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Manure is a good source of nitrogen

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Applying the appropriate level of nitrogen (N) to crops is a goal of all farmers. Too little N means reduced yields and lower returns. Too much N means excessive costs (hence lower profits) and, in many cases, unnecessarily high leaching and runoff of N and nitrates into water supplies. Unfortunately, choosing the appropriate N application is difficult, particularly when manure is one of the sources of N.

Using manure makes N management more difficult for at least three reasons. First, estimating the amount of N (as well as other nutrients) provided by a given manure application requires reasonably careful and extensive calculations. Second, even when the N in a manure application has been estimated, the actual amount made available to the crop will vary from the estimates. Finally, estimating the effects of variations in manure N on yields, the truly important consideration, adds additional complexity to managing the N applied to manured crops.

Studies of N applications to corn by farmers indicate that total applications of N (including commercial and manure N) are, on average, much higher on manured corn acres than on unmanured corn acres. Uncertainty about the N in manure may justify somewhat higher total N applications to manured crops. However, evidence indicates that many farmers could reduce combined commercial and manure N applications without hurting yields. This would increase profits by reducing commercial N costs while reducing nitrate leaching and runoff into water supplies.

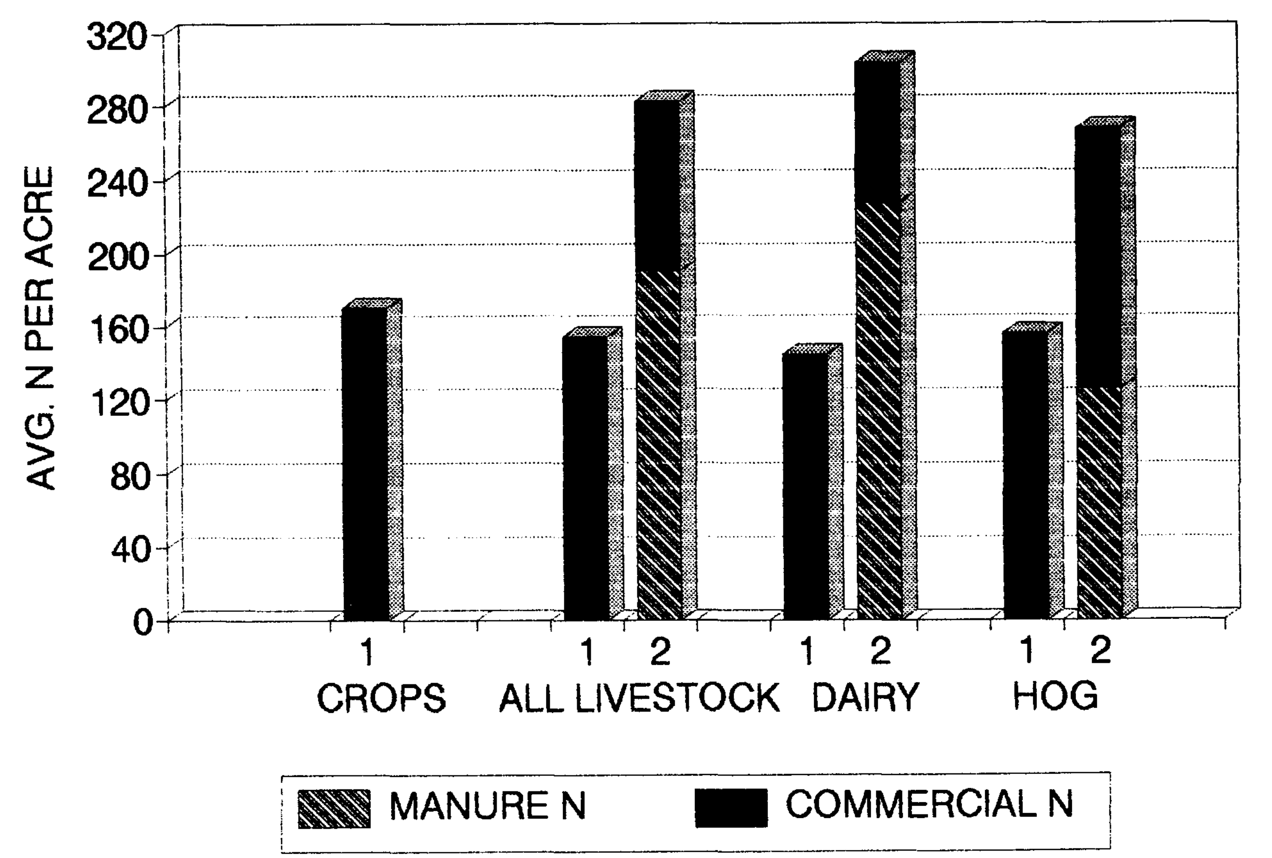
In what follows, average N applications of southeastern Minnesota farmers who participated in a recent study are presented to support the claim that the opportunities to reduce applications are reasonably widespread. Second, we estimate the N provided by manure on a hypothetical farm. Third we consider the effects of variability of manure N on yields and profits, again on the hypothetical farm. Finally, we provide a list of sources of information to assist in making similar estimates for any farm.

