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Project number:	PC 209
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The results and conclusions in this report are based on a carefully monitored applied experiment in a large-scale experimental glasshouse. The conditions under which the studies were carried out and the results have been reported with detail and accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with the interpretation of the results especially if they are used as the basis for commercial product recommendations.

Authentication

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature…………………………………………………………………………….

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- Initial trials with tomato plants (cv Aranca) comparing the performance of four types of wood-based growing media (TGM) with a rockwool control were conducted over a 40 day growth period, during which time growth and fruit yield and quality parameters were determined.
- Symptoms of phytotoxicity were absent in all TGM trialled.
- No significant consistent differences were found in measured parameters, either between the trialled TGM, and the rockwool control.
- Very little structural breakdown occurred in the TGM over the course of the trial, with only slight (half a unit) change in pH to 5.8. Slightly higher nitrogen and potassium levels led to a higher EC in TGM at the end of the trial compared with rockwool.
- Fine-composted conifer bark (FCCB) was chosen as the material to be taken forward to full season trials.

Background and Expected Deliverables

The UK Government has set targets for reducing the amount of waste entering landfill, as this resource is now in short supply. Tax levies on material entering such sites have increased significantly to encourage industries to develop more sustainable solutions to waste disposal. This has placed a considerable financial burden on protected salad growers who have to dispose of rockwool-based growing media at the end of each season.

The overall aim of this work is to improve waste management and reduce the cost of disposal of used growing media for the UK tomato industry. The approach is to assess the potential of candidate forest-residue-based growing media for glasshouse tomatoes. The supply chain for the raw materials is increasingly reliable and the material is derived from an environmentally sustainable source. It is proposed that at the end of a full-season tomato trial t`he successful media, chosen from initial trials investigating a range of candidate material, will be composted and assessed for secondary use as a soil conditioner and/ or growing media for other crops. This will obviate the need for disposal to landfills.

Summary of work and main conclusions

- Initial trials were conducted to determine the best TGM to take forward to full season commercial scale comparison with rockwool.
- Three tomato crops, cultivar Aranca, were grown at 14 day planting intervals for 40 days (post planting) (at which stage truss 3 fruits were ready for harvest) in four candidate growing media: Fine pine fines (FPF), Fine composted conifer bark (FCCB), Fine composted wood fibre (FCWF), Fine composted industrial blends (FCI) (Hereafter collectively referred to as Test Growing Media (TGM)). Rockwool was included in the trial as a control.
- Measurements of growth parameters (i.e. Internode length, stem diameter, leaf length, plant extension) over the lifetime of each crop showed that there were no significant consistent differences between the trialled TGM, nor when compared with the rockwool control.
- At day 40, there were no significant differences between TGM and rockwool with respect to timing of fruit development for the first three trusses. However, at truss 4, rockwool had a significantly larger number of fruit developing than the TGM treatments.
- Brix value in truss 2 fruits from plants grown in FPF was significantly higher than from plants grown in rockwool or FCI. There were no differences between other treatments.
- Post-trial analysis of TGM showed there to be no significant changes with regard to its physical structure. There was a slight increase in pH to 5.8 compared with pre-trial figures and the potassium and nitrogen levels were also higher, reflected by a higher EC.
- Based on economic considerations and previous experience, FCCB (Fine composted conifer bark) was chosen as the material to be taken forward for full-season assessment against rockwool.

Financial benefits to growers

One of the main motivations for this project was to provide data on the feasibility of growing media for protected salad crops that could avoid costly disposal of rockwool to landfill and by providing a resource that could be re-used as an environmentally sustainable product.

An ongoing objective of this work is to perform an economic evaluation of the chosen TGM as a growing system for tomato production. An economic analysis of potential secondary uses (i.e. in containerised nursery stock as soil conditioner) of the TGM will also be undertaken.

Action points for growers

None to date; await completion of the work.

Science Section

1. Introduction

The aim of this first investigation was to evaluate candidate 'test growing media (TGM)' materials selected by the project group that have a potential to improve waste management and reduce disposal costs in glasshouse tomato production systems. Materials chosen for this study were supplied by Melcourt Industries Ltd. and are as follows: fine composted conifer bark (FCCB), fine composted wood fibre (FCWF), fine composted post industrial wood blends (FCI) and fresh pine fines (FPF). The candidate materials chosen as the TGM are increasing in availability, are derived from stable supply chains and are considered environmentally sustainable.

The most commonly used growing media is rockwool. Some facilities exist to recycle this material but most growers have to dispose to landfill at the end of the season. This is placing a considerable financial burden on protected salad growers as the Government is significantly increasing tax levied on waste entering such sites to encourage all industries to develop more sustainable solutions to waste disposal.

2. Materials & Methods

2.1 Cultural Details

Tomato seeds, cultivar Aranca (Enza Zaden, UK) were sown onto either rockwool or standard seedling compost (Levingtons, M3) on three occasions (14 days apart) from the beginning of June 2004. Tomato plants were transferred, approximately 18 days post germination, onto the respective pre-wetted substrate (30 litres volume for growing media) (Table 1) slabs.

