Title: Evaluation of Nutrient Availability from Swine Manure – **NPB# 99-166**

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Abstract

To utilize swine manure nitrogen (N) to meet the needs of crops and protect water quality it is critical that we can confidently estimate the availability of the N. While total nutrient content of manure is easily determined using routine procedures in many labs, estimating the availability of these nutrients both to plants and to the environment is more difficult because of the complex makeup of manure. The availablity of manure N is sensitive to soil and climatic factors that affect microbial mineralization of the compounds that contain much of the N in manure. For this reason it is not possible to confidently use availability factors derived under conditions different from Pennsylvania. This project used experiments on swine farms in Pennsylvania to determine the N availability of swine manure under our conditions.

Several real world issues affected the results of this research. On many farms with a history of manure applications it is difficult to find fields that will respond to N application either from manure or fertilizer because of the residual effects of past manure applications. Also, we experienced the familiar difficulty in collecting representative manure samples. We observed large differences between the farmer's average analysis and the analysis of the manure that we actually applied in our plots. While neither of these issues was the focus of this research it provided good on-farm evidence that confirmed the need for better manure analysis programs and the need for using tools like the Presidedress Soil Nitrate Test (PSNT) or Chlorophyll Meter Test to evaluate the residual benefits from past manure applications when developing manure nutrient management plans. Seven of our on-farm locations yielded limited useful data on

manure N availability because of these two problems. Our results showed that swine manure N availability averaged 49%. Note however that the range was 40 to 76%. With out incorporation the average was 16%. This last number is based on very limited data. With these results we greater confidence in the availability factors used in Pennsylvania to develop nutrient management plans.

Introduction:

One of the main causes of nutrient pollution of water is over application of nutrients in animal manures. One of the reasons for over application of manure nutrients is the large amount of uncertainty about the availability and effectiveness of manure nutrients to meet crop needs. By reducing this uncertainty we can reduce the need for insurance fertilization and over application of manure nutrients and thus prevent excess nutrient applications and reduce nutrient pollution of water. Also, by increasing our understanding of the fate of land applied manure nutrients we can develop more effective BMPs to prevent nutrient pollution. Nutrient plan writers and reviewers use this information to develop and review farm nutrient management plans to match manure spreading to crop needs and protect water quality by reducing erosion and storm event losses of excess nutrients.
Manure nutrients have long been recognized as important contributors to crop nutrition and they have been identified as a potential non-point source of pollution to surface and ground water in Pennsylvania. While total nutrient content of manure is easily determined using routine procedures in many labs, estimating the availability of these nutrients both to plants and to the environment is more difficult. For example, average analyses from 16 swine herds indicated that of the total P in swine manure is broken down into 54.7% inorganic P, 29.7% acid soluble P, 0.4% lipid P, and 15.2% residual P.(Barnett, 1994) In fertilizer, which is the basis for making crop nutrient recommendations all of the P is in one form ie. inorganic P. Thus the availability of nutrients from manure is not the same as from fertilizer because of this complex makeup of the nutrient forms in manures.In Pennsylvania, because of lack of good research information on nutrient availability from swine manure, swine manure was lumped in with many other kinds of manures when this project was initiated. Thus the same nutrient availability factors are used for swine manure as are used for dairy manure even though the manures are very different because these animals have completely different digestive systems and nutritional requirements.

Because of the large proportion of organic forms of nutrients in manure the availablity is sensitive to soil and climatic factors that affect microbial mineralization of these organic compounds. For this reason it is not possible to confidently use availability factors derived under different conditions. For example in Pennsylvania, the mineralization factor for organic N in manure is 35%. In Virginia this factor is 50% (Givens, 1988). Is this due to errors in one or both of these factors or is it an indication of the climatic difference between Pennsylvania and Virginia? Han and Wolf (1992) also showed the effect of temperature and soil on mineralization of N from swine manure. For these reasons it is important that nutrient availability factors for swine manure be determined under soil and climatic conditions similar to where they will be used. Our past experience, primarily with dairy manure, has shown that, while there is significant variability in N availability from manure even within Pennsylvania, N availability factors determined from Pennsylvania and across the northern corn belt are similar. Thus, with appropriate caution, the results of research in on N availability from swine manure in Pennsylvania would also likely be useful across this same region.