I. NITROGEN APPLICATIONS TO CORN

On average, 36 southeastern Minnesota farmers, participants in a University of Minnesota study regarding N management, applied approximately 100 pounds more total N to manured corn following corn than to unmanured corn following corn. The 36 participants included dairy farmers, hog producers, a variety of mixed livestock producers, and crop growers with no livestock.

FIG. 1-NITROGEN APPLICATIONS

MANURED(2) AND UNMANURED(1) CORN-BY FARM TYPE



A comparison of N applications to manured and unmanured corn following corn, by farm type, is shown in Figure 1. Commercial N applications to corn where no manure was applied were similar across farm types, averaging approximately 160 lb. per acre. Total N applications to manured corn, which include manure[1] and commercial N, were also similar across farm types.

We concluded from these results that, on average, farmers of all types apply similar amounts of commercial N to unmanured corn. Livestock farmers, regardless of livestock type, also apply similar amounts of total N to manured corn. However, as stated earlier, livestock farmers, on average, apply over 100 more pounds of total N to manured than unmanured corn (approximately 280 vs. 160 pounds of N).

Livestock farmers do, on average, reduce commercial N applications when manure has been applied. Dairy and hog farmers reduced average commercial N applications by 70 and 14 pounds, respectively, to account for manure applications.

These amounts are all averages. Included in the averages are farmers who did not reflect manure applications in their commercial N applications. In other words, they applied the same amount of commercial N to fields that had been manured as to fields that were not manured. On the other hand, three of the farmers estimated their manure N using manure analysis or computations similar to those used here, and chose total manure and commercial N applications approximately equal to their applications to unmanured corn. None of the surveyed livestock farmers, including the two groups mentioned here, reported substantial yield differences between manured and unmanured corn.

These results indicate that many livestock farmers could reduce applications of N without affecting yields, while saving substantially on commercial fertilizer costs.

II. MANURE N

Manure provides a substantial amount and variety of nutrients, including N, and hence is valuable in crop production. However, many farmers have attributed low or no N value to manure. Difficulties in estimating the average N in a particular application, along with the knowledge that the actual N will vary from year to year and field to field, have helped create this situation.

The following estimates of both the average and range of N for a hypothetical dairy farm shows that, regardless of the methods of handling manure, the manure would provide our farmer a substantial amount of N. This is true even when N losses are very high. Estimates for both a scrape and haul system and a lined liquid storage system (e.g. a concrete pit under the barn) are presented to illustrate the substantial decrease in N losses associated with N conserving handling practices.

The Dairy Farm

The hypothetical farm is typical of small dairies in southeastern Minnesota. The farm totals 300 acres, of which 120 are corn (the only crop to which N is applied). Of the 120 corn acres, 100 are manured and 20 never receive manure. The dairy herd includes 64 Holsteins weighing an average of 1325 lb. each, 38 replacement heifers 1-2 years old, and 40 calves.

