*Iowa Manure Matters*

# Odor and Nutrient Management

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## Crop and soil response to liquid swine manure application

*by John E. Sawyer, Antonio P. Mallarino, and John Lundvall, Department of Agronomy*

In this article, we summarize partial results from a project that has been demonstrating crop utilization of liquid swine manure nutrients—from understanding the nutrient application rate to measuring crop response. General goals and details of methods such as manure sampling, analyses, and application rates being used were outlined in two previous issues of the *Odor and Nutrient Management* newsletter (Fall 2002 and Winter 2002 issues). Herein, we present results for crop response to applied manure nitrogen (N). The final article in this series, planned for the Summer 2003 newsletter, will summarize crop response to applied manure phosphorus (P). For the first 3 years of the project (2000–2002), we worked with 16 producer cooperators at 39 production / field sites located in 12 counties.

**Harvesting replicated strip trails in the swine manure utilization project.**

**Corn response to manure N application.** Low- and high-rate (the target rate at most sites was 75 and 150 lb total manure N / acre for corn rotated with soybean, and 100 and 200 lb total manure N / acre for continuous corn) liquid swine manure applications substantially increased average corn strip yields relative to the no manure check at 15 of 17 evaluation sites in 2000–2002 where manure was applied before

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the corn crop (Table 1). Of the total yield increase from manure application, the majority typically came with the low manure rate (average 27 bu / acre strip yield increase across sites with the low manure rate and an average additional 10 bu / acre increase with the high rate). At several sites, the low rate seemed to supply adequate plant-available N, because there was no additional yield response with the high rate. Two sites in 2000 (Hardin and Plymouth) were nonresponsive due to high manure application history or drought conditions. Strip yield increases were considered mainly due to manure-N at most sites, although part of the strip yield increases could be due to response to manure P or potassium (K) at some sites when soil tests were optimum or lower. When warm, drying conditions during broadcast application (Clay 2001) or excessively wet spring conditions (Washington 2001, Davis 2002, Washington 2002) resulted in apparent N losses, or where corn followed corn, then corn yield was increased with higher manure rates (Table 1). If yield was increased with the higher manure rate, it was due to a combination of specific manure-N rates applied and site conditions (corn N requirement and potential N loss). These results with liquid swine manure, and potential effects from loss conditions, are similar to those encountered with N fertilizer.


**Cooperator Rob Stout during August 27, 2003, field day held at his farm.**

**Table 1. Corn grain yield response to liquid swine manure applied before corn, 2000–2002.**

| Site-Year[a] | Swine Manure Application None | Low | High | Statistics[b] | Manure Total Nutrient Application Low | High | Low | High | Low | High |
|---|---|---|---|---|---|---|---|---|---|---|
| | | bu/acre | | | lb N/acre | | lb $P_2O_5$/acre | | lb $K_2O$/acre | |
| 2000 | | | | | | | | | | |
| Webster (sp) | 119 | 135 | 138 | S | 70 | 139 | 48 | 96 | 43 | 86 |
| Clay (sp) | 130 | 159 | 182 | S | 77 | 154 | 46 | 91 | 38 | 77 |
| Hardin (sp) | 145 | 144 | 145 | NS | 83 | 195 | 100 | 236 | 81 | 191 |
| Washington (lf) | 136 | — | 165 | S | — | 216 | — | 188 | — | 180 |
| Plymouth (sp) | 99 | 110 | 99 | NS | 308 | 526 | 199 | 340 | 164 | 280 |
| 2001 | | | | | | | | | | |
| Cerro Gordo (sp) | 121 | 155 | 161 | S | 92 | 154 | 58 | 97 | 66 | 111 |
| Clay (sp) | 106 | 131 | 145 | S | 71 | 142 | 35 | 70 | 38 | 77 |
| Washington (lf) | 89 | 153 | 169 | S | 105 | 189 | 74 | 140 | 62 | 112 |
| Wright (sp) | 119 | 145 | 157 | S | 91 | 181 | 65 | 130 | 61 | 122 |
| Hardin (c-c)[c] (sp) | 122 | 141 | 146 | S | 115 | 192 | 91 | 152 | 75 | 124 |
| Story (lf) | 148 | 168 | 170 | S | 85 | 171 | 73 | 146 | 48 | 96 |
| Hardin (c-c)[c] (sp) | 131 | 144 | 147 | S | 69 | 189 | 55 | 150 | 45 | 122 |
| 2002 | | | | | | | | | | |
| Davis (sp) | 43 | 76 | 103 | S | 70 | 159 | 48 | 109 | 48 | 109 |
| Hamilton (lf) | 133 | 154 | 174 | S | 94 | 188 | 38 | 76 | 64 | 128 |
| Washington (lf) | 144 | 203 | 224 | S | 119 | 238 | 82 | 165 | 74 | 147 |
| Hardin (lf) | 170 | 196 | 207 | S | 111 | 160 | 59 | 85 | 104 | 150 |
| Hardin (c-c)[c] (lf) | 109 | 151 | 171 | S | 67 | 158 | 35 | 84 | 62 | 148 |

