

ENVIRONMENT

Title: Field-scale evaluation of the value of manure on soil quality and crop production - **NPB #02-216**

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Abstract: Manure generated from swine operations is often considered both a liability rather than an asset. Neighbors view manure as a problem from the perceived environmental and nuisance viewpoint while swine producers view manure as a production problem. Concerns over phosphorus buildup in soils and limitations in the amount of land available for the application of manure creates a concern that the land base will not be sufficient for agronomic application. Producers that have effectively used manure as part of their grain and swine production systems value manure as a part of the enterprise and can not understand why all producers don't treat manure as a resource. This study was undertaken to document the value of manure in swine production systems through the analysis of producer records on manure use and changes in soil properties and crop yield.

A study using actual producer data was conducted by collecting soil and manure test for nutrients across the Midwest. The large amount of soil variability in the samples collected prevented a direct conclusion about the impact of manure in a particular field. However, across the complete set of observations manure increased the soil organic matter by 0.05% per year after 5 years of manure application at agronomic rates. During this same time period, there was no increase in the soil P levels or soil chemicals, e .g., Ca, or K, or pH. Increases in crop yield due to manure application have been reported on farms but were not found in this study because of the lack of a consistent yield data base. Manure can be managed as a valuable soil amendment. Producers can manage manure on their fields and enhance the soil without potential environmental problems.

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Introduction: Animal production agriculture in the United States has changed rapidly in the last 10 years. Overall livestock production numbers increased by 15 % from 1982 through 1992 (USDA Census of Agriculture, 1997). Examples of these changes are: the large increase in swine produced; and new swine production facilities in the Upper Midwest and North Carolina (USDA, 1997); however, within the last 50 years there has been a net decrease in the numbers of animals produced within the United States. There has been a decrease in the number of livestock operations resulting in more concentrated facilities with a larger number of animals at each site. Continued increases in the number of concentrated animal feeding operations (CAFO's) challenges our understanding of how to effectively deal with the volume of manure generated by these facilities and all of animal production. During the early 20th century, manure was handled internally on the farm as a part of the crop production system. Manure produced by the animals was used as the source of nutrients for the crops that produced grain or forage for the animals. This was a balanced ecosystem approach to manure utilization, however, in the late 20th century our view of manure has changed from a resource to a waste and a problem because we have concentrated animals in a smaller area and transport the grain to the livestock. This decoupling of manure production and potential utilization sites has affected our consideration of manure as a nutrient source. Manure hasn't changed, but our attitude has significantly changed about its value and role in agricultural production. One of the major challenges to be faced in the United States is how do we "rediscover" the value of manure and develop systems that preserve the nutrients found in fresh manure and not allow the nitrogen to escape into the atmosphere.

Manure is a valuable and under-appreciated soil resource and reviews by Hatfield and McNeill (2002) and analysis of the livestock numbers from the past 50 years shows that the amount of manure produced has decreased. The trend toward larger numbers of animals at a given site has created a potential problem in application of manure. The current attitude is to treat manure as a waste and not consider its value on increasing the quality of the nation's soil resource. There is ample documentation that manure can increase the quality of the soil, enhance and stabilize crop production, and be managed without imposing an environmental risk. The challenge before us is to develop manure handling systems that eliminate the loss of nitrogen to atmosphere and retain the nutrients within the manure. This has to be coupled with manure application systems that effectively place the manure in the soil to eliminate potential runoff or volatilization of N to the atmosphere. These systems can be developed if we utilize our imagination and place the proper value on manure that it deserves. The information base that exists is primarily from the scientific literature and doesn't represent production operations and producers are reluctant to accept information that is not at the field or farm scale. To address some of the concerns about the value of manure we designed a study to evaluate the value of manure using producer information from the Midwest.

References:

J.L. Hatfield and M. McNeill, 2002. Managing Manure to Achieve Maximum Value, 2002 Watershed Heroes Conference, American Farm Bureau. Chicago, Illinois.

USDA. 1997. 1992 Census of Agriculture. Washington, D.C.

Objectives:

The objectives of this study were to:

1. Evaluate the impact of long-term manure application on changes in soil and efficiency of crop production using producer records;
2. Compare effects of manure compared to commercial fertilizer on crop yield; and
3. Design manure studies to reduce gaseous emissions and increase crop production efficiency.

