Managing Manure from Beef Feedlots for Crop Production

Cattle Feeder's Conference: A New Era of Management June 10-11, 2009

Russ Euken –Extension Livestock Specialist 641-823-2856 or reuken@iastate.edu

Introduction

Cleaning pens and hauling manure for application on crop acres is an expense and can consume considerable time. There is also an opportunity for economic benefit for an operation if manure is managed correctly. Several steps need to be understood and managed to gain value from the nutrients in the manure. Determining the nutrients in manure and the amount of manure to apply are critical to maximize the value of the manure.

Manure production and nutrients

The nutrients excreted in manure will vary with diet, cattle size and performance. The following table shows calculated excretion on a finishing or background diets with two levels of protein and phosphorus in the diets.

Cattle type	Average diet and performance	% CP in diet	% P in diet	Manure and urine excreted/had/day @92% water	Lbs. N excreted /hd/day	Lbs. P excreted /hd/day
Finishing 800- 1250 lbs	20.5 lbs DM intake- .64 NEg 3 lbs. ADG	11%	.36%	66	.32	.07
		16%	.5%	66	.48	.085
Background 500-800 -lbs	14.5 lbs DM intake .5 NEg 2.25 lbs ADG	11%	.3%	55	.22	.035
		14.5%	.4%	55	.33	.055

Most of the nutrients in the manure originate in the feed consumed by the animal. In finishing rations 10-15% of the nitrogen from crude protein fed or the phosphorus fed is retained by the animal on average and the rest is excreted. If larger amounts of protein or phosphorus are in the diet there is more excreted. These amounts can be calculated based on equations developed in the NRC. Spreadsheets that will estimate nitrogen and phosphorus excretion using those equations are listed at the end of this publication.

Facility, management, and environmental effect on manure nutrients and characteristics.

The manure nutrients available for crop application change after the manure is excreted. Facility type and environment will affect how much of the nutrient excreted is captured. This is especially true for nitrogen. Moisture loss and additions from bedding or soil also effects the concentration of nutrients. The nitrogen in manure is in several forms and that form can change over time. One of those forms is ammonia which can volatilize readily under certain conditions. Type of facility and management can affect the amount of volatilization.

Open lots

Open earth lots have potential for a portion of the nitrogen in the ammonia form to volatilize. Research at University of Nebraska accounted for an N loss of 71 % thru volatilization from earth feedlots in the summer.[1] During winter the N loss was 47 %.[1] As more drying occurs on the feedlot surface more ammonia is volatilized.

These volatilization losses can be lowered if pens are cleaned frequently. A Nebraska study showed monthly pen cleaning versus cleaning at the end of a 150 day summer feeding period decreased nitrogen losses from 13 to 18%. [2]

Another method to reduce the volatilization of N is to add bedding or carbon source which helps to immobilize the ammonia. In a University of Nebraska research trial an open earth lot using sawdust bedding increased nitrogen in the manure by 45% during a winter feeding period.[3] The addition of bedding in the summer did not decrease volatilization losses. Increased organic matter in the diet also increased nitrogen in the manure in both summer and winter.

Runoff of nutrients in manure may also occur but if runoff controls are in place the manure and nutrients from the manure can be retained. The nutrient concentrations are typically fairly low and are approximately 2% percent of nutrients captured in the manure but still need to be managed. Depending on rainfall the amount of runoff that needs to be pumped is large compared to the amount of nutrients captured. Irrigation is one method of handling the high volumes.

Bedded confinements

Bedded confinement facilities have the advantage of preventing runoff of manure and reducing volatility of N. A survey of 10 different bedded confinement facilities manure characteristics in 2008 showed consistency in moisture and nutrient concentration as compared to open lots.[4] Although there is moisture loss and some N volatilization it appears to be less than open feedlots, probably because of added bedding and less surface area. Manure volume is also higher therefore nutrient concentration does not appear to be a great deal different than open lots.

Deep pit facilities

A large amount of moisture evaporates in open lots or bedded pens. In a deep pit facility most of that moisture in manure is retained and there is less volatilization of ammonia.

Manure nutrient comparison

The following table shows some comparison of facilities. It is still important to sample manure in your own operation to fine tune manure applications and capture manure nutrients for economic benefit. Values are on a wet basis.