[a] Relative application timing shown in parantheses: sp, spring before planting and lf, late fall.
[b] Statistical significance of yield response to applied manure: S, statistically significant at $P \leq 0.10$; NS, not significant.
[c] Sites where corn followed corn. Hardin site in 2002 was second year with manure application (same site as 2001). At other sites corn was rotated with soybean.

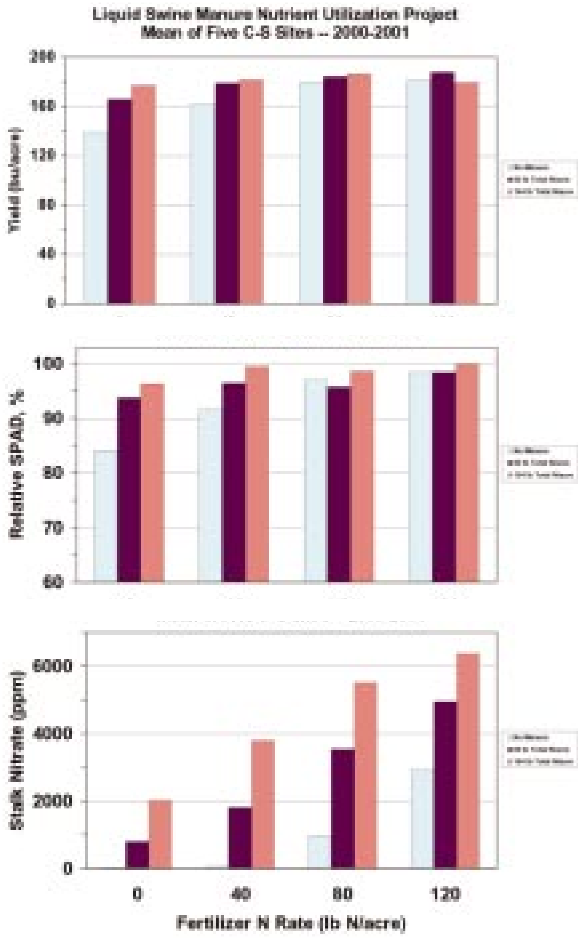


**Figure 1. Effect of average liquid swine manure total-N rate (five corn rotated with soybean sites in 2000 and 2001) and additional fertilizer-N on corn grain yield, relative corn ear leaf SPAD chlorophyll meter reading, and cornstalk nitrate-N concentration.**

Corn yield response to additional N fertilizer was most consistent in the strips that received no manure or the low manure rate. In 2000 and 2001, at only the most N-responsive sites did corn yield increase with additional fertilizer-N applied in addition to the half-rate manure application, and with only up to 40 lb fertilizer N / acre (Figure 1). At those field sites receiving excess rainfall after manure application (denitrification / leaching losses) or warm temperatures at manure application (N volatilization losses of surface applied manure) corn yield increased with additional fertilizer-N applied in addition to the high manure rate—no sites in 2000, one site in 2001, and two sites in 2002. These 3 years of yield data suggest that supplementing swine manure with additional fertilizer N is only necessary when the manure-N rate is inadequate to meet specific corn needs or losses reduce N supply. Corn yield response to fertilizer N in the residual manure year (manure applied before soybean and then corn grown the following year) was similar for all prior year manure rates (Table 2), indicating no second year crop-available manure N supply.

