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Klijavost i vigor sjemena kres salate nakon tretmana biljnim ekstraktima

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SUMMARY

The usage of biologically active and environmentally friendly compounds has increasingly important role in the primary food production. This study was conducted in order to examine the impact of five commercial plant extracts on the seed vigour of garden cress (Lepidium sativum L.). The applied plant extracts significantly increased the germination. The highest fresh weight of seedlings, and also the lowest dry matter accumulation were observed in the treatment KE-plantasalva® without the sea salt addition. Equisetum extract inhibited the root elongation and resulted in the highest percentage of dry matter accumulated in seedlings, but also the lowest fresh weight.

Key-words: garden cress, plant extracts, seed, germination, vigour

INTRODUCTION

Although there are plenty of published papers dealing with some valuable nutritive, antioxidant and curative properties of garden cress (*Lepidium sativum* L.; family *Brasicaceae*), (Kassie et al., 2002; Kasabe et al., 2012; Indumathy and Aruna, 2013), it should be noted that this vegetable crop is unfortunately forgotten, and rarely used in our farming and human diet. On the other side, garden cress is known as a biological indicator of soil contamination due to its ability of heavy metals accumulation (Gunduz et al. 2012; Kiayee et al., 2012; Kathi and Khan, 2011). Thus, it is very important to care about the soil health as well as cultivation technology of this vegetable in order to preserve the quality of its nutritional composition. Residues of pesticides, fertilizers and animal manure, such as immature compost can act phytotoxically, inhibit or reduce the germination and early growth. Biostimulators or so-called biological elicitors are the extracts obtained from one or more plant species, having some stimulatory effects on growth and development of cultivated plants (Zhang and Schmidt, 1997). This group includes the extracts of various microorganisms, algae, fungi and yeasts, as well.

The effect of elicitors is seen through the stimulation of secondary metabolism and sustainable changes within the plant (Saniewski and Czapski, 1983; Seljasen et al., 2001; Briceño et al., 2012), consequently resulting in increasing tolerance to subsequent pathogen infections and pests attack (Buzi et al., 2004; Faoro et al., 2004; Cooper and Goggin, 2005; Bougthon et al., 2006). In general, biostimulators increase tolerance to the oscillations of environmental factors outside the optimum range specific to a particular plant species. In such adverse growth conditions, biostimulators can improve the uptake and usage of nutrients, reduce leaf nitrate content, increase chlorophyll concentration, stimulate antioxidative mechanisms in the cell, resulting in higher yield and quality of different plant species (Vernieri et al., 2002, Maini, 2006; Eyheraguibel et al., 2008; Parađiković et al., 2008, 2009; Feitosa de Vasconcelos et al., 2009; Špoljarević et. al., 2010, Zeljkovic et al., 2010).

The aim of this research was to examine the effects of several commercially available plant extracts on seed germination, root length, fresh and dry mass of seedlings of garden cress (*Lepidium sativum* L.).

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MATERIAL AND METHODS

Seed of garden cress (*Lepidium sativum* L.) from the Austrian manufacturer *"Reinsaat KG"* was treated with 0.5% solutions of five different commercial plant extracts belonging to following groups: growth stimulators (KE-plantasalva® (former name Planta salva®) without and with the addition of sea salt, a manufacturer *"Paracelsus shopping and Vertriebs GmbH"*); soil improvers (Fermented plant extract, Fermentierter Pflanzenextrakt®, manufacturer *"Multikraft Produktions und Handels GmbH"*, Biplantol Universal®, manufacturer *"Bellaflora biogarten gmbH"*); agents for the plant care and strengthening (horsetail (*Equisetum arvense* L.) extract, Acker-Schachtelhalm extract®, manufacturer *"Bellaflora biogarten gmbH"*) as well as water as a control. Seeds of garden cress were germinated on fluted filter paper, previously soaked with plant extract or water respectively, and placed in plastic containers. The experiment was set up in three replicates with 50 seeds in each repetition. To prevent the loss of water, containers were covered with a transparent plastic cover and left in ambient conditions. After 7 days of germination, the number of fully developed and healthy seedlings was counted, weighed whereas root length was measured. After drying at 105°C for 2 hours and at 85°C for the next 24 hours in a drying chamber, samples were weighed again and dry matter (DW) was calculated. Means of replicates of all the tested parameters were analysed by mono-factorial one-way analysis of variance (ANOVA) including statistical tests of significance of the applied treatments - the F test and Fisher's LSD test using SAS Software 9.1.3 (2002nd to 2003rd, SAS Institute Inc., Cary, USA).

