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DIFFERENCES IN RESPONSE OF TWO SPHAGNUM SPECIES TO ELEVATED CO_2 AND NITROGEN INPUT

Jauhiainen, J., Vasander, H. & Silvola, J. 1992: Differences in response of two Sphagnum species to elevated CO_2 and nitrogen input. — Suo 43:211–215. Helsinki. ISSN 0039-5471

Cushions of *Sphagnum fuscum* and *S. angustifolium* were grown in the laboratory in four different CO_2 concentrations (350, 700, 1 000, and 2 000 ppm) and N deposition levels (0, 10, 30, and 100 kg $ha^{-1}a^{-1}$). The same N deposition levels were also applied in the field. CO_2 concentration increased both the shoot density and dry mass of *S. fuscum* but decreased the length increment. There was no net effect on production. For *S. angustifolium*, shoot density did not alter with elevated CO_2 concentration but the CO_2 induced increment in dry mass and length caused increased production. *S. angustifolium* suffered from nutrient deficiency on the 0 kg N $ha^{-1}a^{-1}$ treatment and *S. fuscum* had difficulties to survive at the heaviest N load. No clear trends in length increment or cover was noticed in the field study during the first year.

Keywords: Bryophyte ecology, climate change, peatlands, production

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INTRODUCTION

Sphagnum growth and accumulation as peat represents an important sink for CO_2 in northern latitudes. However, virtually nothing is known about the growth response of *Sphagnum* to elevated concentrations of CO_2.

During recent decades the amount of nitrogen deposition has increased in the northern hemisphere markedly. This deposition may have a significant impact on the sensitive ombrotrophic vegetation, which is adapted to survive at a rather low input of atmospheric nitrogen. On raised bog areas, changes in the growth, abundance and composition of *Sphagnum* may be expected. Ombrotrophic species, such as *S. fuscum*, may thus be expected to give way to indifferent species, such as *S. angustifolium*.

We present preliminary results from a laboratory and field experiment that deals with the growth response of *S. fuscum* and *S. angustifolium* to various concentrations of CO_2 and nitrogen deposition loads.

MATERIAL AND METHODS

Laboratory study

In 1991, *S. fuscum* samples were taken from a raised bog in Ahvensalo and in 1992, *S. angustifolium* samples were taken from a low sedge *S. papillosum* fen (Salmisuo) and a cottongrass pine bog (Raatesuo). All three peatlands located in eastern Finland. For each species, sixty-four 15-cm thick cores (15 cm diam.) of living *Sphagnum* were taken for growth measurements.

The sets of samples were divided into groups of four samples each. The plastic rings containing the samples for the growth study were placed in trays in which the water level was maintained at 10 cm (*S. fuscum*) or at 7 cm (*S. angustifolium*) below the capitulum. Over the study period, the trays were treated with solutions of NH_4NO_3 so that they received an equivalent of either 0, 10, 30, or 100 kg N $ha^{-1}a^{-1}$. The treatment solutions were made up by adding the appropriate amount of NH_4NO_3 to Rudolph's nutrient solution (Rudolph & Voigt 1986).

The trays were placed in four growth chambers in which the ambient CO_2 concentration was maintained automatically at different concentrations (350, 700, 1 000, and 2 000 ppm). Thus, there were four trays (growth measurements) with four replicates of each nitrogen deposition treatment in each of the growth chambers. Inside the chambers, the temperature was regulated and the light (natural sunlight) monitored.

The plastic strip method (Lindholm 1990) was used to follow the length increment for 120 d in the case of *S. fuscum* and for 72 d in the case of *S. angustifolium*. Five capitula were measured per tray, giving a total of 320 measurements. After the last length increment was measured, the number of capitula per area and the stem dry mass per length were determined. Production (g(DW) m^{-2} per experiment time) was calculated using the total length increment during the study period, the stem dry mass values, and information about the surface area of the samples.

Field N deposition study

The experiment was established in the summer of 1991 on Lakkasuo, an eccentric raised bog complex in central Finland (Laine et al. 1986). Three sites where *Sphagnum fuscum* grew alone and with *S. angustifolium* in a mixture were selected. Four 0.5 x 1.0 m plots were delimited at each of the six sites.

On each plot, two 30 x 3 cm plastic strips were anchored in the peat at a depth of 20–30 cm by means of metal wires. The biweekly increment in height growth was measured in a way similar to that in the laboratory experiment. Coverage for each *Sphagnum* species was determined by surveying a 272 cm^2 circular area in the centre of the plot before the experiment was started in August 1991 and the second time in September 1992. The depth to the water table in each plot was measured weekly from a bore hole lined with a perforated plastic tube 2 cm in diameter.

