Introduction

While organic and low-input agriculture rely primarily on manure or composts to meet crop N demands, amino N compounds may be present in greater supply in soils (Reeve et al., 2008). However, we still know considerably less about the dynamics of amino acids than inorganic N, despite our growing recognition of the importance of amino acids to ecosystem N cycling (Warren, 2008). Martens and Loeffelmann (2003) proposed quantifying soil amino acid composition by methanesulfonic acid (MSA) hydrolysis and anion chromatography-pulsed amperometry. Using this method, Olk et al. (2008) observed changes in soil amino compounds during a 28-day laboratory incubation of nine dairy manure-amended soils from six US States. Their results indicate that manuring resulted in soil enrichment by nearly all measured amino compounds. A long-term field experiment of land applied poultry litter (PL) to pasture soils has been maintained for over two decades at the Sand Mountain region of north Alabama, USA (He et al. 2008). The objectives of this study were to apply the proposed new method to evaluate the impact of long-term PL application on soil and plant amino acid compositions.

Materials and Methods

Poultry litter (PL) samples were obtained from 23 broiler houses across three counties (Dekalb, Franklin, and Cullman) in Alabama. Soils were collected from slope positions (3 to 8% slope) of the Hartselle (fine sandy loam, siliceous, thermic, Typic Hapludults) soil series in the Sand Mountain region of north Alabama, USA. Samples were collected randomly at three locations in each field at depth increments of 0-20, 20-40, and 40-60 cm. Soil samples in five fields had received poultry litter continuously for the past 0 (control), 5, 10, 15, and 20 years at rates of 0 (control), 2.27, 2.27, 3.63, and 1.36 Mg ha^{-1} yr^{-1}, respectively. Plant (grass) leaves were clipped where soil samples were being collected and placed in paper bags. There were taken to the laboratory washed with deionized water and oven-dried at 65^{o}C. After drying, the leaves samples were ground and stored in plastic bags. The extraction and analysis of amino compounds (AC) in the PL, soil, and plant samples followed established procedure described by Martens and Loeffelmann (2003).

Results and Discussion

The MSA hydrolysis and anion chromatography-pulsed amperometry method identified 19 amino acids and two amino sugars galactosamine and glucosamine (Fig. 1). In the chromatogram of PL samples, however, two amino acids, serine and proline, are not separated. Arginine was the most abundant AC compound in PL with an average of 13.6 and a standard deviation of 3.0 mg g^{-1} of dry matter. Ornithine was the least abundant AC compound with an average of 0.043 and a standard deviation of 0.056 mg g^{-1} of dry matter. Indeed, ornithine was detected only in nine of 23 PL samples. The average AC-N of the 23 PL samples was 37.0 mg g^{-1} of dry matter with a standard deviation of 8.0. The determined AC-N represented 76.4% of total N in the PL samples. These data indicated that AC-N was the most important form of N in PL.

All the 21 ACs were detected in the pasture soils with or without PL application (Fig. 2). Their concentrations were about 10 times lower than those in PL. The distribution patterns of the 21 individual AC-N concentration in the five soils were similar to each other. The lowest AC concentraions were observed in the soil from the control fields. The highest AC-N concentrations were observed in soils with 10- or 15-year PL applications. These data suggest that ACs from PL had built up in these pasture soils. However, the build-up pattern was not consistent with the order of annual applied PL rate or cumulative applied amount of PL, implying that some of the ACs from PL were mineralized, in runoffs or removed from the soils by other mechanisms. Furthermore the percentage of AC-N in total soil N decreased with the year of PL application as AC-N accounted for 97% of total N in the control pasture soil, but only 40% in the soils with 20-year PL application. This observation indicted that repeated PL application not only contributed AC-N, but also accelerated AC-N transformation in soil.

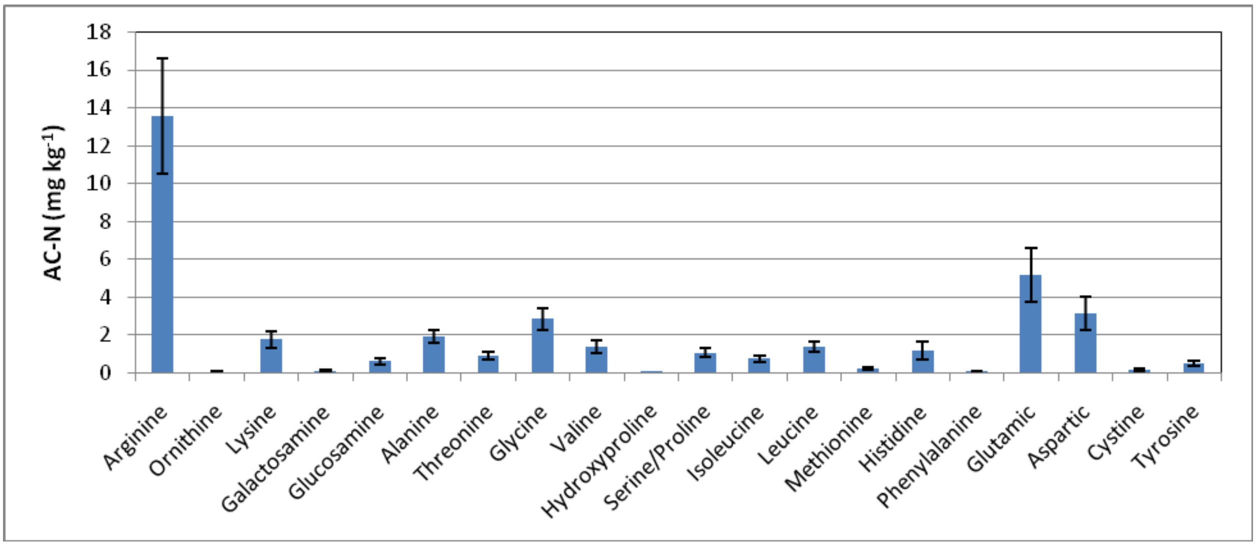

Fig. 1. Averages of amino compound nitrogen concentrations of 23 poultry litter samples. Error bars represent standard deviations.