From the data collected in the on-farm experiments conducted here, the nutrient fertilizer equivalence of swine manure can be determined and factors specific to swine manure can be added to management tables such as in the Penn State Agronomy Guide (Beegle, 1997) and the

Pennsylvania Manure Management Manual. The information in these references are critical for the development of nutrient management plans. This will enable farmers to utilize swine manure with greater confidence that the nutrient availabilities estimated based on their analysis and these factors will be accurate. This, in turn, can improve the economics of crop production using swine manure and reduce the potential for environmental problems due to excess nutrient applications because of uncertainty in estimating manure nutrient availability.

References:
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Objectives:

1. Determine the fertilizer equivalent availability of nutrients in swine manure under Pennsylvania soil and climatic conditions.

2. Develop predictive tools that can be used to assist farmers in managing swine manure nutrients for maximum agronomic and economic benefit with minimum environmental impact.

Procedures

Over the three years of this project field plots were established at 4 on-farm locations each year. The locations were in Union Co., Northumberland Co., and Snyder Co. in central Pennsylvania. In 1999 one plot was lost due to drought, and in 2001 two plots were lost due to farmer error in managing the plot areas. Swine manure from each of the farms was to be applied at a rate to supply 200 lb total N/A. This rate was selected assure that it would be within the responsive range This rate was determined based on the farmer's historical manure analysis and analyses of samples collected by project personnel. Manure was precisely applied at this rate using a scale mounted liquid manure applicator. Actual manure used was sampled and analyzed to determine exact rate of manure N application (Table 1). Because of variability in the manure nutrient content a recurring problem in this project was that the actual manure N applied often did not match the planned rate. At 3 out of the 9 locations excessive manure N was applied. Modifications in the procedure were made which helped some but did not completely eliminate the problem.

Soil tests were taken from each plot area prior to application of the treatments. Nitrogen fertilizer was applied at 0, 50, 100, 150, and 200 lb N/A as ammonium nitrate. Each set of treatments was split with one set being incorporated by the farmer immediately following application and the other set left on the surface for at least one week before incorporation. All treatments were replicated 4 times.

Table 1: Manure analysis and the weight of nitrogen applied per acre based on that analysis for each site/year of the experiments.

Location (Yr)	Manure Analysis (lb/ton)					Total applied lb N/A
	Total N	NH_4-N	Organic N	Total P_2O_5	Total K_2O	
Union (99)	7.3	5.1	2.3	3.1	3.8	340
Snyder (99)	11.1	7.2	3.9	9.8	5.9	387
Northumberland (99)	5.4	4.6	0.8	2.7	4.5	188
Union-W (00)	3.8	2.3	1.6	0.6	2.8	99
Union-K (00)	14	4.9	9.1	2.8	4.3	326
Snyder (00)	12	6.0	6.0	11.9	5.8	178
Northumberland (00)	6.9	5.3	1.6	1.3	4.3	160
Union-K (01)	13.3	8.9	4.4	5.0	6.9	185
Northumberland (01)	6.9	5.3	1.6	1.3	4.3	160

Corn was planted by the farmer at each location. All plot locations were established in a timely manner. Generally early growth was very good. After corn emergence plot boundaries were reestablished and alleys cut in the plots. At the 6-8 leaf stage of corn development each plot was sampled for the pre-sidedress soil nitrate test (PSNT). At this same time chlorophyll meter readings were taken from the plots. Corn was harvested for grain using a plot combine to determine yield and moisture. Data were analyzed using analysis of variance and linear regression. We used a 95% confidence level in interpreting the data. In the tables this is indicated by a prob<f less than 0.05.

Results

Since there was no interaction between the treatments and incorporation, the main effect of the N and manure treatments will be presented combined over the incorporation treatments. Likewise the incorporation treatments will be presented combined over the N and incorporation treatments and for the manure treatments only. This will simplify the presentation and interpretation of the data.

