ACTA Acta Sci. Pol., Hortorum Cultus 11(5) 2012, 43-53

# THE EFFECT OF CHLORIDE ON NUTRIENT CONTENTS IN FRUITS OF GREENHOUSE TOMATO (*Lycopersicon esculentum* Mill.) GROWN IN ROCKWOOL

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**Abstract**. Chlorine plays important role in physiological and biochemical processes in plants. It effects significantly on biological value of yield. In Experiment I (2004–2005) the levels of 15, 30, 60, and 90 mg Cl·dm$^{-3}$ but in Experiment II (2006) the levels of 30, 60, 90 and 120 mg Cl·dm$^{-3}$ in the nutrient solutions on the nutrient contents and some chemical parameters of fruits of greenhouse tomato cv. 'Grace' grown in rockwool were studied. It was found, that increased chloride contents in the nutrient solutions increased the content of chlorine in the fruits. Increasing contents of chloride in the nutrient solution at the range of 90 to 120 mg Cl·dm$^{-3}$ decreased the nitrogen and increased potassium contents in fruits. Contents of chloride in the nutrient solutions above 90 mg Cl·dm$^{-3}$ enhanced the content of α-ascorbic acid and decreased the content of reducing sugars in fruits. There were no effects on the content of nitrate and nitrite contents as well as the acidity and β-carotene in fruits. The tendency of lowering the dry matter of fruits above the level of 90 mg Cl·dm$^{-3}$ in the nutrient solutions was appered. It was not found the effect of increased chloride levels in the nutrient solutions on P, Ca, Mg, S, Na, Fe, Mn, Zn, Cu and B contents in the fruits of tomato.

**Key words**: chlorine, nutrient solution, fertigation, plant nutrition, biological value

## INTRODUCTION

Chlorine as the microelement is involved in many physiological and biochemical functions in plants. Its essentiality for plants was discovered in 1949 by Arnon and Whatley and confirmed by Broyer et al. [1954]. Chlorine plays specific role in photosynthesis. It is a cofactor for the activation of oxygen-evolving enzymes (Hill reaction) with photosystem II. It is also needed for the synthesis of proteins and growth regulators. Chlorine effects on the water uptake and vacular osmoticum [Mengel and Kirkby 2001].

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Many authors reported high tolerance of tomato grown in rockwool on chloride. Nurzyński and Michałojć [1998] found that 12.7 mmol $Cl\cdot dm^{-3}$ (450 mg $Cl\cdot dm^{-3}$) in the nutrient solution did not affect the quantity and quality of tomato yield. Nukaya and Hashimoto [2000] concluded that 7,5 mmol $Cl\cdot dm^{-3}$ (265,9 mg $Cl\cdot dm^{-3}$) in the root environment did not reduce yield of tomato grown in rockwool with the recirculating nutrient solution. Voogt and Sonneveld [2004], pointed out, that decreasing nitrate contents to 3–4 mmol $NO_3\cdot dm^{-3}$ (42–56 mg $N\cdot dm^{-3}$) with chloride increased to 17–18 mmol $Cl\cdot dm^{-3}$ (602,6–638,1 mg $Cl\cdot dm^{-3}$) in nutrient solution did not effect on yield.

On the other hand, there are reports documenting the toxic effect of the only moderate chloride content in the root environment of tomato. Satti and Al-Yahyai [1995] and Caines and Shennan [1999] indicated that toxicity of chloride in nutrient solutions depended on accompanying ions, such as $Na^+$, $K^+$ $Cl^-$ and $H_2PO_4^-$).

Nukaya et al. [1991] showed that increasing content of $SO_4$ and Cl decreased the incidence of blossom-end rot (BER). Higher concentrations of Cl reduced injury of gold speck on tomato fruits. Voogt and Sonneveld [2004] reported that an increase of $Cl:NO_3$ ratio in the nutrient solution decreased blossom-end rot (BER) and shelf life, but increased gold speck in tomato fruits grown in rockwool.

The main aim of the study was to investigate the effects of increased levels of chloride in the nutrient solutions on nutrient contents in fruits and some chemical parameters of yield quality.

