Quality of compost and bedding issues

Compost Bedded Loose
Housing Dairy Barn
Success for the dairyman is based on both the management of the bed and the interaction of the bed and the surrounding managed environment within the structural envelope.
Management of the Bedded Pack
What we have learned from assessment of compost beds
Barn Facility Measurements
Environmental Measurements

- Air temperature, relative humidity, and air velocity and wind direction (0.05 and 1.2 m);
**Bedding Temperature Measurement**

Bedding temperature – surface and two different depths (0.10 and 0.20 m);

**Bedding Moisture Measurement**

Bedding moisture – surface to 0.20 m
Stocking Density

- Stocking Density: ft$^2$/cow
- Adjusted Stocking Density: ft$^2$/cow
- Recommended

Bar chart showing distribution of stocking density categories.
Average Water Holding Capacity = 72.7%

Average Bed Moisture and Air Temperature Over Collection Period

- **Outside Air Temperature (F)**
- **Average Bedding Moisture (%) - wb**

**Collection Date**
- **Outside Temperature F**
- **Bedding Moisture (%) - wb**

- Fall
- Winter

Graph showing the relationship between outside air temperature and average bedding moisture over a collection period from October 5, 2010, to February 7, 2011.
Temporal Compost Bed Monitoring
Stocking Density Effect on Compost Bed Moisture Content

- Fall Bedding Moisture (% - wb)
- Winter Bedding Moisture (% - wb)
Bed Moisture Content Effects on Average Bed Particle Size

Average Bed Particle Size (mm)

Average Bed Moisture Content (% wb)
Temporal Compost Bed Monitoring

Compost Bed Depth Along Length of Barn

Bed Depth - in

0 5 10 15 20 25 30 35


North Center South
Stirring the Bed

2 x per day
religiously

10-12” Stirring Depth
Tillage
How Can You Reduce Bedding Use In Winter

• Allow cow access to pasture in good weather
• Increase air circulation in barn when cows are milking or in pasture
  – But not to point of losing too much bed temperature
• Use kiln dry sawdust in winter, green sawdust during warmer weather
• Stockpile and/or store kiln dry sawdust under roof or tarp
Why Don’t All Packs Work?

- Stocking density
  - too many cows! Poor distribution of cows
- Bed material used
  - straw, cedar
- Insufficient bedding volumes
- Inadequate/ineffective stirring
  - Stirring frequency (less than 2x/day)
  - Depth of stirring (<10-12”)
  - Compaction from tractors
- Starting pack in the late fall/winter
- Too much ventilation in winter
  - no curtains
- Barn design flaws
What we have learned from assessment of barn structural details
Potential Design Flaws

• Not enough space per cow
• Inadequate ventilation
  – Sidewalls too low (<16’)
  – Too close to other buildings
  – Too small ridge opening
  – Poor ridge opening design
  – Fan availability/placement
• Lack of eave overhangs or curtains to block rain and cold wind
• Building orientation
• Walls along pack?

• Proximity to feed
• Not enough feed bunk space (24 to 30” per cow)
• Not enough water space (2 feet of tank perimeter per 15 to 20 cows)
• Cow flow/traffic bottlenecks
• Waterers in pack
• Concrete base?
Barn Ventilation

- Box fans
- High Volume Low Speed Fans (HVLS)
- Natural ventilation
- Tunnel ventilation
## Ridge Design

<table>
<thead>
<tr>
<th>Type</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open ridge with cover</td>
<td>Open Ridge</td>
</tr>
<tr>
<td>Overshot</td>
<td>Hoop structure</td>
</tr>
<tr>
<td>Capped ridge</td>
<td>Capped ridge (n=6)</td>
</tr>
<tr>
<td></td>
<td>Hoop structure (n=2)</td>
</tr>
<tr>
<td></td>
<td>Capped ridge</td>
</tr>
</tbody>
</table>

![Diagram showing types of ridge designs with percentages]

- **Overshot**: 18% (n=8)
- **Open ridge with cover**: 5% (n=2)
- **Hoop structure**: 14% (n=2)
- **Capped ridge**: 58% (n=25)

**Barns = 43**
The smoke was visually observed when it was passed through and over the ridge opening.
Develop CFD model of compost barn

