

Development of Composting Systems for Ohio Dairy and Hog Farms

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Research Objectives

- **Develop strategies to minimize water use and maximize the retention of manure in solid form.**
- **Minimize generation, storage and transport of liquid manure and its associated negative environmental impacts for dairy systems widely used in Ohio.**
- **Develop Management alternatives for manure laden sand bedding.**
- **Reduce odor and ammonia emissions.**
- **Develop composts that suppress plant diseases and reduce pesticide use for value added-markets.**



Introduction

- Results of a survey of Ohio dairies.
- Manure handling on typical farms.
- Composting studies using dairy and hog manure amended with sawdust and straw.
- Composting sand bedded dairy manure.
- Evaluation of a compost stability test.
- Conclusion.



2002 Ohio Dairy Survey

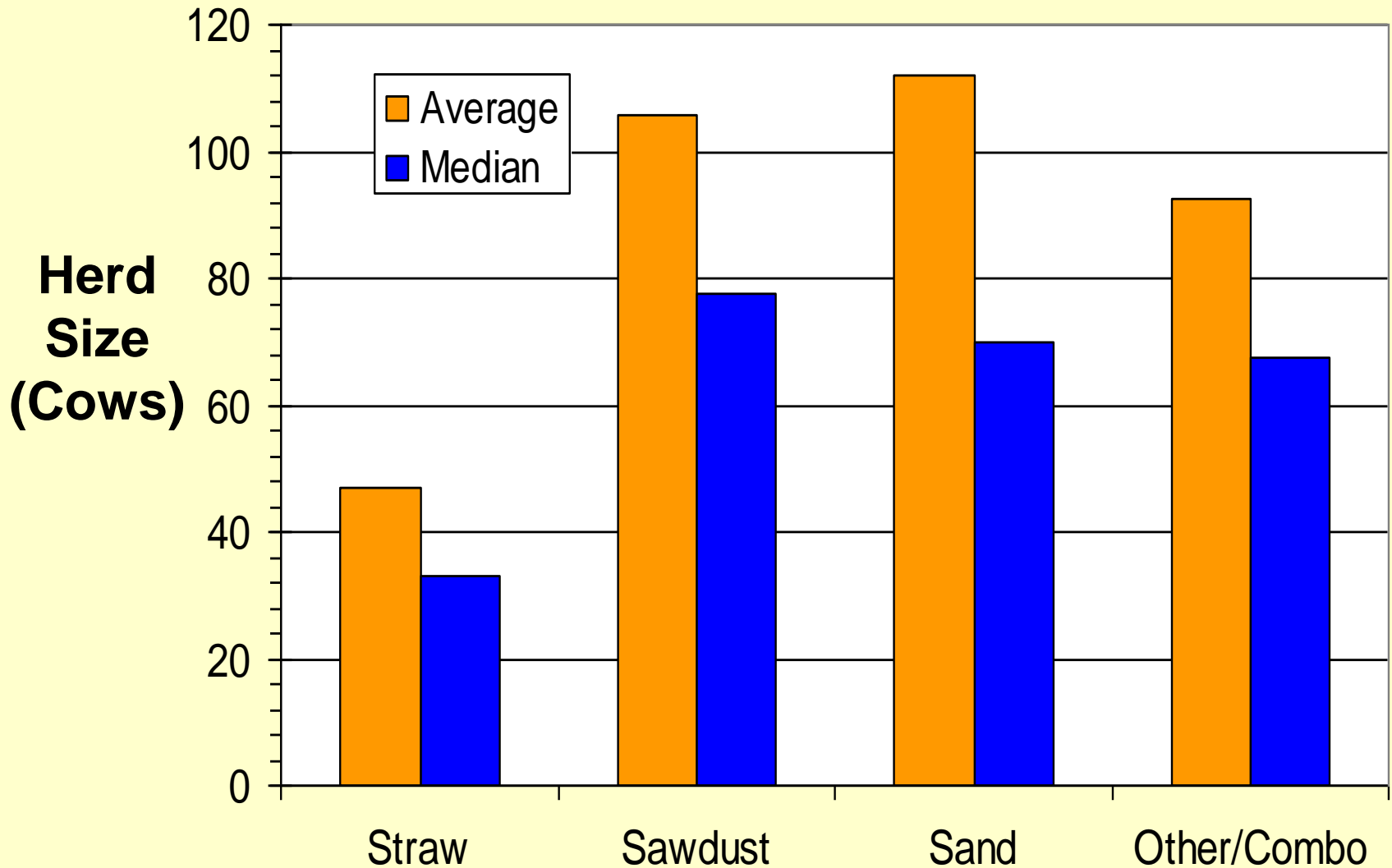
- 800 surveyed, 299 responses (4200 total).
- Milking herd size ranged from 3 to 700 cows.
- Average herd size is 74 cows.
- Land for manure spreading averaged 287 acres.
- 37% have expanded in the last 5 years
- 30% plan to expand in the next 5 years.



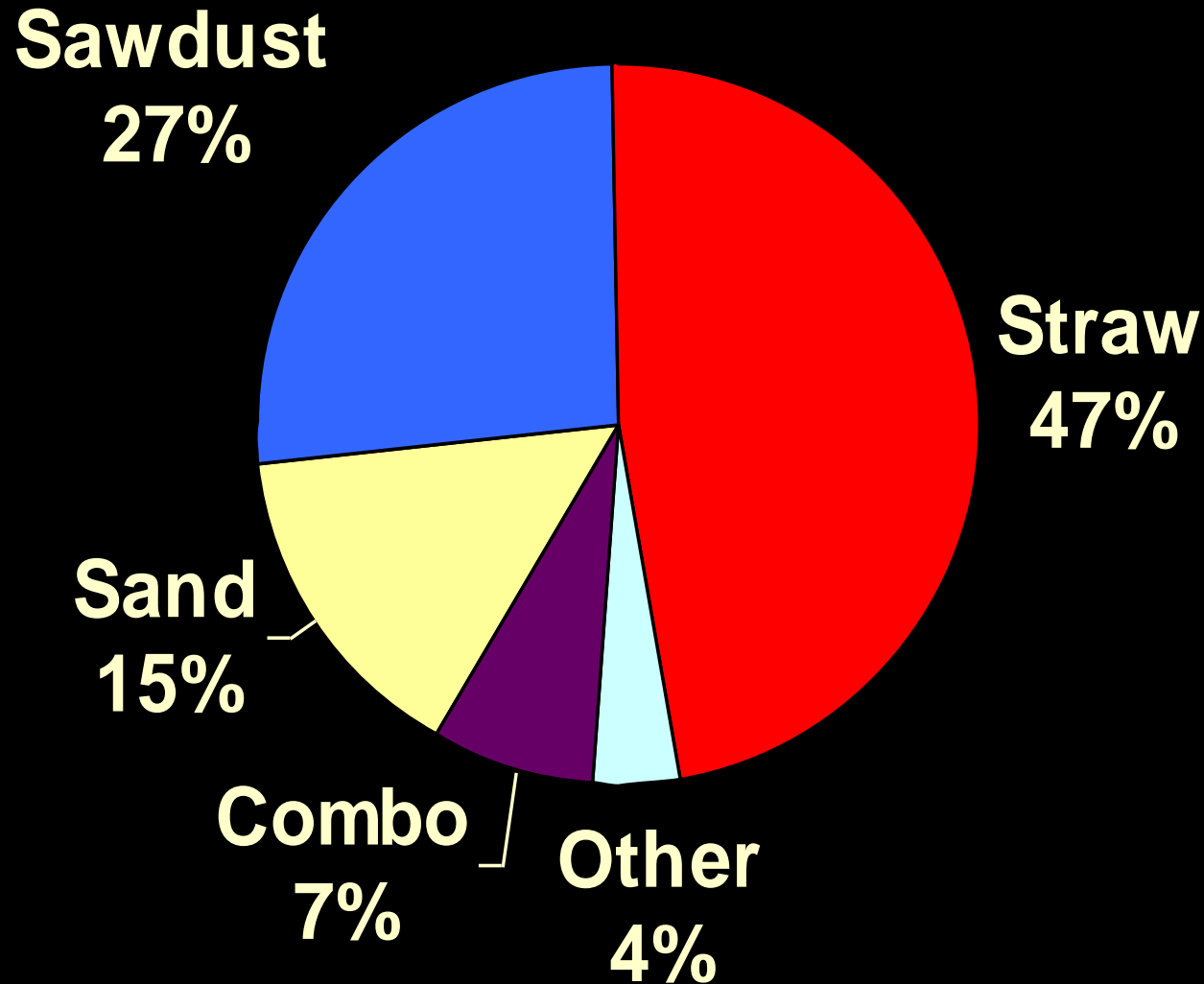
Numbers of Cows

	<u>Avg.</u>	<u>Range</u>
• Milking Herd	74.0	(1-700)
• Heifers > 12 months	27.9	(0-350)
• 2-12 month old Heifers	23.9	(0-300)
• Calves < 2 months	7.2	(0-50)

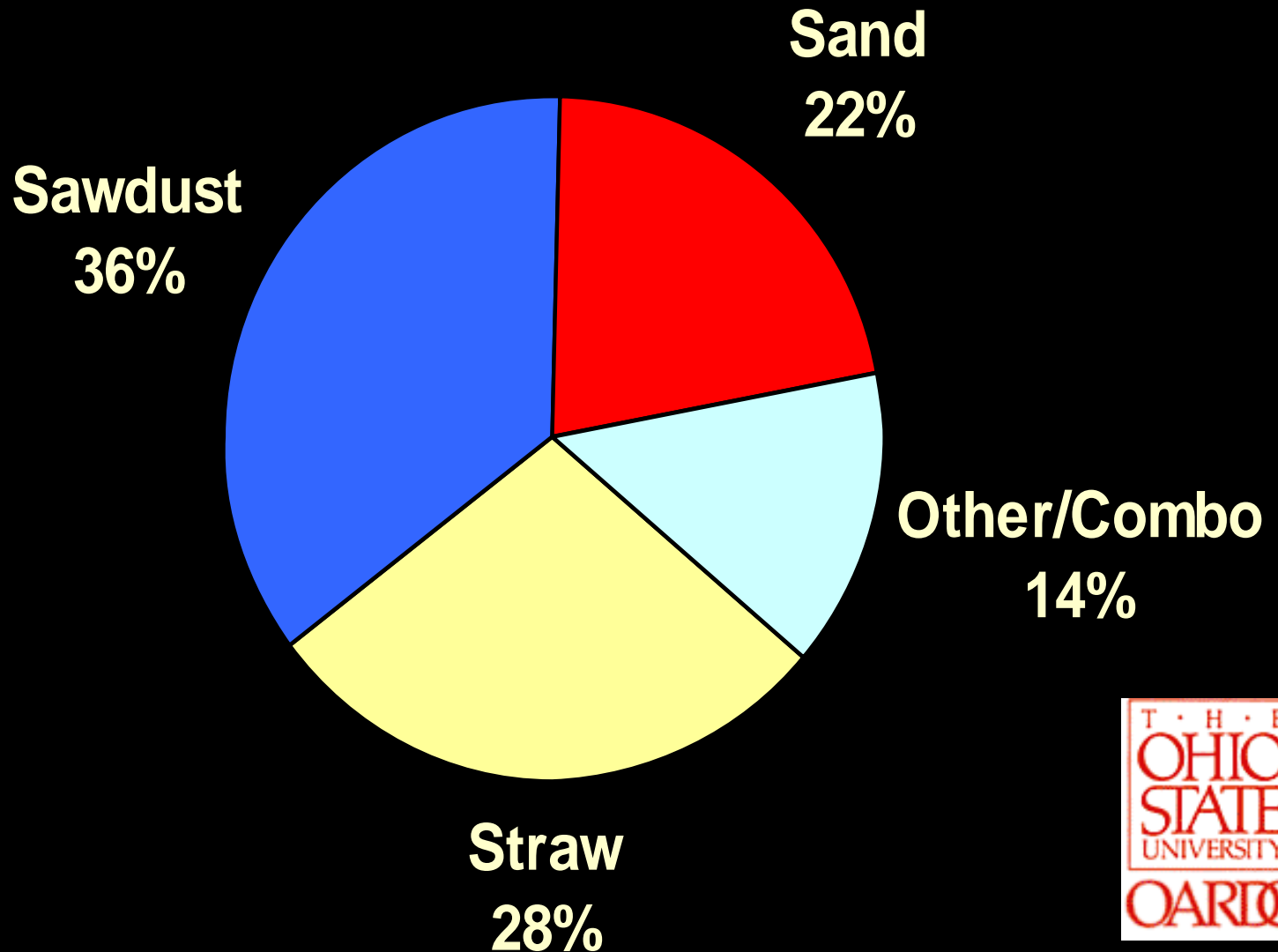
Bedding Type and Milking Herd Size



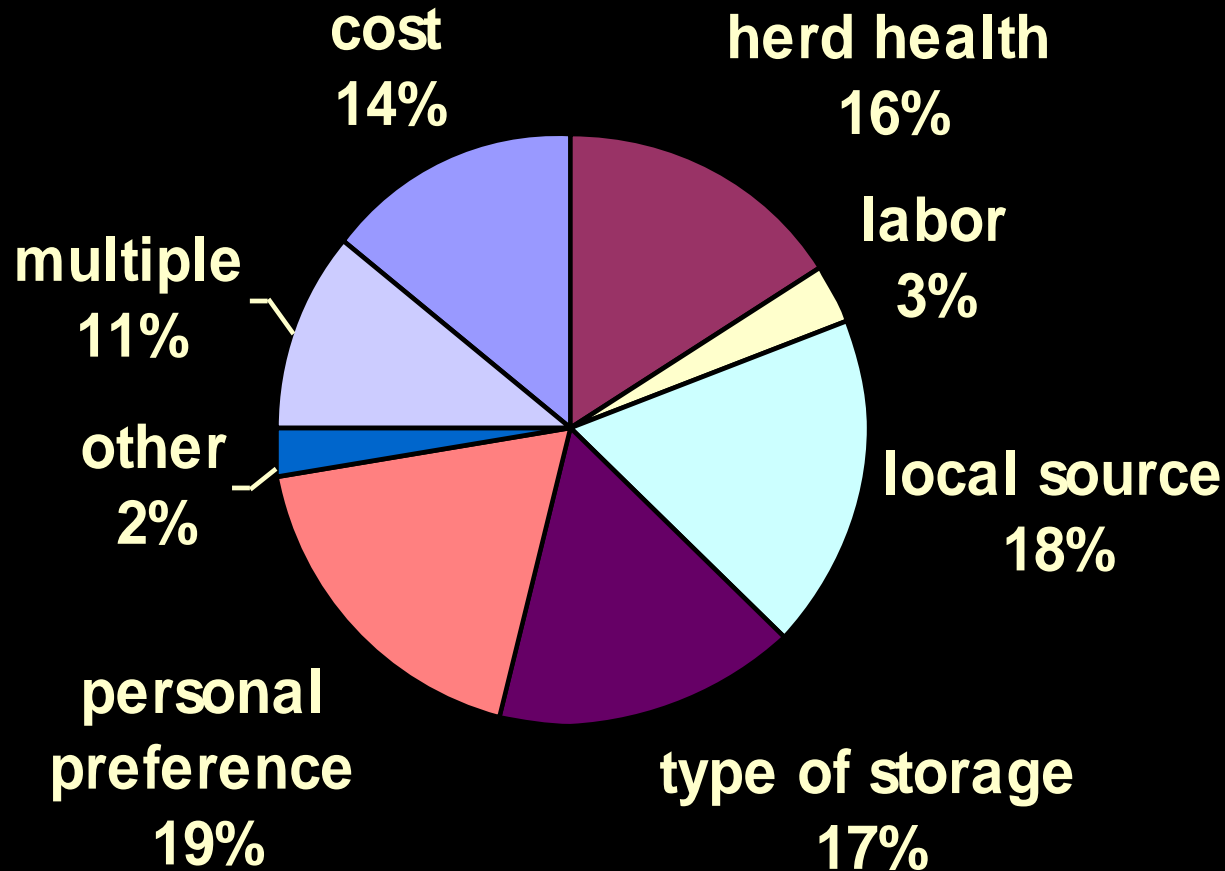
Bedding Types used by Ohio Farms (% of farms)



Bedding Types used by Ohio Cows (% of cows)

