MANURE SOURCE AND RATE EFFECTS ON SOIL TEST LEVELS AND CORN GROWTH

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Introduction

Nutrient management planning has become an important tool in an effort to improve water quality. In Wisconsin, nutrient management regulations are in the process of moving to a phosphorus (P) based standard. As such, P budgeting and the P index will greatly influence manure applications. Thus, there is a need to better understand how soil test P changes with respect to a P based manure application.

In Wisconsin, only 60 % of the total P applied in manure is considered to be available to the crop during the first year after application. From a P budgeting standpoint, this means manure is 60% as effective at increasing soil test P as the same amount of total P applied as fertilizer.

Past research has shown that these assumptions are not always true. Studies have shown that manure phosphorus can vary from being more available to less available depending on animal species, manure type, and storage of the manure. Eghball et al. (2002) found that first year P availability of cattle feed lot manure was 85 % in a field experiment. In a complimentary incubation study, beef cattle feedlot manure averaged 72 % P availability compared to fertilizer while swine slurry averaged 66 % P availability (Eghball et al., 2005). In an incubation study by Kashem et al. (2004), P amendments increased labile P levels to varying degrees with fertilizer increasing labile P the most followed by hog manure, cattle manure, and biosolids. In an incubation study Laboski and Lamb (2003) found that swine slurry applied at high rates increased soil test P more than fertilizer.

Most of the past research on manure P availability has been conducted in laboratory incubations. The purpose of this study was to determine manure P availability to corn on a total P applied basis, as compared to fertilizer in a field setting.

Materials and Methods

This study was conducted at the University of Wisconsin Agricultural Research Stations in Marshfield (central WI) and Arlington (south central WI). General characteristics for soil are provided in Table 1. The experimental design at these locations was a randomized complete block. Treatments consisted of five P sources at Arlington (fertilizer (0-46-0), dairy slurry, solid dairy manure, swine slurry, and poultry pellets) and four P sources at Marshfield (fertilizer, dairy slurry, solid dairy manure, and swine slurry) as well as a no P control for both locations. Table 2 contains characteristics of the manures used at both locations. Plot size was 3.05 m by 10.67 m.

Each P source was hand applied preplant at three target application rates of 90, 179, 314 kg P_2O_5 ha^{-1}, or low, medium, and high rates. Total P in the manure was confirmed in the lab and actual

P_2O_5 application rates calculated (Table 3). Manure credits for nitrogen (N), potassium (K), an sulfur (S), were taken and fertilizer was applied to all plots to meet total application rates of 224 kg N ha^{-1}, 134 kg K_2O ha^{-1}, and 16.8 kg S ha^{-1}. Two days after treatment application, plots were chisel plowed to 20 cm and the seed bed was prepared with a soil finisher. An adapted corn *(Zea mays)* hybrid was planted at each location.

Soil samples (0-15 cm) were taken in every plot prior to treatment application, two, four, and ten weeks after application, and post harvest. Samples were dried and ground to pass a 2 mm sieve. Phosphorus was extracted with Bray-1 and analyzed colorimetrically (Frank et al., 1998).

Plant samples were taken throughout the growing season. Whole plant samples were taken at the V5 growth stage, ear leaf samples were taken at tasseling, and whole plant samples for silage yield were taken at physiological maturity. All plant samples were dried and ground to pass a 2 mm sieve and then digested (H_2SO_4 + H_2O_2) and analyzed colormetrically for total P.

For each location, linear regression was used to model the relationship between the change in STP with P application for each P source and date of sampling. The slope of the regression line for each manure source on a given date and location was compared to the slope of the regression line for fertilizer on the same date and location. If the slopes were significantly different, then manure changed soil test P differently than fertilizer.

Results and Discussion

In general, as total P applied increased so did soil test P (STP) levels. However, different trends were evident between locations and sampling dates (Figure 1, Table 4). In Marshfield, fertilizer and swine slurry showed an immediate and similar increase in STP at the 2 week sampling date (Figure 1). Dairy slurry and solid dairy manure changed STP similarly and significantly less than fertilizer and swine slurry. At the post harvest sampling, all sources changed STP similarly with the change being less than at 2 weeks. At Arlington, fertilizer increased STP significantly more than all manures. By post harvest sampling, all sources changed STP similar to fertilizer and were not significantly different. At Arlington changes in STP at post harvest were less than at 2 weeks after application. The reduction in STP change at post harvest for both locations could be a result of P binding with soil over time or possibly from crop removal.

