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THE YOUNGEST PEAT – SUSTAINABLE PRODUCTION OF PEAT MOSS AND ITS USE AS GROWING MEDIUM IN PROFESSIONAL HORTICULTURE

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SUMMARY

In the European Union, about 29 million m^3 of peat IS used for the production of horticultural growing media every year. Due to its outstanding properties, peat is still the main constituent for growing plants in pots, but it is a diminishing resource. Over the last decades, no viable alternatives for reducing the major proportion of peat in growing media have been found. White peat mainly consists of slightly decomposed peat mosses (*Sphagnum* sp.). Preliminary tests with dried non-decomposed *Sphagnum* biomass indicate that decomposition is not necessary for peat moss to be a perfect constituent of growing media. Thus, we devised a production method for peat mosses on artificial floating mats. After one year of cultivation, the average harvested biomass of *Sphagnum fimbriatum* was as high as 5.4 t ha^{-1} dry weight. Currently, our peat moss production on open water systems covers 2,000 m^2. Investigations with different *Sphagnum*-based growing media led to a product which is made of 70% (v/v) dried *Sphagnum* biomass. On a large scale, this new growing medium has been tested in the commercial production process of an ornamental plant company. Three tested *Euphorbia pulcherrima* cultivars showed a similar plant growth in the new growing medium compared to the peat-based control. Due to potential upcoming regulations for extraction and use of peat, the younger non-decomposed *Sphagnum* appears as a promising alternative and will be investigated in more detail.

KEYWORDS: *Sphagnum*, peat moss, growing medium, plant production

CONSTITUENTS OF GROWING MEDIA

During the last decades, many constituents were tested for being a proper substitution of peat in growing media. In the beginning, the efforts aimed at getting independent of vanishing peat sources. Nowadays, new questions have to be answered concerning peat use in horticulture. Boon and Verhagen (2008) addressed the value of natural environment of peat areas and the lower CO_2 impact of sustainable growing media as the new main market factors to consider. In addition, government policy has changed over the last years and preservation of natural habitats has become more important, forcing the search for sustainable constituents of growing media. Wood fibre, bark and green-compost are available raw materials that might replace peat and, in addition, might allow a production of growing media and its usage for pot culture in the same local region. This could have a tremendous positive effect on the environment, e.g. by reducing transportation and CO_2 emission. However, in reality, there often is a discrepancy between potential and actual environmental impacts of suitable raw materials. In addition, the availability of wood by-products is decreasing because of an

increasing usage as energy resource (Meinken, 2010). Green-compost generates a higher yield when digested in a biogas plant than used as constituent of growing media. Moreover, because of the mentioned competition factors, the lesser woody fraction in the basic material used for composting leads to a lower proportion of structure building material, which would in return be necessary for producing high-quality compost (Boisch, 2010). Processing of coconut products – another source for replacing peat in growing media – expends lots of freshwater. In addition, taking into account the long-distance shipment of coconut products, eco-balance may not be equalized. Besides availability, other organic matters than peat do not have the potential to account for a major proportion in growing media. Several physical and chemical properties (i.e. N-immobilization, high salinity, structural stability) set a limit for the maximum proportion in growing media. Depending on the constituent used, in most cases there is maximum proportion of 30% (v/v) in growing media.

To date, peat has been indispensable for producing high-quality growing media. In the European Union, about 29 million m^3 peat is used for producing growing media every year. Peat combines as many favorable physical, chemical and biological properties as no other material does; thus, it is still the main constituent in growing media production. The percentage of peat in all growing media produced in the EU accounts for approximately 80% (Altmann, 2008). Peat-free growing media play an overall minor role in industrial production. Nevertheless, the market for peat-reduced media is growing (Schmilewski, 2009).

SPHAGNUM AND PEAT – ALMOST THE SAME?

