Soil N and humification in three drained peatland forests with different temperature sums

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Summary

The most important nutrient for forest trees is nitrogen (N). Most peat N is in an organic form, which is unavailable for mycorrhizae and tree roots. Only a small fraction of the N pool is mineralised to compounds that are available for uptake by the trees. A sufficient and lasting source of soil N is a prerequisite for timber production. In this study we will present and discuss some aspects of how the soil N availability is reflected in different peat soils and stand characteristics, such as peat decomposition, botanical residues in peat as well as stand volume and growth.

Key index words: nitrogen, humification, botanical residues, temperature sum

Introduction

In Finland, drained peatland forests form an increasing portion of the nation's wood and timber resources and growing stock (Statistical Yearbook of Finland, 2006). Sites with sufficient timber producing potential range from southern to northern central Finland whereas in Lapland (north Finland) the climatic conditions are considered too unfavourable for profitable wood growth on organic soils.

On boreal drained peatlands (in the north) nitrogen (N) is the most important growth-limiting nutrient for forest trees. The limited availability of N compounds that can be taken up by tree roots constrains stand growth on sites with low or medium fertility (Korkalainen et *al*., 2007). The length and intensity of the growth period expressed as the temperature sum (degree days, d.d.) is a critical factor for the N transformation in peat.

In peat, carbon (C) and N form a close interrelationship. Inorganic C compounds provide the energy sources (e.g. Martin 2000) for N transformations. Peat properties, such as composition of plant residues (e.g. amount of *Sphagnum* or *Carex* residues) and humification (H, von Post) form the physical environment for the microbes that transform N and C. In general, peat N correlates well with peat H and, for instance, phosphorus (Hartman *et al.*, 2001).

In this study we discuss some abiotic factors that may restrain tree stand growth by comparing drained peatlands with fairly similar site characteristics in different climatic regions.

Material and methods

The study sites are three drained peatlands: Ylimysneva in Alkkia (62° 9' N, 22° 52' E, 175 m asl), Haapua in Pudasjärvi (65° 28' N 27° 40' E, 190 m asl) and Hepokangas in Taivalkoski (65° 32' N 28° 25' E, 240 m asl).

The Alkkia experiment (long term temperature sum average 1100° C) had been drained in 1969. In this study 15 sample plots were included. The original site types ranged from ombrotrophic low sedge bog to tall sedge fen and herb rich flark fen. The tree stand consisted of Scots pine (*Pinus sylvestris*), planted after drainage.

The experiment in Haapua (long term temperature sum average 950°C d.d.) that consisted of 35 sample plots drained in 1965. The original site types were cottongrass pine bog, *Carex globularis* pine swamp and tall sedge pine fen (with some features resembling rich fens, for instance patches of *Molinia caerulea* and *Calamagrostis purpurea* var. *phragmitoides*).

At the Hepokangas experiment, drained in 1962 (long term temperature sum average 850°C d.d.) 37 sample plots were studied. The original site types were cottongrass pine bog and *Carex gobularis* pine swamp and herb rich sedge birch-pine fen (for site type descriptions see e.g. Laine and Vasander, 1996).

At both the last-named experiments with lower temperature sums, the Scots pine stands were naturally established. The stands were interspersed with some small downy birch (*Betula pubescens)* and Norway spruce (*Picea*

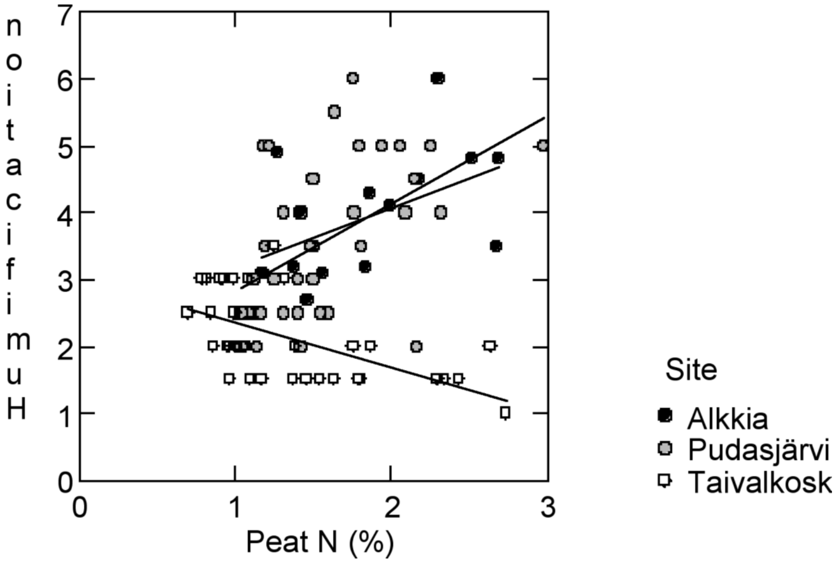

Figure 1. Peat nitrogen concentration and degree of humification on the three sites.

abies). The Alkkia and Haapua sites are transformed drained peatland forests and the Hepokangas site a transforming drained peatland forest.

Starting in 2001 the air and soil temperatures have been measured annually throughout the year. Peat samples were collected to determine the total N, degree of humification and botanical composition in the 0-10 cm layer of the peat. The peat total N was determined with a LECO. The peat humification was determined with the von Post method.

The botanical composition of the peat samples from Haapua and Hepolangas (Hartman and Pietiläinen, 2007) was determined with a light microscope (e.g. Heikurainen and Huikari 1952). The botanical components were separated into the following groups: *Carex* and graminoids, *Bryales* mosses, lignoids (residues from trees and shrubs) *Eriophorum vaginatum*, mesotrohrophic *Shagnum* mosses (sections Subsecunda and Squarrosa and *Sphagnum warnstorfii*) and indifferent e.g. oligotrophic and ombrotrophic Sphagna (mainly sections Palustria, Acutifolia and Cuspidata).

Results

In Alkkia and Haapua experiments there was a positive correlation between peat N and H, while it was negative in Hepokangas (Fig. 1). In Haapua there was a positive correlation between the peat N and the *Carex*+graminoids components, negative between the peat N and the *Sphagnum* (indiff.) and no correlation between peat N and the *Sphagnum* (mesotr.) components. In the Hepokangas experiment no such relationships occurred.

Generally the relationship between peat N and *Carex* peat is positive while that between peat N and *Sphagnum* peat is negative (Laine et *al.,* 2000; Hartman et *al.,* 2001).

In Haapua the proportion of *Sphagnum* (mesotr.) was higher than in Hepokangas, while the proportion of *Sphagnum* (indiff.) was much higher in Hepokangas. The largest difference between the two sites, however, was in the peat H, comparatively low in Haapua, but exceptionally low in Hepokangas. The long time average air temperature sum is 100°C lower in Hepokangas.

Discussion and conclusions

The botanical composition of the peat samples from Haapua and Hepokangas (Hartman and Pietiläinen, 2007) did not differ very much. However, there were considerable differences in the peat N and H. Peat N was mainly accumulated through biological fixation of atmospheric N, an energy-demanding process (Chapman and Hemond, 1982; Hemond, 1983). Along with a drop in the temperature sum from 950 to 850 (Päivänen and Paavilainen, 1996; Päivänen, 2007) a threshold seems to have been reached below which soil processes for N transformation and nutrient uptake were insufficient for providing available nutrients for profitable timber production.

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