Effect of rice husk biochar on nitrous oxide emission from decomposing hairy vetch in two soils under high-soil moisture condition

Yoshitaka **Uchida**[1], Moe **Shimotsuma**[2]

[1] Research Faculty of Agriculture, Hokkaido University, Sapporo, Hokkaido, Japan / [2]Graduate School of Agriculture, Hokkaido University

www.uchidalab.com / uchiday@chem.agr.hokudai.ac.jp

Introduction

- Use of **green manure legume + no-till farming** approach is known as a good method to provide nitrogen (N) to soils in organic farming systems.
- For example, a legume plant **hairy vetch (*Vicia villosa*)** can be planted in early spring before tomato plants are sown thus the tomatoes can utilize hairy vetch derived-N.
- However, the use of hairy vetch-N by the following crop is often not efficient when compared to chemical fertilizer-N and the **improvement of the N use efficiency of green manure legume + no-till systems** is critically needed.
- **Rice husk charcoal (biochar)** has traditionally been used as a soil conditioner made from an agricultural waste, in Japan.
- We tested whether the use of rice husk charcoal changes **N cycle** in soils during the decomposition of surface applied hairy vetch.
- Two contrasting but common Japanese soils (**Andosol (upland soil from a soybean field) and Fluvisol (lowland soil from a rice paddy)**) were used and we performed an incubation experiment under **high-moisture condition** to observe the activities of **N-loss processes** such as denitrification.

Hairy vetch

Rice husk charcoal

Methods

Soils

- Two major soil types, **Andosol** (volcanic ash soil) and **Fluvisol** (gray lowland soil) were used. Total carbon (%), total N(%) and pH of Andosol and Fluvisol were 3.13 and 1.73, 0.26 and 0.15, and 5.9 and 6.3, respectively.

Treatments

- The soils (100 g dry weight) were packed into PVC pipe cores and received one of four treatments. The core diameter was 5.5 cm. Soil height was approximately 5 cm.
  1. **Without hairy vetch without charcoal (HV- B-)**
  2. **Without hairy vetch with charcoal (HV- B+)**
  3. **With hairy vetch without charcoal (HV+ B-)**
  4. **With hairy vetch with charcoal (HV+ B+)**
- Hairy vetch application rates were **0.8 kg hairy vetch m^{-2} soil surface**. It was grown under ^{15}N fertilizer so **the hairy vetch was ^{15}N-labelled (0.49 atom% ^{15}N)**. Charcoal application rates were **2.1 kg charcoal m^{-2} soil surface** (charcoal was mixed into the soils). Temperature = 25°C. Soil moisture was maintained at **~100% WFPS**. They were incubated for 45 d.

Left: Prepared soil cores with and without hairy vetch and charcoal.

Right: Incubation method to measure gas emission.

Inorganic-N, gas (N_2O and N_2) and isotope ratio ($^{15}N_2O$) measurements

- Soils were destructively extracted with KCl and measured colorimetrically for **NH_4^+-N** and **NO_3^--N**. The inorganic-N was measured for **0–1 cm (top layer)** and 1–5 cm (bottom layer). The data for the top layer was shown in this poster.
- **Nitrous oxide (N_2O) gas emissions** were measured every 2–3 d and measured with a gas chromatography with an electron capture detector. Each core was incubated in a bottle for 30 min and N_2O gas concentration changes were measured to calculate the flux. For **$^{15}N_2O$ measurements**, isotope ratio mass spectrometer (Delta V, Thermo Electron Corporation) was used.
- **N_2 emissions** were measured approximately weekly by an **acetylene block method**.

