Effects of different tree species on microclimate and microbial processes on a natural regeneration site

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Introduction

Investigations on water balance, soil fertility and microbial decomposition processes were conducted on a 20 year old wind-throw site. The former spruce monoculture is now replaced by a mixed stand of birch (*Betula pendula*), trembling aspen (*Populus tremula*), spruce *(Picea abies*) and oak (*Quercus robur*). The site is located in a warm area at low altitude on heavy soils, where unfavourable environmental conditions for spruce trees are prevailing.
The aim of this project part was to determine whether birch could be considered as beneficial to forest regrowth in this area. In addition possible ecological effects of different trees concerning litter decomposition, carbon sequestration and the emission of greenhouse gases could be detected.

Study site and methods

The experimental plot is located at about 320 m a.s.l. in the south-east of Styria in Austria. Annual mean air temperature is 8.8 °C with an average precipitation of 765 mm. The soil is characterised by a high content of clay in the mineral soil horizons (”Stagnogley”).
Six sampling sites including three groups of birch (Figure 1) and three groups of spruce were selected. Measurements were made at 35 sampling periods, approximately every two weeks from May 2000 until November 2001. Meteorological and soil parameters were monitored continuously. In addition nitrogen mineralisation and microbial biomass were determined in the litter layer and in the mineral soil (Schinner et al. 1996). Microbial respiration and the emission of the greenhouse gas nitrous oxide (N_2O) were measured in the field by static chambers (Figure 3; Hahn et al. 2000). Nitrogen availability was determined with ion exchange resin bags incubated in 10 cm soil depth (Zechmeister-Boltenstern et al. 2002).

Figure 1. View of one of the birch plots.

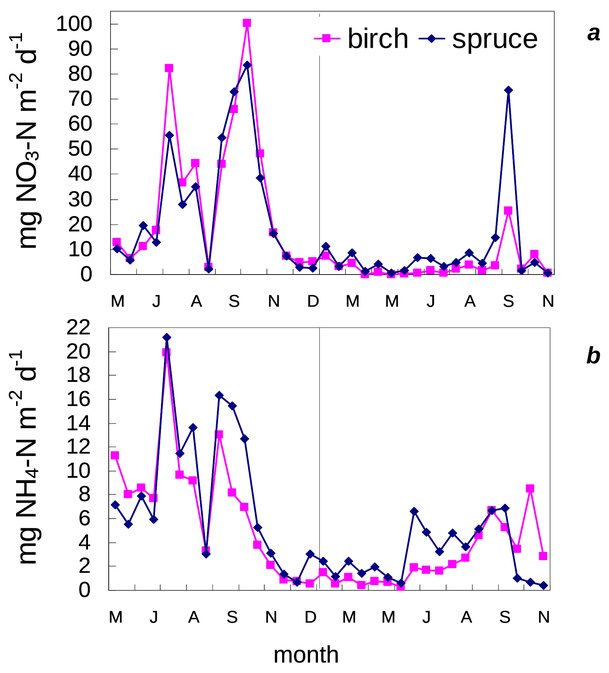

Figure 2. Seasonal dynamics of nitrate (a) and ammonium (b) availability in birch and spruce plots.

Results and discussion

A strong seasonal trend of microbial nutrient dynamics was detected (Figure 2a and b). This trend was dependent on tree species as birch and spruce groups showed different microclimate, root distribution, shading, litter quality and transpiration rates. It turned out that the mineral soil under birch was dryer due to enhanced transpiration (Leitgeb et al., 2002 see neighbouring poster). However, the humic layer under birch was more moist and less susceptible to drying during summer. Birch plots had a higher soil respiration and less acidic pH (Figure 4b). Due to higher root density and the presence of herbal vegetation nitrate and ammonium were quickly taken up by plants in birch plots (Figure 2). Respiration rates were dependent on air temperature. They reached 3.6 Mg CO_2-C ha^{-1} y^{-1}. We conclude that 20 year old birch trees already exerted a positive influence on microbial mineralisation processes and on soil chemistry.