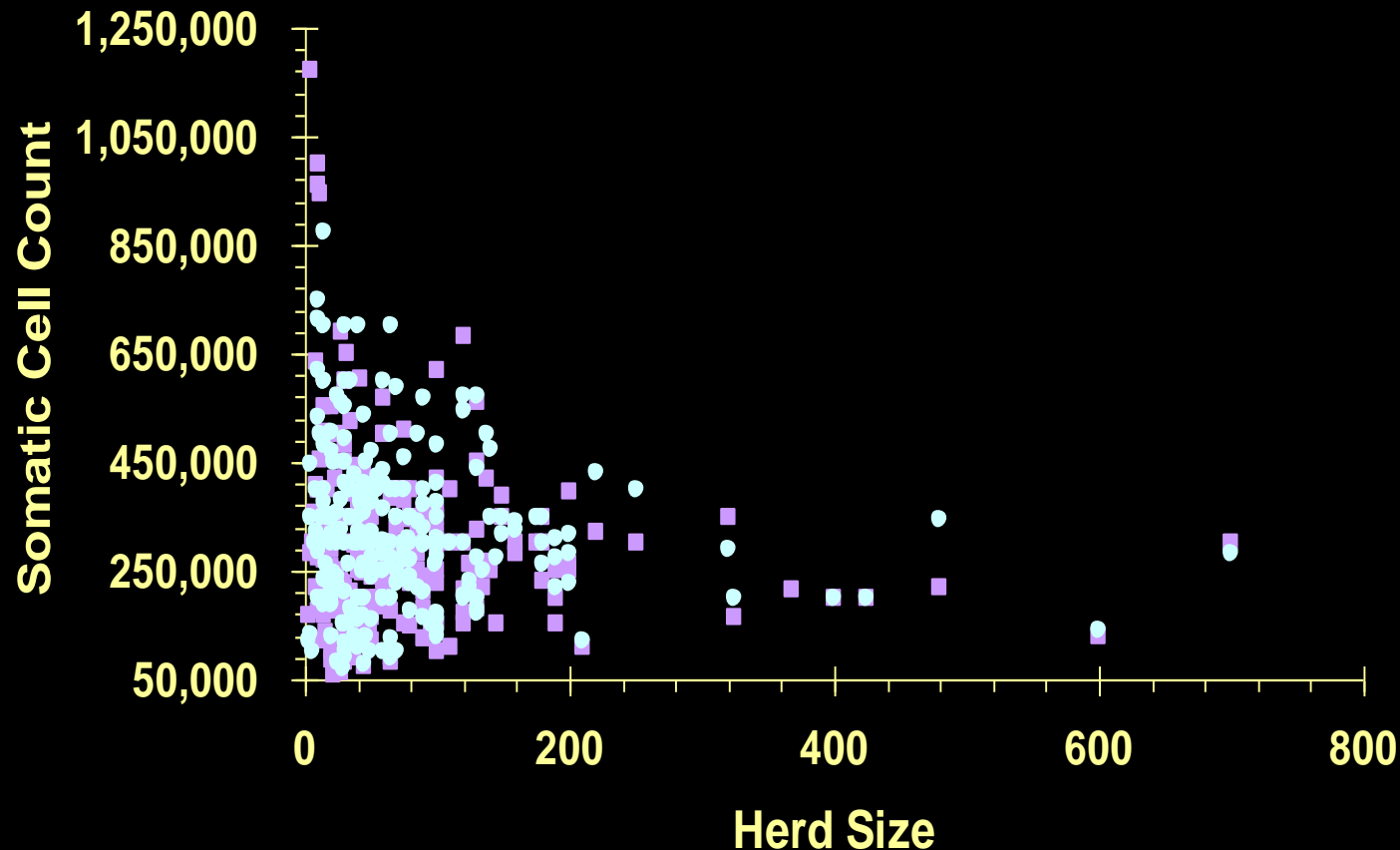


Reasons for Bedding Choice

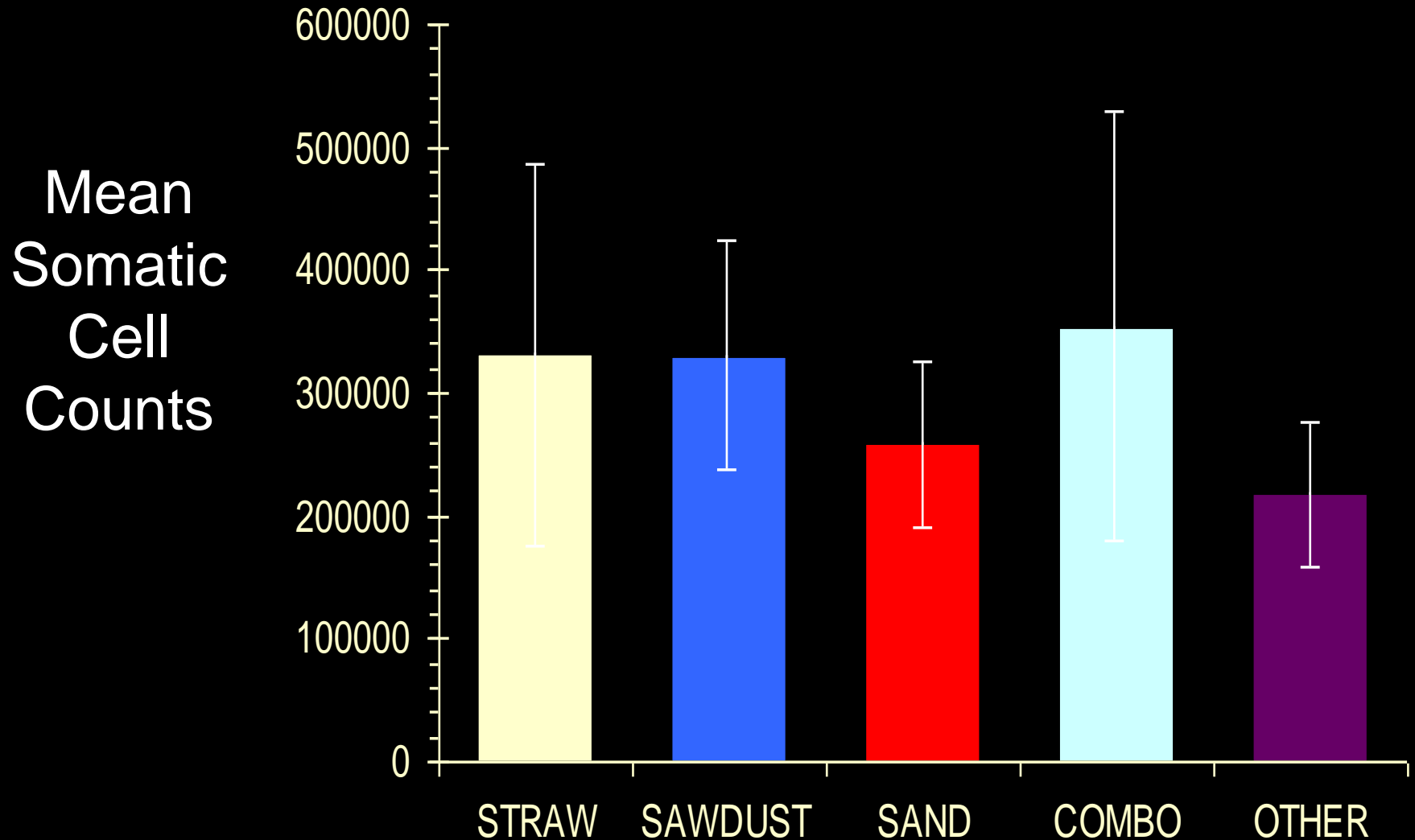


Herd Size and Somatic Cell Counts

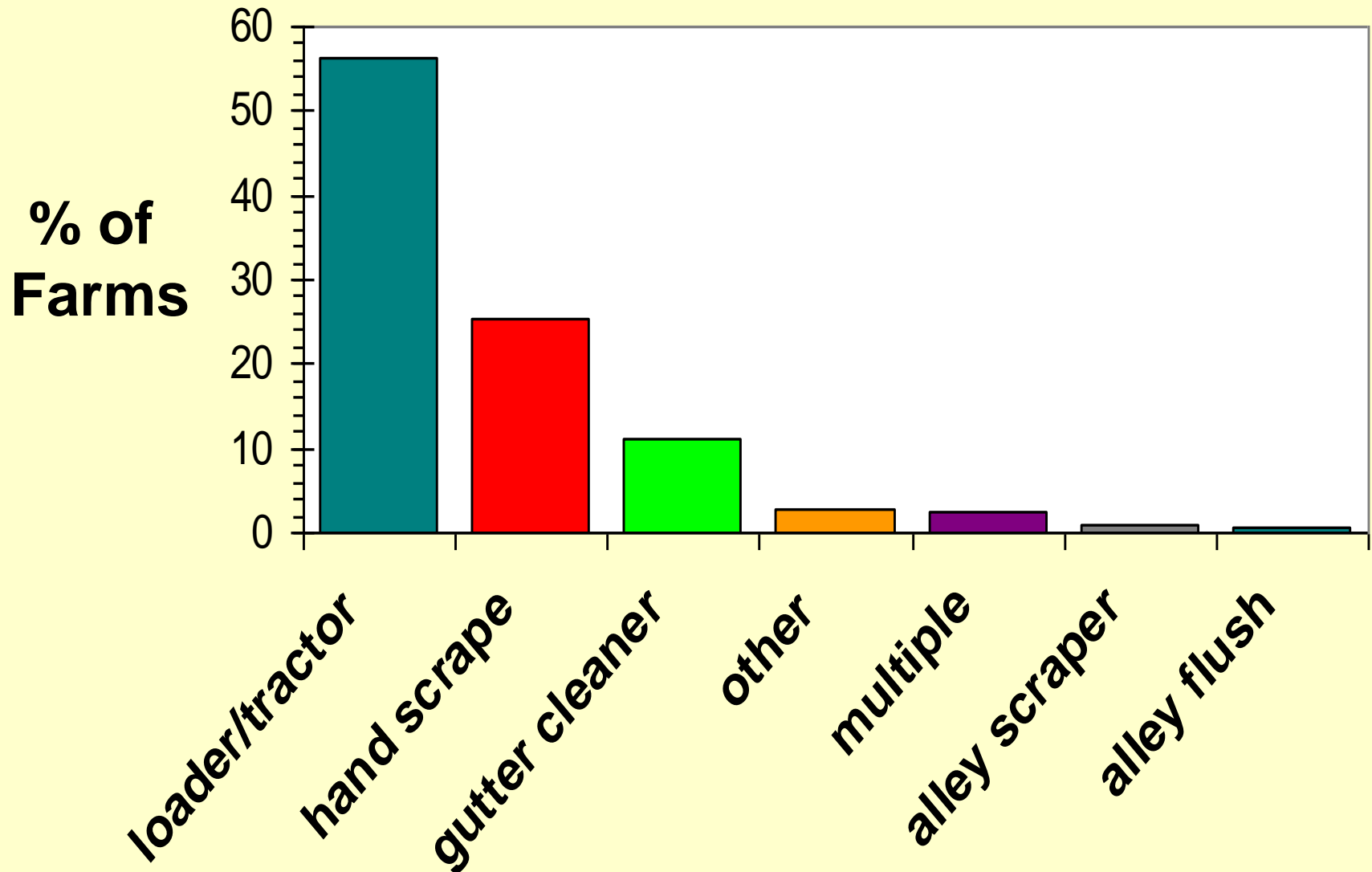
	<u>Avg.</u>	<u>Range</u>
• July 2001	314,000	(34k-875k)
• December 2001	289,000	(25k-1,170k)



