Effects of Dicyandiamide in a Soil Applied with Anaerobic Digestion Effluent

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Introduction

Anaerobic digestion effluents

Methane fermentation processes have gained much attentions as biogas collection technique while decomposing organic matters such as sewage sludge, animal manures, and food wastes. However, substantial amounts of anaerobic digestion effluents (ADEs) remain after the process. ADEs contain abundant plant nutrients such as nitrogen (N) and potassium, and have proven to have equivalent fertilizer effects as chemical fertilizers, although nitrous oxides (N_2O) emissions can be increased from ADEs application to soils.

N_2O emissions from agricultural soil

Ammonium-nitrogen (NH_4^+-N) in agricultural soils can quickly transform to nitrate-nitrogen (NO_3^--N) under aerobic conditions, then to N_2O and nitrogen gas under anaerobic conditions. N_2O is produced as nitrification by-product and/or denitrification intermediate product in these processes. It's been reported that N_2O emission is mainly caused by nitrification from Andisols in Japan. In addition, nitrification inhibitors can prevent nitrification of chemical fertilizer applied to soil, but that effects in ADE-applied soils have not been understood.

Objectives

To evaluate the effect of application of nitrification inhibitor on nitrification in ADE-applied soil

Materials and Methods

- Soil (Hachioji, Tokyo, Japan)
  - Typic Dystrochrept (0-15 cm)
  - Oven dried (45°C) with 2 mm sieved for experiment

Fig. 1. Typic Dystrochrept

Table 1. Soil chemical characteristics

Total N (g kg^{-1})	NH_4^+-N (mg kg^{-1})	NO_3^--N (mg kg^{-1})	pH
2.83 ± 0.1	12.0 ± 1.4	0.056 ± 0.08	7.17 ± 0.01

- Anaerobic digestion effluent
  - Derived from cow manure digestion process
  - NH_4^+-N accounts for 37% of TN

Fig. 2. ADE

Table 2. ADE chemical characteristics

Total N (mg L^{-1})	NH_4^+-N (mg L^{-1})	NO_3^--N (mg L^{-1})	pH
3186 ± 188	1170 ± 52	0.39 ± 0.024	7.90 ± 0.01

- Nitrification inhibitor
  - Dicyandiamide (DCD)
  - ⇒ Applied as 10% of TN in fertilizer
- Experimental treatments
  - No amendment (Cont)
  - Ammonium sulfate as chemical fertilizer (AS)
  - Ammonium sulfate with DCD (AS+DCD)
  - ADE (ADE)
  - ADE with DCD (ADE+DCD)
  - ⇒ Set up three replicate respectively, and fertilizers were applied as 140 kg N ha^{-1} based on N recommended rate for Japanese mustard spinach (*Brassica rapa*).
- Incubation methods
  - Incubated at 30°C with 50% of water filed pore space
  - Sampling at 3, 7, 14, 21, 28, 35, 42, 49, and 56 d
- Analyses
  - NH_4^+-N (indophenol blue method @640 nm)
  - NO_3^--N (ultraviolet spectrophotometric method @220 nm)
  - pH (glass electrode method)

