The role of peat in assuring the quality of growing media

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SUMMARY

Producers and users of growing media are exposed to high risk if significant quantities of potentially unsuitable ingredients are included in the product. Combined with economic reasoning, this dictates that the constituents of growing media should possess as many suitable characteristics as possible. *Sphagnum* peat has been the most important growing medium constituent for many decades because its properties are the best available. The use of other organic and mineral-organic materials is being forced ahead by research and development against a background of public favour for peat replacement, recycling and re-use of biodegradable waste. Considerably more resources have been invested in the testing of peat alternatives than in peat itself during recent years, and the utility of a large number of alternatives has been assessed. Most candidate materials are only slightly or not at all suitable for use in growing media. The exceptions are composts, wood fibre products, bark and composted bark, and coir. These have become established, to a greater or lesser degree, as reliable substrate constituents. Their manufacture, characteristics, advantages and disadvantages are reviewed. A continuing need for peat as a constituent of growing media, at least for dilution purposes, is foreseen. Thus, increased imports of peat and growing media to countries with intensive or expanding commercial horticulture and inadequate domestic peat reserves are to be expected in the future.

KEY WORDS: coir, compost, growing media properties, peat alternatives, professional horticulture.

INTRODUCTION

Growing media are materials, other than soils *in situ*, in which plants are grown (CEN 1999). They include all such materials that are used in the professional and hobby markets, whether produced by the growing media industry or by growers as own-mixes. Media for all types of plant cultivation, usually in containers, are included; as well as fertilised planting media e.g. for trees and shrubs, and casing soil for mushrooms. “Substrate” is often used as a synonym for “growing medium” but its definition is not so precise.

Growing media constituents are the basic components of mixes, which are generally formulated on a percentage volume basis. Such materials include peat, composted biodegradable waste, composted bark, wood fibre, coir, perlite, vermiculite and others. Growing media constituents can usually be sensually detected in the mix.

Growing media additives are additional ingredients of mixes, which are usually added to the mix on a weight basis by the gram or kilogram. Additives include fertilisers, liming materials, buffering materials, binders, wetting agents, hydrogels, chemical pesticides, biological products, dyes and other substances. Often, due to their low rate of application and physical state, additives cannot be sensually detected within the mix.

Composts are any kind of treated (composted) biodegradable waste such as garden and kitchen waste, food waste, paper and card, human waste, manure, sewage and slaughterhouse waste. These may be sub-grouped according to their raw materials. Composted green waste and kitchen waste are the sub-groups that are most likely to be used as constituents of growing media.

For the grower it is absolutely essential that the growing medium functions well under his growing conditions. The price plays the second most important role in his decision to purchase. Although they are repeatedly placed in the foreground, growing media constituents other than peat are subordinate factors in determining saleability.

Composts, wood fibre products, bark and composted bark as well as coir materials are the constituents which have become most successfully established as replacements for peat. Although a number of other materials are available, none has any notable market significance.

In general, environmentalists and others not involved in horticulture or growing media production are unaware of the complexity of requirements for the modern market. This review aims to provide some helpful insights, focusing on peat and the four important non-peat constituents.

GROWING MEDIUM QUALITY

“Poor”, “inferior”, “good”, “suitable” and “outstanding” are adjectives that are used frequently for subjective description of the "quality" of growing media. They mean little, however, if the quality of the substrate cannot be measured against specific product requirements. Horticultural crops have certain requirements which the grower needs to fulfil with the help of individually tailored growing techniques and cultivation measures. Modern horticulture with computer-controlled irrigation and fertilisation programmes, potting machines, pricking robots, climate-controlled greenhouses and just-in-time production requires dependable, quality-assured growing media. In particular, specialist companies rely on ready-made growing media which are either part of the manufacturer's standard range or special mixtures produced at the grower's request.

For the development of formulations and the production of growing media suitable for this market a large number of chemical, physical, biological and economic characteristics of the constituents must be taken into account (Table 1). In the event that a particular growing medium or its constituents prove to have sub-optimal characteristics, it is necessary to know also which alternatives and additives would be suitable for optimisation of the formulation.