Material and Methods: To address the objectives of this study we designed a questionnaire that was sent to several producers within Illinois, Indiana, Iowa, Minnesota, and Wisconsin. The survey that was sent to each producer was as follows.

Case Study Using Producer Data

Background: Manure is one of the most valuable soil amendments in agriculture. However, it is most often considered an environmental liability and a disposal problem. To the public, manure represents a waste that producers don't value or care about as part of their operations. Unfortunately, there are crop and livestock producers who don't fully understand the value of manure. We have forgotten about the worth of the material that is produced by livestock.

We are attempting to turn this perception around through a series of case studies on the value of manure. There is a sense of urgency to document the value of manure that precludes the development of research studies and our goal is to assemble this evaluation through interactions with producers. Producers are valuable sources of information on the use of manure and can greatly contribute to the development of this knowledge base on the value of manure. We are soliciting your assistance on assembling this information base on swine manure and its value as a soil resource. This project will produce three products. First, a report developed for the scientific literature on the value of manure across all different soils, cropping systems, and manure handling types. Second, a tri-fold type of document for easy distribution to the producers and the general public. Third, a design for a series of "Value of Manure" demonstration studies to be implemented in 2003.

Disclaimer: All records obtained from producers will not include producer, specific site location, or field information. All summaries will be by county level only.

Information Needed:

Contact Information:

Name:
Address:
Phone:
Fax:
Email:

1. Are you willing to participate in this study? May we contact you to obtain data for the following questions?
2. How many years have you utilized manure as part of the nutrient supply for crops?
3. What type of manure storage and handling system do you have in your production system?
4. Do you regularly test the manure for nutrient content or use "book" values?
5. Application Information:
How is the manure applied? (Injected, broadcast and incorporated, or broadcast)

When is the typical application time?

Typically what are your application rates per acre?

6. Soils Information:

Do you have soil test records for N, P, K, CEC, pH, and organic carbon or soil organic matter? If so, how long of period and frequency are the data available?

What soil type or texture class is manure applied to on your farm?

7. Cropping System Information:

What is your crop rotation that manure is used as the nutrient source?

How often is manure applied in this rotation?

Do you have crop yields available for this field?

8. What type of tillage system is used in your cropping system with manure? Has the type of tillage system changed over the past few years?

These data were collected from eight producers across the Midwest with a representation of over 50,000 acres of land and an average manure application period of over 15 years. Production and manure records were entered into a spreadsheet to develop a common data base and codes for each producer to permit direct comparisons of the changes in the soil properties over the course of the soil tests. Data received from each producer had different intervals of soil tests which created some difficulty in evaluating the data as a single compilation of data. Soils information within each field and farm were not sampled in the same manner across producers and created some difficulty in completing an analysis of soil type response to manure applications. Soil test and manure nutrient records for nutrients and organic matter were conducted by either state or private laboratories and were accepted as reported by the producers.

Results:

Objective 1. Evaluate the impact of long-term manure application on changes in soil and efficiency of crop production using producer records.

Observations from these data sets revealed that manure application at agronomic rates did not change the phosphorus levels within the soil. The assumption that manure will lead to large increases in soil P levels has caused producer concerns about manure application. Over a seven year period P levels did not show any change except for one sampling sequence in the field (Fig. 1) These results are an atypical where large changes are found but are due to sampling rather than real changes in the soil. The increases in this series of observations across a number of fields were caused by a change of sampling and analysis procedure rather than a real change. These same fields were sampled the next year and the levels decreased by a factor of three. The increase in latter part of the record from 2002 is due to an increase in the soil P levels; however, these are below the recommended level for high P in these soils.