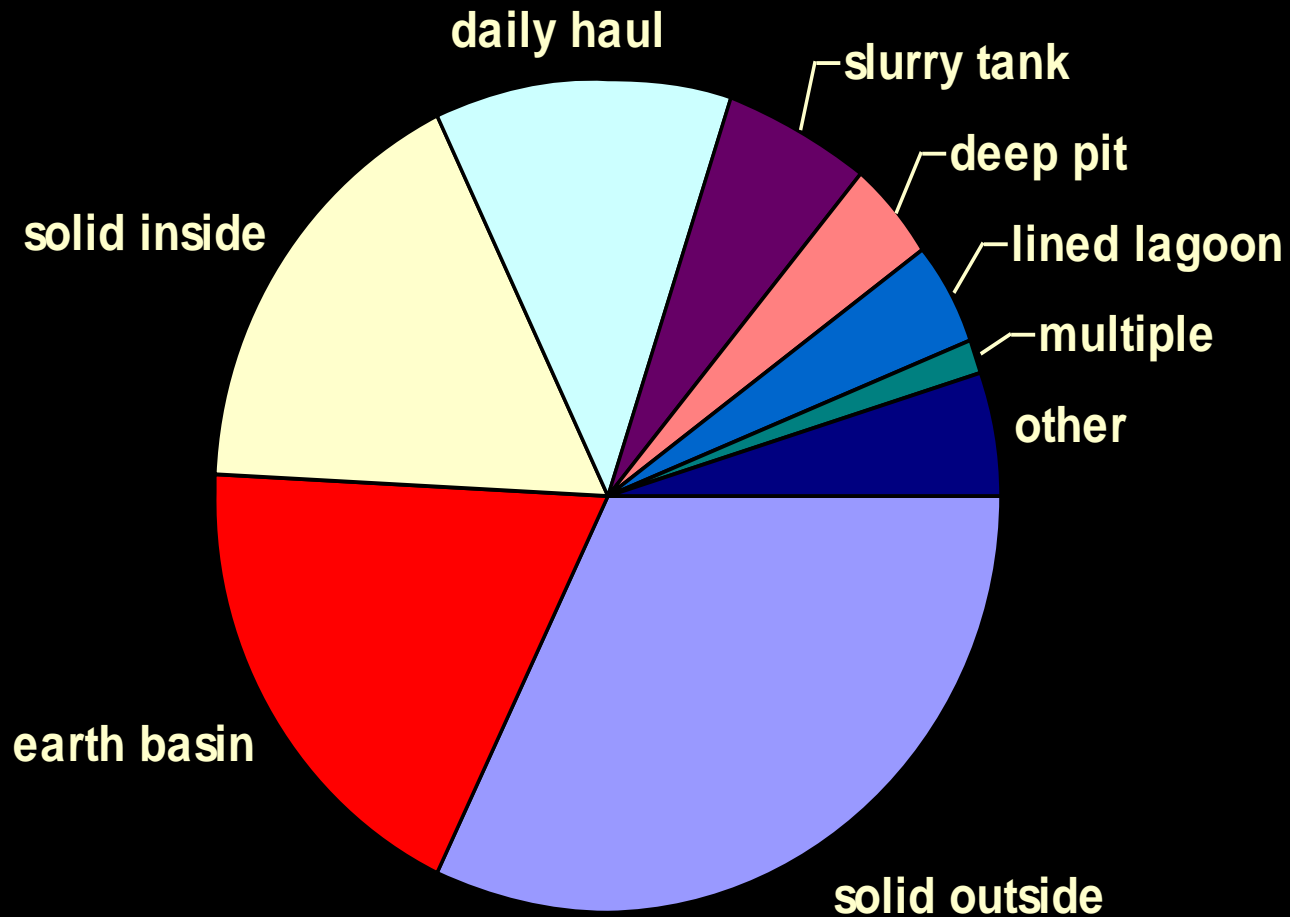
Bedding Type and Somatic Cell Count



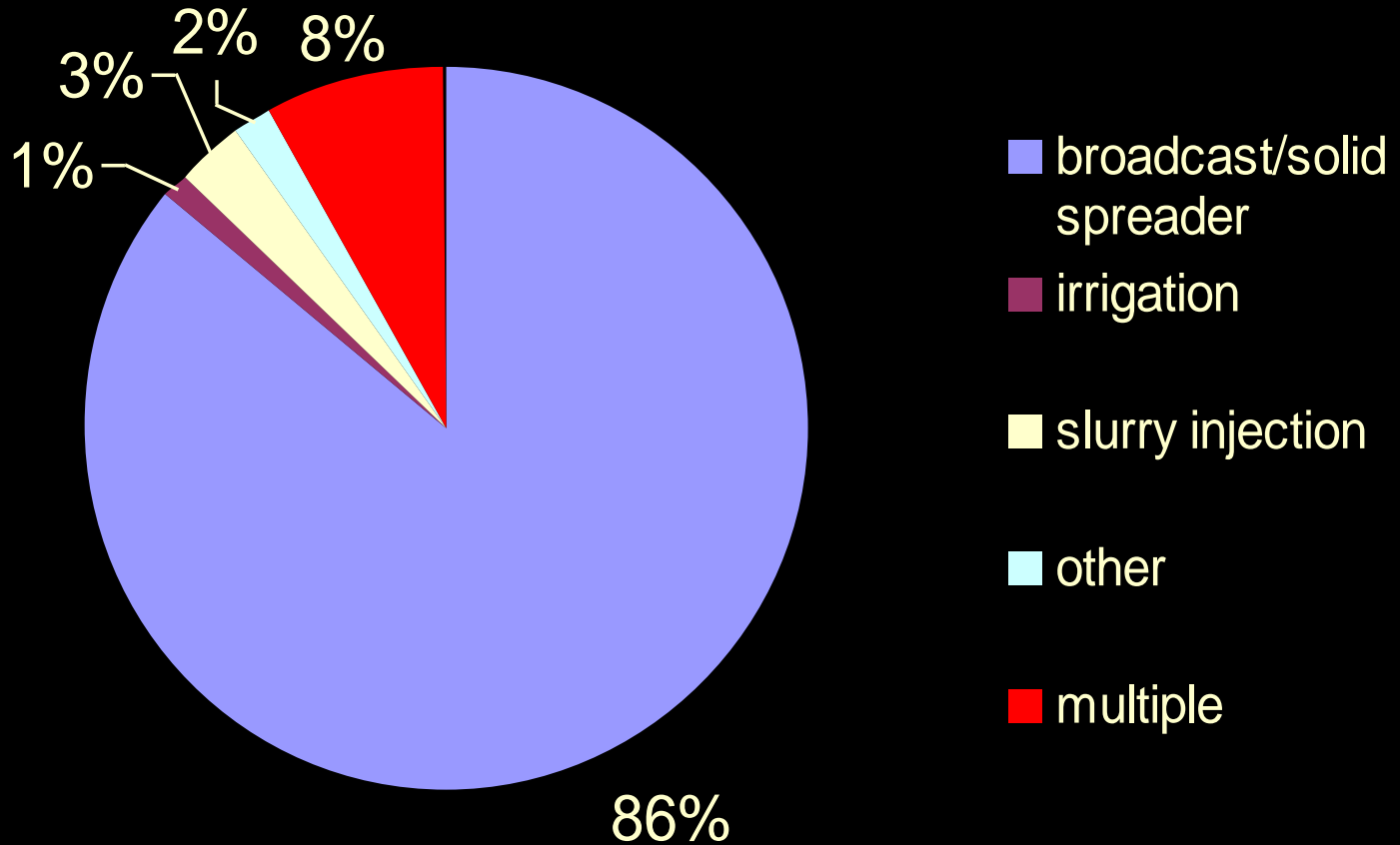
Manure Removal Method



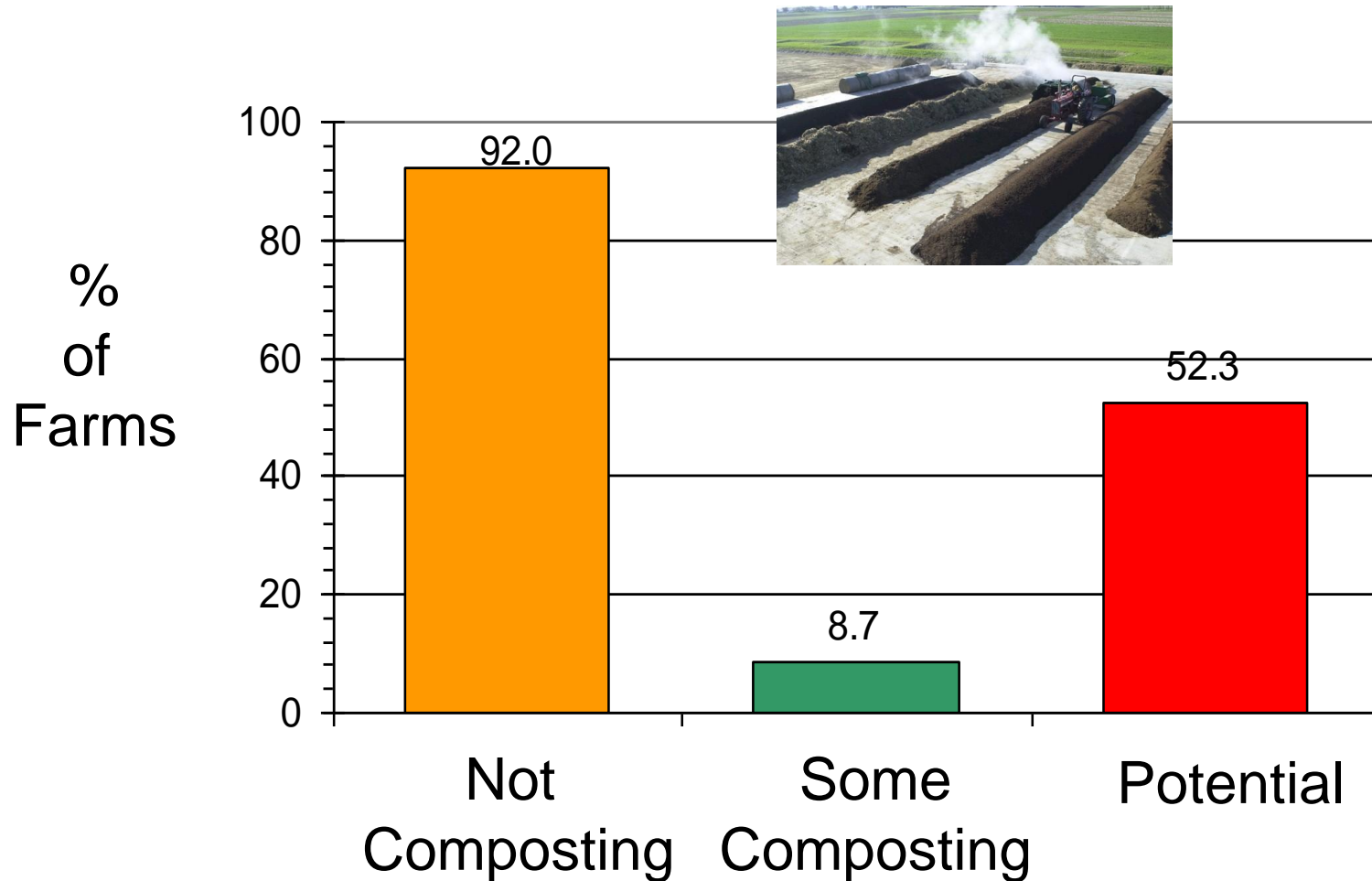
Manure storage



Manure application method



Dairy Farms that Compost



Farms identified for in-depth manure management and water usage analysis

Farm	Location	Milking Cows	Bedding^a	Manure Management System
A	Marshallville	1350	Sand	Scrape/Lagoon storage
B	Jacobsburg	230	Compost/ Sawdust	Separator/Composting/ Lagoon
C	Ashland	430	Sand	Flush/Lagoon storage
D	Putnam	650	Sand	Scrape/Concrete storage
E	Bally	400	Sawdust	Composted bedding/Flush
F	Wooster	70	Straw/ Sawdust	Composting
G	Burton	400	Straw/Sand/ Sawdust	Gravity to liquid storage/ Pile plus daily haul

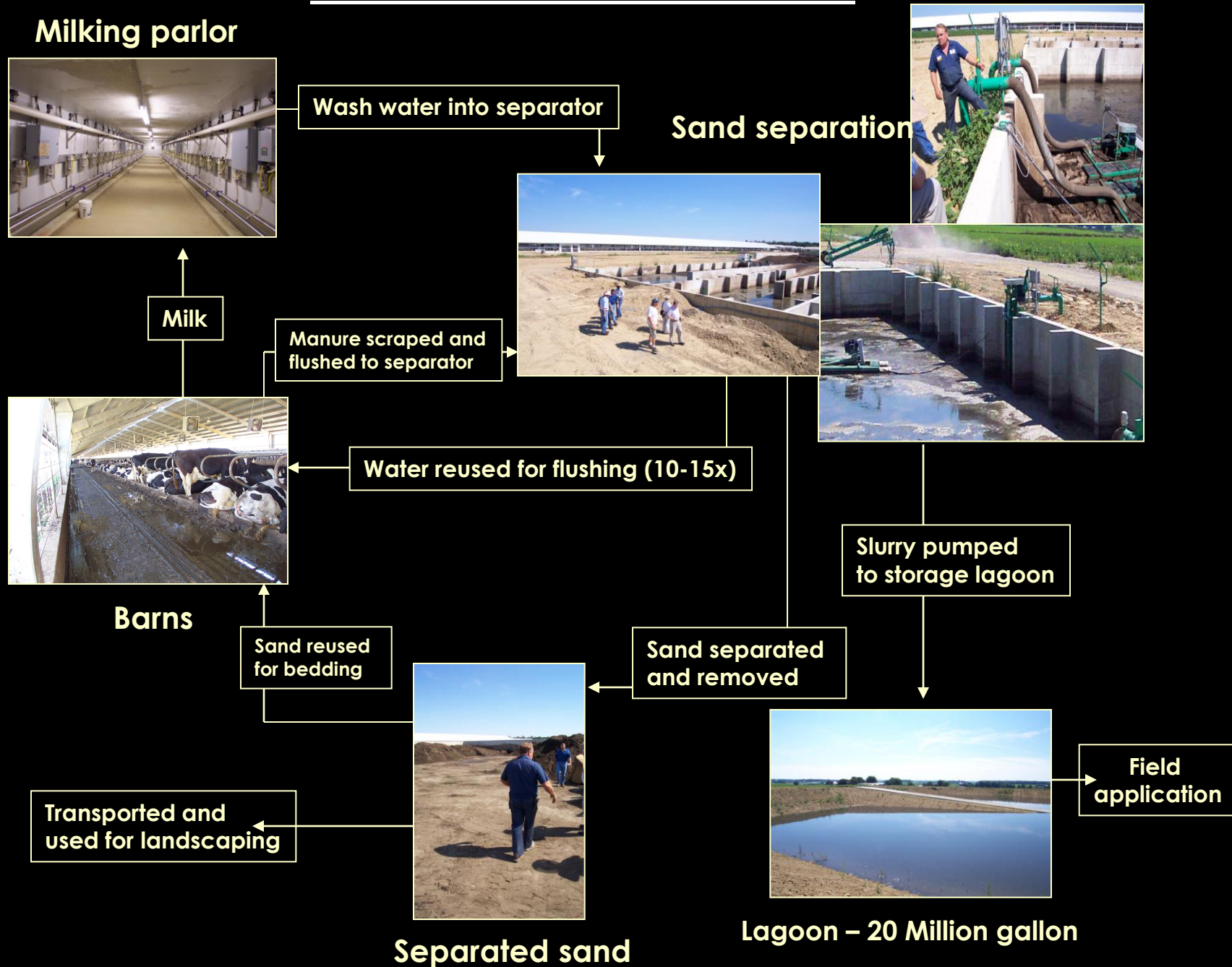


Clean sand bedding



**Scraper alley in barn.
Scraper pushes manure into flume 10 times per day.
Four alleys/barn.**

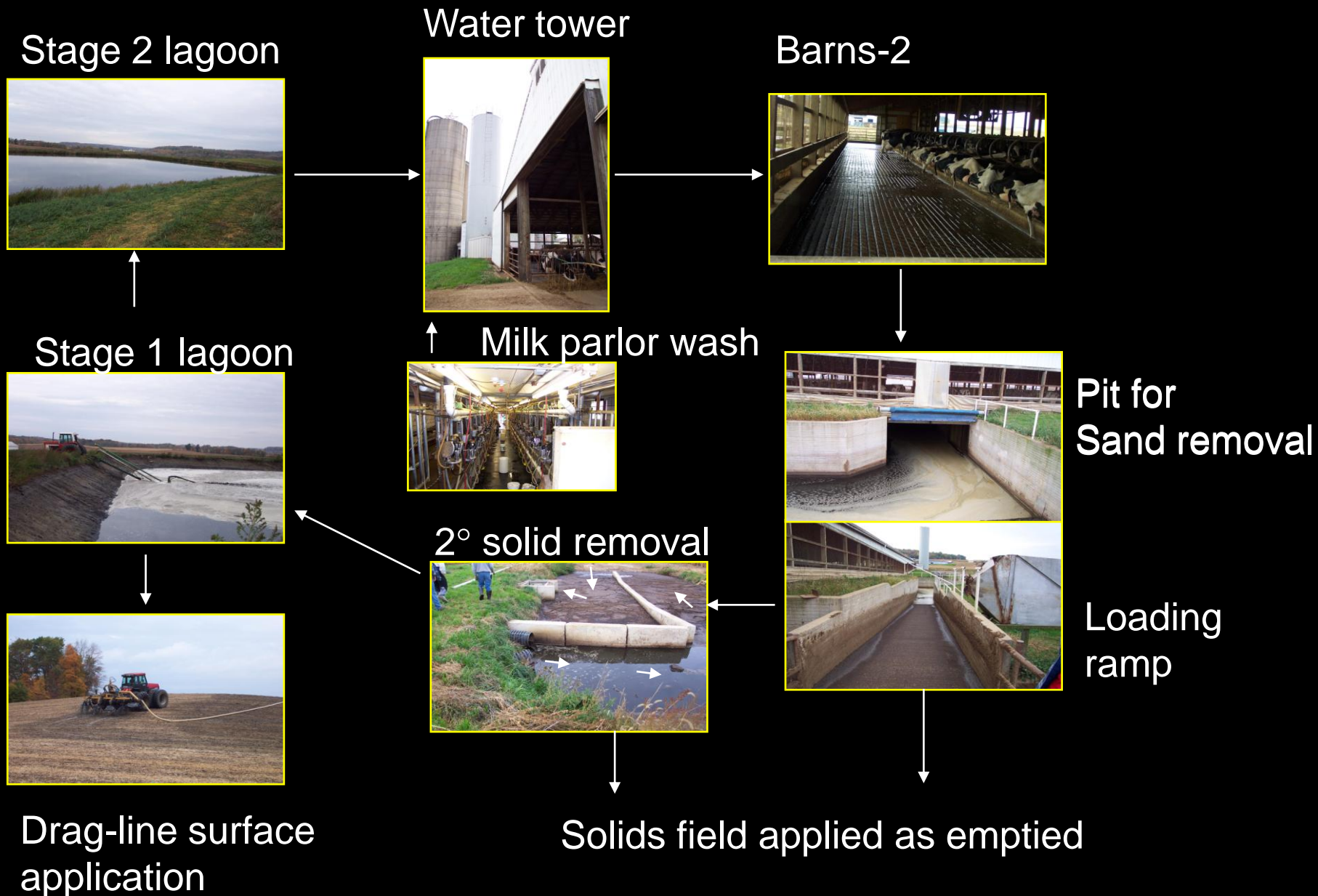
Farm A - LIQUID BASED DAIRY



20,000,000 gallon manure storage lagoon



Farm C. 430 Head, Sand and flush



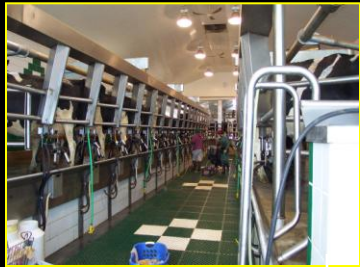
Daily Water Usage (430 head)

	<u>Gallons/Day</u>
• Cleaning milk tanks	126
• Wash Vat	540
–4 cycles, 3x/day	
• Flush:	
walkway to parlor	1050 *
holding pen	1500 **
• Clothes washing	450
–15 loads/day	<hr/>
TOTAL	3666 = <u>8.5 gal/cow/dy</u>

*considering changing to recycled water

** additional water for flushing system

Farm D. 650 Head Dutch Dairy using sand bedding



Wash water



Liquids land
applied



Recycled water in flume

Solids
scraped



Manure carried by
water to separator



Solids removed



Solids land
applied



Farm D - 650 Head Dairy using sand bedding

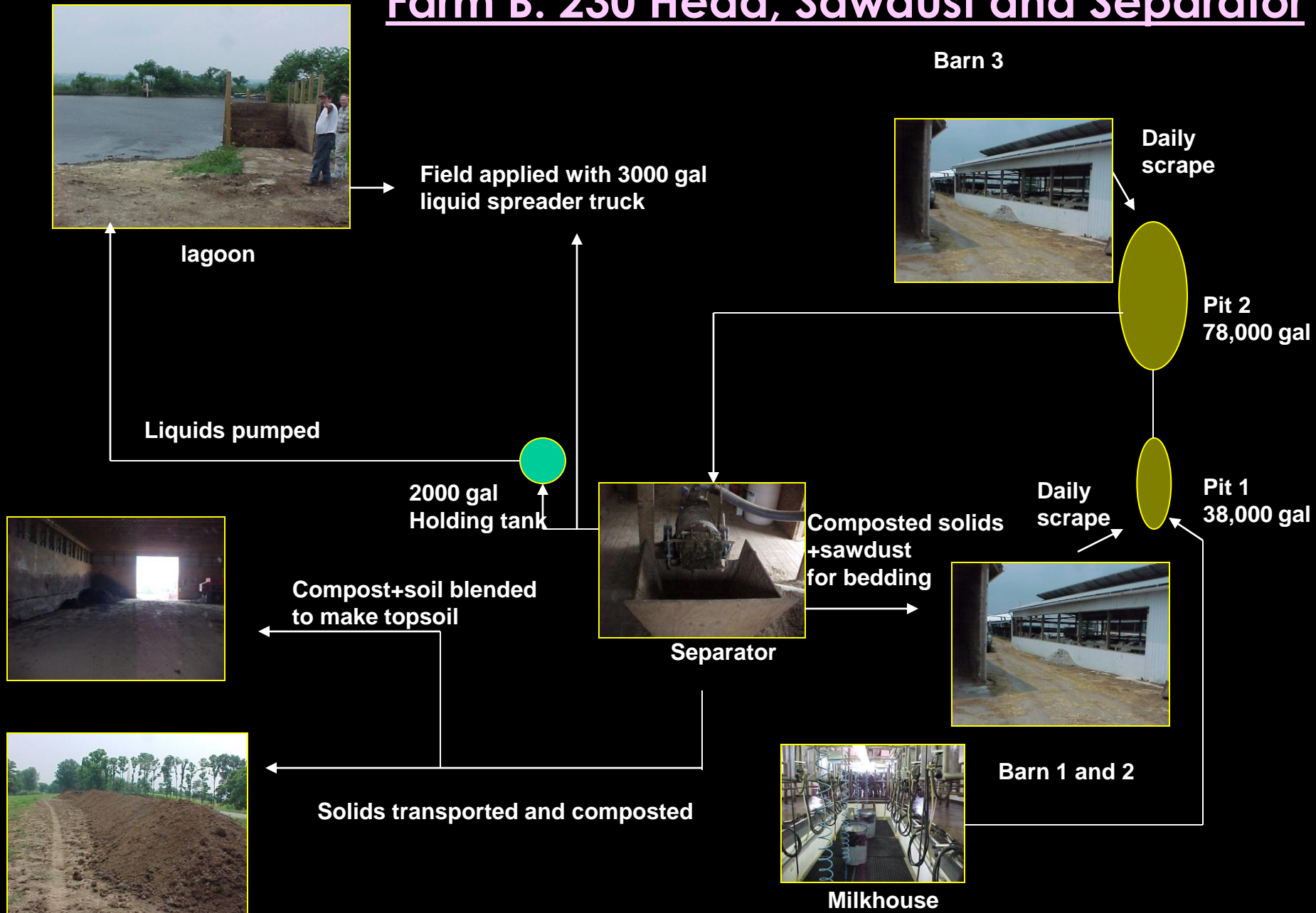
	Moisture (%)	N (%)	P (%)	K (%)	VS (%)	C/N
1=Flush Water	94	5.0	0.7	2.3	76	9
3=SCRAPED MANURE	77	2.2	0.3	0.8	45	12
4=MANURE + SAND	36	0.4	0.1	0.2	11	25
5=LIQUID OVERFLOW	95	5.7	0.8	2.6	73	8



