THE EFFECT OF DIFFERENT SOURCE OF IRON ON NUTRITIONAL VALUE OF GREENHOUSE TOMATO FRUIT GROWN IN PEAT SUBSTRATE

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Received: August 21, 2007; Accepted: October 10, 2007

Summary

The aim of the investigations conducted in 2005-2006 was to estimate the effect of different kind of iron chelates: Fe 8 Forte (EDTA), Top 13 (EDTA+DTPA) and Librel Fe DP7 (DTPA) and iron concentration 50, 75 and 100 mg Fe·dm⁻³ in growing medium on the yield and fruit quality of greenhouse tomato cv. 'Merkury F₁'. Tomato plants were grown in peat substrate produced by Hartmann, which characterized natural low iron content. The experiment was set up in two factorial design in three replications. One plot covered 6 plants grown in spacing 0.6x0.5 m, plant population was 3.0 per 1 m². The best yield of greenhouse tomato cv. 'Merkury F₁' was recorded when Fe 8 Forte in 75 mg Fe·dm⁻³ while Fe 13 Top and Librel Fe DP7 in concentration of 100 mg Fe·dm⁻³ were used. There was not recorded any strongly effect of tested fertilizers and iron concentration in substrate on the nutritional value of fruits.

key words: greenhouse tomato, iron, chelates, yield, fruit nutritional value

INTRODUCTION

Iron is one of the essential nutrients for growth and development of plants which influences the crop yield and its quality. The visible symptom of iron deficiency is the youngest leaf chlorosis due to the reduction of the chlorophyll content in leaves. Deficiency symptoms observed in plants in most cases does not mean a deficiency of this element in the growing medium but rather disability of the plant to take it up. In horticultural practice it often happens problem with correct iron feeding because of its easy transfer into less available form for plants (Bergmann 1992). The main chemical factors determining the level of soluble iron content in the soil solution are: oxidation-reduction reactions and the pH. Iron's ions Fe⁺² in anaerobic conditions quickly change their valence for Fe⁺³ and in this way become more difficult available for plants roots. Moreover,

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lower iron availability may be caused by high concentration of phosphates and carbonates in growing medium. Principle meaning in iron protection against retrogradation is its using in chelate forms, which characterizes good solubility in water and low constant dissociation (Wreesmann 1996).

From such fertilizers Fe cations are gradually released to soil solution or can be absorbed as organic-mineral complex. Durability and availability of iron from chelats considerably depend on ligand properties (Komosa *et al.* 2005).

The aim of the present investigation was the evaluation of suitability of three iron chelates and different iron concentration in the medium for greenhouse tomato grown in peat substrate, taking into account the yield, and nutritional value of fruit.

MATERIAL AND METHODS

Greenhouse experiments were conducted in 2005 and 2006 at the Piastów Horticultural Experimental Station. First experimental factor covered three iron chelates: Fe 8 Forte (EDTA), Fe 13 Top (EDTA+DTPA) i Librel Fe DP7 (DTPA) and the second one was the content of iron in peat substrate: 50, 75 and 100 mg Fe·dm⁻³.

Seeds of cv. Merkury F₁ were sown on 18 February 2005 and 3 March 2006. Seedlings were planted in the first decade of April, at the beginning of the first truss blossoming in benches filled with peat substrate supplied by Hartmann, which characterized natural low iron content.

pH of peat was raised up to the level 6.0 by using calcium carbonate in the amounts calculated on the base on neutralization curve for tomato optimum (Breś *et al.* 2003). The content of macro- and microelements were raised up to standard level for tomato [in mg·dm⁻³]: N - 220, P - 180, K - 350, Ca - 1500, Mg - 200, Mn - 20, Zn - 20, Cu - 5.0, B - 1.5, Mo - 1.5 (Komosa 2005). In third decade of June plants were supplementary fertilized by addition 5 g N and 10 g K for 1m² of the cultivated area. The experiment was set up in two factorial design in three replications. One plot covered 6 plants grown in spacing 0.6 x 0.5 m, which assured the population of 3.0 plants per 1 m². The volume of peat was 50 dm³ per plant.