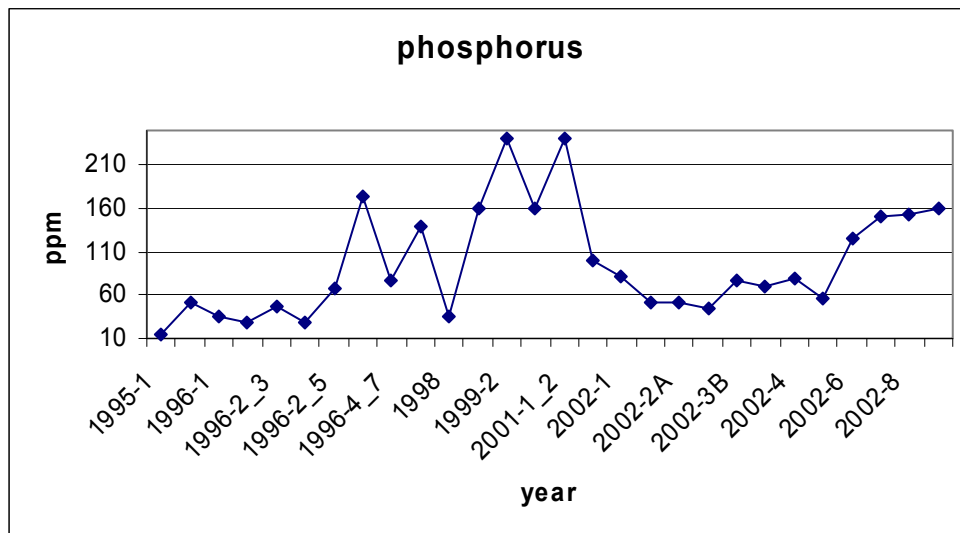


Figure 1. Changes in soil P levels in the upper 25 cm of the soil profile across a range of fields in Wisconsin. The numbers on the X-axis represent the year and field number. [what do the numbers and letters represent in the years on the x axis?]

A series of data were available across a range of soil types for different soil test values. There were differences among the soil that ranged from a silty loam to a clay loam soil. However, these differences are relatively minor. In this study the low soil P values of less than 100 ppm were present even though these soils have had a history of manure application of greater than 10 years (Fig. 2). Soil organic matter levels are above 4% across these soils indicating that there has been an effect of manure application because other reported values for soils in these areas are less than 3%. There is no data for a direct comparison in this data set on organic matter and comparisons were limited to reported values. The soil types are represented by numbers and texture class changes from silty loam (1), silty clay loam (5) to clay (9).]

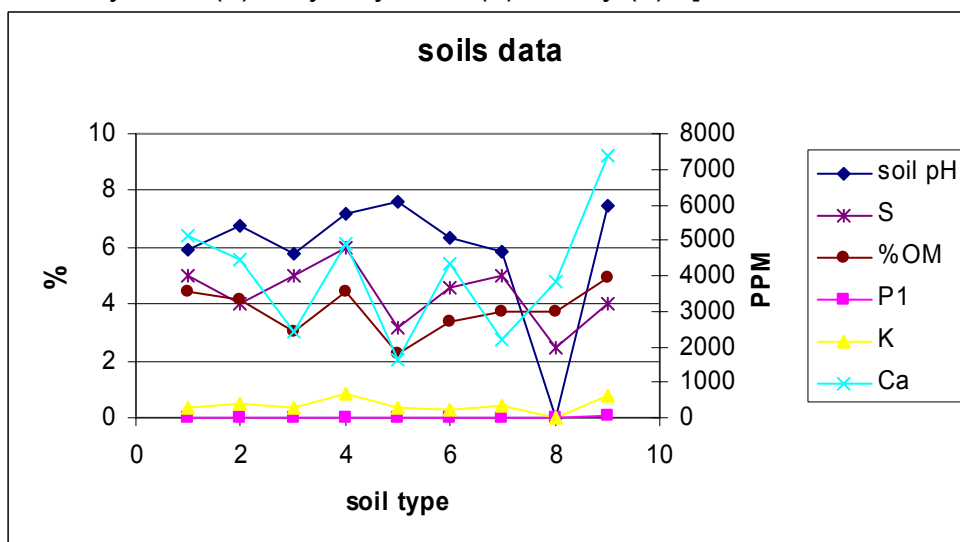


Figure 2. Soil test values collected in 2001 across a series of fields in central Iowa after manure application.

