ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Hortorum Cultus 5(1) 2006, 11-18*

EFFECT OF DIFFERENTS TYPES OF POTASSIUM FERTILISATION ON THE CHEMICAL COMPOSITION OF LEAVES AND FRUITS OF GREENHOUSE TOMATOES GROWN IN VARIOUS SUBSTRATES

Zbigniew Jarosz
Agricultural University in Lublin

Abstract. In the experiment with greenhouse tomato cv. 'Cunero F_1' the effect of nutrient liquid with or without chlorine on the chemical composition of leaves and fruits was investigated. In research rockwool, peat and sand substrates with fertigation system was used. The experiment showed higher potassium, calcium, magnesium and chlorine leaves content in tomato fertilized nutrients liquid with chlorine. Kind of potassium fertilization had no significant effect on the chemical composition of tomato fruits. Lowest witamin C, total nitrogen and potassium content in fruits of tomato grown in sand substrate was detected, compared with peat and rockwool

Key words: greenhouse tomato, fertigation, kinde of potassium fertilization, dry matter, vitamin C, chemical leaves composition

INTRODUCTION

Fertilisation of plants with potassium chloride or potassium sulphate is not irrelevant for plants due to significantly different physiological functions of anions that are brought into the substrate. According to Michałojć [2000] anions, that accompany potassium, influence both the chemical composition of the plant and the quality of the crop. The research of Chapagain et al. [2003] shows that the application of potassium chloride instead of potassium saltpetre with greenhouse tomatoes improves the quality parameters of their fruit. Dorais et al. [2000] and Hao et al. [2000] also identified a positive impact of potassium chloride on the quality of fruit when they applied this fertiliser in order to increase electric conductivity in the plant root area.

Michałojć [2000] reports that fertilisation of vegetables with potassium chloride or potassium sulphate has a significant influence on the nitrate composition of plants. In

Corresponding author – Adres do korespondencji: Zbigniew Jarosz, Department of Soil Cultivation and Fertilization of Horticultural Plants, Agricultural University in Lublin, ul. Leszczyńskiego 58, 20-068 Lublin, e-mail: zmjaro@op.pl

the author's opinion this issue should be regarded as a decisive factor of the crop quality. Nurzyński [1994] follows by adding that nitrates are good and sensitive indicators of the content of nitrogen in plants. Thus, the type of potassium fertiliser that is applied can be misleading in assessing the nitrogen content in plants.

The conducted research was to show the influence of chlorine and non-chlorine fertilisation on the chemical composition of leaves and fruit of the tomato variety 'Cunero F_1' grown on rockwool, transitional peat and sand.

MATERIALS AND METHODS

The influence of chlorine and non-chlorine fertilisation on the chemical composition of leaves and fruit of the tomato variety 'Cunero F1' was tested in the greenhouse environment in the research conducted between 1999 and 2000. Plants were grown on rockwool (Grodan), transitional peat and sand containing 98% of sand fraction (1,0–0,1 mm) and 2% of dust fraction (0,1–0,02 mm). The plant growing was conducted with the use of drop fertilization system and irrigation with a closed fertilizing circuit, without re-circulation. The composition of alimentary solutions and basic methodical assumptions of research were discussed in the first part of the study [Jarosz 2006].

Levels of plant supply in alimentary elements were estimated on the basis of analysis of representative samples of leaves taken in the beginning, in the middle and at the end of their fruiting. The first leaf above the second, the fourth and the sixth fruit-bearing cluster was an indicator. Total amount of nitrogen was measured (by Kjeldahl method)), and in 2% extract of acetic acid – nitrate nitrogen (by Bremner method), sulphur and chlorine (nephelometrically). Having burnt the material in the oven (in temperature 550°C), phosphorous was marked (calorimetrically), potassium, calcium and magnesium (by ASA method). Fruit for analyses was collected in the phase of full ripeness, in the half of fruit-bearing period (the third-fourth cluster). Fruit belonging to commercial crop (with the diameter above 35 mm) constituted a representative sample (6–7 items). In fresh product there were marked – dry mass (weight), the vitamin C by Tillmans' method and carbohydrates in total by Schorl-Regenbogen method. Marking of nitrogen in total, potassium, calcium and magnesium in fruit was done in the same way as in the analyses of leaves.

