

## POSSIBILITY OF SUMMER PLANTING OF POTATO IN AGROECOLOGICAL CONDITIONS OF PODGORICA

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### Abstract

The paper presents results of two-year study of the possibilities of summer growing potatoes in agro ecological conditions of Podgorica (Montenegro). Two potato varieties were tested: Kennebec and Monaco. Research was carried out during 2011 and 2012, in the vicinity of Podgorica, at an altitude of 40 m. Field trials were carried out using the standard methodology in a completely randomized block design with four replications.

In two-year study both varieties had approximately the same number of formed tubers per plant - Kennebec 5.2 and Monaco 4.9. Variety Kennebec had significantly higher tuber weight - 140 g. The average weight of tubers in variety Monaco was - 126.5 g.

On the plots on which was cultivated variety Kennebec yield was 31.3 t.ha<sup>-1</sup>, while the variety Monaco yielded 26.6 t.ha<sup>-1</sup>. The differences in the yield of tubers from the varieties studied were highly significant.

Statistically very significant differences in the average yield of tubers were influenced by the interaction variety x year. Variety Kennebec had a significant increase in yield in 2011 compared to the variety Monaco in 2012.

The results showed that the agro ecological conditions of wider region of Podgorica area under irrigation conditions are ideal for summer planting of potatoes.

**Key words:** *potato, summer planting, agro ecological conditions, yield*

### Introduction

Potato is grown on 11000 ha in Montenegro (<http://www.monstat.org>). Although there is a tendency of decreasing of arable land, the potato production in Montenegro is constantly increasing. In the production structure of the arable land, potato accounts for more than 20% and it is a leading agricultural plant in Montenegro (Jovovi et al., 2012a; 2013a). Production intended for fresh consumption is about 16.8% of total production and is mainly located in the Zeta-Bjelopavlici and the coast. Dominant form of potato production in Montenegro is the production of potatoes for storage (83.2%) and is related to the central and mountainous area. Yield of potatoes in Montenegro is still low (16.5 t.ha<sup>-1</sup>), very unstable and strongly influenced by weather conditions. Differences in yields of potatoes between production regions are also highly expressed (Muminovi et al., 2014).

The main area of production of early potatoes in Montenegro is located in the wider area of the municipality of Podgorica and the coast with the surrounding hilly areas up to 600 m of altitude. This area is represented in the Mediterranean and modified Mediterranean climate with long, hot and dry summers and mild and rainy winters. The average annual temperature in this climatic zone is 13-15 °C, in Podgorica from 16 to 17°C, with relatively high annual sum of precipitation - from 1300 to 2500 mm. Due to the uneven distribution of

rainfall during the year, this zone is characterized by a pronounced aridity, with long drought periods (Jovovi et al., 2013b).

The problem of food production in biggest part of the world is becoming more important and requires urgent action. In conditions when the total area of arable land cannot significantly increase the only option for increasing food production remains increase of production on existing surfaces. This increase includes obtaining a higher yield per unit area and establishing a system of two harvests a year, and in all that irrigation plays a crucial role.

Very favourable climate around Podgorica allows organization of a very intensive plant production system with two or more harvests per year. As here is predominantly present soil of medium production capacities it is necessary to ensure proper fertilization and irrigation to obtain high and stable yields in summer season. Water is one of the most important factors of successful potato production. Only in terms of well-organized irrigation, which requires a sufficient amount of water during the entire growing period, it is possible to obtain high yield and good quality potatoes (Kashyap and Panda, 2003; Yuan et al., 2003; Onder et al., 2005).

As it is assumed that Podgorica is the area with the highest average monthly temperatures during the summer and the highest average number of tropical days a goal was set to test the possibility of summer planting of potatoes in given agro-ecological conditions and to find genotypes which will in these conditions give a satisfactory and stable yields.

### Materials and methods

Studying the possibility of growing potatoes in two seasons was conducted in 2011 and 2012. We tested two varieties of potato early tuberisation: Kennebec (leading variety of potatoes in Montenegro, early main crop, white flesh colour) and Monaco (early variety, yellow flesh colour). Soil type on which experiments were conducted is Terra rossa and it is located on 40 m of altitude. Experiments were carried out using field trials in a randomized block design with 4 replications. The plot size was 28 m<sup>2</sup>. Planting density was 70x33 cm, achieving 43300 plants per hectare. Planting was done in third decade of July (26<sup>th</sup> July in 2011 and 20<sup>th</sup> July 2012). Seed for spring planting was used, that was stored in refrigerator at 4°C until beginning of sprouting (use of seeds from spring planting is complicated and for breaking of seed dormancy requires the use of chemicals - gibberellic acid). Germination on the diffuse light started a month before planting at a temperature of 15°C. Tubers used for planting were weighing approximately 60-70g.

