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The Productivity Analysis of Five Leading Potato Varieties in the Agroecological Conditions of a Mountainous Region in Montenegro

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Abstract

An analysis of genetic productivity potential of five leading varieties in Montenegro (Kennebec, Agria, Aladdin, Tresor and Riviera) was conducted during 2010 and 2011 in the municipalities of Žabljak region, on mountainous black soil at 1,500 meters of altitude. The highest number of tubers was found in a parcel planted with Tresor and Aladdin- 8.5, while the lowest number of tubers was found in Kennebec- 6.8 tubers per plant. Comparing to other tested varieties, Kennebec had a significantly lower number of tubers. On average, Kennebec and Tresor had the largest tubers (96 and 91 g), and differences found were statistically very significant. The biggest tuber yield was measured in Tresor – 32.5 t/ha, while the lowest tuber yield was in Agria and Riviera (24.0 and 25.2 t/ha). Tresor had significantly higher tuber production comparing to other varieties.

Key words: potato, variety, number of tubers, tuber size, yield.

Introduction

According to the planted area, potato is the leading crop in Montenegro. Potato crops are present with more than 20% in the total production structure on arable land (Jovović, et al., 2012a). Along with production of ware potatoes, seed potato production is present in the mountainous region of Montenegro (Jovović et al., 2011; Milošević et al., 2004). At higher altitudes, light intensity is higher (Van der Zaag, 1992) and the usage of solar radiance is higher as well (Pereira et al., 2008). Altered spectral radiation and lower daily air and soil temperatures prolong vegetation period of potato

crop, leading to the development of high-quality tubers. The mountainous region of Montenegro is considered the lowest southern point where it is still possible to produce high-quality seed potatoes. Abundance of solar radiation and low cloudiness make this area ideal for potato seed production. Therefore, the production of seed potatoes has been expanding in recent years. Expansion of seed potato crops is also present in Žabljak, a city at 1,450 a.s.l. and an urban settlement at the highest altitude in the Balkans (Jovović et al., 2012a).

Agro-ecological conditions across potato growing regions are very different, thus the reaction of some varieties is different as well (Momirović et al., 2000). The systematic study of different genotypes at a number of locations is very important because in this way a wider selection of varieties adapted to the given specific conditions is possible (Yang, 2002). Productivity of a variety is a function of its adaptability to environmental conditions, thus it is very important to create varieties that will, in a wide range of environmental factors, be able to provide high yields consistently (Haldavankar et al., 2009).

Potato yields in Montenegro are very unstable and very susceptible to meteorological conditions (Jovović *et al.,* 2002). Choosing adequate varieties would help to overcome adverse impact of vegetation (ecological) factors, especially the soil water-air regime, high air temperatures and shorter growing season in mountainous areas. The aim of this research was to determine genetic potential of five leading potato varieties and examine their reaction in specific conditions of alpine climate in the mountainous region in Montenegro.

Materials and methods

The study of genetic yield potential was conducted for five leading potato varieties in Montenegro (Riviera, Tresor, Kennebec, Aladdin and Agria) in two consecutive years, 2010 and 2011, at Žabljak, mountainous chernozem soil type, at an altitude of 1,500 m. Experiments were conducted in a randomised block design with 4 replications, and the surface of basic plot was 21 m^2. Potatoes were planted manually on 28 May 2010 and 14 May 2011, at a distance of 70 x 33 cm, and the density obtained was 43,300 plants per hectare. Agro-technological practices were standard for potato crops. Potato tubers were harvested on 15 September 2010 and 25 September 2011.

Determination of the tuber number and their mass was done by taking average sample of 10 plants in each repetition after full maturation of canopy. The potato yield in this experiment was determined by measuring the tubers in each elementary plot, and then the yield per hectare was calculated.

Soil of the experimental field (Table 1) has the acid reaction (pH in water is 5.91, and in nKCl 4.85), low quantity of carbonate (2.05%) and high humus content (7.32%). Available phosphorus is deficient (6.2 mg/100 g), while the supply of potassium is very good (23.5 mg/100 g of soil). To achieve high and stable yields on this land, it is necessary to calcify it and increase fertilisation with phosphorus.

