Assessing quality of plant raising media for organic systems

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Executive summary

Good quality transplants are vital to growers for a number of reasons. Their ability to better tolerate pest, disease and weed problems and their capacity to make better use of newly incorporated green manures (compared to direct drilling) make them all the more so in organic systems. The availability of high quality growing media is essential to producing healthy vigorous plants, but the organic standards restrict the choice of products available and many growers do not feel they have sufficient information to base their choices. OCW, with support from Farming Connect, coordinated a project to assess the certified products and looked at a green waste based product under development to help address this problem.

Growers were supplied with samples of certified products (details provided in the table below) and were asked to test them on range of crops. In order to support this work, scientifically robust trials were carried out by a plant raising specialist on cabbage leek and lettuce.

Product	Base	Additives
Bulrush Horticulture Ltd	Peat	DCM; Lime/ Dolodust
Fertile Fibre Seed mix	Coir	MB1 (Nitrogen source including hoof and horn); Vermiculite
• Klasmann modules • Klasmann blocking (Grower Trials Only)	Peat Peat & Green Waste	N, P , K Mg
• West Riding Organics Bio pak 10 • West Riding Organics Seed & Cutting (Grower Trials only)	Moorland Gold Peat	Vermiculite; Coir; Lime; Sugar beet based fertiliser; Basalt minerals
Development product (Formal Trials only)	Peat & green waste	DCM; Dolomite lime; Zeolite

Details of products tested

The quality of media was assessed against a range of plant performance indicators and an analysis of their physical and nutritional properties as described below

Indicator Type	Details
Plant performance	Days to emergence; emergence rate, plant height and general vigour; root development; days to transplanting
Weed burden	No. cells with weeds
Physical and chemical properties	Water retentiveness, Density, Ph, Conductivity, nutrient status

Performance indicators

Key points arising from the work are as follows:

General Observations

- There was a great degree of variability between products and this is not surprising given their very different compositions.

- Over all there was little difference between the compost in terms of time to emergence
- Differences in emergence rates were apparent in the grower trials but emergence was excellent in all products in the formal trials, suggesting that this was not a problem with the media per se
- In terms of vigour, the grower trials suggested vigour in most products was good. The formal trials did not bear this out. West riding, the development product and Bulrush showed good or acceptable vigour. Fertile Fibre and Klasmann had problems that were particularly apparent in cabbage and leeks. The possible reasons for this are discussed in relation to individual products.
- On the whole, most of products retained about the right amount of water for good growth and easy water management. The exception was Fertile Fibre which was more prone to drying out the others
- The development product, based on green waste performed as well and many regards, better than, the certified products. This indicates that there is good potential for green waste based products to play a role in organic systems, but further work is need to further develop them and to certify them for use in organic systems.
- In the grower trials, plants were observed subsequent to planting out. Field development was good in all cases and plants that had comparatively poor vigour at the plant raising stage compensated for this in the field. This information needs to be considered in the light of the field conditions, in particular the pest disease and weed pressures and the nutrient status of the soil.
- Although this project focussed very much on quality issues, growers take into account factors other than plant performance when considering choice of product including
    - *Environmental impact*. This relates mainly to peat; whether the product contains peat at all, and if it does, whether it was extracted from bogs.
    - *Handling properties*. This is a particular issues for larger growers who might wish to use automated systems to fill modules. The peat based products are likely to run well through machines, where as the more open, fibrous coir based product is likely to cause problems. Even where trays are filled by hand, the ease with which this can be done is an issue
    - *Cost and availability*. This is a particular issue for smaller growers who as located some distance form site of production, as is often the case in Wales. The issues of availability in small quantities (say less than a pallet, fro instance), and the cost of delivery per bag can also influence growers choices

Product specific comments

Bulrush

The formal trials showed that this product delivered a high proportion of usable plants of reasonable quality, although some were starting to show signs of stress in cabbage and lettuce towards the end of plant raising period. Laboratory analysis suggested that this could be related to low N levels. However, it performed particularly well in leeks with well developed roots systems and good general health. This may be linked with a slower rate of release of nutrients compared with the others. This is a particularly desirable quality when dealing with leeks as early mineralisation can lead to losses through leaching.

Over all, growers had a relatively positive experience with this product, which supports the conclusions of the formal trials, particularly with regard its good performance with leeks.

Fertile Fibre

In the formal trials, the performance of this product varied between the different crops. It produced reasonable lettuce plants of which practically all were usable although the leaves were tough and there was some veining which may have been linked to a marginal manganese deficiency induced by the relatively high pH. There were however serious problems with cabbage and leeks. For cabbage, only about a third of the plants were judged to be usable for hand planting and none would have been sufficiently robust to go through a planter. The plants struggled throughout the plant raising period, and suffered from tip burn, a problem possibly linked with its low calcium content. With leeks growth was patchy and uneven, and again, would not have been suitable for machine planting.

However, these problems were not reflected in the grower trials both in terms of plant performance and nutritional composition. Laboratory analysis showed the 2006 batch to be high in all the major nutrients, it scored well in terms of vigour for wide range of crops (including cabbage and leek).

A second sample of the formal trials batch was sent away for analysis and the results were much closer to the batch used for the grower trials. The problems in the formal trials may therefore be attributable to mixing problems, which would lead to patchy distribution of available nutrients, or storage conditions. If the compost is kept in a warm environment microbial activity would be greatly increased and this may lead to localised production of ammonia.

Klasmann

In the formal trials, the Klasman (Modules) appeared to start off well, but had a tendency to ‘run out steam’ towards the end of the plant raising period, producing small weak and stressed plants, many of which would not have been sufficiently robust to pass through a planter. In terms of nutrient levels, laboratory analysis showed medium levels of all the major nutrients compared to the other products, and this was reflected in plant performance. It is also possible that early mineralisation of N, which in turn have been influenced by the microbial population of the material, may have lead to leaching.

Growers also detected a certain lack of vigour and staying power with regard to the modular compost, which would be consistent with the above. However, the blocking product, which was not included in the formal trials, had no such problems, and vigour was similar to other products.

West Riding Organic

The over overriding problem here is one of weeds. In the formal trials, all cells in all crops were infested with predominantly grass weeds, but some broad leafs also. In weed susceptible crops such as leeks, the crop plant can be completely smothered out This is unfortunate because in all other respects it appears to perform very well, producing strong and healthy plants when they can out-compete the weeds. However, even when this is the case, the problem carried through to the field phase as the weeds get planted out with the crop.

On the commercial holdings, the growers appeared to pick up an emergence problem, but this was not apparent in the formal experiments. Vigour in the plants that did emerge was very good, and this is consistent with the formal trials. The same was broadly true for the West Riding seed and cutting.

Development product

In general this product grew large, healthy plants for all crops. There were no significant problems is terms of plant colour, and few visible signs of stress. The laboratory analysis shows that this product was high in terms of nitrogen, and comparable in terms of the other major nutrients

It should be stressed that this not an organically approved product, and the question of whether it would meet the organic standards is an open one. The purpose for including it in the trials was to investigate the potential for green waste based products to be developed for plant raising purposes. The results indicate the there are clearly grounds to investigate further, and that green waste based composts could well have a role to play in the organic sector in the future. There is no problem related to the use of green waste compost providing the starting ingredients are compliant with the organic standards and the process is managed under the PAS 100 composting protocols.

Contents

1. Introduction

Raising plants from seed to seedling stage for subsequent transplanting out in to the field is a common practice in both organic and conventional systems. It has a number of advantages as discussed in section 3.1. The use and availability of high quality products is essential to producing healthy vigorous plants. However, organic growers have recently raised concerns about the quality of propagating media in general, and since the standards severely restrict the number products available, this is a significant issue. Many growers feel they do not have sufficient information about the performance of the different media to make an informed choice.

2. Objectives

The project aims to assess and compare the quality of a number of certified organic propagation media products. A product currently under development was included to assess the potential for the green manure to reduce the peat content of certified products.

3. Background information

3.1 Plant establishment systems

There are essentially three approaches to plant establishment; direct sowing, bare root transplants and block/ module transplants.

3.11 Module transplants

Many crops are grown under protection in modular trays or blocks of growing media. The entire plug is then transplanted out in to the field at the appropriate stage after a period of ‘hardening off’. There are a number of advantages to this approach, including:

- The grower has more control over the production environment
- Saving labour; It is easier to look after seedlings in a small protected area compared to a field situation. Also, the plants are planted at their final spacing and do not need thinning subsequently.
- The stand of plants in the field is more uniform because there are no gaps due to germination failure
- Plant development is more uniform across the crop, making harvest periods and intervals more predictable
- Growing in modules makes it easy to transplant into the field by machine
- Transplanted seedlings are stronger and better able to resist pest and disease problems
- Transplanting into a well prepared and weed free bed gives the crop a head start, and increases its chances of out competing weeds.
- Green manures are more effective compared to direct sowing as the transplants perform better in ground with newly incorporated green manures.

The last three points are particularly relevant to organic systems. On the other hand, this method tends to be more expensive and requires some initial outlay if raised on the farm. This is especially true if the plants are raised under protective structures (polytunnels or glasshouses). Transplants may need to be watered in, so the availability of irrigation facilities can also be a factor.

3.12 Direct sowing

In some cases, seeds are sown directly into the field. Some crops, such as carrots, are always direct drilled, where as others such as onions, can also be raised as module transplants. This method tends to be cheaper, for reasons discussed above, but there are a number of issues that need to be considered. Without the benefits of improved pest disease and weed tolerance, some thought needs to be given to the management of these problems in the field. This particularly true of weed problems in the crops with a more upright growth habit, such as onions and leeks, which will not be able smother out weeds.

3.13 Bare root transplants

Bare root transplants are halfway been direct sowing and transplant modules. They are either grown on nursery beds and then lifted and planted into their final position, or they can be raised as rows of seedlings in trays. It offers a number of advantages compared to buying in modular transplants including:

- It is generally cheaper
- The risk of bringing in pest and disease problems is reduced
- The grower has greater flexibility in sowing dates and choice of variety

However there are also problems including an increased need for weed management, susceptibility to damping off diseases and more complicated and slower planting regimes. It should also be noted that this method can only be carried out on the holding where they will be planted out if the holding is registered with Soil Association Certification. The Compendium of UK Organic Standards makes no reference to this practice and it may therefore be possible to buy in organically raised bare root transplants if the holding is registered with other certification bodies though growers should always check.

