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Should Producers Test Solid Dairy Manure and Dairy Manure Compost Before Land Application?

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Introduction

IDAHO'S DAIRY INDUSTRY IS STRONG, ranking third in the nation in milk production. In 2019, the state's 437 dairy operations contained about 586,000 milk cows (Idaho Dairymen's Association 2019) and produced 15,631 million pounds of milk or 8% of US milk production.

Prolific milk production generates substantial amounts of dairy manure each year in Idaho. Based on data compiled by the Livestock and Poultry Environmental Learning Community (2019), a mature dairy cow weighing 1,400 pounds can generate around 120 pounds of feces and urine daily, an average as-excreted solids content of about 12%. Because manure is a natural and superior fertilizer source, we've taken a closer look at its properties both as solid manure and manure compost.

Depending on herd size and site setup (open lot, free stall barn, or a combination of both), Idaho dairies apply different manure-handling methods such as flushing, vacuum truck, and scraper systems, etc. Typically, two different manure streams result from this handling: liquid and solid manure. Our survey targets solid manure, which refers to open-lot scrapings, corral scrapings, settling basin solids, inclined screen–separated solids, centrifuge-separated solids, and lagoon sludge. These solids are typically either composted or stockpiled until they are applied to croplands in the fall or spring.

Dairy manure and dairy manure compost contain nutrients and organic components that benefit soil and crops. These by-products, when used as a soil amendment, improve the soil's physical, chemical, and biological properties by providing essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K), and they enhance the microbial population necessary to increase soil nutrient cycling.

Regulations and good stewardship require that producers apply manure to their fields at a rate that matches crop nutrient needs. The pacing ensures that their fields will realize the maximum advantage created by the intermixture of manure nutrients while also minimizing the negative environmental impacts associated with manure applications. By properly utilizing and monitoring manure nutrients, both dairy and crop producers benefit from dairy manure.

The Study

Objective

The objective of this study is to survey solid dairy manure and manure compost nutrients to better understand the fertilizer value of dairy manure and dairy manure compost. More importantly, this publication intends to show that (1) nutrients in both dairy manure compost and stockpiled dairy manure differ among dairies due to variations in animal diet and manure-handling and -storage practices and that (2) manure sampling and nutrient analysis before land application are important, so that producers can make better use of manure nutrients—thus potentially reducing commercial fertilizer use.

Materials, Methods, and Results

We chose fourteen commercial dairies ranging in size from 300+ to 8,000+ head located in southern Idaho and visited them between May 14 and June 6, 2018, to collect either manure compost or stockpiled manure samples. At each dairy site, we collected at least three samples from compost or manure stockpiles. Each sample contained a mixture of materials collected from three different locations of the compost pile or manure stockpile. We immediately sent the collected samples to a commercial laboratory to analyze their properties (Tables 1 and 2).

Table 1. Summary of properties of thirty-three dairy manure compost samples from eleven dairies.

Characteristic	Median	Minimum	Maximum
Total N	13.64	7.24	30.40
Total C	137.24	79.78	292.32
C:N ratio	10.30	6.60	14.70
Nitrate-N	0.62	0.01	3.65
P_2O_5	13.25	6.93	29.91
K_2O	22.44	8.67	51.50
Calcium	34.12	10.13	63.94
Magnesium	12.09	5.90	20.49
Sulfur	4.26	2.64	8.00
Zinc	0.11	0.05	0.40
Iron	12.63	3.33	18.23
Manganese	0.15	0.05	0.22
Copper	0.04	0.00	0.15
Boron	0.01	0.00	0.07
Sodium	4.34	1.38	10.71
pH	9.30	7.60	9.90
Salts as EC, mmhos/cm	6.50	2.10	13.40
Dry Matter	1436.00	628.00	1716.00

Note: reported lb/ton on As Received Basis.

Table 2. Summary of properties of eighteen stockpiled dairy manure samples from six dairies.

