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Klasmann-Deilmann Ireland Ltd. | Killinagh | Rathowen | Co. Westmeath | N91 WK64 | Ireland

[redacted]

National Peatlands Strategy Co-ordination Unit

National Parks & Wildlife Service

Department of Culture, Heritage and the Gaeltacht

90 King Street North, Dublin 7, D07 N7CV

Your contact person	Phone	Fax	E-mail	Date
[redacted]	[redacted]	[redacted]	[redacted]	22-01-2020

Re: Review of the use of peat in the Horticultural Industry

Dear [redacted]

Thank you for informing us of the opportunity to contribute to the consultation process reviewing the use of peat in the horticultural industry.

In the enclosed submission we have provided our responses to the ten public consultation questions as requested. In addition, we thought it appropriate to comment on some of the commentary outlined in the Consultation Paper and have therefore followed the headings used in the Paper.

Please do not hesitate to contact us should you required any additional clarifications or further information.

Yours sincerely,

[redacted]

Submission to the

Department of Culture, Heritage and the Gaeltacht

In response to the

Consultation Paper Reviewing the Use of Peat in the Horticultural Industry

From:

Klasmann-Deilmann Ireland Limited

19th January 2020

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About us

The Klasmann-Deilmann Group

Klasmann-Deilmann is the leading corporate group in the international substrate industry, with sales and production companies in Europe, Asia and America. On every continent, our growing media provides a vital basis for the growth of fruit, vegetables, edible fungi, ornamental plants, trees and shrubs. They help ensure the success of our partners and customers in the commercial horticulture sector. Our product portfolio includes substrates for professional growers and the consumer sector, white and black peat as raw materials from our own resources, as well as green compost, composted bark and wood fibre manufactured in-house.

As a supplier of renewable resources, we have also established ourselves in the field of renewable energy. Our short-rotation coppice (SRC) plantations contribute to the supply of climate-friendly energy, especially in the Baltic region.

We refer to internationally recognised benchmarks to gauge how seriously we take our responsibility for humankind, the environment and future generations. Regeling Handels Potgronden (RHP) monitors our raw materials and production processes. Our quality management system is certified to the ISO 9001 standard and our environmental management system adheres to ISO 14001. Most of our peat extraction areas are already managed in accordance with Responsibly Produced Peat (RPP) guidelines. We rehabilitate former extraction sites in compliance with statutory and regulatory requirements, chiefly by means of rewetting. We have our carbon footprint verified to the ISO 14064 standard and we prepare our Sustainability Report in line with the Global Reporting Initiative's GRI Standards 2016.

The strategic focus of our company, a medium-sized family business, is extremely forward-looking. Keen to remain the most sustainable producer of growing media, we are working on far-reaching research projects to develop innovative raw materials, substrates and growing systems. In the renewable-energy and resources sector, too, we are single-mindedly pursuing a strategy of growth and are continuing to expand our service portfolio.

In all of our activities, our employees are a foundational asset. Time and again, their expertise and commitment play a crucial role in moving us forward in terms of corporate sustainability and customer satisfaction. We encourage their development and are delighted by their strong ties with our organisation.

Klasmann-Deilmann Ireland Limited

Klasmann-Deilmann is proud to have an association with the development of the Irish peat industry which predates even the establishment of Bord na Móna. In 1934 C.S. 'Todd' Andrews and a delegation from the Turf Development Board met with Georg Klasmann at his turf works and power station at Rühle, near the existing Klasmann-Deilmann head office. Todd Andrews described the "Klasmann works as the most impressive in Germany" and he invited Georg Klasmann to Ireland to advise on setting up peat extraction in Ireland on a commercial basis. Georg Klasmann visited Ireland the following year and in 1937 Klasmann supplied all the initial equipment to allow the mechanisation of the first two Irish bogs (at Lyrecrumpane & Clonsast). ***Per Donal Clarke, 2010, Donal Brown Gold: "A History of Bord Na Móna and the Irish Peat Industry".***

The business now known as Klasmann-Deilmann Ireland Limited was originally established as Midland Irish Peat Moss Limited in 1982 by the Riesselmann family (who hailed from Lohne, also in Lower Saxony where Klasmann-Deilmann is based), with the backing of the National Development Corporation and the explicit support of the then Minister for Industry and Energy, local TD and former Taoiseach, Albert Reynolds. The Riesselmann family initially purchased 200 hectares of bog land and set up a small (450m^2) factory to process peat for the export market.

Klasmann-Deilmann GmbH acquired the business in 1991 and invested heavily in expanding operations, increasing employment and opening up new markets for an extended range of professional horticultural substrates which allowed the Irish factory to produce substrates for specific crops and growing environments.

Typically the company reinvests approximately 3% to 4% of its annual turnover in capital expenditure, upgrading operations and expanding the product offering. For example, in 2013 the company invested just shy of €1 million in a new plant to produce GreenFibre, Klasmann-Deilmann's wood fibre product, which is produced on site from locally sourced woodchip.

In 2019 Klasmann-Deilmann Ireland Limited employed an average of 74 people (with total staff costs of €3 million), had revenues of €15 million, 95% of which were generated from export markets.

Comments on the Consultation Paper

In addition to answering the Public Consultation Questions we have made some general comments on the content of the paper.

Introduction

Comments: None

The Changing View of Irish Peatlands

Comments:

- For centuries the drainage of peatlands, in Ireland as in elsewhere in Europe, was considered as an important means to develop what were considered "wasteland" areas.
- The founding of the Turf Development Board in 1934 marked the beginning of large scale commercial peat in the modern State, until it was succeeded by Bord na Móna in 1946.
- Commercial peat operators were encouraged to set-up in Ireland by government agencies such as the IDA, Enterprise Ireland and the National Development Corporation.
- It has only been since the late 20th century that the nature conservation value of peatlands and more recently their function as a carbon sink were recognised.
- The substrate industry in Europe (especially in Germany, Netherlands, the Baltics and Finland) has introduced measures to ensure that the after-use measures helps

to preserve biological diversity and ecosystem functions once raw material extraction ceases. Programmes such as the RPP scheme help to ensure a most responsible use of peat. (https://www.responsiblyproducedpeat.org/)

Protected Peatlands in Ireland

Comments:

- It is difficult to reconcile the total areas per the table of 1,564,650 ha to the areas identified by Messrs. Hammond and Foss, which would suggest that 460,000 ha of fen have been reclaimed for use as farmland and forestry.
- From work performed by Klasmann-Deilmann on its own peatfields it has been established that carbon emissions vary from about 3 tonne CO2e ha-1 a-1 on very decomposed 'black' peat extraction areas in Germany to about 8 tonne CO2e ha-1 a-1 on younger, 'white' peat sites in Lithuania. *Appendix 5*
- Given that there are almost 700,000 ha of cutaway/cutover peatlands identified in the table these areas are responsible for emitting perhaps 4.2 million tonnes CO2 equivalent (CO2-e) per year (assuming an average of 6 tonne CO2 per hectare per year; per Wilson et al 2015). With the right incentives (grants, carbon credits etc.) this represents a huge opportunity for Ireland to make significant inroads in its GHG emissions balance sheet. *Appendix 4*

Use of Peat in Horticulture

Comments:

- It is possible that by referencing the significance of peat usage in commercial horticulture to merely the mushroom, containerised nursery stock and soft fruit sectors, the importance of peat moss to other segments may be overlooked. Note that almost 45% of Klasmann-Deilmann's production is used in the production of food. Peat is also widely used in propagation of forestry plants and in many other segments e.g.:
  - protected grown vegetable young plants
  - microgreens
  - hydroponically grown vegetables and herbs
  - pot herbs
  - nursery stock
  - bedding plants
  - pot plant crops

The Importance of Horticulture to the Economy

Comments:

- This section makes clear the importance of horticulture to the national economy. It should, however, be further emphasised that horticulture businesses are located mainly in, often disadvantaged, rural locations where there are few other employment prospects. While the horticulture industry is important at a national level it is hugely important to those localities where the businesses are based.
- The Irish peat industry is concentrated mainly in the Midlands and the West, regions that are economically disadvantaged compared to Dublin and the East. The peat sector makes

a significant contribution to employment in these areas, where there are few alternative opportunities.

- The mushroom and nursery stock sectors are identified as important export earners. It should also be highlighted that Irish growing media producers generate most of their revenues from overseas markets.
- The output identified in the table totals €239 million. Presumably the €198 million balance is made up of field grown vegetables and trees?

Sectors Reducing their Peat Use

Comments:

- **Re paragraph 1**: For most commercial growers, peat remains the raw material of choice due to its technical and commercial efficiency as well as its reliable security, which so far is unmatched by any other constituent tested in the past. *Appendix 1*
- **Re paragraph 2:** It is acknowledged that in the soft fruit sector the fertigation systems allow the replacement of peat with coir. However, coir has negative environmental consequences (large water requirement in areas of India and Sri Lanka where water is already in short supply, issues from waste water, significant transport costs, nutrient depletion where coconuts are grown etc.). By using good quality alternatives (e.g. wood fibre, perlite, coir, composted bark materials, pine bark), peat reduction of 20% to 30% is achievable without detrimental effects to plant growth and yield. Many of our customers are successfully using such peat-reduced mixes in many different segments of professional horticulture (e.g. Pot Plants, Nursery Stock, Bedding). However, peat remains the main ingredient in order to secure the reliable performance of the growing media.
- **Re paragraph 3:** In the mushroom sector peat is also needed – and even more importantly - to buffer acids released form the mushroom mycelium and to create a well-balanced air/water ratio on the growing media to promote growth of mycelium.
- Re paragraph 4: Professional growers have done trials with peat free media in recent years and have achieved acceptable results in a range of crops. However, peat free growing media has been proven to require more water and fertiliser input (typically approximately 25% to 30% based on practical experience) and they tend to create a greater inhomogeneity and higher failure rates in crops, so are not commercially acceptable for growers working on tight margins.

Properties of Peat Moss versus Compost or Green Waste

Comments:

- It is somewhat perplexing to understand why Green Waste is singled out with its own chapter as if it was being presented as an alternative to using peat moss. Good quality Green Waste is a useful ***diluent*** to assist in peat-reduction; it is not a full alternative. Although coir has its own environmental baggage (high transport, waste water emissions, clearance of native woodlands, etc.), it has at least the advantage that it can be used as an expensive alternative to peat for many crops; the same cannot be said for Green Waste.
- Other alternatives should be given greater consideration (for example bark, coir, coco fibre, etc.). *Appendix 2* Wood fibre in particular has proven it worth as a very important

diluent for professional growing media due to its chemical, physical and biological characteristics. The expectation is that this constituent will become far more important in future, so a secure supply of suitable woodchip will be required for the horticultural industry. Currently competition from power plants for thermal energy creation is becoming an increasing challenge for the industry elsewhere in Europe.

- **Re Paragraph 1:** Unless there is full quality control and traceability of the source of material used in the production of green waste compost it is unsuitable for use in professional horticulture. For example, material coming from municipal waste collection centres in Ireland and the UK are frequently contaminated with chemical, herbicide and pesticide residues, glass, needles, faeces, plastic, etc.
- In addition, if the production process of the green waste is not carried out to standard (minimum 70°c for 24 hours) there is a risk of dangerous pathogens (e.g. Listeria) remaining in the material. For example, NHS Scotland who monitors and has reported on the increased incidence of Legionnaires' disease caused by Legionella longbeachae, which has been linked to composted materials used in growing media. *Appendix 6*
- Klasmann-Deilmann in Germany has been producing high quality green waste compost since the early 1990s so is very familiar with the product, the production process and its limitations. From the German experience we would suggest that the available volume of good quality source material is a limiting factor. Green waste accounts for less than 4% of the input material required by the Klasmann-Deilmann Group for production of substrates and it has become increasingly expensive due to competition from energy production.
- **Re Paragraph 2:** These comments are only relevant for gardening, landscaping, farming or soil grown soft fruit plantations. For most areas of professional horticulture this parameter is not of interest, since soilless growing media is used.
- **Re Paragraph 3:** Peat moss provides significantly higher water retention compared to green compost. Even more important is the parameter of pore volume and the water to air ratio of peat. Peat provides an excellent physical structure for soilless cultivation in growing media.
- **Re Paragraph 4:** Green compost can only be used at a share of up to 25% maximum in growing media due to unfavourable chemical and physiological properties (high salt levels, high nutrient levels and non-optimal nutrient ratio).
- Commercially, the use of green compost in growing media is limited by weight (leading to higher transport and environmental costs - typically by volume 2 trucks of green compost (minimum) = 1 truck of peat). Moreover, the commercial processing costs for green compost (sourcing of input materials, machines, turning stock piles, labour for temperature control, laboratory quality management) are higher than for those of peat. In combination with the higher weight of compost and the chemical / biological issues makes it commercially unattractive and therefore currently of limited use in professional horticulture.
- **Re Paragraph 6:** the major benefit of peat is the low pH and the very low levels of nutrients alongside a range of other factors. This allows adjusting the pH and all nutrient levels in peat based growing media by using calcium carbonate lime and specific mineral fertiliser exactly to the requirements of any crops. This is one of the major benefits of peat and why it is such a reliable, homogenous and secure growing media for modern professional horticulture
- **Re Paragraph 7:** We would contest the point that peat moss is hard to wet-up and rewet. Peat based growing media is combined with specially developed wetting agents to secure a very quick water uptake both for initial wetting after potting / sowing but also during cultivation of crops. The speed and security of water uptake and the possibility of drying back peat based growing media during cultivation is an important

tool for controlling the growth of crops (e.g. water stress in bedding crops) and the health of crops (reduction of pest and diseases from maintaining a dry surface on the growing media). Due to the high water retention of peat, the intervals of watering can be longer than for other types of growing media, which again allows a drier cultivation and less issues with pests and diseases. To keep these crucial effects for modern horticulture, a share of minimum 50-60% peat in a growing media is important alongside alternatives such as wood fibre and perhaps compost based materials.

- **Re Paragraph 8:** Microbial activity of composted materials is a strong benefit in terms of antagonistic effects against diseases. This effect is desired in certain segments such as organic cultivation, pot herbs production and general pot plant or bedding plant cultivation. Microbial life will also contain *Nitrosomonas* and *Nitrobacter* bacteria which are important to support the release of nitrogen from organic fertilisers. Therefore green compost plays a major role in organic growing media.
- On the other hand, this microbial life has a negative aspect when products are intended to be supplied overseas or need to be stored in packaging. Under storage and transport conditions the microbial life will change the chemical parameters of a growing media and result in strong nitrogen losses and increases in pH which can have detrimental effects on crops. Use of green compost therefore can only be an option for local supply with short storage and transport times.

Disadvantages of Peat Use in Horticulture

Comments:

- The title of this chapter is misleading, as it is not describing the disadvantages of peat in horticulture, but the negative effects of draining peatlands, following decomposition of peat and the loss of ecosystem services.
- From a technical point, peat use in horticulture has no disadvantages, as it is the best known growing media constituent.
- **Re Paragraph b):** the decomposition of peat does lead to the release of carbon into the atmosphere. However, it is used for growing plants which again take up carbon. Certainly peat used for fuel is immediately released into the atmosphere with no corresponding offset as in the case of peat used in horticulture.
- **Re Paragraph c):** This statement would appear to be at odds with experience elsewhere in the world, although it is acknowledged that rewetting work is challenging. The peat industry in Europe and Canada have restored thousands of hectares of former extraction sites and converted them into nature conservation areas by ensuring correct restoration plans and suitable measures are taken during the period of harvesting (e.g. keeping minimum peat layers, creating walls and ditches, etc.). Research on this started in Germany back in the 1970s with rewetting being standard now for peat extraction areas.
- **Re Paragraph d):** In most cases in Ireland peat bogs have been drained decades ago (or longer) and so are no longer carbon sinks. In order to bring peatfields back into conditions suitable for restoration at least a part of the peat layer has to be removed before preparing the bog for rewetting. This follows the experience for example in Germany, the Netherlands, Lithuania, Latvia, etc.
- **Re Paragraph e):** This research is going on in some countries in Europe (including Ireland, Germany, Switzerland, France and the United Kingdom) at universities, research stations and at manufacturers since the 1980s with a considerable increase in efforts during the last 5 years. However after more than 30 years of research and testing of a huge range of potential alternatives there has been no natural or artificial material so far to succeed

peat in professional growing media. Although, alternatives such as wood fibre, coir, coco fibre, bark materials are used in many cases to lower the share of peat in growing media. Conclusive reports on this matter are available from DEFRA in the UK and from the government of Lower Saxony in Germany.

Peat-free Growing Substrates and difficulties in usage

Comments:

- As alternatives to peat, straw, manure and paper were identified in the past but many tests have shown that these alternatives cannot be used as a growing media in the professional sector.
- The re-use of peat has already been investigated, but as most peat is delivered to the end-consumer in pots it cannot be or is already re-used in compost.
- **Re Paragraph 1:** Saving of nutrients often is not the case when using peat free media, since drainage is stronger and thus the leaching of nutrients. This would only apply for green compost materials which can bring in a package of macro and micro nutrients. **Re Paragraph 2:** Applies to soil improvement and mulching only.
- **Re Paragraph 3:** This is the most important parameter. Peat reduced and especially peat free growing media in most cases will result in poorer yields and are more expensive, requiring higher water and nutrient inputs, resulting in higher production costs for vegetables and plants. Cost prices for the end consumer would increase as a result of converting to peat free growing media. Considering the commercial, chemical, physical and biological challenges it is recommended not to consider peat free growing media to be the solution as such, rather peat reduced and strongly peat reduced growing media. Reliable substrates could be made from 50% to 60% alternatives, but still would keep 40% – 50 % peat in the composition to balance out the challenging aspects of other constituents.
- **Paragraph 4:** Correct! Please do not only consider green waste compost, but also wood fibre as a more important and more beneficial material for professional growing media in future. Also other materials such as bark based products, coco fibre, coir and others will need to play a role and do this already widely in modern horticulture wherever technically and commercially suitable.
- **Re Paragraph 5: An** alternative constituent not mentioned here is fresh sphagnum moss which can be harvested from fields that have been rewetted. This constituent has performed well in trials in Germany and benefits from being harvested from fields which are still carbon sinks. On the downside it is not yet economically viable, so such activities would benefit from subsidies to allow them to develop to a scale where they could become viable.

Challenges in moving from the use of peat moss in the Horticultural Industry

Comments:

- Alternatives to peat can be supported not only by referring to the downside of peat, but by better promoting alternatives with communication, financial incentives and ensuring growing media producers have access to alternative raw materials.
- **Re Paragraph 1:** Makes reference to ‘as other countries restrict their peat extraction and usage’ - to our knowledge, currently, only the UK and Switzerland have such plans.
- In any case, demand from China (and developing markets) will drive demand for growing media in the coming years. China only has about 0.1 ha of arable land per

citizen (in the USA the equivalent is 0.5 ha per citizen) so to improve output seedling nurseries are being established to drive food production (for vegetables, fruit, rice, etc.). The Chinese government's strategy to address food security envisages that the country will require 100 million m^3 of growing media by 2030. This compares with current total global production of horticultural peat in 2018 of between 40 and 50 million m^3. *Appendix 3*

- By 2050, the world's population is expected to reach 9.1 billion, and the United Nations' Food and Agriculture Organisation (FAO) predicts that at that point, the world would need to produce 70% more food than today to feed all those people. Other analysis suggests that by 2027 the world could be facing a 214 trillion calorie deficit. *Appendix 7*
- Currently we do not have sufficient supplies of good quality reliable alternative growing media that could replace peat in food production. Unless good quality alternatives are developed very soon the move away from peat will of necessity have to be more gradual than the ambitious targets that have been planned, for example by the UK's DEFRA.
- **Re Paragraph 2:** Again in this paragraph there is the misguided focus on 'natural compost/green waste'. What about other alternatives and diluents, wood fibre, bark materials, even digestate from bio power plants? Green compost can be a highly risky material and is hard to manufacture in a constant homogenous quality, there are other materials which would be easier to deal with.
- **Re Paragraph 3:** What about incentives for alternative growing media and priority access to compost, wood fibre etc.?
- **Re Paragraph 4:** DEFRA will readily admit that the 2020 and 2030 targets set in the 2011 White Paper and restated in the 25 Environmental Plan are unachievable, though the retail phase-out is more likely to be achieved in the short-term.

Public Consultation Questions

What are your views on what more could be done to support and enable the switch to peat free horticulture at professional crop production level and consumer level?

Responses:

- It must be recognised that peat free materials cost substantially more and introduce higher risks in plant production (often lower yields and less consistent crops) and for retailers (shorter shelf-life). A transition to a peat free market will involve growers, retailers and ultimately consumers accepting more expensive potting soils, professional substrates, plants and food (almost 45% of Klasmann-Deilmann's substrate output is used in food production). Alternatively, interventions in the marketplace such as incentives or subsidies could help offset the cost of transitioning to peat-free materials.
- The experience of Klasmann-Deilmann in Germany has been that competition from the energy sector has driven up the cost and limited the availability of alternative raw materials for the horticulture sector. Market interventions to prioritise the availability of alternative materials for the horticulture sector (particularly for food production) over energy use would help alleviate some of this imbalance.
- Klasmann-Deilmann has proven that harvesting sphagnum moss (sphagnum farming) can provide a sustainable solution to the use of peat in horticulture. However, it is

currently not economically feasible to produce fresh sphagnum moss and it would require subsidies to be competitive.

- It is the belief of Klasmann-Deilmann that for the professional sector the focus should be peat-reduced substrates rather than on peat-free, as peat free production introduces too many risks and commercial challenges for both growers and manufacturers.
- The decision of a grower whether to lower the peat content in growing media often comes down to price; a purely peat based product currently makes more commercial sense than a peat-free product. In addition, strongly peat reduced or peat-free substrates often require increased fertiliser and water consumption which adds further to the costs of growers. Unless growers can obtain higher prices for plants grown in peat-free media or can have these costs offset in some way, growers will continue to do what makes sense for them commercially.

What are your views on alternatives to the use of peat in the Horticultural Industry (from, for example, the perspective of the professional grower or consumer/amateur gardener)?

Responses

- For professional growers we believe that currently peat-reduction (20% - 40%) rather than peat-free offers commercial growers a relatively safe, if more expensive, alternative to pure peat based substrates. Although we provide peat-free alternatives to commercial growers who require such growing media, we always communicate the additional risks and management required by such media.
- For amateur gardening the stakes are much lower, so we have no hesitation in providing heavily peat-reduced or even peat-free hobby substrates. However, there is limited availability of quality alternatives to replace the volume of peat currently used in the market, so this is likely to be the limiting factor in increasing the volume of peat-free retail product. Also, as is the case for professional growers, such alternatives come with a higher price tag and perform less well than the pure peat mixes that we would typically recommend.
- For professional growers: wood fibre, composted bark materials, potting bark, coco fibre, and coir are currently the most suitable and safe options. Wood fibre is a particularly safe and reliable material; green compost (which we also produce in-house at Group level) comes with known risks unless the source material is **100%** reliable (glass and herbicide free). If there is not 100% control of the source material unacceptable risks can be introduced into the growing process so it is not a material that we have the same confidence in as peat moss.

