Integrating Compost into Nutrient Planning

Fertilizer Research & Education Program
Western Plant Health Association
Conference
FREP/WPHA
October 23, 2018

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Overview

• Rio Farms’ composting program
• Compost on the Central Coast
• Compost challenges & benefits
• Regulatory context for reporting N applied
• N budgeting resources
• Example N budgeting calculations
• Summary
• Est. 1978 by Allen, David & Steven Gill
• King City and Oxnard, CA, & Yuma, AZ
• About 17,000 acres
• 20+ vegetables, including spinach, lettuce, romaine, celery, broccoli, cauliflower, onions, peppers, tomatoes, baby greens and more
• Major grower for Gills Onions, a fresh onion processor
Rio Farms Compost Ingredients

• Culled onions, leafy greens, vegetable pulp
• Mushroom substrate from Monterey Mushroom Co.
• Grape pomace from local wineries
• Green waste from Johnson Canyon, Gonzales
General Patterns of Compost Use on the Central Coast

• Application rates
  • 3-5 tons/acre per year are typical, considered “maintenance level”
  • 8-10 tons/acre – infrequent & limited to: small growers, self-producers, when new land being brought into production and/or treatment for recent land leveling
• Compost cost: $40-55/ton delivered
• Most use compost for building soil health, maintaining SOM.
• Green material compost most common
• Manure-based compost: not widely available. Supply chain often rejects (although approved by FSMA)
• Cover crops & compost
• Limits to adaptation
Composting Regulations

• California Air Resources Board
• Water Resources Control Board
• California Integrated Waste Management Board (CIWMB)
• FSMA / LGMA / buyer requirements

• In-vessel / static pile system: maintain temps 131°F - 170°F for 3 days
• Windrow composting: 131°F - 170°F for 15 days, turned min 3x
• Temperature & turning logs - 5 years
• Metals sampling
• Fecal coliform
• Salmonella sp
• Pre-harvest interval (45 days), buyers often demand 120 days
• Raw Manure: PHI 90-120 days
### Benefits of Compost in Agriculture

<table>
<thead>
<tr>
<th>Benefit</th>
<th>✔️</th>
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<tbody>
<tr>
<td>Increase Organic Matter</td>
<td>✔️</td>
</tr>
<tr>
<td>Increase Microbial Activity</td>
<td>✔️</td>
</tr>
<tr>
<td>Increase N</td>
<td>✔️</td>
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<tr>
<td>Increase K</td>
<td>✔️</td>
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<tr>
<td>Increase P</td>
<td>✔️</td>
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<tr>
<td>Increase Micronutrients</td>
<td>✔️</td>
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<tr>
<td>Increase Cation Exchange Capacity</td>
<td>✔️</td>
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<tr>
<td>Increase Water Holding Capacity</td>
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<tr>
<td>Reduce Soilborne Disease</td>
<td>✔️</td>
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<tr>
<td>Reduce Soil Erosion</td>
<td>✔️</td>
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<tr>
<td>Reduce Compaction</td>
<td>✔️</td>
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<tr>
<td>Increase Carbon Sequestration</td>
<td>✔️</td>
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Image showing the benefits of compost in agriculture, including crop yield, crop nutritional quality, weed, pest and disease suppression, soil workability, soil moisture content, nutrient supply, soil biological properties and biodiversity, and soil erosion.


From UCANR webpage Compost
https://ucanr.edu/sites/Nutrient_Management_Solutions/stateofscience/Compost/
Compost is a stormwater BMP listed by the EPA

BMPS include: compost blanket, compost sock and compost filter berm.

“Compost blanket: A layer of loosely applied compost that is placed on the soil in disturbed areas to control erosion and retain sediment resulting from sheet flow runoff. Compost blankets are used in place of sediment and erosion control tools such as mulch, netting, or chemical stabilization.”

“Why Should You use Compost BMPs?
• Compost retains a large volume of water, thus helping to prevent/reduce erosion, reduce runoff, and establish vegetation.
• Compost improves downstream water quality by retaining pollutants such as heavy metals, nitrogen, phosphorus, oil and grease, fuels, herbicides, and pesticides.
• Nutrients and hydrocarbons adsorbed and/or trapped by compost are decomposed by naturally occurring microorganisms.
• Compost improves soil structure and nutrient content, which reduces the need for chemical fertilizers.
• Compost-based BMPs remove as much or more sediment from stormwater as a traditional perimeter.”

