Evaluating the Potential of Composted Cow Manure as a Soil Amendment in Urban Landscapes

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Introduction

- Construction activities often result in the establishment of new landscape plants in compacted and infertile soil (Fig. 1).
- Poor soil conditions can lead to failure of sod and newly transplanted ornamentals.
- In addition, reduced infiltration rates due to compaction can lead to significant runoff losses of nutrients when these new residential landscapes are fertilized.
- Amending disturbed soils with organic material may help decrease bulk density, increase infiltration, and improve the rooting environment for establishing ornamental plants and turf.
- Composted cow manure (cowpeat) has the potential to be used as an organic soil amendment for urban residential and commercial landscapes, which will also provide a means for dairy farmers to dispose of unwanted animal waste.
- The objectives of this study are to determine:
  1. The effects of storage and batch on the physical and chemical properties of the cow peat material,
  2. The potential for nutrient leaching losses from cowpeat, and
  3. The benefit of soil amendment with cowpeat on the growth and quality of plants in the landscape and the potential for nutrient leaching at the landscape plot scale.

Materials and Methods

Storage and Batch Effect on Chemical and Physical Composition of Cowpeat

- Composted cow manure (cowpeat) was delivered on 4 May 2007 (batch 1) and 15 June 2007 (batch 2).
- Cowpeat was stored outside in open piles, plastic bins or 75-L clear plastic bags with half of the material stored under a covered structure and the remainder left out in direct sunlight (Fig. 3).
- Cowpeat (batch 1) temperature was monitored for 20 days using thermocouples attached to two Campbell Scientific CR10x data loggers (equipped with multiplexers).
- Cowpeat was analyzed for moisture content, pH, and EC using standard methods for compost analysis.
- Cowpeat was also analyzed for EPA_{3050} digestible P, Al, Ca, Fe, K, Mg, and Na using ICP-AES (Perkin Elmer, Waltham, MA) and water extractable NO_3^-, NH_4^+, and ortho-P using a discrete analyzer (Seal Analytical, West Sussex, UK).
  - Cowpeat batch 1 was analyzed at 0, 7, and 14 days after delivery.
  - Cowpeat batch 2 was analyzed upon delivery.

Potential for Nutrient Leaching Losses from Cowpeat

- As part of a study to evaluate cowpeat as a substitute for peat in potting mixes, five 15 x 11-cm pots were filled with a mixture of 60% cowpeat, 20% vermiculite (inert), and 20% perlite (inert) (Fig. 2).
- Pots were saturated immediately and allowed to drain overnight. Following initial saturation, pots were watered daily to ensure thorough wetting of the cowpeat mixture for 32 d.
- Leachate was collected at 1, 4, 18, and 32 d after saturation and the volume recorded.
- Leachate was filtered through a 0.45-µm membrane filter and analyzed for NO_3^-, NH_4^+, and ortho-P using a discrete analyzer and Ca, Na, Mg, and K by ICP-AES.
- Concentrations of nutrients leached were normalized to account for variations in the volume of leachate collected from each pot.

Fig. 1. New residential landscape planted on compacted soil near Tampa , FL.

Fig. 2. Pot filled with cowpeat used in leachate collection and analysis.

Results and Discussion

Storage and Batch Affects Cowpeat Properties

Table 1. Selected chemical properties of fresh cowpeat delivered in two batches.

Chemical Property	Batch 1	Batch 2
pH	7.24	7.69
Electrical Conductivity, mS/cm	2.8	1.9
NO_3, mg kg^{-1}	<4.00	<4.00
NH_4, mg kg^{-1}	497	ND†
ortho-P, mg kg^{-1}	46	ND
EPA_{3050} P, mg kg^{-1}	5410	3724
EPA_{3050} Al, mg kg^{-1}	1238	1004
EPA_{3050} Ca, mg kg^{-1}	12038	9854
EPA_{3050} Fe, mg kg^{-1}	9149	3831
EPA_{3050} K, mg kg^{-1}	5262	3932
EPA_{3050} Mg, mg kg^{-1}	2560	2175
EPA_{3050} Mn, mg kg^{-1}	76	84
EPA_{3050} Na, mg kg^{-1}	1124	1025

