Biblid: 1821-4487 (2016) 20; 3; p[redacted]
UDK: 633.491

Original Scientific Paper
Originalni naučni rad

EFFECTS OF T[redacted]RIGIN OF POTATO PLANTING MATERIAL ON MORFOL[redacted]AL CHARACTERISTICS OF SEED TUBERS

UTICAJ PO[redacted]LA SADNOG MATERIJALA KROMPIRA NA MOR[redacted]ŠKE OSOBINE SEMENSKE KRTOLE

*Dobrivoj PO[redacted]ebojša MOMIROVIĆ**, Zoran BROĆIĆ**, Rade STANISAVLJEVIĆ*,*
R[redacted]RBANOVIĆ, Dragoslav ĐOKIĆ***, Zoran JOVOVIĆ *****
**Institute f[redacted]rotection and Environment, Teodora Drajzera 9, Belgrade, Serbia*
[redacted]culty of Agriculture, Nemanjina 6,Belgrade, Serbia
[redacted]e for forage crops Kruševac, Globoder 37251, Serbia
*[redacted]** Biotechnical faculty, Podgorica, Montenegro*
e-mail: pdobrivoj@yahoo.com

ABSTRACT

The effects of the origin of pl[redacted]terial on the mophological characteristics of seed tubers of the Kondor potato cultivar (Solanum tuberosum L.) were in[redacted]d within a two-year study (2009-2010). The production conditions of potato planting material at lower altitudes (700 m.a.s.l.) contributed to producing seed tubers of greater physiological age, resulting consequently in a significantly lower average length of sprouts per tuber 1.38 mm, or 13.49 % less, in comparison with the length of sprouts per tuber determined in tubers originating from 1300 m.a.s.l.

Using the Kondor potato cultivar originating from 700 m.a.s.l. as a planting material (which forms a larger number of sprouts per tuber), a higher number of primary stems per plant could be expected, which would be beneficial to seed production (a greater number of small tubers). Provided the Kondor potato cultivar originating from 1300 m.a.s.l. is used as a planting material (which forms a smaller number of sprouts per tuber and potentially a smaller number of stems per plant), the seed tubers should be used in early potato production and for commercial purposes (a small number of large tubers).

Key words: *potato tuber, origin of planting material, diameter and length of sprouts.*

REZIME

Dvogodišnja ispitivanja uticaja porekla sadnog materijala krompira (Solanum tuberosum L), na morfološke osobine semenske krtole sorte Kondor, izvedena su tokom 2009. i 2010. godine. Priprema sadnog materijala paralelnom proizvodnjom semenskog krompira izvedena je tokom 2009. i 2010. godine na dva lokaliteta različite nadmorske visine: Kotraž-Jelica 700 m nv. i Sjenica-Pešter 1300 m nv.

Uslovi proizvodnje sadnog materijala krtola poreklom sa niže nadmorske visine (700 m nv.) doprineli su da semenske krtole budu veće fiziološke starosti i da kao posledica toga obrazuju vrlo značajno manju dužinu klica po krtoli, za 1,38 mm, ili za 13,49% manju, u odnosu na dužinu klica po krtoli utvrđenu na krtolama poreklom sa 1300 m nv. Sadni materijal poreklom sa manje nadmorske visine 700 m nv. je u obe godine istraživanja obrazovao značajno veći broj listova po krtoli, u odnosu na prosečan broj listova po krtoli ustanovljen kod krtola poreklom sa veće nadmorske visine 1300 m nv.

Upotrebom sadnog materijala sorte Kondor poreklom sa 700 m nv. koji obrazuje veći broj klica po krtoli, i samim tim može se očekivati i veći broj primarnih stabala po biljci, što bi odgovaralo u semenskoj proizvodnji (veći broj sitnih krtola). Ukoliko se koristi sadni materijal sorte Kondor poreklom sa 1300 m nv. koji formira manji broj klica po krtoli i potencijalno obrazuje manji broj glavnih stabala po biljci, treba upotrebiti u ranoj proizvodnji krompira i za merkantilnu proizvodnju (mali broj krupnh krtola).

Ključne reči: *krtola krompir, poreklo sadnog materijala, dužina i debljina klica.*