Direct quote from US Environmental Protection Agency
Compost Benefits: Waste Reduction Goals

SB 1383: Reduce disposal of organic waste by 50% of 2014 levels in 2020 & 75% of 2014 levels in 2025.

CalRecycle, 2017 Establishing the Organics Disposal Baseline
https://www2.calrecycle.ca.gov/PublicNotices/Documents/7631
“CalRecycle and CDFA will continue their efforts to incentivize the use of compost on agricultural lands in support of the Healthy Soils Initiative, including developing best management practices for agricultural use. They will also work with the State Water Resources Control Board to evaluate potential mechanisms to account for the use of compost and its impacts on nitrogen budgets in the Irrigated Lands Program as well as the potential impacts of land application of uncomposted organic materials.”

CDFA’s Healthy Soils Program

- Healthy soil & carbon sequestration
- $7.5 Million allocated in 2017
- $15 Million available in 2018, RFP likely November-December 2018
- White Paper on Compost Application Rates
  - Suggest compost application rates CDFA should incentivize
  - Lists research on California compost composition and N mineralization
  - Done in consultation with State Water Resources Control Board staff
- Compost Planner – CARB developed GHG calculator

https://www.cdfa.ca.gov/oefi/healthysoils/
CDFA Healthy Soils Program: 2017 Funded Projects (Incentive Projects only)
Compost Benefits: GHG Reductions
For every 1 acre of compost applied (C:N ratio >11) = 3.8 MT CO$_2$e

Equivalencies from: [https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator](https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator)
Integrating Compost into Nutrient Budgets

• Plant Available Nitrogen (NO$_3$ and precursor NH$_4$) is conveniently the same form of N available to leach or runoff. Therefore reporting this (rather than total N) is more useful for growers and regulators.
• Due to water quality benefits, we must be careful to not to disincentivize the use of compost if growers are labeled as outliers for high N application rates
• Growers need a simple process; they should not have to do extensive N mineralization studies on their farms. Others have already done the work.
• There is a large variation of mineralization rates from different soil amendments
  • Compost
    • Composted green-sourced materials
    • Composted manure
  • Raw manure
  • Other labeled Organic fertilizer products*
    • Chicken manure pellets, fish emulsion
    • Feathermeal, Bloodmeal

*as written, not included in Soil Amendment line of N budget
Plants take up N in the form of ammonium ($\text{NH}_4^+$) and Nitrate ($\text{NO}_3^-$).
Ammonium is only available in soils for short periods of time until converted to nitrate.
The applied organic soil amendments include compost and manure and should be reported as the amount of nitrogen available to the plant during the growing period in pounds per acre. Available nitrogen may be measured by testing the applied compost or manure materials or estimated using reference materials that are available for estimating nitrogen content.
Summary of Compost Reporting instructions from ESJ Order:

- **Applied compost and manure**
  - Doesn’t include organic labeled fertilizers that may also have N mineralization less than 100%

- **Grower reports**
  - Certification required

- **Amount of nitrogen available to the plant**
  - Plant available N, not total N in compost
  - “the plant” = must divide if multiple crops per year

- **During the growing period**
  - Not during fallow periods? Or is this referring to the reporting period (e.g. for year 2019, all N mineralized)?
  - Doesn’t specify how to treat carryover nitrogen from compost applications from previous years.

- **In pounds per acre**
- **Measured or Estimated**
DRAFT Irrigation and Nitrogen Management Plan Worksheet and Instructions

