Suo 43(4–5): 259–262, 1992(1993)

Jouko Silvola, Jukka Alm and Urpo Ahlholm

THE EFFECT OF PLANT ROOTS ON CO_2 RELEASE FROM PEAT SOIL

Silvola, J., Alm, J. & Ahlholm, U. 1992: The effect of plant roots on CO_2 release from peat soil. — Suo 43:259–262. Helsinki. ISSN 0039-5471

The contribution of roots to the release of CO_2 from peat has been examined in both field and laboratory experiments. In the field experiment, columns of peat were isolated from the surrounding peat and the green parts of the plants were continually removed in order to exhaust the living roots contained within the column. The isolated columns released c. 10–20% less CO_2 than the reference spots where only the growth of the green parts was restrained. CO_2 production in isolated columns was thereby reduced mostly in mire site types with largest dwarf shrub root biomass. In the greenhouse experiment, CO_2 release was c. 36% greater from containers containing willow (*Salix phylicifolia*) roots than from bare peat reference containers.

Keywords: Carbon allocation, decomposition, soil respiration

J. Silvola, J. Alm and U. Ahlholm, Department of Biology, University of Joensuu, P.O. Box 111, FIN-80101 Joensuu, Finland

INTRODUCTION

Soil respiration has traditionally been used as an indicator of soil biological activity (Haber 1959). Recently, soil respiration measurements have been given a new dimension in studies of the carbon balance between the soil and the atmosphere. It has been suggested that the increase in soil respiration associated with the predicted climatic warming may result in a significant release of CO_2 from the large carbon store in the soils of northern regions (Billings et al. 1982).

The possible consequences of climatic changes on carbon stores in the soil can only be registered after a very long period of time. However, detectable changes in the fluxes of CO_2 may indicate changes in carbon cycling sooner and could prove useful in predicting changes in the carbon balance. In measuring CO_2 fluxes from the soil it is important to determine how much is due to the oxidation of old carbon stores, root respiration, and the microbial decomposition of newly sequestered carbon derived from roots.

In this study, the contribution of roots to CO_2 production has been examined, both in the field and in laboratory experiments.

MATERIAL AND METHODS

Field experiment

Peat columns were isolated from the surrounding peat by plastic sheeting in various virgin and forested peatland sites (Fig. 1). Peat was first cut to the depth of 40–50 cm with a toothed c. 20 cm diameter steel cylinder. The cylinder was lifted out holding the peat column in place with piston. 3–4 layers of plastic sheeting were then slid into the scar with aid of the cutting device. Green parts of plants and large particles of litter were removed during the growing seasons. The roots in the columns were thus severed (= "no-roots" treatment). The above-ground vegetation on the columns was removed. For every such column, we prepared a reference spot where only the

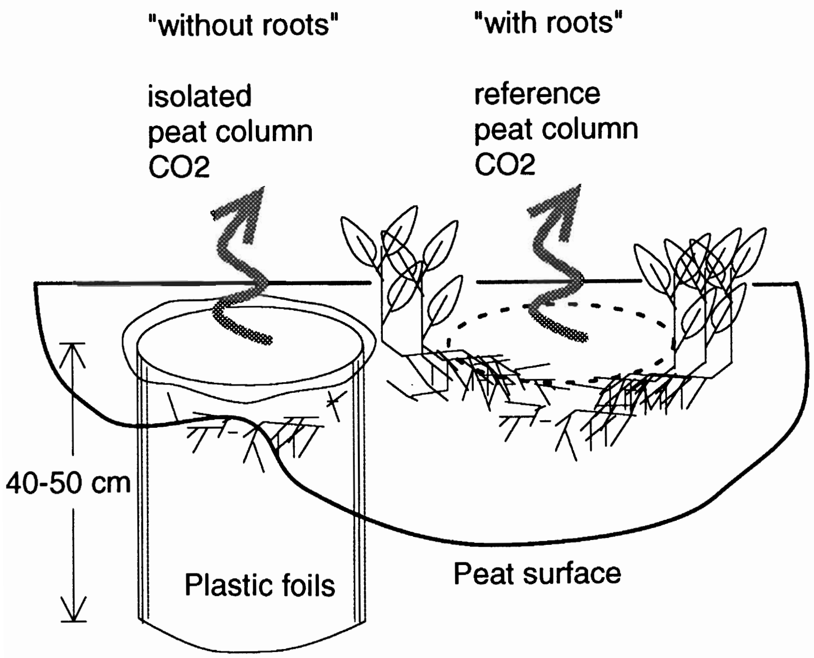

Fig. 1. Method to exhaust the root derived respiration in the field experiment.

above-ground parts of plants was removed (= "with-roots" treatment).

CO_2 release was measured with a portable infrared analyzer. Soil temperature and the depth to water table were also registered. The measurements were made from spring to autumn at 1–2 week intervals during 1991 and 1992. At some sites, the measurements were started already 1990. The data presented are from the "SUOSILMU" study areas in the Lakkasuo mire complex (virgin and drained tall sedge fen ,VSN, VSNmu) and dwarf shrub pine bog (IR, IRmu) in central Finland, and from the sites in Ilomantsi (drained *Sphagnum fuscum* pine bog, RaRmu) and Rääkkylä (drained IRmu) in eastern Finland.

