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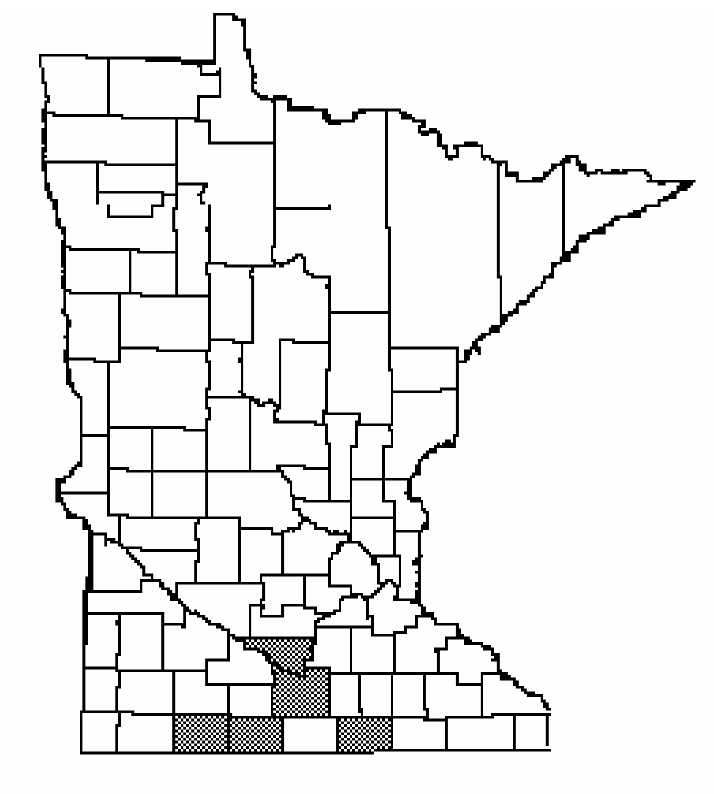
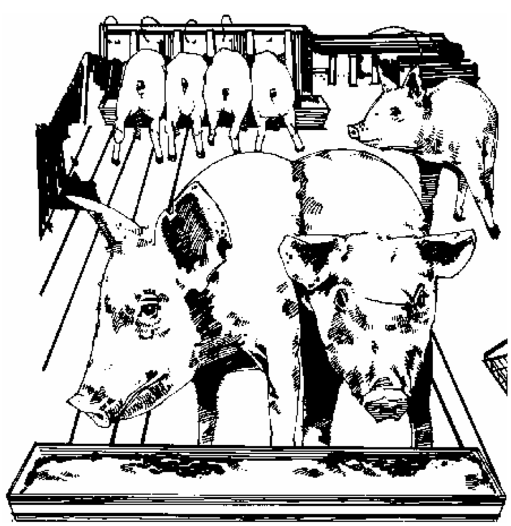
Pork Producers Survey: 1994





- 51 Farms covering 45,000 Acres in South Central Minnesota
- Surveys were conducted in 1994 with cooperation from the Minnesota Pork Producers association.

MDA Nutrient Management Assessment Program
Denton Bruening 612-297-4400

General Information: Pork Producers in South Central Minnesota

The following detailed summary reports the findings under B2 of the project M.L.93, chpt. 172, sect. 14, sub d. 3 (i).

County Educators (MN Extension Service) from Jackson, Blue Earth, Freeborn, Martin, and Nicollet counties were contacted and individually interviewed in March,1994. The purpose of the interviews was: to inform them of the specifics of the project and overall goals; obtain pertinent county information (i.e. demographics of hog producers); and identify potential candidates (farmers) and their agronomic management skills as perceived by the County Educator. County Educators also served as an important link between the farmers and the researchers; Educators commonly made personal telephone calls to the potential participants after the introduction letter (Appendix B-2) was mailed. Fifteen to twenty contacts, classified as either "Low", "Average" , or "High" management skills, were identified in each of the five counties. Introduction letters (Appendix B-2), signed by the Commissioner of Agriculture, were mailed out to the farmers in April, 1994. The letter's intent was to identify: the overall LCMR project; the purpose of the nutrient assessment; why they were selected to participate; and what types of information and amount of their time would be necessary to successfully complete the project. A total of 70 letters were sent and 51 (73%) producers went through the interview process.

Nutrient Management Data Collection: Pork Producers in South Central Minnesota

Inventory forms and database design were patterned after a previous successful project[1] . A copy of the inventory form is included in Appendix B-2. Timing, rates and method of applications were collected for all nitrogen (N) and phosphate (P_2O_5) inputs (fertilizers, manures, and legumes) on **a field-by-field basis for all acres owned or rented**. There were 814 management areas in the entire study. A management area is defined as a field or group of fields (managed by the same producer) that had the same nutrient inputs. If an individual field was not managed uniformly, it was broken down into separate management areas. Soil and manure testing results were also collected if available. Nutrient inputs and yields were specific for the 1994 cropping season. Crop types and manure applications (starting in the fall of 1993) were also collected from the 1993 season for the purpose of 1994 nitrogen crediting. Long term yield data generally reflected the past 3 to 5 years. Livestock census and other specifics for the entire farm (i.e. types of manure storage systems, total farm sizes) were also recorded.

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[1] Effective Nitrogen and Water Management for Water Quality Sensitive Regions of Minnesota, LCMR 1991-93.

Farm Size and Crop Characteristics of the Selected Farms: Pork Producers in South Central Minnesota

Fifty-one (51) farmers were interviewed during May and June, 1994. Total acres inventoried were 44,980. Acres owned by farmers were 19,719 and acres rented by farmers were 25,421. Also there were 160 acres rented out to other farmers not inventoried. Total inventoried acres by county (and number of farms per county) are as follows: Blue Earth 10,579 (10);Freeborn 6,137 (10); Jackson 12,134 (10); Martin 8,640 (10); Nicollet 7,490 (11). Total area covered by the interviews was 44,980 acres; 42,738 acres were identified as tillable (Table 1). The average farm size was 886 acres with 842 acres in cropland. All 51 farmers had some type of pork operation and 10 farmers also raised either some dairy or beef animals.

Table 1. General description of all farms participating in the 1994 South Central Pork Producers nutrient management survey.

		Total Acreage Inventoried			**Average Acreage by Farm**		
County	Farms	Total	Crop	Noncrop(1)	Total	Crop	Noncrop
		.... Number of Acres............					
Blue Earth	10	10,579	9,947	632	1,058	995	63
Freeborn	10	6,137	5,946	191	610	595	19
Jackson	10	12,134	11,579	555	1,214	1,158	56
Martin	10	8,640	8,172	468	864	817	47
Nicollet	11	7,490	7,094	396	681	645	36
Mean	**10**	**8,996**	**8,548**	**448**	**886**	**842**	**44**
Total	**51**	**44,980**	**42,738**	**2,242**			
Percent Total		**100%**	**95%**	**5%**			

(1) Noncrop includes pasture, CRP, building sites and other non-tillable acres

Corn (53%) and soybeans (42%) accounted for 95% of the cropland acres (Figure 1). Remaining acres were highly mixed. In comparison, the cropland distribution across all farms in the five county area[2] was dominated by corn (47%) and soybeans (45%) (Figure 2). County specific data is given in Table 2.

[2]MN Agricultural Statistics 1994. National Agricultural Statistics Service, St. Paul, MN.

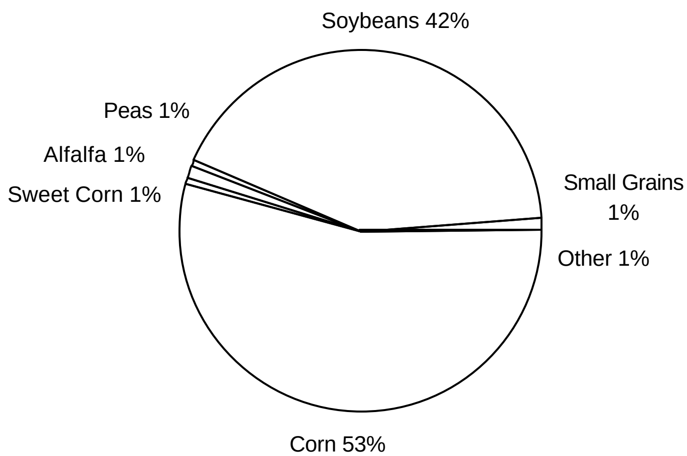

Figure 1. Crop type distribution across all cropland acres of the selected farms.

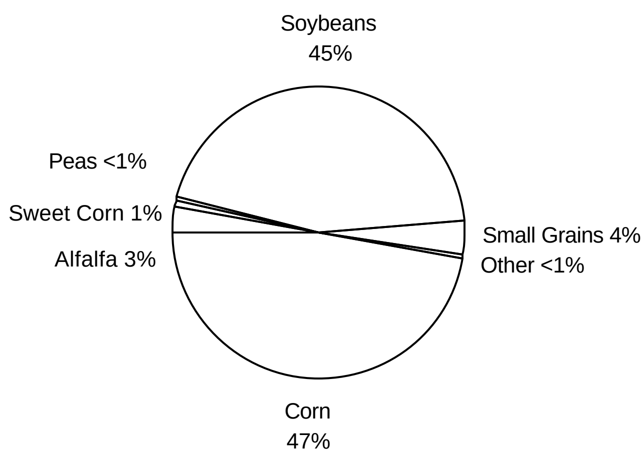

Figure 2: Crop type distribution across **all** cropland acres in Blue Earth, Freeborn, Jackson, Martin, and Nicollet Counties. Acreage based on 1993 statistics (MN Agricultural Statistics, 1994).

