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OPPORTUNITIES AND CHALLENGES OF FARMING SPHAGNUM AS A GROWING MEDIA CONSTITUENT IN GERMANY

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SUMMARY

Its outstanding physical, chemical and biological properties make peat the most important growing-media constituent for commercial growers and amateur gardeners alike. At the same time, pressure is mounting on the peat and growing-media industry not to carry out peat extraction and thus to reduce emissions of harmful greenhouse gases from production sites. Alternative materials such as green compost, wood fibre, composted bark and coco pith are not sufficiently available; additionally, they also have less beneficial characteristics. One potential alternative to peat is peat moss (*Sphagnum* spp.), the main peat-forming plant in ombrotrophic peatlands. A project launched in 2015 with 10 ha of trials is being funded chiefly by Klasmann-Deilmann GmbH itself and by the federal state of Lower Saxony; it involves different *Sphagnum* species being assessed as to their productivity and suitability. The impact on biodiversity and greenhouse gas emissions is being investigated in cooperation with specialised institutes. A particular challenge is optimizing the hydro management of peat moss cultivation areas. An unusual aspect is that this project, unlike previous trials, is taking place on sites where the residual peat layer following depletion consists of black peat. Such areas are (due to their low water conductivity) less suitable, but in Germany – owing to the scarcity of sites where the residual layer is white peat – are the only realistic option. In general, both in Germany and throughout Europe, considerations need to be made concerning the provision of sufficient land. Further obstacles include the procurement of inoculation material, and colonisation with weeds. This project's overall aim is to assess the industrial feasibility of peat moss cultivation on the basis of a profitability analysis.

Keywords: *Sphagnum, growing media, peat replacement, paludiculture*

INTRODUCTION

A considerable majority of Germany's raised bogs is located in the federal state of Lower Saxony, as is the geographical focus of the country's peat and substrate industry. This article, therefore, refers chiefly to the situation in Lower Saxony.

For decades now, the substitution of peat in growing media has been receiving a lot of attention in public debate. This is evident chiefly in Germany, the United Kingdom, Austria, Switzerland and the Netherlands, but also in other countries. In the past, the reasons for this were rooted primarily in the loss of natural habitat (pristine peatland) and its specific biodiversity, caused by state-driven peatland drainage measures and the creation of cultivated agricultural land and space for settlement. Today, the discussion is centred on greenhouse gas emissions. Moreover, the peat and growing media sector is confronted with a massive decline in available peat extraction sites in western and central Europe.

Efforts to develop alternative growing media constituents go back a long way. The market significance of green compost, wood fibre, coir pith and bark products has now increased. Since early in the last decade, the question of peat moss cultivation has also been increasingly debated. *Sphagnum* farming is a form of paludiculture (Latin: palus = marsh, swamp) and involves the agricultural use of wet areas of raised bog (Wichtmann *et al.,* 2010). Paludiculture on fenland sites is focused primarily on the growing of reed, cattail, willow and alder (Wichtmann & Wichmann 2011). Cultivation of peat moss has been explored for a number of years in Germany, Canada and elsewhere (Gaudig *et al.,* 2014; Pouliot *et al.,* 2014). Caspers (2015) notes that, to date, not a single private landowner in Germany has practised paludiculture. Neither, to our knowledge, has there been any commercial horticultural exploitation of peat moss grown as an outdoor crop.

Cultivated peat moss grows more successfully on white peat (weakly decomposed peat; H1-H5 on the Von Post scale) sites than on black peat (strongly decomposed peat; H6-H10 on the Von Post scale) sites, as the former is a

better conductor of water. Virtually all areas of white peat in Lower Saxony are used as private agricultural pastureland. Because of high land prices, strong potential for weed growth and nutrient contamination in these sites, the scope for *Sphagnum* farming is negligible. Moreover, agricultural acceptance and political support for this form of wet land-use is lacking. On peat-depleted areas, however, peat is extracted to the depth of the lower peat horizon, with a 50 cm thick layer of residual peat remaining. Instead of using such sites almost solely for re-wetting, they could alternatively be made available for farming peat moss.

