Study of Dairy Manure N Cycling in Soil-Plant Continuum Using ^{15}N and Other Methods

J. M. Powell
USDA, Agricultural Research Service

P. R. Cusick

K. A. Kelling

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J.M. Powell[1], P.R. Cusick and K.A. Kelling
U.S. Department of Agriculture, Agricultural Research Service, Dairy Forage Research Center, 1925 Linden Dr. West, Madison, WI 53706, USA, Soil Science Department, 1525 Observatory Dr., University of Wisconsin, Madison WI 53706, USA, Email: jmpowel2@wisc.edu

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Introduction Ruminant livestock manure impacts on N cycling in the soil-plant continuum. Most studies of manure N cycling are short-term and rely on indirect methods, i.e. apparent N recovery, fertiliser N equivalents or incorporate ^{15}N into ammonium-N fractions. Direct and perhaps more precise measurements may be achieved by long-term studies using ^{15}N incorporated into all manure N components. This paper summarises results of a 6-year trial to compare indirect and direct measures of manure N uptake by corn for 3 years after application.

Materials and methods ^{15}N enriched dairy manure, obtained by feeding ^{15}N enriched forage (Powell *et al*., 2005) was applied to corn (*Zea mays*) plots on a Plano silt loam (Typic Argiudolls) at rates equivalent to 210 kg N/ha every 1, 2 or 3 years in south central Wisconsin (45° 05' N, 89° 31' W) during 1998-2003 (Cusick, 2004). There were also non-manure control and fertiliser N (0, 45, 90, 135, 179 and 224 kg N/ha as NH_4NO_3) plots. Apparent manure N recovery was determined as differences (DIFF) in corn N uptake in manure-amended and control plots, divided by applied manure N. Fertiliser N equivalent (FE) was interpolated from applied fertiliser N (x) and total corn N uptake (y) regressions. Manure N availability was determined by dividing FE by manure N applied.

Results 1st, 2nd and 3rd year estimates of manure N uptake by corn (Table 1) were 25, 6 and 2% in plots amended with manure ^{15}N; 25, 6 and 0% by DIFF; and 55, 24 and 25% by FE. Although manure ^{15}N and DIFF provided similar estimates, the variability associated with DIFF was much greater, especially for years 2 and 3. Estimate variabilities were greatest with FE. Low manure ^{15}N uptake by corn was due to high background fertility of the plots, which retained 46% of applied manure ^{15}N in the upper 30 cm of soil 3 years after application. Drawbacks of using ^{15}N are labour, cost and advance planning to develop labelled diets. Short-term (<2 years) studies can use manure ^{15}N by feeding urea to cows (Powell *et al*., 2005). "Urea manure" contains labelled urine- and faecal microbial-N (*ca* 50 and 40% of excreted manure N, respectively). The present manure also contains labelled faecal undigested feed N (*ca* 10% of excreted manure N). Both types gave similar 1st and 2nd year estimates of corn ^{15}N uptake and ^{15}N in soil total and inorganic N (Powell *et al*., 2005).

Table 1 Estimates of dairy manure N uptake by corn using ^{15}N manure, difference method (DIFF) and fertiliser equivalent (FE). Values are means (standard error) of four replicates per year (adapted from Cusick, 2004)

Manure application	Corn N uptake		
	1st year (% of applied manure N)		
	^{15}N	DIFF	FE
Single (5 yr)	19 (3.8)	22 (6.9)	52 (13.0)
2 consec. (1 yr)	18 (3.6)	12 (4.0)	17 (7.8)
3 consec. (1 yr)	26 (8.3)	13 (4.8)	57 (14.0)
4 consec. (1 yr)	37 (8.3)	50 (11.3)	75 (16.9)
5 consec. (1 yr)	30 (3.9)	28 (10.8)	102 (1.9)
6 consec. (1 yr)	19 (3.4)	22 (8.4)	28 (16.1)
	2nd year (% of applied manure N)		
Single (5 yr)	6 (1.1)	6 (9.7)	24 (9.8)
	3rd year (% of applied manure N)		
Single (4 yr)	2 (0.4)	0 (7.5)	25 (8.5)

Conclusions Indirect estimates of manure N uptake by plants (i.e. DIFF and FE) are less precise than direct measurements using manure ^{15}N. Long-term manure-soil-plant-N cycling studies require manure ^{15}N derived by feeding ^{15}N-labelled feed; short-term studies may use manure ^{15}N derived from feeding ^{15}N-labelled urea.

References

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