Grain yield and relative leaf greenness indicated similar corn responsiveness to manure and fertilizer N (Figure 1 for five similar C-S rotation sites). Leaf greenness (Minolta SPAD chlorophyll meter readings) will not indicate excess N but will show deficiency (at approximately <95 percent relative SPAD—relative to adequately N fertilized corn greenness); therefore, those readings do not increase once maximum greenness is reached, even with more N. Corn yield responded to higher manure or fertilizer N rates when relative SPAD values were below 95 percent. Relative SPAD values above 95 percent generally indicated yield did not increase with more N. When manure N or manure plus fertilizer N application was greater than corn need (especially when the rate was excessive), stalk nitrate tests indicated high levels (well above 2,000 ppm). The average manure total-N rate of approximately 150 lb N / acre seemed to supply adequate plant-available N at these five sites. At an average 80 lb total manure N, approximately 40 lb additional N / acre was needed from fertilizer.

Corn was very responsive to liquid swine manure application, with large yield increases at responsive sites. Most yield increase was with the low manure rates, with further yield increase from high manure rates at the more N responsive sites. It was possible to meet corn N requirements solely with liquid swine manure. Although it is not possible to exactly discern first year crop availability, yield and plant N measurements suggest that N in liquid swine manure is highly available to corn in the year of application and seems to support the current recommendation that first year swine manure N availability is near 100 percent. The Winter 2002 newsletter article noted that the average ammonium-N in liquid swine manure samples collected at application was 83 percent of the total-N, indicating that crop availability should be high. Results from these 3 years also indicate that liquid swine manure should be applied following steps of known manure total N content (manure preapplication and at application laboratory analysis instead of book values); applied with equipment calibrated at rates to supply corn N fertilization recommendations; applied in a manner to minimize volatile loss (injection instead of broadcast); and applied at times to minimize conversion of manure ammonium to nitrate well before crop use.

**Summary.** The project is documenting the importance and value of liquid swine manure as a nutrient source for crop production in Iowa. Following a comprehensive approach of preapplication manure sampling and laboratory analyses, manure sampling during application,

**Table 2. Corn grain yield response to fertilizer-N applied to corn where liquid swine manure had been applied before the previous year's soybean crop, 2001–2002.**

| Site-Year | Swine Manure Application None | Low | High | Statistics[b] | Manure Total-N[a] Low | High |
|---|---|---|---|---|---|---|
| | bu/acre Increase to Fertilizer N[c] | | | | lb N/acre | |
| 2001 | | | | | | |
| Clay (res.) | 43 | 46 | 43 | S | 114 | 228 |
| Webster (res.) | 46 | 51 | 40 | S | 91 | 182 |
| 2002 | | | | | | |
| Clay (res.) | 23 | 10 | 22 | S | 100 | 201 |
| Washington (res.) | 78 | 99 | 91 | S | 114 | 201 |

[a] Manure total-N applied before the previous-year soybean crop.

[b] Statistical significant response to fertilizer N application: S, statistically significant at $P \leq 0.10$; NS, not significant.

[c] Difference between no fertilizer N applied and the highest fertilizer rate within each swine manure rate. res, residual.

and calibrated rate applications, it is feasible to agronomically provide crop N nutrient needs from liquid swine manure. Results from these 3 years also confirm that best management of liquid swine manure should consider practices that enhance achieving desired manure rates for providing N, minimize potential for N loss, and closely estimate rates of needed N.

