OPEN ACCESS
Potravinarstvo® Scientific Journal for Food Industry
Crossref Similarity Check Powered by iThenticate

potravinárstvo®

Potravinarstvo, vol. 10, 2016, no. 1, p. 631-636
doi:10.5219/677
Received: 21 October 2016. Accepted: 2 November 2016.
Available online: 19 December 2016 at www.potravinarstvo.com

ISSN 1337-0960 (online)

IMPACT OF THE SYMBIVIT PREPARATION ON QUANTITATIVE AND QUALITATIVE INDICATORS OF TOMATO (*Lycopersicon esculentum* Mill.)

Alena Andrejiová, Ivana Mezeyová, Alžbeta Hegedűsová

ABSTRACT

The aim of the work was the verification of Symbivit preparation containing mycorrhiza fungi from the genus *Glomus* in the cultivation of tomato (varieties Uno Rosso F1 and Brixol F1). The impact of mycorrhiza on the growth parameters of seedlings (overground mass, the mass of the root system, stem diameter, plant height), total fruits yield and quality by the spectrophotometric determination of the total carotenoids in fresh fruits was evaluated. According to the statistical evaluation by the method of multifactorial analysis of variance there was found significant effect of the preparation on all evaluated growth parameters. The increase of the overground part in case of variety Uno Rosso F1 was about 62.43%, in Brixol F1 it was about 75.55% in comparison with control variant. Similarly, the increase in the weight of the root system was found for variety Uno Rosso F1 about 31.38% and for Brixol F1 about 35.98%, as well as in plants height of variety Uno Rosso F1 about 14.06% and of Brixol F1 about 31.84 % when compared to control. Application of Symbivit preparation in tomato cultivation had positive effect on total yields of tomato fruits of both selected varieties. Effect of application of Symbivit preparation on the carotenoids content in tomato fresh fruits was not prove to be statistically significant, as well as it was not found significant difference in the content of total carotenoids when evaluating the influence of the variety.

Keywords: tomato; mycorrhiza; growth parameters; yield; carotenoids

INTRODUCTION

Global production of tomato reaches at the present historically the highest value exceeding 163 million tons per year, which makes tomato (*Lycopersicon esculentum* Mill.) the most grown and industrially processed vegetable species in the world. In Slovakia in terms of production it is the second most cultivated vegetables **(Valšíková et al., 2015)**. Besides the taste this species is important for its valuable compounds, particularly carotenoids, concretely lycopene and β-carotene, which are important protective substances with antioxidant effects **(Petříková et al., 2012; García-Valverde et al., 2013; Perveen et al., 2015)**. The most important carotenoid in tomatoes is lycopene **(Yoshida et al., 2011; Mendelová et al., 2012; Mendelová et al., 2013)**.

To increase the production of vegetables in field conditions and for the ecologisation of the production the research is carried out by the use of preparations on the base of mycorrhizal fungi. Arbuscular mycorrhiza fungi have a role in horticulture as a sustainable, biological protection against pathogens, stress from salinity of the soil and heavy metals. For the host plant by the mycelium, which has bigger digging depth than the root system of the plant, they further improve the supply of water and nutrients, especially of phosphorus, which is immovable and often in hard acceptable form to plants, and of nitrogen. For it the plant supplies of 20% of bounded carbon to fungus. Exchange of nutrients is made through the symbiotic structures inside the root cells of the plant called arbusculers **(Parniske, 2008, Gutjahr and Parniske, 2013)**. The main reason for the use of preparations based on mycorrhizal fungi as it was shown in many researches is promoting of the seedlings growth, increasing of the yields, increasing of the resistance to environmental stress factors, the uniformity the crop, earlier and richer setting of inflorescence. Impact of the arbuscular mycorrhiza was also tested on qualitative parameters of tomato plants by **(Nedorost and Pokluda, 2012)**, where they found the positive effect of the inoculation that resulted in the increased content of the vitamin C. One of the preparations is Symbivit that is suitable for tomato, pepper and other fruit vegetables, beans, peas, allium vegetables, fruit bushes and trees. It can be used for field conditions growing as well as in greenhouses and plastic greenhouses. It is not suitable for brassica plants and for *chenopodiaceae* family. Composition of granule formulation Symbivit consists from clay carriers, from the natural ingredient that supports mycorrhiza - extracts of marine organisms, keratin, and milled minerals and from six species of mycorrhizal fungi. They are: *Glomus intraradices* BEG14 *Glomus mosseae* BEG95, *Glomus. etunicatum* BEG92, *Glomus claroideum* BEG96, *Glomus microaggregatum* BEG56, *Glomus geosporum* BEG199 **(Vojtíšková et al., 2011)**.