In both years, two days before planting was done soil drench. The crop of potatoes was regularly treated with products against late blight and one against Colorado potato beetle (due to the high temperature possibility for the emergence of Colorado potato beetles is much lower than in the spring planting). During the hilling potato plants (plant height 20-25 cm) fertilization with nitrogen was done. Irrigation of potatoes was done when the technical minimum was reached at humidity of soil of 75-80% of FWC. Irrigation was done using Microjet irrigation system and irrigation norm was 15 mm.m<sup>-2</sup>.

Table 1 - Chemical characteristics soil on experimental field (Terra rossa)

Depth (cm)	Locality	pH		CaCO <sub>3</sub> %	Humus %	Soluble mg/100 g	
		H <sub>2</sub> O	nKCl			P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
30	Podgorica	6.0	4.97	1.43	4.56	4.3	15.0

Few days before harvesting of potatoes, sampling was done by taking 10 potato plants per replication to determine the number and weight of tubers. Potato harvesting was done manually after full maturation of canopy (1<sup>st</sup> December in 2011 and 20<sup>th</sup> November in 2012).

The potato yield in the experiment was determined by measuring the tubers at each elementary plot and then the yield per hectare was calculated.

The analysis of variance was calculated according to randomized complete block design with two factors: variety (A) and year (B). The significant differences among the means were evaluated according to least significant difference (LSD) test (Maletić, 2005).

Table 2 - Meteorological conditions during the experiments

Year	Month					Average vegetation period	Average annual
	July	August	September	October	November		
Air temperature (°C)							
2011	27.2	29.3	26.3	16.3	9.9	21.8	17
2012	30.4	29.7	23.9	18.2	13.3	23.1	17
Amount of rainfall (mm)							
2011	31.4	2.1	43.3	75.6	37.1	189.5	896.9
2012	11.3	0.5	86.6	296.3	285.8	680.5	1763.6

The soil on which experiments were performed is type terra rossa (tab. 1). It is characterized by low carbonate content and low soil acid reaction (pH). Phosphorus content is low and moderately supplied by potassium. It contains a high percentage of humus. Meteorological conditions during performance of the experiment are shown in table 2.

### Results and discussion

The possibility of growing crops in two or more seasons is a gift of nature that allows more extensive and therefore cheaper production at the same field during the same year. In the agro-ecological conditions of Podgorica water is a limiting factor for summer planting of potatoes and irrigation occurs as the only option to eliminate the negative effects of the summer heat and deficit of rainfall.

Table 3 - Results of the investigation

Parameter	Average tuber number			Average tuber weight (g)			Tuber yield (t.ha <sup>-1</sup> )		
	2011	2012	Average	2011	2012	Average	2011	2012	Average
Variety (A)									
Kennebec	4.9	5.4	<b>5.2 a</b>	149	131	<b>140 a</b>	31.8	30.7	<b>31.3 a</b>
Monaco	4.5	5.2	<b>4.9 a</b>	138	115	<b>126.5 b</b>	27.1	26.0	<b>26.6 b</b>
Average	<b>4.7</b>	<b>5.3</b>	<b>5.1</b>	<b>143.5</b>	<b>123</b>	<b>133.3</b>	<b>29.5</b>	<b>28.4</b>	<b>29</b>

	A			B		A*B	
	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01	LSD 0.05	LSD 0.01	
Average tuber number	0.563	0.789	0.563	0.789	0.796	1.116	
Average tuber weight (g)	12.151	17.036	12.151	17.036	17.185	24.092	
Tuber yield (t.ha <sup>-1</sup> )	3.916	5.490	3.916	5.490	5.538	7.764	

Number of potato tubers is influenced by the number of potato shoots formed by a single plant. If the number of the primary shoots is bigger, the number of tubers formed is

bigger, but their mass is less and vice versa (Bugar i , 2000b; Butorac i Bolf, 2000; Jovovi , 2002). Results in Table 3 show that in the two-year research both varieties had approximately the same number of formed tubers per plant - Kennebec 5.2 and Monaco 4.9. Kennebec and Monaco are varieties that are characterized by a medium level of tuberisation. A smaller number of tubers recorded in the experiments are a consequence of high temperatures during August when plants of potatoes are in tuberisation phase (23.9 in 2011 and 29.7 °C in 2012). Optimal soil temperature in the phase of formation of tubers according to Muminovi et al. (2014) is between 15 and 18°C, and air temperature between 18 and 22°C. As the air temperature in Podgorica during this period was higher these results were expected.

