Using composted biosolids as a peat replacement

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Abstract
If you really want to do it, composted biosolids can be used as peat replacement. A range of horticultural products based on composted biosolids were the first peat-free products that performed as well as and were sold at the same price point as the brand-leading peat-based media. In the first year from launch a nationwide distribution of retail outlets was achieved in Britain. In subsequent years sales doubled year on year. This paper will describe the process of product development, quality control, pre-launch market research and post-launch sales, marketing and logistics. Selling to retail outlets is very different from selling directly to end users of bulk material such as farmers or land restorers.

Keywords:
Compost, branding, faecal phobia, gardening, growing media, growing trials, marketing, quality assurance, selling, standards

Introduction
In 1987 when Thames Water Utilities Ltd began researching composting dewatered raw cake, Little Marlow wastewater treatment works served a population equivalent of about 90,000; it has since doubled in size. It was a conventional design with preliminary treatment, primary settlement, and biological filters but without any form of treatment for the sewage sludge. The annual make, including imports from other works, was about 12,000 tonnes of cake at 25%DS (3,000 tDS). The objective was to control odour and pathogens so that the composted biosolids could be used in agriculture without offence and in compliance with the Sludge Directive (CEC, 1986) and UK regulations (Anon, 1989).

Both aerated static pile and turned windrow composting were tested. A bulking agent is required for composting sludge in order to increase air permeability and to provide additional carbon. Straw and woodchips were tested. Chipped wood had been used extensively in USA where the static windrow process had been developed - at USDA Beltsville and at Rutgers University. Chipped wood can be recycled through the process by screening the compost; the number of cycles is limited by gradual breakdown of the chips and new chips have to be added each cycle. A weakness of this system is that, during screening, some degraded chips break up physically exposing fresh substrate which restarts the composting and increases the oxygen demand in maturation or in bags and consequently may cause anaerobicity. R&D settled on straw as a bulking agent.

Straw is an agricultural by-product of grain production. When it falls out of the back of a combine harvester its only value is the nutrients (largely phosphate and potassium) and organic matter that it contains but it also has disbenefits; straw may carry disease and weed seeds. Most combine harvesters have a straw chopper that can be engaged if the straw is going to be incorporated. Baling

straw and transporting it off fields costs money but adds value so one has to pay for baled straw. Cultivation operations cannot start until straw has been baled and bales have been cleared, which in a wet season can result in delay. There is a yield penalty for each week's delay after the optimum sowing date. Straw has to be stored in stacks because it is produced in about 2 months and used for 12 months. Inevitably the bales on the tops and bottoms of stacks get wet which renders them unsuitable for animal bedding. By forward contracting and by accepting spoilt bales, straw was cost effective for composting.

Various outdoor composting systems were tested and turned windrow composting was eventually adopted using purpose built windrow turners with good mixing capability. The Gore static pile covered system would have been a good choice today but it was not available then.

Operational Composting

R&D was completed in 1992 and management of the composting was handed over to TERRA ECO•SYSTEMS, which was the team within Thames responsible for recycling biosolids. Thames had adopted Quality Assurance in 1989 and even in 1992 TERRA was 100% compliant with all legislative aspects associated with biosolids recycling. It had also made the transition from free give-away to charging customers for treating their land. The prices paid by farmers ranged from £25 to £120 per hectare depending on the product and the location of their farm.

In addition to composting sludge cake, biomaterials were composted for other people. The most established of these was source-separated kitchen and garden waste for a local council. The scheme was limited to 1000 households to test people's level of co-operation. This necessitated applying for and being granted a Waste Management Site Licence. The licence was silent about the compost; "waste" had been received and composted with all the specified controls; no controls were required after maturation. Kerbside collected household waste was composted separately and was not used for growing media because the risk of "sharps" was too great.

The process comprised laying out a line of big-bales, removing the strings, running through them with the turner to break them up and then placing cake on top of the fluffed up straw. The windrow was then turned twice to incorporate the cake. The temperature reached 55°C after about 5 days and windrows are turned 3 times per week for about 6 weeks. Windrows shrank to half their size after about 2 weeks and two windrows were then combined into a single windrow. The history of each windrow was documented and temperatures are recorded at 3 locations in each windrow daily. Occasionally the atmospheric composition inside windrows is measured using a portable gas analyser. The chemical composition of both the raw cake and the composted material was tested on monthly samples. After 5 weeks' composting on the windrowing pad the high rate processes had been completed and the compost had been sanitised but it was not fully stabilised. Full stabilisation was achieved in maturation stockpiles over a period of 6 to 12 months. This very stable material was the raw material from which garden centre products were manufactured.