RESULTS AND DISCUSSION

The most of previous research reported the effects of different plant extracts on plantlets or mature plants (Vernieri et al., 2002; García et al., 2006; Parađiković et al., 2009; Vinković et al., 2009, 2013; Štolfa, 2010), but their effect on seed germination and early development of seedlings was rarely examined. The results of our research on garden cress seed showed significant impact of the applied treatments on germination percentage (P=0.003) (Figure 1). Significant differences among the applied treatments were established and the lowest germination was obtained in the control (71%), while all of the applied biostimulators significantly increased germination.

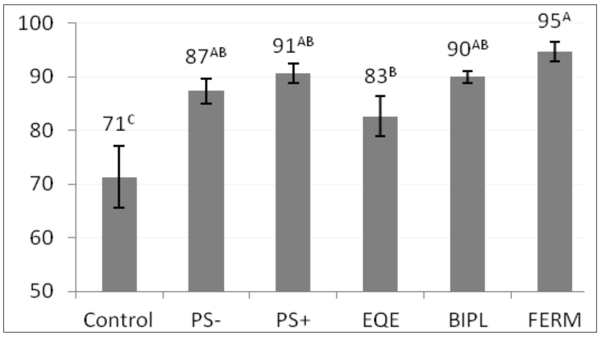

Figure 1. Germination of garden cress (%). *Control (water); PS- (KE-plantasalva without the addition of sea salt); PS+ (KE-plantasalva with sea salt); EQE (Equisetum extract); BIPL (Biplantol); FERM (Fermented plant extract). ^{A,B,C} significant differences among means at P≤0.05 (± standard error; LSD test)

*Grafikon 1. Klijavost kres salate (%).*Kontrola (voda); PS- (KE-plantasalva bez dodatka morske soli); PS+ (KE-plantasalva s dodatkom morske soli); EQE (Equisetum ekstrakt); BIPL (Biplantol); FERM (Fermentirani biljni ekstrakt). ^{A,B,C} značajne razlike na razini pogreške P≤0.05 (± standardna pogreška; LSD test)*

Treatment with fermented plant extract (FERM) resulted in the highest germination percentage (95%). Such result can be attributed to positive and stimulating activity of microorganisms in the fermented plant extract, making the substantial difference between this and all other extracts used in the study. Therefore, it is possible that physiological products of microorganism's metabolism, such as enzymes and other physiologically active substances, might contribute to a decomposition of seed organic matter resulting in better and faster utilization of energy-rich compounds during the heterotrophic period of seedling development. Furthermore, microorganisms synthetize various antibiotic compounds which could suppress seed-born and other pathogens, commonly responsible for a decay of seedlings (Niku-Paavola et al., 1999). Equisetum extract (EQE) resulted in the lowest increase in germination of garden cress (83%), as compared to the control (71%) and all other treatments. Regarding the variants of KE-plantasalva treatment (with or without the sea salt addition) and Biplantol, there were no significant differences in cress seed germination percentage among these treatments (PS- 87%; PS+ 91%; BIPL 90%).

According to F-test, seed treatments significantly influenced root length of garden cress seedlings (P=0.0014; Figure 2).

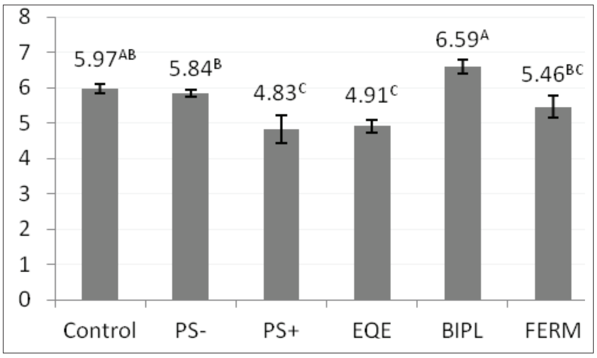

Figure 2. Root length of garden cress seedlings (cm). *Control (water); PS- (KE-plantasalva without the addition of sea salt); PS+ (KE-plantasalva with sea salt); EQE (Equisetum extract); BIPL (Biplantol); FERM (Fermented plant extract). ^{A,B,C} significant differences among means at *P*≤0.05 (± standard error; LSD test)

