Developing testing protocols to ensure the authenticity of fertilizers for organic agriculture

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Introduction

There is growing concern about the authenticity and integrity of soil and crop amendments sold for use in organic production ("*Organic farms unknowingly use synthetic fertilizer*", Sacramento Bee, Dec 28, 2008; see also letter from the Executive Director of the Organic Materials Review Institute, Feb. 20, 2009, http://omri.org/OMRI_PR.html). For example, synthetic ammonia is not permitted in organic production, but it may be added to a product claimed to be derived from fish because, as expected, the resulting product is very effective as a fertilizer, much cheaper to produce, and ensures a higher profit for the manufacturer. In addition, the product quality and consistency is enhanced giving the illusion that the "organic fertilizer" is of a better grade than other materials, or competing products on the market. Since much of the organic amendment certification process is based on trust, such adulterated products are often approved and labeled as suitable for organic agriculture. Depending on the degree of adulteration, basic laboratory tests often cannot indicate a problem. Analysis of nitrogen content, for example, may confirm a product label, but will not indicate the source of nitrogen. The problem has undermined public trust in the "organic" label of produce in California, and this could negatively affect growers of organic foods.

The development of guidelines and protocols to test organic fertilizers for their authenticity will contribute to restoring trust in producers of organic fertilizers, fairness of the marketplace, and the confidence of consumers being offered produce that has been grown according to organic standards. These guidelines and protocols are directly related to the goals of assisting the organic fertilizer industry efforts to increase public confidence in the food supply and to provide for an equitable marketplace.

There is a need to provide methods so that testing labs and regulatory agencies can detect adulteration of organic fertilizers. The development of such methods will provide the basis to develop standards to ensure the authenticity of organic amendments. The success of the guidelines and protocols will ensure that manufacturers of adulterated organic fertilizers and amendments will face the appropriate scrutiny to ensure the authenticity of their products. Legitimate producers of fertilizers will benefit by having a defined set of testing protocols to ensure the quality of their products. The guidelines and protocols will contribute to greater transparency and authenticity of fertilizer products intended for organic agriculture.

The need for research

Previously, no systematic research has been undertaken to develop comprehensive guidelines on testing the authenticity of organic fertilizers and amendments. However, some of the techniques that can be incorporated into the testing protocols, such as the use of stable isotope analysis, have been used in criminal forensic, ecosystem and physiological studies. Important to developing guidelines and protocols is the biogeochemical literature that addresses the sources, fractionation and pathways of carbon, nitrogen and oxygen isotopes within different trophic levels of food webs and unique organismal metabolic pathways (Schimel 1993; Horwath et al. 2001). Other methodologies such as Fourier Transform Infrared (FTIR) and thermogravimetric techniques have been used extensively for forage quality analysis and in the food industry (van Groenigen and Horwath et al., 2001). A great deal of information that can be used to develop guidelines and protocols can be found in the literature although this information is highly fragmented (Table 1).

Table 1. Examples of measured properties of materials potentially used in organic fertilizers and as adulterants, as reported in the scientific literature. The properties are the isotope ratios of carbon and nitrogen (d^{13}C and d^{15}N), carbon content (%C), nitrogen content (%), carbon to nitrogen ratio (C:N), and phosphorus content (%P).

	delta ^{13}C	**delta ^{15}N**	**%C**	**%N**	**C:N ratio**	**%P**	**Reference**
Commercial products							
fish meal (anchovy)	-18	-13	42	11 to	3.8		Yokoyama et al. 2006
fish meal (herring)				11.5		1.7	Luzier et al. 1995
Natural materials							
fish protein	-22 to -17	10 to 16			3 to 5		Sherwood and Rose 2005
seabird guano	-20 to -18	9 to 11	22	13 to 17			Mizutani and Wada 1988
Synthetic materials							
fertilizer ammonium		-4 to 2					Freyer and Aly 1974
urea	-41	-1					Vitoria et al. 2004

