



2950 Niles Road, St. Joseph, MI 49085-9659, USA  
269.429.0300 fax 269.429.3852 hq@asabe.org www.asabe.org

An ASABE Meeting Presentation

Paper Number: 083600

## Utilizing Processed Swine Manure for Row Crop Production

**Kenneth D. Smiciklas**

5020 Agriculture, Illinois State University, Normal, IL 61790-5020. kdsnici@ilstu.edu

**Paul M. Walker**

5020 Agriculture, Illinois State University, Normal, IL 61790-5020.

**Tim R. Kelley**

5020 Agriculture, Illinois State University, Normal, IL 61790-5020.

Written for presentation at the  
**2008 ASABE Annual International Meeting**  
Sponsored by ASABE  
Rhode Island Convention Center  
Providence, Rhode Island  
June 29 – July 2, 2008

**Abstract.** *This project is designed to compare the use of raw and processed swine manure and traditional inorganic fertilizer as soil amendments for corn and soybean production. The field site (University Farm at Lexington, IL) has uniform soil (Parr-Lisbon-Drummer Association), with 1 to 2% slope, good drainage, soil pH of 6, organic matter content of 4 to 5%, and good fertility. Soybean was grown at the site in 2003 and 2005; corn was grown in 2004 and 2006. Each plot consisted of sixteen 76 cm crop rows by 24 m in length. Four replicates are used in a randomized complete block design. Each replicate is separated by an 18 m grass strip. Within each replicate, each plot is separated by a 3 m grass strip. Six treatments were evaluated; processed liquid swine effluent, raw liquid swine manure, inorganic fertilizer nitrogen, two rates of compost made from separated solids of liquid swine manure, and zero rate control. The cost to process swine manure was approximately \$11.00/Mg for the solid-separated compost and ¼¢/l for the liquid-separated effluent. In general, the zero rate control plot was the least productive treatment for corn, in contrast to the other treatments. For soybean, all six treatments usually responded in a similar fashion. After five years of annual treatment application, the processed liquid swine effluent and raw, liquid swine manure treatments were similar for most soil parameters. The separated solid compost treatments typically contained the greatest elemental concentrations of most measured soil parameters.*

**Keywords.** swine manure, crop productivity, soil elements, manure processing.

---

The authors are solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of the American Society of Agricultural and Biological Engineers (ASABE), and its printing and distribution does not constitute an endorsement of views which may be expressed. Technical presentations are not subject to the formal peer review process by ASABE editorial committees; therefore, they are not to be presented as refereed publications. Citation of this work should state that it is from an ASABE meeting paper. EXAMPLE: Author's Last Name, Initials. 2008. Title of Presentation. ASABE Paper No. 08----. St. Joseph, Mich.: ASABE. For information about securing permission to reprint or reproduce a technical presentation, please contact ASABE at rutter@asabe.org or 269-429-0300 (2950 Niles Road, St. Joseph, MI 49085-9659 USA).

---

## Introduction

The potential for animal manure to recycle nutrients, build soil quality, and increase crop productivity is well established (Harada, 1992; Henry and White, 1993; NRAES and Dougherty, 1999). A growing concern is that changes in livestock production systems (larger and more concentrated operations; CFO) may create environmental problems because of excessive amounts of animal manure in localized areas. Specific concerns include the overabundance of nitrogen (N) and phosphorus (P) in the soil (from annual application of excessive rates of manure) and the leaching of nitrate-N ( $\text{NO}_3\text{-N}$ ) through the soil, which might contaminate groundwater. Two conditions are needed to stimulate nitrate leaching:

- the presence of  $\text{NO}_3\text{-N}$  in the soil
- downward movement of soil water

In Illinois, the potential for  $\text{NO}_3\text{-N}$  leaching is minimized due to the timing of rainfall and the uptake of N by the corn plant. Typically, manure is applied in the early spring for use by summer crops like corn (*Zea mays*). Until the corn plants reach mid-vegetative development, N uptake is low and soil  $\text{NO}_3\text{-N}$  levels are high. After the corn plants have reached their maximum rooting depth (mid to late vegetative growth), the increased transpiration rate and N needs of the plant allow for rapid N accumulation in plant tissue. Consequently, the potential for  $\text{NO}_3\text{-N}$  leaching is diminished past this point.

