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THE CHANGES IN SEED QUALITY OF SELECTED PEPPER VARIETIES IN THREE YEARS
PROMENE KVALITETA SEMENA ODABRANIH SORTI PAPRIKE U TROGODIŠNJEM PERIODU

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ABSTRACT

Pepper (Capsicum annuum L.) as a commercial species includes a large number of different varieties and is one of the most popular vegetables around the world. Changes in the quality of the seeds of autochthonous varieties of pepper seeds: Palanačko Čudo, Župska Rana, and Kobra were monitored in three years (2019–2021). It was noticed that the slightest difference in germination was obtained with the cultivar Palnačko Čudo ($p>0.05$) in three years. The Župska Rana had the best germination in 2019 (95%) compared to Palnačko Čudo and Kobra ($p<0.05$). The germination energy of Župska Rana is significantly higher compared to other selected varieties, 89% ($p<0.05$). There was a significant decrease in total germination in 2020. compared to 2019. ($p<0.05$) and amounted to 83%; accordingly, the germination energy decreased. No phytopathogenic fungi were detected in the Župska Rana sample. Total germination and energy decreased significantly compared to the previous two years ($p<0.05$). During the analysis of quality parameters in 2021, the slightest change in quality was observed in the variety Palanačko Čudo, including germination energy and moisture. A significant decrease in the germination of Župska Rana was noticed during the period 2019–2021. The lowest percentage of phytopathogenic fungi in the three years was detected in Župska Rana.

Keywords: *seed, pepper, germination, yield.*

REZIME

Paprika (Capsicum annuum L.) kao komercijalna vrsta obuhvata veliki broj različitih sorti i spada u najpopularnije povrće širom sveta. Promene kvaliteta semena autohtonih sorti semena paprike: Palanačko čudo, Župska rana i Kobra praćene su u trogodišnjem periodu (2019-2021). Uočeno je da je najmanja razlika u klijavosti dobijeno kod sorte Palnačko čudo ($p>0,05$) u trogodišnjem periodu. Župska rana je imala najbolju klijavost 2019. godine (95 %) u odnosu na Palanačko čudo i Kobru ($p < 0,05$). Energija klijanja kod Župske rane je značajno viša u odnosu na druge odabrane sorte, 89 % ($p < 0,05$). Primećeno je značajno opadanje ukupne klijavosti 2020. u odnosu na 2019. godinu ($p < 0,05$) i iznosila je 83 %, shodno tome i energija klijavosti je opala. Nisu detektovane fitopatogene gljive u uzorku Župske rane. Ukupna klijavost i energija značajno su opale u odnosu na predhodne dve godine ($p < 0,05$). Prilikom analize parametra kvaliteta 2021. godine uočena je najmanja promena kvaliteta kod sorte Palanačko čudo uključujući energiju klijavosti i vlagu. Primećen je značajan pad u klijavosti Župske rane u periodu 2019-2021 godine. Najmanji procenat fitopatogenih gljiva u trogodišnjem periodu detektovan je kod Župske rane.

Ključne reči: *seme, paprika, parametri kvaliteta, prinos.*

INTRODUCTION

Pepper (*Capsicum annuum* L.) as a commercial species includes a large number of different varieties that are popular around the world. According to the official data from the Food and Agriculture Organization from 2016, the annual production of pepper reached approximately 3.9 million tons (*Li et al., 2018; FAO, 2016*). Using good quality pepper seeds can enhance the final yield and reduce unnecessary losses caused by defective or diseased pepper seeds. The most common methods for selecting high-quality seeds are based on physical properties, such as weight and germination, biochemical, and other physical tests. Seed germination testing requires 8–14 days (*ISTA Rules, 2008*). Deterioration in seed quality is an unavoidable process, so it is essential to maintain seed quality and vitality during storage. Seeds are an important vector in spreading contamination. Infected seeds may not germinate, and there is a possibility to spread contamination to other seeds. In some cases, germs or seedlings develop, but diseases can develop rapidly and spread among others (*Islam, 2012*). It is known that various factors affect the quality of seeds during storage. Still, the quality is most affected by moisture and seed temperature (*Gebeyehu, 2020*). Various factors such as adequate storage, taking seeds from healthy plants, and different preparations can significantly improve the quality of seeds. In general, the lower the moisture and temperature of the seed, the longer the life of the seed (*Wang et al., 2018*). The aim of our research was to determine the changes in the seed quality of autochthonous pepper varieties: Palanačko Čudo, Župska Rana, and Kobra over a period of three years.

