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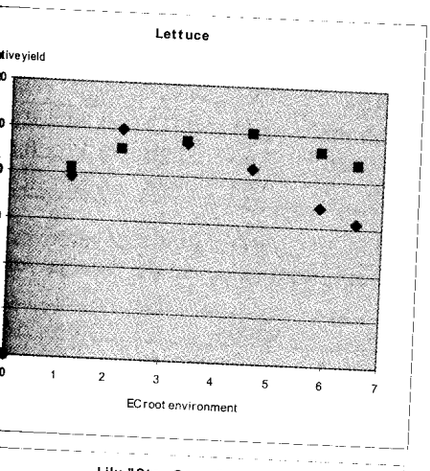

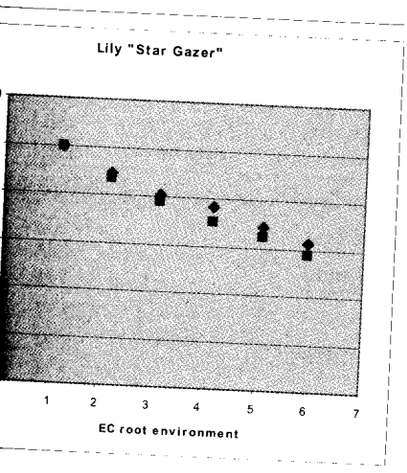

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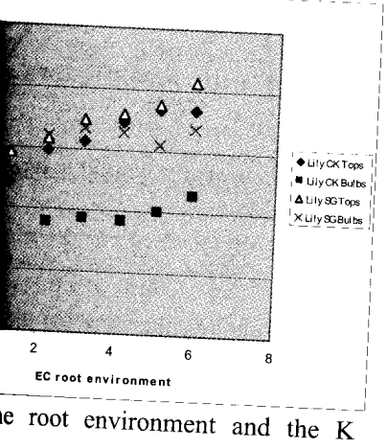

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The Use of Composted Materials in Growing Media

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Abstract

Many composted materials have been studied for their potential as constituents of growing media, including bark, wood fibres, manufactured timber by-products and green composted materials, and in global terms their use in media is currently increasing. Composted materials are used widely in some areas of the world: for example composted bark is the principal constituent of growing media in Australia and much is also used in the United States. Over the last decade, increasing use of bark in growing media has occurred in some Western European countries. In the UK, composted by-products of the timber industry, particularly from mass manufacturers of furniture, are used in growing media. During the last ten years, a tremendous upsurge of interest in the use of green composted materials has developed, particularly in Western Europe.

Composted or aged bark, with its high air content and good drainage properties is widely used for production of large container grown plants. The species used varies across the world according to local availability, from *Pinus radiata* bark in Australia, to *Pinus sylvestris* and *Pinus nigra* var. *maritima* in Europe. Composting of bark for two to six months is common practice prior to use as or inclusion in growing media, and advances in composting processes and blending with other materials have alleviated many of the problems formerly associated with bark-based growing media. Research into the use of wood fibres in growing media has been undertaken in France, Germany and the UK, and use of growing media containing composted wood fibres is currently increasing, particularly in the UK.

An immense amount of research and development into the use of green composted materials has been undertaken in EU countries. Despite the inherent variability of such media, seasonally and from batch to batch, as well as its high bulk density, intensive promotion and funding leading to improvements in quality and availability of products of a consistent nature has led to the adoption of green composted materials in growing media by some manufacturers of growing media in the UK.

Problems of consistency, storage, nitrogen immobilisation and standardisation of composted materials have been addressed through publicly funded research and development studies, as well as in-house and sponsored investigations by manufacturers of growing media. If these improvements in quality and availability are maintained, and lobbyists continue to exert pressures for reduction and/or elimination of peat from growing media, then further increases in the use of composted materials are likely to occur.

