

## **GROWING MEDIA FOR ORGANIC TOMATO PLANTLET PRODUCTION.**

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### Abstract:

The choice of growing media and the strategy of application of organic fertilizers is considered one of the largest challenges for production of organic tomato plantlets for transplanting. We have measured the growth and the ability of young tomato plantlets to extract plant nutrients from an organic growing media. Plants were grown in 0.45L pots. Plant nutrition were either entirely based on the mineral nutrients, available from the organic growing media or based on a combination of nutrients from the organic growing media and fertigation with water-soluble organic fertilizers during plantlet production. The first results shows that plant dry weight and uptake of nitrogen, phosphorus and potassium was reduced in the organic growing media compared to the control, peat based growing media, but the results also indicate a possibility for optimizing the suggested organic growing media in order to increase the nutrient acquisition and utilization efficiency of the plants. Improved organic growing media can supply most of the necessary plant nutrients needed for the plant, limit the need for supplementary fertilisation, and be an alternative to conventional production with inorganic fertilizers.

### 1. Introduction.

The release and availability of nutrients, root growth dynamics and nutrient uptake will affect plant growth and yield. The distance is very short between being able to meet the nutrient demands and having excessive nutrient availability and thereby a risk of nutrient leaching losses to the environment or nutrient imbalances or toxicity problems for the plant.

A number of studies of different soil-less substrates have been made (Lamanna *et al.*, 1991; Ku *et al.*, 1998) using compost from different sources. Many of the problems that have been identified have been related to salt problems, structural problems and water capacity problems, all factors that are very critical in an efficient production (Weinhold *et al.*, 1997). An emphasis on obtaining high quality uniform soil-less substrates is essential to enhance the organic production, but this needs to be closely co-ordinated with water and fertilisation techniques, since the organic fertilisers are releasing their nutrients over a longer period, compared to the immediate availability of chemical fertilisers (Berner *et al.*, 1996). The

choice of growing media and the strategy of application of organic fertilizers is considered one of the largest challenges for production of organic tomato plantlets for transplanting.

An optimal compost should contain enough N rich materials to supply N for the plants during the entire production period. P and S are build into organic compounds similarly to N, and must be mineralised in the compost before they become available for the plants. Previous results have shown that both P and S can be readily mineralised, the mineralisation rate depending on various factors (Dalal, 1979; Till *et al.*, 1978; Enwezor, 1976, Eriksen *et al.*, 1999) where C/P ratio and C/S ratio seem to be of major importance, as the C/N ratio for N mineralisation. On the other hand, K, Ca and Mg is present as ions in the composted material, and do not need mineralisation to become available. K is not bound in the composted material, and can be regarded as immediately available for other plants (Christensen, 1985). Considering the amounts of various nutrients available in the composted materials, this could lead to excess availability of K compared to other nutrients, and an imbalance between K supply and Ca and Mg supply.

When plants are grown without soil contact, the compost must also secure the supply of micro nutrients. The ability of the growth medium to do this, will depend not only on the total content and release of these nutrients, but at least for some nutrients as Mn and Fe it will also depend on pH and redox conditions within the growing medium.

Fluctuations in the availability of nutrients (especially ammonium, potassium and phosphorus) during the production period can be expected due to ongoing composting processes (Jensen *et al.*, 1998). In order to reduce the risk of nutrient fluctuations it is important to use stable and mature compost. The availability of specific nutrients will at times be very high and can depress plant growth and/or fruit quality. To avoid high concentrations of ammonium and other nutrient elements in the root environment a nutrient buffer can be incorporated into the medium, for instance clay minerals such as zeolite or glauconite.

It was the aim of the experiment to describe and compare the growth and nutrient uptake of plants grown in an organic composted peat/manure based growing media to plants grown in a conventional peat based growing media irrigated with a standard nutrient solution. Secondly, it was the aim to evaluate the possibility for optimizing the suggested growing media in order to increase the nutrient availability in the growing media and acquisition efficiency of the plants in order to limit the need for supplementary fertilisation.

## 2. Materials and methods.

### 2.1. Plant material.

Seeds of tomato (*Lycopersicon lycopersicum* 'Aromata') were sowed in plastic pots ( $\varnothing=11$  cm, volume 0.45L) containing either peat based growing media (Pindstrup 2, Pindstrup Mosebrug A/S, Denmark) or an organic composted peat/manure based growing media (Alternativjord, Svalöf Weibull Torv AB, Sweden). The organic composted peat/manure based growing media consisted of peat composted with cow manure for 2 years, then added chicken manure and composted for an additional year and finally mixed with peat in the ratio 40% compost to 60 % peat.

