Nutrient Management in Organic Production
ORGANIC PRODUCTION

• Tradition
• Philosophy
• Science
Characteristics of Organic Production

• Reliance on on-farm nutrient sources, fewer purchased inputs
• Holistic- emphasis on soil building, soil health, crop rotation, nutrient recycling
• Requires natural rather than manufactured nutrient sources
• Essentially all manufactured or synthetic fertilizers and pesticides are prohibited
Characteristics of Organic Production

• Genetically altered or engineered species prohibited
• Materials containing chlorides, nitrates, highly-soluble phosphates are usually prohibited
• Sewage sludge prohibited – concern with metals in sludge
Organic Certification

• Largely by organic growers organizations
• USDA National Organic Program
  – Standardize production, certification, labeling
  – Assure consumers of consistent standards in growing and labeling
• Effect of history and tradition
Organic Production

• Extent of organic food production (USA)
  – < 2% of total sales
  – $ 9 billion in 2002
  – $ 2 billion in 1992
  – 20% annual growth in decade
DETERMINING NUTRIENT NEEDS

• Soil testing
• Nutrient deficiency symptoms
• Plant analysis
Organic certification – General requirements (OCIA)

• Fields or farms certified organic if:
  – No use of unacceptable materials for three years prior to first certifiable harvest
  – Full application of OCIA standards for one year before first organic harvest
Organic certification – General requirements (OCIA)

• Fields or farms certified organic if:
  – Inspection in the final year of conversion to organic.
  – At least three years of information on production methods and materials and an outline of farm management strategies must be provided (audit trail).
Required practices for organic certification

• Soil building program
  — Enhance organic matter
  — Encourage soil health
• Crop rotations
• Soil testing usually not mandatory
  — Testing recommended for problem solving
Soil Organic Matter

- Most Wisconsin soils = 1-5%
- Organic soils = 20-50+ %
- About 2-3% of OM decomposes annually
BENEFICIAL EFFECTS OF CROP ROTATIONS

• Nitrogen from previous legumes
• “Rotation effect” not related to N
  ▪ Soil physical properties
  ▪ Reduced disease and insects
  ▪ Crop residue effects
• Effects on nitrogen cycling
Required practices for organic certification

• Management to control weeds, pests, diseases
  – Resistant varieties
  – Inter-cropping
  – Maintain soil health

• Generate audit trail
  – Sources, amounts of off-farm inputs
  – Date, place of harvest
  – Steps between harvest and sale
• Manure
  —Sources and management documented
  —Amounts of organic materials brought onto farm limited
  —Manure additions cannot exceed farm’s generation potential
Manure
- Composted or uncomposted manures
- Free of contaminants if off-farm
- Fresh manure/uncomposted
  - Apply to perennials, crops not for human consumption
  - Apply at least four months before crop harvest
  - Apply to warm soil (10°C)
Soils and Plants – Authorized Methods and Materials (Organic Matter)

- Green manures, crop residues, peatmoss, straw, seaweed, similar materials
- Composted food and forestry by-products
- Sewage sludge, septic waste prohibited
Soils and Plants – Authorized Methods and Materials (Minerals)

- Agricultural limestone
- Natural rock phosphates
  - Fluorine not to exceed 5 kg/ha/yr
- Wood ash, Sulpomag, bonemeal, fishmeal
- Cottonseed meal, leathermeal
- Potassium sulfate (mined)
Soils and Plants – Authorized Methods and Materials (Minerals)

- Borax (solubor)
- Sodium molybdate
- Sulfate trace mineral salts
- Ammonia and urea, prohibited
- Nutrient sources containing highly-soluble nitrate, phosphate, chloride, prohibited
Rock Phosphate as a Phosphorus Source

\[ \text{Ca}_{10}(\text{PO}_4)_6(\text{X})_2 \quad \text{X} = \text{F}, \text{OH}, \text{Cl} \]

- Minerals called apatites
- Most common is fluorapatite
- Finely-ground rock phosphate (RP) is an effective P source on acidic soils (pH < 6)
- Most effective on acid low-calcium soils
Rock Phosphate as a Phosphorus Source

- Application rates 2 to 3 X rates of manufactured P fertilizer needed to meet crop needs
- If lime is added to soils receiving RP as a P source, apply lime after RP has had time to react with soil for about 6 months.
- Fluorapatite is 3.77% F
- Limitation of 5 kg F/ha/yr means limit of 132 kg/ha of RP/yr
Potential Nutrient Sources for Organic Production - Nitrogen

• Previous legumes in rotations
  – Provide adequate N for most crops
  – Provide an opportunity for application of fresh manures if crop is not for human consumption
Nitrogen credits for forage legumes

Based on:

- Crop
- Soil Texture
- Plant density
- Harvest management
In a mature alfalfa plant, 40-60% of the N is in above-ground plant parts and 40-60% is in the roots.
# Nitrogen Credits for Alfalfa