INTRODUCTION

A major requirement of producers of growing media is the availability of large volumes of raw materials of year-round consistent quality. Inorganic materials including mineral wool, perlite and vermiculite are readily available and consistent from batch to batch in production: the properties of organic materials such as peat and coir obviously vary more than inorganic materials but the consistent nature of plant growth in these materials makes them the preferred choice for growing media of professional and many hobby (amateur) growers. Mineral wool is now the medium of choice for long-season

glasshouse crops in temperate climates, and peat has been the principal constituent of organic growing media since the 1970s.

Where peat is available locally, alternative materials for use in commercially-produced growing media must therefore be available in bulk, as well as of consistent quality and at costs equivalent or lower than that of peat. Plant growth in media containing alternative materials must be at least equivalent to that in peat. Furthermore, such media should not pose risks to health and should be stable in storage.

Many of the alternatives to peat that fulfil at least some of the above criteria are composted: the principal materials used are bark, other timber residues and composted plant residues, usually of municipal origin. For the purposes of this paper, the latter are referred to as composted green materials. Many other materials have been examined for their potential in growing media, and these are summarised in the comprehensive overview of substrates given by Raviv et al. (2002).

This paper focuses on composted materials of plant origin. Coir is not considered in detail, since although some sources of this material imply the use of a composted product, in many cases coir is aged and/or screened and heat-treated before use as a growing medium.

COMPOSTED BARK

The impetus to use bark in growing media came from increased production within wood-processing industries in the 1940s and 1950s which led to the stockpiling of large quantities of bark at pulp and sawmills. Research into the use of bark in growing media initially began in the 1950s, with many major studies being carried out in the 1960s. In the UK the Forestry Commission instigated studies into the use of bark as a replacement for peat in horticulture in 1967, and by 1982 at least 14 companies/organisations were supplying bark or bark-based growing media to both the commercial and amateur (hobby) sector of the market in the UK (Aaron, 1982). Research into the use of bark has been undertaken in many other countries including the USA, Canada, New Zealand, France, Norway, Spain and Australia: reviews of the use of bark in growing media are given by Pokorny (1979); Solbraa (1979); Aaron (1982); Pudelski (1985); Landis (1990) and Miller and Jones (1995).

The species of bark used in growing media varies according to local availability. In Europe species such as *Picea sitchensis* (sitka spruce), *Picea abies* (spruce), *Pinus sylvestris* (Scots pine), *Pinus pinaster* (maritime or cluster pine) and *Pinus nigra* var. *maritima* (Corsican pine) are used: in the USA *Pinus taeda* (loblolly pine), *P. echniata* (shortleaf pine), *P. palustris* (long-leaf pine), *P. elloittii* (slash pine) are used and the latter is used in Australia along with *Pinus radiata* (Monterey pine). *P. radiata* is also used in New Zealand. In Eastern Asian countries such as Korea, pine bark of unspecified origin is also used as a component of growing media (Kang et al., 2005). In addition to coniferous species, bark of hardwood origin has been composted and used in growing media, particularly in the USA (Landis, 1990).

Bark may be composted or aged prior to incorporation into growing media. In Europe much pine bark is aged, whereas spruce bark, or bark from mixed conifer plantations is composted. Prior to stacking, bark is commonly shredded, milled or ground to about 1–3 cm particle size. In the composting process, nitrogen and sometimes other nutrients are added to bark. During the composting phase, piles of bark may be turned, usually at weekly intervals. Composting for 10–15 weeks is normal practice in several parts of the world, including the South Eastern USA, Australia and the UK.

Ageing of bark does not involve addition of nutrients and turning of piles may be intermittent. Piles of bark are usually aged for longer than composting; six months and more is not uncommon. In some cases producers (for example in New Zealand and parts of the USA) have been able to utilise deposits of bark stripped from trees many years ago, and which has undergone ageing over several decades.