This project is part of an integrated research project dealing with animal manure and urban landscape waste disposal (LUW Team; Livestock and Urban Waste team). The LUW team has conducted several studies exploring urban landscape waste and animal manure composting as an alternative to direct land application of swine waste (Smiciklas et al., 1997; Walker et al., 2008a; Walker et al., 2008b). This project has investigated two mechanisms to safely utilize animal manure while ensuring minimal disruption to the soil environment. Both mechanisms involve the use of processed swine manure. One mechanism is separation of solids from liquid swine manure (separated liquid swine effluent). The other mechanism is the use of composting animal manure with urban landscape waste. Solid-liquid separation is a manure treatment technology that separates a portion of the solids from liquid effluent. Solid-liquid separation generally has been used in the last few years as a physical treatment process for animal manure, mainly for the improvement of its handling properties by removing solids and P from the slurry. Solid-liquid separation is integrated into a manure handling system to:

- recycle flush water
- reduce organic matter (including P) in the liquid fraction
- concentrate nutrients in the solid fraction
- make transport and handling easier (less expensive)
- possibly reduce odor emissions

It is ideal to partition as many of the nutrients in the solid stream as possible. The solid fraction (along with the nutrients that it contains) can be spread on distant fields less expensively than hauling raw manure and it also can be used as a soil conditioner (Liao et al., 1993). It is hoped

the liquid effluent can be applied to soils without a corresponding large buildup in soil nutrient (P) levels.

Composting is the process of partially breaking down organic material by aerobic microorganisms such as bacteria and fungi (Atkinson et al., 1996). Lufkin et al. (1994) stated that organic material for compost may include materials such as grass clippings, straw, wood chips or leaves (urban landscape waste). The composting process heats the organic material to temperatures that kill weed seeds and most potential disease causing organisms (Nogueira et al., 1999). Mature compost contains humus, which helps hold nutrients in the soil (Vallini et al., 1997). Humus reduces the need for inorganic fertilizers and helps prevent leaching of  $\text{NO}_3\text{-N}$  into groundwater. Humus also improves soil structure; sandy soils will hold water better while clays will drain faster. The improved soil structure helps reduce erosion as better drainage allows water to flow into lower soil layers, rather than collecting on top and running off. Improved soil structure helps the growth of roots which hold soil in place.

Compost acts differently than manure when applied to agricultural fields. For example, compared to organic materials like raw manure, compost is lower in nitrogen (Pare et al., 1998). During the composting process, ammonia ( $\text{NH}_3$ ) gas is lost from the manure (Larney et al., 1999). On the other hand, P and potassium (K) concentrations may be greater in mature composted material, compared to raw manure (Bujang and Lopez-Real, 1993). Thus, long-term soil nutrient status may differ between fields treated with compost compared to fields treated with manure.

### **Objectives**

This project has investigated the separation of solids from liquid swine manure (separated swine effluent and separated solid compost) to safely utilize animal manure while ensuring minimal disruption to the soil environment. Data has been collected over five growing seasons to assess the long-term effects of annual treatment application on corn and soybean growth and productivity, as well as soil quality. Specific objectives include:

1. Investigate the feasibility of composting solid-separated swine waste or isolating liquid swine effluent in an agricultural setting.
2. Evaluate at least six treatments (specific treatments detailed in materials and methods section of paper) upon plant growth and productivity.
3. Determine the effect of treatments on soil health and quality by monitoring soil pH, organic matter, cation exchange capacity (CEC), and select elemental concentrations.

### **Methods and Materials**

The field site (University Farm at Lexington, IL) has uniform soil (Parr-Lisbon-Drummer Association), with 1 to 2% slope, good drainage, soil pH of 6, organic matter content of 5%, and good fertility. A corn/soybean (*Glycine max*) production system has been employed at the experimental site. Soybean was grown at the site in 2003 and 2005; corn was grown in 2004 and 2006. Representative agronomic practices for Illinois corn and soybean production was utilized for this study (Hoeft and Nafziger, 2002).

