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THE EFFECT OF GENOTYPE AND ECOLOGICAL CONDITIONS ON THE YIELD COMPONENTS OF POTATOES

UTICAJ SORTE I AGROEKOLOŠKIH USLOVA NA KOMPONENTE PRINOSA KROMPIRA

Dobrivoj POŠTIĆ, Nebojša MOMIROVIĆ**, Zoran BROĆIĆ**, Lana ĐUKANOVIĆ*, Ratibor ŠTRBANOVIĆ*, Dragan TERZIĆ ***, Rade STANISAVLJEVIĆ**
**Institute for Plant Protection and Environment, 11040 Beograd, Teodora Drajzera 9,Serbia*
***Faculty of Agriculture, 11000 Beograd, Nemanjina 6, Serbia*
****Institute for forage crops Kruševac, Globoder 37251, Serbia*
e-mail: pdobrivoj@yahoo.com

ABSTRACT

The research on the effect of ecological conditions and cultivars on the yield components of potatoes was conducted in Badovinci (Western Serbia) during the period 2008-2009. The following potato cultivars were included in the experiment: early ('Cleopatra', 'Anushka' and 'Presto'), medium early ('Kuroda', 'Omega' and 'Dita'), and medium late ('Desiree', 'Roko' and 'Jelly'). The four-replicate field trials were set up using the standard methodology according to the random block design.

The research results suggest that genotype (G) and ecological conditions (E) significantly affect all yield components of potatoes. In both years, the highest yield was recorded in the medium late variety 'Desiree' (28.30 t ha^{-1}), followed by the early variety 'Anushka' (26.60 t ha^{-1}), while the lowest yield was recorded in the medium early variety 'Omega' (13.35 t ha^{-1}).

The results obtained show that the highest yields in Western Serbia were recorded in early varieties ('Cleopatra', 'Anushka' and 'Presto') and medium late varieties ('Desiree'), which exhibited considerable resistance to high air temperatures and drought stress.

***Key words**: potato, variety, tuber, yield, drought.*

REZIME

Komponente prinosa devet sorti krompira ispitivane su tokom 2008. i 2009. godine na lokaciji zapadne Srbije u selu Badovinci (75 m nadmorska visina, 44˚ 80' 05"N, 19˚ 35' 39"E). Za istraživanje korišćene su sledeće sorte krompira: rane (Cleopatra, Anushka i Presto), srednje rane (Kuroda, Omega i Dita) i srednje kasne (Desiree, Roko i Jelly). Sadnja je izvedena u prvoj dekadi aprila. Međuredno rastojanje bilo je 0,70 m a između biljaka u redu 0,30 m. Primenjena je standardna tehnologija gajenja krompira. Broj primarnih nadzemnih izdanaka određen je 65 dana posle sadnje krtola. Vađenje krompira izvršeno je početkom septembra kada je izvršeno i utvrđivanje broja krtola po biljci i ukupan prinos. Dobijeni rezultati ukazuju da su sorta (G) i agroekološki uslovi (E) značajno utiču na sve komponente prinosa krompira. U obe godine najveći ukupan prinos krtola zabeležen je kod srednje kasne sorte Desiree (*28,30 t ha^{-1}), zatim kod rane sorte Anushka* (*26,60 t ha^{-1}), dok je najniži prinos krtola utvrđen kod srednje rane sorte* Omega (*13,35 t ha^{-1}). Na osnovu rezultata dvogodišnjih istraživanja uticaja sorte i agroekoloških uslova na komponente prinosa u zapadnoj Srbiji, možemo izvesti sledeće zaključke: - Sorta i uslovi sredine pojedinačno i u interakciji značajno utiču na komponente prinosa*; Za dobijanje visokih prinosa krtola u uslovima zapadne Srbije možemo preporučiti rane sorte (*Cleopatra, Anushka* i *P*resto*), posebno u godinama sa malom količinom padavina, kao i srednje kasnu sortu* (*Desiree), koja je pokazala dobru tolerantnost prema visokim temperaturama vazduha i suši.*

***Ključne reči**: Krompir, sorta, krtola, prinos, suša.*

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} (FAO, 2013). Such low yields are the result of low inputs on small farms which prevail in Serbia. The average potato yield in Serbia 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} (*Poštić et al., 2014; Broćić et al., 2016*). Commercial potato yields (t ha^{-1}) depend on the genetic potential of varieties, agroecological 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 (Poštić et al., 2014; Momirović et al., 2016). However, this is often not the case in practice because early and middle early varieties, characterized by early tuber formation and faster tuber bulking, tend to produce higher yields than potentially high-yielding medium late and late potato varieties, especially under relative drought conditions, unless irrigation, as a compulsory cropping practice, is applied in production (*Poštić, 2013*). Potato yields depend on the variety and its genetic potential, agroecological 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; Poštić et al., 2016*). Higher air temperatures stimulate vegetative development and reduce the tuber formation, average tuber weight, tuber yields, harvest index and concentration of dry matter in tubers. According to *Poštić et al.* (2015) soil

temperatures exceeding 27 ºC in the 10 cm soil surface layer (the main zone for tuber formation) during 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 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 purpose of this research is to determine potato genotypes favourable for high and stable yields under the agroecological conditions in Western Serbia.