PROJECT PLANNING AND IMPLEMENTATION

Although much of value has already been learned from earlier projects on peat moss cultivation (Gaudig *et al.*, 2014), Klasmann-Deilmann's current project (title: 'Extensive cultivation of peat moss in Lower Saxony as a land use subsequent to black peat extraction and its potential for sustainable production of a growing media constituent as a peat substitute') chiefly involves calculating and assessing the profitability of *Sphagnum* farming on former peat production sites with a residual layer of black peat. The impact on biodiversity and climate is being investigated by the University of Hannover and the Thünen Institute in Braunschweig.
Unfortunately, no former peat extraction areas with residual white-peat layers were available for this project – in Germany, peat is always extracted until the degree of decomposition designated H7-H8 on the Von Post scale is reached, which has hydrological disadvantages compared with sites where the residual layers consist of white peat. Furthermore, a previous attempt persuaded us that *Sphagnum* farming should be started as far away as possible from utilized agricultural land, grassland or woodland, as this means the risk of weed seeds and nutrients entering the site is lower. Other prerequisites are scope for creating access routes and a means of irrigation. As the strict protection status of pristine peatland in Germany means procurement of inoculation material (peat moss) in Germany is a major obstacle, it was decided that the company would create its own *Sphagnum* bank on a special site and actually grow the peat moss for growing media production in a second, separate area.
This *Sphagnum* bank site is located in a nature reserve for which regulations permit paludiculture for trial purposes; it has been in the re-wetting phase for six years. The site is around 5 ha in size, with an additional irrigation polder covering 3 ha. This area will provide *Sphagnum* inoculation material in the future. Owing to the site's protected status, large-scale soil preparation was not carried out; a few open channels were created for irrigation and drainage, but that is all. After the peat moss was manually spread with the aid of wooden walkways, it was covered (alternately) with straw and mesh fabric. Irrigation is augmented by open ditches and by means of pipes laid above ground.
The second site is an area of bogland that was prepared for inoculation with peat moss as soon as peat extraction had ceased. A nearby fire pond provides the water necessary for irrigation. Peat moss was distributed by hand over a total of seven polders, and also alternately covered with mesh fabric and straw. For irrigation purposes, open channels alternating with drainage pipes laid just below the site surface were used.
Peat moss (from peat hummocks) required for inoculation was, with official approval, removed from a landscape conservation area in the autumn of 2015. Unwanted vascular plants covering the peat moss were mown, subsequently removed and the upper centimeters of the peat moss then cut off. This *Sphagnum* inoculation material was collected and taken away from the donor site using temporary wooden walkways. With hummock moss accounting for about 25 % of the donor site, the area was sufficiently fit for purpose.

EXPLORING OPPORTUNITES

Our own horticultural growth trials in the 1990s showed that peat moss is, in principle, suitable as a growing media constituent for various different uses (unpublished data). This has been confirmed many times over by other investigators. For all growing media constituents the characteristics described by Schmilewski (2015) need to be evaluated to prove their suitability or non-suitability for use in horticulture. Overarching criteria in this context are horticultural properties as well as ecological, economic and social aspects.

Large-scale *Sphagnum* farming covering many thousands of ha may contribute to sustainable regional development and:

1. provide another growing media constituent;
2. deliver a long-term perspective for the growing media industry;
3. safeguard jobs in economically weaker regions;
4. optimise the colonisation of former peat extraction areas with *Sphagnum*;
5. initiate enhancement of the ecological value of agricultural land;
6. mitigate greenhouse gas emissions.

Greenhouse gas emissions: Greenhouse gas measurements taken by Beyer & Höper (2014) show that, owing to their constant water level a few centimetres below the surface, sites cultivated with *Sphagnum* have a negative global-warming potential (GWP). Water levels in re-wetted production sites are high in some cases, leading to high methane emissions which may in turn result in a positive GWP. Figure 1 shows yearly greenhouse gas emissions from different types of land use. In the project presented here greenhouse gas emissions will be measured over the entire production chain, including irrigation polders, extraction areas, growing sites and control sites.

