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EFFECT OF DIFFERENTS TYPES OF POTASSIUM FERTILIZATION ON THE YIELDING OF GREENHOUSE TOMATOES GROWN IN VARIOUS SUBSTRATES

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Abstract. The investigation was carried out in greenhouse with tomato cv. 'Cunero F_1' grown in rockwool, peat and sand substrates with fertigation system without recirculation. In this research nutrient liquid with or without chlorine was tested. The experiment showed no significant differences on the total, marketable and unmarketable yield of plants fertilized nutrient liquid with or without chlorine. The highest yielding of tomato in rockwool, while lowest in sand substrates was detected. The higher weight of one tomato fruit in peat substrate, compare to sand, was observed. Both substrates and kind of potassium fertilizing had no significant effect on the number fruits per plant.

Key words: greenhouse tomato, substrate, fertigation, kind of potassium fertilization, yield

INTRODUCTION

In the instructions for fertilization, potassium fertilizers which are chlorine-free such as potassium saltpeter or potassium sulphate are to be used for growing tomatoes [Nowosielski 1988, Wysocka-Owczarek 1998]. A lot of researchers think that chlorine has a negative impact on plant growth and development as well as plant yielding. They consider chlorine to be the least important of nutrients necessary for plants [Satti and Al-Yahyai 1995]. According to Zekki et al. [1996] chlorine is burden which, together with sodium, causes unnecessary increase in ion concentration (EC) in the root area of plants. However, numerous researches have not indicated negative impact of chlorine on tomato yielding [Borowski et al. 1998, Chapagain et al. 2003]. Furthermore, Chapagain et al. [2003] claim that the use of potassium chloride instead of potassium saltpeter has a positive impact on fruit quality features. Nowotny-Mieczyńska [1976] states that the element takes part in photosynthesis, transport of assimilative substance and has

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indirect influence in protein synthesis. Thus, it participates in vital productive processes for plants.

Finding an alternative to rockwool is a separate issue. The issue arises mainly due to the problem with utilization of production waste. Inden and Torres [2004] claim that at present replacement of rockwool with environment friendly materials is the priority for soil-less crops .

The conducted research indicated the influence of fertilisation with and without chlorine on the content of nutrients in the root area of plants and yielding of the tomato variety ′Cunero F_1′ grown on rockwool, transitional peat and sand.

MATERIALS AND METHODS

The research was conducted in a greenhouse in the period 1999–2000. The tomato variety ′Cunero F1′ was grown in rockwool (Grodan), transitional peat and fine-grained 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 closed fertilizing circuit, without recirculation.

In the research described two kinds of potassium fertilizing were used – with chlorine (KNO_3+ KH_2PO_4+ KCl) and chlorine-free (KNO_3 + KH_2PO_4+ K_2SO_4). In the form of KCl or K_2SO_4, 40% of all amount of potassium used for fertilizing was contributed. The content of sulphates and chlorine in fertilizers differed depending on potassium fertilizing and the amount was: fertilization with KCl – 58 mg·dm^{-3} S-SO_4 and 120 mg·dm^{-3} Cl; fertilization with K_2SO_4 – 119 mg·dm^{-3} S-SO_4 and 21 mg·dm^{-3} Cl. The amount of other nutrients was equal for all plants and it was: (mg·dm^{-3}): 17 N-NH_4, 186 N-NO_3, 73 P-PO_4, 253 K, 265 Ca, 46 Mg, 0,55 Fe, 0,55 Mn, 0,11, 0,05 Cu, 0,13 Zn, 0,03 Mo. The amount of incoming fertilizer was established at about 20% surplus. Frequency of fertilizer supply, regulated by soltimer, depended on solar radiation rate. Daily intake of fertilizer – from 1 to 2,5 dm^3·plant^{-1}, was adjusted to the development phase. Plants were directed to one shoot and headed above the seventh cluster. The growing was done in the spring-summer cycle at density 3,2 plant·m^{-2}. The experiment was taken in random sub-unit system and was repeated 5 times. A mat covered with substratum where two plants grew was an experimental unit.

Picking fruit was done twice a week. The fruit was counted, weighed and sorted; general crop, commercial crop and crop of fruit which were not chosen, as well as average unit mass per fruit and a number of fruit per plant were calculated. Plant protection activities and activities related to the experiment were conducted according to the relevant recommendation.

The content of N-NO_3, P-PO_4, K, Ca, Mg S-SO_4 i Cl and eletrical conductivity (EC) in the root area were marked every ten days starting from putting plants to permanent place (after February 10). The content of nutrients and EC in rockwool was marked in the extract taken with a syringe in the middle of the distance between plants, out of the half of mat thickness. From other substrates the samples (20 cm^3) were taken and the nutrients were extracted with 0,03 M acetic acid. Electrical conductivity (EC) on these substrates was marked in water extract according to volume ratio substrate to water 1:2.

Nitrate nitrogen was marked by Bremner distillation method in Starck modification; phosphorous – calorimetrically with vanadium-molybdenate, K, Ca, Mg – by ASA method (Perkin-Elmer).

