ASSESSMENT OF NITROGEN SUPPLY FROM POULTRY MANURE APPLIED TO CORN

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Introduction

The production of poultry in the state of Iowa is one of the largest in the nation and growth has continued the past few years. Currently Iowa is the number one egg producing state in the USA (USDA, 2005). This increase in production also implies an increase in manure production from poultry sources. The common end use of manure is application for crop production. Concerns exist regarding application at rates higher than needed for crop use, with potential for contamination of water bodies due to excess nutrients. Producers also question the proportion of the total N that should be accounted for as crop-available in the year of application.

In addition to the environmental implications of excess nutrients from manure application, the economic and agronomic aspects of incorrect application rates also need to be addressed. Poultry manures can have more readily crop-available N compared to other manure sources, such as sheep and cattle. For example, Rees and Castle (2002) found that corn had larger plant growth and yield response to poultry manure application. The current ISU Extension publication in Iowa providing suggested first-year crop availability of N from poultry manure indicates use of 65 percent (Killorn and Lorimor, 2003).

On the other hand, research work such as that of Chambers and Richardson (1993) suggest no need for additional commercial N fertilizer following a recent application of poultry manure. Other studies suggest that poultry manures have a rather slow release of plant-available N and in about one year approximately 67 percent of the organic N fraction is mineralized (Bitzer and Sims, 1988).

The large variability observed in nutrient concentrations in manure is well known, with variation depending on source as well as management (Cooper et al, 1984). This creates a need for understanding poultry manure nutrient content and using local sources of poultry manure to study applications with the soils, cropping systems and climatic characteristics of Iowa. Furthermore, a large percentage of N in poultry manure is in the organic fraction (Sims, 1986), therefore more information on the mineralization of this N will help with prediction of N availability. Also, because 20 to 40% of the total N is inorganic N (Bitzer and Sims, 1988), estimates of nitrification and crop recovery of this fraction is needed as well.

The purpose of this study is to estimate under field conditions the supply of plant-available N to corn from several poultry manure sources and timing of application, and to compare corn yield response between poultry manure N and commercial fertilizer.

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Materials and Methods

The study began in 2004, and is a planned three-year project. Trials are conducted on producers' fields and using their manure sources and crop production practices. The intent is to have sites across Iowa and work with different poultry manure types, soils, and climatic conditions.

The experimental design is a randomized complete block with split-plots. Manure rates are the main plots and fertilizer N rates superimposed split-plots. Manure is applied as strips across producers' fields at three planned total N rates. A high manure rate is based on approximate corn N fertilization requirement in Iowa, 150 lb N/acre (Blackmer et al 1997). There is also a low rate, approximately 75 lb N/acre, and a no-manure control (Table 1). Because the study objective is to measure available manure-N supply for corn, no assumption was made regarding first-year availability. Therefore rates are based on manure total-N. Manure sources used are turkey litter, broiler, and chicken layer.

Fertilizer N rates are 0, 50, 100 and 150 lb N/acre as ammonium nitrate. This fertilizer is applied by hand to small plots superimposed on top of each manure strips shortly after planting. Blanket P and K fertilizer (triple superphosphate and potassium chloride) were applied to all fertilizer split-plots at rates of 75 lb P_2O_5/acre and 70 lb K_2O/acre. Phosphorus and K applications were made to help mask potential effects of P and K applied with the manure, as well as natural field variability.

Given that the project is on producer's fields, the equipment used for manure application varied from field to field. However, manure spreaders were calibrated prior to manure application. Weigh cells were used to determine the amount of manure applied to a known area. Trays and tarps were also used to determine the uniformity and amount of application. At each site there were a number of calibration passes for each applicator. Multiple manure samples were collected from the spreaders at the time of application and frozen until analysis. Manure was applied in the fall, winter, or spring, depending upon the desires of the producer. When possible manure was incorporated shortly after application to avoid N loses. For routine soil tests, sites were sampled at 0-6 inch depth in the split-plot area and in different soil or management zones across the field-length strips. Soil nitrate (late spring) samples, 0-12 inch depth, were collected when corn was 6-12 inch tall in early June (Blackmer et al., 1997). Minolta® SPAD chlorophyll meter (CM) readings were taken at the VT corn stage in all manure strips and fertilizer N split plots. A quadratic plateau segmented function, was used to fit response curves to relative yield using PROC REG in the SAS statistical program (SAS Institute, 2000).