MATERIAL AND METHOD

Seed testing of three pepper varieties (*Capsicum annuum* L.): Palanačko Čudo, Župska Rana, and Kobra was performed by standard methods of assessing the quality and health of in the laboratory for testing quality seeds at Institute for Vegetable Crops, Smederevska Palanka. The quality of three seed varieties was evaluated through the parameters of germination (energy and total germination), moisture, and seed health. The seed quality of selected pepper varieties was tested following the standard on seed quality of agricultural plants (47/87), which is harmonized with the ISTA rules (2020). Total seed germination and germination energy are performed using filter paper's standard method. Samples of selected pepper varieties of 100

seeds in four replicates were placed in Petri dishes with filter paper moistened with 0.2% KNO3. Germination analysis indicates abnormal germs (damaged, defined, rot) that cannot develop into a normal plant and have not developed by the end of the tested time. The set samples were incubated for 7 and 14 days at 23 ºC. The seed health of Palanačko Čudo, Župska Rana, and Kobra was tested on *Alternaria* spp. and *Fusarium* spp. Health testing of three varieties of peppers is performed with the standard method on filter paper. The allowed percentage of infected seeds is 5%. After incubation, the results are read according to the following formula:

$$\text{Seed health} = \frac{\text{number of infected seeds}}{\text{total number of seeds}}\ x\ 100\%$$

Moisture content is defined as the water in the seed and is expressed as a percent. The moisture testing procedure is performed with 5 g of a sample of three pepper varieties on an analytical balance. Moisture determination is performed at a temperature of 105 ºC ± 2 ºC for 17 h ± 1 h. SM (dry mass) calculation is performed according to the following formula and is expressed at one decimal place:

$$\text{SM}\ (\%) = \frac{m_3 - m_1}{m_2 - m_1} \times 100\%$$

whre is: m_1 – the mass of a container and lid; m_2 (g) – the mass of a container, lid, and contents before drying; m_3 (g) – the mass of a container, lid, and contents after drying.

Statistical analysis was carried out with SPSS software (version 23, IBM, USA). Samples were compared with ANOVA and F test. Statistical significance cut off was $p<0.05$.

RESULTS AND DISCUSSION

The analyses of germination parameter values (total germination and energy), moisture, and health were monitored from 2019 to 2021. Pepper varieties were compared with each other, with a statistically significant difference between varieties and within one group in three years (Table 1).

Table 1. Seed quality parameters (total germination, energy, and moisture content) in the three years of the season (2019 – 2021).

Samples	Total germination (%)			Germination energy (%)			Moisture content (%)		
	2019	2020	2021	2019	2020	2021	2019[e]	2020[e]	2021[e]
Palanačko[b] Čudo	89 %[a]	88 %[a]	85 %[a]	79 %[d]	71 %[d]	69 %[d]	9 ±1	6.6 ±0.3	6.4 ±.0.1
Kobra[c]	88 %[a,b]	77 %[a]	66 %[a]	72 %[d]	65 %[d]	50 %[d]	8.9 ±1	8.2 ±1	7.4 ±0.1
Župska Rana[c]	95 %[a]	83 %[a]	75 %[a]	89 %[d]	73%[d]	60 %[d]	8.3 ±0.2	7.9 ±0.5	7.7 ±0.7

a - statistical significance ($p<0.05$) between varieties (Palanačko Čudo, Kobra and Župska Rana), b- obtained decrease of total germination $p>0.05$ between varieties (Palanačko Čudo and Kobra), c-cobtained a decrease in the three years for Župska Rana and Kobra is $p<0.05$, d - obtained decrease of germination energy in the three years for Župska Rana, Kobra, and Palanačko Čudo, $p<0.05$, e - statistical significance for moisture content ($p<0.05$) between varieties and over time (decreased over a period of three years)

In addition, no correlation was observed between the occurrences of phytopathogenic fungi within one group (variety) and between groups for the Palanačko Čudo and Župska Rana. For the Kobra, a decrease in total germination and germination energy was observed with an increase in infection with *Alternaria* spp.

Total germination for Kobra in 2019 was 88%, energy 72%, while Alternaria and Fusarium were present in 1%. Germination (2020) was 77% and energy 65% (Table 1 and Table 2), a significant increase in Alternaria of 5% was observed, while Fusarium was not present (Table 2). In 2021, quality parameters were significantly reduced ($p<0.05$), 66% (germination) and 50% (energy), the presence of Alternaria was 4%, and Fusarium 3%. For the Palanačko Čudo pepper variety (2019) the total germination was 89%, energy 79% (Table 1) and 4% of Alternaria was detected (Table 2).

