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RESEARCH ARTICLE

Biochar amendment with fertilizers increases peanut N uptake, alleviates soil N_2O emissions without affecting NH_3 volatilization in field experiments

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Abstract

Biochar application to soil is currently widely advocated for a variety of reasons related to sustainability. However, the synergistic effects of biochar combined with mineral or organic fertilizer on soil N_2O emissions, NH_3 volatilization, and plant N uptake are poorly documented. Field plot experiments planted with peanut were conducted under the application of biochar (derived from rice husk and cottonseed husk, 50 t ha^{-1}) with organic or mineral fertilizer. It was found that biochar increased soil nutrient availability and decreased surface soil bulk density, demonstrating that biochar could improve the soil quality especially in the 0–20-cm profile. The total N content of the plant changed little with treatments, but the kernel N concentration increased significantly when biochar was applied with organic fertilizer. Peanut yield increased with biochar amendment while no significant difference was observed in plant biomass, suggesting biochar had a positive effect on belowground biomass. Peanut N uptake was also increased following biochar amendment with either organic or mineral fertilizers. While biochar amendment had no significant effect on soil NH_3 volatilization, it did decrease the cumulative N_2O emission by 36.3% on average with organic fertilizer, and by 32.6% with mineral fertilizer, respectively ($p < 0.05$). The copy numbers of 16S rDNA, *nif*H, *nir*K, and *nir*S were not influenced by the application of biochar; however, the copy number of *nos*Z was significantly increased under biochar plus mineral fertilizer treatment. The results imply that biochar application can suppress N_2O emissions, as a result of abiotic factors and enhanced peanut N uptake rather than changes of denitrification genes.

Keywords Biochar · Fertilizer · Greenhouse gas emissions · Nitrogen cycle · Real-time PCR

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Introduction

Managing nitrogen (N) dynamics has received much attention in agricultural systems due to the increased application of N fertilizer. According to Liu et al. (2010), only 55% of the global applied N is taken up by crops while 14% is lost in gaseous emissions. Nitrous oxide (N_2O) emissions and ammonia (NH_3) volatilization are two of the main pathways for gaseous N losses from agricultural system, and result from excessive fertilizer. N_2O is a potential greenhouse gas (GHG) that has a global warming potential 298 times that of carbon dioxide (CO_2) over a 100-year time period (Davidson 2009). Agricultural land contributes approximately 60% to global anthropogenic N_2O emissions (Reay et al. 2012). NH_3 volatilization can contribute to the formation of atmospheric aerosol, and acidification and eutrophication of water systems (Howarth et al. 2002). It is also an indirect source of N_2O and NO (Mosier et al. 1998). The loss of N through

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