Compost Bedded Pack Management

Multi-State Workshop "Compost Bedded Pack Dairy Barns"

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Compost bedded pack system

Characteristics:

- loose housing
- 3-4 ft bedding
- mechanical stirring

Benefits:

- cow comfort
- cow health
- easy to manage

Design and Management Practices in with Reference to MN Recommendation

Practice	Recommend	FarmD-1	FarmD-2	FarmD-3	FarmD-4
Cow spacing (sq ft)	65-80	75	88	90	80
Concrete wall (ft)	4	4	4	4	3
Sidewall height (ft)	16	16	16	16	14
Bedding type	sawdust	sawdust	sawdust + straw[1]	sawdust	sawdust + straw[2]
Bedding depth (in)[4]	12-48	12-48	12-48	12-48	12-36
Bedding additions	as needed	as needed	as needed	as needed	as needed
Stirring frequency	2 times/day	2 times/day	2 times/day[3]	2 times/day	2 times/day[3]
Feed alley	scrape 2x/day	scrape 2x/day	scrape 2x/day[3]	scrape 2x/day	scrape 2x/day[3]
Pack clean out	6-12 months	12+ months[5]	12 months	12 months	9 months

Keener et al., 2009

Composting Fundamentals

- Done mostly by bacteria and fungi.
- Moisture levels
  - 45% for bacteria
  - 15% for fungi (example is grain spoils above 15% due to fungi)
- Oxygen levels
  - 5% supports aerobic bacteria (doesn't generate offensive odors)
- Temperature
  - at 100 ^{o}F (38 ^{o}C) activity level and heat output of bacteria increases
  - usually takes 2-4 days for compost to self heat, bedded pack longer until moisture adequate for organisms
  - moisture loss increases with air exchange (for every 20 ^{o}F rise, the moisture driven/carried out with air doubles)

Ref.: H.M. Keener, Ohio State University

Materials – Basic Concepts

- Decomposition – heat output

  8000 - 8500 BTU/$lb_{dry\ matter\ loss}$

- Decomposition – water generated

  0.45 - 0.66 lb water/$lb_{dry\ matter\ loss}$

- Decomposition – moisture loss [function of airflow] 4-6 lb water/$lb_{dry\ matter\ loss}$

Ref.: H.M. Keener, Ohio State University

Management Fundamentals

- Water in bedding
  - Up to 60% moisture level, bedding is non sticking, i.e. still appears to be solid, little free water
  - Bedding can hold $(m_{final}-m_{initial})/(1-m_{final})$ *Table next slide.*
  - Water requires 1050 BTU of heat per lb_{water} to evaporate, can come from microbes or from unsaturated air.
    - As 1 lb biomass disappears, 4 lbs of water evaporates if air exchange occurs. Importance of stirring to allow it.
    - Surface drying of bedded pack is critical –want air movement into and out of building.

Ref.: H.M. Keener, Ohio State University

Water Loss with Air Exchange (effect of stirring)

Water Loss relative to dry matter loss in composting (Keener et al, 2000)

- Theoretical 6.8 lb_{water} / $lb_{dry\ matter}$; Measured 4.1 lb_{water} / $lb_{dry\ matter}$

Bedding Initial Moisture	Final Moisture	Bedding Water Uptake	No Stirring (25% dm loss)	Stirring (25% dm loss)
% wb	%wb	lbw/lb_b	lbw/lb_b	lbw/lb_b
			Potential	Potential
10	60	1.25	0.80	1.84
20	60	1.00	0.60	1.52
30	60	0.75	0.40	1.21
40	60	0.50	0.20	0.89
50	60	0.25	0.00	0.58
60	60	0.00	-0.20	0.26

Ref.: H.M. Keener, Ohio State University

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Bedding Initial Moisture	Final Moisture	Bedding Water Uptake	No Stirring (25% dm loss)	Stirring (25% dm loss)
% wb	%wb	lbw/lb_b	lbw/lb_b	lbw/lb_b
			Potential	Potential
10	70	2.00	1.36	2.40
20	70	1.67	1.10	2.02
30	70	1.33	0.84	1.64
40	70	1.00	0.58	1.27
50	70	0.67	0.31	0.89
60	70	0.33	0.05	0.51

Ref.: H.M. Keener, Ohio State University

Dairy Cattle Manure Production

Use OSU Extension 604 Bulletin:

ID	Body Wt	Moisture	Manure/day	Water/day
------	lb	%	lb_{manure}/day	lb_{w}/day
Cow (90#/day)	1400	88	153	135
Cow (50#/day)	1400	88	128	113
heifer	750	88	65	57

GOAL: Calculate amount of bedding needed to absorb water from manure to achieve 70% moisture in manure/bedding.