Facility type	% H2O	CV	Total lbs N/ton or /1000 gal	CV	Lbs.P2O5 /ton or/ 1000 gal	CV	Lbs K2O /ton or/ 1000 gal	CV	Tons or gallons /head/yr
Open earth lot-ASABE[5] ISU pub 1867[6]	33%	28%	22	33%	16	36%	14	25%	3.0
Bedded confinement [4]	70%	12%	18.5	21%	10	29%	12	26%	6 calc.
Deep pit [7]	90%	NA	40	NA	25	NA	35	NA	2340

Consistency of nutrients in manure is another issue to consider. Variation in manure from open feedlots can be large. The CV or coefficient of variation provided in the table above give some idea of the variation in the samples represented. The larger the coefficient of variation the more variation exists in the data. A survey of manure nutrients of 10 different bedded facilities shows that consistency of the manure from various locations in the facilities and across operations was lower than open lots and there was no statistical effect of location in the pen or by operation.[4] Data is not available for nutrient variation for pit facilities or concrete open lots but it would be expected that pits would have the lowest variation and concrete open lots somewhere between earth open lots and bedded facilities. With more variation more sampling is required to determine nutrient concentrations.

Concentrations of nutrients do not appear much different in the above table. However how much of the total manure is captured will also make a difference in how much total nutrient is captured. The following table has estimated pounds of manure nutrients excreted per year per animal on feed compared to the estimated amount captured in the manure by type of facility. In an open earth lot the amount of soil removed will affect the quantity of manure. In the bedded facilities the nutrients that would be added from bedding are not included to have a more equal comparison between facilities in nutrient capture.

Manure nutrients excreted per head per year (estimated)

	Nitrogen	P2O5	K2O
Finishing steer 600-1200 lbs	122	68	93

Manure nutrients captured for field application by facility

Facility	Total N lbs/space/year	P2O5 lbs /space/year	K2O lbs/space/year
Open lot- ASAE and ISU	66	48	54
Bedded confinement- w/o nutrient additions from bedding	98	57	58
Deep pit	94	59	82

Sampling and analysis of manure

Sampling manure is not an exact science. Getting a representative sample can be difficult if there are large variations within the lot. For starters in open lots sampling could be done during summer and winter and sample areas that could be contain different nutrient concentrations separately. Maintaining a history of when and where samples are taken and looking at the variation in samples can be a guide in determining when and where samples need to be taken. Getting a good sample involves taking several sub-samples of the area and then combining those to get a representative sample. The sample sent to the lab only needs to be a small sample. In addition to sampling from the pen or lot a sample could be taken from the spreader during application but lab analysis would probably not be available to help make management decisions for that application.

A lab analysis should be done for moisture, Total N, P2O5 and K2O. Adding an analysis for ammonium can help determine what portion of the N is organic and what in inorganic and how much of the N is available to the crop. Ash content of the manure can help determine how much soil is removed in an earth lot.

How to Sample Manure for Nutrient Analysis, PM 1558, is an Iowa State University Extension publication that provides additional information on sampling manure.

Storage of manure

Manure is produced year around and application for row crops basically can occur in spring before planting and in the fall after harvest. Wintertime application of manure may be limited by regulations and environmental precautions and typically prevents incorporation. For pit manure, storage is provided in the pit. The anaerobic environment limits loss of nutrients. Solid manure from an open feedlot or bedded building can be stockpiled following regulations, composted, or land applied. From an economic and environmental standpoint the question becomes, can solid manure be stored economically without nutrient losses between spring and fall periods. Two research trials, one in

Canada and one in Nebraska have compared composting and stockpiling to fresh manure from open beef feedlots. University of Nebraska research comparing nitrogen recovery of stockpiled or composted open beef feedlot manure to fresh scraped manure was 86 % and 56% respectively. [7] 86 % recovery of N in stockpiling would be slightly better than land application without incorporation and also lower opportunity for surface runoff if the stockpile is managed correctly. Building the stockpile so surface exposure is limited will help prevent volatilization and also locate the stockpile away from waterways etc. Composting did provide the advantage of lower quantity of manure to be land applied.

Land application

Once nutrient concentration and consistency is established application to crop land is easier to manage. The availability of nutrients to the crop especially nitrogen and getting a uniform application of manure are keys to the amount of manure to apply.

In beef manure a considerable amount of the N is in organic form which needs to be mineralized to be available to the crop which takes time and the rate depends on a variety of factors. The inorganic N in the manure or ammonium and a portion of the organic N are available to the crop first year of application. Not all the N in the manure should be considered available over time. Phosphorus and potassium can be in several forms in manure. Over the long term all the P and K are expected to be available to the crop.