<table>
<thead>
<tr>
<th>5. Irrigation Efficiency Practices* (Check all that apply)</th>
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<tbody>
<tr>
<td>□ Laser Leveling</td>
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<tr>
<td>□ Use of ET in scheduling irrigations</td>
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<tr>
<td>□ Water application schedule to need</td>
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<td>□ Use of moisture probe (e.g. tensiometer)</td>
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<table>
<thead>
<tr>
<th>HARVEST / YIELD INFORMATION</th>
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<tbody>
<tr>
<td>Harvest / Yield Information</td>
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<table>
<thead>
<tr>
<th>6. Production Unit (lbs, tons, etc.)</th>
<th>7. Harvested Yield*</th>
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<thead>
<tr>
<th>8. Nitrogen Efficiency Practices* (Check all that apply)</th>
<th>Nitrogen Sources</th>
<th>Recommended/Planned N (A)</th>
<th>Actual N (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ Split Fertilizer Applications</td>
<td>9. Soil – Available N in Root Zone (Annualized, lbs/ac)</td>
<td></td>
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</tr>
<tr>
<td>□ Soil Testing</td>
<td>11. Organic Amendments* (Manure/Compost/Other, lbs/ac estimate)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Tissue/Petiole Testing</td>
<td>12. Dry/Liquid Fertilizer N* (lbs/ac)</td>
<td></td>
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</tr>
<tr>
<td>□ Fertigation</td>
<td>13. Foliar Fertilizer N* (lbs/ac)</td>
<td></td>
<td></td>
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<tr>
<td>□ Foliar N Application</td>
<td>14. TOTAL NITROGEN (lbs/ac)</td>
<td></td>
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<tr>
<td>□ Cover Crops</td>
<td></td>
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<tr>
<td>□ Variable Rate Applications using GPS</td>
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<tr>
<td>□ Other:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Other:</td>
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</tbody>
</table>

https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/forms_templates/#ilrpinmp_worksheet
Q: What Percent Nitrogen is Available from Compost?

Depends on:

- Soil microorganisms present: bacteria, fungi
- pH
- Soil temperature
  - N mineralization higher in warmer soils
- Soil moisture
  - Microbes need sweet spot – not too wet or dry
- Carbon to nitrogen ratio
  - C:N > 20 – N can be immobilized
  - C:N < 20 – N will be mineralized
- Particle size / surface area
- Grower-related decisions
  - Timing of application
  - Surface vs. incorporation

Image from: https://ucanr.edu/sites/Nutrient_Management_Solutions/stateofscience/Organic_Sources_of_Nitrogen/
What Percent Nitrogen is Available from Compost in Year 1?

1. Cured Compost: 5-10% , Yet also states “the total N content of the application is used as a N supply for that year” CDFA Grower Nitrogen Management Training for Grower Nitrogen Management Plan Self-Certification
   https://www.cdfa.ca.gov/is/ffldrs/frep/pdfs/Grower_N_TrainingPresentation.pdf

2. 5-10%  CDFA White Paper

3. 5-10%  Hartz, T. 2009. Nutrient Value of Compost Presentation

4. Use PAN, Nitrogen Management Training for Certified Crop Advisors: “Where the material applied is mature compost or weathered corral manure, the N credit will be small, possibly negligible, even though the total amount of N added is significant.”
   Module 5: Nitrogen budgeting "cheat sheet" with definitions & formulas (handout)
   http://ciwr.ucanr.edu/files/205050.pdf

5. 10-15%  (New England soils) University of Massachusetts:
   UMASS Amherst Extension, 2014. Interpreting Your Compost Test Results
   https://ag.umass.edu/sites/ag.umass.edu/files/fact-sheets/pdf/compost_analysis_and_interpretation_with_test.pdf

6. 20%  Colorado State, Calculating a Compost Application Rate based on Fertilizer Needs.
   http://www.extsoilcrop.colostate.edu/Soils/powerpoint/compost/Calculating_compost_application_rate.pdf
“For compost with higher nitrogen (C:N ≤ 11), studies suggested that 5-15% \( \text{average} \approx 10\% \) of the organically-bound nitrogen would be mineralized in the first year of application.

Each subsequent year, additional remaining organically-bound nitrogen would be mineralized, at a rate that would decline by half each year to a minimum of approximately 2% until all of the organic N in the compost had been consumed.

For compost with lower nitrogen (C:N > 11), studies suggested that 2-7% \( \text{average} \approx 5\% \) of the organically-bound nitrogen would be mineralized in the first year.”