Over the growing season (May–October), three of the four plots on each of the six sites received a total of either 0, 30 or 100 $kg^{-1}ha^{-1}$ N by irrigation. Nitrogen was given as NH_4NO_3 solution, and the 0 treatment was deionised water. The treatment solutions were applied on six occasions. The fourth plot at each site received no treatment and served as a control.

RESULTS

Shoot density and dry mass

With increasing CO_2 concentration, the density of *S. fuscum* capitula increased significantly ($p<0.001$, Fig. 1). The capitulum density of *S. angustifolium*, however, did not change significantly ($p>0.05$) at the CO_2 concentrations used. The amount of nitrogen deposited had no clear effect on the density of either species.

For both species, the dry mass of the capitula (for a 1 cm section) and the unit stem dry mass (for a 1 mm section) increased as the CO_2 concentration increased ($p<0.01$, Fig. 2). For neither species was there any actual difference in the dry mass of the capitula between nitrogen deposition treatments. However, the dry mass of *S. fuscum* was significantly greater with the 100 kg N ha^{-1} a^{-1} treatment, because of the insignificant increment in length (Fig. 3) and the fact that the stems were older and thicker than those of the other treatments.

Length increment and production

Length increment of *S. fuscum* decreased with increasing CO_2 concentration. The length incre-

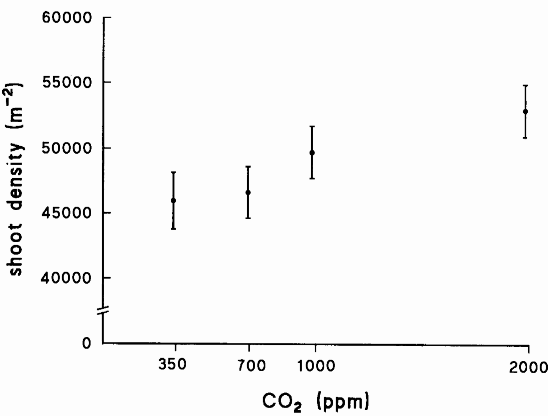

Fig. 1. Shoot density (m^{-2}) of the capitula of *Sphagnum fuscum* in the 1 cm layer (g m^{-2}) at different ambient concentrations of CO_2. Results for all the nitrogen deposition treatments have been combined. The mean and its 95% confidence limits are presented here and in Figs. 2–4.

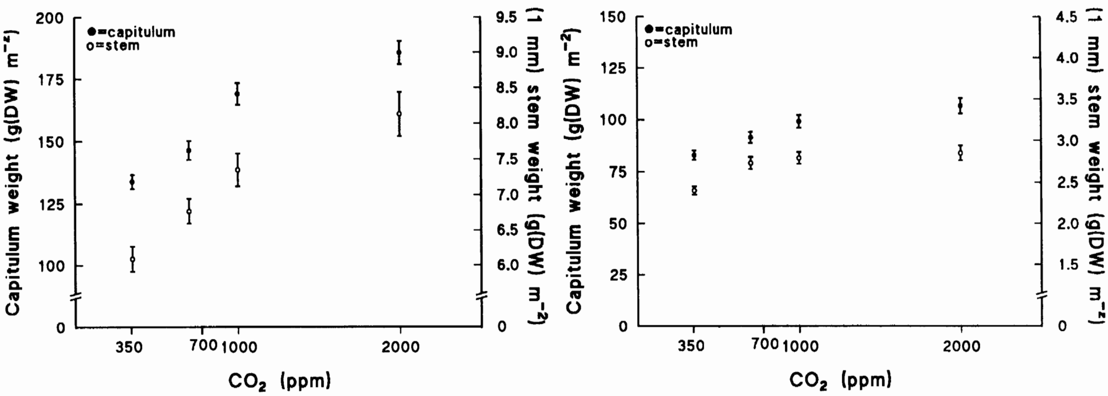

Fig. 2. Dry mass of capitula in the 1 cm layer (g m^{-2}) in different ambient concentrations of CO_2 for *Sphagnum fuscum* (left) and *S. angustifolium* (right). Results for all nitrogen deposition treatments have been combined.

ment differed significantly at concentrations of 350 and 2 000 ppm CO_2 ($p<0.001$, Fig. 3). The influence of CO_2 concentration on length increment was opposite for *S. angustifolium*; CO_2 concentrations above the ambient induced length increment highly significantly ($p<0.001$, Fig. 3). For *S. fuscum*, there was no clear relationship between production and CO_2 concentration. The production of *S. angustifolium*, on the other hand, increased uniformly at higher concentrations of CO_2 ($p<0.001$, Fig. 3).