Scrape and Haul System

All manure is scraped and hauled throughout the year. When possible, manure is spread evenly on land that will be planted to corn. The herd is usually confined, so 90% of the manure is collected and spread. During the summer months, manure is spread on alfalfa and idle land, so the N in that manure is not available to corn.

Using standard per animal estimates of N in manure produced annually, this farm's dairy herd would produce 20,000 pounds of N annually. Of this amount 90%, or 18,000 pounds, would be collected and spread. However, approximately 25% of this would be spread during the summer, leaving 13,500 pounds of N potentially available to be spread on land in or earmarked for corn production.

However, manure N is lost before and during application. And, if manure is spread in fall or winter, additional losses occur prior to crop use. When a scrape and haul system is employed, losses prior to application are estimated to be 15-35%. When the manure is broadcast, losses during and after application are estimated to be an additional 15-30%. Since the manure from a scrape and haul system is spread throughout the year, additional losses prior to crop use are estimated to be 5-10%

After accounting for these losses, 5,500 to 9,500 pounds of N will be available to corn from the year's manure. (Table 1 shows the N loss computations.) On the example farm, with 100 acres of manured corn, the manure will provide from 55 to 95 pounds of N per acre of manured corn.

Scraping and hauling manure is the manure handling method that leads to the highest N losses. However, even when losses are highest (35% before application, 30% during and after application, and 10% more prior to crop use) our farmer can expect to receive 55 pounds of N per manured corn acre[2]. On average, manure N would be approximately 75 pounds per manured corn acre.

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[1]*Manure N applications the estimated N in collected raw manure, reduced by storage and application losses. All estimates were based upon production factors and proportional losses in the* ***Manure Waste Facilities Handbook.*** *Section II provides examples of the computations.*

Table 1
Manure N on a Small Dairy Scrape and Haul System
High, Low, and Average N Losses

Pounds of N	**Low**	**Manure N Losses** **Average**	**High**
N Produced	20,000	20,000	20,000
Not Collected (10%)	2,000	2,000	2,000
N Collected	18,000	18,000	18,000
Summer Applications			
Not to Corn (25%)	4,500	4,500	4,500
Lost Prior to Application	13,500	13,500	13,500
(15%, 25%, 35%)	2,000	,3,400	4,700
N in Applied Manure	11,500	10,100	8,800
Lost during and after application			
(15%, 22.5%, 30%)	1,700	2,100	2,600
Lost Prior to Crop Use	300	500	700
Available to Corn	9,500	7,500	5,500
per Manured Acre	95	75	55

Note: The farmer confines the dairy herd 90% of the time. All manure is broadcast.

Lined Liquid Storage System

If the same farmer collects 90% of the manure in a lined storage system and injects it spring and fall, the manure N available to corn is about twice that provided by the scrape and haul system.

With the lined liquid system, losses before application are estimated at 15-30%. Injection of liquid manure substantially reduces application losses, (estimated at 0-2%). In addition, about 5-10% of the fall application will be lost before the crop is able to use the N.

After accounting for these losses, 11,500-15,000 pounds of N (115-150 pounds of N per acre) will be provided by annual manure applications. The liquid system doubles the N without increasing its variability. (Supporting computations are shown in Table 2).

Table 2
Manure N on a Small Dairy Lined Liquid Storage System
High, Low, and Average N Losses

Pounds of N	**Low**	**Manure N Losses** **Average**	**High**
N Produced	20,000	20,000	20,000
Not Collected (10%)	2,000	2,000	2,000
N Collected	18,000	18,000	18,000
Lost Prior to Application			
(15%, 25%, 35%)	2,000	3,400	4,700
N in Applied Manure	11,500	10,100	8,800
Lost during and after application			
(15%, 22.5%, 30%)	0	100	300
Lost Prior to Crop Use	300	800	800
Available to Corn	15,000	13,200	11,500
per Manured Acre (100 acres)	150	132	115

Note: The farmer confines the dairy herd 90% of the time. Manure is injected in the spring and the fall.