Figure 3. Gas samples taken from static chambers used for the determination of greenhouse gas emissions.

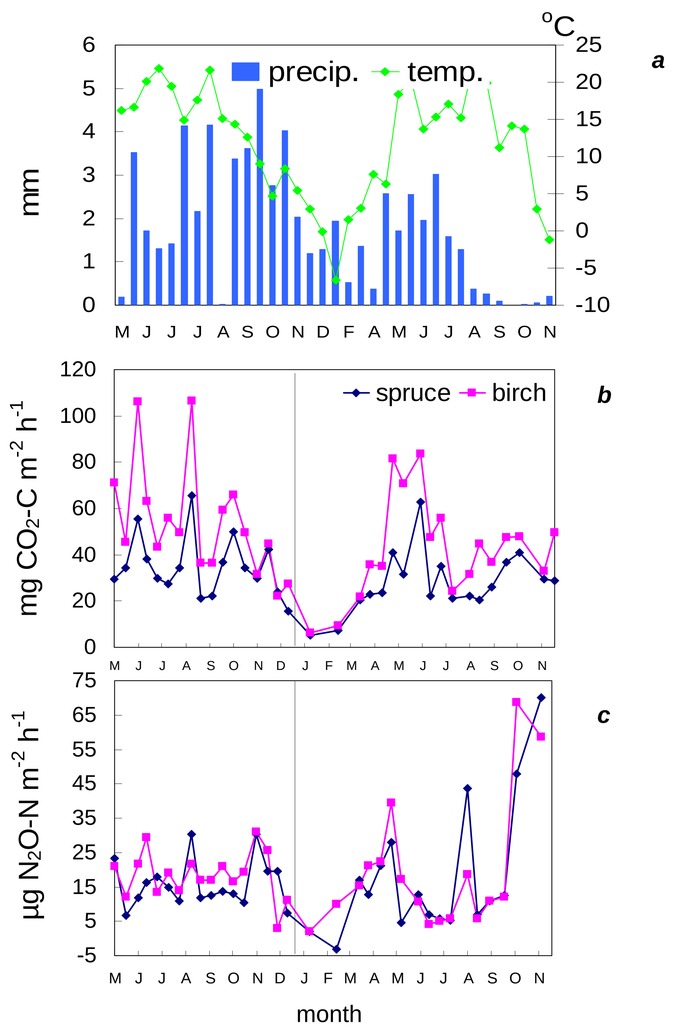

Figure 4. Seasonal dynamics of temperature and precipitation (a), CO_2-emission (b) and N_2O-emission (c) in birch and spruce plots.

In contrast microbial biomass (data not shown) and respiration rates in spruce plots relied on precipitation and on soil moisture (Figure 4a and b). They declined under dry periods, which means that in this climate microbial decomposition processes and nutrient release may be inhibited in summer under spruce. In spruce plots the soil emitted 2.3 Mg CO_2-C ha^{-1} y^{-1}.
There was no significant difference of N_2O emissions between spruce and birch plots (Figure 4c). The investigated plots emitted about 1.4 kg N_2O-N ha^{-1} y^{-1}. This is higher than the European average of about 0.5 kg N_2O-N ha^{-1} y^{-1} but lower than forests close to the city of Vienna, which emit more than the double amount of the greenhouse gas (Zechmeister-Boltenstern et al., 2002). Highest emissions occurred during warm and rainy weather. The availability of NO_3^- and NH_4^+ did not seem to limit the emission of N_2O as there was no correlation with these parameters during the vegetation period.
The results of our study emphasise the possible value of birch as a pioneer tree species. Due to the better litter quality and the stimulation of microbial mineralisation, birch can help in the restoration of secondary coniferous forests and in the conversion into more stable mixed deciduous forests in this area.

References

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