VARIABILITY OF MANURE NUTRIENT CONTENT AND IMPACT ON MANURE SAMPLING PROTOCOL

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ABSTRACT

Beef feedlots and other confined animal feeding operations in Colorado produce large amounts of manure. Before we can promote manure testing we need to understand the variability within stockpiles to know how many subsamples are necessary for accurate analyses. We also want to develop a database of manures from Colorado. Over 150 samples, representing seven types of manure and compost, were collected and analyzed for nutrient and dry matter (d.m.) content. For beef manure, d.m. content was least variable, followed by N, P and K; NH_4 and NO_3 were the most variable. Nutrient and d.m. contents of the beef manure differed from those currently used in extension publications based on older, Midwestern data. The Colorado samples had higher d.m., P, and K contents. Variability among samples shows that 10% error in manure analyses can be achieved for total N with 17 subsamples per stockpile, 20 subsamples would be required for P, 32 for K, 121 for NH_4, and 692 subsamples for NO_3. Other types of manure and compost showed similar variability.

INTRODUCTION

Nutrient management programs throughout the U.S. encourage farmers to sample and analyze animal manure prior to land application. We wanted to test whether manure sampling made sense. How great is the variability of nutrient contents in manure? How many sub-samples do we need to have confidence in our results? Is sampling really better than using table values? Does the semi-arid Colorado climate cause manure composition to be different from other regions?

The objectives of this study were to: 1) compare the variability and nutrient contents of various animal manures; 2) determine how many sub-samples are needed to achieve 10% probable error in N, P, K, NH_4-N, and NO_3-N concentrations in manure; 3) compare Colorado manure sample results with those used in our Best Management Practices tables; 4) evaluate manure variability and its implications for manure sampling and nutrient management.

MATERIALS AND METHODS

Over 150 samples representing seven different manure and compost types were collected throughout eastern Colorado during the summer of 1996. A minimum of six different manure sources, and a maximum of ten, were sampled for each manure type. In each case, six sub-samples were taken from different parts of a stockpile and composited for analysis. In addition, one source of each manure type was sampled intensively with ten sub-samples collected from a stockpile and analyzed separately. Two samples were taken from the top and two from each side (N, S, E, W) of each stockpile. In each pair of samples, one was taken shallowly (30 cm) and one deeply (100 cm) and one was taken from the bottom of the pile and one from the middle of the pile (for samples tal from the sides).

The water content of the manure samples was determined gravimetrically, total N v determined by combustion using a Carlo Erba total C and N analyzer (Schepers et al., 1989), a inorganic N was determined with a 1 M KCl extract in an in-flow injection analyzer using stand colorimetric procedures. For P and K, the samples were digested using nitric and perchloric ac and analyzed by inductively coupled plasma (ICP) (Self and Rodriguez, 1997).

To determine the number of subsamples needed we used the equation, $n_{est} = t^2\ CV^2/$| where *t* is Student's t value for 95% confidence intervals, *CV* is the coefficient of variation of 10 su samples from one stockpile, and *p* is the percent probable error (0.10) (Petersen & Calvin, 198

RESULTS

Nutrient contents of various manure types

Average dry matter content varied from 0.54 in solid dairy manure to 0.78 in horse man (Table 1). Average total N content of the manures and composts (dry mass basis) varied from 1. in composted dairy manure and horse manure to 2.8% in turkey compost. Phosphorus cont averages varied from 0.4% in horse manure to 2.6% in composted turkey manure. Average K lev ranged from 1.9% in horse manure to 2.8% in turkey compost. Ammonium content averages ran from 240 mg/kg (dairy compost) to 7220 mg/kg (chicken manure). Average NO_3 levels varied fr 10 mg/kg (chicken manure) to 957 mg/kg (turkey compost).

Composted turkey manure had the highest average values for most nutrients. Horse man had the lowest average contents for most nutrients and the highest dry matter content.

Variability and number of subsamples required

The variability of samples within a stockpile differed for the various constituents (Table The coefficient of variation (CV) for total N ranged from 5% for dairy compost to 33% for chick manure. Variation in P ranged from 10% CV (dairy compost) to 31% (dairy manure); K from 1 CV (turkey compost) to 48% CV (dairy compost). Dry matter content generally had the le variability while NH_4 and NO_3 had the greatest.

To characterize a beef manure stockpile for total N content it would be necessary to inclu 17 subsamples in an analysis to achieve 95% confidence at 10% error (Table 2). To characteriz beef manure stockpile for other nutrients would require 20 subsamples for P, 32 for K, 121 for N and 692 subsamples for NO_3.