The principal reasons for composting or ageing have been considered at length by many authors: the intention is to eliminate any problems that may arise from phytotoxic

components in raw bark. In addition, composting may reduce the immobilisation of nitrogen that arises during colonisation of media by microorganisms which can utilise the carbon sources in some barks much more freely than in materials rich in lignin, such as peat. In this respect some barks, particularly derived from species of *Pinus sop*, that have a relatively high lignin (and wax) content lead to a lower rate of nitrogen immobilisation when incorporated into media than other barks such as that from *Picea* spp. as well as some hardwoods (Bilderback, 1982). Finally, heating of piles to 50°C may serve to kill unwanted pathogens, pests and weed seeds. A major benefit arising from the use of composted bark is its ability to exert a degree of control over root diseases through their suppression (Raviv, 2008).

Growing media containing bark usually have high air content. Indeed the principal use of bark throughout the world is for plants in large containers for nursery stock, where the root systems require above all, good aeration. Bark may occasionally form the sole constituent of growing media but is more commonly mixed (from 10–80%) with other organic materials such as peat, or inorganic materials such as sand and grit to help with stability of containers. For example, in the South East USA, composted pine bark is the principal constituent in nursery potting substrates: here screened pine bark may be used alone, or in mixture with sand in a ratio of 6:1 or 8:1. Similar high concentrations are employed for container grown plants in Australia. In Europe, composted and aged barks are commonly used as 20–40% in most nursery stock media, with a few suppliers recommending use as high as 80% by volume of media.

Data on the volumes of bark used in growing media is sporadic. In Australia, where growing media containing bark are widely used, an estimated 100,000 cubic metres are used per year in the Sydney area (Parkes, pers. Comm..), and with higher quantities used in other areas such as Queensland, the total quantity used is likely to exceed 1 m cubic metres. Bark is very widely used in the USA in media for nursery stock. Little hard data is available but scrutiny of the number of nursery plants raised according to the USDA Census for Horticulture of 1998 and 2002, as well as opinions of researchers and development officers there (Warren, pers. Comm..) indicate that usage may be in the region 15–20 m cubic metres per annum.

The comprehensive survey of growing media by Bohlin (2002) aggregated bark along with other composted materials, and estimated that composted materials occupied about 4% of the growing media market in eight European countries. The total market was estimated at 16 m cubic metres: the share of the market occupied by composted materials may therefore be estimated at 640,000 cubic metres... In the Netherlands, Van Schie (2001) indicated that about 100,000 cubic metres of bark was used there in 2000. In the UK, government sources (Waller and Temple-Heald, 2003) indicate that 4% of growing media constituents in 2001 was bark-based. Given that the total amount of media used in the UK in 2001 was estimated at 3.6 million cubic metres, the amount of bark used in that year was about 144,000 cubic metres.

COMPOSTED MATERIALS FROM MANUFACTURED WOOD WASTES

In terms of bulk use by manufacturers of growing media, timber wastes derived from the furniture industry are a relatively recent development. The use of these materials has been studied in both the UK and Germany (Dickenson and Carlile, 1995; Bragg, 1998): in the latter country it has been estimated that over 1 million tonnes of waste chipboard arising from the manufacture of furniture may be available, and this could yield over 4 million cubic metres of chippings for potential use in growing media (Molitor et al., 2005). Such quantities are however country-wide figures and local availability may be rather less.

Chipboard in both countries is coated with ureaformaldehyde resin. This has been perceived as a problem due to accumulation of mineral nitrogen from breakdown of ureaformaldehyde to urea, ammonia and then nitrate by microorganisms during the composting process. However, this additional nitrogen can be viewed as a positive feature, in that careful blending of composted timber wastes with other materials that may

cause a certain degree of nitrogen immobilisation, such as composted bark, can produce media of suitable nitrogen status for plant growth. As such, in the UK composted timber wastes are incorporated into growing media, notably peat-free, but probably not more than 5,000 cubic metres is used annually.