- Wind direction
- Open ridge (OR)
- Closed ridge
- Overshot

Temperature (°C):
- 6.90
- 7.00
- 7.10
- 7.20
- 7.30
Develop CFD model of compost barn
Position in the Landscape

HIGH GROUND:
- To reduce the effects of local obstructions such as trees and other buildings
- Takes advantage of upslope air currents

HILLSIDE CUTS:

DEPRESSIONS:
- In upland wind shadow
- Bowl depression subject to temperature inversions
- Does reduce winter radiation losses to sky
Feedbunk Space

Feedbunk Space - ft/cow

Recommended: 22.5 ft/cow
Waterer Space

No Waterer at barn | < 1 | 1-2 | 2-3.5 | 3.5-4.5 | 4.5-5.25 | > 5.25
---|---|---|---|---|---|---
No Waterer at barn | 30% | 25% | 20% | 15% | 10% | 5%

Recommended

Waterers with Openings - cows/opening
Compost Bedded Pack Success

- Maintain bed temperature for:
  - destruction of pathogens
  - increased moisture vaporization
To generate enough heat --

Need to have a high porosity bed for a level of oxygen to sustain the compost process. (But not too high or too low)

- Bed stirring
- Bedding type
- Bedding particle size
Stirring the Bed

Wheels following tillage tool leads to compaction and lower temperatures

Pulling tillage tool
Moisture Levels

Just right leads to clean, comfortable conditions for cow

Too wet leads to poor conditions and a dirty potentially cold stressed cow

Waterers in bed area can create a too wet condition
Type Bedding
Materials

Sawdust/Shavings

Sawdust
Type Bedding
Materials

Sawdust

Shavings

Sawdust/ Shavings

A

B

C
Type Bedding Materials

Not Recommended

Wood chips

Hammer milled
What are Alternative Bedding Sources

- Efforts underway to increase sawdust supply
- Green vs kiln dried sawdust
- Ground corn cobs
- Finely chopped soy straw/stubble
- Kenaf?
- Peanut shells?
- Other ideas?
- Need more definitive research and producer ideas and cooperation to answer these questions
1:1 Chopped Straw:sawdust

Ground Straw
Some Concerns for Greenhouse Gas Generation
Questions?
Soil Aggregate Microenvironment Model

Distribution of physiological properties within an aggregate/particle. Lines represent isobars of $O_2$ concentration (%). Coyne, 2010.

Typical Soil Aggregate
Roof Pitch

Recommended

[Bar chart showing different roof pitches and the recommended one highlighted]
Barn Orientation

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (N-S)</td>
<td>0%</td>
</tr>
<tr>
<td>NE (NE-SW)</td>
<td>35%</td>
</tr>
<tr>
<td>E (E-W)</td>
<td></td>
</tr>
<tr>
<td>NW (NW-SE)</td>
<td>15%</td>
</tr>
</tbody>
</table>
Side Wall Eave Height

Recommended

Side Wall Eave Height - feet
Ridge Opening to Barn Width Ratio

Apparent Ridge Opening (Compost Barns - inch/10 ft width)
- No Opening
  - > 1
  - > 1 - 2
  - > 2 - 2.5
  - > 2.5 - 3
  - > 3 - 4
  - > 4 - 5
  - > 5 - 6
  - > 6

Effective Ridge Opening (Compost Barns - inch/10 ft width)
- No Opening
  - > 1
  - > 1 - 2
  - > 2 - 2.5
  - > 2.5 - 3
  - > 3 - 4
  - > 4 - 5
  - > 5 - 6
  - > 6

Recommended
Ridge Opening Detail

- Apparent vs Effective -
Compost Bedded Pack

- **Ventilation/Circulation Air**
- **Aerobic Zone**
- **Aerobic/Anaerobic Transition Zone**
- **Anaerobic Zone**

**Depth of Compost Bed**
- 24 to 48”
- 10 to 12”

**Temperature, °F**
- Ambient
- 120 - 140 F

**Soil**
Pack Moisture Control

- Biological activity generates heat which helps to dry the bedding material
- Bedding cannot absorb all the water from urine and manure without evaporation of water
- Too wet of a bedded pack reduces aeration, slows biological activity, slow heat generation and water evaporation
COMPOSTING BED MATERIAL INCREASES WATER EVAPORATION

INCREASING AIR VELOCITY OVER BED MATERIAL INCREASES WATER EVAPORATION