What are your views on whether Ireland should cut back or cease the export of peat for use outside of Ireland even if this would result in job losses in Ireland?

Responses

- The horticultural peat industry in Ireland would effectively not exist without the export market; the demand within the Irish horticulture market would not justify the continued presence of companies such as Klasmann-Deilmann, 95% of whose production is exported. With a few exceptions, revenues in the industry are mostly derived from exports.
- In any case, it is unlikely that Irish constitutional law or EU and International competition law would permit such a unilateral action by an EU Member State.

- *Cui bono?* Who would benefit from such a unilateral move by Ireland? There is enough peat available from other EU (Finland, Sweden, the Baltic States and Germany) and non-EU countries (Russia, Belarus & Canada) to replace Irish peat in the markets currently served by Irish based producers. It would only result in a loss of jobs in the peat industry in Ireland and would most likely result in Irish growers paying much higher prices as producers such as Klasmann-Deilmann would cease operations in Ireland. Most likely some Irish growers would be wiped out by imports from the continent as they could not compete with the lower costs of continental growers. Companies like Klasmann-Deilmann would continue to supply the Irish market but would do so by shipping products from its factories in the Baltic, the Netherlands or Germany. Such action would result in a higher environmental cost as peat production is merely shifted from one EU location to another, more distant one, resulting in Irish growers adding almost 3,000km in higher transport costs to their growing media.
- A more sensible approach would involve ensuring that existing peat production sites are not abandoned and left to contribute to Ireland's GHG emissions. Instead, a robust licensing regime would ensure that on completion of production at former extraction sites, operators would be required to renaturalise the bogs by rewetting peatlands to encourage the regrowth of sphagnum mosses and other typical peat bog vegetation. With this approach thousands of hectares in Germany and the Baltics have been re-naturalised (Klasmann-Deilmann alone has rewet over 4,000ha of former extraction sites in Germany and has commenced similar restoration programmes in Lithuania).
- The Dutch RPP programme is a scheme that ensures the sustainable use of peatlands and provides guidance to safeguard the natural environment. (https://www.responsiblyproducedpeat.org/)

Do you consider that a working group should be established to advise on how best to overcome the barriers to reducing peat use in professional horticultural crop production and in the amateur horticultural market?

Responses

- It is probably not necessary to establish such a working group as the barriers to peat-reduction in horticulture are already well established and are largely centred on the price and availability of reliable alternative constituents that can match the performance of peat. However, if such a group were to be established Klasmann-Deilmann should be very pleased to share its experience and knowledge of the issues it has encountered.
- Considerable budgets have been committed by Klasmann-Deilmann and by all significant companies in the sector to identify sustainable alternatives to peat. It is in the interests of participants to achieve a competitive advantage by identifying a cost effective alternative to peat.
- In the past two years alone, Klasmann-Deilmann tested over 50 materials from waste streams as potential alternatives but so far we have encountered challenges with each material related to for example safety, stability, water absorption capacity, lack of availability or lack of consistent availability. Such challenges can often be overcome with technical solutions but at the cost of additional energy, water, fertiliser and/or other chemical resources which undermines the sustainability of their use as alternatives.

If you are in favour of the establishment of a working group, which stakeholder groups do you think should be represented on it?

Responses

- If such a working group were established it would be essential to have professional growers, retailers, growing media manufacturers and their representative national bodies present. Klasmann-Deilmann would be happy to participate in such a working group.

How do you think that those involved in harvesting peat for horticulture could be compensated for any loss arising from a cessation of this activity (for example, on the basis of the profit loss arising or related to the value in ecosystem services retained/provided)?

Responses

- No compensation would be required if operators were allowed to work out their existing peat resources and were required to put in place restoration plans as part of the licensing process.
- If cessation were imposed then it would be appropriate that operators be compensated for the value of profits foregone from the inability to harvest the peat resources remaining in their lands.

How do you think that those involved in harvesting peat for horticulture could be guided towards alternative activities, for example, developing an environmentally suitable alternative material that could replace peat in professional horticultural crop production?

Responses

- It is in the interests of those involved in the harvesting of peat to develop other activities and alternatives to peat. The problem is largely one of economics and risk management. Alternatives to peat come at greater cost and introduce more risks for growers and retailers.
- The availability of peat in Ireland provides a competitive advantage to producers based in Ireland which serve the large horticultural markets in the UK, the EU and beyond. If peat were not the main (or at least a major) component in horticultural substrates, it would not make sense for manufacturers to be based in Ireland, far away from the main markets. The relatively small market available in Ireland would not sustain the manufacturers currently based here. People currently employed by the sector would have to seek employment in other industries, which will be a challenge in the midlands, given there are currently very few employment opportunities in the region.
- Growers could be encouraged to use peat-reduced alternatives by either subsidising sustainable alternatives (bearing in mind that alternatives to peat also have associated environmental costs) or by taxing peat inputs.

What do you consider the value of peatlands to be to (please score out of 100): carbon storage nature conservation the provision of ecosystem services the economy social and cultural needs.

Responses

- The table below is rather reductive. The UN concept of ecosystem services (provisioning, regulating, supporting and regulating) is more comprehensive than the below table would suggest.
  http://www.teebweb.org/resources/ecosystem-services/

carbon storage	**20**
nature conservation	**20**
the provision of ecosystem services	**20**
the economy	**20**
social and cultural needs	**20**
	100

In your opinion should the use of peat within (i) the amateur horticultural market and (ii) the professional horticultural industry be phased out over the next 3, 5, 10, 15 or 20 years and if so, how should this be done bearing in mind the potential job losses and the difficulties with alternative growing media?

Responses

- In the amateur market phasing out of peat in the next ten years is probably a realistic ambition in most cases. Growing media could use chemical hydrogels to replace the water retention of peat. Cost increases and chemical residue issues may arise. The challenge will be the supply of sufficient good quality alternative raw materials such as bark, wood fibre, coir, etc.
- For the professional market the objective of peat-free growing media should be reframed as achieving sustainable growing media. Achieving peat-free professional growing media even in the medium term will introduce too many commercial and technical risks for growers; strong peat reduction of 30% to 50% should be the initial focus in the next fifteen years. This would achieve the objective of reducing peat use while maintaining the supply of reliable growing media for professional nurseries.
- If growers and retailers are forced to use substandard peat-free growing media before they have gained sufficient experience with these materials, this could lead to large crop losses on nurseries and a loss of shelf life (higher losses of plants in the garden centre due to poor water holding capacity). This would not be very environmentally friendly. Likewise if using materials from waste streams increase the risks of dangerous pathogens (salmonella, e-coli, fungi etc.) in growing media then growers and manufactures could be exposed to liabilities and consumers could be exposed to unnecessary risks as well as the bad consumer experience delaying the uptake the transition to new growing media.

Does more need to be done to educate and build consumer awareness of peat free products which are available at retail level?

Responses

- Yes. This would also include advising of the cost implementations for the horticultural industry and the knock on effects of an increase in costs for fresh produce and pot plants etc.
- Full Life Cycle Analysis calculations would be helpful to compare the costs and benefits of other constituents in terms of sustainability, carbon footprint, ethical standards etc. to ensure consumers and growers are aware that alternative materials also come at an environmental cost. Growing Media Europe is currently undertaking such a LCA study.
- In the UK, DEFRA and the Growing Media Association has developed a calculator to help evaluate the sustainability of different types of growing media on a like for like basis which should promote peat reduced and strongly peat reduced growing media. Even with this calculator, a blend of different materials will need to be used due to technical and commercial reasons.

Appendices

Appendix 1 - The role of peat in assuring the quality of growing media - G. Schmilewski, Mires and Peat, Volume 3 (2008), Article 02, http://www.mires-and-peat.net/, ISSN 1819-754X

Appendix 2 – Limitation of additional organic material in growing media - G. Schmilewski, FlowerTECH 2001, Vol. 4 No. 2

Appendix 3 - Facing & Shaping the Future of Peat & Peatlands - Gilbert Ludwig, Chief Executive at International Peatland Society, presentation to Baltic Peat Producers Forum, Palanga, September 5, 2019

Appendix 4 – Klasmann-Deilmann brochure – "Close to nature, Restoration of peat bog areas with peat mosses - Innovation for climate protection and biodiversity"

Appendix 5 – Klasmann-Deilmann Sustainability Report 2017 / 2018

Appendix 6 – NHS Scotland: "Increased incidence of Legionnaires' disease caused by Legionella longbeachae in Scotland" https://hpspubsrepo.blob.core.windows.net/hps-website/nss/2418/documents/1_longbeachae_report2013_final.pdf

Appendix 7 – Article by Abdi Latif Dahir (New York Times and Quartz Africa reporter) referring to TED Talk of Sara Menker, founder and CEO of Gro Intelligence https://qz.com/africa/1064653/the-world-could-run-out-of-food-two-decades-earlier-than-thought/

SUSTAINABILITY REPORT 2017 / 2018

Meeting expectations, gauging limits

1913

we make it grow

Klasmann-Deilmann

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The complete Sustainability Report 2017/2018 according to GRI Standards 2016 is available for download at:
www.klasmann-deilmann.com/sustainabilty

About us

Klasmann-Deilmann is the leading corporate group in the international substrate industry, with sales and production companies in Europe, Asia and America. On every continent, our growing media provide a vital basis for the growth of fruit, vegetables, edible fungi, ornamental plants, trees and shrubs. They help ensure the success of our partners and customers in the commercial horticulture sector. Our product portfolio includes substrates for professional growers and the consumer sector, white and black peat as raw materials from our own resources, and green compost and wood fibre manufactured in-house.

As a supplier of renewable resources, we have also established ourselves in the field of renewable energy. Our short-rotation coppice (SRC) plantations contribute to the supply of climate-friendly energy, especially in the Baltic region.

We refer to internationally recognised benchmarks to gauge how seriously we take our responsibility for humankind, the environment and future generations. Regeling Handels Potgronden (RHP) monitors our raw materials and production processes. Our quality-management system is certified to the ISO 9001 standard and our environmental-management system adheres to ISO 14001. Most of our peat extraction areas are already managed in accordance with Responsibly Produced Peat (RPP) guidelines. We rehabilitate former extraction sites in compliance with statutory and regulatory requirements, chiefly by means of re-wetting. We have our carbon footprint verified to the ISO 14064 standard and we prepare our Sustainability Report in line with the Global Reporting Initiative's GRI Standards 2016.

The strategic focus of our company, a medium-sized family business, is extremely forward-looking. Keen to remain the most sustainable producer of growing media, we are working on far-reaching research projects to develop innovative raw materials, substrates and growing systems. In the renewable-energy and resources sector, too, we are single-mindedly pursuing a strategy of growth and are continuing to expand our service portfolio.

In all of our activities, our employees are a foundational asset. Time and again, their expertise and commitment play a crucial role in moving us forward in terms of corporate sustainability and customer satisfaction. We encourage their development and are delighted by their strong ties with our organisation.

Meeting expectations, gauging limits

In the two years since the last Sustainability Report was published, we have addressed our material sustainability topics in depth. Dialogue with our stakeholders has led to important new ideas arising during this period.

Increased proportion of alternative substrate constituents

Expectations made of us include further progress in the production and use of alternative raw materials that enable limits to be placed on the utilisation of peat as a growing medium for commercial horticulture. In this connection we have made big strides towards our target to increase the proportion of alternative substrate constituents to 15% by volume of our total annual production by the end of 2020. In conjunction with our strategic plan for the period until 2025, we aim to achieve a share of 30% by volume.

This positive development can be perpetuated only if it is accompanied by unbiased discussion of the extraction and use of the raw material that is peat, and of its future prospects. There remains a lack of suitable alternative constituents that are available both in the necessary quality and in the large quantities required if peat use is to be reduced on a global scale. The outlook for international commercial horticulture thus remains uncertain in one crucial regard: where the function in the growth process of a crop has been ideally served for decades now by peat-based growing media, this function must be reliably provided by alternative constituents or be replaced by completely new cultivation methods that can meet rising worldwide demand. Failing this, the importance of peat in horticulture will be maintained and possibly increased into the long term.

We intensified our research activities

Given this situation, additional efforts are expected of us aimed at preventing expansion of peat use. In response, we have further intensified our research activities targeted at developing completely new substrate constituents and growing systems. The versatility of well-established alternative ingredients such as wood fibre, green compost, coir pith and perlite is continuously being improved by our specialists. Our Research & Development division and the Incubator, which has been very active for some years now, are searching – across a sufficiently wide spectrum and with open minds – for new constituents, methods of cultivation and pioneering innovations. For a business with the character of an SME, the financial and human resources involved are considerable. Support measures are desirable here for those countries that are stepping up the phase-out of peat use, or indeed at EU level as well. We are submitting proposals to this end via our trade association and in direct dialogue with political representatives.

It should be borne in mind that by no means all research projects yield the hoped-for outcomes. Only rarely, in fact, are beneficial effects achieved. This was outstandingly the case with our long-term project involving Sphagnum farming: the deliberate cultivation of peat moss. Originally initiated with a view to developing a substrate constituent that is (in the best sense of the word) sustainable, it led to the discovery that peat moss grown in this way is ideally suited as a raw material for substrate production but its cultivation is not at present commercially viable. Excessively high land prices, low productivity, a lack of available means of financial support, inadequate harvesting techniques and other aspects were reasons not to pursue the original goal any further for the time being. At the same time, the project yielded other positive, if unexpected, results regarding the cultivation of peat moss specifically for raised-bog development. It is now clear that the Sphagnum-farming method developed by ourselves and our partners represents a significant advance for the restoration of former extraction areas. Before 2019 is over, we

aim to launch a related business model that can, on an appreciable scale, help to reduce greenhouse gas emissions from peatlands and to create living raised bogs.

Advances in peat moss cultivation

Emissions remain a challenge for Klasmann-Deilmann. Our business growth has been associated with additional greenhouse gas generation over the past two years. About one-third was generated by peat use and the same proportion by worldwide transport. We view this as a priority mission and have explored various scenarios aimed at countering this trend. We have opted for a model that will allow climate impacts from peat use and transport to be reduced: over the next few years we will invest heavily in decentralising our production. We are, with our factories, moving closer to customers in major markets; we will draw on locally available, renewable and sustainable raw materials while at the same time markedly reducing transport distances. This development has been partly driven by further stepping-up of the evaluation of upcoming investments using sustainability criteria.

Our chief commitment will be to the development of alternative constituents and growing systems in order to reduce emissions from peat production and transport, to rehabilitate former extraction areas and to provide renewable resources for the generation of renewable energy.

We look forward to your feedback on our activities and on our Sustainability Report 2017/2018, and to the continuation of our shared dialogue.

Geeste, September 2019
Managing Directors

Moritz Böcking Bernd Wehming

Klasmann-Deilmann Group

Companies of the Klasmann-Deilmann Group

We have assigned all strategic and controlling functions to our Group's lead company, Klasmann-Deilmann GmbH (based in Geeste, Germany). Klasmann-Deilmann Service GmbH, also located in Geeste, is our central service company. All other subsidiaries are either production or sales companies.

Klasmann-Deilmann GmbH
Lead company

Production		Service		Sales	
Klasmann-Deilmann Produktionsgesellschaft Nord mbH	DE	Klasmann-Deilmann Service GmbH	DE	Klasmann-Deilmann Europe GmbH	DE
Klasmann-Deilmann Produktionsgesellschaft Süd mbH	DE			Klasmann-Deilmann Asia Pacific Pte. Ltd.	SG
Schwegermoor GmbH	DE			Klasmann-Deilmann Americas Inc.	US
UAB Klasmann-Deilmann Silute	LT			Klasmann-Deilmann France S. A. R. L.	FR
UAB Klasmann-Deilmann Laukesa	LT			Klasmann-Deilmann Benelux B. V.	NL
UAB Klasmann-Deilmann Ezerelis	LT			Klasmann-Deilmann Belgium N. V.	BE
Klasmann-Deilmann Latvia SIA	LV			Klasmann-Deilmann Austria GmbH	AT
Klasmann-Deilmann Ireland Ltd.	IE			Klasmann-Deilmann Italia S. R. L.	IT
Klasmann-Deilmann Potgrondcentrum B. V.	NL			Klasmann-Deilmann Polska sp. z o.o.	PL
Klasmann-Deilmann Brugge N.V.	BE			Klasmann-Deilmann China Ltd.	CN
Bol Peat GmbH	DE			UAB Klasmann-Deilmann Bioenergy	LT
				Klasmann-Deilmann Bioenergy SIA	LV

Shareholders, management, governance bodies

Klasmann-Deilmann GmbH's shareholders are Deilmann-Montan GmbH (based in Bad Bentheim), with a stake-holding of 57.5 %, and Klasmann Anlage- und Verwaltungs GmbH & Co. KG (based in Meppen), which has a 42.5 % interest. The shareholders appoint members to the Administrative Board of Klasmann-Deilmann GmbH, of which Carl-Gerrit Deilmann has been the chair since 2007.

Managing Directors of the Klasmann-Deilmann Group are Moritz Böcking and Bernd Wehming.

The Managing Directors consult with the Administrative Board on key business developments, primarily with regard to their strategic, economic, environmental or social impact. The Board of Managing Directors was augmented in the summer of 2018 by a four-strong Executive Committee which contributes additional competencies from central corporate divisions. A further key decision-making body is the Management Board, which forms the interface between the strategic and operational levels and is made up of the two senior Managing Directors and the Executive Committee of Klasmann-Deilmann GmbH, as well as well as local-level managing directors of Klasmann-Deilmann Group subsidiaries

Certification

Product quality is controlled in a supply chain control process by the Dutch foundation 'Regeling Handels Potgronden' (RHP). The assessment criteria applied here are among the most stringent worldwide. RHP's quality-assurance process includes all the raw peat materials that we use, as well as our 'TerrAktiv' green compost and our 'GreenFibre' wood fibre product. The production sites in Germany, Ireland, Lithuania and the Netherlands are also RHP-certified; a large part of the marketed substrates originating from these manufacturing facilities is subject to monitoring for compliance with RHP standards.

Klasmann-Deilmann GmbH has been certified to the ISO 9001 standard since 1998 and to the internationally valid environmental standard ISO 14001 since 2008. Both certificates have, since then, been confirmed at each regular audit. Currently, our quality-management system and our environmental-management system satisfy the ISO 9001:2015 and ISO 14001:2015 standards. Our carbon footprint is verified to ISO 14064.

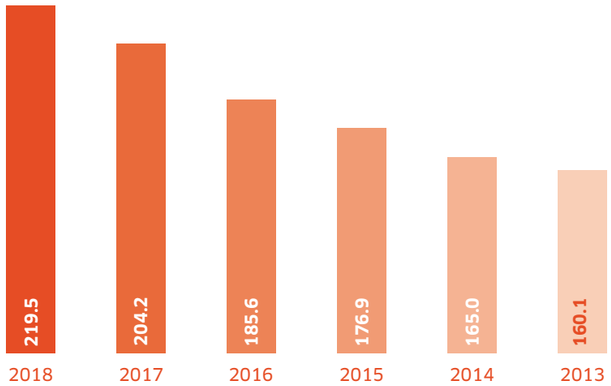
The bulk of our peat extraction areas are managed in accordance with the guidelines of the NGO 'Responsibly Produced Peat' (RPP) (see 5.1).

Our brands

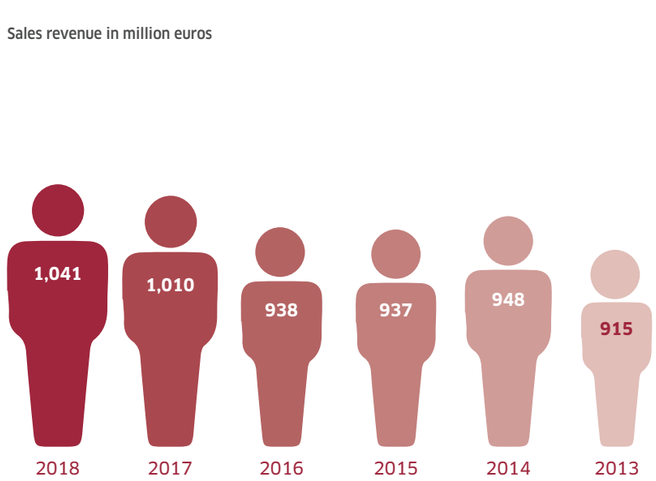
SUBSTRATES	RAW MATERIALS	BIOENERGY	INNOVATION
SUBSTRATES Easy Growing	RAW MATERIALS GreenFibre®	BIOENERGY Wood Chips	INNOVATION Academy
SUBSTRATES Select	RAW MATERIALS TerrAktiv®/FT	BIOENERGY Wood Trading	INNOVATION Growcoon
SUBSTRATES Florabella®	RAW MATERIALS Peat	BIOENERGY Wood Services	INNOVATION Peat Bog Restoration
SUBSTRATES ProLine	RAW MATERIALS Containermulch		

Key performance indicators 2017/2018

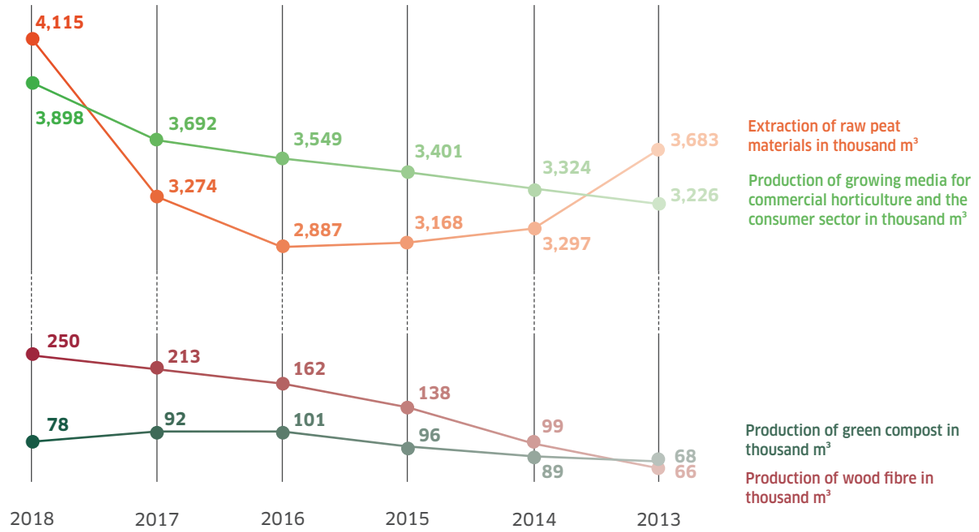
As a benchmark for our sustainable development, we employ key performance indicators (KPIs) that are tailored to specific aspects of our organisation and reflect our performance. Our goal is continuous improvement.