Looking into the genesis, we know that white peat mainly consists of slightly decomposed peat mosses (*Sphagnum* sp.). Even after hundreds of years of conservation under anaerobic conditions in a bog, the plant bodies are still visible. The fast renewability of *Sphagnum* (compared to the long-term genesis of peat) suggests non-decomposed *Sphagnum* biomass as a suitable and sustainable substitute for peat. Thus, we address the question if decomposition of *Sphagnum* plants is even necessary for providing a high-quality growing media constituent. Comparisons of physical and chemical properties showed several similarities between air-dried *Sphagnum* plants and peat (Table 1). Low pH, content of nutrients, hardly nitrogen fixation, and a high structural stability are some of them. However, some differences were also found, including a considerable higher water capacity in peat than in *Sphagnum*, whereas the air capacity was more than twice as high in *Sphagnum* as in peat. Table 1 gives in addition an overview of biological, environmental and economic properties. The properties of air-dried *Sphagnum* biomass strongly support the testing of non-decomposed *Sphagnum* for the production of a new peat-free horticultural growing medium. And, the fast renewability of *Sphagnum* in comparison to the long-term genesis of peat might help to replace peat with sustainably produced *Sphagnum* biomass.

Table 1: Properties of white peat and air-dried *Sphagnum* biomass.

Property	White peat	*Sphagnum* biomass
Physical		
total pore space (%)*	95	99
water capacity (v/v, %)*	66	32
plant available water (v/v, %)*	28	16
air capacity (v/v, %)*	29	66
bulk density (kg m^{-3})*	84	23
wettability	difficult	easy
shrinkage (%)*	29	20
Chemical		
pH-value	low (3-4)	
nutrient content	low	
salinity (EC)	low	
nitrogen immobilisation	not remarkable	
organic matter (w/w, %)**	96	93
hazardous substances	none	
Biological		
content of weeds	negligible	depends on origin
Environmental		
renewability	arguable	yes
local availability	decreasing	to be built up
Economic		
price	unrivaled	depends on production system and quantity of units sold

*Analysis according to DIN EN 13040, DIN EN 13041; ** analysis according to DIN EN 13039; data for *Sphagnum* biomass represent mean of different species (*S. fallax, S. fimbriatum, S. papillosum*). Shrinkage and water capacity were measured at water tension -10 hPa.

ROADMAP TO A *SPHAGNUM* GROWING MEDIUM

Successful introduction of new products to the market necessitates concerted actions to overcome reservations and reticence. Concerning *Sphagnum* biomass implementation to the market of horticultural growing media, one will also face players who will have a bearing on success or on failure of this attempt. For the peat-processing industry, non-decomposed *Sphagnum* could be a competitive constituent with a promising future. However, professional horticultural enterprises have to be convinced that *Sphagnum* in growing media will work as well as peat does. It is, understandably, never easy to change one's mind from well-tried to new thinking and this will only work if the new product fulfill all expectations. Growing media are the basis for successful plant production and thus of the livelihood of countless small and medium-sized enterprises. Failure of growing medium can lead to incalculable outcome. Nevertheless, at the end of the commercialization chain, consumers decide whether new products will work or not. The first step is the purchase decision. It mainly depends on personal preferences, background information about the product (i.e. environmental impact) and last but not least on the product's price. Second step is the performance after purchase, particularly the plant growth and development in the new growing media compared to peat-based media. In addition, to overcome reticence and to convince the consumer, there is another challenge in production and introduction of a new *Sphagnum*-based growing medium: *Sphagnum* plants cannot be collected somewhere in nature without having a negative environmental impact as *Sphagnum* grows in living mires. But these natural habitats are actually what we want to protect. So, *Sphagnum* has to be established as a crop! For that, a production system has to be devised including all steps like getting the starting material, cultivation, harvesting, processing and distribution on the market.

MILESTONES AND CURRENT STATE OF OUR RESEARCH

Since 2007, we have been working on the *Sphagnum* issue. Our main focus still lies on producing *Sphagnum* in an effective, economical way with a high-quality output. To establish *Sphagnum* sp. as a crop, one has to consider that *Sphagnum* naturally grows in habitats with a positive water balance. The nutrient content of rain water is sufficient for *Sphagnum* growth, whereas increased salinity can cause growth depression (with different impacts according to different *Sphagnum* species). For a successful *Sphagnum* production, the most important factor is a constant water supply. In Germany, we have several types of areas potentially suitable for *Sphagnum* production. Besides rewetted abandoned bogs and water filled gravel-pits, we started cultivating *Sphagnum* on opencast mining lakes. As *Sphagnum* needs its heads in the air and its "feet" in the water, we started creating a floating vegetation mat. After three years of engineering and continuously modification, we now have a product that changed from a hand-crafted model to an industrial manufactured product. Our first results showed that producing *Sphagnum* on floating mats on opencast mining lakes is generally possible. After one year of growing, we gained a net biomass accumulation of about 5.4 t ha^{-1} for *Sphagnum fimbriatum* (Blievernicht *et al.*, 2011). Now, we are producing *Sphagnum palustre* on an overall area of 2,000 m^2 floating mats.