III. MANURE N VARIABILITY, YIELDS, AND RETURNS

Regardless of the method of handling manure, the N provided is substantial. However, the manure N will vary from year to year and field to field, potentially adding variability to corn yields and returns. Unfortunately, the commercial N application must be made without knowing the exact amount of N in manure already applied. In this section we consider the effects of uncertainty about manure N on average yields and profits. We conclude that applying approximately the same level of total N to all corn will lead to the highest profits.

Our yield estimates are based on a corn yield to N response function estimated from 10 years of experimental data developed at the Lancaster, Experiment Station. While land characteristics vary, the Lancaster Experiment Station is similar to much of the land in southeastern Minnesota. In all estimates that follow, we use a $2.20 price per bushel of corn and a $0.15 price for a pound of commercial N.

[2]*Only part of the N in manure is available to the corn grown in the first year after application. However, if herd size and corn acres remain reasonably constant, current and past manure applications will provide 55-95 pounds of N per corn acre each year. The fact that manure N becomes available to the crop over approximately three years does need to be considered in N management decisions for particular fields*

At these prices, given land similar to that at the Lancaster, Experiment Station, we estimate that approximately 160 pounds of commercial N applied to unmanured corn following corn will provide an average of 139 bushels of corn and provide the highest average profits. Higher N applications lead to little or no increase in average yields.

Assuming our farmer scrapes and hauls manure and applies it evenly across the 100 acres of manured corn, how much commercial N should be added? Three strategies might be considered:

1) Apply an average of 160 pounds of total N to both manured and unmanured acres. Since manure N averages 75 pounds per acre, commercial N applications would be 85 pounds per acre.

2) Apply enough commercial N to insure that at least 160 pounds of total N is available. Since manure N is estimated to contain 55-95 pounds of N, per acre commercial N applications would be 105 pounds.

3) Ignore manure as a source of N, applying the same amount of commercial N to all corn acres.

Here is a comparison of the N applied to manured corn under each strategy given three levels of manure N:

	If manure N losses are:		
	High	Average	Low
1) Average App. is 160 lb.			
Manure N	55	75	95
Commercial N	85	85	85
Total N	140	160	180
2) Minimum App. is 160 lb.			
Manure N	55	75	95
Commercial N	105	105	105
Total N	160	180	200
3) Apply 160 lb. commercial N[3]			
Manure N	55	75	95
Commercial N	160	160	160
Total N	215	235	255

Table 3 compares yields and returns (value of the expected corn production less commercial fertilizer cost[4]) for the dairy farmer choosing strategies 1, 2, and 3 when manure N losses turn out to be very high, average, and low. Figure 2 graphically compares the per acre returns for each strategy and level of manure N loss.

Table 3
Yields and Returns Per Acre
Three N Application Strategies

	Manure N Losses Are:		
	High	Average	Low
1) Avg. N is 160 lb. per acre			
Total N (Inc. 85 lb. Comm. N)	140	160	180
Avg. Yield Given N App.	137	139	139
Avg. Corn Value (@$2.20/bu.)	$301.40	$305.80	$305.80
Cost of Comm. N (@$0.15/lb.)	12.75	12.75	12.75
Returns per acre	$288.65	$293.05	$293.05
2) Minimum N is 160 lb. per acre			
Total N (Inc. 105 lb. Comm. N)	160	180	200
Avg. Yield Given N App.	139	139	139
Avg. Corn Value (@$2.20/bu.)	$305.80	$305.80	$305.80
Cost of Comm. N (@$0.15'lb.)	15.75	15.75	15.75
Returns per Acre	$290.05	$290.05	$290.05
3) Apply 160 lb. of Comm. N			
Total N (Inc. 160 lb. Comm. N)	215	235	255
Avg. Yield Given N App.	139	139	139
Avg. Corn Value (@$2.20/bu.)	$305.80	$305.80	$305.80
Cost of Comm. N (@$0.15/lb.)	24.00	24.00	24.00
Returns per Acre	$281.80	$281.80	$281.80

Note: In all cases, manure N ranges from 55-95 lb. per acre. The examples reflect three of the possible actual manure N levels: very high N losses (55 lb.), avg. losses (75 lb.), and low losses (95 lb.).