Results & Discussions

- Hairy vetch treatment significantly increased NH_4^+-N. **Charcoal (+B) decreased NH_4^+-N and increased NO_3^--N in Andosol**. **For NO_3^--N, similar trend was observed for Fluvisol but in smaller scale**. The effect of charcoal on Fluvisol NH_4^+-N was unclear.
- With the same amount of legume-N being applied, **the accumulation of inorganic-N in soils markedly differed in the two soils**.
- Rice husk charcoal might have slowed down the **mineralization of hairy vetch-N** (organic N → NH_4^+-N) and/or speeded up the **nitrification processes** (NH_4^+-N → NO_3^--N) in Andosol. More microbial analyses for their activities may be needed.

Inorganic-N

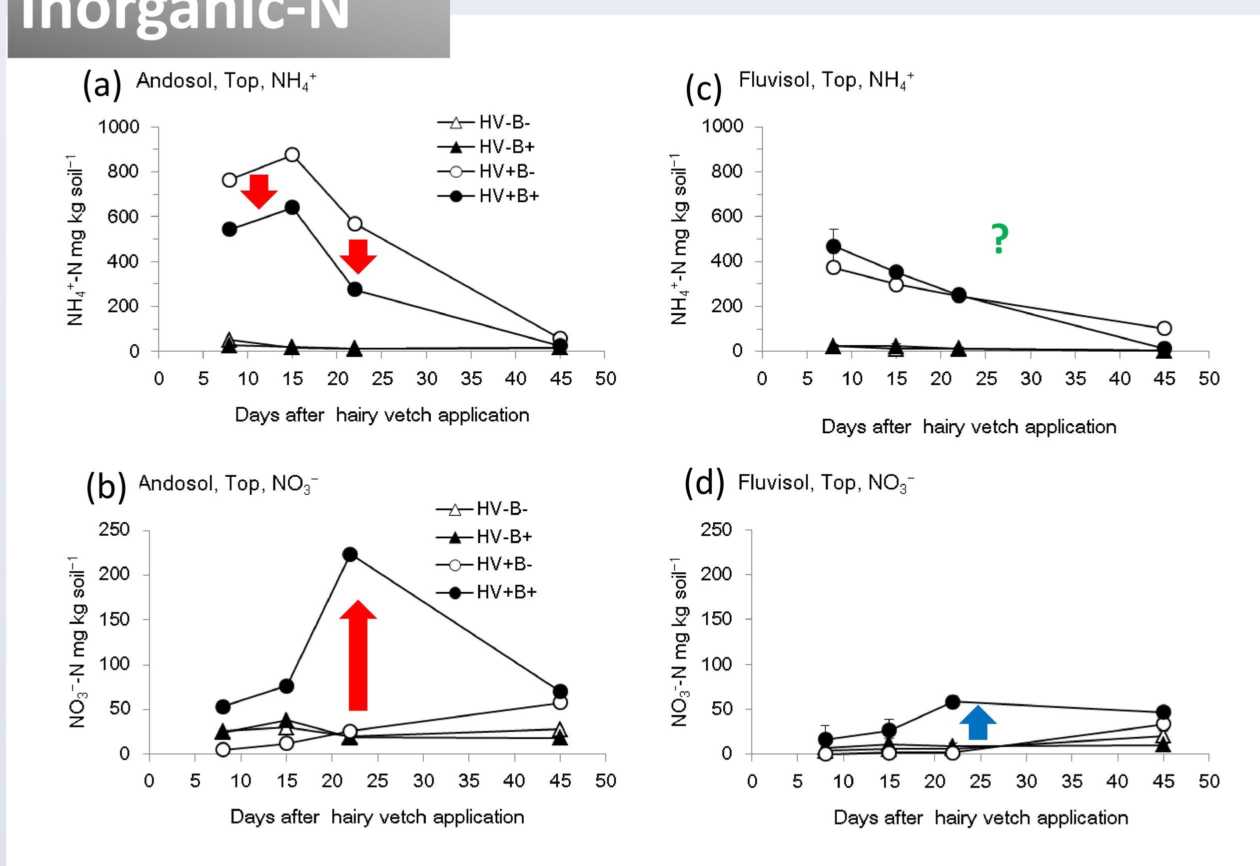

Fig. Time course of NH_4^+-N and NO_3^--N in Andosol (a, b) and Fluvisol (c, d) during the incubation with/without hairy vetch (HV) and with/without rice husk charcoal (B).

