Supplying Nitrogen from Organic Sources: New Tools for an Old Challenge

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Nitrogen management is a challenge because nitrogen occurs in several different forms, some of which are easily lost from soil. Organic nitrogen from soil organic matter, or from added compost or manure, must be transformed to inorganic nitrogen (nitrate, NO_3^-, and ammonium, NH_4^+) before it is available for plant uptake. This microbial transformation of nitrogen, mineralization, can be fast at warmer soil temperatures and optimal moisture contents. The process is slower at cooler temperatures and in soils that are too wet or too dry, making predicting nitrogen supply to plants during the growing season difficult for growers and scientists. It is important to be able to predict nitrogen mineralization during the growing season so that nitrogen is not under-applied, leading to lower than expected yields, or over-applied, leading to wasted resources and money, as well as environmental damage. Human activities, including agriculture, have increased soluble inorganic nitrogen in the environment significantly, resulting in damage to lakes and coastal waters, among other environmental concerns.

There are many possible sources of organic nitrogen in agricultural soils including soil organic matter, plant roots and aboveground plant residues from the previous crop, green manure crops, compost, and non-composted waste, such as leaves, straw, etc. Soil microbes decompose soil organic matter and transform organic nitrogen to inorganic nitrogen. This naturally-occuring process produces about 15-65 lb per acre per year. Soils typically contain 0.5-5% organic matter, and soils with higher levels of organic matter have more potential to supply nitrogen to crops due to mineralization. Tracking levels of organic matter in soils through traditional soil testing is important.

When residuals such as composts are used as soil amendments, testing the material to be used is important due to variability in feedstocks and processes. A study of 4 commercially-available composts was conducted at Highmoor Farm, Monmouth, ME in 2013 and 2014. Composts (applied at a rate of 300 kg total N ha^{-1}) and inorganic nitrogen fertilizer (applied at a rate of 110 kg N ha^{-1}) were added to soil in high tunnels, and tomatoes were grown. Poultry manure compost contained the greatest percentage of inorganic nitrogen both years (Table 1). In both years tomato yield and plant nitrogen uptake were similar in plant grown in soils amended with poultry manure compost and inorganic nitrogen fertilizer (Table 2). In 2013 Beef manure compost also had high inorganic nitrogen, and plants grown in soils amended with Beef manure compost had high yield and nitrogen uptake. In 2014 inorganic nitrogen levels in Beef manure compost were lower and so was yield and nitrogen uptake. Soil nutrient levels at the 2014 site were lower than at the 2013 site, and yields were generally lower in 2014. In this study, and a related laboratory incubation study, the mineralization of organic nitrogen from the compost was relatively low. The composts that boosted yield added significant amounts of inorganic nitrogen to the soils initially, not through later decomposition. We saw no evidence that the relatively warm temperatures and optimal moisture conditions in high tunnels resulted in higher than expected rates of nitrogen mineralization in the first season after compost addition.

Table 1. Selected properties of four composts used in high tunnel tomato cultivation at Highmoor Farm, Monmouth, ME

	N	C:N	NH_4^+-N	NO_3^--N	Inorg N	Appl Rate
2013	(%)		---------(mg kg^{-1})	--------	(%)	(ton ha^{-1})
Beef Compost	2.4	15	295	2880	13	44
Food Compost	1.7	15	4	321	2	47
Dairy Compost	1.3	18	64	364	3	64
Poultry Compost	1.8	14	3850	1220	29	36
2014						
Beef Compost	2.4	13	18	381	2	41
Food Compost	1.7	20	58	416	3	56
Dairy Compost	1.5	17	74	306	3	63
Poultry Compost	2.3	12	2470	314	17	27

Table 2. Tomato plant nitrogen uptake and total marketable yield in high tunnel tomato cultivation at Highmoor Farm, Monmouth, ME

	Treatment	N uptake (g $plant^{-1}$)	Marketable Yield (t ha^{-1})
2013			
	Beef Compost	19.7ab	124a
	Food Compost	15.8b	104b
	Dairy Compost	15.3b	98b
	Poultry Compost	23.8a	124a
	Inorganic N fert	18.9ab	123a
	No amendment	17.4b	101b
2014			
	Beef Compost	5.9b	66b
	Food Compost	7.0b	68b
	Dairy Compost	5.5b	63b
	Poultry Compost	9.7a	96a
	Inorganic N fert	11.7a	109a
	No amendment	5.2b	40c

Values followed by the same letter in a column are not significantly different from each other.

In addition to environmental conditions, such as temperature and moisture, amendment characteristics influence the rate of nitrogen release from organic materials. Perhaps the most useful parameter is the ratio of carbon to nitrogen (C:N) in the material. Organic materials with a C:N ratio less than 10 are likely to supply ~50% of total N over 8-12 weeks. Purchased organic fertilizers such as blood meal or feather meal, can have C:N of ~5. Composts are often in the 12-20 range for C:N, and may supply only 2-10% of their organic nitrogen in the first growing season. Some composts contain significant amounts of inorganic nitrogen, and this fraction is available for plant uptake immediately. Testing composts and other residuals is important, especially to determine % total N, % of total N in the inorganic form, and C:N ratio.

Because the rate of nitrogen mineralization depends on soil temperature and moisture conditions, the challenge of predicting nitrogen availability from organic sources is likely to be even greater in the future due to weather variability and changing climate. Maine, for example, is predicted to grow warmer and wetter in the coming decades. High tunnels may become more popular as a way to moderate weather extremes. Use of tools to monitor and track soil temperature and soil moisture levels may become more common. A variety of commercial and free tools and data streams can be found on-line. The USDA has established 'Climate Hubs' for each region of the U.S., and the NE Climate Hub is compiling a variety of relevant information. The Climate Hubs Tool Shed (http://climatehubs.oce.usda.gov/content/agriculture-tools-0) lists a variety of on-line tools, including those relevant to nitrogen management, such as Adapt-N. This site also lists costs, if any, and the developer of the tool.

For nitrogen, the research base involves mostly inorganic nitrogen and commodity crops, i.e. corn, wheat, switchgrass. There is a need for more information and studies involving organic N sources, diversified vegetable and fruit production systems, and New England climatic conditions.