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ORIGINAL PAPER

Quantifying soil N pools and N_2O emissions after application of chemical fertilizer and straw to a typical chernozem soil

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Abstract

An incubation experiment with equivalent N rates was conducted for 56 days using a typical black soil amended with chemical fertilizer with or without straw amendment using a ^{15}N cross-labeling technique. Compared with the chemical fertilizer treatment (^{15}NCF), chemical fertilizer combined with straw treatment (CF + S) showed a significantly higher ($P < 0.05$) contribution from applied N to microbial biomass N (BN) in the first 14 days and to particulate organic N (PON) and mineral-associated total N (MON) throughout the incubation. Straw application in the CF + S treatment significantly ($P < 0.05$) decreased the recovery of chemical fertilizer N as soil inorganic N except at day 3 but increased the recovery of chemical fertilizer N as BN before day 14 and as PON and MON from day 14 to the end of the incubation period. At the end of the incubation period, the total N_2O-N emissions in the CF + S treatment increased significantly ($P < 0.05$) compared with the CF treatment, and the increase in N_2O-N emissions was 73% from chemical fertilizer and 27% from straw N individually. Our results suggest that the combined application of chemical fertilizer and straw increased soil fertility together with an increase in N_2O emissions in the typical black soil and the N_2O emissions from straw cannot be ignored.

Keywords ^{15}N labeling · Inorganic N · Microbial biomass N · Dissolved organic N · Particulate organic N · Mineral-associated total N · Nitrous oxide

Introduction

The combined application of chemical fertilizer and straw is generally accepted as a promising practice to increase soil fertility (Chivenge et al. 2011; Liang et al. 2012; Pan et al. 2017). This practice can promote the immobilization of chemical fertilizer N in different soil N pools (Luxhøi et al. 2007; Qiu et al. 2012) and may also lead to an increase in greenhouse gas emissions (e.g., N_2O) (Li et al. 2013; Zhou et al. 2017) and this offsets the advantage of increased soil fertility to some extent. Understanding N immobilization in soil N pools and N_2O emissions is therefore necessary to evaluate and implement the practice of chemical fertilizer application combined with straw.

Soil N can be differentiated into labile and passive pools according to their turnover rates. The labile N pools respond sensitively to fertilization practices, and the passive N pools can reflect N retention capacity (Qiu et al. 2016). In agricultural ecosystems soil inorganic N (N_{inorg}), largely exchangeable NH_4^+-N and NO_3^--N is derived mainly from exogenous chemical fertilizers and can be immobilized into and released from soil organic N pools (Luce et al. 2014; Qiu et al. 2012). The labile organic N pools include soil microbial biomass N (BN), dissolved organic N (DON), and particulate organic N (PON) (Qiu et al. 2016). BN is both a source and a sink of soil N and the immobilization and mineralization of N by microorganisms controls the soil N supply (Brookes 2001; Sugihara et al. 2010). DON is generated from microbial decomposition and is utilized for microbial growth. Moreover, it can be

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