Of course, a large proportion of all growing media produced in the EU and elsewhere are hobby market products. The hobby user is not dependent on growing media quality in the same way as the professional grower, but hobby users should nevertheless be able to expect quality standards comparable to those set for the professional market; and in any case the producer is liable for his product.

The quality of a growing medium can be defined in terms of its condition and its suitability for the intended use. For example, a black peat (highly decomposed raised bog peat) with sticky characteristics is well suited for blocking pots and is classified as being of high quality for that type of use; but peat of such quality is totally unsuitable for the cultivation of orchids because its structure is too fine and its air capacity too low. Thus the requirements for a specific use determine the quality assignment in that context.

Table 1. Properties of growing media and their constituents that pertain to “quality”.

PHYSICAL	CHEMICAL	BIOLOGICAL	ECONOMIC
structure and structural stability	pH	weeds, seeds and viable plant propagules	availability
water capacity	nutrient content	pathogens	consistency of quality
air capacity	organic matter	pests	cultivation technique
bulk density	noxious substances	microbial activity	plant requirements
wettability	buffering capacity	storage life	price

MATERIALS FOR GROWING MEDIA

Peat

Growers and producers of growing media are exposed to high risks if constituents with unsatisfactory characteristics are used. In particular, if large percentages of such materials are incorporated it is likely that crops will fail to grow satisfactorily. Therefore each growing medium constituent should possess as many positive characteristics as possible. Bog (*Sphagnum*) peat has been the most important constituent of growing media for several decades because its characteristics make it ideal for this purpose (Table 2). Indeed *Sphagnum* peat, after fertilising and liming, is the sole constituent of many growing media. By contrast, comparatively small amounts of fen peat are used in only a few EU countries such as France, Poland and the UK, mostly in hobby products.

The cellular structure of undecomposed to moderately decomposed (H1–H5 on the von Post scale) *Sphagnum* peat guarantees a high water capacity with simultaneously high air capacity. Highly decomposed *Sphagnum* peat (H6–H10) has a markedly lower air capacity. This is, however, much improved by winter frosting. The low pH and nutrient content permit these characteristics to be raised artificially to crop-specific values. Due to its mode of formation, peat is free of pests and pathogens, and under circumstances of controlled production it is also free of weed seeds. Handling, processing, fractionating and mixing are simple and do not incur health risks. The commercial price of peat is highly competitive compared with other constituents of growing media, and it is available at constant quality in the long term.

The outstanding characteristics of peat are reflected by its ranking relative to other growing medium constituents in terms of the quantities required by the market. Worldwide, Germany is the largest manufacturer of growing media for the professional and hobby markets (Schmilewski 2005a). The Netherlands no longer has domestic peat reserves, but the predominant share of commercial *ex situ* horticulture there is based on the use of peat-based growing media. The same applies to other nations with important horticulture industries. As a result peat imports, mainly from the Baltic countries, continue unabated. Thus it seems that it will remain important to secure suitable reserves of peat as a raw material for the production of growing media in the future.

Table 2. Guide values for the assessment of raised bog (*Sphagnum*) peat (DIN 2005). (v/v) = by volume.

Characteristics	Method	Units	Degree of decomposition of raised bog peat (without additives)				
			Low	Low to Moderate	Moderate	Moderate to High	High
(Degree of) humification	DIN 11540	H (von Post)	2–4	3–5	4–6	5–7	6–8
Bulk density $_{dry}$ D_{BD}	EN 13041*	kg/m³	50–80	60–100	80–130	120–170	160–220
Total pore space P_S	“	% (v/v)	95–97	94–96	92–95	90–93	87–91
Water capacity W_V	“	% (v/v)	42–83	46–84	55–85	63–85	71–85
Air capacity A_V	“	% (v/v)	14–55	12–50	10–40	8–30	6–20
Shrinkage value	“	% (v/v)	20–30	25–35	30–40	35–45	40–50
pH value	EN 13037*				3.5–5.0		
Electrical conductivity G	EN 13038*	mS m^{-1}	1.0–3.0	1.5–4.0	2.0–5.0	2.5–6.0	3.0–7.0
Organic matter W_{om}	EN 13039*	% (m/m)	98–99	94–99	94–99	94–99	94–99
N (CAT)	EN 13651*	mg L^{-1}			up to 50		
P_2O_5 (CAT)	“	mg L^{-1}			up to 30		
K_2O (CAT)	“	mg L^{-1}			up to 40		

* EN = European Standard. European Standards are developed by CEN, the European Commission for Standardisation.