Chlorophyll Meter

Data from the chlorophyll meter readings from all of the plots taken at the V6 stage of growth are shown in Table 2a, b, c. The analysis of variance for this data indicated that there were significant differences in the chlorophyll meter readings due to the experimental treatments at 6 out of 9 experimental locations. The main response was that adding N or manure generally increased the chlorophyll meter readings compared to the 0 N treatment as would be expected. However, there were very few differences between the different fertilizer or manure treatments. This indicated that the manure rates were in the non-responsive range in most of these experiments. At 5 of the 9 locations the chlorophyll meter readings in the check plots were high indicating that there was significant residual N in the soil to begin with. This was not expected because the main criteria for choosing the field locations was to choose fields based that would be expected to have low residual N. This high residual N made it difficult to evaluate the availability of the swine manure that we applied since in most of these cases there was plenty of N already in the soil regardless of what we applied. Yield data (discussed later) confirmed what the chlorophyll meter readings were indicating. The chlorophyll meter correctly predicted crop response or, more often, lack of a response to N at 7 of the 9 locations.

Table 2a: Analysis of variance and mean chlorophyll meter readings resulting from the N and manure treatments for the 1999 cropping season

Treatment	Union	Snyder	Northumberland
0	41 a**	50 a	48 a
50	45 b	52 b	53 b
100	46 b	53 bc	55 bc
150	46 b	55 d	55 bc
200	46 b	54 cd	55 c
Manure*	47 b	57 e	55 c
prob < f	0.0010	0.0001	0.0001

* See Table 1 for amount of N applied per acre.
** Means followed by the same letter in a column are not significantly different from each other at $p < .05$

Table 2b: Analysis of variance and mean chlorophyll meter readings resulting from the N and manure treatments for the 2000 cropping season..

Treatment	Union-W	Union-K	Snyder	Northumberland
0	41 a**	46 a**	49	55
50	47 c	50 b	49	54
100	47 c	55 cd	49	51
150	47 c	56 de	49	55
200	48 c	57 e	51	56
Manure*	45 b	53 c	49	56
prob < f	0.0001	0.0001	0.4761***	0.3526 ***

* See Table 1 for amount of N applied per acre.
** Means followed by the same letter in a column are not significantly different from each other at $p < .05$
*** Not significant at $p < .05$

Table 2c: Chlorophyll meter reading for N and manure treatments combined over incorporation for the 2001 cropping season.

Treatment	Union	Northumberland
0	39.5 a**	47.4
50	42.5 b	48.7
100	45.3 c	48.9
150	45.7 c	49.7
200	47.0 c	49.2
Manure*	43.1 b	48.5
prob < f	0.0001	***0.0882

* See Table 1 for amount of N applied per acre.
** Means followed by the same letter in a column are not significantly different from each other at $p < .05$
*** Not significant at $p < .05$

Immediate incorporation of manure should reduce the volatilization loss of ammonia N from the manure. However as seen in tables 3 a, b, c, there was no significant effect on chlorophyll meter readings due to incorporation of the manure.

Table 3a: Effect of incorporation of manure on chlorophyll meter readings for the 1999 cropping season†.

Treatment	Union	Snyder
Incorporated Unincorporated	47.1 46.7	57.6 55.7
prob < f	0.6032***	0.2593***

†Incorporation was not completed by the farmer as planned therefore it could not be tested at the Northumberland location this year.

*** Not significant at p < .05

Table 3b: Effect of incorporation of manure on chlorophyll meter readings for the 2000 cropping season.

Treatment	Union-W	Union-K	Snyder	Northumberland
Incorporated Unincorporated	44.5 45.3	52.4 53.2	48.9 49.8	54.8 56.3
prob < f	0.5404***	0.4987***	0.3155***	0.1089***

*** Not significant at p < .05

Table 3c: Effect of incorporation of manure on chlorophyll meter readings for the 2001 cropping season.

Treatment	Union	Northumberland
Incorporated Unincorporated	42.4 43.8	48.8 48.2
prob < f	0.1523***	0.4461***

* See Table 5 for amount of N applied per acre.

