ACTA SCIENTIARUM POLONORUM Hortorum Cultus 2(2) 2003, 15-23

NUTRITION STATUS OF GREENHOUSE TOMATO GROWN IN INERT MEDIA. Part II. MICROELEMENTS

Piotr Chohura, Andrzej Komosa

Abstract. The effect of inert media and fertilization levels on nutrition status of green house tomato cv. 'Maeva F_1' was investigated. Mean microelement content was: 118.5 mg Fe, 51.7 mg Zn, 269.0 mg Mn and 11.43 mg Cu kg^{-1} of dry mass of the index parts of the tomato (9–10 leaf form the top). No significant effect of rockwool, expanded clay and polyurethane foam on microelement contents was found in the index parts of the greenhouse tomato, except for zinc whose content was significantly higher in the leaves of the plants grown in rockwool and polyurethane foam than in expanded clay. Fertilization levels did not affect significantly the content of iron, manganese and copper in the index parts, except for zinc whose content lowered at higher fertilization level. High tolerance of the tomato plants to zinc and manganese content in feeding solutions was indicated. No phytotoxicity of zinc nor manganese was found at the content of 2.01 mg Zn and 1.78 mg Mn dm^{-3} of water or feeding solution.

Key words: inert media, soilless culture, fertigation, tomato

INTRODUCTION

For growing plants in inert media the microelement contents in feeding solution is a very important. Particularly significant role plays iron which is used mostly in chelate form preventing fixation and ensuring iron availability in the wide range of pH [Wressmann 1996, Komosa and Roszyk 2000, Komosa et al. 2001]. Recommendations concerning the content of this nutrient in feeding solution given by various researchers are divergent, e.g. Vogt [1993] gives 0.8 mg Fe, Adams [1994] 1.0–1.2 mg Fe and Wysocka-Owczarek [1998] 0.8–4.0 mg Fe dm^{-3} of the nutrient solution.

Manganese content, according to the majority of authors, should be 0.5–1.0 mg Mn dm^{-3}. Le-Bot et al. [1990] stated that phytotoxicity of manganese appeared after exceeding 2.75 mg Mn dm^{-3} of the nutrient solution. Recommendations by different authors concerning copper content in the feeding solution are similar. Most writers gives the concentrations within the range of 0.02–0.04 mg Cu dm^{-3} of the nutrient solution.

For boron Wysocka-Owczarek [1998] and Vogt [1993] recommend 0.3 mg B dm^{-3} of the nutrient solution while Adams indicates higher content: 0.4–0.5 mg B dm^{-3}. Zinc concentration according to Adams [1994] should be 0.4–1.0 mg Zn dm^{-3} while according to Vogt [1993] and Wysocka-Owczarek [1998] this level should be – 0.3 mg Zn dm^{-3} of the nutrient solution.

There are great differences in recommendations concerning the content of molybdenum: Vogt [1993] suggests 0.13 mg Mo, Adams [1994] 0.05–0.1 mg and Wysocka-Owczarek [1998] 0.05 mg Mo dm^{-3} of the nutrient solution.

The main aim of this work was to determine the effect of different fertilization levels and kind of inert media on the micronutrients nutrition status of greenhouse tomato cv. 'Maeva F_1'.

MATERIAL AND METHODS

The study was carried out in 1998–1999 in the greenhouse of the Agricultural Experimental Station "Piasów", Department of Horticulture, Agricultural University in Wrocław, with the greenhouse tomato cv. 'Maeva F_1' grown in rockwool, polyurethane foam (Inert) and expanded clay (granulation 4–8 mm). Two fertilization levels were used in the fertigation system – level I (standard solution) and level II: solution containing macro and microelements contents increased by 20%. The standard composition of nutrient solution (I level) and components for fertigation well water were given in the first part of this work [Chodara and Komosa 2003]. The nutrient solution composition took into account the nutrient contents in water. Detailed description of the materials and research methods is given in the first part of this work [Chohura and Komosa 2003].

RESULTS

Mean iron content in the tomato cv. 'Maeva F_1' plants was 118.5 mg Fe kg^{-1} of the index parts dry mass (9–10 leaf from the top) (tab. 1). The highest content – 161.9 mg Fe kg^{-1} – was found in the plants grown in rockwool at the first fertilization level. No significant differences between fertilization levels were found, however, higher mean iron content (120.4 mg Fe kg^{-1}) was at the first level. The media did not affect significantly iron content in the leaves. Significantly higher content was observed in 1998 than in 1999.

