Managing P & K Fertility in Organic Systems

Rob Mikkelsen, Western Director
Merced, CA
Some organizations offering organic standards:

- USDA Organic
- OMRI Organic Materials Review Institute
- Canadian General Standards Board
- International Federation of Organic Agriculture Movements
- FAO/WHO Food Standards
- CODEX alimentarius

NEW: Organic Fertilizer Association of California
www.organicfertilizerassociation.org
Organic Crop Production Standards Require:

- Use of organic seeds, seedlings or transplants
- Practices to prevent pest and disease pressures
- Harvest and packing to prevent contamination or co-mingling
- Verify that no prohibited materials used in previous 36 months
- Accurate records to verify practices
- Practices that enhance or maintain soil fertility
- Crop rotation or use of cover crops
- Enhance or maintain farm resources
- Use only approved materials
High yielding crops remove large amounts of P

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield</th>
<th>Removal of P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>1500 lb/A</td>
<td>76 lb P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;/A</td>
</tr>
<tr>
<td>Corn</td>
<td>180 bu/A</td>
<td>100 lb P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;/A</td>
</tr>
<tr>
<td>Rice</td>
<td>7000 lb/A</td>
<td>48 lb P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;/A</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>8 ton/A</td>
<td>120 lb P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;/A</td>
</tr>
<tr>
<td>Tomato</td>
<td>600 cwt/A</td>
<td>51 lb P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;/A</td>
</tr>
<tr>
<td>Potato</td>
<td>500 cwt/A</td>
<td>75 lb P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;/A</td>
</tr>
</tbody>
</table>
Is P Fertility Inherently Different in Organic Agriculture?

Remember:

- Organically grown crops still need P

- Soil properties which are affected by management/cropping systems can alter P availability and cycling
Soil pH effect on P precipitation and adsorption

pH 6.5 for optimum availability

Insoluble Fe/Al phosphates. Adsorption to oxides and clay

Insoluble Ca phosphates. Adsorption to CaCO₃
Phosphorus Sources for Organic Agriculture

• Inorganic P Sources
  – Bone Meal
  – Rock Phosphate

• Organic-based P sources
  – Green Manures - ?
  – Manures
  – Composts
Bone Meal:

Bones are very slow to dissolve in many environments… may not meet plant nutrient requirements in a reasonable period

Dinosaur bones

Hydroxyapatite
Bone Meal

Primary mineral is Hydroxyapatite

grinding bones increases reactive surface area

reacting bones with acid makes “single super phosphate”
First Commercial P Fertilizers

Ground bones were treated with sulfuric acid to form single superphosphate (typically < 5% P$_2$O$_5$)

Apatite + H$_2$SO$_4$ →

Ca(H$_2$PO$_4$)$\cdot$H$_2$O + CaSO$_4$
Early P fertilizers were made from adding acid to animal bones.

Acidity required to dissolve the bone material - soil acidity or mineral acids.
First U.S. phosphate deposits discovered and developed in South Carolina (1867)

Rock P is reacted with sulfuric acid or phosphoric acid to make the P soluble
Development of the American P Fertilizer Industry

85% of current production comes from Florida and North Carolina
Rock Phosphate as a P Source

- Rock phosphate (RP) is a slowly soluble P source from mined phosphate (calcium phosphates).
- Solubility is highly dependant on several factors

**Soil type**
- Low pH (most important factor)
- Low Ca
- Low P-fixing Capacity
- Organic C (high CEC)

**RP source**
- Total P can range from 6 to 16%,
  - (2% citric acid extraction is good predictor of availability)
- Sedimentary RP Reactive/soft (North Carolina, Morocco)
- Fine particle size increases reactivity (surface area)
What happens to rock P?

\[
\text{Ca}_{10}(\text{PO}_4)_6\text{F}_2 + 12\text{H}^+ \leftrightarrow 10\text{Ca}^{2+} + 6\text{H}_2\text{PO}_4^- + 2\text{F}^- \\
(\text{Phosphate rock}) \quad (\text{Dissociation products})
\]

Reaction requires acidity to take place.
- More soluble minerals form first
- Then slowly dissolve to form less soluble forms or adsorb to soil mineral surfaces

**DCPD** Dicalcium phosphate dihydrate  
**DCP** Dicalcium phosphate

Lindsey, 1979
Approved Rock P Sources

**Phosphate Rock (OMRI)**

HumaPhos (Midwestern Bio-Ag)
Ida-Gro pelletized Phosphate (Soda Springs)
Ida-Gro powdered
Montana Gray Rock (Montana Gray Rock)
Montana Natural Rock Phosphate (Pacific Calcium)
Phosphate Rock (North Country Organics)
Phyta-Grow Granular Rock P (Calif Organic Fert)
Rock Phosphate (E.E.G.A.L. Farm Service)
Rock Phosphate (Fertrell Co.)
Tennessee Brown Rock (Calcium Silicate Corp.)
Arbuscular Mycorrhizal Fungi (VAM)

• Symbiotic association between fungus and root
  – **Root** provides food (carbon source)
  – **Fungus** increases root exploration and nutrient uptake... esp. when plants are stressed for P

• Organic Agriculture tends to increase VAM
  – Sometimes increase P uptake/crop growth ...and sometimes not

Even with VAM, all crops still respond to P additions when soil reserves are low

Credit: Randy Molina, Oregon State University, Corvallis
Arbuscular Mycorrhizal Fungi

...allows P to be extracted to a lower concentration, but provides no additional P to the rootzone.
Green Manures as a P Source?