Results and Discussion

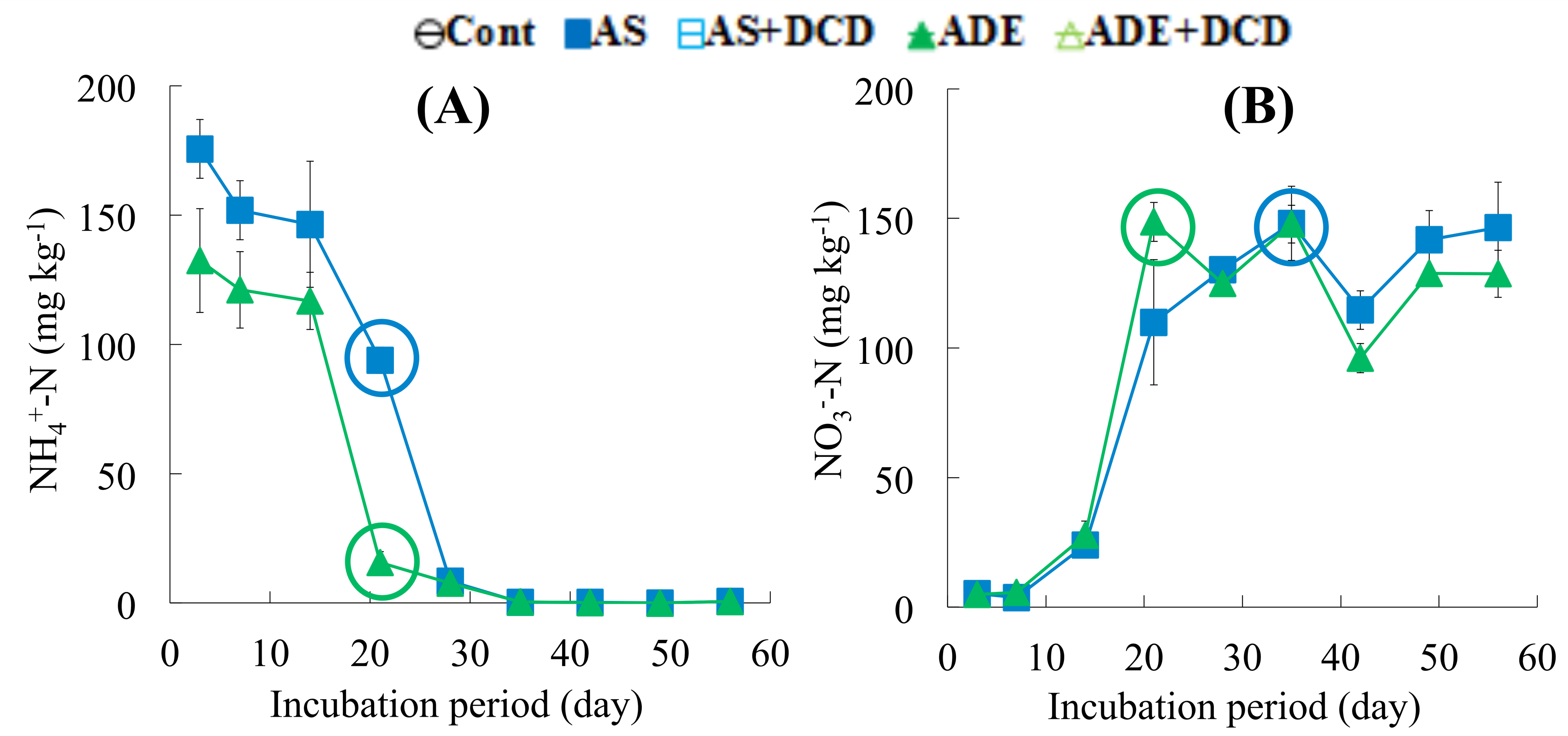

Fig. 3. Temporal change of soil (A) NH_4^+-N (AS and ADE) and (B) NO_3^--N (AS and ADE)

- **NH_4^+-N concentrations in soil with ADE decreased more quickly than those with AS.**
- **NO_3^--N concentrations in soil with ADE reached to the maximum more quickly than those with AS.**
  - **⇒ ADE showed similarly quick fertilizer effects as AS based on similar nitrification rates.**

