Composting – Meeting Challenges in Agriculture and Creating Opportunities

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Challenges in Livestock and Plant Production

The Edmonton Journal Monday 28 August 2000 Neighbours

raising a stink about giant cattle feedlot.
In Ohio - Poultry, Hogs, Dairy, ...

- Number of Livestock in Ohio – 88 million head
- #1 Cage Layers 40.4 million head
- #5 Chickens sold 63.1 million lbs
- #9 Hogs & pigs 1.5 million head
- #9 Milk cows 0.26 million head

Who is Interested in Composting Manures?

- Livestock Industry
  - Odors, Emissions and Disease
  - Clean Water – Point and Non-point pollution
  - Nutrient Cycling
  - Economics
- Plant Production Industry
  - Organic Matter - addition to soil, plant health
  - Nutrients - release rates
  - Disease Control

Continued: Who is Interested in Composting Manures?

- Composers
  - Looking for more revenue stream
    - increased product, product value
  - Improve C/N ratio by blending manures – yardwaste, short paper fiber, …
- Regulators
  - Pathogen control, minimize nuisance problems

WHAT Manures Make Sense to Compost?

- Dairy – bedded pack, separated DS, un-separated?
- Beef – bedded pack , feedlot
- Swine – hoop house & High-Rise™ Hog Bldg.
- Poultry – broiler & cage layer
- Horse – stable manure
- Sheep – bedded pack manure

What is Livestock's Daily Manure Production Per 1000 lb Animal Unit

Livestock	Wet Mass[1]	Total Dry Solids[1]	Moisture, %, w.b.
Feeder Cattle	52	7.1	86
Dairy	78	10.7	86
Swine, mkt pigs	88.4	8.1	91
Poultry			
Broiler	87.9	24.6	72
Hens	72.7	17.8	76
Turkey	55	12.3	78
Sheep	39.0	11.3	71
Horse	54	16.5	69

[1]pounds

Carbon & Nitrogen Levels[1] in Manure

Livestock	Carbon	Nitrogen	C/N
Dairy	25.5	4.9	5.2
Swine (45kg)	43.2	3.6	12
Poultry			
Broiler	41.6	2.6	16
Hen	48.0	8.0	6.0
Horse & Bedding	46.9	1.0	47

[1] % dry basis

Why Compost Manure?

- Less volume to handle: 20 - 50% reduction
- Less weight to handle: moisture & dry matter loss

- EXAMPLE: 40% dry matter loss; dry from from 70% down to 40% moisture. **70% reduction in weight**

- RESULT-
  - improved off-site marketing
  - decreased shipping costs

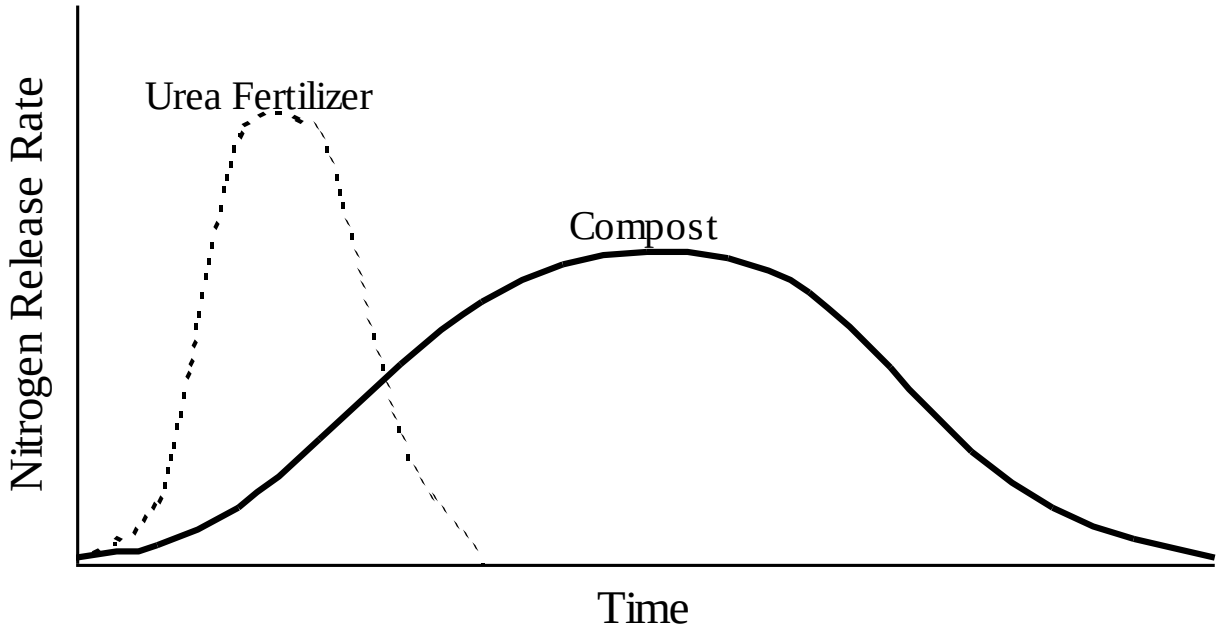
Continue: Why Compost Manure?

- Stable product
  - little odor potential
  - minimal attraction to flies
  - timed nutrient release
- Destroys pathogens
- Finished compost – value added product.

(positive effects on control of plant diseases)