Product Development

Phase 1

In 1993, having access to stockpiles of matured compost and being a keen gardener I started testing formulations of growing media in the greenhouse at home to see if it was possible to formulate a potting medium based on TERRA *compost* that contained no peat but that would perform as well as the brand-leading commercially available peat-based or "John Innes" (soil-based) media. This was a randomised trial with 8 treatments and with triplicate replication. The test subject was *Impatiens* (Busy Lizzie). The height, spread and flower number on each plant were measured over a 12 week

period from potting up the mini-plants. Over this period one of the formulations matched the performance of the brand leading peat-based multi-purpose medium and was far superior to the soil-based one. Tissue analysis showed the nutrition was adequate from the nutrient reserves in the TERRA *compost*. Comparing the analysis of the unused medium with that after 12 weeks' growth confirmed that nutrient reserves were very good. My local Director saw the results and approved taking the development further with the proviso that a step would be installed in the production process to ensure there was not be a hypodermic needle in the product.

The ultimate objective was primarily to demonstrate that the public was not "faecal-phobic" but would buy and use sludge based products provided they worked and were safe and pleasant to use. Thus the objective was to support the bulk of the biosolids recycling programme.

Having established the potential the next step was to work with professionals from the growing media industry to develop the concept further and if possible bring it to a market. Rainbow Wilson Associates, Hallam Marketing and Levington Agriculture were employed on a pragmatic development programme that could be aborted at any stage if results indicated that a credible, marketable product would be unachievable.

A Credible Offer

The leading product of all the major suppliers to the amateur market is multi-purpose compost (growing medium) and therefore, if TERRA ECO•SYSTEMS products were going to be credible in the marketplace, a multi-purpose compost[1] (MPC) was essential with complementary products to complete the range. The requirements for a MPC are quite demanding since it must have sufficient nutrients to support a larger plant for about 6 weeks before feeding is required but it must not be too rich for seed sowing. In addition the bulk density must be small enough that it can be sold in a bag that looks comparable to the competitors without exceeding the 25 kg manual lifting advice (HSE, undated).

Space in a retail outlet is at a premium. When a retailer considers listing a new product range, he or she has to consider giving less space to another product range or de-listing it entirely, so it is not a trivial question. What is going to make the new product sell better than the displaced one, or generate more profit or generate more footfall that will in turn lead to increased sales overall? The answers to these questions depend on raising awareness (quickly) and prices, margins and purchasing facilities that match or beat the competition. For the longer term the products must perform well for the retailer's customers in order that they have repeat business and there is "pull" from the end users.

At the time there was intensive lobbying of gardeners in the UK to stop using peat (to preserve lowland raised bogs). This gave us an advantage, but there had been an untended consequence of the campaign. Some manufacturers had rushed "peat-free" products to market without adequate testing and development and they had not worked very well so retailers were sceptical about peat-frees "I tried some and it didn't sell so I was left with bags at the end of the season".

The project had support from senior management but it did not have a budget for development work or for promoting the products. These had to be funded out of "discretionary" revenue budgets and therefore had to be as inexpensive and cost effective as possible.

[1] Note: There is confusion in English gardening terminology because "compost" can refer to a growing medium (a mixture of ingredients) or to the product of composting (autothermic aerobic biological decomposition of organic materials)

The Commercial Reality of Growing Media

Peat is an extremely good substrate for making growing media. It has a good air/moisture relationship, it has low inherent fertility so the desired nutrient status can be achieved by adding water-soluble fertilisers, it is acid so the desired pH can be achieved by adding lime, it has a low bulk density so large volumes can be transported within vehicle weight limits, it is reasonably consistent and it is inexpensive. Harvested peat arriving at the start of growing media production costs about £6 to £10 /m^3. From that point forward, manufacturing is totally automated. Fertiliser, lime and wetting agent are added, bags are filled, sealed and pressed, stacked on pallets that are capped and wrapped automatically. The only human intervention is to move the completed pallets to the stacking yard to await collection.

It is not surprising that peat dominates the market (Figure 1). Consistency and performance are especially important for the professional sector. A hobby gardener might blame his or her poor technique if things do not go very well but a professional grower with a quality assured production line knows when a growing medium has performed poorly and damages claims can be considerable.