## MATERIALS AND METHODS

Study was carried out in 2004–2006 with greenhouse tomato (*Lycopersicon esculentum* Mill.) cv. 'Grace $F_1$' grown in rockwool slabs using a drip fertigation system. In the standard nutrient solution, the following chloride levels were maintained ($dm^{-3}$): 15, 30, 60, 90 mg $Cl\cdot dm^{-3}$ (Experiment I, 2004–2005) and 30, 60, 90, 120 mg $Cl\cdot dm^{-3}$ (Experiment II, 2006) (marked as: Cl-15 to Cl-120), (tab. 1).The sources of chloride were water containing average 9.6 mg $Cl\cdot dm^{-3}$ and $CaCl_2\cdot 2H_2O$ including 9.6% Ca and 16.8% Cl. The content of the rest macro and microelements in all treatments were the same. The experiments were replicated five times. Each replication consisted of 24 plants (8 rockwool slabs with 3 plants per slab). A total of 480 plants were used (4 treatments × 24 plants × 5 replications).

The nutrient solutions were prepared from 100-fold concentrated stock solutions consisting of: $HNO_3$ (65%) (1/2 of rate), $CaCl_2\cdot 2H_2O$ (9.6% Ca, 16.8% Cl), $CaNO_3$ (18.5% Ca, 15.5% N), $KNO_3$ (38.2% K, 13.0% N), Librel FeDP-7 (7.0% Fe) (tank A) and $HNO_3$ (65%) (1/2 of rate), $KH_2PO_4$ (28.2% K, 22.3% P), $K_2SO_4$ (44.8% K, 17.0% S), $MgSO_4\cdot 7H_2O$ (9.9% Mg, 13.0% S), $MnSO_4\cdot H_2O$ (32.3% Mn), $Na_2B_4O_7\cdot 10\ H_2O$ (11.3% B), $CuSO_4\cdot 5H_2O$ (25.6% Cu), $Na_2MoO_4\cdot 2H_2O$ (54.3% Mo) (tank B).

The stock solutions were diluted using a proportional Dosatron diluter (Clearwater FL, USA). After dilution the nutrient solutions contained standard nutrient levels with pH 5.50 and EC 3.1–3.3 $mS\cdot cm^{-1}$ (solutions no 3, tab 1). The nutrient solutions were transmitted by pipes and applied to the root medium by drippers. Excess nutrient solutions (drainage waters) of 25–30% were collected in an additional tank and used for the nutrition of other plants.

The nutrient solutions were applied 15 times daily at a rate of 50–230 $cm^3 \cdot plant^{-1}$ (750–3450 $cm^3 \cdot plant^{-1} \cdot day^{-1}$) in dependence of the plant development stage. During flowering of the 1–3-rd cluster the nutrient solution were applied at 750–1300 $cm^3$; 3–6-th cluster 1300–1800 $cm^3$; and above the 6-th cluster 1800–3450 $cm^3 \cdot plant^{-1} \cdot day^{-1}$. The first fertigation rate was applied 2 hours after sunrise and the last one 2 hours before sunset. Fertigation frequency was controlled by a Sterling 12 time programmer (Superior Controls Co., Inc., Valencia, CA, USA).

Table 1. Average nutrients and sodium contents in water and in the nutrient solutions (2004–2006)
Tabela 1. Średnie zawartości składników pokarmowych i sodu w wodzie oraz pożywkach (2004–2006)

| Nutrient or other parameter<br>Składnik pokarmowy lub inny parametr | Well water<br>Woda studzienna | Nutrient solutions – Pożywka | | |
|---|---|---|---|---|
| | | No 1<br>sowing<br>wysiew | No 2<br>pricking<br>pikowanie | No 3<br>main cultivation<br>uprawa zasadnicza |
| | | $mg \cdot dm^{-3}$ | | |
| $N\text{-}NH_4$ | trace – śladowo | <14 | <14 | 5.0 |
| $N\text{-}NO_3$ | 0.6 | 180.0 | 220.0 | 220.0 |
| $P\text{-}PO_4$ | 1.0 | 30.0 | 45.0 | 50.0 |
| K | 3.0 | 200.0 | 230.0 | 380.0 |
| Ca | 91.0 | 150.0 | 190.0 | 170.0 |
| Mg | 30.0 | 40.0 | 80.0 | 100.0 |
| $S\text{-}SO_4$ | 65.3 | 111.0 | 123.0 | 170.0 |
| Na | 73.3 | 92.0 | 92.0 | 92.0 |
| Cl | 9.6 | 10.7 | 10.7 | 15*, 30, 60, 90, 120 |
| Fe | 0.127 | 1.60 | 1.80 | 1.80 |
| Mn | 0.027 | 0.80 | 0.90 | 0.80 |
| Zn | 0.700 | 0.70 | 0.70 | 0.70 |
| B | 0.029 | 0.35 | 0.35 | 0.35 |
| Cu | 0.020 | 0.05 | 0.05 | 0.05 |
| Mo | trace – śladowo | 0.05 | 0.05 | 0.05 |
| $HCO_3$ | 502.6 | 42.2 | 42.2 | 42.2 |
| pH | 7.17 | 5.50 | 5.50 | 5.50 |
| EC $mS \cdot cm^{-1}$ | 1.044 | 2.60 | 3.30 | 3.10–3.30 |