3. 2 Plant raising media

3.21 Base substrates

Plant raising media can come in a variety of guises, but are usually consist of a base material with added nutrients, usually derived from composted materials and/ or additional plant feeds.

Many products are based on peat, which for the most part is extracted from bogs. Bogs are ancient and irreplaceable habitats, supporting their own unique range of flora and fauna. This raises huge environmental concerns, and as a result of extraction, peat bogs now constitute one of the most threatened environments in Europe, and lowland raised peat bogs are

particularly vulnerable in the UK (Pryce, 1991). Some peat is not extracted but is derived from sustainable sources. For example, Moorland Gold is produced from peat and silt deposits built up from natural erosion by the filtration of water off the Yorkshire moors, and form the basis of West Riding Organics' product range.

However, this is a tiny proportion of the total and a great deal work has been carried out to identify alternatives to peat, ranging from major organic materials (Animal manures, woodchip, coir, vermicompost); minor organic materials (abbatoir wastes, heather/ bracken bales, seaweed); major semi-organic/inorganic materials (rockwool, vermiculite, etc); and minor semi-organic/inorganic materials (Recycled landfill, lignite, sugar beet washings, zeolites).

Only a handful of these have been developed into commercial plant raising media products, notably coir, vermicompost and heather/bracken while others such as abattoir wastes and zeolites have been used as supplementary feeds as opposed to direct replacements for peat. There is currently a great deal of interest and development work going on to using wood chip and green waste composts. However, at present there are relatively few commercial available products available and even fewer with organic certification. The notable exception here is Fertile Fibre, which is based on coir, and is one the products tested as part of this project.

The use of peat remains widespread including in products approved for use in organic systems. This is largely because peat has a number of attributes that make it an ideal horticultural growth media, and many growers remain to be convinced that there is a viable alternative. These characteristics include:

- An excellent ability to maintain moisture levels that are ideal for many crops
- A high air filled porosity,
- Retains its physical structure over the long periods that some crops need in modules, even under ideal decomposing conditions.
- A reasonable ability to retain and release nutrients. Its own nutrient content is minimal which can be an advantage in managing plant nutrition (but makes it a very poor soil amendment material)
- Relative sterility and therefore free of weeds and pathogens provided it is well processed and harvested.
- Light weight
- Ability to be milled so that it passes easily through machines and automated module-filling system

It is not entirely without its problems. If it does dry out, it very difficult to re-wet. Freedom from weeds is dependent on large scale extraction and processing methods. Moorland gold, for instance can have significant weed problems as discussed later in this report.

3.32 Nutrients and supplementary feeding

The propagation stage has a unique set of requirements and challenges in terms of nutrients. Different crops make different demands on propagation media. Brassicas, such as cabbage, produce vigorous growth reaching transplant size relatively rapidly, while leeks have a slower growth rate and a more extended growth period with slightly different nutrient requirements. The time of year is also an important factor, with higher demands in the late autumn, winter and early spring period, where supplementary feeding is required for many crops

Some of the nutrients are derived from 'Base' feeds, which form an integral part of the media product. They are slow release and become available to the plant throughout its development. The supplementary feed needs to provide more readily available nutrients, especially N. The supplementary feed should ideally be in a liquid form (solution and/or suspension of nutrients) suitable to be delivered through the irrigation system. Alternatively it could be in a granular or powder (solid) form.

While it is possible to grow transplants on base nutrients only, some feeding is usually required to produce transplants of an acceptable quality. These feeds can take various forms and include animal products such as manure, dried blood, hoof and horn and other abattoir waste products. The inclusion of animal products has always been consider far from ideal particularly with regard to organic systems, and work has been carried out to identify non animal alternatives (Stopes, 2001). A study by the Organic Research Centre (Formerly Elm Farm Research Centre) in collaboration with HDRA and HRI Kirton (Elm farm Research Centre, 2000) looked at this issue and identified a number of products suitable that could potentially be used under UK conditions, including AmegA, BIOFEED 5.0-0-2.5, Westland Organic Tomato and Vegetable liquid feed (WTV)

There is very little information on the specific nutrient requirements of key crops in the published literature and what there is does not tend to distinguish between different crops and in practical terms growers usually source one product to use on all their crops. However, it is generally accepted that leeks require more nutrients because they are slower growing, and are in the modules for much longer than other crops. So-called seed or germination media tend to ontain relatively low levels of phosphorus to encourage early root growth and calcium to maintain optimum pH. Otherwise the general view is that nitrogen is the key nutrient once the initial seedling has developed using the nutrients in the seed cotyledons. Growth rate will generally increase in response to increasing levels of nitrogen though there will always be differences between species – the relative growth rates of brassicas and leeks has already been mentioned. The caveat is that excessive nitrogen mediated growth will give a soft seedling that is more prone to disease and physical damage.

3.33 Organic standards and propagation media

Media approved for use in organic plant raising systems must always be used when propagating organic crops. For a propagating media to be labelled as organic, all agricultural ingredients must be from organic origins. There is no specification for the percentage of agricultural ingredients

required. However, because of the particular requirements of propagation media approved products may contain ingredients which would be prohibited in any other type of compost, including blood and bone products.

The fact that a particular product is not registered with an organic certification scheme does not necessarily preclude for use in organic systems. If a grower using a non-certified media can prove that the media is composed only of approved ingredients, it may be permitted. The products trialled in this particular project are all certified.

4. Methods

4.1 General approach

A total of 5 propagation media products were assessed, four were certified organic products and the fifth was a product under development. Details are provided in Table 1.

Quality was assessed by measuring a number of parameters including:

- Laboratory analysis of chemical and physical properties
- Qualitative observations on handling
- Plant growth and development indicators (days to emergence, emergence rate, plant height and general vigour, days to transplanting, qualitative observations root development)
- Water retention capacity
- Weed populations

Data was collected in two separate, but linked trials. On farm trials were carried out during the 2006 season, and generated anecdotal information while providing participating growers with the opportunity to compare the products on their own units. The original intention was to run fully replicated trials at the Welsh College of Horticulture in parallel to the grower work to generating statistically robust data to support the growers. In the event, various management issues and crop failures at the college meant little data could be derived from these trials. They were rerun in the spring of 2007, at Tan yr Allt, near Llanrhystud, Ceredigion. The same products were used as in the grower trials, but the batches and the season were different, weakening the link between the two trials.

4.2 Laboratory analyses

A sample of each product was sent to Eurofin Laboratories and analysed for the following properties

- *Physical & Electrochemical properties*; pH; Conductivity; Density
- *Nutrient content*: Phosphorous; Magnesium; Potassium; Mineral Nitrogen; Calcium; Sodium; Chloride; Sulphur; Trace elements (Boron Copper Manganese Zinc Iron)

Supplier	Product	Description	Certification Status
Bulrush Horticulture Ltd	Transplant/Modular Compost	*Base:* 100% Peat (30% dark 60% light and 10% sod). *Additives (per m^3):* 3 Kg DCM Base 7-7-10; 4.5 Kg Lime/ Dolodust	Soil Association certified
Fertile Fibre	Seed mix	Base: 100% Coir Additives MB1 (Nitrogen source including hoof and horn); Vermiculite	Soil Association certified
Klasmann	Bio Tray (Modular)	*Base:* 100% very fine peat *Additives:* Nitrogen 400 mg/l; Phosphorous (P_2O_5) 250 – 350 mg/l; Potassium (K_2O) 350 – 500 mg/l; Magnesium 100-125 mg/l	
	Bio Potgrond (Blocking)	*Base:* 66% Peat, 33% Green Waste *Additives:* Nitrogen 400mg/l; Phosphorous (P_2O_5) 250 – 350 mg/l; Potassium (K_2O); 350 – 500 mg/l; Magnesium 100-200 mg/l	
West Riding Organics	Bio-Pak 10 Module Compost Seed & Cutting Compost	*Base:* Moorland Gold Peat *Additives* Vermiculite; Coir; Lime; Sugar beet based fertiliser; Basalt minerals	
Development product		*Base:* 66% Peat, 33% Green Waste *Additives* Zeolite N based Feed	

Table 1: Details of products tested

4.3 Detailed methodology - Formal trials

4.31 Crop and media details

The following products were used (see Table 1 for details): Bulrush; Fertile Fibre Organic seed mix; Klassman Bio Tray; West Riding Organics Bio-Pak 10; the development product.

They were each tested on three crops; Cabbage, variety Golden Cross F1; Leek, variety Zermatt; and Lettuce, variety Pinokkio (Cos type)

4.32 Germination tests

Laboratory tests were carried at the Institute of Rural sciences to determine the baseline germination rate of the seed used in the trials to eliminate poor seed quality as cause of any low emergence rates detected in the trials. For each crop 50 seeds were placed in each of 3 petridishes on damp filter paper and arranged on the bench in a Latin Square design. The number of seeds germinated (i.e. the radical was visible) in each dish was recorded for a period of 10 days. The filter papers were monitored and water was added as required to prevent drying out.

4.33 Sowing

For each crop, 3 trays of modules were prepared for each product, and seeds were sown in all three trays on the same day. Details of module systems, sowing dates and number of seeds per cell are summarised in Table 2

Crop	Modules size (cm^3)	Modules/ tray	Sowing Date	No seeds/ cell
Cabbage	37	150	15/03/2007	1
Leek	37	150	15/03/2007	2
Lettuce	53	77	14/03/2007	1

Table 2: Details of module systems and sowing dates

4.34 Plant raising

Plants were raised according to normal commercial practice, using simple standard propagation equipment. Once the seedlings had emerged, the trays were removed from the propagator and arranged on a bench in a randomised block design. About 10 days after sowing the trays were moved to a colder side of the tunnel, retaining the same randomised block design. Plants were watered as necessary

Figure 1: Trial site

4.35 Monitoring and recording

The indicators for which measurements were made and the dates on which they were recorded are summarised in Table 3. In the case of plant height, three assessments were made, one at the beginning, one in the middle and one at the end of the plant raising period. Exact dates depended on the crop and the growing conditions. At each assessment, a randomly selected sample of 10 plants was measured in each tray. Weed populations were assessed at the same time and recorded the number of cells with weeds present rather than actual weed counts.