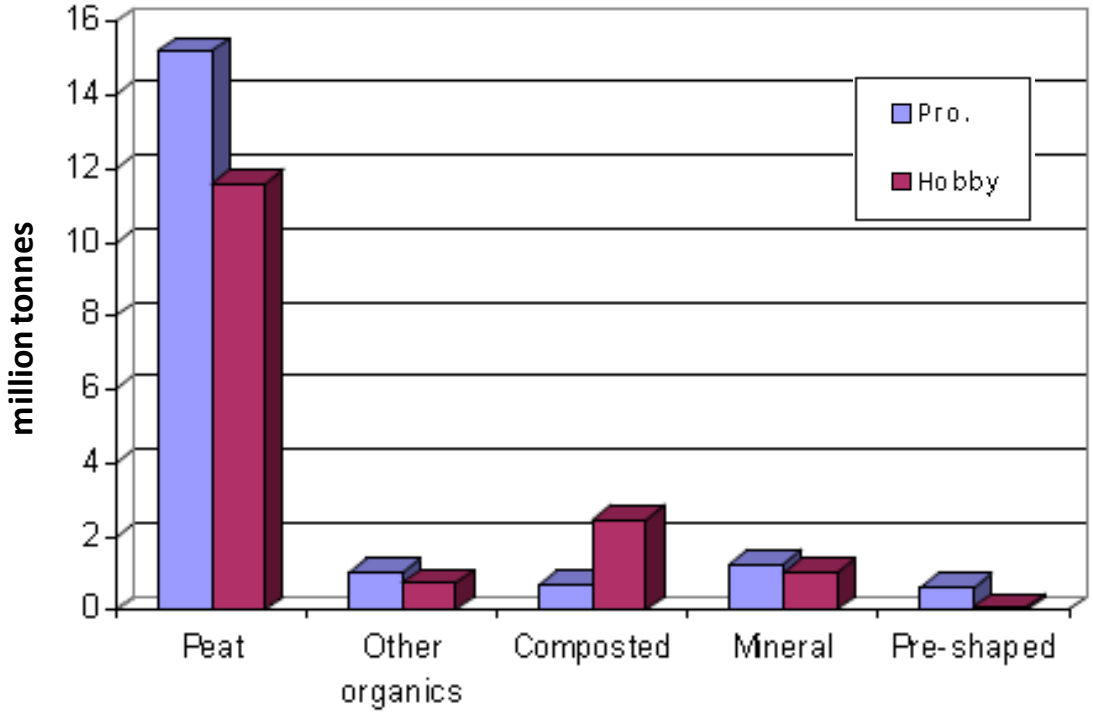

Figure 1 The growing medium constituents used in the EU (total 34,632,300 m³ by EN 12580) split into the different types (Schmilewski, 2008)

Phase 2

Growing trials began at Levington Agriculture's research facilities early in 1995. The results at the end of that season confirmed there was a very strong possibility of success.

For 1996 the products' formulations were refined based on the results from 1995 and a much more extensive range of growing trials was undertaken.

Market research was also undertaken to test whether consumers were ready for such products, and whether they would be compatible with their Thames Water parentage. Market research was also important for developing the packaging design.

The target was to launch the products at the industry's premier trade show, the Gardening and Leisure Equipment Exhibition (GLEE) in September 1996 at the National Exhibition Centre.

Analytical Results

The products formulated for 1996 had reasonable chemical and physical properties (Table 1).

