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Crop Availability of Phosphorus in Beef Cattle Manure for Corn and Soybean

Antonio P. Mallarino
Iowa State University, apmallar@iastate.edu

Mazhar Ul Haq
Iowa State University, mazhar@iastate.edu

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Abstract

An efficient utilization of beef cattle 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. There is large variation in P concentration, manure has organic and inorganic P forms, and manure handling is more difficult. 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 Northern Research Farm, Kanawha, Iowa, in 2012 and 2013 to assess the crop-availability of manure P from selected Iowa beef production systems.

Keywords

Agronomy

Disciplines

Agricultural Science | Agriculture | Agronomy and Crop Sciences

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

Introduction

An efficient utilization of beef cattle 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. There is large variation in P concentration, manure has organic and inorganic P forms, and manure handling is more difficult. 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 Northern Research Farm, Kanawha, 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 at the Northern Research Farm had no recent history of manure application, and the soil type was Nicollet loam. Initial soil-test results (6-in. depth) were 6.0 pH, 5.6 organic matter, and 5.9 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). Bedded manure from a nearby hoop building operation and manure from a nearby dirt-floor operation was used. 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 (5.7 to 19.8 lb P_2O_5/ton as-is and 34 to 63% 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 above-ground corn plant samples at the V5-V6 stage were analyzed to study treatment effects on early growth and P uptake, total plant biomass, P uptake at the black-layer growth stage, grain yield, grain P removal, and post-harvest soil-test P. In the second year, soybean plant samples at the V5-V6 growth stage, top mature leaves at the R2-R3 growth stage, and grain yield were analyzed. The results for selected measurements are shown in this 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 figure shows averages for the fall and spring times of P application because these treatments did not differ consistently and there was high variability.

Because some beef cattle manure P is both organic and inorganic that has low or slow solubility in water, it is important to study manure P effects on early crop growth compared with fertilizer. The low rate of fertilizer and manure increased early corn growth and P uptake less than the high rate. The lower growth and P uptake with the low rate of bedded manure compared with fertilizer and dirt-floor manure was not confirmed by statistical analyses.

Results for corn grain yield in Figure 1 for the three P sources show a large relative yield increase and slightly higher yields for the high P rate from all P sources, which was expected for a low-testing soil. However, the overall yield levels were very low, because the drought of 2012 severely limited corn yield in the region. The three P sources did not differ for any P rate according to statistical analyses, although yield seemed lower for the low rate of dirt-floor manure. The P removed with grain harvest showed a proportionally larger response to P, 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 from P uptake 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 the residual effects of P applied before the previous year's corn on soil-test P of samples taken after harvesting corn in the fall of 2012 and on soybean grain yield in 2013. Data are averages of the two times of P application before corn because these did not affect post-harvest soil-test P or second-year soybean yield. Soybean yields in 2013 were very high. The high P rate increased soil-test P more than the low rate, but the P sources did not differ. Soybean grain yield was higher when P had been applied, but there were no statistically significant differences between P rates or sources in spite of an apparently greater yield for the high rate of dirt-floor manure.

