

## ENVIRONMENT

**Title:** Impact of Liquid Swine Manure Application on Soybean Yield and Surface and Ground Water Quality – NPB #07-135

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### Industry Summary:

In an earlier study conducted at Iowa State University from 2001 to 2006, liquid swine manure was applied to corn plots to give a total nitrogen application of 150 lbs/acre and the targeted nitrogen application rate of 200 lbs/acre to soybean plots under corn-soybean rotation production system. This study clearly showed that soybean plots (in rotation with corn in the previous year) and receiving liquid swine manure application resulted in much higher nitrate-nitrogen (NO<sub>3</sub>-N) leaching losses compared with soybean plots with no manure applications. Therefore, this study concluded that liquid swine manure application to soybeans at rates of 200 lbs-N/acre used in this study is not an acceptable practice. This study also concluded that more research should be conducted with lower nitrogen application rates from manure to soybeans so that farmers may have the option to apply liquid swine manure to soybeans and can still meet the nutrient loss criteria established for nitrogen leaching to groundwater. This resulted in initiating another six year (2007-2012) research study at Iowa State University in 2007 where *the main objective of the study was to find an answer to the key question - “if applying swine manure to soybeans at a lower rate of 100 lbs-N/ac in the soybean year of corn-soybean rotation (but keep nitrogen application rates to corn at 150 lb/ac from swine manure in the corn year) can become an acceptable practice in Iowa”*. In this study we are investigating the effects of lower nitrogen application rate to soybean plots on nitrogen leaching to groundwater. To this point we have collected three years (2007-2009) of nitrogen leaching data and preliminary results have shown that swine manure applications to soybeans at lower nitrogen rates of 100 lbs-N/acre do not necessarily result in increased nitrate-nitrogen (NO<sub>3</sub>-N) leaching losses to groundwater in comparison to swine manure applications to corn only at rates of 150 lbs-N/acre. Also, corn and soybean yields from this practice (when swine manure was applied to both corn and soybean plots) were among the highest. This limited data of three years indicate that swine manure application at the a rate of 100 lb-N/acre to soybeans can potentially become an acceptable practice if the remaining three years data of this study show similar trends as this practice of applying 100 lb/acre of nitrogen from manure does not seem cause additional leaching of nitrogen to groundwater and higher corn and soybean yields are expected. We definitely need to collect three more years of field data on water quality and crop yields before making final

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conclusions on this study. Once all six years of data on water quality are collected from this study, we would be able to conclude with confidence if swine manure applications to soybeans at a lower nitrogen rate of 100 lb/ac could be an acceptable practice for swine and crop producers of Iowa.

### **Scientific Abstract:**

Field experiments were conducted from 2007 through 2009 to determine the effects of liquid swine manure application to soybeans on nitrate-nitrogen ( $\text{NO}_3\text{-N}$ ) leaching to subsurface drainage water (ground water at a depth of four feet from the ground surface) and crop yields under corn-soybean rotations. In this three year study, N-application rates from swine manure to soybean averaged about 100 lb-N/ac and 150 lb-N/ac to corn in the corn-soybean rotation system. Data on  $\text{NO}_3\text{-N}$  concentrations and nitrogen leaching losses to subsurface drainage water and crop yields were collected and analyzed as a randomized complete block design. The results of this study indicated that the average  $\text{NO}_3\text{-N}$  concentrations and  $\text{NO}_3\text{-N}$  leaching losses to subsurface drain water were not significantly different among treatments when liquid swine manure was applied to both corn and soybean in comparison with the treatment when liquid swine manure was applied to corn only. Also, corn and soybean yields were among the highest when soybean plots received the application of swine manure. The results of this three year study clearly indicate that fall applications of liquid swine manure to both corn and soybean at nitrogen application rates of 150 lbs/acre to corn and 100 lbs/acre to soybean, used in this study, could be an acceptable practice for farmers and swine producers.

### **Introduction:**

Currently, Iowa Department of Natural Resources (IDNR) manure management and planning methodology allows a manure nitrogen application rate based on 3.8 lb N/bushel removed in harvested soybean grain. With high yielding soybean, this rate can become quite high; 200 lb N/acre or more, and more than the amount of nitrogen typically symbiotically fixed if no manure is applied. In combination with nitrogen (either manure or fertilizer) applied to a corn crop rotated with soybean, the system total nitrogen application is very high (example, 200 lbs-N/acre from manure applied to soybean and 125 lbs-N/acre applied to corn is 325 lb N/acre total). A significant increase in nitrate leaching to groundwater (monitored as subsurface drain tile-flow nitrate) due to high swine manure application rates to both corn and soybean in a corn-soybean crop sequence has been documented in the earlier research conducted at Iowa State University Water Quality Research Site at Nashua, Iowa (this study was conducted for six years (2001-2006) with nitrogen application rates for corn at the top end of the currently suggested for corn, 150 lbs-N/acre, and a DNR allowable rate to soybean of 200 lbs- N/acre). The increase in nitrate-nitrogen concentration in subsurface drain tile flow was the result of larger amount of nitrogen applied to corn and soybean totaling 325 lb-N/acre.

Another alternative approach or best management practice/guidance tool for manure application rate to soybean would be to approximately compensate for the amount of nitrogen that would not be fixed (but supplied otherwise from the manure). Depending upon yield goals, this amount would be around 100 lb N/acre range. With this approach, the manure application rate for soybean being considerable lower than a yield/removal based rate for soybean, nitrate leaching would be reduced and perhaps result in minimal difference compared to a system where nitrogen is just applied to the corn phase in a corn/soybean rotation. Preliminary studies at Iowa State University have shown increased soybean yields with swine manure applications. Since soybeans result in a net removal of nitrogen from the soil (despite being a legume, and symbiotically fixing nitrogen, the net removal has been estimated to be around 80 lb-N/acre), adding manure nitrogen to help offset soil nitrogen depletion should help maintain soil nitrogen, and thus soil organic matter and associated beneficial factors. *In this study funded by the NPB, our main objective was to find an answer to the key question if applying swine*

*manure to soybeans at a rate of 100 lb-N/ac in the soybean year of rotation (but keep N application rates to corn at 150 lb/ac in the corn year) is an acceptable practice in Iowa.* This study was conducted on new set of plots so that higher manure application rates from previous study do not affect the outcome of this study. We have now collected data from this study for three years but three more years of data are required to complete the six year cycle for each plot with three years of corn and three years of soybean cropping systems. This will provide us with better science based data on determining the appropriate rate of manure applications to soybeans and its effects on crop yields, residual soil nitrogen and phosphorus, and surface and ground water quality. The results of this study would be very useful to researchers, Iowa swine producers, IPPA, NPB and policy makers.

### **Objectives:**

- To determine the impact of appropriate rates of swine manure applications to corn and soybeans based on nitrogen and phosphorus requirements, on crop yields, soil phosphorus accumulation, and nitrate and phosphorus leaching to groundwater, and
- To develop and recommend appropriate manure and nutrient management practices to producers to minimize the potential of water contamination and enhance the use of swine manure as inorganic fertilizer.

### **Materials & Methods:**

The originally proposed experimental treatments in this study (treatments 1 through 3 in Table 1) were established at the Iowa State University Nashua Water Quality Research site in 2007. This study site has 36, one acre plots, with state-of-the-art surface and subsurface water quality monitoring system which was installed in 1988. Each plot at the site is drained separately and has subsurface drain lines installed in the center of each plot at a depth of 1.2-m below the ground surface with a drain spacing of 28.5-m. The cross subsurface drainage flow one plot to another was avoided by installing subsurface drainage lines on the northern and southern borders of the plots and isolating the eastern and western borders with berms (Kanwar et al., 1999). The central subsurface drainage lines are intercepted at the end of the plots and are connected to individual sumps for measuring drainage effluents and collecting water samples for chemical analysis. The sumps are equipped with a 110-volt effluent pump, water flow meter, and an orifice tube to collect water samples. Data loggers, connected to the water flow meters, record subsurface drainage flow continuously as a function of time. Composite water samples are collected for NO<sub>3</sub>-N analysis using an orifice tube located on the discharge pipe of the sump pump. Approximately 0.2% of the water pumped from the sump flows through a 5-mm diameter polyethylene tube to a water sampling bottle located in the collection sump each time the pump empties the sump water. Cumulative subsurface drain flows are recorded, and sampling bottles are removed once per week from mid-March to the beginning of December during the study period.

To meet the objectives of this study, we used 18 experimental plots for establishing the treatments #1, #2, and #3 given in table 1. Each treatment was replicated three times for corn as well as for soybeans in the same year requiring a total of 18 plots. In addition, we added three more experiments treatments (treatments 4 through 6 as shown in Table 1) to answer some additional research questions for other management systems for corn-soybean production in the Midwest. Although data for experimental treatments #4, #5, and #6 will be shown in the tables but results will not be discussed in this report. Table 1 gives details of six experimental treatments of this study.

Groundwater samples were collected at four feet depth using subsurface drains and water samples were collected from experimental plots from about mid March to mid November on weekly basis and were analyzed

for nitrogen and phosphorus concentrations. Soil samples were collected at harvest time from three different locations in each plot to a depth of 120 cm using the zero contamination tubes and a soil probe. The soil samples were split into five depths, 0-15cm, 15-30 cm, 30-60 cm, 60-90 cm and 90-120cm. Soil and water samples were then analyzed for nitrogen and phosphorus concentrations. Data on subsurface drain flows, NO<sub>3</sub>-N and PO<sub>4</sub>-P leaching losses and corn and soybean grain yields will be analyzed using PROC GLM (SAS, 2003). Since 1998, we have completed three major water quality studies at this site to determine the effects of tillage, crop rotations, and manure management practices on surface and groundwater quality resulting in more 10 MS/PhD theses and 30 refereed papers.

Table 1: Experimental treatments - treatments #1, #2, and #3 are important to NPB study

Treatment	Timings and source of N	Crop	Tillage	Application method	Rate, lb/acre	
					N-based	P-based
1	Spring (UAN) -	Corn Soybean	Chisel Plow Field Cultivate	Spoke inject -	150 -	As needed As needed
2	Fall (manure) -	Corn Soybean	Chisel Plow Field Cultivate	Inject -	150 -	- As needed
3 3	Fall (manure) Fall (manure)	Corn Soybean	Chisel Plow Field Cultivate	Inject Inject	150 100	- -
4 4	Fall (manure) Fall (manure)	Cont. Corn Cont.Corn Round Bale Removal	Chisel Plow Chisel Plow	Inject Inject	200 200	As needed As needed
5	Spring (UAN) -	Corn/Rye cover Soybean/ Rye cover	NT NT	Spoke Inject -	150 -	- As needed
6	Fall (manure)	Corn Soybean	NT NT	Inject -	150 -	- As needed

## Results:

Figure 1 gives the average yearly corn and soybean yields from 3 years (2007-2009). Table 2 summarizes experimental results of the yearly and average NO<sub>3</sub>-N concentrations for years 2007 through 2009. All tile flow water samples collected in 2009 have been analyzed now for NO<sub>3</sub>-N concentrations. It took us much longer to complete analyses and that is why this report is so late.