Statistical summary of the results was done using a method of analysis of variations at average values. The differences were evaluated with Tukey's test HSD at the significance level of $\alpha = 0,05$.

RESULTS

In the research significant differences in the chemical composition of tomato leaves were identified depending on the factors under tests (tab. 1). Higher levels of potassium, calcium, magnesium and chlorine were found in leaves of plants fertilised with a feed containing chlorine in comparison to non-chlorine fertilisation. The influence of the applied substrate on the chemical composition of leaves was not revealing. Regardless

Table 1. Effect of types of potassium fertilizing on the nutrients content in tomato leaves (% d.m.)
Tabela 1. Wpływ rodzaju nawożenia potasowego i podłoży na zawartość składników pokarmowych w liściach pomidora (% s.m.)

Substrate Podłoże (A)	Potassium fertilizing Nawożenie potasowe (B)	N-total N-ogółem	$N\text{-}NO_3$	P	K	Ca	Mg	S	Cl
Rockwool Wełna mineralna	with chlorine z chlorem	2.96	0.96	0.83	4.42	5.41	0.59	1.63	1,19
	without chlorine bez chloru	2.95	1.02	0.82	4.41	5.26	0.55	1.84	0,59
$\bar{x}$ for (dla) A		2.96	0.99	0.82	4.41	5.33	0.57	1.73	0,89
Peat Torf	with chlorine z chlorem	2.88	0.90	0.78	4.46	5.36	0.47	1.57	1,15
	without chlorine bez chloru	2.89	0.96	0.86	4.43	5.23	0.42	1.77	0,57
$\bar{x}$ for (dla) A		2.89	0.93	0.82	4.44	5.29	0.45	1.67	0,86
Sand Piasek	with chlorine z chlorem	2.85	0.71	0.67	4.42	5.12	0.49	1.50	1,24
	without chlorine bez chloru	2.95	0.68	0.83	4.18	4.90	0.41	1.82	0,52
$\bar{x}$ for (dla) A		2.90	0.69	0.75	4.30	5.01	0.45	1.66	0,88
$\bar{x}$ for B $\bar{x}$ dla B	with chlorine z chlorem	2.90	0.85	0.76	4.43	5.30	0.52	1.57	1,19
	without chlorine bez chloru	2.93	0.88	0.84	4.34	5.13	0.46	1.81	0,56
$LSD_{0,05}$ for , $NIR_{0,05}$ dla:	A	n.s. – ni.	0.20	n.s. – ni.	0.13	0.24	0.11	n.s. – ni.	n.s. – ni.
	B	n.s. – ni.	n.s. – ni.	0.08	0.08	0.17	0.06	0.14	0.12
	A×B	n.s. – ni.	n.s. – ni.	n.s. – ni.	0.24	n.s. – ni.	0.14	0.23	n.s. – ni.

of the type of potassium fertilisation, the highest content of nitrogen in total, nitrates, calcium, sulphuric magnesium and chlorine was found in leaves of plants grown on rockwool. The highest level of potassium (4.44% dry mass) was in leaves of plants grown on peat. The lowest content of nitrates, phosphorous, potassium, calcium and sulphur was found in tomatoes grown on sand. The statistical analysis showed an equally significant interaction among the factors under tests with regards to the content of potassium, magnesium and sulphur in leaves.

A slightly higher content of dry mass, the vitamin C and sugars in total was identified in the fruit of tomatoes fertilised with a feed containing chlorine in comparison to the fruit of plants fertilised with a non-chlorine feed; however, these differences were not significant (tab. 2). As assessed, regardless of the type of potassium fertilisation applied, the content of dry mass was at the similar level of 6.94% for plants grown on rockwool, 6.73% on peat and 6.52% on sand. The fruit of tomatoes grown on peat and rockwool contained significantly more of the vitamin C than the fruit of plants grown on sand, whereas the content of sugars in total in the fruit of tomatoes grown on the substrates under tests was similar and ranged between 3.16% and 3.28% of fresh mass.

