Soil nitrogen dynamics in a larch forest, Central Siberia: A short review of preliminary results

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1. INTRODUCTION

Boreal forest and tundra contain about one thirds of the terrestrial carbon pool (Prentice et al. 2001). Many studies have pointed out high priority of roots in primary production of high latitude ecosystems. Carbon storage in roots has been reported to comprise 40–50% of total in mature larch forests in eastern and central Siberia (Kanazawa et al. 1994, Kajimoto et al. 1999). Kajimoto and others (2003) found root network of *Larix gmelinii* spreads horizontally especially at mature stage. Thus, recent concerns have been directed to controls of soil nutrient availability in these northern ecosystems.

Nutrient availability is assumed to increase and stimulate ecosystem productivity by global warming in many terrestrial ecosystems in this century (Shaver et al. 1992), while little has been understood on responses of ecosystem processes to these climate changes. Nitrogen (N) is an essential element for organism's growth and productivity in forest ecosystems. In tundra ecosystems, it has been suggested that increased nitrogen availability influences productivity of plants and roots and decomposition process in soil, though researches are limited on nutrient dynamics in Siberian boreal forests. In this paper, we review preliminary results on soil nitrogen dynamics in larch forests, central Siberia, including nitrogen-fertilization experiments. All the results here we introduce are from researches conducted at a larch forest about 105 years after fire (named as the NF site, profile 1), located on Tura, central Siberia (64°N, 100°E).

2. EXTRACTABLE SOIL NITROGEN

Tokuchi and her colleagues have measured pool size and production rate of inorganic nitrogen from 2002. Pool size of inorganic N in 0-to-10 cm mineral soil was mostly less than 5 kgN ha^{-1}, which was significantly greater that in organic layer. Nitrate was considerably low compared with ammonium in the soils. Difference in inorganic N pool was not clear among three N treatments (Control, 0 kgN ha^{-1} yr^{-1}; Low N, 12 kgN ha^{-1} yr^{-1} addition; High N, 60 kgN ha^{-1} yr^{-1} addition) in 2002-2004. However, in 2005, inorganic N pool in organic layer and mineral soil was significantly and slightly higher in High N treatment compared with the other

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treatments (Fig. 1). Thus, it suggests that high N addition can stimulate inorganic N pool in surface soil within one year but low N addition needs more time to stimulate inorganic N pool.

Field incubation was performed for *in situ* estimating inorganic N production before N fertilization experiment (2002 to 2003 and 2003 to 2004) (Kondo et al. in preparation). The net rate of inorganic N production measured in the NF site was less than 8 kgN ha^{-1} yr^{-1} for both organic and 0-10 cm mineral soil in average, and highly variable within site. Therefore, organic N in soil seems not to be mineralized constantly in this site.

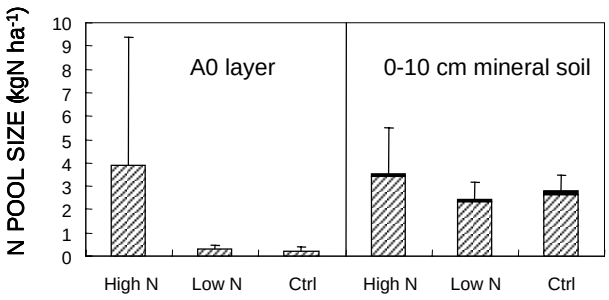

Fig. 1. Mean pool sizes of inorganic N in A0 layer (left) and 0-10 cm mineral soil (right) with standard errors, measured in 2005. Shaded parts indicate ammonium and dark parts indicate nitrate.

3. NITROGEN IN SOIL WATER

Ion-exchange resins were buried beneath organic layer and at the 10 cm depth of mineral soil in the three different N treatment sites. Using them, the amount of inorganic N leaching was estimated before and after the N fertilization experiments. The results indicated quite low (< 2 kgN ha^{-1} yr^{-1}) vertical transport of inorganic N within surface soil before fertilization, while great values from 4 to 10 kgN ha^{-1} yr^{-1} were observed beneath organic layer in high N site after fertilization (Kondo et al. in preparation).

Prokushkin and Hobara measured dissolved N concentrations in soil solutions and found that dominant form in these solutions was dissolved organic nitrogen (DON) (Fig. 2). Concentration of inorganic N (ammonium plus nitrate) was mostly less than 1/10 as compared with that of DON. It is thus suggested that DON is the most important N form constantly supplying dissolved N to soil circum stances in this site.

4. NITROGEN IN PLANTS AND STREAM

Foliar nitrogen content of larch, *Larix gmelinii*, was measured before and after (1 year) fertilization in the N treatment sites. The comparison showed no significant differences among treatments. It suggests that it takes more time that N increase in leaves of this tall species can be observed. We have taken annual leaves of mosses and lichens. Such plants covering forest floor may have earlier response to N fertilization.

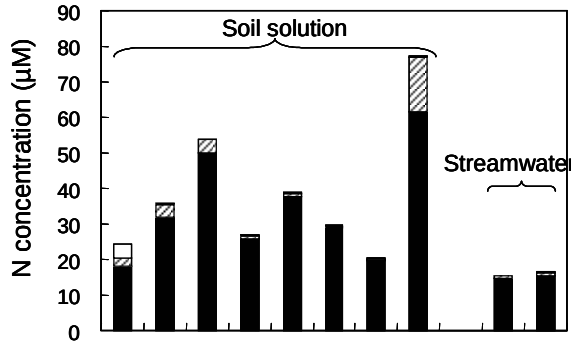

Fig. 2. Dissolved N concentrations in soil solution and stream water from the study site. Dark, shaded, and blank parts indicate DON, ammonium, and nitrate, respectively.

Streamwater taken from bottom of the north slope of NF site showed higher percentage of DON compared with inorganic N (Fig. 2). Concentrations of DON, ammonium, and nitrate in streamwater were lower compared with those of soil waters.

5. CONCLUSIONS

Surface soils (organic layer and 0-10 cm mineral soil) from larch forests, central Siberia, had small pool size of soil inorganic N, while higher values can be observed especially in organic layer in N fertilized sites. Annual leachate of inorganic N was also small before N fertilization, while greater values were observed beneath organic layer in high N site after fertilization. Thus, N treatment seems to stimulate inorganic N dynamics of soil surface, and it may consequently lead to stimulation of lower soils. Dissolved organic nitrogen (DON) was the most important N form constantly supplying dissolved N to soil circumstances in this site, suggesting a possibility of organic N to control on ecosystem processes in these forests.

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