- Green Manures – legume crops grown and tilled in to soil (not harvested)
- Some species can extract soil P that is unavailable to other crops
  (e.g., white lupin, faba bean, nitro alfalfa)
- Decomposition releases P
- Some green manures may decrease P uptake of succeeding crop (e.g., white lupin)

- Green manures may increase P availability, but are not a P source
Manures and Composts as P Sources

- Majority of P in manures and composts is inorganic P

<table>
<thead>
<tr>
<th>Source</th>
<th>% Organic P</th>
<th>% Inorganic P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedlot manure</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Composted manure</td>
<td>16</td>
<td>84</td>
</tr>
<tr>
<td>Dairy</td>
<td>25</td>
<td>75</td>
</tr>
<tr>
<td>Poultry litter</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>Swine</td>
<td>9</td>
<td>91</td>
</tr>
</tbody>
</table>

Using manure and compost as the sole source of nitrogen leads to accumulation of phosphorus.
When P is in Excess

• P inputs to surface waters promote eutrophication and degrade water quality

• Manure P is source of many regulations in several high-rainfall states
In Summary…

• Inorganic P Sources
  – Rock Phosphate – only acidic soils, source of rock is important
  – Bone Meal – acidic conditions only

• Organic-based P sources
  – Manures – good P source 70-100% available
  – Composts
    • Composted Manures – similar to manures
    • Composted Plant Biomass – higher C:P ratio, may be less available than other composts

(Consider the source of the manure or compost nutrients)

-- Cover crops and mycorrhizal fungi useful at recovering P already present in soil

• Use BMPs to reduce erosion and runoff---especially when applying manures and composts
Many excellent sources of K available for organic production
High yielding crops remove large amounts of K

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield</th>
<th>Aboveground K$_2$O/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>3 bales/A</td>
<td>153 lb K$_2$O/A</td>
</tr>
<tr>
<td>Corn</td>
<td>180 bu/A</td>
<td>240 lb K$_2$O/A</td>
</tr>
<tr>
<td>Rice</td>
<td>7000 lb/A</td>
<td>148 lb K$_2$O/A</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>8 ton/A</td>
<td>480 lb K$_2$O/A</td>
</tr>
<tr>
<td>Tomato</td>
<td>600 cwt/A</td>
<td>336 lb K$_2$O/A</td>
</tr>
<tr>
<td>Wheat</td>
<td>80 bu/A</td>
<td>162 lb K$_2$O/A</td>
</tr>
<tr>
<td>Potato</td>
<td>500 cwt/A</td>
<td>546 lb K$_2$O/A</td>
</tr>
</tbody>
</table>
Where does potash come from?

All commercial potash deposits come from marine sources: **Ancient seas** that are now covered: Canada and New Mexico
Where does potash come from?

All commercial potash deposits come from marine sources:

*Ancient seas* that are now covered: Canada and New Mexico

**Salt water brines:** Great Salt Lake, Dead Sea
We have a potassium deficit in Western states and in much of North America.

Sustainable?
Common Organic Potash Fertilizers

- **Muriate of potash (KCl)**

  (0-0-60)

  “allowed **only** if derived from a mined source and applied in a manner that minimizes chloride accumulation in the soil…”(USDA, Canada)

  Generally NOT recommended

  - Concern over Cl content often cited
  - Not restricted by Canadian organic standards
Cl-deficient leaf spot syndrome in winter wheat

Engel et al., Montana State University
Potassium Chloride
(∼0-0-60)

- Muriate of Potash 0-0-62 Untreated Coarse (Mosaic) R
- Muriate of Potash 0-0-62 Untreated Fine (Mosaic) R
- Muriate of Potash 0-0-62 Untreated Granular (Mosaic) R
Common Organic Potash Fertilizers

- **Potassium Sulfate** ($\text{K}_2\text{SO}_4$)
  
  (0-0-50 + 18S)

Solar evaporation (allowed)

Reaction of KCl with sulfate source (not allowed)
Potassium sulfate production from the Great Salt Lake
Potassium Sulfate
(∼0-0-50)