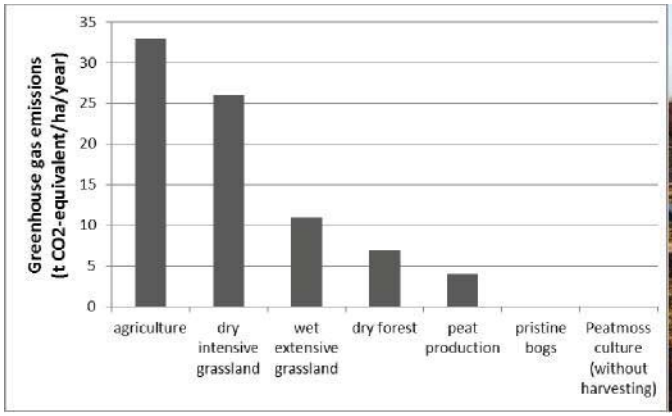

Figure 1: Greenhouse gas emissions for different types of raised-bog use (Lower Saxony Ministry of Environment, Energy and Climate Protection 2015). Figure 2: Distribution of peat moss on the former peat extraction site.

Biodiversity: In Germany, only a very small proportion of the total area of raised bog can be designated as pristine. Even after several decades, many typical plant species, especially peat mosses, struggle to recolonise peatland sites restored through re-wetting. *Sphagnum* farming accelerates peatland regeneration and creates habitat for highly at-risk flora and fauna. As *Sphagnum* is harvested only at intervals of several years, refuge areas for animal and plant species are ensured. Specific aims of our project include assessment of which peat moss species yield the highest biomass productivity on black peat, how their growth is affected by weeds, and which animal and plant species colonise the site.

EXPLORING CHALLENGES

Shortage of sites: In Germany, the only sites suitable are land previously used for agriculture (degraded peatland areas) that have a residual white-peat layer, or former peat extraction sites with the usual thickness of residual black peat, i.e. 50 cm. Because of the poor water conductivity of in situ strongly decomposed (black) peat, it is far more difficult to grow peat moss in these areas than on sites where the residual layer is weakly decomposed (white) peat. Gaudig *et al*,. (2014) assume that 145,000 ha of grassland on peat soil in Lower Saxony (almost all of it privately owned by farmers) may be available for farming peat moss. However, this assumption is only theoretical and is, from the perspective of the farmers who own this land and wish to use it for conventional agriculture, practicable only to an extremely limited degree. *Sphagnum* farming on former peat production areas is possible only where agricultural after-use is envisaged on the land concerned. As almost all such peatland is intended for rewetting/restoration following peat extraction, however, current legislation dictates that these sites cannot be used for peat moss farming.

Hydro management: To create ideal conditions for peat moss growth, an ebb and flow system using local rainwater is recommended (Kamermann & Blankenburg, 2008). This ensures low nutrient availability and a low pH value, which are requirements for *Sphagnum* growth. Overhead irrigation (*e.g.* a sprinkler system) with water from adjacent peatland areas exposes peat mosses to high levels of humic substances, leading to reduced growth (Rochefort & Bastien, 1998). Well water, ditchwater or groundwater are not viable options because of their high nutrient levels and high pH value. The high levels of evapotranspiration from peatland sites necessitate the use of an irrigation system. This loss of water is greatest in the low-rainfall summer months. Irrigation reserves must therefore be set aside for these areas. Different irrigation systems will be trialed in our project: open trenches, drainage pipes laid on the site surface, and surface irrigation pipes.

Inoculation material (peat moss): Procurement of inoculation material from peat moss donor sites is a major challenge. All wild-growing peat moss species are protected in Germany under section 1, sentence 1 of the Country's Federal Regulation on the Protection of Species (BArtSchV 2007). Under section 44 of the Federal Nature Conservation Act, it is forbidden to take these mosses from the wild or to possess, process or market them. However, these prohibitions do not apply to domesticated forms, bred or artificially propagated *Sphagnum* (BNatSchG 2015). Furthermore, the competent authority under federal-state law is entitled – under sections 6 and

17 of the Federal Regulation on the Protection of Species (BArtSchV 2007) – to grant exceptions if this is not in conflict with species protection requirements. Just such an exception was approved for our project. Another potential option is the distribution of inoculation material propagated in vitro, as provided by Micropropagation Services Ltd. (2014).

