Title: Adding Value to Swine Manure Through Accurate Prediction of Organic Nitrogen Availability – **NPB #06-140** revised

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Industry Summary: Swine slurry contains nitrogen primarily in organic and ammonium forms. Ammonium-N is immediately crop available following land application if not lost to volatilization which should be minimal if the slurry is injected. Crop availability of N from the organic fraction is less predictable. The effects of application time, soil water, and soil texture on release of organic N were studied by the University of Nebraska-Lincoln with the application of approximately 150 lb/acre of N. Soil water management was important as 85% more ammonium plus organic N from manure became plant available with irrigation than with rainfed conditions. Soil type was also important with 46% more N plant available N with a silt loam compared with a loamy sand soil. With fall and early spring applied manure, 67 lb/A of plant available N was available from swine slurry by early May, primarily as nitrate-N. By the end of July, >87 lb/A had become available for each application time. On average, approximately 114 lb/A or 76% of the manure N became plant available by the time a corn crop would be physiologically mature. Swine slurry N became available, therefore, as the season progressed, but on average, less than predicted became available. Time of application was important to organic N mineralization with 83% of the applied organic N mineralized with fall application while net mineralization of organic N was not detectable by the end of the crop growing season with May application. These rates of organic N release were greater than observed for feedlot manure. In Nebraska, estimates of 100% of the inorganic N and 35% of the organic N in swine slurry become available to the first crop if the slurry is injected. These estimates were confirmed for fall and early spring application if the crop is irrigated. However, the study found less to be available under rainfed condictions, especially for a loamy sand soil and that less is available with late spring application. The results were, however, quite variable across application times and sampling dates, reminding us that there is a margin of error in estimating plant available N from swine slurry. Less will become available than expected with some applications implying potential for under-supply of N to the crop while more will become available with other applications implying increased potential of nitrate-N loss to ground water or drainage water. High efficiency of use for N supplied in swine slurry can be achieved while ensuring adequate N for the crop and preventing excess nitrate-N leaching by planning to supply no more than 80% of the crop N need for slurry. Additional fertilizer N can be applied in-season by sidedressing or fertigation when the need for additional N is determined by use of the pre-sidedress nitrate test or based on leaf chlorophyll content. Nutrient management records will become valuable in understanding N availability from swine slurry for given fields and management conditions so that rates of swine slurry N rates can be gradually fine-tuned.

Scientific Abstract: Animal manure contains organic and inorganic nitrogen. The inorganic N, which is mostly ammonium-N but nitrate-N can be significant in composted manure, is typically considered to be 100% plant available if there are not significant losses, especially due to volatilization of ammonia-N. The availability of organic N, which is mostly from undigested and partially digested plant material needs to be mineralized to become plant available, is less predictable. Field research was conducted in eastern Nebraska to improve the basis for estimating organic N availability from injected or incorporated swine manure and from surface applied composted and stockpiled FM. The factors studied included manure type, time of application, soil texture, and soil water management. The three manure types were incorporated swine slurry and surface-applied composted or stockpiled feedlot manure. The three application times were in October, March and May. The soil textures were silt loam and loamy sand. Soil water management was irrigated or rainfed. Experimental units consisted of PVC tubes of 50 mm inside diameter fitted with soil-resin traps to retain inorganic N moving downwards with percolating water. Nitrogen release was monitored through out the season by replacing and sampling the traps at 6-week intervals. Manure application rates were determined to supply approximately 180 kg ha^{-1} of plant available N during the crop season. Time of application was important with more manure N available with the October compared with the March and May applications. Soil water management was important as 85% more N from manure became plant available with irrigation than with rainfed conditions. Soil texture was also important with 46% more N plant available N with a silt loam compared with a loamy sand soil. The mean amount of organic N mineralized, by application time ranged from 0 to 82% for swine slurry, 0 to 7% for composted feedlot manure, and 7 to 9% or stockpiled feedlot manure. By the end of July and mid-September, means of 104 and 125 kg ha^{-1} N, respectively, had become plant available with the swine slurry application. However, mean plant available N from the applied feedlot manures by the end of July and mid-September were only 55 and 65 kg ha^{-1} N, respectively. Mean N availability from swine manure was very near expectations for the irrigated treatment and greater than expected with the irrigated silt loam treatments. Plant available N from swine slurry under rainfed conditions, especially with the loamy sand soil, and from the feedlot manure treatments was less than expected. In addition, results were quite variable across application times and sampling dates with a significant margin of error in estimation of plant available N from manure, especially if the manure is high in organic compared with inorganic N as is the case with feedlot manures. High efficiency of use for manure N, while ensuring adequate crop N and preventing excess nitrate-N leaching, may require that estimated N available from applied manure N be no more than 75% of the crop N need. Additional fertilizer N can then be applied in-season by sidedressing or fertigation after assessing N need using the pre-sidedress nitrate test or based on leaf chlorophyll content.