Table 1 Analytical results for the garden centre products

	Soil Improver			**Growing bag**			**MPC**		
bulk density (EN 13041)	680 g/L			660 g/L			560 g/L		
moisture content	60 % m/m			60 % m/m			60 % m/m		
dry matter	40 % m/m			40 % m/m			40 % m/m		
air-filled porosity	15 % v/v			12 % v/v			11 % v/v		
water-holding capacity	77 % v/v			75 % v/v			60 % v/v		
organic matter	42 % m/mDM			44 % m/mDM			45 % m/mDM		
carbon:nitrogen ratio	9			8			10		
pH	6.5			6.5			6.5		
electrical conductivity	900 µS/cm			900 µS/cm			600 µS/cm		
	water-extractable (w-e) mg/L			**total** mg/L			**w-e/total** %		
	SI	GB	MPC	SI	GB	MPC	SI	GB	MPC
nitrogen as N	400	240	200	5500	5000	4000	7.3	4.8	5.0
phosphorus as P	10	25	16	7000	6000	4500	0.14	0.42	0.35
potassium as K	500	500	400	1500	1100	1100	33.3	45.0	36.4
calcium as Ca	1000	600	500	15000	12000	8000	6.7	5.0	6.25
magnesium as Mg	100	80	50	1100	1000	800	9.0	8.0	6.25
sulphur as S	700	400	300	1600	1200	900	43.7	33.3	33.3
iron as Fe	0.3	0.3	0.2	2500	2000	1500	0.01	0.01	0.01
copper as Cu	0.6	0.5	0.4	300	250	150	0.2	0.2	0.27
manganese as Mn	0.1	0.2	0.1	100	80	60	0.1	0.25	0.17
zinc as Zn	0.5	0.5	0.3	200	180	100	0.25	0.28	0.3
boron as B	0.4	1.0	0.7	12	10	8	3.3	10.0	8.75
molybdenum as Mo	1.0	0.8	0.6	10	8	6	10.0	10.0	10.0

SI Soil Improver
GB Growing Bag
MPC Multi Purpose Compost

The laboratory bulk density (EN 13041) was rather high but the bulk density for quantity declaration (EN 12580) was acceptable. The UK growing media industry has used water extraction

(EN 13652) to measure nutrient content, which is acceptable because they use water soluble fertiliser but it is misleading for composted biosolids because the basis of their fertility includes nutrients that are released gradually; calcium chloride – DTPA (CAT) extraction (EN 13651) gives more meaningful results. Pseudo-totals, i.e. aqua regia extractables (EN 13650) could give the misleading impression that the products are too rich. This highlights a difference between these new products and peat, coir or timber based ones; they are inherently fertile with large reserves of nutrients that are gradually released, which means that feeding is less critical.

Seed Germination Trials

This was very demanding. To create a multi-purpose compost from an inherently fertile starting material meant that the readily available nutrients had to be diluted and amended. The trials were conducted in a heated greenhouse at Levington Agriculture as a randomised block design with 3 times' replication. Seeds were surface sown on the test formulations and compared with brand leading products based on peat, coir, bark, timber and loam (John Innes). Germination and growth of lettuce, stock, pansy, antirrhinum, and petunia were tested. Seedlings in the TERRA formulations performed better when the trays were on open staging rather than when they were watered by capillary matting. The formulation that became the TERRA ECO•SYSTEMS *Peat-Free* Multi-Purpose Compost performed as well overall as the brand leading peat-based multi-purpose compost and better than the other branded products, some of which were spectacularly poor (Figure 2).

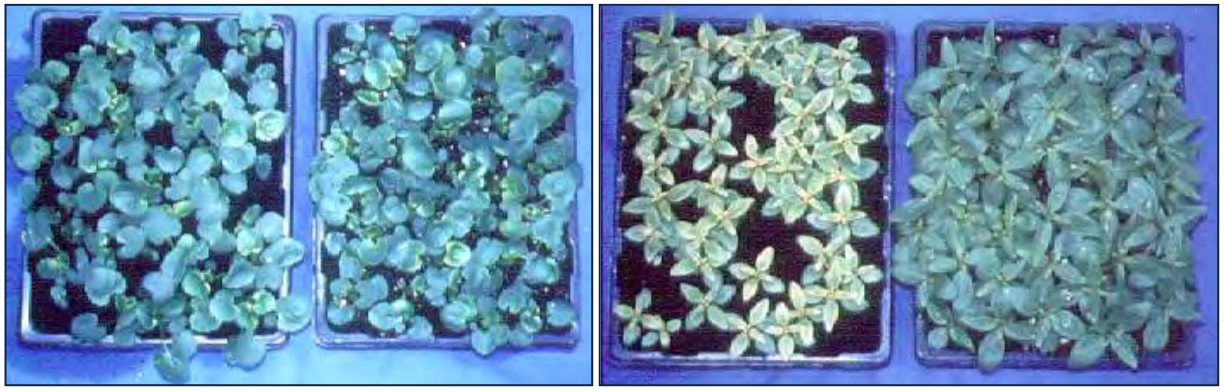

Figure 2 Illustration of seed sowing trial - left pair: pansy, peat vs MPC; right pair: antirrhinum, coir vs MPC (MCP is the right hand of both pairs)

Growing Trials

A wide range of plants was grown to maturity in containers to test the suitability of the multi-purpose compost, these are listed in Appendix. Many of the plants were displayed on the product launch stand at the NEC. The quality, even of difficult subjects, was excellent.