MATERIAL AND METHOD

The production characteristics of nine potato cultivars were studied during the period 2002-2003 in different locations in Western Serbia, i.e. cultivars ('Desiree', 'Roko' and 'Jelly'). The soil properties are shown in Table 1.

Table 1. Properties of soil in the experimental plot

Depth (cm)	Type of soil	CaCO3 %	pH		Humus %	N %	mg/100g soil	
			H2O	nKCl			P2O5	K2O
0-30	Recent alluvium	0.00	6.85	6.53	2.97	0.19	19.84	15.00

The planting was performed in quadruplicate (in April) at an inter-row spacing of 0.70 m and an intra-row spacing of 0.30 m. Standard cropping practices were applied during the growing season. The number of primary stems per plant was established 65 days after planting. The plots were harvested at the beginning of September. The number of tubers per plant and total yield were precisely determined after harvest. The data on meteorological conditions in Table 2 indicate air temperatures which are significantly higher than optimal.

Table 2. Meteorological conditions during the potato growing season (2008 and 2009)and the long-term data (1975-2006) for the area of Western Serbia

Month	2008		2009		1975 - 2006	
	°C	mm	°C	mm	°C	mm
April	12.9	52.4	13.9	12.0	11.1	48.5
May	18.3	42.4	18.9	45.3	16.7	53.4
June	21.7	58.1	19.5	79.8	19.9	81.9
July	21.7	61.0	22.5	10.4	20.9	63.3
August	21.5	22.7	22.3	42.8	20.7	46.8
September	15.4	76.7	19.0	5.8	16.3	56.2
Average amount	18.58	313.3	19.35	196.1	17.6	350.1

The experimental data obtained were processed using the statistical package STATISTICA 8.0 for Windows (Analytical software, Faculty of Agriculture, Novi Sad, Serbia). Differences between the treatments were determined by the analysis of variance (ANOVA) and the least significant difference test (LSD) was used for the individual comparisons.

RESULTS AND DISCUSSION

The analyses of the number of stems per plant, number of tubers per plant and total yield of tubers (Table 3) showed significant differences influenced by the genotype (factor G) and ecological conditions (factor E). A significant correlation was found between both factors and all the traits observed. The results obtained are consistent with the results reported by other authors (Poštić et al., 2012; Fufa, 2013; Flis et al., 2014; Momirović et al., 2016). The number of stems per plant is an extremely important morphological property which affects the development of the aboveground mass and assimilation areas (*Struik, 2007*), the number of seeded tubers per plant, and total yield (*Poštić et al., 2012*).

Table 3. F-*values for the factors observed in 2008 and 2009*

Factors	Number of stems per plant	Number of tubers per plant	Total yield
Genotype (G)	**	**	**
Ecological conditions (E)	**	**	**
G * E	*	*	*

*** - significant at 0.01; * - significant at 0.05; ns – not significant*

The largest number of stems per plant within the two-year average was determined in the 'Anushka' cultivar (4.13), followed by 'Omega' (3.88), whereas the lowest number of stems per plant (2.38) was recorded in 'Kuroda' (Table 4).

Table 4. Effects of the genotype and year on the aboveground stems per plant in 2008 and 2009

Genotype (G)	Year (Y)		Average
	2008	2009	
Cleopatra	4.25	3.00	3.63
Anushka	4.50	3.75	4.13
Presto	4.00	3.00	3.50
Kuroda	2.50	2.25	2.38
Omega	4.25	3.50	3.88
Dita	3.50	2.75	3.13
Desiree	3.50	3.25	3.38
Roko	3.25	2.50	2.88
Jelly	4.25	3.25	3.75
Average	3.78	3.03	3.41
LSD 0.05	*0.52*		
0.01	*0.71*		

The highest number of stems per plant was recorded in all varieties in 2008, compared to the number of stems per plant in 2009 (Table 4), as a result of higher air temperatures and lower precipitation sums (Table 2).

The number of tubers per plant is a distinct cultivar property which is directly dependent on the number of stems per plant, agroecological conditions and production technology (*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). These results are in accordance with the results reported by many authors (*Zebarth et al., 2006; Knowles & Knowles, 2006; Bussan et al., 2007; Poštić et al., 2012; Momirović et al., 2016*), who argued that the number of tubers per plant varied according to changes in the number of stems per plant.

