Effects of green manure storage and incorporation methods on greenhouse gas fluxes and N mineralization after soil application

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Organic arable farming faces challenges with low crop yields, partly due to inefficient use of green manure-derived nitrogen (N). In this 3-month incubation experiment, we tested a new strategy where green manure leys are harvested and preserved until the following spring either as compost mixed with straw (grass-clover : straw, 4:1) or as silage of harvested ley biomass.

Experimental design and objectives

Preserved grass-clover green manures stored as either:

- compost or
- silage

were soil incorporated by either (Fig. 1A):

- ploughing (simulated by placing green manures at 15 cm depth) or
- harrowing (green manures mixed into the top 5-cm soil layer)

in order to assess treatment effects on:

- soil respiratory CO_2 emissions (Fig. 1B)
- N_2O fluxes (Fig. 1B)
- net release of plant-available N

during a 3-month period.

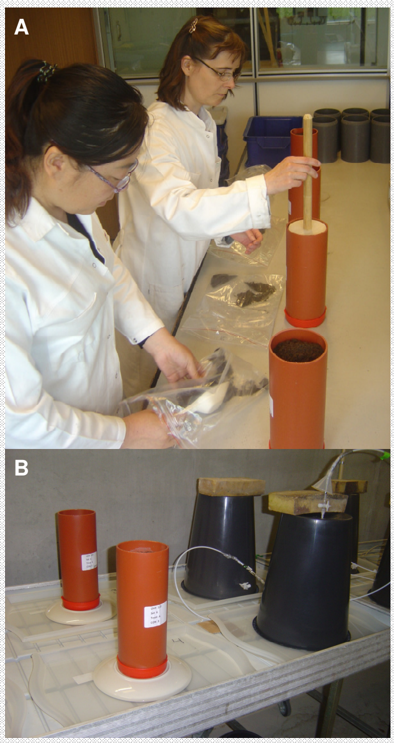

Fig. 1 The study included almost 200 packed soil cores that were incubated at 15 °C in darkness (A). Fluxes of N_2O and CO_2 were measured on nine occasions using a photoacoustic gas analyzer coupled sequentially to 26 static gas-flux chambers (B).

Greenhouse gas fluxes

The grass-clover silage had a high content of labile compounds compared to the more degraded compost, which resulted in higher cumulative CO_2 emissions (Fig. 2A). Between 32 and 54 % of the added green manure carbon was respired during the 3-month experiment.

Silage incorporated by ploughing gave rise to increased N_2O effluxes (Fig. 2B), corresponding to 0.3 % of applied total N. Possibly N_2O production via denitrification was stimulated by oxygen-limited conditions near the decomposing silage. In contrast, compost incorporated by harrowing caused downwards N_2O fluxes, presumably an effect of reduced mineral N availability in this treatment.

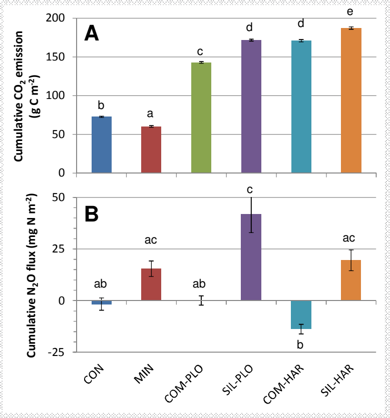

Fig. 2 Cumulative fluxes of CO_2 (A) and N_2O (B) during three months (means ± SE; n = 4). Treatments are control (CON), mineral fertilizer (MIN), compost and silage incorporated by ploughing (COM-PLO and SIL-PLO, respectively), and compost and silage incorporated by harrowing (COM-HAR and SIL-HAR, respectively). Flux rates with same letter are not significantly different.

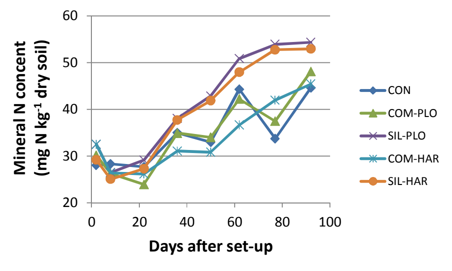

Fig. 3 Soil mineral nitrogen content measured following destructive harvests of soil units incubated for increasing periods of time (means; n = 4). Treatments are control (CON), compost and silage incorporated by ploughing (COM-PLO and SIL-PLO, respectively), and compost and silage incorporated by harrowing (COM-HAR and SIL-HAR, respectively).

Net nitrogen release

Grass-clover silage provided the highest net release of inorganic N with similar results for the two incorporation methods (Fig. 3). About one third of the total N content in the silage became plant-available during the 3-month period. In contrast, no increase in soil mineral N was observed for the composted grass-clover and straw mixture compared to the unfertilized control soil. In fact, soil incorporation of compost by harrowing caused immobilization of soil mineral N 1-2 months after experimental set-up.

Main conclusions

Ensiled grass-clover was the best fertilizer product, and the study indicates that N_2O emissions can be reduced by incorporating green manures by harrowing instead of ploughing.

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