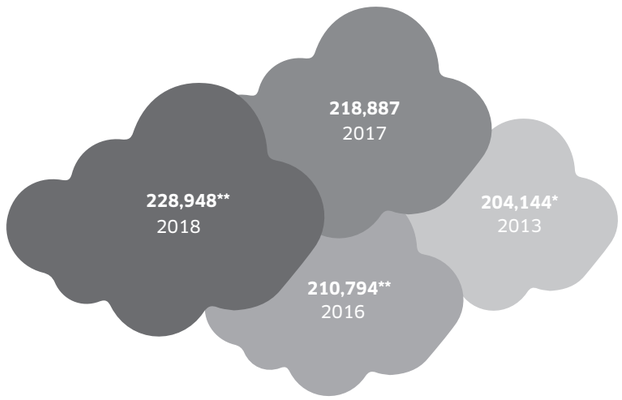


Sales revenue in million euros

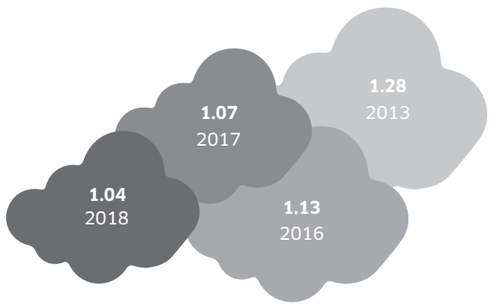


Average headcount (FTE)

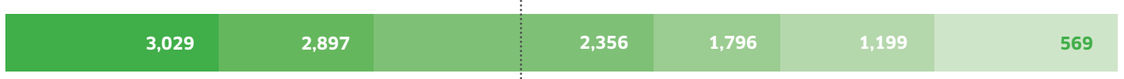




Total emissions in t CO_2e
* Verification 2017
** Verification 2019



Emissions per euro of turnover in kg CO_2e

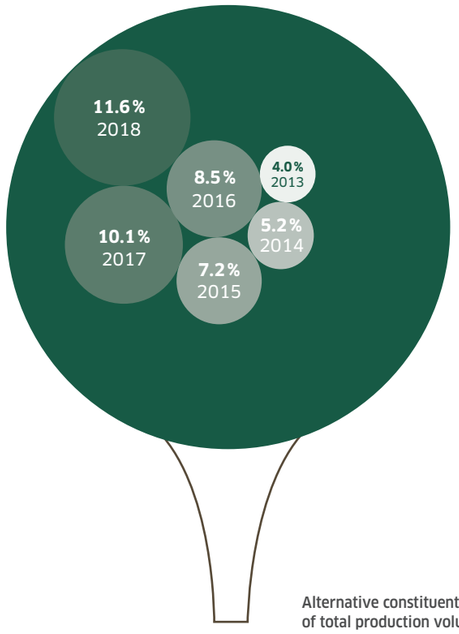


'Active' SRC plantations in ha

Total area of SRC plantations in ha

Alternative constituents

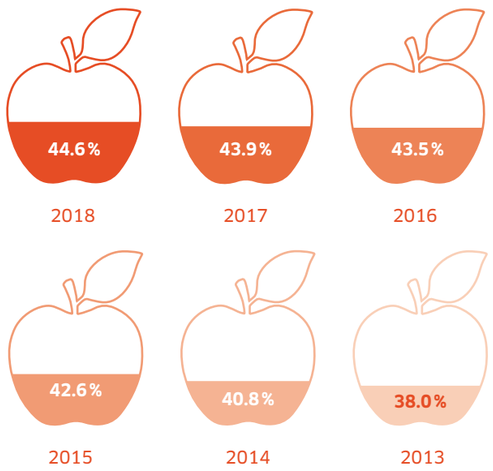
By 2020, we aim to increase the proportion of alternative constituents to at least 15 % of our total annual production. This KPI reflects the used volumes (in m^3) of our wood fibre product 'GreenFibre', our green compost 'TerrAktiv', and all other alternative bulking constituents in relation to the total quantity of growing media (in m^3) produced by the Klasmann-Deilmann Group.



Alternative constituents as proportion of total production volume

Food sector

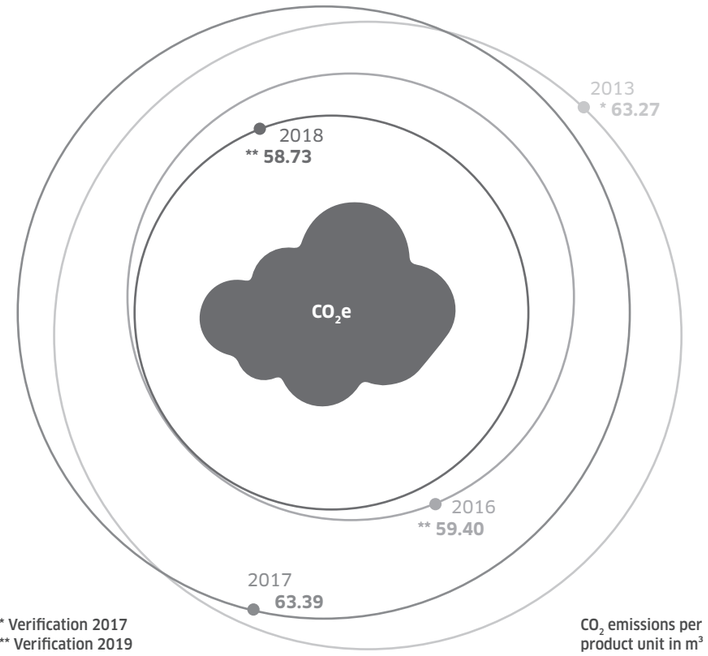
We wish, in future years, to step up our supplies to the fruit- and vegetable-growing sector. To document our progress here, we relate sales figures achieved for this area to total sales of growing media (in m^3 in both cases).



Sales to food sector as proportion of total sales

Emissions

As well as reducing our overall emissions, we are especially keen to reduce emission levels per product unit. In this KPI, therefore, we calculate the ratio between our corporate group's total emissions (in t CO_2e) and our total production volume (in m^3).

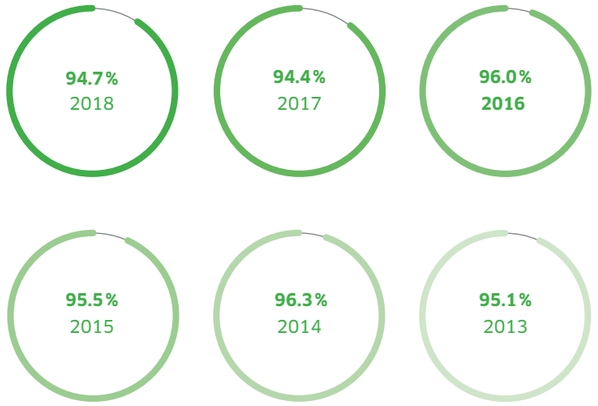


* Verification 2017
** Verification 2019

CO_2 emissions per product unit in m^3

Employee health

The following KPI of employee health gives the ratio between the total number of days to be worked by our international workforce and the number of days off sick (including sickness periods of less than and more than six weeks).



Employee health

Stakeholder groups involved

In the context of our sustainable development, we seek and cultivate direct dialogue with our stakeholders.

- Customers and sales partners in commercial horticulture, the most important target group for our sales activities;
- Customers and business partners in the renewable-energy and renewable-resources sectors, an increasingly important target group for our sales activities;
- Suppliers and other business partners of our corporate group;
- Employees of all companies within our corporate group;
- The Klasmann-Deilmann Group's shareholders;
- Lobby groups, especially at European and international level;
- Environmental organisations as our dialogue partners with regard to the use of peat as well as the management and rehabilitation of extraction sites;
- Public authorities and governments as approval bodies for projects of (in some cases) great importance to our company, and as our dialogue partners with regard to peat use as well as the management and rehabilitation of extraction sites.

Customer satisfaction

So that we can assess how satisfied sales partners and commercial growers – our most important customers – are with our substrates, services and employees, we set great store by direct dialogue on a worldwide scale.

As our experts are regularly on-site, we continuously receive feedback from our international markets and straight from the horse's mouth, so to speak. We evaluate it and take any necessary steps. In this way, we receive criticism and praise very soon after the event and can pass it on to the relevant teams. Problems can be solved and things put right without delay. This results in a continuous process of improvement that benefits our customers.

At less frequent intervals, we complement this non-systematic feedback with a specific customer satisfaction survey targeting professional growers.

Membership of organisations

Among other organisations, Klasmann Deilmann is a member of the following:

- Growing Media Europe AISBL
- International Peatland Society (IPS)
- Deutsche Gesellschaft für Moor- und Torfkunde (DGMT; German Peat Society);
- Regeling Handels Potgronden (RHP);
- Zentralverband Gartenbau (ZVG; Germany's national horticultural association);
- Bundesgütegemeinschaft Kompost e. V. (German Federal Compost Quality Assurance Association);
- Gütegemeinschaft Substrate für Pflanzenbau (GGS; Quality Assurance Association Growing Media for Plant Cultivation);
- Ökoring e. V. (Lower Saxony's advisory organisation for ecological growers);
- Bundesverband BioEnergie e. V. (BBE; German BioEnergy Association);
- Emsländische Stiftung Beruf und Familie (the Emsland region's 'Work and Family' foundation);
- Global Reporting Initiative (GRI);
- Niedersächsische Allianz für Nachhaltigkeit (Lower Saxony's Alliance for Sustainability);
- 3N Kompetenzzentrum e. V. (Lower Saxony's central information point for renewable resources and bioenergy).

Growing media

Quality assurance of our substrate constituents

Both for our customers and ourselves, it is crucial that we secure the constituents we need to produce our substrates – including peat, wood and green compost – while ensuring the highest product standards in terms of functionality and the impact on health and reliability. We therefore continuously test proven and new components as to their suitability for use in substrates. We assess their physical, chemical and biological properties and subject them to growing trials. The same also applies to in-house solutions relating to fertiliser formulations, wetting agents and other additives. To absolutely ensure their highest quality, we commission testing of our raw materials – and, if appropriate, the suppliers – to the requirements of Dutch organisation 'Regeling Handels Potgronden' (RHP).

Peat

Raised-bog peat has been the most important component in growing-media manufacturing for decades now. Commercial horticulture is tailored to its multiple advantages that lead to optimum growth and high yields in industrial-scale plant production. Peat-based substrates deliver unique reliability in crop cultivation. They can be continuously produced and supplied to a consistently high quality. After processing, the different types of peat have physical, chemical and biological properties that make them ideal for horticulture and which, overall, are unmatched by any other raw material.

Securing the sourcing of raw materials is, therefore, a high priority. We have sites in Germany devoted to the extraction of frozen black peat, although this will not last beyond the 2020s. In Lithuania, high-quality grades of more decomposed peat are available, which will replace German black peat to an increasing extent. We use our extensive resources in Lithuania, Latvia and Ireland for sod-cut or milled white-peat extraction – with which supplies to our production facilities are ensured for many years to come. The techniques involved in raw-materials extraction and processing are subject to an ongoing process of improvement.

Why peat?

Chemical properties

- Ideal pH value
- Optimum nutrient levels
- Good nutrient buffering
- Free from harmful substances

Physical properties

- High structural stability
- Optimum ratio between air and water capacity
- Good wettability

Biological properties

- Largely free from weed seeds
- Free from pathogens

Economic properties

- Long-term availability
- Uniform characteristics
- Quality that meets the horticultural requirements of a wide range of plants

Green compost

Since the early 1990s, we have run our own composting facilities in Groß Hesepe and Bohmte – with another plant operating in Dörpen since 2006 – at which green waste is processed into 'TerrAktiv', a compost for growing media. Our units are the only ones in Germany subject to RHP quality assurance. TerrAktiv green compost carries the RAL quality-assurance mark and, for use in substrates for organic production, complies with EU Regulation (EC) No. 834/2007 and Annex I to Implementing Regulation (EC) No. 889/2008.

TerrAktiv green compost and TerrAktiv FT, an innovative variation of this product, play a very important role as chief components of substrates for organic production for ecologically run businesses. By manufacturing them at our own facilities, we ensure the raw material is of consistently high quality.

As green waste is being utilised more and more as an energy source, there is now competition for these materials. Particular grades of green-waste material are no longer available to us. However, we will do all we can to pursue our composting activities at a high level; increasingly, our policy is one of strategic partnerships with external compost producers that meet our quality standards.

Why green compost?

TerrAktiv green compost

- is biologically active
- suppresses root diseases
- ensures potted herbs live longer
- is quality-assured
- acts as a slow-release nutrient source
- has a high buffering capacity
- improves re-wettability
- promotes the conversion of organic fertiliser into plant-available nutrients

TerrAktiv FT wood fibre/compost blend

- is nitrogen-stable
- increases air capacity in press pots
- optimises germination and plant development
- allows peat substitution of up to 50% by volume in combination with other constituents
- lowers the risk of excessive supply of ammonium to seedlings

Wood fibre

We have been using wood fibre as a bulking ingredient in our substrates since the 1990s. Following a develop-mental phase lasting several years, in 2010 we put into operation (in Germany) the first facility for manufacturing our own wood fibre product branded 'GreenFibre'. At the end of 2018 we had a total of six production lines in Germany, Ireland and the Netherlands.

Production of GreenFibre involves subjecting softwood chips to special heat and physical treatment which separ- ates the fibres. The process generates temperatures of over 90 °C, ensuring that unwanted substances escape from the woodchips as gas, sterilising the GreenFibre. This process also allows the structure – and hence the physical properties – of wood fibre to be precisely defined, giving rise to a consistently high-quality component produced from renewable resources.

The woodchips used to produce GreenFibre are sourced entirely from responsibly managed woodland. Whenever possible, we favour raw materials from local sources that meet sustainability criteria, and opt for PEFC- and/or FSC-certified raw wood materials from which to produce our wood fibre. GreenFibre also bears the RHP quality label, which is a long-term endorsement of its suitability for use in commercial horticulture. To ensure its consistently high quality, GreenFibre production units are – like our other facilities – certified to strict RHP standards.

Why wood fibre?

GreenFibre

- supports healthy, rapid root development
- ensures optimum drainage
- increases air capacity and ensures long-term structural stability
- ensures straightforward supplementary fertilisation of crops due to the stable nitrogen cycle
- reduces transport costs due to substrate's low overall weight
- for use in substrates for organic production, complies with EU Regulation (EC) No. 834/2007 and Annex I to Implementing Regulation (EC) No. 889/2008

Procurement practices

Our 'Sustainability guidelines for suppliers', in force since 2012, augment our selection criteria for our suppliers; they contain requirements for upholding human rights, for employees' working conditions and for environmental standards, as well as a business ethics code.

We require all our suppliers to commit to these guidelines. The standards this document defines, and their adoption, are a prerequisite for all supply agreements with Klasmann-Deilmann. In accepting a contract or order, our supplier undertakes to ensure that all their processes conform to the provisions of our guidelines.

The key points of our sustainability guidelines are:

- prohibition of child labour on the part of our business partners or their suppliers;
- prohibition of forced or compulsory labour;
- prohibition of any form of discrimination;
- freedom of association and the right to conduct collective bargaining;
- minimum wage and overtime pay in line with statutory benefits for staff;
- encouraging ongoing improvements and refinements to occupational health and safety arrangements in compliance with national regulations;
- prohibition of bribery, extortion and embezzlement;
- evaluation of suppliers on the basis of their optimisation measures regarding the management of resources, minimisation of ecological damage, adoption of a pre-cautionary approach, and the promotion of environmental responsibility and environmental technologies.

Production

Making a growing medium involves enriching our substrate base materials – peat, green compost and wood fibre – with perlite, lime, fertilisers and additives such as sand or clay. Organic and mineral fertilising solutions ensure that plants are specifically provided with all the nutrients and trace elements they need. The addition of lime regulates the substrate's pH level.

Our growing media are manufactured at our own production facilities, which are equipped with modern machinery and technical installations. A range of around 150 different raw peat materials, alternative constituents, admixing agents, fertilisers and additives are available.

Substrates for organic production

Our organic substrates conform to the regulations and requirements of growers' associa-tions in Germany, Austria and Switzerland. Depending on what our substrates are speci-fically utilised for, in certain cases we achieve peat substitution of up to 50% in organic horticulture by adding TerrAktiv, GreenFibre and clay. In this segment, use is made of organic fertiliser such as hoof and horn shavings from BSE-free countries.

Substrates for the consumer segment

In the consumer segment, we chiefly sell potting soils and garden composts under the Florabella brand. The composition of these products is based on our substrate recipes for commercial horticulture. For reasons of both quality and availability, peat will also remain essential as the main component in consumer products, although here too the utilisation of alternative constituents for substrates is continuously increasing. Overall, at our manufacturing facility that specialises in potting soils and garden composts, alternative substrate constituents account for some 40 % by volume of products made.

Product stewardship

All of our products are made to the highest industry-specific standards. One hundred per cent of our products and services undergo customary inspections with regard to their impact on health and safety, in order to determine additional potential for improvement. As well as using our own raw materials, we buy in components and additives for substrates, choosing only products that comply with RHP standards.

The labelling of our products – and the raw materials we utilise – on packaging, and their designation on delivery notes, consistently complies with the requirements of the recipient countries.

Packaging

The packaging for our growing media is made chiefly from petroleum-based granules. Sometimes, further development of these source materials on the part of our suppliers provides scope for cutting down on packaging material without compromising on quality – by reducing foil thickness, for example. Since the summer of 2018, we have used foil with a thickness of 80 µ instead of 90 µ as previously for the packaging of our 70-litre bags. This equated to CO_2 avoidance of around 55 t by the end of 2018.

We are assessing innovative materials (some based on renewable resources) currently in development, in terms not only of their intrinsic suitability but also their economic, environmental and social impact. However, we are not at present aware of any alternative raw material that satisfies our packaging needs.

Waste disposal

No working policy for recycling is in place for our products and packaging. Our growing media are generally disposed of together with the crop at the end of its life cycle. In the best-case scenario, both are composted as green or organic waste. On an international scale, however, the more likely situation is that both crop and substrate are disposed of with general residual waste. Where they are used outdoors, our substrates remain in the soil for the most part. Our packaging, too, is disposed of in accordance with standard local practice in the country to where the goods are shipped.

A system whereby leftover packaging and substrate are returned to us or sent for proper recycling would be disproportionately effort- and cost-intensive, and associated with additional transport-related emissions.

We appreciate that this state of affairs presents an ongoing challenge, and are therefore pursuing the following remedies:

1. Reduction of foil thickness for our packaging
2. Larger units that require less packaging material than smaller ones
3. Delivery of non-packaged goods, this chiefly being an option for customers located within the region of our production facilities

Water management

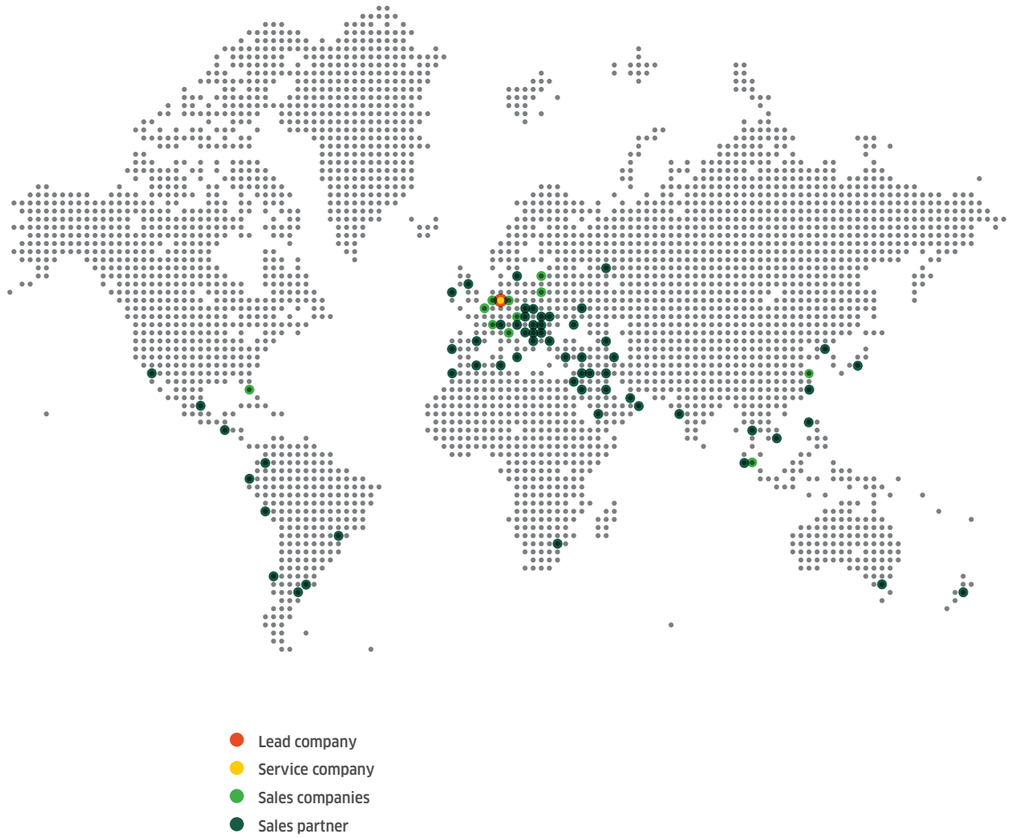
The manufacture of growing media does not require unusually large quantities of water: its consumption in the context of production is of relatively minor importance in terms of our sustainability-related activities. Nevertheless, our water management practices adhere to locally applicable legal provisions and are geared towards consuming resources as sparingly as possible and towards environmentally sound use.

Our customers in commercial horticulture and the consumer segment

Our most important market segment is commercial horticulture, which we supply with ready-to-use growing media, the end customers being nurseries throughout the world. Some 10 % of our total annual production volume of substrates are intended for the consumer segment. As a supplier, we form an integral part of the materials value chain in commercial horticulture. This incorporates our consulting and other services, as well as our innovation management practices.

International sales structure

Our sales of growing media extended to more than 70 countries worldwide in the reporting period. In most of these markets, we supply independent sales partners with which we have long-term agreements and which are exclusively responsible for local distribution. Within the central sales markets, our own subsidiaries are in charge of distribution and providing support to sales partners.



Systematic product development and innovation management

Of crucial importance to our organisation's long-term success is systematic, cross-functional innovation management. To this end, we have formed various teams within the areas of Research & Development, Product Development, Advisory Services and Quality Management as well as an 'incubator' that work closely and conduct joint research projects with higher-education centres, training and research institutes as well as with suppliers. We aim to develop growing media and cultivation systems which, meeting the proven horticultural standards, take into account sustainable criteria and achieve wide acceptance by policy-makers, NGOs and the public at large. At the same time, we are continuing application-targeted engagement with professional growers. We take on board our customers' ideas and needs, and turn them into innovative product solutions that are geared towards long-term gain and bring plant producers tangible advantages.

Joint projects with innovative companies

We have, from the end of 2016 onwards, been distributing an innovative cultivation system called Growcoon, developed by Dutch company Maan BioBased Products B.V. The product has since been finding a continuously expanding customer base in various horti-cultural segments worldwide.

Growcoon is a biodegradable plug with a flexible and open mesh structure. When used in propagation systems, it holds the propagation substrate together and, in this combination, forms a stable root ball. It is made from food-safe components and features the OK COM-POST label certifying it to the EN 13432 standard. This means, among other things, that the Growcoon does not entail any pollution risk with respect to farmland, people or the environment, and leaves no harmful residues. This propagation system is proving espe-cially effective in the rooting of cuttings, in the growing-on of young plants from in vitro propagation systems, and in the use of hydroponic cultivation. The main benefits of using Growcoon for propagating young plants are shorter growing cycles, robust plant health, greater root ball stability and – especially with delicate seedlings – lower failure rates.