Each plot consists of sixteen 76 cm crop rows by 24 m in length. Four replicates are used in a randomized complete block design. Each replicate is separated by an 18 m grass strip. Within each replicate, each plot is separated by a 3 m grass strip. Initial soil parameters were measured prior to treatment application and yearly to determine the influence of treatment application on soil elements [P, K, calcium (Ca), magnesium (Mg), sulfur (S), zinc (Zn), manganese (Mn), and boron (B)], organic matter, pH, and cation exchange capacity (CEC).

To form compost, a mixture of 50% urban landscape waste (leaves, grass clippings, and/or wood chips) and 50% separated solids from swine slurry are placed in long windrows, and mixed weekly as needed until maturity (approximately 4 to 6 months). To produce separated effluent, swine slurry was collected from the Illinois State University Farm farrow-finish operation. A commercially available polymer and a continuous belt thickener-roller press have been identified which can de-water slurry resulting in an effluent that has up to 99% of the total solids removed. Six treatments have been evaluated at this site:

- raw, unprocessed liquid swine manure, rate based on best management practices for N (applied manure rate equivalent to supplying 202 kg N/ha)
- composted separated solid from swine slurry (applied compost rate based on 44.8 Mg/ha – legal maximum limit allowed in state of Illinois)
- composted separated solid from swine slurry (applied compost rate equivalent to 202 kg N/ha; typically 33.6 Mg/ha of applied compost)
- processed separated liquid swine effluent (rate equivalent to 202 kg N/ha, based on N concentration of applied material)
- inorganic fertilizer (for nitrogen, applied 202 kg N/ha; for P and K rates determined by soil sample values based on Illinois recommendation system; Hoefl and Nafziger, 2002)
- zero rate control (no fertilizers applied)

The fertility treatments have been applied to field plots in the spring and annually thereafter via a calibrated manure spreader (compost treatments), calibrated slurry tank wagon (raw, liquid swine manure and separated effluent treatments), or calibrated broadcast spreader (inorganic fertilizer treatment), and incorporated with primary and secondary tillage.

At physiological maturity, several representative plants were hand-harvested from each experimental plot, separated in vegetative growth and reproductive growth (seed), weighed, and dried. A dried subsample was sieved through a 20 mesh screen and analyzed for plant nutrient concentration [N, P, K, Mg, Ca, S, sodium (Na), copper (Cu), Mn, iron (Fe), Zn, and B]. Seed yield at maturity has been measured by harvesting the center plot rows with a calibrated small plot combine. Treatment means have been compared by calculating Fisher's protected least significant difference (LSD) at 0.05 probability level.

## Results and Discussion

The LUW Team has conducted several studies evaluating the effects of various soil amendments on corn and soybean production, and on soil and ground water profiles (Smiciklas et al., 1997; Walker et al., 2008a; Walker et al., 2008b). The results of these projects indicate

that the effects of soil amendments on soil and ground water characteristics should be evaluated over a period of years. It takes a minimum of four years and preferably eight or more years to definitively determine long term benefits or detriments from soil amendments. The current study has four years of treatment data. For this presentation, four main areas of interest have been detailed:

- cost – brief overview of costs to produce processed swine manure treatments
- soil properties – snapshot of soil response after four years of annual treatment application
- soybean productivity – average effects of two years of soybean growth
- corn productivity – average effects of two years of corn growth

### **Cost**

For liquid swine effluent production and usage:

- cost = ¼¢ per liter, excluding application costs
- cost = \$650 per hectare, based on usage rate in 2006

For solid-separated compost production and usage:

- cost = \$11.00 per megagram, excluding application costs, but including some “tipping” fee income for urban landscape waste delivered to the University Farm
- cost = \$1,200 per hectare, based on 33.6 Mg/ha usage rate in 2006

### **Soil properties**

After four years of annual treatment application, the separated solid compost treatments typically contained the greatest elemental concentrations of most measured soil parameters. Note that the soil P levels were dramatically increased for the treatments that applied solid compost, in contrast to the liquid effluent treatment (Table 1).

Table 1. Measurements of select soil element concentration after four years of annual treatment application at Lexington, IL at the end of the 2006 growing season.

