Carbon and nitrogen cycling in a Gainesville soil amended with dairy- and food-derived composts

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ABSTRACT

Nutrient concentrations and availability vary substantially among composts depending on the materials and processes with which they are made. Agricultural operations compost wastes, mostly animal wastes such as manures, whereas composts produced in urban areas mainly incorporate food waste, sometimes with yard waste. Our objective was to measure how different composts affect nutrient availability and cycling, in addition to potential impacts on soil fertility and health. In a laboratory incubation, we compared CO_2 emissions and nitrogen mineralization rates between three dairy-derived composts (composted dairy manure, vermicompost made from dairy manure, and Black Kow™) and two food-derived composts (composted food waste and Ecoscraps™) on a soil from Gainesville, FL. Incubations were conducted at 24˚C and 30˚C for eight weeks, i.e. the annual and July mean soil temperature at the PSREU in Citra, respectively. The composted dairy manure and vermicompost had the highest CO_2 emissions compared to the unamended soil. Soil nitrate increased the most with composted food waste, whereas all three dairy-derived composts resulted in a decrease of nitrate compared to the unamended soil. This suggests that N was immobilized during the incubation, which is supported by the high CO_2 emissions with these amendments. Overall, the food waste compost seemed to have the highest increase in inorganic N during the eight-week incubation, suggesting a greater potential as a nutrient source than the dairy-derived composts.

INTRODUCTION

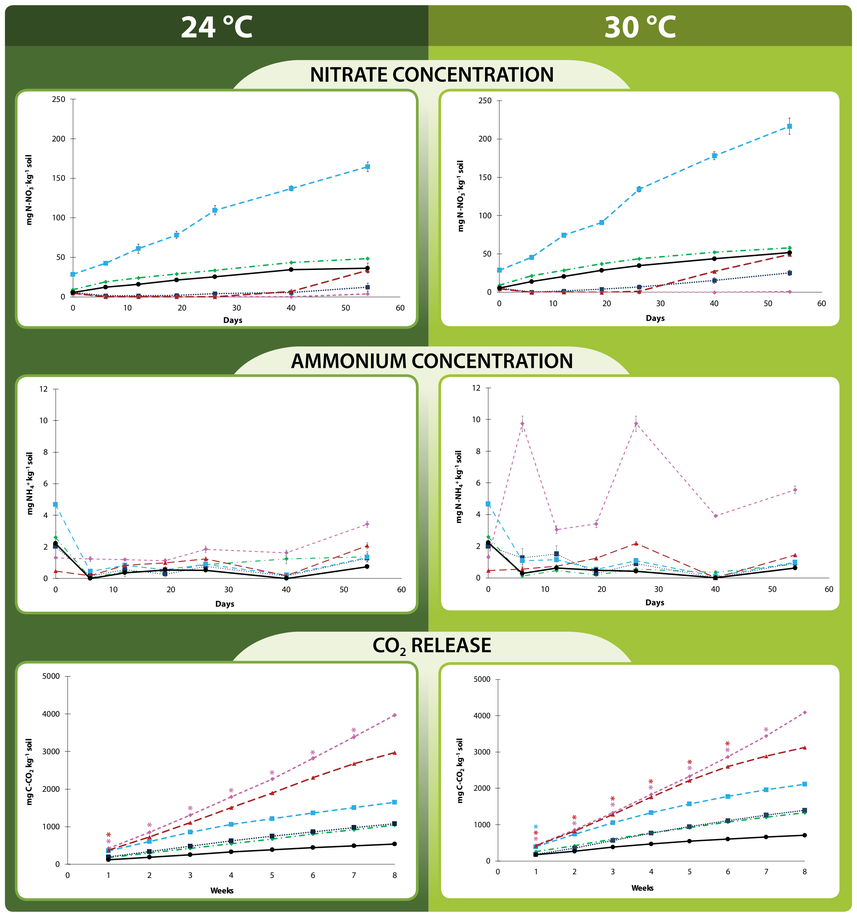
BACKGROUND

- Farms and households produce a substantial quantity of organic wastes, such as animal manure and food wastes
- Composting can effectively recycle organic wastes, but composting practices vary substantially
- Composts are used as soil amendments in crop production to improve soil structure, soil health, and nutrient availability
- Different organic materials and composting processes affect nutrient concentrations and availability
- It is unclear how different composts affect nutrient cycling and soil fertility

OBJECTIVES

- Use an incubation experiment to quantify C and N mineralization during the decomposition of five different composts
- Compare nutrient value of composts derived from dairy and food wastes

RESULTS



NITRATE

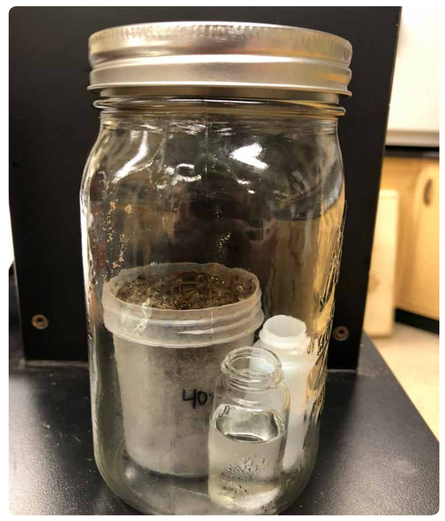
- Nitrate concentration decreased during the incubation with dairy-based products compared to the untreated soil, possibly due to denitrification or immobilization (or a combination of the two).
- Nitrate concentration increased with food-based products; however, nitrate concentration was much lower in the commercial compost (Ecoscraps) than in the composted food waste.
- At 24˚C, nitrate increased in vermicompost at week 8.
- At 30˚C, nitrate increased in vermicompost and Black Kow after day 26.
- Higher rates of nitrogen mineralization observed at the higher temperature.

