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SPHAGNUM FARMING IN GERMANY – 10 YEARS ON THE ROAD TO SUSTAINABLE GROWING MEDIA

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SUMMARY

Since 2001 we are studying the perspectives of peat moss cultivation (‘*Sphagnum* farming’) in greenhouse and field experiments with special attention to propagation, propagules storage, establishment, productivity and regeneration of *Sphagnum*. Our results show that *Sphagnum* farming in Germany is possible and promising and that *Sphagnum* biomass may provide a sustainable high-quality alternative to fossil white peat as a raw material for horticultural growing media. *Sphagnum* farming may enable a climate friendly, sustainable after-use option for abandoned cut-over bogs and degraded bog grasslands (www.sphagnumfarming.net).

KEY WORDS: degraded bog, sustainable land use, *Sphagnum* biomass

INTRODUCTION

The most important raw material for growing media in professional horticulture is slightly decomposed peat moss peat (‘white’ or ‘blond’ peat). This peat has over thousands of years been deposited by peat mosses *Sphagnum* spp. in living bogs. About 30 million m^3 of ‘white’ peat are globally used for growing media annually. Peat is a finite, non-renewable resource, as is illustrated by ‘white’ peat being nearly exhausted in Western and Central Europe and being increasingly imported from further east. Peat extraction thus progressively destroys important ecosystem services of bogs.

A non-polluting alternative ensuring a lasting and sustainable supply of high quality growing media for professional horticulture is needed. Fresh *Sphagnum* biomass, which has similar physical and chemical properties as ‘white’ peat (Emmel, 2008), is currently emerging as such an alternative. In the last decades the re-establishment peat mosses was practised as an approach to regreen and restore cut-over peat extraction sites (Quinty and Rochefort, 2003). These experiences have been further developed for the cultivation of peat mosses (Gaudig and Joosten, 2002; Gaudig and Joosten, 2007; Landry *et al.*, 2011).

The overall aims of *Sphagnum* farming are to provide a sustainable alternative for fossil white peat in horticulture and to replace unsustainable land use types by a wet, site adapted and sustainable alternative. Lower Saxony is the region in Germany most abundant in bogs (ca. 250.000 ha), but only 1% is still in a natural state. The remaining 99% are used as bog grassland (58% = ca. 145.000 ha), for peat extraction (12%, incl. areas rewetted after peat extraction), for arable agriculture (e.g. maize cultivation) and forestry (8%) or consist of drained and fallow degeneration stages (21%) (NLWKN 2006). Virtually the entire bog area is thus losing carbon and heavily emitting greenhouse gases. *Sphagnum* farming allows to use abandoned cut-over bogs and degraded bog grasslands in a climate friendly, sustainable way and to restore many ecosystem services of mires (Barthelmes *et al.*, this volume; Wichmann *et al.*, this volume).

Beside degraded bogs, we surveyed open water areas as potential areas for *Sphagnum* farming using specially constructed floating mats. This option allows bog waters not only to be used as water reservoirs to irrigate cultivated areas in dry periods, but also as additional *Sphagnum* farming areas. A mosaic of rewetted peat areas (with on-the-ground cultivation) and deeper waters (with floating mat cultivation) may present the optimal combination for *Sphagnum* farming on degraded bogs (Fig. 1). In addition, floating mat cultivation is being tested in acid water bodies on abandoned opencast lignite mining areas (Blievernicht *et al.*, 2011).