Growing Bag Trial

Growing bags were trialled with Shirley, Marmande and Gardeners' Delight tomatoes. The largest was the trial with Shirley which again was conducted at Levington against the brand leading peat-based bag. The cumulative yield of good ripe fruit (Figure 3) was that same from both products.

Technicians managing the trial observed that the TERRA bags were easier to water than the peat-based bags where it was well known that the wetter (added to the growing medium) washes down into the bag leaving the surface hydrophobic. The trial also confirmed that the start of feeding could be delayed for 4 weeks compared with the peat-based bag. In a blind flavour tasting the fruit

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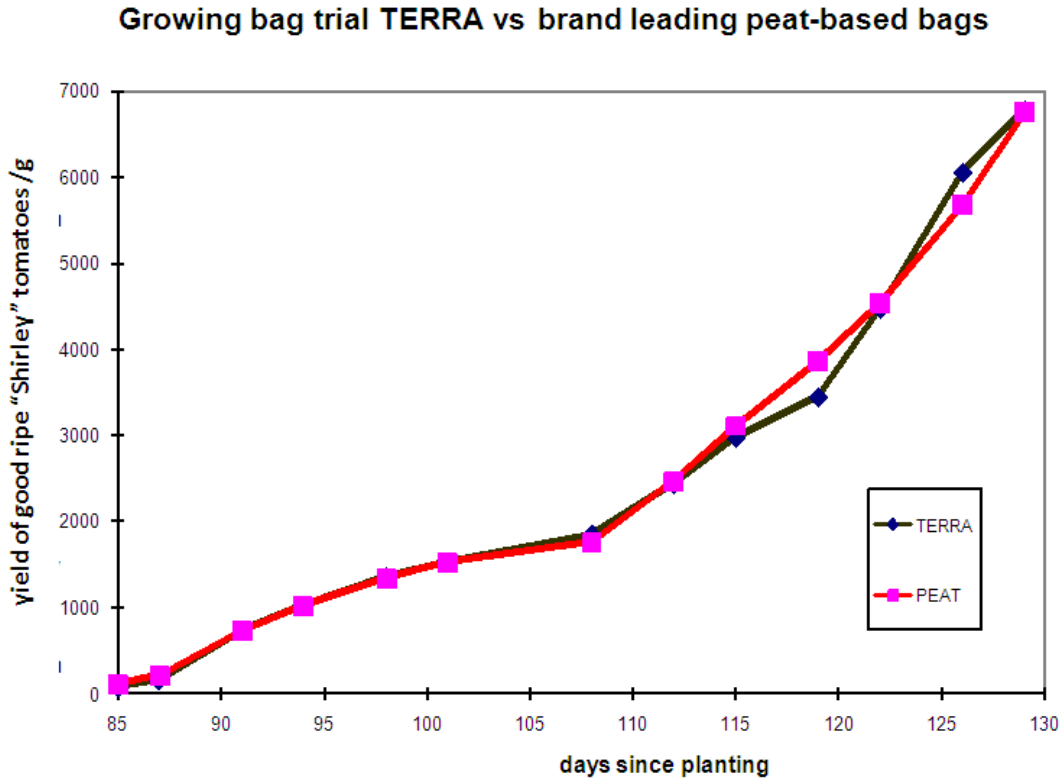

Figure 3 Growing bag trial - TERRA ECO•SYSTEMS *peat free* growing bags compared with brand-leading peat-based growing bags

Manufacturing

A Quality Assured manufacturing process was developed that included selecting/approving the constituent ingredients, these included coir (coconut fibre), a small amount of vermiculite to camouflage any small pieces of plastic, etc. and the matured compost. The composting process itself had been quality assured to meet the most credible limits for unrestricted use of biosolids that were available at the time, i.e. the USEPA Part 503 Class-A EQ standard (USEPA, 1993). It was essential that the compost was fully matured, one of the critical criteria proved to be a wide ratio of nitrate to ammonium. In mature compost the nitrification rate (of ammonium to nitrate) is rapid. QA included blending the ingredients, bagging the products, and distributing them. "Due diligence testing" to compare the products with other products from garden centres and garden soil, etc. was undertaken to ensure the products were beyond reproach.