*** Not significant at p < .05

Pre-sidedress Soil Nitrate Tests (PSNT)

Data from the PSNT from all of the plots taken at the V6 stage of growth are shown in Table 4a, b, c. The analysis of variance for this data indicated that there were significant differences in the PSNT readings due to the experimental treatments at all experimental locations. The main response was that adding N or manure generally increased the PSNT compared to the 0 N treatment as would be expected. However, there were more differences between the different fertilizer or manure treatments than there was with the chlorophyll meter readings. Again as with the chlorophyll meter readings, at 6 of the 9 locations the PSNT in the check plots were high indicating that there was significant residual N in the soil to begin with. The PSNT only correctly predicted crop response or, more often, lack of a response to N at 5 of the 9 locations. Usually the PSNT and the chlorophyll meter test give similar results.

Table 4a: Analysis of variance and mean PSNT nitrate-N levels resulting from the N and manure treatments for the 1999 cropping season.

Treatment	Union	Snyder	Northumberland
	ppm		
0	24 a**	34 a**	25 a**
50	41 a	48 a	36 ab
100	49 ab	69 b	47 bc
150	73 bc	94 c	65 d
200	85 c	106 c	65 d
Manure*	95 c	91 c	55 cd
prob < f	0.0002	0.0001	0.0001

* See Table 1 for amount of N applied per acre.

** Means followed by the same letter in a column are not significantly different from each other at p < .05

Table 4b: Analysis of variance and mean PSNT nitrate-N levels resulting from the N and manure treatments for the 2000 cropping season.

Treatment	Union-W	Union-K	Snyder	Northumberland
0	14 a**	16 a**	31 a**	46 a**
50	22 b	27 b	32 a	58 ab
100	27 b	38 cd	38 ab	62 ab
150	34 c	44 d	35 ab	89 c
200	50 d	57 e	46 b	110 d
Manure*	22 b	33 bc	30 a	73 bc
prob < f	0.0001	0.0001	0.0065	0.0001

* See Table 1 for amount of N applied per acre.

** Means followed by the same letter in a column are not significantly different from each other at p < .05

Table 4c: Analysis of variance and mean PSNT nitrate-N levels resulting from the N and manure treatments for the 2001 cropping season.

Treatment	Union	Northumberland
0	8.2 a**	31.4 a**
50	10.9 ab	43.3 a
100	19.5 c	64.7 bc
150	20.5 c	63.8 bc
200	28.9	81.3 c
Manure*	17.3 bc	47.7 ab
prob < f	0.0003	0.0002

* See Table 1 for amount of N applied per acre.

** Means followed by the same letter in a column are not significantly different from each other at p < .05

As seen in tables 5 a, b, c, there was only one significant effect on PSNT due to incorporation of the manure. At the Northumberland location in 2000 there was a significantly higher PSNT level when the manure was incorporated that when it was not. This is what was expected.

Table 5a: Effect of incorporation of manure on Pre-sidedress Soil Nitrogen Test for year 1999 .

Treatment	Union	Snyder
	ppm	
Incorporated	82.7	90.3
Unincorporated	107	92.3
prob < f	0.2637***	0.9373***

*** Not significant at p < .05

Table 5b: Effect of incorporation of manure on Pre-sidedress Soil Nitrogen Test for year 2000

Treatment	Union-W	Union-K	Snyder	Northumberland
Incorporated	24.5	40.0	33.7	95.1
Unincorporated	21.0	31.5	36.8	50.1
prob < f	0.2702***	0.0693***	0.3321***	0.0341

*** Not significant at p < .05

Table 5c: Effect of incorporation of manure on Pre-sidedress Soil Nitrogen Test for year 2001.

Treatment	Union	Northumberland
Incorporated	15.5	38.4
Unincorporated	19.2	57.1
prob < f	0.4818***	0.6956***

*** Not significant at p < .05

Soil Ammonium Nitrogen

Because of the rapid conversion of ammonium N to nitrate N in the soil it was not expected that there would be a significant response in ammonium N levels due to the N or manure treatments. Data from the ammonium N levels from all of the plots taken at the V6 stage of growth are shown in tables 6a,b,c. The analysis of variance for this data indicted that there were significant differences in the ammonium levels due to the experimental treatments at the 3 Union County locations in 1999 and 2000. However these results were generally very low and there was no trend

Table 6a: Analysis of variance and mean ammonium-N levels resulting from the N and manure treatments for year 1999

Treatment	Union	Snyder	Northumberland
	ppm		
0	6 a**	6	7
50	6 a	7	7
100	7 ab	8	8
150	12 bc	8	8
200	15 c	10	8
Manure*	9 ab	11	8
prob < f	0.0218	0.3239***	0.9468***

* See Table 1 for amount of N applied per acre.

