no-till, especially in short term.

Why?

1. Soil Aeration: bacteria and fungi work faster with oxygen.
2. Breaks up organic particles and colloids: More surface area $\rightarrow$ faster decomposition
3. Temperature slightly higher in spring under tillage, due to less shading/darker surface: Higher temp $\rightarrow$ faster breakdown
Basics, continued

When N fertilizer is surface broadcast, ‘immobilization’ will be higher on no-till than tilled fields.
Why?
Bacteria and fungi use fertilizer N in breaking down stubble at surface.
Solution?
Add 10 lb N/ac more for each ½ ton stubble that remains on surface IF broadcast N (stubble weight = ~1.5 x grain weight).
How does tillage affect O.M. in Montana?

Tillage effect on soil organic carbon, 2002.

Measured SOC (0 to 20-cm) 

Bricklemyer, 2003

α = 0.1
Organic matter and organic N changes with management
Is building O.M. free?

• NO!

• It takes N to ‘grow’ O.M.:
  To gain 1% O.M. in upper 6 inches takes about **1,000 lb N/acre** extra N.
  (assumes 20:1 O.M.:N ratio)

• Need more N in first few years after converting to NT to attain same response as CT. Less N in long-term.
N response curves differ between short- and long-term NT

From Miller et al. 2004

Why is there a larger difference with protein than with yield at high N?
QUESTIONS SO FAR?
What if don’t add anymore N to NT than to CT fields?

- Study site: Moccasin
- Researchers: C. Chen and C. Jones
- 9-yr NT (NTNT) side by side with 30+ yr CT (CTCT). CT = one sweep tillage pass per year (Reduced Till?)
- Organic Matter in top 6 inches was same after 9-yr.
- Part of NT converted to CT in 2005 (NTCT)
- Part of CT converted to NT in 2005 (CTNT)
- Four systems: Fallow, spring pea (grain), winter pea (forage), and spring wheat. All seeded to winter wheat in Fall 2005.
Spring Wheat Grain Yield After 9-yr of Identical N Rates

Moccasin, 2005

Data from C. Chen
Winter Wheat Grain Yield following Fallow

Why the difference?

Data from C. Chen
Winter Wheat Grain Yield following Winter Pea After 10-yr of Identical N Rates

Is difference due to N??

Data from C. Chen
Spring Nitrate-N (2006) after 10-yr of Identical N Rates

Why different?

Previous Crop:
- Fallow
- Winter Pea
- Spring Pea
- Spring Wheat

C. Chen

CT
NT

Spring Soil Nitrate-N (lb/ac)
Moccasin, 2006

Winter Wheat Grain Yield following Spring

Why the difference?

Data from C. Chen
How do grain yields between NT and CT compare in other Montana studies?

- Bricklemyer and Miller, 2006
- Six sites: NT-CT small plot study.
- Data: From 2\textsuperscript{nd} year of ongoing study.
Wheat Yields for NT, CT, after Fallow, and Continuous Cropping (2004)

Average NT yield was 13% higher than average CT yield

Site

Chester  Collins  Conrad  Great Falls  Kremlin  Power

Yield (bu ac\(^{-1}\))

0  10  20  30  40  50  60

No-till  Tilled  Alternate Yr  Continuous
Take home messages on N

• More N will be needed in first few years after conversion to NT, ESPECIALLY when surface broadcast (10 lb N/1000 lb stubble).

• In “mid-term” (5-10 yr?), similar N will be needed to maximize yield.

• In long-term, less N will be needed to maximize yield and protein, especially when more N was added in short-term.
QUESTIONS SO FAR?
Basics on P

• Soil pH controls P availability more than mineralization does. Different than N.
• SO, tillage expected to affect P less than N.
• Soil pH is generally somewhat less near surface of no-till field, which should increase P availability near surface.
• Some are asking if P is concentrating near P subsurface bands more in NT than in tilled systems, and if so, how is this affecting P availability?
P Stratification in Alberta (Lupwayi et al., 2006)

Olsen P (ppm)

Soil depth (cm)

- (b) Pea
- (c) Canola
- (d) Wheat
- (f) Pea
- (g) Canola
- (h) Wheat

Stratification appears dependent on:

- Year
- Crop
- Tillage

Wheat P uptake was not different between tillage systems, suggesting stratification differences did not greatly affect overall P availability.
Does P stratification happen here in Montana?

