Ammonia emissions from a soil amended with urea and an inhibitor of urease activity in a Mediterranean area

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Abstract

Urea and ammonium-based fertilisers are nowadays one of the most important sources of ammonia (NH_3) emissions to the atmosphere in Europe. However, little is known about NH_3 volatilisation in Mediterranean areas. The aim of the present study was the quantifieation of NH_3 emissions by using the Integrated Horizontal Flux (IHF) method after application of urea with the urease inhibitor N-(n-butyl) thiophosphorie triamide (NBPT) to a semiarid agricultural soil. The field experiment was carried out at "La Poveda" field station in Madrid on a sunflower crop in spring 2006. Urea and a mixture of urea and the inhibitor (0.14%) were surfaee-applied by hand at a rate of 170 kg N ha^{-1} to eircular plots (diam. 40 m). The soil was irrigated with 10 mm of water just after the applieation of urea to dissolve and incorporate it onto the first layer of soil. There were three peaks in the NH_3 flux over the duration of the measurement period (36 d). The first peak was associated to irrigation and the others to rainfall events. The total NH_3 emission during the whole experiment (36 days) was 17.3 ± 5.5 kg NH_3-N ha^{-1} in the ease of urea treated soils and 10.0 ± 4.5 kg NH_3-N ha^{-1} where NBPT was ineluded with the urea.

Background and objectives

Urea fertiliser is considered the ehcapest and most eommonly used form of inorganic N fertiliser (Thompson, *2004*). However, important losses of ammonia (NH_3) through volatilisation take place after urea fertiliser application (Misselbrook *et al.*, *2005*). Because N aeid deposition after volatilisation can oceur, important environmental problems such as acidifieation and eutrophieation of natural eeosystems will take place in a regional scale (Sommer and Hutchings, *2001*). In recent years, attention has inereasingly focused on the study of the rate of NH_3 emissions from agrieultural systems (Misselbrook *et al.*, *2005*) within the aim of developing those techniques by whieh a reduetion of NH_3 would be possible (Webb *et al.*, *2005*). Most of the research about NH_3 volatilisation from agricultural practices has been earried out in West Europe and USA, there are relatively few data relating to Mediterranean areas (Rana and Mastrorilli, *1998*). In this eontext, the first aim of the present study was the quantification of NH_3 emissions by using the Integrated Horizontal Flux (IHF) method (Misselbrook *et al.*, *2005*) after applieation of urea to a semiarid agrieultural soil. Our second objective was focussed on evaluating the effectiveness of the urease inhibitor NBPT as a means of minimising NH_3 emissions to the atmosphere.

Materials and methods

The study was carried out in a Typic Xerofluvent soil at "La Poveda" field station in Madrid on a sunflower erop in spring 2006. The average annual temperature and rainfall (over the last 10 years) in this area were 13.5°C and 460 mm, respectively. Four circular plots (r = 20 m) were selected in the experimental area on 20th May. There were two experimental treatments; urea and a mixture of urea within the urease activity inhibitor NBPT. The inelusion rate for the inhibitor in the mixture was 0.14% of the dry weight of urea. The treatments were applied by hand at a rate of 170 kg N ha^{-1}on 24th May. The four plots were irrigated with 10 mm of water just after application of the two treatments within the aim of dissolving and incorporating them onto the first layer of soil. Five passive flux samplers were plaeed in the middle of eaeh plot in order to measure the volatilised NH_3 by the IHF method according to Misselbrook *et al.* (*2005*). Samplers were prepared as described by Leuning *et al.*, (*1985*), coated internally with oxalic aeid, and located at heights of 0.25 m; 0.65 m; 1.2 m; 2.05 m; 3.05 m. Soil samples were collected eight times during the whole experiment in order to analyse changes in soil moisture, soil nitrate (NO_3^--N) and ammonium (NH_4^+-N) concentration as well as urease activity. Urease activity was determined by Nannipieri's method (Nannipieri, *1980*). Wind speed and direction, rainfall and air and soil temperature were recorded using a weather station (Davis Instruments) placed in the experimental field.