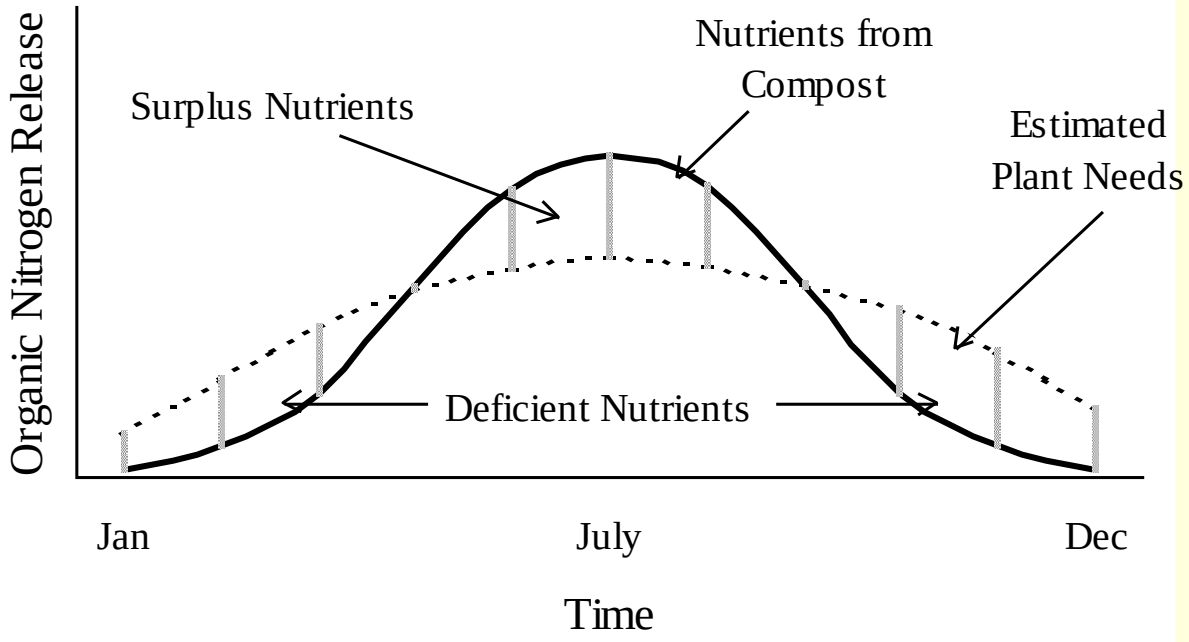
How compost helps reduce non-point source pollution

Figure 5.2



Compost Nutrient Release Rates Compared to Plant Needs

Figure 5.1



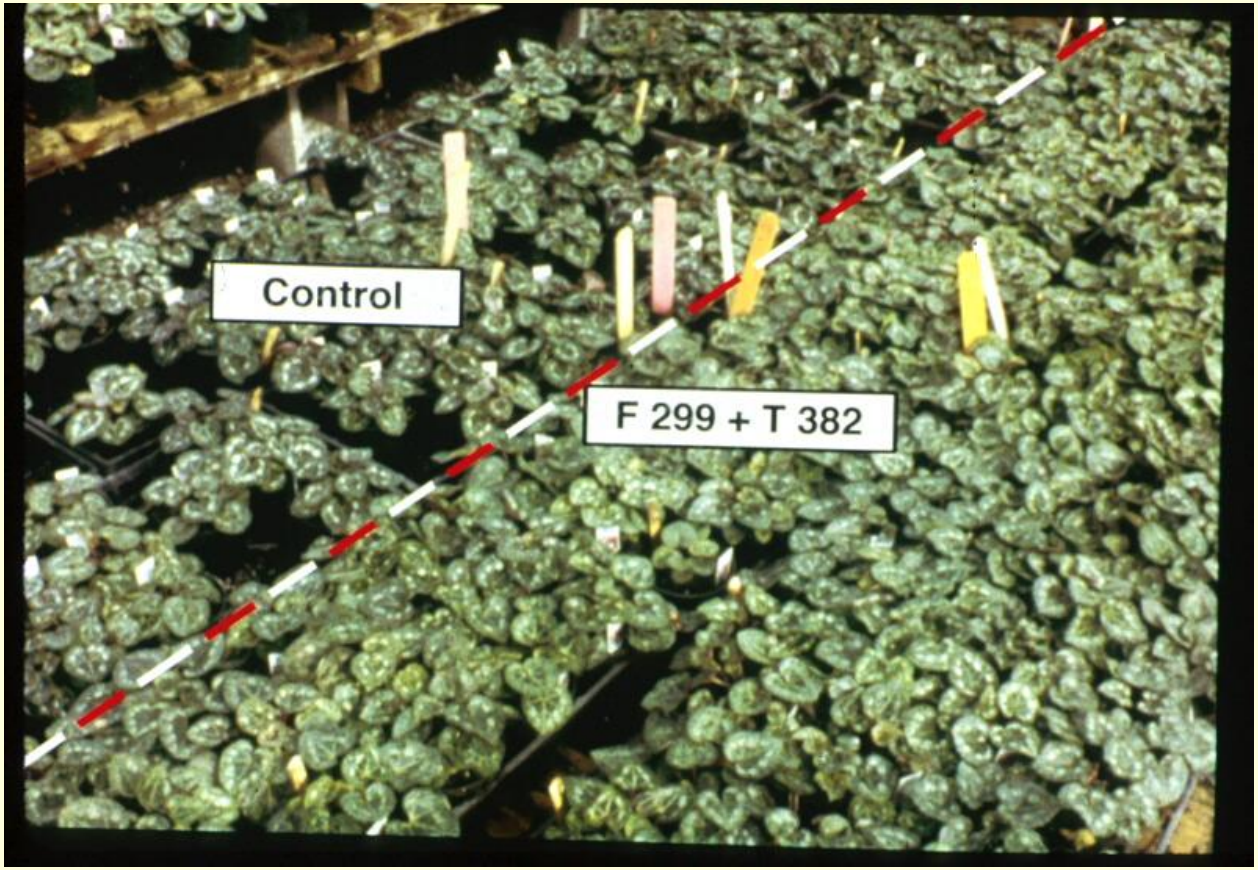
In 1997 Dr. HAJ Hoitink began investigating benefits of compost on disease suppression.

Potted Azaleas on far right indicate *Pythium* and *Phytophthora* spp. are being controlled by addition of compost to mix.

Healthy root system and poinsettia plant as result of adding compost to potting mix.

Greenhouse of poinsettia plants. Nursery industry today uses organic amendments to give them plant protection against root diseases.

Natural Disease Control & Use of Biocontrol. Added a *Trichoderma* spp. during compost curing to achieve control of *Rhizoctonia solani*.



Using compost for biocontrol in strawberries. 3rd year crop

OSU/OARDC Compost Center

HAJ Hoitink

Cure and Store Compost Properly

- Compost was immature and or stored under anaerobic conditions. Organic acids have leached into lawn and killed grass.

