

**PRODUCTIVITY TESTING OF EARLY AND MEDIUM EARLY POTATO VARIETIES IN AGRO-ECOLOGICAL CONDITIONS IN NORTHERN MONTENEGRO**

Zoran JOVOVIC<sup>1\*</sup>, Vesna MILIC<sup>2</sup>, Dobrivoj POSTIC<sup>3</sup>, Ana VELIMIROVIC<sup>1</sup>,  
Milana SILJ<sup>2</sup>, Katarina STRUNJAS<sup>1</sup>

<sup>1</sup> Biotechnical faculty, University of Montenegro, Podgorica, Montenegro \*

<sup>2</sup> Faculty of Agriculture, University of East Sarajevo, Bosnia and Herzegovina

<sup>3</sup> Institute for Plant Protection and Environment, Belgrade, Serbia

(Corresponding author: [jovovic@t-com.me](mailto:jovovic@t-com.me))

**Abstract**

In this paper result of two years study of genetic potential on productivity of seven early and medium early Dutch potato varieties are shown: Riviera, Monaco, Arrow, Artemis and Tresor (early) and Almera and Arnova (medium early). Research was done on three localities in agro ecological conditions of northern Montenegro: Niksic (800 m a.s.l.), Kolasin (900 m a.s.l) and Zabljak (1450 m a.s.l). Field trials were set up using standard methodology; random block design in 4 repetitions.

Variance analysis showed variability of potato yield depending on variety, locality and year of testing. Highest two years average yield had variety Arnova (32.1 tha<sup>-1</sup>), and the lowest variety Arrow (22.9 tha<sup>-1</sup>). Zabljak, located in the highest altitude, had the best conditions for growing of early and medium early potato varieties (30.8 tha<sup>-1</sup>), while the lowest productivity was measured in Niksic (23.6 tha<sup>-1</sup>). In 2011, average yield was higher (31.1 tha<sup>-1</sup>) as a consequence of better rainfall distribution during potato growing season.

**Key words:** *potato, early and medium early varieties, yield*

**Introduction**

According to the planted area, potato represents the leading agricultural crop in Montenegro. In the production structure of the arable land, potato accounts for more than 20%. Zoning of the potato production is closely related to the nature, primarily climatic conditions. The production of early potatoes, intended for fresh consumption, is mainly located in the Zeta-Bjelopavlići plain and the coastal zone with a share in the total production of 16.8%. Production of potatoes intended for the storage is a dominant type of production (83.2%) and is related to hilly-mountainous area (Monstat, Statistical Yearbook for 2011.).

Potato yields are still relatively low in Montenegro. Such condition is caused by various factors, among which, the most important are: the low level of applied technology, growing potatoes in long-term monoculture, fragmentation of production plots, limited application of mechanization, production under dry farming conditions, insufficient use of certified planting material (used on only 10-12% of the surface), adverse effects of agro-ecological factors (high summer temperatures and growing deficit of rainfall during the growing season of potato), periodical epiphytotic attacks of fire blight, etc. (*Jovovic et al., 2011, Milošević et. al. 2004*).

Potato yields in Montenegro are very unstable and very susceptible to the influence of meteorological conditions (*Jovovic et al., 2002*). By proper selection of varieties it is possible

to overcome the adverse impacts of vegetation factors, especially the water-air regime of soil, high air temperatures and short growing season in the mountain area.

Potatoes for human consumption must have the organoleptic quality, i.e. it must be adapted to the requirements of the market. Tubers should be nicely shaped, with shallow buds, healthy, strong and pretty equal in size. Tuber skin and flesh colour are not essential for the quality, but significantly determine customers' interest. Color stability of meat after cooking is also very important feature of tubers' that significantly affect its marketability. Only by good knowledge of biological, morphological and productive traits of potato varieties and their compliance with existing pedoclimatic conditions it is possible to achieve high and stable yields (*Momirovic et al., 2000*).

The systematic study of the different varieties of potatoes on a number of sites is extremely important because it spreads a wider selection of varieties adapted to the given specific conditions (*Yang, 2002*). Some potato genotypes have the ability that in very different environmental conditions provide stable yields, either on a higher or lower level (*Annicchiarico, 2002*). Variety productivity is a function of its adaptability to provide stable yields in very different agro-ecological conditions, so it is very important to create varieties that will, in a wide range of environmental factors, be able to consistently provide high yields (*Haldavankar et al., 2009*).