Media	Abbreviation
Fine composted conifer bark	**FCCB**
Fine composted post industrial wood blends	**FCI**
Fine composted wood fibre	**FCWF**
Fine pine fines	**FPF**
Rockwool (control)	**-**

Table 1. Abbreviations for growing media

Three plants were transplanted per slab and slabs were randomised within three replicated blocks per crop (3 sequential crops, 14 day intervals). For each crop there were three modules (9 plants) per block. The glasshouse unit allocated for this work comprised of 3 bays separated by heating pipes, with a total floor area of 220 m^2. Temperature and humidity control was achieved with a centralised Priva Integro unit. Hydroponic feed was prepared in accordance with best practice guidelines for tomato and delivered to the crop using a Modimax 440 (Van Vliet Computers) irrigation rig. For the first crop, the irrigation frequency was the same for both rockwool and TGM.

In the second and third crop a separate header was introduced into the irrigation system that allowed TGM-grown plants to receive irrigation independently to that applied to plants grown on rockwool. Irrigation cycles were determined by incident radiation measured by meterological instrumentation situated outside the glasshouse. This was converted to radiation sums, such that when a value of 150 and 230 Joules was reached an irrigation start was triggered for rockwool and TGM respectively. The decision was made to reduce irrigation for TGM based on previous observations of water holding capacity in growing media of this type. A spare dripper was taken from each line to measure the daily total water application, per plant, for rockwool and TGM.

2.2 Physico-chemical properties of media

For each TGM, the nutrient composition, nitrogen drawdown index, bulk density, and air filled porosity (BS4156:1990) was determined prior to transplanting with tomato plants. These parameters were also measured after the cropping period to ascertain viability of the media for secondary use as soil conditioner and/ or growing media for other crops.

2.3 Wettability

The 'wettability' of the TGM materials was determined by measuring the water retention over an 8-minute period (SOP code STC/GTGEN/008). Each candidate TGM was adjusted to 50% moisture content by determining the absolute moisture content of the base material and then calculating whether more water needed to be added or if the media needed to be oven-dried (at 80-100 °C) using the following equation:

$$\text{Initial compost weight} \times \frac{(100 - \text{initial moisture content})}{(100 - \text{required moisture content})}$$

9 cm pots containing three replicates of 250 ml volume of each TGM had three applications of 50ml aliquots of water at two minute intervals. Total volume of leachate was determined after 8 minutes and the percentage of the 200 ml of water applied that was retained by the media was determined.

2.4 Plant Assessments

2.4.1 Phytotoxicity

During the growth of the tomato crops, visual assessments were conducted at twice-weekly intervals and pictures of any developing symptoms of phytotoxicity were taken as appropriate.

2.4.2 Growth Characteristics

At 14-day intervals, measurements were taken (nine replicates per treatment) for internode length, stem diameter and leaf length. On each occasion these growth parameters were determined within close proximity to the youngest developing truss on the plant where fruit initiation had begun (see Results).

In order to determine plant extension, support strings were tagged every seven days at the position the growing point of the plant had reached. This practice was carried out for crops 2 and 3, with 18 replicates taken per treatment.

2.4.3 Fruit Number, Yield and Quality

On each measurement occasion the number of fruit developing per truss was recorded. Trusses were managed in such a way that a maximum of 10 fruits were allowed to develop to full maturity. Fruit yield was assessed in the second crop on the third truss. Fruits were harvested as a ‘whole truss’ as this is the industry standard for the Aranca cultivar. Fifteen trusses were randomly selected and harvested per treatment. Fruits from these trusses within each treatment were mixed together and 10 were then randomly chosen for quality analysis. A Brix refractometer (0-30% sucrose scale) was used to determine the levels of sucrose equivalents. A small sample of juice from individual fruits was exuded onto the stage of the refractometer and the brix value was read from the internal calibrated scale.

2.4.4 Nutrient analysis of foliage

Leaf samples were taken from each treatment, from the nearest position above truss 6, and sent for a full nutrient analysis. This was performed for the first and second crop in this investigation.

3. Results & Discussion

3.1 Preliminary TGM analysis

The four test media were sampled and tested for particle size distribution. This was in order to check for any subsequent structural breakdown (Table 2). The figures refer to the percentage by weight of air-dried material left on screens of the given square aperture sizes. Initial work with the TGM showed that FCCB and FPF had more particles in the '2.36 to 4.75 mm' (>2.36 < 4.75) size category than FCWF and FCI. However, the distribution of particles amongst the other size classes was similar in all the TGM, except for FPF, whose particle distribution was approximately 70% comprised of particles greater than 1 mm. The results indicate that there was very little change in particle size across the treatments over the course of the short season trial. Taking the 'less than 1 mm' fraction as an indicator of breakdown, the greatest increase in fine particles of this size was shown by FPF and FCWF. The least change was shown by FCI, where a decrease in fines was measured. The differences are all very slight and should be considered insignificant.

Treatment	**>4.75mm**	**>2.36mm**	**>1.00mm**	**>0.50mm**	**<0.50mm**
FCCB pre-trial	0.1	22.2	36.8	22.6	18.2
post-trial	**0.5**	**23.8**	**34.6**	**19.2**	**21.9**
FCWF pre-trial	0.4	13.3	41.3	23.4	21.7
post-trial	**0.5**	**12.7**	**39.2**	**23.7**	**23.9**
FCI pre-trial	0.1	8.8	40.4	27.7	23.0
post-trial	**0.4**	**8.6**	**40.1**	**25.2**	**25.8**
FPF pre-trial	0.3	20.1	47.7	17.7	14.2
post-trial	**0.6**	**17.5**	**47.5**	**19.1**	**15.4**

Table 2. Pre- and post-trial particle size distribution for TGM. Analyses carried out by Melcourt Industries Ltd.

