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INFLUENCE OF ORIGIN AND SIZE OF POTATO PLANTING MATERIAL ON MORPHOLOGICAL CHARACTERISTICS OF SEED TUBERS

UTICAJ POREKLA I KRUPNOĆE SADNOG MATERIJALA KROMPIRA NA MORFOLOŠKE OSOBINE SEMENSKE KRTOLE

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ABSTRACT

The aim of this study was to determine the influence of the origin and size of planting material on the morphological characteristics of seed tuber's three potato cultivars. The objects of research were three varieties of potatoes: Aladdin, Newton and Desiree. The analysis of the morphological characteristics tuber showed highly significant (p<0.01) differences under influenced origin planting material (factor O) and size of seed tuber (factor S). Significance influence (p<0.01) genotype (factor G) was detected on the number of sprouts per tuber and sprouts length. Seed tubers originating from a lower altitude (350 m a.s.l.) formed a significantly (p<0.01) greater number of sprout per tuber, 0.59 or 7.33% more in comparison with tubers originating from 1300 m a.s.l. Statistical analysis of the number of sprouts per tuber showed a significantly (p<0.01) lower number of germs in fractions of 40 and 60 g, compared to the larger fraction of 80 g.
Keywords: *potato tuber, planting material, sprout*

REZIME

Cilj istraživanja bio je da se utvrdi uticaj porekla i krupnoće sadnog materijala krompira na morfološke osobine semenske krtole. Objekat ispitivanja bile su tri sorte krompira: dve srednje rane (Aladin i Njutn) i srednje kasna (Dezire). Sadni materijala dobijen je paralelnom proizvodnjom semenskog krompira sprovedenom tokom 2016. godine u dva lokaliteta različite nadmorske visine: Guča 350 m i Sjenica-Pešter 1300 m. Istraživanje je izvedeno 2017. godine u fitotronu kao trofaktorni ogled u 4 ponavljanja. Uzorci od po 40 krtola tri semenske frakcije (40 ± 5g), (60 ± 5g) i (80 ± 5g) sve tri sorte sa oba lokaliteta naklijavane su standardnom evropskom metodom. Poreklo i krupnoća sadnog materijal su vrlo značajno (p<0,01) uticali na ispoljavanje svih ispitivanih morfoloških osobina semenske krtole krompira. Značajan uticaj (p<0,01) genotipa (faktor G) na ispoljavanje značajnih razlika zabeležen je kod broja klica i dužini klice po krtoli. Vrednosti ispitivanih morfoloških osobina krtole rastu sa porastom krupnoće sadnog materijala. Semenske krtole poreklom sa (350 m) formirale su veoma značajno veći (p<0,01) broj klica po krtoli 0,59 ili 7,33%, više u poređenju sa krtolama poreklom sa 1300 m nv. Veći broj klica po krtoli preklom sa niže nadmorske visine ima za rezultat formiranje većeg broja stabala po biljci krompira, tj. odgovara proizvodnji većeg broja krtola srednje veličine (semenska proizvodnja). Veći prečnik klica i veća dužina klice po krtoli poreklom sa viših nadmorskih visina uticaće na formiranje manjeg broja stabala po biljci, odnosno srednjeg broja krupnih krtola i treba ih treba koristiti u proizvodnji ranog krompira ili u merkantilnoj proizvodnji.
Ključne reči: *krtola krompira, sadni materijal, klica*

