Compost Production for use in Growing Media – a Good Practice Guide

February 2014
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OUR MISSION: WRAP’s mission is to accelerate the move to a sustainable, resource-efficient economy through:

re-inventing how we design, produce and sell products
re-thinking how we use and consume products
re-defining what is possible through re-use and recycling
This guide provides practical advice to compost producers about the production of quality composts that are consistently fit for purpose as growing media constituents. It also aims to inform growing media manufacturers and growers about quality composts and how they can be used in growing media.

It will:
- help growers understand more about composts and their potential for inclusion in growing media;
- inform compost producers about opportunities in the growing media market;
- assist compost producers in their use of the ‘Guidelines for the Specification of Quality Compost for use in Growing Media, 2014.’ in order to enable them to supply quality products to the growing media sector;
- help compost producers understand the need for measurement of specific quality parameters in composts intended for use as constituents of growing media; and
- help growing media manufacturers understand more about composts, how to specify them and how to use them as constituents of growing media.
1.0 Introduction

1.1 Why use composts in growing media?

Commercial and amateur growers of vegetable transplants and ornamental container-grown/pot plants have traditionally used mainly peat-based growing media but awareness is growing that peat bogs must be preserved due to environmental reasons. There will be increasing pressure on both amateur gardeners and commercial growers to reduce the amount of peat they use and to use more environmentally acceptable alternatives, perhaps based on recycled resources. Increasing numbers of retailers, landscapers and amateur gardeners are now demanding peat-free or reduced-peat growing media, although the use of peat-reduced or peat-free growing media in commercial container production systems is increasing more slowly due to a number of technical reasons.

Quality composts produced according to the British Standards Institution’s Publicly Available Specification for Composted Materials (BSI PAS 100:2011) and processed under the Compost Quality Protocol, CQM [in England, Wales and Northern Ireland] can make excellent constituents for growing media which can be cost-effective alternatives to peat [Scotland does not require the CQM but does require PAS 100 for compost to be classed as a product]. Green compost now makes up 26 per cent of all peat alternatives used in growing media, and at 10 per cent of the total material used in amateur products overall (peat included) it is one of the most used alternatives in amateur growing media.

Quality BSI PAS 100 composts are made using independently audited processes and are produced by composting source-segregated garden and other biodegradable wastes [e.g. lawn clippings, hedge trimmings and tree prunings] under carefully controlled conditions outdoors or in a contained (in-vessel) system. In some cases, food and food-processing wastes may be included in the starting materials (or feedstocks) for the composting process. In all cases, the feedstocks used to produce each compost will be clearly stated on the dispatch note or product label. Quality BSI PAS 100 composts are produced by skilled and experienced professionals. Many of these compost producers are keen to develop closer working relationships with growing media manufacturers in order to better understand the nature of composts required for this sector, so that they can tailor their production processes towards achieving the necessarily stringent requirements. The benefits associated with using quality composts in growing media are discussed in the following pages.

BSI PAS 100:2011 for composted materials acts as a baseline specification, which assures that compost is produced to a level of consistency, reliability and safety laid down by the specification. However, PAS 100 does not set limits for all characteristics required by specific end users such as growing media manufacturers. Guidelines which aim to assist producers of composted green materials to better understand and meet the specific requirements for composts to be used in growing media have recently been published by WRAP (Guidelines for Specification of Composts for Growing Media, WRAP, 2014). These guidelines have been developed in partnership with key stakeholders, including growing media manufacturers and compost producers, with input from the Organics Recycling Group (ORG), which is part of the Renewable Energy Association (REA), and other experts. As the document title indicates they are guidelines only and a compost producer will need to agree exact specifications for compost products with their customer, who may have more exacting standards, in order to guarantee that compost products meet their needs. For the production of food crops for example, human health standards set by the retailer or farm assurance scheme may be more stringent than those set out in this good practice guide and should be referred to.

Users of composts are advised to trial and test the material prior to commercial use.

### 1.2 The composting process

The aerobic decomposition of organic materials is brought about by microbial respiration, a process that involves consumption of oxygen (O₂), the production of carbon dioxide (CO₂) and the release of energy in the form of heat. Aerobic activity is dependent on the supply of oxygen which must be maintained within the composting material. If the supply of air to an actively composting material is restricted, for example through inadequate turning of the material, then the oxygen is rapidly consumed leading to anaerobic conditions and the production of organic acids (which are toxic to plants) and odours.

In creating a large mass of decomposing material (in a windrow or an in-vessel system) the heat is retained leading to an increase in temperature of the material. This causes acceleration in the rate of decomposition, the shift in the microbial population to a thermophilic population, and a high temperature, which effectively kills off potentially pathogenic (disease causing) microbes and weed seeds. As the available energy in the material is used up, the rate of microbial respiration decreases and the temperature drops. Eventually, the rate of aerobic biological activity is considered to be sufficiently low for the material to be stable. The composting process continues more slowly as the mesophilic microbial population in the now cooler material forms humus-like organic matter, which can form part of a good growing medium. As the compost matures, ammonium-nitrogen is converted to nitrate and the compost becomes ready for use.

In BSI PAS 100:2011, this composting process is divided into three phases:

- **Sanitisation** - the initial phase of composting during which weed seeds are destroyed and the risk of human, animal and plant pathogens being present is reduced to an acceptable level as a result of the intense microbial activity and high temperatures. PAS 100 requires composters to tightly define this stage in terms of time, temperature and if a windrow system, turning.

- **Stabilisation** - the phase of composting following sanitisation during which the rate of aerobic biological activity has slowed and the material is considered safe to use. This may be indicated by a downward trend in temperatures within the composting mass and a reduction in oxygen uptake rate or carbon dioxide evolution from the compost. Stable compost should not be attractive to vermin, should not give off any malodours, and should not support the re-growth of pathogens.

- **Maturation** - the final stage of composting (which can last up to 6 months) during which time humus formation completes, nitrification (the microbial conversion of ammonium to nitrate) takes place, and the rate of biodegradation is lower than during stabilisation.
1.3 Benefits of using composts in growing media

High quality PAS 100 compost can be a good ingredient in peat-free or reduced peat growing media. There are a number of advantages of using BSI PAS 100 compost in a growing medium:

- Compost provides major nutrients such as nitrogen, potassium, phosphorus, sulphur, and magnesium as well as trace elements. It provides nutrient holding capacity and water holding capacity in the growing medium in a similar way to loam.

- Compost may assist in the suppression of some plant diseases because it is more biologically active than other growing media constituents such as peat. It is thought that the populations of micro-organisms can out-compete, or in some cases, directly attack plant disease-causing organisms.

- Compost may reduce the growth of liverworts, moss and algae when used in growing medium blends that tend to retain a drier surface than 100% peat mixes.

1.4 The challenges associated with using composts in growing media

Quality composts are very different from peat, and need to be handled differently from peat-based growing media.

Composts have naturally high nutrient levels and relatively high bulk density, and for this reason, rates of compost inclusion in a growing medium are limited, usually to a maximum of 40-50% by volume, depending on the type of growing medium to be made. The compost must therefore be blended with an appropriate low nutrient/low bulk density material such as peat, bark, coir fibre or wood fibre in order to reduce the bulk density of the mix and, if necessary, reduce the nutrient content. High nutrient levels are associated with a high total salt content (measured as Electrical Conductivity (EC)) and such levels can damage plant roots, germinating seedlings and young plants. Growers must recognise that growing media based partly on composts differ from those based on peat, and they are likely to need to modify nutritional regimes to reflect the differences in compost-based growing media. High bulk density tends to make the mix less free-draining, it also causes problems with handling of plants in pots and higher transport costs. Growing media based partly on compost is likely to behave differently from peat-based composts when watered. Growers may have to adapt their irrigation regimes in order to ensure that crops receive the correct amount of water.