	Cabbage	Leek	Lettuce
Emergence rate	25/03/2007	01/04/2007	25/03/2007
Plant height & weediness (1)	02/04/2007	02/04/2007	02/04/2007
Plant height & weediness (2)	14/04/2007	24/04/2007	15/04/2007
Plant height & weediness (3)	21/04/2007	30/04/2007	18/04/2007
Water holding capacity	Throughout	Throughout	Throughout

Table 3: Details of quality assessments

At the end of the third assessment, a judgement was made on the proportion of usable plants from each tray. There were no measurable criteria to define ‘usability’, but decisions were based on the likelihood that the plant would grow on to produce a marketable yield, and were under pinned by 20 years of plant raising experience. The number of usable plants was expressed as a percentage of seeds sown. Observations were also made on the general condition of the plants and the development of the root system.

The data collected was analysed statistically, using analysis of variance (ANNOVA) techniques within Genstat. Data was tested to a significance level of p=0.05.

A diary was kept throughout the trial in which management operations and qualitative observations were recorded. Visual differences between the products were recorded photographically using a digital camera

4.4 Detailed methodology - On farm trials

4.41 Participants and product- crop combinations

Eight commercial growers from across Wales participated in the trials. The protocols were much less rigid than for the formal trials, and were designed to fit around the growers' commercial operation rather than vice versa. They ensured that all participants measured the same parameters on the same scale, but did not dictate sowing dates, seedling management or choice of crop/ variety. Not all growers tested all products, and the assessments were carried out on a wide range of crops, as indicated in Table 4.

	Bulrush	Fertile Fibre	Klas. Modular	Klas. Blocking	W. Riding Biopak	W. Riding Seed & Cut	Sinc.
Broccoli	✓	✓	✓			✓	
Broad Bean	✓						✓
B. Sprouts	✓	✓	✓	✓	✓	✓	
Cabbage	✓	✓	✓	✓	✓		
Calabrese	✓			✓			
Celery	✓	✓					
Chard	✓	✓	✓		✓		
Cucumber	✓	✓					
Kale	✓	✓	✓	✓	✓		✓
Kohl Rabi	✓	✓	✓	✓	✓	✓	
Leeks	✓	✓	✓			✓	✓
Lettuce	✓	✓	✓	✓	✓	✓	
Onions (Mc)	✓	✓	✓				
Onions (Spr)	✓	✓	✓	✓	✓	✓	
Pea	✓	✓					
Rocket	✓	✓	✓		✓	✓	
Spinach	✓	✓	✓		✓		✓
Sweet Corn	✓	✓	✓	✓	✓	✓	✓
Tomato	✓	✓	✓	✓	✓	✓	
Total No. Growers	7	7	5	3	5	3	

Table 4: Crop/ product combinations testing in the grower trials

4.32 Plant raising and monitoring of performance

Growers raised plants according to their usual practice and recorded the following observations:

- Sowing date
- Date of emergence
- Emergence rates - % of seeds sown)
- Plant vigour - Score 1 – 5 (1= very poor, 5 = excellent)
- Weediness - Score 1 – 5 (1= very weedy, 5 = completely clean)
- Water retention – Score 1 - 5 (1= too dry, 3= just right and 5 = too wet)

When they were ready, the young plants were hardened off and planted out in the field, where the following observations were made:

- Date of transplanting
- Crop development in the field - Score 1 – 5 (1= very poor, 5 = excellent)
- Date of harvesting

Data was entered onto record sheets provided along with other comments and observations comments, and were returned to Organic Centre Wales at the end of the season for collation and analysis. Some growers recorded visual differences photographically.

5. Results

5.1 Laboratory analysis

The relative levels of the major nutrients are set out in Table 5, and the actual values in Table 6. The values from the analysis were compared to an ideal target range, based on work done in the University of Kentucky (Murray and Anderson, 2004). Unfortunately, some of the samples that were used in the growers trials and the initial formal trials were not taken, and therefore unavailable for analysis.

It is clear that there are considerable differences, not only between the products, but between batches of the same product in different years. In the case of Fertile Fibre, analysis of the grower and formal products were so different that a second sample of the same batch (but not the same bag) used for the formal trials was sent away for analysis, and came back broadly similar to the products used in the grower trials. This difference could be due to a number of factors including:

- Mixing problems, which would lead to patchy distribution of available nutrients
- Storage conditions. If the compost is kept in a warm environment microbial activity would be greatly increased and this may lead to localised production of ammonia.

The development product stood out as having very high nitrogen (Nitrate) levels. Bulrush was particularly high in P but very low in N. Fertile Fibre is also interesting with regard to N, because in the formal trials it contained low levels of Nitrate but very high ammonia levels.

	pH	N (Nitrate)	N (ammonia)	P	K	Mg	Ca
Bulrush							
F. Fibre (formal 1)							
F. Fibre (formal 2)							
F. Fibre (grower)							
Klas. (formal)							
Klas. (Grower)							
West Riding							
Development							

Very High | High | Target Range | Low | Very Low

Table 5: Relative nutrient levels of products

	Bulrush		F.Fibre			Klasmann		W. Riding		Development		Target
	Formal	*Grower*	*Formal (1)*	*Formal (2)*	*Grower*	*Formal*	*Grower*	*Formal*	*Grower*	*Formal*	*Grower*	
PH	6.5		7.2	5.2	5	6.4	6.1	6.3		5.6		5.6-6.0
Conductivity (uS @20°C)	334 (3)		410 (3)	445 (3)	670 (5)	366 (2)	755 (6)	602 (5)		849 (6)		500-700
Density (g/l)	280		325	418	466.5	313	235.2	523		374		
Nutrients												
Phosphorous (mg/l)	38 (5)		3 (0)	48 (6)	77 (8)	4 (0)	10 (2)	<2 (0)		18 (3)		5-10
Potassium (mg/l)	136 (3)		291 (5)	477 (6)	632 (6)	205 (4)	362 (5)	364 (5)		198 (4)		50-100
Magnesium (mg/l)	15 (2)		4 (0)	33 (4)	77 (6)	68 (6)	182 (8)	27		151 (8)		30-70
Total Nitrogen (mg/l)	8		105	133	158	86	211	131		378		
Nitrates (mg/l)	<6	Sample Lost	14 (0)	130 (4)	156 (5)	85	211	120	Sample Lost	369 (7)	NA	30-75
Ammonia (mg/l)	8		91 (2)	3(0)	2	1	<1	41		9 (0)		
Calcium (mg/l)	23		3	26	65	173	388	178		608		60-120
Sodium (mg/l)	65		117	151	225	28	45	246		168		
Chloride (mg/l)	26		268	175	220	42	92	23		68		
Sulphur (mg/l)	174		167	109	269	201	434	397		414		
Trace elements												
Boron (mg/l)	<0.1		<0.1	0.19	0.48	<0.1	<0.1	<0.1		0.2		
Copper (mg/l)	<0.15		<0.15	<0.15	<0.15	<0.15	<0.15	<0.15		<0.15		
Manganese (mg/l)	<0.1		<0.1	0.4	0.8	0.6	0.3	0.2		2.6		
Zinc (mg/l)	<0.1		0.24	0.58	0.45	1.03	0.7	0.15		0.49		
Iron (mg/l)	<0.5		2	0.86	0.55	0.5	0.61	0.61		0.5		

Table 6: Physio-chemical properties and nutrient values of test products

'Target' figures are from Murray and Anderson (2004). The nutrient level figures are in parts per million (ppm) and are broadly equivalent to the mg/litre figures in the rest of the table. The relatively low nitrate target is based on reducing seedling stress in the early stages and applying additional nitrogen in the later stages.

5.2 Formal trials

5.21 Crop diaries

Detailed records of the various management operations and qualitative observation can be found in Appendix I.

5.22 Seed germination tests

As Figure 2 shows, all cabbage and lettuce seeds germinated and the majority did so within 2 days (91% and 97% for cabbage and lettuce respectively). 96% of leek seeds germinated, 91% after 7 days.

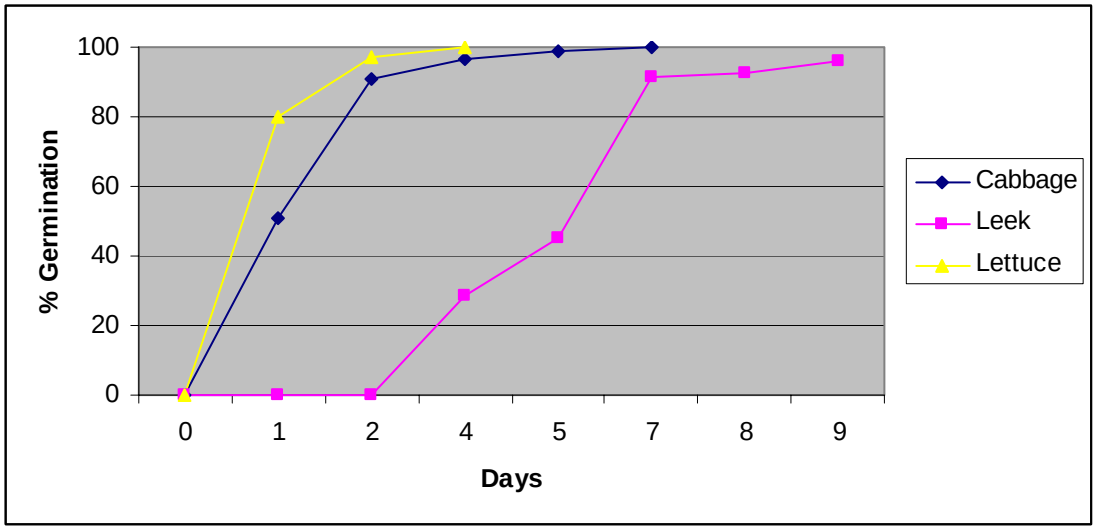


Figure 2: Seed germination rates

5.23 General comments and handling properties

Qualitative observations were made on the ease with which trays were filled, and general handling quality (Table 7). As a rule the peat based products were easiest to work with. Fertile fibre was pleasant to work with, but the fibres caused some difficulties in tray filling. West riding was wet and heavy and had a number of stones, roots and other detritus.

