NITROGEN AVAILABILITY FROM VARIOUS MANURE COMPONENTS[1/]

P.R. Cusick, J.M. Powell, R.F. Hensler, and K.A. Kelling[2/]

Introduction

Manure N mineralization in soil determines manure N availability for crop uptake. In this study we evaluated the N mineralization of dairy manure components (feces, urine and bedding) in soils under different environmental conditions. Soil texture and other controls, such as moisture and temperature, create environments where great differences in manure N mineralization are anticipated to occur. Understanding the influence of these factors under field conditions is crucial to better predicting the amount and rate of how manure N becomes available to agronomic crops.

The objective of this incubation study is to understand how soil type and temperature affect N mineralization of individual dairy manure components (feces, urine and bedding) by use of unlabeled and ^{15}N labeled manure components.

Materials and Methods

A laboratory incubation study was conducted in which ^{15}N-labeled or unlabeled feces, urine and oat straw bedding were incubated in soil for 168 days. Manure amendments were applied at a rate equivalent to 313 lb N acre^{-1} (36% derived from feces, 42% from urine and 22% from bedding) into incubation vessels (2 qt glass jars containing 250 g soil dry weight).

Table 1. Treatment list.

Treatment 1	**^{15}N Feces**, ^{14}N Urine, ^{14}Bedding
Treatment 2	^{14}N Feces, **^{15}N Urine**, ^{14}Bedding
Treatment 3	^{14}N Feces, ^{14}N Urine, **^{15}Bedding**
Treatment 4	**^{15}N Feces, ^{15}N Urine, ^{15}Bedding**
Treatment 5	Control (no manure applied)

Triplicate vessels per manure treatment plus controls were packed to natural bulk density, kept at 60% water filled pore space and incubated at 52, 64, or 77 F°. Vessels were sampled at 0, 14, 21, 42, 84, and 168 days and analyzed for mineralized N (NH_4^+ and NO_3^-) and ^{15}N abundance at day 168. Mineralized N was determined using a 2 M

[1/] Research support provided by the UW Consortium for Agriculture and Natural Resources, the UW-Madison College of Agricultural and Life Sciences and USDA-ARS is gratefully acknowledged.

[2/] Research Assistant, Professor and Extension Soil Scientist, Dept. of Soil Science, Univ. of Wisconsin-Madison. Assoc. Scientist, U.S. Dairy Forage Research Ctr., Univ. of Wisconsin-Madison. Professor, College of Natural Resources, Univ. of Wisconsin-Stevens Point.

KCl extraction and analyzed using QuickChem Method 12-107-04-1-B (NO_3^-) and 12-107-06-2-A (NH_4^+) (Lachat Instruments, Milwaukee, WI). The ^{15}N abundance was determined using a micro diffusion technique used by Stark and Hart (1996) and analyzed using a Carlo Erba (Milan, Italy) elemental analyzer couple with a Europa 20/20 tracermass at the University of California-Davis, Stable Isotope Facility.

Six soils were selected to represent dairying areas within the state of Wisconsin, their types and characteristics may be found in Table 2. Soils were air-dried and passed through a 2-mm sieve. Soils throughout the incubation period were aerated for 1 hr each day or covered with saran wrap on weekends and corrected for moisture loss when needed.

Table 2. Initial soil properties.

Soil Series	Texture	Tot-C	Tot-Org-C	Inorg-C	Bray-P1	Total N	Sand	pH
		%	%	%	mg/kg	%	%	
Loyal	Silt Loam	**2.61**	**2.35**	**0.26**	**42**	**0.212**	**13**	**7.0**
	Fine-loamy, mixed, superactive, frigid Oxyaquic Glossudalfs							
Plano	Silt Loam	**3.55**	**2.56**	**0.99**	**72**	**0.222**	**26**	**7.4**
	Fine-silty, mixed, superactive, mesic Typic Argiudolls							
Rozetta	Silt Loam	**1.82**	**1.23**	**0.59**	**32**	**0.163**	**4**	**6.8**
	Fine-silty, mixed, superactive, mesic Typic Hapludalfs							
Catlin	Silt Loam	**2.86**	**n/a**	**n/a**	**n/a**	**0.173**	**14**	**n/a**
	Fine-silty, mixed, superactive, mesic Oxyaquic Argiudolls							
Symco	Sandy Loam	**0.81**	**0.80**	**0.01**	**35**	**0.087**	**73**	**6.3**
	Fine-loamy, mixed, mesic Aquollic Hapludalfs							
Rosholt	Sandy Loam	**0.87**	**0.83**	**0.04**	**42**	**0.087**	**53**	**5.7**
	Coarse-loamy, mixed, superactive, frigid Haplic Glossudalfs							

Results and Discussion

As it is shown in Table 3, we found that soil type had a significant effect on N mineralization of feces ($p=0.0001$) and straw ($p=0.0093$). Temperature had a significant effect on N mineralization of feces ($p=0.0001$), straw and all components ($p=0.0003$). An interaction between soil type and temperature was found in straw mineralization.

