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Original scientific paper

VARIABILITY OF DUTCH POTATO VARIETIES UNDER VARIOUS AGROECOLOGICAL CONDITIONS IN SERBIA

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The study presents results of a three-year experiment of variability of different Dutch potato varieties in Serbia: Adora and Cleopatra (early), Innovator and Frisia (medium-early) and Desiree and Kondor (medium-late). The research was conducted during 2008, 2009 and 2010, in three different soil and climatic locations: Zemun (100 m a.s.l.), Srbobran (86 m a.s.l.) and Guča (370 m a.s.l.). The four-repplicate field trials were set up using standard methodology according to the random block desing.
The analysis of variance suggest that number of tubers per plant, number of market tubers per plant and total tuber yield were significantly fluctuating depending on genotype (G), year (Y) and the location (L). In addition to individual influences of different factors, their interactions were also pronounced (G x Y, G x L, Y x L, G x Y x L).
In the three-year period average, the highest total yield was recorded in Zemun (35.80 t ha^{-1}), followed by Guča (29.32 t ha^{-1}), while the lowest average yield recorded was in Srbobran (27.38 t ha^{-1}). The highest average yield of tubers in the three-year period was recorded in the Cleopatra variety, followed by Adora variety, while the lowest average yield was recorded in the variety Frisia. Obtained results show that the highest yields over observed locations were recorded in early varieties that formed medium number of tubers per plant (Cleopatra and Adora) and medium late varieties (Desiree and Kondor) that expressed good resistance to high air temperatures and stress caused by drought.

Key words: genotype, potato, tuber, varieties, yield

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INTRODUCTION

The great economic importance of potato arises from the fact that this crop is grown on 78.000 ha, with an average yield (for the period 2003-2013) of 11.3 t ha^{-1}. The mentioned average yield is significantly inferior to the potato yields in Europe and in the world ranging from 37.0 to 55.0 t ha^{-1} (FAO, 2013). Commercial potato production is carried out on 50.000-60.000 ha with an average yield ranging from 15 to 25 t ha^{-1}.

Yields in commercial potato production (t ha^{-1}) depend on the genetic potential of varieties, agro-ecological conditions, technology applied and the length of the growing season, which means that in terms of a longer period of tuber bulking larger tubers are formed and consequently total yields are higher. However, this often does not have to be confirmed in practice, because the early and middle early varieties characterized by the early tuber formation and faster tubers bulking tend to produce higher yields than potentially high yielding medium late and late potato varieties, especially under conditions of relative drought, unless the irrigation, as a compulsory cropping practices, is applied in production (POŠTIĆ, 2013). Potato yield depends on the variety and its genetic potential, agro-ecological conditions, the level of applied cropping practices, tuber viability, seed tuber size, the number of stems per plant and the number of tubers per plant (BUS & WUSTMAN, 2007; MOMIROVIĆ *et al.,* 2010; POŠTIĆ *et al.,* 2012; POŠTIĆ *et al.,* 2013).

Higher air temperatures stimulate vegetative development, and reduce tuber formation, average tuber weight, tuber yields, harvest index and concentration of dry matter in tubers. According to POŠTIĆ *et al.,* 2015 soil temperatures over 27 ºC in the surface 10 cm soil layer (the main zone for the tuber formation) in the phenophase of tuber bulking, play a key role in the reduction of yields and quality of potato tubers. TOMASIEWICZ *et al.* (2003) stated that the soil water during the stolon formation and tuber initiation significantly affected yields, while LAHLOU *et al.* (2003) further stated that drought may reduce tuber yield even by 11 to 53%.

The systematic study of various genotypes over different locations is of a huge importance for the selection of varieties adapted to the specific climatic conditions (YANG, 2002). Vegetation factors together with a genotype have significant impact on potato yields (MOMIROVIĆ *et al.,* 2010; POŠTIĆ *et al.,* 2015). The response of different genotypes under diverse agro-ecological conditions is dependant on their genetic traits (internal factors) and the interaction with the environment (external factors). Knowledge of these traits is very important when selecting varieties as it enables achieving high yields, stable production and the maximum utilization of genetic resources (PETROVIĆ *et al.,* 2010). One of the ways to reduce the negative impact of the interaction between genotype and the environment is the identification and cultivation of stable genotypes (MONDAL, 2003; YAN and KANG, 2003).

Some potato genotypes have the ability to achieve very stable yields under very different environmental conditions (ANNICCHIARICO, 2002). Stability represents a very low genotype response to changed environmental conditions and it is considered a desirable characteristic in agricultural production. Varieties with low interactions under different agro-ecological conditions reach stabile yields (DIMITRIJEVIC *at al.*, 2010), thus the genotypes with a minimum yield variation are considered stable (SABAGHNIAA *et al.,* 2006). In all selection programs genotype stability has a high priority as it is desirable that newly developed genotypes have high yields in a wide environmental array (ABALO *et al.,* 2003).