The highest mean zinc content – 83.5 mg Zn kg^{-1} in the index parts of 'Maeva' cultivar had the plants grown in polyurethane foam at the first fertilization level (tab. 2). In spite of the fact that no zinc was added to the feeding solutions, statistically significant differences in the content of this nutrient in the leaves was noted. Significantly higher content (58.3 mg Zn kg^{-1}) appeared in the plants at the first fertilization level. Also a significant effect of the media on zinc content appeared; significantly lower mean content – 46.0 mg Zn kg^{-1} – was found in the plants grown in expanded clay, whereas the mean values from rockwool (53.2 mg Zn kg^{-1}) and polyurethane foam (56.1 mg Zn kg^{-1}) did not differ significantly.

Table 1. The effect of fertilization levels and inert media on iron content in the index plant part of greenhouse tomato cv. 'Maeva F_1' (mg Fe kg^{-1} d.m., mean for terms)

Tabela 1. Wpływ poziomów nawożenia i podłoży inertnych na zawartość żelaza w części wskaźnikowej pomidora szklarniowego odmiany 'Maeva F_1' (mg Fe·kg^{-1} s.m., średnia z terminów)

Years Lata	Level I (B) – Poziom I (B)				Level II (B) – Poziom II (B)				
	Rockwool Wełna mineralna	Expanded clay Keramzyt	Polyurethane foam Pianka poliuretanowa	$\bar{x}$	Rockwool Wełna mineralna	Expanded clay Keramzyt	Polyurethane foam Pianka poliuretanowa	$\bar{x}$	$\bar{x}$
(A)	(C)	(C)	(C)	(A×B)	(C)	(C)	(C)	(A×B)	(A)
1998	161.9	146.5	139.3	149.2	125.8	133.4	149.6	136.2	142.7
1999	85.5	89.1	100.1	91.5	99.7	102.1	89.2	97.0	94.2
$\bar{x}$ (B×C)	123.7	117.8	119.7		112.7	117.7	119.4		
$\bar{x}$ (B)	120.4				116.6				
$\bar{x}$ (C)	Rockwool – Wełna mineralna (I + II) 118.2			Expanded clay – Keramzyt (I + II) 117.8			Polyurethane foam – Pianka poliuretanowa (I + II) 119.5		
$\bar{x}$	118.5								

Factors: A – years, B – fertilization levels, C – media.
$LSD_{\alpha=0.05}$ for A = 13.0, $LSD_{\alpha=0.05}$ for B – n.s., $LSD_{\alpha=0.05}$ for C – n.s.,
$LSD_{\alpha=0.05}$ for A×B – n.s., $LSD_{\alpha=0.05}$ for B×C – n.s., $LSD_{\alpha=0.05}$ for A×B×C – n.s.

Czynniki: A – lata, B – poziomy nawożenia, C – podłoża.
$NIR_{\alpha=0.05}$ dla A = 13,0, $NIR_{\alpha=0.05}$ dla B – n.i., $NIR_{\alpha=0.05}$ dla C – n.i.,
$NIR_{\alpha=0.05}$ dla A×B – n.i., $NIR_{\alpha=0.05}$ dla B×C – n.i., $NIR_{\alpha=0.05}$ dla A×B×C – n.i.

Table 2. The effect of fertilization levels and inert media on zinc content in the index plant part of greenhouse tomato cv. 'Maeva F_1' (mg Zn kg^{-1} d.m., mean for terms)

Tabela 2. Wpływ poziomów nawożenia i podłoży inertnych na zawartość cynku w części wskaźnikowej pomidora szklarniowego odmiany 'Maeva F_1' (mg Zn·kg^{-1} s.m., średnia z terminów)

Years Lata	Level I (B) – Poziom I (B)				Level II (B) – Poziom II (B)				
	Rockwool Wełna mineralna	Expanded clay Keramzyt	Polyurethane foam Pianka poliuretanowa	$\overline{x}$	Rockwool Wełna mineralna	Expanded clay Keramzyt	Polyurethane foam Pianka poliuretanowa	$\overline{x}$	$\overline{x}$
(A)	(C)	(C)	(C)	(A×B)	(C)	(C)	(C)	(A×B)	(A)
1998	75.8	62.3	83.5	73.8	59.2	53.9	65.8	59.6	66.7
1999	44.0	37.3	46.9	42.6	33.8	30.7	28.2	30.9	36.7
$\overline{x}$ (B×C)	59.9	49.8	65.2		46.5	42.3	47.0		
$\overline{x}$ (B)	58.3				45.3				
$\overline{x}$ (C)	Rockwool – Wełna mineralna (I + II) 53.2			Expanded clay – Keramzyt (I + II) 46.0			Polyurethane foam – Pianka poliuretanowa (I + II) 56.1		
$\overline{x}$	51.7								

Factors: A – years, B – fertilization levels, C – media.
$LSD_{\alpha=0.05}$ for A = 5.7, $LSD_{\alpha=0.05}$ for B = 5.7, $LSD_{\alpha=0.05}$ for C = 7.0,
$LSD_{\alpha=0.05}$ for A×B – n.s., $LSD_{\alpha=0.05}$ for B×C – n.s., $LSD_{\alpha=0.05}$ for A×B×C – n.s.