Of the three strategies considered, the lowest commercial N application (strategy 1) leads to the highest potential returns. Applying more commercial N eliminates the potential for yield reduction caused by insufficient N, but usually reduces returns.

The first strategy, applying 85 lb. of commercial N, leads to the lowest commercial N costs. When manure losses are high, total N is 140 lb. and the average yield is 137 bu, or 2 bu. less than the maximum. When manure N losses turn out to be average or lower, the yield will average 139 bu. Maximum yields and low commercial N costs lead to the highest per acre average returns at

[3]*These amounts are lower than the surveyed farmers' average applications reported on page 3. In general, the surveyed farmers applied more manure per acre than in this example.*

[4]*This measure of returns doesn't reflect the other costs of production. As those costs would be the same whether the farmer applied 75 or 95 pounds of commercial N, the amounts shown here provide a basis for comparison of the strategies.*

$293.05. High manure N losses reduce returns to $288.65 due to lost corn revenues of $4.40 per acre.

Applying 20 lb. more commercial N (strategy 2) guarantees sufficient N to support the maximum yield of 139 bu., regardless of manure N losses. Comparing the results to strategy 1, the additional 20 lb. of commercial N increases fertilizer costs by $3 per acre, reducing returns by a like amount when manure N losses are average or less. When manure N losses are very high, a 105 lb. commercial N application leaves the farmer $1.40 per acre better off than an 85 lb. application.

The third strategy, ignoring the manure N, leads to lower returns than either of the other two. Returns are $8.25 per acre ($825 on the farm) lower than those with strategy 2 and $6.85-$11.25 per acre lower, depending upon manure N losses, than those with strategy 1.

Of course, potential strategies are not limited to the three considered here. Ignoring manure N (strategy 3), in fact, going beyond the level which insures the desirable level of N (strategy 2), reduces returns and increases potential water contamination. Strategy 2 does increase returns over those with strategy 1 (by an average of $1.40 per acre) when losses are high, but reduces returns by $3 per acre when manure N losses are average or low. In conclusion, applications beyond 85 pounds of commercial N provide insurance against insufficient N, but at a relatively high cost. Furthermore, each additional pound of N is less likely to be used by the crop and is more likely to degrade the environment.

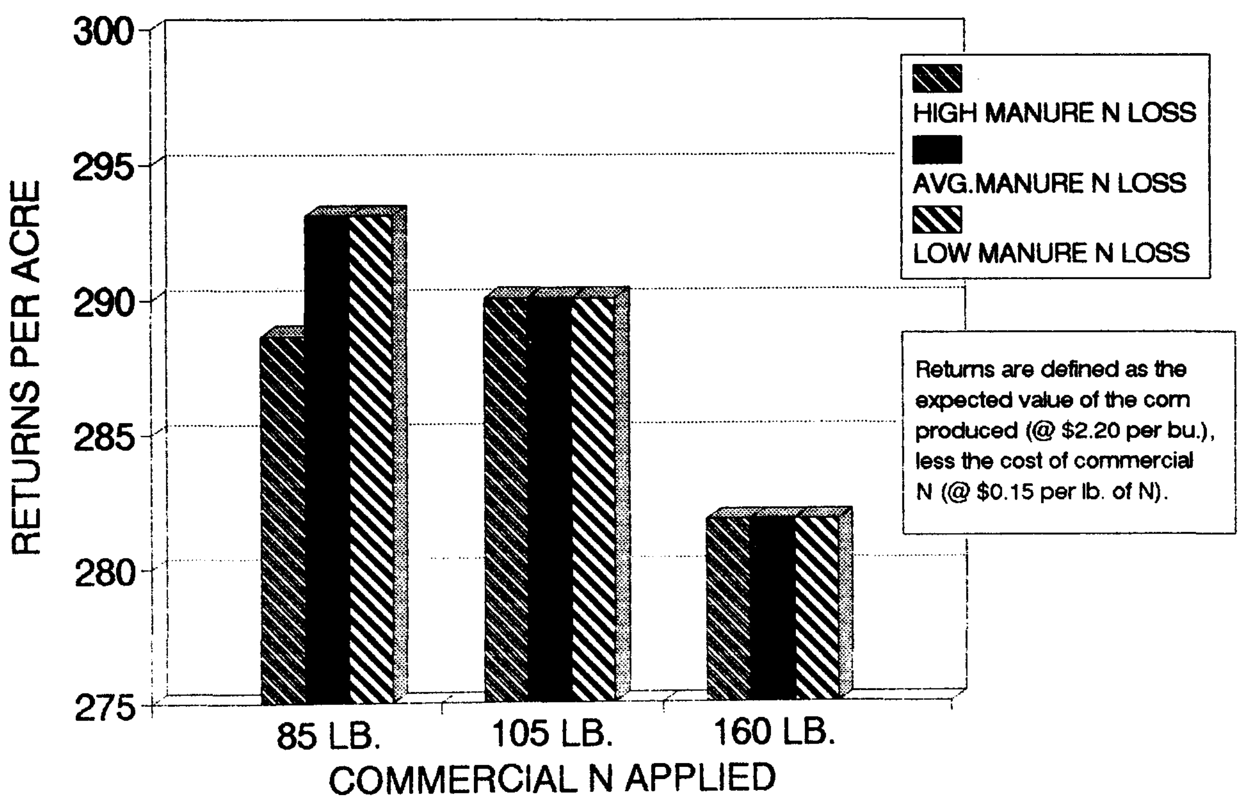
IV. HOW MUCH N IS IN YOUR MANURE?

