Nutrient Content, Availability, and Release Rates from Natural Fertilizers

Bruce Hoskins
University of Maine
Hoskins@maine.edu

Organic farmers can supply nutrients to growing plants from a variety of sources: soil organic matter, animal manures, compost, cover crops, and a bewildering variety of purchased supplements such as blood meal, soy meal, alfalfa meal, and blended natural fertilizers. Most of these sources must go through microbial degradation to release nutrients in a plant-available form. Because of its biological nature, release rates are highly dependent on the complexity of the organic form, soil temperature, and to some extent soil moisture. Nitrogen is especially difficult to manage. Weather-dependent release rates and multiple loss pathways cause the overall complexity of nitrogen management from year to year. A number of laboratory studies have been conducted on natural/organic N sources. Limited work has been done on P and K release rates from natural fertilizers.

Most long-season crop plants take in the bulk of their total seasonal N requirement relatively early in the growth cycle. There is some crop to crop variability, but generally nitrogen uptake increases dramatically starting 3 – 4 weeks after planting. This concentrated uptake period will last for another 3 - 4 weeks, corresponding to the period of rapid height and foliar growth. It is imperative that there be an ample supply of plant-available N (PAN) during this 4 week uptake "window".

A number of studies looking at N mineralization from natural fertilizers have been conducted over the past 5 – 10 years in MI, CA, OR, and VT. These studies either looked at a very limited number of materials, or emphasized short-term release, or documented release rates at relatively warm soil temperature. In 2013, a nitrogen mineralization study was conducted at the University of Maine using a wide variety of locally-available natural N fertilizers, at low soil temperature, for an entire growing season. A field-moist soil was blended with feather meal, blood meal, soy meal, alfalfa meal, fish meal, corn gluten, broiler manure (Nutriwave), and blended natural fertilizers from North Country Organics, NatureSafe, Bradfield Organics, and Espoma. These were compared to 2 chemical N sources: urea and ammonium sulfate. All materials were mixed with soil to supply 100 ppm total N (200 lb/A) and incubated at 15 C (60 F) for 16 weeks. Plant available NO_3-N was measured at 1, 2, 4, 8, 12, and 16 weeks, to document N release rates for an entire growing season at the cooler soil temperatures common in the Northeast.

Chemical sources released the majority of PAN in only 2 – 4 weeks. N release from natural sources maximized at 4 – 8 weeks, better matching the crop uptake window for N. The early release of PAN from chemical sources, prior to crop uptake demand, leaves PAN much more susceptible to major losses from heavy rainfall events. The majority of natural materials studied had nearly identical release rates to blood meal, including feather and soy, traditionally considered to be slow release materials (Figure 1).

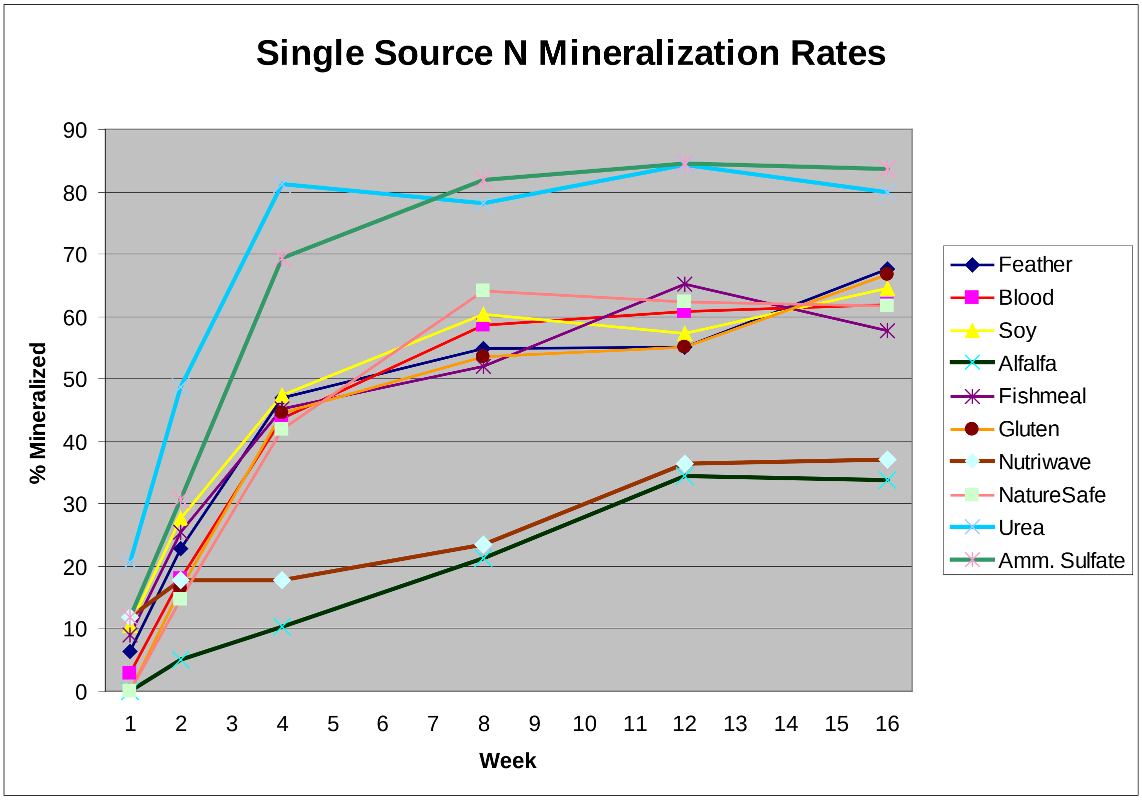

Figure 1. Nitrogen mineralization rates at 60 F soil temp. University of Maine, 2013.

