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THE QUALITY OF POTATO TUBERS DEPENDING ON APPLICATION OF ADSORBENTS

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ABSTRACT

A potato is a field crop that is extremely important in Bosnia and Herzegovina, but according to all indicators the production is very unstable and unreliable (production volume and quality, average yields, range). For the research needs, the experiments were set up at two localities, Bijeljina and East Sarajevo, with use of superadsorbent of different composition (control variant; superadsorbent; superadsorbent enriched with growth stimulants; superadsorbent enriched with microorganisms; superadsorbent enriched with microorganism. The main goal of this research was to determine the influence of superadsorbent and locality on the chemical composition of the tuber.The analysis of the results showed that the use of different variants of the adsorbent had a highly significant effect on the examined properties, while the site influence had high significance for the dry matter, ash and starch content and significantly affected the nitrate content in the tuber. In the control variant, the tubers had the lowest dry matter content, the lowest starch content, but the highest in the variant with superadsorbent enriched with microorganisms. The highest ash content was in tubers in the variant with superadsorbent, and the lowest in the variant with superadsorbent enriched with growth stimulants, microorganisms and microelements. Using the superadsorbent enriched with growth stimulants, the lowest nitrate content in the tuber was determined, and the highest in the control variant. At the site in East Sarajevo, the tubers had a higher content of dry matter and starch, while the content of ash and nitrate was higher in Bijeljina.

Key words: *tuber, starch, ash, dry matter, superadsorbent.*

INTRODUCTION

A Potato (*Solanum tuberosum*) are among the most intensive and profitable cultivated crops. In terms of nutritional value and the areas it occupies in the world as well as in our country, it belongs to the order of leading cultures. Thanks to wide adaptive capabilities, high reproductive capacity (5-30 times) and good nutritional value of tubers, potatoes are grown in over 130 countries on about 18.5 million

hectares with an annual production of about 300 million tons. In the total food production in Bosnia and Herzegovina, potatoes occupy a significant place. The great economic importance of potatoes and over 37,000 ha of areas grown with an average yield of 11.0 t/ha (*The Agency for Statistics of Bosnia and Herzegovina*, 2019) and significantly lags behind the yields of potatoes in Europe and the world. In the conditions of climate change, the occurrence of more and more frequent droughts represents a threat to the sustainable production of agricultural crops, which can have a negative economic and sociological impact (*Rivero et al.*, 2007).Water scarcity is one of the main causes of declining crop yields worldwide and a decrease in average yields of more than 50% in the most important field crops (*Buchanan et al.,* 2000*; Wang et al.,* 2003). Therefore, water scarcity, especially in arid and semi-arid areas, is considered a major problem in food production (*Zhang et al.,* 2014). By applying of natural and synthetic enhancers such as super-adsorbent polymers, it is possible to provide good soil moisture in conditions of insufficient and unevenly distributed rainfall and thus enable the cultivation of plants in arid areas (*Szczerski et al.,* 2013). The yield and quality of potato tubers is influenced by water deficit and depends on the strength, time of occurrence and duration of drought during the vegetation period. Water stress during the vegetation growth phase reduces the leaf surface, the development of aboveground organs and roots as well as the height of the plant. In the tuber initiation phase, stress due to lack of water causes a decrease in the number of tubers formed per plant, which results in a smaller number of larger tubers at the end of the vegetation. The stress in the tuber filling phase reduces the yield and quality of potato tubers. In this phase, the deformations of tubers in the form of cracks and irregular shapes of tubers occur, the percentage of tubers of finer fraction increases and the specific density of tubers decreases. A lack of water during the ripening phase not only reduces the yield but also shortens the dormancy, reduces the specific density and increases the content of reducing sugars in the potato tuber. The two factors that mostly define the quality of potatoes are the dry matter content in the tuber and the structure of the tuber yield. The dry matter content increases during the vegetation from about 10% in the tuber initiation phase to 15-25% at the time of tuber extraction. The dry matter content is affected by a number of factors such as: length of vegetation, variety, average temperature during vegetation and water availability, especially in the period before the end of vegetation. Severe drought reduces the harvest index and in these conditions the dry matter content is lower compared to crops that are grown to full maturity. Moderate drought at the end of the vegetation usually leads to an increase in dry matter content. The aim of this research is to determine the influence of "hard water" superadsorbent and the locality on the quality of potato tubers.

