Gypsum effects on carbon sequestration and soil quality

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Materials and Methods

A no-till corn-soybean expt. with gypsum in RCB design (with 4 reps) was set-up on annually plowed Paulding clay at Defiance County research farm, northern Ohio in 2004.

Gypsum @ 0, 2.5, and 5 Mg/ha was applied in 2004 and 2007.

Composite soils at 0 - 15 cm depth were collected in 2004 and 2009, processed, and analyzed for biological, chemical, and physical properties.
**Microbial biomass**, total, active, and particulate organic C, total N, bulk density, total porosity, and aggregate stability were measured.

**Soil C stocks** were calculated by multiplying with concurrently measured $\rho_b$ and equivalent mass (initial $\rho_b$) (Irfan et al. 2010).

**Data** were normalized to calculate a soil quality index using additive method.

**SAS** was used for data analysis.
Results and Discussion
NT effects

NT + gypsum effect

Microbial biomass (kg/ha)

<table>
<thead>
<tr>
<th>Gypsum (Mg/ha)</th>
<th>Microbial biomass (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2004 (initial pb)</td>
</tr>
<tr>
<td>1</td>
<td>2009 (antecedent pb)</td>
</tr>
<tr>
<td>2</td>
<td>2009 (equivalent soil mass)</td>
</tr>
</tbody>
</table>

2004 (initial pb) $C_{micseq} = 16.3$ kg/ha/yr
2009 (equivalent soil mass) $C_{micseq} = 42.9$ kg/ha/yr

NT + gypsum effect
$y = 1.69 + 0.49X + 1.1X^2$

$R^2 = 0.98^{***}$

NT effects

NT + gypsum effect
Gypsum (Mg/ha)

Total carbon (%)

2004 (initial pb)
2009 (antecedent pb)

TC_{seq} = 680 kg/ha/yr

2009 (equivalent soil mass)

TC_{seq} = 1219.3 kg/ha/yr

NT effects

NT + gypsum effect

NT + gypsum effect

2004 (initial pb)
2009 (antecedent pb)

2009 (equivalent soil mass)

TC_{seq} = 1219.3 kg/ha/yr

Gypsum (Mg/ha)

0 1 2 3 4 5

Total carbon (%)

0
20
40
60

2004 (initial pb)
2009 (antecedent pb)

TC_{seq} = 680 kg/ha/yr
Gypsum (Mg/ha)

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

Total nitrogen (%)

<table>
<thead>
<tr>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
</tr>
</thead>
</table>

2004 (initial $p_b$)

2009 (antecedent $p_b$)

TN$_{seq}$ = 8.4 kg/ha/yr

2009 (equivalent soil mass)

TN$_{seq}$ = 137.5 kg/ha/yr

NT + gypsum effect

NT effects

NT + gypsum effect

2004 (initial $p_b$)

2009 (antecedent $p_b$)

TN$_{seq}$ = 8.4 kg/ha/yr

2009 (equivalent soil mass)

TN$_{seq}$ = 137.5 kg/ha/yr
Gypsum (Mg/ha) | Active carbon (Mg/ha)
---|---
0 | 0.0
1 | 0.5
2 | 1.0
3 | 1.5
4 | 2.0
5 | 2.5

2004 (initial \(p_b\))
2009 (antecedent \(p_b\))
NT effects

\[ \text{AC}_{\text{seq}} = 48.2 \text{ kg/ha/yr} \]

2009 (equivalent soil mass)

\[ \text{AC}_{\text{seq}} = 78 \text{ kg/ha/yr} \]

NT + gypsum effect

- NT effects
- NT + gypsum effect

2004 (initial \(p_b\))
2009 (antecedent \(p_b\))

2009 (equivalent soil mass)
Gypsum (Mg/ha)

Particulate organic carbon (Mg/ha)

2004 (initial pb)
2009 (antecedent pb)

POC\textsubscript{seq} = 420 kg/ha/yr

2009 (equivalent soil mass)
POC\textsubscript{seq} = 784 kg/ha/yr

NT + gypsum effect

NT effects

2004 (initial pb)
2009 (antecedent pb)
POC\textsubscript{seq} = 420 kg/ha/yr

2009 (equivalent soil mass)
POC\textsubscript{seq} = 784 kg/ha/yr
Gypsum (Mg/ha) vs Total porosity (%)

- **NT effects**
- **NT + gypsum effect**

**Graph Details:**
- **Equation:** $y = 42.5 + 1 \times X$
- **$R^2$:** 0.98***

- **Y-axis:** Total porosity (%)
- **X-axis:** Gypsum (Mg/ha)
- **Data Points:**
  - 2004: Red circles
  - 2009: Blue circles

**Key Observations:**
- The graph shows the relationship between gypsum application and total porosity over two years (2004 and 2009).
- The NT + gypsum effect shows a significant increase in porosity compared to NT effects.
- The linear relationship is described by the equation $y = 42.5 + 1 \times X$.
$$y = 58.6 + 5.9(1-\exp(-0.87*X))$$

$$R^2 = 0.99^{***}$$
NT + gypsum effect

NT effects

2004 (initial pb)
Mag formation = 58.2 kg/ha/yr

2009 (antecedent pb)

2009 (equivalent soil mass)
Mag formation = 83.5 kg/ha/yr
$y = 62.1 + 12.8X + 0.21X^2$

$R^2 = 0.97^{***}$

NT effects

NT + gypsum effect
Crop yield (Mg/ha) vs. Gypsum (Mg/ha)

- Corn: ns
- Soybean: ns
Conclusions

- Soil C sequestration in NT was impacted by gypsum especially @ 5 Mg/ha.

- Transitional NT increased C sequestration.

- Soil C sequestration was better predicted by using equivalent mass over variable mass.
• **Inductive** soil quality enhanced in NT by gypsum. Transitional NT **improved** soil quality properties.

• Both soil biological C sequestration and quality were impacted **more** by gypsum than chemical and physical C sequestration and quality

• However, **deductive** soil quality (e.g. crop yield) did not increase significantly by gypsum.