Environmental conditions vary significantly over specific potato growing regions, thus response of some genotypes to these conditions are different as well. Genotype productivity is significantly reduced if a genotype is unable to utilise its full genetic potential under the given environmental conditions, but also if it is susceptible to unfavourable environment effects (GRAY, 1999). It is well known that all the varieties selected for specific agro-ecological conditions can only utilize their maximum genetic potential under such conditions (provided the use of optimal cropping practices are provided).

The objective of the conducted research was to determine potato varieties suitable for certain agro-ecological locations in which they will result in high and stable yields.

MATERIALS AND METHODS

Production characteristics of six potato varieties were studied in three locations in Serbia: Zemun (100 m a.s.l., luvic chernozem), Srbobran (86 m a.s.l., chernozem) and Guča (370 m a.s.l., pseudogley). The objects of research were early maturity varieties (Adora and Cleopatra), medium maturity varieties (Innovator and Frisia) and late maturity varieties (Desiree and Kondor).

The sowing was conducted in four replications in all locations in April. Spacing between rows was 0.70 m and spacing between plants in row was 0.35 m. Standard cropping practices were applied in all locations during growing season. During this period, the number of primary stems per plant 65 days after planting. Plots were harvested at the beginning of September in the first year of the experiment and at the end of September in the second year. After the harvest the number of tubers per plant, number of marketable tubers per plant (properly developed healthy tubers weighing more than 70 g), marketable tuber yield and total yield were precisely determined.

Table 1. Chemical properties of soil in the experimental plots

Depth (cm)	Location	pH		Total N	Humus	Soluble mg/100 g	
		H_2O	nKCl	%	%	P_2O_5	K_2O
40	Zemun	7.60	6.90	0.17	3.52	31.00	34.80
	Srbobran	8.00	7.50	0.19	4.04	35.10	29.10
	Guča	4.60	3.85	0.15	2.22	4.00	14.75

Meteorological conditions data in Table 2 indicate significantly higher air temperatures than optimal. The highest air temperature was in Zemun. There was also a low amount of precipitation in all locations, particularly in June, July and August. During the second year of experiment average air temperatures were closer to long-term average values. The precipitation distribution was better, with low amounts in Zemun and Srbobran in July.

Soil properties are shown in Table 1. In Zemun, luvic chernozem was fairly supplied with humus, well supplied with nutrients and was showing neutral to low alkaline pH reaction. There were higher amounts of nutrients and humus in soil in Srbobran. In Guča, the experiment was conducted on pseudogley with low amounts of humus and nutrients and very acid pH reaction.

Obtained results were analysed by the analysis of variance (ANOVA, F-test; $P \leq 0.05$, $P \leq 0.01$ and $P \leq 0.001$) and effect of factors (year, genotype, locality and their interaction). Tukey's multiple range test and coefficients of variation (CV, %) were used to determine the differences among varieties. Correlation between observed parameters were determined by Pearson correlation coefficients (r). Data were processed by program STATISTICA, version 8 (StatSoft Inc, Tulsa, OK, USA).

Table 2. Meteorological conditions in the course of experiment

Year	Location	Month						Average
		April	May	June	July	August	September	
		Air temperature (°C)						
2008	Zemun	13.7	19.3	23.2	23.4	23.8	16.5	19.98
	Srbobran	13.1	18.7	22.4	22.1	22.5	15.8	19.10
	Guča	11.0	15.4	19.7	20.3	20.0	13.9	16.72
2009	Zemun	15.6	19.8	20.9	24.1	24.1	20.2	20.78
	Srbobran	14.7	18.9	19.7	23.0	23.2	19.5	19.83
	Guča	11.8	16.7	18.4	20.6	20.3	16.2	17.33
2010	Zemun	13.7	18.1	21.2	24.3	24.1	17.2	19.77
	Srbobran	12.7	17.4	20.7	23.3	22.0	16.3	18.73
	Guča	11.0	15.1	19.2	21.0	20.6	15.1	17.00
		Precipitation sum (mm)						Total
2008	Zemun	42.1	64.0	50.7	53.0	45.5	64.9	320.2
	Srbobran	27.9	11.6	97.2	30.5	51.0	76.8	295.0
	Guča	54.2	96.6	76.3	103.1	22.8	112.0	465.0
2009	Zemun	4.9	43.2	122.6	80.0	44.5	3.9	299.1
	Srbobran	5.3	67.4	89.7	22.3	17.6	4.5	206.8
	Guča	22.5	25.3	147.1	70.1	61.9	17.5	344.4
2010	Zemun	41.6	86.4	124.0	24.8	53.5	56.6	386.9
	Srbobran	46.8	81.7	191.1	98.5	58.5	103.7	580.3
	Guča	58.8	66.5	99.7	83.5	38.5	48.3	395.3

RESULTS AND DISCUSSION

The F test, in the complex three factorial analysis, showed a significant effect ($p<0.001$) of the year on the number of marketable tubers. An effect of the variety (genotype) on the number of tubers per plant, marketable tuber yield and total yield was also significant ($p<0.001$); the impact of the year on the number of stems per plant was significant (Table 3), which coincides with the results gained by POŠTIĆ *et al.*, (2015). The effect of the location on the number of stems per plant was not that significant, while the other observed traits were significantly influenced by it ($p<0.05$). Interaction of studied factors were significant among all the factors and for all the traits ($p<0.05$) or ($p<0.01$).