Some composts can increase problems with insect pests such as sciarid and shore flies when used in certain situations (usually production in glasshouses or polythene tunnels, where warm temperatures and moist conditions can be ideal for the insects to breed).

Growing media are handled by both the gardening public and by workers on nurseries, therefore any ingredients used in them must be safe from a human health point of view and free from human pathogens and any glass or sharp material. Although the standards for BSI PAS 100 quality composts stipulate absolute minimum levels of glass, compost producers wishing to supply into the growing media sector must consistently produce products which contain no sharp materials of any sort. Contaminants such as plastic, whilst not dangerous, are also undesirable because the visual appearance of the end product is important.

The specific end use of the growing medium must be taken into account when using compost as an ingredient. Crops which are sensitive to high pH and high EC (for example azalea and rhododendron) are less suited to being grown in media containing composts than other species. Crops grown to schedules and stringent supermarket specifications are also in a higher risk category (for example indoor pot plants). This is mainly because there is often little flexibility in terms of time or crop performance if the crop grows more slowly than the rate which is expected in a crop grown in more familiar peat-based compost. If a crop does not meet the required standard by the appropriate week number during the year, there are few alternative markets for it and the crop may have to be disposed of, with obvious financial implications. There are however, good commercial examples where more sensitive plant species/types are being grown successfully in growing media based partly on composts.

Growing media manufacturers and growers are encouraged to use compost-based growing media on a trial scale before using them on large crops, in order to determine how best to use them. Non-ericaceous shrubs and trees grown for landscaping are less particular in their requirements, and the slow release nutrients provided by compost can be beneficial for these longer term crops.

Commercial growers know what they can achieve in terms of crop quality, growth and health when their crops are grown in peat-based growing media. Similar crop performance would be expected from peat-free and reduced peat media. Although amateur horticulturists may have rather less knowledge of what to expect in terms of plant performance in given situations, they too would be unlikely to continue buying reduced-peat or peat-free growing media if their plants failed to grow and thrive. For these reasons, only the highest quality composts with consistent physical, chemical and biological characteristics are suitable for use in horticultural growing media.

All composts destined for use in growing media must be produced in accordance with the requirements of BSI PAS 100:2011 and the Compost Quality Protocol as a minimum regulatory requirement. (NB. Compliance with the Compost Quality Protocol is not required in Scotland). The Quality Protocol for Compost (CQP) was launched in 2008 and was revised and re-published in 2012 – it defines when compost is considered a product, and no longer falls under the waste regulations. One of the requirements of the CQP is that composts are produced to BSI PAS 100. Extra parameters and controls over and above BSI PAS 100 are recommended for use of compost in a growing media to ensure consistent performance and a product that is fit for the purpose.
2.0 Feedstock types

Composts which are intended for use as growing media constituents must be made from source segregated feedstocks as defined in BSI PAS 100:2011 and the Compost Quality Protocol. Further details, exclusions and limits are detailed below.

2.1 Green garden wastes

Most composts which are intended for use as growing media constituents are based wholly or mainly on separately collected plant waste materials (lawn clippings, hedge, tree, shrub prunings etc.) from municipal and domestic parks and gardens. Following appropriate feedstock and compost management processes (see the following sections and guidance on process management in BSI PAS 100:2011), green garden wastes can make excellent compost suitable for inclusion in growing media.

2.2 Other wastes

With the full knowledge and prior written agreement of the purchaser, compost for inclusion in growing media might also be based partly on the following source-segregated feedstocks, which are approved for use according to BSI PAS 100:2011 and the Compost Quality Protocol:

- Clean cardboard (i.e. brown, white or coloured card which is free from plastic, metals, non-biodegradable coatings and plastic fittings such as lids).
- Clean wood wastes (which must not contain any plastic coatings or veneers, preservatives or metals such as staples and nails).
- Food processing wastes (including or excluding meat).
- Domestic and commercial kitchen and catering wastes (including or excluding meat).
- Manures/animal bedding of animal origin. These are permitted feedstocks for composts produced according to BSI PAS 100:2011 and the Compost Quality Protocol. The composter must ensure that manures, slurries and animal bedding are not sourced from livestock that have grazed on land or forage treated with persistent herbicides, unless the herbicide label and regulatory guidance have been followed. This may mean that manures cannot be accepted for composting within a year of their production (see following sections for more guidance).

Feedstocks which contain high concentrations of nitrogen (N) e.g. food processing wastes, kitchen wastes and animal manures, slurries, should be included in limited volumes in the feedstock mix (i.e. < 20% by volume). This is because composts based on large volumes of animal manures for example, are more likely to have high salt concentrations (EC) and high concentrations of ammonium-N, neither of which are desirable for growing media.

All wastes which are subject to the Animal By-Products Regulations (e.g. meat-included food processing wastes and domestic/commercial kitchen wastes) must be composted according to these regulations.
The following materials are prohibited in composts according to BSI PAS 100:2011 and the Compost Quality Protocol and are therefore not permitted in certified composts which are to be used in growing media:

- Sewage sludge.
- Mixed waste of any type (i.e. waste that has not been separated at source).
- Post-consumer wood waste that is contaminated with metal, glass, plastic and potentially toxic preservatives.

### 2.3 Feedstock mix

For the composting process to proceed efficiently, the carbon:nitrogen (C:N) ratio of the feedstock mix should be close to 30:1. This is the value at which the microorganisms on which the composting process depends can most effectively start to break down the feedstocks. It is particularly important to achieve a feedstock C:N ratio which is close to this value when the finished compost is intended for high value end uses such as growing media. Feedstock mixes which contain excess N tend to be more likely to produce odours and can lose N in the form of ammonium. Feedstock mixes that contain excess C tend to be slow to heat up and are likely to be slow to mature. Green waste alone can often achieve the ideal C:N ratio when shredded and mixed. However, it may be necessary to add materials containing high concentrations of N (such as grass or food wastes) to materials containing a lot of C (such as sawdust or shredded wood) in order to achieve an acceptable C:N ratio. Similarly, it may be necessary to add materials containing a lot of C to food wastes in order to adjust the C:N ratio of the starting mix.

Carbon:nitrogen ratios are calculated by measuring the total N content of the compost by Kjeldahl analysis, whilst the C can be calculated from the organic matter content, which can be measured as loss on ignition in an oven at around 430°C over 5 hours and dividing this value by 1.72. The ratio is often calculated by the laboratory and published along with other results. Some examples of C:N ratios of feedstocks which can be used to make compost are:

- Shredded tree bark ~ 275:1.
- Straw ~ 80:1.
- Vegetable residues, food wastes and grass clippings ~ 10:1.
- Mixed garden wastes ~ 20:1 to 40:1.

When pine bark or other materials with high C:N ratios are added to growing media, it is generally recommended to add some additional N to the mix as the bark will ‘lock up’ N and can deplete the level of soluble N, causing poor plant growth. This N lock up occurs because the microorganisms which break down organic materials require a particular balance of C:N (around 30:1) in the materials which they are living on. If they have insufficient N for their needs in the material they are decomposing, then they will remove it from whichever source they can. Peat (C:N ~ 30:1 to 40:1) and soil (C:N ~ 10:1) have low values for C:N ratio and would not be expected to immobilise N as they are stable materials.

Changes in feedstock mix are likely to result in changes in the physical and chemical properties of the finished compost. In particular, inclusion of food waste (which often contains high concentrations of potassium) in the feedstock may increase the electrical conductivity of the finished compost. For this reason, it is recommended that the rate of inclusion of composts such as these, which also contain high N, should be limited to a low percentage (<20% by volume).