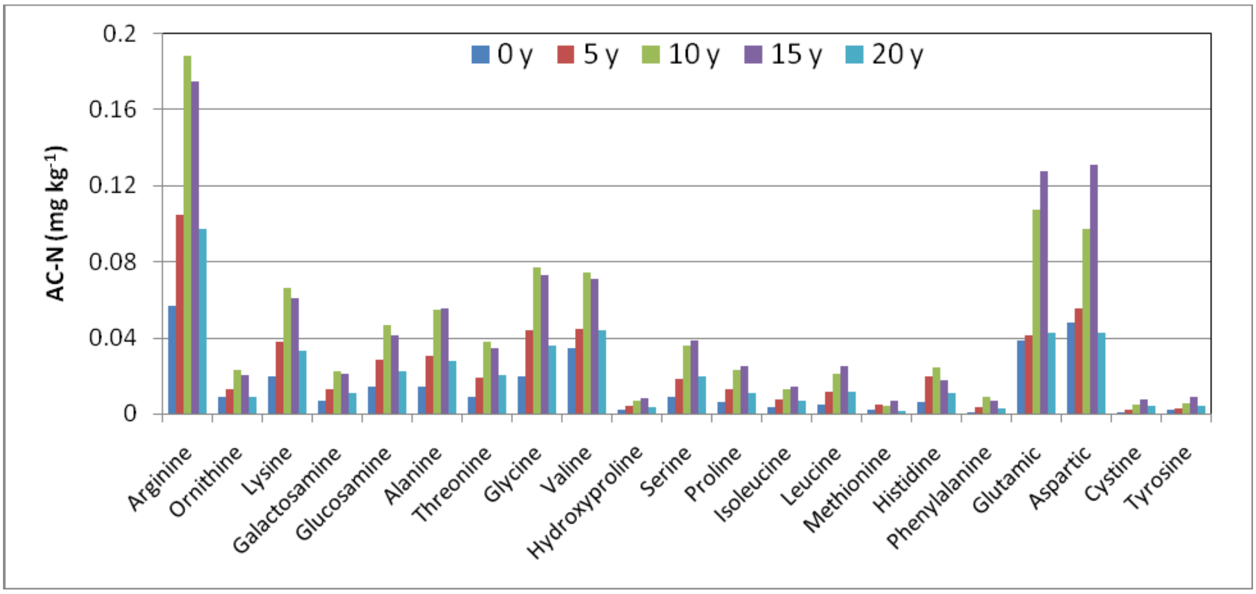

Fig. 2. Amino compound nitrogen concentrations in soils with 0, 5, 10, 15, and 20 years of poultry litter application.

Different levels of the 21 individual AC-N were observed in tall fescue leaves collected from fields with different PL application history. The concentrations and distribution patterns of the 21 ACs of tall fescue leaves from the control fields were similar to those of an unidentified prairie grass (Martens and Loeffelmann, 2003). Application of PL increased the AC concentrations in tall fescue leaves. The highest increase of most AC compounds was with the leaves from fields that received PL for 5 years. Applying PL for more years did not increase ACs in plant leaves although it did increase ACs in soils. Similar to the individual AC-N, the total AC-N concentrations were 10.5 ± 1.0, 27.4± 4.4, 20.5 ± 3.1,17.8 ± 2.4, and 12.3 ± 1.5 mg g^{-1} of dry leaves harvested from the five fields with 0-, 5-, 10-, 15- ,and 20-year PL applications, respectively. The total AC-N concentrations in the five soils from the corresponding fields were 0.31 ± 0.06, 0.52 ± 0.22, 0.94 ± 0.19, 0.97 ± 0.50, and 0.46 ± 0.47 mg g^{-1} of dry soil, respectively. These data suggested that newly applied PL might contain some ACs directly available for take-up by tall fescue although more data are needed to support the hypothesis.

Conclusions

In this work, we determined 21 AC contents in 23 PL, five pasture soils with different poultry litter application, and the grass grown on these pasture fields. The average AC-N of the 23 PL samples was 37.0 mg g^{-1} of dry matter with a standard deviation of 8.0. This amount of AC-N represented 76.4% of total N in these PL samples. AC-N ranged from 0.31 to 0.98 mg g^{-1} of dry matter in the top (0-20 cm) soils collected from the five pasture fields. The greatest levels of AC-N were observed in soils with 10- and 15-yr PL application, which implied that both fresh applied and residual PL had contributions to the soil AC-N. However, the percentage of AC-N in total soil N decreased with the year of PL application as AC-N accounted for 97% of total N in the control pasture soil, but only 40% in the soils with 20-year PL application. This observation indicate that repeated PL application not only contribute AC-N, but also accelerate AC-N transformation in soil. Plants harvested from the control pasture field contained the least abundant AC-N (10.5 mg g^{-1} of dry matter). Plant leaves harvested from the pasture field with 5-year PL application contained the greatest AC-N (23.7 mg g^{-1} of dry matter). It is not conclusive from the plant AC-N data whether the plant took up intact soil amino acids as proposed in numerous literatures.

References

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