The number of stems per plant is extremely important morphological property, because it affects the development of aboveground mass and assimilation area (STRUIK, 2007), the number of seeded tubers per plant, and total yield (KHAN *et al.,* 2004; poštić *et al.,* 2012). The largest number of stems per plant in the three-year average is determined in the variety Desiree in all three locations (Table 4), a consequence of the good tolerance of this variety to drought and its genetic potential to form a larger number of stems per plant.

Table 3. The influence of mean values on the properties by application F test

Source	d.f.	Number of stems	Number of tubers	Number of market tubers	Marketable yield (t ha⁻¹)	Total yield (t ha⁻¹)
Genotype (G)	5	**	*	**	*	*
Year (Y)	2	*	**	***	**	**
G*Y	10	**	*	**	*	**
Location (L)	2	ns	*	*	*	*
G*L	10	*	*	*	**	*
Y*L	4	*	*	**	*	**
G*Y*L	20	*	*	**	**	**

G-genotype (G_1 Adora; G_2 Cleopatra; G_3 Innovator; G_4 Frisia; G_5 Desiree; G_6 Kondor); L-location ^{nsz}=P>0.05,*=P<0.05,**=P<0.01 ***=P<0.001

* Means in the columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

A significant impact of the year on the number of stems per plant was especially distinct in 2009, when the lowest number of stems per plant was recorded in all locations. This was a result of high air temperature accompanied by a small amount of precipitation (Table 2) in the vegetative stage of development. At the same time a large coefficient of variation was recorded (CV > 26.9 %) in all three locations (Table 4). The obtained results are consistent with results gained by other authors (WURR *et al.,* 2001; KHAN *et al.,* 2004; POŠTIĆ *et al.,* 2012), who stated that the number of stems per plant varied considerably depending on the variety and the production conditions. A highly significant correlation (p=0.01) between the number of stems per plant and the total number of tubers per plant was determined, while the correlation between the number of stems and the number of market tubers and marketable yield and total yield was not been established (Table 9).

The number of tubers per plant is distinct property of a variety, but linearly dependent on the number of stems per plant, agro-ecological conditions and production technology (TADESSE *et al.,* 2001; BARKLEY, 2005; POŠTIĆ *et al.,* 2012)**.** The determined number of tubers per plant (Table 5) is a direct consequence of the number of stems per plant (Table 4). The largest number of tubers per plant in all varieties studied was achieved in the years when the largest number of stems per plant was established, and this coincides with results achieved by many authors (ZEBARTH *et al.,* 2006; KNOWLES & KNOWLES, 2006; BUSSAN *et al.,* 2007; GULLUOGLU & ARIOGLU, 2009; POŠTIĆ *et al.,* 2012). This authors stateding that the number of tubers per plant varied according to changes in the number of stems per plant.

The lowest number of tubers per plant was determined in all locations in 2009 (Table 5) as a result of a small number of stems per plant initiated in 2009 (Table 4), as well as a lower amount of precipitation and higher air temperatures in the stage of tuber initiation in 2009 (Table 2). The coefficient of variation in 2009 in all locations was highest (Table 5). These results are in accordance with studies conducted by many authors (FABEIRO *et al.,* 2001; WALWORT & CARLING, 2002; TOMASIEWICZ *et al.,* 2003; BARKLEY, 2005; POŠTIĆ *et al.,* 2012)**,** who stated that the deficit of rainfall and higher air temperatures during the stolon formation and tuber initiation reduce the number of tubers per plant. The correlation analysis revealed a highly significant correlation between the total number of tubers, the number of market tubers, marketable yields and total yields (p=0.001) Table 9.

