Establishing the Value of the Phosphorus and Potassium Contained in Poultry Litter for a No-Till Corn and Soybean Rotation

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INTRODUCTION

With the growth of the poultry industry in Kentucky, more litter/waste has become available to our grain producers. The poultry litter is a source of nutrients, especially N, P, and K. It is also a source of organic matter, which can be. beneficial in other ways (increased soil water holding capacity, formation and maintenance of good soil structure). Much of the plant nutrition contained in poultry litter is in the organic fraction of the waste. Nutrients contained in organic compounds must first be mineralized before they are made available, resulting in slower release of these nutrients.

The nutritional value of one ton of poultry litter can vary considerably. If one assumes a typical moisture content of 40%, and that the remaining dry material averages 3% N, 2% P, and 3% K, then that ton of litter is worth about $24 at today's fertilizer prices. About $10 of that value is in the N. Another large part of that value, $9, is in the P content If all the P and K contained in that ton of litter were available in the first year of application, then the P and K removed by the harvest of 160 bu of corn *(Zea mays* L.) grain could be provided by that ton of litter.

It is unlikely, however, that all the nutrients contained in the litter will be available in the fust year. And though the question of N residuality from poultry waste applications has been well examined, the issue of P and K residuality has not. This is particularly true for no-tillage production systems where the litter will lie on the soil surface. Will fertilizer P and K still be needed to get no-till corn and soybean *(Glycine max* [L.] Merr.) off to a good start albeit at reduced rates, when litter has been applied? How long will litter derived P and K continue to be made available? The lack of incorporation in no-tillage limits nutrient fixation deeper in the soil, but may also slow microbial mineralization of both N and P. How long will it take the grain producer to recover that $24 value in nutrients?

Phosphorus may be of particular importance, as some states use P loading in setting waste loading rate standards. Nutrient management plans will need to be developed and soil testing will be an important part of those plans. How/when will soil test values reflect litter nutrient additions to the surface of no-till soils? Will the test's predictive relationship of the soil's ability to supply P (and K) be changed, and if *so,* how?

MATERIALS AND METHODS

To answer the questions posed above, a field experiment of common design was conducted at each of two locations. The first site was on a Pope silt loam (coarse-loamy, *mixed,* mesic Fluventic Dystrochrept) and the second location was on a Tilsit silt loam (fine-silty, mixed, Typic Fragiudult). Plot size was 30 A by 12 ft (4 rows) on the Pope soil and 35 A by 12 A on the Tilsit soil. Seven fertilizer P and K treatments, involving combinations of four different rates of each nutrient, in the presence and absence of poultry litter, were used at each location (Table 1). Somewhat greater rates of nutrients were used on the Pope silt loam because of the historically greater yield potential at this location.

Litter and fertilizer were applied prior to corn planting in 1995. Amendments were not repeated in 1996. Soil samples (0- to 3- in depth increment) were taken prior to amendment in 1995 and prior to planting in 19% and subjected to Mehlich III extraction for P and K Corn and soybean were planted in middle to late May of each year. Ear leaf samples were taken at silking and topmost trifoliate leaf samples were taken at first flowering. Grain samples were taken at harvest. Corn was hand harvested from 20 feet of each of the two center rows of each plot. Corn yields were corrected to a uniform 15.5% moisture content after determining the moisture content and shelling fraction from ears sampled from each plot Soybean was harvested with a small plot combine from 20 (Pope) or 25 (Tilsit) feet of the center two rows of each plot. Soybean yields were corrected to a uniform 13.5% moisture.

RESULTS AND DISCUSSION

Potassium in litter was readily available to corn in the first year. There was a strong interaction between the litter and fertilizer K on **corn** ear leaf K (Fig. 1a), and litter amendment more positively affected ear leaf K at the lower rates of fertilizer K addition. A

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similar, but stronger interaction was observed on corn grain yield (Fig. 1b), where there was no response to fertilizer K in the presence of litter.

