DETERMINING NUTRIENT RELEASE CHARACTERISTICS OF VARIOUS MANURES

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Justification for Research:

Using manure as a nutrient source can be more complicated than using commercial fertilizers since the nitrogen (N) and phosphorus (P) content can vary depending on species, storage and treatment methods, and application techniques. Farmers, particularly those that grow sugarbeets, are also concerned about when the nutrients are released in the growing season which changes depending on soil types and weather. Despite concerns, there are other benefits of manure beyond being a source of N and P, including improving soil health and providing micronutrients. Plus, the up and down price swings of the commercial fertilizer market make manure more attractive, especially if a farmer has a consistent supply which can offset fertilizer costs.

To help farmers understand nutrient management with manure, the University of Minnesota developed recommendations to help determine N and P credits for a variety of manures. These recommendations were developed several decades ago, however, and since that time the diets of animals, storage of manures, and manure application equipment have changed. As one example, the recommendations to determine N availability treat all dairy liquid manure the same. However, some dairies have implemented technology to separate the solids from the liquids, thus changing the nutrient dynamics of the manure. Will liquid separated dairy manure have the same N availability as unseparated liquid dairy? For both N and P, are there differences in mineralization across soil types? These questions are particularly important for sugarbeet growers due to the effect late season N availability in the soil has on the sugar content of their crop. Our goal is to better understand N and P release from manure so that farmers are able to make better decisions about when to apply manure in their rotation to maximize benefits while reducing fertilizer costs.

Summary of Literature Review:

Understanding N availability in manure is complicated. The amount that is available will depend on the animal species that made the manure, what kind of bedding (if any) was used, how the manure was treated and/or stored, and how the manure was applied. The University of Minnesota has recommendations for what to expect for N availability (Hernandez and Schmitt 2012), but may need updated since there are new manure handling technologies and feeding and bedding strategies being used today. For example, Russelle et al. (2009) found that nutrient release estimates for stratified bedded pack dairy manure were not consistent with solid dairy manure guidelines in Minnesota. With new state regulations pending regarding how much fertilizer N is applied to fields, farmers that also use manure will need to take great care in determining how much N is supplied from the manure before determining how much fertilizer they can apply.

Understanding P availability in manure is also necessary, and luckily is not quite as complicated as it is with N, although there are still uncertainties. We assume approximately 80% of the total manure P is available the first year, but even this can vary depending on weather conditions. Recent studies have shown, however, that P availability may also depend on soil texture (Pagliari and Laboski 2014). In a recent study done at the University of Wisconsin, Pagliari and Laboski (2013; 2014) found that from 40% to 100% of P from manure became plant available within 50 days and the difference was primarily due to manure chemistry and soil texture.

Objectives:

The objective of this study is to evaluate N and P release from a variety of manures and soil types to give farmers a better understanding of how manure will behave.

Materials and Methods:

Laboratory incubations were used to assess N and P release characteristics from a variety of manures in several different soil types. The incubation studies were a complete factorial with 4 replications and with manure type, soil type, and temperature as the main factors. This means all possible soil and manure combinations were tested at all chosen temperatures. We also included a control treatment that did not include any manure application to see how much nitrogen and phosphorus mineralized from the soils themselves. We tested 8 manures, including: dairy liquid (separated and raw [non-separated]), swine liquid (from a finishing house and a sow barn), beef manure (solid bedded pack and liquid from a deep pit), and poultry (turkey litter and chicken layer manure). Manure analyses to determine nutrient content were conducted on all samples prior to incubations. Soils for the incubations included a coarse textured soil from the Sand Plain Research Center at Becker, MN; a medium textured soil from a research field near Rochester, MN; and a fine textured soil from the West Central Research and Outreach Center in Morris, MN. Soils were collected from the top six inches of soil at each location in bulk and then air dried and analyzed for nutrient and organic matter content.

To determine how much plant available N and P was released over time, we made subsamples for each manure by soil type by temperature treatment, and then collected one each at predetermined sampling intervals. Each subsample consisted of 200 grams of soil placed into ball jars and brought to about 60% moisture. These were allowed to incubate for a week prior to manure being added. After one week, manure was mixed into the jars to mimic a given amount of nutrient (e.g. 180 lbs of N per acre). We used the University of Minnesota guidelines and manure analysis results to calculate the appropriate application rate for each manure type. Moisture in the samples was kept at 60% of field capacity and was maintained by weighing every 4-6 days and adding deionized water as needed to replace the weight lost. During the incubation study, the temperature inside the incubator was kept at either 25ºC (77ºF), 15ºC (60ºF), or 5ºC (40ºF). We collected subsamples at 0, 7, 14, 28, and 56 days after the experiment had begun. Subsamples were destructively analyzed for potassium chloride extractable ammonium and nitrate and Bray-1 or Olsen extractable phosphate.