Table 2. Average distribution of cropland acres per farm by county - 1994.								
County	**Corn**	**Soybeans**	**Sweet Corn**	**Alfalfa**	**Small Grains**	**Peas**	**Other**	**Total**
	Acres							
Blue Earth	5,115	4,401	307	0	0	124	0	9,947
Freeborn	3,503	2,279	0	120	34	0	10	5,946
Jackson	6,228	5,192	0	48	111	0	0	11,579
Martin	4,718	3,399	0	8	47	0	0	8,172
Nicollet	3,529	2,987	201	66	181	105	25	7,094
Mean	**4,619**	**3,651**	102	48	75	**46**	**7**	**8,548**
Total	**23,093**	**18,258**	**508**	**242**	**373**	**229**	**35**	**42,738**
Percent Of Total	**53.9**	**42.3**	**1.2**	**0.6**	**0.8**	**0.5**	**0.7**	**100.0**

Commercial Fertilizer Use Characteristics on Selected Farms: Pork Producers in South Central Minnesota

Corn accounted for 97% of the total N commercial fertilizer use (Figure 3). Ninety-eight percent (98%) of the total corn acreage received commercial N fertilizer (Table 3). Average fertilizer N rate on corn acres was 143 lb/A[3]; this rate is calculated as the means across all commercially fertilized corn acres regardless of past manure or legume N credits. Total N inputs will be discussed later in the "Nitrogen Balances and Economic Considerations" section. Approximately 8% of the soybean acreage received N fertilizer. The average N rate on fertilized soybeans was 28 lb/A (Table 3 and Figure 4). Phosphate rates ranged between 15 to 70 lb/A across the major crops (Table 3).

3 Average commercial fertilizer rate across all corn acres, fertilized and non-fertilized, was 141 lb/A.

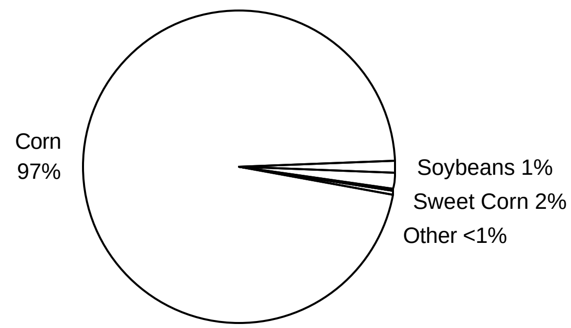

Figure 3. Distribution of commercial nitrogen fertilizer by crop type. Total nitrogen supplied by fertilizer was 3,369,000 pounds across all 51 farms for an average of 66,000 pounds per farm.

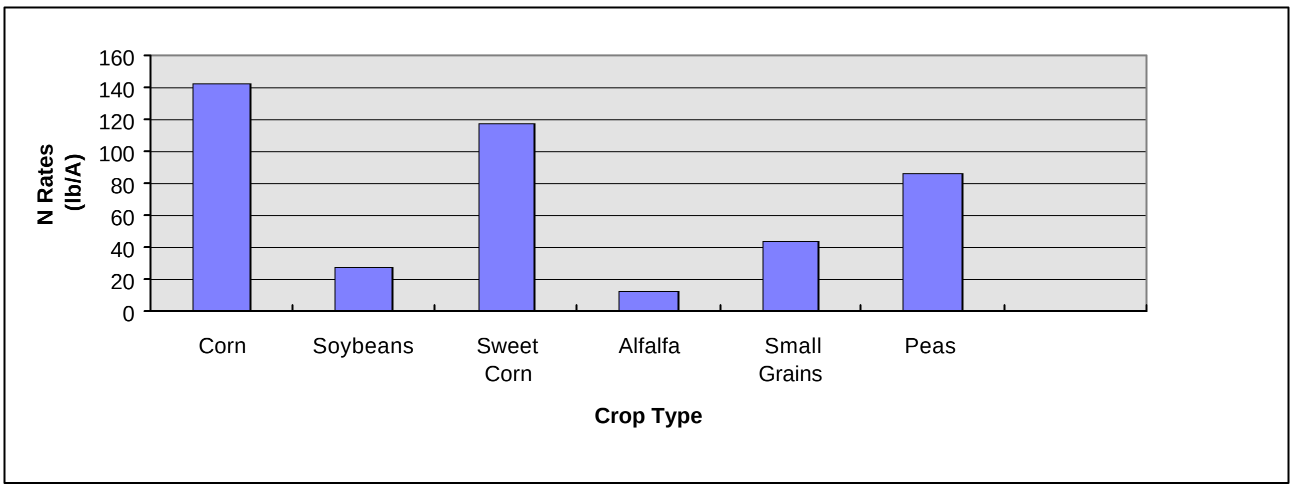

Figure 4. Average N fertilizer rates across fertilized acres by crop type.

Table 3. Distribution of commercial nitrogen and phosphate applications on cropland - 1994.

Crop	Acres Receiving N Fertilizer	Total N Applied (LBS X 1000)	Acres Receiving Phosphate Fertilizer	Total Applied P_2O_5 (LBS X 1000)
Corn	22,677	3,256	16,052	736
Soybeans	1,387	38	856	46
Sweet Corn	508	60	408	14
Alfalfa	55	1	55	1
Small Grains	159	7	94	4
Peas	74	6	74	1
TOTALS	**24,860**	**3,369**	**17,539**	**803**

Timing of N fertilizer applications is an important consideration in maximizing fertilizer use efficiency and minimizing environmental effects. Spring preplant applications of nitrogen in the form of anhydrous ammonia or urea are recommended for South-Central Minnesota[4]. Approximately 27% of commercial nitrogen fertilizer was applied as a spring preplant in the form of anhydrous ammonia or urea. This number is conservative due to the fact some urea was included in the dry mixes applied. Overall, 46% of the fertilizer N was applied as a spring preplant (Table 4).

Fall application of nitrogen in Southwestern and Central Minnesota is recommended if the proper source (anhydrous ammonia) is selected and proper soil temperature is reached. Research indicates anhydrous ammonia is the most efficient source of nitrogen when used for fall fertilization in South-Central and Southwest Minnesota[5]. Producers applied 41% of the total nitrogen for corn during fall applications of 1993 for the 1994 growing season (Figure 5). In this survey 92% of fall applied nitrogen for corn was in the form of anhydrous ammonia and 11% of the anhydrous ammonia was applied with a nitrification inhibitor. The average fall application date of anhydrous ammonia without a nitrification inhibitor was November 1. In contrast, the average application date of anhydrous ammonia with a nitrification inhibitor was October 18. Fall applied anhydrous ammonia accounted for 37% of the total commercial N applications.

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[4] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in South-Central MN. AG-FO-6127-B.

[5] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in South-Central MN. AG-FO-6127-B.

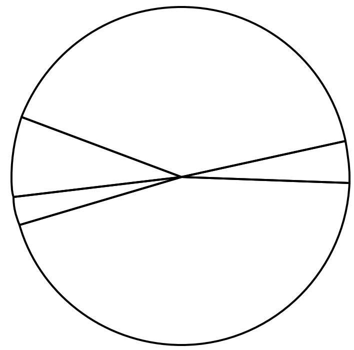

Figure 5. Timing of N fertilizer applications on corn acres. Overall total N applied was 143 lb/A.

Table 4. Timing of fertilizer applications for nitrogen on fertilized corn acres.

Growth Stage	Average Date of N Application	Total Acres Applied (LBS X 1000)	Total N Applied (LBS X 1000)
Fall	10/26/93	13,407	1,307.7
Spring Preplant	4/22/94	14,802	1,490.0
Starter	5/1/94	9,791	100.8
Early Sidedress	6/4/94	986	98.9
Late Sidedress	6/9/94	2,210	258.5
TOTALS			**3,256**

Fall applications of anhydrous ammonia should be delayed until the soil temperature is below 50 F at the 6-inch depth. Long-term climatic data from the Waseca Experiment Station and the Lamberton Experiment Station indicate that soil temperatures will generally remain below 50 F after October 29 and October 30 respectively. Sixty-eight percent (159/233) of producers applied nitrogen before October 29. Delaying fall application of anhydrous ammonia fertilizer until after October 30 could reduce leaching of nitrogen.

The use of nitrification inhibitors can be helpful in controlling either leaching losses (coarse-textured soils) or denitrification during periods of near-saturated conditions on the fine-textured soils. In fine textured soils, inhibitor use is recommended only if soils are poorly drained or the water holding capacity of the soils have been reached[6]. Conditions for the use of a nitrogen inhibitor were optimal due to the unusually wet fall of 1993 and spring of 1994. Six producers used an inhibitor with anhydrous ammonia on 3,800 acres of corn. Only 900 acres of corn were fall applied with an inhibitor while 1,600 acres were spring preplant and the other 1,300 acres were side-dressed with an inhibitor.

Only 2,200 acres(11%) of the 19,600 acres planted with crops other than corn were applied with N fertilizer. Sweet corn accounted for 55% and soybeans accounted for another 30% of "non-corn" commercial N . Due to the very wet spring in 1994, some soybean acres were fertilized with the plan of being planted to corn until the lateness of planting prompted farmers to plant soybeans instead.

Anhydrous ammonia supplied 71% of the total amount of commercial N applied to corn (Figure 6). Forty-nine percent (49%) of anhydrous ammonia was fall-applied and 36% was applied as a preplant application on all acres (Figure 7). The balance (15%) was applied as a sidedress during the growing season.

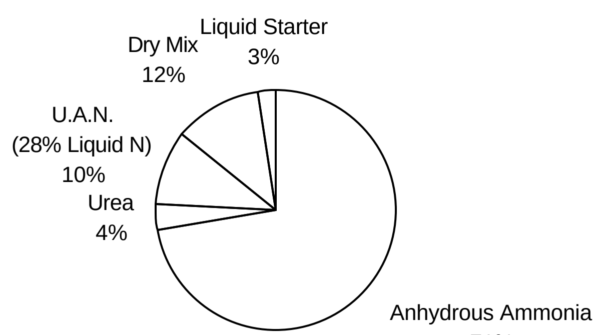

Figure 6. Contributions of N from various fertilizer sources on selected farms for corn.

[6] M.A. Schmitt and G.W. Randall 1993. Best Management Practices for Nitrogen Use in South-Central MN. AG-FO-6127-B.

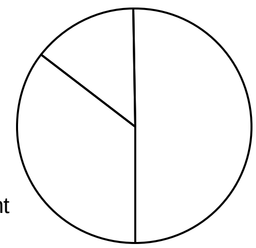

Figure 7. Timing of anhydrous ammonia N fertilizer applications on all corn acres. The overall mean N rate for anhydrous ammonia was 130 lb/A.

