Phosphorus Availability in Beef Cattle Manure for Corn and Soybean

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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 Extension publication PMR 1003). Therefore, a study was conducted at the ISU Armstrong Research Farm, Lewis, 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 Marshall silty clay loam. Initial soil-test results (6-in. depth) were 6.6 pH, 4.5 organic matter, and 8.6 Bray-P1 (borderline between the very low and low classes). 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 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 (11.6 to 64.7 lb P_2O_5/ton as-is and 12 to 69% 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.

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 the 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 brief report.

Results and Discussion

Figure 1 shows results for corn (first crop), including early plant growth and P uptake at the V5/V6 growth stage, grain yield, and P removed with grain harvest. The drought of 2012 severely limited corn yields at this farm and in the region. The figure shows averages for the fall and spring times of P application because the manure treatments were highly variable and did not differ consistently. Phosphorus application using all three sources increased all values of these measurements compared with the control that received no P. The magnitude of the responses was smaller than expected for a low-testing soil, probably because of the drought.

Because some of the P in beef cattle manure is in organic or inorganic forms of low or slow solubility in water, it is important to study manure P effects on early crop growth compared with fertilizer. The low P rates with fertilizer and both manure types had a smaller effect on early corn growth and P uptake than the high rate, but there were no clear differences between P sources.

Results for corn grain yield in Figure 1 for the three P sources show a small yield increase and no large or consistent difference between the low and high application rate for any P source. The amount of P removed with the grain harvested showed a proportionally larger response but still no clear or large differences between the P sources. The results confirmed previous research with P fertilizer, swine manure, or poultry manure that an increase in early corn growth due to P application does not necessarily result in a grain yield increase unless the soil P deficiency is extreme and moisture does not limit yield.

Figure 2 shows soil-test P results from the samples taken after corn harvest in the fall of 2012 and soybean grain yield in 2013. Data are averages of the two times of P application before corn because application timing did not affect soybean yield. Application of fertilizer and dirt-floor-type manure before the previous year corn increased post-harvest soil-test P and second-year soybean yield. There was little difference between the application rates. For bedded manure, however, the low application rate did not increase soil-test P or soybean yield. This result was unexpected because the previous year corn did not show such a lack of yield response (Figure 2). This result has little practical relevance because such a low P rate would not be applied for the two years of the corn-soybean rotation, and the 120-lb rate showed the expected increases.

Conclusions

Fertilizer and beef cattle manure increased early corn growth and P uptake similarly, and the increases were greater for the high P application rate. Corn in 2012 was severely limited by drought at this location, and all the P sources and application rates resulted in similar small increases. The results for early growth, early P uptake, and grain yield suggest similar P efficiency for fertilizer and manure. Application of the recommended P rate as a single application before corn for the corn-soybean rotation increased post-harvest soil-test P and second-year soybean yield. There was no difference between P sources. Overall, results showed the crop-availability of beef cattle manure P is greater than currently assumed in ISU manure management guidelines.