Market Research

The question of fundamental importance was "would gardeners use growing media based on recycled material of human faecal origin?" Our market research showed that 90% of gardeners found no problem with this, and when they saw samples of the products they found them very pleasant and easy to handle. In focus group interviews we tried to get people who were sceptical about privatisation of the water industry, this proved surprisingly difficult. Although Thames Water

had no recent record in horticulture[2] gardeners felt that if the company was involved in the project the products would be safe and of a high standard.

Gardeners had been exposed to intensive lobbying not to use peat but, despite this, peat alternatives only accounted for 3% of the market, having peaked earlier at 5%. Our market research found that 30% of compost users had tried peat free media but it had not come up to their expectations, however 23% said they would be willing to try again. Gardeners were well disposed towards green products, but their prime concern was that they must perform and also that they must be good value for money and be easy and convenient to use.

Market research was also used to test the appeal of different elements of pack design and the messages they conveyed.

Pack Design and Point of Sale Displays

To prevent the potential criticism/scandal that the products were derived from human sewage we stated on the packs and the point of sale notices that they were "based of sewage cake composted with straw and other biomaterials" – no ambiguity or suggestion of obfuscation. There was no adverse reaction to this information. It was consistent with the objective of supporting the bulk of the biosolids recycling programme by demonstrating that the public was not "faecal-phobic" and would buy and use sludge based products provided they worked and were safe and pleasant to use.

The product names included "peat free" because they were, but peat was never criticised because peat has excellent horticultural properties. It is not much of an endorsement of any product if all that can be said about it is that it is not something else. If gardeners wanted good results our products matched the best, they retailed at the same prices and (as a bonus) they did not contain peat.

In accordance with good practice in the UK, the bags were labelled with instructions for use, which helped customers to get good results and avoid disappointment. Growing media can experience compression irreversibly between manufacture and out-turn, for example bags at the bottom of pallets; consequently bags were labelled N litres when packed (according to BS EN 12580).

Getting the Products to Market

This involved another set of skills that were new to TERRA ECO•SYSTEMS as composters and biosolids recyclers. Selling to garden centres is not the same as selling to farmers and a new language had to be learnt. Farmers are interested in how a product works and its benefits, retailers of fast moving consumer goods are interested in whether they will indeed move fast. Is there a programme of marketing/advertising support? Will the product increase footfall? Will customers come back for more?

We decided that we did not have the volume to sell to the "sheds" (the multiple retailers) and neither did we want to be hostage to a small number of very large customers, therefore we decided to target independent retailers, which had the appeal to them of being different from the sheds. Unlike the major manufacturers our customers could buy as few as three pallets rather than a full truck-load. Gardeners could telephone to obtain details of their nearest stockist.

[2] Sales of Morganic (thermally dried digested sludge) in bags ceased in about 1980 when the dryer had reached the end of its life.

Exposure in magazines was an obvious way to develop awareness amongst gardeners but the UK did not have regional gardening magazines so we had to be prepared to sell nationally. We had novelty for the magazines but they tend to "favour" advertisers when they run editorial articles so we had to use our very limited funds for advertising judiciously. Geoff Hamilton, presenter of BBC 2's Gardeners' World (the premier gardening TV programme) and staunch campaigner against peat would have been a great advocate but sadly he died in August 1996, he was an exceptional broadcaster. However, his successor, Alan Titchmarsh, established his popularity quickly, we were able to find his address and deliver bags of product, which he used on the programmes including an enthusiastic description of the initiative.

The proof of the initial success came over the Easter weekend (28th-31st March 1997). Traditionally Easter is the start of the gardening year and we aimed to get product to as many retail outlets as possible. The response was tremendous and on the first working day retailers were placing repeat orders.

All the indicators of sales performance more than doubled from year to year (Figure 4). By year 2 109 garden centres in England, Scotland and Wales stocked the products and revenue from sales was £179,211. Although we had not targeted trade customers such as nurseries, they had bought significant amounts of product because they found that they worked well for the types of plants they grew. It was necessary to "nurse" some of the retailers, check on their stocks and remind them when they were running low and then they would re-order but without this nursing they were as likely to put a competitor's product in place of TERRA and tell customers they were out of stock. Selling had to be proactive. At that rate of growth the project would have covered all its costs and turned a profit by the end of year 4.