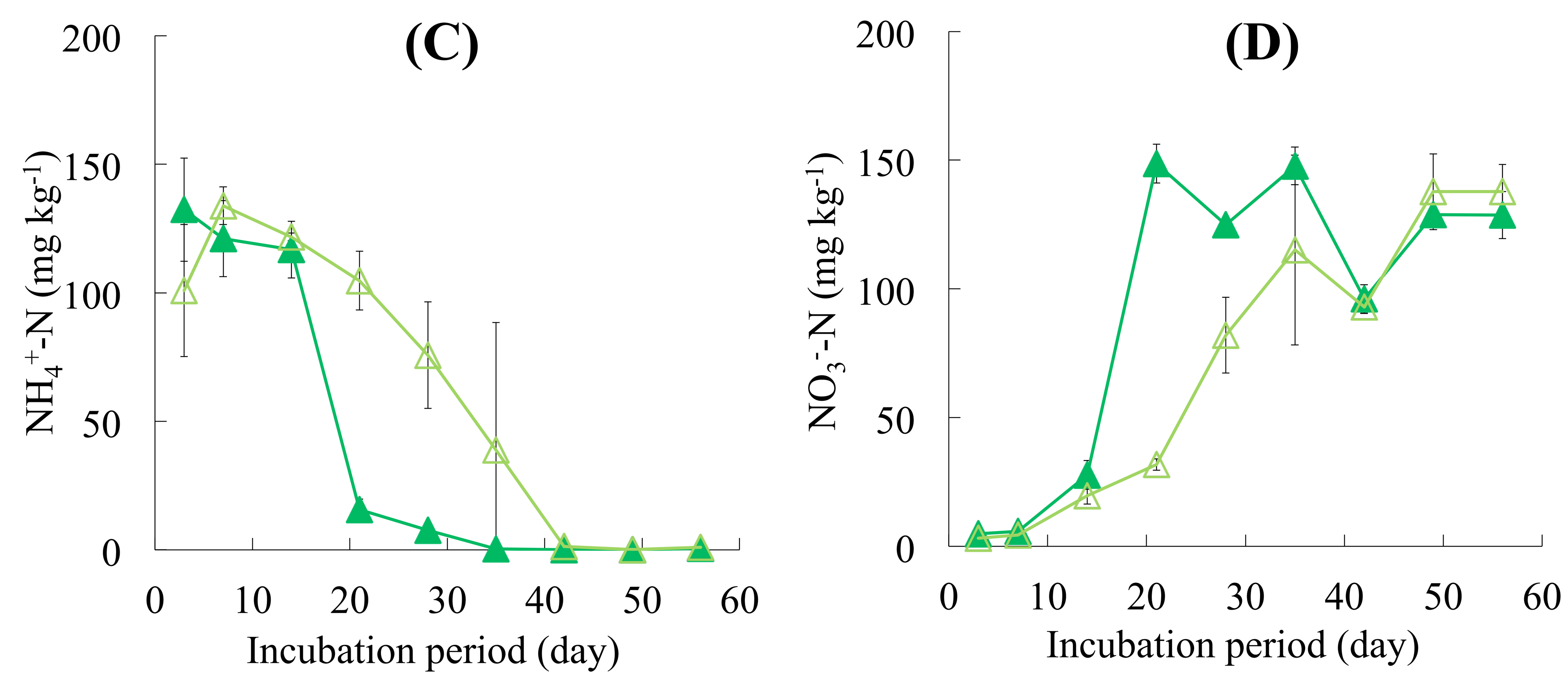

Fig. 4. Temporal change of soil (C) NH_4^+-N (ADE and ADE+DCD) and (D) NO_3^--N (ADE and ADE+DCD)

- **NH_4^+-N and NO_3^--N concentrations in soil with ADE+DCD decreased and increased, respectively, more gradually than those with ADE.**
  - **⇒ Nitrification inhibitory effect of DCD was indicated in ADE-applied soil.**