## 2.2. Irrigation water.

The peat based growing media was irrigated with a standard nutrient solution (Peat + std.; Table 1) and the organic growing media was either irrigated with rain water (Alt.- fert.; Table 1) or with a water soluble organic fertilizer (0.25% BioRika, Neudorff GmbH KG, Emmerthal, Germany, Alt. + fert.; Table 1) giving a total of three treatments. Each treatment was replicated three times in a randomized block design and the experiment was carried out on individually controlled ebb-flood benches. The plants were grown in a greenhouse at Research Centre Aarlev, Denmark, in April 2001, with controlled climate at a temperature of 20 – 25 °C. No artificial lighting or CO<sub>2</sub> was added. The pH of irrigation water was not significantly different when comparing the standard nutrient solution with rain water (Table 1), but was significantly higher in the water soluble organic fertilizer. Although the concentration of PO<sub>4</sub>-P and K was much higher in the water soluble organic fertilizer, the electrical conductivity was lower in this nutrient solution compared to the standard solution. This was due to the lower concentrations of NO<sub>3</sub>-N, magnesium, calcium and sulphate measured in the solution with water soluble organic fertilizer. The content of iron, manganese and copper was also lower in this nutrient solution, but probably not affecting the electrical conductivity significantly.

Table 1. pH, electrical conductivity (EC; mS cm<sup>-1</sup>) and nutrient composition of irrigation water (Irrigation water) (mg L<sup>-1</sup>) and initial pH, EC, and nutrient availability (Growing media; day 0) and pH, EC, and nutrient availability at the end of production (Growing media; day 38) in growing media (mg plant<sup>-1</sup>). The peat based growing media was irrigated with a standard nutrient solution (Peat + std.). The organic growing media was either irrigated with rain water (Alt.-fert.) or with a water soluble organic fertilizer (Alt. + fert.).

	Irrigation water			Growing media; day 0		Growing media; day 38		
	+ std.	- fert.	+ fert.	Peat	Alt.	Peat + std.	Alt. - fert.	Alt. + fert.
pH	5.4	5.6	7	6.1	5.6	6.0	5.1	6.0
EC	1.77	0.35	1.31	3.0	5.7	4.8	5.1	6.6
NO <sub>3</sub> -N	120	1	24	68	154	123	122	147
PO <sub>4</sub> -P	35	0	47	71	44	95	27	75
K	208	1	317	114	230	170	87	614
Mg	39	1	5	-	-	-	-	-
Ca	98	21	15	-	-	-	-	-
Na	14	3	52	-	-	-	-	-
Cl	29	5	61	-	-	-	-	-
SO <sub>4</sub>	69	3	41	-	-	-	-	-
Fe	1.7	0	0.39	-	-	-	-	-
Mn	1.56	0.03	0.09	-	-	-	-	-
B	0.18	0.11	-	-	-	-	-	-
Cu	0.09	0.005	0.02	-	-	-	-	-
Zn	0.42	0.25	0.58	-	-	-	-	-

## 2.3. Plant and growing media analysis.

Samples of the growing media, taken prior to sowing of the tomatoes and 38 days after sowing, was extracted with diluted acetic acid and analyzed for plant available nitrate,

phosphate and potassium ( $\text{NO}_3\text{-N}$ ,  $\text{PO}_4\text{-P}$  and  $\text{K}$ ; Table 1) as well as electrical conductivity (EC) and pH. Destructive plant samples for fresh and dry weight measurements were taken 18, 25, 32 and 38 days after sowing (Figure 1), and at 38 days after sowing samples were analysed for plant content of nitrogen (N), phosphorus (P) and potassium (Figure 2).

### 3. Results.

#### 3.1. Growing media.

Compared to the peat based growing media the organic peat/manure based growing media contained more plant available nitrate and potassium, but less phosphate (Table 1; Growing media day 0). In addition to relatively high nitrate levels the organic peat/manure based growing media contained high levels of ammonium ( $\text{NH}_4\text{-N}$ ) at the time of sowing ( $191 \text{ mg L}^{-1}$ ). The pH was higher in the peat based growing media and the electrical conductivity in the media was lower before sowing of the tomatoes. At 38 days after sowing the nitrate, phosphate and potassium availability of the peat based growing media had increased (Table 1; Growing media day 38). We observed a decline in nutrient availability in the organic peat/manure based growing media that had only received rain water. The most significant decline was of potassium, whereas the decline in nitrate was much less and the availability was comparable to the level found in the peat based substrate. The organic peat/manure based growing media that was irrigated with the water-soluble organic fertilizer had four times higher potassium level compared to peat based growing media irrigated with a standard nutrient solution. This high availability of potassium and higher levels of sodium and chloride in the irrigation water led to significantly higher EC in this media over time.