The air filled porosity (AFP) of TGM, defined as the proportion of the volume of that media which contains air after it has been saturated with water and allowed to drain, should typically be in the range of 10-20% (http://www.melcourt.co.uk/). Media that has an AFP value higher than this suggests there is plenty of oxygen in the media that may result in a requirement for more frequent irrigation. Rockwool, according to published values, has an AFP of 10.3%. The growing media in this trial exceeded this value by magnitudes of 2 (FCCB, FCI) or 4 (FCWF, FPF) times (Table 3). However, it should be borne in mind that the method used for determining AFP in rockwool would not be the same as the method employed for the TGM (BS4156:1990, http://www.melcourt.co.uk/). For this reason care should be taken when making this comparison.

Media	**Air Filled Porosity (%)**
FCCB	23.0
FCWF	44.5
FCI	27.5
FPF	44.0

Table 3. Pre-trial Air filled porosity for TGM. Analyses carried out by Melcourt Industries Ltd.

The nitrogen drawdown index of a media is an estimate of the likelihood that a material will lock up nitrogen (AS 3743-2003). A value of 0 indicates that all the added nitrogen has been immobilised by micro-organisms in the media which could lead to deficiency symptoms in plants (Handreck & Neil, 1999).

Media	**Nitrogen Drawdown Index**
FCCB	0.7
FCWF	0.1
FCI	0.7
FPF	<0.1

Table 4. Nitrogen drawdown index for TGM. Analyses carried out by NRM Ltd .

The fresh pine fines (FPF) and fine composted wood fibre (FCWF) media were shown to have much less available nitrogen in the media compared with the other composted products (FCCB & FCI) in the trial (Table 4). This is not seen to be an issue when media of this type is used for growing tomatoes on a commercial basis, since nutrients are added to irrigation water at sufficient levels to prevent any deficiencies from occurring. There could, however, be implications for fertiliser strategy and management of the product when the chosen TGM from this trial is re-composted for use in containerised plant production.

A chemical analysis of the major elements in each TGM was also carried out (Appendix A), but did not reveal anything of immediate concern for the nutrient requirements and management of tomato plants in this trial.

The water retentive properties of trialled TGM have been shown to differ with respect to rockwool (Figure 1). All media were adjusted to 50% water content (by weight) before the experiment began. FPF and FCCB had lower water retention than FCWF and FCI. This may in part be due to the larger particle sizes associated with these media (Table 2). It is interesting to note that rockwool had a higher overall water retention than the trial TGM. This can have implications for irrigation management as an increase in run-off would be expected, based on these results, with TGM if grown according to rockwool guidelines. The full season trial with the chosen TGM will address this issue by investigating the effect of a 20% reduction in irrigation compared with standard rockwool practice.

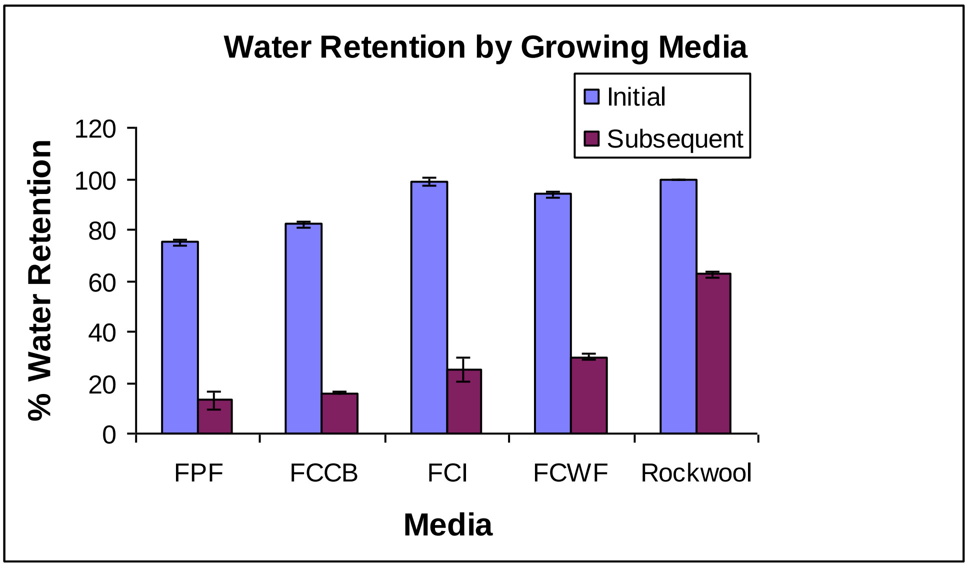

Figure 1. Water retention in sample media volumes of 250 mls (Moisture content was adjusted to 50% but media weight at this volume varied between media type). Initial water retention refers to the application of 50 mls water and measuring run-off after 2 mins. Subsequent water retention refers to the cumulative leachate after 3 more cycles of 50 mls water application every 2 mins. Data represent the mean $\pm$ SE of three replicates.

