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Sphagnum farming: local agricultural production of a horticultural peat substitute

Abstract

In most countries of Western and Central Europe the stocks of fossil white peat – the most important raw material for substrates in professional horticulture – are nearly depleted. About 30 Mio m³ of white peat are globally used for this purpose annually and are converted to CO_2 after a short period of use. To extract the peat, mires with their unique biodiversity are destroyed unrecoverably. As peat is a finite resource the extraction is continually relocated to new areas. This damaging and non sustainable practice continues because an appropriate alternative for peat in horticulture is still lacking.

The cultivation of peat mosses (*Sphagnum*) may provide such alternative. White peat has in fact developed from peat mosses. Fresh peat moss biomass appears to have similar physical and chemical properties as white peat enabling plant cultivation without loss of quality. Potential areas for *Sphagnum* farming include rewetted degraded bogs, such as agriculturally used or cut-over bogs. Their sustainable commercial use for that purpose could ensure continual employment in often depauperated rural areas.

The first results of a three year research project "Peat moss as a renewable resource" show that with adequate management (e.g. water table regulation, fertilization) peat moss production is higher than under natural conditions. New projects on Sphagnum farming on floating mats and in Georgia (Transcaucasia) are introduced.

Why a horticultural peat substitute?

White peat (slightly humified *Sphagnum* peat) offers optimal quality for horticultural substrates (see Schmilewski, this volume). About 30 Mio m³ of this material are globally used for this purpose annually. This peat would normally remain for thousands of years in the mire as an important carbon store but is by using it as a substrate converted to almost 6 Mio t of CO_2 after a short period of use. With current prices of over € 20 per t of CO_2 emission (www.climatecorp.com/pool.htm) this represents a considerable damage that is until now not appearing in macro-economic considerations of peat consumption.

The stocks of white peat in Western and Central Europe are nearly depleted. As peat accumulates so slowly that it is practically a non-renewable resource the extraction is continually relocated to new areas. Peat extraction is thus damaging to the climate and to biodiversity and non sustainable. Alternatives for peat, with equal superb qualities, have therefore urgently been found.

Why *Sphagnum* biomass as a horticultural peat substitute?

White peat mainly consists of incompletely decomposed *Sphagnum* plants. As a result of continuous decomposition in the peatland more and more of the primary production disappears over time – up to 90% after 10.000 years (Turunen & Tolonen 1996). By using fresh *Sphagnum* biomass, i.e. from the very beginning of the decomposition chain, the primary production can be much more efficiently utilised. *Sphagnum* biomass appears to have similar physical and chemical properties as white peat and its use as horticultural peat substitute is possible without a loss of quality of the cultivated plants (Emmel, in press).

Commercial harvest of *Sphagnum* in natural bogs is unfeasible for obtaining enough *Sphagnum* biomass to substitute white peat because this would destroy important self regulation mechanisms necessary for maintaining biodiversity and peat accumulation capacity. The scarcity of undisturbed bogs requires a strict protection of these sensitive ecosystems. In contrast, degraded bogs provide a big potential for agricultural *Sphagnum* cultivation. By rewetting the bogs and stimulating *Sphagnum* establishment, degraded landscapes are converted into green *Sphagnum* lawns that provide habitats for rare species of open mire landscapes, that have no CO_2 emission, and that supply an important raw material. Sustainable commercial production of *Sphagnum* biomass (*'Sphagnum* farming') may so ensure continual employment in often depauperated rural areas.

The German project "Peat moss as a renewable resource"

A three year research project has investigated the feasibility of *Sphagnum* farming in Germany focussing on identifying optimal conditions for *Sphagnum* growth.