* 15, 30, 60, 90 mg $Cl \cdot dm^{-3}$ in 2004–2005 and 30, 60, 90, 120 mg $Cl \cdot dm^{-3}$ in 2006

Tomato seeds were sown onto multiblocs of rockwool (Grodan) on January 2–3 each year and were fertigated with nutrient solution no 1 (tab. 1). After 14–16 days, the seedlings were planted in rockwool cubs (10.0 × 10.0 × 6.5 cm, Grodan) and fertigated with nutrient solution no 2. After 45–50 days, the seedlings were transplanted to roockwool slabs (100 × 15 × 7.5 cm, Grodan) and fertigated with solution nr 3. The experiments lasted from February 16–19 to October 25–28 each year.

At vegetation, the lateral stems and lower leaves were removed. The plants were cultivated on one stem. The plants developed 26 clusters (on average) during the vegetation period. Pollination was supported by *Bombus terrestris* L. Biological protection was applied using predacious insects *Encarsia formosa* (Gahan) and *Macrolophus melanothoma* (Costa). The fungicide Bravo 500 SC (0.25%) was applied to control *Botritis cinerea* (Pers).

In the middle of July, August and September samples of fruits were collected. Each average sample consisted of 20 fruits from the treatment in 5 replications. Analyses of fruits on macro and microelements and sodium were done using the following methods: N in sulfuric acid with an addition of sulfosalicilic acid and reduction of $N\text{-}NO_3$ to $N\text{-}NH_4$ with sodium trisulphate and an addition of selenium; P, K, Ca, Mg and Na in sulfuric acid, sulfur – dry mineralization in muffle furnace with $HNO_3$ and $[Mg(NO_3)_2]$; Fe, Mn, Zn and Cu – in $HNO_3$, $HClO_4$, $H_2SO_4$, (100:1:1 v/v); B - dry mineralization with CaO [IUNG 1972]. After mineralization, the following methods were used: N-total – by Kjeldahl; P – colorimetrically with ammonium molibdate; K, Ca, Na – photometrically on flame photometer; Mg, Fe, Mn, Zn and Cu – by atomic absorption spectroscopy (AAS); S – Butters-Chenery method and B – colorimetrically with curcumin [IUNG 1972]. In August 20, 2005 and September 2, 2006 the samples of fruits were collected for determining: nitrate and nitrite contents by colorimetric method with α-naphthylamine after the reduction of nitrate to nitrite by cadmium [ISO 1984], acidity – titration with NaOH and recalculation on citric acid [Drzazga 1992], ascorbic acid – titration with 2,6 dichlroindophenol [PN-90/A-75101/11], β-carotene – high performance liquid chromatography (HLCP) [Drzazga 1992] and reducing sugars – Bertrand method [PN-67/A-86430].

Results on nutrient contents and parameters of fruit quality were statistically analyzed by Duncan's multiple range test at $\alpha = 0.05$.

