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EFFECT OF POLYMER SUPERSORBENT ADDED TO MEDIUM ON THE CONTENT OF MINERAL ELEMENTS IN STRAWBERRY LEAVES AND FRUIT

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Abstract

The aim of the study was to evaluate the influence of polymer supersorbent AgroHydrogel, added to soil, on the content of some mineral elements in leaves and fruit of strawberry cv. Elsanta. In 2007-2008, a pot experiment set up in a system of complete randomization was carried out in four replications in a greenhouse of the West Pomeranian University of Technology in Szczecin. The experimental factor was the addition of two doses of AgoHydrogel to the medium. The two rates were 1.8 and 3.6 g dm^{-3}, i.e. 15 and 30 g per a Kick's pot versus the control which was the medium with no gel. The experiment was carried out indoors. Soil moisture was measured by means of contact soil tensometers. The plants were watered with 0.5 dm^3 per pot and the tensometer, fitted in the medium with 15 g of gel per pot, showed 450 hPa. The content of the elements in strawberry leaves and fruit was determined by means of the AAS method. The applied polymer supersorbent decreased the cummulation of zinc and lead in leaves and copper, nickel and lead in fruit of strawberry. This effect particularly visible in plants growing in the medium with an increased dose of hydrogel. However, the application of AgroHydrogel did not affect the content of iron, manganese, copper and nickel in leaves and manganese, zinc and iron in fruit of the analyzed variety of strawberry.

Key words: strawberry, AgroHydrogel, microelements.

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WPŁYW SUPERSORBENTU POLIMEROWEGO DODAWANEGO DO PODŁOŻA NA ZAWARTOŚĆ MIKROELEMENTÓW W LIŚCIACH I OWOCACH TRUSKAWKI

Abstrakt

Jednym z głównych czynników ograniczających plon truskawki na plantacjach bez nawadniania jest okresowy niedobór wody w glebie. Korzystny wpływ na właściwości wodno-powietrzne gleby wywierają preparaty zwiększające jej pojemność wodną, tzw. hydrożele (supersorbenty). Związki te mają zdolność wiązania i magazynowania wody grawitacyjnej, co zwiększa ilość wody dostępnej dla systemu korzeniowego roślin.

Celem badań była ocena wpływu supersorbentu polimerowego, AgroHydrogelu, dodawanego do podłoża na zawartość niektórych pierwiastków w liściach oraz owocach truskawki odmiany Elsanta. W latach 2007-2008, w hali wegetacyjnej Zachodniopomorskiego Uniwersytetu Technologicznego w Szczecinie, przeprowadzono doświadczenie wazonowe w układzie kompletnej randomizacji, w czterech powtórzeniach. Czynnikiem doświadczalnym był dodatek AgroHydrogelu do podłoża – zastosowano dwa poziomy: 1,8 oraz 3,6 g dm^{-3}, tj. 15 i 30 g na pojemnik Kicka, oraz kontrola, którą stanowiło podłoże bez dodatku żelu. Doświadczenie przeprowadzono pod zadaszeniem. Wilgotność gleby mierzono za pomocą tensjometrów glebowych kontaktowych. Rośliny podlewano w ilości 0,5 dm^3 na wazon, przy wskazaniu tensjometru, umieszczonego w podłożu z dodatkiem żelu w ilości 15 g na wazon, wynoszącym 450 hPa. Zawartość pierwiastków w liściach oraz owocach truskawki oznaczono metodą ASA. Zastosowany supersorbent polimerowy zmniejszył pobieranie oraz kumulację cynku i ołowiu w liściach oraz miedzi, niklu i ołowiu w owocach truskawki. Szczególnie wyraźnie zaznaczyło się to w roślinach rosnących w podłożu z większą dawką hydrożelu. Dodatek AgroHydrogelu nie wpłynął natomiast na zawartość żelaza, manganu, miedzi i niklu w liściach oraz manganu, cynku i żelaza w owocach badanej odmiany.

Słowa kluczowe: truskawka, AgroHydrogel, mikroelementy.

INTRODUCTION

Poland is one of the largest producers of strawberry fruit (*Fragaria ananassa* Duch.). However, the average strawberry crop does not exceed 3.7 t ha^{-1}, which is due, among other reasons, to the fact that cultivation of strawberries is carried out without irrigation and a high sensitivity of this plant to periodical water defict considerably depressed the yield and its quality (Hołubowicz, Rebandel 1997, Makowska 2004). Hydrogels also known as upersorbents, that is preparations increasing water capacity of soil, have a beneficial influence on water and air properties of soil. Their characteristic feature is an extremely high capability of storing water which otherwise is absorbed from precipitation and some of it can be gradually conveyed to plants (Górecki, Paul 1993, Wierzbicka, Majkowska-Gadomska 2005).