COMPOSTED GREEN MATERIALS

A large amount of research and development work has been undertaken, primarily in Europe, on the use of composted green materials (often also labelled composted green wastes) as soil improvers as well as in growing media. This work has been driven by European Directives on reducing the amount of waste materials going to landfill sites, and the establishment of targets in many EU member states for recycling. Currently the EU landfill directive aims to divert municipal waste away from landfill sites: for example targets in the UK relative to 1995 seek a 25% reduction by 2005; 30% reduction by 2010 and 33% by 2015. In this respect, landfill taxes in the UK in 2005 stand at £18 per tonne of waste, and will increase at £3 per tonne per year up to £35 per tonne. A further impetus in the UK for utilisation of composted green materials has resulted from government targets of 40% of peat in horticultural use to be replaced by alternative materials by 2005, with aspirations of 90% to be replaced by 2010 (Shaw, 2003).

Most green composted materials are derived from gardens and local municipal horticultural activity, and include grass clippings, discarded plants, twigs, leaves and branches. These may then be shredded and composted in large piles or windrows for 12–20 weeks, with regular turning. A principal aim is to reduce the sheer bulk (with consequent need to dispose of less in landfill) of material through microbial degradation. An important aspect of this process in terms of utilisation of composted green materials in growing media is, as described above for bark, the reduction of readily available carbon sources to avoid potential immobilisation of nitrogen as may occur with bark.

The principal problems of composted green materials have been identified as variability between batches and at different times of the year; the inherent high bulk density of the composted product; its relatively high pH and conductivity values, often due to high potassium levels. Potential problems requiring further study include the storage properties of media containing composted green materials and the nature of microorganisms present in media containing composted green materials.

One of the principal problems in the UK with composted green materials is been the inherent variation in the nature of the end product; both from different production sites and at different times of the year. In response to this, the Composting Association in the UK has strongly promoted the quality standard BSI PAS 100 in an attempt to harmonise the production of green composted materials to a consistent standard for horticultural use. In addition, three of the principal companies that compost green materials in the UK formed a partnership in 2003 – the Apex composting group - with the aim of ensuring consistent supplies of material year-round for use in growing media. Quality assurance schemes for compost production have been extant for a number of years in some European countries such as Austria and Germany.

As part of recycling initiatives, the UK has channelled funds raised through its landfill tax to organisations such as the Waste & Resources Action Programme (WRAP). WRAP and other organisations have spent over £40 m in supporting recycling initiatives in the UK in recent years, although only a small part of this has been used to support research into the horticultural use of composted green wastes. Nevertheless a wide range of studies have been undertaken involving the growth of a large range of species in many different sources of composted green wastes, and the results of these are given on the WRAP website (http://www.wrap.org.uk/index.html) In 2003, WRAP sponsored 20 trials across the UK covering a range of crop types and growing media. The trials involved comparisons between the use of peat-free media that included composted green materials: a reduced peat formulation; and a standard peat-based medium. All green composted materials in these trials, which took place in different parts of the UK, appeared to be from different sources, although produced to the BSI PAS 100 standard mentioned above.

During 2005, WRAP has financially supported the construction of blending facilities for incorporation of composted green materials at two of the UK's leading manufacturers of growing media.

Although initially regarded with scepticism (e.g., Shaw, 2003), advances in both production techniques involving care in screening of source materials and consistency of composting procedures have led to end products that can be used as part of growing media. Currently in 2005, both leading manufacturers of growing media in England are adding composted green materials produced in accordance with BSI PAS 100 standards to growing media at between 10 and 20% by volume. In 2003, WRAP stated that about 68,000 cubic metres were used for this purpose. The principal consortium producing composted green materials to the BSI PAS 100 standard produced over 200,000 cubic metres of material in 2004, and is set to vastly expand production in future years. Indeed, WRAP has stated an intention to increase the use in the UK of composted green materials in growing media to over 200,000 cubic metres by 2010.

