

EXAMINATION OF SOME DUTCH RED SKIN POTATO VARIETIES IN DIFFERENT AGRO-ECOLOGICAL CONDITIONS OF MONTENEGRO

Zoran JOVOVIC^{1*}, Ana VELIMIROVIC², Vesna MILIC³, Milana SILJ³

¹University of Montenegro, Biotechnical Faculty Podgorica, Montenegro

²Ministry of Agriculture and Rural Development, Phytosanitary Directorate of Montenegro

³University of East Sarajevo, Agricultural Faculty East Sarajevo, Bosnia and Herzegovina

*(Corresponding author: zoran.jovovic.btf@gmail.com)

Summary

The paper presents results of productivity research of six potato red skin varieties in three different locations in the mountainous regions of Montenegro: Nikši (800 meters of altitude), Kolašin (900 meters of altitude) and Žabljak (1450 meters of altitude). The study took place during 2010 and 2011, and following varieties were tested: Kondor, Kuroda, Aladin, Roko, Desiree and Rudolph.

The highest tuber yield in two-year average had variety Rudolph (32.8 t.ha⁻¹), while the lowest yield was measured in the crop of Kuroda variety (25.4 t.ha⁻¹).

As the agro-ecological conditions in the studied area varied, the varieties reaction differentiated as well. Highest productivity was in Žabljak (29.1 t.ha⁻¹), while the lowest was in Nikši (28 t.ha⁻¹).

Higher potato yields were obtained in 2010 (28.9 t.ha⁻¹) as the result of the higher total amount of rainfall during the potato vegetation period and slightly better monthly distribution. Nevertheless, interactions location x year, variety x year and variety x location x year resulted in statistically significant difference in yield.

Key words: red skin potato varieties, agro-ecological conditions, productivity

Introduction

Potato (*Solanum tuberosum* L.) is the third most important crop in human diet after rice and wheat (FAOSTAT, 2008; CIP, 2011). According to the data of Food and Agriculture Organization of the United Nations (FAO) from 2008, potato was the most important non-cereal crop in human diet.

So far in the world have been selected few thousands of potato varieties among which dominate varieties with yellow skin color. Although the popularity of red skin color varieties increased lately, the surfaces planted with these varieties are still relatively small. Potato varieties with red skin color today are mostly grown in the Mediterranean area, Middle East and North Africa. These varieties, regardless of the flesh color, have high nutritional value and are generally used for direct consumption. Due to the firmness and texture of flesh they are commonly used for soups, salads and frying. Although the skin and flesh color does not affect the quality of the tubers, it significantly determines customer interests. Stability of flesh color after cooking significantly affects its marketability (Momirović et al., 2000).

Natural pigmentation of the skin color makes a group of varieties with red skin color very attractive for supermarkets and green markets (McComber et al., 1994). These varieties are characterized by a slightly higher content of fiber, vitamin C, iron and protein. Although the market is relatively small and unstable for red skin varieties noticeable increase in the consumption of red varieties in the human diet is a consequence of a high content of anti cancer substances in the tubers - anthocyanins and various antioxidant substances (Brown, 2005; Wang and Stoner, 2008).

The study of the different potato varieties on a numerous localities is very important as it helps making the best selection of genotypes adapted to the given agro-ecological conditions (Yang, 2002, Jovovi et al., 2012a, 2012b). Some potato genotypes have the ability to adapt to very different environmental conditions and in the long run provide stable yields to a higher or lower level (Annicchiarico, 2002). Only through knowledge of biological, morphological and productive characteristics of potato varieties, and their reactions to different agro-ecological conditions it is possible to achieve high and stable yields (Momirovi et al., 2000). Productivity is a function of the variety of its adaptability to environmental conditions, so it is very important to choose varieties that will be able to consistently achieve high yields in a wide range of different environmental factors (Haldavankar et al., 2009).