Results

Corn grain yield response to manure N application is clear; however the magnitude of response varied with the site and apparent N need. One site (Site 1) had no response to manure or fertilizer N (Fig. 1). Site 5 was only slightly responsive to fertilizer or manure application. Sites 2, 4 and 6 had large yield increase to manure and fertilizer N.

Corn yield increase due to additional fertilizer N application followed the trend for site responsiveness to N. At N responsive sites, corn yield was increased with fertilizer N applied in addition to the manure applications. With the higher poultry manure application rate, the response to fertilizer N was generally lower, with site 4 being the exception. Leaf greenness, measured with the Minolta® SPAD meter, followed the general corn yield response (Fig. 2).

Soil nitrate-N concentration for samples collected in early June show large increase to the 100 lb N/acre fertilizer N application (Fig. 3). However, the nitrate-N increase associated with manure application was much lower in comparison. This indicates a much different inorganic N supply from the poultry manure compared to fertilizer-N and would reflect less than 100 percent manure-N release and supply as crop available N. This trend does follow the smaller grain yield response with manure application compared to equivalent fertilizer-N application. The small difference observed in soil nitrate-N with manure application and between manure rates suggests also that interpretation of additional N need based on soil nitrate should not be the same with poultry manure as fertilizer. It appears that leaf greenness values, measured with the CM, may be a better indicator of site N responsiveness and corn response to poultry manure N than late spring soil nitrate.

Predicted grain yield response values across all manure sources and fertilizer rates (Fig. 4) indicates that the low rate manure treatment has a relative yield value of 0.95 with approximately 60 lb fertilizer N/acre, that is about 40 lb less N than the no-manure control (100 lb N/acre). This represents approximately 50 percent equivalent of total manure-N supplied to corn from low manure rate (77 lb total-N/acre applied in the low rate, Table 1). With the high manure rate (166 lb total-N/acre, Table 1) manure-N supply equivalent follows the same trend. With just one year of results, across the different manure sources and application practices used at the study sites, approximately 50 percent of poultry manure total-N was being supplied as crop-available N to corn. However, estimates of poultry manure N supply to corn will be further evaluated as the study continues.

Conclusions

Poultry manure N significantly increased corn yield in the year of application. Results from the first year of this study suggest that approximately half of applied poultry manure N was supplied to corn in the year of application. This is lower than the current suggestion in Iowa for poultry manure crop-N availability. However, in this study, with poultry manure applications including fall, winter, and surface application with delayed incorporation, any N losses would also be included in the estimate of manure-N supply to corn. Corn leaf greenness (CM values) appears to give a better reflection of poultry manure N supply to corn than late spring soil nitrate concentrations. Continued work with more poultry manure sources and field applications will help clarify estimates of first-year N supply.

Acknowledgments

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Table 1. Manure rates and total-N application calculated from manure applicator calibration and manure analysis.

Field	Manure Applied		Total N	
	Low	High	Low	High
	-------ton/acre------		-----lb N/acre----	
1	1.1	2.0	55	100
2	1.6	3.2	85	170
3	1.2	3.1	68	177
4	1.9	3.7	106	207
5	1.5	3.3	95	208
6	1.3	3.2	56	138
	Mean Total-N Rate		77	166