It is important to realise that if new feedstocks are introduced, or if the balance changes (e.g. due to the arrival of large quantities of high N feedstock in summer, or high C feedstock in winter) then the compostor must manage the process accordingly and test the product as it approaches maturity. Composters must ensure that they are producing compost of consistent quality for dispatch into the horticultural market. If it is found that the compost does differ from normal, then the compost producer must understand in what ways it differs and buyers must be informed.
2.4 Feedstock management

The way in which the feedstock is managed prior to and during batch formation has a profound effect on the physical and chemical properties of the finished compost. Particle size is particularly important, since it affects the extent to which air can enter the compost during processing. There are no hard and fast rules as to exactly how feedstock should be shredded or what size the particles should be for outdoor windrow composting: it depends in part on the amount of rain likely to fall during the compost process. As a very general rule, feedstock should be shredded more coarsely in the wetter Western regions than in the drier Eastern regions of the UK. However, the machinery used, composting processes used, windrow size, aeration method and frequency of turning all have an impact, and experience will dictate what feedstock preparation methods work best on individual sites in order to ensure that the composting process works effectively. If the compost heats rapidly to the required temperatures following batch formation and if there is little evidence of cold pockets or malodours, then it is likely that the feedstock is being prepared in an appropriate manner for the site in question. With in-vessel systems composting materials classed as animal by-products, there are strict requirements on the particle size of such material under the Animal By-Products Regulations.

Moisture management during feedstock preparation is critical. The feedstock moisture content should be 51% m/m or greater [for the recommended PAS 100 compost sanitisation step] immediately following batch formation, since the composting process will proceed most efficiently in this range. For this reason, it may be necessary to wet the feedstock after shredding and prior to batch formation (as is common practice on PAS 100-certified sites). However, it may also be necessary on rare occasions to cover the feedstock if very heavy rain is forecast to fall on material which has been sitting for several days prior to shredding (wet, old feedstock does not shred well, may become anaerobic, and may not mix well after shredding).

Effective mixing of the shredded feedstock is important in order to ensure that the feedstock C:N ratio is as consistent as possible throughout the batch. This will minimise the likelihood of odours as the process begins, reduce the occurrence of pockets where the composting process fails to progress due to an excess of woody material, and will ensure consistent composting.

When preparing compost for high value end uses such as for inclusion in growing media, it is important to process the feedstock and conduct the process on a purpose-designed concrete pad. Hard-standing or field soils are not suitable due to the likelihood of product contamination with stones. It is without doubt easier to exert control over the properties of the finished compost if the composting process is conducted under cover [e.g. in an in-vessel system or in covered windrows].
3.0 Feedstock acceptability

3.1 Waste acceptance criteria

The quality of the finished compost in terms of it being free from physical contaminants is heavily dependent on the quality of the feedstock used. Compost producers wishing to sell their products into high value markets, such as the growing media market, must be prepared to put a significant amount of effort into working with their feedstock suppliers to minimise contamination (by both physical contaminants and other non-permitted materials) at source. Most PAS 100-certified compost producers set a threshold for contaminants in incoming feedstock, whereby loads containing more than a nominal 5% of contaminants by volume are rejected and may be returned to the sender. It is possible to set lower contamination thresholds for incoming feedstock, whereby for example, loads are rejected if they contain more than 2% contaminants by volume. However, contamination levels as low as this can be difficult to assess quickly and accurately in practice. No specifications currently exist for feedstock quality in terms of limits for specific parameters such as physical contaminants, and feedstock samples are not normally tested prior to the start of the composting process, therefore growing media manufacturers/growers must liaise with their suppliers and if necessary visit the site regularly to ensure that the feedstocks being used for their products are of appropriate quality.

It should be made clear to feedstock suppliers that the site standard operating procedures for acceptance/rejection of loads are strict due to the intended high value market for the finished compost. In order to avoid a high percentage of rejected loads and ongoing difficulties in terms of relationships with feedstock suppliers, it is a good idea for the composting site manager to spend time with these suppliers, exploring practical methods for reducing contamination and discussing good practice options. The eventual aim should be to ensure that every single individual supplier of waste to the composting site (whether domestic or commercial) has a broad understanding of what should and should not be included in the feedstock. Carefully thought-out, simple educational campaigns involving advertising and leafleting of individual waste producers have been successful in reducing feedstock contamination at several PAS100-certified compost facilities. Particular care should be taken to inform individual waste suppliers that glass and metals should never be included in source-segregated organic waste intended for collection, since the presence of a single glass bottle in a load may result in rejection of that load. Effort spent in reducing contamination of loads coming on to the site should pay dividends over time and should greatly reduce time spent inspecting and cleaning feedstock once it arrives on site.
3.2 Inspection and monitoring of feedstock

Inspection and monitoring of feedstock on arrival forms a vital part of the production process for composts intended for high value markets. Elimination of contaminants at the beginning of the process ensures the product is safe with respect to hazards associated with physical contaminants. Composters should not rely solely on screening, air-classifier and/or other mechanical equipment for separating compost particles from physical contaminants. Although conventional, well-configured screening machinery and equipment can be very effective at removing pieces of metal and plastic, it has not been as effective at removing pieces of glass. Consequently, composters should focus primarily on control of delivered materials (inspection and rejection of contaminants or contaminated loads) before they are fed into the composting process. They should also work with feedstock suppliers to minimise contamination at source.

In addition to the measures described above, compost producers are likely to require manual labour to inspect incoming material and to remove physical contaminants. Incoming loads should be spread thinly over a concrete surface and physical contaminants removed by hand for disposal. This approach also allows for careful assessment of the percentage contamination of the load by volume. Some compost producers have picking lines whereby manual labour is used to physically remove contaminants from feedstock which is passed along conveyors prior to shredding. This approach is ideal and should be instigated where commercially feasible. It should be possible for those responsible for assessing feedstock quality to reject the load at any stage during the feedstock assessment process, for example several hours after receipt of the load, if glass is found hidden under piles of green material. An open, but clearly defined relationship with feedstock suppliers is important for this reason.

Feedstock preparation is important and the reasons behind the need for it should be explained clearly to the responsible site personnel, who in practice often take great pride in their work. Experience has shown that it is often better for staff performance and morale to employ two or more people part-time checking and cleaning feedstock for shorter periods, rather than have one person working full time on the job.

3.3 Minimising the risks associated with herbicides/pesticides

A number of the synthetic auxin herbicides (which include clopyralid, aminopyralid, fluroxypyr, 2,4-D, dicamba, and quinmerac) are known to not break down fully during the time-frames of commercial composting operations, and if present at sufficient concentration in the finished compost, could present a risk of damage to sensitive plants grown in those composts. Recognising this, there are statutory restrictions in place which mean that – when label guidance is followed – residues of persistent herbicides should not be present in materials destined for composting, and the resulting composts will present no risks to crops.

A number of plant families are insensitive to these herbicides – particularly the Poaceae (Gramineae) or true grasses, whilst a number are sensitive:

- Asteraceae or Compositae (daisy family)
- Fabaceae or Leguminosae (pea and bean family)
- Solanaceae (potato and tomato family)
- Umbelliferae (carrot family)

Incidences of herbicide contamination in compost have been reported outside the UK (for example, the USA and New Zealand), and there have been a number of incidents where contaminated manures have been used on allotments in the UK. In this context, WRAP supported a project in 2010 to investigate the questions surrounding clopyralid and aminopyralid in composting systems. This concluded that the risks from persistent herbicides in UK composts were likely to be low, but made a number of recommendations, including that the PAS100 plant response test be validated against composts with known herbicide concentrations, to test its sensitivity.
The standard PAS100 plant response test is still considered suitable for screening composts intended for use in agriculture and field horticulture, but the evidence suggests that it is not sufficiently sensitive to detect herbicide concentrations of interest to the growing media sector – specifically when composts are to be included in growing media used for cultivating sensitive plant species. A more sensitive bioassay has therefore been developed using field bean (Vicia faba cv Fuego), and by comparing the response of field bean and a range of common ornamental, herb and vegetable species to known concentrations of clopyralid, it has been possible to develop a 0 to 5 scoring system for the presence of herbicides in composts. Using the field bean test to examine around 300 compost samples submitted for PAS100 testing during 2012, the majority showed very low levels of herbicide contamination. Under the new scoring system, it was estimated that 13% of those samples might not be suitable for use in growing media intended for supply to the open market (ie, where there is the potential for growing media to be used for cultivating sensitive plant species).