Plants were trained to a single stem, and grown for 5 trusses. During the growing period lower leaves located below fruiting truss were removed, and the number of flowers per one truss was reduced to 5-6. *Bombus terrestris* for plant pollination was used. At harvest conducted usually twice a week, the fruit were weighed and sorted out into following grades: IA > 6.5 cm, IB 4.5-6.0 cm, II 3.5-4.5 cm. All this fruits represented marketable yield of tomatoes.

Nutritional value of fruits was assessed on the basis of a dry matter (method of drying to the constant weight at 105°C), vitamin C (Tillman's method), reducing and total sugars content (Lane-Eynon method), P and Mg (calorimetrically), K and Ca (photometric method).

The obtained results of the study were subjected to statistical analysis elaboration involving variance analyses and confidence intervals according to Tukey test for significant level at $P=0.05$.

RESULTS AND DISCUSSION

The best yielding of tomato plants was obtained in treatment Fe 8 Forte use as a source of iron fertilization. Mean total yield of fruit harvested from plants supplied by Fe 8 Forte equal to $13.15 \text{ kg}\cdot\text{m}^{-2}$, was significantly higher in comparison to the other tested fertilizers (Table 1). Plants fertilized by Fe 13 Top and Librel Fe DP7 yielded on the same level, and the differences were not statistically proved. Similar effect was observed by Komosa *et al.* (2002) in the study with tomato grown in rockwool and fed with different iron chelates.

Table 1. The effect of the kind of chelates and iron concentration on yielding of greenhouse tomato cv. 'Merkury F₁' grown in peat substrate (mean for 2005-2006)

Kind of fertilizer	Fe level in $\text{mg}\cdot\text{dm}^{-3}$ of peat substrate			Mean
	50	75	100	
Total yield ($\text{kg}\cdot\text{m}^{-2}$)				
Fe 13 Top	12.03	12.00	12.96	12.33
Fe 8 Forte	12.80	13.42	13.22	13.15
Librel Fe DP7	11.51	12.43	13.61	12.52
Mean	12.11	12.62	13.27	
LSD _{P=0.05} for:				
kind of fertilizer - 0.54, Fe dose - 0.51, interaction - 0.58				
Marketable yield ($\text{kg}\cdot\text{m}^{-2}$)				
				Mean
Fe 13 Top	11.50	11.57	12.43	11.83
Fe 8 Forte	12.22	12.96	12.79	12.66
Librel Fe DP7	11.18	11.94	12.07	11.73
Mean	11.64	12.16	12.43	
LSD _{P=0.05} for:				
kind of fertilizer - 0.49, Fe dose - 0.46, interaction - 0.63				

Data of the study proved that increasing Fe content from 50 to 75 and 100 $\text{mg Fe}\cdot\text{dm}^{-3}$ in growing medium affected significant increment of total yield of tomato fruits from 12.11 to 12.62 and $13.27 \text{ kg}\cdot\text{m}^{-2}$, respectively. Similar effect for comparable growing period was reported by Osińska & Kołota (1995). Statistical analyses showed a significant interaction between tested factors (Table 1). The highest total tomato yields were harvested in the case when Fe 13 Top and Librel Fe DP7 were used in concentration $100 \text{ mg Fe}\cdot\text{dm}^{-3}$ while in treatment with Fe 8 Forte the maximum yield of fruits was achieved at the level of $75 \text{ mg Fe}\cdot\text{dm}^{-3}$.