3.2 Growth Characteristics

The data from the three separate trials was combined to allow robust statistical analyses to be performed across the growing period as it was judged that plants in each crop might have responded differently to the climate control regime. This is because optimal management of the climate for crop one at day 28 would likely not be optimal for crop 3 at day 1. This is a limitation of having sequential crops at different stages in the same glasshouse.

The results for internode length, stem diameter and leaf length showed no consistent significant differences over the duration of the investigations when TGM was compared to rockwool and when analysed against other TGM in the trial.

Figure 2 shows the three temporally separated tomato crops. Throughout the trial, regular inspections were carried out for signs of phytotoxicity/ unusual growth. Across all media no such incidences occurred.

Figure 2. View of Growing media trial with 3 sequential tomato crops planted at 14-day intervals, immediately after planting of third crop.

Internodal Length

At day 14 there were no significant differences between treatments (Fig. 3). However, by day 28 FPF had significantly higher internodal lengths than plants grown on rockwool (Fig. 4).

Day 14

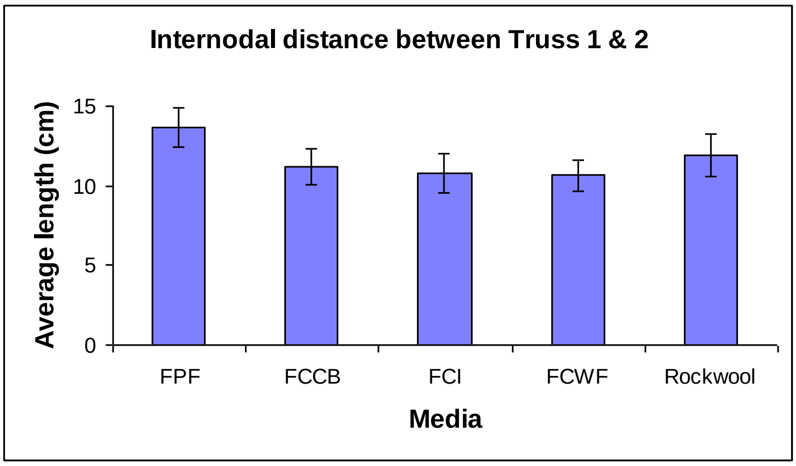

Figure 3. Combined data from three tomato crops, cv. Aranca (Enza Zaden), that were scheduled at two weekly intervals over a cropping period between June and September 2004. Data represents the mean of 27 replicates ± SE. No Significant differences were observed between treatments (t-test, assuming equal variance, P> 0.05, n=27).

Day 28

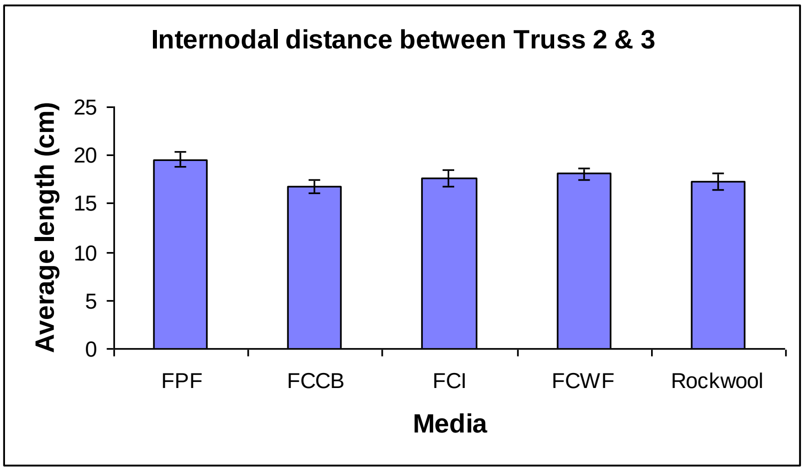

Figure 4. Combined data from three tomato crops, cv. Aranca (Enza Zaden), that were scheduled at two weekly intervals over a cropping period between June and September 2004. Data represents the mean of 27 replicates ±SE. FPF had significantly longer internodes than FCCB (t-test, assuming equal variance, P<0.05, n=27). There was an apparent slight increase in internode length (although not significant at the 95% level, P=0.06) between FPF and rockwool media.

Stem Diameter

Measurements taken at day 14 show that there were no significant differences in stem diameter across treatments (Fig. 5). This changed at day 40, with results showing that FCCB and FCI had significantly thinner stems than rockwool (Fig. 6).

Day 14

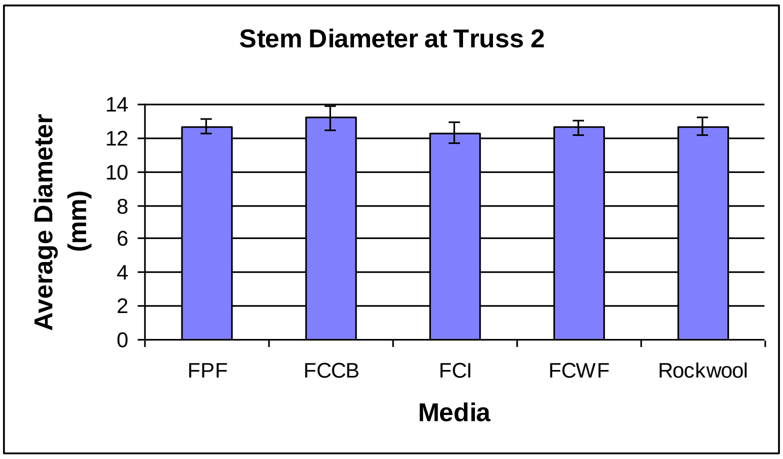

Figure 5. Combined data from three tomato crops, cv. Aranca (Enza Zaden), that were scheduled at two weekly intervals over a cropping period between June and September 2004. Data represent the mean of 18 samples + SE. No significant differences were observed between treatments.