The aim of the work was to verify the Symbivit product for cultivation of tomato, namely the impact of mycorrhiza on growth, yield and quality of selected tomato varieties. For this purpose, the experiment was conducted, which was consisted from the evaluation of plants under laboratory conditions at the stage of pre-cultivated seedlings and at the same time the small plot field trial was established. In the experimental part of the work the effect of the used preparation on growth parameters of seedlings

was evaluated, on the achieved yield and fruit quality by the determination of the total carotenoids.

MATERIAL AND METHODOLOGY

The experiment was established in a Botanical garden of Slovak University of Agriculture (further BZ SUA) in 2015. Sowing was realized in the term of 17th March, 2015 in to seeding trays followed by spacing out of the seedlings on 31st March, 2015 at the growth phase of the first true leaf in containers with volume of 0.2 L by the use of a complete growing medium on the base of peat. Control variant i.e. 30 pieces of seedlings of Brixol F1 variety and 30 pieces of seedlings of Uno Rosso F1 varieties was used without Symbivit application. The same number of the plants was grown with the using of growing medium enriched by Symbivit preparation at a dose of 175 g of product per 14 L of substrate. The effect of used preparation on growth parameters of the seedlings was evaluated in a growth phase of 10 true leaves compared to control (pre-cultivated seedlings without the use of the preparation).

The experiment continued in field conditions. Territory of interest belongs to the warm climate area which is suitable for growing of fruit vegetables. On the basis of agrochemical soil analysis and recommended standards for the production of tomatoes there was two weeks before planting applied 206 kg of potassium sulphate (K_2SO_4).ha^{-1} and LAD (60% of N normative), what amounted 294 kg LAD.ha^{-1}. The remaining 40% of N (197 kg LAD.ha^{-1}) was applied in the early July in the phase of

Figure 1 Brixol F1 **(Andrejiová, 2015)**.

Figure 2 Uno Rosso F1 **(Andrejiová, 2015)**.

full ripening of the plant. Planting of the plants in field trial was conducted on 19th May, 2015 in single spacing 0.7 m x 0.3 m, with two monitored variants: control (planting of the seedlings pre-cultivated without the use of the Symbivit preparation) and variant with Symbivit (application of the Symbivit preparation to the substrate for seedling cultivation), each in three replications. Fruit harvest was carried out in full botanical maturity gradually in five terms from 1st July to 5th October, 2015.

Characteristics of Tomato Varieties

Brixol F1 – mid-early determinate variety suitable for combined harvesting. It has a compact moderate growth. The fruits are elongated, resistant to cracking in more frequent rainfall and irrigation. Due to the high content of lycopene they are quickly coloured in full red colour. The variety is very fertile when grown under irrigation and in warm climate (Figure 1).

Uno Rosso F1 – mid-early determinate variety, suitable for mechanized harvesting. It has strong growth with high fertility. The fruits are small, slightly elongated, they weighs 60 – 70 grams and are resistant to cracking in more frequent rainfall and irrigation. The storage time is at least 20 days (Figure 2).

Determination of the growth parameters of the seedlings

In evaluation of the seedlings the plant height, stem diameter, weight of overground part and root system in fresh mass were evaluated. 15 plants within each variant and variety were taken in account. Plant height was measured from the root collar to growth top of the plant. Plant diameter was measured 10 mm above the root collar. The weight of the overground part and root system in fresh matter was evaluated individually by the abolition of the root in the place of root collar.