AMMONIUM

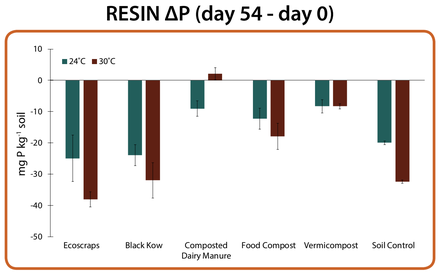
- Composted dairy manure showed consistently higher amounts of ammonium compared to other treatments.
- Food waste compost, Ecoscraps, Black Kow, and vermicompost all showed similar amounts of ammonium, which were slightly higher than the soil control.
- Composted food waste had the highest amount of ammonium at day 0.

CO_2 RELEASE

- All treatments emitted higher CO_2 levels than the soil control, indicating an increase in organic matter decomposition.
- The two commercial products, Black Kow and Ecoscraps, emitted the least amount of CO_2 when compared to the control.
- Composted dairy manure and vermicompost had the highest CO_2 emissions compared to the control.
- Assay reruns for treatments which saturated the base traps (composted dairy manure, vermicompost, and food waste compost) indicate composted dairy manure released the most CO_2 of the amendments (580-620 mg C-CO_2 kg^{-1} soil at week 1).



RESIN ΔP (day 54 - day 0)



RESIN P

- Phosphate declined in all treatments, except for composted dairy manure at 30 °C.
- Food waste compost added more resin P to the soil than the other amendments, but had relatively small changes in resin P during the incubation.

METHODS

MATERIALS AND DESIGN

- Gainesville soil, from the Field and Fork gardens (Entisol)
- 5 amendments
  - 3 dairy-derived composts
    - Compost from separated dairy solids*
    - Vermicompost from separated dairy solids*
    - Black Kow™
  - 2 food-derived composts
    - Food waste compost*
    - Ecoscraps™
- Amendments applied a rate of 125,000 kg/ha (58 mg/g)
- Moisture adjusted to 50% WFPS
- Unamended soil used for control

** - locally-sourced composts supplied by Dr. Ann Wilkie*

PROPERTIES AT ASSAY START

Treatment	pH	CEC (meq/100g)	N-NO3 (mg kg^{-1} soil)	N-NH4 (mg kg^{-1} soil)	P (mg kg^{-1} Mehlich III)	Resin P (mg kg^{-1} soil)	K (mg kg^{-1} Mehlich III)
Soil	6.6	10.2	5	2	426	100	231
Soil + Black Kow	6.9	12.8	6	2	449	121	465
Soil + Food compost	7.1	13.5	29	5	484	180	1290
Soil + Vermicompost	6.8	12.1	5	1	417	100	319
Soil + Composted Dairy Manure	6.9	11.8	4	1	418	97	283
Soil + Esoscraps	6.8	13.2	9	3	459	113	449

LABORATORY INCUBATIONS

- Incubations conducted at two temperatures
  - 24˚C (mean annual soil temperature at Citra PSREU)
  - 30˚C (mean soil temperature of warmest month at Citra PSREU)
- 3 replicates per treatment x temperature combination
- Each replicate consisted of soil or soil + amendment sealed in a 1 L glass canning jar
  - 150 g of material per replicate (on a dry weight basis)
  - 10 ml vial DDI placed in jar to maintain moisture
  - 10 ml vial 1 M NaOH placed in jar as a base trap for CO_2
- Jars incubated for 8 weeks

NUTRIENT ANALYSES

Inorganic nitrogen

- Extracted with 2 M KCl
- Extractions conducted on weeks 0, 1, 2, 3, 4, 6, 8
- Analyzed with colorimetry for ammonium (Weatherburn 1967) and nitrate (Doane and Horwáth 2003)

Resin P

- Extracted with DDI and anion-exchange resin strips (Tiessen and Moir 2007)
- Eluted with 0.5 M HCl
- Extractions conducted on week 0 and week 8
- Phosphorus concentrations analyzed with colorimetry

CO_2 RELEASE

- Titrations conducted every week for 8 weeks
- NaOH vials removed and replaced weekly
- CO_2 precipitated with $BaCl_2$
- Titration with 1 M HCl (+ phenolphthalein indicator as described by Franzluebbers (2016)

$$C\text{-}CO_2\ (mg\ kg^{-1}\ soil) = (mL_{[blank]} - mL_{[sample]}) \times N \times M/S$$

N = normality of acid (1)
M = mass conversion from cmolc to g C (6000)
S = soil weight (g)

CONCLUSIONS

- High CO_2 emissions and low NO_3^- concentrations observed in composted dairy manure and the vermicompost suggests denitrification and/or immobilization of N. For dairy compost at 30˚C, sharp declines in NH_4^+ indicate some N losses due to NH_3 volatilization.
- Black Kow released less CO_2 than the composted dairy manure, but still had a net loss of nitrate compared to the unamended soil. This suggests nitrate losses were due to immobilization.
- Soil amended with locally-sourced food waste compost had the highest nitrate and phosphate concentrations, which was much higher than the commercial equivalent, Ecoscraps.
- Overall, compost derived from food waste demonstrated greater potential as a short-term source of nutrients than the dairy-derived composts.

FUTURE WORK

- Further analyses on active C, total C, soil organic matter, and total N.
- Incubations repeated for treatments which saturated the CO_2 base traps; pH readings as a proxy for potential NH_3 volatilization.
- Second incubation study conducted with a soil with a lower content of organic matter.

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