Effect of Manure P Speciation on Changes in Soil Test Level

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INTRODUCTION

- Animal manure, when used as a nutrient source for crop production has been reported to range from less available to more available for plant uptake compared with commercial phosphorus (P) fertilizers (Griffin et al., 2003; Loria and Sawyer, 2005; Sharpley and Sisak, 1997).
- Phosphorus is found in two forms in manure. Inorganic P (Pi) and organic P (Po). Inorganic can be associated with struvite or several calcium-phosphate minerals (Gungor and Karthikeyan, 2005). The organic fraction has been divided into enzymatic hydrolysable and non-hydrolysable (He et al., 2004). The hydrolysable fraction is usually composed of phytate, monoester and diester-like P, and DNA/RNA.

OBJECTIVES

I. Compare the change in soil test phosphorus (STP0 after manure and fertilizer application.
II. Determine the relative effectiveness (RE) of different manure types to increase STP compared with fertilizer.

METHODS, CALCULATIONS, STATISTICS

- 25 agricultural soil series representing the five major mineral soil groups (A – E) in Wisconsin were collected from 0 – 15 cm. Selected soil chemical and physical characteristics are presented in Table 1.
- 42 manures samples from 8 animal species: 18 dairy (liquid, slurry, semi-solid, and solid), 8 beef (solid), 4 swine (liquid and solid), 3 chicken, 3 turkey (solid), 2 sheep, 2 goat, and 2 horse (solid). Range of selected manure characteristics are presented in Table 2.
- An incubation experiment was conducted using a full factorial design. 25 soils *x* 44 treatments (42 animal manures + triple superphosphate (TSP) + control 0-P) *x* 4 replicates.
- P was applied at 40 mg total P kg^{-1} soil and manures were applied without drying.
- Samples were incubated at 25°C, for 10 weeks, with moisture maintained at 40% to 60% field capacity.
- After 10 weeks, Bray P-1 was measured on oven dried soils (35°C).
- Increase in STP (ΔSTP) was calculated as: STP in manure or fertilizer – STP in control.
- Relative effectiveness: $RE = \frac{\Delta STP manure}{\Delta STP fertilizer} * 100$
- A mixed model ANOVA was used to determine if manure type or soil had a significant effect on the increase in STP after P application or manure RE.
- Stepwise regression and correlation analysis were used to test the effects of chemical and physical soil and manure properties on ΔSTP.

RESULTS

- Soils varied greatly in pH, OM, P, Al, Fe, sand, and clay content (Table 1).
- Manures also varied greatly in DM, Total P, EC, and pH (Table 2). However, these values are within values reported in the literature for animal manures.
- Soils from group E had the greatest increase in STP when TSP was the P source, while soils from groups B and C had the lowest increase in STP (Table 3).
  - These results may relate to the amount of clay in the soil. Groups B and C had the greatest amount of clay and group E had the lowest (Table 1). However, stepwise regression was unable to detect this relationship.
- For all manures, increases in STP were greatest for soils from group E and lowest for soils from groups B and D (Table 3).
- Within soil group, STP increased the most with swine manure and the least with beef and dairy manures (Table 3). Overall, swine manure increased STP more than the TSP treatment in all soil groups (Table 3).

Table 1. Selected soil chemical and physical characteristics for soils from group A-E.

Group	Soil	pH	OM	Bray	Mehlich-3			Sand	Clay
				P	P	Fe	Al		
			(%)	------- mg kg^{-1} -------				-------- % --------	
A	Billet	6.4	2.6	17	86	153	692	70.5	3.5
A	Fayette	6.9	2.7	14	25	100	403	22.5	13.5
A	St Charles	6.7	3.4	64	92	141	455	57.9	9.1
A	Waymor High	7.1	4.2	61	98	132	528	52.2	7.8
A	Waymor Low	6.6	2.9	30	55	199	527	48.9	11.1
B	Dodgeville	5.7	3.4	18	41	134	679	18.2	15.8
B	Hochhein	6.8	3.0	37	91	120	428	36.2	9.8
B	Pella	7.7	5.6	56	103	301	250	26.4	22.6
B	Plano	6.8	3.7	26	55	106	618	17.9	15.1
B	Ringwood	5.5	3.6	27	59	156	739	24.2	12.8
C	Emmet	7.2	3.9	30	55	152	552	70.2	3.8
C	Hortonville High	6.9	2.9	43	80	118	397	17.9	12.1
C	Hortonville Low	7.1	2.6	15	46	114	433	58.5	7.5
C	Kewanee	7.7	3.6	14	32	196	538	45.9	14.1
C	Manawa	8.1	3.3	14	33	116	296	31.2	22.8
D	Antigo	5.6	3.4	24	51	161	1017	55.9	3.1
D	Freeon	7.0	3.3	69	99	152	518	25.9	7.1
D	Loyal	6.4	4.1	26	53	161	608	30.9	7.1
D	Rosholt	6.9	1.3	15	36	79	393	77.4	8.6
D	Withee	6.5	3.0	23	40	150	777	27.9	9.1
E	Chetek	5.3	1.7	37	68	133	617	73.4	6.6
E	Mahtomedi	6.7	1.5	16	45	75	386	87.9	3.1
E	Menominee	6.8	1.8	29	47	98	466	78.9	5.1
E	Plainfield	5.6	1.3	53	98	122	684	87.9	5.1
E	Richford	6.0	1.5	40	70	97	594	90.9	5.1

Table 2. Range of selected chemical and physical characteristics of manure by species.