<table>
<thead>
<tr>
<th>Stand density</th>
<th>Sandy soils</th>
<th>Other soils</th>
<th>Regrowth</th>
<th>Regrowth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;8”</td>
<td>&gt;8”</td>
<td>≤8”</td>
<td>&gt;8”</td>
</tr>
<tr>
<td>Good</td>
<td>100</td>
<td>140</td>
<td>150</td>
<td>190</td>
</tr>
<tr>
<td>(70-100%, &gt;4 plants/sq ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>70</td>
<td>110</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>(30-69%, 1.5-4 plants/sq ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>40</td>
<td>80</td>
<td>90</td>
<td>130</td>
</tr>
<tr>
<td>(0-29%, &lt;1.5 plants/sq ft)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Corn response to N following alfalfa, avg. of 24 sites, 1988-1991*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>No N</td>
<td>144</td>
</tr>
<tr>
<td>With N**</td>
<td>144</td>
</tr>
</tbody>
</table>

* Bundy & Andraski, 1993
** Avg. of 4-5 N rates
## Nitrogen credits for green manure crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>N credit (lb N/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet clover *</td>
<td>80 - 120</td>
</tr>
<tr>
<td>Alfalfa *</td>
<td>60 - 100</td>
</tr>
<tr>
<td>Red clover *</td>
<td>50 - 80</td>
</tr>
<tr>
<td>Vetch **</td>
<td>40 - 90</td>
</tr>
</tbody>
</table>

* 40 lb N/a if less than 6 in. growth

** 110-160 lb N/a if more than 12 in topgrowth
Legume N Credits

- Red clover, Birdsfoot trefoil:
  - Use 80% of alfalfa credit for similar stands
- Forage legumes, 2nd year credit:
  - Credit 50 lb N/a for any good or fair stand
  - No credit on sand or loamy sand
Legume N Credits not affected by:

- Time of killing
  - Spring or fall
- Method of killing
  - Herbicide, tillage, or winterkill
- Tillage
Legume N Credits

- Key information:
  - Stand density
  - Regrowth in late October
- Confirm credits with presidedress soil nitrate test (PSNT)
Legume N Credits

- Soybean – Credit 40 lb N/a
- Vegetable crops: – Peas, beans, dry beans – Credit 20 lb N/a – No credit on sand or loamy sand
Potential Nutrient Sources for Organic Production - Nitrogen

• Manure
  – Composted manure - Nitrogen availability may be reduced
  – Fresh or uncomposted - applied four months in advance to warm soils
<table>
<thead>
<tr>
<th>Product</th>
<th>Surface Applied</th>
<th>Incorporated (lb N / ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Beef</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Swine</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
Manure Nitrogen Content – Solid Manure

Dairy
Beef
Swine

lb N/ton

Total N  Available N
## Estimated N availability from several manure types.

<table>
<thead>
<tr>
<th>Manure type</th>
<th>Fert. equiv.</th>
<th>N recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range</td>
<td>Avg.</td>
</tr>
<tr>
<td>Fresh chicken</td>
<td>26 – 65</td>
<td>45</td>
</tr>
<tr>
<td>Dries chicken</td>
<td>26 – 90</td>
<td>50</td>
</tr>
<tr>
<td>Composted chicken</td>
<td>3 – 31</td>
<td>16</td>
</tr>
<tr>
<td>Composted cow</td>
<td>5 – 27</td>
<td>14</td>
</tr>
</tbody>
</table>

3 year average, Arlington, WI.
Potential Nutrient Sources for Organic Production - Nitrogen

• Waste materials and by-products
  – Uncertainty about N availability
  – May depend on C/N ratio of material
  – Risk of contamination with prohibited materials
  – Many are too expensive to supply entire crop N need
Carbon and nitrogen transformations in corn residue decomposition

Carbon dioxide

Corn residue (C/N = 60) → Soil organic matter (C/N = 10) → Inorganic N (NH₄, NO₃)

Soil microorganisms (C/N = 8) → Corn residue (C/N = 60)
## Carbon: Nitrogen Ratios of Organic Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>C : N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil microorganisms</td>
<td>8</td>
</tr>
<tr>
<td>Soil organic matter</td>
<td>10</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>12</td>
</tr>
<tr>
<td>Rotted manure</td>
<td>20</td>
</tr>
<tr>
<td>Corn residue</td>
<td>60</td>
</tr>
<tr>
<td>Grain straw</td>
<td>80</td>
</tr>
<tr>
<td>Sawdust</td>
<td>300</td>
</tr>
</tbody>
</table>
# Carbon : Nitrogen ratio effects on N release

<table>
<thead>
<tr>
<th>Expected N Effect</th>
<th>C : N range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Release N</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>Depends on Composition</td>
<td>20 - 50</td>
</tr>
<tr>
<td>Immobilize (Tie up) N</td>
<td>&gt; 50</td>
</tr>
</tbody>
</table>
Potential Nutrient Sources for Organic Production - Nitrogen