Table 2. Presence of phytopathogenic fungi in the seeds of selected pepper varieties

Samples	*Fusarium* spp (%)			*Alternaria* spp (%)		
	2019	2020	2021	2019	2020	2021
Kobra	1%	0%	3%	1%	5%	4%
Palanačko čudo	0%	0%	0%	4%	0%	5%
Župska rana	1%	0%	1%	3%	0%	1%

No significant decrease ($p>0.05$) in total germination seeds of Planačko Čudo (2020) was observed, while the decrease in germination energy was 71% ($p<0.05$) (Table 1) and 3% of Alternaria were detected. In the third year (2021), the parameters did not change significantly ($p>0.05$) for total germination. Alternaria detected was 5% (Table 2). The chili pepper Kobra is known as the spicy and reach with capsaicinoids, including capsaicin and dihydrocapsaicin, which are antagonistic to the growth of fungal pathogens. In our sample capsaicin had no antifungal effects, but in other studies, wild chilli peppers were used to inhibit phytopathogenic fungi (Alternaria, Colletotrichum, Fusarium, and Phomopsis) (Naves et al., 2019; Adams et al., 2020). However, in our research we found the highest contamination in the Kobra ($p<0.05$). Seed analyzes have indicated the problem of contamination of this variety (Kobra) and require further research. Contamination was within the legal limits, but the quality must be further tested and improved. In our tested samples, a decrease in moisture content was obtained in the last observed year. While in the first years tested, the highest percentage of impact was determined which had no effect on germination (Table 1)? However, the seed moisture of different species of *Brassica* and the effect on germination were estimated. The obtained results showed that the increased moisture content in the seed reduces germination (*Suma et al., 2013*).

Župska Rana had the best germination in 2019 (95%) in relation to Palanačko Čudo and Kobra ($p<0.05$). Germination energy is significantly higher than other selected varieties, 89% ($p<0.05$). The presence of *Alternaria* spp is 3% and *Fusarium* spp 1%. There was a significant decrease in total germination in 2020 compared to 2019 ($p<0.05$) and amounted to 83%; accordingly, the germination energy decreased. No phytopathogenic fungi were detected in Župska Rana sample. Total germination and energy decreased significantly compared to the previous two years ($p<0.05$). Total germination was 75% and energy 60%. *Alternaria* spp and *Fusarium* spp were detected at 1%. During the analysis of quality parameters in 2021, the slightest change in quality was observed in the variety Palanačko Čudo. A significant decrease in the germination of Župska Rana was noticed during the period 2019–2021. The observed traits

showed that *Fusarium* spp and *Alternaria* spp did not affect the total germination and germination energy for Župska Rana and Planačko čudo (p> 0.05). However, a decrease in total germination and germination energy was noticed for the Kobra which followed by an increase in seed contamination with *Alternaria* spp (p<0.05). In similar studies, *Alternaria* spp was most prevalent with an average infection of 16% in all tested samples that had reduced seed germination (*Tufail et al., 2020*). Currently, there are no varieties of C. annuum L. with total resistance for *Fusarium* spp or *Alternaria spp*. The fungi *Fusarium oxysporum* can infecting roots, stems, leaves, could persistence in seeds and can cause yield losses of up to 100% (*García-Rodríguez et al., 2010; Li et al., 2017*). The lowest percentage of phytopathogenic fungi in the three years was detected in Župska Rana. Different studies indicate that applying different treatments can significantly improve the quality parameter (*Castillo et al., 2009*). A study was performed with a mycorrhizal formulation that increased the total germination of pepper seeds by 3–4% (*Poštić, 2019; White et. 2019*). Also, germination efficiency significantly depends on the percentage of infected seeds. The lowest germination was obtained in samples of seeds with the highest isolation of pathogenic fungi. In contrast, the maximum germination was obtained in samples where the prevalence of pathogenic fungi is lowest (*Debnath et al., 2012*). Also, using *Trichoderma,* strain germination and total germination may be increased (*Konings-Dudin et al., 2014; Murphy., 2017*). Our samples were not treated, and total germination was obtained from natural seeds, which indicates the possibility of increasing germination by applying some organic treatments.

Table 3. The correlation coefficient (r) for the observed traits of three pepper varieties in three-year period

Traits	Total germination	Germination energy	Moisture content	*Fusarium*	*Alternaria*
Total germination	-	0.952498***	0.235219	0.519423	0.632752
Germination energy		-	0.372279	0.635716	0.564929
Moisture content			-	0.146401351	0.054068681
Fusarium					-0.02273
Alternaria					-

Pearson's correlation coefficient: *** p< 0.001

A negative correlation coefficient indicates the possibility of influencing the positive growth of *Alternaria spp*. while another phytopathogenic fungus declined over time, but not at a statistically significant level. (p>0.05). The strongest correlation found between the total germination and germination energy of seed pepper (r = 0.952498, p<0.001). This means that these two traits are related and when one of the observed traits decreased, the other also decreased. Similar results were obtained by *Poštić et al. 2020* with the germination energy and the total germination of the tomato seeds (r = 0.8711, p <0.001). The correlation coefficient for the other observed traits was not at the statistical level (p>0.05).

CONCLUSION

Seed quality and health depend on agronomic measures such as fertilizer, irrigation, crop rotation, handling, and proper seed storage. These techniques contribute to improving yields. The germination of our varieties in the three years is above the legal minimum, and based on the three-year period, it can be classified as quality seed. Also, the use of organic means for seed protection can increase and prolong the quality of our seeds, but that remains for future research.

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