The aim of this study was to examine the genetic potential of six dominant red varieties of potatoes in the conditions of the mountain region of Montenegro in order to find the genotypes that will obtain stable and satisfactory yields in these conditions. In order to ensure high and stable production, which involves the maximum use of the genetic potential, it is necessary to have information on different types of interactions between genotype and the environment (Jovovi et al., 2013c).

Materials and methods

The study of the productivity of six Dutch potato varieties with red skin color, predominantly grown in Montenegro (Kondor, Kuroda, Aladdin, Roko, Desiree and Rudolph) was conducted during 2010 and 2011. The experiments were conducted in different climatic conditions and different soil types: Nikši (800 meters above sea level, acid brown soil), Kolašin (900 meters above sea level, alluvial-diluvial soil) and Žabljak (1450 meters above sea level, black soil on limestone).

Tests were carried out using field trials in a randomized block design with 4 replications. The plot size was 21 m². Planting of potatoes was done manually with 70 cm between row distance and 33 cm within row plant distance respectively, achieving the density of 43300 plants per hectare. Standard agricultural practice for the potato crop was applied. Potato harvesting was done after full maturation of canopy. 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 randomize complete block design with three factors: variety (V), locality (L) and year (Y). The significant differences among the means were evaluated according to least significant difference (Lsd) test (Maleti, 2005).

Soil on which the experiments were carried out is characterized by favorable water and air properties and high humus content. On the other hand these soils are poor in phosphorus and calcium and with moderate potassium content (Table 1).

Table 1 - Chemical characteristics soil on experimental field

Depth (cm)	Locality	pH		CaCO ₃ %	Humus %	Soluble mg/100 g	
		H ₂ O	nKCl			P ₂ O ₅	K ₂ O
40	Nikši	6.57	5.97	1.75	3.05	9.3	17.3
	Kolašin	6.29	5.55	1.1	4.53	2.4	16.0
	Žabljak	5.91	4.85	2.05	7.32	6.2	23.5

As shown in Table 2 meteorological data were significantly different on different sites and between years as well.

Table . 2 - Meteorological conditions during the experiments

Year	Locality	Month					Average
		May	June	July	August	September	
Air temperature (⁰ C)							
2010	Nikši	14	18.6	22	23.3	16.1	18.8
	Kolašin	11.6	15.9	18	18.3	12.6	15.3
	Žabljak	9.2	14.1	16.0	17.1	10.7	13.4
2011	Nikši	15.6	18.5	21.8	22.8	18.1	19.4
	Kolašin	11.3	16.2	17.6	18	15.6	15.7
	Žabljak	8.8	13.9	15.9	16.5	14.1	13.8
Amount of rainfall (mm)							
2010	Nikši	157	220	39	23	210	649
	Kolašin	202	103	34	12	117	468
	Žabljak	163	93	35	20	82	393
2011	Nikši	135	56	40	29	140	400
	Kolašin	148	72	70	40	101	431
	Žabljak	162	43	76	53	113	447

Results and discussion

The average potato yield in investigation years is shown in Table 3. Highest potato yield in two years study was obtained in variety Rudolph - 32.8 t.ha⁻¹, and lowest in Kuroda - 25.4 t.ha⁻¹. High potato yields were also measured in varieties Aladin and Roko (29.6 and 29 t.ha⁻¹, respectively). Differences in yields obtained between variety Rudolph and other varieties were statistically very significant. Also, all varieties gave significantly higher tuber yield compared to Kuroda. Significant differences in the genetic bases among the studied potato varieties is in compliance with the results cited by Jovovi at al. (2012d), Bro i et al. (2000) and Bugar i et al. (1997).