Determination of total carotenoids

Carotenoids were estimated by spectrophotometric measurement of substances absorbance in petroleum ether extract on spectrophotometer PHARO 100 at 445 nm wavelengths. As a dissolution reagent, there was used acetone **(Hegedűsová et al., 2007)**.

Statistical analysis

The analysis of variance (ANOVA), the multifactor analysis of variance and the multiple Range test were done using the Statgraphics XVII (StatPoint Inc. USA). Significant differences among means were tested (Tukey HSD test, $p < 0.05$).

RESULTS AND DISCUSSION

A. Evaluation of the seedling growth parameters

The weight of the overground parts

Application of the Symbivit preparation had a positive effect on the weight of the plants, which led to weight increasing in the variety Uno Rosso F1 about 62.43% and in Brixol F1 variety about 75.55% compared to the control treatment (Table 1, Figure 3) according to evaluating of the weight of overground part of the seedlings. **Hernádi et al., (2012)** studded the effect of the Symbivit on peppers and similar as in our research they found that after application of Symbivit the significant increasing in weight of overground parts was occurred (19.32 g) comparing to control (13.22 g), which means an increase about 46.14%. **Başak et al., (2011)** examined the effect of endomycorrhizal preparation on tomato seedlings with the similar composition as Symbivit. They noticed a significant impact of the preparation on the weight of overground part, which was in variety Aspendos after preparation using 2.22 g in comparison to control 0.81 g, which represents an increase about 174%. The weight of overground mass was in case of variety Donna after preparation use 1.95 g versus 0.69 g in control. This represents an increase about 182.61%.

The weight of the root system

Considering the effects of application of a Symbivit preparation on the weight of the root system of pre-cultivated tomato seedlings it can be said that the increase in weight was noticed compared to the control treatment in case of Uno Rosso F1 variety about 1.61 g, what represent an increase about 31.38% and in Brixol F1 variety about 1.54 g, what represent an increase about 35.98%. **Oseni et al., (2010)** also found a statistically significant increase in the weight of the root system of tomato seedlings 14, 28 and 42 days after application of mycorrhizal product Biocult containing mycorrhiza fungus *Glomus etunicatum* a *Glomus intraradices.* **Salvioli et al., (2008)** examined the effect of mycorrhizal fungi *Glomus mosseae* BEG12 on tomato variety Pearson. For tomatoes with application of *Glomus mosseae* there was demonstrated a statistically significant increase in weight of the overground parts as well as in weight of the root system.

Diameter of the stem

Diameter of the stem in case of monitored tomato seedling plants of a variety Uno Rosso F1 after application of Symbivit preparation reached in average 4.67 mm (Table1). In comparison to control treatment (4.08 mm) an increase about 12.63% was observed. In the variety Brixol F1 application of Symbivit preparation had no statistically significant effect on stem diameter compared to the control treatment.

Plant height

Application of Symbivit preparation had significant effect on the plant high of tomato seedlings (Figure 3). It was noticed an increase in average of 34.16 mm for variety Uno Rosso F1, what means rising about 14.26% and in variety Brixol F1 about 67.92 mm, consequently an increase about 31.84% compared to control. Similar research conducted on pepper seedlings by **Vojtíšková et al., (2011)** showed a positive impact of Symbivit preparation on plant height in variety Slávy F1.

B. Yield

When evaluating the quantitative parameter, obtained yield of fresh fruit, it can be concluded that the applied preparation had a positive impact on achieving yields (Figure 4). In variety Uno Rosso F1 the yield was after application of Symbivit an average 216.87 $t.ha^{-1}$. Compared to the control variant an increase about 19.07% was observed.

Table 1: Evaluation of seedlings growth parameters after application of Symbivit in the frame of each variety*.