As the growth of *Sphagnum* species is largely determined by abiotic conditions (Lütt 1992), aimed nursing may maximize primary production. Studies in *Sphagnum* ecology under natural conditions or for bog restoration indicate that *Sphagnum* productivity can be increased by high water tables (Clymo and Reddaway 1974, Lütt 1992, Rydin 1993), phosphate and potassium fertilisation (under conditions with high atmospheric nitrogen deposition - such as in Western Europe - peat moss growth is not nitrogen-limited, Malmer 1990, Aerts et al. 1992, Verhoeven et al. 1996, Risager 1998, Limpens et al. 2000, Limpens & Berendse 2000), some shading (Pedersen 1975, Clymo & Hayward 1982, Lütt 1992) and increased CO_2 availability (Silvola 1990, Paffen & Roelofs 1991, Smolders et al. 2001). Until recently, however, no research had focused on growing *Sphagnum* for commercial purposes.

On the basis of our pot experiments we can conclude that a high water level (2 cm below the capitulum) is the most decisive factor for *Sphagnum* growth whereas fertilisation has only a minor effect. Shading leads to elongated growth but not to more biomass. *Sphagnum* growth on black peat and bog grassland sods is much better than on limed black peat (which we had limed to stimulate CO_2 production).

In the field experiment (1.200 m²) *Sphagnum* fragments were spread over a cut-over bog surface (that was kept wet by subsurface irrigation) and subsequently covered with a layer of straw mulch to provide a suitable microclimate (Quinty & Rochefort 2003). After 3 years a dense *Sphagnum* lawn with a mean length of ca. 4 cm has developed. In areas with a very high or less straw cover (inundation in the first winter had washed part of the straw away) *Sphagnum* growth is significantly poorer.

Upscaling of *Sphagnum* farming

With a realistic annual harvest of 90 m³ *Sphagnum* biomass per ha, the area for *Sphagnum* farming required to cover the demands for white peat in Germany (3 Mio m³ a^{-1}) is ca. 35.000 ha (provided that *Sphagnum* biomass replaces white peat 1:1). The most promising region to realize this area is Lower Saxony where ca. 165.000 ha of bogs used as grassland ('Deutsche Hochmoorkultur') do not have other perspectives for economic use.

Other potential cultivation areas are cut-over bogs and open water areas in flooded cut-over bogs and abandoned lignite strip mines.

Difficulties and risks of upscaling *Sphagnum* farming have to be tested in large scale field experiments. Experiences from bog restoration and our field experiments show that newly established herbs (*Juncus effusus, Molinia caerulea*) may compete with *Sphagnum*. This may be a problem for using *Sphagnum* mixed with remains of these species as a horticultural substrate. This may be counteracted by regular mowing of the production fields – which is very effective against *Juncus effusus* – or by sterilizing the harvested material by steaming. On the other hand the *Sphagnum* production fields also provide habitat for rare species (e.g. *Drosera intermedia, Rhynchospora alba*).

To guarantee a constant high water level throughout the year AND over the whole area an irrigation system has to be installed. After rewetting, deeper, inundated parts of cut-over bogs can function as reservoirs for excess winter water to supply the cultivation area in dry periods (cf. Quinty & Rochefort 2003).

Monocultures are generally more vulnerable to diseases and parasites (like fungi) than more diverse cultures. We estimate the risk for substantial damage to a *Sphagnum* farming area, however, to be low as extensive monospecific areas of *Sphagnum* also exist in nature.

Outlook

Following the first positive results of *Sphagnum* farming research in Germany new projects focus on accelerating large scale implementation. Beside degraded bogs also open water areas are currently surveyed as potential areas for *Sphagnum* farming using specially constructed floating mats. That would allow bog waters not only to function as water reservoirs (see above) but also and additionally as *Sphagnum* farming areas. As the *Sphagnum* covered mats would have less evapotranspiration than open water, a mosaic of rewetted peat areas (with on-the-ground cultivation) and deeper waters (with floating mat cultivation) could be the optimal constellation for *Sphagnum* farming.

Furthermore we currently investigate the perspectives of *Sphagnum* farming in Georgia (Transcaucasia). The warm-temperate and wet climate of the Kolchis enables peat moss growth all over the year with productivities of *Sphagnum papillosum* reaching 10 t dry weight ha^{-1} y^{-1} (Krebs & Gaudig 2005). This provides optimal perspectives for establishing a new source of income in this economically deprived region.