Meteorological data are presented in Table 2. The statistical analysis was done using factorial analysis of variance (ANOVA) and differences between mean values were determined by LSD test.

Tab. 1. Chemical characteristics of mountainous black soil on the experiment field
Hemijske osobine planinske crnice na eksperimentalnom polju

Depth (cm) *Dubina (cm)*	pH		$CaCO_3$	Humus *Humus*	Soluble mg/100 g *Rastvorljivi mg/100g*	
	H_2O	nKCl	%	%	P_2O_5	K_2O
0-40	5.91	4.85	2.05	7.32	6.2	23.5

Tab. 2. Meteorological conditions during the experiment
Meteorološki uslovi tokom eksperimenta

Year *Godina*	Month *Mjesec*					Average *Prosjek*
	May	June	July	August	September	
	Air temperature (^{0}C) *Temperatura vazduha (^{0}C)*					
2010	9.2	14.1	16.0	17.1	10.7	13.4
2011	8.8	13.9	15.9	16.5	14.1	13.8
	Amount of rainfall (mm) *Količina padavina (mm)*					Total *Ukupno*
2010	163	93	35	20	82	393
2011	162	43	76	53	113	447

Results and discussion

The number of tubers is highly dependent on the number of primary shoots that are formed on a single potato plant, affecting the average production of tubers per plant and total yield per unit area (Broćić et al., 2000). Table 3 shows that the highest number of tubers in trials was formed in Tresor and Aladdin - 8.5 (9.3 and 7.2 in 2010, 7.7 and 9.9 in 2011, respectively), while the smallest number of tubers was in Kennebec - 6.8 (7 in 2010, and 6.6 in 2011). In two-year average, the Kennebec variety had a significantly lower number of tubers in comparison to all other investigated varieties, while significant differences in the number of tubers was found between Tresor and Aladdin and the Agria variety. Bugarčić et al. (2000) state that best varieties for achieving high and stable yields are the ones that form about 10 tubers per plant.

Although the shape and size of tubers are varietal characteristics, they vary widely and are influenced by a number of environmental factors. The number and size of tubers is highly dependent on the number of shoots that are formed in a single plant, so if the number of primary shoots is higher, the number of formed tubers will be higher, but not their mass (Đokić, 1996). The results of measurements show that the tubers with the highest average tuber weight were measured in the Kennebec and Tresor varieties (96 and 91 g) and the lowest in Aladdin (70), Agria (72) and Riviera

(74). An analysis of the average tuber weight showed statistically significant differences between Kennebec and Tresor and all other varieties.

Tab. 3. Yield and yield components of potatoes in the experiments
Prinos i komponente prinosa krompira u eksperimentima

Variety *Sorta*	Year *Godina*	Average tuber number/plant *Prosječan broj krtola/biljka*	Average tuber weight (g) *Prosječna težina krtole (g)*	Tuber yield (t ha^{-1}) *Prinos krtola (t ha^{-1})*
Riviera	2010	9.1	53	21.1
	2011	7.1	95	29.2
	Average *Prosjek*	8.1	74	25.2
Tresor	2010	9.3	60	24.2
	2011	7.7	122	40.7
	Average *Prosjek*	8.5	91	32.5
Kennebec	2010	7	76	23.2
	2011	6.6	116	33.1
	Average *Prosjek*	6.8	96	28.2
Aladdin	2010	7.2	59	18.3
	2011	9.9	82	34.8
	Average *Prosjek*	8.5	70	26.6
Agria	2010	9.1	58	22.8
	2011	6.7	86	25.1
	Average *Prosjek*	7.9	72	24.0

	2010.		2011.		2010-11.	
	$LSD_{0.05}$	$LSD_{0.01}$	$LSD_{0.05}$	$LSD_{0.01}$	$LSD_{0.05}$	$LSD_{0.01}$
Average tuber number	0.825	1.127	0.678	0.927	0.555	0.758
Average tuber weight (g)	7.051	9.639	11.654	15.930	6.997	9.564
Tuber yield (t.ha^{-1})	1.442	1.971	3.003	4.105	1.365	1.865

