Nutrient management and soil health: effective and responsible compost use

Natalie Hoidal, Paulo Pagliari, KaZoua Berry
SFA Soil Health Summit 2022
Outline

- Nutrient management and soil health connections
- Is there such a thing as too much compost?
- Phosphorus build-up and why it matters
- Managing alkalinity on vegetable farms

- How Big River Farms is applying these principles
Nutrient management & soil health connections
Soil microbes make nutrients available to plants

- Higher SOM & reduced tillage generally associated with more microbial diversity
- SOM feeds microbes
- Microbes mineralize N, P and S
- More mycorrhizal association can increase P availability, decrease N leaching
Is there such a thing as too much compost?
Some reasons for using a lot of compost or composted manure

- Locally available
- Deep compost mulch popular among no till growers
- Meeting N needs
- Nutrient contributions generally considered low, slowly available
- Idea that more SOM is always better
A question to inform our discussion:

What is your go-to type of compost (e.g. composted manure, strictly vegetative, a mix of sources)?
What do we mean by compost?

▪ Composted cull piles
▪ Compost from yard waste sites or food scraps
▪ Composted manure

▪ **Really variable and confusing!
### Nutrient contributions of 6 Twin Cities compost sources

<table>
<thead>
<tr>
<th>Source</th>
<th>C:N</th>
<th>EC</th>
<th>pH</th>
<th>NH4-N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cowsmo</td>
<td>14.32</td>
<td>8.7</td>
<td>9.3</td>
<td>13</td>
<td>7262</td>
<td>22402</td>
<td>31946</td>
<td>15495</td>
</tr>
<tr>
<td>Kern c. manure</td>
<td>19.48</td>
<td>5.6</td>
<td>8.5</td>
<td>3065</td>
<td>4802</td>
<td>11656</td>
<td>19248</td>
<td>5907</td>
</tr>
<tr>
<td>Mulch Store</td>
<td>15.89</td>
<td>4.2</td>
<td>7.8</td>
<td>431</td>
<td>1695</td>
<td>4077</td>
<td>32600</td>
<td>7074</td>
</tr>
<tr>
<td>Yard Waste site</td>
<td>21.82</td>
<td>0.5</td>
<td>7.8</td>
<td>3</td>
<td>888</td>
<td>914</td>
<td>23023</td>
<td>7875</td>
</tr>
<tr>
<td>Kern compost*</td>
<td>14.07</td>
<td>5.7</td>
<td>5.6</td>
<td>33</td>
<td>22765</td>
<td>7637</td>
<td>22373</td>
<td>6731</td>
</tr>
<tr>
<td>Mushroom compost</td>
<td>30.73</td>
<td>5.7</td>
<td>7.8</td>
<td>11</td>
<td>2276</td>
<td>5062</td>
<td>46258</td>
<td>6255</td>
</tr>
</tbody>
</table>

All values reported in ppm
How much is needed for your plants to grow?

- More inputs → more potential for losses
- Nitrogen easily lost from soil
- Some research suggests phosphorus saturation rate: after saturation, all additional P could be lost to the environment via leaching or runoff
Nutrient build-up and why it matters
Elevated N impacts to plants & people

- NH4+ can burn plant roots
- Excessive leafy growth & less fruiting
- More disease pressure (Alternaria in broccoli)
- Nitrates in groundwater: excess N easily lost

Photo: Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org
Elevated P impacts to water
How much does it matter?

