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学 位 論 文 題 名

Nitrogen budget and dynamics of taiga forest ecosystem in north eastern Siberia

（東シベリアタイガ林生態系の窒素収支と動態）

学位論文内容の要旨

Boreal forests located in northern regions are considered as an important CO_2 sink. However, northern regions are known to be poor in nitrogen which may limit plant growth. We conducted study on nitrogen cycle and dynamics in boreal forest ecosystem in North- Eastern Siberia, where vast area is covered by the largest and the deepest permafrost in the world, and not so many studies on nitrogen cycle have been done.

The study site was located at Spasskaya Pad station, which is 40 km away from Yakutsk city in Republic of Sakha, Russia. The specie forming the forest stand is larch (*Larix cajanderii L.)*, which is a deciduous conifer.

The amounts of deposited ammonia and nitrate were comparable, nitrite deposition occurred to be very low. Input of inorganic N by deposition was very small (48 mgN m^{-2} $year^{-1}$), and this means importance of recycle of N in the soil. Inorganic nitrogen in the soil pool was increasing from early summer to late autumn, mainly driven by soil temperatures accumulation ($r=0.97$) and through mineralization process. Nitrification process was slow and content of nitrate in the soil pool was minor. The amount of water extractable inorganic nitrogen (potentially available for plants) was several fold less, due to major soil cationic strength. Production of inorganic nitrogen was coupled with strong microbial immobilization, thus strong competition for nutrient between microbiota and plants.

To know important plant nutrition information tracer isotopic label experiments were used. It was found that larch tree assimilated both nitrate and ammonium. Also, exchange between ammonium attached to soil particles and dissolved in soil solution was very slow. Most of nitrogen was assimilated in the second half of growing season. Larch tree showed negative possibility to directly absorb organic nitrogen applied in the form of amino acid. We found seasonal patterns of uptaken nitrogen allocation in the tree body. Accumulation of nitrogen in the tree perennial parts occurred from the middle of summer (mid-July), when soil nitrogen was

maximally abundant, for the next year growing needs. On the other hand, nitrogen uptaken in the early growing season was immediately allocated to new growing tree parts, such as needles and new shoots.

The possibility of direct canopy uptake of deposited nitrogen was shown in the experiment.

In conclusion, the impact of soil temperature and moisture condition to carbon sequestration through nitrogen availability was shown. Nitrogen availability limited carbon sequestration with one year time lag.

学位論文審査の要旨

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学位論文題名

Nitrogen budget and dynamics of taiga forest ecosystem in north eastern Siberia

（東シベリアタイガ林生態系の窒素収支と動態）

Boreal forests located in northern regions are considered as an important CO_2 sink and their distribution is closely related to distribution of permafrost. That is one of the reasons that causes slow microbial processes in the soil and vegetation. Also, northern regions are known to be poor in nitrogen which limits plant growth in these areas. Climate change and its consequences are the hottest topics in the recent decades. If such changes can cause shifts in nutrients cycling it will affect carbon cycle too; which, in turn, through the series of feedbacks might amplify the climate changes even more. Although N cycle have been extensively studied in evergreen or deciduous broadleaf boreal forests of European and American continents, very little information is available from the vast Siberian territories where deciduous conifer - larch, dominates. Therefore we focused our study on nitrogen cycle and dynamics in boreal forest ecosystem in North- Eastern Siberia, where major part of area is covered by the largest and the deepest permafrost in the world, and not so many studies on nitrogen cycle have been done.

Our study site is located at Spasskaya Pad Experimental forest station, which is 40 km away from Yakutsk city in Republic of Sakha, Russia. The specie forming the forest stand is larch (Larix cajanderii L.), which is a deciduous conifer.

The amounts of deposited ammonium and nitrate were comparable, while nitrite deposition occurred to be very low. Input of inorganic N by deposition was very small, and this means importance of recycle of N in the soil. Inorganic nitrogen in the soil pool was increasing from early summer to late autumn, mainly driven by soil temperatures accumulation and because increase in rate of inorganic N production. Nitrification process was slow because content of nitrate in the soil pool was minor. The amount of water extractable inorganic nitrogen (potentially available for plants) was several folds less than that of KC-extractable, due to strong attachment of ammonium on soil particles. Production of inorganic nitrogen was followed by microbial immobilization of inorganic N in the fall; competition for nutrient between microbiota and plants takes place.

To know important plant nutrition information tracer isotopic label experiments were used. Larch did not uptake organic N directly and used ammonium and nitrate as N source instead. Most of nitrogen is uptaken the second half of growing season and accumulated in tree perennial parts to be used in the beginning of the next growing season. On the other hand, N that was uptaken in the beginning of growing season was directly used for the new parts (needles and new shoots) formation. The possibility of direct canopy uptake of deposited nitrogen was shown in the experiment.

Needle N contents were affected by soil temperature and moisture condition. In turn, needle N contents positively correlated with amount of litterfall produced in the next year, therefore, carbon sequestration was affected by N availability. Nitrogen availability limited carbon sequestration with one year time lag.

There were several important and new findings in this study. The description of dynamics of N cycle was pioneer in this area and was not described before neither in international literature, nor in Russian. Described seasonality of size of inorganic N pool was a new finding in our study. Also this study showed that larch did not uptake organic N directly as many of northern plant are reported to do but used only inorganic form of N for nutrition. Early start of accumulation of N in tree perennial parts from the middle of summer to prepare it for new needles and shoots in the next growing season was another important finding.

Seasonality and year to year variation in a soil inorganic N pool has not yet generally recognized. Seasonality observed in this study is a new finding. Direct use of amino acid was not observed in the study site. These findings suggest uniqueness of this ecosystem, while the area covered by this taiga forest is quite large.

All committee members valued dissertation highly, and recognized her ability to conduct research, honesty and enthusiasm, and considering the all activities during the period of doctor course, we concluded that the applicant is worthy to give doctoral degree (Environmental Science).