† ND = not determined

- There were some differences in the chemical properties of the two cowpeat batches (Table 1).
- Cowpeat stored in open piles or plastic bins showed an initial increase in temperature suggesting that the composting process was not complete.
- All storage methods showed diurnal temperature fluctuations (Fig. 4).
- Bagged cowpeat in direct sunlight exhibited extreme diurnal temperature fluctuations (Fig. 4).
- Storage time had a significant effect on concentrations of NH_4 and ortho-P (Tables 1 and 2).
- Storage method (i.e., bag, pile, bin) had a significant effect on pH, ortho-P and NH_4 (Table 1).
- There was no effect of storage location (direct sun, covered) on properties of the cowpeat.
- Results suggest that microbial mineralization of P was occurring more rapidly when cowpeat was stored in piles or bags.
- Results suggest that volatilization of ammonia was inhibited by the use of bags and deep inside the pile.
- Increasing NO_3-N concentrations suggest that nitrification during storage in piles may have a significant environmental impact if cowpeat is used as a potting mix or soil amendment.
- Based on the results of this study, we determined that the cowpeat would be stored outside in covered garbage cans.

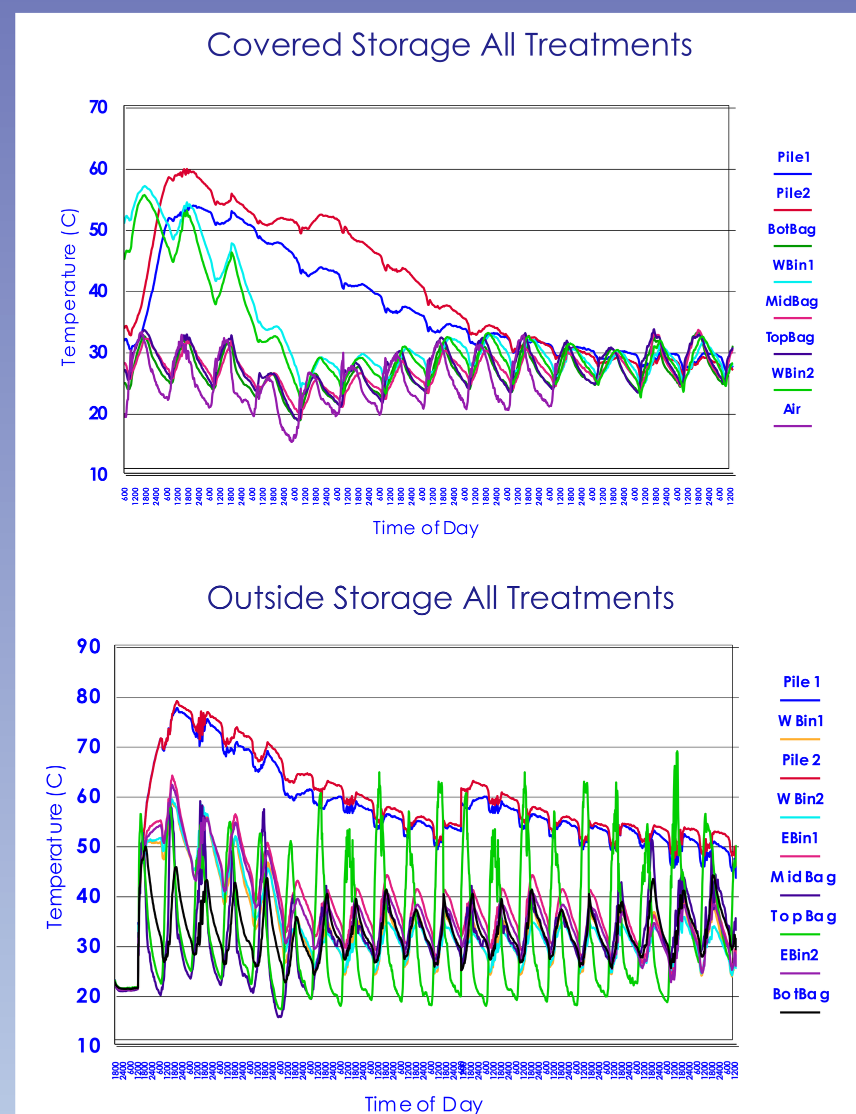

Fig . 4. Temperature of cowpeat stored a) under cover or b) in direct sunlight in open piles, plastic bins, or staked plastic bags for twenty days in Central Florida.