** Means followed by the same letter in a column are not significantly different from each other at p < .05

*** Not significant at p < .05

Table 6b: Analysis of variance and mean ammonium-N levels resulting from the N and manure treatments for year 2000

Treatment	Union-W	Union-K	Snyder	Northumberland
0	7.1 a**	5.5 ab**	8.6	7.7
50	7.1 a	4.8 a	8.5	7.5
100	7.5 a	7.2 bc	9.2	6.6
150	7.4 a	7.7 c	8.5	7.6
200	10.7 b	9.1 c	8.4	9.1
Manure*	7.1 a	5.5 ab	9.4	7.4
prob < f	0.0003	0.0033	0.7831***	0.0855***

* See Table 1 for amount of N applied per acre.
** Means followed by the same letter in a column are not significantly different from each other at p < .05
*** Not significant at p < .05

Table 6c: Analysis of variance and mean ammonium-N levels resulting from the N and manure treatments for year 2001

Treatment	Union	Northumberland
0	5.1	5.0
50	4.8	5.2
100	6.0	6.9
150	5.2	6.3
200	5.9	5.0
Manure*	5.1	5.0
Prob < f	0.2778***	0.0721***

* See Table 1 for amount of N applied per acre.
*** Not significant at p < .05

The effect of the incorporation of the manure on ammonium N in (Tables 7 a, b, c) was also significant at the Northumberland and Union K locations in 2000. There was a significantly higher ammonium N level when the manure was incorporated that when it was not. Again, this is what was expected.

Table 7a: Effect of incorporation of manure on soil ammonium-N for year 1999

Treatment	Union	Snyder
	Ppm	
Incorporated	8.6	14.2
Unincorporated	9.2	7.6
prob < f	0.7580***	0.5211***

*** Not significant at p < .05

Table 7b: Effect of incorporation of manure on soil ammonium-N for year 2000.

Treatment	Union-W	Union-K	Snyder	Northumberland
Incorporated	7.7	7.5	8.7	8.8
Unincorporated	6.5	5.7	8.8	6.1
prob < f	0.3551***	0.0149	0.8901***	0.0019

*** Not significant at p < .05

Table 7c: Effect of incorporation of manure on soil ammonium-N for year 2001.

Treatment	Union	Northumberland
Incorporated	5.1	3.7
Unincorporated	5.1	6.4
prob < f	0.9883***	0.1138***

*** Not significant at p < .05

Corn Grain Yield

Corn grain yield data taken at the maturity are shown in tables 8a,b,c. The chlorophyll meter test predicted that there would be a positive yield response at 4 locations and the PSNT predicted a response at 3 locations. There were actually 5 positive yield responses due to the treatments. There was a negative yield response at the Northumberland location in 1999. We have no explanation for this. While there were significant yield responses at 5 locations the magnitude of the response was generally very small, less than 50 to 100 lb N/A. The expected response on fields with a low residual N level would be more in the 130 to 160 lb N/A range. However, as noted earlier even though the farmers indicated that these field should have a low residual N history the Chlorophyll meter readings, the PSNT levels and now the yield data all seem to indicate that these field actually had a fairly high residual N level. This combined with the difficulty actually applying the planned amount of manure N made it very difficult to accurately determine the availability of the manure N.

Table 8a: Analysis of variance and mean corn grain yields resulting from the N and manure treatments for year 1999.