Disadvantages of Composting Animal Manure

- Amendment additions (moisture, C/N control)
- Nitrogen - losses
- Cost
  - Labor
  - Equipment
  - Utilities

Wisconsin data – composting cost $100/dry ton for dairy manure

Focus of Talk -- Livestock Operations & Composting

- Laying Hens : static pile (storage building), in-vessel
- Broilers – in-house (5 cycle system), used as an amendment (i.e. short paper fiber + broiler litter)
- Beef – in-vessel
- Dairy – windrow (bedded pack), aerated windrow (free stall manure with an amendment)
- Hog –windrow (High-Rise™ Hog Building manure)

Poultry- Caged Layer Manure

Background: Fresh cage layer manure has a low C/N of 6 and moisture of 70%.

Composting books say C:N ratio 25-40.

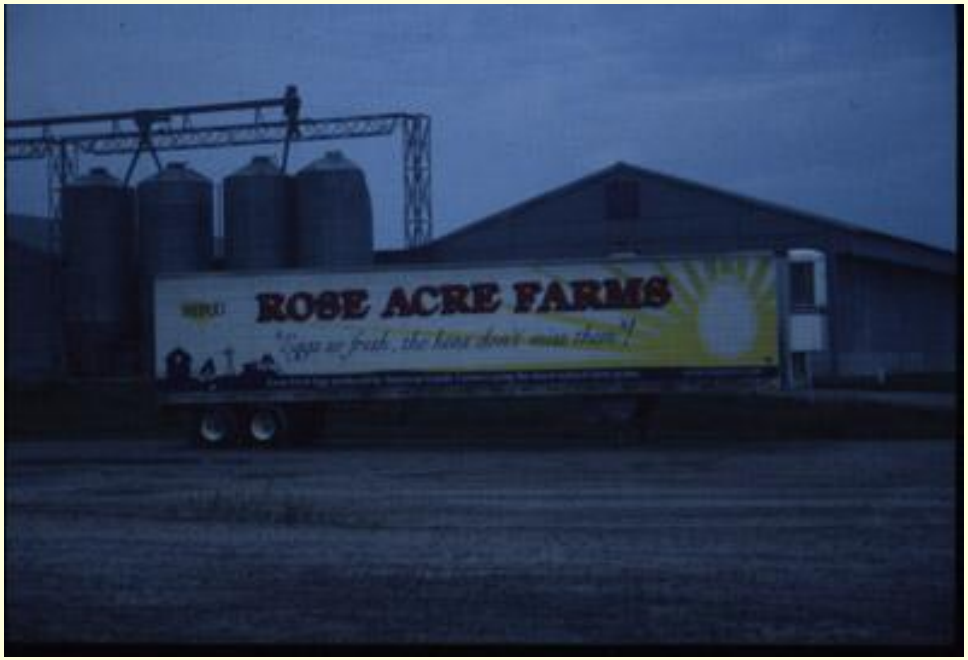
Reality: Better to land apply poultry manure or compost with no amendment unless amendment is a revenue source.

Poultry – ‘Rose Acres’
Caged Layer High Rise Deep Pit + Static Pile Composting in Storage

- Unload manure from high rise @ 1 year
- Haul, dump, layer in composting building using loader on ½ side of storage
- Pile to roof line – depends on equipment
- Let manure compost in static pile ½-1 year

Rose Acres Farms has operations in several states. Farm in Indiana has 2.5 million caged layers. Manure accumulates in houses for a year and dries to under 30%.

Manure can be dried to <20% in summer using pit ventilation fans in addition to regular ventilation fans.



Storage Structure for Caged Layer Manure at Rose Acres Farm (Indiana)

Storage Structure for Caged Layer Manure in Ohio. Operators broker manure.