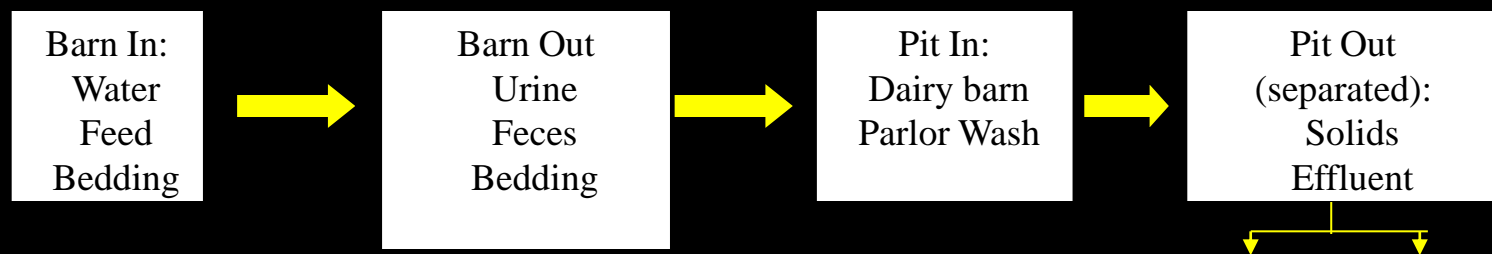
Draining/Drying Separated Sand



Farm B. 230 Head, Sawdust and Separator

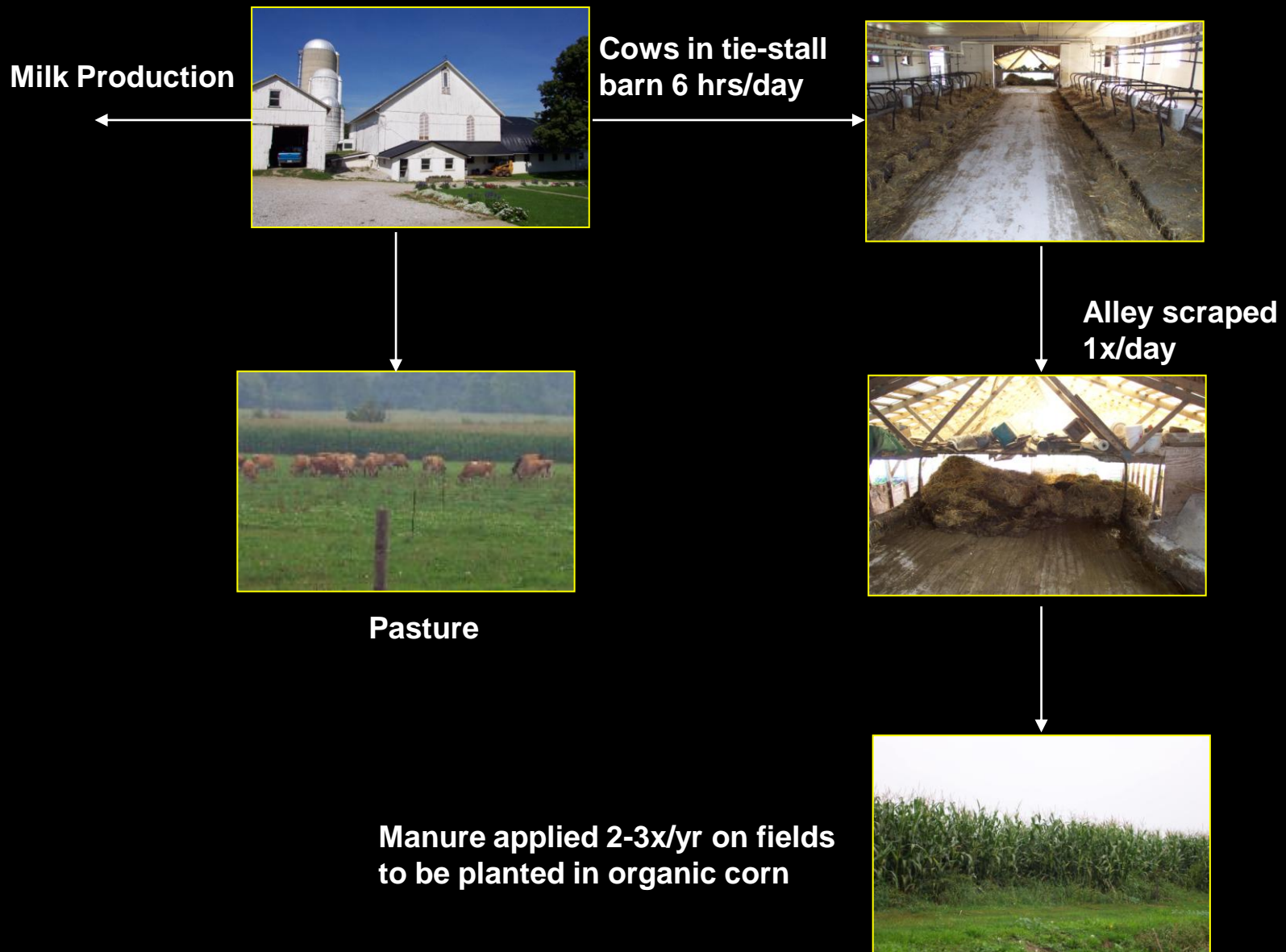


Daily liquid flow per Cow



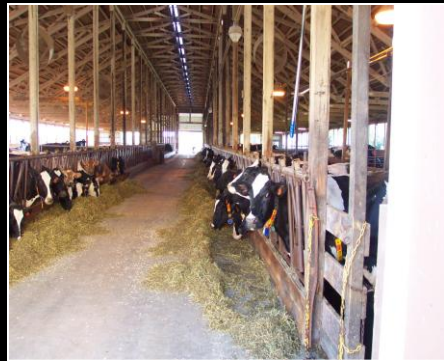
	<u>Barn In</u>	<u>Barn Out</u>	<u>Pit In</u>	<u>Effluent</u>	<u>Solids</u>
Wet wt (lbs)	298	196	256	271	61
Dry wt (lbs)	59	31	31	14	17
Total C (lbs)		14	14	6 (45%)	7
Total N (lbs)	1.1	1.1	0.7 (67%)	0.3	
Ash (lbs)	5.5	6.5	3.9	2.0	
P (lbs)	0.2	0.2	0.14 (78%)	0.04	
K (lbs)	0.5	0.4	0.4 (81%)	0.1	
Ca (lbs)	0.7	0.7	0.4 (66%)	0.2	

Farm F. 70 Head, straw bedding, Organic farm



PROTOTYPE SOLID MANURE BASED DAIRY

Compost amendments
(sawdust, hay, straw, horse bedding, recycled compost, etc.)



Unseparated
Manure



Value
Added
Markets

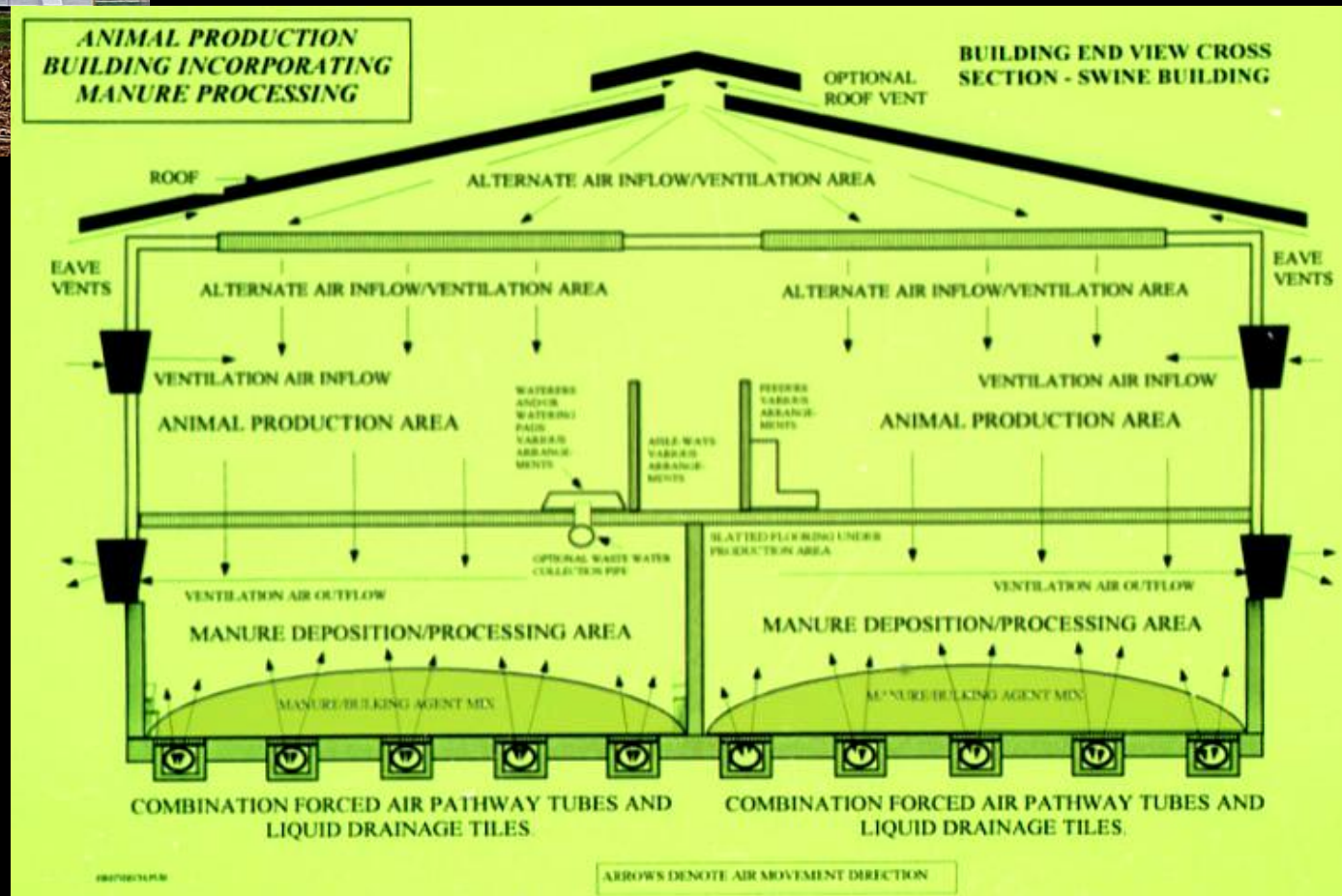
Free-stall barn
Manual
or Automatic
Scrape system,

Sand,
Straw or
Sawdust
bedding

Composting



High-Rise Hog House with Aerated Floor for Composting/Drying



Fresh Aire Farms



Manure composting
4 Windrows made in

- 1. May**
- 2. August**
- 3. Early September**
- 4. Late September**

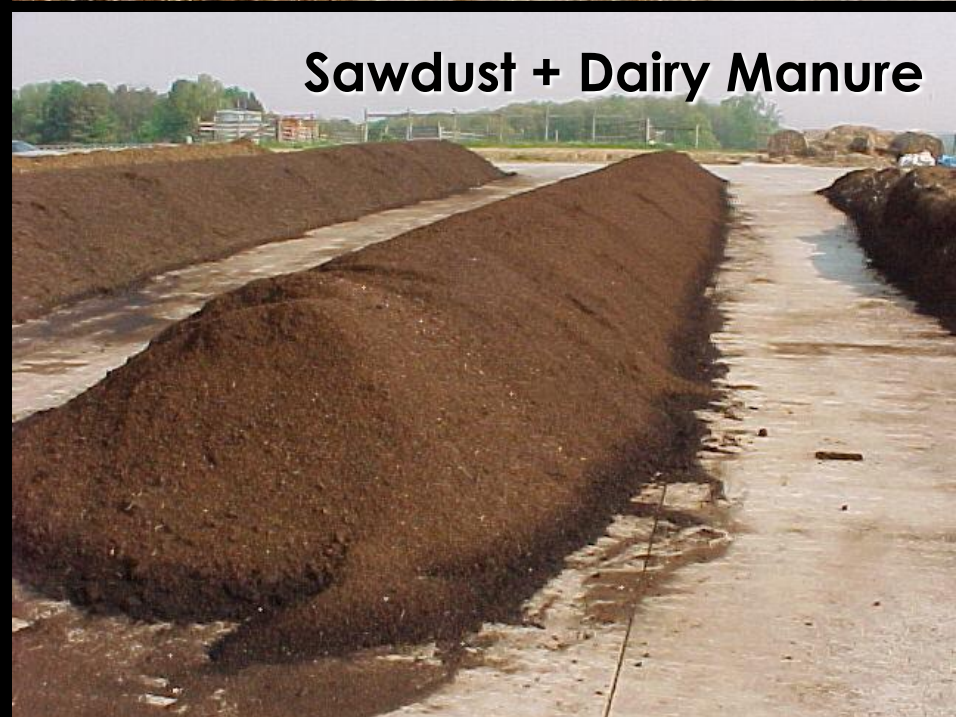
Straw + Dairy Manure



Hog Manure + Wood (HRHB)

