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Crop availability of phosphorus in beef manure

Abstract

This study provided the first Iowa assessment of the availability of beef cattle manure phosphorus (P) for crops since the early 1970s.

Keywords

Agronomy, Nutrient management, Soils and agronomy

Disciplines

Agronomy and Crop Sciences | Soil Science



Crop availability of phosphorus in beef manure

Abstract: This study provided the first Iowa assessment of the availability of beef cattle manure phosphorus (P) for crops since the early 1970s.

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Agronomy

Iowa State University

Budget:

\$25,000 for year one

\$39,935 for year two

\$35,214 for year three

\$12,461 for year four

Q How should the current estimate of beef cattle manure P crop availability in Iowa State University Extension and Outreach guidelines be updated?

A This study showed that for most beef cattle manure types, and under most field conditions, the P availability is higher; ranging from 80 to 100 percent compared to fertilizer. Analysis of manure-soluble P and other fractions did not help to identify the reasons for variation in availability. To minimize risk of yield loss due to P deficiency, the lower part of the availability range should be assumed when the manure is applied to low-testing soils, and the higher part of the range assumed when the objective of the application is to maintain soil-test P in the optimum category for crops.



ECOLOGY

Background

Efficient utilization of beef cattle manure nutrients can improve the sustainability of animal and crop production systems and avoid unnecessary use of energy and non-renewable resources. Uncertainty about the crop availability of manure nutrients encourages disposal as a waste or supplemental application of inorganic fertilizers that may not be needed. Manure as a source of phosphorus differs from inorganic fertilizers in that there is a large variation in phosphorus (P) concentration, it contains organic and inorganic P forms, and handling is more difficult. Organic P forms may not be entirely or immediately available for plant uptake but may become accessible over time.

Research in Iowa during the past decade investigated the crop availability of P in swine and poultry manures. This resulted in very significant changes to published management guidelines (Extension and Outreach publication PMR 1003). For example, it was found that the first-year P availability in these manures was almost twice the value that had been assumed for decades. No research in Iowa has assessed the crop availability of beef manure P for several decades. The overall goal of this project was to provide better information for producers and agronomists about the crop availability of beef cattle manure P.

The specific objectives were to:

- (1) Assess the crop-availability of manure P from distinct Iowa beef production systems,
- (2) Determine if there is a manure P fraction adapted to routine testing that could provide a reasonable estimate of manure P availability, and
- (3) Provide a more precise estimate of beef manure P availability than the current wide range included in ISU application guidelines and update accordingly.



Graduate student Nicholas Dagna in the ISU Agronomy Building incubation room. He is taking care of the pots where project researchers studied the reaction of several beef cattle manure types with three different soils.

Approach and methods

For Stage 1, the team sampled manure from 107 Iowa confined beef operations that represented a wide range of feeding and manure handling systems. They sampled manure from the most common type of operations in Iowa: mono-slope roofed buildings with bedding and a concrete floor; hoop barns with bedding and concrete, compacted soil or crushed limestone floor; open lots with a concrete floor; and open lots with a dirt (soil) floor, which were grouped into the manure types bedded, concrete-floor, and dirt-floor. They also tested manure from the much less common operations that handle liquid manure stored in deep pits or operations that did not feed corn co-products. The manure was analyzed for more than

20 chemical properties, which included the total nutrient concentration measured in routine analysis for production agriculture and several other nutrient fractions. The most relevant measurements for this project were total P and manure water-soluble P concentrations.

For Stage 2, the investigators selected 11 of the collected manure samples that represented the greatest contrasting properties for a detailed manure P fractionation study and an indoor incubation study based on soil P testing. Incubation studies allow for the study of many combinations of manure types, soil types, and manure reaction times with soil using several P extraction methods. The crop availability of P was estimated by analyzing all incubated samples with the three production agriculture soil P test methods, as supported by ISU CALS, and with a research method that extracts water-soluble P.

In Stage 3, researchers did field testing for crop-availability of P in the two most widely used and contrasting solid beef cattle manure samples as indicated by the survey and incubation studies. Four 2-year trials were established in soils at different locations that had contrasting properties and tested low in P. Treatments at each trial were combinations of three P sources, three P rates and two seasonal times of application. The P was applied only once before corn with incorporation into the soils by disking. Soybean was grown the second year without new P additions.

Results and discussion

Stage 1 (manure analysis survey): Total P and the proportion that was water soluble averaged greater for bedded, concrete-floor and pit manures (10 to 15 percent total P, dried basis, and 55 to 59 percent soluble P) than for dirt-floor or no co-products manures (5 and 7 percent total P, and 21 and 42 percent soluble P, respectively). The manure total P concentration can be measured by routine manure analysis and the manure application rate can be adjusted according to its concentration. The proportion of manure water soluble P is not routinely measured, however. The significance of the lower manure water-soluble P in two manure types for the crop availability of P was studied in the subsequent project stages.