Abbreviations: FM, feedlot manure; MDN_i, manure-derived inorganic N; $TMDN_i$, manure-derived inorganic N collected in soil traps.

Introduction: Manure land application is the most common and most efficient method to utilize what would otherwise be a waste product of livestock production. In order to utilize manure effectively the release of nutrients within the manure are estimated. This is necessary since manure contains undigested and partially digested plant material that needs to be mineralized before available to growing crops.

Many studies have quantified this process and several states, in addition to NRCS, and other organizations have suggested decay rates for the organic component of manure. Whitmore (2007) found about 40% of the organic N in composted chicken manure becomes available to crops during the first year and 6-12% during each subsequent year without much effect of soil texture. Abbasi et al. (2007) conducted an incubation study in the laboratory and found similar rates of mineralization of organic N for cattle, poultry and sheep manure and that only 10% of the organic N was in mineral form after 90 days. Morvan et al. (2006) compared 47 different animal wastes and found that net mineralization applied organic N ranged from -31 to 51% of the wastes after 270 days of incubation and 70% of the waste types; mineralization rates were related to organic N content and C:N ratio. Thomsen and Olesen (2000) found net mineralization of organic N to be 16% and negative with up to 30% of applied inorganic N immobilized for three types of composted and anaerobically stored animal manure, respectively, after 266 days of incubation. Sorensen and Jensen (1998) recovered 61% of faecal and feed N as organic N 18 months after application and found that N recovery is greater if slurry manure is injected rather than incorporated or surface applied. Cordillo and Cabrera (1997) estimated total mineralizable N in different poultry litters to range from 46.5 to 86.8% of applied organic N and that mineralizable N could be predicted from uric acid-N and total N concentrations (R2 = 0.91), or from uric acid-N concentration and C/N of the litter (R2 = 0.95). Hadas and Portnoy (1994) evaluated N mineralization for four composted feedlot manures (FMs) and found inorganic N released from the composts after 32 wk of incubation ranged from 11 to 29% of their total N content when 2 to 12% of total compost N were initially inorganic. Eghball (2000) estimated that 11% and 21% of organic N in composted and noncomposted manure, respectively were mineralized during the succeeding growing season. Due to changes in animal feeding changes over time and spatial variation in environmental conditions, organic N mineralization rates need to be determined periodically to refine recommendations.

Objectives: to improve the basis for estimating organic N availability from injected or incorporated swine manure and from surface applied composted and stockpiled FM.

Materials and Methods: The research was conducted in a field of the Agricultural Research and Development Center of the University of Nebraska (42.1^o N, 96.5^o E, 345-m elevation). The soil series was Pohocco silt loam derived from upland loess (fine-silty, mixed, mesic Typic Eutrochrepts; texture 280 g kg^{-1} sand, 580 g kg^{-1} silt, and 140 g kg^{-1} clay). The field was planted to corn in 2006 and to soybean in 2007 and irrigated from a well and a holding pond.

Forty eight treatments were evaluated in a 4 x 3 x 2 x 2 complete factorial with three replications. Four manure treatments included swine slurry, composted FM, stockpiled FM, and the control with no manure. The three application times were Oct 11, 2006; Mar 26, 2007 and May 9, 2007 (Table 1). The two soil texture classes were silt loam collected from the site and loamy sand composed of a blend of sand and the silt loam soil. Soil water was managed in two ways: 1) soil water was kept above 50% of field capacity; and 2) wetting and drying with tubes covered to keep rain and irrigation water out with water added periodically to maintain soil water above 30% of field capacity at the 7 to 12 cm depth. Irrigation from the holding pond was more than normal due to above-normal spring precipitation; a total of 130 mm of effluent and 126 kg ha^{-1} of total N were applied to the irrigated tubes (Table 1). The no-manure control treatments were used to estimate N mineralized from soil organic matter for each soil type, application time, and water regime, while accounting for the effluent N.