The pattern of response observed for soybean trifoliate leaf K (Fig. 1c) was similar to that observed for corn ear leaf K. Soybean yields rose with fertilizer K addition, both in the absence and presence of litter, and there was a consistently greater yield where litter had been applied the previous year (Fig. 1d). The greater responsiveness of soybean to fertilizer K in the presence of litter may reflect removal of K by the prior corn crop (avg. of 27 lb K_2O/a), or the greater responsiveness of this legume species to adverse K nutrition.

Phosphorus in poultry litter was not as readily available to corn as K the first year. Litter amendment again more positively influenced ear leaf P at lower rates of fertilizer addition (Fig. 2a), but the interaction was not as strong as that observed on ear leaf K (Fig. 1a). Fertilizer P additions raised corn grain yields, both in the absence and presence of poultry litter (Fig. 2b). This suggests that the P contained in the litter was not as available as that derived from the fertilizer. This was likely due to the fact that a portion of the litter P is contained in organic compounds that are insoluble and must be mineralized to be made available to the corn crop.

Phosphorus concentrations in trifoliate leaves taken from the second year's soybean crop responded positively to fertilizer P, regardless of litter amendment (Fig. 2c). That leaf P response was somewhat less positive where litter was used. Soybean yields rose with both litter and fertilizer P amendments, but there was no interaction between the two experimental factors (Fig. 2d). Fertilizer P was beneficial to soybean yield without regard to litter amendment, and litter application raised soybean yield without regard to fertilizer P application rate. The results suggest that the litter provided some benefit to the soybean crop beyond additional P nutrition, a result not observed in the first year's corn crop. Another possibility is that the rather large amount of P removed by the corn crop (avg. of 37 lb P_2O_5/a) diminished readily available P reserves in all treatments, causing soybean to rely on relatively more uniform, and less available, soil P fractions.

Relating crop yield to soil test measures of soil P and K provides another way of assessing the relative availability of litter and fertilizer sources of these nutrients. Corn (Fig. 3a) and soybean (Fig. 3b) yield responses to soil test K suggest little difference in K availability from the two sources. Although only data from the Tilsit soil are shown, the other location responded similarly. Litter application raised soil test K values at the end of the first season across both locations, by an average of 14 lb K/a.

Corn yield response to soil test P (Fig. 3c) *suggests* that the crop "sees" litter-derived P to about the same extent that the litter changes soil test measures of available soil P. This does not appear to be the case with soybean (Fig. 3d). At both locations, there was a significantly greater yield response to fertilizer P in the presence of litter. This response was above and beyond that expected from the change in soil test P alone. Litter application raised soil test P values at the end of the season across both locations, by an average of 3.2 lb P/a.

CONCLUSIONS

These preliminary data suggest that poultry litter will provide considerable quantities of plant-available P and K to the crop in the first year after application. Litter K appears to be fully available the first year, while only about 75% of the litter P is available in that season. To the extent that litter P and K were not removed by corn in the first season, they were available to the following soybean crop. At these modest rates of litter application, the row-crop producer will recover most of the P and K value in the litter in this 2-yr year rotation on this and similar soils. Litter amendment does not reduce the ability of the Mehlich III extraction procedure to predict soil P and K availability.

Table 1. Poultry litter and fertilizer P and K rates used in the two field experiments.

Litter			Fertilizer	
N	P_2O_5	K_2O	P_2O_5	K_2O
lb/a				
Pope silt loam				
0	0	0	0	54
61	69	55	23	54
			46	54
			69	54
			69	36
			69	18
			69	0
Tilsit silt loam				
0	0	0	0	36
52	53	41	17	36
			34	36
			52	36
			52	24
			52	12
			52	0