The nitrogen deposition had a significant effect on the length increment of *S. fuscum* and *S. angustifolium* stems ($p<0.01$, Fig. 4). The greatest increment in length was achieved with the 10 kg N $ha^{-1}a^{-1}$ treatment. With the 100 kg N $ha^{-1}a^{-1}$ treatment, there was almost no increment at all in *S. fuscum* (Fig. 4).

The production of *Sphagnum* stems also differed significantly with different N deposition treatments ($p<0.001$, Fig. 4). The highest production was achieved with the 30 kg N $ha^{-1}a^{-1}$ treatment on *S. fuscum*, while the corresponding value for length increment was 10 kg N $ha^{-1}a^{-1}$. Similarly to length increment for *S. angustifolium*, production for this species was maximum in the 10 kg N $ha^{-1}a^{-1}$ deposition treatment (Fig. 4).

In the field study, no clear trend in length increment was noticed. The reaction of different sites (moss stands) also seemed to differ in

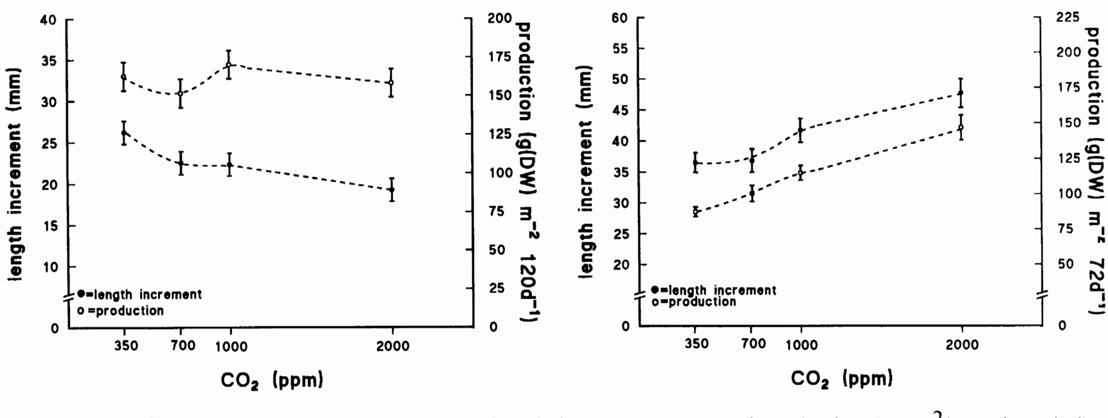

Fig. 3. Effect of CO_2 concentration (ppm) on the length increment (mm) and production (g m^{-2}/growth period) of *Sphagnum fuscum* (left) and *S. angustifolium* (right). Capitula have been excluded. Results for all the nitrogen deposition treatments have been combined.

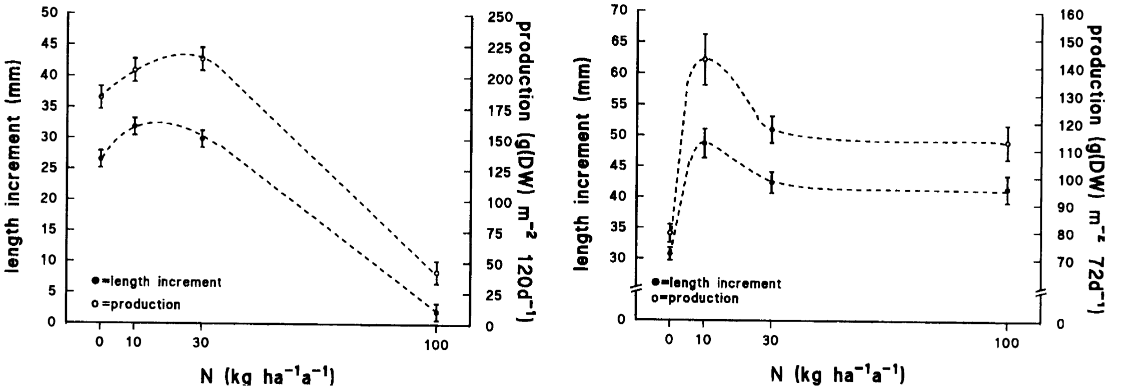

Fig. 4. Effect of nitrogen deposition (kg $ha^{-1}a^{-1}$) on the length increment (mm) and production (g m^{-2}/growth period) of *Sphagnum fuscum* (left) and *S. angustifolium* (right). Results for all the CO_2 concentrations have been combined.

response to nitrogen deposition. On one site, both *Sphagnum* stands increased in length with increasing N deposition while in other two stands there were no clear differences (Fig. 5). Also the changes in coverage of *Sphagnum* during the first year of the experiment were not detected.