Product	Comments
Bulrush	High quality sphagnum peat. Light and fine, but well structured. Easy to fill trays evenly. A nice product to handle and suitable for mechanised filling lines
Fertile Fibre	A light pleasant product, but contains some quite long fibres which make it difficult to fill trays evenly. Could be problematic in mechanised filling lines
Klasmann	High quality sphagnum peat. Light and fine, but well structured. Easy to fill trays evenly. A nice product to handle and suitable for mechanised filling lines
W. Riding Biopak	A wet heavy product containing stones, twigs, unbroken lumps of peat and tufts of what look like grass roots. Unsuitable for commercial filling lines and not very pleasant to use.
Development product	Slightly heavier than Bulrush, Fertile Fibre and Klasmann, probably due to mineral clay and green waste content. Nicely structured and suitable for mechanised filling lines

Table 7. Comments on handling properties of products

5.24 Emergence rates

As Table 8 shows, emergence rates for leek and lettuce were very good (over 97%). Cabbage was a little more variable, ranging from 85 to 94%, but there were no statistically significant differences between the products

	Cabbage	Leek	Lettuce
Bulrush	93.8	99.1	98.7
Fertile Fibre	84.9	98.4	98.7
Klasmann	90.7	98.2	100.0
West riding Organics	90.7	98.9	97.8
Development product	91.3	99.3	99.6

Table 8: Average emergence rates

5.25 Plant growth and development

Tables 9 - 11 show the data collected for all crops. The following section discusses the results on a crop by crop basis

Cabbage

Figures 3 and 4 show there were height differences between the products, which widened as growth period increased. At the first assessment, all plants were of good colour and looked strong. Bulrush, Klassmann and the development product were the tallest, with no significant differences between them. West riding was shorter that the development product, but not significantly different from Klassman or Bulrush.

There was rapid growth between the 1st and 2nd assessments, which coincided with a long period of exceptionally warm weather, and which would have made big demands of the products. The development product was still supporting growth by the third assessment, and produced strong healthy plants (92% of which were usable) that could have been planted out a week before the 3rd Assessment. The plants in Fertile Fibre also continued to grow right through to the end of the trial, but in contrast were small and brittle. At the time of the second assessment, they were also showing signs of tip burn (Figure 4). They grew through the problems to some extent, but were small and sickly looking at the end of the trial and only about 30% were usable.

There was very little growth in Bulrush, Klasmann and West Riding between the 2nd and 3rd assessments, indicating these products were reaching their limits in terms of the ability to support growth. Nevertheless, they produced a high proportion of usable plants (92% for each for Bulrush and West riding and 87% for Klassman). Those raised in in West Riding were strong and which, like the development product, could have been planted out a week prior the 3rd assessment. The Klasmann plants, however, were clearly struggling, and were not only smaller (very similar, in fact, to Fertile Fibre) but showing clear signs of stress. Neither of the latter two products produced plants that could be planted by machine.

	Plant height (mm)			*Proportion Usable plants (%)*	*Comments at planting out stage*
Assessment date	*2/Apr/2007*	*14/04/2007*	*21/04/2007*	*21/04/2007*	*21/04/2007*
Bulrush	37.2 (ab)	106.3 (b)	110.1 (b)	92.4	Plants in reasonable condition, but starting to show signs of stress
Fertile Fibre	27.3 (c)	63.6 (d)	85.4 (c)	36.4	Small brittle plants. Could not be planted out by machine
Klasmann	40.1 (ab)	86.47	84.6 (c)	86.9	Plants pale and stressed. Could not be planted out by machine
West riding	35.1 (b)	122.8 (ab)	123.7 (b)	92.4	Good strong healthy plants, with plenty of root, but full of weeds
Development	44.6 (a)	139.8 (a)	156.4 (a)	92.0	Good strong healthy plants

Table 9: Plant growth and development - Cabbage

	Plant height (mm)			*Proportion Usable plants (%)*	*Comments at 3rd assessment*
Assessment date	*15/Apr/2007*	*24/Apr/2007*	*30/Apr/2007*		*30/04/2007*
Bulrush	90.5 (ab)	146.0 (a)	161.3 (a)	*Plants not taken through to planting out stage*	Good roots, strong healthy plants
Fertile Fibre	51.3 (c)	97.0)b)	132.5 (b)		Good root system. Good growth on individuals but sparse & patchy across the whole. Unlikely to be commercially acceptable
Klasmann	99.9 (a)	139.7 (a)	133.0 (b)		Media ran out of steam- small spindly plants. Could not be planted out by machine
West riding	61.3 (c)	113.2 (b)	113.9 (c)		Strangled by weed (roots and leaves). Unusable
Development	85.6 (b)	160.2 (a)	163.0 (a)		Strong healthy plants, with reasonable root growth

Table 10: Plant growth and development – Leek

	Plant height (mm)			*Proportion Usable plants (%)*	*Comments at planting out stage*
Assessment date	*2/Apr/2007*	*11/Apr/2007*	*18/Apr/2007*	*18/Apr/2007*	*18/Apr/2007*
Bulrush	24.1 (a)	48.0 (b)	60.5 ©	98.3	Plants strong but the media was running out of steam. Tip burn in 2 of 3 replicates
Fertile Fibre	19.2 (b)	44.4 (b)	66.6 (b)	99.1	Strong plants in all 3 replicates, but small, tough leaves with dark & light veining
Klasmann	25.3 (a)	36.3 (c)	37.3 (d)	100.0	Plants are small but usable in all 3 replicates. The media was running out of steam
West riding	22.7 (a)	57.3 (a)	70.6 (b)	99.6	Strong healthy plants, with good root systems, but full of weeds
Development	23.5(a)	59.3(a)	80.4 (a)	100.0	Strong healthy plants in all three replicates

Table 11: Plant growth and development – Lettuce

Means followed by same letter do not significantly differ (P=.05, Student-Newman-Keuls)

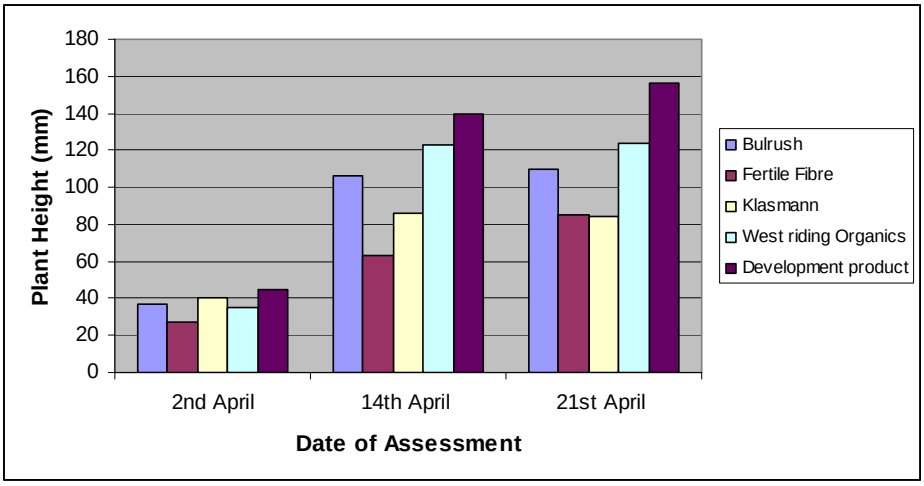


Figure 3: Cabbage plant heights

07/04/2007 – Individual plants

07/04/2007 – Overview of trial

14/04/2007 – Individual plants

07/04/2007 – Overview of trial

24/04/2007 – Individual plants

Tip burn (Fertile fibre)

T1 = Bulrush; T2 = Fertile Fibre; T3 = Klasmann; T4= W. Riding; T5+ Development

Figure 4: Photographs of cabbage growth and development

Leeks

Leeks have much slower growth rate and therefore growth period both in modules and in the field. There was insufficient time in the project to bring them right through to the planting out stage, so it is more difficult to draw conclusions about the quality of the plants

An attempt was made early on to assess plant height, but it proved was impossible to take accurate measurements until the plants had developed more. However, some general observations were made at this stage. The plants appeared to be about 55-60mm in Bulrush, Klasmann, West Riding and the development product, and about 5mm shorter in Fertile Fibre, and all appeared to be healthy.

After the first true leaves appeared it was possible to make the first detailed assessment. The Klasmann plants were the tallest, followed by the development product and Bulrush while Fertile Fibre and West Riding were shortest (Figures 5 & 6). All plants grew steadily up to the second assessment, although Klassman was starting to slow up. As noted above, this coincided with warm weather which placed greater demands all the products than in typical season.

Fertile Fibre and Bulrush continued to grow through to the 3rd assessment and the end of the trial. Bulrush plants were of acceptable quality, but growth in fertile Fibre was sparse and irregular. Growth in the development product slowed down considerably between the second and third assessments (but appeared to continue after the end of the formal period of observation) but the plants were strong and healthy. The Klassman appeared to run out of steam completely towards the end of the trial; the plants stopped growing altogether and were small and spindly. The plants in West Riding also failed to grow in this period, although this is more likely to be related to the weed problem, which by this time had become severe and were strangling the leeks.

Since the plants were not taken through to planting out stage it is difficult to accurately assess proportion of usable plants produced. However, the general health of the Bulrush and development product plants suggest that that the proportion in these products would have been high. Plants in fertile fibre and Klasmann also showed good root growth, but leaf growth was more sparse and patchy that the other products, and it is more difficult to judge the outcome in these cases. The West Riding plants were clearly a write off on account of the weed problems as discussed above.

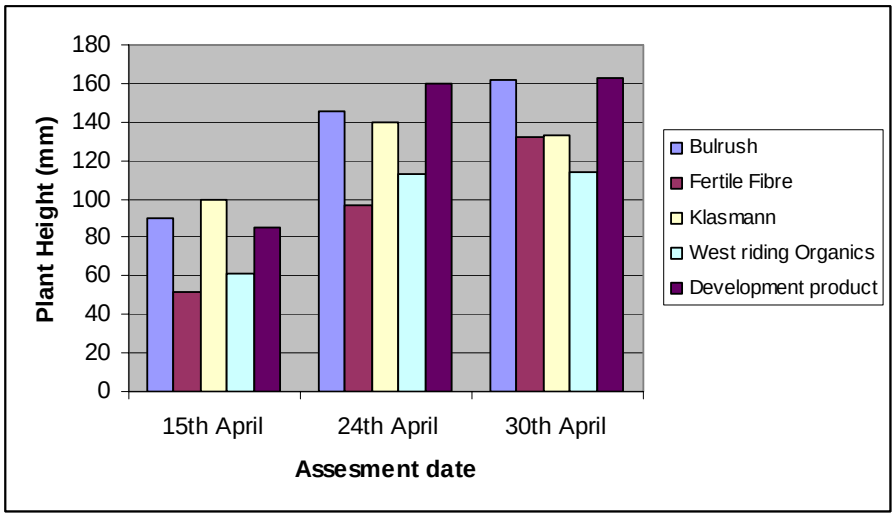


Figure 5: Leek plant heights

15/04/ 2007 – Individual plants

15/04/2007 Trial overview

24/04/2007 – Individual plants

24/04/2007 – Trial overview

06/05/2007 – Individual Plants

Weed problems in West Riding

Figure 6: Photographs of leek growth and development

Lettuce

At the 1st assessment, Fertile Fibre plants were was the smallest by a small margin, but there were no significant differences between the others (Figure 7). In the warm spell that followed the 1st assessment, plants in all media grew well though to the second assessment, with the exception of Klassman which developed more slowly than the other products.