MATERIAL AND METHODS

To examine the influence of superadsorbents and localities on the quality of tubers, tubers were taken from experiments that were monitored in 2019 in the areas of

East Sarajevo and Bijeljina. The tests included six variants of adsorbent application:
control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5) in the amount of 20 kg ha^{-1}.
The experimental plot on the territory of the city of East Sarajevo is located at an altitude of 550 m (43 ° 49′01 ″ NW and 18 ° 20′57 ″ E). It is characterized by strong influences of continental climate. The average annual temperature is 10.2 °C, and the average rainfall is about 900 mm. The experiment was set up on alluvial soil (*Fluvisol*). The experimental plot on the territory of Bijeljina is located at an altitude of 90 m (44 ° 41 ′ N; 19 ° 14 ′ E). The average annual temperature is 12.5 °C, and the average rainfall is about 757.2 mm. The experiment is set on semigley type land. From the qualitative properties of tubers, the following were analyzed: dry matter (%), by drying the plant material in an oven at a temperature of 105 °C to a constant mass; crude ash (%) by annealing the plant material at 550 °C to constant weight; starch (%), determined polarimetrically by Ewers (1908); nitrates (mg kg-1), was determined by molecular absorption spectrometry.
Statistical processing was done using the statistical program STATISTICA 10 (StatSoft, Inc. Corporation, Tulsa, OK, USA).

RESULTS AND DISCUSSION

Table 1 shows the analysis of the variance of adsorbent application influence and localities on the qualitative potatoes properties. The application of different adsorbent variants had a significant effect on the dry matter, ash, starch and nitrate contents in the tuber, while the site had a significant effect on the dry matter, ash and starch contents in the tuber and significantly affected the nitrate content in the tuber. The interaction of adsorbent x locality significantly affected the ash content in potato tubers.

Table 1. The Influence of adsorbent and locality on tuber quality

Factor		% of dry matter	% of ash	% of starch	Nitrate content
Adsorbent		**	**	**	**
Locality		**	**	**	*
A * B		nsd	nsd	nsd	nsd
A	$LSD_{0.05}$	0.6429	0.1436	0.6429	2.854
	$LSD_{0.01}$	0.8638	0.1929	0.8638	3.835
B	$LSD_{0.05}$	0.3712	0.0829	0.3712	1.648
	$LSD_{0.01}$	0.4987	0.1113	0.4987	2.214
A*B	$LSD_{0.05}$	0.9093	0.2030	0.9093	4.037
	$LSD_{0.01}$	1.2215	0.2727	1.2215	5.,423

(*)statistically significant difference, (**)statistically very significant difference , there is no statistically significant difference (nsd)

The dry matter

The dry matter content of tubers is significantly affected by ecological conditions and agrotechnical measures (*Geremew et al.*, 2007), while increasing the amount of nutrients, especially nitrogen to a certain extent leads to a linear increase in dry matter in potatoes (*Zebarth et al.*, 2004), which affects the increase in tuber quality (*Roinila et al.*, 2003).

Table 2. Average dry matter content in potato tubers depending on the adsorbent at selected localities (%)

Adsorbent / Locality	A_0	A_1	A_2	A_3	A_4	A_5	Average
E. Sarajevo (B_1)	24.80	25.78	25.20	26.48	25.94	25.77	25.66
Bijeljina (B_2)	23.89	24.86	24.29	25.56	25.04	24.87	24.75
Average	24.35	25.32	24.75	26,02	25.49	25.32	25.21

Adsorbent: Control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5).

The average dry matter content in potato tubers, regardless of the application of adsorbent and locality, is 25.21%. The control variant had the lowest dry matter content in potato tubers (24.35%), and the highest superadsorbent enriched with microorganisms (26.02%). The determined differences are statistically highly significant, as well as the differences of other variants of superadsorbent in comparison with the control variant, except for variant A_2 where the determined differences did not have statistical significance. The average dry matter content in potato tubers in East Sarajevo (25.66%) is significantly higher compared to Bijeljina (24.75%).