Day 40

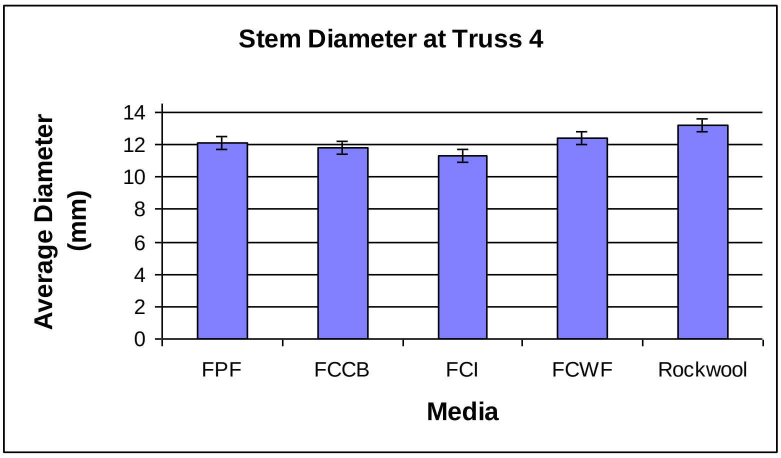

Figure 6. Combined data from three tomato crops, cv. Aranca (Enza Zaden), that were scheduled at two weekly intervals over a cropping period between June and September 2004. Data represents the mean of 18 replicates +SE. FCCB and FCI had significantly thinner stems at truss 4 than rockwool (t-test, assuming equal variance, $P<0.05$, $n=18$). There were no other significant differences.

Leaf Length

At day 14, leaf length at truss three in the FPF media treatment was significantly less than all other treatments (Fig. 7). However, this difference had disappeared by day 40 and plants grown on FCCB and FCWF media had significantly shorter leaves at truss four than rockwool grown plants (Fig. 8).

Day 14

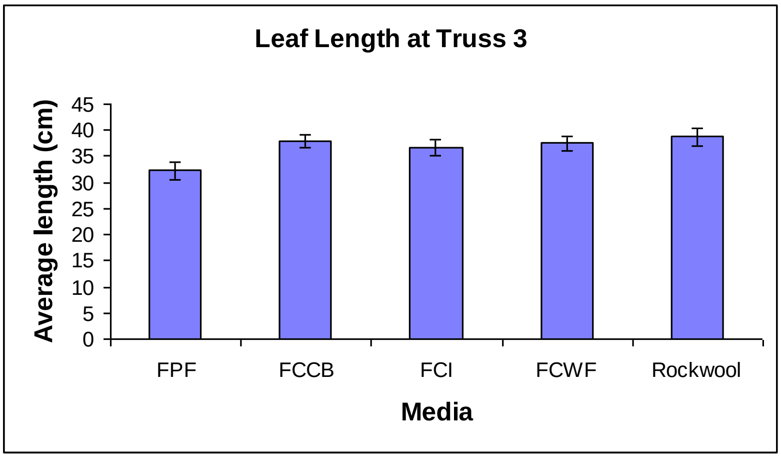

Figure 7. Combined data from three tomato crops, cv. Aranca (Enza Zaden), that were scheduled at two weekly intervals over a cropping period between June and September 2004. Data represents the mean of 27 replicates ±SE. FPF developed significantly shorter leaves than rockwool and other TGM (t-test, assuming equal variance, $P<0.05$, $n=27$). There were no significant differences between other TGM and rockwool.

Day 40

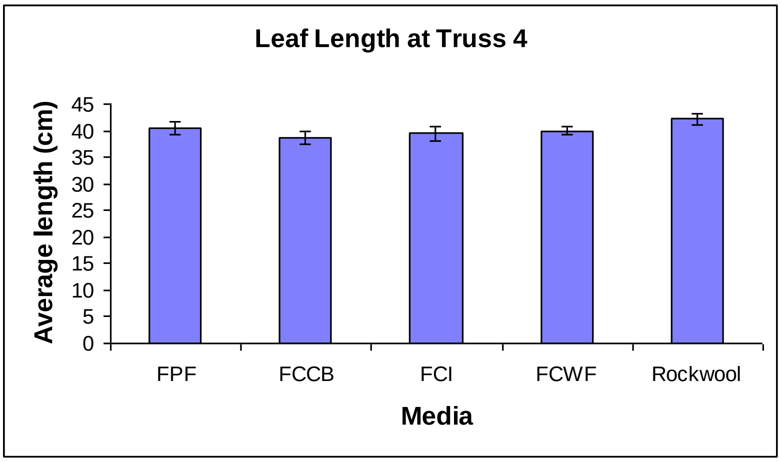

Figure 8. Combined data from three tomato crops, cv. Aranca (Enza Zaden), that were scheduled at two weekly intervals over a cropping period between June and September 2004. Data represents the mean of 27 replicates ±SE. FCCB and FCWF developed significantly shorter leaves than rockwool (t-test, assuming equal variance, $P<0.05$, $n=27$).

