Nitrous oxide emissions from Soddy podzolic sandy loam soil after long-term fertilizer and manure application

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Introduction

Site specific estimates of direct soil N_2O emissions are very uncertain with soil water-filled pore space, temperature and mineral nitrogen content usually being the main controlling factors. Variations in these parameters can lead to substantial differences in N_2O emissions from the same soils during the year (Conen et al. 2000). The information available on N_2O emissions from agricultural soils in different countries varies widely. Emissions in Western Europe, the USA, Canada and elsewhere have been well documented (Stehfest and Bouwman 2006), but for some other countries, including Russia, there is almost no information available, except for soils of North-Western region and soils of Central Russia (Buchkina et al., 2009, 2010). The objective of this study was to estimate direct N_2O emissions from Soddy podzolic sandy loam arable soil in Central Russia after long-term application of manure and mineral fertilizer in different rates.

Material and Methods

The measurements of direct N_2O emission from the soil were conducted during the growing season of 2008 at the long-term field experiment established in 1968 by the All-Russian Research Institute for Organic Fertilizers and Peat (56°03'N, 40°29'E). The climate of the region is temperate, moderately continental, the average annual air temperature is +3.9ºC, the average annual rainfall is 599 mm, the average rainfall of the growing season (May-September) is 281 mm. There were seven different treatments for which the N_2O flux measurements were conducted: (1) Control, (2) FYM 10 t ha^{-1}, (3) FYM 20 t ha^{-1}, (4) N50P25K60, (5) N25P12K30 + FYM 5 t ha^{-1}, (6) N50P25K60 + FYM 10 t ha^{-1}, (7) N100P50K120 Fig.1,2.

The closed chamber technique was used to measure direct N_2O fluxes from the soil. Gas samples were collected twice a week (between noon and 2 pm) throughout the growing seasons (end of April until early October) of 2008. Chambers were put into the field every time before gas samples were collected. Four replicate chambers were used in each plot. A three-way tap on the top of each chamber was closed only after the chamber was fixed into the topsoil, to avoid extra air pressure inside the chamber. After 60–75 min gas samples were collected via the three-way tap. Similar sampling at the end of the closure period has been employed in our earlier works and elsewhere (e.g. Ball et al. 2007; Hergoualc'h et al. 2008). Daily and cumulative N_2O fluxes were calculated based on the measurements.