Ash content in the tuber

Of the total dry matter in the tuber, ash accounts for about 1.1% *(Lešić et al., 2002).* The average ash content in potato tubers regardless of the application of adsorbent and locality is 1.320%. The ash content in the tuber ranged from 1.145% to 1.558%. The application of different variants of superadsorbent had a highly significant effect on the ash content in the tuber. A highly significant influence of the locality was also determined, while the interaction of the adsorbent x locality significantly influenced the ash content in the tuber. In variants A1 and A4, a significantly higher ash content in the tuber was found, and in comparison with other examined variants.

The average ash content in potato tubers in East Sarajevo (1.445%) was highly significantly compared to Bijeljina (1.196%). At the locality of East Sarajevo, the highest ash content in potato tubers was in variant A4, and the lowest in the control

variant, while at the locality in Bijeljina, the highest ash content in potato tubers was achieved in variant A1, and the lowest in variant A5.
When comparing the ash content in the tuber between the examined localities, a significantly higher ash content in the tuber was found for all variants of adsorbents at the locality in East Sarajevo, except for variant A1 where the differences were only 0.005%.

Table 3. Average ash content in potato tubers depending on the adsorbent at selected localities (%)

Adsorbent / Locality	A_0	A_1	A_2	A_3	A_4	A_5	Average
East Sarajevo (B_1)	1.338	1.560	1.430	1.383	1.613	1.345	1.445
Bijeljina (B_2)	1.148	1.555	0.958	1.123	1.448	0.945	1.196
Average	1.243	1.558	1.194	1.253	1.530	1.145	1.320

Adsorbent: Control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5).

Starch content in the tubers

The starch content in tubers is influenced by the method of cultivation and genotype (*Geremew et al.*, 2007; *Tein et al.*, 2014; *Broćić et al.*, 2016), where late varieties stand out due to longer vegetation period and longer period of accumulation of photosynthetic substances. (*Singh and Lovedeep*, 2009).
The average starch content in potato tubers regardless of the application of adsorbent and locality is 17.15%. The control variant had the lowest starch content in potato tubers (16.29%), and the highest superadsorbent enriched with microorganisms (17.26%). The determined differences are statistically highly significant, as well as the differences of other variants of superadsorbent in comparison with the control variant, except for variant A_2 where the determined differences did not have statistical significance. The average starch content in potato tubers in East Sarajevo (18.40%) is significantly higher compared to Bijeljina (15.89%).

Table 4. Average starch content in potato tubers depending on the adsorbent at selected localities (%)

Adsorbent / Locality	A_0	A_1	A_2	A_3	A_4	A_5	Average
East Sarajevo (B_1)	17.54	18.52	17.94	19.22	18.69	18.52	18.40
Bijeljina (B_2)	15.03	16.01	15.43	16.71	16.18	16.01	15.89
Average	16.29	17.26	16.69	17.96	17.44	17.26	17.15

Adsorbent: Control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5)

In the experiment in Bijeljina, the tubers had less starch compared to the experiments in East Sarajevo, which is in accordance with the results of *Tein et al.* (2014) who state that larger tubers have a lower starch content, compared to smaller tubers in general.

Nitrate content in the tubers

The average nitrate content in potato tubers regardless of the application of adsorbent and locality is 151.89 mg kg^{-1}.

Table 5. Average nitrate content in potato tubers depending on the adsorbent at selected localities (mg kg^{-1})

Adsorbent / Locality	A_0	A_1	A_2	A_3	A_4	A_5	Average
East Sarajevo (B_1)	160.04	151,22	146.25	149.40	50.10	148.57	150.93
Bijeljina (B_2)	162.44	153.62	148.15	151.30	51.70	149.88	152.85
Average	161.24	152.42	147.20	150.35	50.90	149.22	151.89

Adsorbent: Control variant (A_0); superadsorbent (A_1); superadsorbent enriched with growth stimulants (A_2); superadsorbent enriched with microorganisms (A_3); superadsorbent enriched with microelements (A_4) and superadsorbent enriched with growth stimulants, microorganisms and microelements (A_5)

In the potato tuber, the control variant had the most nitrate (161.24 mg kg^{-1}), and the superadsorbent enriched with growth stimulants had the least (147.20 mg kg^{-1}). The differences found are statistically highly significant, as are the differences between variants A_1 and A_2. A previous research has shown that the application of polymers prevents pollution of the agro ecosystem and reduces the content of harmful substances in tubers, which increases the tubers economic value *(Islam et al.,* 2011ab). The average nitrate content in potato tubers in East Sarajevo is 150.93 mg kg^{-1}, and in Bijeljina 152.85 mg kg^{-1}. The differences found were significant.