Stage 2 (incubation with soil): As estimated by soil testing, the proportion of manure inorganic or water-soluble P was not a useful indicator of the crop P availability of the manures. On average, across the three agronomic soil P test methods, soil types and incubation times, the manure P efficiency relative to



Nicholas Dagna collecting manure samples for the study from an open lot with a dirt floor.

inorganic fertilizer was the highest for bedded and concrete-floor manures (87 and 85 percent, respectively), intermediate for pit and dirt-floor manures (78 and 76 percent, respectively), and lowest for the uncommon no-co-products manure (69 percent). Analysis of manure soluble P and other fractions did not help to identify reasons for this variation in availability.

Stage 3 (field evaluations): These evaluations in four fields showed that beef cattle manure collected from operations using bedding or dirt-floor confinements and applied using a low, P- deficient rate can result in less early corn growth and early P uptake (7 percent less) than an equivalent P fertilizer rate. However, results for grain yield, total plant P uptake at maturity, grain P removal with harvest, and post-harvest, soil-test P showed no statistically significant difference between the availability of P in manure and fertilizer. Therefore, by considering effects on both early crop growth and grain yield, and in contrast to a short-term indoor incubation study based on soil testing, the field evaluations indicated that the crop P availability of beef cattle manure was 93 to 100 percent compared with the fertilizer P availability, which was even higher than the estimate observed by soil testing in the incubation study. Analysis of manure soluble P and other fractions did not help to identify reasons for a slightly lower availability for early crop growth.

Conclusions

Results of an indoor incubation study of several beef cattle manure types with three contrasting Iowa soils and a field evaluation with the two most common manure types (bedded and dirt-floor) showed that the crop availability of P in manure compared with inorganic fertilizer is higher than the 60 to 100 percent availability range currently suggested in ISU Extension and Outreach publication PM 1003. Considering P application effects on both early crop growth and yield and results of incubation and field studies, results demonstrated that the crop P availability of the predominant types of beef cattle manure in the first year is between 80 and 100 percent compared with the availability in fertilizer. Analysis for manure soluble P and other fractions did not help to identify reasons for variation in crop availability of manure P. To minimize risk of yield loss due to P deficiency, the lower values of the range should be assumed when the manure is applied to low-testing soils and the highest values assumed when the objective of the application is to maintain soil-test P in the optimum category for crops.

Impact of results

The results show there is great potential for improved utilization of beef cattle manure for P management in cropping systems. The crop availability of P in beef cattle manure compared with inorganic fertilizer is higher than currently suggested by ISU guidelines, and the estimates are based on solid science and cited with several conditions. Therefore, the higher P availability and the recent science-based information should result in greater producer confidence when applying manure and lower application rates, which should result in improved soil sustainability and water quality. The Extension and Outreach publication PM 1003 will be updated based on the project results, and will better inform producers, agronomists, and nutrient management planners.

Education and outreach

Publications:

Dagna, N.E., and A.P. Mallarino. 2014. Beef cattle manure survey and assessment of crop availability of phosphorus by soil testing. *Soil Sci. Soc. Am. J.* 78:1035-1050.

Dagna, N.E., and A.P. Mallarino. 2011. Availability of phosphorus in manure from beef cattle feedlot systems evaluated by soil testing. *Agron. Abs. ASA-CSSA-SSSA*. Madison, Wisconsin

Dagna, N.E. 2012. Application of soil test methods to study the availability of phosphorus in beef cattle manure. M.S. Thesis. Iowa State University.

Dagna, N.E., and A.P. Mallarino. 2014. Beef cattle manure survey and assessment of crop availability of phosphorus by soil testing. *Soil Sci. Soc. Am. J.* 78: 1035-1050

Haq, M.U., and A.P. Mallarino. 2014. Availability of phosphorus in beef cattle manure for corn and soybean. *Agron. Abs. ASA-CSSA-SSSA*. Madison, Wisconsin

Presentations:

- Poster presentation at a 2012 meeting for Extension beef specialists and producers with preliminary results of the beef cattle manure survey and evaluations of P availability by indoor incubations.
- Video recording for 2012 ISU Extension manure certification training, which included results of the beef cattle manure survey.
- Poster presentation at the annual meetings of the American Society of Agronomy and Soil Science Society of America. 2011, San Antonio, Texas.
- Results of the manure survey were shared with nearly 100 producers whose operations provided the manure samples. Project personnel answered questions about the results.
- Oral presentations on the beef cattle manure survey at six February 2012 manure management meetings targeted to manure applicators. Meeting sites were Ellsworth, Clarion, Washington, Orange City, Storm Lake, and Greenfield, Iowa.

Leveraged funds

No additional funds were leveraged by this project.

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