Variety/variant	Uno Rosso F1		Brixol F1	
Estimated parameter	**Control**	**Symbivit**	**Control**	**Symbivit**
Weight of overground part (g)	8.73 ±1.28 a	14.18 ±2.11 b	6.79 ±0.74 A	11.92 ±1.79 B
Weight of root system (g)	5.13 ±0.73 a	6.74 ±1.29 b	4.28 ±0.35 A	5.82 ±0.53 B
Diameter of the stem (mm)	4.08 ±0.19 a	4.67 ±0.42 b	4.46 ±0.48 A	4.96 ±0.59 A
Plant height (mm)	242.92 ±25.29 a	277.08 ±30.17 b	213.33 ±19.72 A	281.25 ±28.95 B

Note: *Means ± standard deviation. Different letters in rows denote significantly different, n = 15, p <0.05.

Figure 3 A – Symbivit, B – control.

Brixol F1 variety is characterized by high fertility. In a variant Symbivit the yield reached 234.52 t.ha^{-1}, which meant an increase compared to control only about 3.54% (8.33 t.ha^{-1}). Following the statistical analysis by the methods of analysis of variance, the impact of variant as well as of variety on crop yields was not statistically significant (Figure 4). **Hernádi and Sasvári (2012)** studied the effect of the Symbivit preparation in the cultivation of pepper where they found a significant increase in fruit yield after application of Symbivit from 3189.56 g/100 plants (control) to 5251.27 g/100 plants, what represented an increase about 39.26%.

Helyes et al., (2015) in his work shows a positive effect of mycorrhiza on yield of tomato fruit in Uno Rosso F1 variety which was recorded in 2013. However, in previous experimental year in 2012 the decline has been noticed, except of Triple Red variety, in case of other varieties Heinz, Uno Rosso and Strombolino. **Damaiyanti et al., (2015)** also found a positive effect of mycorrhizal fungi on fertility of tomato variety Betavila F1. In the variants with mycorrhizal fungi in a dose of 5 g, 10 g, 20 g, the yield (kg/plant) was increased about 21.60%, 24.07% and 35.80% comparing to the control.

C. Total carotenoids content in fresh fruit

Total carotenoids content in fresh tomato fruits after application of Symbivit in variety Uno Rosso F1 was 9.69 mg.100 g^{-1} of fresh matter. The control sample reached 7.94 mg.100 g^{-1} fresh matter. The content of carotenoids after application of Symbivit preparation was increased in Uno Rosso F1 about 1.75 mg.100 g^{-1}, what means an increase about 22.04% compared the control. In contrary for Brixol F1 variety the content of carotenoids in the fresh matter after Symbivit application was 10.36 mg.100 g^{-1}, and for the control the value reached 11.10 mg.100 g^{-1}. That means decline about 6.67% comparing to control. The effect of application of a Symbivit preparation on the content of carotenoids in tomato fresh fruits was not proved to be statistically significant, as well as between the varieties was not found any significant difference in the content of total carotenoids (Figure 5). **Helyes et al., (2015)** also found miscellaneous results of mycorrhiza impact on carotenoid content depending on the variety.

In his work reports that under the mycorrhiza influence the content of lycopene, which is a significant part of carotenoids in tomato fruit, was increased in case of Heinz and Strombolino varieties, which contained