Preliminary Results:

At the time of writing, the experiment has been completed at all three temperatures and we have collected 3,672 samples. Sample analysis continues to be underway and we expect to have results by the next reporting period. Since the data collection is not yet complete, statistical analyses have not been conducted at this time. The results of the initial soil and manure tests can be found in Tables 1 and 2, respectively. This will give an idea of the starting conditions of the soils and manures.

Soil phosphorus (Bray-P) testing at 5°C (40°F) showed interesting results (Figure 1). In the control soils that did not have manure applied, Bray-P test levels were similar at the beginning and end of the incubation, although there were some fluctuations across time. All values were below 20 ppm of Bray-P. Within a few days of application, Bray-P levels were more variable across soil types and application rates, likely due to differences in how long it took for the phosphorus to equilibrate across different pools of P. However, there tended to be higher Bray-P levels in the clay loam soil than the silt loam soil at the end of the incubation (56 days). Bray-P tests in the sand loam tended to be between the silt and clay loam or similar to the clay loam. Overall, Bray-P test levels were below 30 ppm for most manures at the end of the incubation, with the exception of some of the turkey litter, swine sow manure, and bedded beef pack manure samples. We expect to see more variability in the incubations at warmer temperatures. More tests are needed and will be completed later in 2020.

References:

- Hernandez JA, Schmitt MA. 2012. Manure management in Minnesota. Saint Paul (MN): University of Minnesota Extension [accessed 24 Nov 2017].
- Pagliari PH, Laboski CAM. 2013. Dairy manure treatment effects on manure phosphorus fractionation and changes in soil test phosphorus. Bio and Fert of Soils 49(8): 987-999.
- Pagliari PH, Laboski CAM. 2014. Effects of manure inorganic and enzymatically hydrolyzable phosphorus on soil test phosphorus. Soil Soc. of Am. J. 78(4): 1301-1309.
- Russelle MP, Blanchet KM, Randall GW, Everett LA. 2009. Characteristics and nitrogen value of stratified bedded pack dairy manure. Crop Management 8(1). https://dl.sciencesocieties.org/publications/cm/abstracts/8/1/2009-0717-01-RS.

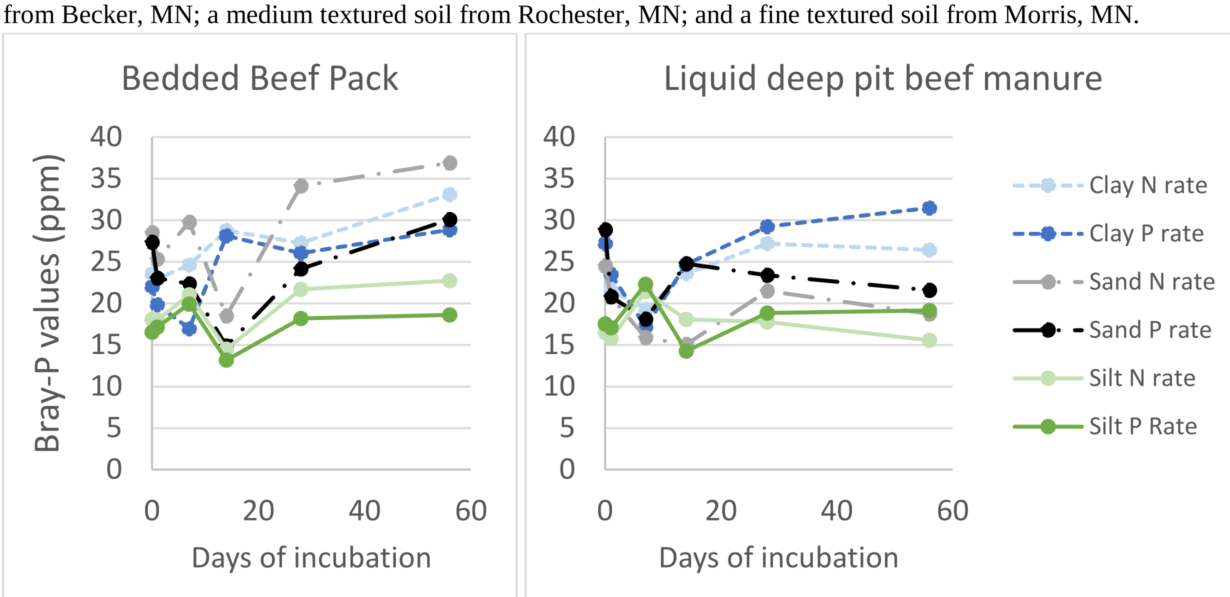
Table 1. Initial characteristics of three soil types used in this study: coarse textured soil from Becker, MN; medium textured soil from Rochester, MN; and a fine-textured soil from Morris, MN.