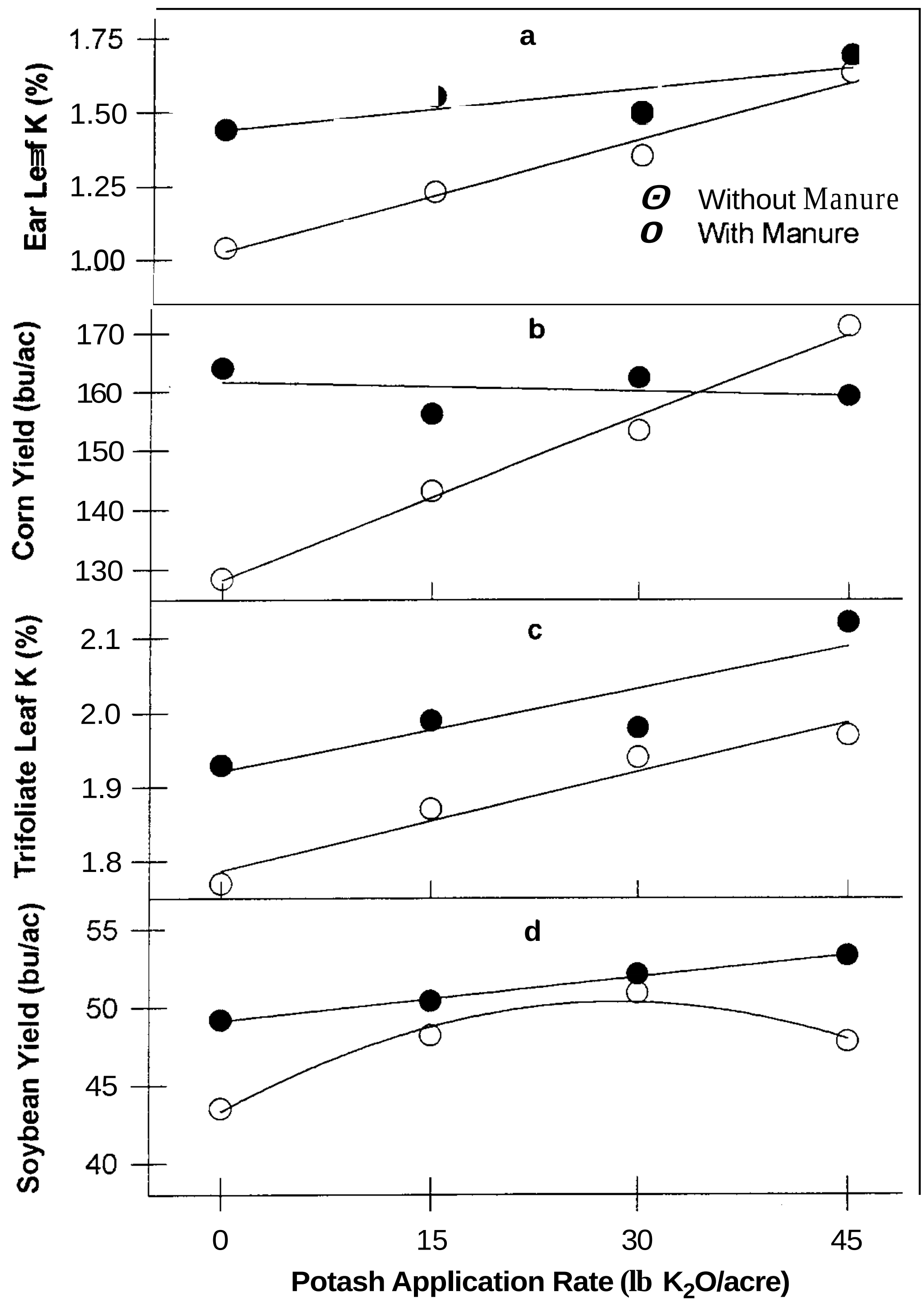

Figure 1. Leaf tissue and grain yield responses of corn and soybean to potash in the absence and presence of poultry litter (ave. of two locations).