Table 2. Effect of types of potassium fertilizing and substrates on the dry matter, vitamin C and total sugars content in tomato fruits

Tabela 2. Wpływ rodzaju nawożenia potasowego i podłoża na zawartość suchej masy, witaminy C i cukrów ogółem w owocach pomidora

Substrate Podłoże (A)	Dry matter (%) Sucha masa (%)			Vitamin C (mg·100 g f.w.$^{-1}$) Witamina C (mg·100 g św.m.$^{-1}$)			Total sugars (% f.w.) Cukry ogółem (% św.m.)		
	types of potassium fertilizing – rodzaj nawożenia potasowego (B)								
	with chlorine z chlorem	without chlorine bez chloru	$\bar{x}$ for A $\bar{x}$ dla A	with chlorine z chlorem	without chlorine bez chloru	$\bar{x}$ for A $\bar{x}$ dla A	with chlorine z chlorem	without chlorine bez chloru	$\bar{x}$ dla A $\bar{x}$ for A
Rockwool Wełna mineralna	7.44	6.45	6.94	23.77	20.42	22.09	3.85	2.47	3.16
Peat Torf	5.87	7.60	6.73	20.19	24.9	22.54	2.96	3.60	3.28
Sand Piasek	6.98	6.05	6.52	20.07	16.45	18.26	3.35	3.05	3.20
$\bar{x}$ for B $\bar{x}$ dla B	6.76	6.70		21.35	20.59		3.39	3.04	
$LSD_{0,05}$ for, $NIR_{0,05}$ dla:	A		n.s. – ni.		3.78			n.s. – ni.	
	B		n.s. – ni.		n.s. – ni.			n.s. – ni.	
	A×B		n.s. – ni.		7.86			0.35	

The conducted research did not show a significant link between the type of potassium fertilisation appplied and the content of nitrogen in total, potassium, calcium and magnesium in tomato leaves (tab. 3). Regardless of the type of potassium fertilisation applied, the highest levels of these components were found in plants grown on peat. The fruit of tomatoes grown on sand contained the lowest levels of nitrogen in total (1.91% dry mass), potassium (3.49% dry mass) and calcium (0.14%). The content of calcium and magnesium in tomato fruit did not statistically differ depending on the type of substrate.

Table 3. Effect of types of potassium fertilizing and substrates on mineral content of tomato fruits (% d.m.)
Tabela 3. Wpływ rodzaju nawożenia potasowego i podłoża na zawartość składników mineralnych w owocach pomidora (% s.m.)

Substrate Podłoże (A)	N-total, N-ogółem			K			Ca			Mg		
	types of potassium fertilizing – rodzaj nawożenia potasowego (B)											
	with Cl^- z Cl^-	without Cl^- bez Cl^-	$\bar{x}$ for A $\bar{x}$ dla A	with Cl^- z Cl^-	without Cl^- bez Cl^-	$\bar{x}$ for A $\bar{x}$ dla A	with Cl^- z Cl^-	without Cl^- bez Cl^-	$\bar{x}$ for A $\bar{x}$ dla A	with Cl^- z Cl^-	without Cl^- bez Cl^-	$\bar{x}$ for A $\bar{x}$ dla A
Rockwool Wełna mineralna	2.26	2.36	2.31	3.88	4.35	4.11	0.15	0.15	0.15	0.12	0.14	0,13
Peat Torf	2.72	2.59	2.66	4.35	3.89	4.12	0.17	0.15	0.16	0.16	0.15	0,16
Sand Piasek	1.95	1.88	1.91	3.55	3.42	3.49	0.15	0.13	0.14	0.12	0.16	0,14
$\bar{x}$ for B $\bar{x}$ dla B	2.31	2.28		3.93	3.89		0.16	0.14		0.13	0.15	
$LSD_{0,05}$ for: A		0.23			0.57			n.s. – ni.			n.s. – ni.	
$NIR_{0,05}$ dla B		n.s. – ni.			n.s. – ni.			n.s. – ni.			n.s. – ni.	
A×B		n.s. – ni.			n.s. – ni.			n.s. – ni.			n.s. – ni.	

DISCUSSION

From numerous researches it is clear that the application of chlorine in fertilisation of tomatoes has an important influence on the feeding of plants and the biological quality of fruit [Bishnu et al. 2003, Dorais et al. 2000, Nurzyński and Michałojć 1998]. According to Michałek [1995] the usage of chlorine reduces the total content of nitrogen in plants. This is not confirmed by the research as the type of potassium fertilisation had no significant impact on the level of this component in leaves. Additionally, the total content of nitrogen in tomato leaves in the presented research ranged from 2.85 to 2.96% in dry mass which is assumed to be the correct level of plant feeding with this component [Atherton and Rudich 1986].