Results of research demonstrated significant impact of the localities on potato yield of studied varieties. Highest yields were obtained in Žabljak (31.3 t.ha⁻¹) in 2011, and lowest in Nikši (25.3 t.ha⁻¹) in the same year. According to location means, the highest potato yield for all varieties was achieved in Žabljak (29.1 t.ha⁻¹), while the lowest in Nikši (28 t.ha⁻¹). Statistical processing of data significant differences was traced exclusively in average yields of potato tubers in localities Žabljak and Nikši . This strong influence of environment on yield of potato has also been reported by Hassanpanah (2011).

By analysis of average potato yields, it can be concluded that in studied years, yields were more or less uniform - 28.9 in 2010 and 28.2 t.ha⁻¹ in 2011. Taking into account that the potato plants require temperatures between 16 do 19 °C in phase of tuberisation, intensive tuber growth and beginning of flowering (Barkley, 2005) it is obvious that the potato crop on all localities in both studied years had favorable thermal conditions (Table 2). Higher precipitation and slightly better monthly distribution caused the slight increase of yield in 2010. The difference in tuber yield in studied years had 5% significance level. Since the research was conducted in the northern region of Montenegro, in the mountain climate conditions, the tuber yield obtained can be considered high.

Table 3 - Potato yield in investigated period

Variety (A)	Locality (B)									Average (A)
	Nikši			Kolašin			Žabljak			
	2010	2011	Average	2010	2011	Average	2010	2011	Average	
Kondor	29.7	25.5	27.6	25.6	27.2	26.4	23.2	34.8	29.0	27.7 c
Kuroda	24.1	25.2	24.7	23.4	24.6	24.0	25.7	29.4	27.6	25.4 d
Aladin	35.2	23.7	29.5	31.5	24.8	28.2	29.7	32.7	31.2	29.6 b
Roko	28.1	26.6	27.4	33.1	31.8	32.5	22.9	31.4	27.2	29.0 b
Desiree	29.9	22.2	26.1	26.7	29.2	28.0	27.3	25.7	26.5	26.8 c
Rudolph	37.4	28.6	33.0 b	33.7	30.9	32.3 ab	32.4	33.7	33.1 a	32.8 a
Average (B)	30.7	25.3	28.0	29.0	28.1	28.5	26.9	31.3	29.1	28.5
Average (C)	2010	28.9 a								
	2011	28.2 b								

Source	lsd	
	0.05	0.01
Variety (V)	0.9292	1.2291
Year (Y)	0.5365	0.7625
Location (L)	0.6570	0.8691
V*Y	1.3140	1.7383
Y*L	0.9292	1.2291
V*Y*L	2.2760	3.0108

Apart from individual influence of the factors, their interactions (V*Y, Y*L, G*Y*L) were also high significant for investigation trait. Analysis of interactive influence of factors studied demonstrates that statistically significant higher tuber yields were obtained in Žabljak in 2011 (31.3 t.ha⁻¹) and Nikši in 2010 (30.7 t.ha⁻¹) comparing to the all other locality x year interactions. Variety Rudolph had significantly higher yields in 2010 (34.5 t.ha⁻¹) while Kuroda significantly lower yields in the same year (24.4 t.ha⁻¹). Highest yield in the research is measured in crops with varieties Rudolph, on locality Nikši, in 2010 (37.4 t.ha⁻¹), while the lower potato yield was obtained in variety Desiree, in Nikši, in 2011 (22.2 t.ha⁻¹).

Conclusion

The two-year research results of investigation of productivity of different red skin potato varieties in mountainous region of Montenegro allow us to conclude:

- The highest tuber yield had in Rudolph variety (32.8 t.ha⁻¹), while the lowest yield was measured in the crop of Kuroda variety (25.4 t.ha⁻¹).
- Highest productivity was in Žabljak (29.1 t.ha⁻¹), while the lowest was in Nikši (28 t.ha⁻¹).
- As the result of the higher total amount of rainfall higher potato yields were obtained in 2010 (28.9 t.ha⁻¹).
- Localities and years of investigation, individually and in interaction, have had a major influence on tuber yield of potato varieties studied
- Considering the obtained yields of tubers of six potato varieties with red skin color tested, the best varieties for growing in the north of Montenegro are Rudolph, Aladin and Roko.