*The ISU Swine Manure Nutrient Utilization Project, part of the Integrated Farm/ Livestock Management (IFLM) Demonstration Program, receives funding from the Iowa Department of Agriculture and Land Stewardship, Division of Soil Conservation, USDA Natural Resources Conservation Service, and the Leopold Center for Sustainable Agriculture.*

*This is the third in a series of newsletter articles highlighting the ISU Swine Manure Nutrient Utilization Project. The final article will appear in the July 2003 ONM newsletter and will highlight crop yield response to manure phosphorus application.*

# Master matrix used to score confinements starting March 1

*by Karen Grimes, Iowa Department of Natural Resources*

Starting March 1, the master matrix can be used to evaluate confinement feeding operations that need a construction permit from the Department of Natural Resources (DNR). Only counties that have adopted a construction evaluation resolution can use the matrix. Producers in these counties must meet a higher standard than is required in counties that do not adopt the matrix.

**Who does the matrix affect?** If the county has a valid construction evaluation resolution on file with the DNR, the matrix must be used to assess all applications for a construction permit after March 1, 2003, in that county. The master matrix will not be used for existing confinement feeding operations constructed before April 1, 2002, that are expanding now to an animal unit capacity of up to 1,666 animal units (AUs).

As a reminder, construction permit applications are required in two situations:

1) for construction or expansion of a confinement feeding operation that uses unformed or earthen manure storage, regardless of the size of operation, and
2) for construction or expansion of a confinement feeding operation that uses formed manure storage structures such as a below-building pit or a slurry store, and the animal unit capacity is 1,000 AUs or more.

**What is the master matrix?** A master matrix is a scoring system that was designed to evaluate the siting and manure management practices of proposed permitted operations based on environmental risks and community impacts. The matrix was required by Iowa law, Senate File 2293, enacted by the 79th General Assembly in spring 2002. It was developed by a 10-member technical advisory committee that was designated in the legislation. The committee met from June through September, 2002, and reached consensus on 44 factors addressing air quality, water quality, and community impacts. After public input and revisions to the proposed matrix, the Environmental Protection Commission set passing scores on the matrix at 440 points of the total available. Producers must pass 25 percent of the available points in each of the subcategories of air quality, water quality, and community impact.

**How do producers receive points?** Points can be attained by choosing a site that exceeds the minimum required distances from protected buildings and areas. For example, a producer could earn 25 points by choosing a location that is 250 to 500 feet further away from the closest neighboring residence, hospital, nursing home, or licensed / registered child care facility than the minimum required separation distance. Points also can be earned by choosing to install odor-reducing practices such as a filter on an exhaust system or management practices such as injecting all land-applied manure.

Whatever a producer chooses, the practices will become part of the construction permit that is issued. So producers need to choose carefully, picking those practices that they know they can achieve and maintain. For example, a producer who chooses to inject all land-applied manure will need to plan carefully to achieve that during wet falls and springs when injection might be difficult.

**How do producers apply?** Copies of the matrix and an electronic form of the matrix are available on the DNR Web site under animal feeding operations at http://www.iowadnr.com/ or directly at http://www.state.ia.us/dnr/organiza/epd/wastewtr/feedlot/masterm.htm. Producers should submit a copy of the matrix scores and their permit application to the DNR and the county where the construction will occur. A list of counties that have valid construction evaluation resolutions on file with the DNR is also available on this Web site.

**What happens if a producer cannot pass the matrix?** Producers have the option of choosing the site location, structures, and management practices that they can attain to pass the matrix. Producers fill out the matrix and then the county evaluates the site using the matrix. If the proposed site meets state requirements but does not attain the required minimum score on the master matrix, the confinement structure will be denied a construction permit. However, the DNR must agree with the county's master matrix evaluation and an applicant has the right to appeal.

**Questions?** Check the Chapter 65 rules for the actual language of the rules. If you have questions about the matrix or construction permits, please contact a DNR animal feeding operations engineer at (515) 281-8941.