LSD (0.05) = 5.1 ppm

Jones and Chen, Moccasin

Is Olsen P the only P fraction that could be affected by tillage?
Average P concentration in top 6 inches for different P fractions

Jones and Chen, Moccasin
But the proof is in the pudding…meaning P uptake is likely best indicator of P availability.

No differences in P uptake between tillage systems when N rate was optimized.
Is P being ‘stranded’ near the surface in reduced till systems (esp. when broadcast or seed-applied)?

• Apparently, yes.

• Where should P be applied for best uptake?

  We regressed P uptake against Olsen P (and resin P) for each 1.2 inch layer to find the depth with the highest correlation and thus possibly best depth to apply P.
Correlation between Olsen P and ‘Resin P’ for each 1.2 in. layer and P uptake (Moccasin)

Table 2. Correlation coefficients between Olsen P and resin-P concentrations and aboveground P uptake in individual soil layers and averaged soil depths.

<table>
<thead>
<tr>
<th>Depth (in.)</th>
<th>Olsen P $r^2$-value</th>
<th>Resin P $r^2$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual layers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 1.2</td>
<td>0.46**</td>
<td>0.12NS</td>
</tr>
<tr>
<td>1.2 - 2.4</td>
<td>0.46**</td>
<td>0.17NS</td>
</tr>
<tr>
<td>2.4 - 3.6</td>
<td>0.57***</td>
<td>0.35*</td>
</tr>
<tr>
<td>3.6 - 4.8</td>
<td>0.50**</td>
<td>0.13NS</td>
</tr>
<tr>
<td>4.8 - 6.0</td>
<td>0.17NS</td>
<td>0.005NS</td>
</tr>
<tr>
<td>Averaged depths</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 - 2.4</td>
<td>0.53**</td>
<td>0.19NS</td>
</tr>
<tr>
<td>0 - 3.6</td>
<td>0.57***</td>
<td>0.28*</td>
</tr>
<tr>
<td>0 - 4.8</td>
<td>0.59***</td>
<td>0.30*</td>
</tr>
<tr>
<td>0 - 6.0</td>
<td>0.57***</td>
<td>0.27*</td>
</tr>
<tr>
<td>0 - 8.3</td>
<td>0.54**</td>
<td></td>
</tr>
<tr>
<td>0 - 12.0</td>
<td>0.42**</td>
<td></td>
</tr>
<tr>
<td>2.4 - 4.8</td>
<td>0.60***</td>
<td>0.32*</td>
</tr>
</tbody>
</table>

NS, not significant at $P=0.05$

*, **, *** significant at $P<0.05$, 0.01, 0.001 respectively

Best correlation at 2.4 to 3.6 in. below soil surface.
How much available P is there at 2.4 to 3.6 inches deep?

LSD (0.05) = 5.1 ppm
Take home messages on P

• There may be some slight, yet not significant, differences in P availability between tillage systems.

• Olsen P measured to 6 inches appears to be a good estimate of available P, regardless of tillage system.

• P should be placed approximately 3 inches beneath soil surface to avoid stranding it near surface, especially in reduced till systems.
Conclusions

• N rates need to be increased in short term NT to maximize yield and build organic matter. This will save on N in long-term.
• P rates can be based on Olsen P levels in upper 6 inches, and do not need to be adjusted based on tillage system.
• Placement of both N and P may be as important as rate in optimizing yield in reduced till systems.
For more information

- Soil Fertility Website: http://landresources.montana.edu/soilfertility
- Cropping Systems Website: http://scarab.msu.montana.edu/CropSystems