Table 4. Average number of above ground stems per plant

Location	Zemun			
Genotype (G)	Year			
	2008	2009	2010	Average
G_1	4.69ab	2.50c	2.75c	3.31
G_2	4.56abc	2.81bc	3.50bc	3.62
G_3	4.38bc	3.38b	4.13b	3.96
G_4	5.75a	3.38b	4.38b	4.50
G_5	5.56ab	5.13a	5.88a	5.52
G_6	3.44c	3.06bc	4.06b	3.52
Average	4.73	3.38	4.12	4.08
CV (%)	17.81	27.35	25.31	
Location	Srbobran			
G_1	4.88bc	3.19b	4.81a	4.29
G_2	4.31cd	3.38b	3.44c	3.71
G_3	4.50cd	3.00b	3.94bc	3.81
G_4	5.81a	2.88b	4.38abc	4.36
G_5	5.50ab	5.44a	4.63ab	5.19
G_6	4.00d	4.35b	3.57bc	4.00
Average	4.83	3.69	4.16	4.23
CV (%)	14.57	26.91	13.71	
Location	Guča			
G_1	3.19d	2.80b	3.75b	3.25
G_2	4.06c	3.13b	4.13b	3.77
G_3	5.00ab	2.88b	5.50a	4.46
G_4	4.38bc	2.94b	5.19a	4.17
G_5	5.06a	5.19a	6.06a	5.44
G_6	4.69ab	2.81b	4.06b	3.85
Average	4.40	3.28	4.78	4.15
CV (%)	15.95	28.44	19.45	
Total CV (%)	16.59	13.40	18.60	

G-genotype (G_1 Adora; G_2 Cleopatra; G_3 Innovator; G_4 Frisia; G_5 Desiree; G_6 Kondor); L-location ^{nsz}=P>0.05 *=P<0.05 **=P<0.01 ***=P<0.001

* Means in the columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Grouping Information Using Tukey Method and 95,0% Confidence

Table 5. Average number of tubers per plant

Location	Zemun			
Genotype (G)	Year			
	2008	2009	2010	Average
G_1	12.69b	5.63c	6.38c	8.23
G_2	11.13bc	6.56bc	8.69bc	8.79
G_3	9.44bc	7.38b	9.88b	8.90
G_4	16.69a	7.00bc	10.06b	11.25
G_5	11.00b	12.67a	12.31a	11.99
G_6	7.69c	5.50c	9.88b	7.69
Average	11.49	7.46	9.53	9.49
CV (%)	27.04	35.66	20.38	
Location	Srbobran			
G_1	12.25ab	7.56b	12.13a	10.65
G_2	9.00d	7.00bc	7.25b	7.75
G_3	9.94cd	5.06c	8.88b	7.96
G_4	12.81a	5.75bc	8.50b	9.02
G_5	10.94bc	9.56a	8.94b	9.81
G_6	9.38cd	7.00bc	7.78b	8.05
Average	10.72	6.99	8.91	8.87
CV (%)	14.52	22.34	19.14	
Location	Guča			
G_1	8.56d	5.44bc	9.50c	7.83
G_2	9.06cd	6.31b	11.06bc	8.81
G_3	10.50ab	4.81c	12.56ab	9.29
G_4	9.94bc	5.38bc	11.44ab	8.92
G_5	11.13a	10.44a	12.94a	11.50
G_6	8.88cd	5.38bc	11.06bc	8.44
Average	9.68	6.29	11.43	9.13
CV (%)	10.46	33.17	10.76	
Total CV (%)	21.23	21.02	18.60	

G-genotype (G_1 Adora; G_2 Cleopatra; G_3 Innovator; G_4 Frisia; G_5 Desiree; G_6 Kondor); L-location ^{nsz}=P>0.05 *=P<0.05 **=P<0.01 ***=P<0.001

* Means in the columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Grouping Information Using Tukey Method and 95,0% Confidence

The largest number of marketable tubers per plant was recorded in all locations in 2010 (Table 6), as a result of the favourable distribution of rainfall (Table 2). The lowest number of marketable tubers was recorded in 2009 (Table 6) in all locations, as a result of higher air temperatures and lower levels of rainfall (Table 2). In 2009 the largest coefficient of variation in all three locations was also determined (Table 6). These results are also in accordance with the researches of many authors (FABEIRO *et al.,* 2001; WALWORT & CARLING, 2002; TOMASIEWICZ *et al.,* 2003; BARKLEY, 2005; POŠTIĆ *et al.,* 2012)**,** and all these authors stated that the lack of water in the soil during tuber bulking was causing the increase in the number of small tubers, or the decrease in the number of larger tubers. A very high correlation (p = 0.001) between the number of marketable tubers, marketable yield and total yield was determined (Table 9).

The highest number of stems per plant (Table 4) was recorded in the variety Desiree at the location of Zemun, in 2009 and 2010, and as a result, the largest number of tubers per plant (Table 5). However, as a result of unfavourable conditions in 2009, the smallest number of marketable tubers were formed in the same variety (Table 6). On the other hand, the largest number of marketable tubers were formed in this variety in most favourable year 2010 (Table 6). The same tendency was established in the variety Desiree in Guča, while the same trend was recorded in Srbobran in 2008. BUSSAN *et al.* (2007) stated that the tubers were smaller in the year when a larger number of stems per plant were formed and this is not in accordance with our results. Based on our results, a greater number of stems in favourable climatic and soil conditions provide higher yields.