Similar to the total yield the highest marketable tomato yield fruits – $12.66 \text{ kg}\cdot\text{m}^{-2}$ was picked up from plants fertilized by Fe 8 Forte. Differences between marketable yields from plants supplied by Fe 13 Top and Librel Fe DP7 were not statistically proved. Increasing of Fe content from 50 to $75 \text{ mg Fe}\cdot\text{dm}^{-3}$ in

growing medium affected significant increment of tomato mean marketable yield from 11.64 do 12.16 kg·m⁻², respectively. Further enrichment of growing medium in Fe to 100 Fe·dm⁻³ caused only a slight marketable yield increment.

The highest marketable tomato yields was achieved when Fe 13 Top and Librel Fe DP7 Fe were used in concentration of 100 mg Fe·dm⁻³ in growing medium. In treatment where Fe 8 Forte was used as a source of Fe, maximum marketable yield was obtained by application of 75 mg Fe·dm⁻³. In the case of Fe 8 Forte and Librel Fe DP7 Fe differences between marketable yields received at the levels 75 and 100 mg Fe·dm⁻³ were not significant.

Vitamin C content in fruits decreased from 20.19 do 17.50 mg·100g f.m.⁻¹ along with Fe concentration increase in growing medium (Table 2). Tomato fruits from plants supplied by Fe 13 Top accumulated higher amounts of this vitamin than by the other chelates. These data were similar to those reported by Chohura & Kołota (2007). Lower content of vitamin C in cv. 'Merkury F' fruits was reported by Biesiada & Kołota 2007.

The content of dry matter in fruits was not significantly differentiated among experimental treatment and ranged from 5.21% to 6.19 (Table 2). Lower content of dry matter in 'Merkury F' cv. fruits was reported by Biesiada & Kołota 2007.

Table 2. The effect of the kind of chelates and iron concentration on vitamin C and dry matter content in fruit of greenhouse tomato cv. 'Merkury F₁' (mean for 2005-2006)

Kind of fertilizer	Fe level in mg·dm ⁻³ of peat substrate			Mean
	50	75	100	
	Dry matter (%)			
Fe 13 Top	6.19	5.21	5.97	5.79
Fe 8 Forte	5.39	5.55	5.57	5.50
Librel Fe DP7	5.54	5.95	5.35	5.61
Mean	5.71	5.57	5.63	
Vitamin C (mg·100g f.m. ⁻¹)				
Fe 13 Top	22.29	18.14	18.72	19.72
Fe 8 Forte	19.95	19.26	17.03	18.75
Librel Fe DP7	18.33	18.72	16.76	17.94
Mean	20.19	18.71	17.50	

There were observed only small differences in the total and reducing sugars concentration in fruits depending on used fertilizers (Table 3). Biesiada & Kołota 2007 reported higher content of sugars in fruits cv. 'Merkury F' while Chohura & Kołota (2007) obtained similar results.

Table 3. The effect of the kind of chelates and iron concentration on total and reducing sugars content in fruit of greenhouse tomato cv. 'Merkury F₁' (mean for 2005-2006)

Kind of fertilizer	Fe level in mg·dm ⁻³ of peat substrate			Mean
	50	75	100	
	Total sugars (g·100g f.m. ⁻¹)			
Fe 13 Top	2.90	2.75	2.89	2.85
Fe 8 Forte	2.88	2.65	2.80	2.78
Librel Fe DP7	2.80	2.75	2.90	2.82
Mean	2.86	2.72	2.86	
Reducing sugars (g·100g f.m. ⁻¹)				
Fe 13 Top	2.42	2.53	2.40	2.45
Fe 8 Forte	2.60	2.40	2.58	2.53
Librel Fe DP7	2.50	2.45	2.75	2.57
Mean	2.51	2.46	2.58	

Generally there were observed no differences in phosphorus, calcium and magnesium content in fruits depending on tested factors (Table 4 & 5). The highest mean concentration of potassium in fruits was recorded when Librel Fe DP7 was used and by iron level 50 mg Fe·dm⁻³.