INTRODUCTION

The quality of potato seed tubers represents the tuber viability to establish new vegetative shoots and new plants after the storage period (*Poštić et al., 2009*). It is evaluated on the basis of the sprout growth. The term biological viability is used to describe the physiological properties of seeds responsible for their ability to germinate rapidly in the soil (*Milošević et al., 2010 and Tabaković et al., 2013*). The biological viability of potato tubers is determined by the following properties: physiological age, sprout development, tuber weight and health. Physiological age refers to the viability of tubers to be used as seeds (*Pavlista, 2004*). It is widely defined as "the developmental stage of potato seed tubers" (*Struik, 2007*) or "...physiological status of the tuber as it affects productivity" (*Bohl et al., 2003*). The physiological age depends on the: variety, growing conditions during the seed tuber formation, maturity at harvesting, storage conditions, damage degree and health conditions (*Poštić, 2006; Struik, 2007*). The sprout development rate at planting determines the biological viability of tubers and may have a strong impact on the speed and uniformity of shoot emergence and the final yield (*Poštić, 2013; Poštić et al., 2014*). The tuber weight and size affect biological viability and determine the increase and the final plant yield (*Rykbost and Locke, 1999; Poštić, 2013*). The significance of a tuber size as an important factor of seed quality is reflected in the number of sprouts and vigour, but it is limited and associated with the physiological age of tubers. The altitude affects the development of potato crops. At higher altitudes, the intensity of light is higher (*van der Zaag, 1992*), the utilisation of solar radiation is greater (*Pereira et al., 2008*), the different spectral composition of light is changed, the daily air temperature is lower and soil maturity is delayed, while the vegetation is prolonged, which favours obtaining seeds of good biological viability. At lower altitudes, the intensity of light is lower (*van der Zaag, 1992*), the effect of utilisation of solar radiation is lower, due to higher air and soil temperatures (*He et al., 1998*), maturity is accelerated, while the vegetation of potato crops is shortened.

The purpose of the present study was to evaluate the impacts of different altitudes on the quality of potato seeds in order to establish an efficient and assured method of sprouting and its effects on the biological viability of the Kondor potato seed tubers.

MATERIAL AND METHOD

The Kondor potato variety was planted in mid-May during two years in two locations Kotraža (700 m a.s.l.) and Sjenica (1300 m a.s.l.). The production of potato crops was performed during 2009 and 2010 by the application of standard cropping practices without irrigation. During the vegetation season, the average daily air temperature and precipitation were recorded (Table 1). Ten typical tubers were taken from 10 sampling places in each seed crop (a total of 100 seed tubers from both seed crops) by the random sampling method. These original samples were formed during harvesting of tubers at the physiological maturity of seed crops. The tubers of 35-55 mm in diameter were taken from both location and the samples of 40 potato tubers were formed. Ten tubers were used in one replication. Tubers were placed in two layers in shallow crates and kept in the dark, RH 95 % and air temperature 2-4 ºC until the end of December. At the beginning of January, the samples were transferred to a growth chamber where they were exposed to thermal induction for 7-10 days in order to break dormancy (from the initial t_0=10-12 °C to the final t_1=18-20 °C in the daily temperature increase by 1-2 °C, RH 90-95 % in the dark). Morphological traits of seed tubers were assessed by the European standard sprouting method consisting of the dark and the light phase. The dark phase lasted two weeks at t=18-20 °C, RH=90-95 % without light. In the light phase which lasted three weeks, the samples were exposed to two temperatures t=10-12 °C with other standard conditions of the fluorescent light of appropriate power (one lamp of 40-65 W per area of 4-5 m² in duration of 9 h each day) and RH=75 %. Morphological characteristics of potato seed tubers were estimated once a week from the beginning of sprouting and the following traits were recorded: number of sprouts per tuber, diameter of sprouts per tuber (mm), sprout length (mm), number of leaves per tuber.

Table 1. Metereological conditions during the potato growing season 2009-2010 in the area of Kotraža and Sjenica

Year	Altitu. (m)	Month						
		April	May	Jun	July	Aug.	Sept.	Aver.
		Average air temperature (°C)						
2009	700	11.5	15.9	18.1	20.2	20.0	15.8	16.92
	1300	9.3	12.5	14.3	17.3	17.0	13.2	13.93
2010	700	10.6	14.6	18.4	20.3	20.1	14.7	16.45
	1300	6.6	10.9	14.9	16.7	17.6	11.6	13.05
		Precipitation (mm)						Total
2009	700	17.5	67.0	185.7	96.9	72.4	27.8	467.3
	1300	20.5	79.2	134.3	93.7	35.0	29.2	391.9
2010	700	105.8	101.5	260.8	118.8	97.5	83.0	767.4
	1300	92.7	81.5	76.8	49.1	15.3	54.0	373.0

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 analysis of tuber morphological characteristics (Table 2) showed highly significant differences caused by location (factor L) and year (factor Y). Significant interactions and mutual influence were determined between the experimental factors L × Y (Table 2).

Table 2. F-values for observed factors in 2008 year

Factors	Number of sprouts per tuber	Diameter of sprouts per tuber	Sprout length	Number of leaves per tuber
Location (L)	**	**	**	**
Year (Y)	**	**	**	**
L × Y	**	**	**	**

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

Growing conditions of seed tubers originating from a lower altitudes (700 m.a.s.l.) contributed to the greater physiological age of seed tubers *(Pavlista, 2004; Poštić et al., 2012; Poštić, 2013)* and consequently formed a significantly greater number of sprout per tuber, 0.87 or 13.12 % more ($p < 0.05$) in comparison with the number of sprouts per tuber originating from 1300 m.a.s.l. (Table 3).