Strawberries easily take up mineral elements from the soil. They also take up macroelements and trace elements and are characterised by their relatively large content as compared to other fruit plants popular in Poland (Jędrzejczak, Szteke 1989, Szteke et al. 2006). The content of mineral elements in plants depends on many environmental factors, including accessibility to soil water.

The available literature does not contain explicit conclusions regarding the effect of hydrogel on chemical composition of berry plants. The present paper shows the results of experiments whose aim was to determine the influence of a polymer supersorbent called AgroHydrogel added to soil on the content of some mineral elements in leaves and fruit of a dessert cultivar of strawberry called Elsanta.

MATERIAL AND METHODS

In 2007-2008, a pot experiment set up in a system of complete randomization was carried out in four replications in a greenhpuse of the West Pomeranian University of Technology in Szczecin. The object of the study was strawberry cv. Elsanta. The experimental factor was the addition of two rates of AgroHydrogel to the medium. The two rates were 1.8 and 3.6 g dm^{-3}, i.e. 15 and 30 g per a Kick's pot versus the control, which was the medium with no gel. The pots of 10 dm^3 capacity were filled with 8 dm^3 of soil material. Prior to filling the pots, hydrogel was added to the medium and then all was mixed. Table 1 shows the characteristics of the soil material.

Table 1

The properties of soil

pH		Percent of clay fraction	S_o (g cm^{-3})	Pkw (%)	Pkv (%)	Wtw (%)	Wtv (%)
H_2O	KCl						
6.58	5.97	21	1.24	24.7	34.0	32.9	38.0

S_o – bulk density, Pkw – capillary weight, Pkv – capillary volume, Wtw – total water capacity in investigated soil – weight, Wtv – total water capacity in investigated soil – volume

The doses of mineral fertilization were 50, 80 and 100 kg NPK ha^{-1}. Potassium, phosphorus and half a dose of nitrogen were applied prior to planting. The remaining half a dose of nitrogen was top-dressed before the flowering of the plants.

In mid-April 2007, frigo seedlings were placed in containers, 1 piece/pot. The experiment was carried out indoors. The plants wintered in pots in an unheated greenhouse. The moisture of soil was measured by means of soil contact tensometers. The plants were watered with 0.5 dm^3 per pot, and the tensometer, fitted in the medium with 15 g of gel per pot, showed 450 hPa. Well grown, healthy leaves and ripe fruit were taken for determination. In both years, the fruit for the analysis were gathered systematically as they were ripening, from the first decade of June to the first decade of July. A collective sample was created for each replication from the gathered fruit. The leaves were gathered once a year (in both years of the experi-

ment) in the second decade of July, after the fruiting of strawberry. The content of iron, manganese, copper, zinc, nickel and lead in fruit and leaves of strawberry was determined in four replications in plant material dried at 105ºC. An average weight of a laboratory sample of dried leaves and fruit for one replication was about 30 g. The plant material (5 g) was wet mineralized in a 03:01 mixture of nitrogen (V) and chloric (VII) acid. The content of the elements in leaves and fruit of strawberry was determined by means of the AAS method (in a SOLAR 939). The determination of the content of chemical elements was carried out at the Department of Soil Science of West Pomeranian University of Technology in Szczecin. The laboratory participated in interlaboratory studies on the comparison of the content of mineral components in reference material (*The Report of Institute of Nuclear...* 2002).

The results of the chemical composition of the plants underwent one-factor analysis of variance. The significance of differences between the averages were defined by Duncan's test at α = 0.05. Due to the homogeneity of the variance of error, the results of two years of experiment were expressed synthetically (WÓJCIK, LAUDAŃSKI 1989). Coefficients of linear correlation between the content of the analyzed elements in fruit and their content in leaves were calculated. When a correlation coefficient was significant at α=0.05, the relationship was shown in a diagram.

RESULTS AND DISCUSSION

The content of iron in fruit of strawberry cv. Elsanta ranged from 59.56 to 79.66 mg kg^{-1} of dry matter (Table 2). According to HAKALA et al. (2003), the average content of this microelement in the strawberry varieties they examined reached 3.2 mg kg^{-1} of fresh matter. According to GAWĘDA and BEN (2004), fruit of cv. Elsanta can accmuluate 103 mg Fe kg^{-1} of dry matter. More iron is accumulated in leaves, where its concentration varied from 146.3 to 273.1 mg kg^{-1} of dry matter. GAWĘDA and BEN (2004) observed that the content of iron in strawberry leaves reached 475 mg kg^{-1} of dry matter. No significant influence of the applied supersorbent on the accumulation of this component was noticed in the fruit or leaves of cv. Elsanta.