## RESULTS AND DISCUSSION

An increase of chloride concentration in the nutrient solutions increased the content of chlorine in fruits (tab. 2). Similar effect was found by Nukaya and Hashimoto [2000] and Voogt and Sonneveld [2004]. There is a few works documented relation between chlorine in the nutrient solutions and fruits but there are many reports pointed out the positive interaction between chloride content in nutrient solutions and content of chlorine in leaves. It was presented in the study of Nukaya et al. [1991], Nurzyński and Michałojć [1998], Michałojć and Nowak [2000] and Kowalczyk et al. [2008]. Increasing content of chloride from 15 to 120 mg $Cl\cdot dm^{-3}$ in the nutrient solutions was reflected in the uprising of chloride in fruits to the range of 0.20–0.41% Cl in d. m. Higher concentration of chloride in nutrient solution decreased the blossom-end rot (BER) and reduced injury of gold speck on tomato fruits [Nukaya et al. 1991]. Also Voogt and Sonneveld [2004] found that an increase of $Cl:NO_3$ ratio in the nutrient solution decreased blossom-end rot (BER) however shelf life was shortage and increased gold speck in tomato fruits.

Chloride in the nutrient solutions lowered the nitrogen content in fruits (tab. 2). It was pointed out at the higher levels of chloride – 90 to 120 mg Cl·dm$^{-3}$ (tab. 2). Reducing of nitrogen content by chloride in plants is the effect of Cl:$NO_3$ antagonism [De Wit et al. 1963, Hiatt and Leggett 1974 and Kafkafi et al. 1982]. Suppressing of nitrogen content in plant may be the result of inhibition of nitrate plant uptake by chloride from the root environment [Kafkafi et al. 1982, Nukaya and Hashimoto 2000, Vogt and Sonneveld 2004].

Table 2. The effect of increased chloride levels in the nutrient solutions on macroelements, chloride, iron and sodium contents in fruits of tomato cv. 'Grace $F_1$' (2004–2006)
Tabela 2. Wpływ wzrastających poziomów chlorków w pożywkach na zawartość makroelementów, chloru, żelaza i sodu w owocach pomidora odmiany 'Grace $F_1$' (2004–2006)

| Cl mg·dm$^{-3}$ | Content in d. m. of fruits – Zawartość w s.m. owoców | | | | | |
|---|---|---|---|---|---|---|
| | % Cl | | % N | | % P | |
| | Exp. I | Exp. II | Exp. I | Exp. II | Exp. I | Exp. II |
| 15 | 0.20 a | n.t. | 2.61 b | n.t. | 0.30 a | n.t. |
| 30 | 0.24 b | 0.22 a | 2.60 ab | 2.55 b | 0.31 a | 0.25 a |
| 60 | 0.31 c | 0.31 b | 2.51 ab | 2.50 ab | 0.33 a | 0.28 a |
| 90 | 0.36 d | 0.36 c | 2.48 a | 2.52 ab | 0.33 a | 0.27 a |
| 120 | n.t. | 0.41 d | n.t. | 2.45 a | n.t. | 0.28 a |
| | % K | | % Ca | | % Mg | |
| 15 | 3.75 ab | n.t. | 0.11 a | n.t. | 0.19 a | n.t. |
| 30 | 3.72 a | 3.40 a | 0.12 a | 0.12 a | 0.20 a | 0.17 a |
| 60 | 3.90 bc | 3.41 ab | 0.13 a | 0.13 a | 0.21 a | 0.20 a |
| 90 | 3.96 c | 3.56 bc | 0.12 a | 0.13 a | 0.19 a | 0.18 a |
| 120 | n.t. | 3.59 c | n.t. | 0.12 a | n.t. | 0,19 a |
| | % S | | % Na | | mg Fe·kg$^{-1}$ | |
| 15 | 0.11 a | n.t. | 0.10 a | n.t. | 48.77 a | n.t. |
| 30 | 0.11 a | 0.12 | 0.09 a | 0.08 a | 48.22 a | 45.34 a |
| 60 | 0.10 a | 0.12 | 0.09 a | 0.09 a | 49.64 a | 42.08 a |
| 90 | 0.11 a | 0.11 | 0.09 a | 0.09 a | 47.85 a | 43.24 a |
| 120 | n.t. | 0.10 | n.t. | 0.08 a | n.t. | 42.26 a |

n.t. – no treatment; values marked with the same letter in a column did not differ significantly
n.t. – brak kombinacji; wartości oznaczone tą samą literą w kolumnie nie różnią się istotnie

It was not found the effect of chloride in the nutrient solution on phosphorus content in fruits (tab. 2). Similar result was shown by Kafkafi et al. [1982]. Wang et al. [1989] reported that the uptake of phosphorus was stimulated by lower and suppressed by higher amounts of chloride. Contents of phosphorus (0.25–0.33% P) and nitrogen (2.45–2.61% N in d.m.) in fruits were similar as in the study of Kowalska [2006].