Laboratory experiment

In the laboratory experiment, plastic containers (42 x 62 cm, depth 30 cm) were filled with horticultural peat. The peat was fertilized with micronutrient/macronutrient mixture with treatments of 0, 100 and 500 kg ha^{-1}. For each fertilizer treatment, two containers were planted with ten *Salix phylicifolia* cuttings and one container remained unplanted. The growth experiment took place from early spring to autumn in a greenhouse in natural light. The temperature varied between 15 and 30°C. The containers were watered regularly so that the surface peat layer (15 cm) was kept above the water level and the bottom layer (13 cm) under water. In the autumn, the willows were harvested and the roots were separated from the peat.

CO_2 release was measured with a portable infrared analyzer. The gas exchange chamber was connected to permanent collars that had been placed on the peat. CO_2 flux and simultaneous soil temperature measurements were continued for five months after harvesting the willows.

RESULTS AND DISCUSSION

In the field experiment, from late June on, the average release rate of CO_2 for the with-roots treatment stayed higher than for the no-roots treatment. The difference between the treatments was assumed to reflect the amount of root derived respiration. The effect prevailed until August in RaRmu and until October in the VSN, VSNmu, IR and IRmu sites (Fig. 2). The magnitude of the difference appeared to be related to site characteristics. For ombrotrophic IR sites with dense shrub vegetation and large root biomass (Finér et al. 1992), the difference was c. 20%, whereas in minerotrophic VSN site, the difference was only about 10%. The proportion of the root effect was fairly consistent within a mire site type, both for virgin and drained states at Lakkasuo. The drained IRmu sites showed distinctly similar strong root effects both in the Lakkasuo and Rääkkylä sites.