Broiler manure and alfalfa meal exhibited a much slower N release rate than other single source materials. This can be attributed to the higher Carbon to Nitrogen (C:N) ratio of these materials. This effect was also documented by Heather Darby in a 2012 N-release study in VT. In both ME and VT studies, materials with a C:N ratio below 10:1 released relatively rapidly while those above 10:1 released more slowly. This was also observed in a very early (1942!) study at Rutgers. Blended fertilizers in the ME study exhibited N release rates between the rapid and slow rate groups, since they contain a variety of N sources meant to provide some rapid release and some slow release nitrogen.

N release from common materials used in ME, MI, OR, CA, and NJ all agreed very well. However, ME release rates in 8 weeks at 60 F were matched by the OR study in only <u>4 weeks</u> at 72 F. In effect OR doubled ME N-mineralization rates by increasing soil temp by 12 F (7 C). This emphasizes the effect of soil temperature on N release from non-chemical sources. N release in warm soil later in the season will be much more rapid than in cool soil in spring. Likewise, N release will be more rapid in high tunnel production, with higher soil temperature, than in open field production.

N release from manures is also biologically mediated and is also affected by C:N ratio and soil temperature. Most manure sources have a significant portion of the total N content in the ammonium form, with the remainder being organic N. The ammonium-N will be converted to nitrate relatively quickly, usually in 2 – 4 weeks, and is considered to be immediately available. N release from the remaining organic fraction will be more gradual, generally about 50 % mineralized in 4 – 8 weeks depending on soil temp and

C:N ratio. There is a well documented N release from manure the second and even third year after application, though at a much diminished rate. Manure organic N release rates are from 25 – 55 % the first year, 10 – 12 % the second year, and 4 – 5 % the third year. N in cover crops (green manures) is almost exclusively in the organic form. Crop residues release nitrogen generally between 2 - 6 weeks after incorporation. However, this will be delayed with higher C:N residue or at lower soil temperatures.

Compost and native soil organic matter have already been partially broken down and so release PA N at a much reduced rate, regardless of C:N ratio. In a compost incubation study at UMaine in 2013, 4 sources of compost were mixed with soil to supply 320 ppm total N (640 lb/A) and incubated at 68 F (20C) for 8 weeks. From all 4 sources, only 5 % of the organic N content was fully mineralized to PAN in 8 weeks. Two of the sources had a substantial portion of total N in plant available form at the start of the incubation, but even these released only an additional 5 % of the organic N during incubation. Compost is a very slow release source of PAN. As with manure, there can be a greatly diminished release of PAN in the subsequent 1-2 years after application.

P and K release from natural sources has not been extensively studied or characterized. The chemistry of plant available K (and especially P) greatly complicates the study of release rates for these nutrients. Available potassium can be lost or temporarily tied up in soil clays. Studies have documented 15 – 20 % loss of applied K to unavailable forms. P is highly reactive, forming stable and often unavailable compounds and complexes with Al and Fe at low soil pH and with Ca and Mg at high soil pH. Studies have documented 70 – 90 % loss of applied chemical P to unavailable forms.

The remaining mixed material from the UMaine natural fertilizer study, not used for N mineralization, was allowed to incubate in unsealed plastic bags for 16 weeks at ambient room temperature. Samples dried slowly and were rewet to original moisture content each month. For those N fertilizers that also contained significant P content, only 5 – 10 % of applied P was plant available after 16 weeks. For those N fertilizers that also had significant K content, 50 – 85 % of applied K was plant available after 16 weeks. P and K recovery (fertilizer efficiency values) from natural sources were therefore comparable to those found using chemical sources.

Plant and animal meals, natural minerals, compost, manure, and cover crops have much more complex nutrient contents than do chemical fertilizers. Trace elements and micronutrients in natural fertilizers are an added benefit not typically found in purified chemical fertilizer salts. Secondary and trace element content from natural fertilizers is highly variable, depending on the source material. Materials derived from or originating in marine environments are especially good sources of a broad spectrum of trace elements, including boron. Kelp meal and Greensand (a marine deposit) are two of the best natural sources of boron. More concentrated sources, such as Borax, are not usually recommended since they must be applied with extreme care to avoid toxicity. A listing of secondary and micronutrient (total content) in a variety of natural fertilizers can be found on the Lab website (anlab.umesci.maine.edu) under the “Understanding Recommendations” tab.