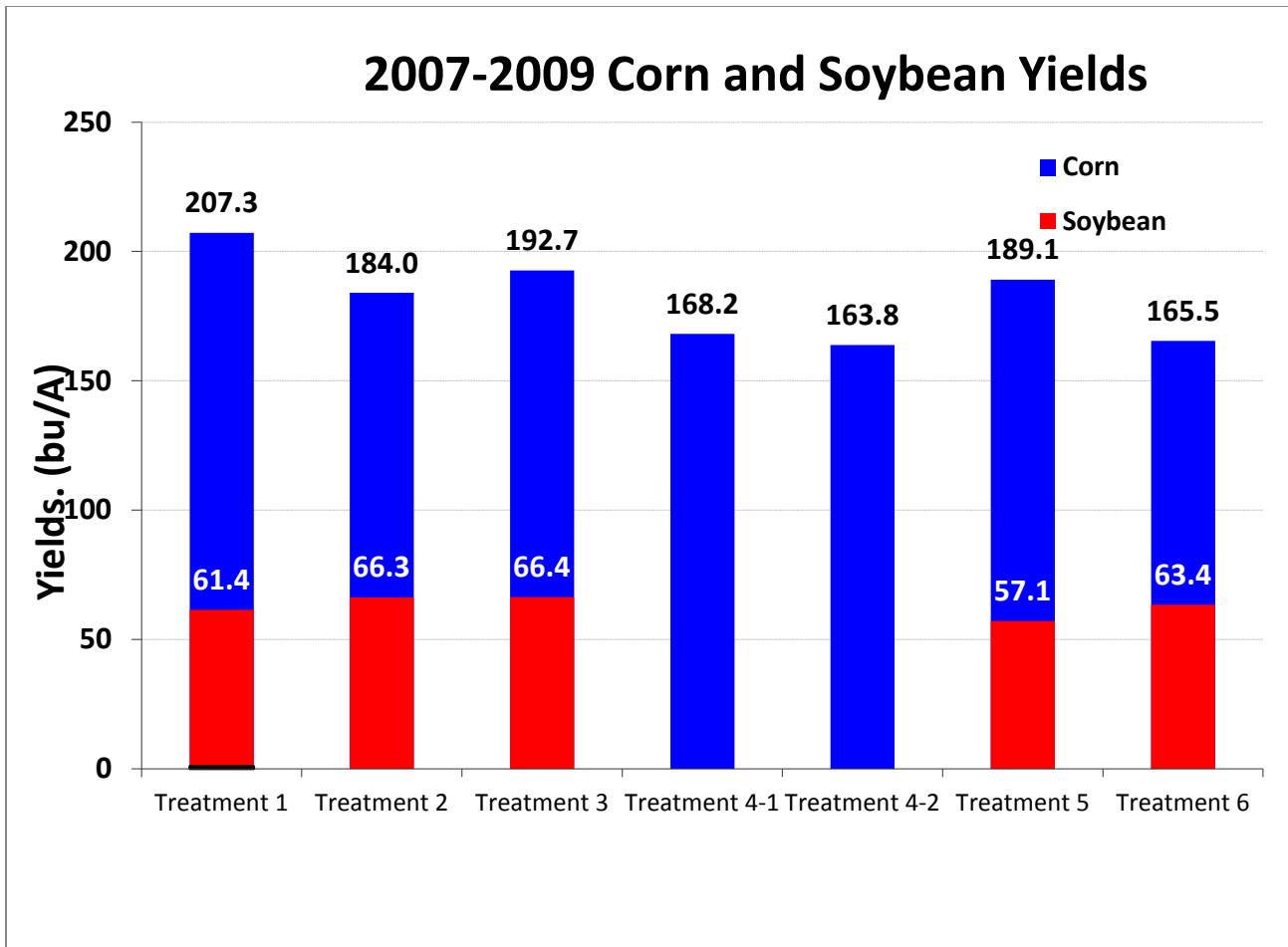


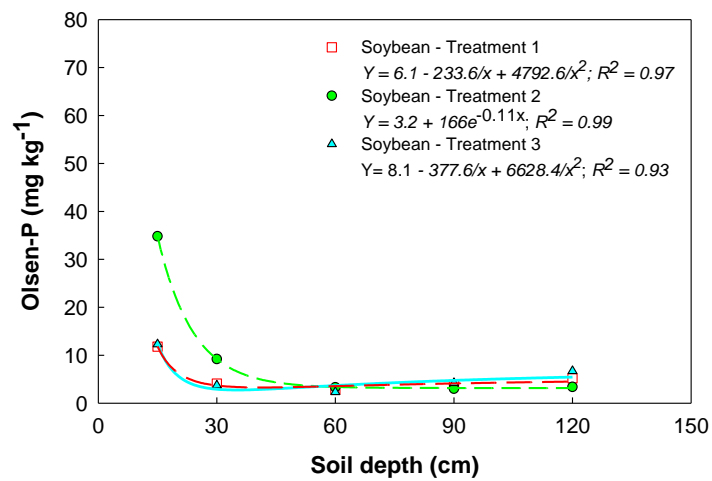
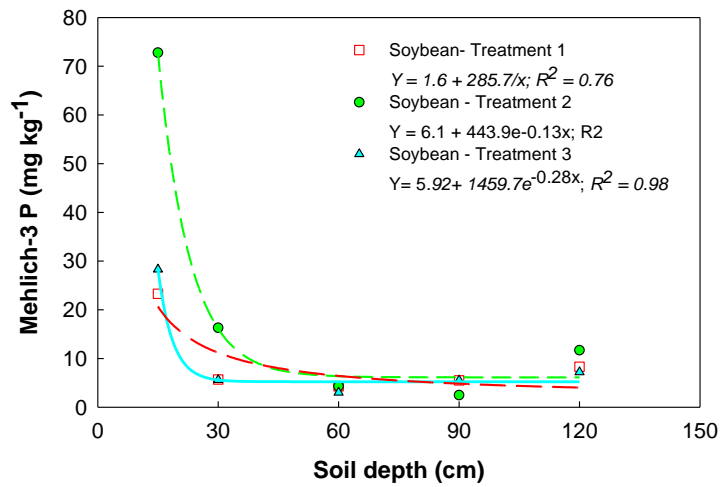
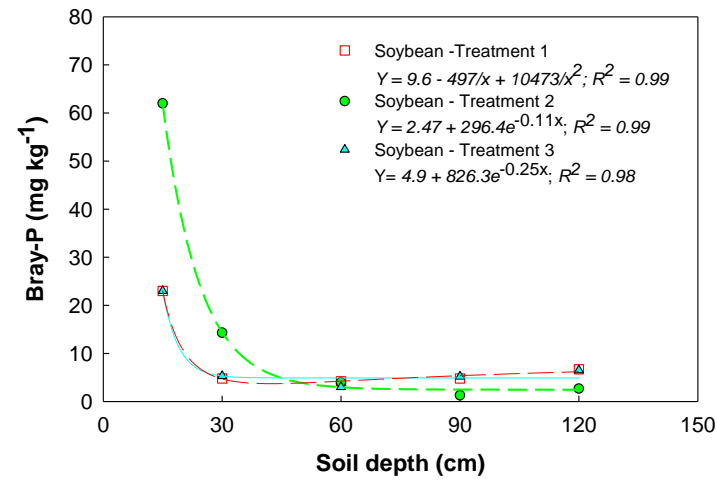
Figure 1: Corn and Soybean crop yields for years 2007-2009

Table 2. Summary of six experimental treatments on flow weighted average NO<sub>3</sub>-N concentrations in subsurface drainage water for three years (2007-2009).

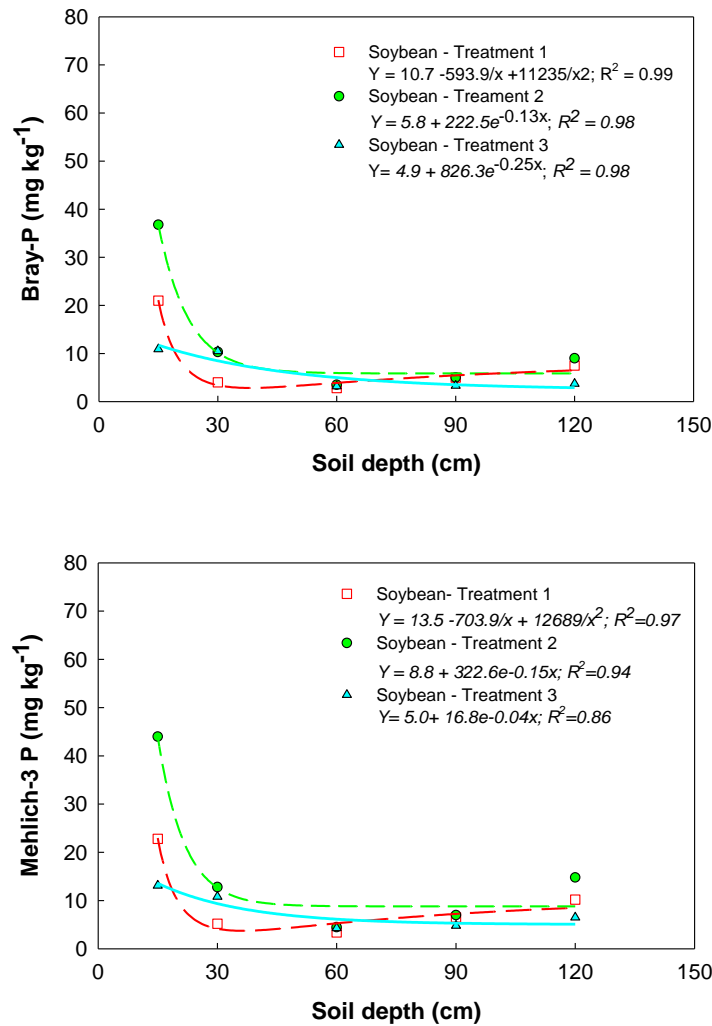
NO <sub>3</sub> -N Conc. in tile water, mg/l	2007		2008		2009		2007-2009	
	CS	SC	CS	CS	CS	SC	CS	SC
1. Spring spoke inject UAN 150 lb N/ac	10.1	11.7	15.1	8.0	12.1	9.5	12.4	9.8
2. Fall manure 150 lb N/ac	15.9	11.8	17.7	8.3	19.8	10.3	17.8	10.2
3. Fall manure 150 lb N/ac to corn and 100lb N/ac to soybean	13.4	12.8	20.3	14.2	20.2	11.1	18.0	13.7
4.1 Fall manure 200 lb N/ac (continuous corn)	20.0		23.1		20.9		21.3	
4.2. Fall manure 200 lb N/ac + Stover removal (continuous corn)	23.9		23.0		20.9		21.5	
5. Spring spoke UAN 150 lb N/ac + Rye removal	9.6	11.5	12.4	8.7	8.9	8.3	10.2	9.5
6. Spring manure 150 lb N/ac	14.8	7.9	15.3	8.9	15.8	8.3	15.3	8.4

CS= Corn and soybean rotation, corn in the first year.

SC= Soybean and corn rotation, soybean in the first year.