3.3 Nutrient Analysis of Foliage

A comprehensive nutrient analysis of leaf material (Appendix B) has revealed that there were no major differences in the levels of macronutrients. The levels of copper in all TGM-grown media was found to be 8 mg/ kg less than in rockwool. The manganese concentration in the FCI substrate also appeared to be lower when compared with respective trial substrates. However, according to the guidelines for glasshouse plants (Winsor & Adams, 1987), the levels in leaves of tomato plants grown on all the substrates in this trial were above the target values. At no time during the growth of the three trial crops were there any symptoms of nutrient deficiency apparent on leaves in low, mid and upper canopy positions.

3.4 Fruit Yield and Quality

Trusses were managed so that only ten fruits were allowed to develop per truss. Fruits were then harvested on a truss basis, when the last developing fruit was judged to be 'almost ripe'. This applied to truss 1 & 2, but not truss 3 & 4, which were still undergoing development.

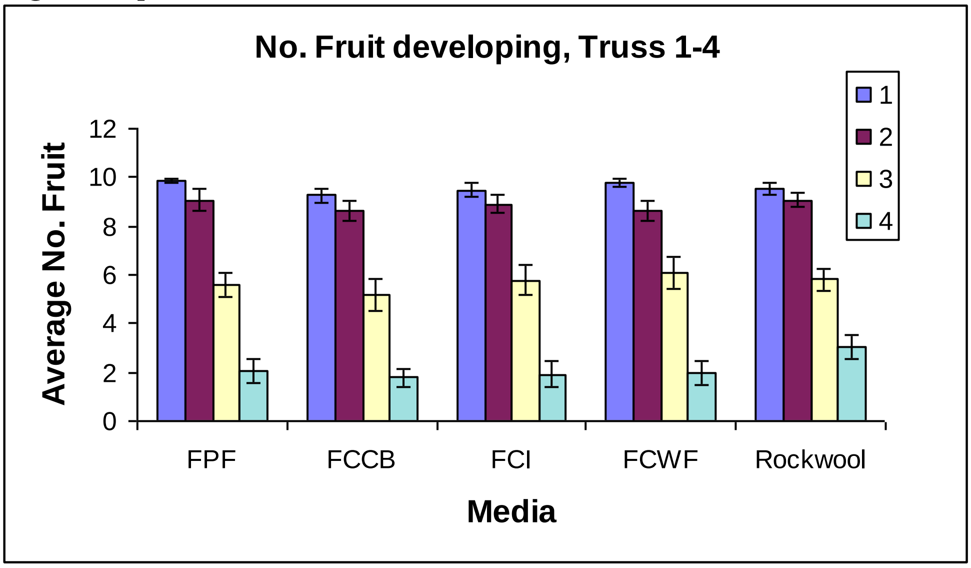

Figure 9. Combined data from three tomato crops, cv. Aranca (Enza Zaden), that were scheduled at two weekly intervals over a cropping period between June and September 2004. Data represents the mean of 27 replicates +SE. Assessments were carried out at day 40. There were no significant differences between treatments in trusses 1-3. Rockwool-grown plants had a significantly higher number of fruit developing on truss 4 than other TGM (t-test, assuming equal variance, $P<0.05$, $n=27$).

From Figure 9 it is apparent that there were no differences between test growing media with respect to timing of fruit development for the first three trusses. However, at truss 4, rockwool had a significantly higher number of fruit developing than the TGM treatments at assessment day 40.

Fruits harvested from truss 2 of the second crop were analysed for their brix, or sugar content. Fruits from plants grown in FPF had significantly higher brix values than rockwool and FCI (Figure 10). Whether or not these differences would be detectable in consumer taste tests remains unclear, but the results are a positive indication that tomatoes produced in composted growing media did not produce fruits of a lower quality than the rockwool control.

