Peat-based organic growbags as a solution to the mineral wool waste problem

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SUMMARY

The vast amount of solid waste produced each year is one of the greatest problems associated with greenhouse horticulture in some European countries. In particular, the disposal of used growing media arising from the soil-less cultivation of vegetables in mineral wool creates serious difficulties. The non-biodegradability of these mainly inorganic substrates causes environmental concern and has prompted the search for alternative growing media such as cocos derivatives, perlite and resin foam (Fytocell®). Organic substrates in combination with biodegradable material such as plastic, rope and clippings have the advantage that re-use or recycling of the waste is easier, cheaper and more environmentally friendly than for mineral wool. However, the differing physical and chemical characteristics of the alternative substrates may affect yield significantly. Substrates based respectively on peat and peat with cocos derivatives were tested against a mineral wool control for the production of tomato in three consecutive years. Both organic substrates were placed in biodegradable plastic bags. Greenhouse experiments demonstrated that plants grown in the pure peat substrate rooted more easily than plants grown in the peat-cocos substrate or mineral wool, and that they developed less blossom-end rot in both peat substrates than in mineral wool. Due to the buffering capacity of the organic substrates, the electrical conductivity of the draining water appeared to be more stable during cultivation. The total yield of tomato fruits was similar for all substrates, and no differences between substrates could be observed in the quality of the fruits produced. On the other hand, flavour tests demonstrated that plants grown on peat substrate produced more tasty fruits under certain conditions. The results of this study show that organic growbags are promising and competitive alternatives to mineral wool.

KEY WORDS: biodegradable substrate, cocos, disposal, recycling, greenhouse grown vegetables, tomato.

INTRODUCTION

Growing media (synthetic substrates) are materials, other than soils *in situ*, in which plants are grown (CEN CR 13456). These can be organic (e.g. peat and cocos) or inorganic (e.g. clay, perlite and mineral wool). The physical and chemical characteristics of the substrate, together with the growing techniques (e.g. fertigation) employed, determine the yield and quality of the vegetables that are produced.

The fruit and vegetable industry in Flanders uses various substrates as growing media for greenhouse-produced plants. Around 59% of the total area under glass (1126.6 ha) is used for the cultivation of vegetables such as tomato, paprika and cucumber. The area of tomato cultivation is 523 ha, of which some 80% utilises substrates. Some 90% (360 ha) of the area using substrates employs mineral wool. The amount of mineral waste that is released into the environment can be calculated from such figures (Nationaal Instituut voor de statistiek, Belgie 2005). Belgium produces 30,000m³ (more than 10,000 tonnes) of inorganic waste in the form of used growing media, often contaminated or mixed with non-biodegradable materials like plastic, every year. Pure organic waste is easier to re-use or recycle than inorganic material. Therefore, the aim of the project described in this paper was to develop an alternative substrate based on peat and biodegradable plastic (EN13432) in order to solve the problems associated with the large quantity of solid waste (substrate and plant material) that is generated by greenhouse crop cultivation.

METHODS

An exploratory study was carried out in 2004, and the results informed new experiments to optimise the composition of the organic substrates, which were carried out in co-operation with the Provinciaal Centrum voor de Groenteteelt, Belgium (PCG) between December 2004 and December 2005. Three different substrates were examined, namely one mineral wool substrate and two organic substrates based on peat and peat-cocos respectively. The dimensions of the mineral wool blocks were 1 x 0.2

x 0.075 (LxWxH) metres. The organic peat-cocos substrate was a mixture of coarse (Fraction 2) peat (H3–H5 von Post) and coir fibre (cocos) contained in biodegradable plastic (European standard EN13432) growbags of dimensions 0.8 x 0.19 x 0.075 metres and capacity about 23L (EN12580). Liming and fertilisation were adjusted to achieve an EC of 120–250 µS cm^{-1} (EN 13038; European Committee for Standardisation 1999a) and a pH (H_2O) of 5.5–6 (EN 13037; European Committee for Standardisation 1999b).

The tests were carried out using the grape tomato Clothilde, which was grown in a double row system under two fertigation regimes, namely "wet" as appropriate for mineral wool and "dry" as appropriate for the organic substrates. The experimental setup was a double randomised block arrangement with three treatments and eight replications (400m²). The slabs were fully saturated with water before transplantation, and the plants were placed directly in the planting holes. The data recorded during the experimental period were yield, number of fruits, number of fruits with the physiological disorder blossom end rot (BER) and taste (0 = not tasty to 10 = very tasty). Chemical analyses of the drainage water were also carried out. For the organic substrates, samples for analysis were taken from the drainage water; and for the mineral wool substrate the samples were taken directly from the slabs. Harvesting lasted from the end of March until the middle of November. At the end of the growing season the loss of water in an open growing system was observed by measuring the weight of each slab as a function of time. This information has important implications for the fertigation regime at the end of the growing season. The heavier the growbag, the more difficult it is to handle; thus substrate weight is relevant and rapid weight loss at the end of the season is advantageous.