The aim of this study was to investigate the genetic potential of the tested potato varieties and examine their reactions to the specific conditions of mountain regions, in order to find the genotypes that will, in the certain production conditions, give satisfactory and stable yields.

### Materials and methods

The study of the productivity of seven early (Riviera, Monaco, Arrow, Artemis and Tresor) and medium early (Almera and Arnova) dutch potato varieties was conducted during 2010. and 2011. Trials were conducted in very different agro-ecological conditions and on different soil types: Nikšić (800 meters above sea level, acid brown), Kolašin (900 m above sea level, alluvial-deluvial) and Žabljak (1450 m above sea level, black soil on limestone).

Tests were carried out using field trials, in a randomized block design with 4 replications. The surface of the elementary plot was 21 m<sup>2</sup>. Potato planting was carried out manually on spacing of 70 cm and the distance between plants in a row of 33 cm, with the obtained density of 43300 plants per hectare. Overall agro-technology was conducted in a standard way for the crop of potatoes. Harvest of potatoes was carried out after the complete maturation of potato vine. The yield of potatoes in the trial was determined by measuring the tubers at each elementary plot, and then the yield per hectare was calculated.

Table 1. Chemical characteristics soil on experimental field

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
40	Nikšić	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

Soils on which the trials have been conducted are characterized by good water-air properties and high humus content. On the other hand, they are poor in phosphorus, low in calcium and moderately supplied with potassium (*Table 1*). Meteorological data during the investigated period are presented in *Table 2*. Statistical analysis was done using factorial analysis of variance (ANOVA), and the score of differences between the mean values was performed using LSD test.

Table 2. Meteorological conditions during the experiment

Year	Locality	Month					Average
		May	June	July	August	September	
Air temperature ( $^{\circ}\text{C}$ )							
2010	Nikšić	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	Nikšić	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)							
							Total
2010	Nikšić	157	220	39	23	210	649
	Kolašin	202	103	34	12	117	468
	Žabljak	163	93	35	20	82	393
2011	Nikšić	135	56	40	29	140	400
	Kolašin	148	72	70	40	101	431
	Žabljak	162	43	76	53	113	447

### Results of the study and discussion

The results in *Table 3* show that the average potato yield in both years studied was under a highly significant effect of genotype and production sites, and their interaction (variety x location).

Variety Arnova had the highest yield of the two-year average ( $32.1 \text{ tha}^{-1}$ ), while the lowest yield was measured at variety Arrow ( $22.9 \text{ tha}^{-1}$ ). Arnova, in comparison to all other varieties (except Tresor in 2010), gave a significantly higher yield of tubers. The lowest yields were measured in the variety crops Arrow, Riviera and Artemis ( $22.9$ ,  $24.5$ , and  $25.1 \text{ tha}^{-1}$ ).

As the agro-ecological conditions in the studied areas were very different, the reaction of varieties to such conditions had been also different. In the mountainous region of Montenegro, Žabljak, which is located at the highest altitude (1450 m), proved to be the most suitable site for the production of early and medium early varieties of potatoes ( $30.8 \text{ tha}^{-1}$ ), while the lowest productivity of potato varieties studied was manifested in Nikšić ( $23.6 \text{ tha}^{-1}$ ). Statistical data analysis showed a significant increase in yield in Žabljak compared to other sites (with the exception of Nikšić in 2010.).

Statistically significant differences in the average yield of potatoes were created by the influence of the interaction variety x location. Arnova x Žabljak, in 2010. ( $27.7$ ) and interaction Almera ( $46.1 \text{ tha}^{-1}$ ) and Arnova ( $45.6 \text{ tha}^{-1}$ ) x Žabljak, in 2011. have caused a significant increase in yield of potatoes in comparison to all other interactions.

The lowest yields in both years studied were realized under the influence of interaction Arrow x Nikšić,  $19.0$ , i.e.  $20.8 \text{ tha}^{-1}$ . Such emphasized effect of the site on potato yield is in accordance with the results of earlier studies (*Jovović et al, 2012; Hassanpanah, 2011*).