Although peat is by far the most important constituent of growing media, the use of other organic and mineral-organic materials is being vigorously promoted - even forced - through research and development. For a number of years now, substantially more funding and effort have been invested in the testing of alternatives to peat than in peat itself. The four most successful groups of peat replacement materials are considered in turn below.

Composted biodegradable waste (composts)

Although *ca.* 4 million m³ of composted biowaste is produced each year in Germany and at least half of it is quality-assured according to the German RAL system for composted materials, only *ca.* 250,000 m³ is used by the professional and hobby growing media markets together.

The reason lies in the raw material. In the case of *Sphagnum* peat the raw material is the S*phagnum* moss which has accumulated in the bog, whereas for compost a large number of different green and other biodegradable wastes enter the composting process. The solid fraction of composted biowastes is most often dominated not by organic but by mineral material, which sometimes reaches levels of 70% or more by mass (m/m). This is mainly due to slovenly separation of the input waste components. Nonetheless, the German RAL standard for compost as a growing media constituent fixes the minimum organic matter content at only 15% (m/m) (Table 3).

Even very carefully collected and composted biodegradable waste from a home garden yields a compost that cannot serve as the sole constituent of a growing medium, in particular due to the very high pH of 8.6 (EN 13037) and the high K_2O content of 1,650 mg L^{-1} (EN 13651) which are typical standards for composts (G. Schmilewski unpublished data 2007). The organic matter content is very high at 75% (m/m), but even this compost cannot be classified as organic; it is organic-mineral on account of its 25% (m/m) mineral content.

Due to its high mineral fraction, compost has rather high bulk density and this can considerably increase the weight of the medium, as for admixtures of clay or sand with peat. This in turn increases the cost of transportation and can cause handling problems for the grower or gardener.

As the pH value, the salinity and the K_2O content of compost are practically always incompatible with plants, compost must always be blended with material with lower pH and concentrations of these compounds in such a way that risks are avoided. Peat is extremely suitable as a blending material.

Table 3. The principal quality criteria for composts permitted as growing media constituents according to the German authority for quality assurance of compost (RAL 2007).

Quality / test feature	Values and/or value ranges	
	Type 1	Type 2
Maximum quantity allowed in a growing medium	40 % (v/v)	20 % (v/v)
Salinity	$\leq$ 2.5 g L^{-1}	$\leq$ 5.0 g L^{-1}
Nitrogen (N)	< 300 mg L^{-1}	< 600 mg L^{-1}
Phosphorus (P_2O_5)	< 1200 mg L^{-1}	< 2400 mg L^{-1}
Potassium (K_2O)	< 2000 mg L^{-1}	< 4000 mg L^{-1}
Chloride	< 500 mg L^{-1}	< 1000 mg L^{-1}
Sodium	< 250 mg L^{-1}	< 500 mg L^{-1}
Carbonate content ($CaCO_3$)	< 10 % ($CaCO_3$) of dry matter (DM)	
Plant response	No N immobilisation, no phytotoxic substances	
Degree of decomposition	V (highest rate)	
Organic matter	> 15 % (m/m) of dry matter (DM)	
Hygiene requirements	No seeds, viable plant propagules or *Salmonella*	

Wood fibres

Wood fibres are mechanically/thermally extracted from wood and wood waste. Only mechanically treated wood is permitted as the raw material; glued, coated, lacquered or painted wood or wood treated with either organic or inorganic substances is excluded. In order to prevent immobilisation of N by the wood fibres, which can lead to cultivation difficulties especially in commercial horticulture, the fibres might be "impregnated" by adding a N-fertiliser to the wood chips before feeding them into the extruder. With this treatment the slow-releasing nitrogenous fertiliser counteracts N immobilisation by continuously feeding nitrogen to the micro-organisms which invade the finished product.