Characteristic	Median	Minimum	Maximum
Total N	11.20	8.80	25.78
Total C	170.25	109.57	323.74
C:N ratio	13.35	8.30	19.40
Nitrate-N	0.01	0.00	0.25
P_2O_5	6.71	4.74	16.55
K_2O	17.42	9.02	41.33
Calcium	13.99	8.79	39.15
Magnesium	4.33	3.42	11.82
Sulfur	2.17	1.41	6.20
Zinc	0.04	0.00	0.25
Iron	3.23	0.87	6.12
Manganese	0.04	0.00	0.11
Copper	0.01	0.00	0.02
Boron	0.02	0.00	0.04
Sodium	2.93	1.02	7.69
pH	8.80	7.80	9.70
Salts as EC, mmhos/cm	10.25	7.40	15.10
Dry Matter	575.00	370.00	1190.00

Note: reported lb/ton on As Received Basis.

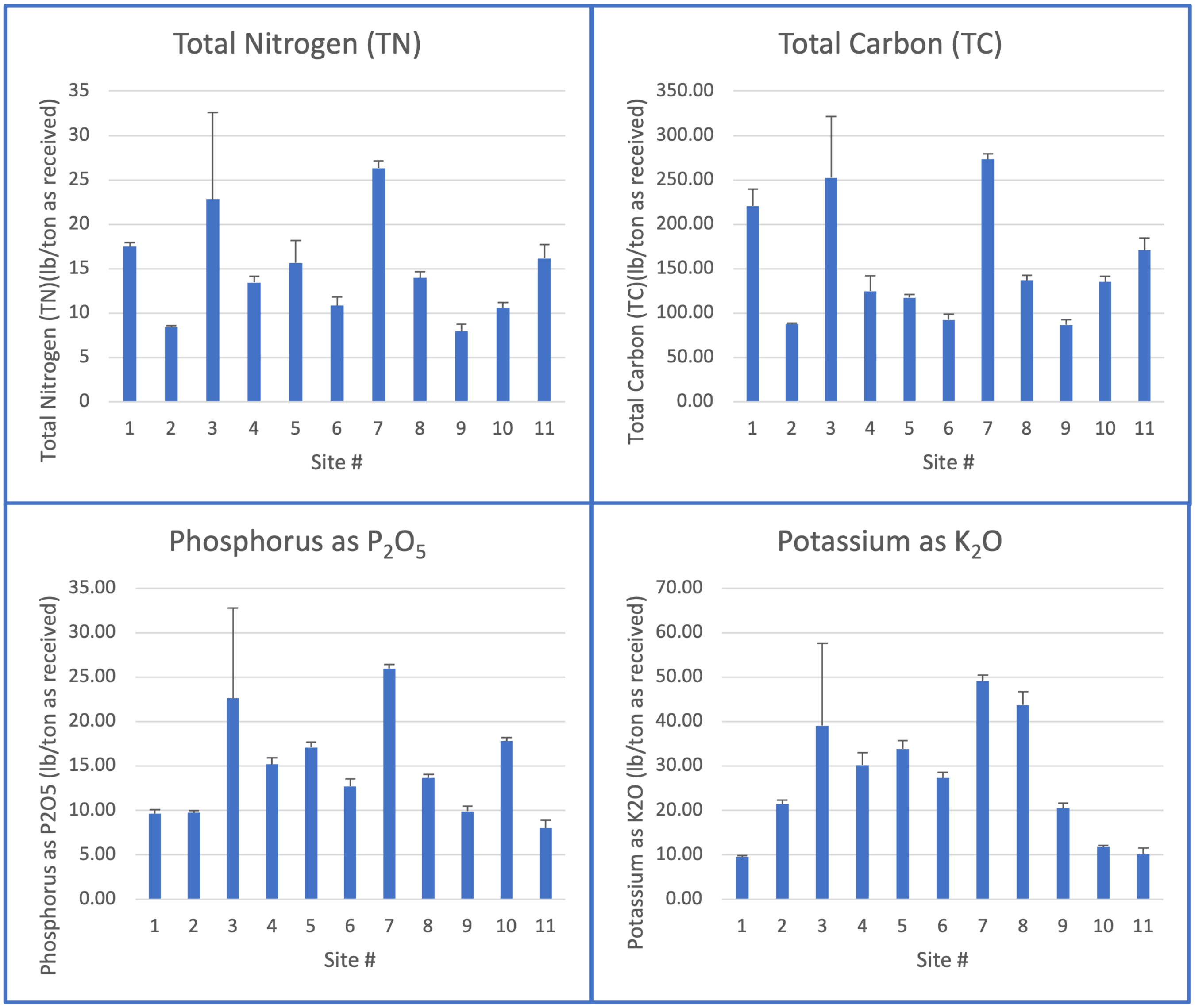

Figure 1. Average values of total nitrogen (top left), total carbon (top right), phosphorus (bottom left), and potassium (bottom right) in composted manure samples collected from eleven dairies. Whiskers represent standard deviations (SD) of three replicates.

Values of total nitrogen (TN), total carbon (TC), phosphorus (reported as P_2O_5), and potassium (reported as K_2O) in the dairy manure compost and stockpiled dairy manure samples are shown in Figures 1 and 2.

Observations

For both manure compost and stockpiled manure, nutrient values varied widely between dairy sites. For example, compost K concentration, which is reported as K_2O, on site 7 was almost five times of that of the compost on site 1. For stockpiled manure, K_2O concentration on site 6 was about four times the value of the manure on site 5. Similar variations in nutrient value were found in the other nutrients tested. Nutrient values of samples collected from a larger compost pile varied even on a single dairy site. For example, TN, TC, P_2O_5, and K_2O concentrations had larger differences, indicated with a long whisker in Figure 1, in three of the compost samples from site 3's compost pile. These larger nutrient differences suggest that increasing sample numbers are needed for larger compost piles and manure stockpiles to get better nutrient results.

While it is important to consider how much N is applied with stockpiled or composted manure, these products are relatively low in N when compared to crop N need. Due to their relatively high