The number of subsamples needed to achieve 10% error for total N ranged from 1 (da compost) to 55 (chicken manure). For P, required subsamples ranged from 5 (dairy compost) to (dairy manure), while for K the range was from 13 (turkey compost) to 119 (dairy compost). T lowest variability was with dry matter content, which required 2 (dairy compost) to 43 (chick manure) subsamples to characterize a stockpile. Ammonium and NO_3 characterization wo require the greatest number of subsamples; NH_4 would require 92 (dairy compost) to 443 (chick manure), and NO_3 would require 191 (dairy compost) to 1914 (dairy manure).

Compare Colorado data to Midwestern data

The manures sampled from Colorado producers and feedlots differed in comparison with those currently used in our extension publications, which originated from sources in the Midwest (Louden, 1985). On a dry-mass basis the total N and NH_4 contents were consistently lower among the CO samples (Table 3a). Phosphate content was higher among the CO manures in three out of five cases, in the other two cases the contents were about equal. Potash was higher in the CO samples in three out of five manures, for the other two manures the Midwest samples were higher.

The dry matter contents of the CO manures were consistently higher than those from the Midwest (Table 3b). On a fresh-weight basis the CO manures had higher total N contents in four out of five cases. Ammonium was lower in all of the Colorado manures on a fresh-weight basis. Colorado P_2O_5 and K_2O contents were higher for all manure types.

DISCUSSION

We compared our survey results with those currently used in our Best Management Practices (BMP) manual, which are from more humid (Midwest) areas. The Colorado samples had considerably higher dry matter content due to our semi-arid climate. The phosphate and potash concentrations on a dry-mass basis were higher in the Colorado samples, perhaps due to changes in feed digestibility, breeding, and other management factors. On a fresh-weight basis these content differences were also greater since the P and K became more concentrated with the greater evaporative losses in Colorado.

On a fresh-weight basis, total N contents in the Colorado samples were higher for all manure types, except chicken manure. Ammonium contents in the CO samples were consistently lower. This might be explained by greater volatilization in the CO climate. Much of the difference in total N between CO and Midwestern samples is probably due to the CO samples' lower NH_4 contents combined with the concentration of organic N which occurs because of the greater evaporation rates in CO. Differences in P_2O_5 and K_2O contents are partly explained by the differences in dry matter content. Some differences, as seen in the dry-mass basis data, may be due to management, diet, and breeding.

The variation in nutrient contents among samples within a stockpile indicate that representative samples require large numbers of sub-samples. To achieve levels of 10% error with a beef manure stockpile one would need 17 sub-samples for total N, 20 sub-samples for P, 32 for K, 121 for NH_4, and 692 sub-samples for NO_3. In other words, it is feasible to accomplish 10% error in estimating the total N in a beef manure stockpile but, if we want to know the NH_4 and NO_3 levels in order to predict N availability to crops, the required sub-sample number becomes impractical. The other manure types have similar variability.

Given the variability of inorganic forms of N in manure stockpiles and the impractical number of subsamples required for an accurate characterization, we propose to base N availability estimates from manure solely on total N content, together with a regular program of soil testing. We are evaluating the pre-sidedress nitrate soil test (PSNT) with this in mind. With lower concentrations of NH_4 our "rules of thumb" for estimating available N from total N content may need to be adjusted from those developed in more humid environments.

The cost of analyses and difficulty of sampling will make "book values" of manure nutrient contents an attractive option for some. We propose to develop a larger database of manure nutrient contents to provide reasonable estimates for determining application rates. These estimates, combined with regular soil testing, may be appropriate management practices for optimum crop production and environmental protection.

CONCLUSION

- Average dry matter contents varied from 0.54 to 0.78 among manure types. Nutrient contents varied among manure types; within types there were large ranges in concentrations.
- Twenty to thirty subsamples are required to characterize a manure stockpile, within 10% error, for total N, P, and K.
- To characterize NH_4 or NO_3 would require hundreds of subsamples and is impractical.
- Colorado manure stockpiles were drier than the Midwest manures that we have used for our extension recommendations. Colorado manures had much lower ammonium contents. On fresh-weight basis, Colorado manures contained higher levels of P and K; most Colorado manure types contained slightly higher levels of total N.
- We challenge the common practice of separating organic and inorganic N forms for prediction of mineralization rates, due to the large variability in NH_4 levels and the very low NH_4 contents.
- We propose to develop a database of Colorado manures to assist growers who are not able to collect representative samples due to the cost of analyses, difficulty of sampling, and the large number of subsamples required. Using book values and regular soil testing, perhaps including the pre-sidedress nitrate test, may be the best management option for optimum crop production and environmental protection.