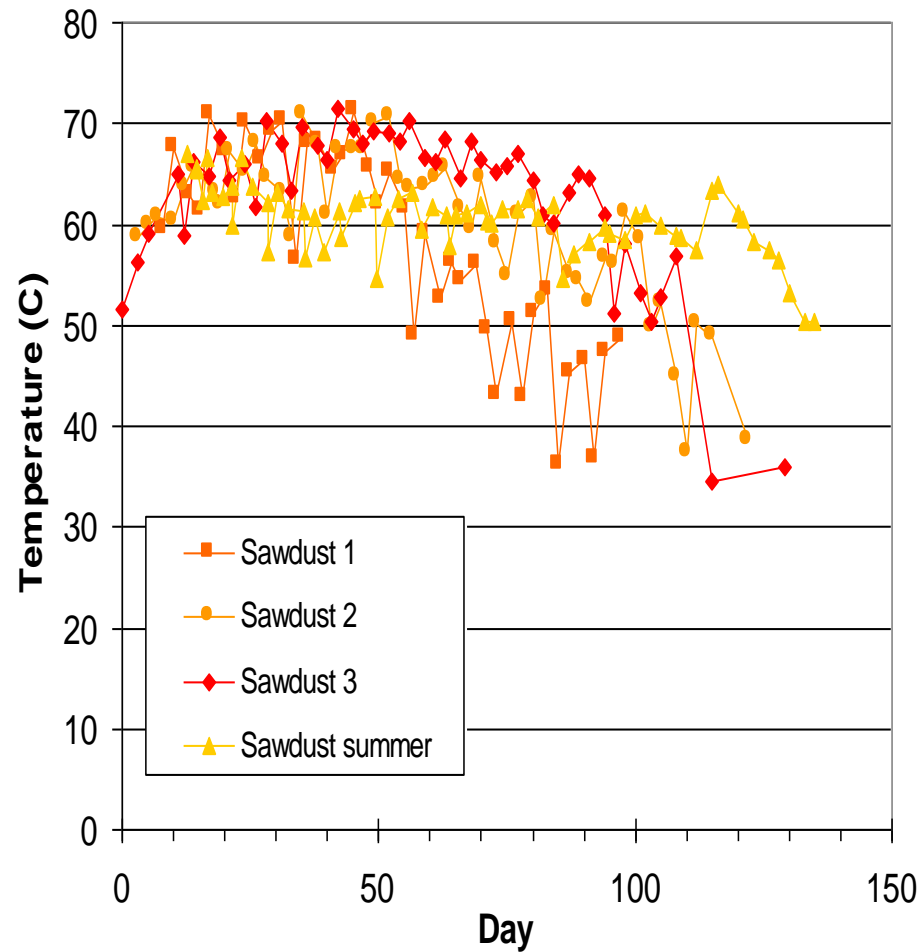


Sawdust + Dairy Manure

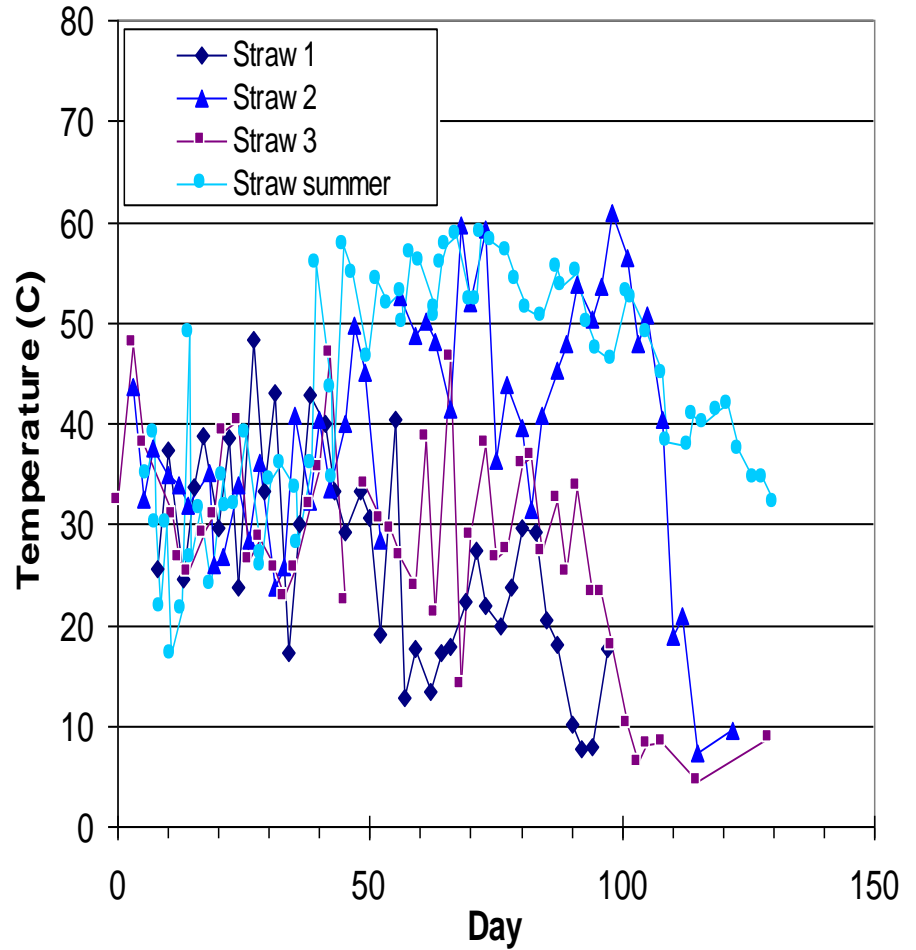


Composting Temperatures

Sawdust

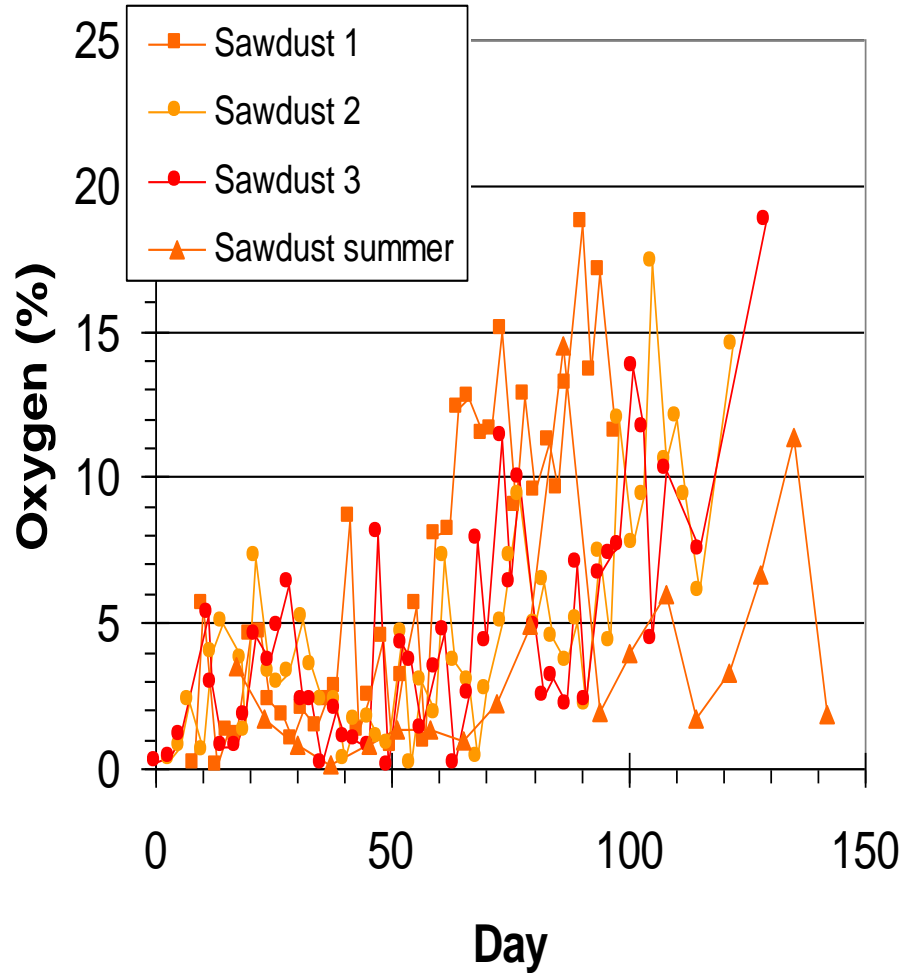


Straw

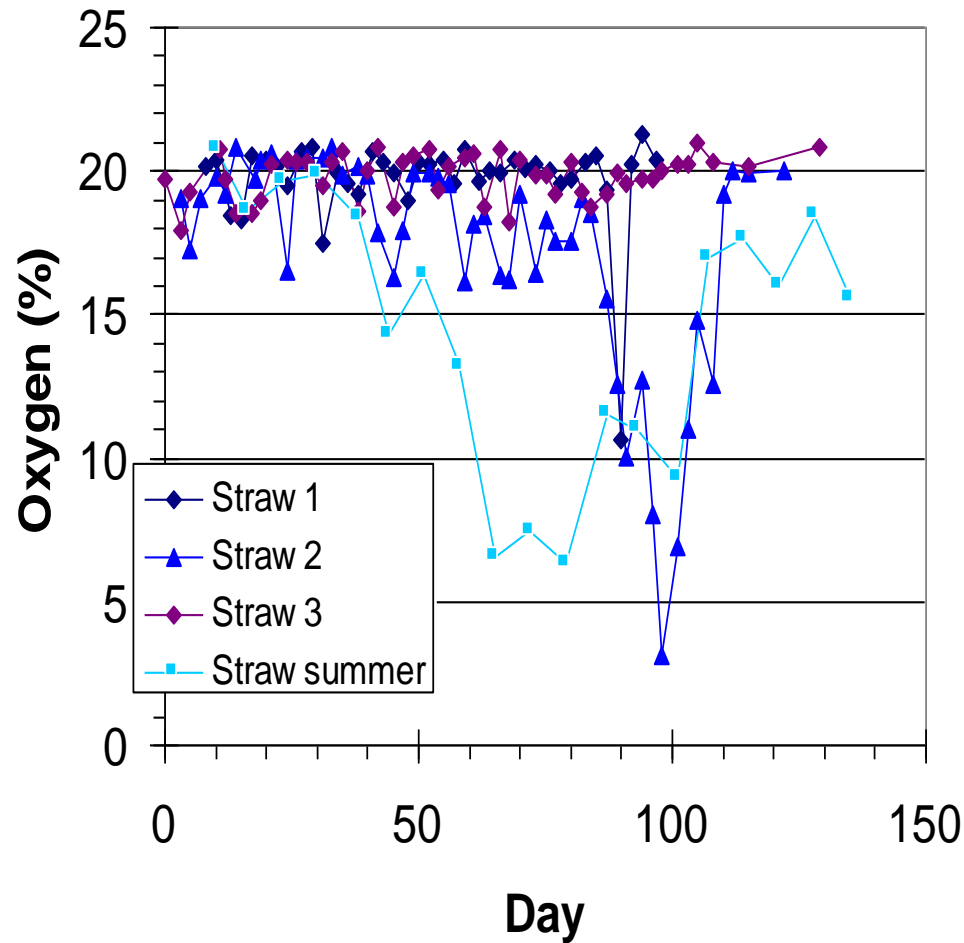


Oxygen Concentrations

Sawdust



Straw





Physical properties of dairy manure compost during composting.

	Dairy + Sawdust			
	Day 0	Day 61	Day 88	Day 122
Volume (m ³)	60.5	29.0	20.5	11.8
Moisture (%)	65.0	60.9	67.0	46.0
Wet Density (kg/m ³)	368	342	354	338
Dry Density (kg/m ³)	129	134	117	182
Uncompacted Porosity	0.66	0.64	0.60	0.58
Total Wet Weight (kg)	22253	9921	7238	3974
Total Dry Weight (kg)	7789	3879	2389	2146
Dry Matter loss (%)		50.2	69.3	72.5
Volume Reduction (%)		52.0	66.2	80.5

**72% reduction in
transportation weight
versus fresh manure**

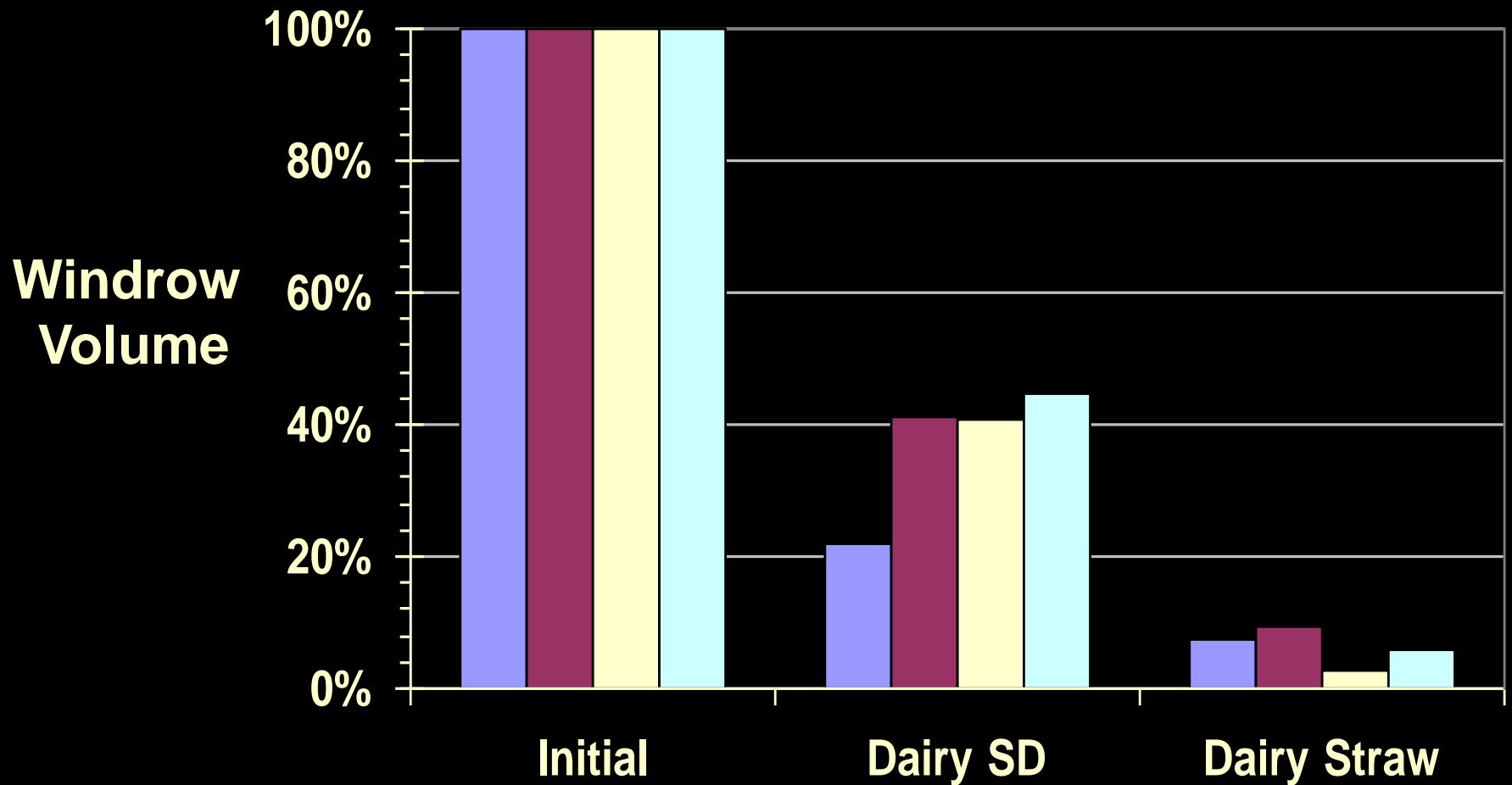
Physical properties of dairy manure compost during composting.

	Dairy + Straw			
	Day 0	Day 54	Day 81	Day 115
Volume (m ³)	92.26	46.65	16.54	9.80
Moisture (%)	65.0	66.5	58.9	38.5
Wet Density (kg/m ³)	172.7	175.6	238.4	331.7
Dry Density (kg/m ³)	60.4	58.8	98.0	204.0
Uncompacted Porosity	0.76	0.78	0.71	0.73
Total Wet Weight (kg)	15933	8192	3943	3250
Total Dry Weight (kg)	5576.7	2744.2	1620.6	1998.3
Dry Matter loss (%)		50.79	70.94	64.17
Volume Reduction (%)		49.44	82.07	89.38

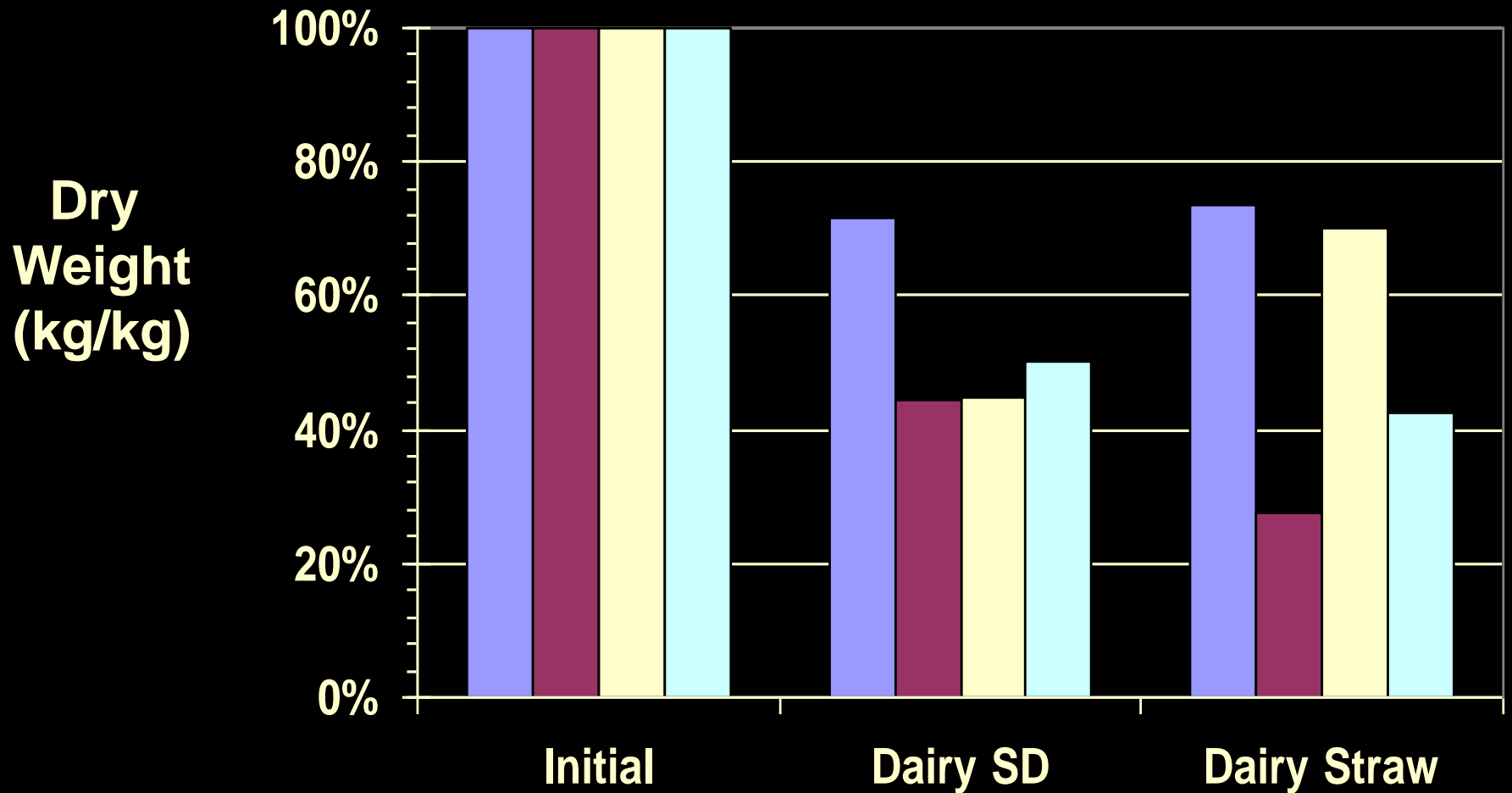
Properties of Hog Manure compost during composting.

