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Impacts of Soil Amendment History on Nitrogen Availability from Manure and Fertilizer

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Repeated, long-term additions of organic materials not only increase stocks of mineralizable soil N, but also bring about changes in soil characteristics that influence N dynamics. We conducted an aerobic incubation to explore how soil amendment history affects the transformation and availability of recently added N. Soil was collected from plots under contrasting amended and nonamended soil management systems in a 13-yr cropping systems experiment. Nitrogen source treatments were: no added N (control), NH_4^+ fertilizer (Fert), a net mineralizing manure (MManure), and a net immobilizing manure (IManure). Soil NH_4^+ and NO_3^- concentrations were monitored for 282 d. A two-pool, first-order model with fixed rate parameters was fitted to the NO_3^- accumulation data. When no N was added, net mineralization in the historically amended soil was twice that in the historically nonamended soil, mostly due to differences in soil total N stocks. When N sources were added, NH_4^+ consumption, net N mineralization, and estimated N pools were affected by both soil amendment history and N source, with a significant interaction between the two factors. Historically amended soil reduced the availability of recently added N relative to the nonamended soil. This reduction occurred in the active pool (N_1) for MManure and in the slow pool (N_2) for Fert. It appeared to be related to the timing of C availability. Future work modeling N availability should consider soil amendment history not only for its effects on soil N supply capacity, but also for its effects on the availability of recently added N sources.

Abbreviations: Fert, ammonium fertilizer; IManure, net immobilizing manure; MManure, net mineralizing manure; SMB, soil microbial biomass.

Tightening the N cycle by optimizing N use efficiency is fundamental to the design of sustainable agricultural systems (Christensen, 2004). Achieving this goal requires the ability to predict N release from soil organic matter and added N sources (Christensen, 2004; Honeycutt et al., 1991). Soil N dynamics are influenced by environmental factors such as temperature (Andersen and Jensen, 2001; Griffin and Honeycutt, 2000; Honeycutt, 1999) and soil moisture (Griffin et al., 2002; Thomsen et al., 1999). Even under similar environmental conditions, however, N dynamics are also substantially affected by substrate and soil characteristics.

For animal manures, there has been considerable effort to identify chemical characteristics that can be used to refine predictions of N mineralization potential (Cabrera et al., 2005). Most of these studies have focused on the release of plant-available N from manure within a single cropping season. The repeated addition of manure and other organic materials, however, brings about important changes in the soil that can affect N dynamics. Most obvious is the enhancement of the soil organic N pool. Only a portion of the organic N in manure is mineralized during the year of application; the remainder accumulates in the soil. While any given application contributes only a small amount to mineralized N in a subsequent year, the combined contributions of organic N from repeated applications can lead to a substantial residual N effect (Eghball et al., 2004; Schröder, 2005), emphasizing the need for consideration of soil amendment history in nutrient management plans (Beauchamp et al., 1986; Feng et al., 2005; Whalen et al., 2001).

In addition to the quantitative increase in the size of the soil organic N pool, repeated long-term application of organic amendments also brings about changes in soil characteristics that could affect N dynamics. As reviewed recently by Cabrera et al. (2005), reduced net N mineralization has been observed repeatedly in finer vs. coarser textured soils following organic N additions, with effects attributed to adsorption of N by clays (Van Veen et al., 1985), greater protection of microbial biomass N (Kuikman et al., 1991; Van Veen et al., 1985), pore-size effects on water availability (Thomsen et al., 1999), and differences in the microbial and grazer communities (Hassink et al., 1994). While organic amendment does not alter soil texture, added organic matter can affect all of the above processes.

Repeated application of organic amendments also adds to the pool of available soil C (Aoyama et al., 1999; Cambardella and Elliott, 1992; Griffin and Porter, 2004; Sommerfeldt et al., 1988) and enhances microbial biomass and activity (Fauci and Dick, 1994; Gunapala and Scow, 1998; Houot and Chaussod, 1995; Witter et al., 1993). Carbon and N cycles are tightly coupled in the soil (Chantigny et al., 2001). The site of this coupling is the soil microbial community, which acts as an important source and sink of both C and N. Research on untilled soils illustrates this

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