Most of the wood fibre products that have been marketed in Europe so far (Hortifibre®, Culti-Fibre®, Torbella®, Bio-Culta®-Faser, Toresa®, Pietal® and Torbo®) no longer have any significant market relevance, if they ever did. There are other nameless wood fibre products which have very low regional significance. However Toresa® wood fibres enjoy a moderate level of acceptance by the German, Swiss and UK growing media industries (Schmilewski 2005b). For the production of Toresa® 90–95% of the wood used is, as a matter of principle, from *Picea* species. The remaining 5–10% is made up of other softwood species belonging to the genera *Abies* and *Populus* as well as hardwoods such as *Fraxinus*, *Salix* and *Fagus* (Gumy 2001). Hortifibre®, a French product, has also gained acceptance as a constituent in some EU countries.

Wood fibres are fibrous in structure, porous, loose and elastic. They have low bulk density, very high air capacity (good drainability) and very low water capacity. Due to their low shrinkage value they can reduce the shrinkage of a peat mix in the pot. Furthermore, they have good rewettability and are free of weed seeds and pathogens. Their pH is between 4.5 and 6.0 (H_2O).

Figure 1 shows how the physical characteristics of a peat-based growing medium change when wood fibre is added. A number of standard growing media contain up to 30% by volume of wood fibres, and the potential for co-use of wood fibres in growing media has not yet been fully exploited.

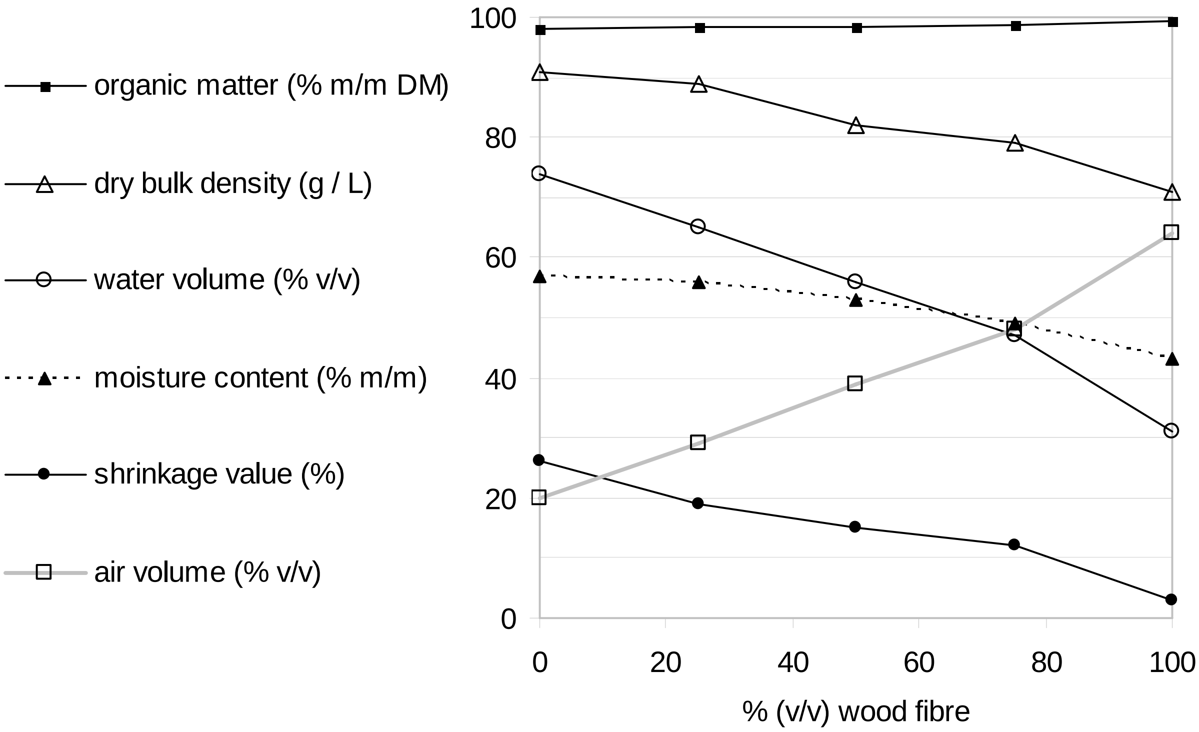

Figure 1. Changes in six growing medium properties for a mixture of bog peat (H3–H5) and wood fibres (Toresa®) as the fraction of wood fibres is progressively increased.