The arrangement with Maan BioBased Products has been extended to include cooperation on other innovative products as well. Joint projects will be launched in the next few years aimed at developing new substrate constituents.

Furthermore, partnerships have been established in the Netherlands with the new World Horti Center, the Vertical Farming Association and StartLife, an organisation based at the University of Wageningen. This positioning, closely aligned with highly innovative net-works, gives Klasmann-Deilmann direct access to those projects in research and industry (including startups) that are geared towards new technologies and solutions for commer-cial horticulture and the food sector.

'Smart Growing Systems', an incubator launched by Klasmann-Deilmann, has tested more than 40 potential new substrate constituents in recent years. One recurrent difficulty with possible substitute materials is their poor water uptake and storage capacity compared with peat. There are at present no prospects of a breakthrough involving an ingredient that can fully replace peat.

Renewable resources

In view of climate change, increasing importance is being attached to alternative energy sources which more and more contribute to a balanced and reliable overall mix of different energies in future years. The objective is to supply both power and heat in an environmentally friendly manner. Renewable resources such as wood are firmly established in this context.

Among the renewable resources especially in demand is forestry and timber industry waste, which is utilised as biogenic solid fuel (in the form of woodchips) in biomass co-generation plants.

Short-rotation coppice (SRC) plantations are also playing an increasingly important role in this context. This involves planting cuttings of fast-growing tree species such as willows or poplars: their wood growth is harvested after three to four years and the biomass then goes for energy production. Over a period of at least 20 years, growth and harvest cycles repeat at intervals of three to four years. Compared with other energy crops such as maize, the relationship between inputs and yield is especially positive.

Biomass production in the Baltic region

We have been carrying out extensive SRC projects in the Baltic region since 2010. The situation is especially good here in terms of production and sales of renewable resources: demand for biomass for energy use is increasing in the Baltic States and the economic environment is far more favourable towards sustainable energy solutions than in Germany.

In 2016, subject to consolidation of already existing areas, we acquired additional agricultural land in Lithuania for planting with SRC. The total area increased from 3,131 hectares in 2016 to 3,267 hectares in 2017 and 3,350 hectares as at the end of 2018. In addition, further SRC sites were planted with cuttings, making a total of 3,029 hectares of actively cultivated land by the end of 2018 (2017: 2,897 hectares). Yield from corporate SRC sites in the same year amounted to 46,000 m³ of woodchips (2016: 15,000 m³).

3,350 2018

3,267 2017

3,131 2016

Agricultural land in Lithuania for planting with SRC in hectares

We also provide close-to-nature forest management services. Timber felled in this connection is processed and marketed.

To ensure that the strong demand for wood (especially in cold winter periods) is met in terms of raw materials sourcing, agreements covering the supply of substantial resources are in place with external suppliers.

Alongside woodchips, fuel peat continues to play a part in the region's energy mix. The scope for using the Baltic states' own resources in generating heat and power helps make them independent of gas, oil and coal supplies from abroad.

In Lithuania, woodchips produced in-house and bought in are marketed through UAB Klasmann-Deilmann Bioenergy, as are biomass blends of woodchips and fuel peat. Since 2017 we also have, in the form of Klasmann-Deilmann Bioenergy SIA, a sales company distributing biomass for energy and heat generation. The total volume sold in 2018 was 1,056,000 m³ (2017: 1,013,000 m³).

Nature conservation and climate protection

In 1913, the formation of the Heseper Torfwerk GmbH peat plant laid the foundation for the present-day Klasmann-Deilmann Group. Georg Klasmann was appointed its manager. Within only a few years, the firm had risen to become the leading supplier of animal bedding and also benefited the economic development of the Emsland region by constructing a fuel peat-fired power station. In the aftermath of the Second World War, the company was instrumental in achieving the goal – defined under the Marshall Plan – of making agriculture and housing development possible on a large scale in north-western Germany by draining peatland. In those decades peat extraction was expressly desired politically, and socially accepted.

With the growing environmental consciousness in the 1970s, a fundamental change was clearly on the way. In Lower Saxony, peat production legislation came into force in 1981 (see Niedersächsischer Minister für Ernährung, Landwirtschaft und Forsten 1981). Our company adapted to these new circumstances and, since then, has used only peatlands that are already drained or degraded to extract raw peat materials; this included land either owned or leased. Pristine bogs have been designated protection areas in Germany and are left untouched by us. After peat extraction has ceased, we initiate rehabilitation measures at our extraction sites in line with official requirements. We also apply this principle with our activities in the Baltic region and Ireland. However, as we continue to extract and process peat, our organisation must help strike a balance between peatland protection and responsible usage of this raw material in commercial horticulture.

RPP-certified extraction areas

The European certification system 'Responsibly Produced Peat' (RPP) was established in 2013 with the following aims:

- Leaving natural peatlands of high conservation value untouched, and preserving them over the long term;
- Permitting controlled peat production solely on sites already drained and/or previously used for agriculture;
- Ensuring the long-term availability of peat as a valuable growing-media constituent;
- Increasing the rate of peat production from degraded peatlands so that restoration measures can be started as early as possible.

responsibly produced peat

A European non-governmental organisation, RPP brings together relevant lobby groups across the peat and substrate industry, including renowned scientists, environmental associations and many companies in the sector. RPP aspires to consistently achieve a workable balance between the interests of the substrate industry and those of nature conservation and climate protection. The aim is to establish the RPP label as a prestigious, reliable and recognised environmental standard similar to PEFC and FSC.

To this end, RPP has established a reliable and transparent certification system for responsible peat production. Member companies and their extraction areas are examined by an independent auditor on behalf of certification organisation ECAS.

Against this background, we have applied for RPP certification for most of our extraction sites in recent years. By the end of 2018, this had been obtained for 76 % of our total extraction area. And, in the 2018 financial year, 75 % of the peat we produced was from RPP-certified sites.

Measures following cessation of peat extraction

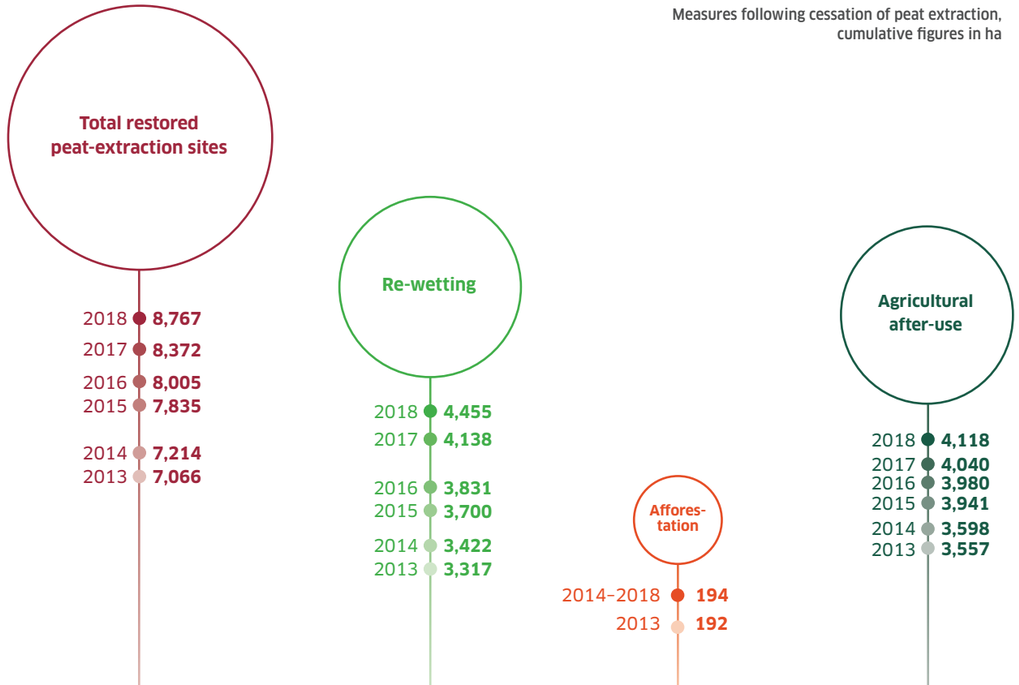
Depending on the method used, peat production on a given site may continue for several decades. After raw-material extraction has ceased, sites remain covered with residual peat to at least the legally required depth. There are essentially four options for their subsequent usage, and which of these is implemented in a given case is stipulated by the relevant authorities in permit documents issued prior to commencement of extraction activities.

The most important form of after-use in Germany is re-wetting. Its aim is to establish peat moss (Sphagnum) and other typical peatland plants, such as cotton grass. In re-wetted areas, the presence of standing water will lead to the former hydrological conditions being restored, resulting in bog-like vegetation (i.e. rehabilitation) or even typical bogland vegetation (i.e. regeneration), and these sites can become CO_2 sinks when the peat body begins to grow again. In this way, a re-wetted area can contribute to the biodiversity typical of peatland – in this case, to the variety of ecosystems present – and again become a characteristic feature of the landscape.

Because local geological and hydrological situations differ, not all sites can be returned to nature in this way once peat extraction comes to an end. Instead, some former production areas are afforested or prepared for agricultural after-use. In some cases, buffer zones are also established between differently utilised areas and left to the process of natural succession.

Since 1960 we have re-wetted, afforested or made available for agricultural after-use a total of 8,767 hectares.

Measures following cessation of peat extraction, cumulative figures in ha



Peatland restoration measures in Ireland and the Baltic states

In 2016, and for the first time, we returned to the state of Lithuania a re-wetted extraction site some 43 hectares in size. Projects aimed at rehabilitating former extraction sites are also in preparation at other locations in the Baltic region and Ireland. Here, we are seeking to put into practice innovative approaches to peatland restoration that provide additional environmental and climate benefits, such as Sphagnum farming. In all such cases, we are tailoring our practice to local conditions and adhering to applicable local laws. Klasmann-Deilmann's locally responsible subsidiaries are liaising closely with the relevant authorities on this matter.

Sphagnum-farming project

In close collaboration with the University of Hanover and the Thünen Institute in Braunschweig, Klasmann-Deilmann carried out an extensive Sphagnum-farming project between 2015 and 2018. A total of 10 hectares of former extraction areas were prepared for the cultivation of peat moss on black peat. The special moss required for the project – namely, moss obtained from peat hummocks – was removed from semi-natural peatland and then distributed over already re-wetted sites or sites earmarked for re-wetting. This made it Germany's largest project involving the farming of Sphagnum on black peat.

The aim of this effort, funded with resources from the federal state of Lower Saxony, was to achieve Sphagnum growth that is reproducible under specific conditions, producing material that could then be used as a peat substitute and in creating further such sites. Any changes over time in biodiversity on the sites in question, and in greenhouse gas emissions, were scientifically investigated by the University of Hannover and the Thünen Institute, with funding by the German Federal Environmental Foundation (DBU). Klasmann-Deilmann worked intensively on assessing the profitability of peat moss cultivation, starting with land acquisition and going on to consider site establishment, operational aspects, maintenance and, finally, the use of peat moss as a substrate constituent. The project's original aim of developing a renewable resource for substrate production has been abandoned for the time being. Although trials have now confirmed that peat moss is indeed very much suitable as a substrate constituent, its economic viability cannot currently be demonstrated. In this context, clarification is sought on other key issues:

- How to increase yields;
- Provision of land on a sufficiently large scale;
- Mechanisation of distribution, maintenance and harvesting;
- Sufficient availability of irrigation water;
- Eligibility for funding as an agricultural crop.

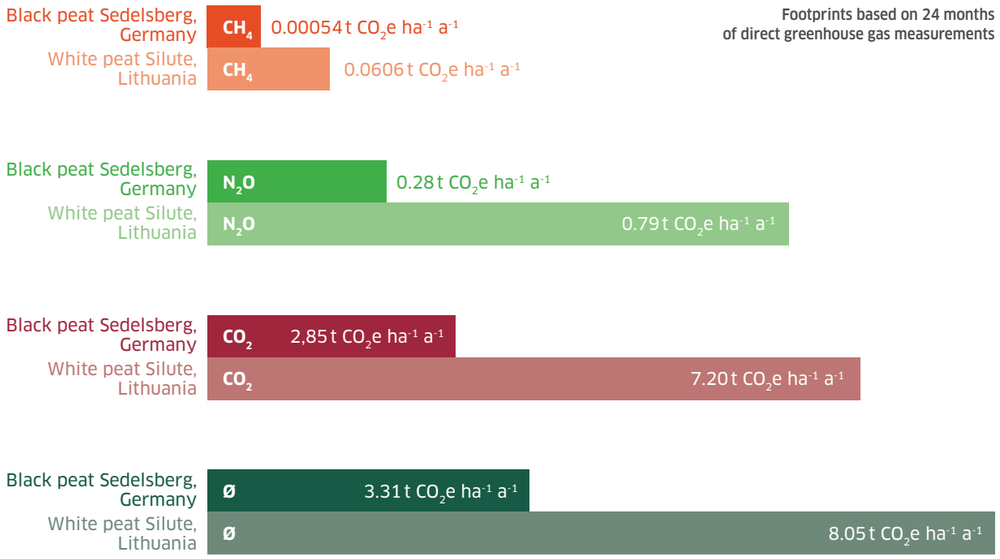
However, the successful outcome concurrently achieved in the rehabilitation of degraded peatland is something we wish to build on in the near future. The scientific studies on our optimised practices have shown that flora and fauna similar to that of raised bogs can develop within a short period of time while greenhouse gas emissions decrease considerably. This means that former extraction sites can contribute sooner to climate protection and nature conservation. Klasmann-Deilmann will continue this approach and make it available as a service to third parties.

Emissions from peat extraction

For the last 10 years there has been an overlap between, on the one hand, the discussion on emissions from the extraction and usage of peat and, on the other, the conservation-related debate that has been continuing since the 1970s on the preservation of peatland. Until a few years ago, however, scientific knowledge on the climate impact of peat extraction and use existed only to a small extent.

In view of this, we initiated a study and, between February 2015 and February 2017, conducted greenhouse gas measurements on our white-peat and black-peat extraction areas. The aim was to close the existing gap in the scientific data and to provide reliable information about emissions from the extraction and use of peat. We were ably assisted, in both the monitoring campaigns and in drawing up the footprint, by the Cologne-based Meo Carbon Solutions GmbH. On completion of the first 12 months, and after the entire project had been concluded and evaluated, we discussed our approach and results with experts from Meo, the Müncheberg-based Leibniz Centre for Agricultural Landscape Research (ZALF), the regional State Agency for Mining, Energy and Geology (LBEG) in Hanover, the German Research Centre for Geosciences (GFZ) in Potsdam, and the Kiel Institute for the World Economy (IFW). It was confirmed that measurements and footprinting activities in the first year had yielded valid outcomes and that, since a second year of monitoring had been completed, these also meet scientific criteria.

The mean emission levels determined for the black-peat extraction area used for monitoring in Germany were 3,13 t CO_2e ha^{-1} a^{-1}. On the white-peat extraction site in Lithuania, monitoring revealed average emissions of 8.05 t CO_2e ha^{-1} a^{-1}.

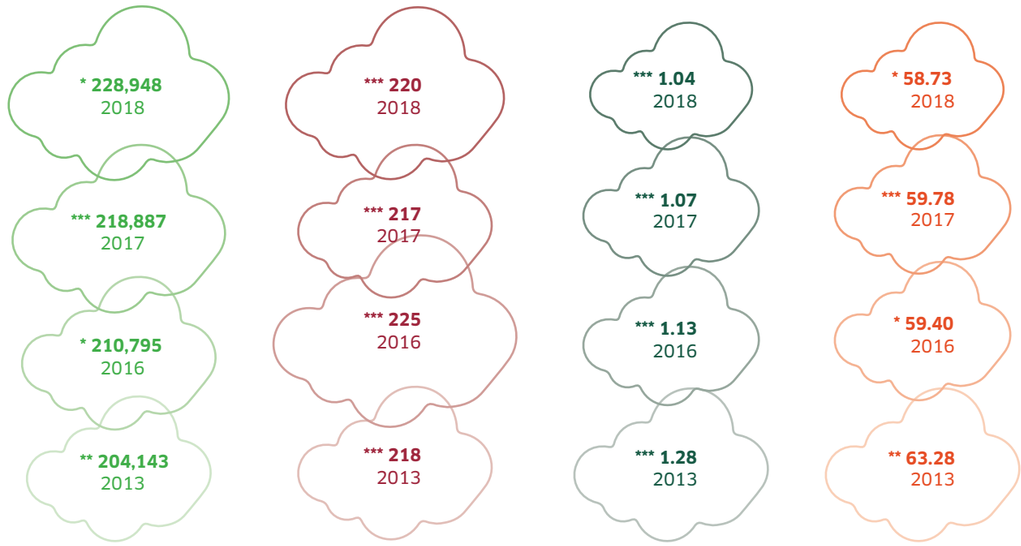


Carbon footprint for 2017/2018

In our Sustainability Report 2013 we published a world first: a carbon footprint for a company in the peat and substrate industry. Since then, we have had enhanced the calculation model in each successive year, especially in order to be able to precisely convey complex issues relating to land management and the use of raw materials in subsequent carbon footprints.

The calculation model has now achieved a degree of precision that led us, in addition to the calculation of the 2018 carbon footprint, to recalculate and re-verify the footprint for 2016. In consultation with the partners involved in drawing up these footprints, we took 2016 as the new base year instead of (as previously) 2013. A carbon footprint is also available for the 2017 financial year, though this has not been verified.

Our corporate and product carbon footprints were calculated by Cologne-based Meo Carbon Solutions GmbH. The carbon footprint was audited and verified by SGS United Kingdom Ltd. (Cheshire, UK), with regard to its assumptions, function and internal coherence, in accordance with the ISO 14064-1 standard and at a limited level of assurance.



Emissions in CO_2e

* Verification 2019 / ** Verification 2017 / *** These figures have not been verified

System boundary for carbon footprints 2017/2018

The new 'base year' for calculating our carbon footprint is 2016. Our corporate carbon footprints for 2016, 2017 and 2018 include all emissions arising within the system boundary 'cradle to gate, plus transport to customers'. We are incorporating the Logistics division as it is a major factor in our turnover.

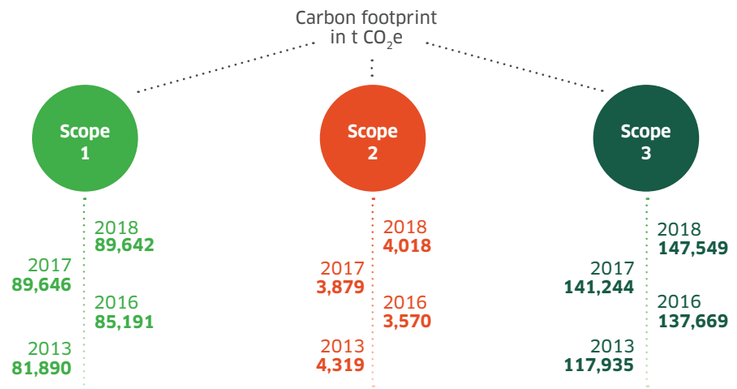
Carbon footprint					
Emission sources	2018 in t CO_2e	% of total footprint	2017 in t CO_2e	2016 in t CO_2e	*2013 in t CO_2e
Extraction areas	70,471	30.79	66,333	60,682	75,474
Energy consumption	23,084	10.08	19,808	21,357	19,692
Transport	83,412	36.43	84,050	85,599	65,759
External suppliers	51,981	22.70	48,696	43,157	43,218
Carbon footprint of company as a whole	228,948		218,887	210,795	204,143
Total quantity of substrates, raw materials incl. trading (tm^3)	3,898		3,662	3,549	3,226
Carbon footprint per m^3 of substrate (kg CO_2e)	58.73		59.78	59.40	63.28

* Figures from the Sustainability Report for 2016

Classification of emissions into scopes

The greenhouse gas calculating tool classifies emissions into three categories called 'scopes' in conformity with ISO 14064 and the requirements of the Kyoto Protocol.

- Scope 1 includes all emissions directly generated, for example, from combustion processes in the company's own facilities and the decomposition of raw peat materials.
- Scope 2 covers emissions relating to either purchased energy such as electricity or heat energy sources such as woodchips.
- Scope 3 refers to emissions from third-party services and purchased preliminary services.



‘Positive’ footprint for 2017/2018

Renewable-energy and -resources activities are to be considerably expanded as a business area in the coming years. They also contribute to emissions avoidance. Under the requirements of the ISO 14064 standard, however, these positive effects are disclosed separately from the carbon footprint. The chief reason for this is that the bulk of the energy generated in this way will not be consumed by Klasmann-Deilmann itself, but fed into the grid and sold. In addition to our carbon footprints, ‘positive’ carbon footprints have therefore also been drawn up (i.e. footprints that take only carbon-positive measures into account). They disclose how many emissions from fossil energy sources such as coal, oil and natural gas are avoided by usage of renewable energy from short-rotation coppice (SRC) and photovoltaic installations.

2018	2017	2016	2013
16,240 t CO_2e	*2,470 t CO_2e	18,881 t CO_2e	11,193 t CO_2e

Use and generation of renewable energy and of forest resources

* Lower quantities were sold due to the relatively warm winter in the Baltic region.

Product carbon footprint

The product carbon footprint (PCF) we publish differs from the corporate carbon footprint (CCF) in that the former includes the ‘cradle to grave’ system boundary, i.e. one that incorporates both the use phase and the ‘end of life’ of our substrates.

Based on this breakdown, the bulk of the emissions are generated outside our system boundaries. We regard this as affirmation of our responsibility to enhance our range of substrates so as to produce fewer greenhouse gases at every link of the value and consumption chains. This is the foundation of measures that are an integral part of our strategy, such as increasing the proportion of alternative constituents in our substrate blends to 15 % by volume by 2020 and 30 % by volume by 2025.

With reference to a recipe database, the data for the corporate carbon footprint can be converted for individual products, creating PCFs. By way of example, the table below gives the carbon footprints of selected growing media for the years 2016 to 2018 within the ‘cradle to gate’ and ‘cradle to grave’ system boundaries.