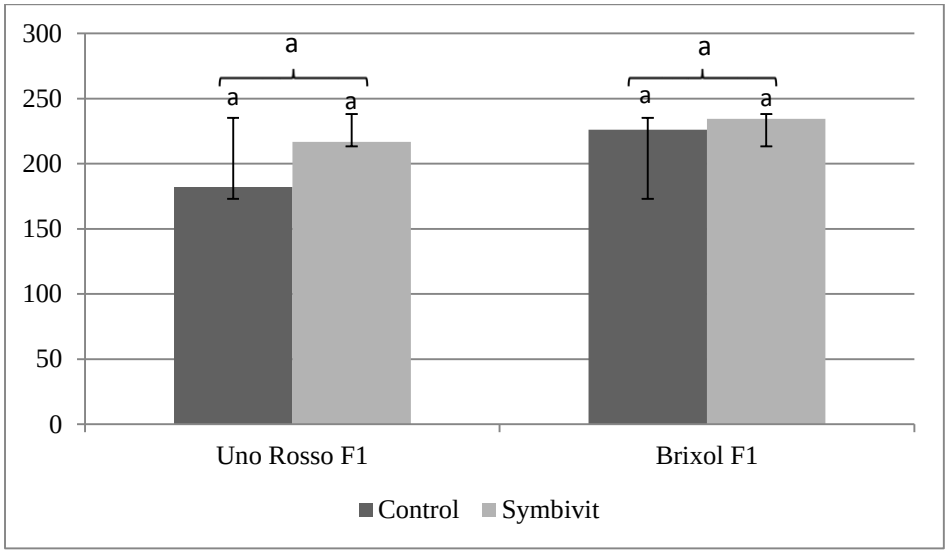

Figure 4: Effect of application of Symbivit preparation on the yield of selected tomato varieties (t.ha^{-1}) ± standard deviation. Note: Columns marked with different letters are significantly different at the level of p <0.05. The same letters above the varieties mean that between them is not a significant difference.

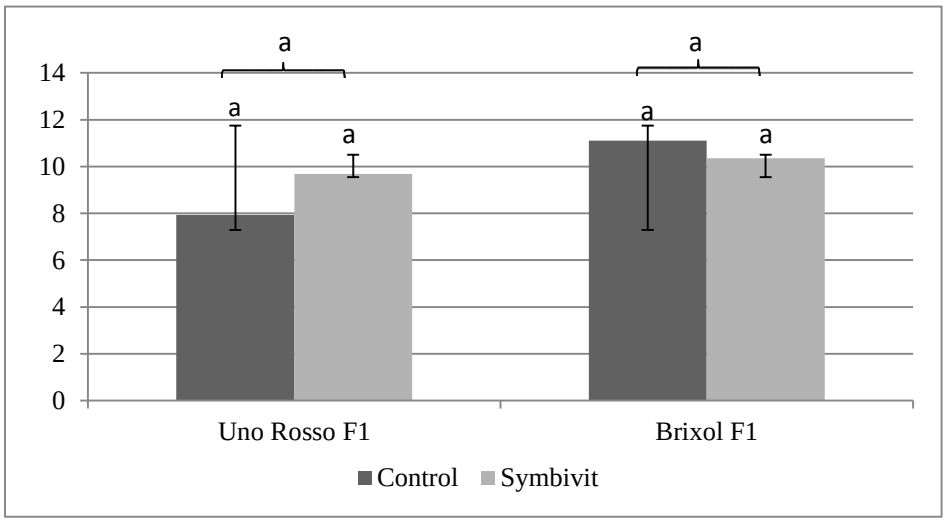

Figure 5 Effect of application of Symbivit preparation on the total carotenoid content in fruits of selected tomato varieties (mg.100 g^{-1} fresh matter) ± standard deviation. Note: Columns marked with same letters are not significantly different at the level of p <0.05. The same letter above the varieties mean that between them is not a significant difference.

9.97 mg.100 g^{-1} and Heinz and 12.22 mg.100 g^{-1} of lycopene compared to control 8.56 mg.100 g^{-1} and 10.86 mg.100 g^{-1}, and it decreased in case of Triple Red and Uno Rosso F1 varieties, containing 10.89 mg.100 g^{-1} and 9.21 mg.100 g^{-1} vs. control 12.46 mg.100 g^{-1} and 9.96 mg.100 g^{-1}.

Hart et al., (2014) found a statistically significant increase in the total carotenoids in the tomato fruits after application of mycorrhizal fungi *Glomus etunicatum* a *Glomus intraradices*.