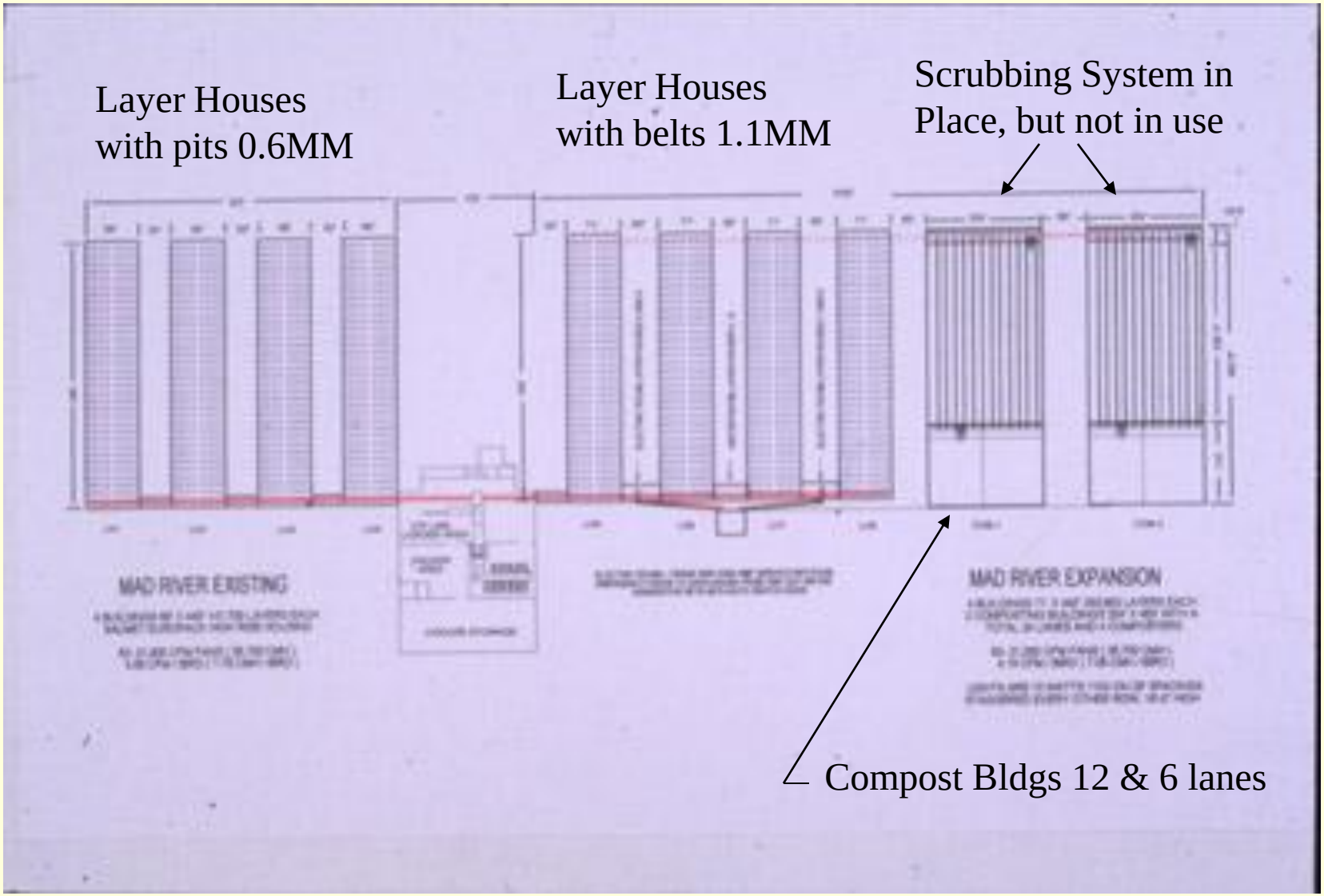
DEEP PILE STORAGE OF POULTRY MANURE

	pH	DM %	Ash %	N %	C/N	NH_3N ug/g	NO_3N ug/g
Poultry Manure	**7.5**	**25-32**	**30.3**	**5.7**	**6.0**	**6811**	**232**
Deep Pit (1 yr)	**7.5**	**85.4**	**50.8**	**4.57**	**5.5**	**4432**	**387**
Marketed (1.5 yr)	**7.4**	**86.3**	**47.1**	**4.74**	**5.6**	**3484**	**262**

Results suggest little change in composition if manure is stored under 20% moisture.

NOTE: Flies, darkling beetles not an issue in finished product.

Daylay Farms 1,700,000 birds



Management Practices ‘Daylay’

- Unload manure from high rise every 3 days
- Transfer by belt to compost building
- Piled at the input end of an aerated in-vessel composting system with turner
- Material turned every 3 days – moved 6 meters toward output end
- After 18 turns leaves composter & stored untilled marketed.

Battery of Cages at Daylay with manure belt removal system under each cage.

Manure being scraped from belt onto cross conveyor for delivery to compost building. Manure dries on belt from 70% to 50-55% moisture. Manure never goes outside.

Compost building & turning machine @ Daylay Farms. Two buildings, one 12 lanes and one 6 lanes. One machine per 6 lanes.

Finished Compost at Daylay Farms. Composted material 10-20% moisture and granular nature

Dry Solids and Moisture Loss from Composting of Caged Layer Manure – No Amendment

Daylay (56 days)	Laboratory (28 days)
• Dry solids loss 30% • Moisture decreased from 50-55% to < 20%	• 44% solids lost • Moisture < 40%.

Continue: Dry Solids and Moisture Loss from Composting of Caged Layer Manure

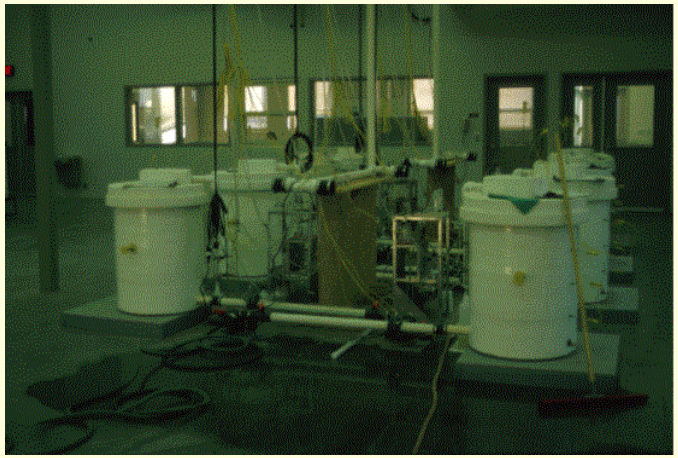
Analysis of Manure from Daylay Farms

ID	pH	DM %	Ash %	N %	C/N	NH_3N ug/g	NO_3 ug/g
Manure Belt	**8.0**	**52**	**31**	**5.9**	**5.8**	**6566**	**212**
Compost	**7.9**	**90**	**34**	**5.6**	**5.8**	**4847**	**213**
Deep Pit	**8.5**	**71**	**44**	**4.0**	**7.4**	**4783**	**94**

Laboratory at OSU/OARDC used in studies.

Compost Research Building at OSU/OARDC, Wooster, Ohio

Mission Control Center at Composting Building



Eight 200 L Aerated Reactor Vessels with Temperature Control. Set point 60^{o}C.

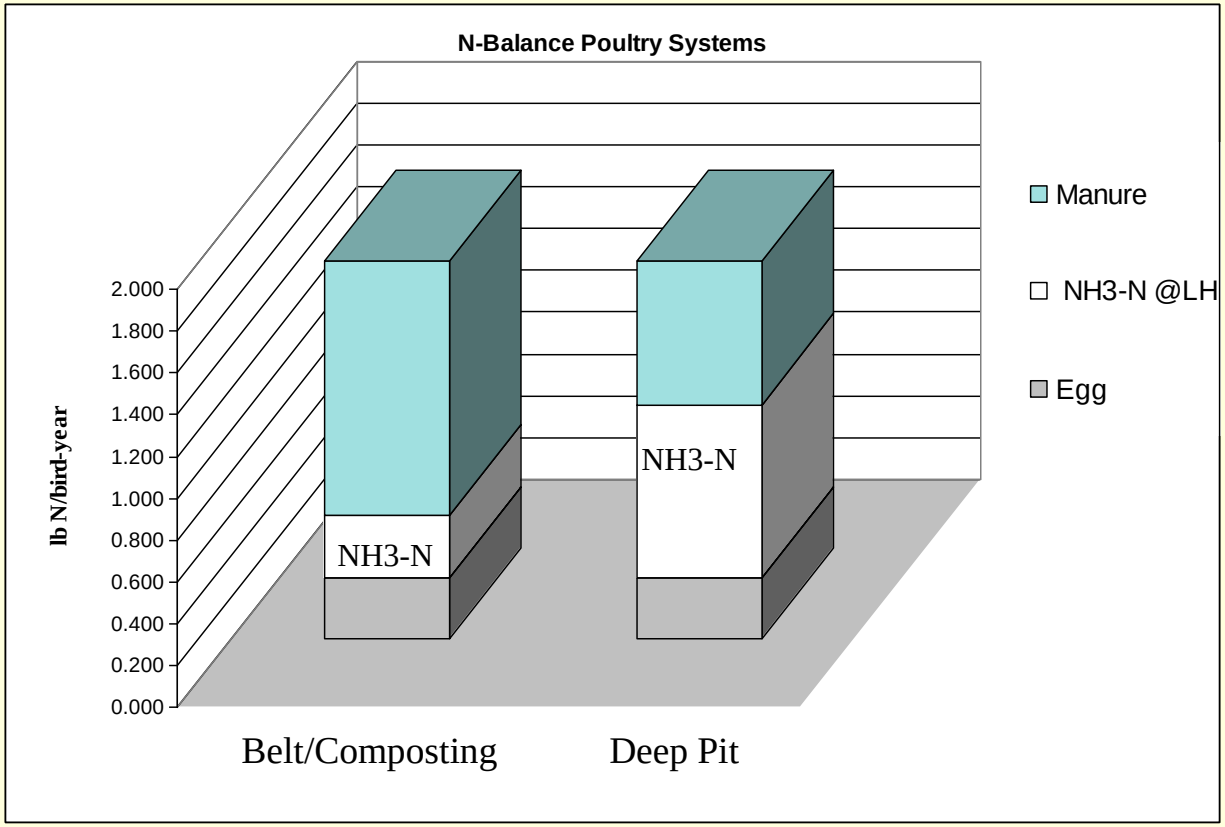
Value of compost sold on nutrient basis. Daylay's selling price is about $40/ton[1] bulk.