Treatment	Union	Snyder	Northumberland
	bu/A		
0	119 a**	134	116 b**
50	137 a	120	119 b
100	175 b	127	101 a
150	163 b	120	106 a
200	167 b	135	102 a
Manure*	172 b	124	101 a
prob < f	0.0001	0.1224***	0.0004

* See Table 1 for amount of N applied per acre.
** Means followed by the same letter in a column are not significantly different from each other at p < .05
*** Not significant at p < .05

Table 8b: Analysis of variance and mean corn grain yields resulting from the N and manure treatments for year 2000

Treatment	Union-W	Union-K	Snyder	Northumberland
0	76 a**	110 a**	144	183
50	105 b	125 b	128	182
100	109 bc	128 bc	139	193
150	110 bc	140 d	134	179
200	117 c	130 bc	141	178
Manure*	106 bc	134 cd	133	185
prob < f	0.0001	0.0001	0.7911***	0.4084***

* See Table 1 for amount of N applied per acre.
** Means followed by the same letter in a column are not significantly different from each other at p < .05
*** Not significant at p < .05

Table 8c: Analysis of variance and mean corn grain yields resulting from the N and manure treatments for year 2001

Treatment	Union	Northumberland
0	60 a**	141 a **
50	65 ab	153 b
100	75 c	173 c
150	73 bc	166 c
200	79 c	163 bc
Manure*	72 bc	169 c
prob < f	0.0084	0.0001

* See Table 1 for amount of N applied per acre.
** Means followed by the same letter in a column are not significantly different from each other at p < .05

The effect of the incorporation of the manure on Yield in (Tables 9 a, b, c) was significant at only one location. Surprisingly though it was the Union county location in 2001 not the Northumberland location in 2000 where the PSNT and ammonium N levels were significantly higher. In this instance, the yield was higher when the manure was incorporated than when it was not. This is what was expected to see at all locations.

Table 9a: Effect of incorporation of manure on corn grain yield for year 1999

Treatment	Union	Snyder
	bu/A	
Incorporated	174	129
Unincorporated	169	119
prob < f	0.6098***	0.5865***

*** Not significant at p < .05

Table 9b: Effect of incorporation of manure on corn grain yield for year 2000.

Treatment	Union-W	Union-K	Snyder	Northumberland
Incorporated	103	128	132	186
Unincorporated	108	128	141	184
prob < f	0.6589***	0.8779***	0.1674***	0.6889***

*** Not significant at p < .05

Table 9c: Effect of incorporation of manure on corn grain yield for year 2001.

Treatment	Union	Northumberland
Incorporated	78	173
Unincorporated	66	164
prob < f	0.0467	0.6857***

*** Not significant at p < .05

Significance of the Findings and Recommendations

Difficulties were encountered in selecting fields that would have a low residual N level based on farmer information, consequently we only got a significant response to N on 5 out of the 9 locations. In only 3 out of these 5 locations (Union W 2000, Union K 2000, Union K 2001) where there was a significant response was the manure treatment within the responsive range so that N availability could be calculated. The other locations received excessive rates of manure N based on the farmer's historical manure analysis. For the three sites where we could calculate an N availability factor the average N availability factor was 49%. At the one site (Union K 2001) where there was a significant difference due to incorporation the availability factor for unincorporated swine manure was only 16%. Both of these factors agree very closely with the traditional N availability factors for swine manure of 50% for incorporated swine manure and 20% for unincorporated swine manure. At the two other locations where there was a significant response to N but excess manure N applied, while we cannot calculate the exact availability factor we can confidently calculate that at the Union 99 location the availability factor is at least 40% and at the Northumberland 2001 location the availability factor was at least 76%.

It is very disappointing that out of 12 experiments we only ended up with 5 which gave us results that we could be confident in. However, all of those confirmed the validity of the availability factors that we have traditionally used to manage swine manure in Pennsylvania. However, this pointed out the value of using tools such as the PSNT and Chlorophyll Meter Test to fine tune manure management decisions. The sites selected for this study were chosen because the farmer felt that there should be low residual N in these soils. However, 7 of the 12 sites actually had high residual soil N. Adding any N, either fertilizer or manure, to these sites would not have been economical. However without additional information, the farmers would have added N at a significant cost. Based on this research, use of the PSNT or Chlorophyll Meter Test would have provided accurate information on the levels of residual N and thus the likelihood of a profitable response from adding N for a cost of less than $1 per acre. Our experience in similar situations (not based on data from these specific experimental sites), is that the common practice in this type of situation would have been to apply additional fertilizer N to these sites costing from $20 to $40 per acre applied. Therefore using one of these tests on 7 of the 12 farms in our research could have saved the farmers this significant cost. Also, any unnecessary N applied to these non-responsive fields would have been likely to contribute to environmental degradation.