Silage harvest P uptake data was fitted with a linear plateau model. At Marshfield, P uptake increased as total P applied increased up to 137 kg P_2O_5 ha^{-1} for all sources and then plateaued (Figure 2). The high rate of solid dairy manure was removed from the data set before the model was fit because the large increase in uptake was caused by a large biomass yield. Greater biomass yield in the high rate of solid dairy manure is believed to result from a mulching effect of the solids (bedding, undigested feed, etc.) in the manure maintaining soil moisture. This was evidenced by the fact that the corn was slower to show signs of moisture stress during a period of dry weather. The relationship between total P_2O_5 applied and P uptake indicates that for corn, manure P is equally effective at supplying P as fertilizer. At Arlington, for all manure sources, P uptake increased as total P applied increased up to 189 kg P_2O_5 ha^{-1}. After this rate, P uptake leveled off. Fertilizer was not used in the linear plateau model because it appeared to follow a more linear trend and seemed to have reduce P uptake compared to manures.

At Marshfield, silage yield response to applied P was fit to a linear plateau model (Figure 3). Again, data from the high rate of solid dairy manure was not used for the reason explained previously. Silage yield increased as total P applied increased up to 102 kg P_2O_5 ha^{-1} and then plateaued. Trends in silage yield were not as easily observed in the Arlington data (data not shown). At Arlington, it is believed that the variation in initial soil test levels within the field may have affected the P responsiveness at Arlington. Additional statistical analysis is being conducted on this data.

Conclusions

Differences between P sources in their ability to change STP were observed. Additionally, change in STP varied with soil type. This implies that using a constant availability coefficient, such as 60 % of total P applied, for all manures may not be the most effective way to account for manure P. Details of these relationships will be investigated further. From the P uptake and yield data, manures are equivalent sources of P for corn based on total P applied. Thus, manure can be considered an effective P source for crop growth. Changes in STP by manures may not be as important to determining crop response and growth but rather play an important role in addressing environmental concerns from P loss. Through further analysis and research, a better understanding of the differences between manure sources and soil types is hoped to be gained.

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Table 1. Soil characteristics.

Location	Soil series	Taxonomic name	pH	P	K	Ca	Mg	OM
				mg kg^{-1}				%
Arlington	Plano silt loam	Fine-silty, mixed, superactive, mesic Typic Argiudolls	6.5	16.8	77.3	1784	535	3.7
Marshfield	Withee silt loam	Fine-loamy, mixed, superactive, frigid Aqvic Glossudalfs	7.1	14.3	125.3	1441	433	2.7

Table 2. Manure characteristics.

Manure	Total N	NH_4-N	P	K	S	DM†
	mg kg^{-1}					%
Arlington						
Dairy Slurry	4103	1784	627	2408	197	10.3
Solid Dairy Manure	5381	463	810	3083	3083	18.9
Swine Slurry	1362	2106	596	1362	129	2.7
Poultry Pellets	35273	1057	16826	21266	461	84.0
Marshfield						
Dairy Slurry	2418	1221	461	1888	161	6.1
Solid Dairy Manure	4703	321	826	5220	79	19.9
Swine Slurry	1243	2103	561	1243	122	2.8

† DM, dry matter.

Table 3. Amount of phosphorus applied for each phosphorus source and rate at Arlington and Marshfield.

	Phosphorus Application Rate		
Source	Low	Medium	High
	kg P_2O_5 ha^{-1}		
Arlington			
Fertilizer	93	186	278
Dairy Slurry	84	170	255
Solid Dairy Manure	75	150	225
Swine Slurry	70	140	257
Poultry Pellets	86	172	258
Marshfield			
Fertilizer	93	186	278
Dairy Slurry	64	128	192
Solid Dairy Manure	53	153	230
Swine Slurry	66	132	197

Table 4. Comparison of the ability of manure phosphorus to change STP similarly to fertilizer phosphorus.