Rezeptur	70413	70002	70062	70080	70698
Name	Base substrate	Potgrond P	KKS organic tray substrate	Seedling substrate	BP substrate
Typ	White-peat substrate	Black-peat substrate	Black-peat / white-peat blend with green compost	Black-peat / white-peat blend with coir pith	Black-peat / white-peat blend with wood fibre
Emissions 2018 "cradle to gate"	36.56	24.22	39.66	32.77	25.77
Emissions 2018 "cradle to grave"	216.22	245.17	195.78	184.76	168.05
Emissions 2017 "cradle to gate"	45.40	16.52	28.05	30.41	20.58
Emissions 2017 "cradle to grave"	165.42	240.48	155.25	147.22	146.17
Emissions 2016 "cradle to gate"	48.30	14.18	28.80	31.71	20.51
Emissions 2016 "cradle to grave"	162.53	241.98	154.25	145.82	145.90

Figures in kg CO_2e/m^3

Energy management

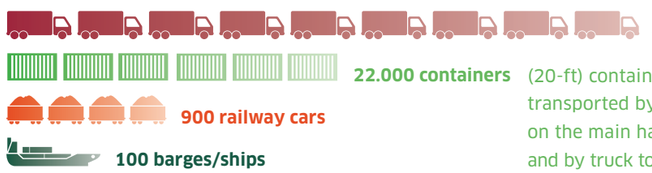
Among the measures by which we wish to lower our emissions are those aimed at reducing our energy needs. To identify potential here, energy consumption is monitored and evaluated on an ongoing basis. For this purpose, we use the automated recording and processing system that forms part of our energy management scheme. Furthermore, to increase the energy efficiency of our facilities and machinery, we keep abreast of technical developments in this area and apply them whenever it is possible and expedient to do so. Our organisation's overall heating requirements are decreasing thanks to ongoing improvements in heating technology and insulation standards, although needs do partly depend on winter temperatures. Our German sites obtain electricity from hydropower and our Irish production company uses only wind power-derived electricity. Additional savings are achieved by optimising lighting and compressed-air generation.

Energy consumption by use	2018	+/- in %	2017	2016	2013
Energy consumption for extraction sites (diesel, electricity)	18,149	6.0	17,120	18,664	18,160
Internal peat transport (diesel)	10,196	- 8.3	11,118	13,797	16,704
Energy consumption for buildings (electricity, gas)	4,935	19.8	2,245	2,693	1,532
Packaging material (film)	6,048	11.5	5,426	5,401	4,657

Figures in t CO_2e for the Group as a whole

Logistics

Thanks to long-standing relations with dependable national and international haulage companies and transport service providers, Klasmann-Deilmann can guarantee that all orders are processed reliably and quickly. We utilise rail and shipping wherever these are feasible and efficient options. In 2018, Klasmann-Deilmann used:



42.000 lorries

22.000 containers (20-ft) containers which are transported by seagoing vessel on the main haul of the journey and by truck to and from the ports.

900 railway cars

100 barges/ships

The resulting greenhouse gas emissions add up to about one-third of all those caused by Klasmann-Deilmann, so our Logistics operations play a highly responsible role in terms of sustainability. At the same time, however, and in this area in particular, we repeatedly come up against the limits of what is feasible and commercially viable.

For example, rail transport still often proves uneconomical compared with road haulage, a major factor being high transhipment costs. Moreover, many customers want their orders delivered as quickly as possible, within a few days. This is often not feasible by rail. With regard to movement of goods between Western and Eastern Europe, another problem is that of rail gauge incompatibility as this means there are no direct rail links. Nevertheless, as production company Klasmann-Deilmann Produktionsgesellschaft Nord mbH has its own rail connection to the Deutsche Bahn rail network, we use this for as many shipments as possible.

Within Western Europe, we also make use of the opportunities provided by domestic waterway shipping. Water routes needed for a comparable volume of trade in goods with Eastern Europe are lacking, so that chartering seagoing vessels is the only realistic alternative. For deliveries overseas, we make exclusive use of container transport.

Overall, road transport is essential to us, whether for direct deliveries to our customers in Europe or as a component of combined (road/water/road) transport.

Nevertheless, we strive to keep the environmental impact of our logistics operations as low as possible. We reduce internal transport between our various production sites. Setting up intermediate storage facilities in selected European target regions, too, enabled us to switch to rail for a significant proportion of the annual volume transported. The weight of our raw materials and growing media is another starting point: the drier – and hence lighter – these materials, the greater the volumes that can be carried in each transport unit. And we will, in the future, focus more on decentralised production so that transport distances to our customers can be shortened and that far larger quantities of raw materials can be transported in a more climate-friendly way, namely by water.

Emissions reduction measures

Apart from its strategically integrated carbon-effective projects, Klasmann-Deilmann will also identify emissions reduction measures from its carbon footprint – especially with regard to emissions from extraction areas.

- Set-aside of land used for peat extraction is planned, especially in Germany, but also in the Baltic region.
- Transport to customers accounts for around one-third of our carbon footprint. There is potential for emissions reduction here, with one starting point being the weight of raw materials and substrates. The drier – and hence lighter – these are, the greater the volumes that can be carried in each transport unit.
- Decentralised production close to our customers could also help avoid transport-related emissions, as raw materials are delivered by water, which is more climate-friendly than the alternatives, and include regionally available constituents. Marketing-strategy analyses are currently underway in this connection, which could lead to the construction of new production facilities located nearer to sales markets in Europe and overseas. The expected reduction in transport-related emissions is a major criterion here.
- Klasmann-Deilmann has set itself the target of increasing the proportion of alternative constituents – such as its GreenFibre wood fibre product and TerrAktiv green compost – by at least 30 % (in volume terms) overall by 2025.
- Carbon is actively removed from the air, and stored in the form of woody biomass, both through creation of short-rotation coppice (SRC) plantations and by woodland managed by Klasmann-Deilmann. We see additional potential here from our activities in the renewable energy and resources sector.

It follows from the Klasmann-Deilmann Group's own strategic guidelines and the carbon footprint for 2018 that the Group is committed to considerably reducing its own emissions at both company and product level. At company level, economic growth runs counter to the lowering of emissions. However, the fact that further progress is being made in the reduction of emissions is indicated by the product carbon footprint within the 'cradle to grave' system boundary. This is an approach by which future developments could be represented.

Green services

A policy of continuing sustainable development is, for us, among the major strategic goals for the coming years. We are also keen to make progress on the climate front. To further raise awareness of this important issue among our customers too, and to encourage demand for alternative constituents, we provide services relating to horticultural carbon footprints.

Carbon footprint for substrates supplied

As of 2018, our customers can now have the carbon footprint disclosed for the growing medium we supply them with. Upon request, the level of CO_2 emissions – expressed in carbon dioxide equivalents (CO_2e) – will be individually calculated and a product carbon footprint (PCF) sent by e-mail to the horticultural business in question. In this way we aim to further increase awareness, in a direct manner, of a key sustainability issue within our own customer base.

Under the cradle-to-grave approach, the bulk of product-related emissions, especially from peat use, are generated (primarily by the consumer) during the substrate's use phase. The proportion attributable directly to Klasmann-Deilmann or in the nursery is considerably lower. Here we acknowledge our responsibility to increasingly focus on ensuring that, with our range of substrates, fewer greenhouse gases are produced at every link of the value and consumption chains. This is the rationale behind measures that are an integral part of our strategy such as increasing to 15 % by volume the proportion of alternative raw materials in our total annual production by 2020.

Optimised substrate blends lead to lower CO_2 levels

Additionally, and as of 2018, our customers are able to request a calculation of which substrate blends they can use to achieve improved CO_2 levels. A calculating tool available to our company's specialists precisely reveals how the selection of substrate components impacts the product carbon footprint (PCF). Called the PCF Compass, it shows real-time changes in a PCF as soon as the substrate blend is manually adjusted. A direct comparison with the actually used substrate demonstrates how, for example, the use of different grades of peat – or proportions of the GreenFibre wood fibre product – affect the carbon footprint.

Carbon footprint for a nursery or crop

Growers can also request that we prepare a carbon footprint for their own business. For this purpose, a calculating tool was developed, based on the same program as that used to calculate our own carbon footprint. Nurseries provide the necessary key data on, for example energy consumption and operational inputs used. Based on this, the tool computes the carbon footprint for the business as a whole (corporate carbon footprint, CCF); it can also provide a data breakdown for an individual crop, resulting in a product carbon footprint (PCF).

Employees

Maintaining and strengthening employer attractiveness

We want our employees to enjoy working in our company. Our low staff turnover shows that a lot of them do, with many of our employees having been with us for several decades. We want this to remain the case. Which is why we are intensifying and being innovative with ways to keep us attractive as an employer.

In the years ahead, a generational shift is coming for a number of positions – and this includes key posts within Klasmann-Deilmann. In succession planning, our policy is to focus on our own young employees. Our business growth means that, particularly for highly specialised business units and employee roles, we need additional expertise that we wish to develop internally and, as required, enrich with new recruits from outside.

Demographic change and the skills shortage, especially in rural areas, require the enhancement of employer-branding measures. We are an attractive employer and as such have a presence at both regional and national trade and job fairs, aiming to recruit qualified specialists and young people to our organisation.

A modern work environment

After an 18-month construction phase the 'Innovation Center', Klasmann-Deilmann GmbH's new head office in Geeste, Germany, opened in the summer of 2018. The reason for the investment in this new building is our continuous growth. For some years, the previous administrative building (the 'Business Center') no longer had sufficient space. In the Innovation Center, additional PC workstations and open-plan areas are now in place for more than 40 employees. It also houses an Academy and a multimedia exhibition area, thus providing a suitable setting for events. From this new building, the Group is now managed, and strategic and international cooperation strengthened – both within the Klasmann-Deilmann Group and with partners, customers and stakeholders. A modern experimental greenhouse called the Research Center has been purpose-built for research projects on innovative growing media, growing systems and raw materials for substrates. An additional technical facility, the Technikum, is currently under construction. The entire location is thus geared towards research, development and innovation. And large parts of the former administrative building have been extensively refurbished and modernised. Taken as a whole, these new or redesigned buildings contribute significantly to enhancing Klasmann-Deilmann's appeal as an employer.

Vocational training, on-the-job trainees and scholarships

We continue to offer a number of vocational training places, especially for administrative and IT-related job profiles. Dual training programmes are playing an increasingly important role in this regard. At the end of 2016, the Chamber of Commerce and Industry (IHK) for Osnabrück, Emsland and Bentheim County awarded us 'IHK Top Training Workplace' status. Internships combined with work or studies, and opportunities to produce Bachelor's and Master's theses are also increasingly made use of. Our measures also include awarding further Deutschlandstipendium scholarships and, for the first time, a locally based scholarship for the Emsland region ('Emslandstipendium').

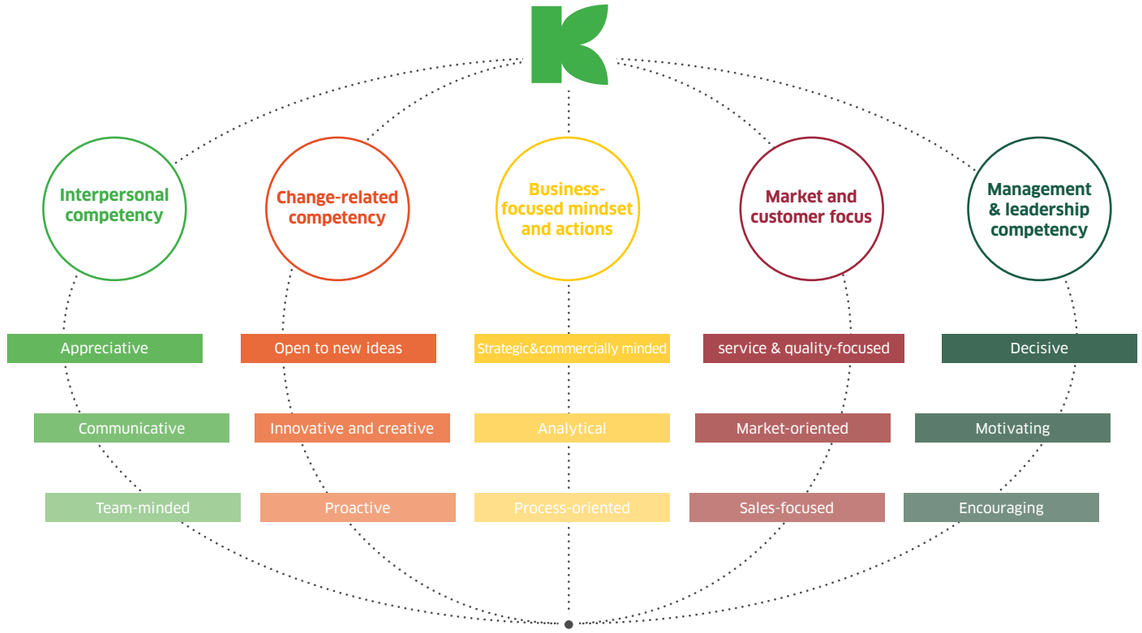
In order to attract especially promising candidates, particularly international ones, we are increasing opportunities enabling recruits to join us as on-the-job trainees. For some years now, we have continuously had two International Trainees on our team. The prime focus here is on future opportunities in market development, production and digital business models. Against this background, we are expanding our contacts with higher-education institutions – including Osnabrück University of Applied Sciences, and Wageningen University & Research in the Netherlands – that specialise in professional fields of particular relevance to us.

We ensure that, in all cases, close guidance is provided within the relevant departments. It is not only high-quality training in the subject matter itself that is important to us, but also personality development. Many of the young people who complete their vocational training journey with us are subsequently taken on as new employees.

Strengthening competencies, encouraging talent

As part of our long-term personnel development strategy, we have developed and launched several programmes over the last two years aimed at improving our employees' competencies, integrating them more fully in our business development, and encouraging their stronger identification with our organisation. This is an investment aimed at enhancing our appeal as an employer both internally and externally.

Our in-house model of competency management is proving useful in this context. This has, since 2017, been the key approach for many tools used in systematic personnel development. Its very specific requirements make targeted support measures possible.



Competency management model

A family-friendly company

Klasmann-Deilmann is among the founding members of the Emsland region's 'Work and Family' foundation (www.familienstiftung-emsland.de), whose aim is to help local people combine family and career. The foundation first certified us as a family-friendly company in 2012. Its November 2018 audit resulted in our family-friendliness being confirmed for the third time and this quality label being renewed.

Promoting health

For many years now, we have been running a proactive health management programme, the aim of which is to maintain, improve or restore the health and well-being of our employees. Accordingly, health management is an integral part of all operating processes.

Central elements are regular preventive health check-ups as well as promoting various measures aimed at improving employees' general health, including free flu vaccinations. Additionally, an internal works agreement enables all employees to exercise in gyms and other fitness facilities, with Klasmann-Deilmann covering a substantial part of the costs.

Measures to prevent psychological stress are also in place. In conjunction with the employee representation body and health and safety committees, a risk assessment approach was developed in which psychological stress for different work areas was listed and weighted, with Procedural instructions for line managers drawn up on this basis.

The working-life span lengthens

We have adjusted to the fact that our staff will remain in employment for longer than would have been the case a few years ago. To the greatest extent possible, we intend to encourage this trend by creating attractive conditions with regard to working hours, provision of the right equipment and resources and, in particular, health promotion. The mechanisation of work processes in our technical/industrial operations has reached a high level at all locations, as has the equipping of office workplaces, so that physically demanding work is required only in exceptional cases. In Germany, our workforce also benefits from the option of partial retirement.

Health and safety management strengthened

Klasmann-Deilmann maintains a health and safety management system whose goal is the total prevention of accidents. Its aim is to identify potential workplace hazards in good time and, as far as possible, to remove or remedy them. Among the measures to achieve this are regular on-site inspections by in-house and external safety experts, company medical officers and safety officers, as well as meetings of the health and safety committees. Additionally, incidents are automatically documented at organisational level. Near misses, too, are thoroughly documented and assessed within the health and safety committee. Employees periodically receive training on this topic. To involve them closely in the implementation of health and safety measures, special rewards are available for ideas to enhance workplace safety proposed under the employee suggestion scheme.

Nevertheless, we recorded a total of 32 work-related accidents in 2018, of which 17 were notifiable. In 2017, 10 of the 25 work-related accidents were notifiable.

Our leadership standards

Our company leaders are asked to perform a balancing act, reconciling diverse interests. Considerable demands are placed on them – both by their staff and by their own line managers. And a lot is required of them in dealings with customers and suppliers as well. Our executives also greatly influence the way the firm does business, what the working atmosphere is like and where a given department stands in relation to the organisation as an integrated whole. In view of this, Klasmann-Deilmann has developed what we call Leadership Standards, which constitute a binding framework for action on the part of every executive in our organisation.

Female executives

Across the Group, we currently employ 15 female executives, nine of them at our international locations. These account for 14 % of our worldwide total of 110 executives. Our female executives include:

- a production manager in Germany;
- a divisional director on our international Management Board; and
- a managing director at our sales company in the Netherlands.

Compliance requirements for the entire workforce

The point of departure for our rigorously implemented compliance policy was an event in 2009 at which Klasmann-Deilmann GmbH's executives underwent comprehensive training. On its completion, they signed a statement undertaking to observe our company's compliance principles. Since then, newly appointed executives have been familiarised with, and commit to, these principles as part of their induction training.

Additionally, an agreement with the Management Board and the General Works Council came into effect In November 2013 that requires all employees of Klasmann-Deilmann GmbH to comply, among other things, with competition and monopolies law, with a prohibition on the offering and granting of benefits, and the prohibition of money laundering.

The managing directors and the financial executives from our subsidiaries undergo training on Group-wide compliance requirements, most recently in the autumn of 2018. They were also put in charge of implementing relevant arrangements in their particular company.

Moderate increase in headcount

The average number of staff employed within the Klasmann-Deilmann Group increased from 938 in 2016 to 1,010 in 2017 and 1,041 in 2018. Of these, 410 men and women were in technical jobs in 2018, with 631 in administrative activities. The proportion of those employed outside Germany was 66.9 % in 2018 (having been 65.2 % in 2017 and 62.0 % in 2016).

	2018			2017			2015			2013		
	Σ	♂	♀	Σ	♂	♀	Σ	♂	♀	Σ	♂	♀
Germany	344	276	68	351	285	66	362	294	68	371	302	68
Lithuania	392	335	57	376	325	51	301	253	48	295	259	36
Latvia	110	86	24	105	85	20	100	68	32	88	59	29
Ireland	71	68	3	64	61	3	63	60	3	69	66	3
Netherlands	47	44	3	38	35	3	38	36	2	34	32	2
France	20	11	9	21	12	9	21	13	8	19	11	8
Belgium	14	10	4	12	10	2	11	9	2	9	7	2
Singapore	11	3	8	11	3	8	10	2	8	9	2	7
China	14	8	6	13	8	5	9	6	3	0	0	0
Poland	8	6	2	9	7	2	9	7	2	9	7	2
Italy	6	3	3	6	3	3	6	3	3	6	3	3
USA	2	2	0	2	2	0	5	2	3	4	1	3
Austria	2	1	1	2	1	1	2	1	1	2	1	1
Summe	1041	853	188	1010	837	173	937	754	183	915	750	165

All figures are full-time equivalents (FTE)

The majority of our activities are carried out by our permanent employees. Additionally, the Klasmann-Deilmann Group employs workers of subcontracted employers at its production sites, especially during the summer months; these may total between 100 and 200 individuals at any given time.

Community commitment

In this globalised wold, our company is part of a diverse network involving people, professional associations and other organisations, and the worlds of politics, culture and sport, as well as very different interest and needs. We take our social responsibility (which extends beyond our business objectives) seriously. That's why we do what we can to get involved: financially, in the realm of ideas, on a voluntary basis and always with great dedication.

Klasmann-Deilmann GmbH supports local sports clubs, for example – especially in communities that are home to our employees. It also sponsors specific charitable and cultural projects. Every year during the Advent season, a major fundraising effort takes place, with selected clubs, associations and projects in the social, political and economic spheres receiving financial assistance.

1913

we make it grow

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INNOVATION
Peat Bog Restoration

Close to nature

Restoration of peat bog areas with peat mosses – Innovation for climate protection and biodiversity

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Moors & rewetting

The majority of German peatland sites are in poor condition thanks to human intervention. In stark contrast to their original function as carbon sinks, these areas in Germany currently release 43.8 million tonnes CO_2 equivalent (CO_2-e) per year. This corresponds to 4.6 % of German greenhouse gas emissions[1]. In Lower Saxony, peatland areas alone account for around 11 % of total emissions[2].

To restore damaged peat bogs to their natural state after intensive peat harvesting typically the sites are rewetted and allowed to return to their natural habitat. This can often take decades, or doesn't happen at all in many cases.

In addition to the absence of seed potential, over half of all rewetted areas are either too dry or too wet and as a result there is little prospect of them returning to a living peat bog. Most typical bog species such as peat-forming hummock mosses and other typical vascular plants are unlikely to establish independently. These areas stay sources of greenhouse gases; in 2013 they emitted 190.000 tonnes CO_2 equivalent in Lower Saxony[3].

Peat bog restoration

Restoration of damaged peat bogs can be accelerated by introducing typical raised bog vegetation such as peat-forming hummock mosses (*Sphagnum* spp.) and carefully adapted water management techniques.

This innovative process can help establish typical peat bog vegetation and achieve positive climate effects at least 30 years earlier than can be attained by using traditional rewetting methods. The resulting ecosystem services can be assessed in the form of Ecopoints (Germany) or climate certificates.

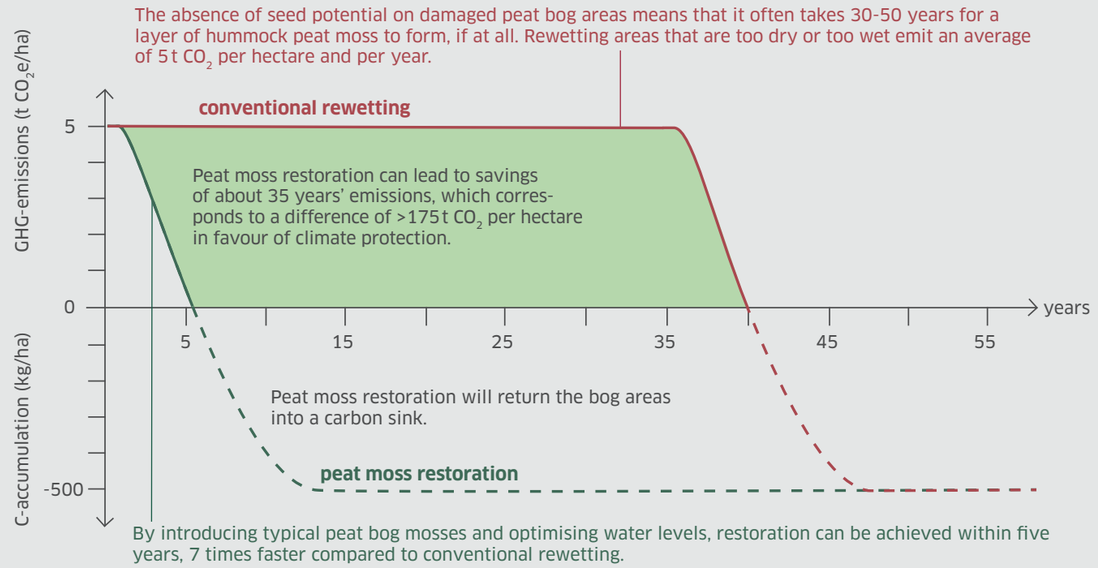
[1] Umweltbundesamt (2014). Berichterstattung unter der Klimarahmenkonvention der Vereinten Nationen und dem Kyoto-Protokoll 2014. - Nationaler Inventarbericht zum Deutschen Treibhausgasinventar 1990-2012. - Climate Change 24/2014, p. 963
[2] Niedersächsisches Ministerium für Umwelt, Energie und Klimaschutz (2016). Programm Niedersächsische Moorlandschaften - Grundlagen, Ziele, Umsetzung, p. 72
[3] Höper, Heinrich (2015). Treibhausgasemissionen aus Mooren und Möglichkeiten der Verringerung, TELMA Beiheft 5, p. 133-158

Ecosystem services

Restoring damaged bogs with peat moss encourages the settlement of typical bog flora and fauna and the accelerated re-establishment of rare and protected biotope types.