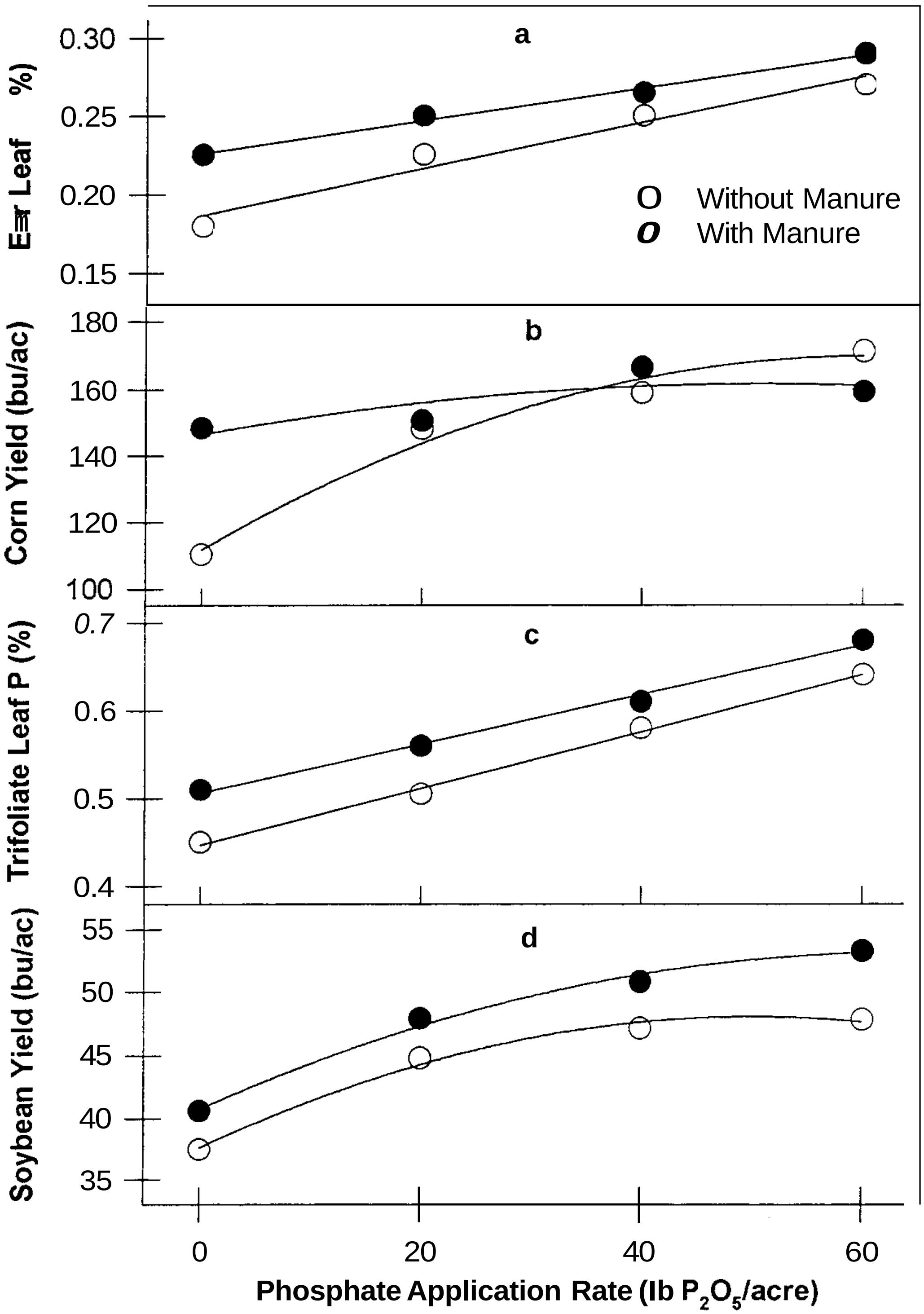

Figure 2. Leaf tissue and grain yield responses of corn and soybean to phosphate in the absence and presence of poultry litter (ave. of two locations).