Table 2. Effect of storage time and method on chemical and physical properties of the cowpeat (batch 1).

Storage Method	pH Day 7	pH Day 14	EC Day 7	EC Day 14	Moisture Content Day 7	Moisture Content Day 14	NO_3-N Day 7	NO_3-N Day 14	NH_4-N Day 7	NH_4-N Day 14	ortho-P Day 7	ortho-P Day 14
			mS cm^{-1}		g kg^{-1}		mg kg^{-1}					
Covered												
Bag	7.2	7.3	3.0	2.8	457	489	<4.00	<4.00	283	233	62	57
Plastic Bin	6.7	6.7	3.0	3.0	312	296	<4.00	<4.00	16	15	90	90
Pile	6.8	6.7	3.0	3.2	215	198	5.53	14.48	65	69	83	92
Direct Sunlight												
Bag	7.1	7.5	3.1	2.6	389	475	<4.00	<4.00	301	291	64	53
Plastic Bin	6.7	6.7	2.9	3.1	218	271	<4.00	<4.00	29	22	90	91
Pile	6.8	6.7	3.1	3.2	221	63	5.84	6.27	88	110	95	101

Fig. 3. Composted cow manure (cowpeat) stored in a pile out of direct sunlight (covered).

Nutrient Leaching from Cowpeat

- Nutrient losses were highest for the second leachate collection (3 days after initial saturation) (Fig. 5).
- The amount of ortho-P leached from the pots was much higher than either of the N forms (Fig. 5).
- Leachate also contained significant amounts of Na, K, Ca, and Mg. (Volume normalized data in parentheses.)
  - Na = 201 mg L^{-1} (188 mg)
  - K = 153 mg L^{-1} (143 mg)
  - Ca = 23 mg L^{-1} (21 mg)
  - Mg = 15 mg L^{-1} (14 mg)
- Results indicate that P losses may be a concern if cowpeat is applied as a soil amendment. This effect may be enhanced in Florida's sandy, low P saturation soils.

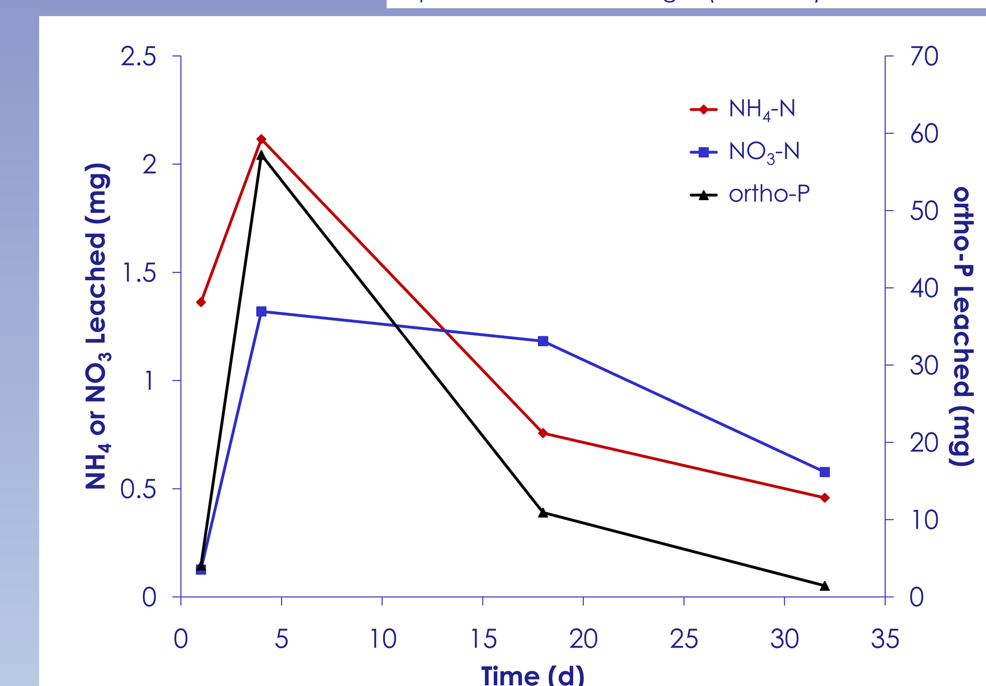

Fig. 5. Nutrients leached from 15- x 11-cm pots filled with a mixture of 60% cowpeat, 20% perlite and 20% vermiculite. Values are normalized based on the volume of leachate collected from each pot.