The same comparative substrate tests were carried out on grape tomatoes (Tricia) grown over the full season December 2005 to December 2006. These plants were grown in a V-system, with two plants per slab. For each plant, two stems (forming a V) were retained initially and one additional stem was allowed to grow in mid-March.

RESULTS

The results of the 2005 experiments are shown in Table 1. No significant differences were found between the organic and the inorganic substrates in terms of yield, the number of fruits, or the number of fruits with BER. The number of fruits with BER did not differ between the substrates, but more fruits with BER were produced under the dry fertigation regime than under the wet regime. This can be explained by the fact that the number of fruits affected by BER increases with increasing electrical conductivity (EC) (Adams & Ho 1992, De Kreij 1995, Ho 1999). Although no significant differences between the substrates were found, the organic substrates, and especially the peat-cocos substrate, produced the lowest number of fruits with BER under both fertigation regimes. The difference between the substrates was greatest in the dry fertigation regime. The taste of the fruits did not differ significantly between the different substrates. This can be explained by the fact that the tomatoes chosen for the flavour test were from the wet fertigation regime, and so were cultivated at lower EC. Increasing EC increases fruit EC, which in turn gives better flavour intensity and higher consumer satisfaction (Dorais *et al*. 2000), although different tomato cultivars respond differently to salinity.

Table 1. Summary of the results of the comparative substrate test carried out using the grape tomato Clothilde in 2005. The taste of the fruits was evaluated on a scale of 0 (= absolutely not tasty) to 10 (= very tasty). Asterisks indicate data that are averages of different treatments. ANOVA analysis using SPSS 11.5 showed no statistical differences ($P<0.05$), as indicated by the appended letters. ND = not determined.

Fertigation regime	Substrate	Yield (kg m^{-2})	Number of fruits (m^{-2})	Number of fruits with BER (m^{-2})	Taste
Wet	Mineral wool	46.72 a*	349.5 a	2.4 a	5.94 a*
	Peat	48.15 a	360.8 a	3.6 a	6.02 a
	Peat-cocos	46.76 a	353.9 a	1.5 a	5.83 a
Dry	Mineral wool	46.15 a	349.9 a	10.3 a	ND
	Peat	45.80 a	350.6 a	9.8 a	ND
	Peat-cocos	46.32 a	353.8 a	4.0 a	ND

One of the few differences between the organic and inorganic substrates was in fruit colour. EC was much higher in the organic than in the mineral wool slabs, and peaked significantly in July. This can partly explain the dark red colour of the fruits grown in the peat-cocos substrate (data not shown), although this was not produced on the peat-only substrate. More roots were observed in the organic substrates than in the mineral wool, with plants in peat developing more roots than those in peat-cocos.

The weight loss of the slabs at the end of the growing season is shown in Figure 1. The organic substrates lost weight more rapidly than mineral wool but the mineral wool substrate always exhibited the lowest weight per slab. No problems arose during the removal of either peat or peat-cocos slabs at the end of the season. However, the biodegradable plastic was fragile and showed symptoms of degradation especially where mechanical contact with the gutter had occurred.