INTRODUCTION

One of the basic conditions for successful potato production is the use of quality planting material for planting. Only by planting adequate planting material can healthy, strong plants be obtained that will give a high yield of good quality. Economical and profitable production of potatoes with other equal conditions (agrotechnics, fertilization and protection, etc.) is possible only with the use of good quality seeds (*Poštić et al.,* 2012). The quality of potato planting material depends on agroecological production conditions (altitude), cultivation technology and storage conditions during storage. Hence, the above-mentioned factors determine the properties of planting material that directly affect and define the quality of potato tubers for planting (*Poštić et al.*, 2016). The physiological quality of planting material affects the morphological characteristics of potato tubers, i.e. the behaviour of tubers during sprouting, the sprouting of each eye, the number of formed sprouts per eye and their strength (vigor) (*Poštić,* 2013). The characteristics of seed tubers are physiological age, sprout development, tuber weight and health. Physiological age represents the viability of the seed tuber (*Pavlista*, 2004). Struik, (2007) states that the physiological age of a seed tuber depends on: variety, production conditions, maturity at harvest, storage conditions, degree of damage and health tubers. The size of seed tubers is an important characteristic and a measurable component of quality seed potatoes, which significantly affects the biological ability of tubers, which depends directly on the degree of development of sprouts, the number of sprouts per tuber and viability *(Poštić, 2013)*, development of crops in the field and the number of primary stems per plant *(Khan et al., 2004, Poštić et al., 2012; Poštić et al., 2014)*. The number of primary stems per plant significantly affects the development of aboveground mass and assimilation surface, the number of a set of tubers per plant, and the total tuber yield *(Khan et al., 2004; Struik, 2007; Poštić et al., 2012; Momirović et al., 2016; Poštić et al., 2016)*. The conducted research aimed to = i) determine the influence of origin - altitude and size of planting material on the quality of seed potatoes, ii) point out the importance of assessing the quality of seed tubers and iii) make the most precise choice of adequate planting material for different production purposes.

MATERIAL AND METHOD

Production seeds tubers

Three potato varieties, two middle-early (Aladdin and Newton) and middle-late (Desiree) were planted in mid-May in the year 2016 on two locations, Guča (350 m a.s.l.) and Sjenica (1300 m a.s.l.). The production of potato crops was performed by the application of standard cropping practices without irrigation. During the vegetation season, the average daily air temperature and precipitation were recorded (Table 1).

Table 1. Meteorological conditions during the potato growing season 2016 in the area of Guča and Sjenica.

Altitude (m)	Month						
	April	May	Jun	July	August	Sept.	Avera.
	Average air temperature (°C)						
350	12.3	14.2	19.9	21.1	18.7	15.7	16.98
1300	9.7	10.5	16.4	17.6	15.6	12.1	13.65
	Amount precipitation (mm)						Total
350	46.6	145.5	75.8	72.4	180.2	43.8	564.3
1300	31.6	118.2	90.4	58.2	138.3	99.1	525.8

Sampling planting material

After harvest in mid-October, ten healthy typical tubers of physiological maturity were taken from 15 sampling places in each seed crop (a total of 150 seed tubers) by the random sampling method. Planting material from both origins of all three cultivars seed size fraction 35-55 mm, calibrated and in a working sample was allocated to 40 different sized tubers (mass 40 ± 5 g, 60 ± 5 g and 80 ± 5 g). Sorted out samples of tubers were stored in the dark at 2 to 4°C (95% RH) until the end of December.

Sprouting method and data collection

At the beginning of January, samples were transferred to a growth chamber where they were exposed to thermal induction for 7-10 days under conditions (18°C, 95% RH, dark) in order to break dormancy. Morphological traits of seed tubers were assessed by the European standard sprouting method *(Poštić et al., 2016)*. After five weeks from the beginning of sprouting the following indicators were recorded: the number of sprouts per tuber, the diameter of sprouts per tuber and sprout length (mm). All 40 tubers from samples were used to determine the average number of sprouts per tuber. The diameter of sprouts per tuber was evaluated by measurements of all sprouts per tubers. The sprout length was determined by measuring the length of the longest sprout of the potato seed tubers to the nearest 1 mm using a calliper.

Statistical analysis

The obtained experimental data were processed by a mathematical-statistical procedure using the statistical package STATISTICA 8.0 for Windows (Analytical software, Faculty of Agriculture, Novi Sad, Serbia). The 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 F test, in the complex three factorial analysis (Table 2), showed highly significant ($p<0.01$) differences under influenced origin planting material (factor O) and size of seed tuber (factor S). Present results agree with previous research *Poštić et al., (2016)*. Significance influence ($p<0.01$) genotype (factor G) was detected on a number of sprouts per tuber and sprouts length. Influence all interactions of studied factors (O × S, O × G, S × G and O × S × G) were determined only for sprouts length.

A higher average number of sprouts per tuber 8.04 was recorded on planting material originating from the locality of Guča (350 m a.s.l.), compared to the average number of sprouts per tuber 7.45 originating from the locality Sjenica (1300 m a.s.l.). The determined difference in the number of sprouts of 0.59 per tuber or 7.33% between planting material from different localities was very significant. Higher average monthly air temperatures (Table 1) at the Guča locality influenced the physiological age of the tubers to be higher compared to the tubers originating from the Sjenica locality. These results coincide with the results of other researchers (*Pavlista, 2004; Poštić et al., 2012; Poštić, 2013; Poštić et al., 2016*).