Economic Value of Compost Nutrients, Cage Layer Compost						
	Chemical Analysis		value	Nutrients	$	$
	%db	%wb	$/lb	lbs/ton	per cwt	per ton
water		10	0.00	200.00		
Nitrogen	5.8		0.25	104.40	1.31	26.10
P2O5	5.2		0.25	93.60	1.17	23.40
K2O	3.9		0.10	70.20	0.35	7.02
Ca	5.4		0.12	97.20	0.58	11.66
Mg	0.7		0.00	12.60	0.00	0.00
Zn	0.034		1.50		0.05	0.92
					3.46	69.10

[1] ton is 2000 lbs in table.

Nitrogen Balance in System for Daylay Farms

Belt & composting system retained about 2x N of conventional deep pit system. Belt & composting had 1/3 nitrogen loss conventional deep pit.



Poultry - Broiler Industry

Park Farms uses 5 cycles (42-49 days/cycle) manure removal with broilers. Bedding added for 1st cycle only. Very consistent product because they manage manure & bedding. **Product is marketed to mushroom producers.**

Broiler house with bedding (sawdust) placed. Prior to placing chicks, 1st cycle.

Using Broiler Litter as an Amendment

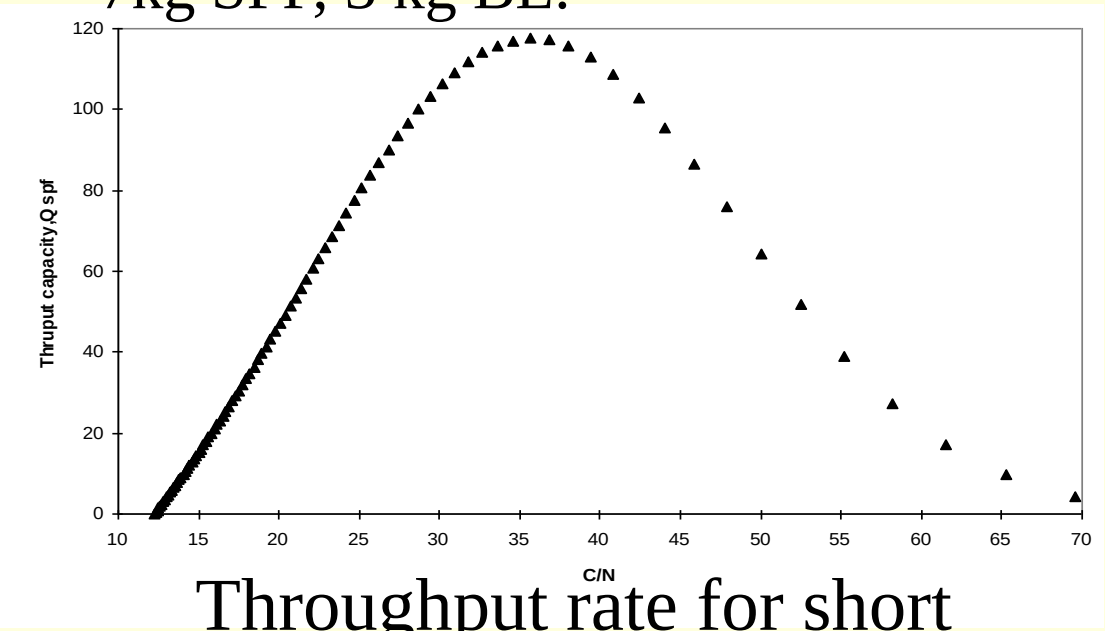
Analysis of Broiler Litter (1st cycle) & Short Paper Fiber (SPF)

- Broiler Litter
  - Ash 16%
  - pH 7.6
  - Moisture 31%
  - Nitrogen 3.3%
  - C/N 12
- SPF
  - Ash 45%, 80%
  - pH 8.0, 10.5
  - Moisture 61 %, 41 %
  - Nitrogen 0.1% , 0.06%
  - C/N 237, 264

When mixing for compost moisture use ash free basis

Short Paper Fiber & Broiler Litter Mix

Optimum mixing ratio(miR)≅0.7,i.e. 7kg SPF, 3 kg BL.



Throughput rate for short paper fiber per unit weight of mix (kg_{spf}/day Mg_c) versus C/N ratio. Optimum C/N was 35-38 to maximize use of composting space.

Beef feedlot manure at Paygro, South Charleston, Ohio.

Paygro – Use an in-vessel forced aerated system. Compost about 3 weeks.

Material is removed with turning machine, placed on a belt (shown) and is then screened. Overs go back through the system.

After screening material is conveyed to outside curing pile. If space limited, material move to another area. Will cure several months before bagged.

Storage of compost for curing. Paygro uses a deep pile to avoid rainfall excessively rewetting compost.