Table 3. Effects of the location of planting material and the year on average number of sprouts per tuber

Year (Y)	Location of planting material (L)		Average (Y)
	Kotraža	Sjenica	
2009	7.90a	6.56a	7.23
2010	5.36b	4.78b	5.07
Average (L)	6.63	5.76	6.15

Different letters between cultivars denote significant differences (LSD test, $p < 0.05$)

The analysis of the average number of sprouts per tuber showed ($p < 0.05$) differences between the growing season of 2009, and the growing period of 2010. Very significantly ($p < 0.05$) lower sprouts per tuber 2.16, or 29.88 %, determined on the tubers produced in the growing season of 2010, compared to up the number of sprouts per tuber in the vegetation period of 2009 years (Table 3), which is the result of higher air temperatures in 2009 (Table 1), the greater the stimulation of the physiological age of seed tubers, respectively. Higher physiological age of planting material originating from (700 m a.s.l.), as a result, formed in a significantly lower ($p < 0.05$) average diameter of sprouts per tuber, of 0.60 mm or 10.29 % less, than the diameter of sprouts per tubers originate from 1300 m a.s.l. (Table 4), respectively. These results are in agreement with the results (*Moll, 1994; Poštić, 2006*). Morphological characteristics of the diameter of sprouts per tuber is determined by the number of sprouts per tuber and is contrary to it, which is in accordance with results *Poštić, (2006)*.

Table 4. Effect of location planting material and year on average diameter of sprouts (mm) per tuber

Year (Y)	Location of planting material (L)		Average (Y)
	Kotraža	Sjenica	
2009	3.95b	4.76b	4.36
2010	6.51a	6.90a	6.71
Average (L)	5.23	5.83	5.53

Different letters between cultivars denote significant differences (LSD test, $p < 0.05$)

Higher average air temperatures in 2009 (Table 1) and a greater number of formed sprouts per tuber (Table 3) caused the a significantly greater ($p < 0.05$) diameter sprouts per tuber 2.35 mm, or 35.02 %, was determined on the tubers produced in growing season of 2010, compared with the established diameter sprouts per tuber in the vegetation period of 2009 (Table 4), respectively.

Similar findings as in the diameter of sprout per tuber (Table 4) were determined in the case of the length of sprout per tuber (Table 5). Growing conditions of a planting material originating from lower altitudes (700 m.a.s.l.) contributed to the greater physiological age of seed tubers (*Pavlista, 2004; Poštić et al.,* *2010*) and consequently formed a significantly lower average ($p < 0.05$) length of sprout per tuber, 1.38 mm, or 13.49 % less in comparison with the length of sprout per tubers originating from 1300 m.a.s.l. (Table 5).

Table 5. Effect of location planting material and year on average length of sprouts (mm) per tuber

Year (Y)	Location of planting material (L)		Average (Y)
	Kotraža	Sjenica	
2009	6.51b	8.83b	7.67
2010	11.18a	11.63a	11.41
Average (L)	8.85	10.23	9.54

Different letters assigned to cultivars denote significant differences (LSD test, $p < 0.05$)

These results are consistent with the results (*Moll, 1994; Poštić, 2006*) which stated that the increase of the physiological age of seed tubers reduces the length of sprout per tuber. The length of sprouts per tuber, caused by the number of formed sprouts per tuber, had an inverse tendency with the increase in the number of formed sprouts per tuber. The statistical analysis of the length of sprouts per tuber indicates significant differences ($p < 0.05$) between the vegetation period of 2009, and the vegetation period of 2010 (Table 5). A significantly ($p < 0.05$) higher length of sprouts per tuber of 3.74 mm, or 32.78 %, was determined on the tubers produced in the vegetation period of 2010 in comparison with the established length of sprouts per tuber in the growing period of 2009 (Table 5) as a result of higher air temperatures in 2009 (Table 1). Growing conditions of a planting material originating from lower altitudes (700 m a.s.l.) contributed to the greater physiological age of seed tubers (*Pavlista, 2004; Poštić et al., 2011*) and consequently formed a significantly ($p < 0.05$) higher number of leaves per tuber, 2.71, or 8.16 % higher, in comparison with the number of leaves per tuber determined on the tubers originating from 1300 m.a.s.l. (Table 6). The number of leaves per tuber is in linear correlation with the number of sprouts per tuber and increase with the increasing number of sprouts per tuber, which is in accordance with the results stated by *Poštić,* (2006).