# An infiltration and wetland system to treat beef feedlot runoff

*by Jeffery Lorimor, Department of Agricultural and Biosystems Engineering*

Beef and dairy producers are interested in systems to remove contaminants from open feedlot runoff before it is released into the environment. Feedlots larger than 1,000 animal units (one animal unit equals a 1,000-pound beef animal) must capture the runoff and store it in a sealed containment basin until they can irrigate it onto agricultural land. They cannot release it. Smaller lots, however, do not legally have to capture the runoff, but cannot release it directly to a waterway. They should improve the quality of the runoff to remove most of the pollutants (solids, nutrients, and microorganisms) before releasing it.

Feedlot runoff cleanup starts with settling solids. Every feedlot should have a solids settling area below it. A properly designed settling area effectively removes most of the solids, is inexpensive, and is easily managed. Once the runoff leaves the settling area, three basic treatment technologies are of interest to producers: vegetative filter strips, wetlands, and infiltration areas.

Iowa State University has been investigating a treatment system at its Beef Nutrition Farm to improve the quality of the feedlot runoff before it reaches nearby Onion Creek. The system consists of solids settling, followed by infiltration into the soil and then wetland treatment. The system was designed for the 380+ head lot when the farm was improved in 1998. Figure 1 shows the layout of the overall system.

The infiltration area is 20 percent as large as the drainage area above it. It is designed to hold the 25-year, 24-hour storm (5.2 inches) without overtopping (it has overtopped briefly on several occasions during the 5 years of monitoring due to large storms or combinations of storms). The berm holds the runoff from the feedlot and forces it to infiltrate into the soil. The infiltrated water is collected by three tiles lines approximately 5 feet in depth. As the runoff infiltrates, the aerobic soil mass and its microbiological population change ammonia in the runoff into nitrate and organic nitrogen within the soil mass. The soil also traps and removes most of the phosphorus. The tile lines transport the infiltrated liquid to the wetland. The small wetland serves as a "polishing" treatment to further reduce nitrogen and phosphorus.

**Solids settling basin at ISU Beef Nutrition Farm.**

Water quality has been monitored for the past 5 years at four locations between the feedlot and the creek, and the creek was monitored. Feedlot effluent (called infiltration inflow) was sampled and measured. Infiltrated liquid as it entered the wetland via the tile lines (called wetland inflow), and wetland outflow were sampled. From the wetland, the effluent flows through a long grassed waterway and flat vegetated area between the wetland and the creek. The liquid was sampled as it left the vegetated area at the edge of the creek. Finally, the creek was sampled upstream. Table 1 shows sampling results.

Most of the cleanup occurs in the infiltration area where 80 percent of the total Kjeldahl nitrogen and ammonia are removed, as is 77 percent of the phosphorus. Nitrate almost doubled in the infiltration area. The removal rates in the wetland are lower with the incoming Kjeldahl nitrogen and ammonia reduced 22 and 6 percent, respectively. Phosphorus out of the wetland was 22 percent less than the inflow.

A significant additional cleanup results as the wetland outflow travels through the vegetated area toward the creek. TKN is reduced 68 percent; ammonia, 81percent, and phosphorus, 34 percent. The overall reduction through the system is 95, 97, and 88 percent for TKN, ammonia, and phosphorus, respectively. Nitrate increased from 0.9 to 9.2 ppm overall, but is still below the Public Health limit of 10 ppm.

Infiltration / wetland systems will not work everywhere, but where the soils are right … where they can be tile drained, and the feedlot is situated correctly, this system provides the potential for effective cleanup of feedlot runoff. Additional advantages include

**Table 1. Sampling results of treated feedlot runoff from the feedlot to Onion Creek.**

| | TKN mg/l as N | $NO_3 + NO_2$ mg/l as N | $NH_3$ mg/l as N | Total P mg/l as P | TS mg/l |
|---|---|---|---|---|---|
| Infiltration inflow | 196.1 | 0.9 | 109.0 | 46.6 | 3,294.1 |
| Wetland inflow | 39.6 | 1.7 | 20.7 | 10.5 | 1,149.6 |
| Wetland outflow | 30.7 | 1.3 | 19.5 | 8.2 | 964.8 |
| Edge of Onion Creek* | 9.7 | 9.2 | 3.7 | 5.4 | 614.4 |
| Onion Creek (upstream)* | 3.3 | 15.3 | 0.5 | 4.1 | 782.0 |

*Onion Creek and the edge of Onion Creek have been sampled for 2 years. Other numbers are 5-year averages.
N, nitrogen; $NH_3$, ammonia; $NO_3$, nitrate; $NO_2$, nitrite; P, phosphorus; TKN, total Kjeldahl nitrogen; TS, total solids.