**Figure 2: Relationships between mean phosphorus concentration (BP, M3P and OP) and soil depths for soybean crop in 2007 (This figure has been revised and legends on this figure have been changed to treatment #1, #2, and #3 from the earlier version of system #1, #2, and #3 ).**



**Figure 3: Relationships between mean phosphorus concentration (BP, M3P and OP) and soil depths for soybean crop in 2008 (This figure has been revised and legends on this figure have been changed to treatment #1, #2, and #3 from the earlier version of system #1, #2, and #3 ).**

## Discussions

**Effect of nitrogen application from swine manure on corn and soybean yields:** Figure 1 shows clearly that spring UAN application at an N rate of 150 lb N/ac resulted in an average corn yield of 207.3 bu/ac, which was the highest corn yield in comparison to other systems. The second highest of corn yield of 192.7 bu/ac was observed from system 3 receiving swine manure to both corn and soybean plots. Also, soybean yields from plots receiving swine manure resulted in highest soybean yields (66 bu/ac). This indicates that some beneficial effects on corn and soybean yields from manure applications can be realized to provide profitable margin for the farmer and still meet the goal on water quality preservation from excessive manure applications within acceptable range. The effect of timing of N application can be seen on systems 1 and 5 with spring UAN applications. Data from recent and current research are helping fill critical gaps in knowledge of manure use in Midwestern agronomic and climatic systems. They also helping growers make more informed decisions on post-harvest applications, when most swine manure is applied.

**Effect of swine manure application on NO<sub>3</sub>-N leaching to subsurface drain water:** Experimental plots under continuous corn and receiving swine manure every year (system 4) resulted in the highest three- year average NO<sub>3</sub>-N concentrations in subsurface drain (tile) water in comparison to other systems. This could be the result of higher application of N (at a rate of 200 lb/ac) in comparison to other systems. System 3, which received fall application of swine manure to both corn and soybean plots every year (at a lower rate of 150 lb-N/ac every year to corn and soybeans under corn-soybean rotation system)), resulted in slighter higher NO<sub>3</sub>-N concentrations in tile water in comparison to fall application of swine manure to corn plots only under corn-soybean rotation and also in comparison to other systems under corn and soybean rotation (treatments #1, #2, #5 and #6) but these concentrations were not significant. Two treatments (#1 and #5) receiving UAN, resulted in the lowest NO<sub>3</sub>-N concentrations among all six treatments. There were no significant differences in the NO<sub>3</sub>-N concentrations in tile water between treatments #1 and #5. This limited data of three years indicate that swine manure application at the a rate of 100 lb-N/ac to soybeans in rotation with corn can be an acceptable practice as it does not result in causing additional environmental pollution of subsurface drainage water systems. Once all six years (2005-2011) of data are collected from this study we would be able to conclude with confidence that manure applications to soybeans at a lower N rate could be an acceptable practice.

**Effect of swine manure application on PO<sub>4</sub>-P leaching to subsurface drain water** Unlike NO<sub>3</sub>-N ion which is highly soluble and dissolves in water, PO<sub>4</sub>-P is mainly adsorbed to soil particles and will gradually accumulate in the soil, and runoff would be the main pathway of PO<sub>4</sub>-P losses. Because of that characteristic, leaching losses and concentrations of PO<sub>4</sub>-P in subsurface drainage water were consequently much lower than that of NO<sub>3</sub>-N. Effects of treatments and growing seasons on PO<sub>4</sub>-P leaching losses to subsurface drainage and subsurface flow-weighted PO<sub>4</sub>-P concentrations were not significant on yearly basis. Overall three-year average and yearly average flow-weighted PO<sub>4</sub>-P concentrations in subsurface flow are presented in Tables 22-27 of the Appendix. There are no significant differences among all treatments for the data collected from 2007-2009. This shows that PO<sub>4</sub>-P concentrations in subsurface drainage do not correspond to manure application rates. Similar finding was also reported by other researchers such as Algoazany et al (2007) that higher soluble P concentrations were found in the years without even P applications.

**Effect of swine manure application on soil nitrate concentrations:** Tables 20 and 21 give residual nitrate-nitrogen concentrations at different soil depths (0-120cm) for all six treatments for 2007 and 2008, respectively. It is clear from two year data that surface soil layer (0-15cm) had the highest nitrate concentrations for all six treatments but no significant differences were found in residual soil nitrate concentrations between treatments #1, #2, and #3 for the surface layer. This shows that residual soil nitrate concentrations were not affected by the rate of nitrogen application from manure or UAN fertilizer but we will have better conclusions at the end of this study which will be completed in 2012. The residual soil nitrate concentrations decreased with the increase in depth.

**Effect of swine manure application on soil phosphorus concentrations:** Tables 22 -27 give data on residual soil PO<sub>4</sub>-P concentrations for all six treatments but Figures 2 and 3 show residual soil PO<sub>4</sub>-P concentrations for three treatments ( #1, #2, and #3 which were the focus of NPB funded study) for the years 2007 and 2008. These two year data on residual soil PO<sub>4</sub>-P concentrations (for all three types Bray-P, Mehlich-3 and Osen-P) show that treatment #2 (with manure application to corn only) resulted in the highest soil PO<sub>4</sub>-P concentrations for the two surface layers (0-15 cm and 15-50 cm) and these soil PO<sub>4</sub>-P concentrations significantly different in comparison with other two treatments (#1 and system #3). Further examinations of the experimental plots indicated that treatment #2 plots had very high initial soil PO<sub>4</sub>-P concentrations in surface layers from the previous experiments. Therefore, this increase in soil PO<sub>4</sub>-P concentrations for treatment #2 is not the effect of the treatment but is due to higher initial soil PO<sub>4</sub>-P concentrations. Hopefully, at the completion of this field

study in 2012 and with additional four year (2009-2012) of data will help us in making better conclusions on treatment effects on residual soil  $\text{PO}_4\text{-P}$  concentrations.

In addition, we have added several extra tables in the Appendix (tables 4-29) at the end of this report on raw data which are being collected in this long-term study. This appendix gives detailed monthly data on rainfall, subsurface drain flows, nitrate-nitrogen and  $\text{PO}_4\text{-P}$  concentrations in subsurface drain water, soil organic matter, and nitrate-nitrogen and  $\text{PO}_4\text{-P}$  concentrations build up in the soil. Four more years (2009- 2012) of data will be collected before arriving at final conclusions of the effect of various treatments on soil and water quality.

**Appendix (Tables 4-29)**

**Table 4.** Subsurface drain flows for 2007 as a function of farming systems

Month 2007	Rain (cm)	Subsurface Drainage water, mm						LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	5.7	7.9 a	6.2 A	8.3 a	4.2 a	15.1 a	13.0	
April	9.3	29.5 a	48.2 a	59.0 a	47.9 a	58.2 a	35.2	
May	11.2	27.7 ab	32.9 ab	40.6 ab	25.6 b	53.0 a	27.0	
June	10.1	14.3 a	16.3 a	12.9 a	14.7 a	25.8 a	16.8	
July	11.6	0.2 b	0.4 ab	0.0 b	0.0 b	0.9 a	0.5	
August	24.8	6.2 b	8.1 b	11.1 b	10.5 b	28.4 a	13.2	
September	5.4	0.9 b	1.7 b	0.4 b	1.1 b	0.5 a	1.6	
October	13.7	33.6 a	42.8 a	59.8 a	30.2 a	54.7 a	35.6	
November	0.2	5.9 ab	8.2 ab	3.3 b	6.2 ab	1.1 a	6.9	
Total/Ave.	92.1	126.4 b	164.7 ab	195.5 ab	140.5 ab	252.9 a	121.1	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	5.7	21.1 ab	34.3 a	14.1 b	15.4 b	25.8 ab	16.2	
April	9.3	65.1 a	84.9 a	54.5 a	70.5 a	82.4 a	39.7	
May	11.2	37.6 a	51.0 a	42.8 a	38.8 a	53.4 a	25.4	
June	10.1	21.9 b	38.5 ab	25.2 ab	31.2 ab	50.2 a	26.8	
July	11.6	0.3 b	2.6 ab	25.2 b	2.3 ab	5.5 a	3.9	
August	24.8	9.8 a	29.6 a	12.7 a	17.2 a	32.7 a	33.6	
September	5.4	0.9 a	22.1 a	1.7 a	7.6 a	35.5 a	42.7	
October	13.7	39.7 a	67.4 a	45.4 a	55.4 a	48.8 a	33.4	
November	0.2	39.0 a	129.1 a	64.2 a	129.3 a	152.5 a	155.1	
Total/Ave.	92.1	199.5 a	323.5 a	202.1 a	244.5 a	317.5 a	177.5	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	5.7	11.1 a	27.1 a	21.3				
April	9.3	49.0 a	72.1 a	65.5				
May	11.2	35.5 a	36.9 a	30.9				
June	10.1	16.0 a	21.8 a	14.2				
July	11.6	0.4 a	0.2 a	1.1				
August	24.8	12.5 a	11.8 a	18.9				
September	5.4	0.6 a	2.4 a	3.3				
October	13.7	47.6 a	38.1 a	66.1				
November	0.2	6.9 a	6.6 a	7.8				
Total/Ave.	92.1	179.6 a	217.0 a	200.7				

**Table 5.** Subsurface drain flows for 2008 as a function of farming systems

Month 2008	Rain (cm)	Subsurface Drainage water, mm						LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	4.1	0.0 a	0.8 a	0.0 a	0.0 a	0.4 a	1.1	
April	22.7	86.1 a	136.0 a	79.2 a	74.9 a	94.5 a	82.3	
May	11.0	21.0 a	32.0 a	24.0 a	22.0 a	32.1 a	24.1	
June	23.8	95.6 a	127.2 a	110.3 a	73.0 a	79.0 a	76.9	
July	15.1	3.5 a	27.2 a	8.4 a	15.8 a	30.5 a	33.6	
August	3.6	0.0 a	0.4 a	0.1 a	0.6 a	1.1 a	1.3	
September	6.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0	
October	6.6	33.6 a	42.8 a	59.8 a	30.2 a	54.7 a	35.6	
November	4.5	0.1 a	2.3 a	0.0 a	0.2 a	0.7 a	3.4	
<b>Total</b>	97.8	206.4 a	325.9 a	221.6 a	186.5 a	237.6 a	193.3	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	4.1	0.0 b	0.0 b	0.0 b	0.0 b	1.7 a	0.6	
April	22.7	43.4 b	77.8 ab	107.8 a	73.2 ab	122.2 a	49.5	
May	11.0	15.5 a	20.2 a	18.4 a	20.0 a	30.0 a	18.1	
June	23.8	65.3 a	81.6 a	108.5 a	77.5 a	103.1 a	55.6	
July	15.1	9.6 ab	13.0 ab	7.7 b	23.7 ab	24.5 a	16.5	
August	3.6	0.1 b	0.0 b	0.0 b	0.1 b	0.9 a	0.8	
September	6.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0	
October	6.6	39.7 a	67.4 a	45.4 a	55.4 a	48.8 a	33.4	
November	4.5	0.0 a	0.0 a	0.0 a	0.0 a	0.6 a	0.8	
<b>Total/Ave.</b>	97.8	133.9 b	192.8 ab	242.4 ab	194.5 ab	282.7 a	123.6	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	4.1	11.1 a	27.1 a	21.3				
April	22.7	108.1 a	71.1 a	67.0				
May	11.0	21.5 a	17.9 a	4.8				
June	23.8	106.9 a	80.2 a	47.7				
July	15.1	18.1 a	8.8 a	11.8				
August	3.6	0.3 a	0.0 a	0.6				
September	6.3	0.0 a	0.0 a	0.0				
October	6.6	0.0 a	0.0 a	0.0				
November	4.5	0.0 a	0.0 a	0.0				
<b>Total/Ave.</b>	97.8	254.9 a	178.1 a	124.7				

