Applying Swine Wastewater with SDI and LEPA Sprinkler Irrigation
A progress report

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ABSTRACT

A two-year study was initiated in the spring of 2000 at the Northwest Research-Extension Center, Colby, Kansas to compare the application of swine wastewater through subsurface drip irrigation (SDI) and low energy precision application (LEPA) sprinkler irrigation. Preliminary results suggest both methods can be successfully used, obtaining crop yields of approximately 250 bu/acre with good nutrient uptake. Irrigation needs with LEPA sprinkler irrigation may be higher than with SDI, though more years of data is needed. These preliminary conclusions should be tempered with the fact that an extensive set of soil nutrient data that remains to be analyzed will form the core information about how well each irrigation method performed.

INTRODUCTION

The use of livestock wastewater through agricultural irrigation systems can have positive or negative impacts on the environment, depending on the method and intensity of use. The wastewater can also be a inexpensive fertilizer resource for crop producers, providing nutrients in a timely fashion to the crop in a readily plant-available form.

Subsurface drip irrigation (SDI) has been shown to be technically feasible with beef feedlot runoff wastewater in K-State research performed in western Kansas. The use of SDI with wastewater brings many potential advantages but measured comparisons of SDI to sprinkler (such as low-energy precision application, abbreviated LEPA) application of wastewater have not been performed. Use of swine wastewater through SDI may or may not bring real environmental advantages in the form of reduced nutrient accumulation at the soil surface or in or below the root zone. Sprinkler irrigation is currently the common practice for wastewater application in the Great Plains.

The overall objective of this project is to compare the environmental, cropping, and irrigation system impacts to swine wastewater applied with SDI or simulated LEPA sprinkler irrigation. The specific questions we hope to answer are ***1) What are the environmental impacts of swine wastewater when applied with SDI or LEPA irrigation, specifically in terms of nutrient utilization and redistribution in the soil profile? 2) What are the crop impacts of swine wastewater application through SDI compared to LEPA irrigation? 3) Is swine wastewater use through SDI technically feasible?***

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METHODS

Research plots were established at the Northwest Research-Extension Center at Colby, Kansas in the spring of 2000. The study will be conducted for both crop years 2000 and 2001. Swine wastewater was hauled to the site from Premier Pork, Scott City, Kansas. The logistics of hauling sizable quantities of wastewater necessitated relatively small research plots. The plots were 15 ft wide accommodating 6 corn rows and 54 ft long. Buffer areas of irrigated corn (50 ft wide) surround the plot area to minimize the effect of wind and heat on the plot area. Each treatment was replicated 3 times in a complete randomized block design.

Since livestock wastewater can experience volatilization losses and other transformations when transferred from larger lagoons into smaller tanks, the application methodology was restricted to two 2-day application periods during mid to late June. The water was hauled to the site and immediately applied during a two-day period.

The treatments were as follows:

1. SDI control treatment (No application of wastewater, but SDI fertigation of commercial fertilizer, 200 lbs N/acre inseason through dripline.)
2. Application of 1 inches of wastewater per year with SDI, 0.5 inch per application.
3. Application of 2 inches of wastewater per year with SDI, 0.5 inch per application.
4. Application of 0.6 inches of wastewater per year with simulated LEPA.
5. Application of 1 inches of wastewater per year with simulated LEPA, 1 inch per application.
6. Application of 2 inches of wastewater per year with simulated LEPA, 1 inch per application.

The wastewater/fertigation for treatments 3 and 6 were applied in two separate periods 2 weeks apart (June 15 and June 29, 2001). An application period for SDI was two consecutive daily <u>events</u> of 0.5 inches (1 inch in 2 days). The application period for LEPA was initiated at the same time but just consisted of a single 1 inch application (1 inch in 1 day). Additional freshwater irrigation was scheduled as needed using a calculated water budget approach. SDI and LEPA irrigation capacity was limited to 0.25 inches/day that approximates full irrigation in the majority of years in Northwest Kansas. The SDI treatments received as needed irrigations of 0.5 inches every two days while the LEPA had 1-inch applications on a 4-day schedule. Soil water measurements were made on a weekly basis to determine crop water use but were not used to adjust irrigation schedules.