The largest number of market tubers per plant in Srbobran in 2008 and 2009 was recorded in the variety Desiree, while in 2010 the highest number was recorded in the variety Adora (Table 6).

Furthermore, in the location of Guča, the largest number of marketable tubers was recorded the variety Desiree in 2008 and 2010, while in 2009, this number was the largest in the early maturity variety Cleopatra (Table 6), which have a faster rate of tuber initiation and tuber bulking.

With regard to locations, the highest three-year average yield of marketable tubers 28.77 t ha^{-1} was recorded in the location of Zemun, then in the location of Guča 23.57 t ha^{-1}, while the lowest marketable tuber yield (21.65 t ha^{-1}) was established in Srbobran (Table 7).

Records of the three-year average marketable tuber yield in the locations of Zemun and Guča show that the variety Kondor was the top yielding variety, while in Srbobran, the highest yield of marketable tubers was recorded in the variety Cleopatra. The lowest yield of marketable tubers in the three-year average in all three locations was determined in Frisia variety (Table 7).

The highest, i.e. lowest marketable tubers yields over all locations were determined in 2010, i.e. 2009, respectively (Table 7).

As a result of a smaller number of stems per plant (Table 4), smaller number of tubers per plant (Table 5) and the smaller number of marketable tubers per plant (Table 6) in 2009 the lowest yield of marketable tubers was also determined (Table 7) in all tested locations; it is direct consequence of unfavourable agro-ecological conditions during the growing season in 2009 (Table 2), which coincides with the results of POŠTIĆ, (2013).

In 2009 and 2010 at the location of Zemun, the highest marketable yield was determined in the variety Kondor, as a result of the genetic potential of the variety to form a smaller number of larger tubers (Table 7). The highest marketable yield in 2008 at the location of Zemun was determined in the variety Adora, as a result of genetic predisposition of Adora to produce more tubers of medium size, while the lowest marketable yield was determined in the variety Desiree (Table 7).

The highest marketable yield in the location of Srbobran in 2008, 2009 and 2010 was established in the varieties Cleopatra, Innovator and Kondor, respectively. The lowest marketable yield in the location of Srbobran in 2009 and 2010 was recorded in the variety Frisia, while in 2008 the lowest marketable yield was recorded in the variety Desiree (Table 7).

Table 6. Average number of marketable tubers per plant

Location	Zemun			
Genotype (G)	Year			
	2008	2009	2010	Average
G_1	7.25a	3.25ab	5.5c	5.33
G_2	5.50ab	1.75b	5.8bc	4.35
G_3	7.0a	4.50a	6.5abc	6.00
G_4	7.50a	2.50ab	7.3ab	5.77
G_5	3.0b	1.50b	7.5a	4.00
G_6	6.0ab	3.0ab	7.3ab	5.43
Average	6.04	2.75	6.65	5.15
CV (%)	27.75	39.83	12.82	
Location	Srbobran			
G_1	5.70ab	3.5ab	7.5a	5.57
G_2	4.50b	4.3ab	6.0ab	4.93
G_3	5.50ab	4.3ab	6.0ab	5.27
G_4	6.70ab	2.7b	5.3b	4.90
G_5	8.00a	5.3a	6.2ab	6.50
G_6	6.70ab	4.5ab	6.3ab	5.83
Average	6.18	4.1	6.21	5.50
CV (%)	19.63	21.82	11.57	
Location	Guča			
G_1	5.5b	2.5ab	7.2ab	5.07
G_2	6.3ab	3.25a	7.5ab	5.68
G_3	6.3ab	1.50b	8.0a	5.27
G_4	6.5ab	2.25ab	6.0b	4.92
G_5	7.5a	3.0a	8.8a	6.43
G_6	6.5ab	2.75ab	8.7a	6.02
Average	6.43	2.54	7.72	5.56
CV (%)	9.96	24.43	13.82	
Total CV (%)	40.76	22.05	48.47	

G-genotype (G_1 Adora; G_2 Cleopatra; G_3 Innovator; G_4 Frisia; G_5 Desiree; G_6 Kondor); L-location ^{nsz}=P>0.05 *=P<0.05 **=P<0.01 ***=P<0.001

* Means in the columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Grouping Information Using Tukey Method and 95,0% Confidence

As far as the location of Guča is concerned, the highest marketable yield in 2008 and 2009 was determined in the variety Kondor. On the other hand, the highest marketable yield in 2010 was recorded in the variety Adora. The lowest marketable yield in Guča in 2008 and 2010, i.e. 2009, was determined in the variety Frisia, i.e. variety Innovator, respectively (Table 7).

More favourable weather conditions in 2008 and 2010, compared to 2009 (Table 2) resulted in significantly higher marketable yields (Table 7), which coincides with the results of other researches (MOMIROVIĆ *et al.*, 2010; POŠTIĆ *et al.*, 2012).