	Hog + Sawdust			
	Day 0	Day 40	Day 67	Day 101
Volume (m ³)	50.5	55.7	48.7	42.7
Moisture (%)	67.3	64.8	56.9	45.5
Wet Density (kg/m ³)	795.3	501.6	406.9	381.2
Dry Density (kg/m ³)	260.1	176.6	175.4	207.8
Uncompacted Porosity	0.26	0.51	0.61	0.60
Total Wet Weight (kg)	40178	27914	19828	16281
Total Dry Weight (kg)	13138	9825	8546	8873
Dry Matter loss (%)		25.2	34.9	32.5
Volume Reduction (%)		-10.2	3.5	15.5

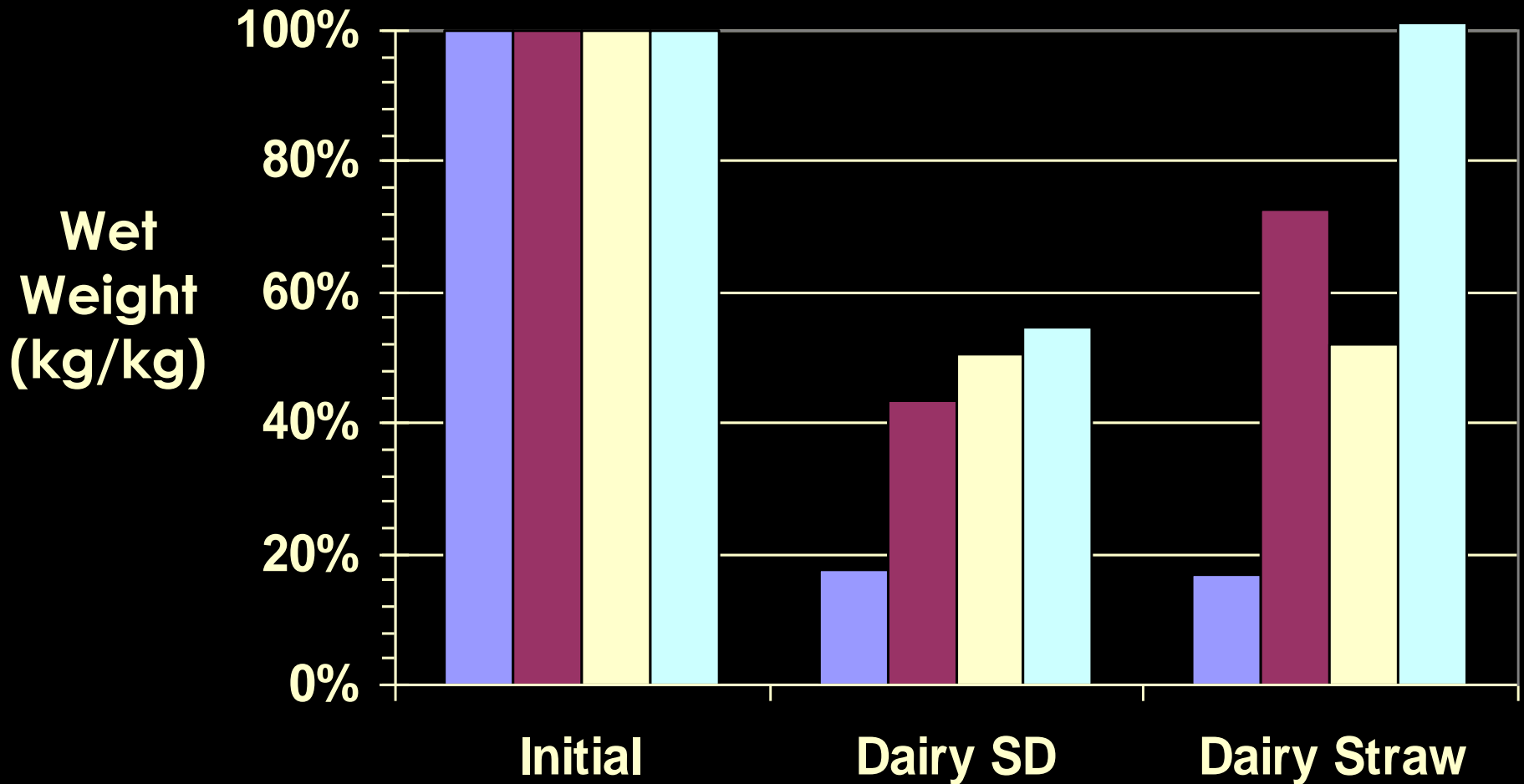
Volume Remaining after Composting



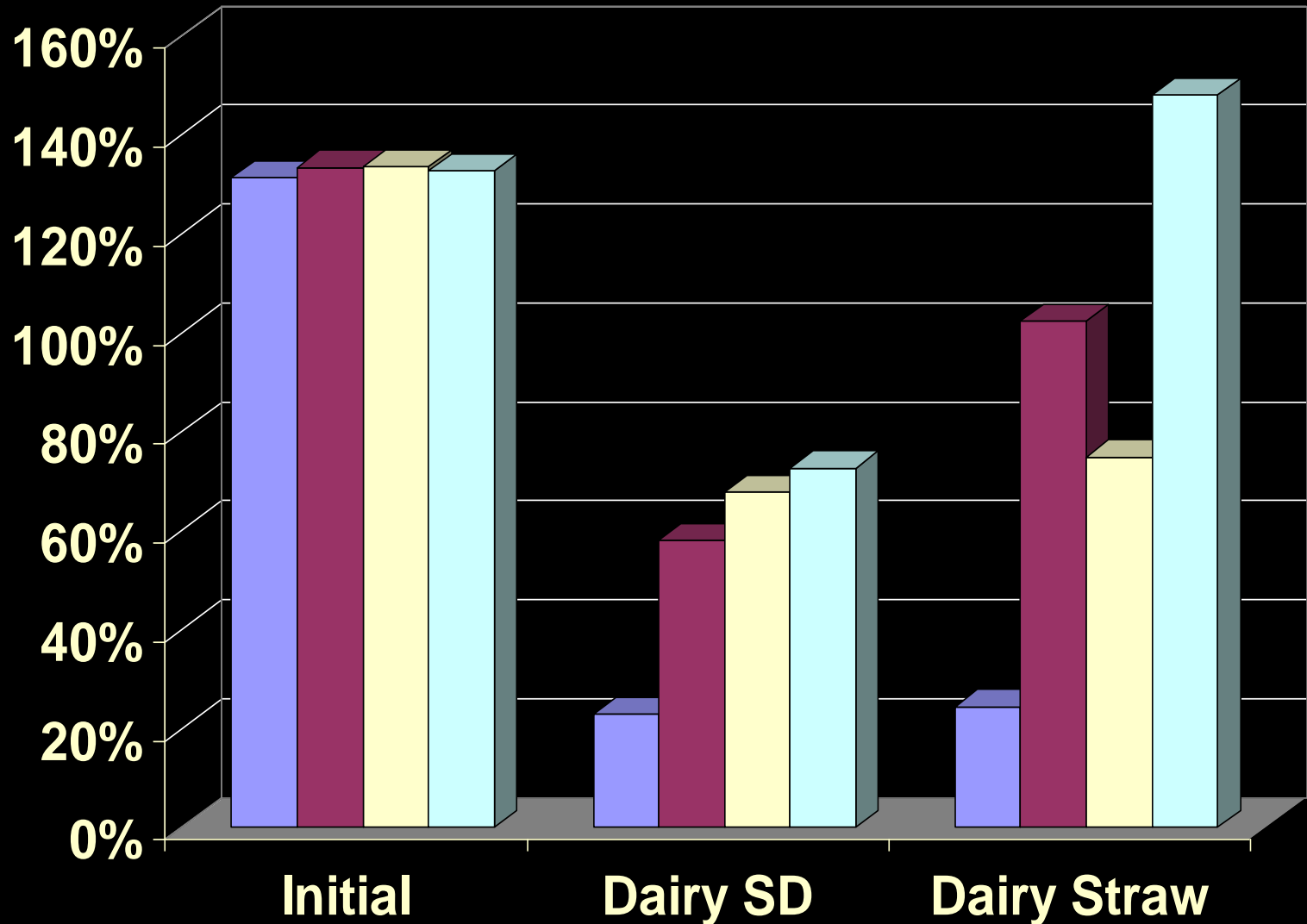
Weight Remaining after Composting (dry)



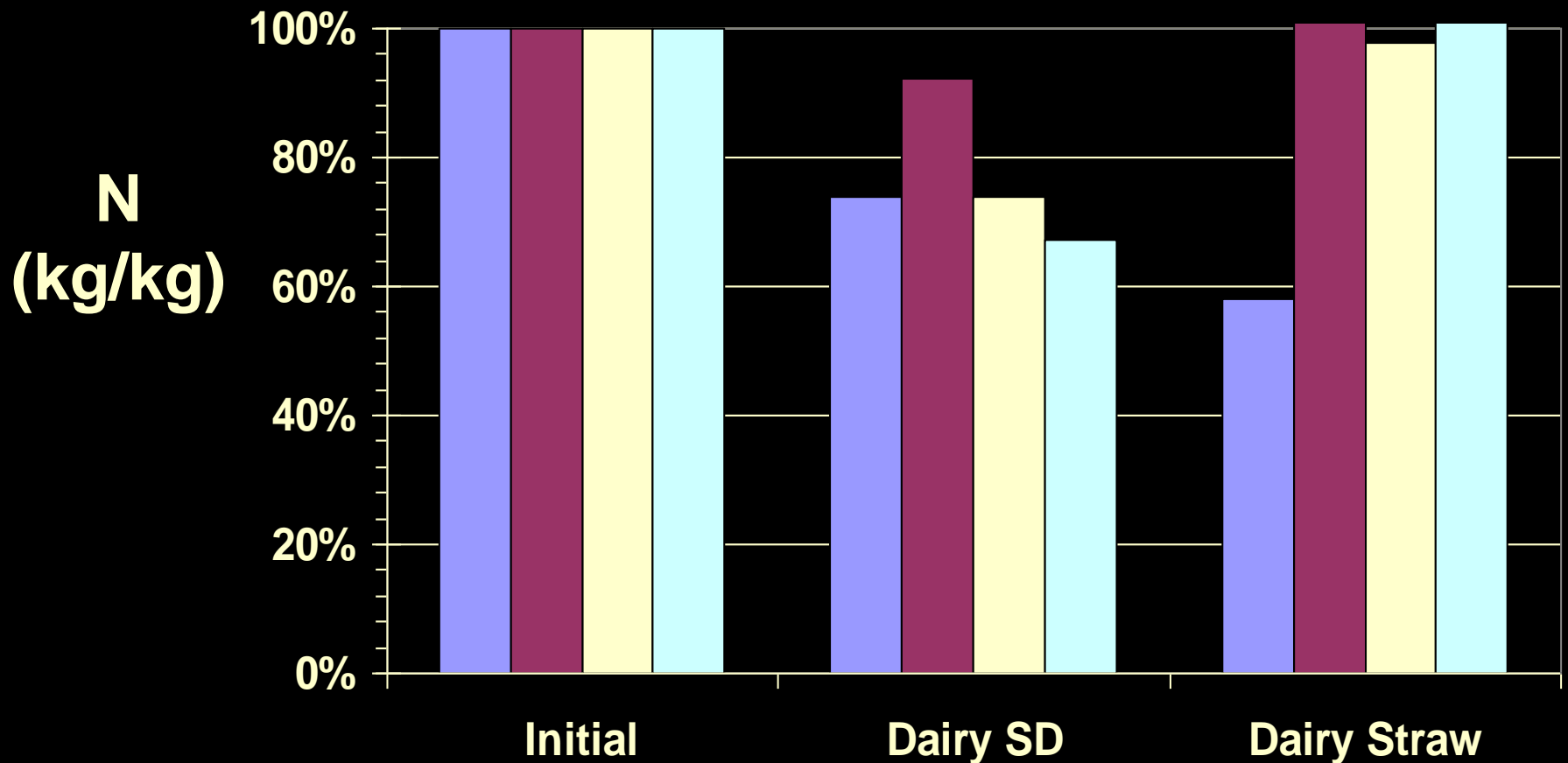
Weight after composting (wet)



