Atmospheric Environment 152 (2017) 377–388

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

Nitrous oxide emissions from soils amended by cover-crops and under plastic film mulching: Fluxes, emission factors and yield-scaled emissions

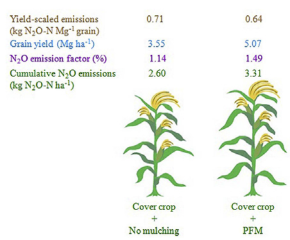
Gil Won Kim [a, 1], Suvendu Das [b, 1], Hyun Young Hwang [a], Pil Joo Kim [a, b, *]

[a] Division of Applied Life Science, Gyeongsang National University, Jinju 660-701, South Korea
[b] Institute of Agriculture and Life Science, Gyeongsang National University, Jinju 660-701, South Korea

HIGHLIGHTS

- N_2O EFs from green manure amended soils were 1.13% under NM and 1.49% under PFM.
- The values were comparable to the N_2O EFs reported by IPCC default EF (1%).
- N_2O emissions significantly increased under PFM than under NM.
- Yield-scaled emissions markedly decreased under PFM compared to NM.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 27 September 2016
Received in revised form
30 December 2016
Accepted 3 January 2017
Available online 3 January 2017

Keywords:
Nitrous oxide
Emission factors
Yield-scaled emissions
Plastic film mulching
Cover crop

ABSTRACT

Assessment of nitrous oxide (N_2O) emission factor (EF) for N_2O emission inventory from arable crops fertilized with different nitrogen sources are under increased scrutiny because of discrepancies between the default IPCC EFs and low EFs reported by many researchers. Mixing ratio of leguminous and non-leguminous cover crop residues incorporation and plastic film mulching (PFM) in upland soil has been recommended as a vital agronomic practice to enhance yield and soil quality. However, how these practices together affect N_2O emissions, yield-scaled emissions and the EFs remain uncertain. Field experiments spanning two consecutive years were conducted to evaluate the effects of PFM on N_2O emissions, yield-scaled emissions and the seasonal EFs in cover crop residues amended soil during maize cultivation. The mixture of barley (*Hordeum vulgare*) and hairy vetch (*Vicia villosa*) seeds with 75% recommended dose (RD 140 kg ha^{-1}) and 25% recommended dose (RD 90 kg ha^{-1}), respectively, were broadcasted during the fallow period and 0, 25, 50 and 100% of the total aboveground harvested biomass that correspond to 0, 76, 152 and 304 kg N ha^{-1} were incorporated before maize transplanting. It was found that the mean seasonal EFs from cover crop residues amended soil under No-mulching (NM) and PFM were 1.13% (ranging from 0.81 to 1.23%) and 1.49% (ranging from 1.02 to 1.63%), respectively, which are comparable to the IPCC (2006) default EF (1%) for emission inventories of N_2O from crop residues. The emission fluxes were greatly influenced by NH_4^+–N, NO_3^--N, DOC and DON contents of soil. The cumulative N_2O emissions markedly increased with the increase in cover crop residues application rates and it was more prominent under PFM than under NM. However, the yield-scaled emissions markedly decreased under PFM compared to NM due to the improved yield. With relatively low yield-scaled N_2O

* Corresponding author. Division of Applied Life Science, Gyeongsang National University, Jinju 660-701, South Korea.
E-mail address: pjkim@gnu.ac.kr (P.J. Kim).
[1] The first two authors contributed equally and should be considered as joint first authors.

http://dx.doi.org/10.1016/j.atmosenv.2017.01.007
1352-2310/

emissions, 25% biomass mixing ratio of barley and hairy vetch (76 kg N ha^{-1}) under PFM could be recommended to enhance yield and to mitigate N_2O emissions in an upland maize cropping system.

1. Introduction

Agricultural intensification to meet the growing demand for food threatens environmental sustainability which necessitates designing or adopting alternative cropping practices that ensure more productivity and less environmental problems (Linquist et al., 2012; Uprety et al., 2012). Among such cropping practices, cover crop residues incorporation and mulching in arable soil are the common management practices in sustainable agriculture worldwide (Hobbs et al., 2008; Cuello et al., 2015). The leguminous cover crops either alone or in combination with non-legume are generally used as green manure to minimize chemical N fertilizer application and to improve soil organic carbon storage (Poeplau and Don, 2015; Tribouillois et al., 2015), whereas plastic film mulching (PFM) has been used to reduce soil evaporation, to control weed and soil-borne pathogens and to improve soil nutrient availability (Berger et al., 2013; Qin et al., 2015). Basically, most of the studies regarding cover crops incorporation and mulching in arable soils highlight the efficiency of these practices to maintain and/or to improve crop productivity and soil quality (Sharma et al., 2011; Cuello et al., 2015). However, the comprehensive effects of these two most widely agricultural practices in arable upland soils on the greenhouse gases intensity, mostly nitrous oxide (N_2O) fluxes, yield-scaled emissions and emission factors (EFs) are elusive.