Table 7. Average marketable yield of potato (t ha^{-1}) and analysis of variance

Location	Zemun			
Genotype (G)	Year			
	2008	2009	2010	Average
G_1	38.5a	13.2de	32.5ab	28.07
G_2	34.8ab	18.6cd	41.3ab	31,57
G_3	25.8c	20.4bc	40.0ab	28.73
G_4	28.6bc	9.1e	29.4b	22.37
G_5	25.4c	26.1ab	36.7ab	29.40
G_6	27.2c	27.5a	42.8a	32.50
Average	30.05	19.15	37.12	28.77
CV (%)	17.85	37.39	14.21	
Location	Srbobran			
G_1	21.8ab	15.4ab	30.7a	22.63
G_2	25.9a	17.9a	30.9a	24.90
G_3	20.8ab	19.1a	26.4ab	22.10
G_4	20.8ab	9.4b	15.3b	15.17
G_5	18.7b	16.1a	28.2a	21.00
G_6	20.7ab	15.9a	35.8a	24.10
Average	21.45	15.62	27.88	21.65
CV (%)	11.21	17.24	24.87	
Location	Guča			
G_1	22.8bc	11.9b	53.4a	29.37
G_2	23.8bc	14.8ab	36.3b	24.97
G_3	19.7c	5.9c	21.6c	15.73
G_4	19.2c	11.3b	14.8c	15.10
G_5	25.0b	10.1bc	42.6ab	25.90
G_6	31.2a	18.1a	41.8ab	30.37
Average	23.62	12.02	35.08	23.57
CV (%)	18.45	34.59	40.95	
Total CV (%)	17.86	22.86	14.55	

G-genotype (G_1 Adora; G_2 Cleopatra; G_3 Innovator; G_4 Frisia; G_5 Desiree; G_6 Kondor); L-location ^{nsz}=P>0.05 *=P<0.05 **=P<0.01 ***=P<0.001

* Means in the columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Grouping Information Using Tukey Method and 95,0% Confidence

Table 8. Average yield of potato (t ha⁻¹) and analysis of variance

Location	Zemun			
Genotype (G)	Year			
	2008	2009	2010	Average
G_1	43.3a	16.4d	41.0b	33.6
G_2	41.2a	24.6c	59.1a	41.6
G_3	30.6b	25.5bc	46.3ab	34.1
G_4	36.6ab	24.6c	35.7c	32.3
G_5	30.8b	32.1a	46.3ab	36.4
G_6	30.7b	31.2ab	48.0ab	36.6
Average	35.50	25.70	46.10	35.80
CV (%)	16.10	21.99	17.01	
Location	Srbobran			
G_1	31.0a	21.6ab	40.6a	31.1
G_2	31.1a	26.9a	36.3a	31.4
G_3	26.7ab	21.9ab	31.3ab	26.6
G_4	25.1ab	18.7b	20.1b	21.3
G_5	24.1b	21.0ab	34.7a	26.6
G_6	24.0b	18.5b	39.2a	27.2
Average	27.00	21.43	33.70	27.38
CV (%)	12.32	14.21	22.06	
Location	Guča			
G_1	27.7bcd	15.5b	62.4a	35.2
G_2	29.5abc	19.2ab	43.5bc	30.7
G_3	23.9d	17.4ab	26.0cd	22.4
G_4	25.3cd	16.4ab	18.5d	20.1
G_5	31.2ab	16.1b	51.8ab	33.0
G_6	34.5a	21.2a	47.8ab	34.5
Average	28.70	17.63	41.70	29.32
CV (%)	13.60	12.30	39.52	
Total CV (%)	28.43	18.70	41.16	

G-genotype (G_1 Adora; G_2 Cleopatra; G_3 Innovator; G_4 Frisia; G_5 Desiree; G_6 Kondor); L-location ^{nsz}=P>0.05 *=P<0.05 **=P<0.01 ***=P<0.001

* Means in the columns followed by the same letter are not significantly different according to Fisher's protected LSD values (P=0.05)

Grouping Information Using Tukey Method and 95,0% Confidence

According to the three-year averages of total yields obtained in all locations, the highest average total yield was detected in the location of Zemun (35.80 t ha⁻¹), then in Guča (29.32 t ha⁻¹), while the lowest total yield (29.32 t ha⁻¹) was established in Srbobran (Table 8).

With regard to varieties, the highest three-year total yield of Zemun and Srbobran, i.e. Guča, was recorded in the variety Cleopatra, i.e. Adora, respectively. This results are in accordance with the results gained by POŠTIĆ (2013), who found out that early varieties can achieve higher yields, compared to later varieties, because of early tuberisation and faster tuber bulking.

The highest total yields were recorded in 2010 in all localities, while the lowest total yields were recorded in 2009 (Table 8) as a result of higher air temperatures and lower precipitation sums (Table 2) and lower values of all evaluated parameters in 2009.