Weight of tubers is an important parameter of productivity and quality and it significantly affect the viability of the plant and also affects the final yield (Rykbost and Locke, 1999). The importance of the size of the tubers is expressed through the number of sprouts and their biological potency, and is closely associated with the physiological age of the tubers (Pošti , 2006). Table 3 shows that the higher average weight of tubers was measured in crop variety Kennebec – 140 g (149 g in 2011 and 131 g in 2012). Average weight of tubers in variety Monaco was – 126, 5 g (138 g in 2011 and 115 g in 2012). Differences in the average weight of tubers from the varieties of potato were statistically significant. The optimal temperature of the air at the period of intensive tuber growth is 21-25°C (Muminovi et al., 2014). Table 2 shows that the potato plants at this stage had very favourable thermal conditions that along with good supply of plants with water caused the formation of relatively large tubers.

Results presented in Table 3 show that the highest yield of tubers in the experiments was measured in crop variety Kennebec in 2011 – 31.8 t.ha<sup>-1</sup>, while the lowest yield had the variety Monaco in 2012 – 26.0 t.ha<sup>-1</sup>. In two years average variety Kennebec had yield of 31.3 t.ha<sup>-1</sup>, and Monaco 26.6 t.ha<sup>-1</sup>. In comparison with the variety Monaco, variety Kennebec gave a significantly higher yield of tubers.

In the two years studies slightly higher average yields of potatoes were measured in 2011 – 29, 5 t.ha<sup>-1</sup>. Average yield of potato in 2012 was 28.4 t.ha<sup>-1</sup>. Between the years studied there were no statistically significant differences with respect to this parameter.

Statistically very significant differences in the average yield of tubers were formed and influenced by the interaction variety x year. Variety Kennebec in 2011 exhibited a significant increase in yield compared with the yield of variety Monaco in 2012. Such an expressed influence of meteorological conditions on the yield of potatoes is in accordance with the results of previous research (Jovovi at al, 2012b; Hassanpanah, 2011).

Bearing in mind that this was a summer production of potatoes and potato cultivation in the second season, yields was more than satisfactory. Yields were at the level of spring planting yields and those obtained by growing potatoes in the continental part of Montenegro. Jovovi at al., (2012c) trough studying the productivity of a large number of varieties of potatoes in a number of localities in the mountainous regions of Montenegro established average yield of variety Monaco of 27.2 t.ha<sup>-1</sup>, meaning that this yield was at the level of yields obtained in previous studies. The yield of variety Kennebec obtained in this study (31.3 t.ha<sup>-1</sup>) was higher than yields obtained in continental area – 28.3 t.ha<sup>-1</sup> (Jovovi at al., 2013c). Summer planting of potatoes allows production of 50 or more tons of potatoes per hectare in one year in the southern area of Montenegro which is significantly higher than average yields that have the most developed countries in the world.

### Conclusions

Based on two years of studying the possibility of summer planting of potatoes in agro ecological conditions of Podgorica area can be concluded:

1. The agro ecological conditions of Podgorica are very favourable conditions for summer planting of potatoes. To obtain high and stable yields in summer production it is necessary to provide irrigation. In such conditions, the success of this production is guaranteed.
2. Both varieties studied had approximately the same number of formed tubers per plant - Kennebec 5.2 and Monaco 4.9. No statistically significant difference between the varieties was determined in terms of these properties.
3. Variety Kennebec (140 g) in comparison with the variety Monaco (126.5 g) had a significantly higher average weight of tubers.
4. Highest tuber yield in the experiments was measured in crop varieties Kennebec - 31.3 t.ha<sup>-1</sup>, while the lowest yield was in variety Monaco - 26.6 t.ha<sup>-1</sup>. The differences in the yield were statistically highly significant.
5. Summer planting potatoes in Podgorica in irrigation allows very satisfactory yields. For these reasons, growing potatoes in this method should be paid more attention in the future.