<b>Annual treatment</b>	<b>pH</b>	<b>P</b>	<b>K</b>	<b>Mg</b>	<b>Zn</b>	<b>Fe</b>
		<i>kg/ha</i>	<i>kg/ha</i>	<i>µg/g</i>	<i>µg/g</i>	<i>µg/g</i>
Control	6.5	66	370	609	1.2	30
Solid compost (33.6)	7.1	198	578	799	2.5	34
Solid compost (44.8)	7.0	207	632	797	2.8	34
Fertilizer	6.2	90	434	599	1.2	35
Raw manure	6.2	181	636	664	3.4	36
Liquid effluent	6.2	123	742	661	1.7	36
<i>LSD(0.05)</i>	<i>0.2</i>	<i>37</i>	<i>101</i>	<i>113</i>	<i>0.7</i>	<i>4</i>

## Soybean

For soybean, seed yield was similar for the six treatments. (Table 2). Since soybean can acquire N from the atmosphere, and the fertility of all plots was similar at the start of the experiment, this result was expected. In terms of seed nutrient accumulation, some minor differences between the treatments were observed (Table 2).

Table 2. Average measurements of soybean plant productivity after four years of annual treatment application at Lexington, IL.

Annual treatment	Seed yield	Seed P	Seed Cu	Seed Fe	Seed Zn
	<i>Mg/ha</i>	<i>%</i>	<i>µg/g</i>	<i>µg/g</i>	<i>µg/g</i>
Control	2.3	0.54	11.5	89.5	37.6
Solid compost (33.6)	2.2	0.58	12.0	92.8	39.0
Solid compost (44.8)	2.4	0.58	12.0	95.9	37.4
Fertilizer	2.2	0.55	11.6	89.1	37.0
Raw manure	2.5	0.59	11.5	90.3	44.9
Liquid effluent	2.4	0.55	13.3	91.1	39.0
<i>LSD(0.05)</i>	<i>n.s.</i>	<i>0.03</i>	<i>1.1</i>	<i>3.7</i>	<i>3.8</i>

## Corn

For corn, grain yield of plants supplied with separated effluent or manure was the greatest (Table 3). The two solid compost treatments and the inorganic fertilizer treatment tended to be somewhat lower yielding. For the solid compost treatments, we assumed 50% N availability from the applied compost, based on previous work. However, based on the observed corn grain yields, the solid compost availability is actually closer to 33%, not 50%. Thus, we speculate that the grain yield of the solid compost treatments may have been limited by the lack of soil N. This speculation is supported the lower N accumulation observed in the corn plants supplied with solid compost (Table 4). The lowest yielding treatment was the zero rate control (Table 3). This observation was expected, since the corn plants must rely on soil N, and cannot obtain N from the atmosphere like soybean.

Table 3. Average measurements of corn plant productivity after four years of annual treatment application at Lexington, IL.

Annual treatment	Plant weight	Kernel weight	Kernel number	Harvest index	Grain yield
	<i>g/plant</i>	<i>mg/kernel</i>	<i>per plant</i>	<i>%</i>	<i>Mg/ha</i>
Control	190	265	362	49	6.3
Solid compost (33.6)	247	293	438	51	8.2
Solid compost (44.8)	274	320	447	50	8.8
Fertilizer	290	334	455	52	10.7
Raw manure	329	337	512	52	11.5
Liquid effluent	298	311	535	56	11.4
<i>LSD(0.05)</i>	<i>42</i>	<i>40</i>	<i>n.s.</i>	<i>n.s.</i>	<i>3.0</i>

Table 4. Average measurements of corn plant nutrient productivity after four years of annual treatment application at Lexington, IL.

Annual treatment	Plant N	Plant P	Plant K	Plant Zn	Plant Cu
	<i>g</i>	<i>g</i>	<i>g</i>	<i>mg</i>	<i>mg</i>
Control	1.6	0.35	0.9	59	4.8
Solid compost (33.6)	2.2	0.51	1.3	69	6.8
Solid compost (44.8)	2.5	0.54	1.7	81	8.3
Fertilizer	3.3	0.52	1.5	76	11.3
Raw manure	4.1	0.58	2.0	92	13.4
Liquid effluent	3.4	0.50	1.7	77	11.1
<i>LSD(0.05)</i>	<i>0.5</i>	<i>0.09</i>	<i>0.7</i>	<i>11</i>	<i>2.8</i>