- Ag Granular SOP Organic (Great Salt Lake Minerals) A
- Champion Sulfate of Potash Granulated (SQM NA Corp.) A
- Choice Granular SOP Organic (Great Salt Lake Minerals) A
- Mid Granular SOP Organic (Great Salt Lake Minerals) A
- Mini Granular SOP Organic (Great Salt Lake Minerals) A
- Natural Sulphate of Potash (North Country Organics) A
- Quick Solution (Pacific Coast Resources Corp.) A
- Soluble Fines SOP Organic (Great Salt Lake Minerals) A
- Standard SOP Organic (Great Salt Lake Minerals) A
- Standard Sulfate of Potash (SQM North America Corp.) A
- Ultra Fines™ Sulfate of Potash (Diamond K Gypsum) A
- Water Soluble Sulphate of Potash (SQM NA Corp.) A
Common Potash Fertilizers

- Muriate of potash (KCl)
- Potassium Sulfate (K₂SO₄)
- Potassium magnesium sulfate (K-Mag, Sul-Po-Mag, MagmaK)  
  \(\text{K}_2\text{SO}_4 - 2\text{MgSO}_4\)  
  (0-0-22 +22S + 11Mg)

Langbeinite is mined directly in New Mexico
Allowed as organic source of K
Common Organic Potash Fertilizers

**Potassium magnesium sulfate**
*(K-Mag, Sul-Po-Mag, MagmaK)*

*(K$_2$SO$_4$ – 2MgSO$_4$)*

(0-0-22 with 22% S + 11% Mg)

Langbeinite is mined directly in New Mexico
Allowed as organic source of K
Langbeinite
(∼0-0-22)

- K-Mag® Natural Granular (Mosaic USA, LLC) A
- K-Mag® Natural Standard (Mosaic USA, LLC) A
- MagmaK (Intrepid) A
- KMS (Diamond K Gypsum) A
Kelp-based products are available as specialty K products.
Kelp Meal
(∼0-0-2)

- Algit Norwegian Kelp Meal (Ohrstrom (P.B.) & Sons, Inc.)
- Fertrell's North Atlantic Kelp Meal (Fertrell Company)
- Ground Seaweeds (ABK-GASPÉSIE, INC.)
- GroundsKeeper's Pride Kelp Meal 1-0.15-1.5 (Int Comp.)
- Kelp Meal Fertilizer (Acadian Seaplant)
- Kelpropac (Productos del Pacifico, S.A. de C.V.)
- Thorvin™ Kelp for Plants (Thorvin, Inc.)
- Thorvin™ Kelp for Plants (Thorvin, Inc.)
- Tidal Organics Kelp Meal (Tidal Organics, Inc.)
- Wegener's Oceanic Kelp Meal 1-0.15-1.5 (Rambridge Wholesale Supply)
Potassium Bicarbonate
(~0-0-48)

- Bi-Carb Old Fashioned Fungicide (Lawn & Garden) A
- Kaligreen® Potassium Bicarbonate (Arysta) A
- MilStop™ Broad Spectrum Foliar Fungicide (BioWorks, Inc.) A
Potassium Nitrate
(~13-0-44)

Mined on Chile... (OK)

Reaction of KCl and nitric acid (not allowed)
Greensand (glauconite)

Developed as potential K source

• low K (5 to 7% K2O)
• low solubility
• bulky and expensive to transport
• poor source of plant-available K
Greensand (Glauconite) (~0-0-5)

- Greensand (North Country Organics) A
- Jersey Greensand (The Fertrell® Company) A
Ash
(~0-2-5)

Only wood ash allowed...
manure, coal, biosolid ash
not allowed

Highly variable:
contains whatever was
in the wood when burned
and was not volatilized

pH ranges from 9 to 13
Lime equivalent of 8 to 90% depending on many factors
Crushed rocks as a potassium source for ryegrass?

Bakken et al., 1997
Rate of nutrient availability…. 

Allowable Rock Powders include…

ballast, biotite, mica, feldspar, granite, greensand, etc

some are unsuitable as K sources due to their limited solubility and bulky nature

…. but some may have value over long periods of time
Rapidly growing plants can induce a potassium deficiency in the plant when the plant demand exceeds the uptake rate by the roots.
Will Cover Crops Help with Potassium Supply?

May provide additional N, but no other nutrients

Plant roots will speed soil weathering (Depletion of rhizosphere K can enhance clay transformations)

Subsoil K may contribute K to next crop if not harvested (and no root-limiting factors such as compaction, salinity, acidity…)
Manure and Compost K

Highly variable K content depending on the feedstock, manure characteristics, and manure handling.

Generally very soluble and readily available.

Animal K is largely excreted in the urine...

so manure handling makes a large difference.
**Potassium**

- High yielding crops remove large amounts of K

- Penalty for inadequate K is:  
  - loss of yield
  - increased disease pressure
  - greater insect damage
  - poor water use efficiency
  - low utilization of N

- Many acceptable and affordable options available for organic growers
  - but consider overall farm balance and time scale
    - (“soluble” is not bad)

- Recommendations should begin with proper soil sampling
Summary

Many excellent sources of nutrients for organic production… some materials not beneficial

Additional management is required to maintain adequate supplies of nutrients in rootzone when using organic nutrient sources

Use organic materials that are suited for your particular needs and learn how they behave