The highest total yield in the location of Zemun in 2008 and 2009 was determined in the varieties Adora, Desiree, respectively (due to genetic predisposition to have high resistance to drought stress), while the highest total yield in 2010 was recorded in the variety Cleopatra. The lowest total yield in location of Zemun in 2008, 2009 and 2010 was found in the varieties Innovator, in 2009 in the Adora anf Frisia, respectively (Table 8).

In the location of Srbobran in 2008 and 2009, the highest total yield was determined in the variety Cleopatra. On the other hand, in 2010, the highest total tuber yield was determined in the variety Adora. The lowest total yield in location of Srbobran in 2008 and 2009, i.e. 2010 was determined in the varieties Kondor and Frisia, respectively (Table 8).

Table 9. The correlation coefficients between the observed traits (n=54)

Traits	Total yield	Number market tubers	Total number tubers	Number stems per plant
Marketable yield	0,965***	0,651***	0,432***	0,058 ns
Total yield	-	0,599***	0,4261***	0,081 ns
Number market tubers		-	0,654***	0,088 ns
Total number tubers			-	0,379**
Number stems per plant				-

Pearson correlation coefficient: *** P≤ 0.001, ** P≤ 0.01, * P ≤ 0.05, respectively

As far as Guča is concerned, the highest total yield was recorded in the variety Kondor in 2008 and 2009, while the corresponding value for the year of 2010 was recorded in the variety Adora. The lowest total yield in Guča was determined in the variety Innovator in 2008, while the corresponding values for 2009 and 2010 were established in varieties Adora and Frisia, respectively (Table 8).

Lower average total yield of potatoes in 2009 compared to 2008 and 2010 (Table 8) is due to a lower precipitation sum and very high air temperatures (Table 2), which coincides with yields obtained in trails carried out by other researches (TADESSe *et al.,* 2001; MOMIROVIĆ *et al.,* 2010; poštić *et al.,* 2015). Based on the correlation analysis, correlations between total yields and marketable yields are high (p = 0.001) Table 9.

The distribution of rainfall during the growing season in 2010 (Table 2) was mostly satisfying to the needs of potato, influencing total yields to be significantly higher (Table 8) compared to the previous two years. These results are consistent with the results achieved by many authors (TADESSE *et al.,* 2001; TOMASIEWICZ *et al.,* 2003; MOMIROVIĆ *et al.,* 2010; JOVOVIĆ *et al.,* 2012; POŠTIĆ *et al.,* 2012), stating that the production conditions significantly affects total yield of potatoes.

High air temperature during the stage of tuber bulking significantly limits the development of the plants and potato yield itself (TADESSE *et al.*, 2001; GULLUOGLU & ARIOGLU, 2009; POŠTIĆ, 2013).