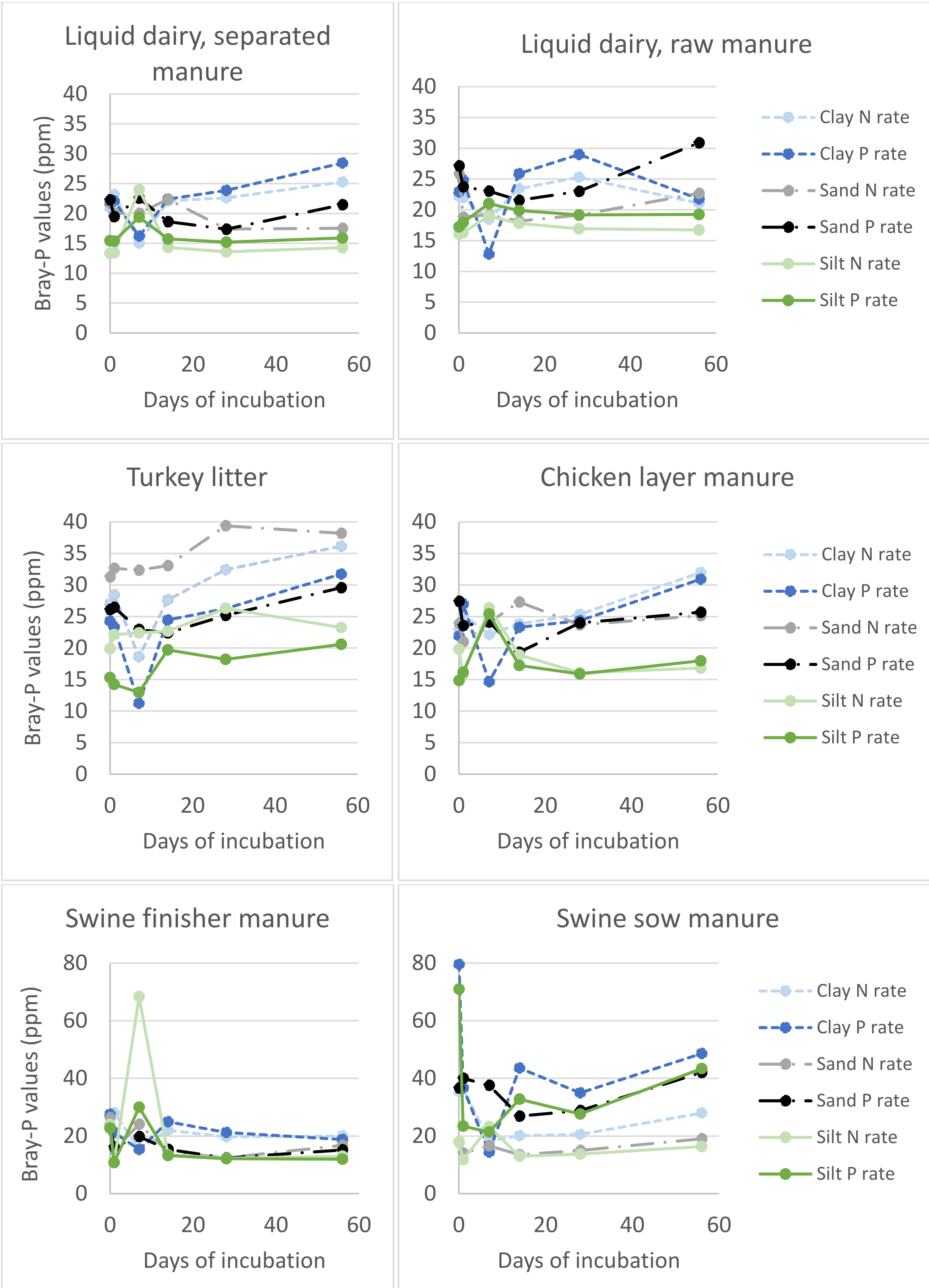
Soil Characteristics	Soil Textural Class		
	Coarse	Medium	Fine
Organic matter (%)	1.1	1.0	3.3
pH	5.1	5.2	7.9
Phosphorus - Olsen (ppm)	11	8	7
Potassium (ppm)	95	101	140
Magnesium (ppm)	42	49	570
Calcium (ppm)	274	310	3482
Ammonium (ppm)	3.4	2.8	8.6
Nitrate (lb/acre)	3.0	2.5	8.5