Likewise, AgroHydrogel did not affect significantly the amount of manganese in fruit and leaves (Table 2). According to SZTEKE et al. (2006), the content of this microelement in strawberry leaves is on average 4.51 mg kg^{-1} of fresh matter. These authors emphasize the relationship between soil pH and manganese cumulation by strawberry fruit, with an increase in the soil reaction being inhibitory to the uptake of this element by plants. As GAWĘDA and BEN report (2004), the content of manganese in fruit of cv. Elsanta is 54 mg kg^{-1} of dry matter, whereas in leaves it can be 137 mg kg^{-1} of

Table 2

Content of mineral elements in leaves and fruit of strawberry cv. Elsanta (mg kg^{-1} d. m.)

Dose of AgroHydrogel	Fe	Mn	Zn	Cu	Ni	Pb
Fruit						
Control	79.66 *a*	14.57 *a*	19.84 *a*	4.866 *b*	5.296 *b*	6.556 *b*
15 g per pot	71.47 *a*	14.36 *a*	18.46 *a*	3.742 *a*	2.970 *a*	1.851 *a*
30 g per pot	59.56 *a*	14.20 *a*	16.51 *a*	3.49 *a*	1.890 *a*	1.297 *a*
Leaves						
Control	214.1 *a*	27.24 *a*	37.38 *b*	4.187 *a*	2.888 *a*	3.588 *b*
15 g per pot	273.1 *a*	29.40 *a*	34.89 *ab*	3.290 *a*	2.595 *a*	2.198 *ab*
30 g per pot	146.3 *a*	33.21 *a*	28.25 *a*	3.166 *a*	2.320 *a*	1.384 *a*

Means assigned identical letters do not differ significantly at the level of significance $\alpha = 0.05$.

dry matter. The authors have also observed that the content of iron, manganese zinc and copper in strawberries decreased significantly as they grew older.

Our experiments did not show any influence of the addition of AgroHydrogel to the medium on the content of zinc in fruit. However, the supersorbent significantly decreased the content of this element in leaves (Table 2). According to Szteke et al. (2006), strawberry fruit accumulates on average 1.13 mg Zn kg^{-1} of fresh matter, and the uptake of this element by plants does not depend on its content in soil. Gawęda and Ben (2004) report that the concentration of this element in fruit of cv. Elsanta is 31 mg kg^{-1}, whereas in leaves, it can reach 50 mg kg^{-1} of dry matter.

Hakala et al. (2003) claim that the amount of copper in strawberry fruit varies from 0.38 to 0.98 mg kg^{-1} of fresh matter. According to Gawęda and Ben (2004), the amount of copper in strawberry fruit equals 7.8 mg kg^{-1} of dry matter, and in leaves it is 8.8 mg kg^{-1} of dry matter. The supersorbent caused a significant decrease in the content of copper in fruit. The largest content of this element in leaves was found in the control plants, while the lower copper concentration in leaves appeared in plants cultivated in the medium with of 3.6 g dm^{-3} of AgroHydrogel. However, the differences were not statistically significant (Table 2).

The results of our experiment show a considerable influence of the supersorbant added to the medium, such as a decrease in the content of lead and nickel in fruit (Table 2). Significant decrease in the content of heavy metals in fruit can prove that these heavy metals are strongly absorbed by the applied preparation, which reduced amounts of these elements in plant available forms in the medium, which in turn limits their accumulation in

fruit and increases the biological value of the yield. According to SZTEKE et al. (2006), strawberry fruit contain on average 0.01 mg Pb kg^{-1} of fresh matter. Addition of 3.6 g dm^{-3} AgroHydrogel to the medium caused a significant decrease in accumulation of lead in leaves, i.e. by 61% in versus the control. A similar relationship was also observed for the content of nickel in leaves of the analyzed strawberry cultivar (at the dose of 3.6 g dm^{-3} of the gel, the nickel concentration was 19.7% lower than in the control).

Our analysis of the rectilinear correlation showed that only copper demonstrated a significant positive relationship between its content of in fruit and the amounts in strawberry leaves (Figure 1). Regarding the other elements, the coefficients of correlation (r) were non-significant.