**Table 6:** Subsurface drain flows for 2009 as a function of farming systems

Month 2009	Rain (cm)	Subsurface Drainage water, mm					LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N	
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>
March	3.4	0.0 a	0.0 a	0.0 a	0.0 a	0.2 a	0.2
April	13.4	9.5 a	10.7 a	13.1 a	13.6 a	13.3 a	14.0
May	13.3	30.4 a	27.3 a	42.5 a	42.7 a	49.0 a	40.0
June	9.2	14.1 a	13.8 a	17.1 a	22.0 a	30.0 a	26.8
July	9.4	2.0 b	2.4 ab	1.1 b	3.9 b	9.3 a	7.1
August	9.5	0.0 a	0.0 a	0.0 a	0.0 a	0.1 a	0.2
September	5.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
October	16.2	0.5 a	1.0 a	1.2 a	3.0 a	13.6 a	13.6
November	1.6	5.1 b	8.3 ab	3.9 ab	12.7 ab	20.5 a	12.0
December	3.6	0.1 b	0.2 b	0.0 b	0.2 b	1.4	1.1
<b>Total/Ave.</b>	<b>84.8</b>	<b>61.8 a</b>	<b>64.2 a</b>	<b>83.8 a</b>	<b>98.0 a</b>	<b>137.4 a</b>	<b>99.1</b>
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>
March	3.4	0.1 a	6.3 a	0.1 a	0.0 a	1.3 a	8.8
April	13.4	25.9 a	51.4 a	69.6 a	23.7 a	40.8 a	82.9
May	13.3	57.9 a	65.4 a	50.1 a	62.7 a	77.9 a	37.0
June	9.2	26.9 a	48.7 a	25.9 a	46.2 a	54.2 a	36.6
July	9.4	3.5 a	14.3 a	3.4 a	18.8 a	5.5 a	18.6
August	9.5	0.0 a	0.2 a	0.0 a	1.4 a	0.1 a	2.0
September	5.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.1
October	16.2	0.3 a	18.6 a	0.9 a	8.3 a	8.4 a	21.0
November	1.6	3.4 b	26.9 a	7.6 ab	19.3 ab	14.0 a	23.3
December	3.6	0.0 a	0.3 a	0.1 a	2.4 a	1.6 a	5.4
<b>Total/Ave.</b>	<b>84.8</b>	<b>118.0 a</b>	<b>235.1 a</b>	<b>157.9 a</b>	<b>182.6 a</b>	<b>217.4 a</b>	<b>202.4</b>
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>			
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>				
March	3.4	0.0 a	0.0 a	0.0			
April	13.4	24.1 a	11.0 a	17.4			
May	13.3	47.6 a	36.8 a	25.2			
June	9.2	28.1 a	16.6 b	6.1			
July	9.4	3.6 a	2.6 a	5.8			
August	9.5	0.0 a	0.0 a	0.0			
September	5.3	0.0 a	0.0 a	0.0			
October	16.2	3.5 a	2.9 a	9.1			
November	1.6	8.6 a	11.8 a	10.8			
December	3.6	0.0 a	17.6 a	47.4			
<b>Total/Ave.</b>	<b>84.8</b>	<b>115.7 a</b>	<b>99.5 a</b>	<b>51.7</b>			

**Table 7:** Subsurface drain flows for 2007-2009 as a function of farming systems

Month 2007-2009	Rain (cm)	Subsurface Drainage water, mm					LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N	
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>
March	4.4	2.7 a	2.3 a	2.8 a	1.4 a	5.2 a	5.5
April	15.1	41.7 a	65.0 a	50.4 a	45.5 a	55.4 a	43.0
May	11.8	26.4 b	30.8 ab	35.7 ab	30.1 ab	44.7 a	15.9
June	14.4	41.3 a	52.4 a	46.8 a	36.6 a	44.7 a	44.9
July	12.1	1.9 a	19.9 a	3.1 a	6.6 a	13.6 a	12.5
August	12.7	2.1 a	2.8 a	3.7 a	3.7 a	9.9 a	7.9
September	5.6	0.3 b	0.6 ab	0.1 b	0.4 b	1.8 a	1.3
October	12.2	17.0 a	21.9 a	30.5 a	16.6 a	34.1 a	31.4
November	2.1	3.7 b	6.4 ab	4.1 b	6.3 ab	10.9 a	6.2
<b>Total/Ave.</b>	90.4	131.6 a	184.9 a	167.1 a	141.6 a	209.3 a	94.2
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>
March	4.4	7.0 a	13.5 a	4.7 a	5.2 a	9.6 a	11.6
April	15.1	44.8 b	71.4 ab	77.3 ab	55.8 ab	81.8 a	35.7
May	11.8	37.0 a	45.6 a	37.1 a	40.5 a	53.7 a	21.7
June	14.4	38.0 a	56.3 a	53.2 a	51.6 a	69.2 a	31.7
July	12.1	4.5 b	10.0 ab	4.0 b	15.0 a	16.4 a	9.2
August	12.7	3.3 a	9.9 a	4.3 a	6.2 a	11.2 a	13.7
September	5.6	0.0 a	0.8 a	0.1 a	0.3 a	1.2 a	1.4
October	12.2	20.0 a	23.2 a	45.4 a	31.9 a	28.6 a	33.1
November	2.1	2.4 b	13.3 a	4.7 ab	10.7 ab	9.9 ab	10.2
<b>Total/Ave.</b>	90.4	199.5 a	323.5 a	202.1 a	244.5 a	317.5 a	177.5
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>			
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>				
March	4.4	3.7 a	9.1 a	11.4			
April	15.1	60.4 a	51.4 a	40.0			
May	11.8	34.9 a	30.5 a	13.7			
June	14.4	50.3 a	39.6 a	38.7			
July	12.1	7.4 a	3.9 a	7.0			
August	12.7	4.3 a	3.9 a	7.3			
September	5.6	0.2 a	0.8 a	1.1			
October	12.2	25.6 a	20.5 a	37.0			
November	2.1	6.1 a	5.2 a	5.4			
<b>Total/Ave.</b>	90.4	183.4 a	164.9 a	77.5			

**Table 8:** Nitrate-Nitrogen losses for 2007 as a function of farming systems

Month 2007	Rain (cm)	Nitrate-Nitrogen losses, kg ha <sup>-1</sup>						LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	5.7	1.0 a	1.0 a	1.2 a	0.5 a	2.3 a	2.0	
April	9.3	3.4 b	8.9 a	7.9 ab	5.4 ab	9.6 a	5.0	
May	11.2	3.8 b	8.5 ab	8.3 ab	3.7 b	11.6 a	5.4	
June	10.1	2.0 b	4.3 ab	2.8 ab	2.3 b	6.2 a	3.4	
July	11.6	0.0 b	0.1 b	0.0 b	0.0 b	0.2 a	0.1	
August	24.8	0.4 b	0.8 ab	0.9 ab	0.6 ab	2.6 a	2.0	
September	5.4	0.1 b	0.2 b	0.0 b	0.1 b	0.4 a	0.2	
October	13.7	1.9 ab	2.7 ab	4.8 a	1.7 b	4.0 ab	3.0	
November	0.2	0.3 a	0.5 a	0.2 a	0.3 a	0.5 a	0.4	
<b>Total/Ave.</b>	92.1	12.9 b	27.0 ab	26.2 ab	14.8 b	37.6 a	17.1	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	5.7	2.9 ab	4.7 a	2.1 b	2.3 b	2.3 b	2.2	
April	9.3	7.3 a	9.5 a	6.6 a	8.2 a	6.4 a	4.2	
May	11.2	5.5 a	7.1 a	6.3 a	5.7 a	4.7 a	3.4	
June	10.1	3.1 a	5.2 a	3.8 a	4.4 a	4.4 a	3.2	
July	11.6	0.0 b	0.4 ab	0.1 ab	0.3 ab	0.5 a	0.4	
August	24.8	0.7 a	2.9 a	1.2 a	1.4 a	1.9 a	2.8	
September	5.4	0.0 a	0.2 a	0.0 a	0.0 a	0.2 a	0.4	
October	13.7	3.6 b	6.2 a	5.1 ab	4.7 ab	3.3 b	2.3	
November	0.2	0.2 a	0.9 a	0.7 a	1.0 a	0.8 a	0.9	
<b>Total/Ave.</b>	92.1	23.3 a	37.1 a	25.9 a	28.0 a	24.6 a	16.7	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	5.7	3.2 a	8.2 a	5.8				
April	9.3	12.1 a	20.0 a	15.8				
May	11.2	12.7 a	14.0 a	10.9				
June	10.1	6.1 a	8.2 a	5.4				
July	11.6	0.0 a	0.0 a	0.1				
August	24.8	2.3 a	1.7 a	3.3				
September	5.4	0.0 a	0.3 a	0.6				
October	13.7	7.6 a	4.8 a	9.9				
November	0.2	1.1 a	0.8 a	1.1				
<b>Total/Ave.</b>	92.1	34.1 a	50.4 a	34.7				

**Table 9:** Nitrate-Nitrogen losses for 2008 as a function of farming systems

Month 2008	Rain (cm)	Nitrate-Nitrogen losses, kg ha <sup>-1</sup>					LSD
		UAN Spring Inject 150 # N	Fall-CP Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	Fall-NT Manure 150 # N	
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>
March	4.1	0.0 a	0.1 a	0.0	0.0 a	0.0 a	0.1
April	22.7	10.0 bc	20.7 a	14.9 ab	7.1 c	11.7 bc	7.7
May	11.0	2.6 a	4.9 a	4.3 a	2.5 a	4.5 a	2.7
June	23.8	17.8 a	24.0 a	24.5 a	12.7 a	14.1 a	12.1
July	15.1	0.5 a	3.7 a	1.2 a	1.9 a	4.1 a	4.5
August	3.6	0.0 a	0.1 a	0.0 a	0.0 a	0.1 a	0.2
September	6.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
October	6.6	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
November	4.5	0.0 a	0.0 a	0.0 a	0.0 a	0.1 a	0.1
<b>Total/Ave.</b>	97.8	30.9 b	53.4 a	45.6 ab	24.3 b	34.6 ab	21.2
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>
March	4.1	0.0 b	0.0 b	0.0 b	0.0 b	0.2 a	0.0
April	22.7	3.6 c	6.4 bc	14.7 a	6.7 bc	11.6 ab	6.9
May	11.0	1.4 a	2.0 a	2.6 a	2.0 a	2.9 a	2.2
June	23.8	5.3 b	7.1 b	16.1 a	7.0 a	8.6 b	7.2
July	15.1	0.7 a	1.2 a	0.9 a	2.5 a	1.9 a	1.9
August	3.6	0.0 b	0.0 b	0.0 b	0.0 b	0.1 a	0.0
September	6.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
October	6.6	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
November	4.5	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
<b>Total/Ave.</b>	97.8	11.1 b	16.7 b	34.4 a	18.1 b	25.3 ab	39.5
<b>Continuous Corn</b>		<b>System 4: Fall manure inject (4.1) 200 # N</b>		<b>(4.2) 200 #N + Stover removal</b>	<b>LSD</b>		
March	4.1	0.0 a	0.0 a	0.0			
April	22.7	24.6 a	15.7 a	13.8			
May	11.0	5.1 a	4.1 a	1.3			
June	23.8	24.7 a	19.9 a	9.1			
July	15.1	3.6 a	1.2 b	1.4			
August	3.6	0.1 a	0.0 a	0.1			
September	6.3	0.0 a	0.0 a	0.0			
October	6.6	0.0 a	0.0 a	0.0			
November	4.5	0.0 a	0.0 a	0.0			
<b>Total/Ave.</b>	97.8	58.0 a	40.9 a	23.4			