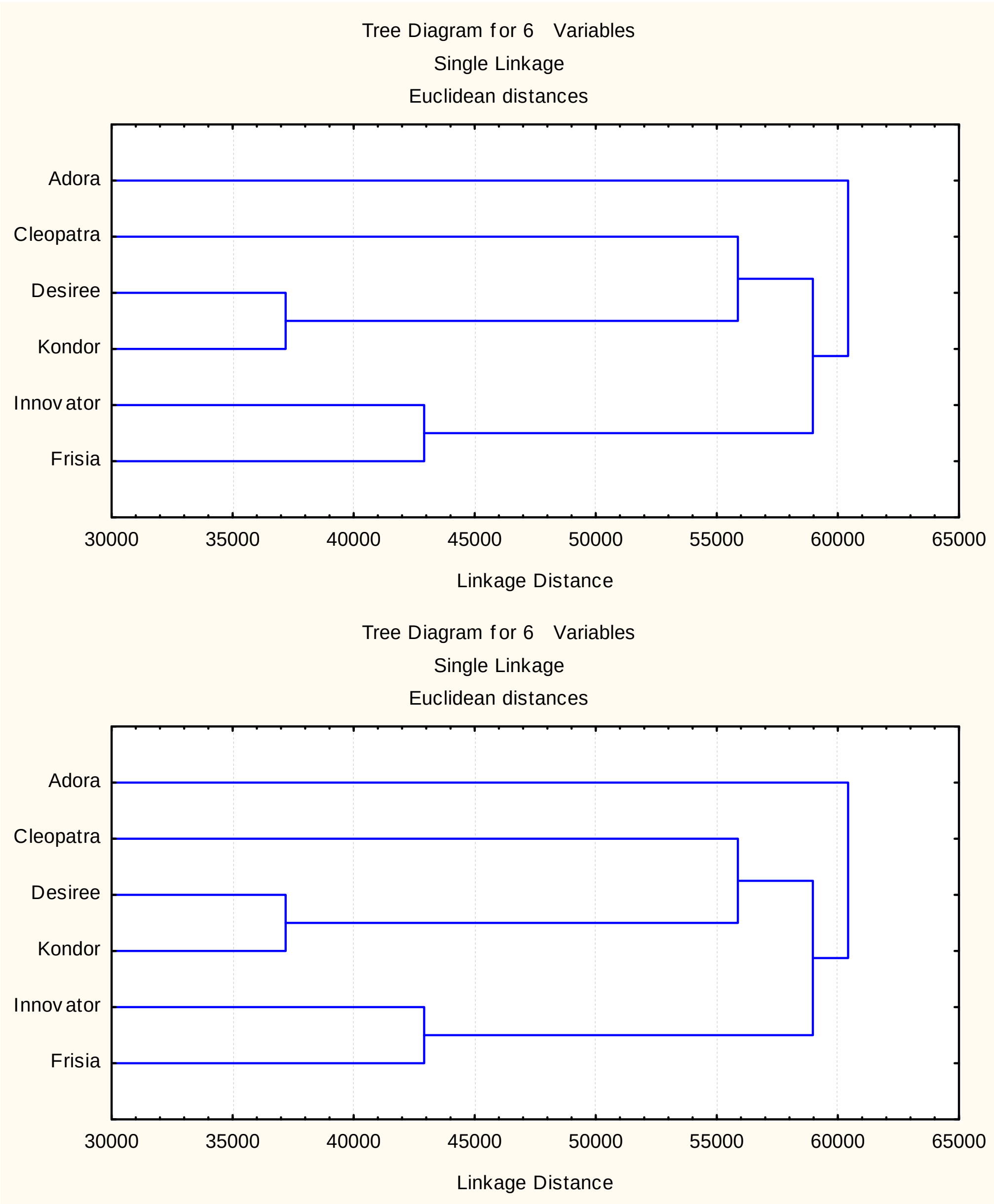

Figure 1. Dendrogram of morphological and productive traits in 6 potato varieties

According to the analysed traits, the early maturity variety Adora clearly distinguishes from remaining in the first cluster, while varieties Cleopatra, together with late maturity Desiree and Kondor, are the most distinguishable varieties in the second cluster. Finally, in the third cluster, the medium early maturity varieties Innovator and Frisia stand out (Figure 1).

CONCLUSION

According to the three-year research results on variability of Dutch potato varieties under different agro-ecological conditions in Serbia, the following can be concluded:

- Different locations and years individually and by their interactions significantly affected the productive properties of studied varieties (genotypes);
- High correlation between the number of tubers per plant, marketable yield and total yield of potatoes were determined;
- Based on the total yields of all six genotypes observed in different locations, we recommend growing early maturity varieties (Cleopatra and Adora), especially in the years with low precipitation sums, as well as medium-late maturity varieties (Desiree and Kondor), that have shown good resistance to high air temperature and drought stress.

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VARIJABILNOST HOLANDSKIH SORTI KROMPIRA U RAZLIČITIM USLOVIMA SRBIJE

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Izvod

U radu su predstavljeni rezultati trogodišnjih istraživanja varijabilnosti različitih holandskih sorti krompira u Srbiji: Adora i Cleopatra (rane), Innovator i Frisia (srednje rane) i Desiree i Kondor (srednje kasne). Ispitivanja su izvedena tokom 2008, 2009 i 2010. godine, na tri pedoklimatski različita lokaliteta: Zemun (100 m n.v.), Srbobran (86 m n.v.) i Guča (370 m n.v.). Poljski ogledi su izvedeni po standarnoj metodologiji u potpuno slučajnom blok sistemu u 4 ponavljanja.

Analiza varijanse je pokazala da su broj krtola po biljci, prinos tržišnih krtola i ukupan prinos krtola značajno varirali u zavisnosti od genotipa, ispitivane godine i lokacije. Pored individualnih uticaja proučavanih faktora značajno su ocenjene i njihove interakcije (genotip x godina, genotip x lokalitet, godina x lokalitet, genotip x godina x lokacija).

U trogodišnjem proseku najveći ukupan prinos krtola utvrđen je u Zemunu (35,80 t ha^{-1}), zatim u Guči (29,32 t ha^{-1}), dok je najmanji prosečan prinos zabeležen na lokalitetu Srbobran (27,38 t ha^{-1}). Najveći prinos krtola u trogodišnjem proseku ustanovljen je kod sorte Cleopatra, zatim kod sorte Adora, dok je najmanji prinos krtola konstatovan kod sorte Frisia. Rezultati ovih istraživanja su pokazali da na ispitivanim lokalitetima najveće prinose postižu rane sorte koje formiraju srednji broj krtola po biljci (Cleopatra i Adora), kao i srednje kasne sorte (Desiree i Kondor) koje su pokazale vesoku otpornost na visoke temperature vazduha stres izazvan sušom.

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