Results and discussion

Average temperature and rainfall were 25°C and 15 mm, respectively, during the experimental period. Urease activity remained almost constant until the 15th day (8 μmoles NH_3 g^{-1} h^{-1} L^{-1}) on the urea-only treated plots, but showed a strong decrease on the 4th day after (<1 μmoles NH_3 g^{-1} h^{-1} L^{-1}) in the plots where the inhibitor NBPT was included (Fig. 1). NBPT slowed the hydrolysis of urea and, therefore, the release of NH_3 (NH_4^+) into the upper layer of soil was also slower than in the case of urea-only treatment. Effectiveness of the inhibitor was observed for 11 days after application, which seems to be shorter than the effective time noticed by Watson *et al.*, (*1990*).

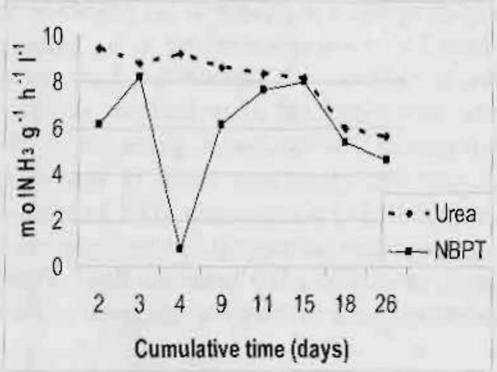

Figure 1. Urease activity (μmoles NH_3 g^{-1} h^{-1} L^{-1}).

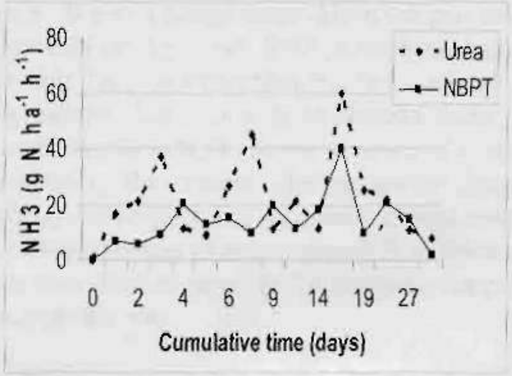

Figure 2. Ammonia volatilisation (g N ha^{-1} h^{-1}).

Volatilisation rates of NH_3 did not exceed the value of 60 g N ha^{-1} h^{-1} during the whole experiment (Fig. 2). In soils treated with urea only, fluxes of NH_3 peaked three times, the first peak (36.8 g N ha^{-1} day^{-1}) was driven by irrigation and the other two by rainfall events (44.8 and 60 g N ha^{-1} day^{-1}). For those soils where urea and NBTP was applied, three peaks in emission rate were also observed. However, the first two peaks were significantly lower than those observed on the urea-only plots. The total NH_3 emission over the whole experiment (36 days) was 17.3±5.5 and 10.0±4.5 kg NH_3-N ha^{-1} for the urea only and urea + NBPT treated plots, respectively. Losses of total N applied to the soil were 9.4 and 5.9% for the urea-only and urea + NBPT treatments, respectively. These results are generally lower than those reported elsewhere (for "Atlantic conditions") which might be explained by the initial irrigation event washing the urea into the soil. NH_3 emissions from plots treated within NBPT were 33% lower than those from soils where only urea was applied.

Conclusions

This experiment represents the first time that the IHF method has been used to measure NH_3 emissions from urea under Spanish conditions. The use of a urease inhibitor seems to be an effective mitigation measure which could be used by farmers when applying urea fertiliser in order to reduce emissions from agricultural lands. In addition, a future study based on comparing both irrigation and non-irrigation conditions over NH_3 emissions might complete the results of this experiment.

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