### References

- Bugar i , Ž. (2000): Krompir - Tehnologija proizvodnje, skladištenje i zaštita /Potato- Production technologies, storage and protection/. Beograd.
- Butorac, J., Bolf, M. (2000): Proizvodnja krumpira /Potato production/. Biblioteka "Zadružni poduzetni ki savjetnik", Zagreb.
- Hassanpanah, D. (2011): Analysis of G × E interaction using the additive main effects and multiplicative interaction (AMMI) in potato cultivars. African Journal of Biotechnology, Vol. 10 (2), pp. 154-158.
- Jovovi , Z., Velimirovi , Ana, Mili , Vesna, Šilj, Milana (2013a): Examination of some Dutch red skin potato varieties in different agro-ecological conditions of Montenegro. IV International Symposium „Agrosym 2013“, Book of abstracts, 465-469, Jahorina, Bosnia and Herzegovina, October 3-6, 2013.
- Jovovi , Z., Steševi , Danijela, Megli , V., Dolni ar, P. (2013b): Old potato varieties in Montenegro. Monograph, University of Montenegro, Biotechnical faculty Podgorica
- Jovovic, Z., Dolijanovic, Z., Milosevic, D., Velimirovic, A., Biberdzic, M. (2013c): Influence of different nutrition systems on yield and other parameters of productivity of potato. 2nd international symposium on agronomy and physiology of potato (Potato Agrophysiology 2013), September 15-19, 2013, Prague, Czech Republic, Proceedings, 216-223.
- Jovovi , Z., Dolijanovi , Ž., Kova evi , D., Velimirovi , Ana, Biberdži , M. (2012a): The productive traits of different potato genotypes in mountainous region of Montenegro. Genetika, Vol. 44, No 2, 389-397, Belgrade.
- Jovovi , Z., Dolijanovi , Ž., Velimirovi , A., Pošti , D., Hrn i , S. (2012b): Ispitivanje produktivnosti pet vode ih sorti krumpira u Crnoj Gori u agroekološkim uslovima visoko planinskog podru ja /Testing of productivity of leading five varieties of potatoes in Montenegro in agroecological conditions of high mountain areas/. I me unarodni simpozijum i XVII nau no-stru no savjetovanje agronoma Republike Srpske, Zbornik sažetaka, 52, Trebinje, Bosna i Hercegovina, 19-22. marta 2012.
- Jovovi , Z., Mili , V., Pošti , D., Velimirovi , A., Šilj, M., Strunjaš, K. (2012c): Productivity testing of early and medium erly potato varieties in agro-ecological conditions in northern Montenegro. Third International Scientific Symposium "Agrosym Jahorina 2012", Book of abstracts, 200-204, Jahorina, Bosnia and Herzegovina.

- Jovovi , Z. (2002): Uticaj na ina suzbijanja korova na prinos sjemenskog usjeva razli itih sorti krompira /Influence of weed control on the yield of seed crops of different potato varieties/, Doktorska disertacija. Poljoprivredni fakultet, Beograd.
- Kashyap, P.S. and R.K. Panda (2003): Effect of irrigation scheduling on potato crop parameters under water stressed conditions. *Agric. Water Manage.*, 59: 49-66.
- Maleti , R. (2005): Statistics. Reference book. University of Belgrade, Faculty of Agriculture, Belgrade.
- Muminovi , Š., Lutvija, Kari , Jovovi , Z., Jasminka, Žurovec (2014): Krompir /Potato/. Monografija, Univerzitet u Sarajevu, Poljoprivredno-prehrambeni fakultet Sarajevo.
- Onder, S., M.E. Caliskan, D. Onder and S. Caliskan (2005): Different irrigation methods and water stress effects on potato yield and yield components. *Agric. Water Manage.*, 73: 73-86.
- Pošti , D. (2006): Uticaj agroekoloških uslova proizvodnje semenskog useva na životnu sposobnost krtola krompira / Influence of agroecological conditions of seed crops production on the viability of the potato/. pp. 1-128, Poljoprivredni fakultet, Beograd. Zbornik nau nih radova, Vol. 15 br. 1-2 (2009), 110.
- Rykbost, K.A., Locke, K.A. (1999): Effect of seed piece size on performance of three varieties in the Klamath Basin of Oregon. *American Journal of Potato Research.* 76, 75-82.
- Yuan, B.Z., S. Nishiyama and Y. Kang (2003): Effects of different irrigation regimes on the growth and yield of drip-irrigated potato. *Agric. Water Manage.*, 63: 153-167.