초본군락 산림토양의 질소동태

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NH_4^+ mineralization and nitrification rate at two grassland stands established on volcano Mt. Showa-Shinzan, in northern Japan

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1. Introduction

In grassland ecosystems, it is well known that NH_4^+ and NO_3^- concentrations are usually low because of their rapid utilization and immobilization by grasses and decomposer organisms. A number of previous investigations have been concerned with fertilization in grassland ecosystems. The effects of fertilization on species compositional changes have been measured. However, particularly in grassland established after volcanic eruptions, effects of soil nutrient with respect to vegetation recovery on volcano has never been examined. Furthermore, considering vegetation recovery after volcanic eruptions, more accurate informations on nutrient distribution and cycling in grassland ecosystems should be required, because it is no exaggeration to say that grassland is one transitional zone in successional processes, especially in volcanic area. Therefore, understanding the soil N cycle in the grassland requires information about seasonal dynamics of soil N in the grassland ecosystem.

The purpose of this study is to describe the soil N dynamics including extractable N-form, NH_4^+ mineralization and nitrification rate in the two grassland stands, and to understand the influence of grassland on vegetation recovery after volcanic eruptions on volcano Mt. Showa-Shinzan, northern Japan.

2. Materials and methods

2.1. Study site

This study was conducted on Mt. Showa-Shinzan(407 m in alt., 42°33'N, 140°52'E) which was created by volcanic eruptions in the period of 1944-45. Annual precipitation in this area is about 991 mm, with about half of this falling in the summer months. The mean annual temperature is 8℃. Large temperature fluctuations occur monthly, with mean monthly temperatures ranging from -16.7℃ (Min.) in January to 26.9℃ (Max.) in August. This study area was covered by snow for about 4 months, from late December to early April.

In shrub stand, 14 woody plants of approximately 5m height such as *Salix hultenii* v. *angustifolia*, poplar (*Populus maximowiczii*) and birch (*Betula ermanii*) were found, but no woody species were found in grassland community. The dominant herbaceous species within two study stands were orchard grass (*Dactylis glomerata*) and white clover (*Trifolium repens*).

2.2. Soil N analysis and incubation

On each stand seven samples of soil were randomly collected at a depth of 0 - 5 cm. Organic materials such as roots and litters were removed from soil samples, and all the samples were returned to the laboratory and refrigerated at 4℃. Sampling was carried out monthly from May 2002 to November 2004.

The concentrations of extractable NH_4^+ and NO_3^--N in each sample were determined. Seven 20 g soil were extracted by shaking with 80 ml of 2 N KCl before incubation. The extracts were analyzed by an automated colorimetric method using the nitroprusside-catalysed indophenol reaction and analyzed as NO_2^- after reduction in a Cadmium column to obtain the initial concentrations of NH_4^+ and NO_3^--N. The concentrations of extractable NH_4^+ and NO_3^--N were expressed as N milligram per kilogram of dry soil.

In the absence of direct methods for measuring N mineralization, a wide variety of methods that provide a comparative index of mineralization have been developed. In this study, potential NH_4^+ mineralization and nitrification rate were determined after 30 day aerobic incubations in the laboratory. At the end of the incubation time, samples were also extracted and analyzed as described above. Final minus initial values of NH_4^+-N gave net NH_4^+ mineralization rates. Similarly, the nitrification rate was taken to be the concentration after incubation and after correction for the initial NO_3^--N concentration. Final minus initial values of NH_4^+-N plus NO_3^--N gave net N-availability.

3. Results and Discussion

3.1. Extractable NH_4^+ and NO_3^-

The concentrations of extractable NH_4^+ varied throughout the year, ranging from 1.42 in September 2004 to 3.89mg/kg in May 2002 at the grassland stand and 1.42 to 3.89mg/kg at the shrub stand(Fig. 1). At both of the two study stands, a conspicuous peak for extractable NH_4^+ was observed in the early growing season of May, June, and July and declined throughout the late summer and fall. The average annual NH_4^+ concentrations at the grassland and shrub stand were 2.50 and 2.65mg/kg, respectively.

Extractable NO_3^- concentrations were ranged from 1.78mg/kg in November 2002 to 2.94mg/kg in June 2003 at the grassland stand and 1.59mg/kg in October 2004 to 2.66 in July 2003 at the shrub stand. Large peak in extractable NO3- occurred in August and June The concentrations of extractable NO_3^- were relatively low throughout the study period, and showed significant seasonal changes. Average value of extractable NO_3^- concentration at the grassland and shrub stand were 2.02mg/kg and 2.17mg/kg, respectively.. The average concentration of extractable NH_4^+ was higher than that of the average NO_3^- concentration during the period of sampling.

