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Optimizing swine hoop manure management of soil quality and crop system performance

Abstract: *What is the best way to deal with manure from hoop hog structures and other deep-bedding systems? This study offers agronomic and economic data to help farmers make a sound manure management decision.*

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Background

Hoop hog structures have become a viable alternative for producers seeking a less costly and more environmentally friendly option for raising swine. More than 2,000 hoop structures are being used in Iowa and there are many questions about the best way to handle the manure that results from finishing hogs in these surroundings. Every time a group of pigs leaves a hoop structure, farmers must decide whether to haul the bedded manure directly to the field or stockpile it for more extensive composting. There are a number of tradeoffs between these two alternatives.

Yet, there are no available guidelines for when and in what form (fresh or composted) swine hoop manure should be field-applied to best utilize it as a cropping system nutrient resource and to minimize negative environmental impacts. In this project, investigators looked at the impact of these alternative hoop manure management strategies on soil quality and cropping system performance.

Objectives of this study were to:

1a) Establish an on-station field experiment to evaluate the impacts of alternative management strategies for swine hoop manure on soil quality.

1b) Evaluate the impacts of alternative management strategies on crop system performance for on-station research plots.

1c) Evaluate the temporal pattern of soil nitrogen mineralization every two weeks from pre-plant to post-harvest for on-station research plots.

2) Coordinate and monitor on-farm trials of alternative manure management strategies implemented by cooperating members of Practical Farmers of Iowa (PFI).

Approach and methods

Alternatives tested included both fall and spring applications of composted or bedded manure in a corn-soybean rotation. The study was composed of replicated plot studies at an ISU research farm (on-station) and field trials with cooperating farmers (on-farm). The on-station experiments included many well-controlled replicated experiments that evaluated a wide range of soil, manure, and crop management practices to help define the range of potential outcomes. The on-farm research also provided an opportunity to gather data on labor, equipment, and management options. Farmers will ultimately balance these tradeoffs against the agronomic impacts in deciding which strategy to pursue.

A variety of soil quality and crop performance indicators were measured in both the on-station and on-farm trials. Of particular interest are the seasonal patterns of nitrogen mineralization and the synchronization of soil nitro-

gen (N) release patterns with crop growth and nutrient uptake. These patterns largely determine the efficiency of nutrient cycling in the different management systems. Nutrient uptake, biomass production, and yield were measured to assess the agronomic impacts of contrasting manure management strategies.

Results and discussion

In the on-station trials, the compost treatments outperformed the fresh manure treatments in both biomass growth and yield. In 2000 and 2001, corn in the composted manure treatment was significantly larger and produced more grain than did corn in the fresh manure treatment. In 2000, size differences were evident early in the season, whereas in 2001, size differences appeared near flowering. In both years, the initiation of these size advantages for the compost treatments coincided with the driest soil conditions of the season. When compared to the fresh manure treatment, composted manure increased corn crop growth rate, leaf N concentration, leaf area index, and in one of two years, net assimilation rate. In 2000, fresh manure had phytotoxic effects on annual ryegrass seedlings in a laboratory experiment. Substances in the compost that stimulate plant growth and/or phytotoxic substances in the fresh manure may have been important factors affecting corn growth responses and merit further study.

Spring application of fresh hoop manure resulted in problems with corn emergence, lower N-use efficiencies, and inconsistent yields. Although treatment effects were not always significant, measurements of soil nitrate concentrations at plant growth stage V6 and apparent ear leaf chlorophyll and N concentrations at growth stage R1 indicated that spring-applied fresh manure supplied less N to the plants prior to and during flowering than did the other amendment treatments. Thus, N deficits may have contributed to lower yields in the spring-applied fresh manure treatment compared to the other amendment treatments. The N deficits likely were caused by immobilization of soil organic N during decomposition of the relatively high carbon to nitrogen ratio in the corn stalk component of the fresh hoop house manure. Increased application rates of spring-applied fresh hoop manure to meet crop

Swine hoop house with corn stalk bedding at the Vic Madsen farm. After removal from hoop buildings, mixtures of bedding and manure can be spread directly on fields or composted to reduce weight and volume prior to later application.