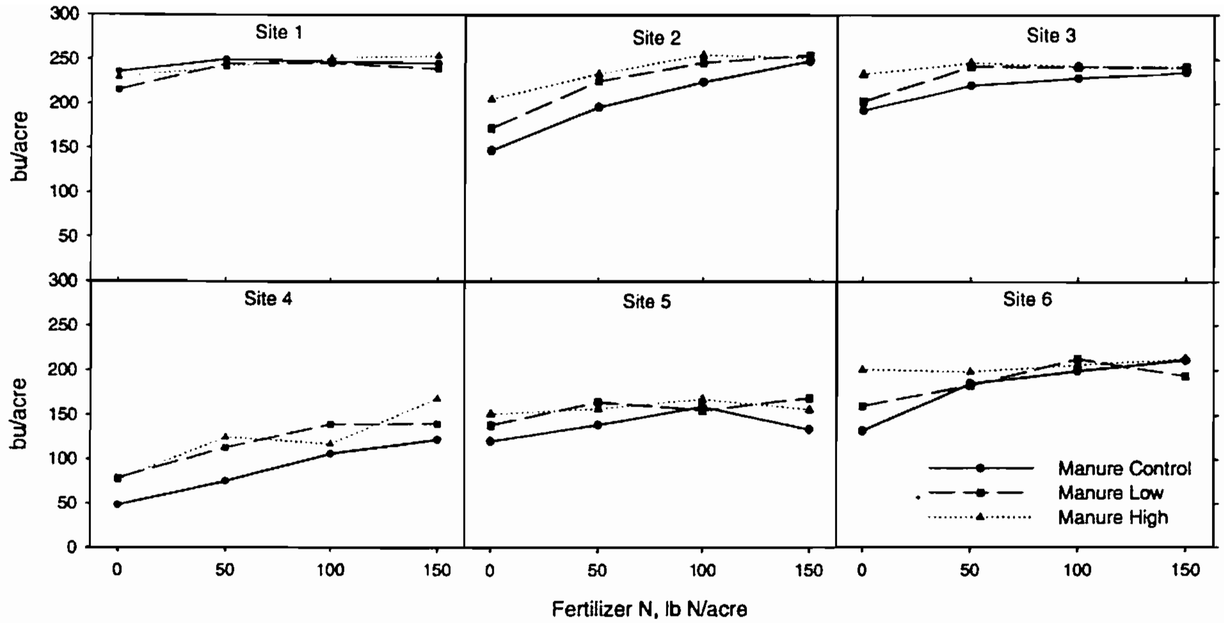

Figure 1. Grain yield response to poultry manure rate and additional N fertilizer.

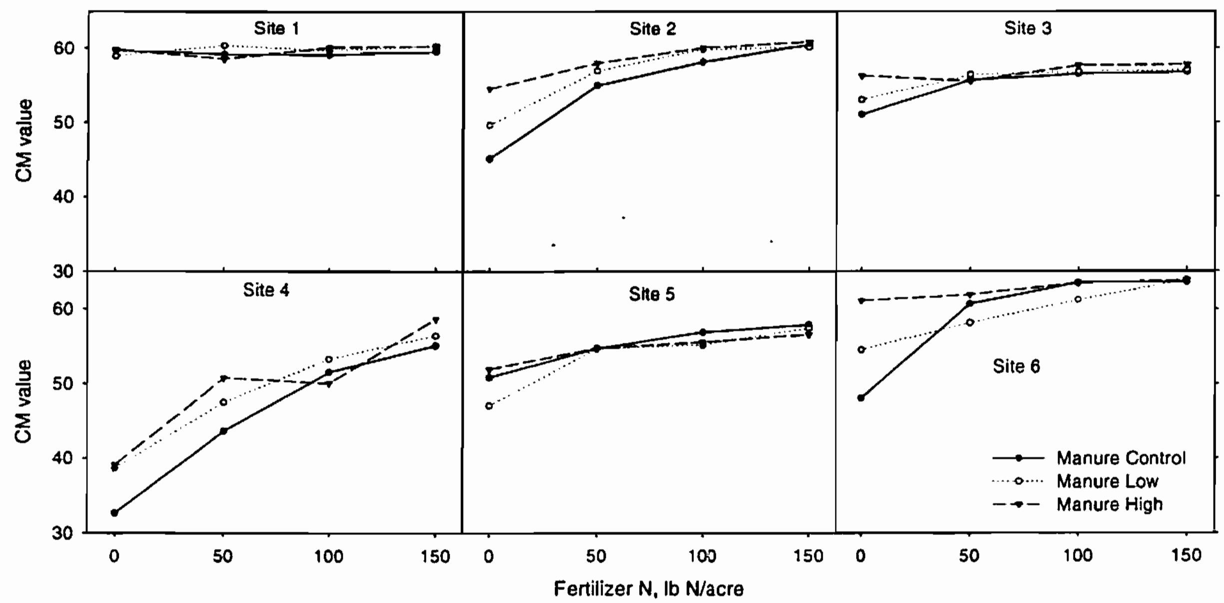

Figure 2. Corn leaf greenness (CM values) response to poultry manure rate and additional fertilizer N.