Conclusions

- Dairies producing cowpeat must ensure that the product is thoroughly composted prior to shipment.
- Cowpeat material can be stored in piles, bins, or bags; however, changes in chemical properties will occur with time due to ammonia volatilization, nitrification or microbial mineralization.
- We suggest storing cowpeat out of direct sunlight.
- Piles stored on bare ground have the potential to leach nutrients.
- When used as a landscape amendment, there is the possibility that some nutrients will be lost in leachate or runoff, however, the benefits to the soil should outweigh this potential for nutrient losses.

Future Research

- Field study evaluating cowpeat as a soil amendment for establishment of new residential landscapes on compacted soils.
- Sixteen simulated mixed landscape plots will be constructed at a 2% grade and soil will be compacted to a bulk density = 1.7 g cm^{-3} (Fig. 6).
- Plots will be established in a Zolfo fine sand (Table 3) and planted with mixed ornamental plants (50%) and St. Augustinegrass sod (50%).

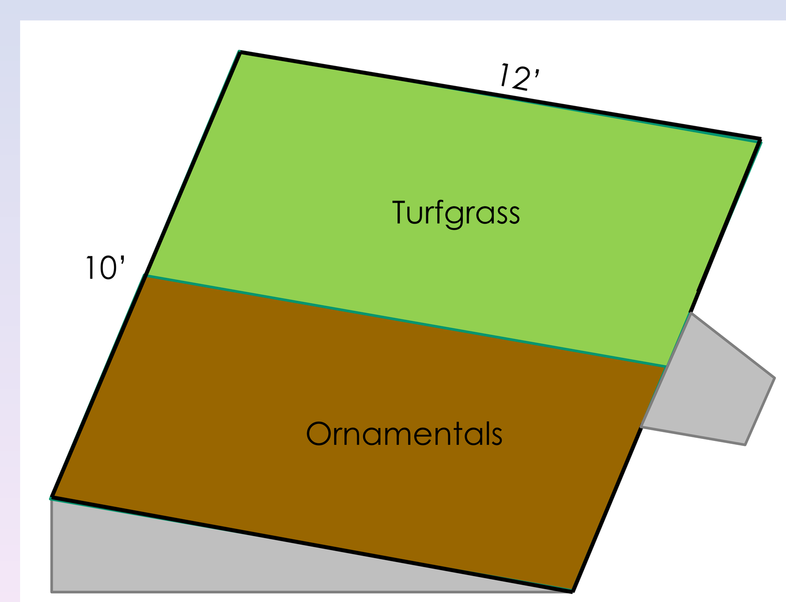

Fig. 6. Schematic of simulated mixed landscape plots that will be installed to evaluate cowpeat as a landscape amendment.

- Plots will be equipped with gutters and passive wick lysimeters to allow collection of runoff and leachate, respectively (Fig. 7).
- Four treatments will be evaluated:
  1. Compost (surface applied)
  2. Aeration or tillage
  3. Tillage and compost
  4. Unamended control
- Soil bulk density and infiltration rate will be monitored
- Plant growth and quality will be monitored.

Table 3. Selected chemical properties of a Zolfo fine sand soil used in landscape establishment study.

Chemical Property	Zolfo fine sand
pH	7.02
Electrical Conductivity, µS/cm	112.7
Mehlich 1 P, mg kg^{-1}	314
Mehlich 1 Al, mg kg^{-1}	385
Mehlich 1 Fe, mg kg^{-1}	82.1
Mehlich 1 K, mg kg^{-1}	27
Mehlich 1 Ca, mg kg^{-1}	596
Mehlich 1 Mg, mg kg^{-1}	38.8
Mehlich 1 Mn, mg kg^{-1}	9.27

Fig. 7. A passive wick leachate collector that will be installed under simulated mixed landscape plots.