At the 5 sites where there was a response to N, in all but one case the manure rate applied in our research would have been very close to supplying adequate N for optimum economic yields. The PSNT and Chlorophyll Meter Test both accurately indicated that the manure was supplying adequate N and that little or no additional N was needed. This potentially saved the farmers the cost of additional fertilizer N and the cost and time to sidedress the crop. Again based on common practice in Pennsylvania, insurance fertilization on top of manure applications typically would have cost the farm approximately $20 per acre. This additional cost could have been avoided for the less than $1 per acre cost of using these tests. In the one case where the manure application in our research was well below the amount needed to meet the N requirement of the crop, both tests would have accurately told the farmer that additional N was required for optimum economic yield. In this one case, applying the necessary N would have resulted in approximately $6 per acre greater profit compared to not applying the N.

Results of this work have been published in the Manure Nitrogen Availability tables in the Current Penn State Agronomy Guide and are being used as the official availability factors for nutrient management plans in Pennsylvania.

Evaluation of Nutrient Availability from Swine Manure

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Manure nitrogen (N) is a very valuable component of crop production systems and also at times is can be an environmental concern, thus it must be carefully managed to maximize the economic benefits and minimize the potential environmental impact. A key to successful manure management is balancing the crop N requirements with the available N in manure. Because of the many different mineral and organic forms of N in animal manures, the availability of manure N is not the same as fertilizer N. To confidently utilize the N in manure to meet the needs of crops, in addition to knowing the total amount of N in the manure, we must also be able to accurately estimate the availability of that N. Nitrogen availability factors for swine manure have been used in Pennsylvania for many years. The original work to determine these factors is very old. Concerns have been raised regarding the validity of these availability factors in modern swine production systems. Thus, the main objective of this research was to determine the fertilizer equivalent availability of N in swine manure under Pennsylvania soil and climatic conditions.

Over the three years of this project plots were established at 4 on-farm locations each year in central Pennsylvania. Swine manure from each of the farms was precisely applied using a scale mounted liquid manure applicator. Also, a range of nitrogen fertilizer rates were applied. The manure was sampled and analyzed to determine exact rate of manure N application. A practical problem encountered in the research, that also has broader implications, is that we saw extreme variability in the manure analyses both within and between these farms. This reinforces the critical need for a comprehensive manure analysis program on swine farms Because it is well established that incorporation can influence the availability of manure N, each set of treatments was split with one set being incorporated by the farmer immediately following application and the other set left on the surface for at least one week before incorporation. Nitrogen status in the research plots was monitored using chlorophyll meter N tests and pre-sidedress soil nitrate tests (PSNT). The ultimate measurement was corn grain yield for each treatment.

The results of this research were mixed. To successfully estimate N availability from manure experimental locations with low soil N must be used. This was the primary criteria for selecting the fields for this research. However, only 5 out of 12 locations selected based on farmer knowledge of the field history were low enough to even get a N response. In other words 7 of the 12 locations had more than enough N to grow maximum corn yield with no additional N. The broader implication of this is that farmers maybe generally underestimating the residual N levels in their fields and thus over applying fertilizer N at a significant economic cost to them and increased threat to the environment. The results of this research showed that the use of the Chlorophyll meter test or the PSNT by farmers would be very helpful in avoiding this over fertilization in manure systems. At the locations where we did get a response to swine manure N and thus could accurately evaluate the N availability the average availability factor was 49%. This compares very well with the traditional availability factor of 50%. We were only able to measure the effect of incorporation on N availability at one location. At that location the availability factor was 16% which again compares well with the traditional factor or 20%.

To summarize, there are three important conclusions from this research. First farmers tend to underestimate the residual N levels in their soils which may lead to over application of N fertilizer. Use of the PSNT or Chlorophyll Meter Test could significantly help correct this problem. Second, manure analyses vary considerably within and between farms. Thus a good program of manure analysis is essential if manure is to be confidently used as a nutrient source for economic crop production and so as not to harm the environment. Finally, the availability factors determined from this research seem to confirm the validity of the availability factors traditionally used to manage swine manure in Pennsylvania.