Availability of Phosphorus in Beef Cattle Manure for Corn and Soybean

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Antonio Mallarino, professor
Mazhar Haq, assistant scientist
Department of Agronomy

Introduction

An efficient utilization of beef manure nutrients is important to improve the sustainability of animal and crop production systems and avoid unnecessary use of energy and non-renewable resources. Manure phosphorus (P) management differs from inorganic fertilizers for several reasons. Manure is variable in P concentration. It has both organic and inorganic P forms. Also, manure handling is more difficult than corn fertilizer. Organic P forms may not be entirely or immediately available for plant uptake but may become available over time. There is uncertainty about the crop-availability of beef manure P, which is reflected by a wide range (60 to 100%) of estimated availability in Iowa (see ISU Extension publication PMR 1003). Therefore, a study was conducted at the ISU Northwest Research Farm, Sutherland, Iowa in 2012 and 2013 to assess the crop-availability of manure P from selected Iowa beef production systems.

Materials and Methods

The research site had no recent history of manure application, and the soil type was Galva silty clay loam. Initial soil-test results (6-in. depth) were 6.1 pH, 4.4 organic matter, and 5.3 Bray-P1 (very low P). Corn was planted in 2012 and soybean was planted in 2013. Treatments (replicated three times) were applied only the first year before corn and consisted of a control receiving no P, three P sources, two P application rates (in addition to the control), and two application times (13 treatments total). The P sources were two beef cattle manure types and diammonium phosphate fertilizer (DAP). We used bedded manure from a nearby mono-slope building and manure from a nearby dirt-floor confinement operation. Each P source was applied at rates of 0, 50, and 120 lb P_2O_5/acre of total P in the fall (between crop harvest and before snow) or in early April. The two application times, (both before corn), were in October 2011 and in early April 2012. The manure was collected from the same farms and buildings each season. The total P and moisture concentration of the manures varied greatly between manure types and seasons (7.8 to 22 lb P_2O_5/ton as-is and 29 to 73% moisture), but the application rates were based on the total P concentration. Uniform, non-limiting rates of nitrogen, potassium, sulfur, and several micronutrients were applied across all plots.

To evaluate the treatment effects, the first year we analyzed above-ground corn plant samples at the V5-V6 stage to study treatment effects on early growth and P uptake, total plant biomass, P uptake at black-layer stage, grain yield, grain P removal, and post-harvest soil-test P. In the second year, we analyzed soybean plant samples at the V5-V6 growth stage, top mature leaves at the R2-R3 stage, and grain yield. The results for selected measurements are shown in this report.

Results and Discussion

Figure 1 shows results for corn (first crop), including early growth and P uptake at the V5/V6 growth stage, grain yield, and P removed with grain harvest. Phosphorus application using all three sources greatly increased all these measurements compared with the control plots that received no P.

Large responses were expected because initial soil-test P was very low. Because some of the P in beef cattle manure is in forms of low or slow solubility in water, it is important to study its effects on early growth compared with fertilizer.

The results in Figure 1 show the low rates of both manure types had a smaller effect on both early growth and P uptake compared with DAP fertilizer. For the high application rate of 120 lb P_2O_5/acre, however, the effect of the P sources on these measurements was not statistically different, although increases seemed smaller for the manure from the dirt-floor beef confinement. Statistical analyses indicated that applying the three P sources in the spring or the fall did not influence the observed responses, in spite of apparently larger increases for the high P rate applied in the spring.

Results for corn grain yield in Figure 1 for the three P sources show a large yield increase for the low P rate and a larger increase for the high rate (about 38 bu/acre). However, there were no agronomic or statistical differences between the three P sources or between the application times for any rate. The amount of P removed with grain harvest showed, however, a larger P removal increase for the high P rate with the three sources. The yield results indicate the smaller effects of the low manure P rate on early growth and P uptake did not influence yield. Previous research with P fertilizer, swine manure, or poultry manure also showed an increase in early growth does not necessarily result in a grain yield increase unless the soil P deficiency is extreme.

Figure 2 shows soil-test P results from the samples taken after corn harvest in the fall of 2012 and soybean in 2013. Data are averages of the two times of P application before corn because these did not affect soybean yield. The two P application rates increased post-harvest soil-test P. The soil-test P levels were higher for the high P application rate because more P was applied than removed by corn. However, the soil levels did not differ between the P sources. Soybean grain yield was greatly increased by the residual soil P from the P applied the previous year. Yields were higher for the high P rate than for the low rate, which is reasonable because soil-test P in plots that received the low P rate tested 10 to 11 ppm (Low interpretation class). Soybean yield did not differ statistically between the three P sources for any rate applied, although there was a slightly larger increase for bedded manure.

Conclusions

Corn grain yield was greatly increased by applying fertilizer and beef cattle manure, but the increases did not differ between the P sources. The P sources did not affect early growth and P uptake when a rate high enough to maximize yield was applied. However, when a low (deficient) P rate was applied, then fertilizer P was more efficient than manure P. Second-year soybean grain yield was increased by P applied before corn the previous year, but the effects of P sources did not differ. Overall, results showed that the crop-availability of beef cattle manure P is greater than currently assumed in ISU manure management guidelines.