Livestock and Manure Characteristics of the Selected Farms: Pork Producers in South Central Minnesota

Factors directly affecting crop nutrient availability from land applied manure (including manure storage, types, manure amounts being generated, application methods, incorporation factors and rates) were also quantified to complete the "whole farm" nutrient balance. All farms had some type of hog operation and some producers had additional livestock as indicated by Table 5. This table includes a complete animal inventory, including estimates of N, P_2O_5 and K_2O produced[7] and collected in various types of manure systems for spreading on acres in the survey (manure collected but spread on acres not in the survey are not considered in the collected amounts). Manure not collected from the cattle is usually due to time spent on pastures and large lots where manure is not collected. The amount of manure collected from hogs is less than that produced due to producers with hogs raised off-site and the manure is not available for spreading on acres in the survey.

Dairy population counts represent the average number of animals on hand per year. Boars and sows are also recorded as the average number of animals on hand per year. Hog feeders and finishers are the number of animals sold per year. Beef calves raised to one year and beef calves purchased for raising are also the number of animals sold per year. All other beef numbers are recorded as the average number of animals on hand per year. Animals were recorded as animal numbers sold per year when the time on the farm was often less than one year.

[7] Livestock Waste Facilities Handbook, Midwest Plan Services, Iowa State University, Ames, Iowa. 1993.

Table 5. 1993 livestock numbers, and manure N, P_2O_5 and K_20 produced and collected by livestock types in sample population.							
Livestock Type	**Livestock Number**	**Manure Nitrogen Produced**	**Manure Nitrogen Collected**	**Manure P_2O_5 Produced**	**Manure P_2O_5 Collected**	**Manure K_2o Produced**	**Manure K_2o Collected**
		Pounds X 1000		**Pounds X 1000**		**Pounds X 1000**	
Boars	403	13.3	12.5	9.3	8.7	9.3	8.7
Sows	8,572	222.9	212.0	154.3	146.8	154.3	146.8
Farrow to Feeders	28,360	27.2	24.2	16.4	14.6	16.3	14.6
Feeder to Finishers	30,950	260.0	249.9	185.7	178.5	200.6	192.8
Farrow to Finishers	126,110	1,180.4	935.5	829.3	657.9	889.8	706.1
Dairy Cows	50	10.1	9.2	4.1	3.7	8.1	7.5
Calves	25	1.7	1.5	.8	.7	1.2	1.1
Replacement Heifers	25	3.1	2.8	1.2	1.1	2.7	2.4
Dairy Steers	25	3.9	3.6	1.6	1.4	3.1	2.9
Bulls	10	1.6	.7	1.1	.5	1.4	.6
Beef Cows	238	31.2	13.2	23.8	10.1	27.1	11.5
Beef Feeders (raised to 500 lbs)	204	11.4	6.6	8.7	5.0	10.1	5.9
Beef Feeders (purchased)	472	60.1	48.2	44.0	35.3	53.3	42.8
Beef Feeders Birth to Market	20	1.7	.9	1.2	.6	1.6	.8
TOTAL	**195,464**	**1,828**	**1,521**	**1,279**	**1,065**	**1,379**	**1,144**

Estimated amounts of N, P_2O_5 and K_20 **per farm** produced from all livestock averaged 35,850, 25,122 and 27,037 pounds, respectively . Hogs generated approximately 93% of the associated N (Figure 8) and P_2O_5 (Figure 9) produced through manure .

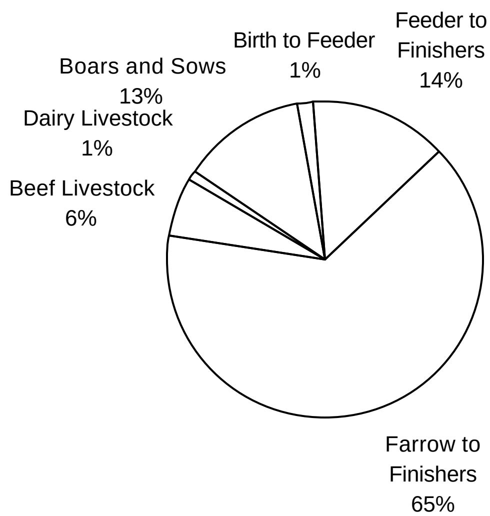

Figure 8. Amounts of nitrogen (total) generated by animal types across all selected farms. Total N produced was 35,850 pounds/farm.

Types of storage systems available for producers is an important consideration in efficiently retaining nutrients and allowing enough storage to field apply the manure in an environmentally safe manner. Types of manure collection systems of the 51 farms can be best categorized as 142 liquid systems and 58 solid systems.

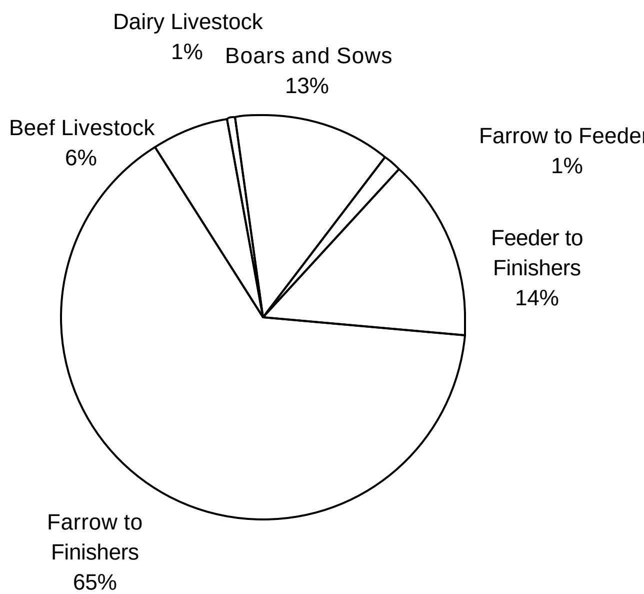

Figure 9. Amounts of P_2O_5 generated by animal types across all selected farms. Total P_2O_5 produced was 25,122 pounds/farm.

For purposes of this report, the following storage system definitions were used: *Daily Scrape and Haul*-No storage available, manure is hauled generally on a daily basis. Common in dairy operations with stanchion or tie-stall barn designs; *Paved and Unpaved Pads*-Areas where solid manure is stacked on either the ground or cement pads to allow storage through the winter months until fields are accessible for spreading; *Paved and Unpaved Lots*-Cement or gravel covered areas that confine cattle. Manure (solid) is often hauled once or twice a year although some are cleaned monthly: *Animal Barns*- Buildings used to house livestock. The floors can either be cement, such as in a normal frame barn, or commonly a dirt floor often found in pole barns. Manure (solid) is often hauled in spring and fall, although the barns housing young calves are usually hauled more frequently;

Earthen Pits- A majority of these pits are designed to meet Minnesota Pollution Control Agency and Natural Resource Conservation Service standards. Bottoms are frequently lined with compacted clay or other near-impervious material. Pits are usually emptied once or twice a year and are not covered; *Treatment lagoon*- Similar to an earthen pit but often not lined with clay or other impervious material and often much larger enabling less frequent manure hauling; *Slurry Store*-Above ground steel tanks which are generally emptied once or twice per year; Cement tanks above ground-Similar to a Slurry Store and also emptied once or twice per year. Tanks are generally not covered.

Amounts of N and P collected, lost in storage, and amounts retained for land application are summarized by collection systems in Table 6. Based on the N collected (Figure 10), the dominant collection systems for hog producers on South Central Minnesota farms are; pits under barns (58%), above ground concrete tanks (12%), lagoons (12%) and animal barns (11%). It appears that producers have the equipment facilities to store roughly four-fifths (86%) of the manure (based on retained N) and should not be subjected to applying manure during poor weather conditions. Daily scrape and haul systems pose difficult environmental challenges and field-applied losses after are high if not properly incorporated. The daily scrape and haul system, based on nutrients generated, contributes less than 1% of the manure produced. A more serious challenge is the animal barns that may be cleaned and hauled every one to four weeks throughout the year, although even this category contains less than 12% of the total N produced.

Table 6. Manure N, P_2O_5 and K_2O collected and storage losses by all livestock on all farms in 1993.

System Type	Number of Systems	Manure Nitrogen Collected	Retained N After System Losses	Manure P_2O_5 Collected	Retained P After System Losses	Manure K_2o Collecte d	Retained K After System Losses
		Pounds X 1000		Pounds X 1000		Pounds X 1000	
Daily Scrape/Haul	1	2.2	1.6	1.5	1.5	1.5	1.5
Unpaved Lot	2	2.5	1.2	1.9	1.0	2.2	1.4
Paved Lot	10	24.3	11.1	17.1	11.1	18.0	13.5
Animal Barn	43	171.7	120.2	118.0	118.0	137.1	137.1
Pit Under Barn	126	839.0	650.2	586.3	586.3	621.5	621.5
Above Ground Tank	3	173.9	139.1	124.0	124.0	133.8	133.8
Slurrystore	2	24.3	19.5	17.0	17.0	18.0	18.0
Earthen Pit	7	92.1	64.4	64.3	64.3	67.5	67.5
Treatment Lagoon	4	182.2	109.3	128.5	64.3	137.3	68.7
Half Barn/Half Lot	2	8.6	5.2	6.4	5.1	7.6	6.9
TOTAL	**200**	**1,521**	**1,124**	**1,065**	**992**	**1,144**	**1,070**

Nutrient losses from collection and storage were estimated from accepted guidelines[8] for each individual storage system. Losses as a function of application methods and timing factors were calculated on a field-by-field basis (Table 7)[9]. Manure generated a total of 455,000 lb of "first year available" N. This represents 8,900 lb/N/farm.

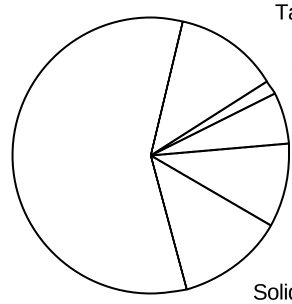

Figure 10. Contributions of total **nitrogen retained after storage losses** by type of manure collection system.