In opposition to nitrogen, increased chloride levels in the nutrient solutions enhanced the potassium content in fruits (tab. 2). The synergistic effect between Cl and K was appeared at the high levels of chloride 90 to 120 mg Cl·dm$^{-3}$. There is no work on the effect of chloride on the potassium content in fruits but these relations were considered for leaves. Wang et al. [1989] and Lahav et al. [1992] reported the positive effect of chloride on potassium contents in leaves. Callan and Westcott [1996] concluded that chloride at high concentrations can inhibit potassium uptake. Many reports concluded that chloride did not influence on potassium content [Uexküll and Sanders 1986, Smith et al. 1987, Wang et al. 1989, Adler and Wilcox 1995, Bar et al. 1996]. In own study, contents of potassium in fruits were 3.40–3.96% K in d. m. This range is similar like in the study of Kowalska [2006], Nurzyński and Michałojć [1998] and Benton [1999].

The increased chloride levels did not effect on the calcium content in fruits (tab. 2). These results conform to the study done by Toor et al. [2006]. Nukaya et al. [1991], Lopez et al. [1996] and Nukaya and Hashimoto [2000] considered that chloride enhanced the content of calcium in fruits. Many authors searched the interaction between Cl and Ca in leaves. Nukaya and Hashimoto [2000] pointed out that content of calcium in tomato laminae depended on relative amounts of $NO_3$:Cl:$SO_4$. Voogt and Sonneveld [2004] showed that lowered nitrate and increased chloride concentration in nutrient solution improved calcium content in tomato laminae and it could be connected with decreasing of blossom-end rot (BER). Lahav et al. [1992] stated that chloride lowered the content of calcium in leaves.

In the own study the content of calcium in fruits was 0.11–0.13% Ca in d. m. and was similar like as the study of Nurzyński et al. [2000a, b]. According by Benton [1999] blossom end-rot of fruits was appearing below the content of 0.12% Ca in d. m. of fruits. In own study blossom end-rot was not appeared.

As in the case of calcium, there was not effect of chloride on magnesium and sodium contents in fruits (tab. 2). Fruits contained 0.17–0.21% Mg and 0.08–0.10% Na in d. m. There is lack of data on the interaction between Cl : Mg and Cl : Na in fruits of tomato.

Table 3. The effect of increasing chloride levels in the nutrient solutions on Mn, Zn, Cu and B contents in fruits of tomato cv. 'Grace $F_1$'

Tabela 3. Wpływ wzrastających poziomów chlorków w pożywkach na zawartość manganu, cynku, miedzi i boru w owocach pomidora odmiany 'Grace $F_1$' (2004–2006)

| Cl $mg \cdot dm^{-3}$ | In dry matter of fruits – W suchej masie owoców | | | |
|---|---|---|---|---|
| | $mg\ Mn \cdot kg^{-1}$ | | $mg\ Zn \cdot kg^{-1}$ | |
| | Exp. I | Exp. II | Exp. I | Exp. II |
| 15 | 10.29 a | n.t. | 18.55 a | n.t. |
| 30 | 10.35 a | 12.15 a | 18.41 a | 13.19 a |
| 60 | 10.16 a | 11.87 a | 18.42 a | 12.53 a |
| 90 | 10.71 a | 12.76 a | 18.55 a | 12.83 a |
| 120 | n.t. | 11.96 a | n.t. | 12,91 a |
| | $mg\ Cu \cdot kg^{-1}$ | | $mg\ B \cdot kg^{-1}$ | |
| 15 | 7.52 a | n.t. | 41.38 c | n.t. |
| 30 | 7.61 a | 6.73 a | 38.76 a | 32.45 a |
| 60 | 7.69 a | 7.44 a | 39.20 a | 34.12 a |
| 90 | 7.97 a | 6.72 a | 36.88 a | 32.52 a |
| 120 | n.t. | 6.98 a | n.t. | 34.81 a |

Note: see Table 2 – Objaśnienia: patrz tabela 2

It was not found the influence of chloride in the nutrient solution on the content of sulfur in fruits (tab. 2). They contained 0.10–0.12% S in d. m. In literature is known antagonism between $Cl^-$ and $SO_4^{2-}$, similarly to $Cl^-$ and $NO_3^-$ in root environment [Muraka et al. 1973]. This interactions are more visible for leaves than for fruits.