To create a new horticultural growing media based on air-dried *Sphagnum* plants, non-decomposed *Sphagnum* was combined with other organic and mineral constituents in different proportions, according to the specific requirements of different plants on the properties of the growing medium, and tested in a large number of plant growth tests. We

started with three different proportions (25, 50, 75% [v/v]) of air-dried *Sphagnum* biomass in peat-based growing media and with a pure *Sphagnum* growing medium. Nine different plant species were tested for growth. We found that non-decomposed *Sphagnum* biomass can be used as constituent of growing media and that pure *Sphagnum palustre* can act a suitable growing medium in which the majority of tested plants grew as well as in the peat-based control.

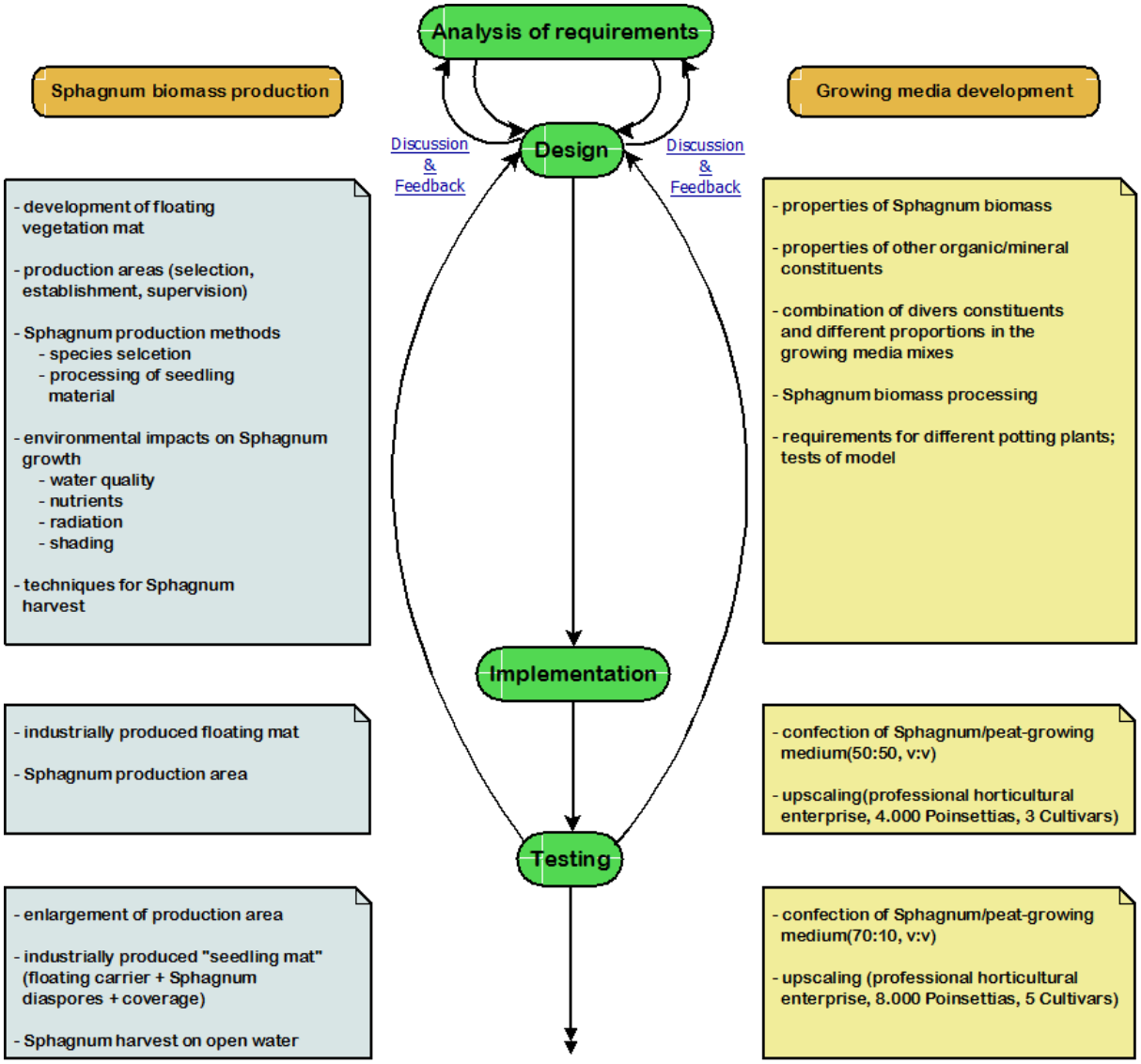

Fig. 1. Implementation of *Sphagnum* to the market of horticultural growing media. Proof-of-principle and proof-of-technology.