Soil type and temperature did not have a significant effect on ^{15}N urine likely due to the rapid breakdown of most, if not all urine in the soil. Average ^{15}N recovered in the mineralized N fraction from urine over all soils and temperatures is 55%. Because it is unlikely losses occurred during the incubation, the remaining 45% unaccounted for may have exchanged with unlabeled N or may have been immobilized. In a comparable field study performed in 2001 on a Plano silt loam at West Madison Agricultural Research Station, Madison, WI (unpublished) it was found that 31% of urine ^{15}N was uptaken in corn (*Zea mays L.*). The difference between N availability in the lab versus N uptake in the field illustrates that urine N may be readily available but losses are expected to occur.

Soil type had a significant effect on fecal ^{15}N mineralization with Plano and Symco soils having the highest. It is unclear based on the physical properties of these soils why they mineralized the highest amount of ^{15}N from the feces. Temperature also had a significant effect on the mineralization of fecal ^{15}N. Highest mineralization was found at the highest temperature, 77ºF. In the same field study on the Plano silt loam, 17% ^{15}N uptake was found in the fecal portion, whereas the incubation trial found that 19% of the ^{15}N from the fecal portion was available in the Plano silt loam.

Soil type and temperature interacted for straw ^{15}N mineralization. Plano, Symco and Loyal soils had increasing ^{15}N mineralization with increasing temperature. The Rosholt soil decreased ^{15}N mineralization with increasing temperature. The Rozetta soil ^{15}N mineralization remained stable for all temperatures. It should be noted that straw N mineralization was similar to fecal N mineralization, averaging 17 and 15%, respectively over all soils and temperatures.

Soil type did not have an effect on ^{15}N mineralization when all components were labeled. Temperature was significant with the highest mineralization occurring at 52 and 77ºF. Average ^{15}N mineralized over all soils and temperatures was 23%. Average manure ^{15}N mineralization by adding component averages equaled 32%. Muñoz (2001) on the Plano silt loam, found 14% uptake of ^{15}N in corn averaged over 3 yr of data. Only feces and urine were labeled in the Muñoz trial and bedding contributions were not considered. University of Wisconsin recommendations for first year N availability of dairy manure are 30% when surface applied and 40% when incorporated (Kelling et al., 1998). Though these data suggest that recommendations may be high, it should be noted that isotopic studies generally underestimate availability due to labeled nitrogen exchanging with organic N pools, releasing unlabeled N pools. Isotopic estimations can be viewed as a minimum availability.

Conclusion

Further investigation is needed to understand how soil type effects N availability of dairy manure components namely bedding and feces. Urine N availability is estimated at 55% regardless of soil type or temperature. The urine fraction may be responsible for the lack of significance for soil type when all components were labeled.

Acknowledgments

The authors appreciated the diligent effort of Jennifer Hegge and Chris Fellner, Univ. of Wisconsin- Stevens Point in the daily maintenance of this experiment.

References

Kelling, K.A., L.G. Bundy, S.M. Combs, and J.B. Peters. 1998. Soil test recommendations to field, vegetable and fruit crops. Univ. of Wisconsin Extension. Pub. A2809.

Muñoz, G.R. 2001. Estimate of manure availability using ^{15}N-labeled manure and other techniques. M.S. Thesis, Dept. of Soil Science, Univ. of Wisconsin, Madison.

Stark, J.M., and S.C. Hart. 1996. Diffusion technique for preparing salt solutions, Kjeldahl digests and persulfate digests for nitrogen-15 analysis. Soil Sci. Soc. Am. J. 60:1846-1855.

Table 3. Mineralized ^{15}N recovered from labeled manure components over various soils and temperatures.

Soil type	Fecal ^{15}N‡				Urine ^{15}N ‡				Straw ^{15}N ‡				All Components ^{15}N ‡			
	11ºC	18ºC	25ºC	Soil Avg.	11ºC	18ºC	25ºC	Soil Avg.	11ºC	18ºC	25ºC	Soil Avg.	11ºC	18º C	25º C	Soil Avg.
	-----% ^{15}N Recovered-----															
Loyal	8	8	12	**10**	52	45	69	**55**	12	20	19	**17**	20	23	25	**22**
Symco	20	16	27	**21**	49	54	56	**53**	14	16	22	**18**	26	19	23	**23**
Plano	13	18	26	**19**	44	60	63	**55**	15	24	25	**22**	24	30	36	**30**
Rozetta	12	5	15	**11**	61	61	59	**60**	15	12	16	**14**	40	18	30	**29**
Rosholt	15	7	16	**13**	52	46	51	**50**	20	14	15	**16**	25	16	22	**21**
Catlin	-----	-----	-----		-----	-----	-----		-----	-----	-----		16	13	10	**13**
Temp Avg.	**14**	**11**	**19**		**51**	**53**	**60**		**15**	**17**	**19**		**25**	**20**	**24**	

-----Statistical Significance-----

	Fecal Pr>F	Fecal LSD	Urine Pr>F	Urine LSD	Straw Pr>F	Straw LSD	All Pr>F	All LSD
Soil	0.0001	3.81	0.2467	NS	0.0093	*	0.0924	NS
Temp	0.0001	2.95	0.5932	NS	0.0015	*	0.0003	5.01
S*T	0.0989		0.6240		0.0036		0.1003	

‡See treatment list in Materials and Methods for details.

*Interaction significant at p=0.05