Mineralization of organic N in manure was monitored using a resin trap technique that captured soil nitrate-N and ammonium-N (Hanselman et al., 2004). This was a modification of a technique previously used in Nebraska by Eghball (2000) for FM and by Nygren (2005) for beef, dairy and poultry manure. The technique used a 'trap' made from an outside-fitting PVC coupler closed at the bottom with nylon mesh held in place with a ring clamp. The resin trap was filled by adding and lightly packing 20 g of soil followed by the addition of a mixture of 70 g of soil, 21 g of Resin USF A-464 (Cl) Anion and 7 g of Resin C-249 Cation Ionac (Siemens Water Technology, Broadview, IL). This filled the trap to above the upper edge of the inside coupler ring to ensure good contact with soil in the above tube. A disk of plastic 2-mm mesh was placed on top of the soil in the trap. The trap was attached to a 51 mm diameter PVC pipe of 330-mm length and the pipe was then filled with soil to within 125 mm of the top with light packing. The swine manure was added, and another 75 mm of soil was added with packing, leaving the top 50 mm empty for water application. For the stockpiled and composted FM, the tube was filled with soil to 50 mm from the top and the manure was applied to the surface. The amounts of swine slurry, composted FM and stockpiled FM applied per tube were 9.2 g, 36.6 g and 12.6 g, respectively. After manure and/or soil were added to the tubes, 80 ml of water was added to minimize ammonium-N loss. The manure containers were closed except when removing manure for application to minimize ammonium-N loss.

The manure for all three application times was collected at once, divided into three batches, frozen and stored until applied to prevent N transformation and loss during storage (Van Kessel et al., 1999). The composted and stockpiled FMs were spread out on a table in a greenhouse and aerated for one week to cause loss of ammonium-N to minimize ammonia-N during and following application; the remaining ammonium-N content was determined and 95% was assumed to contribute to mineral N. The manure application rate was intended to supply approximately 200 kg N ha^{-1} to the first crop assuming N availability factors of: 100, 95, and 95% of ammonium-N for swine slurry, composted FM, and stockpiled FM, respectively; 100% of nitrate-N; and of 35, 15, and 25% of the organic N for swine slurry, composted FM, and stockpiled FM, respectively (Table 2). Due to errors in the original calculation, the estimated available N applied was 166, 188, 182 kg ha^{-1} for swine slurry, composted FM, and stockpiled FM, respectively.

The filled tubes were placed in furrows after lining the bottom of the furrows with 2 cm of the mixture of the soils used to fill the tubes to ensure ready water movement from the tube to the soil below. The area around the tubes was filled with soil and firmed with light tamping. Tubes were placed in a completely randomized arrangement by application date.

Soil trap samples were collected by replacing the traps at 6-week intervals (Table 1). Soil plus resin in the traps was dried and ground. Ammonium-N and nitrate-N contents were determined after extraction by shaking 5 g of soil with 50 ml of 2M KCl for one hour and filtering. Soil in the tubes at the last sampling date, that is the non-trap soil, was similarly handled.

Soil water was continuously monitored using soil matric potential sensors (Watermark Granular Matrix, Irrometer Co., Riverside, CA) connected to a data logger with one sensor placed in each of two tubes per soil-water combination for each manure application time. Soil temperature was continuously monitored with sensors (Optic Stow-away Temp, Onset Computer Corp., Bourne, MA) placed in tubes with two tubes for each soil-water combination. All sensors were placed at a soil depth of 75 to 125 mm.

ANOVAs were conducted for effects on mineral N in soil traps across sample dates, and in non-trap soil at the end of the experiment, with mineral N expressed in kg ha^{-1}. The quantities of mineral N with the no manure treatment were subtracted from the quantities of the manure applied treatments for each soil texture and soil water regime combination to remove effects not due to application of the manure treatments.

An alternative calculation of organic manure N mineralized was done. Total soil N concentration was determined for the non-trap soil samples collected in September and total N amount per hectare was calculated. The difference between the manure-applied treatments and the no manure control treatments was determined for each soil texture and soil water regime combination to estimate remaining manure N in the soil. The difference of total manure N applied and manure N remaining and the percent of manure N remaining was calculated. The amount of $\mathbf{MDN_i}$ remaining in non-trap soil in September was subtracted from manure N remaining to estimate the amount of organic manure N remaining in the soil. The percent of organic manure N mineralized was calculated.

Results: The soil water differences for irrigated and rainfed conditions were less than expected. Soil matric potential for the irrigated and rainfed treatments was greater than 20 kPa, respectively, 19 and 23% of the time for the silt loam and just 2 and 7% of the time for the loamy sand. Soil matric potential for the irrigated and rainfed treatments was less than 5 kPa 24 and 12% of the time, respectively, indicating more percolation potential with the irrigated treatments. Mean soil temperature during the six weeks following the October application was 5.0 ^{o}C. For the six weeks ending with the May, June, July, and September sampling dates, the mean soil temperatures were 10.1, 19.2, 26.2, and 25.6 ^{o}C.