The fate of manure-N has been summarized in a simple flow diagram (Figure 11). This diagram simplifies the complexities associated with N from excretion to "plant available". Over three-fourths of the "first year available" N (on a weight basis) was applied to corn (Figure 12). Soybeans (20%) received the bulk of the difference. Out of all the corn acres in the survey, only 27% received manure applications (Table 7).

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8 Livestock Waste Facilities Handbook, Midwest Plan Services, Iowa State University, Ames, Iowa. 1993.

9 M. Schmitt, and G. Rehm. Fertilizing Cropland with Dairy Manure. FO-5880-C. M. Schmitt, and G. Rehm. Fertilizing Cropland with Swine Manure. FO-5880-C. M. Schmitt, and G. Rehm. Fertilizing Cropland with Beef Manure. FO-5880-C.

Over 40% of the farm generated manure on corn acres was applied as a broadcast with no incorporation[10]. Incorporation of broadcast manure within 4 days would increase the retained N available for crop use by 50% or an additional 50,000 pounds that would be available for crop use. Thirty-six percent of the manure was incorporated within 4 days and 24% of the manure was knife-injected.

Seventy percent of the manure[11] applied came from storage facilities of 6 months storage capacity or longer and was applied in spring and fall. Another 14% of the manure was applied during fall and spring but came from storage systems with less than 6 months capacity. Application timing of all manure applied to corn acres, regardless of storage system, is shown in Figure 13. Spring applications were March through May, summer applications were June through August, fall applications were September through November and winter applications were December through February.

Table 7. Distribution of first year available farm generated manure to cropland in 1994[12].

Crop	Manured Acres	Total Acres	% of Acres	Available N	Available P_2o_5	Available K_20
Alfalfa	24	242	10%	867	2,098	2,353
Corn	6,170	23,093	27%	356,007	632,101	680,862
Other Crop	0	7	0%	0	0	0
Grasses	15	28	54%	393	1,113	1,268
Pasture (non-crop)	84	292	29%	77	207	281
Peas	40	229	17%	250	559	648
Small Grains	126	373	34%	5,405	12,455	14,670
Soybeans	1,859	18,258	10%	90,920	152,721	163,088
Sweet Corn	32	508	6%	1,058	3,009	3,515
TOTAL	**8,350**	**43,030**	**19%**	**449,153**	**804,303**	**866,689**
CROP TOTAL	**8,266**	**42,738**	**19%**	**449,076**	**804,096**	**866,408**

10 Based on total N available from all farm generated manure after storage losses have been attached.

11 Based on total N available from all farm generated manure after storage losses have been attached

12 M. Schmitt, and G. Rehm. Fertilizing Cropland with Dairy Manure. FO-5880-C. M. Schmitt, and G. Rehm. Fertilizing Cropland with Swine Manure. FO-5880-C. M. Schmitt, and G. Rehm. Fertilizing Cropland with Beef Manure. FO-5880-C.

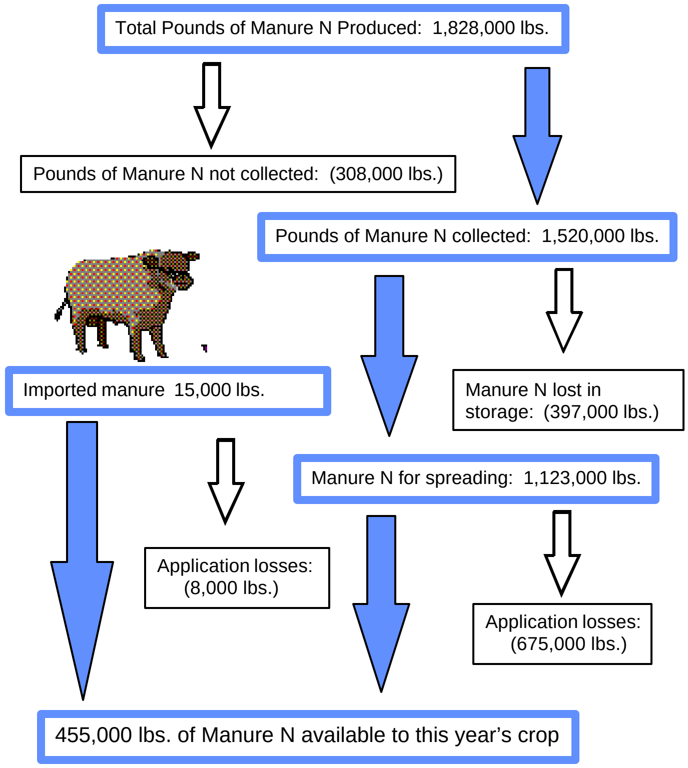

Figure 11. Fate of farm generated and imported manure-N across all storage and management factors.

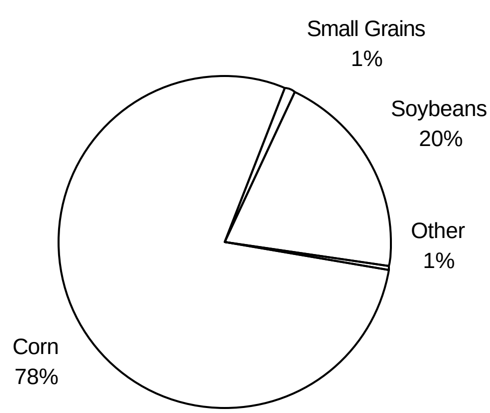

Figure 12. Distribution of "first year available" nitrogen by crop type calculated on a weight basis.

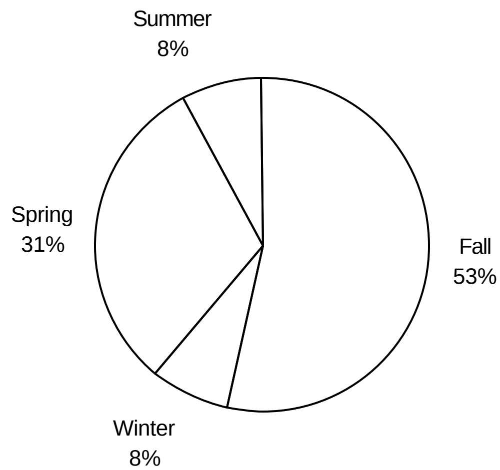

Figure 13. Timing of manure applications on corn acres.

Manure testing is a critical component in nutrient management planning. Eighteen (35%) producers had done some manure testing prior to this project. Usually these producers had tested the manure only once. Participants were offered manure and well water testing as part of the program. Due to the high variability of N, P_2O_5 and K_20 found in manure systems, individual tests greatly enhanced the value of the on-farm nutrient balance. Sixty-six manure samples were gathered and had analyses performed on them. Table 8 is a summary of those samples.

Table 8. Manure test results

System Description	Number of	Nitrogen			Phosphate			Potash		
Lbs per Ton	**Samples**	**Min.**	**Ave**	**Max.**	**Min.**	**Ave**	**Max.**	**Min.**	**Ave**	**Max.**
Animal Barn	7	14	20	29	8	43	89	4	11	20
Lbs per 1000 Gallon										
Pit Under Barn	45	9	45	99	5	37	107	3	26	77
Cement Tank	1	21	21	21	7	7	7	15	15	15
Slurry store	4	20	33	40	9	29	39	11	20	23
Earthen Pit	6	8	50	84	1	45	69	7	29	48
Lagoon	3	33	42	56	14	30	55	17	23	29

Manure test results from animal barns (7 samples) and pits under barns (45 samples) are illustrated in Figure 14A and 14B, respectively. Samples were highly variable. Nutrient values within this sample group were generally higher than University of MN average values. Liquid manure values were somewhat more consistent with the U/M values than were those of solid manure. These data are additional evidence of the large variability from farm to farm and manure testing is highly recommended.

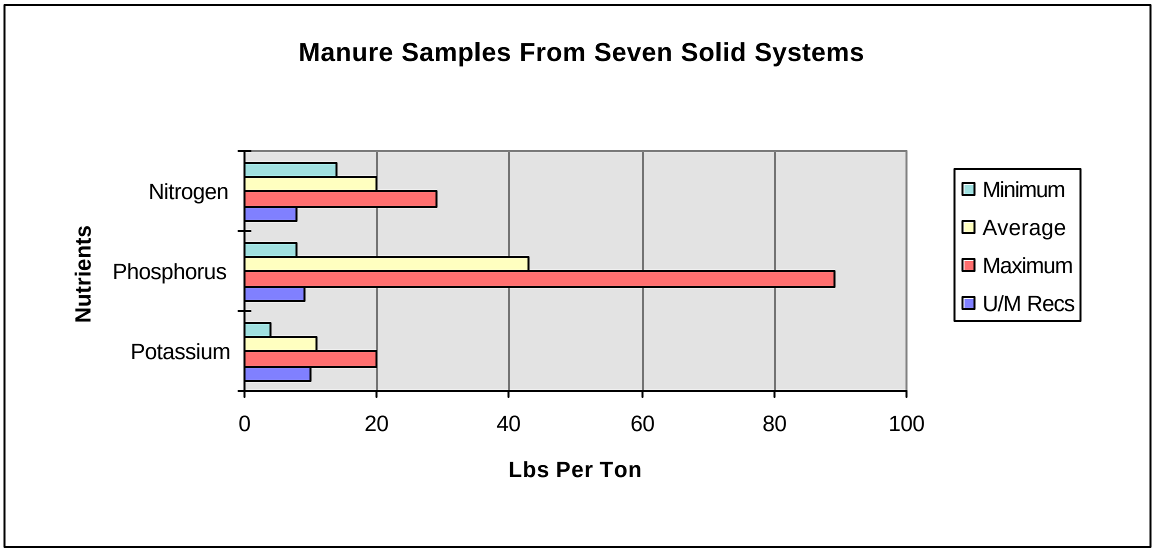

Figure 14A. Nutrient values of manure from 7 animal barns. University of MN average values are also included for comparison.