N demands may be detrimental to plant emergence. It also may increase soil N immobilization and therefore is not suggested.

The on-farm trends for general indicators of compost quality (C:N ratios, ammonia concentrations, and electric conductivity) were consistent with prior research expectations. However, the variability in amendment characteristics and the lower amendment application rates resulted in amendment variations that were not statistically different for fresh vs. composted manure or for spring vs. fall applications. However, at all farms these amendment treatments outperformed the controls that were not amended. The differences were statistically significant in seven of ten on-farm trials.

Although researchers observed similar mean N supply efficiencies for fall-applied fresh manure (24.3 percent) and spring-applied compost (25 percent), the potential for large N losses during composting of fresh hoop manure suggests that fall-applied fresh manure may be more desirable than spring-applied compost for whole-farm N conservation. However, nitrate leaching potential is relatively high with fall-applied fresh manure, which can have negative environmental consequences. The multiple pathways through which N may be lost following fall application of amendments should be taken into account when creating a more complete whole-farm N budget that considers both production and environmental endpoints.

In cases where producers remove fresh manure from hoop structures in the spring, composting the material before applying it in the fall appears to be a better strategy than spreading it immediately before planting corn, since mean N supply efficiency was higher for the former management system (34.7 percent) than for the latter (10.9 percent). However, economic comparisons of manure management alternatives are needed to examine possible tradeoffs among composting costs, hauling distance to the field with the associated reduction in compost volume, and crop yield benefits.

Impact of results

This study identified several factors that can influence solid manure and compost mineralization and nutrient availability, and provides practical recommendations for agronomic use of bedded swine hoop manure in corn-soybean rotations. The following are important implications of these results for sustainable agriculture in Iowa.

1. Spring application of fresh hoop manure can have phytotoxic effects on plants and reduce seed germination, while the microbial degradation of the bedding fraction may in some cases immobilize some of the N needed by crops. Because spring applications of fresh hoop manure can reduce crop yields, producers emptying hoop structures in the spring generally should pile their manure for composting and wait to apply the compost during the following fall or spring.
2. Fall application of fresh hoop manure did not have measurable impacts on seedling germination or N immobilization, and had a nitrogen equivalency similar to compost. Direct application of manure from hoops emptied in the fall is likely to have cost advantages over composting for short hauling distances and eliminates the losses of nutrients associated with the composting process. However, fall application of fresh manure may increase the risk of nitrogen leaching and the resulting negative impacts on water quality.
3. Economic and environmental analyses are needed to complement the agronomic results obtained by this project, as all play critical roles in assessing the suitability and sustainability of solid manure management alternatives.

When cleaning out the manure from deep-bedded swine production systems, is it better to immediately spread it on cropland or compost it first? How does the time of year affect the answer to that question?

If the bedded manure pack is being cleaned out in the fall, both direct application and composting have similar crop effects. For spring clean-out, composting is recommended, as direct application of heavily bedded manure can cause soil immobilization and crop N stress.

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4. There also is a strong need for mechanistic research to understand how fresh manures and composts affect N mineralization, immobilization, phytotoxicity, and plant growth promotion. Additional scientific understanding is needed to build synergies in the agroecological interactions among organic amendments, soil, microorganisms, and plants.

Education and outreach

Two scientific articles have been submitted to refereed journals. Coverage of the on-farm trials was included in several issues of *The Practical Farmer*.

Five of the six PFI cooperating farmers hosted field days in at least one year of the project, and two cooperators held field days three summers in a row. Cooperators and project staff discussed the project with 329 attendees. Two poster presentations were made at the January 2001 PFI winter meeting. Project results were included in a presentation at the January 2003 PFI Annual Conference.

Application of composted swine manure to experiment plots near Boone, Iowa, October 1999.