Calculating Compost N contribution for Nitrogen Budgets

<table>
<thead>
<tr>
<th></th>
<th>% total N wet weight basis (compost sample)</th>
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<tbody>
<tr>
<td>1.10%</td>
<td>% total N wet weight basis (compost sample)</td>
</tr>
<tr>
<td>4</td>
<td>tons/acre applied</td>
</tr>
<tr>
<td>2000</td>
<td>pounds per ton</td>
</tr>
<tr>
<td>88</td>
<td>Total lb N/land acre applied (organic &amp; inorganic) via compost</td>
</tr>
<tr>
<td>12.7</td>
<td>C:N ratio</td>
</tr>
<tr>
<td>5%</td>
<td>% available year 1</td>
</tr>
<tr>
<td></td>
<td>C:N &gt; 11, mineralization = 5%</td>
</tr>
<tr>
<td></td>
<td>C:N &lt; 11, mineralization = 10%</td>
</tr>
<tr>
<td>4.4</td>
<td>Total lb N/land acre expected to be mineralized in year 1 (inorganic N)</td>
</tr>
<tr>
<td>2</td>
<td>average # crops per year</td>
</tr>
<tr>
<td>2.2</td>
<td>Total lb N/crop acre expected to be mineralized in year 1 (inorganic N)</td>
</tr>
</tbody>
</table>
Is N released in future years significant?

Scenario: Apply same compost 4 tons/acre for 20 years (from 2000-2020), assuming 2 crops/year. Use CDFA method to determine PAN through time (5-10% based on C:N ratio).

Questions:
- How many lbs N/crop acre are mineralized each year?
- How long does it take all of the N in the first year of application to get used up?
- Is this a major contribution to crop N budgets?
Scenario: 20 years compost application
Lb N mineralized/crop acre
Scenario Results

- How many lbs N available to each crop each year?
  \[ \text{Min} = 2.2 \text{ lb N/crop acre (Year1)} \text{ to} \]
  \[ \text{Max} = 20 \text{ lbs N/crop acre (Year 20)} \]

- How long does it take all of the N in the first year of application to get used up?
  - It takes 47 years for all 88 lbs N from Y1 application to be mineralized (assuming no losses)

- Is this a major contribution to crop N budgets?
  - In 2020, the cumulative max N available = 20 lb N/crop acre.
  - 20 lbs N = 5-15% of total crop N needs, is this significant?
  - Note, the N release of 20 years of compost application is only 46% of total N applied in one year (40/88).
Is it there? Test the Soil.
Caution: consider that soil reflects all N previously applied

- Fertilizer
- Compost
- Irrigation water
- Crop residue / Cover Crop
Compost Calculations – Next Steps

1. Growers can estimate and report as only they know what type and quantity of manure or composts they are working with.

2. Grower Coalitions, SWRCB and CDFA should develop a fact sheet to aid growers
   a) Growers need a simple %N of total N applied to report
   b) Are there different values for different CA climate regions or green vs. manure-based compost? Or is there a state wide calculation that can be suggested?
   c) Require a lab tested compost sample, or are estimates ok?
   d) Does SWRCB want a way to include previous years’ N now being mineralized? How? How will land tenure affect this?

3. SWRCB & CDFA – review certification course training information provided

4. Consider allowing growers to report on a ranch (land basis) and not per crop.

5. Do not label growers as outliers for AR metrics due to compost use. Acknowledge that compost has a host of water quality benefits that may override its potential negative N contribution.

6. Consider that organic labeled fertilizers (chicken meal, feather meal, blood meal etc.) have 40-80% plant available nitrogen yet are reported in the fertilizer category. Clarify how those growers should report.

7. Similar to ESJ Order, do not count soil N as an additive source of N. It is a useful tool for grower budgets, but the N came from another source and shouldn’t be double-counted in N mass balance studies.
Because there are a host of water quality and other benefits, RWQCBs and growers have reason to continue to use and incentivize compost.

Low “maintenance level” applications of compost are most common and equate to 2-5 ton/acre applied.

Compost provides a small percent of N to the total nutrient requirements of a crop, even after decades of compost application.

Green-based compost is more widely used on the Central Coast than manure due to food safety & availability.

Growers need a simple process for reporting compost application in their N budgets.

CDFA and the SWRCB should summarize the research in fact sheets and review the current Certification Course curriculum.

Growers can use a soil sample to determine how much mineralized nitrogen is in the soil, however this will reflect all previously applied N.
Questions/Comments

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