The plot area had 5 ft spaced raised beds with two corn rows centered on the shoulders of the bed. This is the traditional "K-State bed system for SDI". Each had a dripline installed at a depth of 16-18 inches. Even the LEPA plots had driplines because the study area was developed in the spring of 2000. The installation period required some freshwater application, so the driplines in the LEPA plots allowed equal soil water conditions at the beginning of the actual study.

The simulated LEPA was accomplished by applying equal amounts of water to furrow basins between adjacent pairs of corn rows. Equal amounts of water are accomplished by delivering water to each furrow basin through a small-diameter irrigation tube connected to a flow divider. This differs from surface drip irrigation in that the application time is much less. The application time for the 1-inch application is approximately 45 minutes, similar to LEPA irrigation, rather than as much as 20 hours for surface drip irrigation. The geometry of the irrigation delivery points for the SDI and LEPA systems indicates that the edge rows in the LEPA plot do not receive an adequate irrigation amount. Periodic surface irrigation amounts were supplied to these LEPA edge rows to alleviate this problem, yet not influence the center plot rows being utilized for sampling.

A starter fertilizer was band-applied at planting to all plots in the amount of 30 lbs N/acre and 45 lbs P/acre. Additionally the fresh irrigation water was sampled to determine its contribution of N. The swine wastewater was monitored and analyzed as it came out of the lagoon and as it was actually applied to insure that it was physically, chemically and biologically representative of a typical wastewater application. The nutrient conditions at the time of application were the values used to compare applied to recovered nutrients.

Initial soil sampling of each plot was used to determine baseline N, P, EC and pH conditions for the plot area. There was no reason to believe that there would be any stratification in any horizontal direction at the initiation of the study, so only one sampling hole for each plot was utilized. Samples were taken in 6-inch increments in the top 3 ft and 1 ft increments in the 3-8 ft depth range (18 plots x 11 depth increments = 198 samples).

Soil sampling after crop harvest was as follows for N, P, EC and pH

- LEPA: 0 to 1 ft in 3-inch depth increments, 1-3 ft in 6-inch depth increments, 3 to 8 ft in 1 ft depth increments, with horizontal locations at the middle of bed, 7.5 inches from middle of bed, corn row, 7.5 inches from middle of furrow, and corn furrow (9 LEPA plots x 5 horizontal locations x 13 depths = 585 samples)

- SDI: 0 to 2 ft in 3-inch depth increments, 2-3 ft in 6-inch depth increments, 3 to 8 ft in 1 ft depth increments at distances from dripline of 0, 3, 6, 10, 15, 20 and 30 inches (9 SDI plots x 7 horizontal locations x 15 depths = 945 samples)

Plant sampling at physiological maturity was used to determine biomass, and the N-P-K uptake of above ground dry matter. Grain yield was determined from hand harvesting a representative area at physiological maturity.

Analyses include (or will include at the conclusion of the project in 2001) determination of corn grain yield, nutrient uptake by crop, water use and soil profile distribution, water use efficiency, residual N and P in soil, N, P, EC and pH distribution patterns in soil, and comparisons of applied nutrients to those recovered in crop and soil.

RESULTS AND DISCUSSION

Irrigation and water use

Cumulative precipitation and corn evapotranspiration for the 120-day corn growing period at Colby, Kansas from May 8, 2000 through September 4, 2000 was 6.18 inches and 25.85 inches, respectively. The long term average (1972-99) precipitation and corn evapotranspiration for the more typical 120-day period running from May 15 through September 11 is 12.61 inches and 22.56 inches, respectively. Thus irrigation requirements were much higher than normal (19.5 inches for the SDI and 20.0 inches for the LEPA irrigation).

Water use was significantly higher (P=0.05) for the LEPA sprinkler irrigation plots as compared to the SDI plots averaging approximately 3 additional inches of use (Table 1). Since irrigation was only 0.5 additional inches for the LEPA sprinkler irrigation plots, this extra water use came by decreasing soil water storage. This extra water use was visually evident near the end of the cropping season because there was increased early senescence for the LEPA sprinkler irrigation plots due to decreased soil water reserves. It is not clear why the LEPA sprinkler irrigation treatments had higher total water use, but a partial reason may be increased water losses from evaporation from the soil surface or deep drainage. Drier soil surfaces with SDI can reduce soil evaporation while smaller SDI applications can also decrease deep drainage.