Bagged product. Paygro makes designer blends for retail markets by adding soil, sand, etc.

Dairy Manure & Sawdust, Sigrist Farms

Using skid loader, to turn manure. They have a turning machine (wildcat) but many times don't use it.

Aerated bin system at Sigrist Farms. Uses a perforated pipe in bottom and fan. Fan is operated intermittently. Compost removed after 4-8 weeks.

Compost is store under roof for curing approximately 6 months. Material then bagged for marketing

Screening equipment at Sigrist Farms. Screening is essential for marketing a quality product. Sigrist uses home made equipment.

Sigrist Farms bagged product (about 18 kg per bag) is sold under name Bull Country Compost.

Dan Young Compost Cattle Manure and Yard Trimmings

Dan Young speaking to crowd of farmers, agricultural specialists, university persons at August field day.

Compost turner & water addition tank. Water addition often necessary earlier in process if start with materials < 60% moisture.

Fleece cover used to shed rainfall from finished compost (important in wet climate). Finished compost has little activity to evaporate moisture. Cover will last over 5 years.

Dan Young markets product in mini bulk bags as well as truckloads. Mini bulks are liked by suburban customers. Set off at home, no mess in driveway. Bags have a refundable deposit.

COMPOSTING NON-SEPARATED DAIRY MANURE

Free stall dairy barn at OSU/OARDC, Wooster, Ohio. Composting dairy manure poses special problems. Without bedding it is 90% moisture. Separation of solids not practical in Midwest USA as expensive and the farmer now has two waste streams to handle.

Background

- Non-separated dairy manure has a moisture content of about 90%. This imposes restrictions on mixing ratios for composting. Requires amendments.

- Estimated fuel and electric cost for drying manure from 90% moisture down to 15% is $165-200 per tonne generated at 15% moisture.

Research at OSU/OARDC on Dairy Manure

Loading free stall dairy manure

Adding horse manure/ bedding (sawdust)

Research at OSU/OARDC on Dairy Manure

Unloading from mixer wagon the mix (1:1 w/w) of free stall dairy manure (includes liquids) and horse manure /sawdust.

Windrowed compost after several weeks of composting.

Chemical Analysis for Dairy Manure, Horse Manure/Bedding, and Dairy Solids Compost

Material	pH	water	Ash	C	N	C/N
		%	%	%	%	
Dairy Manure		90.5	46.5	25.5	4.9	5.2
Horse Manure	8.2 ±0.7	57.3 ±2.1	5.6 ±1.1	46.9 ±1.2	1.0 ±0.1	47.1 ±4.5
Dairy Solids Compost		66	11.5	42.8	2.2	19.2

Chemical Analysis of Compost Mixes - Dairy Manure, Horse Manure and Bedding

Material DM:HM:Recycle	pH	water %	Ash %	C %	N %	C/N
Mix 1. 1:1 w/w	7.9	74.0	13.0	43.0	1.71	25.2
	±0.0	±0.1	±0.8	±0.6	±0.02	±0.3
Mix 2. 1:1:1 w/w	8.1	71.3	12.4	43.0	1.91	22.5
	±0.1	±0.0	±0.6	±0.4	±0.03	±0.3

- **Pilot Scale Studies**: Continuous and intermittent aeration regimes - two different mixes of dairy manure and horse stable bedding.

Results from 21 day pilot scale studies

	DM_{loss} %	H2O %	pH	Ash %	C %	N %	C/N
CA	**24.6**	**68.6**	**8.6**	**17.2**	**40.6**	**2.2**	**18.7**
IA	**27.2**	**73.6**	**8.4**	**17.8**	**40.8**	**2.4**	**17.6**

Results - continued

- Windrow study - compost went from 70% water down to 54 % in ten weeks.

- Pilot vessels - 25 to 30% solids lost in 21 days. Moisture loss 0.5 – 1.0%.

Conclusions

- aeration was critical in reducing compost moisture levels if initial compost moisture was above 70% moisture;
- moisture removal for continuous aeration was 2/3 of theoretical values @ - 4.4 kg w/kgdm ; and
- compost mixes above 81% would likely increase in moisture during decomposition.

High-Rise™ Hog Building, "HRHB"

980 head High- Rise™ Hog Building located on 4-M farms, Greenville, Ohio. First one built (1998). Have completed 6 batches of hogs.

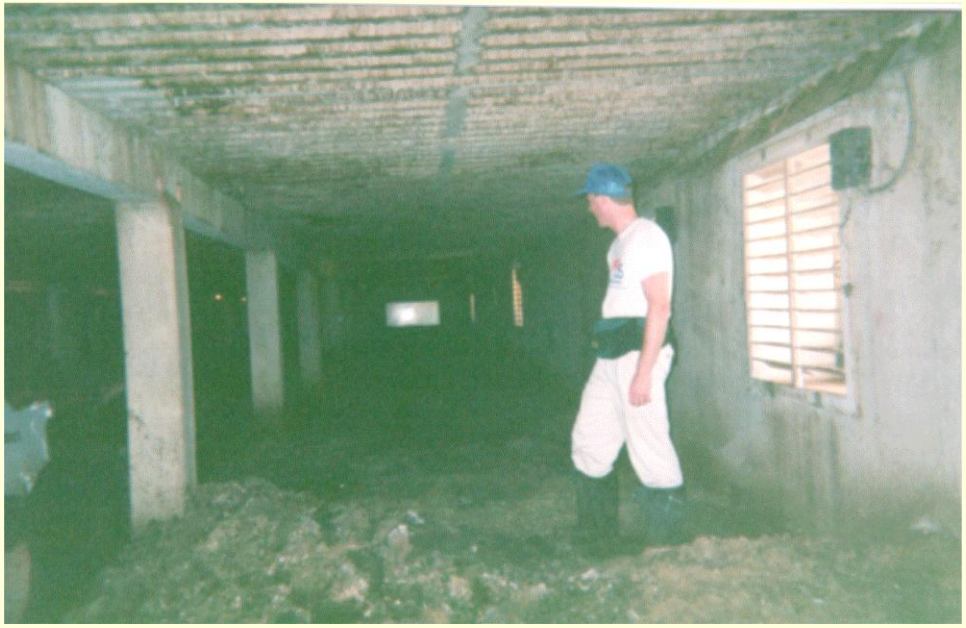
2nd story for hogs. Lower floor is drying bed. Building ventilation fans are located in lower area of building.