Species	Number of Samples (n)	DM†	Total P	EC	pH
		g kg^{-1}	g kg^{-1} DM	dS m^{-1}	
Beef	8	270 – 623	4.5 – 14.2	2.6 – 6.62	4.9 – 8.6
Dairy	18	8 – 547	2.8 – 18.7	2.2 – 12.8	6.4 – 10.3
Goat	2	311 – 313	10.3 – 13.1	5.9 – 8.1	7.5 – 7.9
Sheep	2	374 – 397	7.2 – 10.7	3.6 – 5.3	7.9 – 9.0
Swine	4	1 – 303	24.1 – 48.7	3.0 – 13.7	5.8 – 7.9
Chicken	3	263 – 941	17.7 – 23.9	10.3 – 15.2	6.1 – 7.0
Turkey	3	577 – 856	11.3 – 28.2	4.5 – 12.3	5.5 – 5.9
Horse	2	308 – 899	5.4 – 12.4	1.4 – 2.0	7.2 – 9.0

† DM, dry matter; EC, electrical conductivity.

- Increases in STP with dairy liquid manure were significantly greater than those with solid dairy manures. Overall, increases in STP with liquid dairy was as much as 30 to 57% greater than in semisolid and solid manures (data not shown).
- Increases in STP with swine liquid manure were significantly greater than those with solid swine manures. Overall, increases in STP with liquid swine was as much as 106 to 182% greater than with solid manures (data not shown).
- Even though increases in STP tended to be greater for liquid manures, correlation analysis using manure DM and ΔSTP yielded an r of -0.11 for dairy (n=18) and -0.68 for swine (n=4).

Table 3. Increase in soil test phosphorus in each soil group as a function of P source.

P Source	Soil Group									
	A		B		C		D		E	
	---------- Increase in STP mg kg^{-1} ----------									
TSP	20.6	b† B	16.6	b C	17.1	b C	20.8	b B	25.9	b A
Beef	10.2	f B	9.7	d BC	9.6	f C	9.3	e C	15.9	h A
Dairy	10.0	f C	7.6	e E	10.5	e B	8.0	f D	17.7	g A
Goat	15.3	d B	9.5	d E	14.1	c C	10.9	d D	19.7	e A
Sheep	13.7	e B	11.8	c C	14.1	c B	11.3	d C	21.5	d A
Swine	24.5	a B	21.3	a D	24.0	a B	22.5	a C	36.0	a A
Chicken	17.4	c B	12.5	c D	15.8	b C	15.3	c C	23.9	c A
Turkey	13.4	e B	9.1	d D	12.6	d B	11.3	d C	19.2	ef A
Horse	13.2	e B	9.6	d D	12.1	d B	10.8	d C	18.3	fg A

† Means followed by the same lower case letter in a column, or uppercase letter in a row are not significantly different (*P = 0.05*).

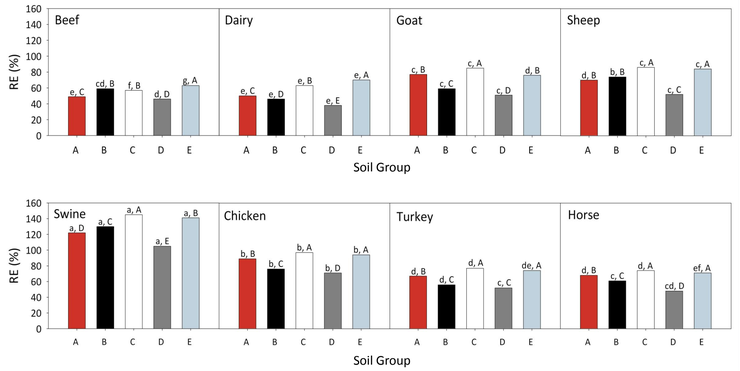

Figure 1. Manure relative effectiveness (RE) to increase STP compared with fertilizer. Uppercase letters compare the RE of a given animal species across soil groups. Lowercase letter compare the RE of a given soil group across all animal species (*P = 0.05*).

- Soil groups C and E behaved similarly in terms of manure relative effectiveness (RE) to increase STP compared with fertilizer and had the greatest RE among all soil groups, while soil group D had the lowest (Figure 1).
- Within soil groups, swine manure had the greatest RE, and beef and dairy had the lowest (Figure 1).

CONCLUSIONS

- The increase in STP with manure application varied with both animal species and soil series.
- Knowing the forms of P in manure might be useful in interpreting the interaction between soils and manures with regard to how much STP increases with manure application.
- The results suggest that assuming all manures and fertilizer increase STP the same amount on all medium- and fine-textured soils or all coarse-textured soils is incorrect.

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