Water use efficiency was also significantly affected by irrigation method with the SDI treatments averaging 476 lbs of grain for each inch of total water use and the LEPA treatments averaging 413 lbs/acre-in (Table 1).

There was no apparent effect of wastewater application or amount on the total water use or water use efficiency.

Corn yields and yield components

There were no significant differences in corn yields due to irrigation method or wastewater application, though SDI yields tended to have slightly higher yields (Table 1). Kernel weight at harvest was significantly affected (P=0.05) with the LEPA plots generally having lower kernel weight (Table 1). This reduction in kernel weight may be reflecting the previously mentioned crop water stress that was apparent on the LEPA plots near physiological maturity. Final kernel weight is set just prior to physiological maturity in mid to late September in this region.

There were no significant differences in biomass at physiological maturity as affected by irrigation method or wastewater application. Dry above-ground biomass was approximately 11 tons/acre at physiological maturity (Table 1).

Nutrient utilization

There were no significant differences in crop uptake of the macronutrients N, P or K. Uptake of N, P and K averaged 230, 58 and 258 lbs/acre for the macronutrients, respectively.

The extensive set of soil nutrient data has not been analyzed at this point in time. This analysis will be required before many conclusions can be drawn about efficiency of nutrient utilization (applied vs. recovered) and about how the nutrients are distributed in the soil profile.

PRELIMINARY CONCLUSIONS

Both SDI and LEPA sprinkler irrigation appear to be acceptable methods in terms of obtaining high crop yields and good nutrient uptake when applying swine wastewater.

Irrigation requirements may need to be further adjusted upward for LEPA to reflect a higher total water use that may be caused by increased soil evaporation or possibly deep drainage. However, yields were not significantly affected by the crop water stress that was observed in the LEPA treatments near physiological maturity.

This report should be considered as a progress report, because a large portion of the experimental results remains to be analyzed. Soil nutrient data related to the nutrient utilization and soil profile redistribution will be crucial information in evaluating these two irrigation methods for application of swine wastewater.

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Table 1. Summary of corn yield, nutrient, and water use data from a swine wastewater study utilizing SDI and LEPA sprinkler irrigation, KSU Northwest Research-Extension Center, Colby, Kansas. 2000.

Wastewater Treatment	Total applied nutrients[1] N	P_2O_5	K_2O	Grain yield	Kernel wt.	Irrigation	Water use [2]	WUE [3]	Biomass	N uptake [4]	P uptake [4]	K uptake [4]
				bu/a	g/100 seed	inches	inches	lb/acre-inch	tons/acre	lb/acre	lb/acre	lb/acre
SDI - No wastewater	245	45	0	253.5	41.4	19.5	30.1	472	10.7	234	53	223
SDI - 1 inch	229	86	165	251.6	40.6	19.5	30.4	464	11.4	246	60	277
SDI - 2 inches	388	136	306	259.5	41.4	19.5	29.5	492	10.9	236	55	254
LEPA - 0.6 inch	155	70	99	236.6	38.6	20.0	33.2	399	10.9	206	60	268
LEPA - 1 inch	229	86	165	250.3	40	20.0	32.8	427	11.1	225	60	256
LEPA - 2 inches	388	136	306	246.0	39.4	20.0	33.2	415	10.7	231	60	274
Least Significant Difference $(LSD)_{0.05}$	--	--	--	NS	1.6	--	1.5	51	NS	NS	NS	NS

[1] Total applied N-P-K from the three sources: starter treatment at planting (30 lbs N/acre + 45 lbs/a P_20_5), wastewater application, and the amount naturally occurring in the irrigation water (0.75 lbs/acre-inch).

[2] Total of seasonal change of soil water storage in the 2.4-in profile plus irrigation and precipitation.

[3] Water use efficiency is defined as grain yield in lb/acre divided by water use in inches.

[4] N, P and K fertilizer accounted for by the above-ground dry matter at harvest.