One of the primary benefits of manure is the change in soil organic matter levels in the soil. Over an 11 year period, soil organic matter levels in a series of fields did not change (Fig. 3). The soil organic matter levels averaged 2% across this period with a

slight increase in the last sampling in 2002. Examination of the tillage management for these fields showed that manure was injected and then a primary tillage operation of chisel-plowing followed with spring cultivation was the normal practice. Comparison of these organic matter values with other fields in the area show that the manure application has increased the nominal values by 0.5%. This increase in soil organic matter with manure application is responsible for positive changes in soil properties and production capability.

Yield information collected from the producers was on a field level and not separated by soil type. The aggregate yield records across the fields were not as useful as anticipated because of the lack of precipitation records on some of the farms.

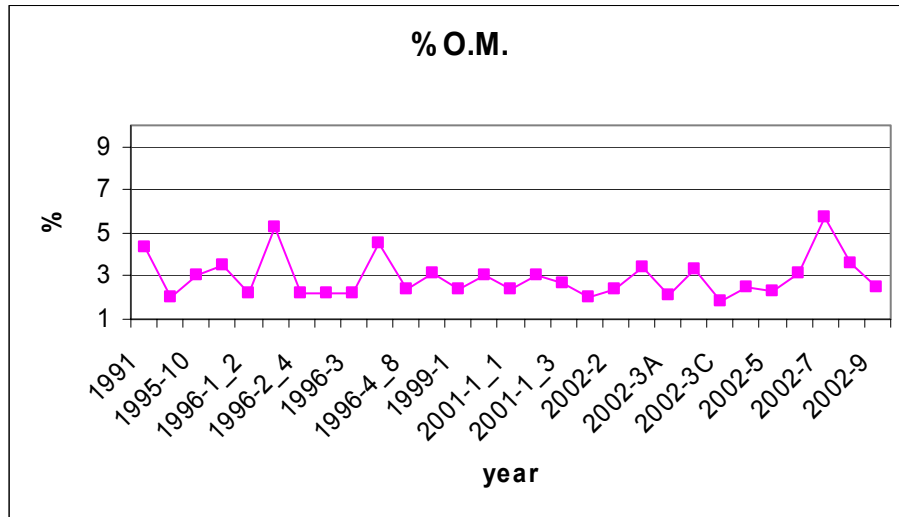


Figure 3. Changes in soil organic matter values (%) across a range of fields sampled in Wisconsin from 1991 through 2002. The numbers on the X-axis represent year and field number.

The variation in manure for P levels was of importance because of the concern about the effect of manure as a P source. Samples collected across a range of facilities and different times (spring vs. fall) show there was good consistency except for a couple of units (Fig. 4). Three facilities show high P levels in one sampling period; however, at other sampling times these were not evident. This would suggest that more care be taken in sample collection procedures to quantify the nutrient levels in manure.