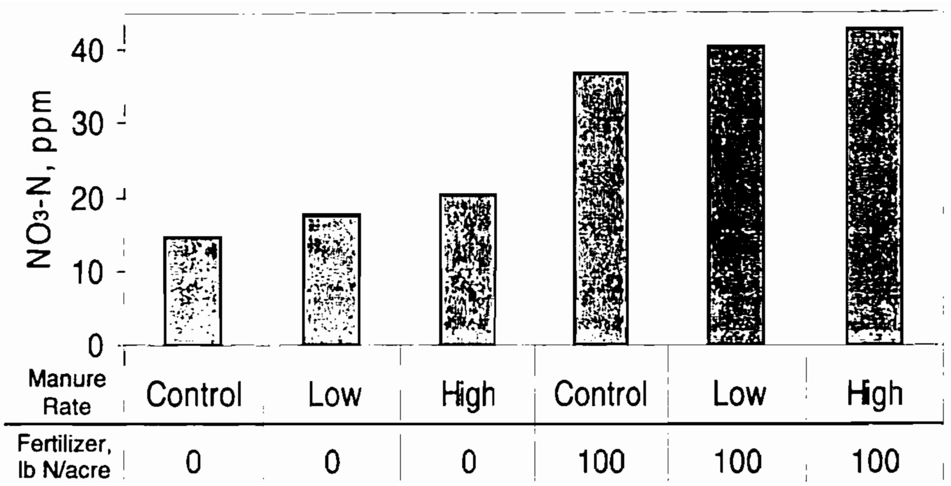

Figure 3. Late-spring soil nitrate concentration response to poultry manure rate and fertilizer N application.

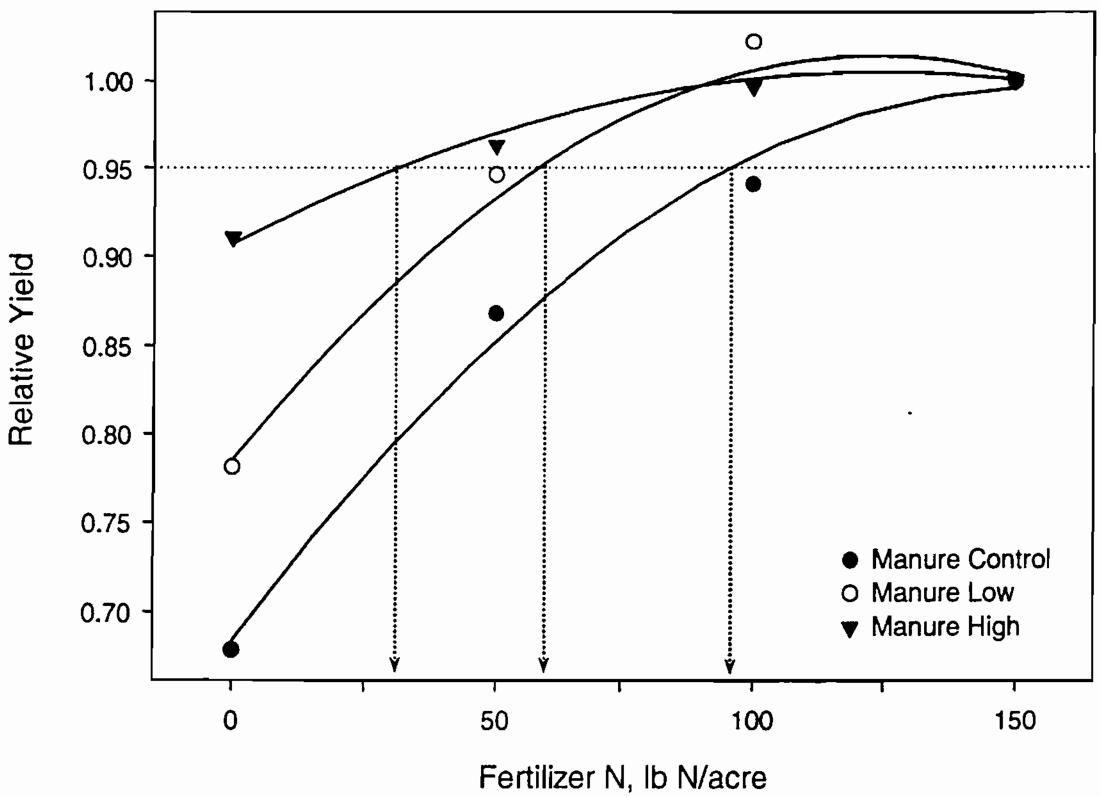

Figure 4. Average predicted regression lines for relative grain yield for each manure application rate. Maximum relative yield response is 155, 123, and 124 lb N/acre, respectively, for the no-manure, low and high manure rates. Manure N supply comparison made at 0.95 relative yield.

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