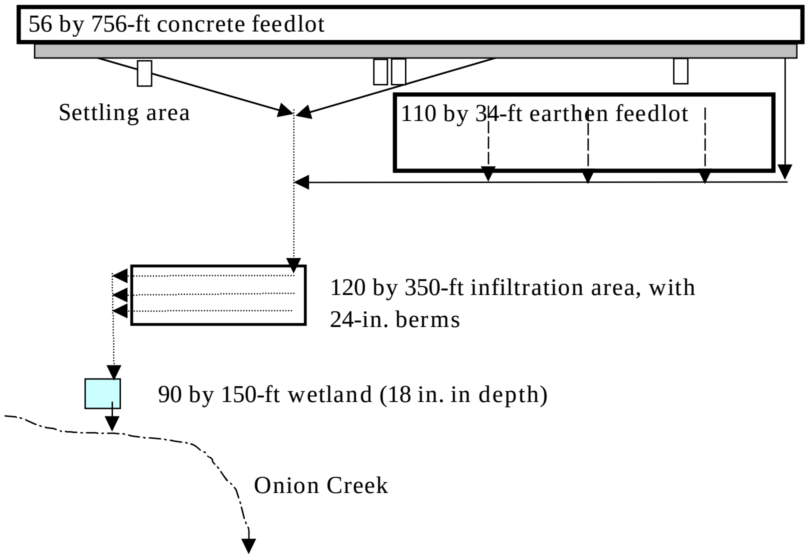


**Figure 1. Overall layout of infiltration/wetland system at the ISU Beef Nutrition Farm.**

potential low cost to construct and that the system is passive, requiring little input by the producer after construction. Clearly, the effluent from the infiltration / wetland system is much higher quality than the raw feedlot runoff.

Alternative treatment systems such as this infiltration and wetland system may be allowed for facilities with more than 1,000 animal units if they can be shown to provide water quality protection equal to, or better than, conventional irrigation systems. Whether allowed for large lots or not, they have potential to help small feedlot operators improve their environmental stewardship.

# Iowa Commercial Nutrient Applicators Association

*by Kevin Westaby, Iowa Commercial Nutrient Applicators Association*

The Iowa Commercial Nutrient Applicators Association (ICNAA) was recently formed to unite commercial and confinement site manure applicators. Many issues concerning the industry have been passed into law over the past several years without input from this sect of the industry. It is the association's intent to address the issues impacting applicators as a united voice.

ICNAA has several goals for 2003 and beyond, with many of them currently in motion. Goals include 1) maintaining a positive image by educating the public of the industry's professionalism while promoting environmental stewardship, 2) working with state legislators and regulators to become proactive participants in legislative matters and committees, and 3) providing direct input in the certification process and training requirements.

ICNAA membership consists of commercial nutrient applicators, confinement site manure applicators, service providers, and associate members. A membership application form is available on the Iowa Manure Management Action Group Web site at http://extension.agron.iastate.edu/immag/certification/icnaaapplform.doc or by contacting a current association officer.

ICNAA, in a very short time, has been recognized as a united voice and is currently providing input to elected officials on issues concerning our industry. Legislation has been introduced to allow for a change in the current certification fees. ICNAA also will continue to provide additional subject matter ideas for the applicator certification training workshops. The officers and board of directors are very excited about the progress the association has made thus far. Feel free to contact the officers listed herein for further information and please consider joining this unified effort.

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