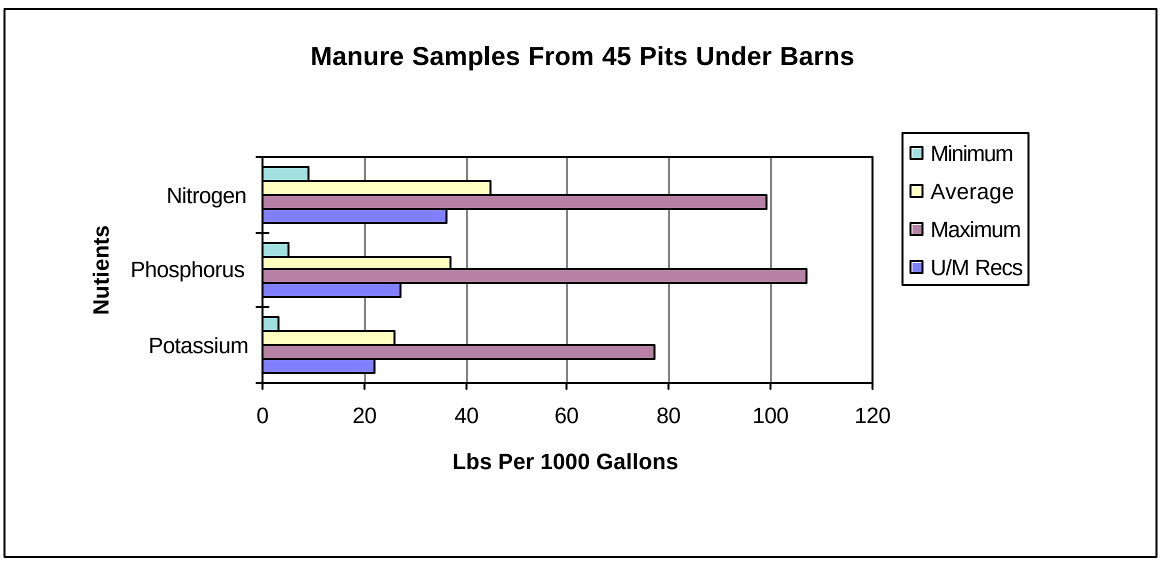

Figure 14B. Nutrient values of manure from 45 pits under barns. University of MN average values are also included for comparison.

Relative Importance of N and P Sources on the Selected Farms: Pork Producers in South Central Minnesota

University of Minnesota recommendations for nitrogen provide N credits from legumes. Legume N credits from the U/M recommendations were calculated by subtracting fertilizer N recommendations for corn planted after legumes from the N recommendations for crops without legume credits[13]. Alfalfa was assumed to have 2-3 plants per square foot when tilled for the following corn crop. Based on these calculations soybeans provided a 40 lb/A credit, first year alfalfa provided a 75 lb/A credit, and second year alfalfa provided a 50 lb/A credit. These N credits will later be compared to the reductions in nitrogen on corn acres with no legume N credits to those corn acres with legume N credits.
In the South-Central survey soybeans were by far the most important source of legume N, supplying over 98% of all legume N. Alfalfa (first and second year credits) supplied the balance.

Commercial fertilizer (75%), manure (8%), and legume (17%) contributed a total of 4,375,000 pounds of "first year available N" to **corn acres** (Figure 15). This is an average N rate of 189 lb/A across all corn acres. Proper crediting for these sources is critical in maintaining economic and environmental balances.

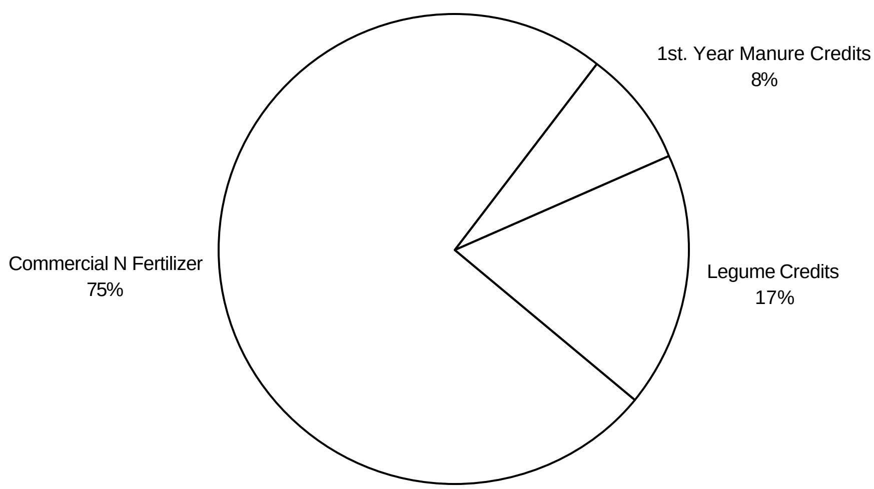

Figure 15. Relative N contributions from fertilizers, manures and legumes across all corn acres. N inputs totaled 4,375,000 for all sources. N contributions averaged 189 lb/A across all corn acres.

[13] G. Rehm, M. Schmitt, and R. Munter. Fertilizing Corn in Minnesota. FO-3790-C.

Nitrogen Balances and Economic Considerations: Pork Producers in South Central Minnesota

The corn yield goal across selected farms in all five counties averaged 154 bushels/A. University of Minnesota N recommendations were based on yield goal, crop history, and soil organic matter level was compared to actual amounts of fertilizer and manure applied to each field. Ten thousand acres had soil tests with soil organic matter level listed and 97% of those acres were in the medium and high range. Analysis of corn acres was based on the assumption all corn acres had organic matter levels in the medium to high range. University of Minnesota N recommendations to fulfill this goal averaged 105 lb/N/A (Figure 16). Actual amounts of N applied from fertilizer and manure averaged 141 lb N/A and 15 lb/A respectively across all corn acres. Factoring in all appropriate credits from fertilizer, legumes and manures, there was an over-application rate of 51lb/N/A. Within this report, averages across fields (on a county basis) have been reported. More detailed analysis will immediately follow to "weight" the data to account for the wide range in field sizes.

These numbers are somewhat conservative in nature due to the fact that only "first year credits" from manure are included in the analysis. A vast majority of the producers did not have adequate records from the previous year (1993[14]) to accurately credits these sources. Statewide[15] recommended N credit for previous soybean crop is now 40 lb/A.

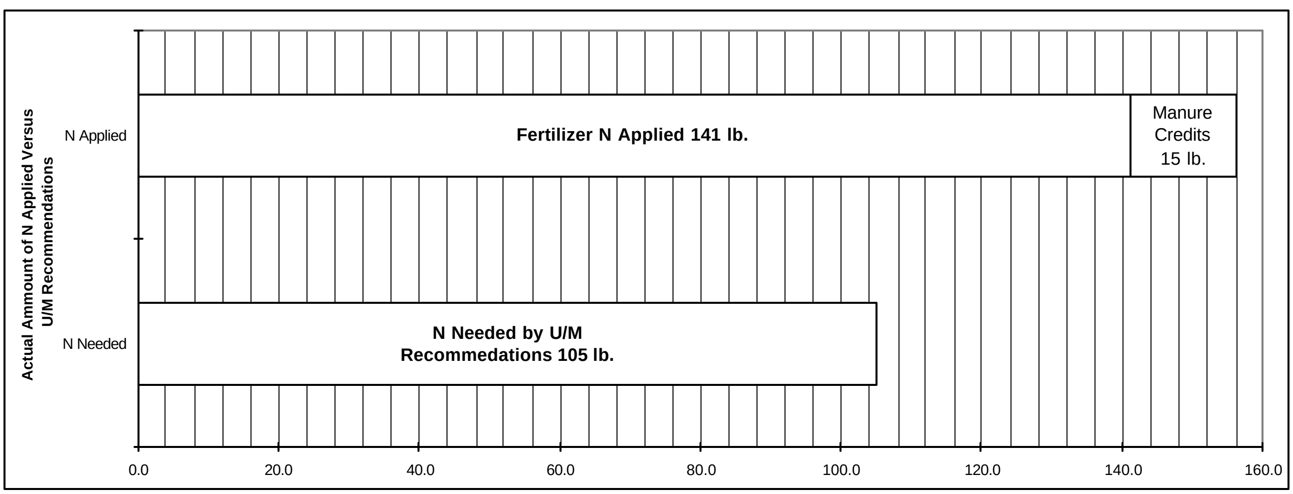

Figure 16. Crop N requirements based on University of MN recommendations in comparison to actual N inputs (fertilizer, and manure) across all corn acres. Total corn area in this analysis was 23,093 acres. Legumes also provided 33 lb/A N across all acres and is already reflected in the U/M recommendations.

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14 Referring to any manure applications prior to those made in the fall of 1993.

15 G. Rehm, M. Schmitt, and R. Munter. Fertilizer Recommendations for Agronomic Crops in Minnesota. 1994. BU-6240-E.

Figure 17 details the average amount of N needed by each crop[16] in the survey and compares it to the contributions of N supplied by each source to fulfill the N requirements on an average farm. Approximately 64,000 pounds of N is required to fulfill the needs of all crops and approximately 24,000 pounds of N are available through manure and legumes. An additional 40,000 pounds of N would therefor needed to be provided through commercial fertilizer to fulfill the needs of the various crops.