*Grafikon 2. Dužina korjenčića klijanaca kres salate (cm). *Kontrola (voda); PS- (KE-plantasalva bez dodatka morske soli); PS+ (KE-plantasalva s dodatkom morske soli); EQE (Equisetum ekstrakt); BIPL (Biplantol); FERM (Fermentirani biljni ekstrakt). ^{A,B,C} značajne razlike na razini pogreške P≤0.05 (± standardna pogreška; LSD test)*

Treatments with KE-plantasalva with sea salt and equisetum extract significantly reduced root length of garden cress seedlings (PS+ 4.83 cm; EQE 4.91 cm). Bajguz and Tretyn (2003) attributed this inhibitory effect of equisetum extract to relatively high concentrations of brassinosteroids stored in strobilus. Brassinosteroids stimulate synthesis of ethylene which influences the synthesis and transport of auxin, which finally results in inhibition of primary root cells elongation (Růžička et al., 2007). Also, it is possible that sea salt added to KE-plantasalva, caused moderate salt stress because seedlings germinated on filter paper were in direct contact with solution of biostimulator. Probably, the applied concentration of KE-plantasalva added into the substrate would not exhibit the same effect as seen here, as one part of active ions would be inactivated due to the reactions with substrate. However, this could apply to all the other plant extracts tested in our research, as well. The effects of biological elicitors depend on the concentration of the solution but also on media in which plants are grown. Therefore, high concentrations of biostimulators as well as increased availability of physiologically active compounds in their composition, could adversely affect seed vigour (Bergmayr et al., 2013). In addition, there are many environmental factors that can reduce or intensify the effect of biostimulators.

The applied biostimulators significantly affected fresh weight of seedlings (*P*=0.0014; Figure 3).

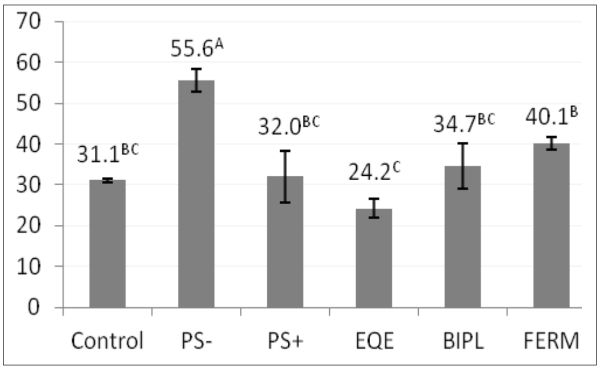

Figure 3. Fresh weight of garden cress seedlings (mg/plant). *Control (water); PS- (KE-plantasalva without the addition of sea salt); PS+ (KE-plantasalva with sea salt); EQE (Equisetum extract); BIPL (Biplantol); FERM (Fermented plant extract). ^{A,B,C} significant differences among means at *P*≤0.05 (± standard error; LSD test)

*Grafikon 3. Svježa masa klijanaca kres salate (mg/biljci). *Kontrola (voda); PS- (KE-plantasalva bez dodatka morske soli); PS+ (KE-plantasalva s dodatkom morske soli); EQE (Equisetum ekstrakt); BIPL (Biplantol); FERM (Fermentirani biljni ekstrakt). ^{A,B,C} značajne razlike na razini pogreške P≤0.05 (± standardna pogreška; LSD test)*

Here, we can compare these results with dry matter content (Figure 4) where the lowest seedlings fresh weight was established in treatment with equisetum extract (24.2 mg/plant). This, on the other hand, accumulated the highest amount of dry matter (7.50%). The highest seedlings fresh weight (55.6 mg/plant) was obtained in treatment KE-plantasalva without sea salt, and it was on the average by 23.18 mg/seedling higher in comparison with all the other applied treatments. In research of Kappert et al. (2011) conducted with spinach and pak choi, KE-plantasalva treatment increased the number of leaves on both plant species. In our research, KE-plantasalva treatment with the addition of sea salt significantly decreased plant fresh weight in comparison with the same biostimulator without the addition of sea salt. Also, as with root length, it could be assumed that sea salt in extract caused salt stress which adversely affected development of seedlings. To be more specific, it was reported that the increase of osmotic potential of surrounding solution reduces seed water uptake, which directly reflects as decline in plant fresh weight (Kurth et al., 1986; Tunçtürk et al., 2011).