The computations and conclusions above were specific to the example. Below are three publications that provide information which will assist you in estimating the nutrients in your manure.

"Utilization of Animal Manure as Fertilizer" Minnesota Extension Service Publication AG-FO-2613.

This publication provides all the factors necessary to compute manure nutrient production, losses, and amounts

FIG.2-RETURNS ON MANURED CORN
THREE N APPLICATION STRATEGIES



available to crops. Loss ranges, as well as averages are included. A worksheet is included for computing the average nutrients provided, additional commercial nutrients needed, and the minimum land area necessary for utilization of available manure.

"*Manure Management in Minnesota*", Minnesota Extension Service Publication AG-FO-3553.

This publication concisely describes the factors that should be considered in manure management decisions. A simple worksheet is provided to estimate the average per acre nutrients in manure applications.

Both of these publications are available for a nominal fee from:

Minnesota Extension Service Distribution Center
20 Coffey Hall
University of Minnesota
1420 Eckles Avenue
St. Paul, MN 55108

Livestock Waste Facilities Handbook, Midwest Plan Service Publication MPWS-18.

This includes the information from the other publications, as well as a detailed discussion of manure handling facilities and equipment. This book would be particularly useful to those considering changes in manure handling methods.

This publication is available, again for a nominal fee, from:

Midwest Plan Service
Iowa State University
Ames, IA 50011

V. SUMMARY

Many livestock farmers could reduce commercial N purchases, maintain crop yields, and reduce contamination of water supplies simply by taking appropriate credit for the N in applied manure. Determining the appropriate credit first requires an estimate of the N available to the crop from applied manure. Second, the amount of commercial N to apply to manured fields must be chosen.

Several sources of information are available to assist in estimating both the average and range of N a given application of manure will provide. While these computations require some effort initially, most livestock operations and manure handling and application methods are relatively stable, substantially simplifying subsequent computations.

Choosing a level of commercial N to add to the manure application is seemingly complicated by the fact that the actual N in manure applications varies. However, in most instances, the effects of low manure N (high losses) on yields and returns are surprisingly low. In most instances, the costs of adding commercial N for the purpose of insuring against low manure N exceed the losses prevented. This was illustrated by comparing strategies 1 and 2 above. In short, farmers will generally achieve the highest average profits by giving full credit to their manure. That is, if the available manure N is estimated to be 100 pounds per acre on a particular field, the best strategy is to reduce commercial applications by at or near the full 100 pounds of manure N.

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