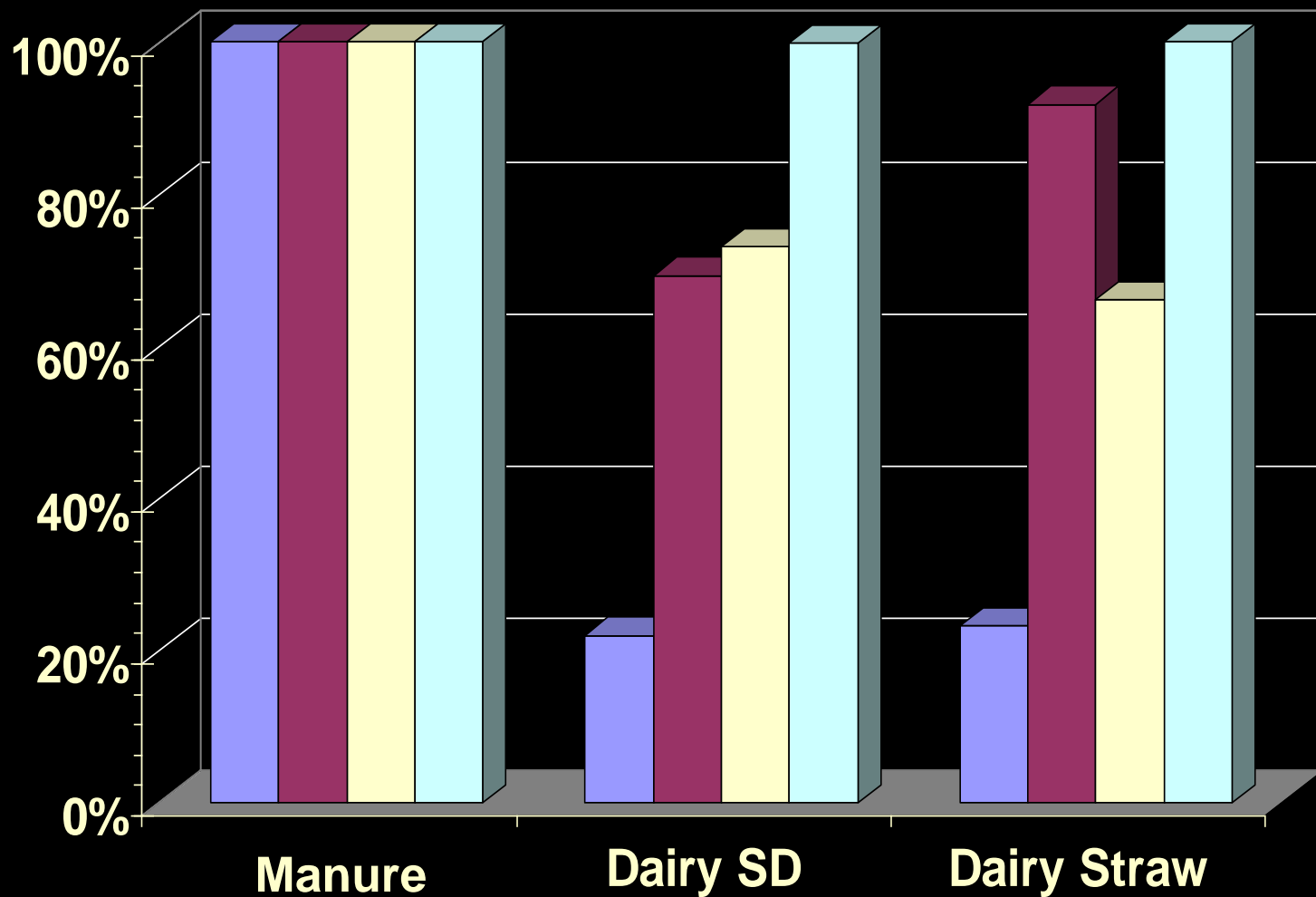
Compost Weight/Manure Weight



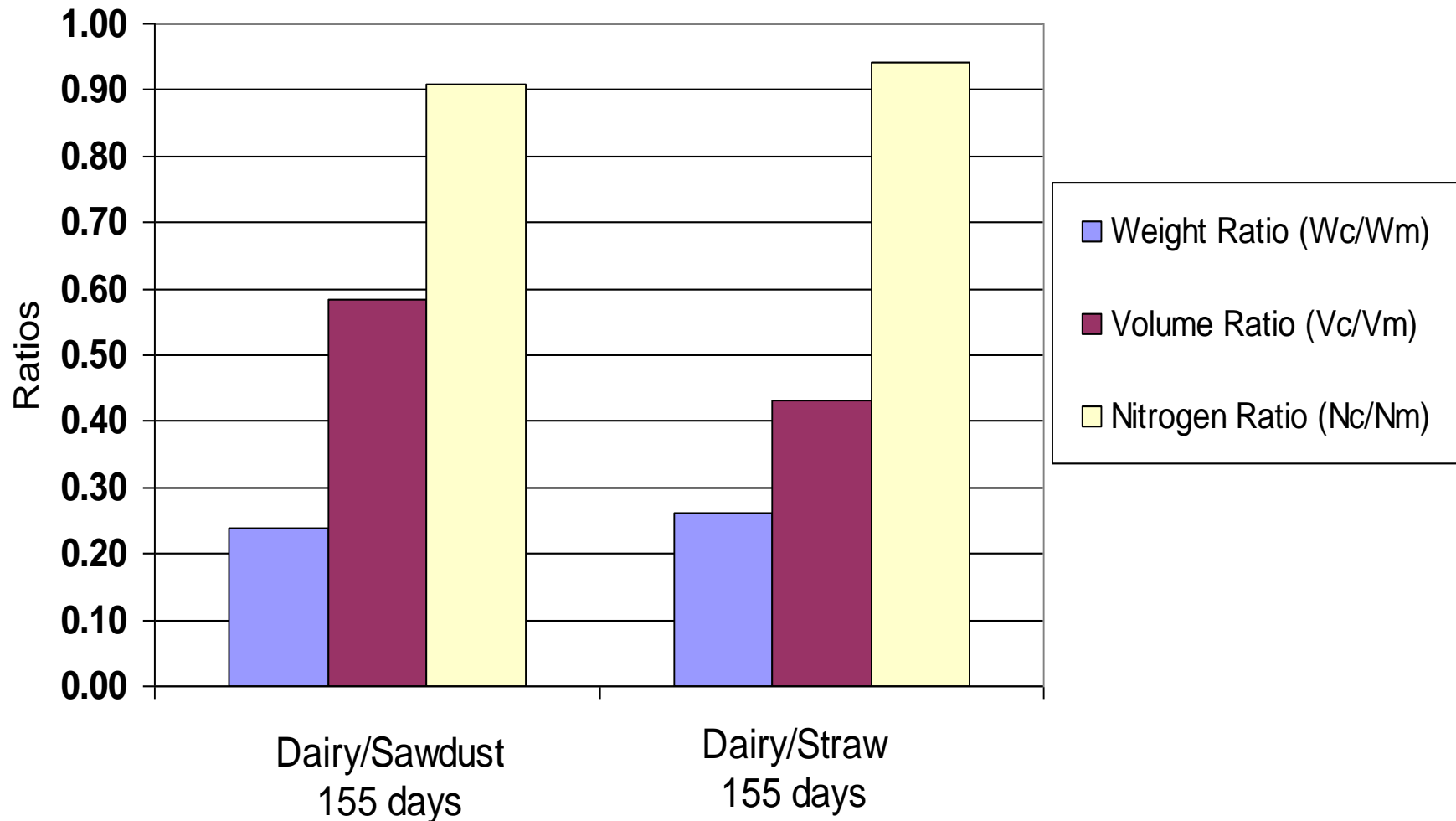
Nitrogen Remaining



Equivalent N Weight



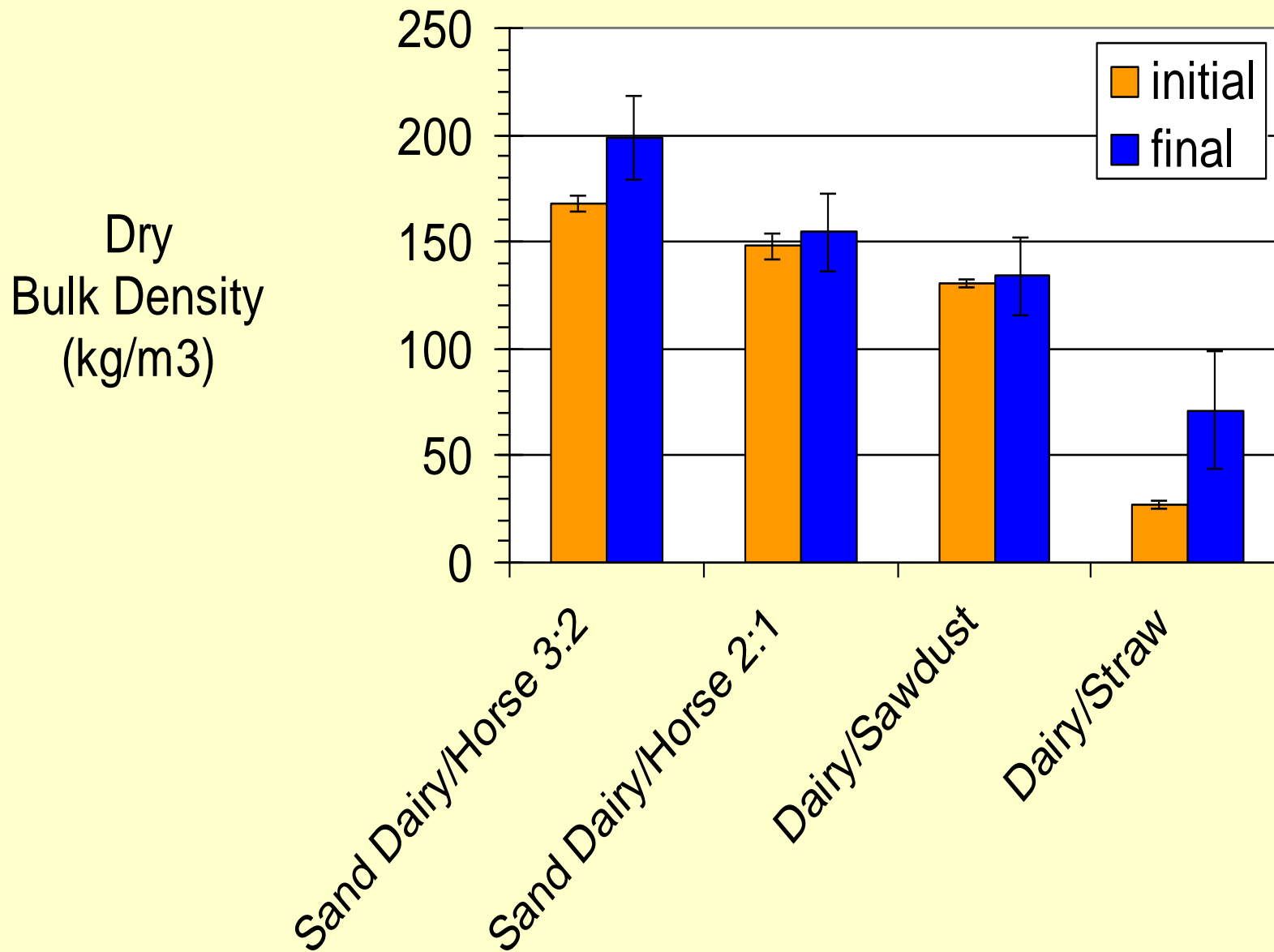
Composted Dairy Manure versus Original Manure



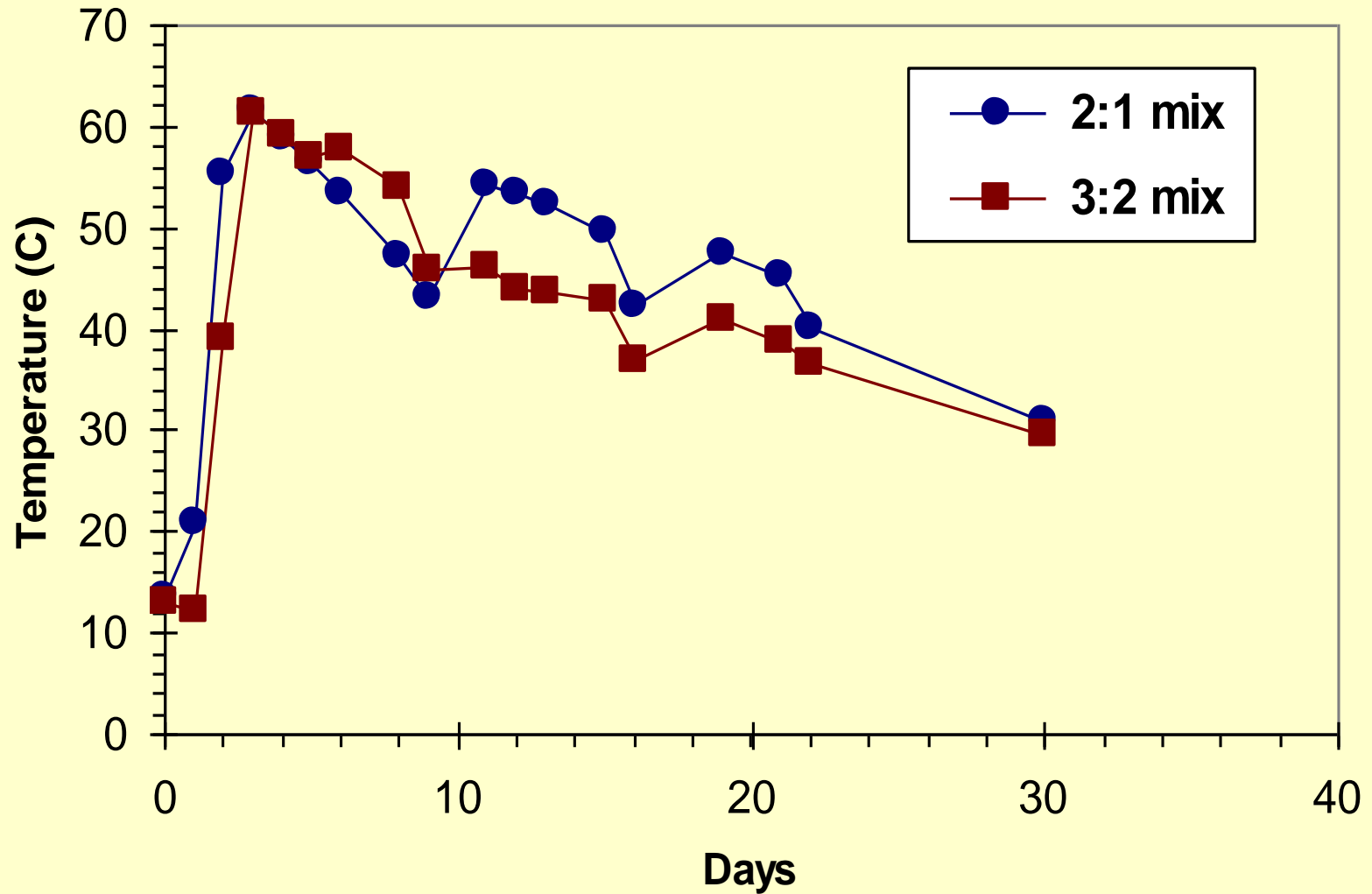
Unseparated Sand bedded manure



Compost Dry Bulk Density



Composting Sand Bedded Dairy Manure



Conclusions

- Composting can reduce wet weight relative to that of manure by up to 75% reduction.
- Volume reduced 20 - 50%.
- Only modest amounts (0-30%) of Nitrogen lost.
- Moisture control is critical to obtain potential weight reductions.
- Sand bedded dairy manures can be effectively composted with organic amendments.
- Technologies for separated sand still need to be developed.
- A simple stability test is useful for compost quality control purposes by farmers.

Objective

- Determine standards for stability of composted dairy and swine manures to allow production of value-added disease suppressive products with reproducible characteristics.