DISCUSSION AND CONCLUSIONS

Both of the *Sphagnum* species studied were sensitive to CO_2 concentration and nitrogen deposition, but the response differed. For *S. fuscum*, the CO_2 concentration increased both shoot density and dry mass but decreased the length increment; therefore, there was no net effect on production. For *S. angustifolium* shoot density did not alter with elevated concentrations of CO_2, but the CO_2 induced increment in dry mass and length caused increased production.

The present nitrogen deposition load in southern Finland (c. 6 kg N $ha^{-1}a^{-1}$) seemed to be optimal for length increment and production of these two *Sphagnum* species. On the other hand, *S. angustifolium* suffered from nutrient deficiency on the 0 kg N $ha^{-1}a^{-1}$ treatment, and *S. fuscum*

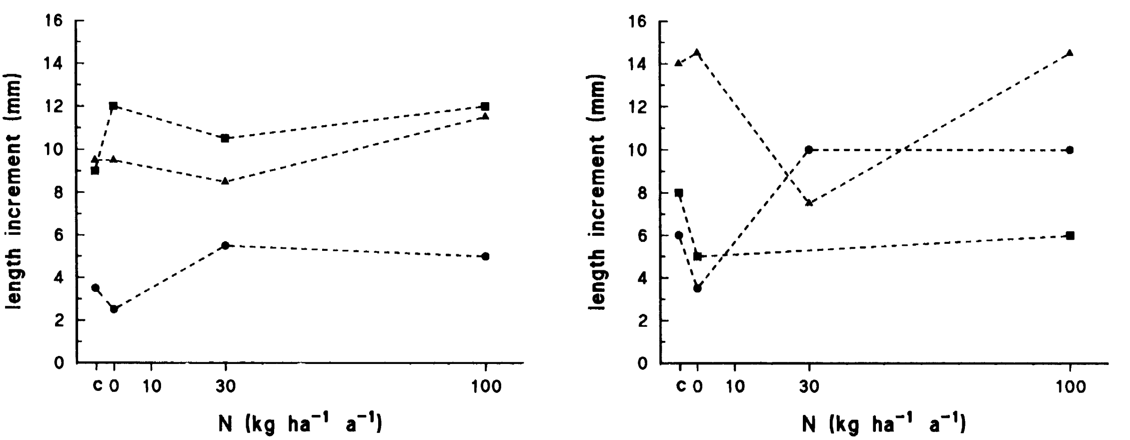

Fig 5. Effect of nitrogen deposition (kg $ha^{-1}a^{-1}$) on the length increment (mm) of *Sphagnum* stems in the field between 26.V.–16.IX.1992. c = no treatment, 0 = deionized water. Different sites are presented by different symbols. Pure *S. fuscum* stands on the left and mixtures of *S. fuscum* and *S. angustifolium* on the right.

had difficulties to survive at the heaviest nitrogen loads. The highest nitrogen deposition did not decrease length increment on *S. angustifolium* in such a dramatic way. *S. angustifolium* as a trophic indifferent species may have better control over nutrient intake than the ombrotrophic *S. fuscum*. Nutrient wet deposition may also go through the loose capitulum level of *S. angustifolium* more quickly, and therefore this species may be better sheltered against potential nutrient overload.

In the laboratory study, due the optimal and controlled growth circumstances, the differences in the growth response of *Sphagnum* were clear. In the field, due to the more changeable environmental conditions, response is still weak. Probably it must be waited some years before any trends in the field in the growth response of the two species in relation to the treatments can be seen (Rochefort et al. 1990). The fate of the deposited nitrogen must be traced, and potential changes in the rate of decomposition of peat will also be of interest in further studies.

If N deposition increases, regional differences in the vitality of the species may be expected as well as changes in species composition.

REFERENCES

Laine, J., Päivänen, J., Schneider, H. & Vasander, H. 1986: Site types at Lakkasuo mire complex. Field guide. — Publ. Dept. Peatland For., Univ. Helsinki 8:1–35.

Lindholm, T. 1990: Growth dynamics of peat moss Sphagnum fuscum on hummocks on a raised bog in southern Finland. — Ann. Bot. Fennici 27:67–78.

Rochefort, L., Vitt, D.H. & Bayley, S.E. 1990: Growth, production, and decomposition dynamics of Sphagnum under natural and experimentally acidified conditions. — Ecology 71:1986–2000.

Rudolph, H. & Voigt, J.U. 1986: Effects of NH_4-N and NO_3-N on growth and metabolism of Sphagnum magellanicum. — Physiol. Plant. 66:339–343.