Composted bark

Usually, spruce and other softwood barks are used for composting. Crushed and screened raw bark is subjected to a rotting process in which the bark ferments in heaps outdoors. The aim of the fermentation is to eliminate N immobilisation which would otherwise lead to plant growth problems. At the beginning of the fermentation process, nitrogen is added to the bark, mostly in the form of urea, in order to accelerate microbial activity. As a result of this process, the C:N ratio decreases and N immobilisation is reduced.

By admixing composted bark with growing media, the air capacity can be increased, the drainability can be improved, the cation exchange capacity can be raised and a pH-buffering effect can be achieved. However, the pH and salt content of composted bark can be too high. This material is used in quantities of up to 50% (v/v) by some growing media producers. On the other hand its use in growing media is stagnating or declining in some countries as the use of raw bark in wood-burning energy plants increases, causing a shortage of bark and raising the price to a level at which it is hardly competitive as a growing medium constituent.

To emphasise that mixtures need careful formulation, Table 4 compares some properties of two mixes. The objective was to achieve an air capacity of 25 % (v/v) for a potting mix. This can be done by using peat alone (Mix 1) or, for example, by mixing composted green biowaste, composted bark and a wood fibre product. Although the air capacities of the two mixes are identical, their chemical characteristics differ considerably. In this comparison, neither lime nor fertiliser was added to the constituents.

Coir

Ambiguous definitions are repeatedly encountered for growing medium constituents belonging to this product group. Coconut products originate from the fruit of the coconut palm, *Cocos nucifera*. Only the fibres of the mesocarp (the thick spongy layer within the fruit wall) should be designated as coconut or coir fibres, but the remaining tissue of the mesocarp is frequently described as coir (or coco) pith, meal or dust. Use of the term "coconut peat" or "coco peat" for coir pith is factually incorrect, as coir pith is not a type of peat. The fibrous coconut material is designated as coir fibres or simply coir. The coarse chips that are sometimes used are called coir chips. Sri Lanka and India supply most horticultural coir products to Europe, so they are expensive due to long transport routes.

Table 4. Comparison of some analysis data for pure peat and a peat-free mixture (both without addition of lime or fertiliser) whose air capacities have been adjusted to the same level.

QUALITY-ASSURED CONSTITUENT		Units	Mix 1	Mix 2
Weakly decomposed peat	< 20 mm	% (v/v)	100	0
Composted green biowaste	< 15 mm	% (v/v)	0	40
Composted bark	< 15 mm	% (v/v)	0	30
Wood fibres (Toresa®)		% (v/v)	0	30
CHARACTERISTIC	METHOD			
Dry bulk density	EN 13040	g L^{-1}	90	280
$Water_V$	EN 13041	%	70	57
Air_V	EN 13041	%	25	25
pH	EN 13037		4.0	6.9
N : P_2O_5 : K_2O	VDLUFA*	mg L^{-1}	30 : 20 : 40	100 : 470 : 1400

*According to VDLUFA (Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten, the German Association of Agricultural Laboratories and Research Centres) methods: N ($CaCl_2$), P_2O_5 and K_2O (CAL).

Fibre production for ropes, mats *etc*. involves soaking the coconut fruits in water for several weeks so that the fibres can be more easily separated from the coconut. The pith is then mechanically or manually combed out (van Doren 2001) to extract the long coir fibres for further processing. Thus the fine spongy coir tissue is a waste product or by-product of fibre production. The chemical and physical characteristics of coir materials vary greatly with their origin, time in storage and the duration of the treatment process (Table 5).

Buffered coir pith has been commercially available for some years. Its ability to bind Ca^{2+} and Mg^{2+} is exploited by adding a calcium/magnesium salt to the pith during the treatment phase, as a result of which K^+ is displaced from ion exchange sites. The material is classed as buffered coir pith when the exchanger complex is saturated with Ca^{2+} and Mg^{2+}. Uncontrolled potassium release during crop cultivation is thus prevented, but this process increases the cost of the coir pith constituent.