Acknowledgements

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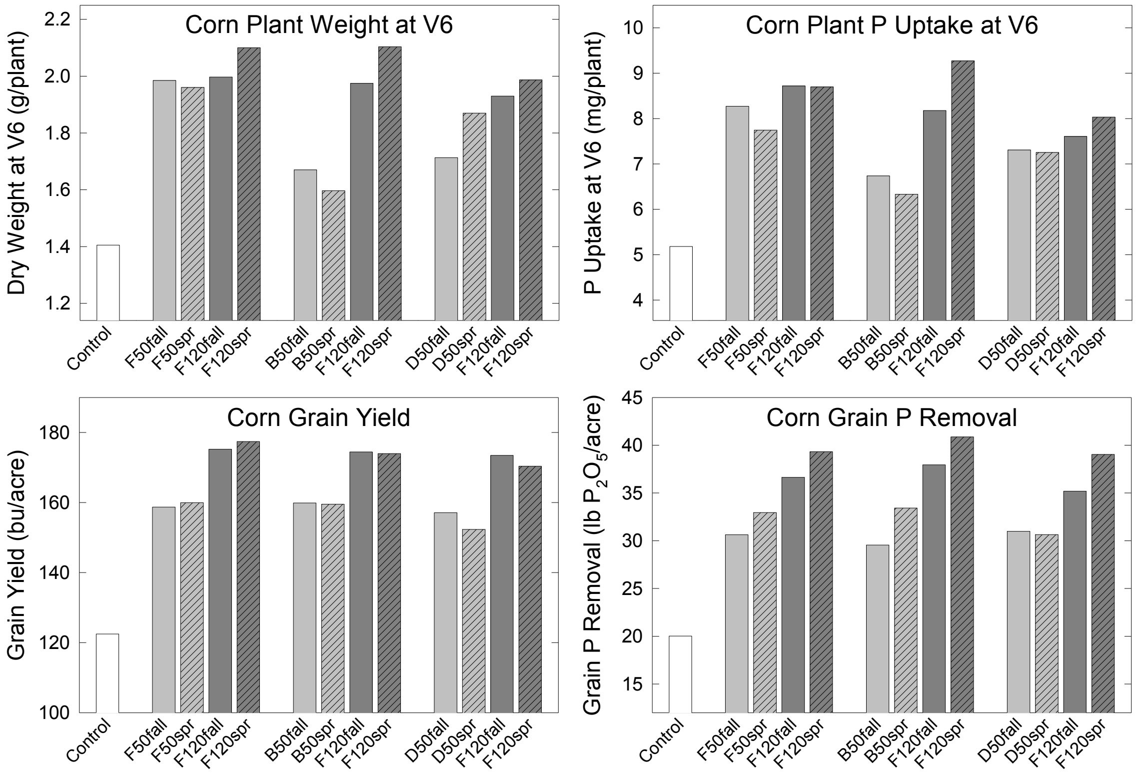

Figure 1. Effects of fertilizer and beef cattle manure on early corn growth and P uptake, grain yield, and P removed with grain harvest. F=fall, B=bedded manure, and D=dirt-floor confinement. Control=0 lb P_2O_5/acre, 50=50 lb P_2O_5/acre, 100=100 lb P_2O_5/acre.

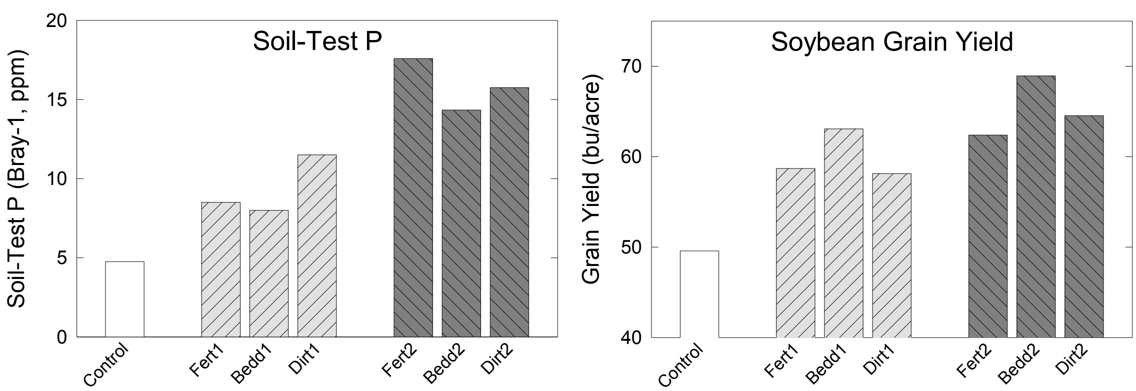

Figure 2. Effects of fertilizer and beef cattle manure applied before the previous year corn on soil-test P measured after harvesting corn and soybean grain yield. Fert=fertilizer, Bedd=bedded manure, and Dirt=dirt-floor confinement.