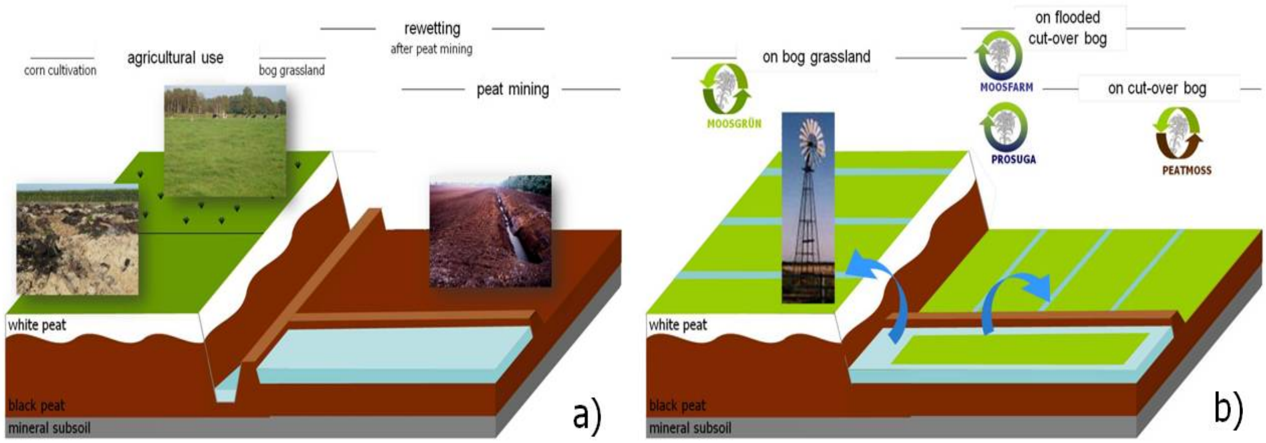

Fig. 1. Mosaic of degraded bogs a) with current land use and management and b) with *Sphagnum* farming and our associated research projects. (from Gaudig, 2008)

After an initial literature survey in 2001, the prospects of *Sphagnum* farming in Germany have been investigated by the University of Greifswald and various partners in four projects:

1. PEATMOSS – Peat moss as a renewable resource (2004-2007)
2. MOOSFARM - Production of a sustainable and environmentally friendly substitute for peat in professional horticulture by *Sphagnum* farming on floating mats (2007-2010)
3. PROSUGA - Industrial cultivation of peat moss for the production of innovative growing media for horticulture (2010-2013)
4. MOOSGRÜN - Peat moss cultivation on bog grassland (2010-2013)

We conducted greenhouse and field experiments with respect to propagation, propagules storage, establishment, productivity and regeneration of *Sphagnum* on cut-over bogs, floating mats and former bog grassland (Tab. 1). This paper presents an overview of the results and gives an outlook of *Sphagnum* farming in Germany.

Table 1. Experiments at the University of Greifswald.

theme	climate	factors	project
propagation	greenhouse	vegetative: application density, fragment size, fertilization, *Sphagnum* species, stem segment, growing medium	PEATMOSS, PROSUGA
	greenhouse	generative: *Sphagnum* species, growing medium, fertilization	PROSUGA
storage of propagules	greenhouse	*Sphagnum* species, duration and temperature, drying, growing medium	PROSUGA
establishment	greenhouse	*Sphagnum* species, fragment size	MOOSFARM
	cut-over bog	thickness and density of straw mulch coverage, coverage vascular plants	PEATMOSS
	former bog grassland	*Sphagnum* species, fragment size, thickness and density of straw mulch coverage, site preparation method	MOOSGRÜN
productivity	greenhouse	*Sphagnum* species, *Sphagnum* mix, water level, water quality, fertilization, shading	PEATMOSS
	cut-over bog	Water level, coverage vascular plants	PEATMOSS
	flooded bog, greenhouse	*Sphagnum* species, *Sphagnum* mix, fragment size, coverage type, floating mat type	MOOSFARM
	former bog grassland	*Sphagnum* species, fragment size, coverage type and density, site preparation method	MOOSSGRÜN
regeneration	cut-over bog	after cutting	MOOSGRÜN

MATERIALS AND METHODS

Peat moss was cultivated in the greenhouse in different sized plant containers filled with steamed peat or a nutrient solution after Rudolph *et al.* (1988). Different water levels were maintained by irrigating with demineralised water (several times a day). Every week or every third week the mosses were provided with a nutrient solution a) after Rudolph *et al.* (1988) or b) proportional to the annual deposition in Lower Saxony or c) with different concentrations of phosphorus and potassium.

Field experiments were established in Northwest Germany (Lower Saxony) in Ramsloh (cut-over bog, plot size 1.200 m²; N53°5.31'; E 07°38.90' PEATMOSS, MOOSFARM) and Rastede (former bog grassland, plot size 4 ha; N 53°15.80'; E 08°16.05' MOOSGRÜN). *Sphagnum* fragments or whole mosses were spread an Table 1. Experiments at the University of Greifswald.
d subsequently covered with straw mulch to provide a suitable microclimate (Quinty and Rochefort, 2003). On the floating mats mosses and straw were fixed with a net. To keep the surface sufficiently wet (on-the-ground cultivation) a subsurface (Ramsloh) or surface (Rastede) irrigation system was installed.

We monitored vegetation development, *Sphagnum* growth (e.g. coverage, length, number of capitula, biomass) and water levels in permanent plots with a size of 10x10 cm (greenhouse) to 25x25 cm (field).