The next step in creating a new growing medium was to find out how the properties of a *Sphagnum*-based growing medium could be more precisely adjusted to plant-specific requirements. For this, we used other organic materials (i.e. composted biodegradable waste) as additives. Plant experiments were performed in our greenhouse. In parallel, we started implementation of *Sphagnum* as growing media constituent in professional horticulture in 2010. One of our project partners runs a horticultural enterprise where a *Sphagnum*/peat mix

(1:1, v:v) was tested on large-scale. Around 4,000 poinsettias (*Euphorbia pulcherrima*) were produced under normal conditions in a greenhouse. No differences were found between plants grown in the *Sphagnum*/peat mix and plants grown in the standard peat-based medium. All poinsettias were successfully sold to the customer. In 2011, for the latest cultivation cycle of poinsettias under production conditions, the *Sphagnum*-based growing medium was adjusted to an almost a peat-free growing medium, containing only 10% (v/v) peat. Above-ground growth of poinsettias produced in the *Sphagnum*-based medium was at least as good as of plants produced in the standard peat-based medium (Table 2). Actually, one cultivar ('Scandic Early') grew even better in *Sphagnum*-based than in peat-based growing medium.

Table 2. Comparison of selected growth parameters of three different *Euphorbia pulcherrima* cultivars grown in different growing media under normal production conditions.

Tested cultivar	Growing medium	Shoot fresh weight (g)	Shoot dry weight (g)	Shoot height (g)	Diameter Max[1] (cm)	Diameter Crossed[2] (cm)
'Scandic Early'	*Sphagnum*[3]	38,81±5,11 a	8,40±0,87 a	11,69±1,33 a	30,19±2,52 a	26,14±2,94 a
	Control[4]	32,93±4,27 b	7,80±0,76 b	10,95±1,00 b	30,76±2,72 a	25,71±3,24 a
'Primero Red'	*Sphagnum*	44,48±7,02 a	8,80±0,99 a	13,55±1,60 a	34,71±3,36 a	28,95±3,74 a
	Control	43,21±6,96 a	8,79±1,10 a	13,88±1,81 a	34,00±2,81 a	29,10±2,86 a
'SK 79'	*Sphagnum*	40,88±5,71 a	8,15±0,88 a	13,95±1,81 a	33,10±3,16 a	28,76±3,59 a
	Control	35,00±7,06 b	7,68±1,04 a	13,95±1,89 a	33,67±3,99 a	28,29±4,30 a

[1]Diameter Max was measured in top view as maximum length from one outermost point of the foliage straightly through the middle of the plant to the outermost point of the opposite foliage.
[2]Diameter Crossed was measured in the same way with a rotation angle to the Diameter Max line of 90 degrees.
[3]*Sphagnum*: growing medium containing 70% (v/v) non-decomposed *Sphagnum* biomass, 20% (v:v) organic additives, 10% peat (v:v).
[4]Control: standard peat-based growing medium particularly manufactured for the production of poinsettias.
Data are given as mean values ± SD (n=21). Statistical analyses were performed by the Tuckey's HSD test. For each cultivar and growth parameter, the data of plants cultivated in the *Sphagnum*-based medium were pairwise compared to those of the control. Different letters indicate significant differences with $P<0.05$.

OUTLOOK

As our results are promising for production of both *Sphagnum* biomass and *Sphagnum*-based growing media, we are going to strengthen our efforts. A lot of questions have been answered so far but there are still a lot undone. Currently, we are planning growth tests with several garden and balcony plants in completely peat-free *Sphagnum* growing media for this year's vegetation period in the greenhouse. Moreover, this year, our *Sphagnum* production area will be harvested by a buoyant harvester directly on open water for the first time. The harvested biomass will hopefully be the basis for a strong expansion of our *Sphagnum* production area.

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