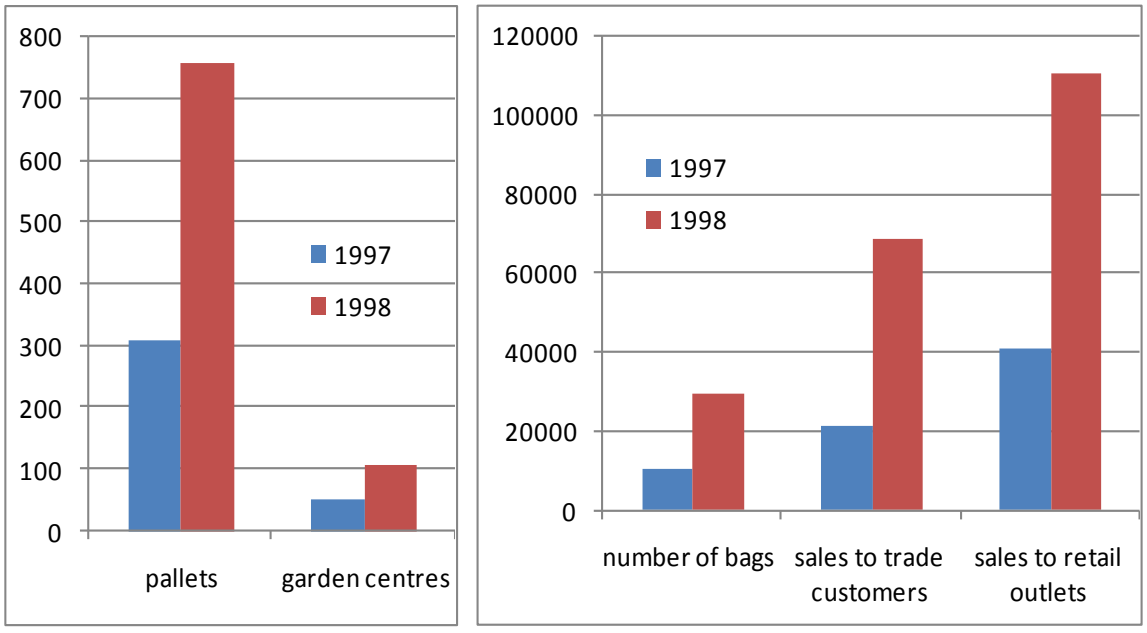

Figure 4 Sales performance showing pallets sold, garden centre stockists recruited, bags sold and sales (£) to trade and retail customers

Legal Position

To a large extent "the law was silent", there was no specific law, but then there is no specific law from most products. Clearly the products were outside the Sludge Regulations (Anon, 1989) because we were not selling to agriculture. The Site Licence did not consider the product was "waste". We complied with the Trading Standards requirements as far as merchantable, fit for purpose products that were sold by volume correctly measured and stated were concerned. We had extensive records to show the chemical quality and the time-temperature achievement of the critical control point for pathogen control backed up by verification data to demonstrate the products complied with the most credible, science-based requirements in the world. These were the first peat-free products that performed as well as the brand-leading peat-based products and sold at the same prices and they had been praised on the nation's premier gardening TV programme.

Conclusions

The project has been described as "skunk works" and it certainly had much in common with Lockheed Martin's "The 14 Practices and Rules for Skunk Works" [3] - success was very much about people.

Composted wastewater biosolids can be turned into high quality garden centre products but only with a lot of effort and a rigorous development programme that involves skills that most wastewater treatment operators almost certainly do not possess. These include horticulture, marketing, design, brand management, process engineering and selling; they all require considerable attention and the autonomy to be able to respond quickly. Any change in feedstock to the composting process may significantly change the characteristics of the compost and necessitate re-formulation and further testing of the products. Since the ultimate test of a growing medium is growing plants this takes appreciable time. There are a few textbooks, such as Bunt (1988) that can give some guidance but plants do not read textbooks so ultimately it is a matter of growing plants to test and refine the formulations.

It is essential that the whole process is quality assured and that there is adequate traceability including an archive of analytical and monitoring data with depth and breadth so that the products can sustain scrutiny. If you would not be confident going into the witness box (literally or metaphorically) to defend your products, don't go down this path. The quality of the compost feedstock must be demonstrably above reproach. The composting process must achieve adequate time/temperature for pathogen control. The composted material must be fully matured and stabilised. Any additional ingredients must also be of defined and consistent quality.