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Table 1. Nutrient Content of Colorado animal manure stockpiles (dry mass basis).

Material		n	D.M.	N	P	K	NH_4-N	NO_3-N
				----- % ------			-------- mg/kg --------	
Manures								
Beef		11						
	Avg		**0.68**	**1.7**	**0.7**	**2.5**	**2346**	**50**
	Max		0.80	2.3	1.1	5.4	4484	471
	Min		0.48	1.0	0.1	1.3	261	2
Dairy		8						
	Avg		**0.54**	**1.3**	**0.6**	**2.6**	**1407**	**86**
	Max		0.59	1.8	0.9	3.6	3024	478
	Min		0.48	0.7	0.3	1.4	190	3
Horse		9						
	Avg		**0.78**	**1.2**	**0.4**	**1.9**	**728**	**286**
	Max		0.90	1.6	0.5	2.4	2628	1298
	Min		0.67	0.6	0.2	1.1	62	1
Sheep		9						
	Avg		**0.69**	**2.1**	**0.8**	**2.3**	**1708**	**449**
	Max		0.76	2.9	1.2	2.8	3515	2406
	Min		0.63	1.9	0.6	1.5	840	2
Chicken		8						
	Avg		**0.60**	**2.6**	**2.4**	**2.7**	**7220**	**10**
	Max		0.71	5.4	3.1	3.2	12150	17
	Min		0.44	1.2	1.6	2.3	4260	5
Composts								
Dairy		6						
	Avg		**0.69**	**1.2**	**0.6**	**2.3**	**240**	**428**
	Max		0.76	1.4	0.8	3.0	441	523
	Min		0.64	0.9	0.1	0.8	107	221
Turkey		6						
	Avg		**0.68**	**2.8**	**2.6**	**2.8**	**2891**	**957**
	Max		0.72	3.5	3.0	3.5	4571	1483
	Min		0.63	2.1	2.2	2.0	1916	330

Table 2. Number of subsamples needed to characterize Colorado animal manure stockpiles within 10% error at 95% confidence interval (coefficient of variation is given in parenthesis on a percentage basis.)

	% N	**% P**	**% K**	**NH_4-N**	**NO_3-N**	**% D. M.**
	-------- number of subsamples needed ---------					
Beef manure	17	20	32	121	692	3
	(18)	(20)	(25)	(49)	(116)	(8)
Dairy manure	19	49	14	255	1914	22
	(19)	(31)	(17)	(71)	(194)	(21)
Horse manure	17	11	14	211	802	12
	(18)	(15)	(17)	(64)	(125)	(16)
Sheep manure	13	23	19	360	688	7
	(16)	(21)	(19)	(84)	(116)	(12)
Chicken manure	55	31	27	443	147	43
	(33)	(25)	(23)	(93)	(54)	(29)
Dairy compost	1	5	119	92	191	2
	(5)	(10)	(48)	(43)	(61)	(6)
Turkey compost	40	26	13	128	440	2
	(28)	(23)	(16)	(50)	(93)	(7)

Table 3a. Comparison of solid animal manures from Colorado and Midwest (dry-mass basis).

Manure type		n	DM	Total N	NH_4-N	P_2O_5	K_2O
				------------- lb / ton -------------			
Beef							
	Colorado	11	0.68	34	4	35	60
	Midwest		0.52	40	13	27	50
Dairy							
	Colorado	8	0.54	24	4	30	63
	Midwest		0.18	50	22	22	56
Horse							
	Colorado	9	0.78	24	1	18	46
	Midwest		0.46	30	9	9	30
Sheep							
	Colorado	9	0.69	42	3	38	55
	Midwest		0.28	64	18	39	93
Chicken							
	Colorado	8	0.60	50	13	107	65
	Midwest		0.45	73	58	107	76

Table 3b. Comparison of solid animal manures from Colorado and Midwest (fresh-mass basis).

Manure Type		n	DM	Total N	NH_4-N	P_2O_5	K_2O
				-------------lb/ton---------------			
Beef							
	Colorado	11	0.68	23	3	24	41
	Midwest		0.52	21	7	14	26
Dairy							
	Colorado	8	0.54	13	2	16	34
	Midwest		0.15	9	4	4	10
Horse							
	Colorado	9	0.78	19	1	14	36
	Midwest		0.46	14	4	4	14
Sheep							
	Colorado	9	0.69	29	2	26	38
	Midwest		0.28	18	5	11	26
Chicken							
	Colorado	8	0.60	30	8	64	39
	Midwest		0.45	33	26	48	34