Nurzyński and Michałojć [1998] draw attention to a significant reduction of the content of nitrates in tomato leaves resulting from fertilisation with potassium chloride. This is also confirmed by the research conducted by Bishnu et al. [2004]. Although in the presented research fewer nitrates were identified in leaves of plants fertilised with a feed containing chlorine in comparison to non-chlorine fertilisation, the differences were not supported statistically.

The significant increase of the content of potassium in leaves of plants resulting from fertilisation with chlorine also needs to be emphasised in the research. Most probably it is a consequence of the tendency of plants to keep the balance between cations and anions. The intake of large numbers of chlorine anions is balanced with a higher intake of cations, including potassium. According to Bishnu et al. [2003] and Hartz et al. [2001] the increased level of potassium in tomatoes improves the quality of fruit significantly. In the conducted research no important influence of the type of potassium fertilisation on the chemical composition of tomato fruit was identified.

Nurzyński and Michałojć [1998] proved the increase of the content of calcium in tomato leaves in the fertilisation with a feed containing chlorine in comparison to non-chlorine fertilisation. This is also supported by my own research. Lopez et al. [1998] emphasises that the increase in the concentration of sulphates in the substrate may cause a reduction in the content of calcium in tomato leaves due to the precipitation of insoluble calcium sulphates in the root area of plants. The same researchers report that this may lead to a high decrease in the content of calcium in tomato fruit. In this research, although it has been shown that the level of calcium in the fruit of tomatoes fertilised with a non-chlorine feed is lower, the differences, however, have not be supported statistically.

Bishnu et al. [2004] proved that the application of potassium chloride in the fertilisation of tomatoes may cause a lack of magnesium in plants. It is assumed that the lack of this macro component takes place when its level is below 0.4% in dry mass. This has not been confirmed by my research where a significantly higher content of magnesium was found with the application of KC1 feed.

According to Lopez et al. [1996] tomatoes are sensitive to sulphur deficiency. In the opinion of Atherton and Rudich [1986] the content of this component in tomato leaves should range between 1.0 and 3.2% in dry mass. It needs to be emphasised that despite different concentration of sulphates in the applied feeds, the content of this component

in leaves of tomatoes grown in the researched substrates was between 1.50 and 1.84%, which is at the optimum level.

The conducted research did not show a significant influence of the potassium fertilisation on the content of dry mass, vitamin C and sugars totally in tomato fruit. The results are confirmed by earlier researches performed by Nurzyński and Michałojć [1998] and Nurzyński et al. [2001] where there was no important link between chlorine and non-chlorine fertilisation and the biological quality of tomato and pepper fruit. According to Kowalska [1996] the content of the vitamin C in tomato fruit depends mainly on the physical properties of the substrate (water capacity, absorbing capacity) and also on the quantity and form of nitrogen. My research showed significant differences in the content of the vitamin C in fruit depending on the type of substrate which may be related to the differences in the physical properties of the applied substrates.

CONCLUSIONS

1. Higher levels of potassium, calcium, magnesium and chlorine were identified in leaves of tomatoes fertilised with a chlorine feed.
2. The applied type of potassium fertiliser had no significant influence on the chemical composition of tomato fruit.
3. The lowest levels of vitamin C, nitrogen totally and potassium were found in the fruit of tomatoes grown on sand.

REFERENCES

Atherton J. G., Rudich J., 1986. The tomato crop – a scientific basis for improvement. Chapman and Hall Ltd, London.

Bishnu P., Chapagain B.P., Wiesman Z., 2004. Effect of potassium magnesium chloride in the fertigation solution as partial source of potassium on growth, yield and quality of greenhouse tomato. Sci. Hort. 99, 279–288.

Chapagain B.P., Wiesman Z., Zaccai M., Imas P., Magen H., 2003. Potassium chloride enhances fruit appearance and improves quality of fertigated greenhouse tomato compared to potassium nitrate. J. Plant Nutr. 26 (3), 643–658.