By the 3rd assessment, the plants had come on a lot faster than normal, due to the warm conditions and had to be held back long enough to carry out the final assessment. Those in West riding and the development product would ideally have planted out a week or so prior to the assessment. This is not an uncommon occurrence in commercial situations (usually because cold/ wet conditions delay planting out) and it therefore not unreasonable to expect products to able to cope with this.

The development product and West Riding both produced excellent plants. The development product were the taller of the two batches, but both produced strong healthy plants which, as indicated above, reached the planting out stage about a week ahead of the other products. Fertile Fibre also produced good strong plants, although the leaves were quite tough, with dark and light veining. Bulrush produced acceptable plants, smaller than West riding, the development product and Fertile fibre, but nevertheless quite usable. The Klasmann plants were significantly smaller than the other products at the end of the third assessment the plants and it was the only product that appear not to sustain growth between the 2nd and 3rd assessments. This may be nutrient related, but there could also be a water issue at play. As discussed below, Klassman appeared to retain more water better than the other products, and since all of received the same amount of water, the conditions may have been to wet for ideal growth in this product. With careful monitoring at minimal watering, these plants may have done better.

Having said that, practically all plants in all products were usable (ranging from 98.3% for Bulrush to 100% for Klassman and the development product).

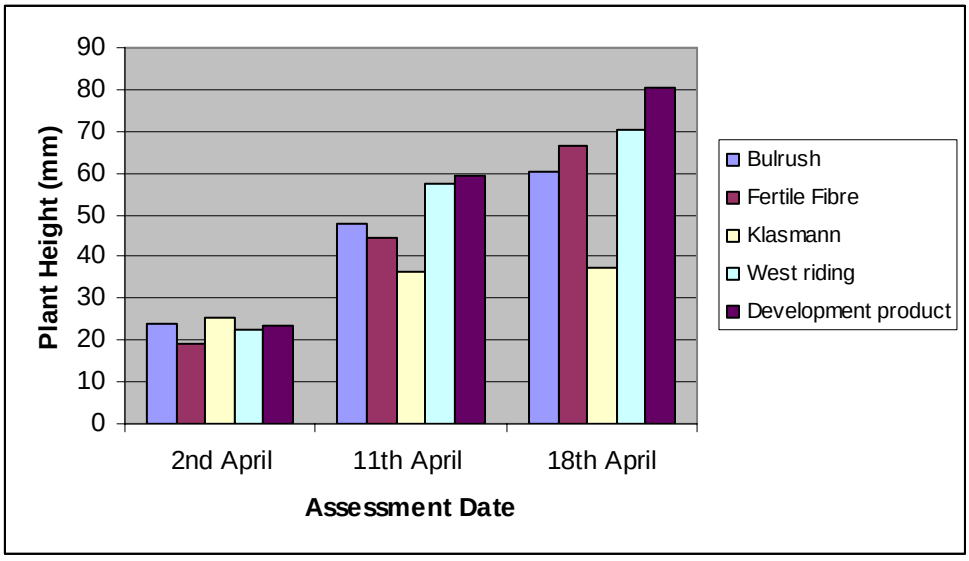
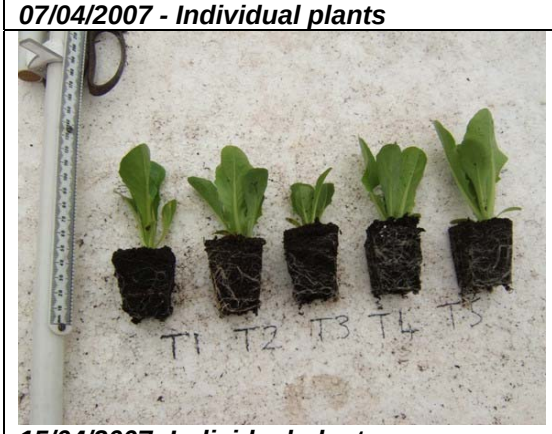


Figure 7: Lettuce plant heights

07/04/2007 - Individual plants

07/04/2007 - Trial overview



15/04/2007- Individual plants

15/04/2007 - Trial overview

Figure 8: Photographs of lettuce growth and development

5.26 Weediness

Weeds were only a serious problem in West Riding (Table 12). By the first assessment they had established in this product all cells and in all crops. By the second assessment they were probably beginning to affect growth, and as already noted, the impact on leeks was particularly severe (Figure 6). The other products were almost completely weed free in all crops, with one literally one of two cells containing weeds, some of which may have been windblown. This is not only an issue at the plant raising stage, but also has implications for the field crop. A grower put it best during the open day when she said '' just can't bring myself to plant out weeds!'

	Average no cells with weeds								
	Cabbage (			**Leek**			**Lettuce**		
Date	*2nd April*	*14th April*	*21st April*	*15th April*	*24th April*	*30th April*	*2nd April*	*11th April*	*18th April*
Bulrush	0.3	-	0.0	1.0	1.0	1.0	0.0	0.0	0.0
Fertile Fibre	0.0	-	0.0	0.7	0.3	1.3	0.0	0.0	0.0
Klassman	0.0	-	1.3	0.3	0.3	0.3	0.0	0.0	0.0
W. Riding	150.0	-	150.0	150.0	150.0	150.0	77.0	77.0	77.0
Development	0.7	-	0.0	2.0	2.3	2.3	1.0	0.7	0.3

Table 12: Weed populations

5.27 Water holding capacity

Within each crop all trays received the same amount. Klasmann retained the most water, and in fact was probably to wet for optimal lettuce growth. Bulrush also dried out relatively slowly, but was difficult to rewet. West Riding and development product also dried out relatively quickly but were easy to re-wet, while Fertile Fibre due its very open structure, dried out relatively quickly.

5.3 Grower Trials

All eight participating growers returned record sheets at the end of the growing season and collectively they made observations on some 20 crops. There was considerable variation between growers in all aspects of quality assessed, due to different management practices including sowing date, module cell size, temperature, watering regime, pest and disease management and others. It is the differences between the media on the same holding that is of interest in this context and growers took care, as far as was practical, to ensure identical management of all plants of the same species in all products. Nevertheless, the information generated by this trial is anecdotal and should be treated as such.

5.31 Overview

There was very little observable impact on the time to emergence between the different media (although considerable variation between growers). In the vast majority of crops emergence times were identical in all products. Similarly, differences in number of days to transplanting were few. Only in two instances were any differences observed; one in broccoli where plants raised in Bulrush was ready 4 days ahead of the others (36 days vs 42) and the other in calabrese, where a poor emergence rate in bulrush meant a resowing and the resulting transplants were 11 days behind the others. No differences in the number of days to harvest were recorded at all

In general terms, the majority of growers felt that the water retention capacity was about right (not too wet and not too dry) for all products. One grower found Fertile Fibre difficult in terms of water management and felt that extra care and management time was required to prevent drying out. In a few cases, growers found Bulrush and the both Klasmann products a little wet (score 4). It is harder to generalise about the West Riding products; while most growers found it about right, some indicated that they were a little dry in some crops while others observed the opposite.

With respect to weeds, only the West Riding products had significant problems. However, some growers expressed the opinion that products that relied on peat extraction should not be permitted in organic systems and saw the weed burden in the West Riding as a ‘price worth paying’ for a product with a better environmental record.

Although assessments were made mainly on plant growth and water retention, some growers also commented on other aspects, including the handling properties. Two growers cited problems in loading modules with Fertile Fibre, and many sieved the product before using it. This was not the case for other products.

The major differences observed were with respect to emergence rate, vigour and development in the field. These are discussed in detail in the following sections.

5.32 Emergence rates

The emergence rates are summarised in Table 13 for the different product/ crop combinations. No one product performed consistently well across all the crops, but neither was any one consistently poor. That said, the two West Riding products did appear to have lower emergence rates overall compared to the other products. In the 'Seed and Cutting' only 1 grower in 1 crop (broccoli) achieved over 90% emergence. While the picture for the Biopak is better (4 growers achieved over 90% cabbage, kale spinach and tomato), it is still poorer than the others.

Among the other products, there were no clear differences. In many cases where the average emergence rate was relatively poor, individual growers attained good results indicating that the poorer performances are less likely to be attributable to the media. This is neatly illustrated by chard in Fertile Fibre which was tested by 2 growers, one of which achieved 100% emergence, the other 20%.

What is clearer is that emergence was better across the board for some crops compared to others. Broccoli, broad beans, brussels sprouts, cabbage, calbrese, kohl rabi, pea, rocket spinach and tomato did well overall, but poorer rates were observed for celery, kale, leeks, onions and sweetcorn. This is not particularly surprising, given the different demands of the various crops on the media discussed in section 3.2.

5.33 Vigour

For vigour, differences were observed more between products and less between crops. In general terms vigour was acceptable in all the products but each, with the exception of Sinclair which performed consistently well, had one crop in which vigour was low.

Bulrush and Fertile Fibre raised consistently vigorous plants across a range of crops and growing conditions. Lettuce illustrates the point well. Fertile Fibre scored 4 or 5 in 9 cases, while Bulrush scored 4 or 5 in 7 out of 8 cases. Both seemed to do better than the Klasmann modular which was tested over a similar range of crops.

The Klasmann Blocking and the two West Riding products were tested on few crops and were broadly similar in terms of vigour. In the case of West Riding this would indicate that although emergence can be low the seedlings that do make grow with reasonable vigour.