RESULTS

Growing media

The literature survey (Gaudig and Joosten, 2002) revealed rapid mass losses of *Sphagnum* biomass in the first phases of peat formation. To maximize yields the initial idea of substituting the fossil 'white' peat by "cultivated" peat (Joosten 1998, Gaudig and Joosten, 2002) was abandoned to focus on *Sphagnum* farming, i.e. harvesting as early as possible and using fresh *Sphagnum* biomass. The suitability of *Sphagnum* biomass as a raw material for horticultural growing media – up to a proportion of 100% – was tested successfully in plant cultivation experiments by our partners (Emmel, 2008).

Propagation

Methods for generative and vegetative reproduction were investigated in order to produce sufficient *Sphagnum* propagules to establish large-scale *Sphagnum* farming sites.

Spores of different *Sphagnum* species appeared to germinate well and to build protonemata and first plantlets on various subsoils in greenhouse experiments, nut not in the field. After moss lawns with branches had been formed, the lawns were transplanted to the field and were fully established three months later (Gahlert *et al.*, this volume).

Large (> 5 mm) vegetative fragments initially produced more biomass, against small fragments (1-3 mm) more capitula. Fragments produced many capitula when growing submerged under aeration but not more than on wet peat.

Propagules of *Sphagnum palustre* stored for up to twelve months at 6°C developed lawns with a similarly vital moss cover as fresh propagules. Fresh propagules, however, produced significantly more biomass when growing on peat. The fresher the propagules the better they are suited for *Sphagnum* farm establishment (Prager *et al.*, this volume).

Establishment

In greenhouse experiments large propagules (5-10 cm) started increasing length and cover faster than small propagules (1-3 mm). These results were confirmed by field experiments, where *Sphagnum palustre* spread as entire plants established best both on peat (Krebs *et al.*, this volume) and on floating mats.

At the (manually installed) study plot in Ramsloh a dense, well-growing *Sphagnum papillosum* lawn (mean coverage > 90%) had developed after 3.5 years. Establishment was faster in parts with lower straw mulch coverage (Kamermann and Blankenburg, 2008) and significantly slower with both too much straw (90% straw cover still after six months) and without straw. However, our results indicate that establishment can be accelerated by maintaining continuously high water levels.

Productivity

Our experiments in the greenhouse showed that a high and stable water level is the most decisive factor for *Sphagnum* growth whereas fertilisation has only minor effect (Gaudig, 2008). Productivity values mainly ranged between 3 and 6 t dry mass ha^{-1} yr^{-1}. In the field (Ramsloh) productivity of *Sphagnum papillosum* reached after the establishment phase mean values of 3.6 t dry mass ha^{-1} yr^{-1} with highest productivity (5 t dry mass ha^{-1} yr^{-1}) being reached on sites with permanently high water levels. Peat mosses growing on floating mats produced between 2 and 3.5 t dry mass ha^{-1} yr^{-1} (mean values for single species), with *Sphagnum palustre* being the most productive species (up to 6.9 t dry mass ha^{-1} yr^{-1}).

Regeneration

Six month after cutting the peat mosses to a length of 2 to 5 cm only 15% had regenerated new capitula. Another six month later new capitula covered 80% and after 2.5 years almost 100%.

CONCLUSION

After ten years we know:

- That *Sphagnum* biomass is a suitable raw material for horticultural growing media. In future new and adapted *Sphagnum* based substrates have to be developed for more and more applications in horticulture.
- Which *Sphagnum* species are suitable both for growing media and for *Sphagnum* farming and which not. So far we used only mosses of a few origins. Further selection is needed to find better provenances.
- How *Sphagnum* farming on rewetted peat areas (with on-the-ground cultivation) and deeper water (with floating mat cultivation) works and which risks are to be expected. Future challenge is to mechanize the entire production process to foster broad implementation of *Sphagnum* farming. Machines and methods have to be developed for mass production of *Sphagnum* propagules and for managing and harvesting *Sphagnum* cultures.
- That farming *Sphagnum* biomass is already profitable for niche markets with high revenues, but so far cannot compete with low-priced white peat. The external costs of peat extraction and drainage based peatland use on the one hand and the external benefits of *Sphagnum* farming for society on the other hand provide, however, good reasons for facilitating the sustainable production of this promising, renewable raw material (Wichmann *et al.*, this volume).

The road to sustainable growing media is not a dead-end street; we are on the ramp to the highway.

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