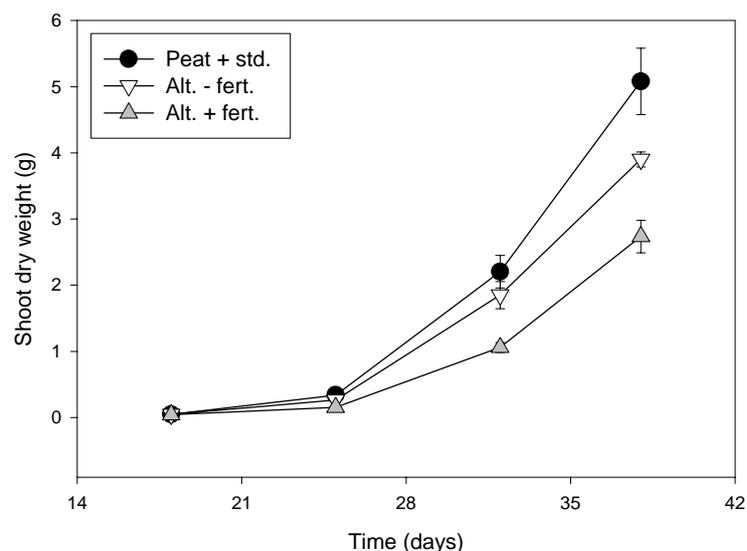


Figure 1. Effect of growing media and fertigation on shoot dry weight of tomato plantlets over time. The standard growing media was irrigated with a standard nutrient solution (Peat + std.). The organic growing media was either irrigated with rain water (Alt. - fert.) or with a water soluble organic fertilizer (Alt. + fert.). Data shown are mean  $\pm$  standard error of the mean ( $n=3$ ).

### 3.2. Plant growth

Plant DW increased over time for all treatments and the quality of the tomato plantlets were acceptable and comparable. The shoot dry weight of the plants grown in organic peat/manure based growing media and irrigated with rain water was reduced by approximately 25% and plants irrigated with water soluble organic fertilizer was reduced by approximately 50% compared to plants grown in peat based growing media and irrigated with standard nutrient solution (Figure 1). The dry weight percentage of the plants grown in organic peat/manure based growing media and irrigated with rain water was 12.4% and plants irrigated with water soluble organic fertilizer was 9.4% compared to the 8.3% of the plants grown in peat based growing media and irrigated with standard nutrient solution.

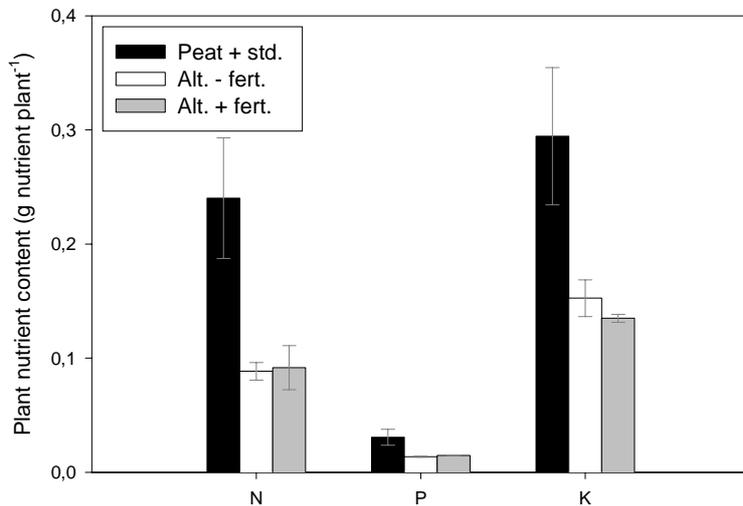


Figure 2. Effect of growing media and fertigation on plant nutrient content of tomato plantlets measured 38 days after sowing. The standard growing media was irrigated with a standard nutrient solution (Peat + std.). The organic growing media was either irrigated with rain water (Alt.- fert.) or with a water soluble organic fertilizer (Alt. + fert.). Data shown are mean  $\pm$  standard error of the mean ( $n=3$ ).

### 3.3. Nutrient acquisition

The nutrient content of the plants was significantly affected by the growing media. Plants grown in organic peat/manure based growing media contained significantly less total N (38%), total P (47%), and total K (49%) compared to plants grown in peat based growing media (Figure 2). There were no significant differences when comparing the contrasting fertigation treatments of plants grown in organic peat/manure based growing media on the total plant nutrient content, but the concentration in the tissue was significantly higher in plants irrigated with water soluble organic fertilizer due to their lower dry weight.