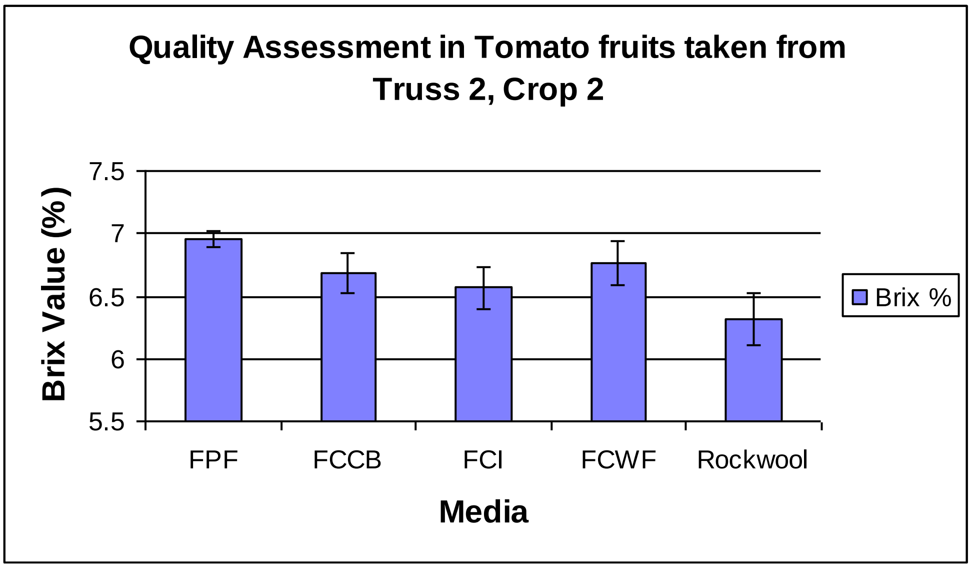

Figure 10. Brix refractometer measurements of sucrose content in truss 2 tomato fruits (cv. Aranca, Enza Zaden). Data represent the mean ± SE of 10 replicates. FPF had significantly higher brix value than rockwool and FCI (t-test, assuming equal variance, $P<0.05$, $n=10$). There were no other significant differences.

Total truss fruit yield was recorded in the second truss of the second crop (Figure 11). The data shows that there was a significant increase in truss fresh weight in FPF-grown plants compared to those grown in rockwool, with no other differences between rockwool and other treatments. In terms of commercial production, this apparent increase in fruit size with FPF media compared with rockwool may not be a desirable trait since Aranca is a cocktail variety and is grown for its smaller size

(about 30-35g per fruit, http://www.enzazaden.nl/site/uk/products/ fruit_vegetables /tomato/cocktail/)

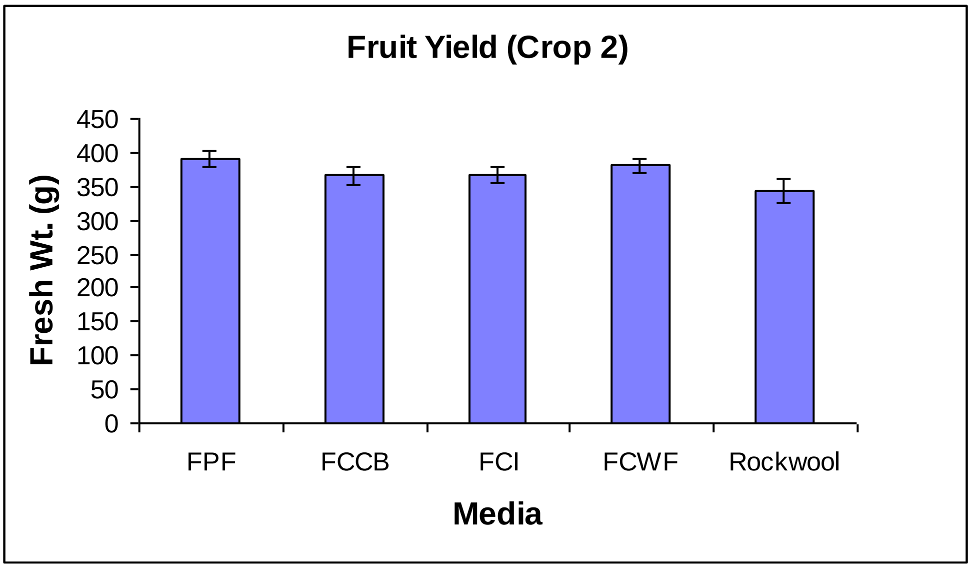

Figure 11. Truss 3 fresh weight (10 fruits) from randomly selected tomato plants (cv. Aranca, Enza Zaden) within each treatment at day 40. Data represent the mean $\pm$ SE of 15 replicates. FPF had a significantly higher truss weight than rockwool (t-test, assuming equal variance, $P<0.05$, n=15). There were no other differences.

3.5 Root Proliferation in TGM

At the end of the investigation, the TGM was removed from its sleeves and various sections were taken to assess the extent of root proliferation within the media (Fig. 12). There appeared to be no significant differences with respect to the ability of the roots to develop in the TGM and the overall root distribution was very similar to rockwool.

Figure 12. Sections of growing media from the third crop of tomatoes. Bags were removed and sections cut to allow an assessment of the degree of root penetration throughout the media.

3.6 Justification for chosen TGM

The overall result from the initial, short season trial in which four TGM were compared against the rockwool control demonstrated that all four equalled or exceeded the rockwool control in terms of yield and fruit quality. Within most of the other measured criteria they also equalled or exceeded the performance of the control treatment.

Therefore, the choice of material to go forward to the next stage of the trial was made on the basis of other parameters, as listed below.

Fresh Pine Fines (FPF) – The Fresh Pine Fines are an extremely consistent, single source, fresh pine wood chip. In their 'as received' state, they were the lightest of the test treatments and were therefore the easiest to handle. They frequently gave the best performance across the measured criteria, although not usually to a statistically significant degree.

However, the fresh pine fines arise from another industry. They are used for co-firing conventional coal-fired power stations and since choosing them to take part as one of the test treatments, the future of the particular source used in the trial has become less certain. This has served as a useful reminder about the potential problems that can arise when using as raw material a substance that arises from a completely separate industry. Political or practical changes to the other industry can markedly influence price and availability.

In addition, the energy input required to make this material is greater than the other treatments. In order to prepare the fine pine fines for power generation they need to be dried and machined to a fine chip. The other treatments are only chipped and/or screened, with a much lower energy requirement. For these reasons this treatment was not selected to go forward to the next stage.