Several other countries have explored the potential for use of composted green materials. In the USA composted so-called yard wastes have been incorporated into media, but as with green composted materials at low proportions of 10–20%. In 1999, at least 30,000 cubic metres of composted yard wastes were used in media for nursery stock in California (Lanthier, 1999). Research studies have been carried out in many European countries on the potential use of composted green materials in growing media. In some countries composted materials are incorporated in media, but not to any great extent. For example in the Netherlands, the RHP foundation reported the use of less than 10,000 cubic metres (Boon, Sonneveld, pers. commun.). In Germany, composted green materials have been included within composted biogenic wastes, and many publications exist on production and potential of this material, including its manufacture (as with BSI PAS 100) to a specified quality standard. The overall share of the growing media market by biogenic composted material was stated in 2001 to be very low in Germany, but some niche producers were using the material at up to 50% in growing media (Grantzau, 2001).

In addition to the use of compost prepared from the entire spectrum of green materials collected by municipal authorities, more selective use of composted plant materials has been practised. Principal among these is the preparation and use of wood fibres prepared from lop and top operations in Forestry. Here the branches removed during timber harvesting are composted to produce a wood fibre material (Sylvafibre®) marketed in the UK. This material has proved a very popular alternative to peat, and its use is rapidly increasing in the UK, with about 100,000 cubic metres being used in 2002. Many wood fibre materials used in Europe such as Hortifibre® and Toresa® are produced without composting but at least one – Pietal® – is produced by steaming followed by composting.

FUTURE PROSPECTS FOR USE OF COMPOSTED MATERIALS IN GROWING MEDIA

Several factors determine the use of composted materials in growing media including local availability of large quantities of composted material; comparative availability of peat and in some cases coir; the relative costs of growing media constituents, not just for the raw material but transport to manufacturing plants and possible modifications of the latter to enable storage and incorporation of composted material into the finished product. In some parts of the globe, a fourth factor is extant: that of environmental pressures to reduce peat use.

In some countries such as the UK, composted green materials are seen as a viable alternative to peat in growing media, and given the considerable resources directed towards establishing composted green materials of consistent quality, and the support given to major producers to establish plant and facilities for incorporation of these materials into growing media, further increases in the use of composted green materials in growing media in the UK will occur.

However, given the fact that producers are currently unwilling to use composted

green materials at higher levels than 15–20%, incorporation of these will only partially solve the government's aim of replacing 90% of peat in UK horticulture by 2010. Increases in production of other composted materials such as composted wood fibres may occur, although vast expansion will be needed to make inroads into the current estimated 4 m cubic metres of peat used in UK horticulture.

The drive to use composted materials is not as yet as pronounced in other parts of Europe. However, if the political and environmental pressures exerted in the UK to reduce peat use in horticulture are extended to the European continent through EU Directives, then an expansion of use of composted green materials is likely.

In many parts of the world, the use of composted materials, notably bark, is already well established and likely to continue. However, competing markets for bark have led to a tightening of supplies, as has occurred in the SE USA over the last two years (Warren, pers. commun.). Such pressures may stimulate research into the use of other composted materials.

Overall the prospects for use of composted materials appear bright: however, as with all new materials, thorough evaluation of their production, performance and viability is required before they can be considered successful, and in particular acceptable to commercial growers. In this respect, some materials that have been avidly promoted for use in growing media, such as composted straw and paper wastes, have proved to be unsatisfactory in terms of for example, structural degradation and nitrogen immobilisation. Those familiar with the use of peat as a growing medium point to the large amount of research carried out in the 1960s and 1970s to optimise the use of peat in growing systems, contrasting this with the paucity of research of similar depth and quality on potential constituents such as composted green materials and wood fibres. Research into the use of peat came at a time when government funding in many countries for horticulture were far more generous than at present. It is only recently, at least in the UK, that research initiatives such as those funded by WRAP have enabled extensive studies, including comparative trials on the premises of growers, to be undertaken on the potential of composted green materials in growing media. Manufacturers themselves have supported research and development on the potential of constituents such as composted timber wastes and wood fibres. However funded or undertaken, it is such studies that will establish the suitability of composted materials as constituents of growing media; and give both manufacturers and growers the confidence to adopt such materials.

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