The mineral N in soil traps was 3 and 97% ammonium-N and nitrate-N, respectively. The total mineral N in soil traps varied from 74 to 192 kg ha^{-1} for the irrigated loamy sand and rainfed silt loam treatments, respectively. Mineral N in the non-trap soil was 19 and 81% ammonium-N and nitrate-N, respectively.

The total amount of $TMDN_i$ was greatest with swine slurry applied (Table 3 and 4). The mean amounts of $TMDN_i$ collected over the three applications were 125, 72 and 59 kg ha^{-1} for swine slurry, composted FM and stockpiled FM, respectively. More $TMDN_i$ was collected with the October compared with March and May applications.

Less $TMDN_i$ was collected with the November sampling date following fall application compared with other sampling dates, probably because low temperature following application prevented much mineralization and conversion of ammonium-N to nitrate-N (Table 4). There was little percolation during this period as well as soil matrx potential was always about 5 kPa. More $TMDN_i$ was collected with the May compared with other sampling dates, both for the fall and the early spring applications. Relatively little was captured with the June, July and September sample dates, except for a high rate of N capture from May-applied swine slurry during the

June to July 6-week period (Fig. 1).

The sampling date by manure type interaction significantly affected the amount of $TMDN_i$ but the interaction effects were not consistent across application dates (Table 3; Fig. 1). Much of the interaction effect with the October application was due to relatively little $TMDN_i$ collected prior to the May sampling date with stockpiled FM compared with the other manures. The interaction effect with March application was due to relatively more $TMDN_i$ with swine slurry compared with other manures in the May and June samples. The interaction effect with May application was due to relatively more $TMDN_i$ with swine slurry compared with other manures in the July and September samples.

Soil water management effects were significant with more $TMDN_i$ under rainfed compared with irrigated conditions with October application but the opposite effect occurred with March and May applications (Table 3 and 4). Overall, $TMDN_i$ was 85% more with irrigation than with rainfed conditions. The water treatment by sampling date interaction affected $TMDN_i$ for the October and May applications (Fig. 2). Relatively more $TMDN_i$ was collected with the July and September samples with October application under rainfed compared with irrigated conditions. With May application, $TMDN_i$ was relatively more in June and July with irrigation compared with rainfed conditions.

Overall, $TMDN_i$ was more with silt loam compared with loamy sand soil with October and March application but the opposite was true for May application (Table 3 and 4). The sampling day by soil texture interaction was significant for the March application due to more $TMDN_i$ with silt loam compared to loamy sand in June but similar amounts on other sample dates. The manure type by soil texture interaction was significant for $TMDN_i$ for the October and May applications (Table 3, Figure 2). Swine slurry $TMDN_i$ was not much affected by soil texture for all application times while $TMDN_i$ with composted and stockpiled FM was inconsistently affected. With October application, $TMDN_i$ was much increased when applied to the silt loam compared to loamy sand for composted FM but not for other manure types. With the March and May application, $TMDN_i$ was less affected by soil texture for swine slurry compared with composted and stockpiled FM. With March application, $TMDN_i$ with silt loam soil was much more compared with loamy sand for composted and stockpiled FM but the opposite was true with May application.

The interaction of soil texture and water management was significant for the October and March applications. $TMDN_i$ increased with irrigation relative to rainfed on silt loam but not on sandy loam (Table 3, Fig. 4). More mineral N was trapped with rainfed than with irrigation for the March and May applications.

Manure-derived inorganic N (MDN_i) in the non-trap soil was 36, 7 and 50 kg ha^{-1} for swine slurry, composted FM and stockpiled FM, respectively (Table 3 and 4). Interaction effects were not significant for MDN_i. The total MDN_i, including $TMDN_i$ and that in the non-trap soil, was 161, 79, and 109 kg ha^{-1} for swine slurry, composted FM and stockpiled FM, respectively. Approximately 35, 2 and 8% of the manure organic N was mineralized for swine slurry, composted FM and stockpiled FM, respectively. More manure organic N was mineralized October application of swine slurry than with the later applications. Mineralization of organic N was not related to the C:N ratio.

Assuming all MDN_i was trapped or remained in the non-trap soil, the percentage of organic N available as mineralized N was 0 to 82%, 0 to 7%, and 7 to 9% for swine slurry, composted FM and stockpiled FM, respectively (Table 4).

The alternative method of estimating manure N mineralized, based on total soil N balance, gave means of 18, 16, and 21% of the organic N from manure mineralized for swine slurry, composted FM and stockpiled FM, respectively. The opportunity for error with this method is great, especially when the amount of organic N applied is small relative to the total soil N as is the case for swine slurry. This is indicated by estimates of total manure N remaining exceeding manure N applied. The estimate for swine slurry should therefore be considered unreliable whereas the estimates for the FMs have more validity, especially for the composted FM. As with original method of estimation of manure N mineralization, there is inconsistency across application dates. With the alternative method, estimated manure N mineralization was greatest with the latest application date while the greatest mineralization was found with the first application date using the original method.