*Comparing the studied years shows that higher potato yields were achieved in 2011. ( $31.1 \text{ tha}^{-1}$ ) as a result of better distribution of rainfall in the growing season, but excessive amounts*

Table 3. Average yield of potato (tha<sup>-1</sup>)

Lokal. (B)	Year	Variety (A)							Average
		Riviera	Monaco	Arrow	Artemis	Tresor	Almera	Arnova	
Nikšić	2010.	24.1	22.7	19.0	22.9	24.1	21.5	23.0	22.5
	2011.	26.1	23.6	20.8	22.7	24.9	22.0	33.0	24.7
	<b>Aver.</b>	<b>25.1</b>	<b>23.2</b>	<b>19.9</b>	<b>22.8</b>	<b>24.5</b>	<b>21.8</b>	<b>28.0</b>	<b>23.6</b>
Kolašin	2010.	22.8	22.2	19.9	20.1	24.2	19.6	23.3	21.7
	2011.	21.7	30.9	26.2	30.3	31.7	30.8	40.4	30.3
	<b>Aver.</b>	<b>22.3</b>	<b>26.6</b>	<b>23.1</b>	<b>25.2</b>	<b>28.0</b>	<b>25.2</b>	<b>31.9</b>	<b>26.0</b>
Žabljak	2010.	21.3	25.2	20.6	21.5	24.5	20.7	27.7	23.1
	2011.	29.4	41.6	30.7	34.7	40.7	46.1	45.6	38.4
	<b>Aver.</b>	<b>25.4</b>	<b>33.4</b>	<b>25.7</b>	<b>28.1</b>	<b>32.6</b>	<b>33.4</b>	<b>36.7</b>	<b>30.7</b>
Average	2010.	23.2	22.4	19.8	21.0	24.3	20.6	24.6	22.3
	2011.	25.7	32.0	25.9	29.2	32.4	33.0	39.6	31.1
	<b>Aver.</b>	<b>24.5</b>	<b>27.2</b>	<b>22.9</b>	<b>25.1</b>	<b>28.4</b>	<b>26.8</b>	<b>32.1</b>	<b>26.7</b>
Nikšić	2010.								22.5
	2011.								24.7
	<b>Aver.</b>								<b>23.6</b>
Kolašin	2010.								21.7
	2011.								30.3
	<b>Aver.</b>								<b>26.0</b>
Žabljak	2010.								23.1
	2011.								38.4
	<b>Aver.</b>								<b>30.8</b>
<i>Lsd</i>		2010.			2011.				
		<i>A</i> **	<i>B</i> **	<i>AxB</i> **	<i>A</i> **	<i>B</i> **	<i>AxB</i> **		
	0.05	0.939	0.615	1.627	1.687	1.104	2.922		
	0.01	1.249	0.817	2.162	2.242	1.468	3.884		

Comparison the studied years shows that higher potato yields were achieved in 2011. (31.1 tha<sup>-1</sup>) as a result of better distribution of rainfall in the growing season, but the excessive amount of rainfall in May in 2010., with severe drought in the coming months (22.3 tha<sup>-1</sup>). Phenotypic variability of the main components of yield is primarily determined by the differences between the genotypes of tested varieties, while the variation of their derivatives (tuber number and yield per plant) is highly dependent on the interaction of genotype with environmental factors (Nacheva, 2006). To ensure high and stable production, which means the maximum utilization of genetic potential, it is necessary to have as much information as possible about the different effects of interaction of the genotype x environment.

### Conclusion

Based on the results of two-year study of seven Dutch potato varieties at three different sites in the mountain region of Montenegro, it can be concluded:

1. Arnova had the highest yield in the two-year average (32.1 tha<sup>-1</sup>), while the lowest yield was measured in the case of variety Arrow (22.9 tha<sup>-1</sup>). Arnova, in comparison to all other varieties (except from Tresor in 2010.), had a significantly higher yield of tubers.
2. Žabljak proved to be the most favorable site for the production of early and medium early varieties of potatoes (30.8 tha<sup>-1</sup>), while the varieties studied showed the lowest productivity in Nikšić (23.6 tha<sup>-1</sup>).
3. Statistically very significant differences in the average yield of potatoes were created by the influenced of variety x location interaction. Interactions Arnova x Žabljak, in

2010. (27.7  $\text{tha}^{-1}$ ) and Almera (46.1  $\text{tha}^{-1}$ ) and Arnova (45.6  $\text{tha}^{-1}$ ) x Žabljak, in 2011 gave significantly higher average yields of tubers in comparison to all other interactions.
4. The lowest yields in both years studied were achieved under the influence of interaction Arrow x Nikšić (19.0 and 20.8  $\text{tha}^{-1}$ ).

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