The largest number of sprouts per tuber (8.92) is formed on average by the largest fraction of 80 g, followed by the fraction 60 g (7.72), while the smallest number of sprouts (6.61) is formed by 40 g fraction. Statistical analysis of the number of sprouts per tuber showed a significantly ($p<0.01$) lower number of sprouts in fractions of 40 and 60 g, compared to the larger fraction of 80 g. A very significantly ($p<0.01$) higher number of sprouts were found in the fraction of 60 g, compared to the smallest fraction of 40 g.

Table 2. The influence of mean values on the properties by application F test.

Factors	Number of sprouts per tuber	The diameter of sprouts per tuber	Sprout length
Origin (O)	**	**	**
Size seed tuber (S)	**	**	**
Genotype (G)	**	ns	**
O × S	ns	ns	**
O × G	ns	**	**
S × G	ns	ns	**
O × S × G	ns	ns	**

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

Observed by varieties, the highest number of sprouts per tuber (8.35) was recorded in the variety Desiree, then in Newton (7.47), while the lowest number of sprouts per tuber (7.43) was found in the variety Aladdin. A very significantly ($p<0.01$) higher number of germs per tuber was recorded in the cultivar Desire, compared to the determined number of germs per tuber in the cultivars Aladdin and Newton. No significant difference in the number of sprouts per tuber was found between the varieties Aladdin and Newton.

A larger average sprout diameter of 5.00 mm per tuber was recorded on planting material originating from the Sjenica (1300 m a.s.l.), compared to the average sprout diameter per tuber 4.65 mm originating from the Guča (350 m a.s.l.). The determined difference in sprout diameter of 0.35 mm per tuber or 7.0% between localities was very significant. Such results are in agreement with the results of the authors (*Poštić, 2013; Poštić et al., 2016*).

Table 3. Effect of origin and size planting material on an average number of sprouts per tuber.

Seed tuber size (g) S	Origin of planting material (O)								Average (S)
	Guča				Sjenica				
	Desiree	Aladdin	Newton	Average	Desiree	Aladdin	Newton	Average	
40	7.50	6.33	6.67	6.83	6.58	6.50	6.08	6.39	6.61
60	8.58	7.83	7.75	8.05	7.83	6.83	7.50	7.39	7.72
80	10.33	8.92	8.50	9.25	9.25	8.17	8.33	8.58	8.92
Average (O)	8.80	7.69	7.64	8.04	7.89	7.17	7.30	7.45	7.75
Average (G)	8.35	7.43	7.47						

		O	S	G	OS	OG	SG	OSG
LSD	0.05	0.23	0.28	0.28	0.40	0.40	0.49	0.69
	0.01	0.40	0.48	0.48	0.69	0.69	0.84	1.19

Table 4. Effect of origin and size planting material on an average diameter of sprouts (mm) per tuber.

Seed tuber size (g) S	Origin of planting material (O)								Average (S)
	Guča				Sjenica				
	Desiree	Aladdin	Newton	Average	Desiree	Aladdin	Newton	Average	
40	4.51	4.19	4.39	4.36	4.40	4.78	4.83	4.67	4.52
60	4.64	4.71	4.46	4.60	4.91	5.04	4.85	4.93	4.77
80	5.24	4.97	4.77	4.99	5.30	5.32	5.60	5.41	5.20
Average (O)	4.80	4.62	4.54	4.65	4.87	5.05	5.09	5.00	4.83
Average (G)	4.83	4.84	4.81						

		O	S	G	OS	OG	SG	OSG
LSD	0.05	0.14	0.17	0.17	0.25	0.25	0.30	0.43
	0.01	0.24	0.30	0.30	0.42	0.42	0.52	0.73

Table 5. Effect of origin and size planting material on an average length of sprouts (mm) per tuber.