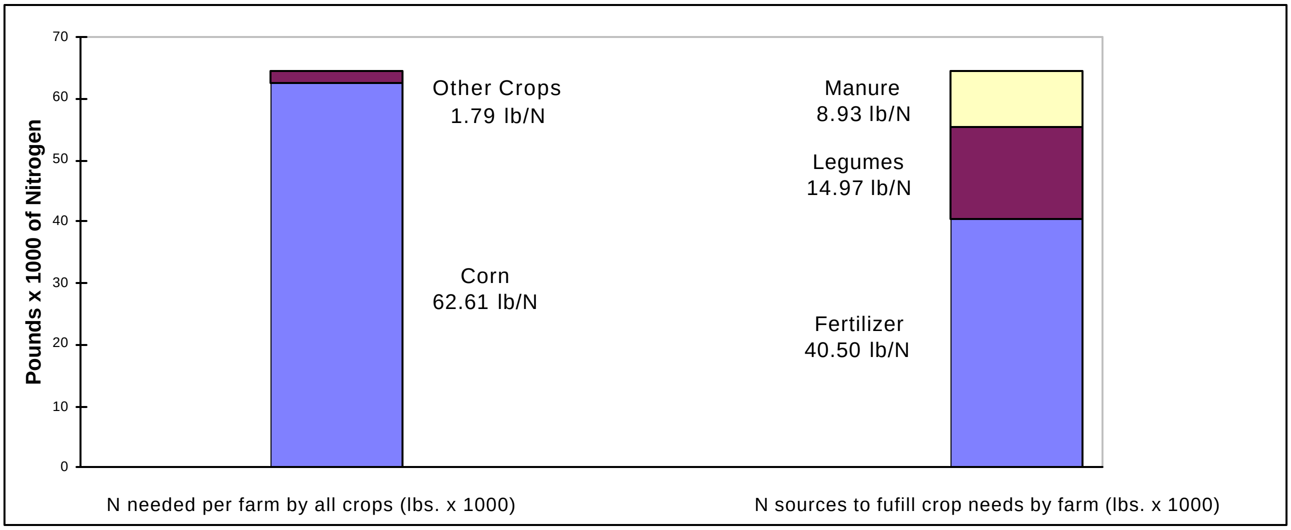

Figure 17. Crop needs for nitrogen and various sources to fulfill those needs. If manure and legumes supplied a total of 24,000 lb/N 40,000 of commercial N would fulfill the crop requirements of N for the average farm.

Balances were examined in more detail by lumping the **1994 corn acreage** into six different scenarios:

> **Scenario 1: N from fertilizer only; no legume or manure credits;**
> **Scenario 2: N from fertilizer; no legume credits; manure applied.**
> **Scenario 3: Previously soybeans (1993); no manure applied;**
> **Scenario 4: Previously soybeans (1993), manure applied;**
> **Scenario 5: Previously alfalfa (1993 or 1994); no manure applied;**
> **Scenario 6: Previously alfalfa (1993 or 1994); manure applied.**

Nitrogen balances for all corn acres are broken down into these scenarios in Table 9. Fertilizer N rates specific to each of the first four scenarios are illustrated in Figure 18. Fields previously in alfalfa in 1992 or 1993 were limited to 166 acres and therefore will not be used for comparison. The commercial N rates in scenario 1 (no legumes, no manure) averaged 152 lb/A. One method to determine the credits attributed to the various organic contributions is to compare the subsequent commercial N rates.

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[16] Crop needs of N for crops other than corn were based on average yields for the area and medium to high organic mater.

The following comments are based completely on the net differences in fertilizer N inputs comparing corn fields receiving only fertilizer N to the other scenarios:

* Scenario #2: Corn acres with no legume credits and receiving manure credits had a decrease of 20 lb/A in commercial N fertilizer.

* Scenario #3: Producers reduced fertilizer inputs on fields previously in soybeans. Fertilizer N rates in scenario 3 averaged 147 lb/A, an decrease of just 5 lb/A below the average fertilizer N rate of scenario 1 (no manure or legume credits). Based only on the N fertilizer replacement value, proper crediting could save these producers approximately $6/A[17] ,on average, assuming no additional transportation and labor costs.

* Scenario #4 : Producers also reduced fertilizer inputs on manured corn fields previously in soybeans. Fertilizer N rates in scenario 4 were reduced by 34 lb/A compared to corn acres with no legume or manure credits and by 29 lb/A compared to corn following soybeans without manure.

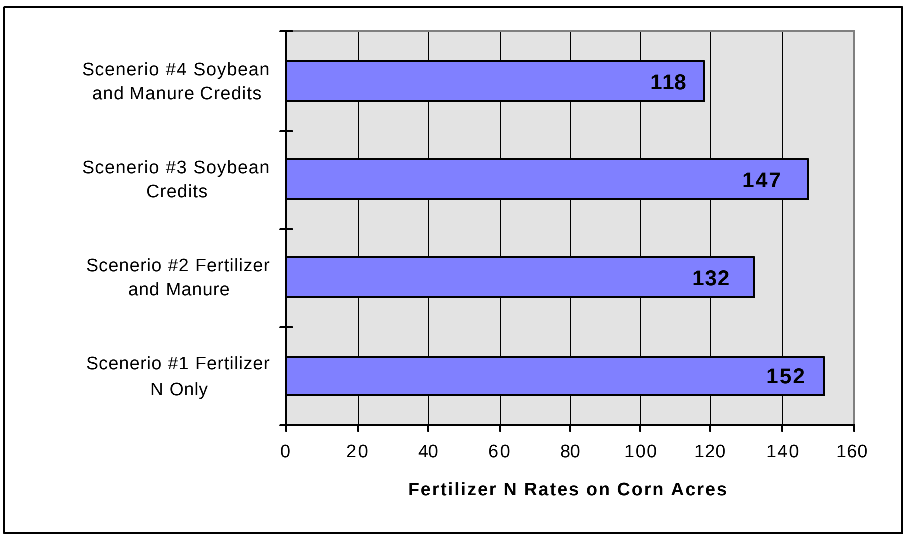

Figure 18. Commercial fertilizer N rates on corn by management scenario.
See definitions for complete description of rotation and land application details.

Factoring in legume N credits and manure N inputs into the process on a field-by-field basis, the amounts in excess of 1994 University of MN recommendations are illustrated in Figure 19. One of the huge advantages of the technique developed through the nutrient assessment process is the ability to examine in great detail the nutrient balances and make some inferences on where the biggest gains in water quality can be obtained through focused educational programs. Nitrogen balances are given in Table 9.

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17 Based on a nitrogen fertilizer price of $0.20/pound.

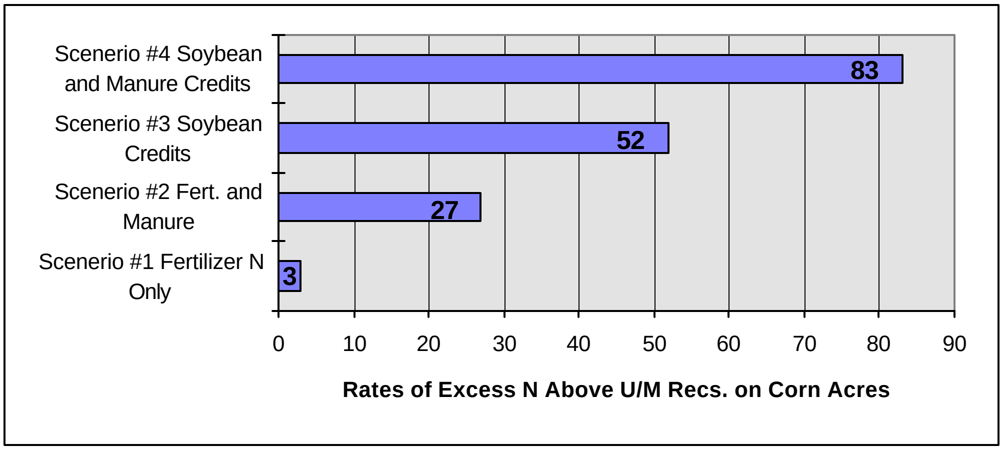

Figure 19. Amounts of N in excess of 1994 University of Minnesota recommendations across the different management scenarios. Analysis includes all 23,093 acres of corn.

It appears producers were making minor over-applications in Scenario 1. However, in Scenerio 1, producers were over-applying N by an average of 30 lb/A on about 50% of the acres where neither legume or manure N credits existed. In Scenario 2, 77% of acres previously applied with manure but had no legume credits were in excess of recommendations by 41 lb/A. Scenario 3, corn with legume N credits and no manure N credits, had excess N applied on 95% of acres by a rate of 55 lb/A. In Scenario 4, manure and soybean credits of N, 95% of the acres were over-applied by an average of 88 lb/A. Of the 23,093 acres of corn, 20,530 (89%) were over-applied with nitrogen.

Acreage distributions and N balances were then divided into three categories; AVERAGE, ABOVE and BELOW UM recommendations. Data are given in Tables 9A, 9B, and 9C respectively. Eighty-eight (89%) of the total corn acres were classified into the ABOVE category. Excess amounts of N averaged 60 lb/A across all acres in this category. The remaining acres (12%) were classified as BELOW[18] UM recommendations. Shortage amounts of N average 22 lb/A and it is interesting to note that most of this shortage fell into Scenario 1 (commercial N only).

[18] Includes acres where amounts equal U/M recs.