Literature

- Annicchiarico, P. (2002): Genotype \times Environment Interactions –Challenges and Opportunities for Plant Breeding and Cultivar Recommendations. FAO Plant Production and Protection Paper-174. Food and Agriculture Organization of the United Nations, Rome, Italy.
- Barkley, S. (2005): Botany of the Potato Plant. Agriculture, Food and Rural Development, Government of Alberta.
- Broji, Z., Momirovi N., Barik, B., eki, R. (2000): Journal of Scientific agricultural research. Vol. 61, No 215, 131–141, Belgrade.
- Bugar i, Ž., Bugar i, R.A., eki, R., Ivan, J. (2000): A study of yields of Duch potato varieties in different agro-ecological conditions in Serbia. Journal of Scientific agricultural research. Vol. 61, No 215, 143–150, Belgrade.
- Brown, C. R. (2005): Antioxidants in potato. American Journal of Potato Research 82: 163-172.
- CIP, International Potato Center, 2011, <http://www.cipotato.org/potato>
- FAOSTAT, Food and Agriculture Organization of the United Nations, 2008, <http://faostat.fao.org/>
- Haldavankar, P.C., G.D. Joshi, S.G. Bhav, R.G. Khandekar and S.S. Sawant (2009): Stability of Yield and Yield Attributing Phenotypic Characters in Sweet potato (*Ipomoea batatas* (L.) Lam.). Journal of Root Crops, Vol. 35 No. 1, pp. 28-35, Indian Society for Root Crops
- Hassanpanah, D. (2011): Analysis of G \times 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., Dolijanovi, Ž., Velimirovi, Ana, Pošti, D., Hrni, Snježana (2012a): Productivity analysis of five leading potato varieties in agro-ecological conditions of mountainous region in Montenegro. Agro – knowledge, Vol. 13, br. 4, 583-589, University of Banjaluka, Faculty of agriculture.
- Jovovi, Z., Mili, Vesna, Pošti, D., Velimirovi, Ana, Šilj, Milana, Strunjaš, Katarina (2012b): Productivity testing of early and medium early 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., Dolijanovi, Ž., Kova evi, D., Velimirovi, Ana, Biberdži, M. (2012c): The productive traits of different potato genotypes in mountainous region of Montenegro. Genetika, Vol. 44, No 2, 389-397, Belgrade.
- Jovovi, Z., Miloševi, D. Dolijanovi, Ž., Ana, Velimirovi, Pošti, D. (2012d): Results of testing novel potato varieties in agroecological conditions of Žabljak, Montenegro. The 17th international symposium on biotechnology, Abstract book, 19-23, a ak, Serbia.
- Maleti, R. (2005): Statistics. Reference book. University of Belgrade, Faculty of Agriculture, Belgrade.
- McComber, D. R., Horner, H. T., Chamberlin, M. A., Cox, D. F. (1994): Potato cultivar differences associated with mealiness. Journal of Agriculture 42:2433–2439.
- Momirovi, N., Mišovi, M., Broji, Z. (2000): Modern technology of growing multi-purpose potato. Journal of Scientific agricultural research. Vol. 61, No 215, 45–70, Belgrade.
- Pardo, J. A., Alvarruiz, A., Perez, J. I., Gomez, R., Vron, R. (2000): Physical-chemical and sensory quality evaluation of potato varieties (*Solanum tuberosum* L.). Journal of Food Quality 23:149–160.
- Wang, L. S. and Stoner, G. D. (2008): Anthocyanins and their role in cancer prevention. Cancer Letters 269: 281-290.
- Yang, C. (2002): Analysis of genotype and environment (GxA) interaction in grain yield and leaf blast reaction of rice varieties through multi-location trials. Dissertation, Kangown National University. Korea, pp. 34-50.