Acknowledgements

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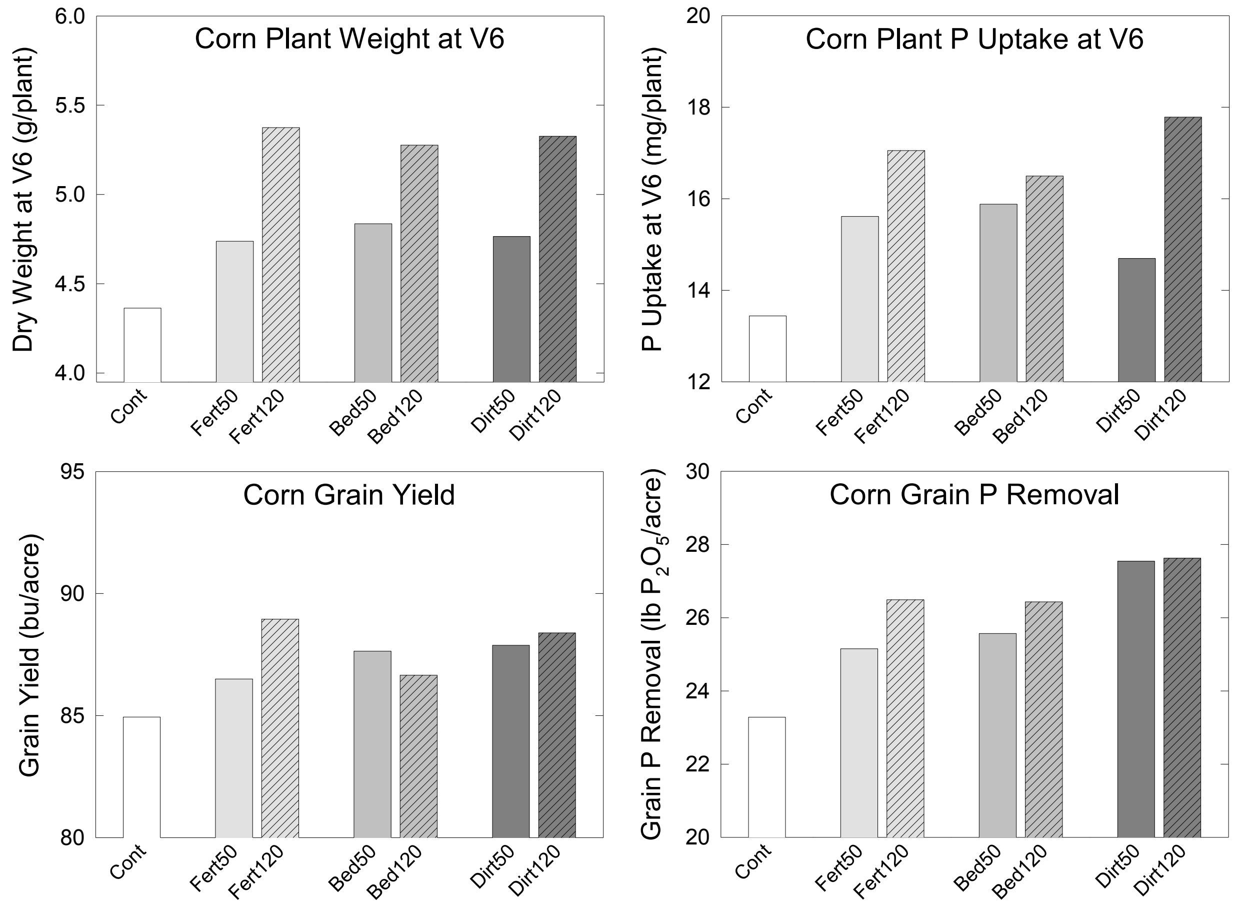

Figure 1. Effects of fertilizer and beef cattle manure on early corn growth and P uptake, grain yield, and P removed with grain harvest. Fert=fertilizer, Bed=bedded manure, and Dirt=dirt-floor confinement.

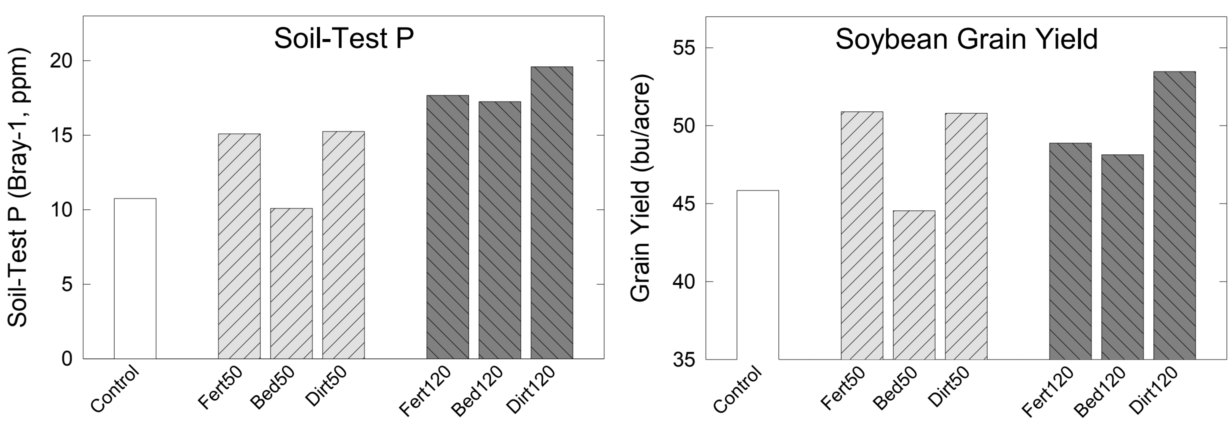

Figure 2. Effects of fertilizer and beef cattle manure applied before the previous year corn on soil-test P measured after harvesting corn and soybean grain yield. Fert=fertilizer, Bed=bedded manure, and Dirt=dirt-floor confinement.