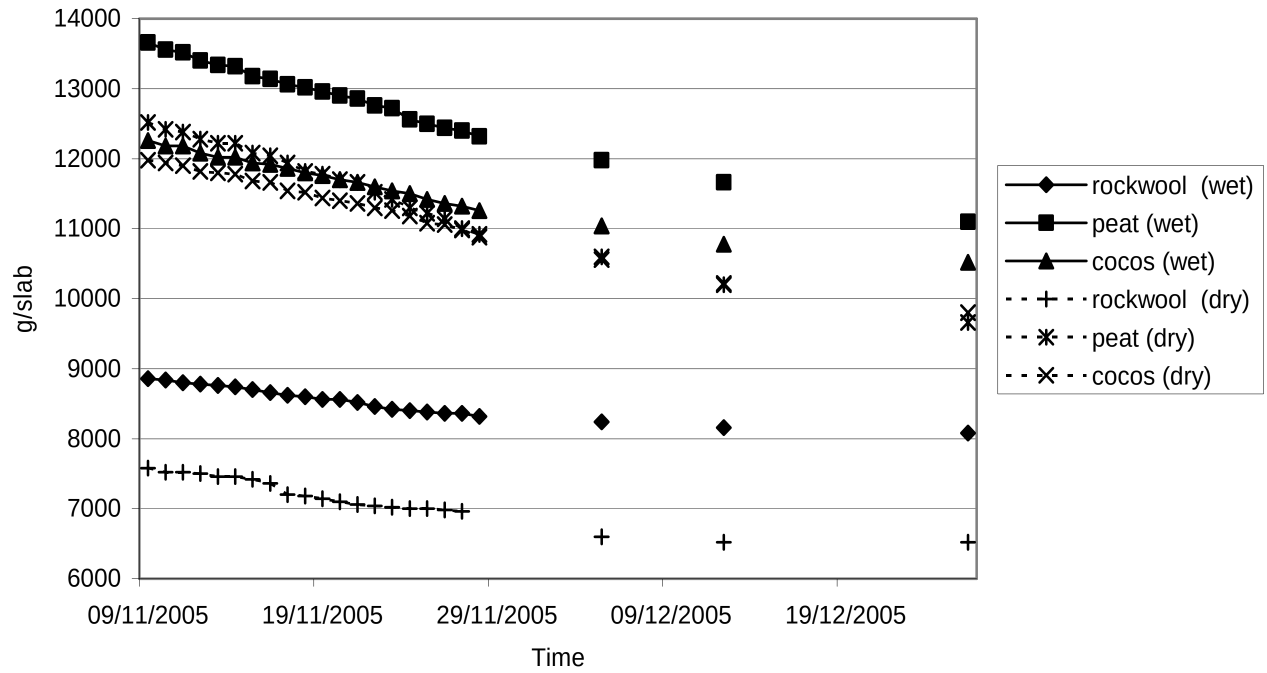

Figure 1. Loss of weight (in grams per slab) for mineral wool ("rockwool"), peat and peat-cocos ("cocos") at the end of the 2005 growing season.

The results of the 2006 experiments are shown in Table 2. Again, no significant differences in yield and fruit quantity were found between the inorganic and the organic substrates. The number of fruits with BER did not differ between the substrates in the wet fertigation regime, but there were significant differences in the dry regime. Also, significantly fewer fruits with BER were produced on the organic substrates under the dry fertigation regime. The taste of the fruits produced on the different substrates did not differ significantly, but tomatoes grown on the peat-cocos substrate attained the highest value for taste. Table 1 shows that plants grown on mineral wool produced more fruits with BER than those grown on either of the organic substrates. The results from 2006 (Table 2) confirm that plants grown on peat and peat-cocos substrates produce fewer fruits with BER. Thus it is suggested that plants develop less BER when grown on substrates with high buffering capacity, such as organic substrates.

It seemed that the fluctuations of EC were more balanced in the organic substrates, where samples for EC analyses were taken from the drainage water, than in the mineral wool substrates (samples taken directly from the slabs). In the wet fertigation regime, the peat and peat-cocos substrates showed the lowest-amplitude fluctuations of EC (Figure 2).

Table 2. Summary of the results of the comparative substrate test carried out using the grape tomato Tricia in 2006. Fruit taste was evaluated on a scale of 0 (= absolutely not tasty) to 10 (= very tasty). Asterisks indicate data that are averages of different treatments. Values with different letters appended are statistically different from one other (P<0.05) as indicated by ANOVA analysis (SPSS 11.5). ND= not determined.

Fertigation regime	Substrate	Yield (kg m^{-2})	Number of fruits (m^{-2})	Number of fruits with BER (m^{-2})	Taste
Wet	Mineral wool	47.95 a*	335.3 a	7.1 a	4.68 a
	Peat	49.25 a	336.5 a	5.8 a	4.64 a
	Peat-cocos	51.08 a	349.8 a	5.9 a	5.04 a
Dry	Mineral wool	51.77 a	357.0 a	5.0 b	ND
	Peat	51.61 a	362.9 a	2.1 ab	ND
	Peat-cocos	51.47 a	353.4 a	1.3 a	ND