**Table 10:** Nitrate- Nitrogen losses for 2009 as a function of farming systems

Month 2009	Rain (cm)	Nitrate - Nitrogen losses, kg ha <sup>-1</sup>					LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N	
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>
March	3.4	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
April	13.4	1.2 a	2.1 a	2.4 a	1.2 a	2.1 a	2.3
May	13.3	3.8 a	6.9 a	9.4 a	4.3 a	9.4 a	7.5
June	9.2	1.8 a	3.3 a	4.1 a	2.5 a	5.7 a	5.0
July	9.4	0.2 b	0.4 b	0.3 b	0.5 b	1.8 a	1.3
August	9.5	0.0 a	0.0 a	0.0 a	0.0 a	0.1 a	0.0
September	5.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
October	16.2	0.0 a	0.1 a	0.1 a	0.1 a	1.7 a	2.1
November	1.6	0.4 a	0.9 a	0.7 a	0.8 a	2.2 a	1.9
December	3.6	0.0 b	0.0 ab	0.0 b	0.0 ab	0.1 a	0.1
<b>Total/Ave.</b>	<b>84.8</b>	<b>7.4 a</b>	<b>13.6 a</b>	<b>17.0 a</b>	<b>9.4 a</b>	<b>23.0 a</b>	<b>17.0</b>
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>
March	3.4	0.1 a	6.3 a	0.1 a	0.0 a	1.3 a	8.8
April	13.4	25.9 a	51.4 a	69.6 a	23.7 a	40.8 a	82.9
May	13.3	57.9 a	65.4 a	50.1 a	62.7 a	77.9 a	37.0
June	9.2	26.9 a	48.7 a	25.9 a	46.2 a	54.2 a	36.6
July	9.4	3.5 a	14.3 a	3.4 a	18.8 a	5.5 a	18.6
August	9.5	0.0 a	0.2 a	0.0 a	1.4 a	0.1 a	2.0
September	5.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.1
October	16.2	0.3 a	18.6 a	0.9 a	8.3 a	8.4 a	21.0
November	1.6	3.4 b	26.9 a	7.6 ab	19.3 ab	14.0 a	23.3
December	3.6	0.0 a	0.3 a	0.1 a	2.4 a	1.6 a	5.4
<b>Total/Ave.</b>	<b>84.8</b>	<b>118.0 a</b>	<b>235.1 a</b>	<b>157.9 a</b>	<b>182.6 a</b>	<b>217.4 a</b>	<b>202.4</b>
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>			
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stove removal</b>				
March	3.4	0.0 a	0.0 a	0.0			
April	13.4	4.9 a	2.2 a	2.8			
May	13.3	10.0 a	8.5 a	4.3			
June	9.2	6.1 a	3.8 b	2.3			
July	9.4	0.9 a	0.6 a	1.4			
August	9.5	0.0 a	0.0 a	0.0			
September	5.3	0.0 a	0.0 a	0.0			
October	16.2	0.5 a	0.3 a	1.3			
November	1.6	1.3 a	1.6 a	1.9			
December	3.6	0.0 a	0.0 a	0.0			
<b>Total/Ave.</b>	<b>84.8</b>	<b>23.7 a</b>	<b>17.0 a</b>	<b>8.4</b>			

**Table 11:** Nitrate-Nitrogen losses for 2007-2009 as a function of farming systems

		Nitrate-Nitrogen losses, kg ha <sup>-1</sup>					
Month 2007-2009	Rain (cm)	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N	
		<b>Corn Rotation</b>		System 1	System 2	System 3	System 5
March	4.4	0.3 a	0.4 a	0.4 a	0.2 a	0.8 a	0.8
April	15.1	4.8 b	10.6 a	8.4 ab	4.6 ab	7.8 ab	5.6
May	11.8	3.3 b	6.7 a	7.3 a	3.5 b	8.5 a	3.1
June	14.4	7.2 a	10.5 a	10.5 a	5.8 a	8.6 a	8.4
July	12.1	0.3 b	1.4 ab	0.5 ab	0.8 ab	2.0 a	1.7
August	12.7	0.1 a	0.3 a	0.3 a	0.2 a	0.9 a	0.8
September	5.6	0.0 b	0.1 ab	0.0 b	0.0 b	0.1 a	0.1
October	12.2	0.9 a	1.4 a	2.5 a	0.9 a	2.9 a	2.4
November	2.1	0.2 a	0.5 a	0.3 a	0.4 a	0.9 a	0.8
<b>Total/Ave.</b>	90.4	17.1 b	31.3 a	29.4 ab	16.2 b	31.7 a	13.8
<b>Soybean Rotation</b>				Fall manure 100 # N			<b>LSD</b>
March	4.4	1.0 a	1.8 a	0.7 a	0.7 a	0.8 a	1.5
April	15.1	4.5 a	7.0 a	7.9 a	5.7 a	7.1 a	4.0
May	11.8	4.2 a	5.2 a	5.3 a	4.4 a	4.7 a	2.3
June	14.4	3.7 b	5.7 ab	7.9 a	5.1 ab	5.8 ab	3.7
July	12.1	0.4 c	1.0 abc	0.5 bc	1.5 a	1.3 ab	0.9
August	12.7	0.7 a	1.0 a	1.2 a	1.4 a	0.6 a	1.1
September	5.6	0.0 a	0.1 a	0.0 a	0.0 a	0.1 a	0.1
October	12.2	1.8 b	3.9 a	2.6 a	2.6 a	1.9 a	2.9
November	2.1	0.1 b	1.2 a	0.2 b	0.8 ab	0.7 ab	0.8
<b>Total/Ave.</b>	90.4	15.2 b	25.7 a	25.1 a	20.6 ab	22.5 ab	9.8
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		LSD				
		<b>4.1. 200 # N</b>		<b>4.2. 200 #N + Stover removal</b>			
March	4.4	1.0 a	2.7 a	3.3			
April	15.1	13.9 a	12.6 a	9.6			
May	11.8	9.3 a	8.8 a	4.6			
June	14.4	12.3 a	10.6 a	8.6			
July	12.1	1.5 a	0.6 a	1.3			
August	12.7	0.6 a	0.8 a	1.2			
September	5.6	0.0 a	0.1 a	0.2			
October	12.2	4.0 a	2.5 a	5.5			
November	2.1	0.8 a	0.8 a	0.8			
<b>Total/Ave.</b>	90.4	38.6 a	36.1 a	17.8			

**Table 12:** Nitrate-Nitrogen concentrations for 2007 as a function of farming systems

Month 2007	Rain (cm)	Nitrate-Nitrogen Concentrations, ppm						LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	5.7	12.6 bc	16.6 a	14.5 ab	11.6 c	15.1 a	2.8	
April	9.3	11.0 b	18.8 a	13.2 b	10.5 b	16.7 a	2.7	
May	11.2	13.6 c	24.5 a	20.4 b	13.8 c	22.1 ab	4.0	
June	10.1	14.3 b	24.5 a	21.8 a	14.7 b	24.6 a	6.8	
July	11.6	13.7 a	21.2 a	18.4 a	11.4 a	24.2 a	13.4	
August	24.8	5.3 a	9.3 a	8.3 a	5.2 a	8.4 a	5.1	
September	5.4	6.2 a	7.1 a	1.9 a	5.9 a	7.9 a	8.8	
October	13.7	5.6 a	6.0 a	7.9 a	5.5 a	7.7 a	4.2	
November	0.2	5.4 a	6.7 a	6.6 a	3.5 a	4.4 a	3.7	
Total/Ave.	92.1	10.1 b	15.9 a	13.4 a	9.6 b	14.8 a	2.8	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	5.7	14.0 a	14.0 a	14.9 a	14.3 a	8.8 b	3.2	
April	9.3	11.2 ab	11.3 ab	12.5 a	11.7 a	7.8 b	3.5	
May	11.2	14.8 a	14.1 a	14.8 a	14.1 a	8.9 b	3.2	
June	10.1	14.3 a	14.0 a	15.2 a	13.8 a	9.0 b	3.3	
July	11.6	14.6 a	15.3 a	14.4 a	13.4 a	9.2 b	4.2	
August	24.8	6.3 a	7.0 a	8.9 a	8.3 a	6.3 a	6.1	
September	5.4	.	10.9 a	.	7.1 b	6.4 b	5.1	
October	13.7	8.9 ab	9.8 ab	11.2 a	8.6 ab	7.0 b	2.8	
November	0.2	6.0 a	5.9 a	9.7 a	8.2 a	6.0 a	6.7	
Total/Ave.	92.1	11.7 a	11.8 a	12.8 a	11.5 a	7.9 b	2.9	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	5.7	30.1 a	30.4 a	7.8				
April	9.3	27.1 a	27.9 a	10.6				
May	11.2	36.4 a	37.7 a	5.4				
June	10.1	38.4 a	37.8 a	3.3				
July	11.6	38.9 a	20.9 a	45.2				
August	24.8	20.0 a	14.2 a	6.2				
September	5.4	21.9 a	11.2 a	26.8				
October	13.7	15.9 a	11.9 b	3.0				
November	0.2	15.6 a	10.7 b	3.5				
Total/Ave.	92.1	20.0 a	23.9 a	7.7				