Enhancing the range of biotope types can also act as an intervention, compensation or substitution measure, generating up to 2.5 Ecopoints per square metre in Germany. This in turn corresponds to 25,000 Ecopoints per hectare, with a current value of over €5.00 per Ecopoint. As a result, peat moss restoration can be regarded as a lucrative investment, while simultaneously protecting our climate.

Example of development of a rewetting area



How do we achieve restoration of natural peatland?

- Hydrological evaluation of the area and professional preparation of the site
- Ensuring optimal irrigation and maintenance of areas
- Harvesting moss from our own peat moss bank or reproduction of mosses in a greenhouse
- Coverage of various types of peat moss in a short period of time
- Placement of peat moss fragments and accompanying vegetation where appropriate

Advantages for the climate

- Preservation of the peat body, Prevention of peat decomposition, if possible, creation of a carbon sink
- The establishment, within 5 years, of climate neutral peat moss areas, 35 years earlier than current techniques allow
- Saving of 175 t CO_2 per hectare over at least 35 years (equivalent to the CO_2 sequestration of 1750 trees)
- Lower emissions of methane and carbon dioxide greenhouse gases

Advantages for biodiversity

- Creation of habitats for endangered and protected species, such as:
  - Hunting grounds for amphibians (e.g. moor frog)
  - Breeding areas for ground nesting birds (e.g. Northern lapwing)
  - Environments for many species of insects (e.g. beetles, bugs) and spiders
  - Nectar plants for butterflies (e.g. Silver-studded blue)
- Immediate increase in biodiversity of natural peat bog vegetation (e.g. sundew & cotton grass)

Peat moss inoculants

Due to the rarity of peat bog habitats in Germany, one of the major problems lies in getting hold of source material for inoculation. Klasmann-Deilmann cultivates protected peat mosses in their own peat moss bank (open field site) and using peat moss brought on in a greenhouse environment. This means we no longer need to access natural or semi-natural peatland areas to obtain inoculants.

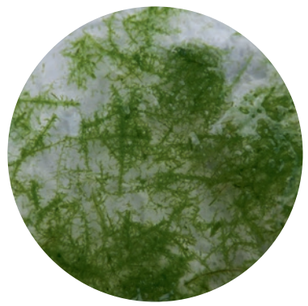
Either individual species or a mixture of species can be provided, depending on the client's wishes. Regional peat moss varieties can also be propagated for specific requirements.

Advantages of moss from Klasmann-Deilmann's own peat moss bank

- Raised bog open field cultivation
- Seven peat moss species
- Sites are colonised directly with flora and fauna (up to 40 plant species, usually those typical of upland moors, plus a variety of insect and spider species)

BeadaHumok™ peat moss bundles*

- 20 peat moss species are currently available
- Targeted propagation of native, local origin species
- Pure Sphagnum moss without accompanying flora and fauna
- Plants take quickly as they have been pre-cultivated



BeadaGel™ peat moss fragments*

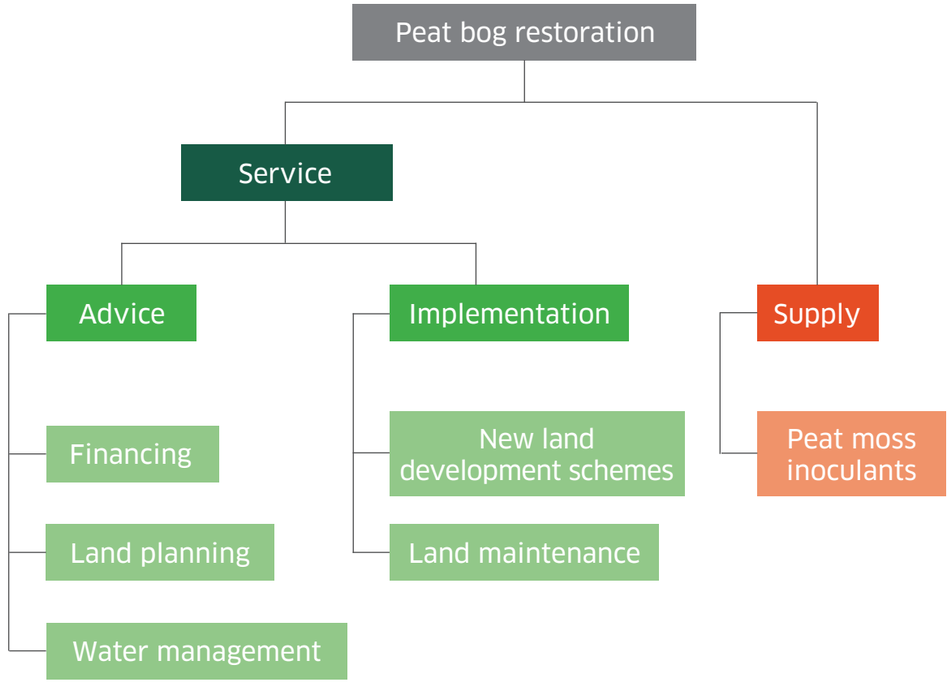
- 20 peat moss species are currently available
- Pure peat moss without accompanying flora and fauna
- Plants take quickly as they have been pre-cultivated
- Laboratory propagation of native species
- Simple area-wide spraying of the gel
- Without damage to natural moors

*BeadaHumok™ and BeadaGel™ are registered trademarks of Micropropagation Services Ltd. Klasmann-Deilmann own the exclusive distribution rights.

BeadaMoss® Sustainably Produced Sphagnum

Our services at a glance

- **Advice** on finance options, land planning and water management
- Complete **implementation** and maintenance of new land development schemes
- **Supply** of peat-forming hummock peat moss from a range of sources



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Version 12-2019

Limitations of additional organic material in growing media

Peat is the predominant constituent of growing media for professional growers. However, more and more research is being conducted on other organic materials to evaluate their suitability as a substitute for peat. This is especially true in countries where industrialised production and public environmental awareness is high. Is R + D on the verge of a breakthrough?

By Gerald Schmilewski, Klasmann-Deilmann GmbH, Research and Development Centre, Germany

Over the past 50 years horticultural peat has facilitated industrial production of growing media. Like fertiliser, peat is a cultural input which helps sustain horticulture as we know it today. No other material combines as many favourable physical, chemical and biological properties as raised bog peat. Economical reasons and its long-term availability for processing assure its continued use.

Nevertheless, the overall need to recycle organic wastes and the appropriate use of such processed material, have urged manufacturers of growing media to look into the possibilities and limits of their application. Don't forget, before the peat era, there was extensive use of organic materials in self-made mixes, i.e. composted green waste, leaf mould, rotted animal manure, coniferous litter and others, which were mixed with soil or sand to produce a substrate. However, during that time, horticulture was not an industrial business evermore pushing the limits of productivity, as it is today, with automated, on schedule production of homogeneous horticultural products.

An increasing number of growers, particularly organic growers, prefer media containing a certain percentage of recycled organic material. Before appropriate media formulations can be adopted, the materials in question must be checked for their general and specific suitability by examining their physical, chemical and biological properties.

Table 1. Properties of the main organic constituents of growing media

Properties / Criteria	White (weakly decomposed) *Spahgnum* peat	Frozen black (strongly decomposed) *Sphagnum* peat	Composted softwood bark	Composted green waste	Composted biogenic waste	Wood fibers	Coir	Rice hulls
Chemical properties								
pH-value	very low	very low	medium-high	high-very high	very high	low-medium	medium	medium
Salinity	very low	very low	low	high-very high	very high	very low	low-very high	very low
NaCl content	very low	very low	very low	lo -high	low -very high	very low	low-very high	very low
Nutrients content	very low	very low	medium	high	high-very high	very low	low	low
pH/nutrients buffer capacity	low	medium	very high	very high	very high	low	low-high	medium
N-immobilization	none	none	low-medium	medium-high	medium-high	low-high	low	low-high
Heavy metal load	very low	very low	low	medium-high	medium-high	low	low	low
Physical properties								
Water capacity	very high	medium	medium-high	medium	medium	low-medium	low-very high	low
Air capacity	high-medium	low	high	medium	medium	very high	medium-very high	very high
Structure stability	very high	very high	high	medium	medium	medium	very high	very high
Biological properties								
Suitability for plant growth	very high	very high	high-very high	medium	very low	high	high	low-medium
General aspects								
Suitability as a constituent	very high	very high	high	medium	very low	high	medium-high	medium
Availability	very high	very high	medium	medium	very low	medium	medium	low
Overall rating as constituent	very high	very high	high	medium	very low	high	high	medium

Peat harvesting – decomposed peat is still the most favoured material for growing media.

Furthermore, the applicability of a material is dependent on the intended use of the medium.

Table 1 gives a fairly good indication of the basic properties of the main organic constituents of growing media. It shows clearly why both weakly and strongly decomposed peat is the overall favoured material for growing media. Independent of this fact, other organics can be used as media constituents, but hardly ever as pure materials or blended with each other.

Green composts

In the past, composted materials have served as constituents of growing media. They are mineral organic, secondary raw materials.

Only separately collected green waste, i.e. branches, grass clippings, leaves, should be considered for the production of composts for growing media. Other biogenic waste materials, such as food waste, should not be a source for composts used in growing media, since they usually have high salinity values caused by excessively high K_2O and high P_2O_5 contents but also NaCl.

In Germany extensive research on the possibilities and limits of the use of composted materials was conducted in the 1990s. The outcome of some of this research resulted in a standard adopted by the German quality control system known as RAL. Together with the German quality assurance association for composts, RAL has published quality requirements for composts used as constituents in growing media. The main criteria and limit values are given in *Table 2*. Meanwhile millions of m^3 of composts are produced annually in Germany, most of which are applied as soil improvers and only a relatively small quantity as constituents of growing media.

Klasmann-Deilmann GmbH, for example as a leading producer of growing media for professional growers, incorporates a maximum of 30 % volume:volume (*v/v*) of their own green compost into media for the cultivation of a wide range of crops and situations such as a blocking medium, tray substrate, substrate for cultivating herbs, growing bedding and balcony plants and as a container medium. In some countries organic growing requires the use of peat-reduced media.

Composted bark

In general, composted bark is fermented and fractioned coniferous bark. In Germany only quality certified composted bark is used in growing media, in amounts of 20-40 % (*v/v*), with peat being the main constituent. Composted bark is sieved to particle size ranges of 0-10 mm (fine), 0-20 mm (medium) and 0-40 mm (coarse). Depending on the intended application and given growing conditions, these fractions are added to positively influence the air or water capacity of a medium: Coarse material is added to container media while medium and fine composted bark is used in mixes for pot plants and perrenials. Composted bark has a very good buffer capacity, which can reduce the risk of pH variation and severe changes of nutrient availability in the medium, caused by fertilisation or unfavourable irrigation water. Composted bark contains plant available nutrients, in particular K and P, which must be considered when making a blend. Its pH is > 6.0 (H_2O 1+5), meaning that the amount of liming material needed to adjust the pH can be reduced.

Table 2. Main quality criteria for composts used as growing media constituents according to the German RAL quality system for composts (RAL Gütesicherung Komposte, 1999)

Quality criterion	Quality requirement for Compost	
	Type 1	Type 2
Max. amount of compost that can be added to growing media	40 % (*v/v*)	20 % (*v/v*)
Salinity	≤ 2.5 g/l	≤ 5.0 g/l
Nitrogen (N)	< 300 mg/l	< 600 mg/l
Phosphate (P_2O_5)	< 1200 mg/l	< 2400 mg/l
Potassium (K_2O)	< 2000 mg/l	< 4000 mg/l
Chloride	< 500 mg/l	< 1000 mg/l
Sodium	< 250 mg/l	< 500 mg/l
Carbonates	< 10 % ($CaCO_3$) in dry matter	
Suitability for plants	without N-Immobilization	
Moisture content	adequate for processing @ 50 - 60 % of max. water retention	
Particle size	> 50 % (*v/v*) particle sizes 0 - 5 mm	
Organic matter	> 15 % (*w/w*) in dry matter	
Hygenic criteria	Free from viable seeds and plant propagules. Free from *Plasmodiophora brassicae*.	

Peat is basically the only material that can be used as a pure material in all situations of plant production.

Wood fibres

There is an increasing interest in and a potentially large market for, the use of wood fibres in Germany and other countries. Like peat, composts and composted bark, wood fibres are subject to the stringent quality specifications of the RAL if used as constituents of growing media. This ensures that products meet the crucial limits such as for N-immobilisation, pH, nutrient contents and criteria.

Wood fibre products are manufactured by steam-treatment of coniferous wood chips (mainly pine) obtained from thinning or recycling. At temperatures of 120-180 °C the wood chips are defibrated, the result being a finely structured material. Microbial activity can be intensive, which is why wood fibres have an initial nitrogen demand. To ensure bio-stability of the product and sufficient N-supply during cropping from the start, nitrogen must be added, either during the production process of the fibres and/or during plant growth .

Due to the steam treatment, wood fibres are free from weeds and pathogens. Their main advantage is a very high air capacity which can improve the air regime of e.g. a peat mix. The water capacity of the fibres is low, which is why peat would still be the main component in the mix. A well-balanced composition of the mix is essential. *Figure 1* shows clearly the effect wood fibres have on a weakly decomposed *Sphagnum* peat. Increasing amounts of wood fibres:

- Decrease dry bulk density
- Increase air capacity and decrease water capacity
- Reduce shrinkage value
- Improve the wettability of the medium when dry.

Of all growing media contituents, wood fibres have the lowest shrinkage value. Depending on the wood source, their pH is between 4.5 and 6.0 (H_2O). If nitrogen was added to the fibres during the production phase, then this must be taken into consideration when producing a mix.

Coir

Coir is the waste product combed or washed out during the dehusking of coconuts. In past years coir has accumulated in countries like SriLanka, India, Mexico and Indonesia where coconuts are processed. Recycling of this organic material is a positive environmental measure, although transportation from countries of origin to user countries does have a negative affect on its longevity.

Like peat, coir has a fibrous texture, a low bulk density and a high organic matter content. Its physical properties are good. The content of nitrogen and minor elements is low although high potassium and sodium content as well as weeds are only a potential problem if the material is not quality-controlled (as buffered coir is), according to the Dutch Foundation, Regeling Handels Potgronden (RHP) quality criteria.

Coir is very easy to rewet, even when air-dry, which gives reason to add it to some mixtures. Mixes of 20 % (*v/v*) will hardly influence a grower's fertigation regime.

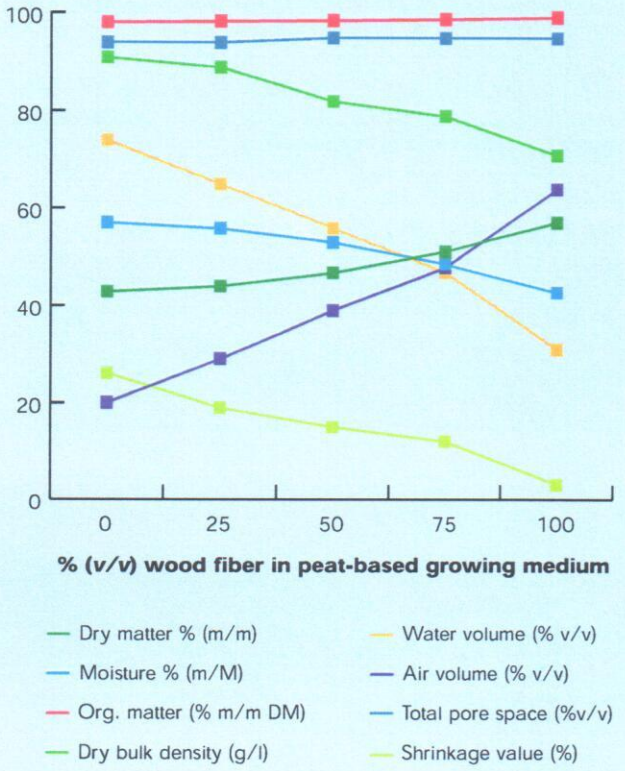
Rice hulls

Rice hulls are not regularly used in growing media and are of less importance. They will never be used as a pure medium, but rather as an air capacity-improving material in amounts up to 20 % (*v/v*). Better drainage of materials with a high water capacity is the main objective when adding rice hulls. Care should be taken that only hulls from parboiled rice are applied to ensure that weeds (rice seeds) do not contaminate the medium. Negative growth results have been observed in the past when cultivating species of the *Gesneriaceae* family, such as *Saintpaulia*, in media containing rice hulls.

Practical considerations

The question of whether R+D is on the verge of a breakthrough, can clearly be answered with "No". When using other organic materials in peat-based mixtures, the objective is always to improve

Figure 1. Change of physical properties (acc. to EN 13041), org. matter content (acc. to EN 13039) and moisture content (acc. to EN 13040) of a growing medium based on white *Sphagnum* peat with increasing amounts of wood fiber.



or at least not impair the physical, chemical and/or biological properties of a medium and, at the same time, apply recycled materials in a meaningful way.

Peat, however, is basically the only material that can be used as a pure material in all situations of horticultural production, from growing young vegetable plants in the smallest tray modules to container-grown trees. Addition of the above discussed organic materials generally do not necessitate a change of fertigation or other cultivation practice if the proportion of alternative material is well balanced and based on the reliable assessment of its properties. A producer of growing media will not add excessive amounts of composted material to a medium due to its high salinity. Wood fibres will only be added in amounts that still allow reasonable irrigation intervals and bear no hazard caused by N-fixation. Rice hulls have practically no water capacity, which reduces their applicability. Other organic materials like straw, seaweed, spent hops, coffee grounds or paper processing waste are negligable, since their characteristics as growing media constituents are either disadvantageous or they are only available regionally and in small quantities. Therefore they are only of likely interest to local growers but not to the media producing industry in need of a basic raw material with overall excellent properties for the production of reproducible, best-quality media.

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	≤ 2.5 g L^{-1}	≤ 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.

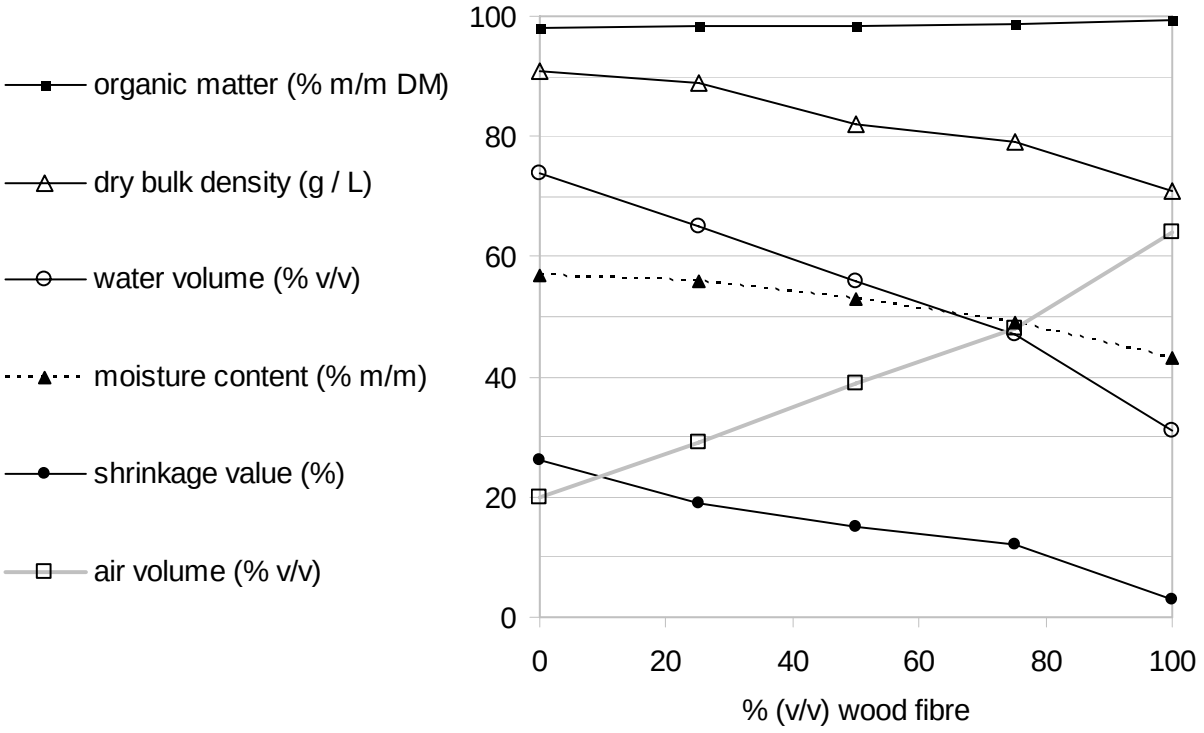

Figure 1. Changes in six growing medium properties for a mixture of bog peat (H3–H5) and wood fibres (Toresa®) as the fraction of wood fibres is progressively increased.

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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Report from a National Incident Management Team

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1. Introduction

Legionella species are environmentally abundant bacteria. They are often isolated from water and soil samples. There are two forms of legionellosis:

- Legionnaires' disease (characterised by fever, myalgia, cough, and pneumonia);
- Pontiac fever (a milder, shorter-lived illness without pneumonia).

Legionnaires' disease is recognised as an important cause of severe, sporadic community-acquired pneumonia. Pneumonias caused by *Legionella* species are not uncommonly associated with respiratory failure and thus have a relatively high mortality rate.

The detection by a microbiological laboratory of any member of the *Legionella* genus in a clinical sample has to be notified to a NHS board and Health Protection Scotland (HPS), under the Public Health (Scotland) Act of 2008. HPS undertakes enhanced surveillance of notified cases of *Legionella* infections in conjunction with NHS boards and the Scottish Haemophilus, Legionella, Meningococcus and Pneumococcus Reference Laboratory (SHLMPRL). The purpose of this enhanced surveillance is to characterise the *Legionella* species causing infection and identify likely sources and exposures to the organism. Legionnaires' disease is monitored by the European Centre for Disease Control (ECDC) through the European Legionnaires' Disease Surveillance Network (ELDSNet). Guidelines on the management of outbreaks of Legionnaires' disease have been developed by the Health Protection Network.[1]

Over the period 2008-2012, nine cases of *L. longbeachae* infection have been notified to HPS, making it the most common pathogenic species of *Legionella* identified after *L. pneumophila*. Two cases have died and all others have had severe illness. In the same period, there has been one case reported in England & Wales (in 2008). In the period 2007-08, ECDC reported nine cases of *L. longbeachae* across the whole of Europe, three of which were in the UK.[2] Because of this and some expressions of concern from the relatives of cases, the Minister of Public Health has indicated an interest in exploring how best to prevent this infection and in particular whether bags of growing media should be labelled with a warning on how to avoid possible exposure to the organism.