Since growing media could be used to cultivate both sensitive and insensitive plant species, it is recommended that all batches of compost intended for supply to the growing media sector be subjected to testing using the field bean (Available on the ORG website), and that any composts scoring symptoms greater than 2 are not used in growing media. This recommendation covers finished composts, but a number of other actions are also recommended, to minimise the potential for contaminated material to enter composting systems:

- Compost producers should ensure that any animal manures included in the feedstock have not been produced from livestock fed on herbage treated with persistent herbicides.

- Where composters are accepting local authority green wastes for processing, they should work with their local authority suppliers to remind householders and landscapers to read herbicide product labels carefully before use, and to follow the guidance – particularly the instructions on disposal of plant wastes treated with the herbicide.

Image courtesy of Stockbridge Technology Centre
All composters should ensure that they follow the prevailing advice and guidance from Organics Recycling Group – Renewable Energy Association (ORG-REA) on this subject in order to minimise the risks associated with herbicides (www.organics-recycling.org.uk). Current advice is to ensure that composters should not knowingly compost plant tissues that have been treated with the herbicides clopyralid or aminopyralid (including animal bedding) or manures from animals that have eaten plant tissues treated with either of these compounds. Each composter should, as far as practicable, check with each supplier of the feedstocks, that these herbicides have not been applied to the material. Similarly, each supplier of manure or stable waste for composting should work within the appropriate regulatory controls and in line with the manufacturer’s guidelines. Composters may decide to completely exclude manures or stable wastes from their feedstocks where the resulting composts are intended to be supplied into sensitive applications and/or they are in doubt about herbicide use from particular feedstock sources. See ORG link for an up to date list of products containing these two herbicides.

Although such sources are expected to present a low risk, where composters are accepting local authority green wastes for processing, they should work with their local authority suppliers to remind householders to read herbicide product labels carefully before use, and to follow the guidance – particularly the instructions on disposal of plant wastes treated with the herbicide.

Composters should work closely with higher risk feedstock suppliers to ensure risks are minimised and bioassay test their composts more frequently.
There is more advice in section 6.7.4.

4.0 Processing guidelines to avoid contamination and to maximise product quality

In order to comply with the high compost quality requirements set out in the Guidelines for Specification of Compost in Growing Media (WRAP, 2014), compost producers should take great care to consider every part of the compost production process which follows batch formation, in order to minimise contamination of the compost and maximise product quality. Compost producers wishing to supply to the growing media sector should aim to produce a consistent, high quality product all year round. In particular, they should tackle the issues of physical contamination (partly addressed through appropriate feedstock selection and treatment, covered in Section 3), weed seed risk, sanitisation, stability/maturity and bulk density.

4.1 Process conditions

The optimum processing conditions for compost which is intended for use in growing media are exactly the same as for all PAS 100 composts. However, particular care should be taken to ensure that the process is proceeding optimally at every stage, since poor process conditions may affect the quality of the final product and will almost certainly slow the composting process, leading to extended processing periods or compost of variable maturity. Particular care should be taken to ensure that compost temperatures remain as required and that the moisture content of the compost is within an acceptable range. During sanitisation and stabilisation phases of composting, PAS 100 requires the composter to maintain moisture content within the ranges he/she has set. Guideline values suggested in PAS 100’s Annex B are equal to or greater than 51% m/m during the sanitisation phase and at least 40% m/m during the stabilisation phase. Moisture content should not be greater than 65% m/m in order to ensure the composting pile has enough air available for the aerobic microbes. If composting outdoors, the compost producer should be ready to cover the compost at any stage during the process in order to ensure that it does not become too wet. If the compost does become too wet, the process will slow, could turn anaerobic, and wet compost may not screen well (see Section 5).

4.2 Minimisation of physical contaminants in the finished product

There is little point in compost producers striving to achieve feedstocks which are largely free from physical contaminants if they then fail to protect the compost from contamination from external sources during the composting process. Physical contaminants in the form of plastics, paper and card can sometimes blow in to the composting site and contaminate windrows. If contamination of compost windrows is likely to be a problem, compost producers should consider erecting windbreak fences to catch plastics, covering the windrows in breathable membrane and/or housing the windrows to prevent aerial contamination. It is also good practice to hand pick windrows periodically and prior to screening, for example after each turn, to reduce any contamination missed earlier.
4.3 Production of compost with appropriate bulk density

Compost is often heavier than other growing medium constituents such as peat, coir and bark, and can therefore be more expensive to transport and heavier/more awkward to lift when in use. Compost producers should strive to attain products with a bulk density of around 400 g/l (the WRAP specification guideline limits are 400–500 g/l with a maximum of 550 g/l). For this reason, every effort should be made to prevent comports from becoming too wet towards the end of the composting process. This can be difficult, especially during wet periods, towards the end of the composting process, when compost temperatures are dropping, and particularly when the compost has been screened prior to maturation. In order to produce a consistently high quality product, many compost producers will find that they must cover the windrows, at least during maturation, or create larger piles of product to increase water run off. Ideally, the compost should be housed in ventilated sheds, but breathable membrane covers can also be used. Just prior to screening, compost producers should aim to produce a product that contains 30 to 40 % moisture in order to achieve a sufficiently low bulk density and to increase the amount of compost passing through the screen. Compost should ideally be stored on a well drained concrete floor as it will absorb a great deal of standing water.

4.4 Production of compost which is free from weed seeds

Weed seeds are usually killed by composting, however it is important to note that weed seeds can be blown onto the compost during maturation or storage. The standard operating procedures required as part of BSI PAS 100:2011 should minimise any risk of weed seeds in the finished compost, and the BSI PAS 100 specification dictates that compost should be free from weed seeds. However, extra care should be taken to ensure that weed seeds do not contaminate the compost during the extended composting/maturation process which is required during the production of compost suitable for high quality end uses such as growing media. For this reason, depending upon the location of the site and compost storage area, it may be necessary to cover the compost as noted in Section 4.2, anytime following the last turning in the stabilisation phase of the composting process, to ensure that wind-blown seeds cannot re-contaminate the compost.
4.5 Production of compost which is sufficiently stable and mature

A stable compost is one where biological activity and biodegradation has completed and slowed enough and will not resurge under altered conditions such as manipulation of moisture or oxygen levels, or through the addition of a source of water soluble nitrogen. A mature compost is one where the rate of organic matter decomposition has slowed to the point that turning or forced aeration is no longer necessary. Some slower microbial activity and chemical changes carry on, such as the oxidation of ammonium ions to nitrate continues and beneficial soil micro-organisms that were inhibited or destroyed during the active composting process begin re-colonising the material and improve it.