Dorais M., Dorval R., Demers D.A., Micevic D., Turcotte G., Hao X., Papadopoulos A.P, Ehret D.L., Gosselin A., 2000. Improving tomato fruit quality by increasing salinity: effect on jon uptake, growth and yield. Acta Hort. 511, 185–195.

Hao X., Papadopoulos A. P., Dorais M., Ehret D.L., Turcotte G., Gosselin A., 2000. Improving tomato fruit quality by raising the EC of NFT nutrient solution and calcium spraing: effect of growth, photosynthesis, yield and quality. Acta Hort. 511, 213–221.

Hartz T.K., Miyao E.M., Mullen R.J., Cahn M.D., 2001. Potassium fertilization effect on processing tomato yield and fruit quality. Acta Hort. 542, 127–132.

Jarosz Z., 2006. Effect of differents types of potassium fertilization on the yielding of greenhouse tomatoes grown in various substrates. Acta Sci. Pol., Hortorum Cultus 5(1), 3–9

Kowalska I., 1996. Ocena przydatności mocznikowej, amonowej i azotanowej formy azotu nawozowego w uprawie szklarniowej pomidora przy zastosowaniu różnych podłoży ogrodniczych. Zesz. Probl. Post. Nauk Rol. 429, 175–180.

Lopez J., Tremblay N., Voogt W., Dube S., Gosselin A., 1996. Effect of varying sulphate concentrations on growth, physiology and yield of the greenhouse tomato. Sci. Hort. 67, 207–217.
Lopez J., Dorais M., Tremblay N., Gsselin A., 1998. Effects of varying sulphate concentrations and vapour pressure deficits (VPD) on greenhouse tomato fruit quality, foliar nutrient concentration and amino acid components. Acta Hort. 458, 303–311.
Michałek W., 1995. Wpływ chlorków na plon i wartość biologiczną rzodkiewki (*Raphanus sativus* L. subvar. *radicula* Pers.). Mat. Ogólnopol. Konf. Nauk., Lublin, 591–594
Michałojć Z., 2000. Wpływ nawożenia azotem i potasem oraz terminu uprawy na plonowanie i skład chemiczny sałaty, rzodkiewki oraz szpinaku. Rozpr. Nauk. 238, Wyd. AR Lublin.
Nurzyński J., 1994. Zawartość składników mineralnych w roślinach w zależności od nawożenia potasowego. V Jubileuszowa Konferencja Katedr Uprawy Roli i Nawożenia Roślin Ogrodniczych, Poznań, 12–16.
Nurzyński J., Michałojć Z. 1998., Plonowanie pomidora uprawianego na wełnie mineralnej w zależności od nawożenia potasowego. Zesz. Nauk. AR w Krakowie 333, 235–239.
Nurzyński J., Michałojć Z., Nowak L., 2001. Wpływ nawożenia potasowego na plon i skład chemiczny papryki. Zesz. Nauk. ART Bydgoszcz 234, 99–103.

WPŁYW RODZAJU NAWOŻENIA POTASOWEGO NA SKŁAD CHEMICZNY LIŚCI I OWOCÓW POMIDORA UPRAWIANEGO W RÓŻNYCH PODŁOŻACH

Streszczenie. W doświadczeniu z pomidorem odmiany 'Cunero F_1' uprawianym w szklarni badano wpływ pożywki zawierającej chlor oraz bezchlorkowej na skład chemiczny liści i owoców pomidora. Badaniami objęto rośliny uprawiane w wełnie mineralnej, torfie i piasku z wykorzystaniem kroplowego systemu fertygacji, bez recyrkulacji pożywki.
Stwierdzono wyższą zawartość potasu, wapnia, magnezu i chloru w liściach pomidora nawożonego pożywką zawierającą chlor, w porównaniu do nawożenia bezchlorkowego. Rodzaj nawożenia potasowego nie wpływał istotnie na skład chemiczny owoców pomidora. Najwięcej witaminy C, cukrów ogółem, azotu ogółem i potasu odnotowano w owocach pomidora uprawianego w torfie.

Słowa kluczowe: pomidor szklarniowy, fertygacja, rodzaj nawożenia potasowego, sucha masa, witamina C, skład chemiczny liści

Accepted for print – Zaakceptowano do druku: 24.11.2005