According to Iowa State University Extension publication, PM 1003, Using Manure Nutrients for Crop production, the following are good estimates to use for availability of nutrients.

Estimates of first year availability of nutrients- PM 1003 Iowa State University

First-year nutrient availability for beef cattle manure – percent of nutrient applied

Nitrogen- 30-40 Phosphorus 60–100 Potassium 90–100

P and K from manure applied on medium to high testing soils should be considered to 100 % available in the year of application. For lower soil tests use the low range of availability in the first year.

N losses due to volatilization at application also need to be considered. The following tables are estimates losses of N to volatilization from application method again from PM 1003.

Nitrogen losses in field application and incorporation timing

Broadcast (liquid/solid) incorporation within 24 hours 1-5 %

Broadcast (liquid) No incorporation 10-25 %

Broadcast (solid) No incorporation 15-30%

Season of application relative to the growing season may affect the amount of mineralization that can occur. Fall application would theoretically allow more time for mineralization than spring application but that has not been shown in research trials.

Calibration and uniformity of manure application

Calibration of the spreader is a critical step in managing manure nutrients. Two methods are commonly used to calibrate a solid manure spreader. Determine the weight of manure applying over a known area gives a general idea of application rate. Using a small sheet of plastic of a known size laid in the spread pattern and weighing the manure on the sheet can help fine tune application rates and determine uniformity of the application. Spread pattern will vary with equipment. Typically a narrow application width will increase uniformity of application. Refer to publication Calibration and Uniformity of Solid

Manure Spreaders, PM 1941, on variation in spread pattern for different spreaders and calibration techniques.

Amount to apply

With most feedlot manure and crop rotations and in this example the amount of phosphorus and potassium applied in the manure will exceed one year crop removal if the manure is applied to meet nitrogen requirements of a corn crop. If a lower rate is applied it takes more time and costs more for application. The key to capturing economic value is to take credit for the nutrients applied when they will be used by the crop or in other words if the nutrients aren't needed they don't have value. Following is an example that follows through the steps in taking value for nutrients applied.

Example of capturing manure value- Assumptions

700 head feedlot 500 head bedded confinement facility and 200 head outside lot.

Amount of manure- 3000 ton of manure from bedded confinement and 600 ton from outside lot 3600 ton total annually

Nutrients analysis of manure per ton 21 lbs N – (8 lbs N available 1st year, 2 lbs 2nd year, and 1 lb 3rd year), 12 lbs P_2O_5, 14 lbs K_2O

5200 lbs of cornstalks harvested per acre in year manure applied

Continuous 180 bu. Corn - - High testing soils maintenance rate applied

Nutrient need - 190 lbs N- 80 lbs P_2O_5, 126 lbs. K_2O- with corn stalk removal

67 lbs P_2O_5, 54 lbs K_2O w/o cornstalk removal

Manure is incorporated within 1 day of application

Commercial fertilizer cost- $.28/lb N, $.55/lb P_2O_5, $.65/lb K_2O

Example - Apply 25 tons of manure/acre every 4 years on 144 acres --- 576 total acres needed

Nutrients applied with manure

500 lbs of total N applied-475 lbs after application loss 190 lbs available 1st year, 47.5 lbs 2nd year and 24 lbs 3rd year, 300 lbs P_2O_5, 350 lbs K_2O

Potential value of manure

Per ton $18.78---$3.08 for N, $6.60 for P_2O_5, and $9.10 for K_2O

Per acre is $73 for N, $165 for P_2O_5, and $227.50 for K_2O for a total of $465.50.

4 years of application rates and value per year

Year 1

	N lbs	P_2O_5 lbs	K_2O lbs	
Manure nutrients available	190	300	350	
Commercial fertilizer applied	0	0	0	
Crop use	190	80	126	Total
Excess or deficient	0	220	224	Value/ yr
Manure nutrients value	$53.20	$44.00	$81.90	$179.10

Year 2

	N lbs	**P2O5 lbs**	**K2O lbs**	
Manure nutrients available	47.5	220	224	
Commercial fertilizer applied	142.5	0	0	
Crop use	190	67	54	Total
Excess or deficient	0	153	170	Value /yr
Manure nutrients value	$13.30	$36.85	$35.10	$85.25

Year 3

	N lbs	P2O5 lbs	K2O lbs	
Manure nutrients available	24	153	170	
Commercial fertilizer applied	166	0	0	
Crop use	190	67	54	Total
Excess or deficient	0	86	116	Value/yr
Manure nutrients value	$6.72	$36.85	$35.10	$78.67

Year 4

	N lbs	P2O5 lbs	K2O lbs	
Manure nutrients available	0	86	116	
Commercial fertilizer applied	190	0	0	
Crop use	190	67	54	Total
Excess of deficient	0	19	62	Value/yr
Manure nutrients value	$0.00	$36.85	$35.10	$71.95

Over the fours the nutrients utilized from manure would equal $415/acre in value or at 25 ton/acre $16.60/ton. The majority of the value is from the P and K applied. N value was $73/acre, P2O5 value was $154/acre and K2O value was $187/acre.