**Table 13:** Nitrate-Nitrogen concentrations for 2008 as a function of farming systems

Month 2008	Rain (cm)	Nitrate-Nitrogen Concentrations, ppm						LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	4.1	2.2 a	7.6 a	0.0 a	2.7 a	2.3 a	9.2	
April	22.7	11.5 c	16.4 ab	18.7 a	9.6 c	13.5 bc	4.0	
May	11.0	12.2 bc	16.3 ab	18.0 a	11.0 c	15.0 abc	4.3	
June	23.8	19.2 ab	19.7 ab	22.3 a	16.5 a	17.7 ab	4.6	
July	15.1	14.3 a	15.5 a	13.4 a	13.0 a	14.3 a	7.0	
August	3.6	3.5 b	17.9 a	7.6 ab	10.5 ab	13.3 ab	13.5	
September	6.3	0	0	0	0	0	0	
October	6.6	0	0	0	0	0	0	
November	4.5	0	0	0	0	0	0	
Total/Ave.	97.8	15.1 bc	17.7 ab	20.3 a	12.4 c	15.3 bc	4.6	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	4.1	0.0 b	0.0 b	0.0 b	0.0 b	10.1 a	1.9	
April	22.7	8.3 b	8.1 b	13.7 a	8.7 b	9.4 b	3.2	
May	11.0	8.7 b	9.6 b	14.4 a	8.7 b	9.3 b	3.1	
June	23.8	7.8 b	8.2 b	14.7 a	8.1 b	8.5 b	4.4	
July	15.1	7.1 b	9.3 ab	12.2 a	10.9 ab	8.2 ab	3.9	
August	3.6	4.1 a	7.5 a	0 a	4.3 a	7.1 a	10.6	
September	6.3	.	.	.	.	.	.	
October	6.6	.	.	.	.	.	.	
November	4.5	.	.	.	.	.	.	
Total/Ave.	97.8	8.0 b	8.3 b	14.2 a	8.7 b	8.9 b	3.4	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	4.1	.	.	.				
April	22.7	23.1 a	22.2 a	3.1				
May	11.0	23.6 a	23.0 a	4.2				
June	23.8	23.3 a	24.9 a	2.4				
July	15.1	20.4 a	14.8 a	7.6				
August	3.6	21.6 a	12.8 b	6.4				
September	6.3	.	.	.				
October	6.6	.	.	.				
November	4.5	.	.	.				
Total/Ave.	97.8	23.1 a	23.0 a	2.7				

**Table 14:** Nitrate-Nitrogen concentrations for 2009 as a function of farming systems

Month 2009	Rain (cm)	Nitrate-Nitrogen Concentrations, ppm						LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	3.4	6.0 b	8.7 ab	.	1.8 b	21.5 a	16.8	
April	13.4	12.2 c	19.1 a	19.0 a	8.5 d	15.6 b	3.1	
May	13.3	12.5 c	23.5 a	22.2 ab	9.6 c	18.7 b	4.5	
June	9.2	12.6 b	21.5 a	23.3 a	10.7 b	19.3 a	5.9	
July	9.4	13.5 bc	18.9 ab	24.7 a	11.4 c	18.9 a	7.0	
August	9.5	.	.	.	.	.	.	
September	5.3	.	.	.	.	.	.	
October	16.2	.	.	.	.	.	.	
November	1.6	7.1 ab	9.1 ab	11.6 a	5.4 b	9.3 ab	5.2	
December	3.6	6.8 ab	10.1 a	.	6.5 ab	5.8 b	2.2	
Total/Ave.	84.8	12.1 bc	19.8 a	20.2 a	8.9 c	15.8 ab	4.9	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	3.4	8.0 a	8.8 a	4.7 a	7.2 a	7.1 a	8.3	
April	13.4	9.6 a	10.9 a	7.8 a	8.9 a	8.4 a	4.9	
May	13.3	9.9 bc	10.3 b	13.8 a	8.8 bc	8.3 c	1.7	
June	9.2	9.3 b	10.0 b	14.8 a	8.1 b	8.2 b	2.0	
July	9.4	9.6 bc	11.1 b	15.7 a	8.3 c	8.9 cb	2.4	
August	9.5	.	11.5 a	.	9.5 a	9.1 a	23.4	
September	5.3	.	.	.	.	.	.	
October	16.2	7.2 b	9.2 a	11.3 a	6.0 b	7.4 b	1.8	
November	1.6	5.8 a	10.0 ab	12.2 a	7.1 c	8.1 bc	2.6	
December	3.6	7.0 b	6.3 b	13.9 a	6.0 b	7.1 b	5.2	
Total/Ave.	84.8	9.5 a	10.3 a	11.1 a	8.3 a	8.3 a	3.4	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	3.4	14.8 a	6.7 a	35.0				
April	13.4	21.3 a	19.2 a	7.0				
May	13.3	21.5 a	23.0 a	4.3				
June	9.2	22.8 a	21.7 a	4.4				
July	9.4	23.8 a	21.7 a	5.4				
August	9.5	.	.	.				
September	5.3	.	.	.				
October	16.2	11.6 a	8.0 a	8.2				
November	1.6	15.1 a	13.2 a	4.1				
December	3.6	16.3 a	6.9 a	29.5				
Total/Ave.	84.8	20.9 a	17.6 a	10.1				

**Table 15:** Nitrate-Nitrogen concentrations for 2007-2009 as a function of farming systems

Month 2007-2009	Rain (cm)	Nitrate-Nitrogen Concentrations, ppm						LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	4.4	6.9 a	10.9 a	8.7 a	6.4 a	11.9 a	7.2	
April	15.1	11.5 c	18.1 a	17.0 ab	9.5 c	15.3 b	2.1	
May	11.8	12.1 b	21.4 a	20.2 a	11.4 b	18.6 a	3.1	
June	14.4	15.4 b	21.9 a	22.5 a	13.9 c	20.5 a	3.5	
July	12.1	13.8 bc	18.0 ab	18.8 a	11.7 c	19.1 a	8.0	
August	12.7	4.8 b	12.7 a	8.0 ab	7.3 ab	11.4 a	5.0	
September	5.6	6.2 a	7.1 a	1.9 a	3.9 a	6.3 a	8.4	
October	12.2	6.1 ab	6.4 ab	8.3 a	4.8 b	8.0 a	5.1	
November	2.1	6.1 ab	8.1 ab	8.5 a	4.5 b	7.5 ab	6.6	
Total/Ave.	90.4	12.4 b	17.8 a	18.0 a	10.2 b	15.3 a	2.8	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	4.4	7.4 a	7.5 a	7.1 a	7.2 a	8.8 a	8.1	
April	15.1	9.7 ab	10.1 ab	13.3 a	9.8 ab	8.5 b	2.4	
May	11.8	11.1 bc	11.3 b	14.3 a	10.6 bc	8.8 c	2.2	
June	14.4	10.5 b	10.7 b	14.9 a	10.0 b	8.6 b	2.6	
July	12.1	10.4 bc	11.6 ab	14.0 a	10.7 bc	8.7 c	8.3	
August	12.7	5.4 a	8.6 a	6.6 a	6.9 a	7.1 a	5.5	
September	5.6	.	9.5 a	. b	2.4 b	4.3 ab	2.7	
October	12.2	8.0 bc	9.7 ab	11.3 a	7.3 c	7.2 c	1.7	
November	2.1	5.9 b	7.7 ab	11.0 a	7.6 ab	6.3 b	6.2	
Total/Ave.	90.4	9.8 b	10.2 b	13.7 a	9.5 b	8.4 b	2.0	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	4.4	15.1 a	13.1 a	15.8				
April	15.1	23.8 a	23.2 a	4.3				
May	11.8	27.2 a	27.9 a	7.4				
June	14.4	27.8 a	28.5 a	7.6				
July	12.1	23.1 a	18.8 a	10.1				
August	12.7	18.0 a	13.6 a	7.8				
September	5.6	7.3 a	11.2 a	22.0				
October	12.2	13.7 a	9.9 a	4.3				
November	2.1	15.3 a	11.9 b	2.3				
Total/Ave.	90.4	21.3 a	21.5 a	3.7				

**Table 16:** Orthophosphate losses for 2007 as a function of farming systems

Month 2007	Rain (cm)							LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	5.7	0.0 a	0.2 a	0.0 a	0.0 a	0.3 a	2.2	
April	9.3	0.1 a	0.4 a	0.2 a	0.1 a	0.6 a	0.7	
May	11.2	0.2 a	0.2 a	0.2 a	0.2 a	0.3 a	0.1	
June	10.1	0.4 a	0.6 a	0.2 a	0.3 a	0.5 a	0.0	
July	11.6	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0	
August	24.8	0.5 b	0.9 b	0.8 b	0.8 b	2.3 a	0.9	
September	5.4	0.1 b	0.2 b	0.0 b	0.1 b	0.5 a	0.2	
October	13.7	1.7 b	4.5 a	3.0 ab	1.5 b	3.1 ab	2.6	
November	0.2	0.3 b	1.0 a	0.2 b	0.2 b	0.4 b	0.5	
<b>Total/Ave.</b>	92.1	3.3 b	8.0 a	4.6 ab	3.3 b	8.0 a	3.7	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	5.7	0.1 a	0.2 a	0.1 a	0.2 a	0.2 a	0.2	
April	9.3	0.2 a	0.4 a	0.2 a	0.5 a	0.5 a	0.5	
May	11.2	0.2 a	0.3 a	0.3 a	0.2 a	0.4 a	0.2	
June	10.1	0.5 b	1.1 ab	0.6 b	0.8 b	1.5 a	0.7	
July	11.6	0.0 b	0.1 ab	0.0 b	0.1 ab	0.3 a	0.2	
August	24.8	0.6 a	2.0 a	0.9 a	1.2 a	2.4 a	2.6	
September	5.4	0.0 a	0.2 a	0.0 a	0.0 a	0.3 a	0.4	
October	13.7	1.9 b	4. a	2.9 ab	3.1 ab	3.2 ab	1.7	
November	0.2	0.2 a	0.6 a	0.5 a	0.9 a	0.8 a	0.8	
<b>Total/Ave.</b>	92.1	3.8 a	8.9 a	5.4 a	6.9 a	9.7 a	6.5	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	5.7	0.1 b	0.3 a	0.2				
April	9.3	0.4 a	2.4 a	2.7				
May	11.2	0.2 a	0.2 a	0.2				
June	10.1	0.4 a	0.4 a	0.5				
July	11.6	0.0 a	0.0 a	0.0				
August	24.8	1.0 a	0.9 a	1.5				
September	5.4	0.0 a	0.2 a	0.3				
October	13.7	2.7 a	1.9 a	3.3				
November	0.2	0.5 a	0.3 a	0.5				
<b>Total/Ave.</b>	92.1	1.1 a	3.4 a	3.3				