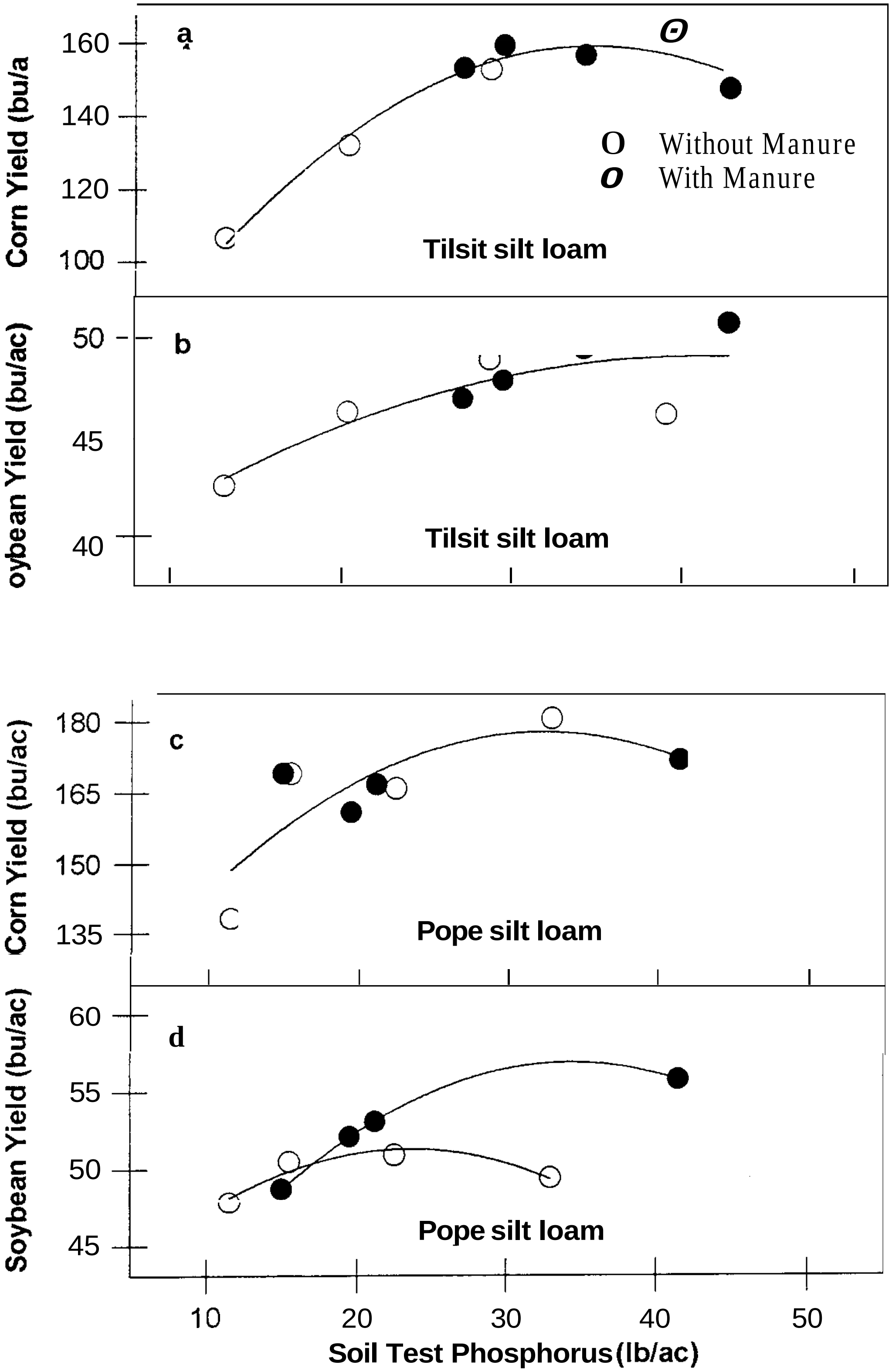

Figure 3. Grain yield responses of corn and soybean to soil test potassium and phosphorus for selected soils in the absence and presence of poultry litter.