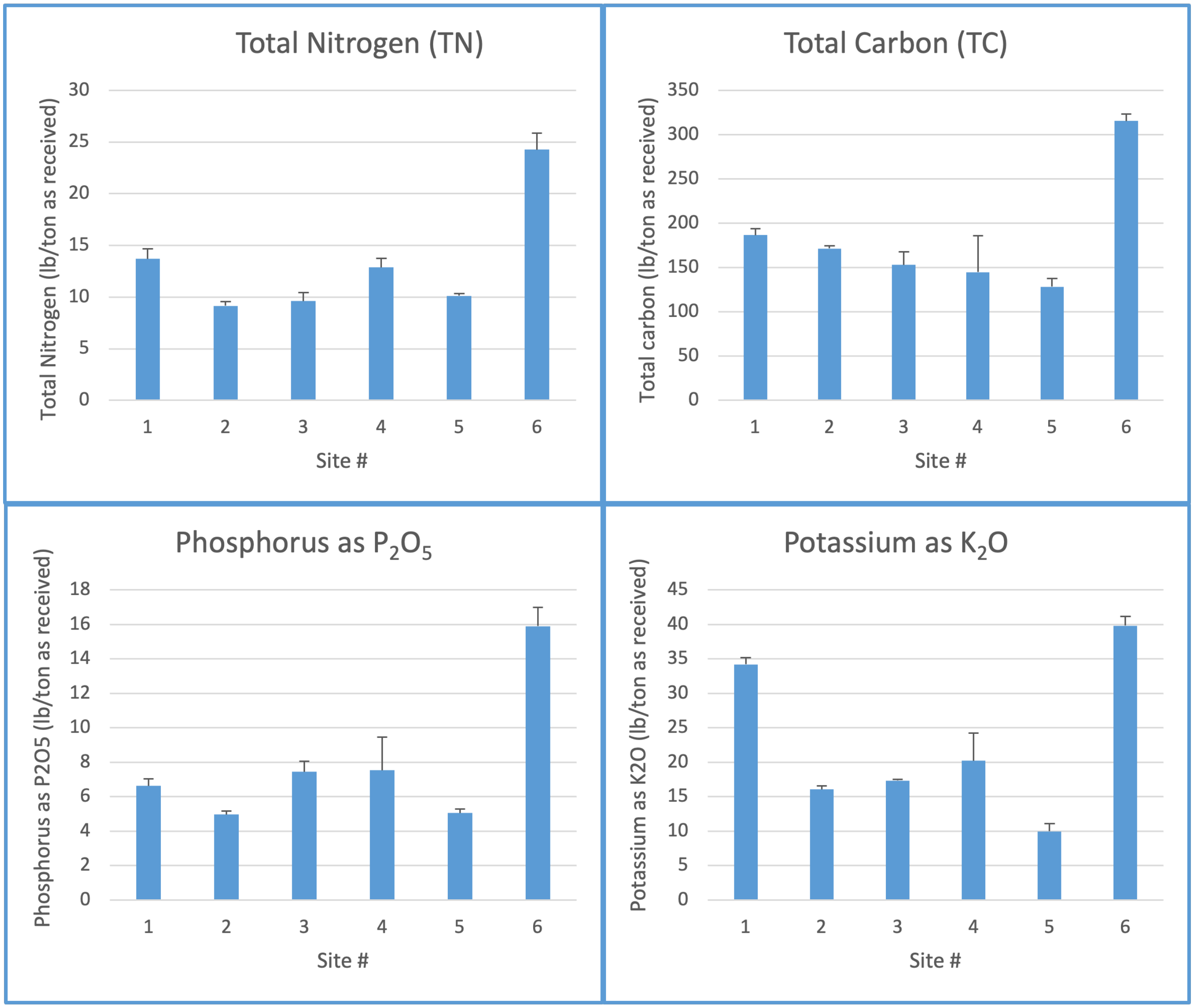

Figure 2. Average values of total nitrogen (top left), total carbon (top right), phosphorus (bottom left), and potassium (bottom right) in stockpiled manure samples collected from six dairies. Whiskers represent standard deviations (SD) of three replicates.

concentrations of P and K, manure products make excellent fertilizers. However, variations in animal diet, manure handling, and storage practices result in differing nutrient contents in manure and manure compost on dairies. Using the latest data set available of average crop input costs from the University of Idaho, the fertilizer value of stockpiled and composted manure was calculated for each dairy site (Tables 3 and 4) (Patterson et al. 2016). It is important to note that these valuation calculations do not include the cost of acquiring stockpiled or composted manure, transportation costs, or equipment costs. The calculation puts a value on the product based on its ability to replace inorganic fertilizer.

In general, manure compost had higher nutrient values compared to stockpiled manure, except TC and salts as electrical conductivity (EC). Stockpiled manure median TC value was about 8.5% and manure compost median TC value was about 6.9%. Both manure compost and stockpiled manure are good C sources for soils given the fact that soil organic matter in southern Idaho is low, ranging between 1.5% and 3%.

Determining manure and manure compost nutrient contents prior to land application can potentially result in significant fertilizer savings (Tables 3 and 4). For example, let's say a field needs 80 lbs of P_2O_5/acre for sugar beet production (based on soil tests).

Table 3. Fertilizer values of composted manure relative to common P and K inorganic fertilizers from samples collected from eleven dairies.