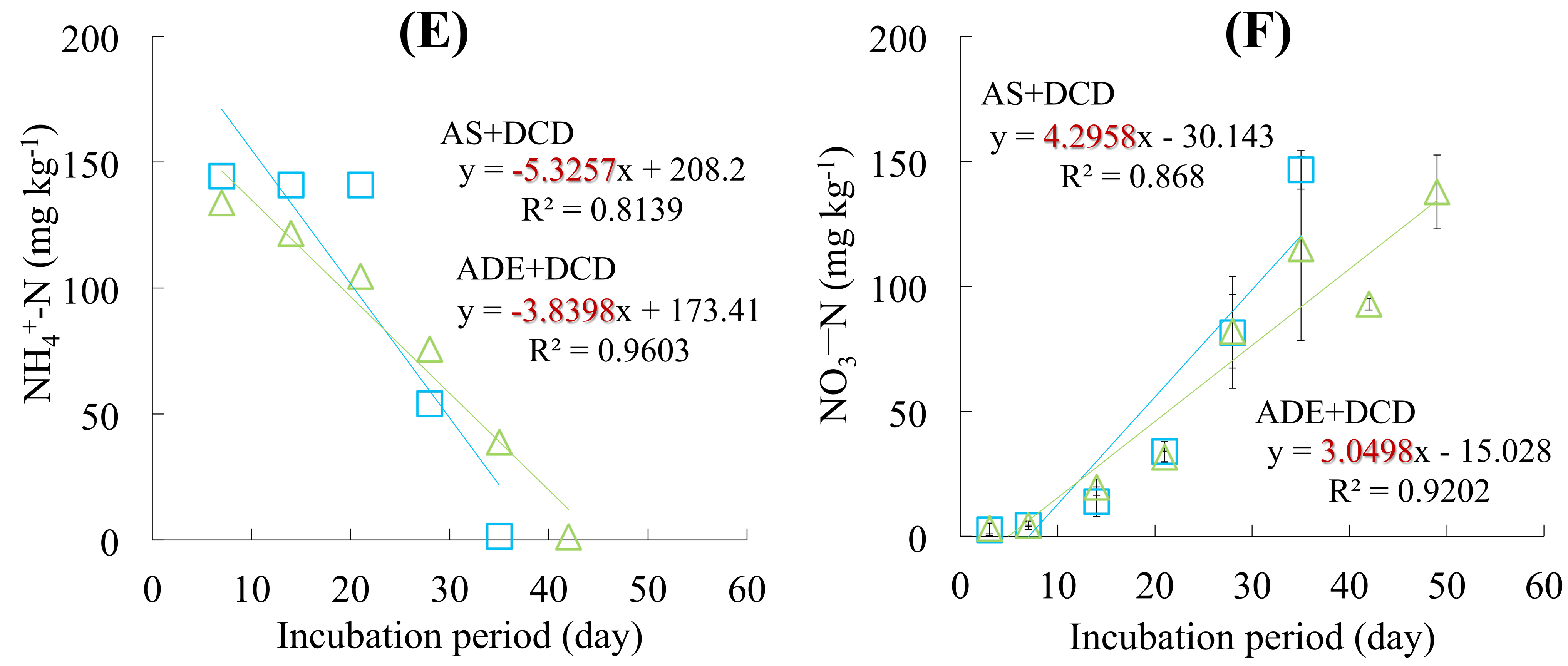

Fig. 5. Regression lines from 3 d to (E) the minimum rate on NH_4^+-N (AS+DCD and ADE+DCD) and (F) the maximum rate on NO_3^--N (AS+DCD and ADE+DCD)

- **Slopes of the regression lines of NH_4^+-N and NO_3^--N in soil with ADE+DCD were more gradual than those with AS+DCD, respectively.**
  - **⇒ It was inferred that nitrification inhibitory effect of DCD on nitrification in ADE-applied soil was stronger compared with that in AS-applied soil.**

Conclusions

- Anaerobic digestion effluents could have similar fertilizer effects as soluble chemical fertilizers.
- Dicyandiamide showed sufficient inhibitory effects on nitrification in ADE-applied soils.
- Effect of dicyandiamide on nitrification inhibition in ADE-applied soil may be greater than that in chemical fertilizer-applied soil.