F-test showed significant effect of the applied biostimulators on seedling dry matter accumulation (*P*≤0.0002; Figure 4).

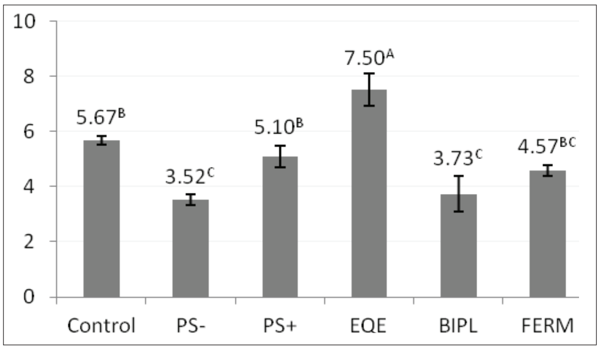

Figure 4. Dry weight of garden cress seedlings (%). *Control (water); PS- (KE-plantasalva without the addition of sea salt); PS+ (KE-plantasalva with sea salt); EQE (Equisetum extract); BIPL (Biplantol); FERM (Fermented plant extract). A,B,C significant differences among means at $P \leq 0.05$ (± standard error; LSD test)

*Grafikon 4. Suha masa klijanaca kres salate (%). *Kontrola (voda); PS- (KE-plantasalva bez dodatka morske soli); PS+ (KE-plantasalva s dodatkom morske soli); EQE (Equisetum ekstrakt); BIPL (Biplantol); FERM (Fermentirani biljni ekstrakt). A,B,C značajne razlike na razini pogreške P≤0.05 (± standardna pogreška; LSD test)*

Significantly lower accumulation of dry matter in seedlings was observed in treatments with KE-plantasalva without the sea salt addition (3.52%) and Biplantol (3.73%), as compared to the control (5.67%). In treatment with equisetum extract, dry weight of seedlings increased on the average 39% as compared to the control and treatment with KE-plantasalva with the sea salt addition, and 90% on the average for all other biostimulators applied. Horsetail (*Equisetum arvense* L.) is known as hyperaccumulator of silicone, which is in layers of varying thickness deposited in cell walls (Sapei et al., 2007; Law and Exley, 2011). Numerous studies have confirmed positive effect of silicone on plant growth and development, especially under stress conditions (Lux et al., 2002; Liang et al., 2003; Gong et al., 2003, 2005; Kaya et al., 2006, Rohanipoor et al., 2013) which imply that significant increase of dry matter of seedlings in aforementioned treatment may be attributed to stimulating effect of silicon.

CONCLUSIONS

Since organic production through sustainable agriculture is increasingly interesting, it is assumed that plant extracts acting as biological elicitors might play an important role in the primary food production. Considering the effects of the applied plant extracts on indicators of garden cress seed vigour, it is difficult to distinguish which plant extract can make the most favourable influence on growth and seedlings development. The opposite effect of KE-plantasalva® without the addition of sea salt and Equisetum extract on dry and fresh matter accumulation, suggest that the chemical composition of plant extracts may have an influence on seed water uptake and seedling development. It should also be noted that, depending on the type of plant extract and the concentration applied, biostimulators may show different effects. Therefore, further research is needed to reveal the exact physiological mechanisms of a wide range of physiologically active compounds in the composition of tested biostimulators, with aim of better usage in plant production.