Dairy Site	Average P_2O_5 of composted manure (lb/ton)	Fertilizer Value for Dry Phosphate (11-52-0)[1] ($/ton)	Value for Liquid Phosphate (10-34-0)[2] ($/ton)	Average K_2O of composted manure (lb/ton)	Fertilizer Value for Potassium (0-0-60)[3] ($/ton)
1	9.6	5.09	6.91	9.5	4.18
2	9.8	5.19	7.06	21.4	9.42
3	22.7	12.03	16.34	39.1	17.20
4	15.2	8.06	10.94	30.3	13.33
5	17.1	9.06	12.31	33.9	14.92
6	12.7	6.73	9.14	27.3	12.01
7	26.0	13.78	18.72	49.2	21.65
8	13.7	7.26	9.86	43.8	19.27
9	9.9	5.25	7.13	20.6	9.06
10	17.8	9.43	12.82	11.8	5.19
11	8.0	4.24	5.76	10.3	4.53

[1]Assumes the cost of dry phosphate (11-52-0) is $0.53.

[2]Assumes the cost of liquid phosphate (10-34-0) is $0.72.

[3]Assumes the cost of potassium (0-0-60) is $0.44.

Table 4. Fertilizer values of stockpiled manure relative to common P and K inorganic fertilizers from samples collected from six dairies.

Dairy Site	Average P_2O_5 of stockpiled manure (lb/ton)	Fertilizer Value of Dry Phosphate (11-52-0)[1] ($/ton)	Value for Liquid Phosphate (10-34-0)[2] ($/ton)	Average K_2O of composted manure (lb/ton)	Fertilizer Value for Potassium (0-0-60)[3] ($/ton)
1	6.6	3.50	4.75	34.2	15.05
2	5.0	2.65	3.60	16.1	7.08
3	7.5	3.98	5.40	17.3	7.61
4	7.5	3.98	5.40	20.2	8.89
5	5.1	2.70	3.67	10.0	4.40
6	15.9	8.43	11.45	39.8	17.51

[1]Assumes the cost of dry phosphate (11-52-0) is $0.53.

[2]Assumes the cost of liquid phosphate (10-34-0) is $0.72.

[3]Assumes the cost of potassium (0-0-60) is $0.44.

Your neighbor, dairy site 1, had some compost available, which you used to meet crop P needs and increase soil C for soil health purposes. By testing the composted manure before application, you know that you need to apply about 8.5 tons/acre. The strategy saves you $5.09 per acre in inorganic fertilizer costs. However, if dairy site 3 is next to you, you'd only need to apply 3 tons/acre, which would not only save you $18.72/acre in fertilizer costs but also would help you save on transportation and application expenses. By testing, you'd also know how much nitrate-N was applied, which is important to know for all crops but especially so for sugar beet production given that excess available soil N near the end of the growing season can reduce sucrose concentrations in harvested sugar beets.

Manure compost had much higher dry matter content (1,436 lb/ton) compared to stockpiled manure (575 lb/ton). This is not surprising as the composting process dramatically reduces manure moisture and volume, resulting in concentrated nutrients. Other benefits of composting include fewer viable weed seeds and less pathogens. In general, composting is a practical way to overcome some of the barriers of the land application of manure, such as high transportation costs due to high water content, low nutrient density, non-uniform nutrient composition, presence of weed seeds, and potential pathogens.

Summary

Due to variations in animal diet and manure-handling and storage practices, nutrients in both the dairy manure compost and stockpiled dairy manure differ among dairies. Sampling and analyzing manure and compost before land application are important strategies to better utilize manure nutrients in cropping systems. The practices also may significantly reduce commercial fertilizer usage. Lastly, both manure compost and stockpiled manure are good sources of organic C, which additionally benefits crop production and soil health.

Further Reading

Idaho Dairymen's Association. 2019. 2019 Industry Profile. Twin Falls, ID: Idaho Dairymen's Association. 32 p.

Livestock and Poultry Environmental Learning Community (LPELC). 2019. "Liquid Manure Storage Ponds, Pits, and Tanks." https://lpelc.org/liquid-manure-storage-ponds-pits-and-tanks/#:~:text=Dairy cattle generally generate larger,content of around 12 percent. Accessed 18 January 2021.

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