	Arlington		Marshfield	
Source	Two week	Post harvest	Two week	Post harvest
	P value†			
Dairy Slurry	0.0001	0.3127	0.0028	0.3687
Solid Dairy Manure	<0.0001	0.4405	0.0626	0.4728
Swine Slurry	<0.0001	0.2935	0.7114	0.3106
Poultry Pellets	<0.0001	0.6210	—	—

† H_o: slope of change in STP with manure p applied = slope of change in STP with fertilizer P applied.

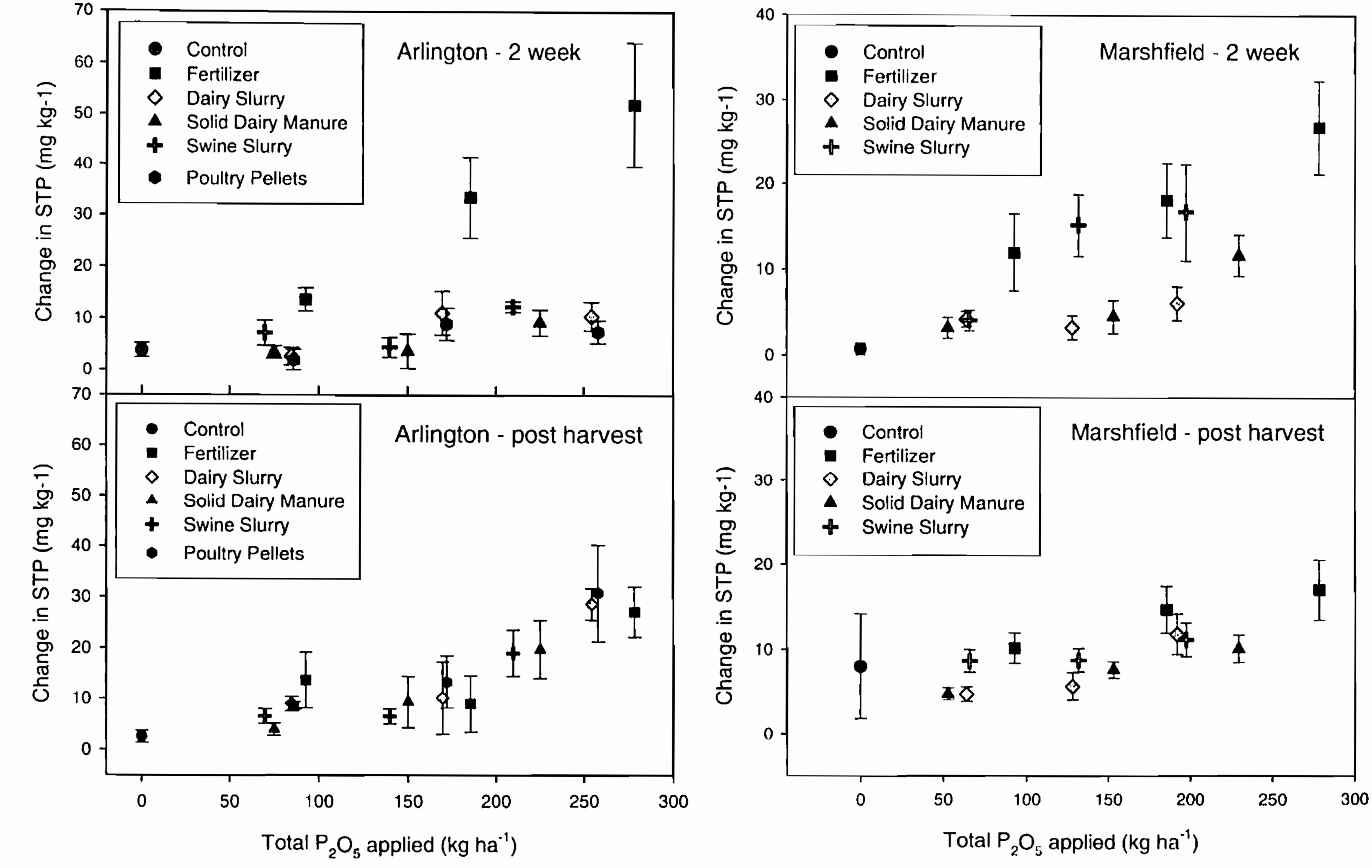

Figure 1. Change in STP with P_2O_5 applied for each P source at Arlington and Marshfield at the 2 week and post harvest sampling date.