REFERENCES

1. Bajguz, A., Tretyn, A. (2003): The chemical characteristic and distribution of brassinosteroids in plants. Science Direct, 62(7): 1027–1046. doi: http://dx.doi.org/10.1016/S0031-9422(02)00656-8
2. Bergmayr, L., Hartmann, M., Helm, C. (2013): Wirkung von Pflanzenstärkungsmitteln und Biochar-Additiven auf die Keimung (Kressetest). Graduate thesis. Universität für Bodenkultur, Wien, Austrija. Projekt Garten-, Obst- und Weinbau.
3. Boughton, A.J., Hoover, K., Felton, G.W. (2006): Impact of chemical elicitors applications on greenhouse tomato plants and population growth of the green peach aphid, *Myzus persicae*. Entomologia Experimentalis et Applicata, 120: 175-188. doi: http://dx.doi.org/10.1111/j.1570-7458.2006.00443.x
4. Briceño, Z., Almagro, L., Sabater-Jara, A.B., Calderón, A.A., Pedreño, M.A., Ferrer, M.A. (2012): Enhancement of phytosterols, taraxasterol and induction of extracellular pathogenesis-related proteins in cell cultures of Solanum lycopersicum cv Micro-Tom elicited with cyclodextrins and methyl jasmonate. Journal of Plant Physiology, 169: 1050-1058. doi: http://dx.doi.org/10.1016/j.jplph.2012.03.008
5. Buzi, A., Chilosi, G., Magro, P. (2004): Induction of resistance in melon seedlings against soil-borne fungal pathogens by gaseous treatments with methyl jasmonate and ethylene. Journal of Phytopathology, 152: 491–497. doi: http://dx.doi.org/10.1111/j.1439-0434.2004.00885.x
6. Cooper, W.R., Goggin, F.L. (2005): Effects of jasmonate-induced defenses in tomato on the potato aphid, *Macrosiphum euphorbiae*. Entomologia Experimentalis et Applicata, 15: 107-115. doi: http://dx.doi.org/10.1111/j.1570-7458.2005.00289.x
7. Eyheraguibel, B., Silvestre, J., Morard, P. (2008): Effects of humic substances derived from organic waste enhancement on the growth and mineral nutrition of maize. Bioresource Technology, 99: 4206-4212. doi: http://dx.doi.org/10.1016/j.biortech.2007.08.082
8. Faoro, F., Maffi, D., Cantu, D., Iriti, M. (2008): Chemical-induced resistance against powdery mildew in barley: the effects of chitosan and benzothiadiazole. Biocontrol, 53: 387–401. doi: http://dx.doi.org/10.1007/s10526-007-9091-3
9. Feitosa de Vasconcelos, A.C., Zhang, X., Ervin, E.H., Kiehl, J. (2009): Enzymatic antioxidant responses to biostimulants in maize and soybean subjected to drought. Scientia Agriculturae, 66(3): 395-402.
10. García, A.L., Franco, J.A., Nuria, N., Madrid Vicente, R. (2006): Influence of amino acids in the hydroponic medium on the growth of tomato plants. Journal of Plant Nutrition, 29 (12): 2093-2104. doi: http://dx.doi.org/10.1080/01904160600972183