**Table 17:** Orthophosphate losses for 2008 as a function of farming systems

Month 2008	Rain (cm)	Orthophosphate losses, g ha <sup>-1</sup>					LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N	
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>
March	4.1	0.0 a	0.3 a	0.0	0.0 a	0.0 a	0.4
April	22.7	12.3 a	36.7 a	64.6 a	18.7 a	18.4 a	75.0
May	11.0	1.2 a	2.7 a	1.5 a	1.8 a	1.9 a	2.2
June	23.8	4.1 b	14.2 a	9.6 ab	6.0 ab	13.1 a	8.7
July	15.1	0.3 a	1.5 a	0.6 a	1.1 a	2.0 a	2.0
August	3.6	0.0 a	0.0 a	0.0 a	0.0 a	0.1 a	0.1
September	6.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
October	6.6	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
November	4.5	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.1
<b>Total/Ave.</b>	<b>97.8</b>	<b>17.9 a</b>	<b>55.4 a</b>	<b>76.3 a</b>	<b>27.7 a</b>	<b>35.6 a</b>	<b>73.3</b>
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>
March	4.1	0.0 a	0.0 a	0.0 a	0.0 a	1.3 a	1.7
April	22.7	6.7 a	45.5 a	19.5 a	24.5 a	41.0 a	45.9
May	11.0	1.0 b	1.3 b	2.6 a	1.5 b	18.0 a	16.2
June	23.8	6.6 a	17.2 a	16.3 a	9.3 a	12.7 a	19.2
July	15.1	0.9 a	1.4 a	0.4 a	1.2 a	1.6 a	1.3
August	3.6	0.0 b	0.0 b	0.0 b	0.0 b	0.1 a	0.0
September	6.3	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
October	6.6	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
November	4.5	0.0 a	0.0 a	0.0 a	0.0 a	0.2 a	0.2
<b>Total/Ave.</b>	<b>97.8</b>	<b>15.2 b</b>	<b>68.0 ab</b>	<b>37.5 ab</b>	<b>36.4 ab</b>	<b>74.8 a</b>	<b>57.4</b>
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>			
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>				
March	4.1	0.0 a	0.0 a	0.0			
April	22.7	112.4 a	139.2 a	118.9			
May	11.0	2.0 a	1.3 a	1.7			
June	23.8	56.4 a	49.9 a	46.7			
July	15.1	1.4 a	0.7 b	0.6			
August	3.6	0.0 a	0.0 a	0.0			
September	6.3	0.0 a	0.0 a	0.0			
October	6.6	0.0 a	0.0 a	0.0			
November	4.5	172.2 a	191.1 a	0.0			
<b>Total/Ave.</b>	<b>97.8</b>	<b>58.0 a</b>	<b>40.9 a</b>	<b>128.8</b>			

**Table 18:** Orthophosphate concentrations for 2007 as a function of farming systems

Month 2007	Rain (cm)	Orthophosphate Concentrations, ppb					LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N	
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>
March	5.7	0.5 a	3.1 a	0.5 a	1.1 a	2.4 a	3.0
April	9.3	0.3 a	1.3 a	0.2 a	0.3 a	0.9 a	1.6
May	11.2	0.6 a	0.9 a	0.6 a	0.6 a	0.6 a	0.4
June	10.1	2.6 a	4.9 a	1.4 a	3.3 a	1.9 a	4.2
July	11.6	4.9 a	4.7 a	4.7 a	3.6 a	5.0 a	1.7
August	24.8	6.5 b	11.7 a	7.2 b	7.2 b	8.6 ab	4.2
September	5.4	8.6 a	10.8 a	8.9 a	11.1 a	9.0 a	4.5
October	13.7	4.8 b	11.6 a	5.1 b	5.5 b	5.5 b	5.5
November	0.2	6.1 b	11.7 a	5.7 b	3.6 b	4.1 b	2.7
Total/Ave.	92.1	2.3 b	5.5 a	2.4 b	2.5 b	3.2 ab	2.4
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>
March	5.7	0.5 a	0.6 a	0.6 a	1.0 a	0.8 a	0.6
April	9.3	0.3 a	0.4 a	0.4 a	0.6 a	0.7 a	0.6
May	11.2	0.6 c	0.7 a	0.6 bc	0.6 bc	0.7 a	0.1
June	10.1	2.2 a	2.8 a	2.4 a	2.5 a	3.2 a	0.9
July	11.6	3.9 b	4.9 ab	4.2 ab	4.3 ab	6.2 a	1.9
August	24.8	5.5 a	6.9 a	7.3 a	7.3 a	7.9 a	2.7
September	5.4	.	10.0 a	.	10.2 a	10.0 a	3.9
October	13.7	4.8 b	6.1 ab	6.5 a	5.5 ab	6.8 a	1.5
November	0.2	5.3 a	4.6 a	7.3 a	6.5 a	5.3 a	3.8
Total/Ave.	92.1	1.8 b	2.6 ab	2.7 ab	2.8 a	3.0 a	0.9
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>			
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>				
March	5.7	1.2 a	0.8 a	0.9			
April	9.3	3.5 a	0.6 a	3.8			
May	11.2	0.6 a	0.6 a	0.0			
June	10.1	2.7 a	1.9 a	1.5			
July	11.6	4.4 a	2.5 a	7.0			
August	24.8	8.0 a	7.7 a	2.2			
September	5.4	10.3 a	9.1 a	14.0			
October	13.7	5.0 a	6.4 a	2.4			
November	0.2	7.1 a	6.0 a	3.1			
Total/Ave.	92.1	0.6 a	1.6 a	1.1			

**Table 19: Orthophosphate Concentrations for 2008 as a function of farming systems**

Month 2008	Rain (cm)	Orthophosphate Concentrations, ppb						LSD
		UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>		<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
March	4.1	17.6 a	25.1 a	.	9.3 a	5.2 a	65.2	
April	22.7	13.0 a	26.4 a	80.6 a	26.0 a	23.8 a	88.4	
May	11.0	5.5 a	7.8 a	6.2 a	7.7 a	6.1 a	3.3	
June	23.8	4.2 c	12.6 ab	9.1 abc	8.0 bc	16.3 a	8.1	
July	15.1	11.3 a	5.9 a	8.2 a	7.6 a	7.3 a	8.0	
August	3.6	6.6 a	7.2 a	6.4 a	6.1 a	6.6 a	2.5	
September	6.3	.	.	.	.	.	.	
October	6.6	.	.	.	.	.	.	
November	4.5	6.8 a	5.4 a	.	6.8 a	5.0 a	100	
Total/Ave.	97.8	8.2 a	17.5 a	43.7 a	17.8 a	16.5 a	32.7	
<b>Soybean Rotation</b>				<b>Fall manure 100 # N</b>			<b>LSD</b>	
March	4.1	.	.	.	.	.	.	
April	22.7	14.9 a	59.5 a	19.2 a	31.5 a	35.1 a	54.2	
May	11.0	6.6 a	32.9 a	7.2 a	10.3 a	53.3 a	51.2	
June	23.8	9.2 a	27.1 a	16.2 a	12.1 a	12.3 a	26.3	
July	15.1	8.2 a	13.7 a	4.9 a	5.5 a	6.7 a	11.2	
August	3.6	6.4 a	4.5 b	.	5.3 ab	5.9 ab	1.6	
September	6.3	.	.	.	.	.	.	
October	6.6	.	.	.	.	.	.	
November	4.5	.	.	.	.	.	.	
Total/Ave.	97.8	10.7 a	43.0 a	15.9 a	18.5 a	27.3 a	39.5	
<b>Continuous Corn</b>		<b>System 4: Fall manure inject</b>		<b>LSD</b>				
		<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
March	4.1	.	.	.				
April	22.7	102.1 b	199.0 a	96.5				
May	11.0	9.2 a	7.2 a	8.9				
June	23.8	51.7 a	63.3 a	36.5				
July	15.1	8.5 a	8.4 a	5.1				
August	3.6	6.5 a	9.2 a	12.6				
September	6.3	.	.	.				
October	6.6	.	.	.				
November	4.5	.	.	.				
Total/Ave.	97.8	65.8 b	108.4 a	38.0				

**Table 20:** NO<sub>3</sub>-N concentrations of the soil (0-120 cm depth) for 2007 as a function of farming systems

Depth (cm)	NO <sub>3</sub> -N concentration, mg kg <sup>-1</sup>						
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
0-15	14.5 b	13.3 b	14.6 b	14.8 b	19.5 a	3.4	
15-30	6.3 b	6.8 ab	7.4 ab	6.2 b	8.6 a	1.9	
30-60	3.8 a	3.8 a	4.5 a	3.0 a	4.6 a	2.0	
60-90	2.9 a	2.3 a	2.3 a	2.0 a	2.8 a	1.1	
90-120	2.2 a	1.3 a	1.3 a	1.1 a	1.8 a	1.2	
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>			<b>LSD</b>	
0-15	16.7 a	20.9 a	15 a	16.7 a	15.9 a	6.4	
15-30	7.7 a	9.2 a	7.6 a	8.2 a	8.3 a	6.5	
30-60	5.0 ab	6.2 a	4.5 ab	5.0 ab	4.8 ab	1.6	
60-90	3.5 abc	4.0 ab	5.2 a	2.6 c	4.2 a	1.2	
90-120	2.3 ab	2.7 a	2.3 ab	1.6 b	2.3 ab	1.1	
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	17.5 a	15.3 a	4.0				
15-30	7.9 a	8.6 a	3.5				
30-60	5.0 a	4.2 a	2.8				
60-90	3.1 a	2.2 a	1.9				
90-120	1.9 a	1.3 a	1.3				
Total/Ave.							

**Table 21:** NO<sub>3</sub>-N concentrations of the soil (0-120 cm depth) for 2008 as a function of farming systems

Depth (cm)	NO <sub>3</sub> -N concentration, mg kg <sup>-1</sup>						
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
0-15	15.0 a	10.6 a	12.7 a	13.5 a	15.0 a	5.8	
15-30	8.1 a	5.7 b	5.9 b	6.4 ab	7.0 ab	2.2	
30-60	4.2 ab	4.4 a	2.7 b	3.7 ab	3.8 ab	1.6	
60-90	2.3 a	5.7 a	1.6 a	1.9 a	2.4 a	4.4	
90-120	1.7 a	2.0 a	1.1 a	1.8 a	2.7 a	2.0	
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>			<b>LSD</b>	
0-15	15.0 a	16.2 a	13.2 a	12.8 a	14.1 a	6.6	
15-30	9.2 a	7.9 a	10.3 a	6.7 a	7.1 a	5.1	
30-60	4.3 a	4.1 a	5.2 a	3.8 a	4.2 a	2.3	
60-90	2.3 a	2.2 a	2.7 a	2.6 a	2.7 a	2.3	
90-120	1.7 a	1.8 a	2.1 a	1.3 a	2.0 a	1.1	
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	12.6 a	11.4 a	2.4				
15-30	5.9 a	6.7 a	2.8				
30-60	3.2 a	3.3 a	1.3				
60-90	1.6 a	1.9 a	1.2				
90-120	1.5 a	1.8 a	1.7				
Total/Ave.							

**Table 22:** Bray-P concentrations of the soil (0-120 cm depth) for 2007 as a function of farming systems

Depth (cm)	Bray-P concentration, mg kg <sup>-1</sup>						LSD
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
0-15	20.7 b	39.8 ab	17.2 b	20.3 b	49.1 a	25.4	
15-30	4.1 b	9.8 ab	5.7 ab	5.7 ab	12.5 a	3.2	
30-60	3.7 a	3.3 a	3 a	2.5 a	3.2 a	1.8	
60-90	4.7 a	5.5 b	3 a	3.8 a	2.8 a	3.4	
90-120	6.2 a	7.7 a	3.8 a	5.1 a	5 a	4.8	
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>			<b>LSD</b>	
0-15	23 b	62 a	23 b	22 b	15 b	8.1	
15-30	4.8 c	14.3 a	5.3 bc	4.8 c	11.2 ab	6.2	
30-60	4.2 a	4.0 a	3 a	3.5 a	2.8 a	2.1	
60-90	4.8 a	1.3 b	5.2 a	3 ab	2 b	2.5	
90-120	6.7 a	2.7 a	6.5 a	7.2 a	4.2 a	4.9	
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	89 a	113.6 a	26.1				
15-30	15.3 a	45.2 a	30.2				
30-60	3.5 a	5.7 a	2.3				
60-90	3 a	6.3 a	3.3				
90-120	3.5 b	8.8 a	4.1				
Total/Ave.							