CONCLUSION

The effect of mycorrhizal granular Symbivit preparation on observed growth parameters in the phase of seedling in both varieties Uno Rosso F1 and Brixol F1 was positive. Based on the statistical evaluation by the method of multifactorial analysis of variance the effect of the preparation on all evaluated parameters was shown to be very significant. Furthermore, it can be concluded that application of the Symbivit preparation in tomato cultivation had positive impact on achieved yields of both observed varieties. However, in assessing of the fruit quality by determining of the total carotenoids it can be said that the choosing of the variety has proved to be a limiting factor in the use of estimated preparation. Based on the statistical evaluation the effect of the Symbivit preparation was not prove to be statistically significant factor of increasing the fertility and total carotenoids in tomato fruit. For more complex results, there is recommendation to verify Symbivit preparation in future in cultivation of a wider range of tomato varieties as well as its use in the production of other types of fruit vegetables.

REFERENCES

Başak, H., Demđr, K., Kasim, R., Okay, F. Y. 2011. The effect of endo-mycorrhiza (VAM) treatment on growth of tomato seedling grown under saline conditions. *African Journal of Agricultural Research*, vol. 6, no. 11, p. 2532-2538.

Damaiyanti, D. R. R. 2015. Effects of arbuscular mycorrhiza inoculation on growth and yield of tomato (*Lycopersicum esculentum* Mill.) under salinity stress. *Journal of degraded and mining lands managemenet*, vol. 3, no 1, p. 447-452.

García-Valverde, V., Navarro-González, I., García-Alonso, J., Periago, M. J. 2013. Antioxidant Bioactive Compounds in Selected Industrial Processing and Fresh Consumption Tomato Cultivars. *Food and Bioprocess Technology*, vol. 6, no. 2, p 391-402. https://doi.org/10.1007/s11947-011-0687-3

Gutjahr, C., Parniske, M. 2013. Cell and Developmental Biology of Arbuscular Mycorrhiza Symbiosis. *Annual reviews*, vol. 29, p.593-617.

Hart, M., Ehret, D. L., Krumbein, A., Leung, C., Murch, S., Turi, C., Franken, P. 2014. Inoculation with arbuscular mycorrhizal fungi improves the nutritional value of tomatoes. *Mycorrhiza*, vol. 25, no. 5, p. 359-376. https://doi.org/10.1007/s00572-014-0617-0 PMid:25391485

Hegedüsová, A., Musilová, J., Jomová, K., Hegedüs, O., Bystrická, J. 2007. *Laboratórne experimenty z organickej chémie a biochémie pre špecializáciu Chémia životného prostredia* (Laboratory experiments of organic chemistry and biochemistry for study specialization Chemistry of environment). UKF : Nitra, 2007, pp.103. ISBN 978-80-8094-211-3.

Helyes, L., Pék, Z., Daood, H. G., Posta, K. 2015. Effect of Mycorrhizae on Main Antioxidant Content of Processing Tomato. *ISHS Acta Horticulturae 1081: XIII International Symposium on Processing Tomato*, p. 105-110. https://doi.org/10.17660/actahortic.2015.1081.10

Hernádi, I., Sasvári, Z. 2012. Arbuscular Mycorrhizal Inoculant Increases Yield of Spice Pepper and Affects the Indigenous Fungal Community in the Field. *Hort. Science*, vol. 47, no. 5, p. 603-606.

Mendelová, A., Andrejiová, A., Líšková, M., Kozelová, D., Mareček, J. 2012. Analysis of carotenoids and lycopene in tomato (*Lycopersicon esculentum* Mill.) and their retention in tomato juice. *Potravinarstvo*, vol. 6, no. 2, p. 36-38. https://doi.org/10.5219/195

Mendelová, A., Mendel, Ľ., Fikselová, M., Czako, P. 2013. Effect of drying temperature on lycopene content of processed tomatoes. *Potravinarstvo*, vol. 7, no. 1, p. 141-145. https://doi.org/10.5219/300

Nedorost, L., Pokluda, R. 2012. Effects of Arbuscular Mycorrhizal Fungi on Tomato Yield and Nutrient Uptake under Differentfertilization Levels. *Acta universitatis agriculturae et silviculturae mendelianae brunensis*, vol. 60, no. 8, p. 181-186. https://doi.org/10.11118/actaun201260080181

Oseni, T., Shongwe, N. S., Masarirambi, M. T. 2010. Effect of Arbuscular Mycorrhiza (AM) Inoculation on the Performance of Tomato Nursery Seedlings in Vermiculite. *International Journal of Agriculture and Biology*, vol. 12, no. 5.