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. There were large corn grain yield responses to P even though the yield levels were very low due to severe drought in 2012, but all the P sources resulted in statistically similar increases. The results for early growth, early P uptake, and grain yield suggest similar P efficiency for fertilizer and manure. Soil-test P levels after corn harvest and second-year soybean grain yield reflected the P applied with fertilizer and manure before corn the previous year, but there were no differences between fertilizer or manure 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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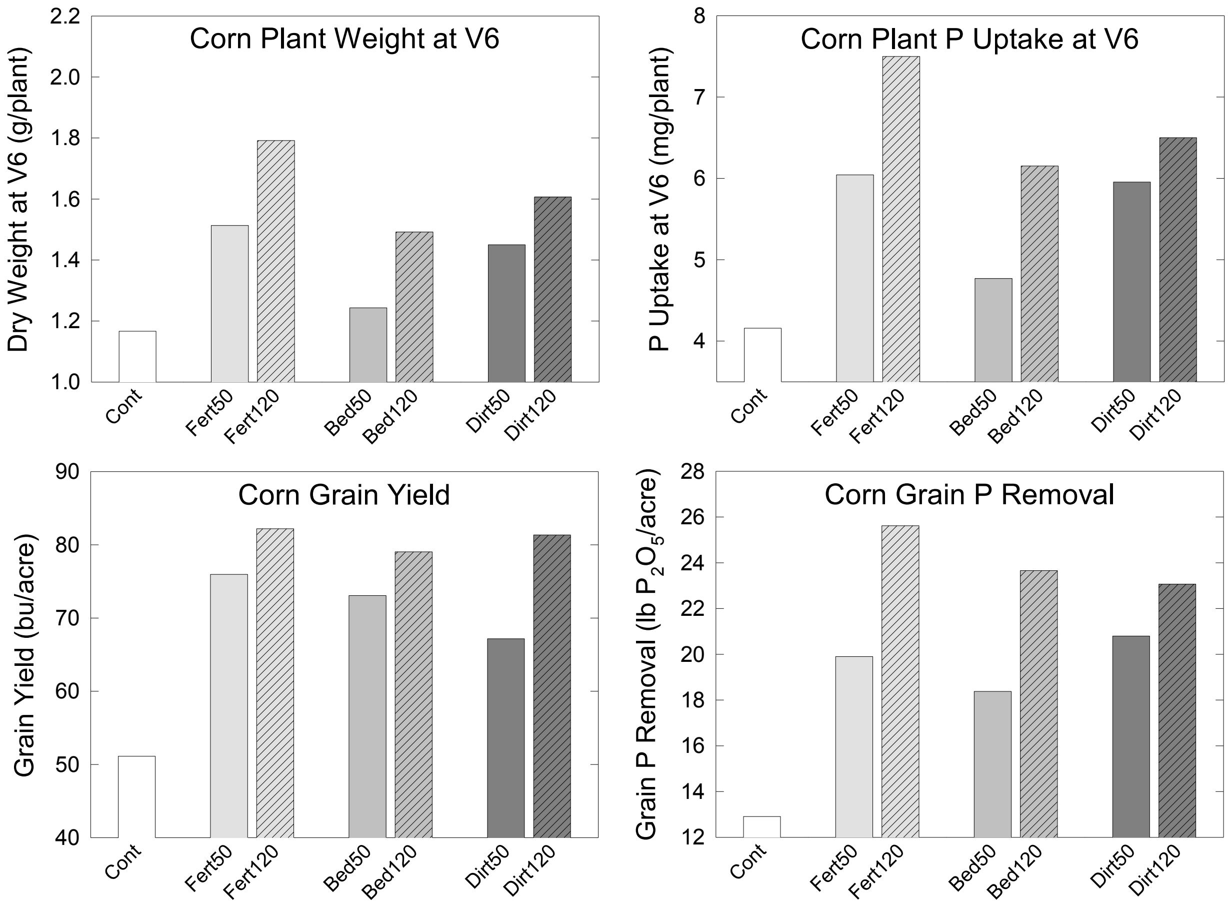

Figure 1. Effects of fertilizer and beef cattle manure on early corn growth and P uptake, grain yield, and P removed with grain harvest. Fert=fertilizer, Bed=bedded manure, and Dirt=dirt-floor confinement.

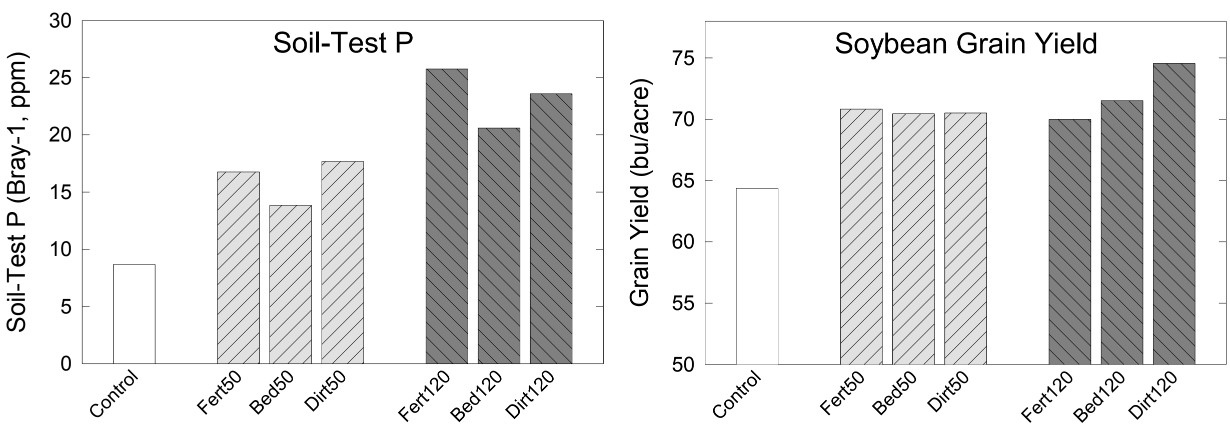

Figure 2. Effects of fertilizer and beef cattle manure applied before the previous year corn on soil-test P measured after harvesting corn and soybean grain yield. Fert=fertilizer, Bed=bedded manure, and Dirt=dirt-floor confinement.