Fine Composted Industrial Residues (FCI) – The Fine Composted Industrial residues also performed well throughout the trial, across the measured parameters. However, although the source of composted recycled wood used within the mix was carefully sourced from a known site, growers expressed concerns that any recycled material could be inherently too variable for a sensitive food crop. In view of the fact that other test treatment mixes have performed just as effectively without this uncertainty, it was decided on this factor alone not to consider this treatment further.

Fine Composted Wood fibre (FCWF) and Fine Composted Conifer Bark (FCCB) – The fine composted wood fibre and fine composted conifer bark both performed well across all of the measured parameters, with not much to choose between them overall.

In terms of energy input to manufacture the product, there is slightly less used in the case of the FCCB as it is only screened, whereas the wood fibre is chipped and then screened. Both products are currently available and widely used in the ornamentals industry, and have a proven track record of quality and consistency.

In preliminary work carried out since 2000, grower trials to investigate rockwool substitution have mainly used the FCCB. On the one occasion that FCWF was also used it did not perform quite as well as the FCCB. In every trial where the FCCB was used it performed consistently well. Taking this into account together with the availability and price of each material, it was decided that the FCCB was the best material to take forward to the long season trial.

Following this decision, FCCB was tested for post-trial available nutrient content. The results (not presented) showed few significant changes in terms of the potential for secondary use of the post-harvest material.

4. Full Season Trial 2005

At project management meetings in November and December 2004, FCCB media was decided, based on the reasoning laid out in section 3.5, as the best option to take forward in 2005 for a full-season crop comparison with rockwool.

Tomato seeds, cultivar Aranca, were sown on the 6th of December 2004 and either transplanted to rockwool blocks or to standard seedling compost (Levingtons M3), with the aim of planting out in the glasshouse at the end of January 2005. Two glasshouses (one for each treatment), each approximately 150 m^2 effective crop area, were laid out to allow an initial plant density of 2.6 m^2 (400 plants per glasshouse). The trial will initially be conducted using a typical feed recipe for a tomato crop grown in rockwool. This will be modified as appropriate, for FCCB media, during the course of the investigation. In the FCCB media glasshouse, two irrigation regimes will be established. The first will be as rockwool, whilst the second valve will operate at approximately 80% delivery of the first. Assessments in this investigation are as follows:

<u>Growth</u>

- Regular tag of plant apex and measurements to be taken between tags of
    - Internode distance
    - Stem diameter at previous tag
    - Number of leaves/ trusses (Flowers on truss. Score youngest truss that has open flowers)
    - Leaf length

- Fruit Yield/ Quality
    - Harvest as whole truss
    - Fresh weight (FW) to be taken weekly
    - Brix index as quality indicator. Take samples at specific colour stage of fruit (Tomato colour chart)

- Nutrient analysis of slab
    - Samples to be taken at distinct phases in crop development
        - Start of plant establishment
        - One week after picking
        - Every 3 weeks thereafter

- Regular crop inspection for symptoms of phytotoxicity in leaves/ fruit (incidences of which to be photographed)

<u>Irrigation Measurements</u>

- Daily water use.
- Run-off measurements from troughs beneath 3 slabs in each irrigation treatment
- % Moisture content (continuously)
- Slab EC & pH (every 3 days for first 4 weeks, then weekly)

5. References

Winsor, G. & Adams, P. (1987). Diagnosis of Mineral Disorders in Plants: Volume 3 Glasshouse crops.

Handreck, K.A. & Neil, D.B.(1999). Growing media for ornamental plants and turf. University of New South Wales Press, Sydney.

6. Acknowledgements

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Appendix A- Physico-chemical properties of TGM.

Media	FPF	FCCB	FCI	FCWF
pH	4.85	5.28	7.12	5.5
Density (kg/ m3)	192	426	379	312
Dry Matter (%)	87	42.6	42.7	49.3
Dry Density (kg/m3)	167	181.5	161.8	153.8
Nitrogen Drawdown Index	<0.1	0.7	0.7	0.1
Cl (mg/l)	16.3	32.9	64.5	20.2
P (mg/l)	23.2	9.2	0.6	23.5
K (mg/l)	111	40.8	114.6	110.6
Mg (mg/l)	3.9	0.7	1.5	4.1
Ca (mg/l)	7.2	1.7	12	11.5
Na (mg/l)	5.8	12.5	35	6.8
Conductivity (uS/cm)	88	47	132	95
Amm-N (mg/l)	2.6	4.3	13.3	0.8
Nitrate-N (mg/l)	0.6	< 0.6	< 0.6	< 0.6
Tot. Sol. N (mg/l)	3.2	4.3	13.3	0.8
Sulphate (mg/l)	18.2	13	< 0.6	< 0.6
B (mg/l)	0.13	< 0.06	0.67	0.23
Cu (mg/l)	< 0.06	< 0.06	0.09	< 0.06
Mn (mg/l)	0.53	< 0.06	0.15	0.84
Zn (mg/l)	0.11	0.08	0.3	0.13
Fe (mg/l)	0.43	0.57	0.59	0.923

Appendix B- Nutrient analysis of leaf material from a mid-canopy position in tomato plants (Crop 2) grown in a range of wood-based media.