Discussion: The mean amount of organic N in slurry manure was near expectations but the results varied widely across application times with more N mineralization with the October application than with the spring applications. Much less organic N in composted and stockpiled FM was mineralized than expected with more mineralization with the October application compared with spring application for composted FM. Organic N mineralization with stockpiled FM was similar for all application dates. Recovery of manure N was greater with irrigation that rainfed conditions for the FM manures and recovery was greater for all manures with silt loam compared with loamy sand soil. The results were, however, very inconsistent over manure types, application dates and sample dates.

The lower than expected rates of organic N mineralization may have been due to loss of N. However, more recovery with irrigated compared with rainfed conditions suggest that significant losses did not occur due to leaching or denitrification as these losses would have been greater with the irrigated than with the rainfed treatments. Less $TMDN_i$ with loamy sand than with silt loam, however, suggests that some nitrate-N may have leached during the soil traps. If so, estimates with the silt loam would be more reliable than with the loamy sand soil and would increase the mean amount of organic N mineralized to 51, 8 and 11% for swine slurry, composted FM and stockpiled FM, respectively.

With the experimental procedure used, microbial activity may be higher than typical. Plants would normally take up much of N once it is mineralized but plant roots were excluded from the tubes leaving the inorganic N available for uptake by microbes. Microbial activity is expected to be greater with increased inorganic N concentration. While this increased activity is expected to result in more mineralization of organic N from manure, it also results in re-immobilization due to N tie-up in microbial biomass. This would leave less inorganic N to be retained in the traps or to remain in non-trap soil.

Conclusion: Mineralization of organic N in swine slurry varied with the management conditions and application time and was greater with irrigated (35%) than rainfed conditions, with silt loam (50%) than with loamy sand, and with October (82%) compared with spring application. Mineralization of organic N in the feedlot manures compared with swine slurry was much less and was less affected by time of application and water management. The estimates of 100% of the inorganic N and 35% of the organic N in swine slurry that is immediately incorporated were found to be accurate, on average, for irrigated conditions but over-estimated N release under rainfed conditions, especially for loamy sand soil but much less so for silt loam soil. Results for swine slurry were, however, quite variable across application times and sampling dates, implying low predictability of organic N availability. High efficiency of use for N supplied in swine slurry can be achieved while ensuring adequate N for the crop and preventing excess nitrate-N leaching. Slurry should be applied to supply no more than 80% of the crop N need. Additional fertilizer N can be applied in-season by sidedressing or fertigation when the need for additional N is determined such as by use of the pre-sidedress nitrate test or based on leaf chlorophyll content. These points hold true for the feedlot manures as well but given the slow release of organic N and the large amounts applied, the in-season monitoring to determine the need for sidedress or fertigation application of N needs to continue for several years after heavy application of composted or stockpiled FM.

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Table 1. Time of operations for a study of manure nitrogen mineralization.

Date	**Operation**	**Application Time and Sampling Number** **Oct**	**Mar**	**May**
Oct. 11 2006	Installation of 64 tubes with manure treatments applied and of tubes with temperature and Watermark sensors			
Nov 28 2006	64 tubes removed and stored in an unheated building during the winter	1		
Mar 26 2007	Reinstallation of the 64 Oct tubes with new traps; installation of an additional 64 tubes with manure treatments applied			
Mar 27 to Apr 30 2007	Holding pond effluent (73 mm) applied to irrigated tubes containing 45 and 50 kg ha^{-1} of organic N and ammonium-N, respectively.			
May 7 2007	Trap replacement and reinstallation of the Oct and Mar tubes; installation of an additional 64 tubes	2	1	
May 16 2007	Holding pond effluent (57 mm) applied containing 14 and 17 kg ha^{-1} of organic N and ammonium-N, respectively.			
June 18 2007	Trap replacement and reinstallation of all 192 tubes	3	2	1
July 30 2007	Trap replacement and reinstallation of all 192 tubes	4	3	2
Sep 10 2007	Final removal of all 192 tubes	5	4	3

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Table 2. Nitrogen content, N applied and C:N ratio of manure on a fresh weight basis.