- Acreage of vegetable farms is quite small relative to commodity ag… so it’s a small contribution, right?
- P is immobile in soil, right?
P contributions
Soil test from a farm that relied primarily on composted manure for many years

<table>
<thead>
<tr>
<th>Lab Sample Number</th>
<th>Sample ID</th>
<th>Bray P (mg/kg soil)</th>
<th>NH4OAc-K (mg/kg soil)</th>
<th>LOI OM (%)</th>
<th>Water pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>K2E1</td>
<td>349 / 329</td>
<td>596 / 576</td>
<td>5.5 / 5.3</td>
<td>7.0 / 7.1</td>
</tr>
<tr>
<td>2</td>
<td>K2E2</td>
<td>387</td>
<td>668</td>
<td>5.4</td>
<td>7.0</td>
</tr>
<tr>
<td>3</td>
<td>K2E3</td>
<td>416</td>
<td>672</td>
<td>5.4</td>
<td>7.0</td>
</tr>
<tr>
<td>4</td>
<td>K2E4</td>
<td>461</td>
<td>612</td>
<td>5.5</td>
<td>7.1</td>
</tr>
<tr>
<td>5</td>
<td>K2E5</td>
<td>395</td>
<td>676</td>
<td>5.3</td>
<td>6.8</td>
</tr>
</tbody>
</table>

What do you notice? Bray P level of 50 = very high, no P recommended
K level 200 = very high, no K recommended
What is considered normal?

<table>
<thead>
<tr>
<th>Relative Level</th>
<th>Bray-P1</th>
<th>Olsen-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0-10</td>
<td>0-7</td>
</tr>
<tr>
<td>Medium</td>
<td>11-20</td>
<td>8-15</td>
</tr>
<tr>
<td>Medium-high</td>
<td>21-30</td>
<td>16-25</td>
</tr>
<tr>
<td>High</td>
<td>31-40</td>
<td>26-33</td>
</tr>
<tr>
<td>Very high</td>
<td>41+</td>
<td>34+</td>
</tr>
</tbody>
</table>

100 ppm often cited as ballpark “threshold” number


<table>
<thead>
<tr>
<th>Relative Level</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>0-40</td>
</tr>
<tr>
<td>Medium</td>
<td>41-80</td>
</tr>
<tr>
<td>Medium-high</td>
<td>81-120</td>
</tr>
<tr>
<td>High</td>
<td>121-160</td>
</tr>
<tr>
<td>Very high</td>
<td>161+</td>
</tr>
</tbody>
</table>
Soil samples from 27 PA farms

- Study of 1359 commercial vegetable fields 2016-2017 + study of 27 high tunnels
  - Baseline: 321 lb/acre P2O5 considered “exceeding crop needs”
  - Average from fields 751 lb/acre (164 ppm P)
  - Average from tunnels 1580 lb/acre (345 ppm P)
    - 96% had phosphate levels exceeding crop needs.
    - *This is just extractable P, total P could be much higher

Sanchez & Ford, 2020
2019 Study of Twin Cities urban gardens

- Gardeners applied av. 384 lb/acre P annually
- P (Bray): Median 60 ppm
  - Total combined garden area: 29 acres
  - 0.1% of the total watershed area
  - 19% of the P budget for the entire watershed

Garden inputs 30x greater than mean P applications in conventional ag.

Nutrient use efficiency for P was 2.5%. Conventional ag has a P use efficiency of 89%.

Study: Small et al., 2019
Additional stats

- Colorado Citizen Science Soil Health Project: 10.5% conventional farms and 47.8% organic farms met or exceeded the recommended P threshold (defined by Penn State)

Image: University of Colorado Boulder, Data collected from the Citizen Science Soil Health Project.
An ecological rift

Images from Wikimedia: Alexandra Pugachevsky, Illustratedjc, Trougnouf, Jessica Reeder, Paul Clarke
P losses
Soil test phosphorus levels in the top of the soil profile influence both surface and tile water dissolved phosphorus concentrations.
Iowa
from webinar with Antonio Mallarino

Ontario
from Wang et al., 2010
Beyond environmental effects

- Fertilizer & compost are expensive!
- Fertilizer prices driving manure shortages
Supplying nutrients without over-doing P

- We are likely over-applying N too, sometimes K
- Test, test, test!
- Apply to meet the nutrient requirements of the most abundant nutrient, then use single-nutrient sources
- Utilize foliar testing to adjust
Supplying N without over-doing P and K