The following example illustrates how a relatively simple measurement such as the carbon to nitrogen (C:N) ratio with a suggested threshold value, may be used to question the integrity of an organic fertilizer product (Figure 1). The preliminary data shown in Figure 3 represent fish-based fertilizers from several different suppliers. The N contained in fish tissue is organic, consisting primarily of protein-derived amino acids, which range in C:N from just above 1 to approximately 8. A product derived exclusively from fish should therefore not have a C:N lower than about 1 or 2, even in the extreme case that the protein consisted of mostly N-rich amino acids, such as arginine. Adulteration with ammonia/ammonium would increase the amount of N relative to C, decreasing the C:N ratio such that a C:N ratio that is too low could indicate some degree of adulteration. Indeed, all of the products which show a low C:N have the potential of being adulterated. In combination with a more advanced measurement such as nitrogen isotope ratio (expressed as $\delta^{15}N$), a stronger tentative assessment can be done. Synthetic nitrogen has a low (zero to negative) $\delta^{15}N$ value relative to fish-nitrogen (see table 1). This is because synthetic N is derived from atmospheric N_2 (with a $\delta^{15}N$ of zero), whereas animal tissues have higher $\delta^{15}N$ values reflecting biochemical preference for retaining the heavier isotope as new tissue is synthesized and as the food chain advances to higher trophic levels (Peterson and Fry 1987, Kendall 1998). The addition of synthetic N to a product would therefore tend to lower the $\delta^{15}N$ of an organic fertilizer derived solely from fish. Figure 1 shows that the samples with a low C:N ratio also had a relatively low $\delta^{15}N$ value. As expected, there was a relationship between C:N and $\delta^{15}N$.

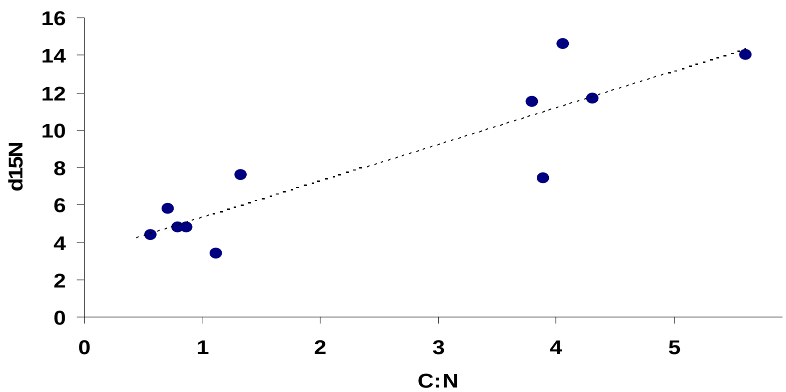

Figure 1. The carbon to nitrogen ratio *vs.* the $\delta^{15}N$ value of 11 fish-based fertilizers analyzed in our lab and at the UC Davis Stable Isotope Facility.

Other properties, such as ash content, nitrogen to phosphorus ratio, phosphorus content, and content of other elements, can vary widely depending on the nature of a product and the way in which it has been processed. For example, a product made primarily from fish flesh scraps (no bones) has less ash, phosphorus, and calcium compared to a product made from whole fish or fish offal. Nevertheless, such parameters may still be used to evaluate a product if the manufacturer's claims regarding its composition are considered.

Constructing guidelines for quality assurance

The evaluation and principal trends of properties of materials used to make organic fertilizers can be incorporated into a recommended course of action as shown in Figure 2. The flowchart is based on findings, such as those listed in Table 1. According to our present knowledge, the C:N ratio would be an easy-to-measure property giving a strong indication on the authenticity of a tested product. If the C:N ratio was suspect, further tests could be

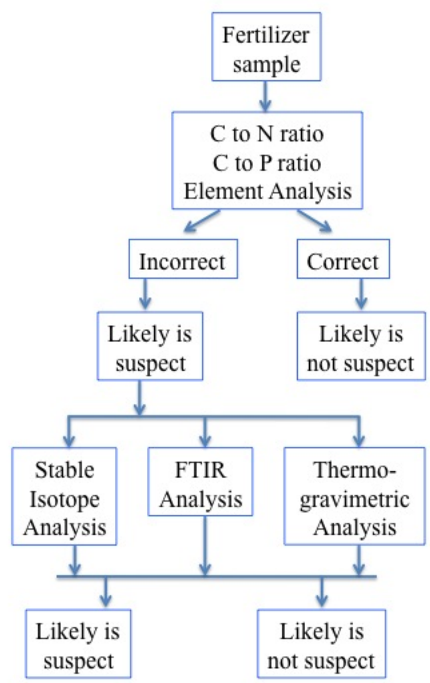

Figure 2. A conceptual flow chart showing a recommended course of action for test labs and regulatory agencies. The purpose of these actions is to ascertain the authenticity of organic fertilizers. The example is based on preliminary results and illustrates how a series of tests will lead to a recommended inspection of a manufacturing facility if results look suspect.

recommended. Measurement of isotope ratios of C, N, and O would be recommended if multiple variables suggested that adulteration of a natural product with synthetic fertilizer might have occurred.

The guidelines for the testing labs and regulatory agencies will include all the information about a material and possible steps that need to be taken to evaluate such a product. The guidelines will provide the organic industry the tools necessary to evaluate fertilizers and ensure that the trust in the organic label has integrity.

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