The stability/maturity of compost is measured (according to PAS 100:2011) in terms of the carbon dioxide (CO₂) evolution rate from the compost. Compost which is to be used as a component of growing media must be more stable/mature than that required for PAS100:2011 composts in general, since there is a strong likelihood that the plants which will be grown in it will be sensitive to some of the features associated with immature composts (e.g. high conductivity and organic acids). It is therefore currently recommended that the CO₂ evolution rate for compost to be used in growing media should be less than 8 mg CO₂/g organic matter/day, whereas PAS 100:2011 composts for general use have a maximum CO₂ evolution rate of less than 16 mg CO₂/g organic matter/day. For this reason, compost which is intended for use as a constituent of growing media will require a longer maturation period than that required for compost intended for use as a soil conditioner or mulch. It may also have higher aeration requirements and require more frequent turning during the stabilisation phase, and perhaps a longer stabilisation phase. There are no hard or fast rules governing the length of the process required to produce compost which is sufficiently stable for use in growing media. Compost retention time alone, may not be a reliable indicator of stability, and compost producers are encouraged not simply to rely on the measurement of process duration as a gauge of stability and maturity. This said, a composting time of 12 to 20 weeks would be a rough guide. The duration of the various phases of composting (in particular, stabilisation and maturation) will depend on the nature of the feedstocks, the exact procedures used during the composting process and on the weather/processing conditions, and may vary from season to season or even from batch to batch. For this reason, compost producers are encouraged to undertake recognised testing of the stability/maturity of their composts at various points during production, in order to determine when stabilisation and maturation have been achieved (see section 6.1.8 for how to do this).

The compost stability test method (ORG020) was principally developed on evidence provided for composts based on green waste feedstocks, reflecting the prevalence of these composts in the UK industry at the time. Since the test was developed, increasing tonnages of food wastes have been composted along with green wastes and there is evidence that the current ORG020 test may not be appropriate for the resulting green/food composts. The main reason for this is that samples of green/food composts may present conditions (e.g. acidity and/or anaerobicity) that inhibit the aerobic microbial population, resulting in very low microbial activity, and high (apparent but not necessarily correct) compost stability under the ORG020 test. Work is underway to evaluate the suitability of the current compost stability test, along with a range of alternatives.
5.0 Product screening

Compost of a 0 - 10 mm grade will be suitable as a constituent for a wide range of growing media applications. However, for some specific applications such as growing media for longer-term crops such as nursery stock in larger containers, a proportion of coarser grade material is likely to be more appropriate (up to 20 mm for example). Similarly, finer grades of compost may be required for production of growing media for seedlings or cuttings in small modules (e.g. 0 - 6 mm). The compost should be shown to the customer prior to sale and particle size specification should be set by the customer and agreed prior to delivery.

Some BSI PAS 100 certified compost producers currently use grading/screening equipment which has been designed for other applications (e.g. root crop grading) for product preparation, however, such equipment is unlikely to be suitable for production of composts intended for use in growing media. Growing media manufacturers are likely to specify that compost intended for their use passes a laboratory particle size distribution analysis test whereby only a very small quantity of the compost fails to pass through a sieve of the particle size specified. For example, where a particle size of 0 – 10 mm is specified, the ideal would be that all particles pass through a 0 – 10 mm sieve. Purpose-built punch plate trommel screens, which have been specifically designed to screen compost are an example of the type of screen required in order to produce compost of consistent, defined grades.
6.0 Product testing

6.1 Why test compost which is to be used as a constituent of growing media?

Compost producers must agree with their customers the frequency of testing, and the type of additional tests that should be conducted on the finished compost. Agreed, clearly documented procedures should be followed if batches fail to conform to the agreed standards. Compost that is intended for use in growing media is generally subjected to a whole series of chemical, physical and biological tests (some conducted on site, some at a REAL approved laboratory) for two main reasons:

a. To ensure that the compost is safe to use - these tests form the central suite of laboratory analyses that are required for BSI PAS 100:2011 certification. This includes tests and limits for potentially toxic elements such as copper and lead, for physical contaminants such as plastics, glass and stones, for pathogenic indicator micro-organisms such as Salmonella spp. and E. coli and tests to ensure that the active phase of composting has finished and the material is stable. A plant growth test provides additional reassurance that the material is safe to use and helps indicate that it shows no signs of phytotoxicity.

b. To ensure that the compost is fit for purpose - these tests are used to establish that a particular batch of compost is suitable for use in a specific market sector such as growing media. They provide an additional level of quality assurance above and beyond the general PAS 100:2011 specification, and make up the further laboratory testing that is usually included in a PAS 100 suite of laboratory tests. This includes tests for bulk density, moisture content, pH, electrical conductivity, soluble nutrients (including ammonium and chloride), and testing for compost maturity.

The precise specifications required by the growing media manufacturer will depend on the type of plants which will be grown in the final growing medium, the percentage inclusion of the compost and the physical and chemical nature of other constituents being used in the growing media. Depending on the test results obtained for a particular batch, and its intended use, the appropriate rates of use may be as low as 5% but could be up to 40-50%. The growing medium formulator must evaluate the suitability of any particular source of composted material and must determine the appropriate limits and rate of use according to technical and commercial factors.
6.1 Why test compost which is to be used as a constituent of growing media?

Compost that is to be used in growing media must meet the BSI PAS 100:2011 specification and should meet additional guideline values for the following parameters:

- Bulk density.
- Moisture content.
- pH.
- Electrical conductivity.
- Water extractable ammonium.
- Water extractable sodium.
- Water extractable chloride.

Also, the guideline values for the following tests are stricter than the requirements for PAS 100:2011:

- Particle size.
- Stability/maturity.
- Sharps.
- Glass, metals, plastic (limits are suggested on an individual material basis).
- Stones.

The rationale for testing for these parameters is outlined below. Compost producers can refer to the "WRAP Guidelines for specification of compost for growing media" (WRAP, 2014) for recommended limits.

6.1.1 Bulk density

Compost consists of solid material and spaces. The spaces are filled with either air or water. Plants need both air and water, and so the relative proportion of solid material, air-filled spaces and water-filled spaces is important in determining the ideal physical conditions suitable for plant growth. The fresh bulk density of compost is the mass of solid material (including water) per unit volume. It is normally expressed in g/l or kg/m³ (1 g/l is equivalent to 1 kg/m³). Lower bulk density values (400-500 g/l) are desirable for growing media to reduce the weight of material that has to be transported per unit volume.

Dry bulk density is the mass of dry solid material (excluding water) per unit volume, and is related to the porosity of the material.

See the WRAP Guidelines for specification of compost for growing media (WRAP, 2014) for recommended limits.

6.1.2 Moisture content

A growing medium should contain a suitable ratio of spaces filled with water and spaces filled with air. Too much water and the supply of oxygen to the roots is restricted, too little water and the uptake of water and nutrients is restricted. The moisture content can be expressed as either the mass of water per unit mass of compost [g water/100 g fresh compost which is equivalent to % water content] or volume of water per unit volume of compost (volumetric water content expressed as cm³ water per cm³ of compost). Relatively low moisture content (around 30 - 40%) is desirable for growing media to reduce the weight of material that has to be transported per unit volume. See the WRAP Guidelines for specification of compost for growing media (WRAP, 2014) for recommended limits.
6.1.3 pH

pH is a measure of the balance between acidity and alkalinity, and is expressed in terms of the concentration of hydrogen ions (these are the ions that contribute to acidity). Most plants prefer a (soil) pH value of around 7 with a range of up to two units on either side. Ericaceous plants are an exception, preferring more acidic (lower) pH values.

The concentration of hydrogen ions is not normally as critical to plant growth as the effect the resulting acidity has on the solubility (and therefore availability to plants) of nutrients. For example, high pH values cause a reduction in the solubility of iron, and increase the solubility of molybdenum, so changes of one or two pH units can have a significant impact on the availability of nutrients.

Growing media manufacturers usually aim for a pH of around 5.5 - 6.0 if formulating media based on peat. Growing media containing compost will have greater chemical buffering so in practice it is unlikely that problems such as iron deficiency will be seen even at pH values as high as 7.5 in the final medium mix. Problems such as this would definitely occur in peat-based substrates which had been limed to that pH (due to the free calcium carbonate present). The range of optimum pH values in growing media based partly on compost are therefore likely to be wider and higher than those in peat-based media. See the WRAP Guidelines for the Specification of Quality Compost for use in Growing Media (WRAP, 2014) for recommended limits.