Manure type	**Manure N conc.**			**Application rate**					
	NO_3^-–N	NH_4^+–N	Org. N	Manure, as applied	Total N	Available N[1]	Inorg. N	Org. N	**C:N**
	mg kg^{-1}			Mg ha^{-1}	kg ha^{-1}				
Swine slurry	0	2868	1981	45.2	219	161	130	89	20.0
Feedlot compost	404	33	4053	180.5	807	188	79	728	14.7
Feedlot stockpile	274	857	7359	62.3	529	182	70	458	12.4

[1] Available N to the first crop was estimated assuming N availability factors of 100, 95, and 95% of inorganic N for swine manure, compost and feedlot manure, respectively, and of 35, 15, and 25% of the organic N for swine slurry, composted feedlot manure, and stockpiled feedlot manure, respectively.

Table 3. ANOVA for mineral N from swine slurry, beef feedlot stockpiled manure, and beef feedlot composted manure collected in a cation/anion resin mix and in the non-trap soil at the last sampling date.

		Manure application dates			Non-trap soil[1]
		October	March	May	
	df	kg ha^{-1}			
Sample date (D)†	2-4	***	***	***	NA
Manure type (M)	2	***	*	***	*
Water (W)	1	NS	***	***	NS
Soil (S)	1	**	***	*	NS
D*M	4-8	**	*	**	NA
D*W	2-4	*	NS	*	NA
D*S	2-4	NS	***	NS	NA
M*W	2	NS	NS	NS	NS
M*S	2	*	NS	*	NS
W*S	1	***	*	NS	NS
D*M*W	4-8	**	NS	**	NA
D*M*S	4-8	NS	NS	NS	NA
D*W*S	2-4	***	NS	*	NA
M*W*S	2	NS	*	NS	NS
D*M*W*S	4-8	NS	NS	NS	NA
CV		36.96	31.6	27.1	72.0

†Degrees of freedom differ for sampling days since there were 5, 4 and 3 samplings for the October, March and May manure application times, respectively.
[1] Date of application and its interactions with manure type did not affect non-trap soil N content.

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Table 4. The main effects of factors on inorganic N from manure collected in soil traps following manure application and inorganic N in the non-trap soil with the September sampling dat.

Inorganic N from manure collected in soil traps			
	Application times		
	October	March	May
	kg ha^{-1}		
Manure type			
Swine slurry	144.6	100.8	129.0
Composted feedlot manure	133.5	30.1	51.7
Stockpiled feedlot manure	50.0	61.1	65.8
	***	*	***
Mean	109.4	64.0	82.1
Sample date			
November	3.1		
May	42.5	60.5	
June	12.3	3.6	15.2
July	19.7	3.0	53.0
September	31.8	0.0	13.8
	***	***	***
Soil water			
Rainfed	118.8	6.8	53.9
Irrigated	99.9	121.2	110.4
	NS	***	***
Soil texture			
Silt loam	138.3	100.4	64.8
Loamy sand	80.4	27.6	99.5
	**	***	*
Inorganic N from manure remaining in non-trap soil			
Manure type			
Swine slurry	58.3	50.2	0.0
Composted feedlot manure	0.0	8.3	13.1
Stockpiled feedlot manure	63.4	48.9	36.7
	NS	NS	***
Total inorganic N from manure			
Manure type			
Swine slurry	202.9	151.0	129.0
Composted feedlot manure	133.5	38.4	64.8
Stockpiled feedlot manure	113.4	110.0	102.5
Inorganic N from manure organic N (% manure organic N mineralized)			
Manure type			
Swine slurry	73 (82%)	21 (23%)	0 (0%)
Composted feedlot manure	54 (7%)	0 (0%)	0 (0%)
Stockpiled feedlot manure	43 (9%)	40 (9%)	32 (7%)

Total manure inorganic N applied was 130, 79 and 70 kg ha^{-1} for swine slurry, composted feedlot manure and stockpiled feedlot manure, respectively. Total manure organic N applied was 89, 728 and 458 kg ha^{-1} for swine slurry, composted feedlot manure and stockpiled feedlot manure, respectively.