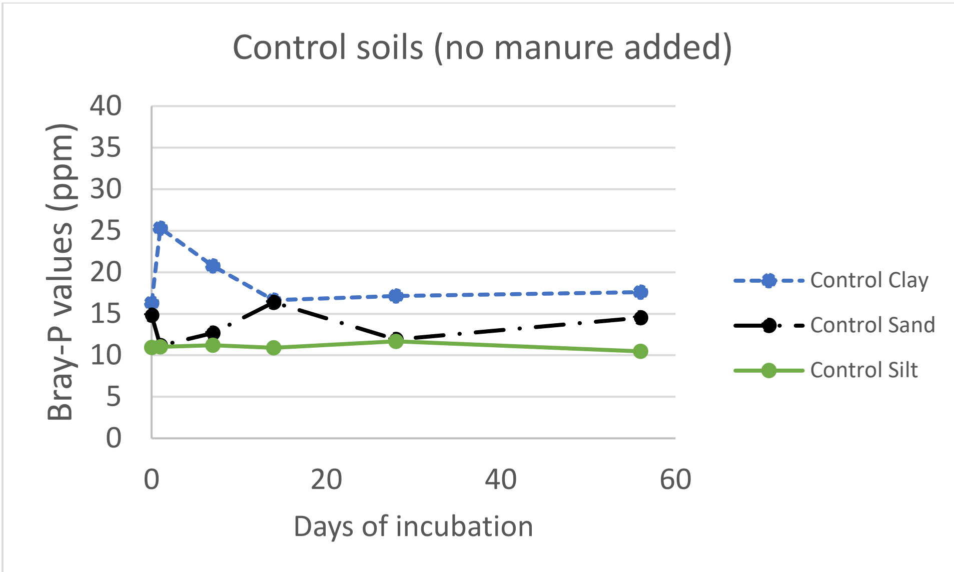
Table 2. Initial characteristics of eight manure types used in this study. The units of nutrients will be in pounds per ton for solid manure and in pounds per 1000 gallons for liquid manure.

Species Type	Manure Type	Moisture	Total N	Ammonium-N	Total P (as P_2O_5)	Total K (as K_2O)	C:N Ratio
		(%)	(lbs per unit)	(lbs per unit)	(lbs per unit)	(lbs per unit)	
Beef	Bedded Pack, Solid	60.5	13.43	2.37	9.59	18.01	22:1
	Deep Pit, Liquid	86.6	56.72	36.7	23.43	30.83	9:1
Dairy	Separated, Liquid	93.2	32.7	15.8	13.31	29.26	7:1
	Raw, Liquid	88.9	33.17	15.66	13.08	31.29	13:1
Swine	Finisher, Liquid	86.8	59.16	41.63	37.63	27.35	9:1
	Sow, Liquid	99.3	16.5	15.69	1.38	11.34	1:1
Poultry	Chicken Layer, Solid	48.6	55.51	14.39	35.78	25.91	7:1
	Turkey Litter, Solid	53.0	28.2	13.16	26.69	28.65	12:1

Figure 1. Soil test phosphorus levels (Bray-P) in soil mixed with various manure types in a coarse textured soil from Becker, MN; a medium textured soil from Rochester, MN; and a fine textured soil from Morris, MN.




Liquid dairy, separated manure
Bray-P values (ppm)
Days of incubation
Liquid dairy, raw manure
Days of incubation
Clay N rate
Clay P rate
Sand N rate
Sand P rate
Silt N rate
Silt P rate
Turkey litter
Bray-P values (ppm)
Days of incubation
Chicken layer manure
Days of incubation
Clay N rate
Clay P rate
Sand N rate
Sand P rate
Silt N rate
Silt P rate
Swine finisher manure
Bray-P values (ppm)
Days of incubation
Swine sow manure
Days of incubation
Clay N rate
Clay P rate
Sand N rate
Sand P rate
Silt N rate
Silt P rate



Control soils (no manure added)
Bray-P values (ppm)
40
35
30
25
20
15
10
5
0
0
20
40
60
Days of incubation
Control Clay
Control Sand
Control Silt