Czynniki: A – lata, B – poziomy nawożenia, C – podłoża,
$NIR_{\alpha=0.05}$ dla A = 5,7, $NIR_{\alpha=0.05}$ dla B = 5,7, $NIR_{\alpha=0.05}$ dla C = 7,0,
$NIR_{\alpha=0.05}$ dla A×B – n.i., $NIR_{\alpha=0.05}$ dla B×C – n.i., $NIR_{\alpha=0.05}$ dla A×B×C – n.i.

Table 3. The effect of fertilization levels and inert media on manganese content in the index plant part of greenhouse tomato cv. 'Maeva F_1' (mg Mn kg^{-1} d.m., mean for terms)

Tabela 3. Wpływ poziomów nawożenia i podłoży inertnych na zawartość manganu w części wskaźnikowej pomidora szklarniowego odmiany 'Maeva F_1' (mg Mn·kg^{-1} s.m., średnia z terminów)

Years Lata	Level I (B) – Poziom I (B)				Level II (B) – Poziom II (B)				
	Rockwool Wełna mineralna	Expanded clay Keramzyt	Polyurethane foam Pianka poliuretanowa	$\bar{x}$	Rockwool Wełna mineralna	Expanded clay Keramzyt	Polyurethane foam Pianka poliuretanowa	$\bar{x}$	$\bar{x}$
(A)	(C)	(C)	(C)	(A×B)	(C)	(C)	(C)	(A×B)	(A)
1998	255.5	254.9	296.6	269.0	273.3	270.8	290.5	278.2	273.6
1999	252.0	263.3	274.9	263.4	264.4	269.1	263.5	265.6	264.5
$\bar{x}$ (B×C)	253.7	259.1	285.7		268.8	269.9	277.0		
$\bar{x}$ (B)	266.2				271.9				
$\bar{x}$ (C)	Rockwool – Wełna mineralna (I + II) 261.2			Expanded clay – Keramzyt (I + II) 264.5			Polyurethane foam – Pianka poliuretanowa (I + II) 281.3		
$\bar{x}$	269.0								

Factors: A – years, B – fertilization levels, C – media.
$LSD_{\alpha=0.05}$ for A – n.s., $LSD_{\alpha=0.05}$ for B – n.s., $LSD_{\alpha=0.05}$ for C – n.s.,
$LSD_{\alpha=0.05}$ for A×B – n.s., $LSD_{\alpha=0.05}$ for B×C – n.s., $LSD_{\alpha=0.05}$ for A×B×C – n.s.

Czynniki: A – lata, B – poziomy nawożenia, C – podłoża.
$NIR_{\alpha=0.05}$ dla A – n.i., $NIR_{\alpha=0.05}$ dla B – n.i., $NIR_{\alpha=0.05}$ dla C – n.i.,
$NIR_{\alpha=0.05}$ dla A×B – n.i., $NIR_{\alpha=0.05}$ dla B×C – n.i., $NIR_{\alpha=0.05}$ dla A×B×C – n.i.

Table 4. The effect of fertilization levels and inert media on copper content in the index plant part of greenhouse tomato cv. 'Maeva F_1' (mg Cu kg^{-1} d.m., mean for terms)

Tabela 4. Wpływ poziomów nawożenia i podłoży inertnych na zawartość miedzi w części wskaźnikowej pomidora szklarniowego odmiany 'Maeva F_1' (mg Cu·kg^{-1} s.m., średnia z terminów)

Years Lata	Level I (B) – Poziom I (B)				Level II (B) – Poziom II (B)				
	Rockwool Wełna mineralna	Expanded clay Keramzyt	Polyurethane foam Pianka poliuretanowa	$\bar{x}$	Rockwool Wełna mineralna	Expanded clay Keramzyt	Polyurethane foam Pianka poliuretanowa	$\bar{x}$	$\bar{x}$
(A)	(C)	(C)	(C)	(A×B)	(C)	(C)	(C)	(A×B)	(A)
1998	13.22	13.15	13.77	13.38	13.84	12.97	12.66	13.16	13.27
1999	10.23	8.87	10.31	9.82	10.63	8.90	8.59	9.37	9.60
$\bar{x}$ (B×C)	11.72	11.01	12.04		12.23	10.93	10.62		
$\bar{x}$ (B)	11.59				11.26				
$\bar{x}$ (C)	Rockwool – Wełna mineralna (I + II) 11.97			Expanded clay – Keramzyt (I + II) 10.97			Polyurethane foam – Pianka poliuretanowa (I + II) 11.33		
$\bar{x}$	11.43								