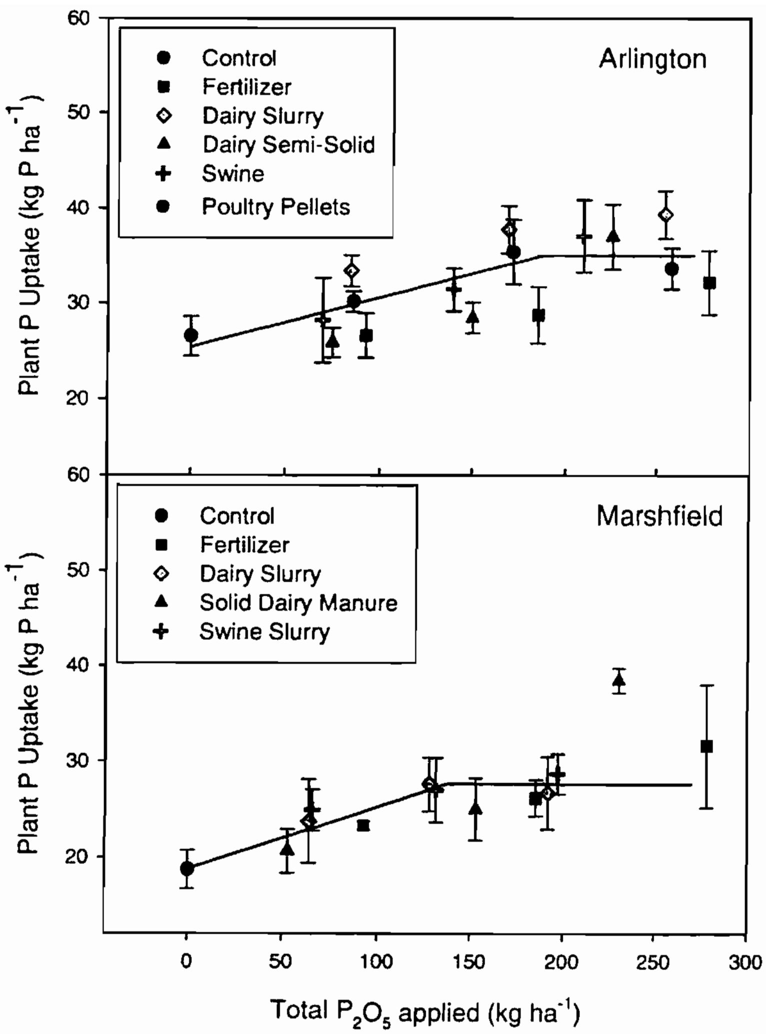

Figure 2. Relationship between plant uptake of phosphorus in silage and P_2O_5 applied for each P source at Arlington and Marshfield.

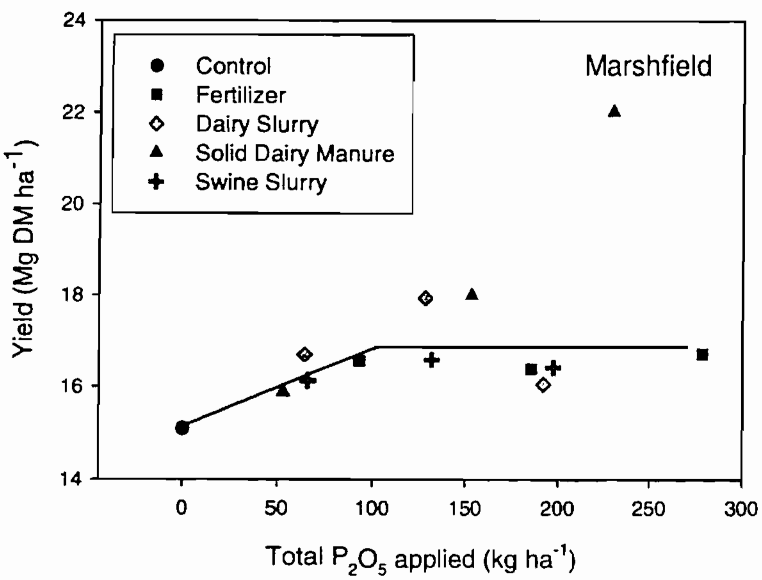

Figure 3. Relationship between silage yield and P_2O_5 applied for each source at Marshfield.

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