Nitrous oxide, a major greenhouse gas contributed 6.2% to the anthropogenic global worming (IPCC, 2014) and globally 60% of the anthropogenic N_2O comes from agricultural soils (Lam et al., 2016). Nitrous oxide production in agricultural soil is mostly driven by two microbial processes i.e., nitrification and denitrification which are predominantly controlled by soil C and N availability, soil moisture, redox potential, temperature and oxygen content (Barnard et al., 2005; van Groenigen et al., 2015). As agricultural management practices can modify soil physicochemical properties and nutrient availability, they are expected to have notable impacts on N_2O emissions. Plastic film mulching may promote N_2O emissions because it generally increases soil moisture and temperature (Nishimura et al., 2012; Cuello et al., 2015). Nevertheless, the increase in crop production due to mulching enhances plant N uptake and thus reduces soil N availability and N_2O emissions (Liu et al., 2014). Reports on the effects of PFM on N_2O emissions are very few and contradictory. Some of the studies reported an increase in N_2O emissions (Nishimura et al., 2012; Cuello et al., 2015), while other studies reported a decrease in N_2O emissions (Berger et al., 2013; Liu et al., 2014). These inconsistent results have been attributed to the differences in soil N availability, soil moisture and temperature and plant N uptake (Nishimura et al., 2012; Berger et al., 2013). Likewise, cover crop effects on N_2O emissions mostly depend on cover crop types (legume, non-legume or a mixture of both) (Kim et al., 2013). Use of mixtures of non-legumes and legumes has been encouraged to merge the synergism of the individual species for better crop production and efficient use of resources (Hwang et al., 2015). Legume cover crops either alone or in combination with non-legume provide an additional N to soil and can affect soil moisture content through increase transpiration thus likely influence N_2O emissions (Peyrard et al., 2016). A meta-analysis revealed a short term increase in N_2O emissions due to the cover crop (especially legume) incorporation in agricultural soils (Basche et al., 2014). A year-long study conducted by Sanz-Cobena et al. (2014) reported little effect of cover crops on N_2O emissions. Although there are spatial variability and uncertainty in overall estimate of N_2O emissions from individual agricultural management practice (Berger et al., 2013; Basche et al., 2014; Liu et al., 2014), the interactive effects of the management practices even make it more uncertain.

Uncertainties in N_2O emission estimates have led many countries to adopt the default IPCC Tier 1 EF to calculate N_2O emissions from N source applied to soil. According to the Intergovernmental Panel on Climate Change (IPCC) 2006 guidelines the updated default EF for N inputs from mineral fertilizers, organic amendments and crop residues is 1% of the total N applied, regardless of soil type, climate and fertilizer type (IPCC, 2006; Lesschen et al., 2011; Bell et al., 2016), thus may not necessarily represents country-specific conditions. The default Tier 1 EFs are primarily used to estimate N_2O emissions from cropping systems in the absence of country-specific N_2O EFs and do not represent the spatiotemporal variability and the influences of soil physiochemical parameters, fertilizer types and climate conditions on N_2O emissions (Bell et al., 2016). In this consequence, if there are variations in N_2O emissions with soil, climate and fertilizer types then developing the location based EFs may ameliorate the N_2O emission inventory accuracy. In fact, the IPCC guidelines encourage countries to use Tier 2 approaches to increase the certainty of the emissions (Lesschen et al., 2011). Assessment of the influence of cover crop residues amendment and plastic film mulching on N_2O EFs could also aid the selection of the best mitigation option for arable soils under particular climate conditions. However, the information on N_2O EFs from cover crop residues amended soils under PFM is lacking. In this study, with two successive years field trials, we aim i) to develop seasonal N_2O EFs for arable soils amended with mixing ratio of legume and non-legume cover crop residues under PFM and NM and ii) to investigate how interactions of these practices together with soil conditions, influence seasonal N_2O EFs and iii) to identify the appropriate management practice for cover crop residues incorporation and mulching in maize cropping system that produce high yield and low N_2O emissions. The results of this work should better inform N_2O inventory calculations for cover crop residues (as green manure) amended soil under PFM and can be used to validate and further develop models of N_2O emissions from arable upland soils.

2. Materials and methods

2.1. Site description, experimental design and treatments

The field experiments were conducted at the experimental upland farms of the Gyeongsang National University Experimental plots (36°50′N, 128°26′E), Jinju, Republic of Korea, from 2012 to 2014. The soil of the experimental fields was fine silty, and mesic typic Endoaquenpts and the physiochemical properties of soil were as follows: pH 7.4 (1:5 with H_2O), total C 14.2 g kg^{-1}, total N 1.3 g kg^{-1}, NH_4^+–N 34.25 mg kg^{-1}, NO_3^--N 22.35 mg kg^{-1}, and available P_2O_5 188 mg kg^{-1}.

To investigate the effect of cover crop residues application rates