Fig.1The long-term field experiment

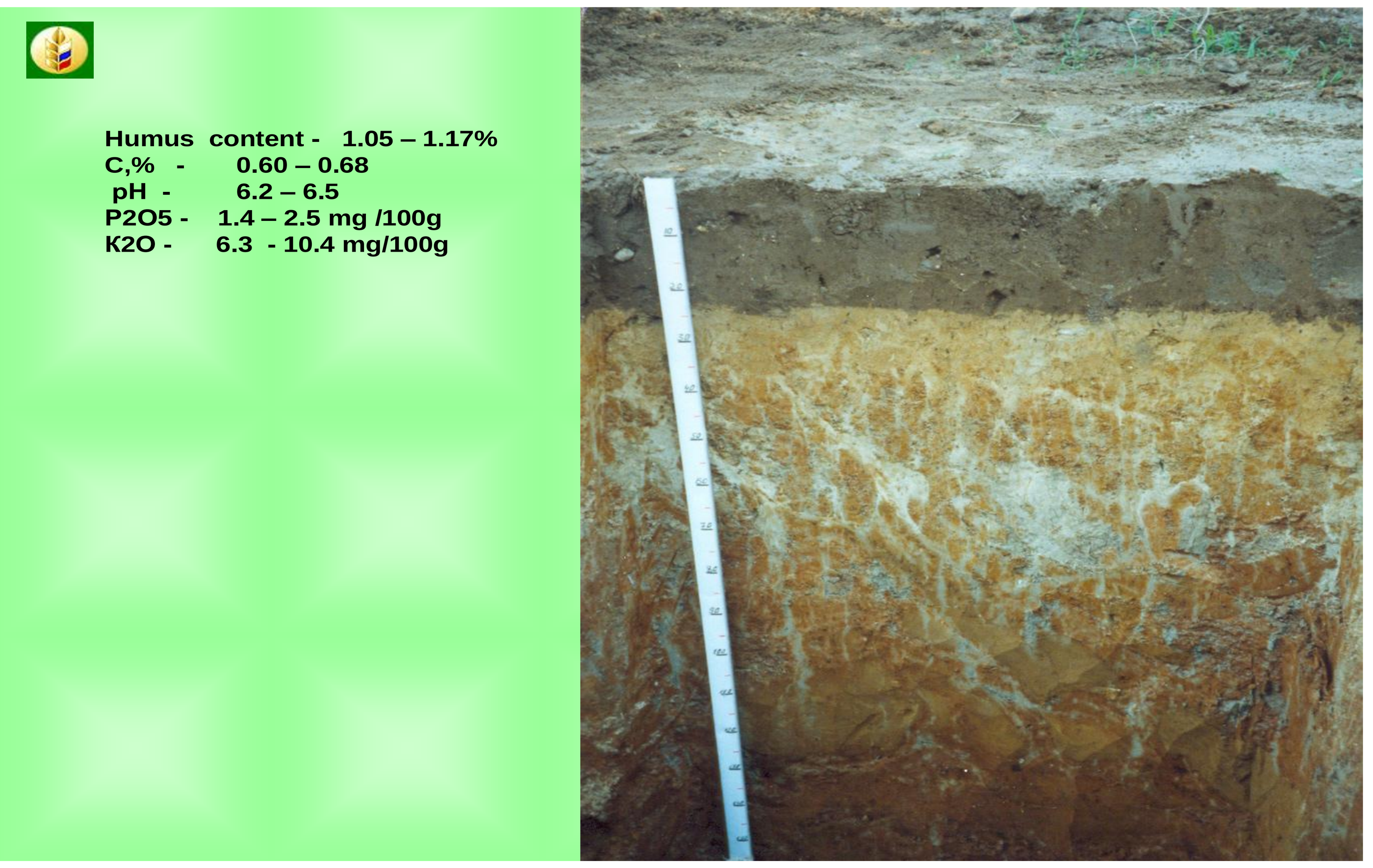

Fig.2. The soil profile

Results

The minimum daily N_2O fluxes varied between 0,05 and 0,21 g N_2O-N ha^{-1} day^{-1} for all the studied treatments with the significantly lowest flux measured from the soil with the FYM 20 t ha^{-1} treatment (Fig. 3a). The maximum daily N_2O fluxes varied between 5 and 39 g N_2O-N ha^{-1} day^{-1} with no significant differences between the studied treatments (Fig. 3b). The variability of the daily fluxes was higher for those treatments where higher rates of mineral N fertilizer or manure, or the combinations of the two, were applied. Cumulative N_2O fluxes for the growing seasons of 2008 for all the studied treatments were between 350 and 900 g N_2O-N ha^{-1}. There was no significant differences in this parameter between all the studied treatments. The cumulative N_2O fluxes in our experiment were slightly lower than reported by Buchkina et al. (2010) for the light-textured soils of North-Western Russia, particularly for the treatments with FYM and higher rates of mineral N fertilizer applied. These differences could be explained by lower amount of precipitation and lower content of available N in the studied soil. Nonetheless, the relative values obtained here, showing differences between fertiliser regimes and changes over the season, are very similar to the patterns reported elsewhere (Akiyama et al. 2000; Ruser et al. 2001; Dobbie and Smith 2003).