6.1.4 Electrical conductivity

Electrical conductivity (EC) is the ability of an aqueous extract of compost or soil to conduct electricity and is a function of the concentration of all the ions (e.g. potassium, sodium, chloride, ammonium, nitrate etc.) present in the extract. A high EC value means there is a high concentration of ions in solution, which can indicate a high concentration of plant nutrients such as potassium, or a high concentration of sodium and chloride ions, which can be damaging to plants.

The EC of the final growing media product will depend upon the inclusion rate of green compost with other materials such as bark; the EC of the compost can therefore be used as an indicator of the possible inclusion rate in a growing media product. See the WRAP Guidelines for the Specification of Quality Compost for use in Growing Media (WRAP, 2014) for recommended limits.

6.1.5 Water extractable ammonium

Ammonium and nitrate are the two forms of nitrogen which plants can use, but nitrate is preferred by most plant species. Ammonium is produced from organic matter by a wide range of microbes in compost and soil. Nitrate is produced from ammonium by a very specialized group of bacteria which only become established in compost during the maturation stage (by a process termed nitrification).

Immature compost normally has a relatively high concentration of ammonium compared to the concentration of nitrate (measured in an aqueous extract) which can negatively affect plant growth. The ratio of ammonium to nitrate tends to drop steadily as compost matures, with nitrate tending to predominate in mature composts. Many plant species are sensitive to high ammonium concentrations in growing media, particularly when young, and this is one of the reasons that longer maturation periods are required for composts intended for use as growing medium constituents. Water-extractable ammonium is a useful indicator of the plant-available nitrogen in compost, but it is also an indicator of compost maturity. If the concentration of ammonium-N is greater than 50 mg/l in compost which is to be used as a growing medium constituent then the value obtained should be less than that for nitrate. If this is not so, then the compost should be matured for longer. If ammonium-N concentrations in loamless growing media are around 100 mg/l or higher [ADAS Index 3] then toxicity to emerging seedlings and young plants is possible, particularly under low light conditions e.g. early spring sowing of seeds. In addition a high concentration of ammonium-N will affect uptake of other ions, especially calcium, leading to leaf tip burn. At concentrations above 150 mg/l ammonium-N in the growing medium [ADAS index 4] there is a high risk of toxicity to young plants. See the WRAP Guidelines for Specification of Compost for Growing Media (WRAP, 2014) for recommended limits.
6.1.6 Water extractable chloride

High concentrations of chloride can be toxic to plants. A high EC value may indicate high chloride, but not necessarily so, therefore it’s important to measure the concentration of chloride in an aqueous extract of compost to ensure it is at an acceptable concentration. See the WRAP Guidelines for specification of compost for growing media (WRAP, 2014) for recommended limits.

6.1.7 Particle size

Particle size is determined by the initial shredding of the material and the screening of the material following composting. The size of particle influences the bulk density and the potential final use of the media, for example a finer material might be used for seedling compost, but a coarser particle size may be more appropriate for a container mix.

Particle size is determined analytically by passing the material through a series of sieves of decreasing mesh size, and measuring the weight of material retained on each sieve.

As a general rule, a material with a finer particle size will be more consistent and will be less likely to contain physical contaminants. See the WRAP Guidelines for specification of compost for growing media (WRAP, 2014) for recommended limits.

6.1.8 Stability/maturity

Composting is based on a microbial process that involves consumption of oxygen (O2), production of carbon dioxide (CO2) and the release of energy in the form of heat. Work is presently underway to re-evaluate the suitability of the current compost stability test for use with green/food composts typically produced in the UK. This may lead to changes to recommended procedures for stability testing of composts. The stability and maturity of compost (capacity for aerobic biological activity) can therefore be estimated from the capacity of the material to consume O2 or produce CO2 under aerobic conditions, or from the capacity of the material to generate heat (self-heating test). European standard methods for measuring stability of compost based on self-heating and on oxygen uptake have been developed (BS EN 16087-1:2011 and BS EN 16087-2:2011). The UK has also developed a laboratory method (ORG0020) which is based on CO2 production (Wood et al., 2009) and is currently used as part of BSI PAS 100. This test forms part of the standard PAS 100:2011 suite of laboratory tests. See the Guidelines for the Specification of Quality Compost for use in Growing Media (WRAP, 2014) for recommended limits.

For woody composted material with high C:N ratio it may also be useful to measure the Nitrogen Drawdown Index AS 3743 – 2003 (Australian Standard, Appendix E). This test indicates whether green compost incorporated into a growing medium to which nitrogen fertilizer has been added is likely to immobilize the added nitrogen causing a temporary shortage in the growing medium. A target index of 1 is recommended.

6.1.9 Sharps

Sharps are unacceptable in any compost to be used in growing media. As part of the standard laboratory testing for BSI PAS 100:2011 the presence of any sharps is quantified as part of the physical contaminants and particle size distribution test.

Further checks should be made to ensure that no sharps are present in any batch of compost. See the WRAP Guidelines for Specification of Compost for Growing Media (WRAP, 2014) for recommended limits.

6.1.10 Stones

Stones don’t constitute a hazard for plants, and small stones (< 2 mm) are unlikely to present a problem in growing media. However, stones can damage equipment used in the production of growing media, therefore the limits for stones in compost to be used in growing media are stricter than for general BSI PAS 100:2011 compost. See the WRAP Guidelines for Specification of Compost for Growing Media (WRAP, 2014) for recommended limits.
6.2 Sampling

The extent to which compost test results genuinely reflect the true values of individual parameters in the batch is dependent on a truly representative sample being sent for analysis. Effective sampling is vital if representative accurate test results are to be obtained. The sample used for analysis should be representative of the entire batch. Details of correct sampling procedures are given in BSI PAS 100:2011. Staff should be made aware through training of the importance of representative sampling. They should also understand the reasons behind the site standard operating procedures for sampling and the potential implications if short-cuts are taken when sampling. Refer to the Guidelines for the Specification of Quality Compost for use in Growing Media [WRAP 2014] for information on sampling frequency.

6.3 On-site testing

BSI PAS 100:2011 testing will be undertaken by the compost producer at the end of the process period as specified in the BSI PAS 100 certification approval in order to validate and monitor the process (e.g. 8 weeks for open windrow composting). However, compost that is intended for use in growing media is likely to undergo further maturation for several months on site before dispatch. On-site testing can provide useful information on the progress of this final stage of the composting process, e.g. when the compost is mature. Growing media manufacturers may also require test results for each batch of compost at the point of dispatch from the site.

The following tests can be carried out on-site by suitably trained staff:

- Bulk density.
- Particle size.
- pH.
- Electrical conductivity.
- Stability/maturity.
- Bioassays for plant growth.

6.3.1 Bulk density

Bulk density can be measured relatively easily on site using the methodology described in BS EN 12580:2000. This involves taking a sample of at least 30 litres, placing it in a 20 litre measuring cylinder with a collar and suitable fall controller, and measuring the weight of the compost. A simple calculation will give the bulk density value (in g/l or kg/m³).

6.3.2 Particle size

Particle size is assessed on site by passing a sample of compost through a sieve of appropriate mesh size. For a 10 mm grade, a 10 mm mesh size would be appropriate, and the sieve test can be done prior to measuring bulk density as described in BS EN 12580:2000.

6.3.3 pH testing

pH can be measured on site using the methodology described in BS EN 13037:2000. The principle of the method is that a sample of compost is mixed with deionised water in a ratio of 1 part by volume compost to 5 parts deionised water, and after a fixed period of time the pH is measured using a pH electrode. It is important that the electrode is routinely calibrated and maintained in good working order, as per the manufacturers’ guidance.
6.3.4 Electrical Conductivity testing
EC can be measured on site using the methodology described in BS EN 13038:2000. It is useful to be able to do this quickly and cheaply on site. The principle of the method is that a sample of compost is mixed with deionised water in a ratio of 1 part by volume compost to 5 parts water, and after a fixed period of time the EC is measured using a conductivity electrode. It is important that the EC of the water is also tested and the electrode is routinely calibrated and maintained in good working order, as per the manufacturers guidance. For convenience the pH and conductivity can be measured on the same sample. It is also important to note that portable EC meters usually require the user to measure at a temperature of 25˚C, whereas labs quote that their tests are conducted at 20˚C. If comparing results, it must be remembered that on site readings will be 10% higher than laboratory readings.