1

25

53

81

95

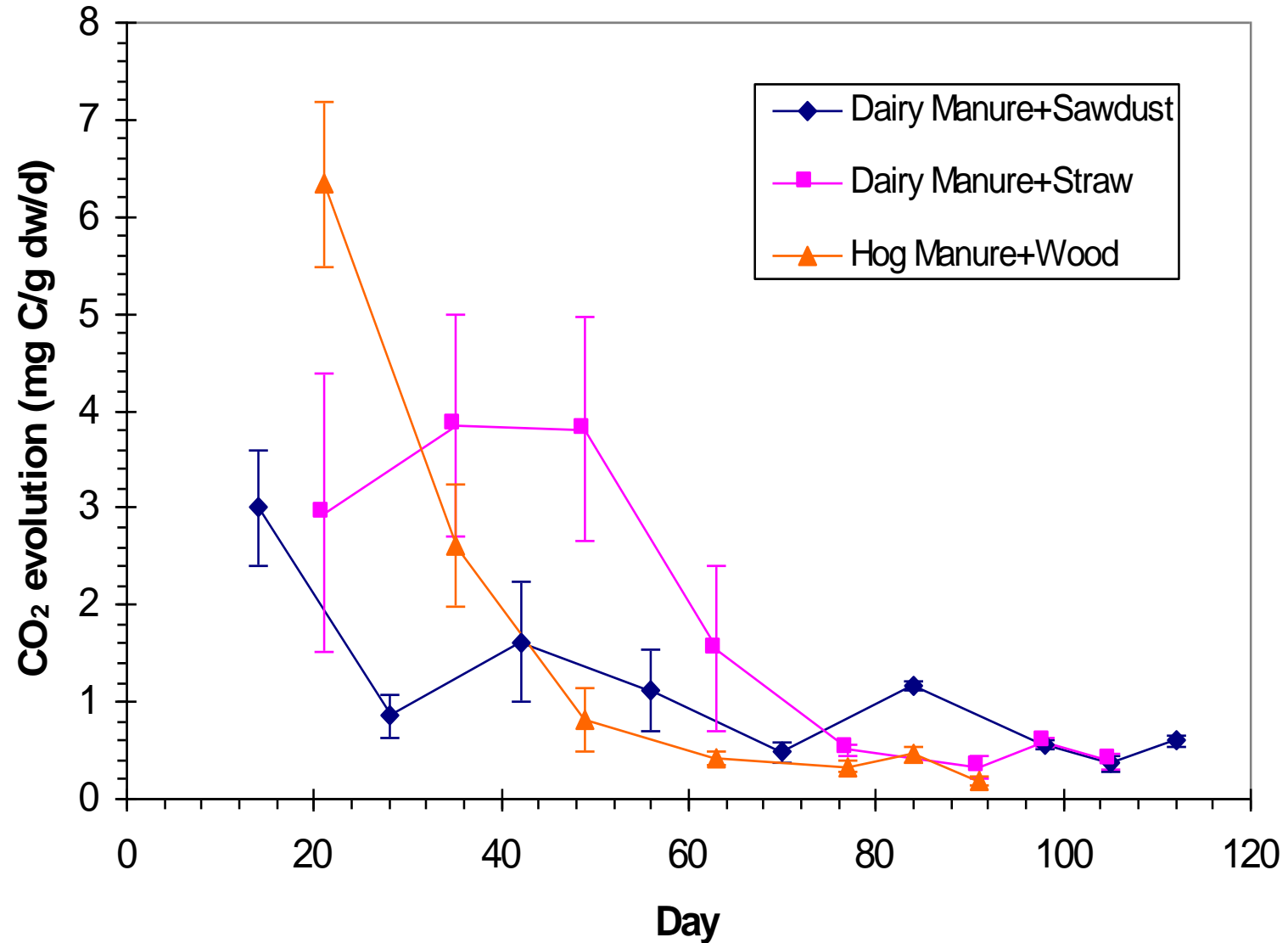
102

109

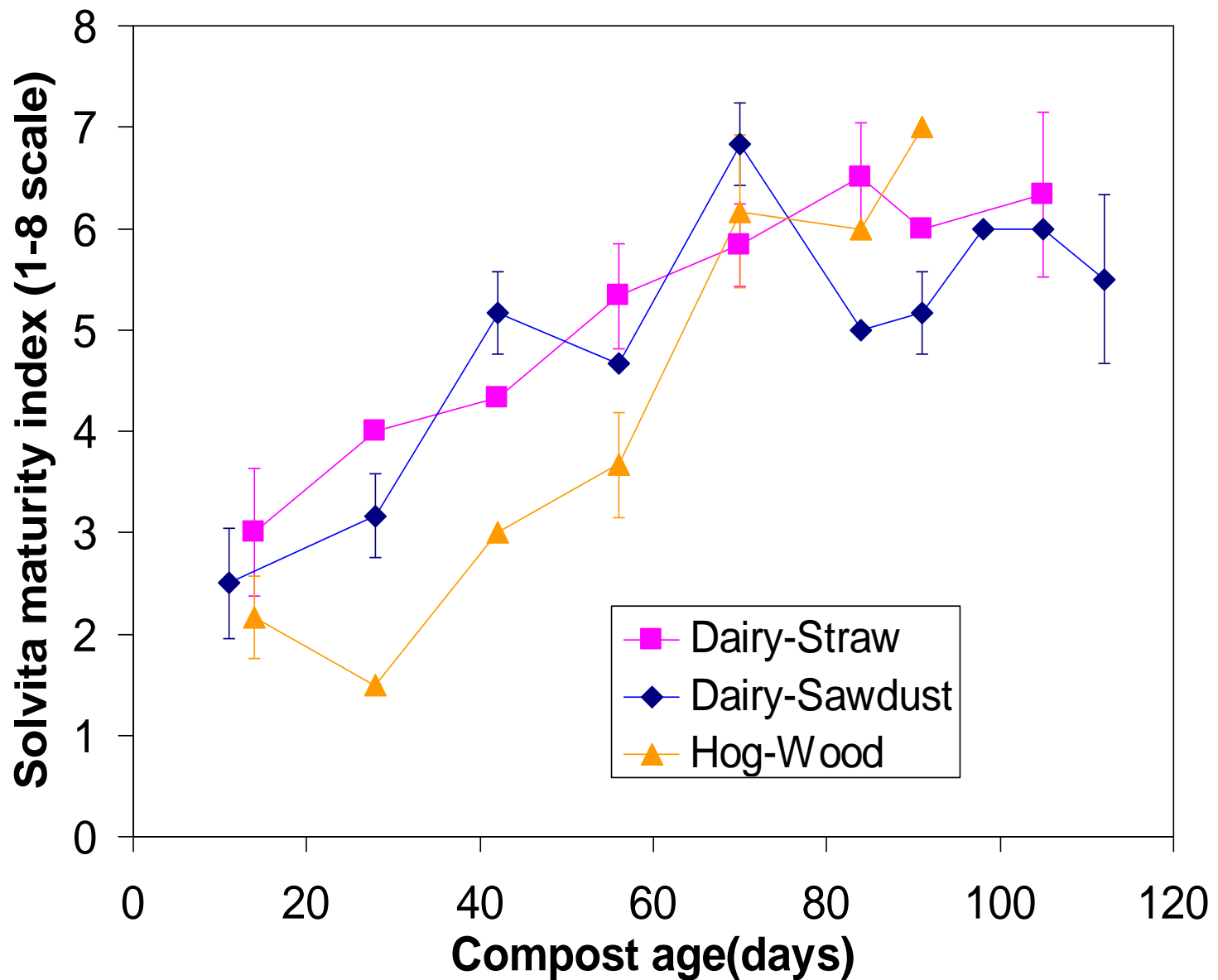
SD - CCM



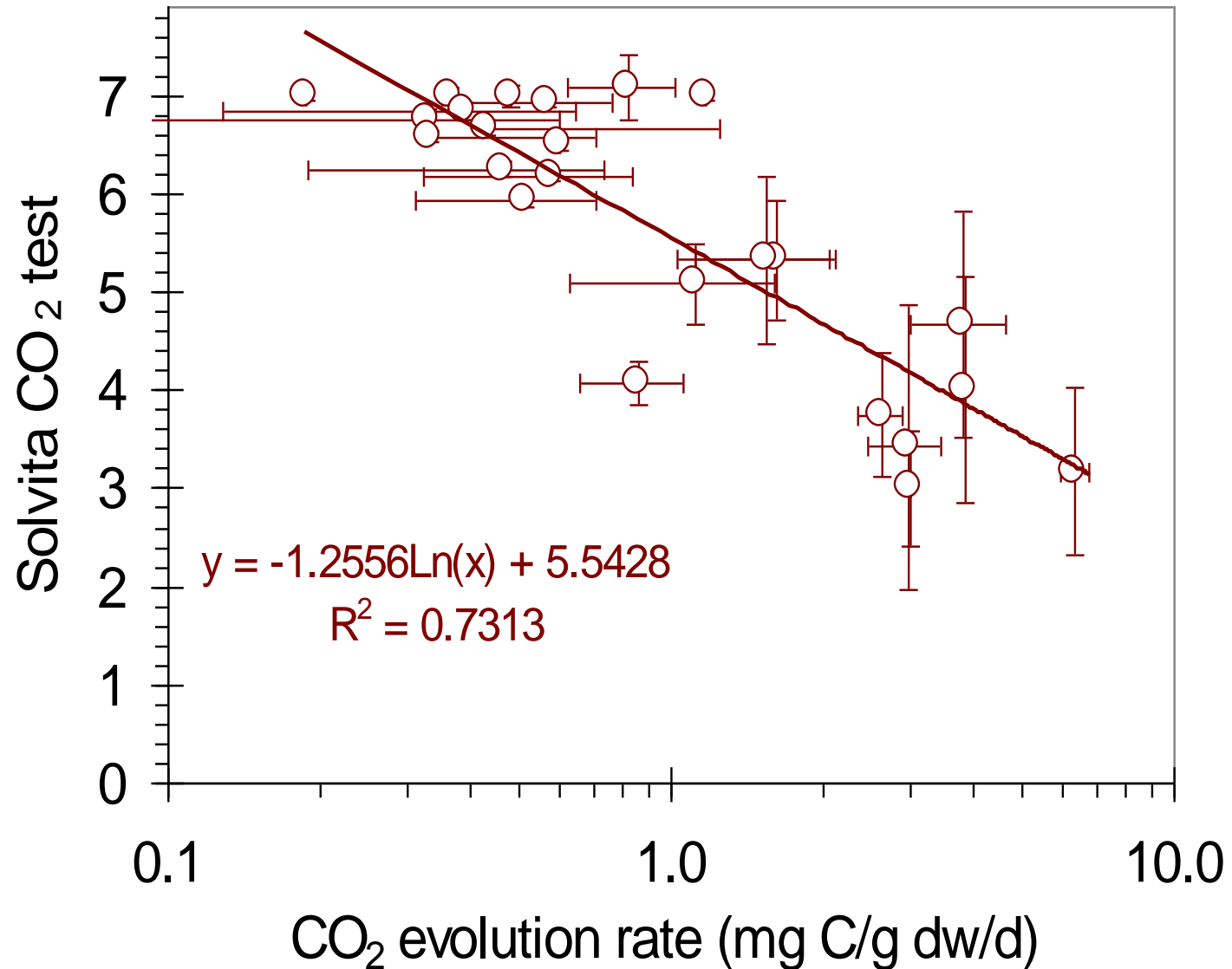
Compost Stability (CO_2 evolution rate)



Solvita CO₂ test



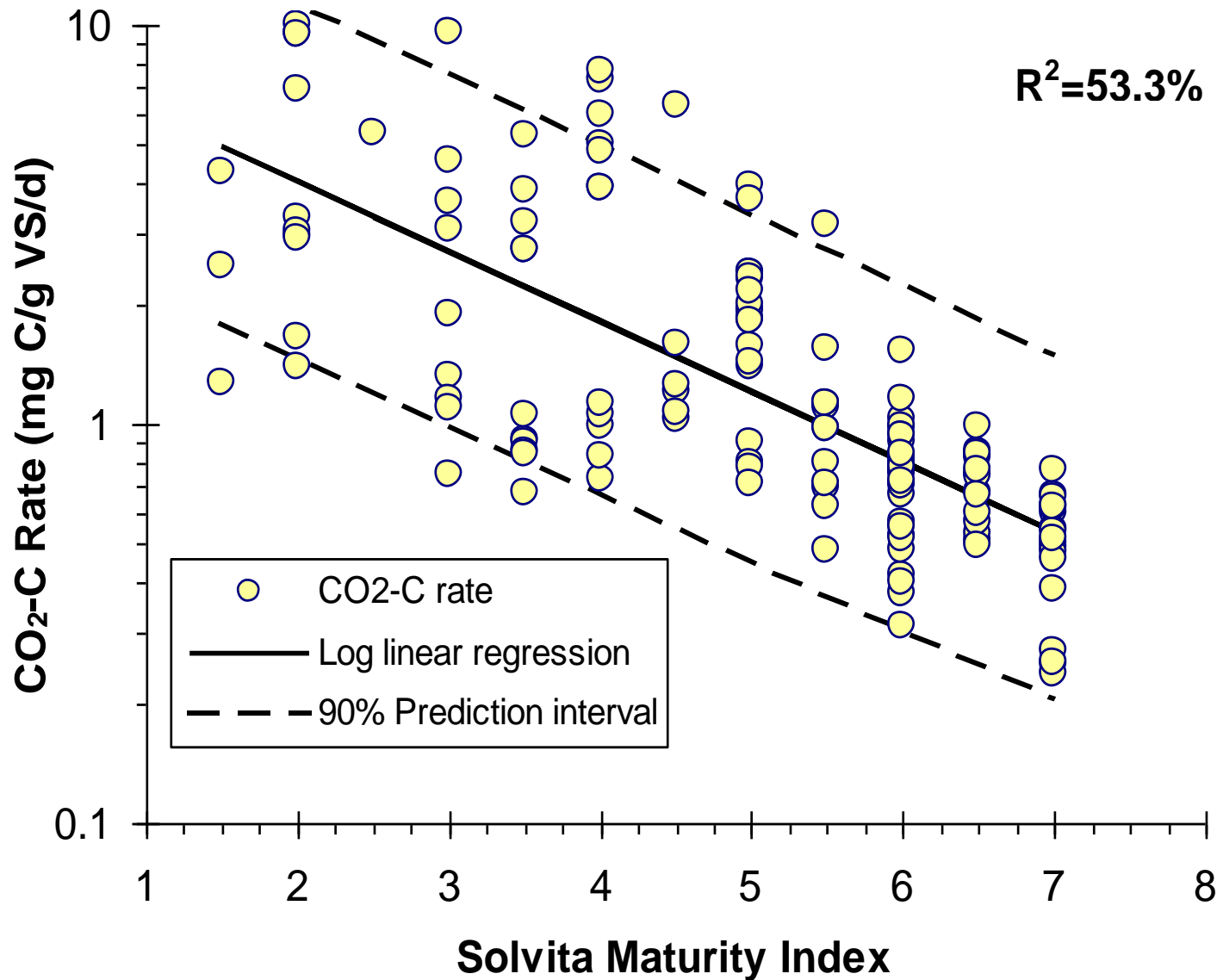
Regression Analysis of Solvita test versus Stability



Correlations between Solvita® test values and various combined characteristics of three different manure composts.

Characteristic	Solvita® CO ₂ test			Solvita® NH ₃ test			Solvita® Maturity Index		
	r	n	P-value	r	n	P-value	r	n	P-value
CO₂ evolution	-0.79	150	<0.0001	0.05	150	0.5093	-0.67	150	<0.0001
Compost age	0.82	150	<0.0001	0.07	150	0.3698	0.82	150	<0.0001
% VS	-0.56	150	<0.0001	0.01	150	0.9312	-0.45	150	<0.0001
C/N ratio	-0.54	150	<0.0001	-0.26	150	0.0012	-0.62	150	<0.0001
Organic C	-0.30	150	0.0002	0.09	150	0.2546	-0.12	150	0.1590
Total N	0.43	150	<0.0001	0.29	150	0.0003	0.57	150	<0.0001
Ammoniacal N	-0.21	150	0.0108	-0.68	150	<0.0001	-0.61	150	<0.0001
Nitrate N	0.25	150	0.0014	0.17	150	0.0356	0.31	150	<0.0001

Use of Solvita Maturity Index to Measure Compost Stability



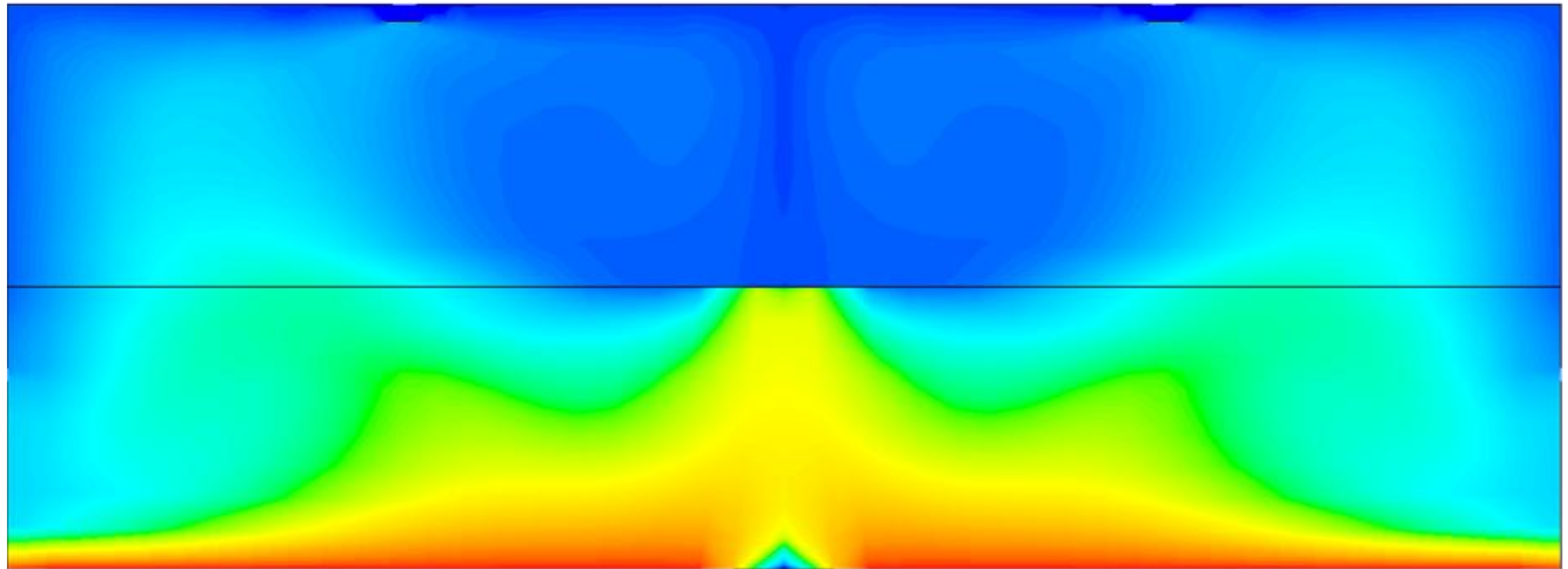
Correlation of compost variables with cucumber dry weight (R²)

	Compost		
Characteristics	Dairy-Straw	Dairy-Sawdust	Hog-Wood
Electrical Conductivity	0.817	0.443	0.242
Compost age	0.814	0.415	0.117
Total N	0.742	0.406	-0.056
Organic C	0.680	0.360	0.010
C/N ratio	0.880	0.295	-0.079
Solvita CO ₂ index	0.767	0.164	0.102
Ash	0.754	0.131	0.123
Solvita NH ₃ index	0.378	0.108	-0.030
CO ₂ respirometry	0.642	0.070	0.167
Solvita maturity index	0.782	0.059	0.092
NO ₃ -N	0.264	0.036	< 0.00
NH ₃ -N	0.209	-0.028	0.182

Measurement and Modeling NH_3 concentration in livestock facilities

NH_3 (ppm)

70
60
50
40
30
20
10
0



Effects of Nutrition and Waste Management Technologies on Pathogens in Animal Excreta



- Enterohemorrhagic and related *E. coli*
- *Salmonella*
- *Campylobacter*
- *Cryptosporidium parvum* (bovine, swine, sheep)
- *Mycobacterium av. Paratuberculosis* (dairy)
- Rotavirus - groups A & B (bovine, swine)
- Calicivirus (bovine, swine)

OARDC Studies of Root Disease Control via Compost



Compost Utilization





Dan Young Fresh Air Farms