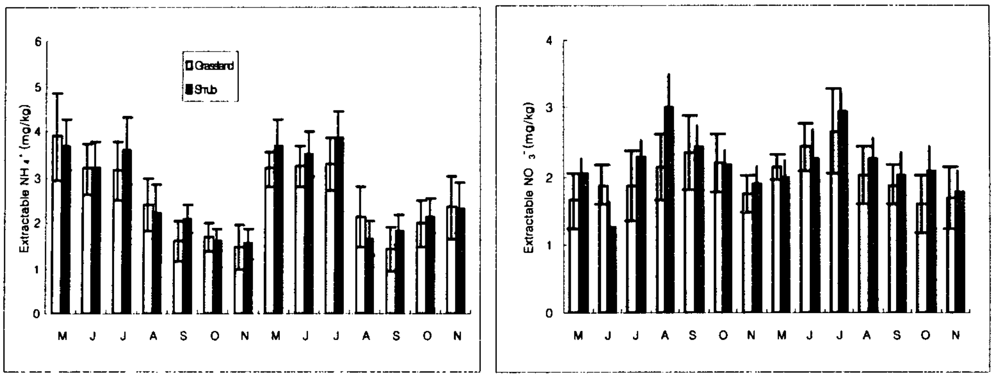

Fig. 1. Seasonal patterns and amounts of extractable NH_4^+ and NO_3^- of grassland and shrub stands.

3.2. NH_4^+ mineralization and nitrification rate

Seasonal patterns in net NH_4^+ mineralization and nitrification rate are show in Fig. 2. Generally, net NH_4^+ mineralization reflected the amount of organic N and the qualuty/qualtity of soil organic matter available for mineralization. At both of two study stands. net NH_4^+ mineralization was greater in May, June and July, decreased in the late summer and fall. No significant difference was observed in NH_4^+ mineralization between the two stands. NH_4^+ mineralization for mineral soil of grassland varied seasonally, with remarkable peaks in May, June and July. Throughout the study period, nitrification rates were comparatively low. Although the nitrification rates throughout the study period showed no remarkable differences between the two stands, higher values for nitrification rates at the two stands were observed in May, June and July, and declined in the fall. The percentage of nitrification to N availability ranged from 40% to 97% at the grassland and 22% to 49% at the shrub stand.

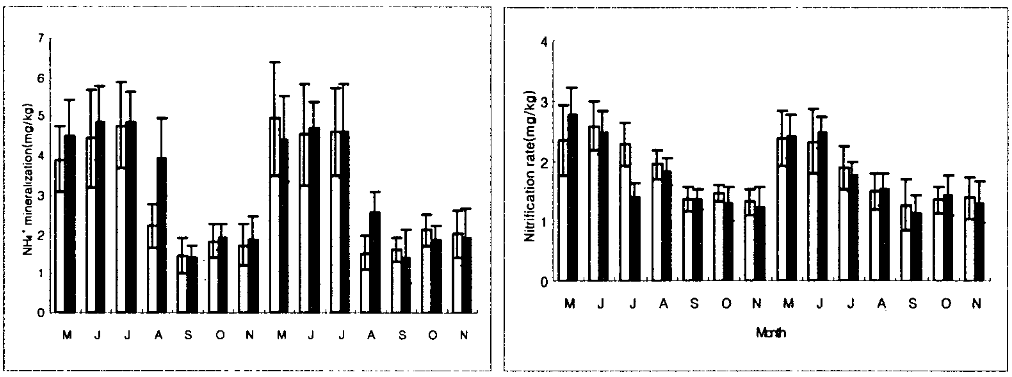

Fig. 2. Seasonal patterns and net NH_4^+ mineralization and nitrification rate of grassland and shrub stands.

On the upper slopes of volcano Mt. Showa-Shinzan, two grassland ecosystems form two communities displaying differences species composition. Taking vegetation recovery in a volcano into consideration, it is to be expected that two grassland stand will be gradually by other species as a result of the stabilization from the standpoint of soil N availability. Ecosystem succession, in the limited sense of the term, begins with the establishment of pioneer plants such as N-fixing species and proceeds by successive replacement of these species with trees that profit from the changing environment. In the present study, the appearances of orchard grass (*Dactylis glomerata* L.) and white clover (*Trifolium repens* L.) are remarkable. These early pioneer herbaceous species are well adapted to nutrient-poor sites after volcanic eruption because of their nitrogen-fixing properties that increase nutrient availability in the forest ecosystem.