In order to ensure high and stable potato production, it is necessary to have information on different types of interaction between a genotype and the environment. This means that the knowledge on the reactions of different potato varieties in different growing conditions is more important than the knowledge on their genetic potential (Jovovićet al., 2012b). The highest yield of tubers in the two-year average was measured in Tresor - 32.5 t.ha^{-1}, while the lowest was in Agria and Riviera (24.0 and 25.2 t.ha^{-1}). The analysis of variance showed that the potato tuber yield differences observed between Tresor and all other tested varieties were statistically highly significant. Statistically justified differences were measured between the Kennebec variety and Agria and Riviera, and between varieties Aladdin and Agria. Significant

influence of genotype and meteorological conditions on potato tuber yield during the experiments is stated in the papers by Bugarčić et al. (1997), Đorđević (2000), Broćić et al. (2000), Milić and Bogdanović (2007) and Jovović at al. (2012a).

Significantly higher yield and average tuber weight were measured in 2011in all studied varieties of potato. This is explained by the fact that that year was wetter and distribution of rainfall was more favourable. In 2010, precipitation amounted to 393 mm in the potato growing season, while in the same period of 2011, 447 mm were measured. As in July and August 2011 (phase of intensive tuber building), precipitation was 74 mm higher than in 2010, the obtained results were expected. More favourable air temperature and sufficient rainfall in 2011 caused longer potato growing period and thus higher yields.

Bearing in mind that this study was conducted in environmental conditions of alpine climate where winters are long and cold, and summers short and cool, the results are satisfactory. For these reasons, the study of potato in this area should be continued, as the adverse environmental effects could be significantly diminished by adequate selection of varieties.

Conclusion

Based on the results of a two-year study of the top five potato varieties in the mountainous region of Montenegro, the following conclusions were made:

1. The highest yield in the two-year average was found in the Tresor variety (32.5 $t.ha^{-1}$), while Agria and Riviera had the lowest yields (24.0 and 25.2 $t.ha^{-1}$). Compared with other varieties, Tresor gave significantly higher tuber yield.
2. Tresor and Aladdin had the biggest number of tubers– 8.5, while Kennebec had the lowest number of tubers – 6.8. In the two-year average, Kennebec had a significantly lower number of tubers compared to all other varieties studied.
3. The highest average mass of tubers was measured in lots planted with Kennebec and Tresor (96 and 91 g), while the lowest mass was found in Aladdin (70), Agria (72) and Riviera (74). The analysis of average tuber mass showed statistically very significant differences between Kennebec and Tresor and all other varieties studied.
4. This research showed that successful potato production can be organised in Žabljak, but the genotype x environment interaction study should be conducted in order to identify stable genotypes with high yields.

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Ispitivanje produktivnosti pet vodećih sorti krompira u Crnoj Gori u agroekološkim uslovima visoko planinskog područja

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Sažetak

U radu su prikazani rezultati dvogodišnjih proučavanja pet vodećih sorti krompira u Crnoj Gori u uslovima visoko planinskog područja Crne Gore. Najveći broj krtola utvrđen je na parcelama gdje su sađene sorte Tresor i Aladin– 8.5, dok je najmanji broj evidentiran kod sorte Kennebec – 6.8 ktrola/biljci. Kennebec je u poređenju sa ostalim testiranim sortama imao značajno manji broj krtola. Sorte Kennebec i Tresor dale su prosječno najkrupnije krtole (96 i 91 g), a ustanovljene razlike u poređenju sa ostalim varijantama označene su veoma značajnim. Najveći prinos krtola izmjeren je kod sorte Tresor - 32,5 t/ha, dok su najmanji prinos dale sorte Agria i Riviera (24,0 i 25,2 t/ha). Tresor je u poređenju sa svim proučavanim sortama imao značajno veću produkciju krtola.

Ključne riječi: krompir, sorta, broj krtola, veličina krtole, prinos.

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