In the above example most of the potential nutrients in the manure were used. If manure was applied again in year 3 commercial N would not need to be purchased but the P and K applied would not have value on those acres since it would not be used. The 166 lbs of commercial N purchased in year 3 would be worth $46.50 which is the savings with manure application in year 3. The P and K from the manure that would not be utilized in year 3 are worth $72, plus the P and K have additional value in the next crop year. Not applying manure on those acres and purchasing commercial N makes economic sense. Manure could be applied at a lower rate along with adding nitrogen in the first year. Operators may choose to do this to help manage N crop needs if N availability in the first year is lower than expected. However applying to much commercial N will reduce the value of the manure but the chances of a lower yield due to not enough N need to be weighed against the cost of commercial N and environmental stewardship.

Heavier rates of manure application makes sense to limit application costs but if the nutrients applied exceed crop needs then manure application needs to be rotated to other fields in subsequent years. If limited to smaller applications due to phosphorus restrictions manure value can still be captured however application costs may increase.

If rotating fields means longer hauls only the time and expense of extra road miles are added. It takes the same amount of cost and time to load and unload the spreader. In most cases the value of the P and K gained by rotating the fields will more than offset the additional road miles. In the above example

assume that half of the 576 acres are with ½ mile of the feedlot and the additional 288 acres are 5 miles down the road. If it takes 40 minutes round trip to go the additional 5 miles is it worth it? If labor is $15 per hour and additional fuel for 40 minutes on the road is 4 gal at $3.00/gal. The cost for time and fuel for the additional 30 minutes per load is $22.00. Assuming 15 ton of manure are hauled per load, 1.66 loads are needed to apply 25 tons per acre. At $22.00 per load the cost per acre is $36.50. The value gained from P and K utilized in year 3 and 4 are worth $144 per acre so the additional value pays for the cost. However, timeliness may be an issue. The additional time to haul 3600 tons of manure the extra 5 miles is 160 hours with 15 ton loads so using equipment to move more tons faster may be beneficial.

Summary

Manure can be a valuable resource but it takes management to capture the value. It is different than commercial fertilizer since it is variable. Understanding the steps in managing manure nutrients and where variation occurs will help capture the potential value of the manure nutrients.

Resources

Spreadsheets to calculate manure value;
Feedlot cattle phosphorus and nitrogen excretion- no charge
http://www.iowabeefcenter.org/content/software_calculator.html
Manure nutrient value calculator- $10 charge
http://www.ipic.iastate.edu/softwarepurchase.html
Several different spreadsheets to calculate nutrient balance, nutrient excretion and use for crop production – no charge
http://water.unl.edu/mmresources/software
Websites
http://www.extension.org/pages/Manure_Nutrient_Management_Articles
http://www.iowabeefcenter.org/

References:

[1] 2006 Nebraska Beef Cattle Report- Summary of Manure Amounts, Characteristics, and Nitrogen Mass Balance for Open Feedlot Pens in Summer Compared to Winter- Kissinger, Erickson, Klopfenstein
[2] 2004 Nebraska Beef Cattle Report- Impact of Cleaning Frequency on Nitrogen Balance in Open Feedlot Pens-Wilson, Erickson, Macken, Klopfenstein
[3]2003 Nebraska Beef Cattle Report- Effect of Organic Matter Addition to the Pen Surface on Feedlot Nitrogen Balance Adams, Erickson, Klopfenstein, Macken, Wilson
[4]2009 Animal Industry Reports – A Survey of Manure Characteristics from Bedded Confinement Buildings for Feedlot Beef Production - Progress Report- Euken
[5]ASAE D384.2 March 2005 Standards Manure Production and Characteristics – Table 19 As removed Manure Production and Characteristics Beef Earthen Lot
[6] PM 1867 Beef Feedlot Systems manual – Iowa State University Extension Publication Lawrence, Edwards, Shouse, Loy
[7]Iowa Department of Natural Resources Appendix A Manure Management Plan forms