- Waste materials and by-products
  - Uncertainty about N availability
  - May depend on C/N ratio of material
  - Risk of contamination with prohibited materials
  - Many are too expensive to supply entire crop N need
Potential Nutrient Sources for Organic Production

• Phosphorus
  – Rock phosphate
  – Manures

• Potassium
  – Potassium sulfate – mined sources only
  – Manures
# Manure Credits

Nutrients available for crop use in the first year after spreading manure

<table>
<thead>
<tr>
<th>Animal</th>
<th>Solid</th>
<th>Liquid</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P$_2$O$_5$</td>
<td>K$_2$O</td>
<td>N</td>
<td>P$_2$O$_5$</td>
<td>K$_2$O</td>
<td></td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Incorp*</td>
<td>Not Incorp</td>
<td>Incorp*</td>
<td>Not Incorp</td>
<td>Incorp*</td>
<td>Not Incorp</td>
<td></td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td>------------</td>
<td></td>
</tr>
<tr>
<td>Dairy</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>8</td>
<td>10</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>12</td>
<td>10</td>
<td>14</td>
<td>14</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swine (finish)</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>28</td>
<td>22</td>
<td>15</td>
<td>15</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Swine (farrow)</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>15</td>
<td>12</td>
<td>6</td>
<td>6</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poultry</td>
<td>15</td>
<td>13</td>
<td>14</td>
<td>9</td>
<td>41</td>
<td>35</td>
<td>38</td>
<td>38</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*injected or incorporated into the soil within 72 hours after spreading.

Source: Dept. of Soil science, College of Agricultural and Life Sciences, University of Wisconsin-Madison, University of Wisconsin-Extension.
Potential Nutrient Sources for Organic Production

• Sulfur
  – Manures
  – Gypsum, potassium sulfate – mined sources only
  – Potassium magnesium sulfate (sulpomag) – mineral forms

• Micronutrients
  – Sulfate salts of some cationic nutrients may be allowed
## Sources of potassium & sulfur

<table>
<thead>
<tr>
<th>Name of fertilizer</th>
<th>Chemical formula</th>
<th>Fertilizer analysis (%)</th>
<th>Sulfur Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium sulfate (gypsum)</td>
<td>CaSO$_4$ • 2H$_2$O</td>
<td>0-0-0</td>
<td>17</td>
</tr>
<tr>
<td>Potassium sulfate</td>
<td>K$_2$SO$_4$</td>
<td>0-0-50</td>
<td>18</td>
</tr>
<tr>
<td>Potassium-magnesium sulfate (langbeinite)</td>
<td>K$_2$SO$_4$ • 2MgSO$_4$</td>
<td>0-0-22</td>
<td>23</td>
</tr>
<tr>
<td>Greensand (glauconite)</td>
<td></td>
<td>0-0-7</td>
<td>0</td>
</tr>
</tbody>
</table>
Available sulfur from several types of manure

<table>
<thead>
<tr>
<th>Animal type</th>
<th>Solid (lb S/ton)</th>
<th>Liquid (lb S/1000 gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Avail.</td>
</tr>
<tr>
<td>Beef</td>
<td>1.7</td>
<td>0.9</td>
</tr>
<tr>
<td>Dairy</td>
<td>1.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Poultry</td>
<td>3.2</td>
<td>1.8</td>
</tr>
<tr>
<td>Swine</td>
<td>2.7</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Yield and Vitamin Content of Organically and Conventionally Grown Sweet Corn, Nova Scotia

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Year 1</th>
<th></th>
<th>Year 2</th>
<th></th>
<th>Year 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>O</td>
<td>C</td>
<td>O</td>
<td>C</td>
<td>O</td>
</tr>
<tr>
<td>Sweet corn yield, tons/ha</td>
<td>4.73</td>
<td>4.80</td>
<td>12.95</td>
<td>11.16</td>
<td>8.92</td>
<td>5.97</td>
</tr>
<tr>
<td>Vitamin C, ppm</td>
<td>78</td>
<td>73</td>
<td>109</td>
<td>105</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>Vitamin E, ppm</td>
<td>4.3</td>
<td>3.7</td>
<td>2.6</td>
<td>2.5</td>
<td>0.9</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Figure 1: Certified organic farms by state, 2001

- California: 1011
- Washington: 548
- Wisconsin: 469
- Minnesota: 421
- Iowa: 384

Figure 2: Certified organic cropland by state, 2001

- California: 148,664
- North Dakota: 144,896
- Minnesota: 98,256
- Wisconsin: 79,128
- Iowa: 71,798

Source: USDA ERS
Figure 3

Certified Organic Farms by County

Source: CIAS
Figure 8: National Sales of Organic Products, 1990-2002

Source: Dimitri and Greene
Figure 6: Home Grown Wisconsin Annual Gross Sales

Source: Home Grown Wisconsin
Figure 7: National Organic Price Premiums for Producers

Source: Rodale Inst. (corn, soy, wheat); CROPP 5-year avg. (milk)