Selection of *Sphagnum* species: Peats associated with different *Sphagnum* species differ in their horticultural properties. The same applies to the peat mosses from which these peats are formed. In peat moss cultivation, the aim is to establish and grow the most productive moss species. Horticultural aspects are also important, however. For example, Emmel (2007) concluded that, as tested using a range of cultivated plants, *S. fallax* is wholly unsuitable in terms of its propagation, and the proportion of peat moss biomass in growing media for propagation should not generally exceed 50 % (v/v). Depending on the species of *Sphagnum*, biomass production in optimum conditions is between 2 and 16 t/ha/annum of dry mass (Gaudig, 2001). It may be that peat mosses from hollows have greater biomass productivity. However, the intention will be to establish mosses extracted from peat hummocks, as this enables subsequent harvesting to be easier and carried out mechanically. Furthermore, the latter types of moss have better physical and horticultural properties. Gaudig (2001) also points out that mosses from peat hummocks degrade more slowly than those extracted from hollows. Conditions for growth and harvesting are favourable only when the cultivated peat moss has formed an extensive closed carpet of peat moss, *i.e.* when it grows as in a raised bog.

Weeds: The presence of weeds in growing media constituents is not tolerable. Various plant species can present a problem for *Sphagnum* farming on outdoor sites, as experience has shown that associated living plants which are undesirable (or viable plant propagules), such as cross-leaved heath (*Erica tetralix*), ling heather (*Calluna vulgaris*), purple moor-grass (*Molinia caerulea*), grasses or non-peat moss species invade cultivation areas via the inoculation material. It can also be expected that seeds or spores carried on the wind and in irrigation water will enter the site. Moreover, areas previously used for agriculture or sites with increased input of nutrients (e.g. from adjacent farmland) have potential for weed infestation. For example, rushes (*Juncus* spp.) frequently dominate on grassland on peat soils. Some vascular plants may promote the growth of peat mosses by serving as support or improving the microclimate; however, if they progressively spread they will compete strongly with the mosses. They also make harvesting more difficult and considerably affect the quality of the growing medium. As the use of herbicides on peatland is prohibited, the only weed control currently possible is that by mechanical means, which is very costly. The Dutch foundation for quality assurance of growing media, R.H.P. requires the hygienization of any species of *Sphagnum* by means of gamma radiation or steam treatment, the aim being to prove compliance with the zero-tolerance policy for weed infestation.

Sphagnicolous fungi and other fungi: It is fungi, of which more than 600 species are reported to occur in peatlands, that are chiefly responsible for the breakdown of organic matter in peatlands; many of these have also been found on peat mosses (Markus N. Thormann, pers. comm. 2016). Tsuneda *et al*. (2001) note that some of these *Sphagnum*-colonising fungi are pathogenic. *Sphagnurus paluster* is a sphagnicolous fungus that is not uncommon in both natural peatland and in cultivated peat moss sites in spring, and which is dependent on peat moss as its host. Fungi of this kind can lead to spot-like or carpet-like chlorosis, necrosis and ultimately to the death of the peat moss. Although it is unlikely that sphagnicolous fungi lead to symptoms in horticultural crops, it is indisputable that they have an adverse effect on peat moss farming.

Profitability: All costs incurred by the project are recorded on an ongoing basis and included in a profitability analysis. Although the project is still in the early stages, it is already evident that the biggest cost factors are site preparation, the extraction and distribution of the peat moss, and irrigation. However, a number of potential improvements can be made in this respect. If it is to be a realistic after-use alternative, the cultivation of peat moss – like all forms of paludiculture – must be recognised as a form of agriculture and funded accordingly.

CONCLUSION

As early as 1999, Joosten & Timmermann posed questions that make it clear why *Sphagnum* farming to produce a growing media constituent has still not yet caught on to this day. "Paludiculture raises issues concerning the selection of suitable *Sphagnum* species, methods of establishing and harvesting them on peatlands, optimising yields and quality of growing media, the size of site required, financial viability, and positive and negative side-effects." In various projects both in Germany and elsewhere, work has been done on answering these and other questions; however, only partial answers have been obtained. In Germany, obtaining sites for peat moss cultivation remains problematic due to a lack of incentives for the agricultural sector. Furthermore, there are serious misgivings in the peat industry regarding the feasibility and profitability of *Sphagnum* farming. The aim of the project presented here is to help to assess the profitability of growing peat mosses on a large scale following peat extraction, and to create a decision-making basis/tool to help our company consider how to proceed further. Amidst all the euphoria surrounding the potential of *Sphagnum* cultivation, it must be borne in mind that other peat substitutes of different natures and origins are being investigated and have indeed been established on the international growing media market for some years. Whether farmed *Sphagnum* can compete with these remains to be seen.