The increased chloride levels in the nutrient solutions not influenced the content of microelements, such as Fe, Mn, Zn, Cu and B, in fruits (tab. 2, 3). Fruits contained 42.26–49.64 mg Fe, 10.16–12.76 mg Mn, 12.53–18.55 mg Zn, 6.72–7.97 mg Cu and 32.45–41.38 mg B·$kg^{-1}$ d. m. There is lack of scientific works on interaction between chlorine and microelements for tomato fruits in soilless culture.

It was not found the effect of increased chloride concentrations on the content of dry matter, however the tendency for the lowering was visible (tab. 4). At the low levels of 15–60 mg Cl·$dm^{-3}$ the dry matter content was 4.82–7.04% but at the higher ones 90–120 mg Cl·$dm^{-3}$ it was 5.01–6.35%. Jarosz [2006] pointed out on the increasing tendency of fruits dry matter affected by chloride.

Table 4. The effect of increased chloride levels in the nutrient solutions on dry matter, nitrate and nitrite contents in tomato fruits cv. 'Grace $F_1$' (2005–2006)

Tabela 4. Wpływ wzrastających poziomów chlorków w pożywkach na zawartość suchej masy, azotanów i azotynów w owocach pomidora odmiany 'Grace $F_1$' (2005–2006)

| Cl mg·$dm^{-3}$ | Dry mass – Sucha masa % | | mg $NO_3$·$kg^{-1}$ f.m. – ś.m. | | mg $NO_2$·$kg^{-1}$ f.m. – ś.m. | |
|---|---|---|---|---|---|---|
| | Exp. I | Exp. II | Exp. I | Exp. II | Exp. I | Exp. II |
| 15 | 4.82 a | - | 89.7 a | n.t. | tr. | n.t. |
| 30 | 5.27 a | 7.47 a | 84.4 a | 87.3 a | tr. | tr. |
| 60 | 4.96 a | 7.04 a | 81.8 a | 81.8 a | tr. | tr. |
| 90 | 5.01 a | 6.35 a | 84.4 a | 85.1 a | tr. | tr. |
| 120 | n.t. | 6.92 a | n.t. | 83.2 a | n.t. | tr. |

Note: see Table 2 – Objaśnienia: patrz tabela 2

Table 5. The effect of increased chloride levels in the nutrient solutions on acidity and α-ascorbic acid, β-carotene and reducing sugars contents in tomato fruits cv. 'Grace $F_1$'(2005–2006)

Tabela 5. Wpływ wzrastających poziomów chlorków w pożywkach na kwasowość oraz zawartość kwasu α-askorbinowego, β-karotenu i cukrów redukujących w owocach pomidora odmiany 'Grace $F_1$' (2005–2006)

| Cl mg·$dm^{-3}$ | Acidity Kwasowość g·100 $g^{-1}$ f.m. – ś.m. | | α-ascorbic acid Witamina C mg·100 $g^{-1}$ f.m. – ś.m. | | β-carotene β-karoten µg·100 $g^{-1}$ f.m. – ś.m. | | Reducting sugars Cukry redukujące g·100 $g^{-1}$ f.m. – ś.m. | |
|---|---|---|---|---|---|---|---|---|
| | Exp. I | Exp. II | Exp. I | Exp. II | Exp. I | Exp. II | Exp. I | Exp. II |
| 15 | 0.51 a | n.t. | 9.90 a | n.t. | 41.8 a | n.t. | 3.39 b | n.t. |
| 30 | 0.57 a | 0.60 a | 10.50 ab | 10.80 a | 50.6 b | 97.7 a | 2.98 ab | 3.97 b |
| 60 | 0.62 a | 0.56 a | 10.90 ab | 11.00 a | 44.4 a | 87.0 a | 2.93 ab | 3.47 ab |
| 90 | 0.54 a | 0.65 a | 11.50 b | 11.00 a | 41.1 a | 70.8 a | 2.66 a | 3.40 a |
| 120 | n.t. | 0.51 a | n.t. | 11.50 a | n.t. | 87.2 b | n.t. | 3.27 a |

Note: see Table 2 — Objaśnienia: patrz tabela 2

The increasing concentrations of chloride in nutrient solution had no effect on the nitrate and nitrite contents in fruits (tab. 4). The contents of nitrate was 81.8–89.7 mg $NO_3 \cdot kg^{-1}$ of fresh matter but nitrite content was on the trace levels. Many authors reported that increased chloride contents in the nutrient solution reduced the nitrate contents in fruits. It could be the effect of the antagonism between $Cl:NO_3$ [Chapagain et al. 2003, Chapagain and Wiesman 2004]. These authors tested higher concentrations of chloride than in the own study.

