3rd International Biochar Conference
IBI 2010
Progressing from Terra Preta de Índios to the Whole World

Biochar Use in the Poultry Industry

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Key words: *manure, carbonization, nitrogen*

Introduction

There is growing concern about the large amounts of manure nutrients being generated by large animal feeding operations and the potential hazard for water recourses and air quality. In many cases there is insufficient land available for spreading the manure at agronomic rates and the growing concentration and size of animal feeding operations increased the accumulation of excess nutrients. Biochar might reduce some of the problems associated with large scale poultry production. Potential applications for biochar in poultry production systems include the carbonization of the poultry litter (PL) or composting PL with biochar.

During the pyrolysis process important plant nutrients concentrate in biochar (*1*). This might facilitate a more efficient nutrient recovery by reducing the costs associated with land application and transportation. But depending on pyrolysis temperature, some nutrients susceptible to volatilization such as nitrogen (N) are partially lost during the process. At pyrolysis temperatures of 400 °C and 500 °C, 69 and 76% of the original feedstock N was lost respectively (*1*). Formation of heterocyclic N and aromatization increases the recalcitrance of the carbonized material (*2*), and has implications on N availability (*3*).

Therefore we compared the fertilization efficiency of carbonized chicken litter with that of un-carbonized chicken litter and mineral fertilizer. The experiment was established in a greenhouse using pots with a volume of 4 liters. First 1200g of soil (Cecil sandy loam, clayey, kaolinitic thermic Typic Kanhapludult; Chromi-Alumic Acrisol, near Watkinsville, Georgia) was filled on the bottom of the pot and the remaining 2400g was mixed with the fertilizers. The organic amendments PL and carbonized PL (PLc) were applied at the rates of 1.5, 3.0 and 6.0 Mg ha^{-1}. By coincidence the N content of PL (35.2 g kg^{-1}) was very close to that of PLc (35.0 g kg^{-1}) and the corresponding N applications were 52.5, 105 and 210 kg ha^{-1} for the 3 application rates respectively. The concentrations of other elements such as P, K, Ca and Mg were approximately twice as high in PLc as PL. The 3 application rates and the nutrient concentrations allowed comparing the N supply of the different fertilizers. For the mineral fertilized controls we mixed ammonium nitrate (NH_4NO_3), potassium chlorate (KCl), calcium phosphate ($CaHPO_4$) and magnesium sulfate ($MgSO_4$) in a ratio to match the nutrient contents of PL and PLc (MF and MFc, respectively). One unfertilized control was established additionally (C). All treatments were arranged in a randomized complete block design with 4 replicates. Five plants of ryegrass were established in each pot and harvested regularly (4 harvests) to assess the biomass production and nutrient uptake.

Results and Discussions

Total biomass production increased with increasing levels of fertilization except for PLc where a doubling and quadruplicating of the amount of fertilized N did not result in higher productivity. The cumulative N uptake from plants fertilized with PLc was significantly lower than that from plants fertilized with PL. While the N uptake of PLc fertilized plants remained close to the control (unfertilized plants) the uptake of PL fertilized plants lay inbetween MF and the control (Figure 1).

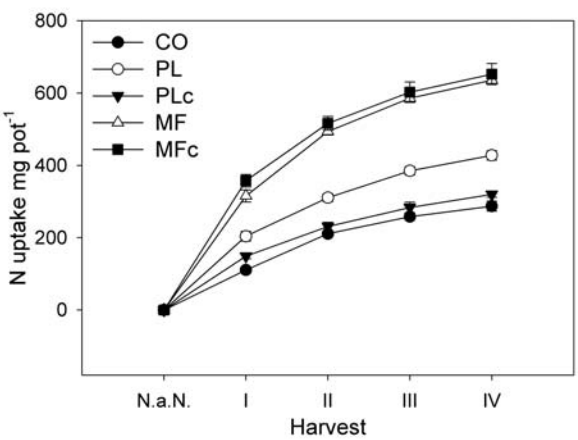

Figure 1. Cumulative nitrogen uptake by ryegrass over 4 harvests at the highest N fertilization level (210 kg ha^{-1}). CO = control, PL = poultry litter, PLc = carbonized poultry litter, MF = mineral fertilization based on PL, MFc = mineral fertilization based on PLc. Means and standard errors, n = 4.

Composting of PL is an alternative way to reduce potential pathogens; weed seeds and odor. However N is also lost during composting through ammonia (NH_3) volatilization. Ogunwande et al. (*4*) found a cumulative N loss to vary between 71 and 88% during composting of PL. This reduces the fertilizer potential and economic value of the product while causing environmental pollution (*5*). Activated carbon was successfully used to adsorb NH_3 (*6*). A cheaper option would be biochar and Iyobe et al. (*7*) showed that woody charcoal produced at 500°C had a higher capacity for NH_3 adsorption than the activated C. The recalcitrance of biochar, its pore space and moisture adsorption may provide ideal properties to be used as bulking agent in manure composting operations.

Adding 20% pine chip biochar to PL reduced NH_3 emissions significantly during composting and reduced N losses by up to 52%, without compromising the speed of decomposition. PL mass loss during composting was not altered due to biochar additions, peak CO_2 and temperatures increased (*8*).

Conclusions

The limited supply of fossil fuels as well as climate change and environmental impacts makes it imperative to increase N fertilizer use efficiency and improve nutrient cycling. Weather combusted, pyrolysed or composted, N rich materials loose a significant proportion of N during these treatments. However, the reduced bulk density and higher mineral concentration (mainly P and K) of ash or biochar may facilitate transportation to areas where fertilizer is needed.

Increasing the carbon content of agricultural soils would be negligible, if PLc is applied at agronomic rates (based on the phosphorus (P) demand of crops) due to the high P content of PLc. Using biochar produced from N poor materials as bulking agent for manure composting operations may reduce N losses and improve N cycling.

Acknowledgements

The authors acknowledge the financial support of the US DOE, State of Georgia, and the University of Georgia experiment station for partial support of this work through the Biorefinery and Carbon Cycling Program.

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