- Rely more on cover crops
- Organic growers: blood meal, certain fish products, various crop products: soybean, peanut, alfalfa, castor bean, cotton seed meal
- Conventional growers, carefully applied urea, ammonium nitrate, ammonium sulfate
Nutrient credits

- Cover crops: can supply a significant amount of nitrogen (40-100+ lbs / acre)
- Previous compost applications
  - Dairy manure: 50% N in Y1, ~35% in Y2
  - Turkey manure: 50-75% in Y1, ~25% in Y2.
  - 70-90% P & K available in Y1
  - Fully composted: even less available
- Residues. e.g. sweet corn stover ~20 lbs N
Reducing nutrient loss to the environment

Impacts elevated near lakes, rivers

- Reducing losses:
  - Banded vs. broadcast
  - Perennial strips and buffers
  - Reducing tillage – erosion
  - Cover crops
  - Mulching to prevent runoff
Managing alkalinity on vegetable farms
Compost and pH

Soluble salts in the soil → more alkalinity → higher pH
Case study: P & pH at an incubator farm
Applications of Ca, Mg, other soluble salts →

Increased alkalinity →

Increased pH →

Decreased nutrient availability to plants
Compost and pH

- Soluble salts in the soil → more alkalinity → higher pH
  - Soluble salt tests – really influenced by sodium and ammonium, less so by Mg, K, Ca. Other salts can still increase alkalinity.

- Fresh manure: nitrates are acidic, balances pH
- Composted manure: N lost, Ca & Mg retained, more alkalinity
- Vegetable compost: Variable, but can have highest alkalinity!!
- Worse in high tunnels – cations not flushed via rainwater
Reducing the pH of your soil

- Sulfur → sulfuric acid in soil
- Gypsum, sulfates don’t affect pH. Not oxidized. Use source with fine granules of elemental sulfur.
- Irrigation water – acidify if needed. AlkCalc tool can help you calculate.

Sand, loamy sand, sandy loam soils: 8 lb / 1000 sq. feet, or 350 lb / acre.

Loam & silt loam: 24 lb / 1000 sq. feet, or 1045 lb / acre
Recap

- Many organic vegetable farms rely on composted manure for nutrient management
- Over-fertilization is common, impacts may be significant
- Test your compost
- Pay attention to nutrient “budgets” to avoid excess P
- Utilize cover crops: N + organic matter without the rest
- Watch pH closely, act to keep it below 7
Additional resources

Nutrient Management for Commercial Fruit & Vegetable Crops in Minnesota

Carl E. Rosso and Roger Elison
Department of Soil, Water, and Climate
University of Minnesota

Features

Farm food safety training
These educational opportunities are for small to medium-sized fruit and vegetable farms, but any farmer or gardener is welcome to attend.

Water testing for the FSMA Produce Safety Rule
The FSMA Produce Safety Rule requires that lots use approved testing methods to run these tests, to ensure results are accurate. The water labs listed conduct these allowable testing methods.

Supply chains
We work to build the relationships that bring University crop research to farmers, markets and, ultimately, dinner plates.

Nutrient management and soil health

For specialty crops

Cover crops and soil health
Cover crop rotation, reducing tillage

Soil and foliar testing
Soil testing for Fruit and vegetable growers, interpreting a soil test, foliar testing in fruit and vegetable crops

Nutrient management
Maintaining soil fertility in organic fruit and vegetable crop systems, nutrient cycling

Mantaining soil fertility in an organic system

Accumulated interest in organic crop production has been prompted by both consumer demand and the desire to avoid or improve soil conditions. One of the many fundamental goals of sustainable farming is to produce a crop with minimal external inputs. The soil cycle, which helps determine crop productivity, is heavily influenced by the health and balance of the organic matter and nutrients found within the soil. These nutrients are essential to crop growth and development, and influences the quality of the final product.

