Carbon and nitrogen turnover in adjacent grassland and cropland ecosystems

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Abstract. The effects of cultivation and soil texture on net and gross N mineralization, CO$_2$ evolution and C and N turnover were investigated using paired grassland and cropped sites on soils of three textures. Gross N mineralization and immobilization were measured using $^{15}$N-isotope dilution. Grassland soils had high CO$_2$ evolution and gross N mineralization rates, and low net N mineralization rates. Cropland soils had low CO$_2$ evolution rates but had high net and gross N mineralization rates. Grassland soils thus had high immobilization rates and cropland soils had low immobilization rates. Cultivation increased N turnover but reduced C turnover. The data suggest that the microflora in grassland soils are N limited, while those of cropland soils are limited by C availability. Increasing clay content reduced N turnover. C turnover was less clearly related to texture. Differences in the immobilization potential of substrates help explain why agricultural soils have higher N losses than do grassland soils.

Introduction

Although general principles governing carbon-nitrogen interactions during decomposition are beginning to be understood, problems of characterizing soil organic matter quality and belowground inputs of carbon have hampered efforts to study C-N interactions in the soil (McClaugherty et al., 1982, Paul 1984). Turnover of soil organic N has also proved very difficult to study because it can only be measured using tracer techniques (Nishio et al., 1985, Vitousek and Matson 1985, Paul and Juma 1981, Jansson 1958). Soil N turnover is apparently regulated by interactions with soil physical properties; turnover appears to be inhibited by clay (Ladd et al., 1981, Campbell and Souster 1982, Van Veen et al., 1984, Schimel et al., 1985a, Schimel et al., 1985b).

Conversion of grasslands to croplands affects carbon fluxes by reducing carbon inputs to the soil, reducing root:shoot ratios in dominant vegetation and increasing decomposition rates (Anderson and Coleman 1985, Coleman et al., 1984, Voroney et al., 1981). Conversion may also alter soil texture by increasing erosion rates (Ruhe and Walker 1968). Paired cultivated and native ecosystems can provide an experimental setting for
studies on the effects of carbon inputs and soil texture on soil carbon and nitrogen turnover. Studies on such paired sites in North Dakota showed that that ratio of CO$_2$ evolution to net N mineralization was higher in grassland than cropland soils (Schimel et al., 1985b). We hypothesized that substrate quality is different between grassland and cropland soils, which results in grassland soils having more immobilization per unit gross mineralization than cropland soils. The objective of this study was to test this hypothesis by measuring C and N mineralization and indices of C and N turnover as affected by cultivation and soil texture.

**Methods**

*Site description*

Soils from the summit positions of three paired grassland and cultivated toposequences were used in this study. The sites, located in southwestern North Dakota, have been the subject of intensive studies of erosion and organic matter changes resulting from cultivation (Aguilar 1984, Kelly 1984, Schimel et al., 1985b, Schimel et al., 1985c). The cultivated sites had all been in wheat-fallow rotations for 45 y at the time of sampling. The toposequences were on three different parent materials with varying textures (sandstone, siltstone, and shale), with grassland and cropland components separated by fences or, in one case, by a road. The siltstone site has never been fertilized; the other sites have received about 10 kg N·ha$^{-1}$·y$^{-1}$. The soils of all three sites were classified as typic Haploborolls (Soil Survey Staff 1975). Detailed site and soil descriptions are in Schimel et al., (1985b) and Aguilar (1984). Selected soil properties are shown in Table 1. Organic C and N are shown in Table 5.

*Field sampling*

Soil samples for incubations were collected in August 1984, at which time the cropland sites had been recently harvested. Three 7.5-cm-diameter by 10-cm-depth cores were composited for each sample and three samples were collected for each site. The depth increment was within the surface horizon of every soil sampled. The samples were kept in a cooler with ice and returned to Fort Collins for analysis.

*Incubations*

Soil samples were mixed gently and all obvious organic debris, including live and dead roots, was removed by hand to minimize disturbance of soil structure. Moisture contents were determined by drying subsamples at 105°C for 48 h. Initial NH$_4^+$ and NO$_3^-$ contents were determined by extraction of 3 subsamples with 2 mol·L$^{-1}$ KCl and subsequent colorimetric analysis. Each field sample was then split into twelve 50-g dry weight aliquots for incubation. Nine aliquots were used for aerobic in-