Some growers took photographs of the visual differences for a range of crops, which are shown in Figure 9

	Bulrush	Fertile Fibre	Klasmann Modular	Klasmann Blocking	West Riding Biopak	West Riding Seed & Cut	Sinclair
Broccoli							
Broad Bean							
B. Sprouts							
Cabbage	2 (82-95)						
Calabrese							
Celery							
Chard	2 (90-100)	2 (20-100)	2 (70-100)				
Cucumber							
Kale	3 (75-95)			2 (75-98)	2 (40-90)		
Kohl Rabi							
Leeks	2 (65-90)	2 (65-90)	2 (65-85)				
Lettuce	8 (60-96)	9 (59-100)	7 (50-100)	2 (100)	5 (30-85)	5 (56-72)	2 (75-100)
Onions (Maincrop)							
Onions (Spring)	2 (70-90)	(65-90)					
Pea							
Rocket		2 (85-100)					
Spinach			2 (90-98)		2 (85-91)		
Sweet Corn							
Tomato	4 (80-100)	4 (70-100)	2 (100)		2 (60-100)	2 (70)	

Key

90 – 100%	70 – 89%	50- 69%	Less than 50%	No data collected

Notation

Figures are average emergence rates. Where more than one grower made observations, the number of growers is recorded in the cell and the range of values is given in brackets. For example 2 (65-95) means that 2 growers recorded observations, the average is between 70 and 89% and the range was 65-95%. No notation means only 1 grower made observations

Table 13: Emergence rates in grower trials

	Bulrush	Fertile Fibre	Klasmann Modular	Klasmann Blocking	West Riding Biopak	West Riding Seed & Cut	Sinclair
Broccoli							
Broad Bean							
B. Sprouts							
Cabbage	2 (4)						
Calabrese							
Celery							
Chard	2 (3-4)	2 (3-4.5)	2 (3-4)				
Cucumber							
Kale	3 (4)			2 (3-5)	2 (1-4)		
Kohl Rabi							
Leeks	2 (4)	2 (2-5)	2 (3-4)				
Lettuce	8 (1-5)	9 (4.5–5)	7 (2-4)	2 (3)	5 (4)	3 (1.5-2.5)	2 (5)
Onions (Maincrop)							
Onions (Spring)	2 (4-5)	2 (4-5)					
Pea							
Rocket		2 (3)					
Spinach		2 (4.5)	3 (3-4)		2 (2)		
Sweet Corn							
Tomato	2 (4)	2(5)					

Key : Score 4-5 | Score 3 – 3.9 | Score 1-2.9 | No data collected

Notation

Figures are average vigour scores (5= excellent, 1 = very poor). Where more than one grower made observations, the number of growers is recorded in the cell and the range of values is given in brackets. For example 7 (2-4) means that 7 growers recorded observations, the average is between 3 and 3.9 and the range was 2-4. No notation means only one grower made observations

Table 14: Vigour in grower trials

5.34 Field development

The purpose behind collecting this information was to gain some indication as the impact the health of the transplants had on the subsequent development of the crop in the field. Data for this phase was not as detailed as for the propagation phase. Nevertheless, most crops were represented by at least one grower. Results are summarised in Table 16. Over all field development was very good, with only 4 instances where it was poor (Score 2 or less).

Table 15 records whether field vigour score was higher, lower or the same as the vigour score at the plant stage.

	Bulrush	Fertile Fibre	Klas. Mod	Klas. Blk	WR Biopak	WR Seed & Cut	Sinclair
Broccoli	+	+	+			+	
Broad Bean	0	+					
B. Sprouts	+	+	+	+	0	+	0
Cabbage	0	0	+	0			
Calabrese	+			0			
Celery	0	0					
Chard	-	+	-		0		
Cucumber	0	0					
Kale	0			0	-		
Kohl Rabi	0	0	+	+	+	+	0
Leeks	0	+	+			+	
Lettuce	0	0	+	+	0	+	0
Onions (Mc)	0	0	0				
Onions (Spr)	0	0	0		0	0	
Pea							
Rocket		-			+		
Spinach			+	+	+		
Sweet Corn	0	0	0	0	+	0	0
Tomato	0	0	+	0	0	0	

+ = Increase, - = Decrease, 0= No change

Table 15: Relative score of seedling vigour and subsequent field development

In a number of cases where vigour at the plant raising stage was mediocre (Score 3 – 3.9) the subsequent field development improved (score 4 or 5), and by harvest there were very few differences between plants raised in the different media. Given the benefits of transplanting outlined in 3.1, we might expect that the more vigorous the seedling transplanted out, the better the subsequent development in the field. This relationship is not borne out in this data. However, no information was collected on the pest disease or weed pressures in the field stage or the fertility building practices of the growers, making it difficult to draw firm conclusions.

	Bulrush	Fertile Fibre	Klasmann Modular	Klasmann Blocking	West Riding Biopak	West Riding Seed & Cut	Sinclair
Broccoli							
Broad Bean							
B. Sprouts							
Cabbage							
Calabrese							
Celery							
Chard							
Cucumber							
Kale	2 (4)						
Kohl Rabi							
Leeks	2 (4)	2 (4-5)	2 (4)				
Lettuce	6 (4)	7 (4-5)	4 (4)			2 (4)	2(4)
Onions (Maincrop)							
Onions (Spring)	2 (4)	2 (4-5)					
Pea							
Rocket							
Spinach							
Sweet Corn							
Tomato	3 (4-5)	3 (3-5)				2 (4-5)	

Key: Score 4-5 | Score 3 – 3.9 | Score 1-2.9 | No data collected

Notation

Figures are average field development scores (5= excellent, 1 = very poor). Where more than one grower made observations, the number of growers is recorded in the cell and the range of values is given in brackets. For example 3 (4-5) means that 3 growers recorded observations, the average is between 3 and 3.9 and the range was 4 - 5

No notation means only one grower made observations.

Table 16: Field Development

5.35 Product profiles

The discussion thus far has focused on the different aspects by which quality was assessed, rather than the over all performance of individual products. Table 17 presents same data in a different format, allowing growers to compare the performance of the individual media.

	Bulrush			Fertile Fibre		
	Emerge	Vigour	Field Dev	Emerge	Vigour	Field Dev
Broccoli						
Broad Bean						
B. Sprouts						
Cabbage	2 (82-95)					
Calabrese		2 (4)				
Celery						
Chard	2 (90-100)	2 (3-4)		2 (20-100)	2(3-4.5)	
Cucumber						
Kale	3 (75-95)	3 (4)	2 (4)			
Kohl Rabi						
Leeks	2 (65-90)	2 (4)	2 (4)	2 (65-90)	2 (2-5)	2 (4-5)
Lettuce	8 (60-96)	8 (1-5)	6 (4)	9 (59-100)	9 (4.5-5)	7 (4-5)
Onions (Mc)						
Onions (Spr)	2 (70-90)	2 (4-5)	2 (4)	(65-90)	2 (4-5)	2 (4-5)
Pea						
Rocket				2 (85-100)	2 (3)	
Spinach					2 (4.5)	
Sweet Corn						
Tomato	4 (80-100)	2 (4)	3 (4-5)	4 (70-100)	2 (5)	3 (3-5)

	Klasmann modules			Klasmann Blocking		
	Emerge	Vigour	Field Dev	Emerge	Vigour	Field Dev
Broccoli						
Broad Bean						
B. Sprouts						
Cabbage						
Calabrese						
Celery						
Chard	2 (70-100)	2 (3-4)				
Cucumber						
Kale				2 (75-98)	2 (3-5)	
Kohl Rabi						
Leeks	2 (65-85)	2 (3-4)	2 (4)			
Lettuce	7 (50-100)	7 (2-4)	4 (4)	2 (100)	2 (3)	
Onions (Mc)						
Onions (Spr)						
Pea						
Rocket						
Spinach	2 (90-98)	3 (3-4)				
Sweet Corn						
Tomato	2 (100)					

Table 17: Product profiles for emergence, vigour and field development

	West Riding Biopak			West Riding (S&C)		
	Emerge	Vigour	Field Dev	Emerge	Vigour	Field Dev
Broccoli						
Broad Bean						
B. Sprouts						
Cabbage						
Calabrese						
Celery						
Chard						
Cucumber						
Kale	2 (40-90)	2 (1-4)				
Kohl Rabi						
Leeks						
Lettuce	5 (30-85)	5 (4)		5 (56-72)	3 (1.5-2.5)	2 (4)
Onions (Mc)						
Onions (Spr)						
Pea						
Rocket						
Spinach	2 (85-91)	2 (2)				
Sweet Corn						
Tomato	2 (60-100)			2 (70)		2 (4-5)

	Sinclair		
	Emerge	Vigour	Field Dev
B. Sprouts			
Kohl Rabi			
Lettuce	2 (75-100)	2 (5)	2 (4)
Sweet Corn			

Key

Emerg. (%)			90 – 100		70 – 89		50- 69		> 50		No data
Vigour (1-5)			4 – 5		3 – 3.9		1 - 2.9		No data		
F. Dev (1-5)			4 – 5		3 – 3.9		1 - 2.9		No data		

Table 17 continued: Product profiles for emergence, vigour and field development.

A number of growers noted visual differences, particularly in terms of vigour (Figure 9) and a record of detailed comments in provided in Appendix II.