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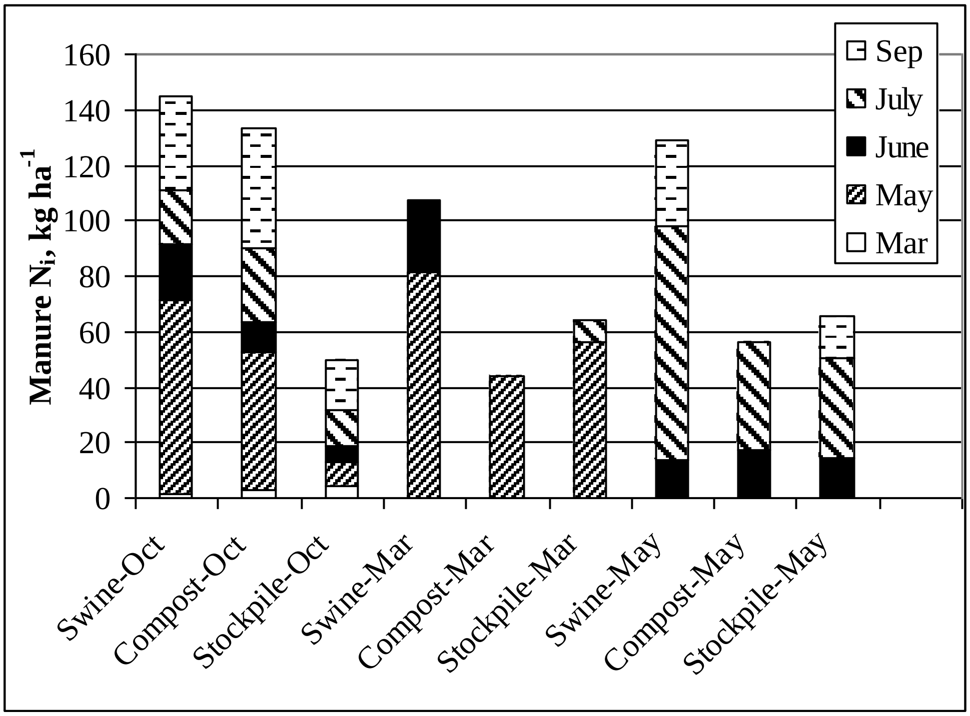
Table 5. Estimates of organic manure N (N_o) mineralized by the alternative method based on total soil N and manure-derived inorganic N (MDN_i) remaining in the non-trap soil (NTS); total manure N = TMN.

Manure type	TMN remaining in NTS	TMN lost from NTS (applied – remaining)	MDN_i in NTS	N_o lost from NTS
October application				
Swine slurry	387	<0 (0%)	58a	<0 (0%)
Composted feedlot manure	551	256 (32%)	0b	177 (24%)
Stockpiled feedlot manure	656	<0 (0%)	63a	<0 (0%)
March application				
Swine slurry	234b	<0 (0%)	50a	<0 (0%)
Composted feedlot manure	710a	97 (12%)	8b	26 (4%)
Stockpiled feedlot manure	333b	196 (37%)	49a	174 (38%)
May application				
Swine slurry	40b	179 (82%)	0b	49 (55%)
Composted feedlot manure	589a	196 (27%)	13ab	152 (21%)
Stockpiled feedlot manure	378a	151 (29%)	37a	117 (26%)

Total manure N applied was 219, 807, and 529 kg ha^{-1} for swine slurry, composted feedlot manure and stockpiled feedlot manure, respectively. Total manure organic N applied was 89, 728 and 458 kg ha^{-1} for swine slurry, composted feedlot manure and stockpiled feedlot manure, respectively. Total manure inorganic N applied was 130, 79 and 70 kg ha^{-1} for swine slurry, composted feedlot manure and stockpiled feedlot manure, respectively.

Figure 1. Inorganic N (N_i) from manure captured in soil traps over five sampling dates for three manure types applied in October, March or May. The manure types were swine slurry, composted feedlot manure and stockpiled feedlot manure.



The LSD 0.05 values for the manure type x sampling date interactions are 19.5, 23.5, 20.0 kg ha^{-1} for October, March and May application, respectively.