6.3.5 Stability/maturity testing
Solivita® test kits can be used to give a measure on site of the stability/maturity of compost. The test is used to analyze the stability of the compost. It is quick, easy to use, and therefore enables more frequent testing than that required for PAS 100:2011. Compost producers supplying the growing media market may need to test every batch in order to reassure customers that the compost has achieved the required degree of maturity prior to dispatch.

The Solvita® test is a commercial kit developed by Woods End Laboratories, USA for routine testing of composts for stability and maturity and was evaluated as part of the ORG 0020 method development specifically for on-site testing. The test measures carbon dioxide evolution and ammonia release in sealed jars using a paddle containing a gel which changes colour in response to the concentrations in the headspace of the container. The colour changes are referenced against a look-up table/chart in order to determine the degree of compost maturation. A Digital Colour Reader can be used for more accurate measurement of the colour changes. The information can be used to assess compliance with stability and maturity standards, to determine compost status and aeration needs, and to provide a guide to product best-use (http://solvita.com/compost).

The result of any biological test will be influenced by moisture, temperature and the duration of the test. A squeeze test is recommended to make sure the compost has a suitable moisture content prior to undertaking the Solvita® test. Compost should be squeezed hard: moisture should appear between the fingers but not drip out if the compost is at the correct moisture content. If the compost is too dry then water should be added gradually to achieve the correct moisture content. The sample should then be left overnight for the sample to equilibrate before carrying out the Solvita® test. The Solvita® test should be carried out for 4 hours and should be at 20-25˚C. Records must be kept of the start time, finish time, and temperature recorded during the test (Woods End Laboratories, 2006).

6.4 Standard laboratory testing as required by BSI PAS 100:2011
The full suite of tests which are required for BSI PAS 100:2011 composts are still required for composts intended for use in growing media. In addition to the obligatory tests for which more stringent target values have been set for composts to be used in growing media (WRAP, 2014) [e.g. tests for stability/maturity and physical contaminants], tests must also be conducted to determine whether concentrations of potentially toxic elements and numbers of human/animal pathogens are sufficiently low. Details of the test methods to be used and the required value/values for each parameter are provided in BSI PAS 100:2011 (BSI, 2011).
6.5  Additional tests to determine plant nutrient content in composts

Most growing media manufacturers will require a full set of tests to show the total and plant-available nutrient content of the compost supplied. This requirement will often be for individual batches rather than according to the frequency of testing required through PAS 100:2011. Plant nutrient content is important, because growing media manufacturers will wish to ensure that growing media for different purposes have an appropriate balance of plant nutrients. Peat is usually almost devoid of plant nutrients, therefore it is simple for growing media manufacturers to calculate what to add. Composts naturally contain the whole range of plant major, minor and trace nutrients in varying quantities. Growing media manufacturers must know what is present in order to calculate the quantities of nutrients to add to the mix to produce the correct balance required. Manufacturers rely on ingredients being within fairly tight tolerances when formulating mixes for different purposes. It is not feasible for manufacturers to change formulations if individual loads are variable in, for example pH and conductivity (which is directly related to total nutrient concentrations) and the onus lies on the composters to ensure consistency as far as possible from batch to batch. Many growing media manufacturers will also test the compost for a range of parameters prior to use.

6.6  Nursery-based trials

It is essential for new growing media containing compost to be trialled on a small scale first on each nursery, in the same way as any other new growing media formulation is trialled before being introduced more generally. This is necessary because different growing media may give different results and may need specific watering and feeding regimes, so growers must adapt crop management accordingly.
6.7 Extra customer specifications

The onus for specifying particular process monitoring techniques and appropriate properties for composts to be used as constituents of growing media lies with the growing media manufacturer. Some growing media manufacturers will want to see the results of extra process monitoring or testing (over and above that required by PAS 100:2011) in order to show that the compost is, for example sufficiently mature, or has followed normal moisture and temperature curves during the composting process.

Some growing media manufacturers may wish to know the air-filled porosity (AFP) of composts being considered for use as growing media constituents. Air-filled porosity is defined as the percentage of the total volume, within a medium, that is air space immediately after the medium has drained after being saturated with water. There are established laboratory methods for measuring it in growing media and constituents of growing media. Growing media which have AFP values which are too low for a given type/age of plants will contain too little oxygen for good root growth, especially when the medium is watered. Because composts contain mineral material of small particle size, adding composts to coir or peat-based media often reduces the medium AFP. For this reason, some growing media manufacturers may wish to measure compost AFP in order to help them estimate the likely impact of the compost on the AFP of proposed growing media blends. Although AFP can easily be measured in composts, it is important to note that it can decrease over time as the compost particles continue to decompose, therefore stability of air-filled porosity over time can be as important as the measurement of AFP at the time composts are mixed with other growing media constituents.

Growing media manufacturers may require test results for every batch, rather than the frequency required by PAS 100:2011. Although the buyer may rely partly on the Guidelines for the Specification of Quality Compost for use in Growing Media (WRAP 2014), he or she may specify different limits and/or additional parameters not outlined, particularly where composts are to be used to make growing media for specialist purposes. Some examples of these special cases are outlined below:

6.7.1 Composts for use in seedling/propagation media

Germinating seeds and young seedlings are particularly sensitive to high salt concentrations and high ammonium concentrations. For this reason, lower limits on compost EC and ammonium concentrations are likely to be specified in composts to be used in growing media intended for this purpose. Young plants are also sensitive to high chloride and sodium concentrations and for this reason, lower limits may be specified for these elements than for composts to be used for other growing media purposes. Since many seeds and cuttings are now raised in small modules, some growing media manufacturers will specify small particle size ranges (e.g. 0 - 6 mm or smaller). The inclusion rate of compost in this type of growing media may be lower than it is for other cases.

6.7.2 Composts for use in ericaceous media

Ericaceous plants prefer acid growing media and can also be sensitive to high salt concentrations. A pH limit may be specified for composts which are intended for use in ericaceous growing media. It may also be likely that lower limits than those specified in the Guidelines for the Specification of Quality Compost for use in Growing Media, WRAP 2014 will be required for EC. Again the inclusion rate can be lowered.

6.7.3 Composts for use in large long-term containers for nursery stock etc.

Plants that are to be grown in large containers over a long period of time require a growing medium with a larger particle size and with a more stable open structure than that required for smaller containers. For this reason, a larger particle size is likely to be specified in composts to be used in growing media intended for this purpose.
6.7.4 Concerns over Legionella

There has been recent concern about a possible link between potting compost and Legionnaires’ disease caused by the bacterium Legionella longbeachae. These links have been recognised in Australia for some time – for example, in a soil survey performed in 1989 to 1990, 33 (73%) of 45 ‘potting soil’ (growing media) samples tested positive for Legionella species; 26 (79%) of the 33 contained L. longbeachae (Steele et al., 1990).

The question of L. longbeachae is not confined to green composts and growing media that include composts. It has been detected in other types of growing media including those based on coir, wood fibre, composted bark and more rarely peat (Casati et al., 2009; Whiley & Bentham, 2011).

L. longbeachae has only recently been detected as a cause of respiratory illness in the UK – in Scotland. A recent Health Protection Scotland report (Health Protection Scotland, 2013) provides a useful overview of the underlying incidences of Legionnaires’ Disease in Scotland, and examines the potential relationship between nine cases of L. longbeachae and gardening activities. It reaches the following conclusions over risk:

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.