Ref.: H.M. Keener, Ohio State University

Dairy Cattle Bedding Needs

Bedding Requirements for 88% moisture manure to achieve 60% moisture level

(Water to remove is 0.7 * weight of manure)

Manure Produced	Deposited Bedded Pack	Manure Deposition	water to absorb/loose	Bedding @ 10% moisture	Bedding @ 20%	Bedding @ 40%
lb/day	%	lb/day	lb/day	lb_b/day	lb_b/day	lb_b/day
160	25	40	28	15	18	31
120	25	30	21	11	14	24
80	25	20	14	8	9	16
40	25	10	7	4	5	8
160	50	80	56	30	37	63
120	50	60	42	23	28	47
80	50	40	28	15	18	31
40	50	20	14	8	9	16
160	75	120	84	46	55	94
120	75	90	63	34	41	71
80	75	60	42	23	28	47
40	75	30	21	11	14	24

Ref.: H.M. Keener, Ohio State University

Dairy Cattle Bedding Needs

Bedding Requirements for 88% moisture manure to achieve 70% moisture level

(Water to remove is 0.6 * weight of manure)

Manure Produced	Deposited Bedded Pack	Manure Deposition	water to absorb/loose	Bedding @ 10% moisture	Bedding @ 20%	Bedding @ 40%
lb/day	%	lb/day	lb/day	lb_b/day	lb_b/day	lb_b/day
160	25	40	24	10	12	19
120	25	30	18	8	9	14
80	25	20	12	5	6	9
40	25	10	6	3	3	5
160	50	80	48	20	24	38
120	50	60	36	15	18	28
80	50	40	24	10	12	19
40	50	20	12	5	6	9
160	75	120	72	30	36	57
120	75	90	54	23	27	43
80	75	60	36	15	18	28
40	75	30	18	8	9	14

Ref.: H.M. Keener, Ohio State University

Dairy Cattle Bedding Needs

Bedding Required for cattle to maintain 60% moisture level in manure/bedding

Manure* Produced	**Deposited Bedded Pack**	**Bedding @ 10%**	**Bedding @ 20%**	**Bedding @ 40%**
lb/day	%	lb_b/day	lb_b/day	lb_b/day
160	25	15	18	31
160	50	30	37	63
160	75	46	55	94

*1400 lb cow, 90 lbmilk/day,

Ref.: H.M. Keener, Ohio State University

Dairy Cattle Bedding Needs

Bedding Required for cattle to maintain 70% moisture level in manure/bedding

Manure* Produced	**Deposited Bedded Pack**	**Bedding @ 10%**	**Bedding @ 20%**	**Bedding @ 40%**
lb/day	%	lb_b/day	lb_b/day	lb_b/day
160	25	10	12	19
160	50	20	24	38
160	75	30	36	57

*1400 lb cow, 90 lbmilk/day,

Ref.: H.M. Keener, Ohio State University


Field cultivator


Field cultivator


Chisel plow


Chisel plow

Separation of Feed Alley from Bedded Area

Characteristics of Bedded Pack

PARAMETERS	MEASUREMENT VALUES
Temperature	90° – 120 °F
Oxygen	7 – 9 %
C/N ratio	9-36
ash	9.6 – 52.0 %
pH	7 - 9
N-P-K	1.8-3.3 (N); ~1 (P_2O_5); 2-3 (K_2O)

- T, oxygen, pH indicate composting conditions.
- High variability of C/N and ash due to continuous additions of feces and urine.
- Assuming a 2.5:1:2 N:P:K content and 65% moisture , each ton of wet pack would supply 17.5, 7 and 14 lbs of N, P_2O_5, and K_2O, respectively.

Keener et al., 2009

Recommendations for Ohio

Barn design:

- Spacing: 70-90 sq-ft/cow (900 – 1,400 lbs)
- Concrete wall: 3-4 ft to hold 6-12 months accumulation of bedding and manure
- Feed alley: concrete, 12-ft wide, separated from pack (ideally)
- Waterers: in feed alley along concrete wall
- Ventilation: 14-16 ft side curtain; openings on short sides; overhead fans

Keener et al., 2009

Recommendations for Ohio

Bedding management:

- Type: fine dry sawdust; if supplement with straw, chop & alternate with sawdust
- Depth: initial depth 12-18 in; include bedding from clean out to inoculate for composting; clean out when reach wall height (~12 months)
- Additions: add 1-2 in when bedding sticks to cow after lying down (~10-14 days)
- Stirring: 2x/day to depth of 10-12 in

Keener et al., 2009

Recommendations for Ohio

Manure management:

- Feed alley: scrape 2x/day; separate storage
- Pack: remove every 6-12 months depending on depth and condition (e.g., moisture)

Keener et al., 2009

Recommendations for Ohio

Other considerations

- Pasture: adjust frequency of stirring, bedding additions and alley scraping
- Land application: land apply pack; if C/N ratio exceeds 20:1, may tie up nitrogen

Reference for study:
Keener, H.M, L.Zhao, M. Wicks, M. Brugger, S. Want, J. Rausch, A. Meddles, M. Klingman, R. Manuzon, J. Upadhyay. 2009. Evaluating the Effectiveness of Dairy Bedded Pack Systems in Ohio. Final project report for USDA-NRCS. Submitted December 31, 2009.