Background
Some crops in soil contain soil microorganisms. While many soils can quickly extract for crop purposes other beneficial additives, many soils are not used as efficiently as the same soils could be. Many soils require quality of soil quality for crop production. Soil testing is important because, the soil is already high in nutrients. Farmers must also continuously check for plant growth. Healthy soil contains the right balance of nutrients for plant growth. Inorganic inputs such as inorganic fertilizers can be added once nutrient levels are determined to ensure proper nutrition levels.

Objectives
Soil testing is vital for determining the quality of the soil. Nutrients can also be tested. Nutrient management strategies include long-term soil fertility or organic matter and applying nutrients from known soil applications. Nutrient management strategies include long-term soil fertility or organic matter and applying nutrients from known soil applications. Nutrient management strategies include long-term soil fertility or organic matter and applying nutrients from known soil applications.
Thank you!

Follow up:
hoidea016@umn.edu
University of Minnesota Fruit and Vegetable Growers News
The Vegetable Beet podcast
Part 2: Soil Health and Nutrient Management at Big River Farms

- 50 Acres within the fence
- 38 tillable
- 15-20 farm teams
Problems with growing at the Farm

- Major pest issues
  - Flea beetles, cucumber beetles, and potato beetle infestations
- Soil health issues
  - Tilling too much
  - Not enough cover cropping (bare soil)
  - Using too much Sustane/ pelleted manure
  - Water erosion/ over watering
- Challenges with so many farming practices
Soil health/ Fertility Plan

- Do a soil test every 2-3 years, keep record
- Always keep the soil covered
  - Mulch
  - Cover crop
  - Grass (terminate before seeds form)
  - Tarp
- Focus on cover cropping
- Only open up the area when you are ready to plant
- Don’t till too much
  - Mow weeds in between aisles and around fields
- Don’t water too much!
- Explore other sources of plant food
What’s The Difference?

**other than the name of the bottles**
¾ acre
.35 cover cropped + garlic
.4 annual
.25 perennials

First Part of the Season
1. 2021- Peanuts planted in May; garlic in October
2. 2021- Cover crop mix (oats and peas); 2022 leafy greens, flowers, and herbs (not-brassicas)
3. 2021- winter rye cover crop; 2022- mixed veggies; 4 beds of cover crop mix (sudan grass and cowpeas)
4. 2021- Winter Rye cover crop; Mow in May; plant buckwheat, sunflowers, sudangrass cover crop mix)
Second Part of the Season

1. July- Harvest garlic; cover crop (buckwheat); terminate buckwheat in end of August; peas and winter rye
2. Grow Peas and Beans; cover crop winter rye in October
3. mixed veggies; grow mustard varieties and radishes in cover cropped area
4. Terminate in August; Plant field peas and winter rye mix

¾ acre
.35 cover cropped + garlic
.4 annual
.25 perennials
Comparing Costs for ¼ acre to grow Spinach

Spinach Needs: 80 lb/acre N, 75 lb/acre P, 100 lb/acre K based on BRF soil test

Option 1
use 4-6-4 to meet N needs:
- 4000 lbs (4-6-4) / acre
- 240 lbs P / acre
- 160 lbs K / acre

$800 per ¼ acre plot
*Way too much P and K

Option 2
use 4-6-4 to meet P needs:
- 1250 lbs (4-6-4) / acre
- 50 lbs K / acre.
- Supplement with langbeinite
- 25 lbs N / acre
- Supplement with blood meal

$480 per ¼ acre plot

Option 3
use 4-6-4 to meet P needs:
- 1250 lbs (4-6-4) / acre
- 50 lbs K / acre.
- Supplement with langbeinite
- 25 lbs N / acre
- Supplement with cover crop

$400 per ¼ acre plot

Assumptions: ~50 pounds N from cover crop, no N credits from previous years
N is 50% available in the 4-6-4 product, so remember to credit 40% of the N in year 2
Don’t Lose your mind over this!

Happy to connect

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Mixed Vegetable grower

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