11. Gong, H., Chen, K., Chen, G., Wang, S., Zhang, C. (2003): Effects of silicon on growth of wheat under drought. Journal of Plant Nutrition, 26: 1055–1063.
    doi: http://dx.doi.org/10.1081/PLN-120020075
12. Gong, H., Zhu, X., Chen, K., Wang, S. Zhang, C. (2005): Silicon alleviates oxidative damage of wheat plants in pots under drought. Plant Science, 169: 313–321.
    doi: http://dx.doi.org/10.1016/j.plantsci.2005.02.023
13. Gunduz, S., Uygur, F.N., Kahramanoğlu, I. (2012): Heavy metal phytoremediation potentials of *Lepidum sativum* L., *Lactuca sativa* L., *Spinacia oleracea* L. and *Raphanus sativus* L. Agriculture and Food Science Research, 1(1): 001–005.
14. Indumathy, R., Aruna, D.A. (2013): Free radical scavenging activities, total phenolic and flavonoid content of *Lepidium sativum* (Linn.). International Journal of Pharmacy and Pharmaceutical Sciences, 5(4): 634-637.
15. Kappert, R., Djufri, I., Balas, J. (2011): Testing a Plant Strengthening Agent in Horticulture. Bulletin UASVM Horticulture, 68(1): 1843-5254.
16. Kasabe, P.J., Patil, P.N., Kamble, D.D., Dandge, P.B. (2012): Nutritional, elemental analysis and antioxidant activity of garden cress (*Lepidium sativum* L.) seeds. International Journal of Pharmacy and Pharmaceutical Sciences, 4(3): 392-395.
17. Kassie, F., Rabot, S., Uhl, M., Huber, W., Min Qin, H., Helma, C., Schulte-Hermann, R., Knasmüller, S. (2002): Chemoprotective effects of garden cress (*Lepidium sativum*) and its constituents towards 2-amino-3-methyl-imidazo[4,5-f]quinoline (IQ)-induced genotoxic effects and colonic preneoplastic lesions. Carcinogenesis, 23(7): 1155-1161.
    doi: http://dx.doi.org/10.1093/carcin/23.7.1155
18. Kathi S., Khan A. B. (2011): Phytoremediation approaches to PAH contaminated soil. Indian Journal of Science and Technology, 4(1): 56-63.
    doi: http://dx.doi.org/10.17485/ijst/2011/v4i1/29935
19. Kaya, C., Tuna, L., Higgs, D. (2006): Effect of silicon on plant growth and mineral nutrition of maize grown under water-stress conditions. Journal of Plant Nutrition, 29: 1469–1480.
    doi: http://dx.doi.org/10.1080/01904160600837238
20. Kiayee S. B., Kumleh A. S., Amirossadat, Z. (2012): Phytoextraction of lead from soil by *Lepidium sativum* L. Caspian Journal of Applied Sciences Research, 1(1): 1-6.
21. Kurth, E., Cramer G.R., Lauchli A., Epstein, E. (1986): Effects of NaCl and $CaCl_2$ on cell enlargement and cell production in cotton roots. Plant Physiology, 82: 1102-1106.
22. Law, C., Exley, C. (2011): New insight into silica deposition in horsetail (Equisetum arvense). Bio Med Central, Plant Biology, 11: 112.
    doi: http://dx.doi.org/10.1186/1471-2229-11-112
23. Liang, Y.C., Chen, Q.R., Liu, Q., Zhang, W.H., Ding, R.X. (2003): Exogenous silicon (Si) increases antioxidant enzyme activity and reduces lipid peroxidation in roots of salt-stressed barley (*Hordeum vulgare* L.). Journal of Plant Physiology, 160: 1157–1164.
    doi: http://dx.doi.org/10.1078/0176-1617-01065
24. Lux, A., Luxova, M., Hattori, T., Inanaga, S., Sugimoto, Y. (2002): Silicification in sorghum (Sorghum bicolor) cultivars with different drought tolerance. Physiologia Plantarum, 115: 87–92.
    doi: http://dx.doi.org/10.1034/j.1399-3054.2002.1150110.x
25. Maini, P. (2006): The experience of the first biostimulant, based on aminoacids and peptides: a short retrospective review on the laboratory researches and the practical results. Fertilitas Agrorum, 1(1): 29-43.
26. Niku-Paavola, M.-L., Laitila, A., Mattila-Sandholm, T., Haikara, A. (1999): New types of antimicrobial compounds produced by *Lactobacillus plantarum*. Journal of Applied Microbiology, 86: 29–35.
    doi: http://dx.doi.org/10.1046/j.1365-2672.1999.00632.x
27. Parađiković, N., Vinković, T., Radman, D. (2008): Utjecaj biostimulatora na klijavost sjemena cvjetnih vrsta. Sjemenarstvo, 25(1): 25-33.
28. Parađiković, N., Zeljković, S., Đurić, G., Vinković, T., Mustapić-Karlić, J., Kanižai, G., Iljkić, D. (2009): Rast i razvoj kadife (*Tagetes erecta* L.) pod utjecajem volumena supstrata i tretmana biostimulatorom. Zbornik radova 44. hrvatskog i 4. međunarodnog simpozija agronoma. Lončarić, Z.; Marić, S. (ur.). Osijek: Sveučilište J. J. Strossmayera, Poljoprivredni fakultet u Osijeku, Opatija, Hrvatska, str.786-790.
29. Rohanipoor, A., Norouzi, M., Moezzi, A., Hassibi, P. (2013): Effect of silicon on some physiological properties of maize (*Zea Mays*) under salt stress. Journal of Biodiversity and Environmental Sciences, 7(20): 71-79.
30. Růžička, K., Ljung, K., Vanneste, S., Podhorská, R., Beeckman, T., Friml, J., Benková, E. (2007): Ethylene Regulates Root Growth through Effects on Auxin Biosynthesis and Transport-Dependent Auxin Distribution. The Plant Cell, 19(7): 2197–2212.
    doi: http://dx.doi.org/10.1105/tpc.107.052126
31. Saniewski, M., Czapski, J. (1983): The effect of methyl jasmonate on lycopene and ß- carotene accumulation in ripening red tomatoes. Experientia, 39: 1373–1374.
32. Sapei, L., Gierlinger, N., Hartmann, J., Nöske, R., Strauch, P., Paris, O. (2007): Structural and analytical studies of silica accumulations in Equisetum hyemale. Analytical and Bioanalytical Chemistry, 389(4): 1249-1257.
    doi: http://dx.doi.org/10.1007/s00216-007-1522-6
33. Seljasen, R., Hoftun, H., Bengtsson, G.B. (2001): Sensory quality of ethyleneexposed carrots (Daucus carota L., cv 'Yukon') related to the contents of 6- methoxymellein, terpenes and sugars. Journal of the Science of Food and Agriculture, 81: 54–61.
    doi: http://dx.doi.org/10.1002/1097-0010(20010101)81:1<54::AID-JSFA781>3.0.CO;2-K
34. Špoljarević, M., Štolfa, I., Lisjak, M., Stanisavljević, A., Vinković, T., Agić, D., Parađiković, N., Teklić, T., Engler, M., Klešić, K. (2010): Strawberry (Fragaria x ananassa Duch) leaf antioxidative response to biostimulators and reduced fertilization with N and K. Poljoprivreda/Agriculture, 16(1): 50-56.
35. Štolfa, I. (2010): Utjecaj biostimulatora i reducirane gnojidbe na kvalitetu ploda jagoda i zaštitu okoliša. Disertacija, Odjel za biologiju, Sveučilište J. J. Strossmayera u Osijeku, Osijek.