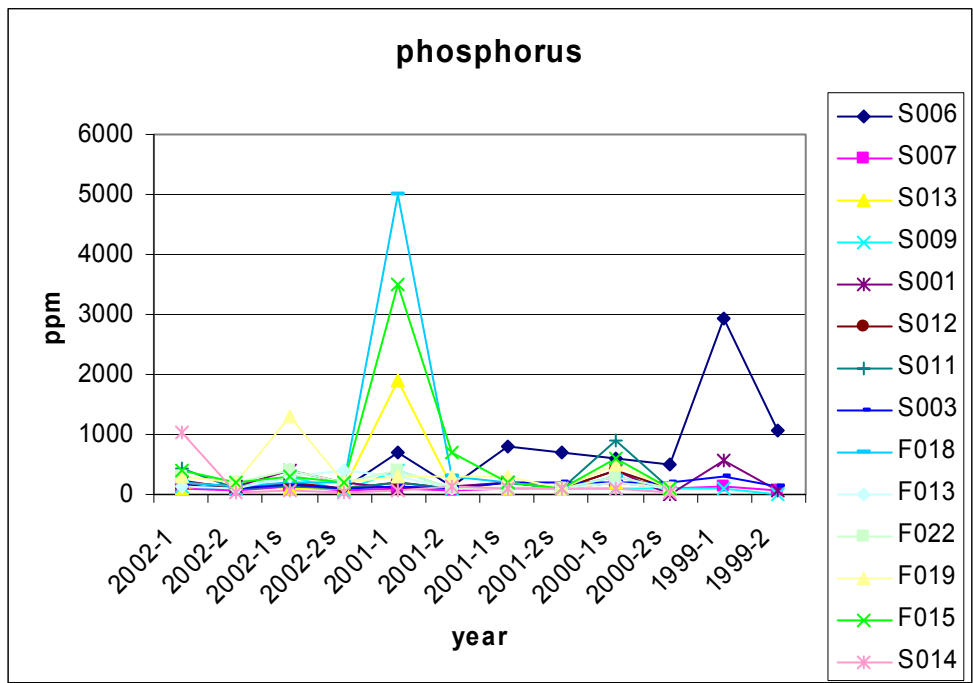


Figure 4. Phosphorus values in manure across a range of swine production facilities and sampling times.

Discussion: The aggregate data on the role of manure in soil showed more positive results than the individual fields. When the data were combined across all of the fields a few patterns began to emerge. The addition of manure at agronomic rates did not significantly change the soil test P levels. This is significant since it is assumed that manure application results in rapid increases in soil P levels. There were no significant changes in the soil P levels across the fields evaluated in this study. Likewise, there were no significant changes in other soil tests values for potassium, calcium, or pH in the soil profile. There was an increase in soil organic matter levels of 0.5% over the 10 year period of these observations. This is a rate of 0.05%/year with sustained manure application of a minimum of 5 years. It was not possible to separate the effects within a given soil type to determine if there was a greater response in some soils compared to others. Manure has a positive effect on the soil although these differences may not be observed in an individual field because of sampling variation, the aggregate effect across a range of soils is detectable.

These observations caused producers to ask a series of questions about manure application. These are addressed in the progress on objectives 2 and 3 of this study.

Objective 2. Compare effects of manure compared to commercial fertilizer on crop yield. The data base we developed from the producer information focused on the soil tests and crop yield data across different fields. There was insufficient information to directly compare commercial fertilizer to manure application in terms of yield and soil properties. One piece of evidence that was detectable in these observations was that the yields from manured fields were not different from the county average yields. These data show that manure did not have a negative impact on yields. There are reports from producers that manured fields have higher yields in both corn and soybean but these need to be documented more carefully than is available in this data.

Objective 3. Design manure studies to reduce gaseous emissions and increase crop production efficiency.

To address objectives 2 and 3 we have developed in cooperation with three producers a series of field-scale studies to demonstrate the value of manure. These studies were developed from the information collected in this study and will focus on the following treatments placed as strips across a field. Strips will be placed across a field of commercial fertilizer at the recommended N and P rate, manure at the rate estimated from nutrient management plans, manure applied at the rate to satisfy N needs of the corn crop, manure applied at the rate to satisfy P needs of the crop with the additional N supplied with commercial N sources. The studies would be conducted in Buena Vista, Greene, and Kossuth counties in Iowa with the potential for an additional site in southern Minnesota in 2005. These field sites are being established in the fall of 2003 with a series of soil tests in each strip area and then following the nutrient response of the corn crop and crop yield. These sites are located near highways to promote visibility of the value of manure.

The information that is of value to producers is that manure has positive effects on the soil and can be used to increase soil organic matter. These data are being assembled into a tri-fold on the value of manure for use by producers to educate their neighbors and grain producers. This tri-fold will be completed in the spring of 2004.

Lay Interpretation: Manure is a valuable source of nutrients and organic material for the soil. The observations that have been conducted across several studies have been completed in research plots. A study using actual producer data was conducted by collecting soil and manure test for nutrients across the Midwest. The aggregate data set from these surveys was over 50,000 acres of cropland in four states. There is a large amount of soil variability in the samples collected that often prevented a direct statement about the impact of manure in a particular field. However, across the complete set of observations manure increased the soil organic matter by 0.05% per year after five years of manure application at agronomic rates. During this same time period, there was no increase in the soil P levels or soil chemicals or pH. Increases in crop yield due to manure application have been reported on farms but were not found in this study because of the lack of a consistent yield data base. Producers can manage manure on their fields and enhance the soil without potential environmental problems. This study has promoted the development of three manure studies on producer fields in Iowa to be implemented in the fall of 2003 to directly compare manure versus commercial fertilizer and the changes in soil properties.