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

RESULTS

The research conducted indicated significant differences in content of nutrients in the root area of plants depending on factors measured (tab. 1). In the evaluation irrespective of substrate, while using fertilizer containing chlorine higher content of nitrates, calcium, magnesium, chlorine and higher EC in the plant root area were measured in comparison to chlorine-free fertilizer. Irrespective of the type of potassium fertilization, the biggest amount of nitrate nitrogen, potassium, sulphates, chlorine and the highest EC was found in rockwool. The lowest number of nutrients, beside phosphorous, was found in sand substrate. In peat bigger amount of calcium and magnesium was measured in comparison to other substrates.

Table 1. Modyfications of nutrients content ($mg \cdot dm^{-3}$) and EC ($mS \cdot cm^{-1}$) in root medium according to types of potassium fertilizing and substrates
Tabela 1. Zmiany zawartość składników pokarmowych ($mg \cdot dm^{-3}$) oraz EC ($mS \cdot cm^{-1}$) w strefie korzeniowej roślin w zależności od rodzaju nawożenia potasowego i podłoża

Substrate Podłoże (A)	Potassium fertilizing Nawożenie potasowe (B)	$N\text{-}NO_3$	$P\text{-}PO_4$	K	Ca	Mg	$S\text{-}SO_4$	Cl	EC
Rockwool Wełna mineralna	with chlorine z chlorem	360	40	354	612	116	138	427	3.76
	without chlorine bez chloru	336	46	372	522	99	287	72	3.49
$\bar{x}$ for (dla) A		348	43	363	567	107	212	249	3.63
Peat Torf	with chlorine z chlorem	219	60	312	1347	155	141	396	1.25
	without chlorine bez chloru	213	102	401	1217	157	265	73	1.13
$\bar{x}$ for (dla) A		216	81	356	1282	156	198	234	1.19
Sand Piasek	with chlorine z chlorem	88	71	174	371	60	48	149	0.52
	without chlorine bez chloru	101	99	224	466	66	137	43	0.63
$\bar{x}$ for (dla) A		94	85	199	418	63	92	96	0.57
$\bar{x}$ for B $\bar{x}$ dla B	with chlorine z chlorem	222	57	280	776	110	109	324	1.84
	without chlorine bez chloru	217	82	332	735	107	230	63	1.75

In the experiment no considerable impact of potassium fertilization on tomato yielding was seen. However, general crop and commercial crop of fruit were slightly higher (respectively 4,52 and 4,14 kg·plant^{-1}) at chlorine-free plant fertilization. (tab. 2). Irrespective of the type of potassium fertilization considerably lower general crop (4,09 kg·plant^{-1}) and commercial crop of fruit (3,85 kg·plant^{-1}) was noticed in sand in comparison to other substrates. The impact of other factors tested on mass of fruit outside the choice was negligible.

Table 2. Effect of types potassium fertilizing and substrates on the yielding of greenhouse tomato (kg·plant^{-1})

Tabela 2. Wpływ rodzaju nawożenia potasowego i podłoża na plonowanie pomidora szklarniowego (kg·roślina^{-1})

Podłoże Substrate (A)	Total yield Plon ogólny			Marketable yield Plon handlowy			Unmarketable yield Plon poza wyborem		
	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	$\bar{x}$ for A $\bar{x}$ dla A
Rockwool Wełna mineralna	4.49	4.74	4.62	4.07	4.33	4.20	0.42	0.41	0.41
Peat Torf	4.43	4.61	4.52	4.07	4.23	4.15	0.36	0.38	0.37
Sand Piasek	3.96	4.22	4.09	3.55	3.85	3.70	0.41	0.36	0.38
$\bar{x}$ for B $\bar{x}$ dla B	4.29	4.52		3.90	4.14		0.40	0.38	
$LSD_{0,05}$ for, $NIR_{0,05}$ dla: A	0.38			0.35			n.s. – ni.		
B	n.s. – ni.			n.s. – ni.			n.s. – ni.		
A×B	n.s. – ni.			0,56			n.s. – ni.		

Table 3. Effectt of types of potassium fertilizing and substrates on the fruit mean weigt and number of fruits per plant

Tabela 3. Wpływ rodzaju nawożenia potasowego i podłoża na masę jednostkową owocu i liczbę owoców z rośliny

Substrate Podłoże (A)	Fruit mean weigt (g) Średnia masa owocu (g)			Number of fruits per plant Liczba owoców z rośliny		
	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
Rockwool Wełna mineralna	132.3	141.4	136.8	33.9	33.6	33.7
Peat Torf	137.6	147.2	142.4	32.2	31.4	31.8
Sand Piasek	117.1	130.2	123.7	33.8	32.4	33.1
$\bar{x}$ for B $\bar{x}$ dla B	129.3	139.6		33.3	32.5	
$LSD_{0,05}$ for, $NIR_{0,05}$ dla: A		17.8			n.s. – ni.	
B		n.s. – ni.			n.s. – ni.	
A×B		n.s. – ni.			n.s. – ni.	