Factors: A – years, B – fertilization levels, C – media.
$LSD_{\alpha = 0.05}$ for A = 0.88, $LSD_{\alpha = 0.05}$ for C = 1.15, $LSD_{\alpha = 0.05}$ for B – n.s.,
$LSD_{\alpha = 0.05}$ for A×B – n.s., $LSD_{\alpha = 0.05}$ for B×C – n.s., $LSD_{\alpha = 0.05}$ for A×B×C – n.s.

Czynniki: A – lata, B – poziomy nawożenia, C – podłoża.
$NIR_{\alpha = 0.05}$ dla A = 0,93, $NIR_{\alpha = 0.05}$ dla B – n.i., $NIR_{\alpha = 0.05}$ dla C = 1,15,
$NIR_{\alpha = 0.05}$ dla A×B – n.i., $NIR_{\alpha = 0.05}$ dla B×C – n.i., $NIR_{\alpha = 0.05}$ dla A×B×C – n.i.

High content of manganese in feeding solutions – as a result of its high content in water – was reflected in the high content of this nutrient in the index plant parts. Mean manganese content in the index parts of the tomato cv. 'Maeva' was 269.0 mg Mn kg^{-1}, the highest content – 296.6 mg Mn kg^{-1} was in the plants grown in polyurethane foam at the first fertilization level (tab. 3). The media did not affect significantly manganese content in the leaves. The highest mean content was indicated in the leaves of the plants grown in polyurethane foam – 281.3 ppm Mn kg^{-1}. Fertilization levels and years of cultivation also did not affect significantly manganese nutrition of the plants.

The highest copper content – 13.84 mg Cu kg^{-1} – was in the index parts of the tomato cv. 'Maeva' plants grown in rockwool at the second fertilization level (tab. 4). Fertilization levels and root media did not affect the copper leaves content significantly. Mean copper content was the highest in the plants grown in rockwool – 11.97 mg Cu, lower in polyurethane foam and expanded clay – 11.33 and 10.97 mg Cu kg^{-1}, respectively. In 1998 the plants contained significantly more copper – 13.27 mg Cu, than in 1999 – 9.60 mg Cu kg^{-1} dry mass of the index plant parts.

DISCUSSION

According to Atherton and Rudish [1986] recommended iron content should be over 60.0 mg Fe·kg^{-1} of leaves dry mass. Authors' own investigations indicated considerably higher content: on average 118.5 mg Fe kg^{-1} in dry mass of the index parts. Even higher content: 127.8–161.1 mg Fe kg^{-1} were noted by Komosa et al. [2001].

In spite of the fact that in the feeding solutions zinc content was not differentiated due to its high content in the water amounting to 2.01 mg Zn dm^{-3}, significant differences in nutrition status for this microelement were noted. Significantly higher zinc content was in the plants grown at the first fertilization level (58.3 mg Zn kg^{-1}) than at the second one (45.3 mg Zn kg^{-1}). Mean zinc content was 51.7 mg Zn kg^{-1} of the index parts dry mass and was within the range of 25.0–250.0 mg Zn kg^{-1} leaves dry mass given by Atherton and Rudish [1986].

Also manganese was not added to the solutions due to its high content in the water – 1.78 mg Mn dm^{-3}. However, no differences in its content in the index parts were found. Mean content – 269.0 mg Mn kg^{-1} – was similar to given by Bergman [1992] and was included in the range recommended by Atherton and Rudish [1986] which was 25.0–1000.0 mg Mn kg^{-1}. Despite high content of manganese in the nutrient solutions no symptoms of its phytotoxicity on the leaves were noted. These symptoms were observed by Le Bot et al. [1990]. These authors indicate the Mg:Mn ratio stating that magnesium may limit toxic activity of manganese.

Mean copper content – 11.43 mg Cu kg^{-1} dry mass of the index parts – was in the range given by Atherton and Rudish [1986]. This authors recommended levels more than 4.00 mg Cu kg^{-1} dry mass of leaves. However, there is no data concerning the upper acceptable copper content in the leaves.

