Availability of Nutrients in Manure

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Role of Manure

- Manures, composts have been used to sustain soil fertility and crop production for 1000’s of years.

- Value of barnyard manure well known to farmers: improves soil tilth, crop growth for many years.
Manure:

*A resource:*

**Fertilizer**: N, P, K, S, Micronutrients

**Soil Builder**: Organic Matter, especially solid manures

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Manure:

A challenge:

• Dilute  e.g. Liquid hog effluent  0.1% N to 0.5% N
  Cattle penning manure 0.5% N to 1.5% N
  Liquid N fertilizer         28% N

• Variable  Must test to know what is in it.

• Restrictive  May not have the balance of nutrients needed by crops

  (Usually too much P relative to N)
How to Manage Manure?

- As a Fertilizer
  - Know What’s In It
  - Know How It Behaves

All Manures Are Not Created Equal!

*Liquid Effluents:* High availability of nutrient in year of application, not much organic matter.

*Solid Manures:* Slow availability of nutrients, lots of organic matter, long-term soil builder.
Nature of Manure Nutrients

Nitrogen in Liquid Effluent

Availability of effluent N in year of application

Ammonium N + Organic N
(100% available) (20% - 30% available)

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Phosphorus in Liquid Effluent:
- closely related to solids content: solids↑, P ↑
  10% to 50% of P is readily soluble

Availability of effluent P in year of application
~ 50% compared to commercial P fertilizer.
P in manure initially quite strongly fixed in soil
– Repeated application can result in saturation of fixation sites.
Potassium, Sulfur, Micronutrients in Effluent:  

**Example: Liquid Swine Effluent**

- **8 to 20 lbs K / 1000 gallons**  
  - Manures are good source of K, especially liquid effluents. Too much K uptake in forage can be an issue: tetany, milk fever

- **0.1 to 3 lbs S / 1000 gallons**  
  - S content of many effluents is low: high S demanding crops may benefit from additional fertilizer S.

- **0.05 to 0.5 lbs Cu, Mn, Zn / 1000 gallons**  
  - Micros often strongly fixed but over time, manures increase micronutrient metal availability.

- **Sodium content 3- 8 lbs Na / 1000 gallons**  
  - Effects of repeated applications on soil sodicity and salinity should be monitored.
### Soil electrical conductivity (salinity)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Electrical Conductivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.14</td>
</tr>
<tr>
<td>Low rate effluent</td>
<td>0.21</td>
</tr>
<tr>
<td>High rate effluent</td>
<td>0.32</td>
</tr>
</tbody>
</table>

Watch for salt loading on poorly drained soils!
Solid Manures

- ~ 50% water (varies!).
- Compared to effluents, much more organic matter: improves soil tilth, slowly increases nutrient supply power.

Long-term soil builders \(\rightarrow\) soil organic matter

Carbon Sequestration!
Soil organic C contents (T/ha 0-15cm) in a Black Chernozem after 7 yearly applications of Cattle Manure at 15, 30 and 60 T/ha (6.7, 13.4 and 27 tons/acre)
Majority of Nitrogen in solid cattle manure is in the organic form, associated with carbon.
- Requires mineralization to be released.

Release of organic manure nutrients into plant available inorganic forms like ammonium and nitrate can be slow, especially for penning manure that contains lots of straw bedding.

10-20% release of available N in year of application is typical for feedlot cattle manure in Northern Great Plains.
C:N ratio of manure is driving factor affecting available N release

- Negative relationship between cattle manure organic C:N ratio and mineralization.

C:N ratios in manure or compost of < 13 we saw net release of available N over 10 wks, while > 15 showed temporary tie-up of available N.
Solid cattle manure of high C:N applied every year for eight years in Black soil zone of Saskatchewan, sampled at end of 8 years.

<table>
<thead>
<tr>
<th></th>
<th>0-2ft</th>
<th>2ft-3ft</th>
<th>3ft-4ft</th>
<th>4ft-5ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>~100 lb N/ac/yr (10 T/ha)</td>
<td>16</td>
<td>3</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>~400 lb N/ac/yr (40 T/ha)</td>
<td>24</td>
<td>6</td>
<td>9</td>
<td>14</td>
</tr>
</tbody>
</table>

Still lots of organic N added as cattle manure that has not mineralized to available inorganic forms yet. Continued application at high rate is anticipated to eventually result in mineralization rates that exceed crop use.
N:P Ratio

Some Livestock Manure  
3-5:1

Crop Uptake  
8-10:1

Application of P - rich manure based on crop N requirements = residual P
## P Balance at Dixon Solid Cattle Manure Site from 1997-2004

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inputs† (A)</td>
</tr>
<tr>
<td>Control</td>
<td>0</td>
</tr>
<tr>
<td>7.6 T ha(^{-1}) B&amp;I§</td>
<td>265</td>
</tr>
<tr>
<td>15.2 T ha(^{-1}) B&amp;I</td>
<td>531</td>
</tr>
<tr>
<td>30.4 T ha(^{-1}) B&amp;I</td>
<td>1062</td>
</tr>
<tr>
<td>112 kg N ha(^{-1}) Urea</td>
<td>0</td>
</tr>
</tbody>
</table>

† Calculated from manure P concentration applied each year
‡ Calculated from grain yield multiplied by %P concentration in grain
§ B&I denotes broadcast and incorporate application

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Phosphate (kg P/ha) removed in simulated snowmelt run-off from soils receiving cattle manure applied at 40 T/ha for two years.
Method of Application

- Manure applications to surface generally result in higher losses compared to injection or incorp:

  *Ammonia volatilization losses increased when surface placed.*
  *Removal of nutrients in surface run-off water.*

But injection also shown to promote nitrous oxide production.
Solid Manure Injection?

Three years of data (07-09) revealed slightly better yield and nutrient recovery from in-soil placement of solid manure compared to surface.

Solid manure used had low ammonium content: mainly organic N. As such, limited potential for volatile gaseous ammonia losses.

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Concluding Points on Manure

- Knowing forms and composition of manure, effects of rate, placement, timing can increase efficiency of manure nutrient utilization by crops: more closely match application with crop needs.

- Water quality can be protected by recognizing potential for nutrient transport with run-off and leaching water, and monitoring, addressing soil nutrient load through rate adjustment: rate of nutrient applied is in balance with that needed by and removed by crops over the years.
Thanks for opportunity to participate in 2017 California Plant and Soil Conference!

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