In the evaluation irrespective of types of substrates, slightly bigger unit mass per fruit (139,6 g) was found out in growing tomato with chlorine-free fertilization (tab. 3). Statistical analysis of results has not confirmed, however, the importance of differences. Irrespective of type of potassium substrate used, fruit picked from plants grown on peat and rockwool had bigger unit mass (respectively 142,4 g and 136,8 g). Furthermore, tomato fruit grown in sand was considerably smaller (123,7 g).

The factors tested did not have substantial impact on the number of items of plant fruit.

DISCUSSION

In growing plants which are sheltered both the amount of nutrients supplied and the kind of salt taken into root area are important. It is particularly important for soil-less growing where plant root system develops in small substrate volume. Plant fertilization with chlorine or potassium sulphate is not irrelevant for plants due to decisively different physiological functions brought into anion substrate. This fact has utmost importance for plant growth and yielding [Nurzyński et al. 2001]. The research done did not show considerable impact of type of potassium fertilization on general and commercial crop of tomato fruit. The results corroborate earlier tests by Borowski et al. [2000], Hand et al. [1995] and Nurzyński and Michałojć [1998], in which no relevant differences were found out in tomato yielding while fertilizing with and without chlorine. According to Nukaya et al. [1991] chlorine concentration in plant root area which does not exceed the value 10 $mmol \cdot dm^{-3}$ (i.e. 355 $mg \cdot dm^{-3}$) does not negatively influence tomato growth or yielding. Nurzyński and Michałojć [1998] give evidence that the right growth or yielding of this species in peat substrate is possible at concentration 1300 $mg \cdot dm^{-3}$ Cl. In their tests the amount of chlorine in substrates tested ranged 43–427 $mg \cdot dm^{-3}$. A lot of scientists doing research on possibilities of sand use as substrate in greenhouse tomato growing claim that plant yielding is worse in this substrate in comparison to rockwool or peat [Borowski et al. 2000, Nurzyński et al. 2001]. This is also confirmed by other research in which general crop and commercial crop of fruit picked in sand were considerably smaller. According to Nurzyński et al. [2001] sand use in greenhouse tomato growing requires differentiation in concentration of nitrate, potassium, calcium and magnesium in comparison to the amount recommended for growing in rockwool or peat. Other research of the same scientists show that the results of tomato crop in sand are closely related to physical properties of the material, especially regarding to air conditions [Nurzyński et al. 2003]. In the research insufficient root area aeration of plants grown in sand could have been the reason for worse tomato yielding in comparison to rockwool or peat.

The research done indicate that tomato fertilizing with fertilizer containing cholrine or chlorine-free did not have substantial influence on tomato unit mass, which has been also confirmed by the earlier results of Bishnu et al. [2004] and Nurzyński and Michałojć [1998]. Hao et al. [2000] recorded considerable decrease in fruit mass while there was increase in electrical conductivity in plant root area – 3,0–4,6 $mS \cdot cm^{-1}$. The research presented here do not confirm the connection. Fruit with smallest mass was grown is sand which had the lowest EC of all substrates tested.

Lopez et al. [1996] indicated that low sulphur content in substrate can effectively reduce number of plant fruit. My own research do not confirm the fact – more fruit grew on plants fertilized with chlorine fertilizer which had lower sulphate content in plant root area. Bishnu et al. [2004] did not indicate considerable difference in number of plant fruit depending on fertilizer with or without chlorine.

CONCLUSIONS

1. No considerable difference in tomato general crop and commercial crop of fruit depending on type of potassium fertilization was indicated.
2. Type of potassium fertilization did not substantially influence unit mass of fruit and average number of pieces of fruit.
3. Growing plants in sand resulted in considerably lower general crop and commercial crop of fruit in comparison to other substrates.
4. There were recorded bigger pieces of fruit in plants grown on peat and rockwool and considerably smaller ones in hothouse tomato growing in sand.

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WPŁYW RODZAJU NAWOŻENIA POTASOWEGO NA PLONOWANIE POMIDORA SZKLARNIOWEGO UPRAWIANEGO W RÓŻNYCH PODŁOŻACH

Streszczenie. Badania przeprowadzono z pomidorem szklarniowym odmiany 'Cunero F_1' uprawianym w wełnie mineralnej, torfie i piasku z wykorzystaniem kroplowego systemu fertygacji, bez recyrkulacji pożywki. W badaniach zastosowano pożywkę z chlorem (KNO_3 + KH_2PO_4+ KCl) oraz bezchlorkową (KNO_3 + KH_2PO_4+ K_2SO_4) . Nie wykazano istotnych różnic w plonie ogólnym, handlowym oraz plonie owoców poza wyborem pomidora nawożonego pożywką zawierającą chlor i bezchlorkową. Niezależnie od rodzaju nawożenia potasowego najwyższy plon ogólny oraz handlowy wykazano w uprawie roślin w wełnie mineralnej, natomiast istotnie najniższy w piasku. Większą masą jednostkową cechowały się owoce pomidora uprawianego w torfie oraz w wełnie mineralnej. Nie stwierdzono istotnego wpływu badanych czynników na średnią liczbę owoców z rośliny.

Słowa kluczowe: pomidor szklarniowy, podłoża, fertygacja, rodzaj nawożenia potasowego, plonowanie

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