CONCLUSIONS

1. No significant effect of the studied root media – rockwool, expanded clay and polyurethane foam – on iron, manganese and copper contents in the index parts (9–10 leaf from the top) of greenhouse tomato cv. 'Maeva F_1' was found. Only zinc content was significantly higher in the plants grown in rockwool and polyurethane foam than in expanded clay.

2. Fertilization levels did not affect significantly iron, manganese and copper content in the index parts of the greenhouse tomato. However, they caused significant differentiation in zinc content which lowered at higher fertilization level.

3. Mean content of the studied microelements in greenhouse tomato cv. 'Maeva F_1' was: 118.5 mg Fe, 51.7 mg Zn, 269.0 mg Mn and 11.43 mg Cu mg kg^{-1} of dry mass of the index plant parts (9–10 leaf from the top).

4. High tolerance of tomato cv. 'Maeva F_1' to zinc and manganese contents in water or feeding solution was indicated. No phytotoxicity of zinc and manganese was found at the content 2.01 mg Zn and 1.78 mg Mn dm^{-3} of water or nutrient solution.

REFERENCES

Adams P., 1994. Nutrition of greenhouse vegetables in NFT and hydroponics systems. Acta Hort. 361, 245–257.

Atherton J. G., Rudisch J., 1986. The tomato crop. Chapman and Hall. London, New York, 281–334.

Bergman W., 1992. Nutritional Disorders of Plants. Gustav Fischer New York, 132–150, 247–265.

Chohura P., Komosa A., 2003. Nutrition status of greenhouse tomato grown in inert media. Part I. Macroelements. Acta Sci. Pol., Hortorum Cultus 2(2), 3–13.

Komosa A., Kołota E., Chohura P., 2001. Usefulness of iron chelates for fertilization of greenhouse tomato cultivated in rockwool. Veg. Crops Res. Bull., Res. Inst. Veg. Crops – Skierniewice, 55, 35–39.

Komosa A., Roszyk J., 2000. Dostępność żelaza z chelatów żelazowych w pożywkach stosowanych do fertygacji. Mat. Konf. „Efektywność stosowania nawozów w uprawach ogrodniczych – Zmiany ilościowe i jakościowe w warunkach stresu". SGGW Warszawa 20-21.06.2000, 106–109.

Le Bot J., Kirkby E. A., Van-Beusichem M. l., 1990. Manganese toxicity in tomato plants: effects on cation uptake and distribution. J. Plant Nut. 13, 5, 513–525.

Vogt W., 1993. Nutrient uptake of year round tomato crops. Acta Hort. 339, 99–112.

Wreesmann C., 1996. Chelated micronutrients for soilless culture. ISOSC Proc. of the 9th Int. Cong. on Soilless Culture. St Helier, Jersey 12–19 April 1996, 559–572.

Wysocka-Owczarek M., 1998. Pomidory pod osłonami. Uprawa tradycyjna i nowoczesna. Hortpress Sp. z o.o. Warszawa, 166–187.

STAN ODŻYWIENIA POMIDORA SZKLARNIOWEGO UPRAWIANEGO W PODŁOŻACH INERTNYCH. CZ. II. MIKROELEMENTY

Streszczenie. Badano wpływ podłoży inertnych oraz poziomów nawożenia na stan odżywienia pomidora szklarniowego. W częściach wskaźnikowych pomidora szklarniowego odmiany 'Maeva F_1' (9–10 liść od wierzchołka) średnia zawartość mikroelementów wynosiła: Fe – 118,5, Zn – 51,7, Mn – 269,0, Cu – 11,43 mg kg^{-1} s.m. części wskaźnikowych. Nie stwierdzono istotnego wpływu wełny mineralnej, keramzytu oraz pianki poliuretanowej na zawartość mikroelementów w częściach wskaźnikowych pomidora szklarniowego z wyjątkiem cynku, którego zawartość była istotnie niższa w liściach roślin uprawianych w keramzycie. Poziomy nawożenia również nie wpływały istotnie na zawartość mikroskładników w częściach wskaźnikowych z wyjątkiem cynku. Wykazano wysoką tolerancję pomidora na zawartość cynku i manganu w pożywkach. Nie stwierdzono fitotoksyczności cynku przy zawartości 2,01 mg $Zn \cdot dm^{-3}$ i 1,78 mg $Mn \cdot dm^{-3}$ wody lub pożywki.

Słowa kluczowe: podłoża inertne, uprawy bezglebowe, fertygacja, pomidor

Piotr Chohura, Andrzej Komosa, Katedra Ogrodnictwa, Akademia Rolnicza we Wrocławiu, ul. Rozbrat 7, 50-334 Wrocław, e-mail: chohura@ozi.ar.wroc.pl