**Table 23:** Bray-P concentrations of the soil (0- 120 cm depth) for 2008 as a function of farming systems

Depth (cm)	Bray-P concentration, mg kg <sup>-1</sup>						LSD
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
0-15	17.6 a	25.1 a	.	9.3 a	5.2 a	65.2	
15-30	13.0 a	26.4 a	80.6 a	26.0 a	23.8 a	88.4	
30-60	5.5 a	7.8 a	6.2 a	7.7 a	6.1 a	3.3	
60-90	4.2 c	12.6 ab	9.1 abc	8.0 bc	16.3 a	8.1	
90-120	11.3 a	5.9 a	8.2 a	7.6 a	7.3 a	8.0	
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>			<b>LSD</b>	
0-15	21 bc	36.8 a	10.9 c	19.7 bc	30.3 ab	8.1	
15-30	4 a	10.3 a	10.5 a	4.8 a	5.5 a	8.1	
30-60	2.8 a	3.5 a	3.2 a	2.3 a	3.2 a	3	
60-90	5 a	5 a	3.3 a	3.3 a	3 a	3	
90-120	7.5 a	9 a	3.7 a	4.8 a	4.7 a	5.5	
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	80.2 a	91.4 a	28.2				
15-30	24.2 a	42.2 a	19.5				
30-60	5 a	6.6 a	3.7				
60-90	3.6 a	7.3 a	5.9				
90-120	3.2 a	7 a	5.1				
Total/Ave.							

**Table 24:** Mehlich 3-P concentrations of the soil (0- 120 cm depth) for 2007 as a function of farming systems

Depth (cm)	Mehlich-3 phosphorus concentration, mg kg <sup>-1</sup>						LSD
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
0-15	22.8 b	46.5 a	17.8 b	21 b	57.9 a	25.4	
15-30	4.7 b	12 ab	6.3 ab	6.7 ab	12.7 a	7.8	
30-60	3.3 a	4.3 a	3.5 a	3 a	4 a	1.7	
60-90	4 a	6.7 a	4 a	4.3 a	4.5 a	3.5	
90-120	8.8 a	11.7 a	4.5 a	6 a	5.7 a	7.2	
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>			<b>LSD</b>	
0-15	23.3 b	72.8 a	28.3 b	25 b	16.5 b	9.6	
15-30	5.7 b	16.3 a	5.6 b	5.7 b	12.6 a	6.4	
30-60	4.3 a	4.3 a	3 a	3.7 a	3.3 a	1.7	
60-90	5.5 a	2.5 b	5.5 a	3.8 ab	3 ab	2.6	
90-120	8.3 a	11.7 a	7.2 a	10.8 a	7.3 a	4.9	
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	95.7 a	121.6 a	39.1				
15-30	17 b	51.5 a	32.3				
30-60	3.8 a	7.3 a	2.9				
60-90	4.5 a	7.2 a	2.9				
90-120	7.5 a	9.3 a	4.8				
Total/Ave.							

**Table 25:** Mehlich-3 P concentrations of the soil (0- 120 cm depth) for 2008 as a function of farming systems

Depth (cm)	Mehlich-3 phosphorus concentration, mg kg <sup>-1</sup>						LSD
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>		<b>LSD</b>
0-15	25.8 c	75.2 a	26.8 c	30.5 bc	48 b		18.9
15-30	6.8 b	17.3 a	8.2 b	6.2 b	15.3 a		5.7
30-60	5.7 a	4.8 a	4.3 a	4.3 a	4.2 a		1.9
60-90	6.3 a	3.2 c	6.2 a	5.5 ab	4 bc		2
90-120	8.7 a	16.7 a	9.7 a	10.5 a	11.7 a		13.4
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>				<b>LSD</b>
0-15	22.8 bc	44 a	13.1 c	22 bc	35.5 ab		8.1
15-30	5.2 a	12.8 a	10.8 a	6 a	6.7 a		9.1
30-60	3.4 a	4.5 a	4.3 a	3.2 a	4.3 a		2
60-90	6.5 a	7 a	4.8 a	5 a	4.3 a		3.2
90-120	10.2 a	14.8 a	6.5 a	8 a	8.3 a		8.7
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	91.3 a	109.5 a	26.5				
15-30	25.5 a	46.7 a	21.2				
30-60	5.7 a	8 a	2.2				
60-90	4.7 a	8.7 a	4.9				
90-120	8.3 a	4.2 a	8.9				
Total/Ave.							

**Table 26 :** Olsen-P concentrations of the soil (0- 120 cm depth) for 2007 as a function of farming systems

Depth (cm)	Olsen-P concentration, mg kg <sup>-1</sup>						LSD
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
0-15	12.1 ab	21.3 ab	10 b	13 ab	24.3 a	12.8	
15-30	3.2 a	6.2 a	4.3 a	4.2 a	6.7 a	3.9	
30-60	2.5 a	2.8 a	2.8 a	3 a	3.3 a	1.5	
60-90	3.8 bc	5.5 a	4.3 abc	4.8 ab	3.2 c	1.4	
90-120	6.7 a	8.3 a	5.8 a	6.5 a	5.7 a	4	
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>			<b>LSD</b>	
0-15	11.8 b	34.8 a	12.3 b	14 b	9.2 b	5.5	
15-30	4.1 b	9.2 a	3.7 b	3.3 b	7.2 a	2.5	
30-60	2.8 a	3.3 a	2.3 a	2.8 a	2.8 a	1.1	
60-90	3.8 a	3 a	4.2 a	3 a	4.2 a	2.3	
90-120	5.2 ab	3.4 b	6.7 a	7.5 a	5.5 ab	2.9	
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	42.7 b	57.1 a	9.8				
15-30	8.7 b	25.5 a	14.1				
30-60	2.8 b	4.2 a	1				
60-90	4.2 a	5 a	2.9				
90-120	4.7 a	7.7 a	3.6				
Total/Ave.							

**Table 27:** Olsen-P concentrations of the soil (0- 120 cm depth) for 2008 as a function of farming systems

Depth (cm)	Bray-P concentration, mg kg <sup>-1</sup>						LSD
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
0-15	12.3 c	36.3 a	12.1 c	15 bc	20.8 b	8.4	
15-30	3.2 b	9.3 a	4 b	2.8 b	7.3 a	2.5	
30-60	2.3 ab	2.8 a	1.5 b	1.5 b	2.2 ab	1	
60-90	3.7 a	2.3 a	3.8 a	2.8 a	3.2 a	1.7	
90-120	5.2 ab	2 b	7.3 a	6 a	4.7 ab	3.5	
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>			<b>LSD</b>	
0-15	11.5 bc	19.7 a	5.8 c	9.2 c	16.7 ab	7.4	
15-30	2.3 a	6.2 a	5.3 a	2.7 a	3.5 a	4.7	
30-60	1.8 b	3 a	2.3 ab	1.7 b	2.5 ab	1.1	
60-90	3.7 ab	6.2 a	3.5 ab	4.2 a	3 b	2.7	
90-120	6.7 ab	10.2 a	4.2 b	6.3 ab	4.5 b	4.8	
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	40.7 a	48.3 a	12.7				
15-30	12.5 a	21.3 a	12.9				
30-60	5.7 a	8 a	2.2				
60-90	3.2 a	5 a	2.4				
90-120	3.5 a	5.8 a	2.9				
Total/Ave.							

**Table 28:** Organic matter of the soil (0- 120 cm depth) for year 2007

Depth	Organic matter (%)						LSD
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>		<b>LSD</b>
<b>0-15</b>	3 ab	2.8 b	3.3 ab	3 ab	3.7 a		0.8
<b>15-30</b>	2.3 ab	2.5 ab	2.7 ab	2.1 b	3.1 a		0.8
<b>30-60</b>	0.9 a	1.1 a	1.2 a	0.9 a	1.3 a		0.5
<b>60-90</b>	0.5 a	0.5 a	0.6 a	0.5 a	0.5 a		0.2
<b>90-120</b>	0.4 a	0.5 a	0.4 a	0.6 a	0.5 a		0.4
<b>Total/Ave.</b>							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>				<b>LSD</b>
<b>0-15</b>	3.1 a	3.6 a	2.9 a	3.8 a	3.3 a		1.2
<b>15-30</b>	2.7 a	3.3 a	2.4 a	4 a	2.4 a		2.2
<b>30-60</b>	1.6 a	1.6 a	1 a	1.9 a	1 a		1.3
<b>60-90</b>	0.7 a	0.5 a	0.5 a	0.7 a	0.5 a		0.4
<b>90-120</b>	0.4 a	0.7 a	0.4 a	0.4 a	0.4 a		0.6
<b>Total/Ave.</b>							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
<b>0-15</b>	3.6 a	3.3 a	1.4				
<b>15-30</b>	3 a	2.5 a	1.8				
<b>30-60</b>	1 a	1.3 a	1				
<b>60-90</b>	0.5 a	0.5 a	0.2				
<b>90-120</b>	0.5 a	0.5 a	0.3				
<b>Total/Ave.</b>							

**Table 29:** Organic matter of the soil (0- 120 cm depth) for 2008

Depth (cm)	Organic matter (%)						LSD
	UAN Spring Inject 150 # N	Chisel Plow Fall Manure 150 # N	Fall Manure 150 # N	UAN Spring inject + Rye removal 150 # N	No-Till Fall Manure 150 # N		
<b>Corn Rotation</b>	<b>System 1</b>	<b>System 2</b>	<b>System 3</b>	<b>System 5</b>	<b>System 6</b>	<b>LSD</b>	
0-15	3.3 a	3.7 a	3.1 a	4.2 a	3.7 a		1.2
15-30	2.9 a	3.2 a	3.4 a	3.4 a	2.4 a		1
30-60	1.5 a	1.6 a	1 a	1.7 a	1 a		0.7
60-90	0.6 a	0.6 ab	0.5 ab	0.6 a	0.4 b		0.2
90-120	0.4 a	0.4 a	0.4 a	0.5 a	0.8 a		0.5
Total/Ave.							
<b>Soybean Rotation</b>			<b>Fall manure 100 # N</b>			<b>LSD</b>	
0-15	3.2 ab	3 ab	3.3 ab	2.8 b	3.9 a		1.1
15-30	2.3 a	2.5 a	3 a	2.3 a	2.9 a		0.9
30-60	1 a	1.1 a	1.3 a	0.9 a	1.2 a		0.5
60-90	0.5 a	0.5 a	0.6 a	0.5 a	0.6 a		0.2
90-120	0.4 a	0.4 a	0.4 a	0.5 a	0.5 a		0.2
Total/Ave.							
<b>Continuous Corn</b>	<b>System 4: Fall manure inject</b>		<b>LSD</b>				
	<b>(4.1) 200 # N</b>	<b>(4.2) 200 #N + Stover removal</b>					
0-15	3.9 a	3 a	1.6				
15-30	2.7 a	2.5 a	1.7				
30-60	1.4 a	1.1 a	1.3				
60-90	0.6 a	0.5 a	0.2				
90-120	0.5 a	0.6 a	0.5				
Total/Ave.							