To further reduce risks of exposure, the Growing Media Association has recently produced label guidance for growing media. These recommend that growing media users always wear gloves when gardening and then wash hands after use. They also recommend that growing media be used in a well-ventilated place and that users avoid breathing in dust.
7.0 Conclusions

A compost producer who intends to sell products into the growing media sector must have a comprehensive understanding of the composting process and the factors affecting compost quality. A consistently top quality product must be achievable, which is not only compliant with the requirements of PAS 100:2011, but also the additional requirements of customers, which may vary depending on the intended use for the growing media concerned. Compost producers who see their composting process primarily as a waste management activity are unlikely to be seen as potential compost suppliers by growing media manufacturers or growers. Instead, those compost producers who are focussed on producing quality composts for high value markets and are prepared to make the extra investment required are likely to be the ones who can consistently deliver good products to this market.

Compost producers wishing to supply into the growing media market must recognise the need for close working relationships with their buyers and must be willing to alter feedstock acceptance criteria, production processes, monitoring and testing regimes in order to optimise the quality of their products. Composters must ensure that they follow the prevailing advice and guidance from ORG.

Production of compost for use in growing media involves considerable time, expertise and expenditure and the sales price of the products should reflect this.

The time and financial outlay for the required extra monitoring and testing can be considerable. It should be costed carefully and should be reflected in the sale price of composts produced for specialist applications. Growing media manufacturers look not only for high quality in composts, but also consistency in terms of product quality over time. Achieving that quality throughout a calendar year is challenging for the compost producer, but it is possible, given the flexibility to move some composts to alternative markets if necessary e.g. landscaping, to alter feedstock blends where necessary, to cover compost where required and to alter process conditions if monitoring indicates that this would help.

The properties of finished composts intended for use as growing media constituents will differ depending on the feedstocks and on process management. There may be instances where a blend of two or more different composts would be more suitable for a particular growing medium than one alone. For example, food-derived composts, although nutrient-rich often have high EC (conductivity) values and it may be possible to blend them with green compost which contains less nutrients and is likely to have a lower [and more appropriate] EC value. It is unlikely that compost producers will be expected to make decisions as to the suitability of compost blends. Instead, the growing media manufacturer would do this, following a discussion with the compost producer about quantities and properties of the composts available from the site.

It is unrealistic to expect every single batch of compost to pass the required tests for use as growing medium constituents. It is likely that a failed batch will still be a useful product however if it still meets BSI PAS 100 requirements and analysis. For that reason, and for the reason that composters will usually be left with coarser oversize products after screening, composters producing material mainly for the growing media sector are advised to develop other markets [e.g. landscaping, turf culture/maintenance] which may be ready to accept coarser graded compost or composts which have achieved PAS 100:2011 but has failed on one or more of the requirements for use in growing media.
8.0 References

ADAS [2005] Assessment of options and requirements for stability and maturity testing of composts (Issue 2) WRAP, UK.


http://www2.wrap.org.uk/downloads/BSI_PAS_100_Update.1924a4bb.6962.pdf [Accessed 31st December 2013]

Woods End Laboratories [2006] Official Solvita Guideline Compost Respiration Test version 5.0. Woods End Laboratories, Maine, USA.


9.0 Glossary

Aeration – The process by which oxygen-rich air is supplied to compost to replace air depleted of oxygen.

Aerobic – An organism or process that requires oxygen.

Ammonia (NH₃) – A gaseous compound comprised of nitrogen and hydrogen, with a pungent odour.

Anaerobic – Metabolic process occurring in the absence of oxygen.

Animal By-Products Regulations – A set of European regulations designed to ensure food safety under the ‘farm to table’ approach set out in the EU White Paper on Food Safety adopted in January 2000 and amended in 2011. They contain strict animal and public health rules for the collection, transport, storage, handling, processing and use or disposal of all animal by-products (ABPs).

Bacteria – A group of micro-organisms with a primitive cellular structure, in which the genetic material is not retained within an internal membrane (nucleus).

Biodegradable – Can be broken down through biological processes.

BSI PAS 100:2011 – A publicly available specification which covers the entire production process for composts and which assures that compost is produced to a level of consistency, reliability and safety laid down by the specification.

Bulk density – The mass per unit volume of materials.

Carbon dioxide – A colourless, odourless, tasteless gas that is produced as a result of respiration (by plants and animals including microorganisms).

Compost – A stable, sanitised, soil-like material, which has been made through mixing, self-generated heating and aeration.

Compost Quality Protocol – A standard which describes parameters for the full recovery of compost in England, Wales and Northern Ireland which provides user confidence, protects the environment and eases the regulatory burden on compost producers. It does not apply in Scotland.

Composting – The natural breakdown of biodegradable materials through mixing, self-generated heating and aeration to form a stable, soil-like material.

Density – The weight or mass of a substance per unit of volume.
**Ericaceous** – Plants belonging to the family Ericaceae including rhododendrons and heaths and heathers. This family of plants prefers to grow in acid soils or growing media and in this respect, they differ from most other common commercially grown plant families.

**Feedstock** – The biodegradable materials present at the start of a composting process.

**Green waste** – Grass cuttings, leaves and prunings, from parks or gardens.

**Growing medium** – A material, usually used for potting plants or sowing seeds, which can be made from single constituents or more usually a mixture of constituents such as peat, perlite, compost or loam.

**In-vessel composting** – A diverse group of composting methods in which the materials are contained in a building, reactor or vessel.

**Loam** – Soil containing a desirable mixture of sand, silt and clay, suitable for crop production.

**Major nutrient** – Essential elements required in large quantities from soils by plants.

**Maturation** – A period [within the composting process] of lower biodegradation than in the preceding steps of composting. The stabilisation continues but the rate of decomposition has slowed to the point that turning or forced aeration is no longer necessary. Some microbial activity and chemical changes, such as the oxidation of ammonium ions to nitrate, will continue. Beneficial soil micro-organisms that were inhibited or destroyed during the active composting process will begin to re-colonise the composted materials.

**Mature compost** – Compost in which biological activity (as measured by microbial respiration) has slowed. All of the easily degradable molecules have been broken down, leaving the complex organic material behind. It is difficult or impossible to identify the original feedstock materials. Mature composts usually have a dark colour and a rich, earthy smell.

**Micro-organism** – An organism too small to see with the naked eye that is capable of living on its own.

**Moisture content** – Percentage of a substance comprised of water. Moisture content equals the mass of the water portion divided by the total mass.


**Pathogen** – Any organism capable of producing disease through infection.

**pH** – A measure of the concentration of hydrogen ions in solution. pH below 7 = acidic, pH above 7 = alkaline.

**Potentially toxic elements** – Chemical elements that have the potential to cause harm to humans, animals and/or plants.

**Sanitisation** – Biological processes that together with conditions in the composting mass give rise to a compost in which levels of any human, animal or plant pathogens which may have been present are reduced to acceptably low levels.

**Secondary nutrient** – Essential elements for plant growth which are required in smaller quantities than major nutrients, but larger quantities than trace elements.

**Sewage sludge** – A semi-liquid waste with a solid concentration in excess of 2500 parts per million, obtained from the purification of municipal sewage. Also known as sludge.

**Stabilisation** – Biological processes that together with conditions in the composting mass give rise to compost that is nominally stable (that is a condition whereby biological activity and biodegradation has slowed and will not resurge under altered conditions such as manipulation of moisture or oxygen levels, or through the addition of a source of water soluble nitrogen).
**Trace element** – Essential elements for plant growth which are required in very small quantities.

**Turning** – An operation that mixes and agitates material in a windrow, pile or vessel.

**Weed propagule** – A piece of plant material from which weeds can grow (e.g. seed, rhizome or root fragment).

**Windrow** – Elongated pile of composting material.