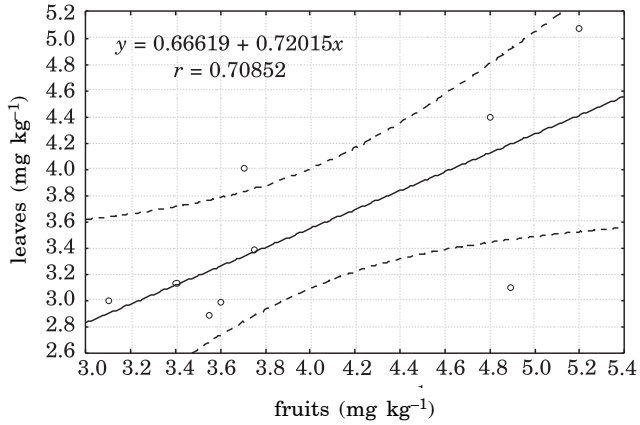

Fig. 1. Dependence of Cu content in fruit on Cu content in leaves of cv. Elsanta strawberry

CONCLUSIONS

1. AgroHydrogel added to the medium did not significantly affect the content of Fe, Mn, Zn in fruit and the amount of Fe, Mn, Cu and Ni in leaves of cv. Elsanta.

2. The polymer supersorbent significantly decreased accumulation of Cu, Pb and Ni in strawberry fruit and Zn and Pb in leaves.

3. The analysis of the rectilinear corrlation showed a strong positive relationship between the content of copper in fruit and its amount in leaves of strawberry.

REFERENCES

GAWĘDA M., BEN J. 2004. *Zmiany zawartości mikroelementów w roślinach truskawki (Fragaria ananassa Duch.) w zależności od czasu uprawy [Changes in the content of micronutrients in strawberry plants (Fragaria ananassa Duch.) depending on the cultivation time].* Fol. Univ. Agric. Stetin., Agricult., 240(96): 55-58. (in Polish)

GÓRECKI R., PAUL M. 1993. *Supersorbenty w ogrodnictwie [Supersorbents in horticulture]* Ogrodnictwo, 4: 12-13. (in Polish)

HAKALA M., LAPVETELAINEN A., HUOPALAHTI R., KALIO H., TAHVONEN R. 2003. *Effects of varieties and cultivation conditions on the composition of strawberries.* J. Food Comp. Anal., 16: 67-80.

HOŁUBOWICZ T., REBANDEL Z. 1997. *Wpływ nawadniania i nawożenia mineralnego na plonowanie truskawki [Effect of irrigation and mineral fertilization on strawberry yield].* Pr. Kom. Nauk Leś., 43:83-89. (in Polish)

JĘDRZEJCZAK R., SZTEKE B. 1989. *Zawartość kadmu i ołowiu w owocach jagodowych i ziarnkowych [Content of cadmium and lead in berty and grain fruits].* Rocz. PZH, 40:274-278. (in Polish)

MAKOWSKA M. 2004. *Przyjęcia sadzonek i wartość handlowa owoców truskawki uprawianej w czarnej ziemi i glebie piaszczystej z dodatkiem ekosorbu [Strawberry seedlings taking roots and the commercial value of strawberry fruit grown in black soil and sandy soil with ecosorbent].* Fol. Univ. Agric. Stetin., Agricult., 240(96): 109-112. (in Polish)

Report of Institute of Nuclear Chemistry and Technology. 2002. *Collaborative study on the determination of trace elements in two candidate reference materials: tea leaves (INCT--TL-1) and mixed Polish herbs (INCT-MPH-2). Preliminary report.* Seria B, 2. Warszawa.

SZTEKE B., JĘDRZEJCZAK R., RĘCZAJSKA W. 2006. *Wpływ niektórych czynników środowiskowych na zawartość metali w truskawkach [Effect of some environmental factors on the content of metals in strawberries].* J. Elementol., 11(2):213-222. (in Polish)

WIERZBICKA B., MAJKOWSKA-GADOMSKA J. 2005. *Wpływ akryżelu sodowego na zawartość niektórych składników organicznych i mineralnych w wybranych odmianach sałaty głowiastej masłowej i kruchej (Lactuca sativa* L. *var. capitata* L.*) [Effect of sodium akryl gel on content of some organic and mineral components in selected cultivars of butterhead and crisphead lettuce Lactuca sativa* L. *var. capitata* L.*)].* J. Elementol., 10(1):193-199. (in Polish)

WÓJCIK A.R., LAUDAŃSKI Z. 1989. *Planowanie i wnioskowanie statystyczne w doświadczalnictwie [Yields and statistical conclusions in experimentation].* PWN, Warszawa. (in Polish)