Acknowledgements

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EN 13039:1999 Soil Improvers and growing media – determination of organic matter and ash

EN 13040:1999 Soil Improvers and growing media – sample preparation for chemical and physical tests, determination of dry matter content, moisture content and laboratory bulk density

EN 13041:1999 Soil Improvers and growing media – determination of physical properties – dry bulk density, air volume, water volume, shrinkage value and total pore space

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EN 13651:2001 Soil Improvers and growing media – $CaCl_2$-DTPA extraction

EN 13652:2001 Soil Improvers and growing media – water extraction

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Appendix

The following varieties were used in the course of developing and proving TERRA ECO•SYSTEMS *Peat Free* Multi-Purpose Compost and gratitude was due to Thompson & Morgan and to Unwins for their advice and support

Species	Cultivar	Source
Ageratum	Blue Mink	TM
Anagallis linifolia	Gentian Blue	TM
Antirrhinum	F1 Chimes Bronze	O
Balsam	Baby Bush	U
Begonia	Rieger	O
Begonia semperflorens	Viva	TM
Begonia (corms)	Pastels	O
Cactus	Various	O
Canary Creeper		O
Chilean Bellflower *Nolana*	Bluebird	U
Chilean Glory Vine	Fireworks	U
Cineraria	Royalty	O
Cobaea scandens	Cathedral Bells	U
Coleus	Rainbow mixed	O
Cyclamen	F1 Laser Rose Flame	O
Dahlia	Dwarf	TM
Epipremnum aureum	Marble Queen	O
Ferns	Various	O
Ficus benjamina	Variagata	O
Fuchsia	Various	O
Hyacinthus orientalis	Various	O
Impatiens	Various cultivars	TM
Impatiens	Double flowered	TM
Impatiens	Tempo White	TM
Impatiens	F1 Accent White	O
Ipomoea	Mini Sky Blue	TM
Lilium	Various	O
Lobelia	Cascade Mixed	O
Lobelia	Blue Splash	TM
Marigold	Gold 'n Vanilla	U
Marigold	French Vanilla	TM
Marvel of Peru *Mirabilis jalopa*	Afternoon Delight	U
Narcissus	Various	O
Nasturtium	Whirleybird Mixed	U
Nasturtium	Tall climbing mix	U
Nasturtium	Dwarf semi-dbl	U
Nasturtium	Peach Melba	U
Nasturtium - dwarf	Salmon Baby	U
Nasturtium - dwarf variegated	Alaska	U
Nasturtium - variegated	Jewel of Africa	TM
Nemophila maculata	Five Spot	U
Nepeta	Trailing	TM
Pansy	Super Beaconsfield	U
Pansy	Love Duet	U
Pansy	Silhouette Mixed	TM

Species	Cultivar	Source
Pansy	F1 Ultima Blue Centre	O
Passiflora	Mollissima	TM
Pelargonium	Various cultivars	TM
Pelargonium	F1 Salmon Elite	O
Pelargonium - regal	Mixed	O
Pelargonium zonale	Dwarf Century	O
Petunia	Buttercream	U
Petunia	Lavender Storm	U
Petunia	Giant Victorious	O
Petunia	F1 Frenzy Red Vein	O
Polyanthus	Crescendo Blue	O
Sansevieria trifasciata		O
Saxifraga	Rock garden mixed	TM
Silene	Pink Pirouette	TM
Spathiphyllum wallisii		O
Stock	Apple Blossom	TM
Stock	Cinderella Rose	O
Stocks (column)	Giant Excelsior	U
Sunflower	Pastiche	TM
Sunflower	Moonwalker	TM
Sunflower - dwarf	Teddy Bear	U
Sunflower - dwarf	Music Box	U
Sweet Pea	9 cultivars	U
Thunbergia	Susie Mixed	U TM
Tobacco *Nicotiana*	Sensation Mixed	U
Tobacco *Nicotiana*	Little Nicky	U
Tobacco *Nicotinia*	Appleblossom	TM
Tobacco *Nicotinia*	Breakthrough Mixed	TM
Tobacco *Nicotinia*	Dwarf White Bedder	TM
Alpine Strawberry	Baron Solemacher	O
Aubergine	Slice Rite No. 23	U
Courgette	Gold Rush	U
Courgette	Zucchini Hybrid	U
Globe Artichoke	Green Globe	U
Onion	Ailsa Craig	O
Runner Bean	Scarlet Emperor	U
Runner Bean	White Emergo	U
Strawberry	Serenata	O
Strawberry Spinach		U
Tomato	Gardeners' Delight	O
Tomato	F1 Shirley	O
Tomato	Super Marmande	O
Tomato	Tumbler	U

Key:
U = Unwins
TM = Thompson & Morgan
O = Other sources