The increasing concentrations of chloride in nutrient solution had no effect on the acidity and β-carotene content but affected the contents of reducing sugars in fruits (tab. 5). Lowering effect of chloride on reducing sugar contents was shown on the high levels of chloride at the range of 90–120 mg $Cl \cdot dm^{-3}$.

Concentration of chloride above 90 mg $Cl \cdot dm^{-3}$ enhanced the content of α-ascorbic acid (tab. 5). It was marked significantly in the Experiment I but in the Experiment II was indicated only as the tendency. Jarosz [2006] reported that chloride applied with KCl tended the increase of vitamin C in tomato fruits.

## CONCLUSIONS

1. The increased chloride contents in the nutrient solutions increased the content of chlorine in the fruits.

2. Increasing contents of chloride in the nutrient solution at the range of 90 to 120 mg $Cl \cdot dm^{-3}$ decreased the nitrogen and increased potassium contents in fruits.

3. Contents of chloride in the nutrient solutions above 90 mg $Cl \cdot dm^{-3}$ enhanced the content of α-ascorbic acid and decreased the content of reducing sugars in fruits. There were no effects on the nitrate and β-carotene contents as well as the acidity of fruits. It was shown the tendency to suppress the dry matter of fruits above the level of 90 mg $Cl \cdot dm^{-3}$ in the nutrient solutions.

4. It was not found the effect of increased chloride levels in the nutrient solutions on P, Ca, Mg, S, Na, Fe, Mn, Zn, Cu and B contents in fruits of tomato.

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## WPŁYW CHLORKÓW NA ZAWARTOŚĆ SKŁADNIKÓW POKARMOWYCH W OWOCACH POMIDORA SZKLARNIOWEGO (*Lycopersicon esculentum* Mill.) UPRAWIANEGO W WEŁNIE MINERALNEJ

**Streszczenie**. Chlor odgrywa ważną rolę w procesach fizjologicznych i biochemicznych roślin. Ma istotny wpływ na wartość biologiczną plonu. W doświadczeniu I (2004–2005) badano wpływ chlorków w stężeniach 15, 30, 60 i 90 mg $Cl·dm^{-3}$ natomiast w doświadczeniu II (2006) wpływ stężeń 30, 60 i 90 i 120 mg $Cl·dm^{-3}$ w pożywkach na zawartość składników pokarmowych i niektóre chemiczne parametry jakościowe owoców pomidora szklarniowego odmiany 'Grace", uprawianego w wełnie mineralnej. Wykazano, że wzrastające poziomy chlorków w pożywkach zwiększały zawartość chloru w owocach. Przy wyższych zawartościach chlorków w pożywkach, wynoszących 90 i 120 mg $Cl·dm^{-3}$, a tym samym chloru w owocach, następowało obniżenia zwartości azotu i wzrost zawartości potasu w owocach. Powyżej 90 mg Cl·dm$^{-3}$ w pożywkach zwiększała się zawartość kwasu α-askorbinowego i obniżała zawartość cukrów redukujących. Nie stwierdzono wpływu chlorków na zawartość azotanów, azotynów i β-karotenu. Wykazano natomiast tendencję do obniżania się zawartości suchej masy w owocach przy stężeniach równych i wyższych od 90 mg Cl·dm$^{-3}$ pożywki w stosunku do zawartości 15–30 mg Cl·dm$^{-3}$. Nie stwierdzono istotnego wpływu wpływu chlorków na zawartość P, Ca, Mg, S, Na, Fe, Mn, Zn, Cu i B w owocach pomidora.

**Słowa kluczowe**: chlor, pożywka, fertygacja, żywienie roślin, wartość biologiczna

Accepted for print – Zaakceptowano do druku: 29.05.2012