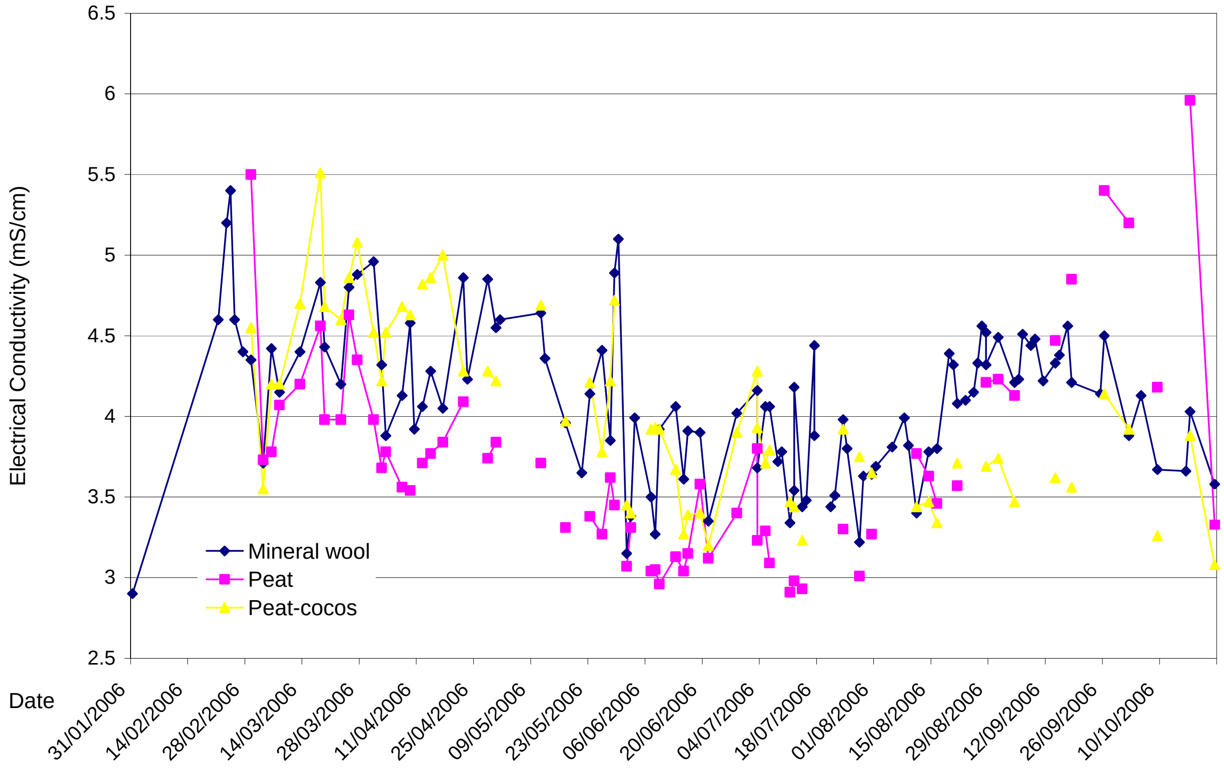

Figure 2. Electrical conductivity (EC, mS cm^{-1}) fluctuations for the three substrates tested in the wet fertigation regime during the 2006 production season.

DISCUSSION

It is well known from literature that plants growing on substrates such as mineral wool, peat and cocos respond differently to nutrient solutions (Xu *et al.* 1995). Some substrates also support more rapid responses to changes in growing conditions arising from daily weather variations. Experiments have shown that using feed solution with an EC of 2.5 mS cm^{-1} results in higher EC in a peat substrate than in a mineral wool substrate (Norrie *et al.* 1995). Thus, the EC of the feed solution, the frequency of irrigation and the quantity of nutrient solution provided to the plants varies between growing media and this will affect yield and fruit quality (Mitchell *et al.* 1991, Peet & Willits 1995, Tüzel *et al.* 1993). It has also been shown that the effect of high salinity on fruit yield can vary according to the cultivar, and not all tomato cultivars reduce their fruit size to the same degree (Cuartero & Fernandez-Munoz 1999).

Tomato is one of the world's most important horticultural crops. Modern greenhouse production is driven by a requirement for high yields of fruit with very high quality and flavour, which are all essential for consumer satisfaction and the success of the industry. Growing systems that re-circulate the nutrient solution are very attractive because they couple savings of water and fertilisers with decreased leaching. However, the more times the irrigation water is collected and re-used, the higher the concentration of salts (EC) becomes. Dramatic changes to root zone EC can have negative effects on root and plant growth as well as on fruit quality, but none of this occurred in the plants grown on the organic growing media in our trials.

CONCLUSION

During three consecutive experimental years, no significant differences in yield and number of tomato fruits were found between the inorganic and the organic substrates that were tested, but the plants developed less blossom-end rot in peat and cocos based substrates. The electrical conductivity of the water draining from the organic substrates appeared to be more constant during cultivation due to their buffering capacity.

So far, the results of this study have shown that organic substrates or organic growbags are promising and competitive alternatives to mineral wool. New experiments were set up in 2007 in Belgium, Poland and France in order to confirm the results from 2005 and 2006 and to investigate the composting process of the end of production season.

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