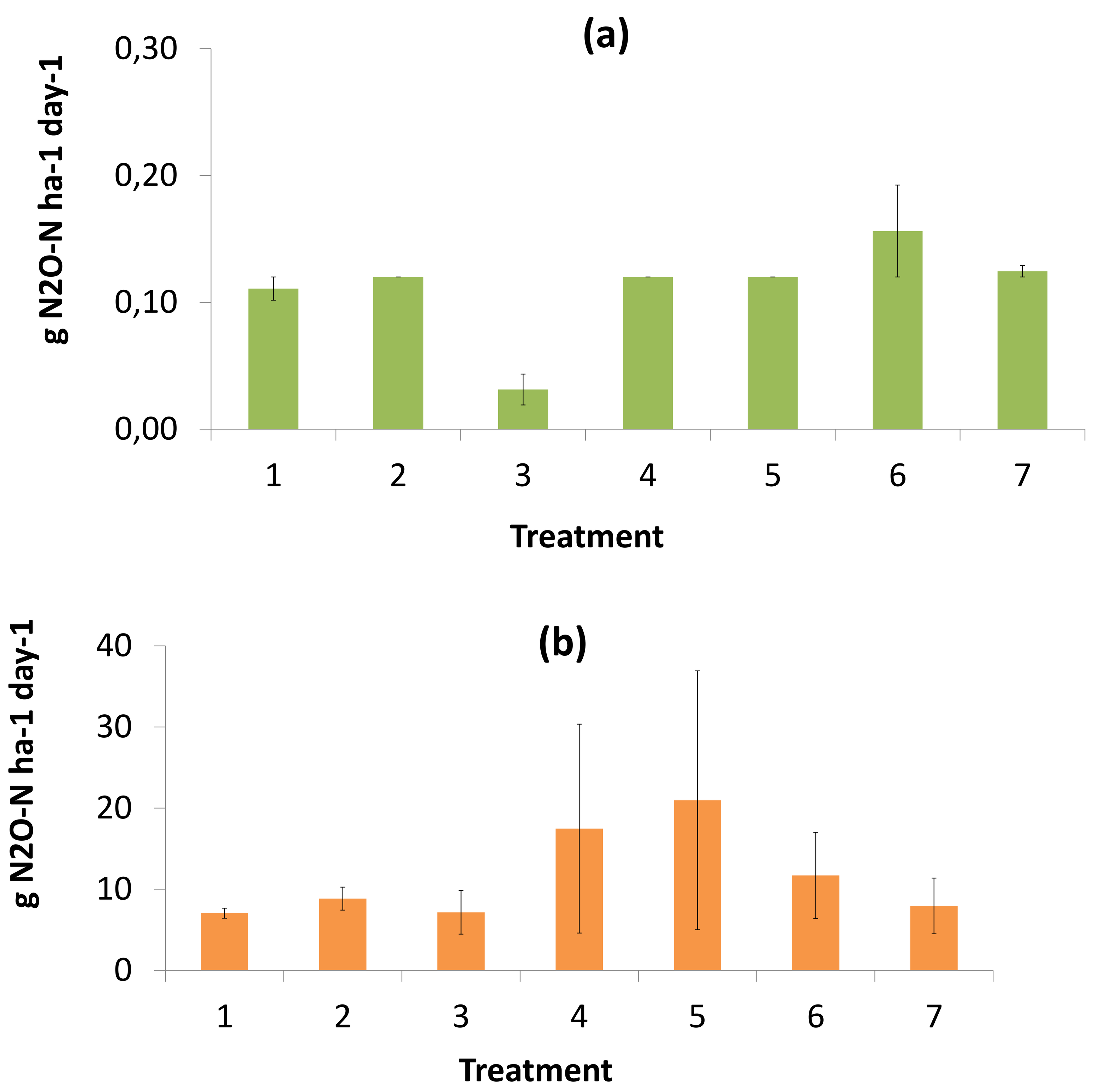

Fig. 3. Minimum (a) and maximum (b) daily N_2O fluxes from Soddy podzolic sandy loam soil after long-term fertilizer and manure application. Treatments: (1) Control, (2) FYM 10 t ha^{-1}, (3) FYM 20 t ha^{-1}, (4) N50P25K60, (5) N25P12K30 + FYM 5 t ha^{-1}, (6) N50P25K60 + FYM 10 t ha^{-1}, (7) N100P50K120.

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