Table 9A.
Nitrogen Inputs and Balances-Average Nitrogen-Across All South-Central Areas

Scenario Number	Total Acres	Legume credits (lb/A)	Legume Credits Total	Manure N (lb/A)	Manure Total	Fert N (lb/A)	Fert Total	N Rec. (lb/A)	N Rec. Total	Excess (lb/A)	Yield Goal
1	2,709	0	0	0	0	152	411,345	148	402,340	3	156
2	1,386	0	0	47	65,526	132	182,755	152	210,510	27	160
3	14,200	40	568,000	0	0	147	2,090,446	96	1,358,020	52	153
4	4,632	40	185,280	62	285,412	118	546,610	96	445,820	83	154
5	14	75	1,050	0	0	119	1,666	45	630	74	140
6	152	60	9,100	33	5,069	151	23,021	80	12,140	105	148
TOTALS FOR ALL SCENARIOS	**23,093**	**33**	**763,430**	**15**	**356,007**	**141**	**3,255,843**	**105**	**2,429,460**	**51**	**154**

Table 9B.
Nitrogen Inputs and Balances-Excess Nitrogen-Across All South-Central Areas

Scenario Number	Total Acres	Legume credits (lb/A)	Legume Credits Total	Manure N (lb/A)	Manure Total	Fert N (lb/A)	Fert Total	N Rec. (lb/A)	N Rec. Total	Excess (lbs/A)	Excess Total
1	1,308	0	0	0	0	166	216,879	136	177,780	30	39,099
2	1,097	0	0	49	53,810	139	152,239	146	160,680	41	45,366
3	13,559	40	542,360	0	0	150	2,029,335	95	1,281,670	55	747,666
4	4,400	40	176,000	63	275,007	121	533,596	95	419,300	88	389,303
5	14	75	1,050	0	0	119	1,666	45	630	74	1,036
6	152	60	9,100	33	5,069	151	23,021	80	12,140	105	15,951
TOTALS FOR ALL SCENARIOS	**20,530**	**35**	**728,510**	**16**	**333,886**	**144**	**2,956,736**	**100**	**2,052,200**	**60**	**1,238,421**

Table 9C.
Nitrogen Inputs and Balances-Shortage Nitrogen-Across All South-Central Areas

Scenario Number	Total Acres	Legume credits (lb/A)	Legume Credits Total	Manure N (lb/A)	Manure Total	Fert N (lb/A)	Fert Total	N Rec. (lb/A)	N Rec. Total	Shortage (lb/A)	Shortage Total
1	1,401	0	0	0	0	139	194,465	160	224,560	21	30,945
2	289	0	0	41	11,716	106	30,519	172	49,830	26	7,595
3	641	40	25,640	0	0	95	61,110	119	76,350	23	15,239
4	232	40	9,280	45	10,405	56	13,014	114	26,520	13	3,100
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
TOTALS FOR ALL SCENARIOS	**2,563**	**14**	**34,920**	**8**	**22,121**	**117**	**299,108**	**147**	**376,810**	**22**	**56,879**

Scenario Definitions:

Scenario 1: N from fertilizer only; no legume or manure credits;
Scenario 2: N from fertilizer; no legume credits; manure applied.
Scenario 3: Previously soybeans (1993); no manure applied;
Scenario 4: Previously soybeans (1993), manure applied;
Scenario 5: Previously alfalfa (1993 or 1994); no manure applied;
Scenario 6: Previously alfalfa (1993 or 1994); manure applied.

Viewing the distribution of excess N from a water quality perspective, a helpful indicator is the cumulative excess N values found in Table 9b. These figures factor in both the total acres of any given scenario as well as the rate of excess N. Clearly where producers could gain the most N credits and make the biggest impact on water quality is to take the credits associated with Scenario #4 (61% of the total) and #3 (31%). Figure 20 captures this concept by illustrating the relative excess N by the various management scenarios.

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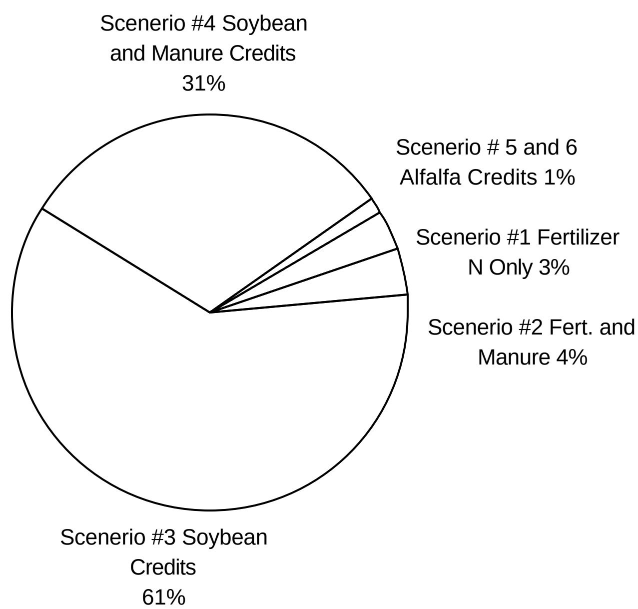

Figure 20. Relative contributions of total excess N by the different management scenarios across all corn acres.

Corn acres were also divided into categories according to how close the amount of N applied was to the amount of N recommended by the U/M. There were 1,987 acres of corn within 10 lb/A of U/M recommendations. Figure 21 further shows the distribution of all corn acres in comparison to the U/M recommendations by categorizing the acres according to whether or not the N available was within 30 lb/A of U/M recommendations. A 30 lb/A range on either side of the U/M recommendations should allow for most site specific management decisions or problems such as the wet fall of 1993 and spring of 1994 which may affect decisions on the amount of N to apply.

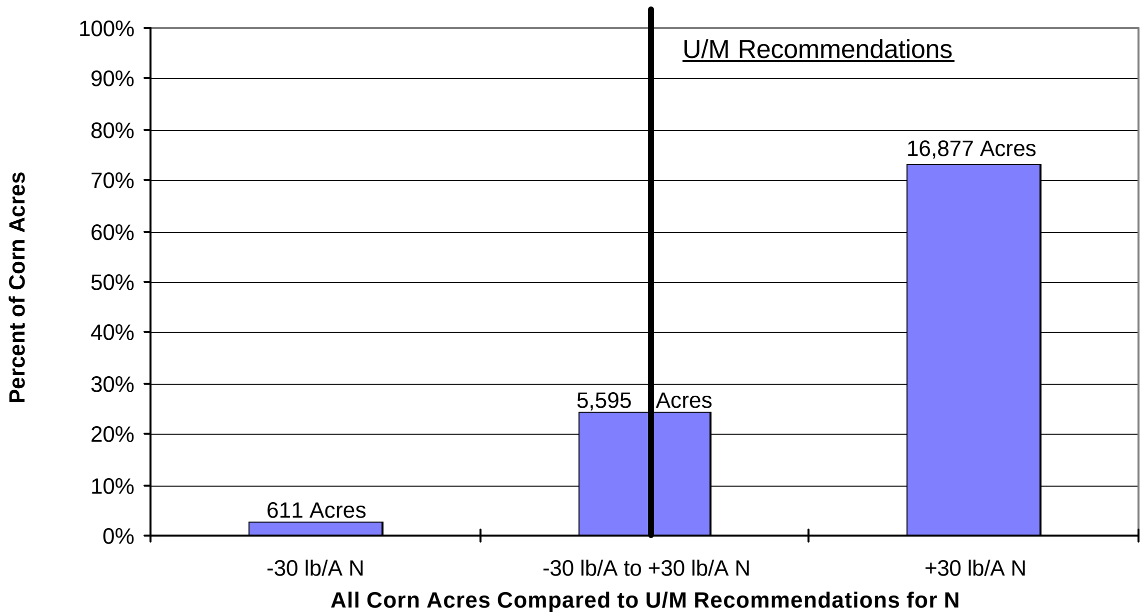

Figure 21. Acres of corn within 30 lb/A of U/M recommendations for N.

Clearly the area where reductions of N inputs could be made is in the 73% of acres with N inputs exceeding U/M recommendations by 30 lb/A or more. Table 10 describes the different scenarios in regard to excess amounts more than 30 lb/A above U/M recommendations and the average reductions possible that would reduce N inputs to within 30 lb/A of recommendations. In most cases a reduction of fertilizer N would be possible to reduce the N inputs to within 30 lb/A of U/M recommendations. Out of all manured acres, (6,170) only 1,068 (17%) acres had more N applied from manure than the U/M recommendations required for N[19]. Corn acres with manure in excess of 30 lb/A of U/M recommendations totaled 429 (7%) acres. On acres of corn with excess N from manure, reduction in the application rate of the manure applied in needed, and often reduction of fertilizer N.

[19] Some of these manured acres received N credits from legumes also.

Table 10. Corn acres where N inputs were more than 30/A above U/M recommendations.			
Scenario	**Acres**	**Total Reduction of N Possible**	**Average Reduction of N Possible**
N From Fertilizer Only	590	8,297	14
N From Fertilizer And Manure	494	23,166	47
N From Fertilizer And Soybeans Credits	11,601	359,560	31
N From Fertilizer, Manure, And Soybean Credits	4,036	263,155	65
N From Fertilizer And Alfalfa Credits	14	616	44
N From Fertilizer, Manure, And Alfalfa Credits	152	11,390	75
All Scenarios Totals and Averages	**16,887**	**666,184**	**39**

Soil test results were available for 10,814 (25%) of all 42,738 acres of cropland. A much larger percentage of the acres had recently been soil tested, but the tests were not available at the time of the interviews. Figure 22 shows the pH levels on acres with soil tests. Ranges of soil tests were: below 5.5, 5.5 to 7.0, which is the range P_2O_5 has the highest availability for plant uptake[20], and above 7.0. Fixation of phosphorus as calcium phosphate may become a concern with pH levels above 7.3, which occurred on 24%of acres tested. Neither the $Bray_{p1}$ or the Olsen test will measure the phosphorus that is fixed but only the phosphorus that is available. $Bray_{p1}$ test was generally used for soil tests with pH levels below 7.3 and the Olsen test was generally used for soil tests with pH levels of 7.3 and above. Figure 23 shows the P_2O_5 levels by the range in which each test fell[21]. Eighteen percent of the tests were Olsen tests and the remainder were $Bray_{p1}$ tests for measuring P_2O_5. Figure 24 shows the K_2O levels by the range in which each test fell[22]. In this analysis K_2O amounts were not a consideration, but the soil tests do provide a feel as to whether the K_2O from manure could replace K_2O from fertilizer.

20 G. Rehm and M. Schmitt. Understanding Phosphorus In Minnesota Soils.

21 Ranges for P_2O_5 for $Bray_{p1}$ tests are: very low 0-5, low 6-10, medium 11-15, high 16-21, very high 21+. Ranges for P_2O_5 for Olsen tests are: very low 0-3, low 4-7, medium 8-11, high 12-15, very high 16+.