36. Tunçtürk, M., Tunçtürk, R., Yildirim, B., Çiftçi, V. (2011): Effect of salinity stress on plant fresh weight and nutrient composition of some Canola (*Brassica napus* L.) cultivars. African Journal of Biotechnology, 10(10): 1827-1832.
doi: http://dx.doi.org/10.5897/AJB10.1618

37. Vernieri, P., Malorgio, F., Tognoni, F. (2002): Use of biostimulants in production of vegetable seedlings. Colture-Protette, 31(1): 75-79.

38. Vinković, T. (2011): Učinkovitost primjene biostimulatora u uzgoju presadnica rajčice. Disertacija, Poljoprivredni fakultet u Osijeku, Sveučilište J. J. Strossmayera u Osijeku, Osijek.

39. Vinković, T., Parađiković, N., Teklić, T., Tkalec, M., Josipović, A. (2013): Utjecaj biostimulatora na indeks lisne površine kod rajčice. Zbornik radova 48. hrvatskog i 8. međunarodnog simpozija agronoma. Lončarić, Z.; Marić, S. (ur.). Osijek: Sveučilište J. J. Strossmayera, Poljoprivredni fakultet u Osijeku, Dubrovnik, Hrvatska, str. 358-362.

40. Zeljković, S., Parađiković, N., Babić T., Đurić, G., Oljača, R., Vinković, T., Tkalec, M. (2010): Influence of biostimulant and substrate volume on root growth and development of scarlet sage (*Salvia splendens* L.) transplants. Journal of Agricultural Sciences, 55(1): 29-36.
doi: http://dx.doi.org/10.2298/JAS1001029Z

41. Zhang, X., Schmidt, R. E. (1997): Biostimulating turfgrasses. Grounds Maintenance November, 1999: 15-32.

KLIJAVOST I VIGOR SJEMENA KRES SALATE NAKON TRETMANA BILJNIM EKSTRAKTIMA

SAŽETAK

Korištenje biološki aktivnih i okolišno prihvatljivih pripravaka ima vrlo značajnu ulogu u primarnoj proizvodnji hrane. Ovo istraživanje provedeno je s ciljem ispitivanja utjecaja pet komercijalnih biljnih ekstrakata na vigor sjemena kres salate (Lepidium sativum L.). Korišteni biljni ekstrakti značajno su povećali klijavost. Najveća svježa masa klijanaca, a ujedno i najniža akumulacija suhe tvari, utvrđena je pri tretmanu KE-plantasalva® bez dodatka morske soli. Ekstrakt preslice inhibirao je izduživanje korijena i rezultirao najvišim postotkom akumulacije suhe tvari u klijancima, ali, također, i najnižom svježom masom.

Ključne riječi: kres salata, biljni ekstrakti, sjeme, klijanje, vigor

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