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Literature cited

Aerts, R., Wallen, B. and Malmer, N. 1992. Growth-limiting nutrients in *Sphagnum*-dominated bogs subject to low and high atmospheric nitrogen supply. J. Ecol. 80:131-140.

Clymo, R.S. and Hayward, P.M. 1982. The ecology of *Sphagnum*. p. 229-289. In: A.J.E. Smith, (ed.): Bryophyte ecology. Chapman and Hall, London - New York

Clymo, R.S. and Reddaway, E.J.F. 1974. Growth rate of *Sphagnum rubellum* Wils. on Pennine blanket bog. J. Ecol. 62:191-196.

Emmel, M. in press. Growing ornamental plants in *Sphagnum* biomass. Acta Horticulturae, ISHS Symposium on growing media, September 4.-10.09.2005, Angers, France.

Krebs, M. and Gaudig, G. 2005. Torfmoos (*Sphagnum*) als nachwachsender Rohstoff - Untersuchungen zur Maximierung der Produktivität von *Sphagnum papillosum* im Regendurchströmungsmoor Ispani 2 (Georgien). Telma 35: 171-189.

Limpens, J. and Berendse, F. 2000. Effect of elevated nitrogen deposition on production and decomposition in raised bogs. Proc. International Peat Symposium. Quebéc, Canada 6-12 August. p. 150.

Limpens, J., Tomassen, H.B.M., Berendse, F. and Roelofs, J.G.M. 2000. Dutch survival plan for bogs: Impact of enhanced nitrogen deposition on ombrotrophic bogs. Proc. International Peat Symposium. Quebéc, Canada 6-12 August. p. 486.

Lütt, S. 1992. Produktionsbiologische Untersuchungen zur Sukzession der Torfstichvegetation in Schleswig-Holstein. Mitt. d. AG Geobotanik in Schleswig Holstein und Hamburg, Vol. 43.

Malmer, N. 1990. Constant or increasing nitrogen concentrations in *Sphagnum* mosses on mires in Southern Sweden during the last few decades. Aquilo Ser. Bot. 28:57 – 65.

Paffen, B.G.P. and Roelofs, J.G.M. 1991. Impact of carbon dioxide and ammonium on the growth of submerged *Sphagnum cuspidatum*. Aquatic Botany 40:61-71.

Pedersen, A. 1975. Growth measurements of five *Sphagnum* species in South Norway. Norw. J. Bot. 22:277-284.

Quinty, F. and Rochefort, L. 2003. Peatland Restoration Guide, second edition. Canadian *Sphagnum* Peat Moss Association and New Brunswick Department of Natural Resources and Energy. Québec, Québec.

Risager, M. 1998. Impacts of nitrogen on *Sphagnum* dominated bogs with emphasis on critical load assessment. Ph.D thesis, department of Plant Ecology, Botanical Institute, Faculty of Science, University of Copenhagen.

Rydin, H. 1993. Mechanisms of interactions among *Sphagnum* species along water-level gradients. p. 153-185. In: N.G. Miller (ed.): Advances in Bryology, Vol. 5. J. Cramer, Berlin.

Schmilewski, G. 2007. this volume.

Silvola, J. 1990. Combined effects of varying water content and CO_2 concentration on photosynthesis in *Sphagnum fuscum*. Holarctic Ecology 13:224 – 228.

Smolders, A.J.P., Tomassen, H.B.M., Pijnappel, H., Lamers, L.P.M. and Roelofs, J.G.M. 2001. The role of substrate-derived CO_2 in the development of *Sphagnum magellanicum* hummocks under wet conditions. Unpublished script, Nijmegen.

Turunen, J. & Tolonen, K. 1996. Rate of carbon accumulation in boreal peatlands and climate change. - In: Lappalainen, E. (ed.): Global Peat Resources: 21-28, International Peat Society, Jyskä.

Verhoeven, J.T.A., Koerselman, W. & Meuleman, A.F.M. 1996. Nitrogen- or phosphorus-limited growth in herbaceous, wet vegetation: relations with atmospheric inputs and management regimes. Trends in Ecol. and Evol. 11: 494-497.

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