CONCLUSION

The use of different variants of superadsorbent at both sites had a positive impact. In the control variant, the tubers had the lowest dry matter content, the lowest starch content, while the highest nitrate content. In the variant with adsorbent enriched with microorganisms, the tubers had the highest dry matter content and the highest starch content. In the superadsorbent variant, the tubers had the highest ash content. In the variant with superadsorbent enriched with growth stimulants, microorganisms and microelements, the tubers had the lowest ash content. The lowest nitrate content in the tuber was determined by applying a superadsorbent enriched with growth stimulants. At the site in East Sarajevo, the tubers had a higher dry matter content, the highest starch content, while the ash and nitrate content was higher in Bijeljina.

REFERENCES

Agency for Statistics in Bosnia and Herzegovina (2019): Harvested area and production of late crops, fruits and grapes, pp.1-3).

Broćić Z., Dolijanović Ž., Poštić D., Milošević D., Savić J. (2016): Yield, Tuber Quality and Weight Losses During Storage of Ten Potato Cultivars Grown at Three Sites in Serbia. Potato Research, DOI:10.1007/s11540-015-9311-7, 1-14.

Buchanan B.B., Gruissem W., Jones R.L. (2000): Biochemistry & molecular biology of plants. American Society of Plant Physiologists Rockville, MD.

Geremew E.B., Steyn J.M., Annandale J.G. (2007): Evaluation of growth performance and dry matter partitioning of four processing potato (Solanum tuberosum) cultivars. New Zealand Journal of Crop and Horticultural Science, 35 (3):385-393.

Islam M.R., Xue X., Mao S., Ren C., Eneji A.E., Hu Y.G. (2011): Effects of water-saving superadsorbent polymer on antioxidant enzyme activities and lipid peroxidation in oat (Avena sativa L.) under drought stress. Journal of the Science of Food and Agriculture, 91(4): 680-686.

Islam M.R., Xue X., Mao S., Zhao X., Eneji A.E., Hu Y. (2011a): Superadsorbent polymers (SAP) enhance efficient and eco-friendly production of corn (Zea mays L.) in drought affected areas of northern china. – African Journal of Biotechnology 10(24): 4887-4894.

Lešić R., Borošić J., Buturac I., Ćustić M., Poljak M., Romić D. (2002): Povrćarstvo, Zrinski d.d., Čakovec. (Vegetable growing).

Singh J., Kaur Lovedeep (2009): Advanches in Potato Chemistry and Technology, Elsevier, USA.

Rivero R.M., Kojima M., Gepstein A., Sakakibara H., Mittler R., Gepstein S., Blumwald E. (2007): Delayed leaf senescence induces extreme drought tolerance in a flowering plant. Proceedings of the National Academy of Sciences of the United States of America USA, 104(49): 19631-19636.

Roinila P., Vaisanen J., Granstedt A. (2003): Effects of different organic fertilization practices and mineral fertilization on potato quality. Biological agriculture and horticulture 21:165-194.

Szczerski C., Naguit C., Markham J., Goh T.B., Renault S. (2013): Short- and long-term effects of modified humic substances on soil evolution and plant growth in gold mine tailings. Water Air Soil Poll, 224(3): 1471.

Berit T., Kauer K., Eremeev V, Luik A., Selge A., Loit E. (2014): Farming systems affect potato (Solanum tuberosum L.) tuber and soil quality. Field Crops Research 156, 1–11.

Zebarth B.J., Tai G., Tarn R., de Jong H., Milburn P.H. (2004): Nitrogen use efficiency characteristics of commercial potato cultivars. Canadian Journal of Plant Science, 84 (2):589-598.

Zhang S.L., Sadras V., Chen X.P., Zhang F.S. (2014): Water use efficiency of dryland maize in the Loess Plateau of China in response to crop management. Field Crops Research, 163: 55-63.

Wang W., Vinocur B., Altman A. (2003): Plant responses to drought, salinity and extreme temperatures: towards genetic engineering for stress tolerance. Planta, 218(1): 1-14.