22 Ranges for the K_2O tests are: very low 0-40, low 41-80, medium 81-120, high 121-160, very high 161+.

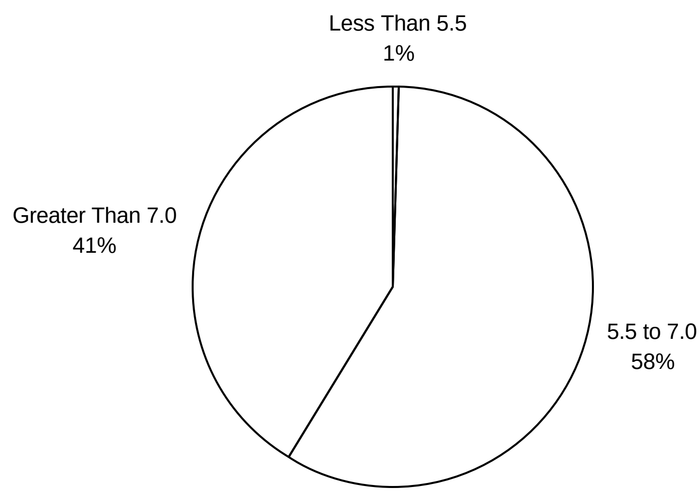

Figure 22. Range of pH levels from soil tests. Levels of pH from 5.5 to 7.0 provide the optimum range for highest uptake of phosphorus.

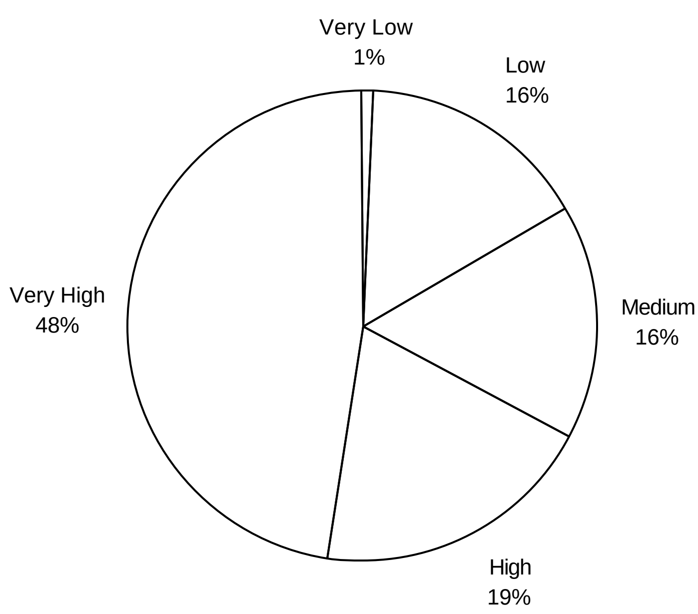

Figure 23. Soil test results of P_2O_5 levels. Sixty-seven of the soil tests were in the high to very high range.

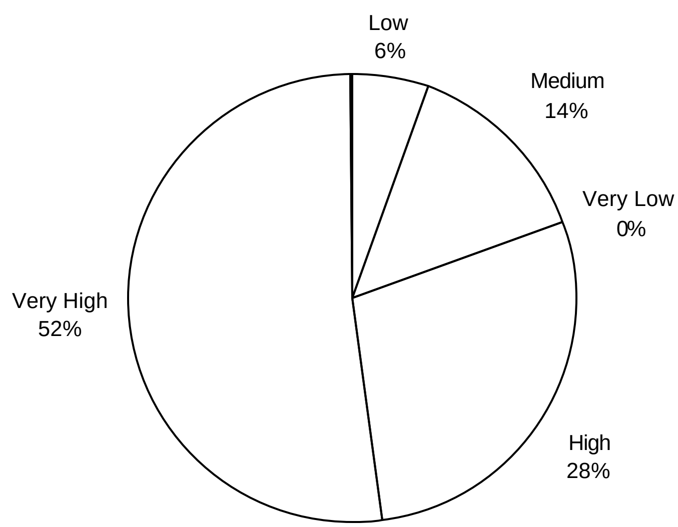

Figure 24. Soil test results for K_2O levels. Eighty of the soil tests were in the high to very high range.

Applications of P_2O_5 on corn acres with manure and without manure were 20 lb/A and 36 lb/A respectively. Although there was a 16 lb/A reduction of P_2O_5 on manured corn acres, manure contributed an additional 102 lb/A of P_2O_5 to each acre of manured corn. Applications of K_2O were not gathered but K_2O applied from manure averaged 110 lb/A across all manured corn acres.

The value of manure would be the greatest if placed on corn acres with the lowest P_2O_5 and K_2O levels, **and** reducing fertilizer rates on those acres (nutrients from the manure should replace those from commercial fertilizer). Assuming the soil tests represent most acres in the survey, the most value from the manure would be on corn acres (corn acres have the greatest need for nutrients in this survey) with P_2O_5 and K_2O levels in the very low to medium range, according to soil tests. Thirty-three percent of the acres tested were in the very low to medium range with regard to P_2O_5 and 20% of the acres tested were in the very low to medium range in regard to K_2O. With an average contribution of 102 lb/A of P_2O_5 on manured corn the average farmer could receive value from 30% to 100% of the P_2O_5 applied from the manure on very low to medium testing soils, depending on the yield goal and soil test of the particular field. On corn acres testing in the high or very high range farmers could generally receive 15% or less of the value (15 lb/A) of the P_2O_5 applied from the manure, again depending on the yield goal and particular soil test of the field and assuming replacement of commercial P_2O_5.

Manure contributed and average of 110 lb/A of K_2O per acre on manured corn. The average farmer could receive value from an average of 50% to 100% of the of K_2O from manure on corn acres with K_2O levels in the very low to medium range, depending on the yield goal and particular soil test of the field and assuming replacement of commercial K_2O. On corn acres with high to very high K_2O levels an average farmer could receive value from 25% or less of the of the K_2O, if an average rate of 110 lb/A is applied and depending on the yield goal and particular soil test of the field and assuming replacement of commercial K_2O.

Conclusions and Summary of the Current Nutrient Management Practices on Pork Producers in South Central Minnesota

Fifty-one farms, covering over 44,000 acres, participated in the FArm Nutrient Management Assessment Program (FANMAP) with staff from the Minnesota Department of Agriculture. Producers volunteered 2-4 hours of their time to share information about their farming operation. Producers were carefully selected to represent a wide diversity of management skills and farm characteristics. The overall purpose of the program was to develop a clear understanding of current farm practices regarding agricultural nutrients and utilize this knowledge for future water quality educational programs.

Over 40% of commercial N used on corn was fall applied and anhydrous ammonia was the dominant source of N for fall application (88%). Over half of the anhydrous was applied before October 29, the average date when the soil temperature does not rise above 50 degrees. Delaying these applications until October 29 could decrease nitrogen leaching from fall applications.

Manure accounted for 8% of the total N available the first year while legumes and commercial N accounted for 17% and 73% respectively. Twenty-seven percent (27%) of corn acres received applications of manure leaving ample land for manure application. Storage of manure in manure systems was ample enough to prevent excessive applications of manure during winter months. Manure N exceeded crop requirements on 17% of the manured corn acres. On these acres a reduction in the rate of application of manure and coverage of more acres would increase the value of the retained N from manure in addition to reducing the potential of N leaching.

Only 8% of the farm-generated manure was spread during the winter months. Over 40% of the manure was applied as a broadcast. Incorporation of broadcast manure within 4 days would provide an extra 50,000 of N to be available for crop use.

Manure testing was previously done by 35% of the producers and approximately half of the producers took advantage of the free manure testing. Tests results from those test show slightly higher nutrient levels than the UM standard recommendations.

On corn acres where no previous manure or legume credits existed to confound the rate selection process of N, producers appeared to be in agreement with recommendations that were made by UM/MES. Corn acres which were above or below the UM recommendations were equally distributed and the overall average was 3 lbs. over the UM recommendations. As manure and legume credits are added to the selection process of determining the correct N rate, producers were not taking enough credits from either source, resulting in over-application of N.

Overall, producers reduced N fertilizer inputs by 5lb/A on corn following soybeans. However, additional reductions (20-30 lb/A) could be made with a low probability of yield loss. One of the difficulties in the data collection process was obtaining reliable information that farmers used to make fertilizer recommendations. The extremely wet year in 1993, along with soybean yields around 20 bushel per acre may have caused producers to credit less N from their soybeans than they normally would.

Producers were basically reducing commercial N inputs by 20 lb/A in scenarios where previous manure applications were made to non-legume crops such as corn. Producers were only taking about 40% of the proper N credit from manure, thus, they were under-estimating the value of the manure by approximately 25 lb/A. Here again, additional reductions (20-30 lb/A) could be made with a low probability of yield loss. In the scenario where manure applications were made to fields in legumes(usually soybeans) in 1993 producers were reducing commercial N by 34 lb/A. An additional reduction of 60 lb/A to 80 lb/A could be made in this scenario resulting in a savings of over $12.00/A in commercial N costs alone. Approximately 75% of the corn acres did not receive any manure applications so there are ample locations to apply the manure. From a water quality perspective, the most significant impacts could be made by improving the N crediting process for both manured and unmanured corn previously in soybeans.

Soil testing was available for 25% of all crop acres. A much larger percentage of the acres had been recently tested but the tests were not available at the time of the interview. Sixty-seven percent of the tested acres were in the high or very high range for P_2O_5 and 80% of the tested acres were in the high to very high range for K_2O. Farmers reduced P_2O_5 on manured corn acres by 16 lb/A compared to non-manured corn, but manure contributed an additional 102 lb/A of P_2O_5 to manured acres of corn. Application amounts of K_2O were not gathered during the survey but manure contributed an additional 110 lb/A of K_2O to manured acres. Manure would have its greatest value by being applied to corn acres with very low to medium P_2O_5 and K_2O levels and reducing the amounts of P_2O_5 and K_2O in the fertilizer. At current rates of application, producers could receive value from 30% to 100% of the P_2O_5 and K_2O in the manure if applied on soils testing in the very low to medium range for P_2O_5 and K_2O.

There were some very positive findings from this study. There is strong evidence that producers are voluntarily adopting the educational materials and strategies developed by the University of Minnesota/MN Extension Service. It is also evident that promotional activities need to continue and be specifically targeted to deliver the most recent technology and recommendations. Strong similarities exist in all existing FANMAP projects: producers are generally managing commercial N inputs successfully (although frequently using outdated recommendations) but continually under-estimate the N credits associated with manure and legume inputs.