In accordance with the Scottish Government's "Management of Public Health Incidents: Guidance on the Roles and Responsibilities of NHS-led Incident Management Teams"[3] in January 2012, HPS convened a national Incident Management Team (IMT) to manage this national outbreak and decide on what to recommend to the Minster for action to prevent it. The IMT met on three occasions to review and discuss evidence, (see Appendix 1 for membership). At the last meeting horticultural and organic waste experts attended to provide expert advice.

2. Background

The incidence of legionellosis in Scotland is low. There are usually between 20 and 40 cases per year, the majority of whom contract the infection overseas. Older age and male gender are both associated with increased risk, as are smoking and underlying respiratory disease. The majority of cases in Scotland are caused by *Legionella pneumophila*. In 2009 and 2010 (HPS last report), of the 41 confirmed and probable cases of legionellosis reported in Scotland, 38 were caused by *L. pneumophila*, two by *L. longbeachae* and one by *L. anisa*.[4]

L. longbeachae is an unusual form of *Legionella*, which can cause a wide range of symptoms from mild flu-like illness to acute atypical community acquired pneumonia and death. The major source of human infection is considered to be commercial growing media and other composted materials such as bark and sawdust. *L. longbeachae* has never been identified in man-made water systems, unlike all other strains of *Legionella*.[5]

Legionnaires' disease caused by *L. longbeachae* presents as atypical community acquired pneumonia. It can often take some time to identify the causal organism, as urine tests which identify most cases of Legionnaires' disease only identify *L. pneumophila* Sg1. *L. longbeachae* is only identified by elevated antibody titre, PCR and culture, all of which may not be routinely performed.

The number of cases in Europe is small but growing[2], however, up to half of *Legionella* cases in Australia and New Zealand are *L. longbeachae*. Investigations of growing media in Australia have revealed that a large proportion of Australian potting mixes are contaminated with *Legionella*.[6] A main difference between Australian growing media and those in Europe is that Australian growing media are made mostly from composted pine sawdust and bark, whereas in Europe growing media until recently were mostly peat based[5]. The proportion of peat and composted material in growing media in the UK is changing, to support minimum use of peat. This is in support of UK legislation[7] put in place to preserve our peat sources. Australian growing media are labelled with a warning about risk of exposure to *L. longbeachae* and advice to wear gloves and a facemask whilst handling the potting mix (see Appendix 2).

The mechanism by which an individual can contract *L. longbeachae* infection from compost and growing media, is not currently known but is assumed to be through inhalation of aerosolised dust or contaminated water.

There are a number of terms used by cases and investigators which had been referred to as "compost". Horticultural experts in the UK refer to:

- Growing media – media for growing plants, sold through garden centres or other retail outlets. These products are usually branded and traditionally described, for example, as Multipurpose, Potting or John Innes 'Compost'. Growing media can contain a mixture of any of the following: composted material; bark or other wood products; soil; peat; sand; minerals. However, they may contain no composted material whatsoever. This is the European accepted meaning; however, in some European countries and in the US, Australia and NZ the term 'potting soil' or 'potting mix' is still used.
- Composted material or compost – such as composted green waste (derived from garden, horticultural and in some cases food waste). Green waste undergoes a composting process, after which it is called 'green compost' by the composting industry and can be used for soil improvement or as a growing media constituent

Wherever possible, these terms are used in this report.

2.1 Initial Detection and Response

The first case of *L. longbeachae* infection detected in Scotland was in 2004 although exposure had occurred in Australia. The first case whose infection was due to an exposure to the causative agent in Scotland was notified in April 2008. The case was a resident of Lanarkshire and was investigated by NHS Lanarkshire Health Protection Team. They found that the most likely exposure of the case to the organism was through the use of growing media. A report was compiled and submitted to HPS in August 2008. NHS Lanarkshire requested that as the case had been associated with compost exposure, (although not confirmed microbiologically), a review of compost labelling apropos *L. longbeachae* be considered. Later retesting of compost samples identified an indistinguishable *L. longbeachae* strain to that of the patient.

HPS responded that with only one case involved, it was doubtful as to whether labelling with appropriate handling precautions would be considered proportionate by the regulating agency. However in view of the concerns of the case's family, it was agreed that the most appropriate route would be for NHS Lanarkshire to engage South Lanarkshire Council Trading Standards officers to take the matter further.

A report explaining that there was an epidemiological link which had not been confirmed microbiologically was passed to Consumer and Trading Standards and was subsequently considered by the West of Scotland Safety Group. The issue was then referred to the UK Local Authority Co-ordinating body on Regulatory Services but no consequent action ensued.

2.2 Nature of the Incident

Following the actions described above, eight further cases of *L. longbeachae* infection in those carrying out gardening activities using either growing media or compost, were reported to HPS. Cases were investigated by the NHS board of residence with HPS and SHPMRL providing support. One case was re-infected and is counted twice for the purposes of this review.

Although the increased incidence of *L. longbeachae* infection does not conform to the traditional view of an outbreak (a cluster of cases of a disease or syndrome linked in space and time), by 2012 it did represent a significant excess in the observed level of a disease over that expected and could thus indicate that a sector of the Scottish public was at increased risk. As such, it required the organised efforts of an IMT to co-ordinate investigation and management.

3. Investigation

3.1 Epidemiological investigation

The epidemiological investigation on each individual case was carried out using the standard pro-forma of the Scottish Enhanced Surveillance of *Legionella* Infections Surveillance System. There are no specific questions about gardening exposure on this form. Further details were collected through in-depth case and family interviews by local NHS board Health Protection Team or Environmental Heath Officers. These details were collated and the descriptive epidemiology reviewed by HPS initially and the IMT subsequently.

3.1.1 Review of descriptive epidemiology

a. Case definitions

All cases meet ECDC case definition for a confirmed or probable case (see Appendix 3 for ECDC case definitions of Legionnaires' disease cases). All have been reported as cases of Legionnaires' disease by HPS in reports and to ECDC in annual data sets.

For the purpose of this IMT investigation, cases were reclassified according to an extended case definition that included time and exposure factors. The case definitions used by the IMT were:

Confirmed case

- Meets ECDC clinical definition for case of Legionnaires' disease and
- Case has been identified in Scotland since 2008 and
- Exposure to growing medium in Scotland and
- *L. longbeachae* isolated by culture

Probable case

- Meets ECDC clinical definition for case of Legionnaires' disease and
- Case has been identified in Scotland since 2008 and
- Exposure to growing medium in Scotland and
- Serological 4-fold rise in titre to *L. longbeachae* specific antibody

Possible case

- Meets ECDC clinical definition for case of Legionnaires' disease and
- Case has been identified in Scotland since 2008 and
- Serological 4-fold rise in titre to *L. longbeachae* specific antibody or *L. longbeachae* isolated by culture **BUT**
- No exposure to growing medium in Scotland identified.

b. Distribution by case definition

The nine cases include one individual who has had two separate episodes of Legionnaires' disease caused by *L. longbeachae* (so 9 cases involve 8 individuals). Reinfection is very unusual and laboratory staff had not seen such a case before, therefore additional expert advice was sought to confirm this diagnosis. The second infection was accompanied by a four-fold rise on titre which is indicative of current infection. Two cases (one confirmed, one possible) died whilst infected with *L. longbeachae*.

L. longbeachae infection in Scotland since 2008: distribution by case status

Case status	Number	Note
Confirmed	3	One confirmed case was re-infected and also counted as probable below. One death.
Probable	4	See above
Possible	2	No further investigation carried out. One death.

Source: HPS

For the cases where no investigation took place (both possible cases): one case died of the infection and lived alone - no family or friends could be identified to provide exposure details; the other case could not be interviewed as they were receiving treatment for a condition identified during hospitalisation for *Legionella* infection.

c. Distribution by age/sex

Of the 9 cases, seven are male (77.8%). All confirmed cases are male. The average age is 66.5 years (median is 65 years).

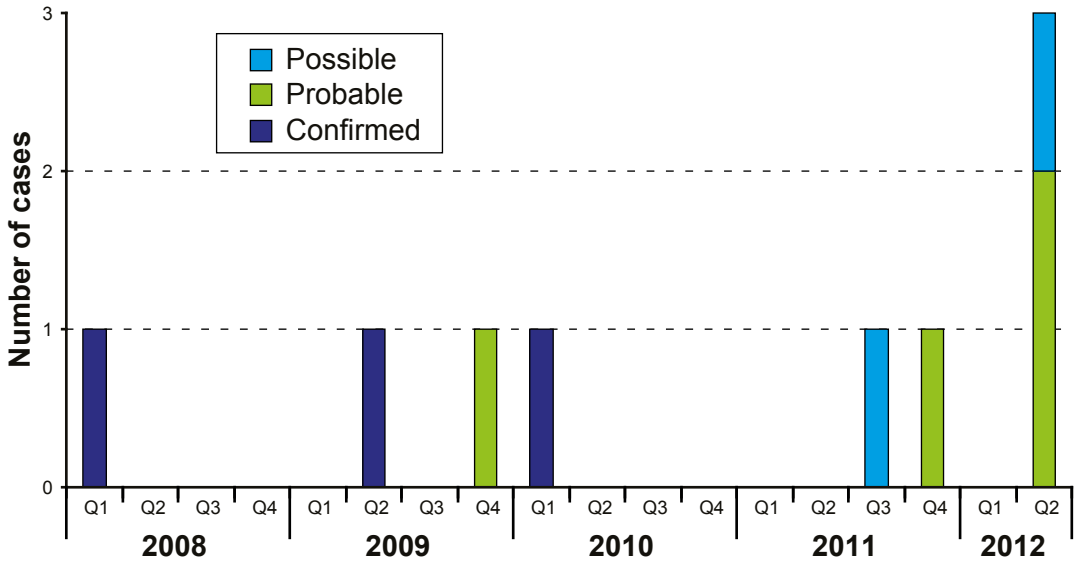
d. Distribution by place

Cases came from six different NHS boards: Dumfries & Galloway, Forth Valley, Greater Glasgow & Clyde, Lanarkshire, Lothian and Tayside.

e. Distribution by time (epidemiological curve)

The epidemiological curve is presented below, with the timeline shown in quarter years for 2008 to 2012. There is no clear seasonal pattern. There may have been increased ascertainment in 2012 due to an increase in general testing for *Legionella* associated with the Edinburgh outbreak (two cases were identified at this time).

Cases of *Legionella longbeachae* in Scotland 2008 - 2012



Source: HPS

f. Distribution by potential exposure

Seven cases (or relatives of cases) were interviewed about potential exposures to a waterborne aerosol or proximity to cooling towers. No potential exposures of this type were identified.

All the cases who participated fully in the epidemiological investigation (six), including all three confirmed cases, were keen gardeners i.e. owned a garden and spent a considerable part of their leisure time in gardening activities. All participating individuals provided information about the use of growing media or composted waste in the incubation period for the disease although details on these were collected in a non-standardised manner.

With regard to the type of product used by an individual, all six reported having used growing media although these were not of a similar composition. The individual, who was a case on two separate occasions, reported having used a large volume of composted waste purchased directly from an agricultural producer during the incubation period for his second illness.

With regard to gardening activities, five of the six individuals provided details. Three had been engaged in potting, two in preparing and fitting hanging baskets, two in planting plants in trays in a greenhouse, one in general digging and ground preparation using compost.

All five had carried out at least one of the gardening activities in an indoor setting (i.e. in a greenhouse or shed or conservatory).

g. Distribution by risk factor

Six cases were current or ex-smokers. Six cases had underlying disease or were taking medication which could lead to immuno-suppression. Two cases had carcinomas.

h. International evidence of the epidemiology of *L. longbeachae* infection

The IMT reviewed the international epidemiological evidence on *L. longbeachae* infection. A literature search was carried out using Medline and Pubmed. There were 152 references within Medline and 164 in Pubmed related to *L. longbeachae*. A large proportion of the articles featured microbiological studies on the nature of the organism, its presence in different environments (for example growing media) and on the clinical features of the infection. On refining the search and looking separately into control, labelling, prevention and transmission, it would appear that the mechanism for transmission remains unknown. It has been hypothesised that it comes from inhaling dust aerosols.[8] There are no studies specifically evaluating the impact of control measures on disease transmission and incidence.

The main articles cited when discussing potential transmission mechanisms came from South Australia. With regard to prevention, the key findings were:

a) increased risk of Legionnaires' disease due to *L. longbeachae* associated with being near to dripping hanging baskets;[8]

b) increased risk of Legionnaires' disease due to *L. longbeachae* associated with eating or drinking after gardening without washing hands;[8]

c) decreased risk of Legionnaires' disease due to *L. longbeachae* associated with awareness of possible risk of potting;[8]

d) exposure to aerosolised potting mix being the cause of an outbreak of Pontiac Fever due to *L. longbeachae* in workers in a horticultural nursery in New Zealand.[9]

3.2 Microbiological investigation

a. Clinical microbiology by local NHS diagnostic laboratories

L. longbeachae identification and serology is carried out in Scotland by SHLMPRL. Samples were taken on the basis of clinical suspicion of Legionnaires' disease. Six diagnostic laboratories submitted the specimens to SHLMPRL and subsequently tested positive. Of the nine cases, six are recorded as having had a negative urinary antigen test undertaken at the diagnostic (local) laboratory. Urinary antigen testing detects *L. pneumophila* serogroup 1, which account for up to 90% of Legionnaires' disease cases

b. Clinical microbiology by SHLMPRL

Culture

Patient respiratory samples were cultured both untreated and after heating to 50°C for 30 minutes, then plated onto buffer charcoal yeast extract (BCYE) and BMPA media (Oxoid) and incubated at 37°C for up to 10 days.

PCR

DNA was extracted from the respiratory samples using an appropriate method, amplified with *Legionella*-specific primers and digoxigenin-labelled. PCR products were visualised on an agarose gel. A PCR ELISA was performed using kit reagents and a *Legionella*-specific biotin-labelled DNA probe. Any positives were then re-tested with a *L. pneumophila*-specific biotin labelled gene probe.

Serology

Antibody response to all *Legionella* species known to cause human disease is assessed at SHLMPRL. Of the nine cases, the immunofluorescent antibody (IFA) test was performed if serum was available

Summary of results

Summary of Results				
Case	**PCR**	**Culture**	**Single high titre**	**>four-fold rise in titre**
Confirmed	+	+	+	
Confirmed	+	+		
Probable	n.a.	n.a.		+
Confirmed	+	+		+
Possible	+	-		+
Probable	+	-		+
Probable	n.a.	n.a.		+
Probable	+	-		+
Possible	+	+		+

n.a.: not available
Source: SHLMPRL

c. Environmental microbiology

Samples were taken by Environmental Health Officers from the local authority where the case resided. Environmental samples relating to six cases were taken. Samples were of a variety of substances e.g. growing media, composted waste, soil, water, pots, hanging baskets, trays, bags of purchased compost, greenhouse surfaces and hoses. These were collected according to local standard procedures (no amendments were made to ensure uniformity across all the cases during the investigation).

For each sample, 5g of sample was added to 50ml sterile distilled water and rotated at room temperature (RT). The compost samples were left for 30minutes at RT then centrifuged for 1minute at 1000 g. 200microlitres of compost supernatant was added to HCl/KCl acid solution for 10minutes at RT. The sample was then immediately diluted and was added to glycine polymyxin B sulphate, vancomycin hydrochloride and cycloheximide and modified Wadowsky-Yee (Oxoid) plates. The plates were allowed to dry, placed in a moistened chamber, left for 3–4 days and examined daily for up to 10 days. Any suspect colonies were inoculated on to blood agar and BCYE plates. In the case of blue–white *Legionella* strains, these were viewed visually under long-wave UV for autofluorescence. *Legionella* species were identified by polyclonal IFA and *mip* speciation.

Summary of Results

L. longbeachae was isolated from the following environmental samples (related to three individual cases:

- growing media used by a confirmed case in a glass conservatory. The media contained a variety of *Legionella* species, including *L. anisa*, *L. londiniensis*, *L. sainthelensi*;
- growing media used as a bedding plant mixture that had been handled in a greenhouse environment prior to disease onset;
- soil into which growing media had been mixed by a probable case for use in a greenhouse.

Environmental samples related to the three other cases (two individuals) were all negative for *Legionella* contamination.

d. Strain and genotyping of isolates from clinical and environmental samples by SHLMPRL

In total there were six isolates (three from clinical samples and three from environmental samples).

Strain identification

The isolates were tested using polyclonal IFA serology[10] and *mip* gene speciation[11] and then genotyped by amplified fragment length polymorphism (AFLP) using the standard European Working Group for Legionella Infection method.[12]

AFLP

Briefly, restriction–ligation reactions were performed at 37°C for 3hours. PCR was performed in a reaction mixture of 25ml comprising approximately 1ng template and 400nM selective primer using Ready-To-Go beads (Amersham Biosciences). Amplified products were separated by electrophoresis in 1.5% agarose.

Summary of Results

All six isolates were identified as *L. longbeachae* serogroup 1. Isolates of *L. longbeachae* serogroup 1 from the two confirmed cases' clinical samples were identified as indistinguishable strains from the respective isolates from samples of growing media used by them.

With regard to the genotyping undertaken using AFLP, two genotypes were identified 1a and 1b:

- one confirmed case had genotype 1a identified in the isolate from a clinical sample and genotypes 1a and 1b in the isolate from the case's respective growing media sample;
- another confirmed case had 1b identified in the isolate from a clinical sample and only genotype 1b in the isolates from the case's respective growing media sample;
- the results of the epidemiological, microbiological and environmental investigations into three cases has been peer-reviewed and published in the scientific literature.[13,14]

3.3 Environmental investigation

The environmental investigation comprised:

a. field investigation of cases' homes and gardens;

b. tracing products identified in the field investigation as potentially being implicated in the case's exposure to the organism;

c. reviewing processing of compost into growing media and the distribution of growing media to define possible factors which could increase the probability of exposure to *L. longbeachae*.

a. Field investigation of cases' homes and gardens

Where an environmental investigation was possible, Environmental Health Officers visited the homes of the cases and investigated water sources at the property and gardening activities. The garden and settings where gardening activities took place were assessed and findings recorded. These were analysed and reported in the epidemiological investigation.

b. Tracing products identified in the field investigation as potentially being implicated in the case's exposure to the organism

In terms of the growing media used by the cases, the brand of bag and the retail point of purchase were ascertained. Four cases were able to provide details. With regard to the brand of bag, there was no common brand; John Innes, B&Q Multipurpose, Miracle Gro Ecosense, J. Arthur Bowers Instant Planter Compost, Gardenline Compost were all identified. The four brands are all supplied UK-wide. Where full brand name was available, details of the ingredients were reviewed. There was no common source of ingredient(s). There was no common retail unit. The products are available from a range of outlets.

c. Reviewing the contents, processing of compost into growing media and the distribution of the latter to define possible factors which could increase the probability of exposure to *L. longbeachae*

A range of papers were identified and circulated prior to the IMT meeting which discussed these issues. The paragraphs below summarise the outcome of discussions at the meeting.

Contents of growing media

Growing media producers in the UK have reduced their reliance on peat, which now accounts for only about two thirds of the material used (on average). Composted material, bark, wood fibre and coir are the principle peat replacements. Since composted material is relatively dense it will be sourced as locally as possible to the manufacturing sites, due to transport costs. In general, manufacturing sites will be supplied by a small number of compost producers producing compost that will have to reach higher quality specifications (set by the growing media manufacturers) than the UK standard (PAS100) and be able to accommodate changes in available raw materials throughout the year.

Processing of composted material

Composted material is produced from green waste by an aerobic composting process. Temperature and water content are monitored throughout to ensure an adequate sanitisation phase for the control of human and plant pathogens. Large scale compost production is done on registered sites by licensed companies, with many of the sites producing compost which meets the PAS100 specification. Small scale compost production (up to 400 tonnes per year) is exempt from current licensing requirements although registration with SEPA is required.

The PAS100 certification specifies requirements for the processing of composting, the selection of input materials, the minimum quality of composted materials and the storage, labelling and traceability of compost products. It specifies requirements for a Quality Management System (QMS) for the production of composts to ensure they are consistently fit for their intended uses. In order to sell composted material as a quality product a site must be PAS100 certified, this certification sets out the requirement for microbiological testing (for *E. coli* and *Salmonella*, not *Legionella*) to ensure the composting process has been properly managed.

Of the components in growing media that could be contaminated with *Legionella*, it is most likely that composted material could become contaminated. There is scientific literature supporting contamination of composting heaps with *Legionella*.[16] Composting heaps contain many ingredients which make it suitable for growth of *Legionella* – water, warmth, biofilm, organic nutrients. However, the composting process, if certified to PAS100 standard, requires that all material is exposed to 65°C for seven days. It is likely that this treatment will kill free living *Legionella* but may not kill *Legionella* organisms encysted within amoebal hosts (for which there is evidence lacking for reliable killing temperature).

Distribution of growing media

The vast majority of growing media produced in the UK is used in agriculture (60%) and landscaping or land restoration (18%) and only a limited amount by the horticultural industry (9% amateur and 5% professional) based on 2009 tonnages, according to the Association for Organics Recycling. Due to the weight of growing media, it is made as locally as possible to the point of sale, in order to reduce transport costs. There are no manufacturing sites in Scotland supplying the amateur garden market and only one supplying the professional market. Growing media supplied to Scotland to the public comes from sites in the north of England or Northern Ireland, which also supply customers in the north of England and Northern Ireland. It is unlikely that batches of growing media will be made specifically for Scotland.

Handling and use of growing media

Due to the large scale mixing of components to produce growing media, it is unlikely that individual bags will be contaminated. Rather, if a component of the batch is contaminated, then all bags in the batch will become contaminated. Individual bags are perforated so that air can be expelled for stacking and transport. These perforations were deemed low risk to enable individual bag contamination.

There is currently no published evidence to suggest how *L. longbeachae* transfers from compost into lungs causing legionellosis. Opening the bag of growing media was identified as a possible source of aerosolisation. Hanging baskets could be source of airborne droplets through watering, drainage and splash.

There is no published evidence that this aerosolisation has occurred in relation to specified cases of Legionnaires' disease but the investigation of an outbreak of Pontiac fever due to the organism in horticultural nursery workers did demonstrate a link to aerosolisation[9]. There is no published evidence of the dose of *Legionella* bacteria required to cause legionellosis.

4. Risk Assessment

Based on the findings of the IMT investigation, there is a definite, but very small, risk of *L. longbeachae* infection from using growing media in those undertaking gardening activities in Scotland. The risk appears to be associated with gardening activities being undertaken in indoor settings and is greatest in those aged over 55 years who smoke or have underlying chronic, medical conditions.

L. longbeachae infection in the cases identified in Scotland so far appears to be severe. There have been two deaths in the nine cases (three confirmed, four probable and two possible cases) reported to HPS: one with a recorded link to exposure to growing media; the other with no history as information was not available.

However, the incidence of *L. longbeachae* infection in Scotland is very low: less than one confirmed case per million total population per year since 2008 with only one death in a confirmed case in the same period. There is no evidence from Scotland of horticultural workers, who have continuous workplace exposure to compost and growing media, suffering from legionellosis caused by *L. longbeachae*. Most cases are aged over 55 years of age and most have underlying, chronic diseases. In population terms, the burden of disease (i.e. years of expected life lost, years of life with added disability and years of poor quality of life) resulting from the infection is comparatively small. Given the volume of growing media products and compost sold and the number of gardeners in Scotland, the risk of exposure to this organism resulting in diagnosed, severe disease appears to be very low.