End view showing attic intake for air. Fan and plenum for air into underfloor aeration shown at base of building.

Aeration controlled by using 0.9 cm diameter holes 0.32 m on center.

Hogs nearing end of production cycle, 110-120 days in length. Pigs are grouped 20 per pen with 48 production pens

View of bedded section in lower floor after two production cycles.



Removal of manure to outside area. Moisture of manure/drying bed material is 65% wb.

Studies on windrow composting with turner being done at OSU/OARDC composting pad at Wooster, Ohio.

OSU/OARDC EXPERIMENTS

- Pilot Scale Studies – four 208 liter vessels, 2 vessels per treatment.
- Windrow Study – used 25 m^3. Windrow size 3m wide x 1.5m high

Hog Manure Mix from HRHB[1]	**[fresh feces & urine]**
Moisture = 62% wb, pH = 8.1	**[91% wb, 5.5-6.5]**
N = 2.0%, C/N = 20.6 , Ash = 15.7%	**[3.6%, 12, ?]**

[1] (2 cycles of pigs with wood shaving bulking agent)

Experimental Design

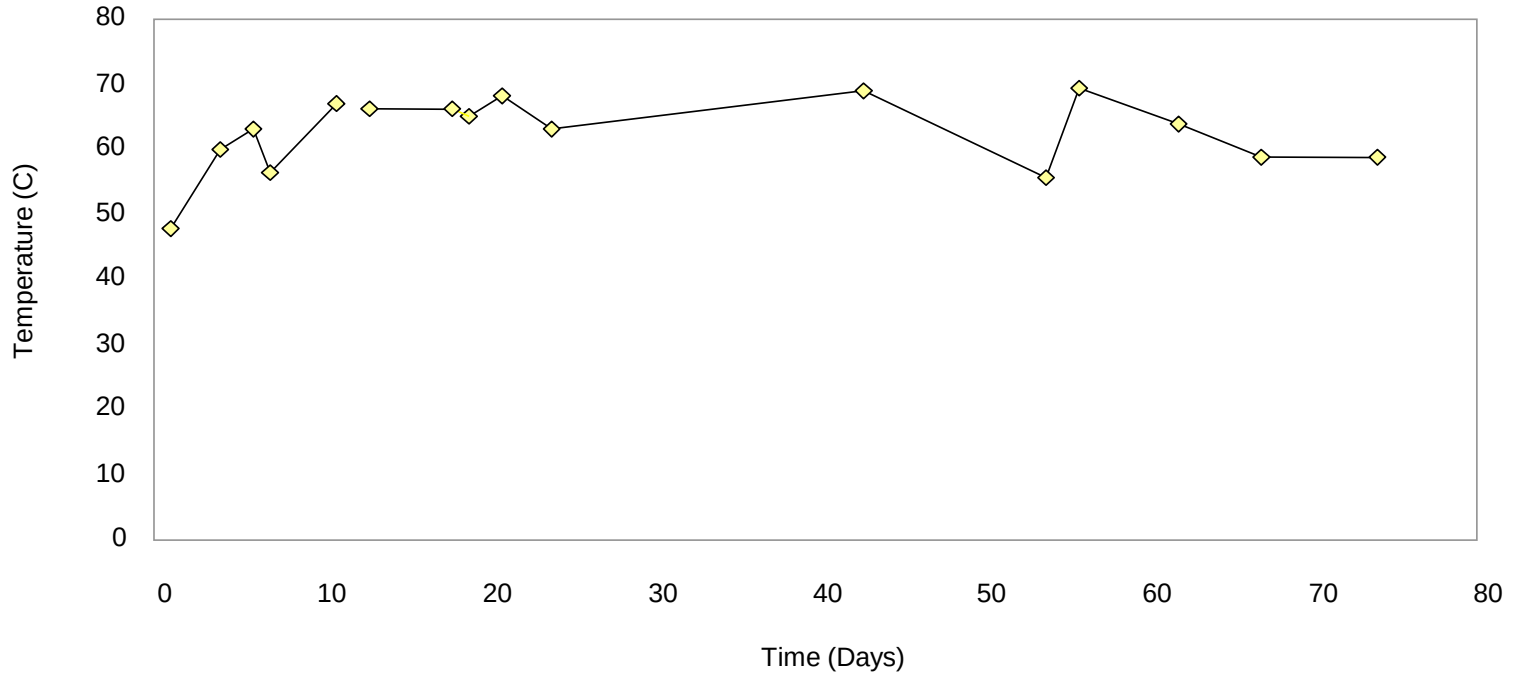
Pilot Scale

- Airflow – intermittent (IA) & continuous (CA) with temperature control on continuous (58^{O}C)
- 28 day trial
- Remix weekly

