FROM FERTILIZER TO FOOD: TRACING N DYNAMICS IN CONVENTIONAL AND ORGANIC CROPPING SYSTEMS USING ^{15}N

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1. Gaseous N losses and $\delta^{15}N$ signatures during storage or composting of animal wastes

Ammonia volatilization of stored manure is most significant during early storage (e.g. 3 days) and 90% of the emitted ammonia-N comes from the urinary–N as a consequence of rapid urea hydrolysis [1]. The ammonia-N lost is highly depleted in ^{15}N which results in an increase of $\delta^{15}N$ of the total N remaining in the stored manure. The relationship between cumulative ammonia losses and $\delta^{15}N$ of manure was highly significant ($p<0.001$; $r^2 = 0.76$) (Fig. 1) [2]. The intramolecular distribution of ^{15}N in N_2O was used to identify denitrification as the main source of N_2O evolved during composting with a minor contribution from nitrification in the surface of the compost pile [3].

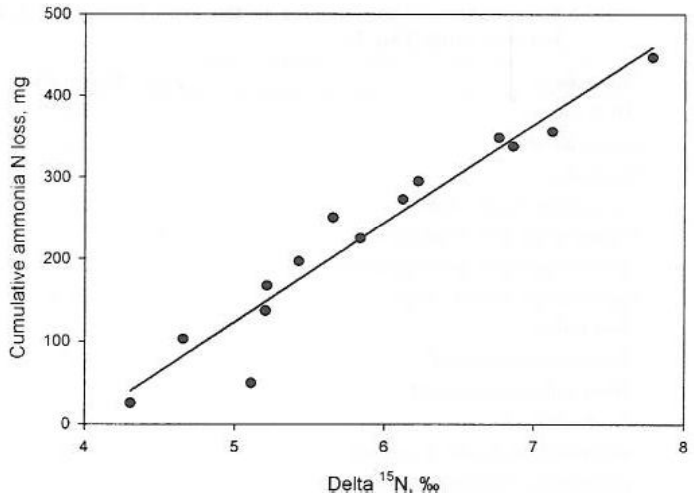

FIG.1. Relationship between cumulative losses of ammonia N from manure and $\delta^{15}N$ of manure [2]

2. $\delta^{15}N$ signatures of synthetic vs. organic fertilizers

Soluble N fertilizers (e.g. urea, ammonium salts) are often slightly depleted or slightly enriched in ^{15}N as they are derived from atmospheric N_2 ($\delta^{15}N = 0$ ‰). Organic fertilizers such as manures and composts are usually enriched in ^{15}N compared with feedstocks (Table 1). Ammonia volatilization and nitrification in the early stages (10 days) are the primary reasons for the increase in $\delta^{15}N$ in the composted material whereas denitrification in the latter stage (after 60 days) leads to ^{15}N enrichment of residual nitrate in the compost [4, 5].

TABLE 1. RELATIVE ^{15}N ABUNDANCE IN AGRICULTURAL WASTES AND DERIVED COMPOSTS

Residue	$\delta^{15}N$ (‰)	Reference
Cattle manure	+ 7.6	[4]
Cattle manure + rice hull[a] compost	+ 11.0	
Cattle manure	+ 11.4	
Cattle manure + sawdust[b] compost	+ 15.6	
Corn silage	+ 0.3 ± 1.3	[5]
Corn silage compost	+ 8.2 ± 0.4	

[a]$\delta^{15}N$ of rice hull = + 4.9 ± 0.1‰
[b]$\delta^{15}N$ of sawdust = + 1.7 ± 0.2‰

3. N fertilizer value of manure and derived compost

Animal excreta (urine, faeces) and composts derived from the excreta have been artificially labelled with ^{15}N by feeding ^{15}N enriched roughage or grain to sheep or poultry. Alternatively, ^{15}N labelled compost can be produced from unlabelled feedstock by co-composting with ^{15}N-labelled fertilizer.

Many studies have shown that the N fertilizer value of compost is low compared with the feedstock [6, 7] (Table 2). However, compost can play an important role in reducing N fertilizer losses by conserving N through promoting biological N immobilization. However, compost and fertilizer should not be applied simultaneously due to the danger of enhanced compost-induced urease activity which can promote NH_3 volatilization, particularly from alkaline-hydrolysing N fertilizers such as urea [7].

TABLE 2. RECOVERY OF ^{15}N LABELLED POULTRY MANURE AND DERIVED COMPOST BY RYEGRASS [6]

Material	C: N ratio	Recovery (%)
Poultry manure	30.0	25.7
Poultry manure + straw compost	14.9	3.8

4. Conventional vs. organic plant products

Because organic and synthetic fertilizer sources differ markedly in $\delta^{15}N$ composition, it would appear to be a promising marker to distinguish organically- and conventionally-fertilized plant products (Table 3). The greater the difference between organic and synthetic fertilizer the more robust will be the differentiation. Nevertheless, many production or external factors may confound product designation. e.g. (i) legume products or the use of legume cover crops (BNF) on organic farms (ii) crop species with a low N requirement (iii) annual vs. perennial growth habit (iv) use of organic fertilizers by conventional farmers (v) marketing of organic products as conventional products [8].

TABLE 3. $\delta^{15}N$ RANGE OF CONVENTIONAL AND ORGANIC PLANT PRODUCTS [8]

Production system	$\delta^{15}N$ (‰)
Conventional [a]	–2.5 to +8.7
Organic [b]	+0.3 to +14.6

[a] Synthetic N-fertilizer alone or with organic fertilizer
[b] Synthetic N-fertilizer excluded

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