The largest number of tubers per plant within the two-year average was determined in the 'Desiree' cultivar (9.63), followed by 'Jelly' (9.50), whereas the lowest number of tubers per plant (4.75) was recorded in the 'Kuroda' cultivar (Table 5). The highest number of tubers per plant was recorded in all varieties in 2008, compared to the number of tubers per plant in 2009, (Table 5) as a result of higher air temperatures, lower precipitation sums (Table 2) and lower values of all the parameters observed in 2009.

Table 5. Effects of the genotype and year on the average number of tubers per plant in 2008 and 2009

Genotype (G)	Year (Y)		Average
	2008	2009	
Cleopatra	8.50	7.25	7.88
Anushka	9.50	8.25	8.88
Presto	8.50	7.00	7.75
Kuroda	7.50	6.50	7.00
Omega	6.75	6.00	6.88
Dita	7.25	6.25	6.75
Desiree	10.25	9.00	9.63
Roko	5.50	4.00	4.75
Jelly	10.75	8.25	9.50
Average	8.28	6.94	7.61
LSD 0.05	0.74		
0.01	1.02		

According to the average total yields obtained over a two-year period, the highest average total yield was detected in the 'Desiree' cultivar (28,30 t ha^{-1}), followed by 'Anushka' (26.60 t ha^{-1}), whereas the lowest total yield (13.35 t ha^{-1}) was established in the 'Omega' cultivar (Table 6).

Table 6. Effects of the genotype and year on the average total yield of tubers (t ha^{-1}) in 2008 and 2009

Genotype (G)	Year (Y)		Average
	2008	2009	
Cleopatra	29.4	23.7	26.55
Anushka	27.9	25.3	26.60
Presto	26.8	23.4	25.10
Kuroda	23.8	19.3	21.55
Omega	13.8	12.9	13.35
Dita	15.9	15.1	15.50
Desiree	29.7	26.9	28.30
Roko	18.7	16.5	17.60
Jelly	15.8	14.3	15.05
Average	22.42	19.71	21.07
LSD 0.05	2.24		
0.01	3.07		

More favorable weather conditions in 2008, compared to 2009 (Table 2), resulted in significantly higher total yields (Table 6), which in congruent with the findings of other authors (*Momirović et al., 2010; Fufa, 2013; Flis et al., 2014; Poštić et al., 2015; Momirović et al., 2016*).

The distribution of rainfall during the growing season of 2008 (Table 2) was mostly favourable to potatoes, rendering the total yields significantly higher (Table 6) compared to 2009. These results are consistent with the results reported by many authors (*Tomasiewicz et al., 2003; Momirović et al., 2010; Poštić et al., 2012*), stating that the production conditions greatly affect the total yield of potatoes. High air temperatures during the stage of tuber bulking significantly limit the development of potato crops and yields (*Poštić,* 2013).

According to the traits analysed, the early-maturity cultivars such as 'Cleopatra' and 'Presto' can be clearly distinguished from the rest in the first cluster, whereas the late-maturity cultivars such as 'Desiree' are clearly discernible in the second cluster. In the third cluster, the early-maturity cultivar 'Anushka' and the medium-early 'Kuroda' are readily distinguishable (Figure 1).

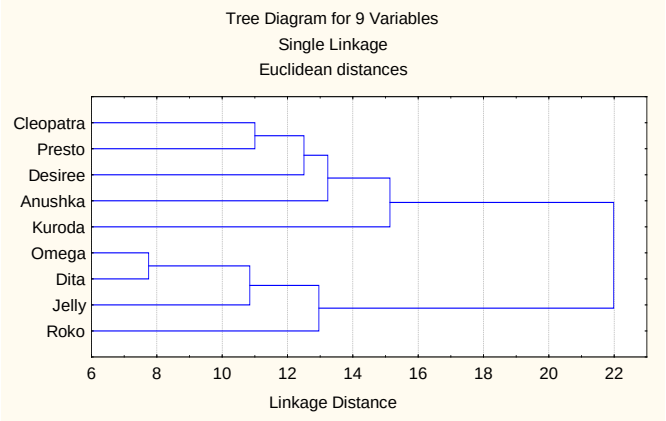

Fig. 1. Dendrogram of morphological and productive traits of 9 potato varieties

In the fourth cluster, the medium-early cultivars 'Omega' and 'Dita' are describable, whereas the late-maturity cultivars 'Jelly' and 'Roko' are distinguishable in the fifth cluster (Figure 1).

CONCLUSION

According to the research results obtained over a -year experimental period, the following conclusions can be drawn with regard to the effect of genotype and ecological conditions on the yield components of potatoes in Western Serbia:

- Genotypes and ecological conditions, individually and in combination, significantly affect the productive properties of potatoes.

- Based on the total yields of all nine potato genotypes observed over a two-year experimental period, we recommend growing early-maturity cultivars such as 'Cleopatra', 'Anushka' and 'Presto', especially in years with low precipitation sums, as well as medium-late maturity cultivars such as 'Desiree', which exhibited considerable resistance to high air temperatures and drought stress.

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