Seed tuber size (g) S	Origin of planting material (O)								Average (S)
	Guča				Sjenica				
	Desiree	Aladdin	Newton	Average	Desiree	Aladdin	Newton	Average	
40	7.19	8.23	7.40	7.61	10.12	10.27	10.20	10.20	8.90
60	8.10	8.23	8.07	8.13	11.17	11.43	12.19	11.60	9.87
80	8.92	9.47	9.20	9.20	12.20	12.13	12.40	12.24	10.72
Average (O)	8.07	8.64	8.22	8.31	11.16	11.28	11.60	11.35	9.83
Average (G)	9.62	9.96	9.91						

		O	S	G	OS	OG	SG	OSG
LSD	0.05	0.09	0.11	0.11	0.15	0.15	0.19	0.27
	0.01	0.15	0.19	0.19	0.27	0.27	0.33	0.46

The largest sprout's diameter (5.20 mm) is formed on average by the biggest fraction of 80 g, followed by 60 g (4.77 mm), while the smallest sprout's diameter (4.52 mm) forms a 40 g fraction. Present results agree with previous research *Poštić, (2013)*. Statistical analysis of sprouts diameter per tuber showed a significantly (r <0.01) smaller diameter of sprouts in fractions of 40 and 60 g, compared to the larger fraction of 80 g. At tubers fraction of 60 g was noted a statistically significantly (r <0.05) larger sprout diameter per tuber, compared to the sprout diameter determined in the 40 g fraction.

From the performed measurements at the examined cultivars, the diameter of the sprouts per tuber was in a very narrow interval from 4.81 to 4.84 mm, so there was no statistically significant difference between the varieties in the diameter of the sprout per tuber.

On planting material originating from the Sjenica, a significantly longer sprouts length of 3.04 mm, or 26.80%, was recorded, compared to planting material originating from the Guča. Such results are a consequence of the higher physiological age of tubers originating from the Guča, due to higher average monthly air temperatures (Table 1), during the vegetation period, in relation to tubers originating from the Sjenica. These results coincide with the results of other researchers (*Pavlista, 2004; Poštić et al., 2016*).

The largest sprout length (10.72 mm) is formed on average by the biggest fraction of 80 g, followed by 60 g (9.87 mm), while the smallest sprout length (8.90 mm) is formed by a 40 g fraction. Present results agree with previous research *Poštić et al., (2016)*. Statistical analysis of the length of the longest germ per tuber determined a very significantly (r <0.01) shorter sprout length in fractions of 40 and 60 g, compared to the larger fraction of 80 g. In the case of tubers of the 60 g fraction, statistics show a significantly (r <0.01) larger sprout diameter per tuber was recorded, compared to the sprout length determined in the 40 g fraction.

A completely opposite distribution observed by varieties was found when it comes to the length of sprouts per tuber (Table 5), in relation to the number of sprouts per tuber (Table 3). The highest sprouts length per tuber (9.96 mm) was recorded in the Aladdin variety, followed by the Newton (9.91 mm), while the smallest length of sprout per tuber (9.62 mm) was found in the Desiree. A significantly smaller (p <0.01) sprout length per tuber was recorded in the cultivar Desiree, compared to the determined sprout length per tuber in the Aladdin and Newton. No significant difference in sprout length per tuber was found between the varieties Aladdin and Newton.

Table 6. The correlation coefficients between the observed traits (n=16).

Traits	Number of sprouts per tuber	The diameter of sprouts per tuber	Sprout length
Number of sprouts per tuber	-	0.59457**	0.09655
The diameter of sprouts per tuber		-	0.73119***
Sprout length			-

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

On the basis of correlation analysis and gained correlation coefficients, very high ($r = 0.73119$, $p<0.001$) dependences are noticed between the diameter of sprouts per tuber and sprout length. Further, the number of sprouts per tuber correlated ($r = 0.59457$, $p<0.01$) with the diameter of sprouts per tuber, while the correlation between the number of sprouts per tuber and the sprout length has not been established.

CONCLUSION

According to the obtained results of research on the influence of the origin and size of potato planting material on the morphological characteristics of seed tubers, the following can be concluded:

- The analysis of the morphological characteristics tuber showed highly significant ($p<0.01$) differences under influenced origin planting material (factor O) and size of seed tuber (factor S). Significance influence ($p<0.01$) genotype (factor G) was detected on the number of sprouts per tuber and sprouts length.
- All examined morphological characteristics of the tuber grew with the increase of the size of the planting material, i.e. the highest values of the evaluated indicators of the quality of the seed tuber were recorded in the largest fraction.
- Based on the number of sprouts per tuber and the distance between the tubers in a row, the number of plants per unit area can be calculated more precisely, which is different for different purposes of growing potatoes (seed or market production).

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