Table 4. The effect of the kind of chelates and iron concentration on phosphorus and potassium content in fruit of greenhouse tomato cv. 'Merkury F₁' (mean for 2005-2006)

Kind of fertilizer	Fe level in mg·dm ⁻³ of peat substrate			Mean
	50	75	100	
	Phosphorus (mg P·100g f.m. ⁻¹)			
Fe 13 Top	30.39	24.22	22.99	25.87
Fe 8 Forte	24.23	26.99	23.33	24.85
Librel Fe DP7	24.01	24.52	28.00	25.51
Mean	26.21	25.24	24.77	
	Potassium (mg K·100g f.m. ⁻¹)			
Fe 13 Top	280.16	263.89	251.26	265.10
Fe 8 Forte	246.95	238.81	267.86	251.20
Librel Fe DP7	282.11	258.06	276.48	272.22
Mean	269.74	253.59	265.20	

Table 5. The effect of the kind of chelates and iron concentration on calcium and magnesium content in fruit of greenhouse tomato cv. 'Merkury F₁' (mean for 2005-2006)

Kind of fertilizer	Fe level in mg·dm ⁻³ of peat substrate			Mean
	50	75	100	
	Calcium (mg Ca·100g f.m. ⁻¹)			
Fe 13 Top	16.15	12.50	16.02	14.89
Fe 8 Forte	13.07	13.73	13.10	13.30
Librel Fe DP7	13.51	14.19	13.39	13.70
Mean	14.24	13.47	14.17	
	Magnesium (mg Mg·100g f.m. ⁻¹)			
Fe 13 Top	22.74	20.28	19.79	20.94
Fe 8 Forte	18.59	18.81	19.94	19.11
Librel Fe DP7	20.11	19.03	20.08	19.74
Mean	20.48	19.37	19.94	

CONCLUSIONS

1. Chelate Fe 8 Forte appeared to be a better source of iron for tomato plants grown in peat substrate than Fe 13 Top or commonly used for this purposes Librel Fe DP7.
2. The maximum yield of fruits was produced at the level of 75 mg Fe·dm⁻³ in treatment with Fe 8 Forte application or 100 mg Fe·dm⁻³ if the other source of this nutrient was used.
3. The quality of fruits expressed by the content of dry matter, sugars, vitamin C and macroelements was not influenced by the source and level of Fe applied to the growing medium.

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WPLYW ZRÓŻNICOWANEGO NAWOŻENIA ŻELAZEM
NA WARTOŚĆ ODŻYWCZĄ OWOCÓW POMIDORA SZKLARNIOWEGO
UPRAWIANEGO W SUBSTRACIE TORFOWYM

Streszczenie

W doświadczeniach szklarniowych przeprowadzonych w latach 2005-2006 badano wpływ kilku chelatów żelazowych: Fe 8 Forte (EDTA), Top 13 (EDTA+DTPA) i Librel Fe DP7 (DTPA) na plonowanie i jakość owoców pomidora szklarniowego odmiany 'Merkury F₁'. Drugi czynnik badawczy obejmował zróżnicowane nawożenie żelazem, zastosowano trzy poziomy jego koncentracji w podłożu tj.: 50, 75 i 100 mg Fe·dm⁻³. Rośliny uprawiano w substracie torfowym przygotowanym z torfu firmy Hartmann charakteryzującym się niską naturalną zawartością żelaza. Uprawę prowadzono na stołach w cyklu wiosennym na 5 gron. Rozsadę posadzono w rozstawie 0,6x0,5m w zagęszczeniu 3 szt·m⁻². Najlepsze plonowanie pomidora odmiany 'Merkury F₁' uzyskano po zastosowaniu Fe 8 Forte w dawce 75 mg Fe·dm⁻³ oraz Fe 13 Top i Librel Fe DP7 w stężeniu 100 mg Fe·dm⁻³. Nie stwierdzono istotnego wpływu badanych chelatów i dawek żelaza na oceniane cechy jakościowe owoców pomidora, które kształtowały się na typowym poziomie.