## Conclusion

This project has investigated the separation of solids from liquid swine manure (separated swine effluent and separated solid compost) to safely utilize animal manure while ensuring minimal disruption to the soil environment. The cost to process swine manure was approximately \$11.00/Mg for the solid-separated compost and ¼¢/l for the liquid-separated effluent. In general, the zero rate control plot was the least productive treatment for corn, in contrast to the other treatments. For soybean, all six treatments responded in a similar fashion for seed yield. After four years of annual treatment application, the processed liquid swine effluent and raw, liquid swine manure treatments were similar for most soil parameters. The separated solid compost (greatest rate) typically contained the greatest elemental concentrations of most measured soil parameters. Data collected thus far suggest that separated liquid effluent can serve as satisfactory replacement for inorganic nitrogen fertilizer. Data needs to be collected over a

number of years to assess seasonal variation and long-term effects of annual application to agricultural soils.

### **Acknowledgements**

Fiscal resources for this project have been provided by the Illinois Council on Food and Agricultural Research (C-FAR) program.

### **References**

- Atkinson, C. F., D. D. Jones, and J. J. Gauthier. 1996. Biodegradability and microbial activities during composting of poultry litter. *Poultry Sci.* 75(5): 608-617.
- Bujang, K. B., and J. M. Lopez-Real. 1993. Composting for the treatment of cattle wastes. *Compost Sci. Utiliz.* 1(3): 38-40.
- Harada, Y. 1992. Composting and land application of animal wastes. *Asian Australasian J. Anim. Sci.* 5(1): 113-121.
- Henry, S. T., and R. K. White. 1993. Composting broiler litter from two management systems. *Trans ASAE* 36(3): 873-877.
- Hoelt, R. and E. Nafziger. 2002. *Illinois Agronomy Handbook, 23<sup>rd</sup> Edition.* University of Illinois Extension. Urbana, IL, USA.
- Larney, F. J., A. F. Olson, A. A. Carcamo, and C. Chang. 1999. Physical and chemical changes during windrow composting of feedlot manure. In *The Soil and Air Quality Connection: 36<sup>th</sup> Annual Alberta Soil Science Workshop*, 168-173. Edmonton, Alberta Soil Science Workshop.
- Liao, P. H., A. T. Vizcarra, A. Chen, and K. V. Lo. 1993. Composting of separated solid swine manure. *J Environ. Sci. Health* 28(9): 1889-1901.
- Lufkin, C. S., M. Kenny, T. L. Loudon, and J. Scott. 1994. Composting manures using various carbon sources. In *Partnerships for Pollution Solutions*, p. 105-112. Proceedings of the National Symposium on Protecting Rural America's Water Resources, Oklahoma, City, OK, Ground Water Protection Council.
- Nogueira W. A., F. N. Nogueira, and D. C. Devens. 1999. Temperature and pH control in composting of coffee and agricultural wastes. *Water Sci. Tech.* 40(1): 113-119.
- NRAES, and Mark Dougherty, editor. 1999. *Field guide to on-farm composting*, NRAES-114. Ithaca, N.Y, NRAES.
- Pare, T., H. Dinel, M. Schnitzer, and S. Dumontet. 1998. Transformation of carbon and nitrogen during composting of animal manure and shredded paper. *Biol. Fert. Soils* 26(3): 173-178.
- Smiciklas, K.D., P.M. Walker, and T.R. Kelley. 1997. Utilization of compost (food, paper, landscape and manure) in row crop production. *ASA-CSSA-SSSA Annual Meetings.*
- Walker, P.M., T.R. Kelley, and K.D. Smiciklas. 2008a. Evaluation of pulverized trommel fines for use as a soil amendment for crop production. *BioResource Tech.* (accepted).
- Walker, P.M., K.D. Smiciklas and T.R. Kelley. 2008b. Evaluation of compost for use as a soil amendment in corn and soybean production. *Compost Sci. Utiliz.* (accepted)
- Vallini, G., A. Pera, M. Agnolucci, and M. M. Valdrighi. 1997. Humic acids stimulate growth and activity of in vitro tested axenic cultures of soil autotrophic nitrifying bacteria. *Biol. Fert. Soils* 24(3): 243-248.