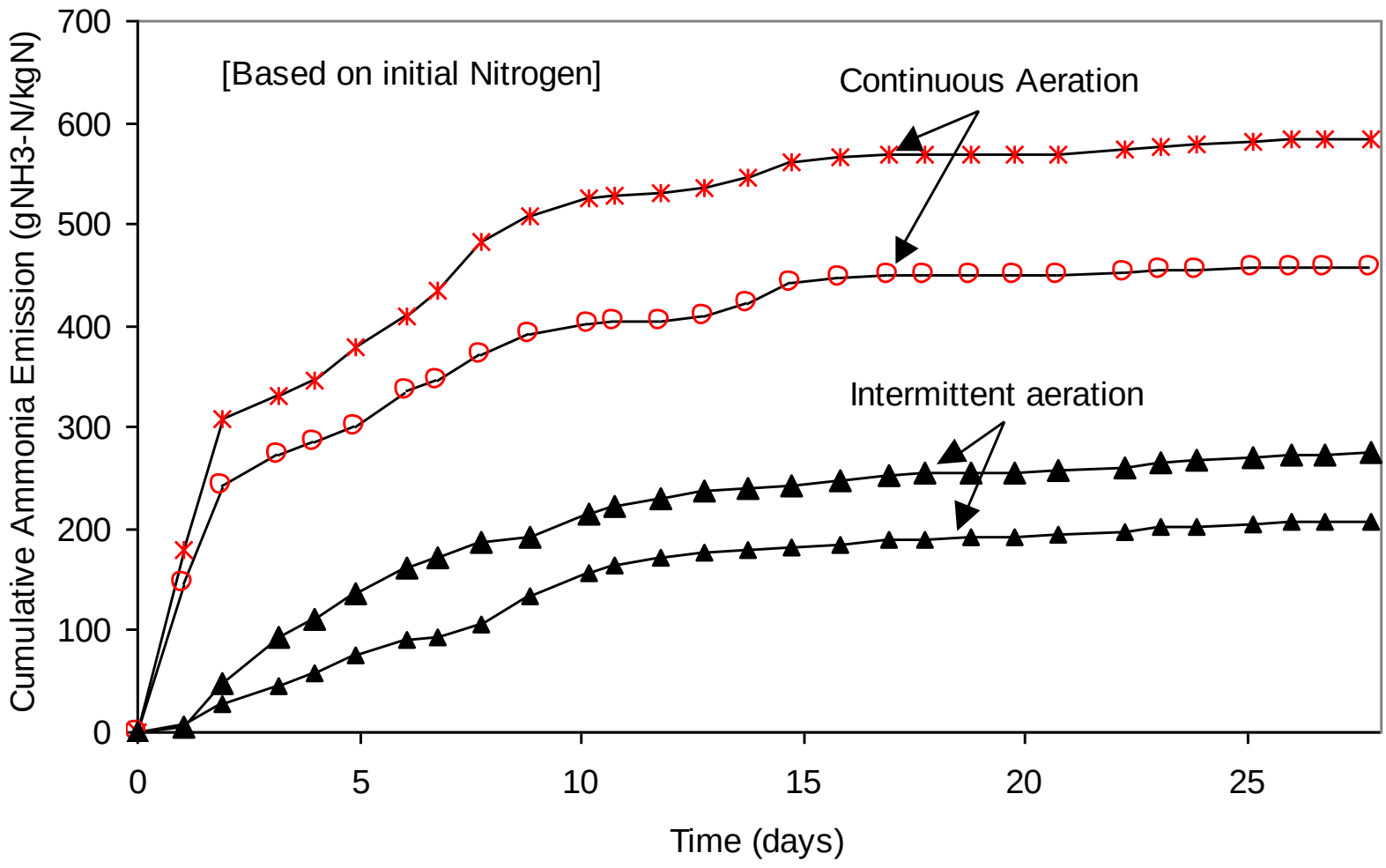
Windrow System

- Windrow turning machine – days 4,6,18,24,55, 74 (moved)
- Composted 74 days, cured to day 106.

Temperature history of compost during full scale windrow composting of material from HRHB.



NH3-N Emissions, Pilot Studies when composting manure/bed material from HRHB



Composting Results HRHB Manure

Pilot Scale

- Dry matter loss 30% ; volume decreased 16–24%.
- IA 54% reduction in NH3-N emissions and 78% in airflow over CA.
- CA lower moisture than IA at end (47 vs 55%).

Windrow

- Final moisture dropped to 42.5% moisture content.
- pH 8.4, 2.4% N, C/N 17, NH_3-N 3820 ppm
- Ash content increased from 15.7% to 24.8%.

Growth studies using compost made from HRHB manure/bedding Deutizia “Gracillus”

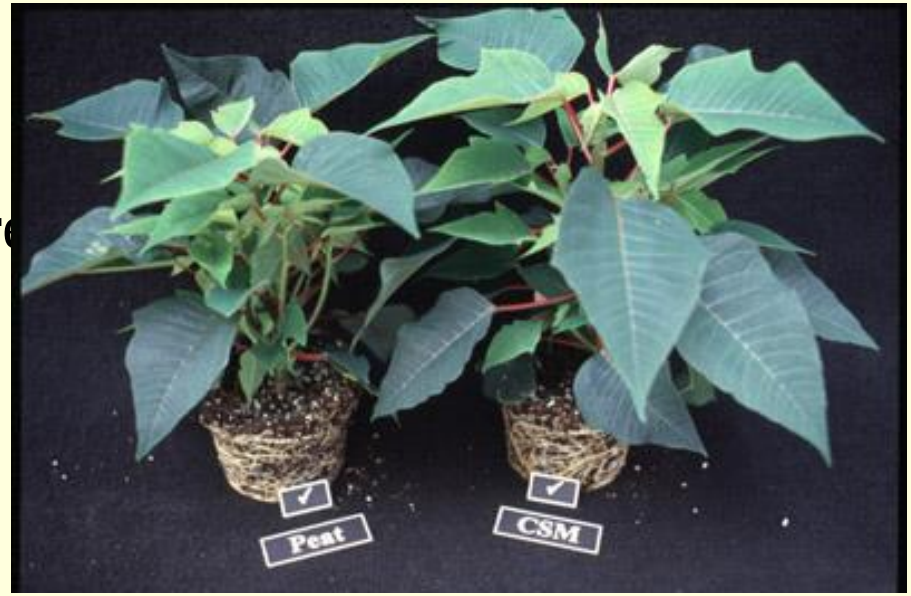
Results – Plant Studies

- Taxus and juniper - no treatment effect
- Deutzia - limit compost to 4% of mix (ammonium toxicity) @ 4% better growth than control

Compost Addition, %	Plant Dry Wt.
0	5.05
4	**6.08**
8	4.00
12	4.26
16	3.86
LSD 0.05	0.8

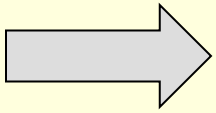
Growth studies on Poinsetta using compost made from HRHB manure bedding. 10%V/V in potting mix. Compost improved plant growth.

Results –



Trt.	Pythium Inoculum	Dry Wt. g	Root Rot Severity
Peat Mix	-	11.7	1.3
Peat Mix	+	8.7	4.2
Compost Mix	-	14.6	1.3
Compost Mix	+	14.9	2.2
LSD 0.05		2.3	0.7

Value of Composted HRHB manure for potting mixes

- Canadian Sphagnum Peat $22/yd3
- HRHB $72/ton (based on 670 lb/yd3 @ 50% moisture).
- Fungicide drench @ $10/yd3 of mix
-  $23/ton
- Total Value @ $95/ton

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References Used in Presentation

- Research at OARDC/OSU
- Other
  - On Farm Composting Handbook
  - Biocycle Magazine
  - Research Journals (composting, agriculture, environment, ….)