Klasmann	W. Riding	Bulrush	Fertile Fibre

Fertile Fibre	Klasmann	Bulrush	W. Riding

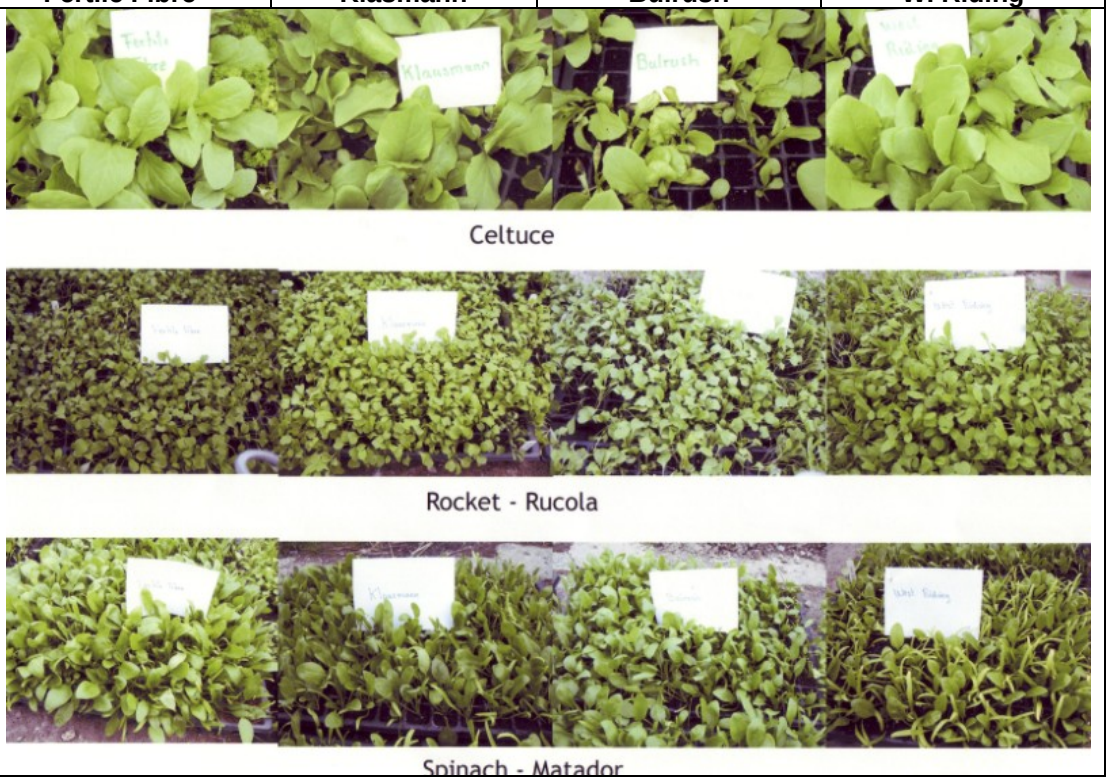


Figure 9: Grower photographs

6. Discussion and conclusions

6.1 General comments

There was a great degree of variability between products and this is not surprising given the very different compositions of the products, ranging from entirely peat based, to completely peat free.

There were also key differences between the grower trials and the formal trials. They can in part be explained by different batches of composts being used. This arose out of the difficulties for the formal trials in 2006 and was unfortunate because using the same composts would have eliminated much of the uncertainty inherent in the interpretation. However, there are also likely to be other factors at play. As pointed out in Section 5.2, the objectives and the basis on which the work was very different for the two studies. The grower trials are unreplicated, with several different growers working with several different crops all sowing and raising plants under slightly different conditions. This data can therefore gives a good overview of the performance of the products in the field, but cannot and should not form the basis of a detailed comparison.

Another issue is that the formal trials were conducted by a specialist plant raiser, with over 20 years experience in plant raising, and working with several different products. Within the growers there was a wide range of not only knowledge and experience of plant raising, also good facilities and equipment.

Development in the field, subsequent to planting out (monitored in the grower trials, but not in formal trials) was generally very good, and many plants that had comparatively poor vigour at the plant raising stage compensated for this in the field. By harvest time there were no discernable differences between plants raised in different media for all crops. This information needs to be considered in the light of the field conditions, in particular the pest disease and weed pressures and the nutrient status of the soil. Assessments of actual saleable yields may have shown some differences.

This project focussed very much on quality issues, but it should be remembered that growers take into account factors other than plant performance when considering choice of product including

- *Environmental impact*. This relates mainly to peat; whether the product contains peat at all, and if it does, whether it was extracted from bogs.
- *Handling properties*. This is a particular issue for larger growers who might wish to use automated systems to fill modules. The peat based products are likely to run well through machines, where as the more open, fibrous coir based product is likely to cause problems. Even where trays are filled by hand, the ease with which this can be done is an issue
- *Cost and availability*. This is a particular issue for smaller growers who as located some distance form site of production, as is often the case in Wales. The issues of availability in small quantities (say

less than a pallet, fro instance), and the cost of delivery per bag can also influence growers choices

6.2 Product analyses

6.21 Bulrush

The formal trials showed that this product delivered a high proportion of usable plants of reasonable quality, although they were starting to show signs of stress in cabbage and lettuce towards the end of plant raising period. Laboratory analysis showed that this product was low in N compared all the others except Fertile Fibre, which would explain this. It performed particularly well in leeks, where it produced the tallest plants of all the organic certified media (i.e. not counting the development product), with well developed roots systems and good general health – this may be linked with a slower rate of release of nutrients compared with the others. This is a particularly desirable quality when dealing with leeks – early mineralisation can lead to losses through leaching.

Over all, growers had a relatively positive experience with this product, which supports the conclusions of the formal trials, particularly with regard its good performance with leeks. Some growers experienced relatively low emergence rates for some crops including lettuce and cabbage but the results of the formal trials would indicate this is not directly attributable to the media. One grower found the product a bit wet which caused damping off in calabrese.

6.22 Fertile Fibre

In the formal trials, the performance of this product varied between the different crops. It produced reasonable lettuce plants of which practically all were usable. However, the leaves were tough and there was some unexplained veining which may have been linked to a marginal manganese deficiency induced by the relatively high pH. There were however serious problems with cabbage and leeks. For cabbage, only about a third of the plants were judged to be usable for hand planting, and none would have been sufficiently robust to go through a planter. The plants struggled throughout the plant raising period, and suffered from tip burn, a problem possibly linked with its low calcium content. With leeks, growth was patchy and uneven, and again, would not have been suitable for machine planting. These problems are likely to be related to the high levels of ammonia found in the sample analyses.

These problems, however, were not reflected in the grower trials both in terms of plant performance and nutritional composition. Laboratory analysis showed the 2006 batch to be high in all the major nutrients, it scored well in terms of vigour for wide range of crops (including cabbage and leek).

As discussed in section 5.1 a second sample of eth formal trials batch was sent away for analysis, the results were much closer to the batch used for the grower trials. The problems in the formal trials may therefore be attributable to mixing problems, which would lead to patchy distribution of available nutrients, or storage conditions. If the compost is kept in a warm environment microbial activity would be greatly increased and this may lead to localised production of ammonia.

6.23 Klasmann

In the formal trials, the Klasman (Modules) appeared to start off well, but had a tendency to ‘run out steam’ towards the end of the plant raising period. This was particularly apparent for the faster growing crops (lettuce and cabbage). In terms of nutrient levels, laboratory analysis showed medium levels of all the major nutrients compared to the other products, and this was reflected in plant performance.

Growers also detected a certain lack of vigour with regard to the modular compost, which would be consistent with the above. As noted above this may relate to the rate of mineralisation that may in turn have been influenced by the microbial population of the material. However, the blocking product, which was not included in the formal trials, had no such problems, and vigour was similar to other products.

6.24 West Riding Organic

The over overriding problem here is one of weeds. In the formal trials, all cells in all crops were infested with predominantly grass weeds, but some cells also had broad leafs. This is unfortunate because in all other respects it appears to perform very well, producing strong and healthy plants when they can out-compete the weeds. However, even when this is the case, the problem carried through to the field phase as the weeds get planted out with the crop.

On the commercial holdings, the growers appeared to pick an emergence problem, but this was not apparent in the more controlled formal experiments. Vigour in the plants that did emerge was very good, and this is consistent with the formal trials. The same was broadly true for the West Riding seed and cutting.

6.25 Development product

In general this product grew large, healthy plants for all crops. There were no significant problems is terms of plant colour, and few visible signs of stress. The laboratory analysis shows that this product was high in terms of nitrogen, and comparable in terms of the other major nutrients

It should be stressed that this not an organically approved product, and the question of whether it would meet the organic standards is an open one. The purpose for including it in the trials was to investigate the potential for green waste based products to be developed for plant raising purposes. The results indicate the there are clearly grounds to investigate further, and that green waste based composts could well have a role to play in the organic sector in the future. There is no problem related to the use of green waste compost providing the starting ingredients are compliant with the organic standards and the process is managed under the PAS 100 composting protocols.

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Appendix I: Crop Diaries

Cabbage

Date	Comments/ Observations
15 March	Seeds sown (Temperature in propagator 18^{o}C)
17 March	Moved from propagator onto bench. Trays arranged according to randomised block design
19 March	1st seedlings emerged, in order of greatest emergence rate: Klasmann, development product, W. Riding Bulrush, Fertile Fibre (well behind).
20 March	Emergence is good in all trays now.
21 March	Plants still emerging well in all products
25 March	Moved into colder side of tunnel. Assessed for emergence rates. Frost protection only at this stage, and tunnel well ventilated during the day.
26 – 31 Mar	General maintenance watering. West Riding and development product seem to dry out more quickly, but are easy to re-wet. Bulrush is more difficult to re-wet with out over soaking. Growth rates appear similar in all treatments except Fertile Fibre, which is clearly lagging. The weed population is now very high in the West Riding, but almost zero in the others.
2 April	First assessment of height and weed population
4 April	Fertile Fibre beginning to lag further behind the other products
11 April	Rapid growth due to warm weather 4 – 11th April. Fertile Fibre now well behind, and Klassmann and Bulrush also running out of steam. West riding and Development product working well.
14 April	2nd Plant height and weed assessment. Development product appears to be largest, followed by W. Riding. Stunted grow and tip burn observed previously in Fertile Fibre, but the plants appear to be growing through this problem.
21 April	3rd and final plant height and weed assessment. • *Bulrush*: Acceptable plants • *Fertile Fibre*. Serious problems here. Some have grown through the tip burn, but they do not look good and are very brittle. Some might be usable, but most growers would probably bin the lot. Could possibly be a mixing problem, with too much nutrient in patches • *Klasmann*: Small stressed plants • *W. Riding*: Strong healthy plants but weeds will cause problems in the field. Could have been planted out a week ago • *Development product*: Strong healthy plants. Could have been planted out a week ago

Leeks

Date	Comments
15 March	Seeds sown (2 per module) in propagating box at 18^{o}C
21 March	Emergence just beginning. Seedlings transferred from box to bench according to randomised block design.
26 – 31 Mar	West Riding and development product seem to dry out more quickly, but are easy to re-wet. Bulrush is more difficult to re-wet with out over soaking. Plants in Fertile Fibre are clearly lagging behind the others. The weed population is now very high in the West Riding, but is almost zero in the others.
1 April	Plants moved into colder side of the tunnel. Emergence rate assessed
4 April	Due to slow growth, it is impossible to measure plant height accurately, until 1st leaves develop. However, it is possible to make some general comments at this stage. Trays are about 55-60mm in Bulrush, Klasmann, West Riding and the development product, but Fertile Fibre seems to be 5 mm shorter, and not as strong generally.
11 April	Rapid growth due to warm weather 4 – 11th April. Fertile well behind, and Klassman and Bulrush also running out of steam. West riding and Development product working well.
15 April	1st plant height and weed assessment.
23 April	2nd plant height and weed assessment
30 April	3rd and final assessment. These plants still need a bit longer to reach planting out stage – Root growth needs to fill the module to avoid breaking up when handling and the tops need to toughen up so they can go through a planter. General comments: • *Bulrush*: Acceptable plants, but should grow on a little more • *Fertile Fibre*: Spare irregular growth – not commercially acceptable • *Klasmann*: Media running out of steam – small and spindly plants • *W. Riding*: Plants completely smothered by weeds – not commercially acceptable • *Development product*: good sized plant, that look as though they grown on well.