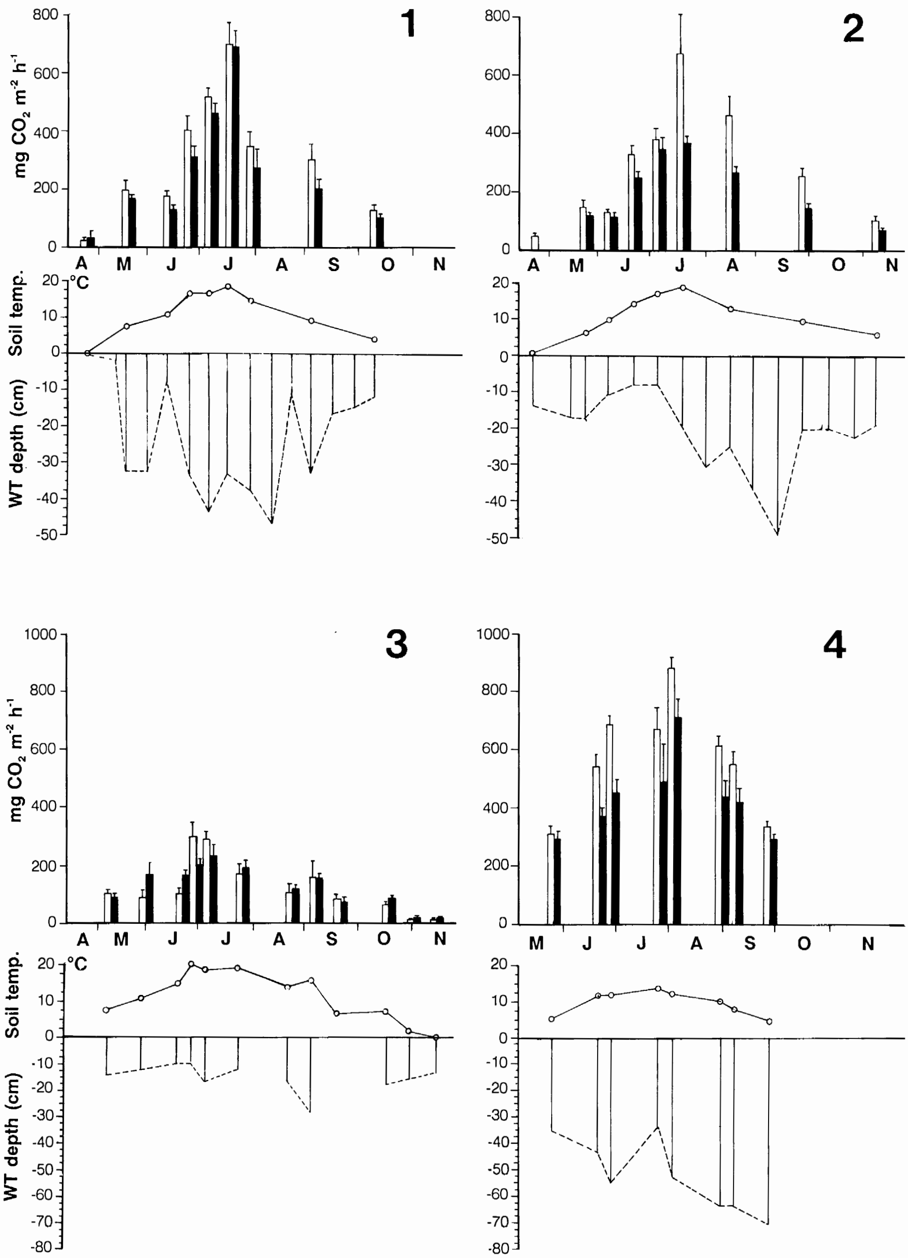

Fig. 2. Average CO_2 release (mg $m^{-2}h^{-1}$) with S.E. in some drained field sites. Temperature of soil surface (°C) and level of ground water table (cm) below the peat surface also shown. Tall sedge fen (1), dwarf shrub pine bog (2) in Orivesi Lakkasuo mire complex 1991. *S. fuscum* pine bog (3) Ilomantsi in 1991 and dwarf shrub pine bog (4) Rääkkylä in 1990. White bars = plots with living root connections, black bars = plots with root connections cut off.

Emergent peat surfaces in ombrotrophic with-root sites (often hummocks with dense vascular vegetation) released significantly more CO_2 than bare *Sphagnum* lawns. Furthermore, the soil respiration rate was higher for the with-roots spots surrounded by dense vascular vegetation. This indicates that the differences were due root derived respiration. In sedge-dominated minerotrophic sites, the highest CO_2 emissions were measured from flooded sites. In this case, the release of CO_2 appears to be more due to the decomposition throughout the peat layer, which is promoted by the flow of nutrient-rich groundwater, rather than due to root derived respiration near the peat surface.

In the greenhouse experiment, the release of soil CO_2 from the willow growing containers increased by an average of 36% compared to the

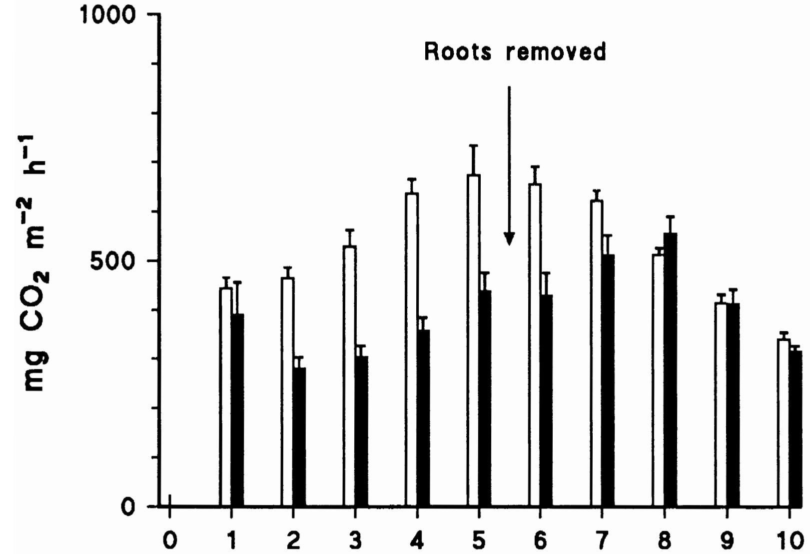

Fig. 3. Monthly average CO_2 release (mg $m^{-2}h^{-1}$) with S.E. in peat incubation pools with growing willow saplings (white bars) and bare peat (black bars) in the study period of c. 9 months.

bare peat containers (Fig. 3), a root effect considerably bigger than that observed in the field experiment. After removing the roots, the residual root effect in peat prevailed for a further 2–3 months. CO_2 release rate from horticultural peat was comparable to the rate from a well-drained forested site (Silvola & Alm 1992).

The effect of living roots on soil respiration thus seems to be well below 40% of the total respiration, both in virgin and drained peatlands. Therefore, the major part (perhaps 60–90%) of the CO_2 released from peat seems to originate from the microbial decomposition of older carbon. Our data are well in accordance with those recorded in southern Quebec, where CO_2 fluxes from vegetated drained peat soils were 20–40% higher than from unvegetated surfaces (Tim Moore, personal communication).

REFERENCES

Billings, W.D., Luken, J.O., Moser, T.J. & Peterson, K.M. 1982: Arctic tundra: A source or sink for atmospheric carbon dioxide in a changing environment. — Oecologia 53:7–11.

Finér, L., Laine, J. & Halko, L. 1992: Fine root production on peatlands. — In: Kanninen, M. & Anttila, P. (eds.), The Finnish research programme on climate change. Progress report. Publ. Acad. Finland 3/92: 211–213.

Haber, W. 1959: Ökologische Untersuchung der Bodenatmung. — Flora 146:109–157.

Silvola, J. & Alm, J. 1992: Dynamics of greenhouse gases in virgin and managed peatlands. — In: Kanninen, M. & Anttila, P. (eds.), The Finnish research programme on climate change. Progress report. Publ. Acad. Finland 3/92: 193–198.