Table 6. Effects of the location of planting material and the year on the average number of leaves per tuber

Year (Y)	Location of planting material (L)		Average (Y)
	Kotraža	Sjenica	
2009	31.31b	28.56b	29.94
2010	35.13a	32.45a	33.79
Average (L)	33.22	30.51	31.86

Different letters assigned to cultivars denote significant differences (LSD test, $p < 0.05$)

The statistical analysis of the number of leaves per tuber indicates significant ($p < 0.05$) differences between the growing season of 2009, and the growing period of 2010 (table 6). A significantly ($p < 0.05$) higher number of leaves per tuber of 3.85, or 11.39 %, were determined on the tubers produced in the growing season of 2010 in comparison with the established number of leaves per tuber in the growing season of 2009 (Table 6) as a result of slightly higher air temperatures in 2009 (Table 1) and a larger number of formed sprouts per tuber (Table 3).

CONCLUSION

Based on the results of the conducted research, the following conclusions can be drawn:

1. Larger number of seed tubers and larger number of leaves per tuber (at lower altitudes) could eventually result in the formation of a greater number of primary stems per potato plant, i.e. the production of more tubers under regular and favorable conditions.
2. Larger diameters of sprouts and smaller sprouts lengths per tuber (at high altitudes) could be useful for short seasons and early potato production with a smaller number of primary stems and faster formation of heavier tubers.

ACKNOWLEGEMENT: The research was conducted within the projects TR 31018 and III 46007, The Ministry of Education, Science and Technological Development of the Republic of Serbia.

REFERENCES

Bohl, W.H., Olsen, N., Love, S.L., Nolte, P. (2003). Seed and planting management In Potato Production Systems. Publ. Univ. Idaho Extension Chap. 7, 91-114.

He, W., Struik, P.C., Wang, J., Zhang, X. (1998). Potencial and actual yilds of potato et different elevations and in different seasons in subtropical southwest China. J. Agron. Crop Sci., 180, 93-99.

Milošević, M., Vujaković, M., Karagić, Đ. (2010). Vigour tests as indicators of seed viability. Genetika, 42 (1), 103-118.

Moll, A. (1994). The effects of physiological aging of seed tubers on growth characteristics of eight potato cultivars tested under controlled conditions. Plant Breeding Abstract, 64, 1462-1463.

Pavlista, A.D. (2004). Physiological aging seed tubers. Potato eyes, University of Nebraska. NPE 16 (1), 1-3.

Pereira, A.B., Villa Nova, N.A., Ramos, V.J. (2008). Potato potential yield based on climatic elements and characteristics. Bragantia, 67, 327-334.

Poštić, D. (2006). Uticaj agroekoloških uslova proizvodnje semenskog useva na životnu sposobnost krtola krompira. Poljoprivredni fakultet, Univerzitet u Beogradu, 1-128.

Poštić, D., Sabovljević, R., Ikanović, J., Davidović, M., Goranović, Đ. (2009). Effect of agroecological condition of production and pre-plant storage on viability of potatoe seed tubers cv. Desiree. Proceedings of research papers XXIII Conference of Agronomists, Veterinarians and Technologists, 15, 99-111.

Poštić, D., Momirović, N., Broćić, Z., Dolijanović, Ž., Aleksić, G., Trkulja, N., Ivanović, Ž. (2010). Effect conditions of production on quality potato seed tubers cv. Desiree. 3rd international scientific/professional conference, Vukovar, 215-220.

Poštić, D., Momirović, N., Broćić, N., Dolijanović, Ž., Aleksić, G. (2012). The evaluation of biological viability of potato seed tubers grown at defferent altitudes. African Journal of Agricultural Research 70 (20), 3073-3080.

Poštić, D. (2013). Uticaj porekla sadnog materijala i veličine semenske krtole na morfološke i produktivne osobine krompira. Poljoprivredni fakultet, Univerzitet u Beogradu, 1-167.

Poštić D., Momirović N., Jovović Z., Đukanović L., Štrbanović R., Stanisavljević R., Knežević J., (2014), Effect of Seed Tuber Size and Pretreatment on the Total Yield Potato**.** Journal on Processing and Energy in Agriculture, 18 (5), 214-216.

Rykbost, K.A., Locke, K.A. (1999). Effect of seed piece size on performance of three varietes in the Klamath Basin of Oregon. Ame. J. Potato Res., 76, 75-82.

Struik, P.C. (2007). Physiological Age of Seed Tubers. Potato Research, 50, 375-377.

Tabaković, M., Sabovljević, R., Crevar, M., Mišović, M., Jovanović, S., Ćurčić, N., Pavlov, M. (2013), Uticaj vlažnosti pri berbi na klijavost semena kukuruza. Journal on Processing and Energy in Agriculture, 17 (2), 73-75.

Van der Zaag, D.E. (1992). Potatoes and their cultivation in the Netherland. NIVAA, 1-47.

Received: 21. 03. 2016. Accepted: 24. 05. 2016.