Journal of Integrative Agriculture 2016, 15(2): 451–464

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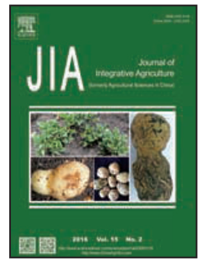

RESEARCH ARTICLE

Effects of plastic film mulching on soil greenhouse gases (CO_2, CH_4 and N_2O) concentration within soil profiles in maize fields on the Loess Plateau, China

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Abstract

To better understand the effects of plastic film mulching on soil greenhouse gases (GHGs) emissions, we compared seasonal and vertical variations of GHG concentrations at seven soil depths in maize (*Zea mays* L.) fields at Changwu station in Shaanxi, a semi-humid region, between 2012 and 2013. Gas samples were taken simultaneously every one week from non-mulched (BP) and plastic film-mulched (FM) field plots. The results showed that the concentration of GHGs varied distinctly at the soil-atmosphere interface and in the soil profile during the maize growing season (MS). Both carbon dioxide (CO_2) and nitrous oxide (N_2O) concentrations increased with increasement of soil depth, while the methane (CH_4) concentrations decreased with increasement of soil depth. A strong seasonal variation pattern was found for CO_2 and N_2O concentrations, as compared to an inconspicuous seasonal variation of CH_4 concentrations. The mean CO_2 and N_2O concentrations were higher, but the mean CH_4 concentration in the soil profiles was lower in the FM plots than in the BP plots. The results of this study suggested that plastic film mulching significantly increased the potential emissions of CO_2 and N_2O from the soil, and promoted CH_4 absorption by the soil, particularly during the MS.

Keywords: greenhouse gas, soil profile, plastic film mulching, growing season

1. Introduction

The buildup of greenhouse gases (GHGs) in the atmosphere is assumed to be responsible for increasing global mean temperature (Tett *et al.* 1999; Crowley 2000). Agricultural land covers 37% of earth's landmass and is responsible for 10–12% of anthropogenic GHGs emissions (IPCC 2007). It has been estimated that agriculture soils contribute approximately 52 and 84% to the global anthropogenic methane (CH_4) and nitrous oxide (N_2O) emissions, respectively (Smith *et al.* 2008). Agricultural soil is a complex medium that consists of a broad range of organo-mineral particles and aggregates, where numerous organisms exhibit different physiological processes (Fang and Moncrieff 1999). Soil properties vary temporally, horizontally and vertically (Davidson and Trumbore 1995). As a result of production and consumption and their upward, downward or horizontal

Received 17 December, 2014 Accepted 8 June, 2015
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doi: 10.1016/S2095-3119(15)61106-6

movements, the temporal and spatial dynamics of GHGs in soil profiles and different patterns of soil GHG concentrations have been reported (Pei *et al.* 2004; Fierer *et al.* 2005; Fang *et al.* 2009; Kusa *et al.* 2010). Furthermore, the spatial heterogeneity of GHG production and accumulation due to diffusion limitation has also been reported (van Groenigen *et al.* 2005; Koehler *et al.* 2012). However, the relationships between GHGs emission and climate, soil characteristics and management are not well known because of the large spatial and temporal variations. Thus, measurements of the GHGs concentration in soils may facilitate a better understanding of the temporal variations in their exchange between the soil and atmosphere.

Plastic film mulching is a common agricultural management practice worldwide and has been adopted for many years, especially in arid regions (Adams 1967; Sharma *et al.* 2011; Wang *et al.* 2011). Plastic film mulching can reduce soil surface evaporation, increase soil temperature and moisture (Adams 1970; Mahrer *et al.* 1984), improve the availability of soil nutrients (Li *et al.* 2004), and promote crop growth and yield (Liu *et al.* 2010; Zhao *et al.* 2012; Braun *et al.* 2013; Gan *et al.* 2013; Ruidisch *et al.* 2013). In addition, plastic film mulching may affect the growth and distribution of plant roots. Thus, plastic film mulching could affect the production, consumption and transport of GHGs in soils (Nishimura *et al.* 2012; Berger *et al.* 2013). However, very few studies have focused on the effects of plastic film mulching on the concentration of GHGs in soil profile in a typical cropping system.

Net soil surface gas fluxes result from production, consumption and transport through the soil profile. To understand where and how soil GHGs are produced, it is important to determine GHG concentrations in the near-surface atmosphere and their distribution throughout different soil profiles (Fang and Moncrieff 1999; Novak 2007). Some studies have shown that approximately 70–80% of the measured soil CO_2 fluxes derived from the top 100 cm of the soil (Davidson and Trumbore 1995; Koehler *et al.* 2012). Thus, we investigated GHGs concentration in the 100-cm soil profile to examine the effects of plastic film mulching on the distribution of GHGs in maize fields on the Loess Plateau.

2. Results

2.1. Soil temperature and soil water-filled pore space

In line with air temperature, soil temperature at different soil depths showed a similar seasonal variation pattern (Figs. 1 and 2). The extent of soil temperature variation over the whole annual cycle decreased with soil depth, with a range of –5.0 to 28.4°C at 0 cm soil depth and 12.4 to 21.6°C at 90 cm soil depth for the plastic film mulching (FM) treatment (Fig. 2). Relative to the bare plot without mulching (BP) treatment, mulching significantly increased the seasonal total of soil temperature during the maize growing season (MS), with an increase of 196.2, 179.2, 156.9, 119.9, 87.5, 41.2 and 33.5°C at soil depths of 0, 7, 15, 30, 50, 70 and 90 cm, respectively (Fig. 2).

In addition, the fluctuations for soil water-filled pore space (WFPS) decreased with greater soil depth for both the FM and BP treatments (Fig. 3). The WFPS varied from 28.5 to

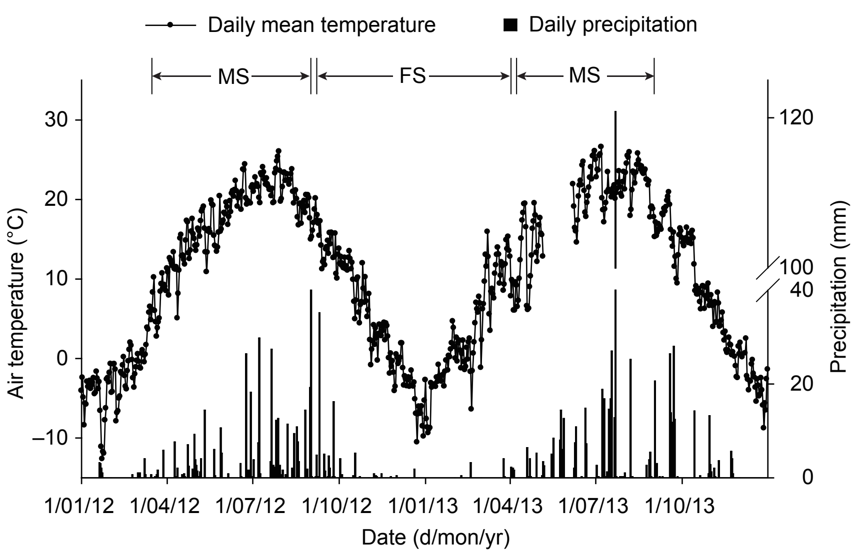

Fig. 1 Daily air temperature and precipitation means in 2012 and 2013. MS and FS denote the maize growing season and the fallow season, the same as below. Extraordinary precipitation of 120.8 mm occurred on 22 July in 2013. Data for air temperature were missing from 7 May to 6 June in 2013 as a result of equipment failure.