5. Risk Management

Measures to control further spread of the infection after a case had been identified were discussed, but none were identified. This was due to limited evidence available. The primary task therefore is prevention, by reducing the possibility of *Legionella* growth in compost and the use of protective measures by those using growing media, especially those in the at-risk sector of the population.

With regard to preventing the infection and lowering the burden of disease associated with *L. longbeachae* infection, there is no indication that specific risk management measures are a priority for public health. However given that this is a potentially avoidable risk, members of the public are seeking action and there is interest from the media and parliamentarians, the need for taking an approach based more on public interest and precaution to help prevent further cases, should be considered. This is explored below.

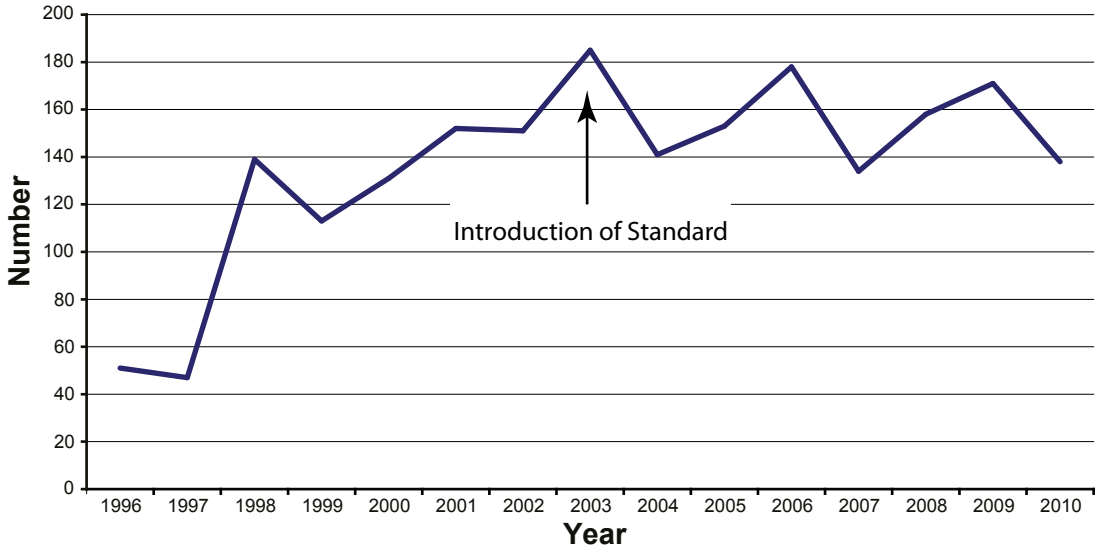
a. Managing the risk of *L. longbeachae* infection: lessons from Australia and New Zealand

Legionnaires' disease due to *L. longbeachae* is relatively common in Australia (see graph below), with up to half of Legionnaires' disease cases every year caused by *L. longbeachae*. As a result, a number of steps have been taken to reduce the risk of infection.

- The "Australian Standard on Composts, Soil Conditioners and Mulches" (AS 4454, 4th Edition 2012) published by Standards Australia which specifies physical, chemical, biological and labelling requirements for products that have been derived largely from compostable organic material. Requirements for claiming compliance include product warning labels. These standards, although not statutory in themselves, can be referred to in State regulations or used in case law. This standard was introduced in 2003.
- Codes of practice on the prevention and control of Legionnaires' disease published by the different states' Health Departments which usually have a section giving guidance on precautions when handling compost, garden soils and potting mix. An example is provided in Appendix 2.

No publication has been found which provides evidence of the effectiveness of these measures in terms of reducing the overall public health risk associated with *L. longbeachae* exposure. The graph below shows the trend in the annual number of *L. longbeachae* infections notified to the Australian National Notifiable Disease Surveillance (estimated population 22.7 million) in the period 1995-2010.[17] In most years since 2000, the organism has been the most common cause of Legionnaires' disease in the country. The number of cases rises between 1995 and 2003, and from 2003 onwards has fallen slightly. It is unclear what relationship, if any, this has had to the control measures - the introduction of the Australian labelling standard in 2003.

Annual Number of Notifications of *L. longbeachae* infection to Australian National Notifiable Diseases Surveillance System: 1996 - 2010



Source: Australian Government, Department of Health and Ageing

In 2005, New Zealand (estimated population 4.4 million) introduced virtually the same standard on Composts, Soil Conditioners and Mulches as the Australian 2003 standard. This features a similar warning for display on bags of growing media. The New Zealand Ministry of Health has also developed a resource titled *Safer and Healthier Gardening*[18] to help reduce the risk for the home gardener, which is also be made available at point of sale. A health education resource for soil and compost product suppliers has been produced by the Department of Labour, Occupational Safety and Health Service.[19]

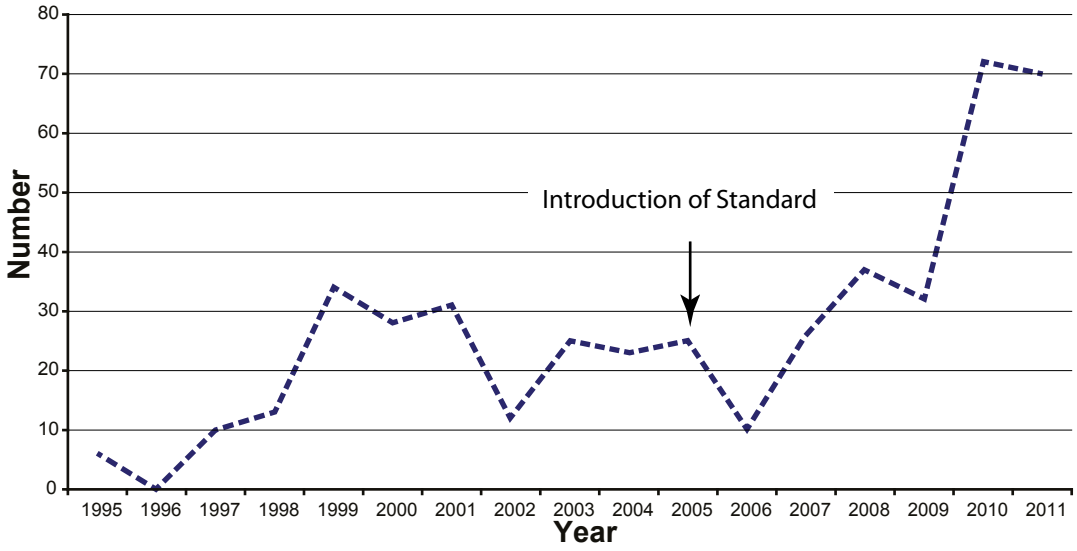
Since 2008, over 40% of cases of Legionnaires disease notified to the New Zealand Ministry of Health have been due to *L. longbeachae*, making it the most common cause of Legionnaires' disease in New Zealand. There has been a relatively rapid rise in the number of cases notified in the period 2006 to 2011, see figure below.[20] The rise could be due to:

- the ineffectiveness of the control measure or its application in reducing levels of the bacteria in growing media;
- or an increase in the number of people liable to be exposed because of lack of attention to the warning;
- or an increase in those participating in gardening;
- or an increase in ascertainment by healthcare services.

It is unclear which.

The case definitions for legionellosis in Australia and New Zealand differ from those used in the EC countries. Confirmed cases in Australia and New Zealand correspond to confirmed and probable in EC countries. Using the former, the average annual rate of confirmed *L. longbeachae* infection per million population in the last three complete years for which data are available, were: 7.2 per million (2008-10) in Australia, 13.2 per million in New Zealand (2009-11) and 0.8 per million in Scotland (2009-11).

Annual Number of Notifications of *L. longbeachae* infection to New Zealand Ministry of Health: 1995 - 2011



Source: Institute of Environmental Science and Research Ltd, New Zealand

b. Lowering the risk of *Legionella* growth in growing media

L. longbeachae has been isolated in growing media in a large range of countries: Australia, New Zealand, Japan, Thailand, Netherlands, UK, Switzerland, USA, and Poland. The composition of these mixes has been varied. However, incidence is highest in those countries who produce growing media with a high proportion of composted materials (Australia, New Zealand and Japan) and lowest in those countries for which peat is the base material for growing media (Europe).[5] Other species of *Legionella* have also been isolated from growing media, these include frequently *L. pneumophila* (most serogroups) and also *L. micdadei*, *L. bozemanii*, *L. jamestowniensis*, *L. cincinnatiensis*, *L. oakridgensis*, *L. anisa,*[6, 16]

Factors such as the processing of growing media and the presence of other micro-organisms, for example amoeba, are thought to be important in the ecology of *Legionellae* in the environment. *L. longbeachae* is predominantly terrestrial and shows genetic adaptations to a terrestrial environment including addition genes that encode plant digesting enzymes.[21] *L. longbeachae* has rarely been detected in water samples[22] and never in man-made water systems.

The inclusion of a biomarker test for the presence of *L. longbeachae* (or *Legionella* species in general) could possibly act as a standard for the processing of compost under PAS100. This would be subject to the development of methods, which would subsequently need to be standardised, to determine the presence of the organism in any suspect horticultural source material.

c. Labelling bags of growing media

As indicated previously, there is no statutory requirement in Australia or New Zealand for growing media to have warning labels on bags because most manufacturers have volunteered to use an industry-agreed warning label, as recommended by their respective standards body. Safe handling information provided in New Zealand and Australia highlights taking a series of precautionary steps.

- Wear a face mask when handling soil, mulches, compost or growing media indoors or in windy conditions.
- Open the bag using a blade with care to avoid inhaling airborne growing media, i.e. slowly and away from the face.
- Moisten the contents of the bag on opening, by making a small opening and insert a garden hose to dampen the growing media.
- Avoid potting-up plants in unventilated areas, such as enclosed greenhouses or sheds.
- Wear gloves.
- Avoid transferring growing media from hand to mouth (e.g. rubbing face with a soiled hand or glove).
- Always wash hands after handling growing media, even if gloves have been worn, as *Legionella* bacteria can remain on hands contaminated by growing media.
- Store growing media in a cool place, away from the sun.
- Keep soils and growing media damp.
- Avoid raising soil near evaporative coolers.
- Water gardens and composts gently, using a low-pressure hose.
- When handling bulk quantities of growing media or other soil products, follow procedures that minimise dust generation.

As noted above, there is no evidence that the provision of this information is having any effect on the incidence of the disease.

Currently the UK equivalent to the Australian and New Zealand standards, the British Institute of Standards PAS100, states that:

> *"the following information about each consignment of conforming compost dispatched shall be printed on packaging or on a separate document supplied to the compost recipient ……..h) warning about product misuse, risks when handling and safety advice or symbols as appropriate;"*

The Association for Organics Recycling recommends in their guidance on *L. longbeachae*[23] that to meet the PAS100 standard, a warning statement should be included in labelling which reads:

> *"SAFE HANDLING AND USE*
>
> *Every effort has been made to ensure this compost contains no germs, sharp fragments, toxins or regenerative plant parts. However the compost producer cannot guarantee they will never be present. As with all products of this type, wear gloves when handling and wash hands after use. During handling avoid inhaling any dust or water vapour or droplets from it, or ingesting any of it"*

Information from previous discussions with the horticultural industry suggests that general wording on a label may exacerbate liability issues and that a voluntary agreement to label products would be unlikely to be agreed among all manufacturers. This raises the issue as to whether labelling should be a statutory requirement.

6. Discussion and Conclusion

6.1 The epidemiology of *L. longbeachae* infection in Scotland and in particular the differences in ascertainment of cases between Scotland and England and Wales

A prompt for the formation of the IMT was to explore the differences in ascertainment of Legionnaires' disease cases caused by *L. longbeachae* between Scotland and England & Wales. In the period 2008-12 Scotland reported nine cases (population 5.2 million), England & Wales reported one case (population 56.1 million).

There are three possible explanations for this.

1. Differences in clinical and microbiological practice in testing for species of *Legionella* other than *L. pneumophila*

A meeting was held with HPA colleagues to review this issue. There was no available evidence of any systemic difference in clinical practice between Scotland and England. With regard to guidelines, there are no specific SIGN or Nice Guidelines on the hospital management of pneumonias. The British Thoracic Society publishes "Guidelines for the Management of Community Acquired Pneumonia in Adults"[24] which were updated in 2009, recommend:

> *"As the culture of legionella is very important for clinical reasons and source identification, specimens of respiratory secretions, including sputum, should be sent from patients with high severity CAP or where Legionnaires' disease is suspected on epidemiological or clinical grounds."*

With regards to microbiological practice, given the scale of Scotland compared to England, SHLMPRL (with specialised serological tests) may be more accessible to frontline NHS microbiological laboratories and clinicians within Scotland than its counterpart in England. This frequently entails conversations about the testing regimen for individual cases which are sent to the reference laboratory for confirmation or further specialised testing.

Another factor is the availability of testing for suspected cases of legionellosis which test negative by urinary antigen testing. The table below shows the numbers of cases of Legionnaires' disease associated with *L. pneumonphila* Sg1 (will test positive with urinary antigen testing); other *L. pneumophila* serogroups (will test negative with urinary antigen testing); and non-*pneumophila* strains (will test negative with urinary antigen testing). Scotland has a higher proportion of non-*pneumophila* cases of Legionnaires' disease than England and Wales. From early 2012, specialist detection of *L. longbeachae* antibodies or detection of *L. longbeachae* by PCR is no longer available at HPA Colindale.

The IMT concluded that these factors indicate that many cases of pneumonia, especially those negative on urinary antigen testing, probably undergo more extensive testing for *Legionella* in Scotland.

	Year	Total number of LD cases	Number of cases associated with *L. pneumophila* Sg1	%	Cases associated with other *L. pneumophila* serogroups	%	Cases associated with non-pneumophila serogroups	%
England & Wales	2008	363	281	77	81	22	1	0
	2009	344	275	80	68	20	1	0
	2010	357	285	80	72	20	0	0
	2011	235	179	76	55	23	1	0
Scotland	2008	27	10	37	15	56	2	7
	2009	25	12	48	10	40	3	12
	2010	18	17	94	0	0	1	6
	2011	35	30	86	3	9	2	6

Source: Health Protection Agency and HPS

2. Differences in statutory notifications between the Scotland and the rest of the UK

In Scotland, all *Legionella* detected by laboratories in clinical samples are notifiable. Legionnaires' disease is not clinically notifiable. In England, Legionnaires' disease is clinically notifiable and all *Legionella* species detected as causative agents in human disease are also notifiable. If anything, this difference could explain an under-ascertainment in Scotland not the opposite.

3. A difference in the probability of being exposed in Scotland and thereafter of contracting Legionnaires' disease

There is conclusive epidemiological, microbiological and environmental evidence in two cases that *L. longbeachae* in growing media caused Legionnaires' disease in the person using it during the incubation period. In a further case, the evidence is highly indicative. In all other cases, the evidence is more indicative than conclusive.

The IMT concluded that there is an increased incidence of *L. longbeachae* infection in Scotland most probably due to exposure to growing media containing the organism. Given the increasing popularity of gardening as a hobby and the growing number of over 65s with a higher prevalence of at-risk conditions in the population likely to participate in it, further cases of Legionnaires' disease due to this cause can be expected. There is a need for more thorough evidence as to how future cases will have been exposed to the organism. HPS should develop a hypothesis generating ("trawling") questionnaire specifically for cases of *L. longbeachae* infection and a protocol for their environmental investigation (including sampling).

6.2 The environmental factors linked to *L. longbeachae* infection, especially differences in growing media composition or source of materials in Scotland compared with the rest of the UK

There is no current evidence for any difference in the components, production, processing, distribution or retailing of growing media explaining why the disease appears to be occurring in Scotland and not in other parts of the UK and indeed Europe.

The IMT concluded that much remains to be known about the ecology of *L. longbeachae* and how best to limit its growth in the components of growing media. However, there could be merit in the inclusion of testing for presence of *L. longbeachae*, or *Legionella* species in general, which may act as a standard for the processing of compost under PAS100.

6.3 The evidence for the control of *L. longbeachae*, in particular if there is sufficient evidence to support legal requirement for labelling of compost bags

Statutory labelling of consumer products is a legal requirement placed on a range of manufacturers (for example tobacco, pharmaceuticals, food, upholstery) to provide information on their product. If a business produces or supplies potentially dangerous goods, it is often required to provide appropriate safety information, for example instructions on safe handling.

There in no conclusive evidence that labelling bags of growing media with a safe handling warning will lead to reduction in the very low incidence of this disease in Scotland. After the introduction of labelling in Australia, the number of confirmed cases did not markedly increase; whereas in New Zealand, the number of cases continued to increase after the intervention. However, there is often no definitive evidence that labelling has reduced the level of other threats to health. On balance, therefore, the IMT concluded that as a general precaution, manufacturers should include a label on all bags of growing media sold to the public, containing generic advice on good hygiene in relation to gardening. The label should cover:

- Wearing gloves;
- Wearing a mask if dusty, especially indoors;
- Washing hands immediately after use.

A voluntary agreement with manufacturers is preferred but if this cannot be obtained, the introduction of relevant regulation on the labelling of bags should be considered.

The issue of health and safety guidance for those involved in handling composted waste in agriculture or horticultural nurseries or in the preparation of growing media was not considered by the IMT. HPS has received no reports of *L. longbeachae* infection in workers in the horticultural industry in Scotland or the UK.

7. Recommendations

a) HPS should develop a hypothesis generating ("trawling") questionnaire specifically for *L. longbeachae* cases and a protocol for their environmental investigation (including sampling). Based on indications from this trawling questionnaire a targeted investigation may be merited.

b) HPS should explore how best to raise awareness of risk of *L. longbeachae* infection from growing media, amongst those with highest risk – older and immunocompromised.

c) The British Standards Institution should investigate the merit of inclusion of a test for the presence of *L. longbeachae* or *Legionella* species in general, which could possibly act as a standard for the processing of compost under PAS100.

d) Scottish Government should explore with its relevant UK counterparts how best to secure agreement with manufacturers and/or retailers to include on all bags of gardening media sold to the public, a label containing generic advice on good hygiene in relation to gardening. The label should cover:

- Wearing gloves;
- Wearing a mask if dusty, especially indoors;
- Washing hands immediately after use.

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Appendix 1 Membership of IMT

Dr Martin Donaghy – Chair (HPS Medical Director and Strategic Lead for *Legionella*)

Dr Alison Potts (Epidemiologist, HPS)

Lynn Cree (Lead Environmental Health Advisor, HPS)

Michelle Marley (Environmental Health Advisor, HPS)

Louise Kelly (Communications Officer, HPS)

Dr Giles Edwards (Consultant Microbiologist, Scottish *Legionella* Reference Laboratory)

Dr Diane Lindsay (Senior Clinical Scientist, Scottish *Legionella* Reference Laboratory)

Dr Nick Phin (Strategic Lead for *Legionella*, HPA)

Dr Rishma Maini (HPA)

Dr Josephine Pravinkumar (CPHM, NHS Lanarkshire)

Dr. Eleanor Anderson (CPHM, NHS Greater Glasgow and Clyde)

Gareth Brown (Policy Team, Scottish Government Health and Social Care Directorate)

Dr Andrew Riley (CMO Office, Scottish Government)

Support for meeting was provided by Linda Moan (Project Support Officer, HPS)

Expert advisors to IMT:

Paul Waller (Consultant, Paul Waller Consulting)

Fiona Donaldson (National Operations Waste Unit, SEPA)

Appendix 2 Health warning found on bagged growing media that meet standard AS 4454 in Australia – main label and detailed label

HEALTH WARNING

THIS PRODUCT CONTAINS MICRO-ORGANISMS

**AVOID BREATHING DUST OR MISTS—
WEAR PARTICULATE MASK IF DUSTY**

WEAR GLOVES AND KEEP PRODUCT MOIST WHEN HANDLING

WASH HANDS IMMEDIATELY AFTER USE

READ DETAILED WARNING LABEL ON THIS BAG

HAZARDOUS

COMPOSTS, POTTING MIXES
AND OTHER ORGANIC GARDENING MATERIALS

This product is made from organic materials, including composted pinebark, and contains living microorganisms, including bacteria, fungi and protozoa. May also contain mineral and fertiliser additives.

RISK	Inhalation of dust and/or liquid mists may irritate, inflame or sensitise the nose, throat, and lungs resulting in illness ranging from hayfever or asthma, to pneumonia (e.g. Legionnaires' disease) or pneumonia-like illnesses. Direct contact with this material or its dust and/or liquid mists (bioaerosols) may cause skin irritation (dermatitis), and skin or eye infections or irritation. People particularly at risk are those suffering from asthma or allergies, and those whose immune defence system are compromised.
SAFETY	Avoid contact with eyes and skin. Avoid breathing dust and/or liquid mists (bioaerosols). Wear suitable protective clothing and standard duty gloves (AS/NZS 2161.2). If exposed to dust and/or liquid mists, also wear dust resistant eye protections (AS/NZS 1336) and particulate respirator (AS/NZS 1715 and 1716). Wash thoroughly immediately after handling. Wash work clothes regularly. Clean up by wet sweeping or vacuuming. Store this product in a cool location.
FIRST AID	Irrigate eyes with plenty of water for 10 minutes. Wash skin with soap and water. Seek medical attention for any persistent skin, eye or respiratory symptoms.
DISPOSAL	Follow above safety precautions and collect in containers for disposal as trade waste in accordance with local authority guidelines.
MANUFACTURER	xxxx

For further information, refer to the Material Safety Data Sheet for this product which is available from xxx.

Appendix 3 ECDC case definitions for Legionnaires' disease

Legionnaires' disease is an uncommon form of pneumonia. The disease has no particular clinical features that clearly distinguish it from other types of pneumonia, and laboratory investigations must therefore be carried out in order to obtain a diagnosis.

The following definitions have been agreed:[25]

Clinical criteria: Any person with pneumonia

Laboratory criteria for case confirmation:

At least one of the following three:

1. Isolation of *Legionella* spp. from respiratory secretions or any normally sterile site;
2. Detection of *L. pneumophila* antigen in urine;
3. L. pneumophila serogroup 1 specific antibody response.

Laboratory criteria for a probable case:

At least one of the following four:

1. Detection of *L. pneumophila* antigen in respiratory secretions or lung tissue;
2. Detection of *Legionella* spp. nucleic acid in a clinical specimen;
3. *L. pneumophila* non-serogroup 1 or other *Legionella* spp. specific antibody response;
4. *L. pneumophila* serogroup 1, other serogroups or other *Legionella* species: single high titre in specific serum antibody.

Epidemiological criteria:

At least one of the following two epidemiological links:

1. Environmental exposure;
2. Exposure to the same common source.

Case classification

1. Probable case

Any person meeting the clinical criteria AND at least one positive laboratory test for a probable case OR an epidemiological link.

2. Confirmed case

Any person meeting the clinical and the laboratory criteria for case confirmation.

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