- For **N_2O emissions**, their patterns were different between +charcoal and −charcoal. However, the **cumulative N_2O emissions were not different when + and − charcoals were compared**.
- $^{15}N_2O$ data might have suggested that relatively **more N_2O-N was derived from the hairy vetch in +charcoal treatment**. Also, **higher complete denitrification (N_2O → N_2) was occurring in −charcoal treatment**.

N_2O and N_2

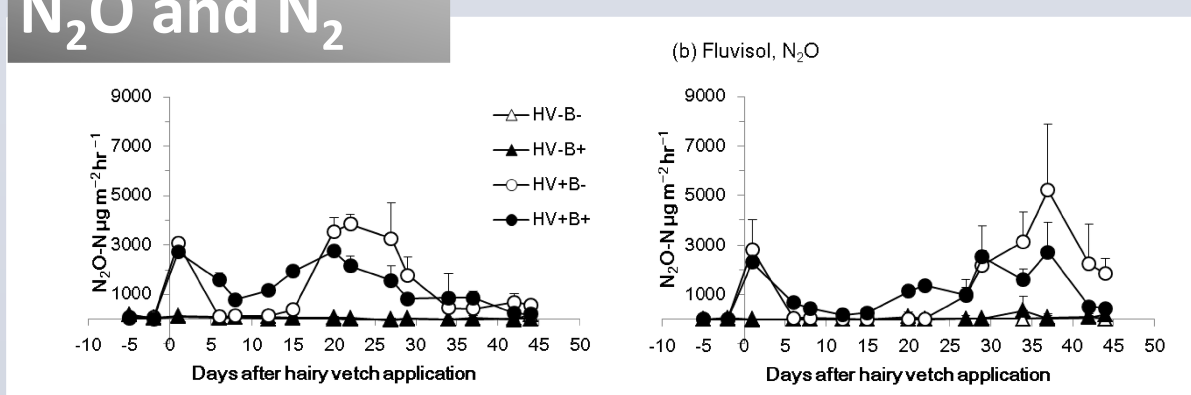

Fig. N_2O emission patterns.

Soil types	Treatments		Cumulative N_2O emission (μg N m^{-2})	Cumulative recovery of applied hairy vetch-N as N_2O-N (%)	N_2 emission (μg N m^{-2})
	Hairy vetch	**Biochar**			
Andosol	−	−	0.24 ± 0.09		0.04 ± 0.03
		+	0.10 ± 0.04		0.01 ± 0.01
	+	−	3.09 ± 0.04	1.73 ± 0.05	3.51 ± 1.11
		+	2.96 ± 0.45	2.63 ± 0.50	2.06 ± 0.58
Fluvisol	−	−	0.10 ± 0.01		0.07 ± 0.05
		+	0.29 ± 0.26		0.08 ± 0.11
	+	−	3.56 ± 0.82	2.34 ± 0.24	2.06 ± 0.49
		+	2.87 ± 0.39	2.90 ± 0.29	0.70 ± 0.34

Table. Cumulative N_2O emissions, recovery of applied hairy vetch-N as N_2O-N and cumulative N_2 emissions.

Conclusions

- **The effect of the surface applied legume residue, hairy vetch, on inorganic N concentration, N_2O, and N_2 emission were influenced by the presence of rice husk biochar.**
- **Under saturated soil moisture conditions, the addition of biochar reduced the amount of soil NH_4^+-N in an Andosol but the effect of biochar on NH_4^+-N was not clear for a Fluvisol. The effect of biochar on N-related microbial processes has to be investigated further in detail.**
- **The cumulative emission of N_2O was not significantly different with and without biochar both in an Andosol and a Fluvisol. However, the cumulative recovery of applied hairy vetch-N as N_2O-N was higher with biochar.**

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