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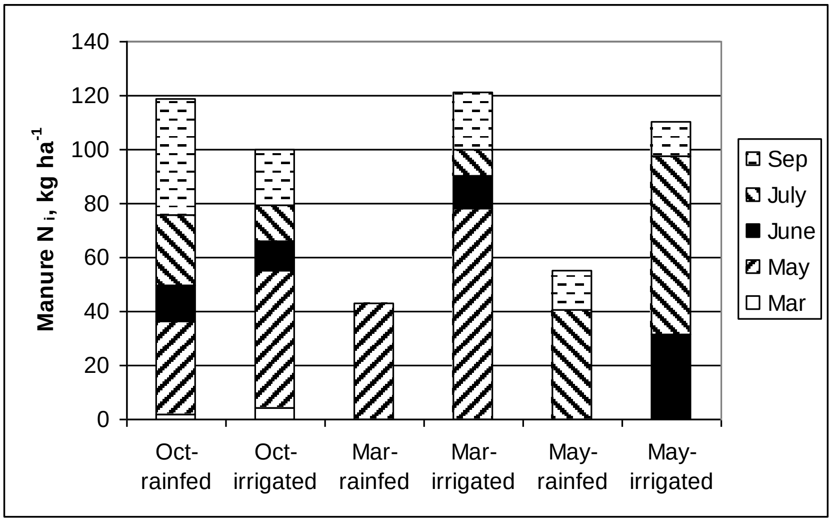
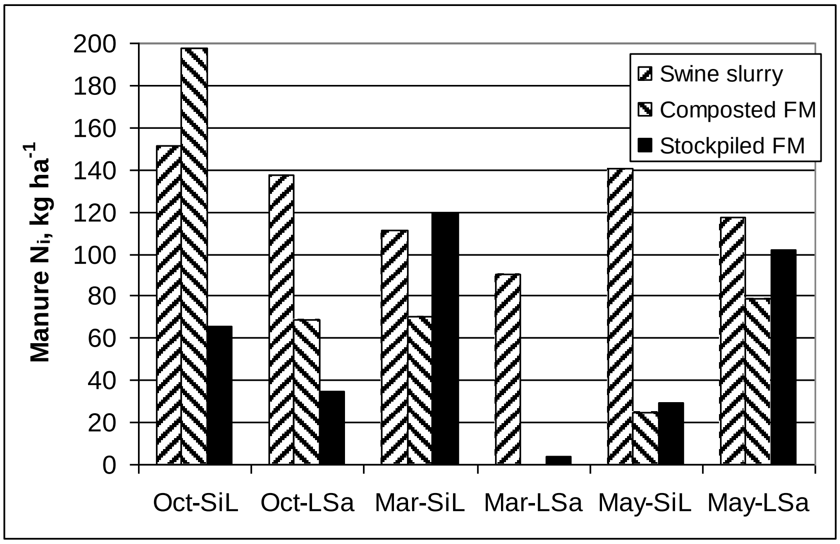
Figure 2. The effect of water management on the amount of manure-derived inorganic N retained in soil traps varied by sampling date for October and May application of manure.



The LSD 0.05 values for the effect of water management by sampling date interactions are 13.0, NS and 17.8 kg ha^{-1} for October, March and May application, respectively.

Figure 3. The effect of manure type on the amount of manure-derived inorganic N retained in soil traps varied by soil texture for all three manure application times.



The LSD 0.05 values for the manure type x soil texture interactions are 13.0, 17.8, and 17.8 kg ha^{-1} for October, March and May application, respectively.

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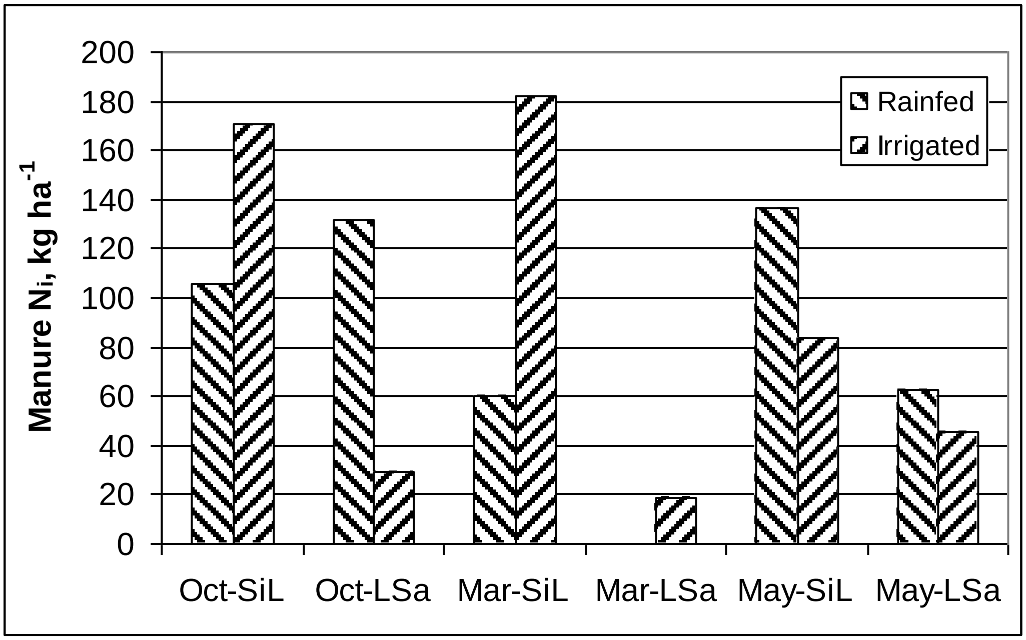
Figure 4. The effect of water management on the amount of manure-derived inorganic N retained in soil traps varied by soil texture for October and April application of manure.



The LSD 0.05 values for the water management x soil texture interactions are 10.6, 14.6, and NS kg ha^{-1} for October, March and May application, respectively.