## 4. Discussion

Although the content of  $\text{PO}_4\text{-P}$  and K was higher in the irrigation water containing a water soluble organic fertilizer (Alt. + fert.), this did not lead to higher total uptake in the plant. Since these plants had significantly lower shoot dry weight, the concentration of total P and K in the tissue was higher. The high levels of especially K, sodium and chloride and the higher electrical conductivity of the organic peat/manure based growing media irrigated with water soluble organic fertilizer (Alt. + fert.), can be the cause of the severe reduction in plant dry weight of the plants grown in this treatment. Since K is not bound in the plant material, and can be regarded as immediately available for other plants (Christensen, 1985) and considering the possible imbalance between K supply and Ca and Mg supply, great caution should be used when fertigating the plants with water soluble organic fertilizer (Alt. + fert.) with a high content of K. The decline in K availability over time in the organic peat/manure based growing media irrigated with rain water (Table 1) indicates that it might have been advantageous to add smaller amounts of or fewer irrigations with the water soluble organic fertilizer, in order to maintain the initial level in the growing media..

The lack of difference in total uptake of P and K between the contrasting fertigation treatments of plants grown in organic peat/manure based growing media indicate that the growth of these plants were not limited by the availability of these nutrients. Addition of the water soluble organic fertilizer (Alt. + fert.), did not enhance the growth rate of the plants, but merely led to increasing electrical conductivity and no noteworthy increase in  $\text{NO}_3\text{-N}$  availability.

Although the  $\text{NO}_3\text{-N}$  content in the growing media was initially higher in the organic peat/manure based growing media and at a comparable level to the peat based growing media at 38 days after sowing the total N uptake of the plants were significantly lower compared to plants grown in peat based growing media. The much lower total N and P content and the increased dry weight percentage of the plants grown in the organic peat/manure based growing media compared to the peat based growing media, regardless of fertigation treatment, indicate that the reduced shoot dry weight and growth rate of these plants are influenced by the N and /or P availability over time. Growth inhibition due to ammonium nutrition is normally closely related to decreased growing media pH (Findenegg *et al.*, 1982). We did not observe a significant drop in the growing media pH in this experiment (Table 1). A temporary depletions of the  $\text{NO}_3\text{-N}$  sources due to biological immobilization as suggested by Smith *et al.* (1989) does not seem realistic due to the long composting period prior to the experiment (3 years), but high ratios of  $\text{NH}_4\text{-N}$  to  $\text{NO}_3\text{-N}$  as measured in the organic peat/manure based growing media are known to reduce dry matter production in tomatoes (Ali *et al.*, 1994).

The plants grown in organic peat/manure based growing media and irrigated with rain water, thus dependent on the nutrients available in the growing media or mineralized from the growing media, were able to extract 88 mg N, 13 mg P, and 152 mg K from the growing media (Figure 1). The demand for N is increasing over time as the daily biomass gain increases. Considerable uptake of  $\text{NH}_4\text{-N}$  or net N-mineralisation or leaching of  $\text{NO}_3\text{-N}$  is occurring since the amount of nitrogen taken up by the plant (88 mg N) and remaining  $\text{NO}_3\text{-N}$  in the growing media (122 mg  $\text{NO}_3\text{-N}$ ) exceeds the amount of  $\text{NO}_3\text{-N}$  available initially (154 mg  $\text{NO}_3\text{-N}$ ). Net mineralisation of  $\text{PO}_4\text{-P}$  does not exceed  $\text{PO}_4\text{-P}$  leaching, since the amount of P taken up by the plant (14 mg P) and remaining  $\text{PO}_4\text{-P}$  in the growing media (27 mg  $\text{PO}_4\text{-P}$ ).

P) is equivalent to the amount of PO<sub>4</sub>-P available initially (44 mg PO<sub>4</sub>-P). All the K is available for the plant, as indicated by the sum of the amounts taken up by the plant (152 mg K) and remaining in the growing media at the end of the experiment (87 mg K), is almost identical to the amount available initially (230 mg K). Based on the measurements from this experiment we do not have data to support a discussion on plant acquisition and mineralisation of nutrients from the other two treatments.

The first results points out the need for optimizing the tested organic growing media in order to increase the nutrient acquisition and utilization efficiency of the plants. The results also allow the conclusion that improved organic growing media can supply most of the necessary plant nutrients needed for the plant, thus limiting the need for supplementary fertilisation and being an alternative to conventional production with inorganic fertilizers.

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