The fibres have very good re-wettability, extremely high air capacity and low water capacity. Coir pith has a better balance between water and air capacity and can be used systematically in all areas of growing media production. Indeed, the

Table 5. Some physical characteristics of coir pith and coir fibres (ranges of average values).

Physical characteristic	Method	Units	Coir pith*	Coir fibres
Moisture content W_m	EN 13040	% (m/m)	60–75	15–20
Dry matter D_M	EN 13040	% (m/m)	25–40	80–85
Organic matter W_{om}	EN 13039	% (m/m)	90–95	94–97
Bulk density D_B	EN 12580	g L^{-1}	200–300	30–50
Laboratory bulk density L_D	EN 13040	g L^{-1}	250–350	70–100
Bulk $density_{dry}$ D_{BD}	EN 13041	kg m^{-3} (g L^{-1})	60–90	35–45
Water capacity	EN 13041	g/100g DM	600–800	200–270
Total pore space P_S	EN 13041	% (v/v)	85–95	95–98
Water capacity W_V	EN 13041	% (v/v)	60–70	8–12
Air capacity A_V	EN 13041	% (v/v)	15–35	83–90
Shrinkage value	EN 13041	%	15–25	4–10

* Reconstituted pressed coir pith with a fibre content of approximately 10% by volume.

characteristics of coir pith come rather close to those of peat, which means that the market for this constituent will increase gradually in the future despite its high price. Coir pith has already found its way into growing media formulated for the propagation of young vegetable plants, grow bags in which certain vegetable and cut flower crops are cultivated, and potting media for floriculture. Although use in nursery stock growing media is still very restricted, the possibilities are considerable.

PROSPECTS FOR PEAT ALTERNATIVES

Consideration of mineral materials such as mineral wool, perlite, vermiculite, sand, clay and clay products has been deliberately omitted from this paper, although these materials are significant in the context of growing media. This is because they are not regarded as peat alternatives; rather they have particular physical or chemical functions within a growing medium or they may be growing medium systems in themselves (e.g. mineral wool).

Bragg (1990) and Pryce (1991) list numerous organic and mineral-organic materials as possible replacements for peat in horticulture and landscaping. The constituents (or ‘additives to peat’ according to Bragg) they mention - including composted and soil-like materials - are animal waste, bark, hop waste, grain waste, coir, loam, sewage sludge, spent mushroom compost, vermicompost, wood wastes (i.e. chips and sawdust), straw products, paper waste, seaweed, food processing waste, rice hulls, sugar waste, tobacco waste, cocoa shells, liquorice root, lignite, biomass by-products, garden compost, leafmould, municipal compost and wood fibre.

At the time of these publications it was evident that most of the materials listed had not been tested and trialled for use in professional horticulture. All of them, sourced from a range of origins, have since been evaluated for the industry. Of the kaleidoscope of peat alternatives suggested, those which have consequently become most firmly established as growing medium constituents are composted biowaste, bark and composted bark, wood fibre and coir products. Others may be used for special purposes (e.g. rice hulls for aeration) or because they are locally available and their extraction is permitted (e.g. leafmould in France), but have not been widely adopted. Despite the background of favour for peat replacement, it remains necessary to include peat in most formulations as a diluent to compensate for the less favourable characteristics of the “alternatives”. Thus, although they are repeatedly placed in the foreground, the role of alternative growing medium constituents is still subordinate to that of peat, and this situation is likely to continue into the foreseeable future.

Given the constantly high demand for high quality growing media, volume reduction of growth modules (pots, trays etc.) and the restrictive approval practice for peat extraction in those European countries that impose stringent official controls, it seems inevitable that companies manufacturing growing media will import more peat in future than they do today. The demand for growing media from countries with intensive commercial horticulture which lack adequate peat deposits or commercial growing media production facilities of their own will necessitate imports, which are presently sourced mainly from the Baltic countries. The Netherlands moved in this direction long ago when their extractable domestic peat reserves became exhausted and they found, as still seems to be the case today, that highly technical and specialised horticulture is impossible without peat.

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