Parniske, M. 2008. Arbuscular mycorrhiza: the mother of plant root endosymbioses. *Nature Reviews Microbiology*, vol. 6, no. 10, p. 763-775. https://doi.org/10.1038/nrmicro1987 PMid:18794914

Perveen, A. R., Suleria, H. A. R., Anjum, F. M., Butt, M. S., Pasha, I., Ahmad, S. 2015. Tomato (*Solanum lycopersicum*) carotenoids & lycopenes chemistry; Metabolism. Absorption. Nutrition and Allied health claims - A comprehensive review. *Critical Reviews in Food Science and Nutrition*, vol. 55, no. 7, p. 919-929. https://doi.org/10.1080/10408398.2012.657809 PMid:24915375

Petříková, K., Hlušek, J. et al. 2012. *Zelenina (Vegetable)*. Praha : Profi Press, 191 p. ISBN 978-80-86726-50-2.

Salvioli, A., Novero, M., Lacourt, I., Bonfante, P. 2008. The impact of mycorrhizal symbiosis on tomato fruit quality. [online] 2016-20-19 [2016-20-19] Available at: http://orgprints.org/12844/1/12844.pdf.

Valšíková, M., Bellan, Ľ., Rehuš, M. 2015. Produkcia rajčiakov v Slovenskej republike (Lycopersicum production in Slovak republic), *Zahradnictví*, vol. 12, p. 28-29.

Vojtíšková, J., Nedorast, Ľ. Pokluda, R. 2011. Využití mykorhizní symbiózy při předpěstování papriky (Use of mycorrhiza in pre-cultivated peppers). In *Salaš,* P. (ed.) *Rostliny v podmínkách měnícího se klimatu, (Plants in a changing climate)*, Lednice 20.-21. October 2011, Czech Republic. *Úroda* (scientific appendix) p. 662-667. ISSN 0139-6013. Available at: http://www.cbks.cz/Rostliny2011/prispevky/VojtiskovaNedorostPokluda.pdf

Yoshida, K., Yokoyama, H., Oteki, T., Matsumoto, G., Aizawa, K., Inakuma, T. 2011. Evaluation of the effect of dietary lycopene, the main carotenoid in tomato (*Lycopersicon esculentum*), on the in vivo renal reducing ability by a radiofrequency electron paramagnetic resonance method. *Journal of Agricultural and Food Chemistry*, vol. 59, no. 7, p. 2966-2971. https://doi.org/10.1021/jf1041883 PMid:21381743

Acknowledgments:

The work was supported by VEGA project No. 1/0105/14 and KEGA project No. 038SPU-4/2014.

Contact address:

Ing. Alena Andrejiová, PhD., Slovak University of Agriculture, Horticulture and Landscape Engineering Faculty, Department of Vegetable Production, Tr. A. Hlinku 2, 949 76 Nitra Slovakia, E-mail: alena.andrejiova@uniag.sk.

Ing. Ivana Mezeyová, PhD., Slovak University of Agriculture, Horticulture and Landscape Engineering Faculty, Department of Vegetable Production, Tr. A. Hlinku 2, 949 76 Nitra Slovakia, E-mail: ivana.mezeyova@uniag.sk.

prof. RNDr. Alžbeta Hegedűsová, PhD., Slovak University of Agriculture, Horticulture and Landscape Engineering Faculty, Department of Vegetable Production, Tr. A. Hlinku 2, 949 76 Nitra Slovakia, E-mail: alzbeta.hegedusova@uniag.sk.