Lettuce

Date	Comments
14 March	Seeds sown, with thermostatic heater. Min Temps: 10^{o}C (night), 15^{o}C (day)
17 March	Lettuce pills are splitting and radicals emerging. No observable differences between products at this stage.
18 March	Mist sprayed to facilitate splitting and shedding of clay pellet. Cotyledons beginning to show. No observable differences at this stage.
24 March	Fleece removed – Cotyledons are strong in all products.
25 March	Moved into colder side of tunnel. Assessed for emergence rates. Frost protection only at this stage, and tunnel well ventilated during the day.
26 – 31 Mar	Observations on water holding capacity: West Riding and development product seem to dry out more quickly, but are easy to re-wet. Bulrush is more difficult to re-wet with out over soaking. Growth rates appear similar in all treatments except Fertile Fibre, which is clearly lagging. The weed population is now very high in the West Riding, but almost zero in the others
2 April	First assessment of height and weed population
4 April	Fertile Fibre beginning to lag behind the others
11 April	Plant height assessed. Rapid growth due to warm weather 4 – 11th April. Fertile well behind, and Klassman and Bulrush also running out of steam. West riding and Development product working well.
12 April	Lettuce moved out to harden off
18 April	3rd and final plant height and weeds assessment. Plants have come on a lot faster than normal, due to usually hot dry weather and had to be held back long enough to carry out the final assessment. They would ideally have planted out a few days ago. This is not an uncommon occurrence in commercial situations (usually because cold/ wet conditions delay planting out) and products should therefore able to cope with this. Overall comments • *Bulrush*: Quite good plants – would be acceptable to most growers but the media has run out of steam • *Fertile Fibre*: Good strong plants, still holding well. There is some unexplained light and dark veining in the leaves, but it does not seem to have affected the growth and vigour of the plant • *Klasmann*: Disappointing in terms of size and sustained growth. This product needs less water that the others and since all products received the equal amounts of water, these plants were effectively too wet. With careful monitoring at minimal watering, these plants would probably have done better. • *W Riding*: Big strong plants, still growing and would have been ready to plant out at least a week ago. However, the weed problem is very bad (predominantly grass, but also docks, thistles and nettles) • *Development product*. Again, big strong plants that would have been ready to plant out at least a week ago.

Appendix II: Grower comments

Crop	Products	No. Growers	Observations
Broccoli	Bulrush	1	No differences between products. Plants were in still in the field when the record sheets were returned, so no field data was collected
	Fertile Fibre	1	
	Klasmann (Modules)	1	
	West Riding seed & cutting	1	
Broad Bean	Bulrush	1	Bulrush was slightly too dry. Big differences in **emergence rate** and **vigour**. Plants sown in Fertile Fibre smaller and only about half emerged, compared to nearly 100% in Bulrush. But the ones that did emerge had several small shoots as opposed to one large one. Plants sown in Fertile Fibre caught up in the field.
	Fertile Fibre	1	
Brussel Sprouts	Bulrush	1	Only a small number of plants raised in each product and a great deal of variation between plants grown in the same media. **Emergence rates** poor in the two West Riding and the Klasmann blocking products (50 – 75%) compared to the others which achieved between 90 and 100%.**Vigour** was good in Sinclair (score 5), average (score 3) in Bulrush, Klasmann blocking, and the two West Riding products and low (score 2) in Klasmann modules. **Water retention** was good in all products except West Riding Biopak which was slightly to wet. Field development was good (score 4 or 5) for all products except West Riding Biopak, which scored 3.
	Fertile Fibre	1	
	Klasmann (Modules)	1	
	Klasmann (Blocks)	1	
	West Riding Biopak	1	
	West Riding seed & cutting	1	
	Sinclair	1	
Cabbage	Bulrush	2	**Vigour** was good in all products (score 4 or 5) in all products except Klasmann modules which scored 3, but caught up in the field. **Water retention** was good in all products, although Klasmann blocking was a little wet, and West Riding Biopak a little dry. Mould was observed on the surface of Bulrush.
	Fertile Fibre	1	
	Klasmann (Modules)	1	
	Klasmann (Blocks)	1	
	West Riding Biopak	1	
Calabrese	Bulrush	1	Poor **emergence rates** in Bulrush, possibly due to damping off, but did not occur in Klasmann. Surface mould observed on Bulrush. The Bulrush plants were re-sown, but had very poor **vigour** and planted were out as small seedlings. **Field development** was also poorer in plants raised in Bulrush.
	Klasmann (Modules)	1	

Crop	Products	No. Growers	Observations
Celery	Bulrush	1	No differences were apparent between products.
	Fertile Fibre	1	
Courgettes/ Squash	Bulrush		**Emergence rates** were poor in the West Riding, 30% losses. **Vigour** was poor in both products (score 3 for Bulrush and 2 for WR). Both products retained too much water. Fertile fibre was mixed with both composts, and was more successful in terms of vigour.
	West Riding Organic (seed& Cutting)		
Cucumber	Bulrush	1	Bulrush were much slower to **emerge** and some damped off after a few days. Root growth in Fertile Fibre was much better. However, after planting out the plants raised in Bulrush caught up during **development in the field** and by **harvest** there were no discernable differences.
	Fertile Fibre	1	
Kale	Bulrush	3	For one grower, **emergence rates** were very variable between products (40 – 92%), but this was not reflected by other growers. Also true for **vigour**. Inconsistent results make it difficult to make meaningful observations for this crop. One grower observed strong red tinge in Klasmann but not other products. Plants were initially spindly but caught up before transplanting.
	Fertile Fibre	1	
	Klasmann (Modules)	1	
	Klasmann (Blocks)	2	
	West Riding Biopak	2	
	West Riding seed & cutting	1	
Kohl Rabi	Bulrush	1	Sinclair, Bulrush and Fertile Fibre all performed well. Both Klasmann and both West Riding products had vigour problems at the plant raising stage, but developed well in the field subsequently. Weeds were a problem in West Riding.
	Fertile Fibre	1	
	Klasmann (Modules)	1	
	Klasmann (Blocks)	1	
	West Riding Biopak	1	
	West Riding seed & cutting	1	
	Sinclair	1	
Leeks	Bulrush	2	Bulrush performed well. One grower had **vigour** problems with Fertile Fibre (Score 2), this was not an issue for the other. All crops **developed well in the field** subsequently. **Weeds** were a problem in both the West Riding Products.
	Fertile Fibre	2	
	Klasmann (Modules)	2	
	West Riding Biopak		
	West Riding seed & cutting		

Crop	Products	No. Growers	Observations
Lettuce	Bulrush	8	**Emergence rates** were variable. At least one grower experienced difficulties with all products, but only the two West Riding products were consistently poor. **Vigour** was good (score 4 or 5) in most products, but West Riding seed and cutting struggled (scores 1.5 – 2.5). In some cases, plants were held in the modules for longer than usual to dry field conditions, but vigour was maintained. **Water retention** was generally considered to be about right (score 3) for all products. One grower comment that it was much harder to maintain the right balance with Fertile Fibre compared to other products. West Riding transplants that lacked vigour in the modules caught up after planting out. Field data difficult to assess because extreme conditions (hot dry summer) and slug damage.
	Fertile Fibre	9	
	Klasmann (Modules)	7	
	Klasmann (Blocks)	2	
	West Riding Biopak	5	
	West Riding seed & cutting	3	
	Sinclair	1	
Onions (Maincrop)	Bulrush	1	No significant differences between the products
	Fertile Fibre	1	
	Klasmann (Modules)	1	
Onions (Spring)	Bulrush	2	There were no significant differences between the products, except that both the West Riding products were weedy
	Fertile Fibre	2	
	Klasmann (Modules)	1	
	Klasmann (Blocks)	1	
	West Riding Biopak	1	
	West Riding seed & cutting	1	
Pea	Bulrush	2	No big differences between the two products. The plants in Fertile Fibre were smaller at first, but by planting out, they were noticeably stronger.
	Fertile Fibre	2	
Rocket	Bulrush	2	For one grower the plants bolted in trays, and were not planted out. **Emergence rate** was low for West Riding seed and cutting, but those did emerge were the more vigorous that in other products. One grower noted a pink tinge was more prominent on Fertile Fibre than on other products
	Fertile Fibre	2	
	Klasmann (Modules)	2	
	West Riding Biopak	1	
	West Riding seed & cutting	1	
Spinach	Bulrush	2	One grower had problems with mice eating seed, and bolting in trays, but data that was collected showed no differences between products, except a weed problem in the West Riding. One grower had vigour problems (score 2) with the West Riding Biopak, but the other had no problem (Score 4).
	Fertile Fibre	2	
	Klasmann (Modules)	3	
	West Riding Biopak	3	

Crop	Products	No. Growers	Observations
Sweet Corn	Bulrush	1	No differences between products observed
	Fertile Fibre	1	
	Klasmann (Modules)	1	
	Klasmann (Blocks)	1	
	West Riding Biopak	1	
	West Riding seed & cutting	1	
	Sinclair	1	
Tomato	Bulrush	4	Some growers experienced poor germination rates for Fertile Fibre and West Riding, but others had no problems with the same products. Vigour was good across all products and growers (score 4 or 5) except Klasmann Modular (Score 3). In all other areas there were no differences.
	Fertile Fibre	4	
	Klasmann (Modules)	2	
	Klasmann (Blocks)	1	
	West Riding Biopak	2	
	West Riding seed & cutting	2	
	Sinclair	1	