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CHANGES IN QUALITY INDICATORS OF DIFFERENT CUCUMBER HYBRID SEEDS DURING FIVE YEARS OF AGING

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INTRODUCTION

Cucumber belongs to the group of the most important vegetable species, primarily due to its wide area of cultivation and diverse ways of use. Cucumber is produced in the world on an area of about 2.2 million hectares with an average yield of 34.4 t ha^{-1}. China is the largest cucumber producer in the world with 70.338.971 t production per year, which represents more than 80 % of world's cucumber, Turkey comes second with 1.916.645 t yearly production. With 1.626.360 t of production per year, Russian Federation is the third largest producer of cucumber. In the Republic of Serbia, it is grown on about 3.020 ha with an average with a yield of 12.6 t ha^{-1}, with reference to at 2008, we see a trend of decreasing surfaces under this plant species but also the growth average yield per unit area (*FAOSTAT, 2022*). Good quality seeds (high vigor) play a decisive role in the production of every plant species (*Tabaković et al., 2013; Poštić et al., 2019*). The speed of seed aging, i.e. the decrease in the percentage of germination, depends on the degree of vigor of the seed. Seeds with high vigor will record a relatively smaller decrease in seed germination, while seeds with low vigor will had a significant decrease in germination (*Milošević and Ćirović, 1994*). The vigor of seeds is determined by the nature of the plant species itself, production conditions and seed storage conditions. Different genotypes within a variety can vary significantly in the length of the seed viability period. Seed ageing is a consequence of the production and accumulation of reactive oxygen species (ROS), which are toxic oxidants that bring about physical and biochemical lesions (*Adetunji, et al., 2020*). The ROS attack major biomolecules such as proteins, nucleic acids, and lipids during oxidative stress, resulting in physiological injuries like the loss of membrane integrity, degradation and inactivation of enzymes and reduced respiration, thereby affecting seed quality, vigour and early seedling growth (*Adetunji, et al., 2021*). The purpose of this paper is to evaluate the effect of the year on the main indicators of seed quality of three cucumber hybrids. The obtained results should contribute to the understanding of the rate of change of vigor of cucumber hybrid seeds during years of storage.

MATERIAL AND METHOD

Our research was done on the seed of three different cucumber hybrids (two early - Centauro F1 and Edona F1; mid-early - Solatio F1), which were produced in 2017. and imported in 2018 to the Republic of Serbia. The seeds were stored in a warehouse packed in PVC bags at a temperature below 15 ºC, RH 50 %. All three hybrids are parthenocarpic and 100 % female flowering with a high yield potential. Suitable for late autumn, early winter and spring production, therefore these hybrids occupy a significant place in our market. Due to good seeding and fruit production in conditions of lower temperatures and lower lighting, these hybrids have proven to be an excellent and reliable choice for our producers. The evaluation of cucumber seed hybrids quality indicators (germination energy, seed germination, abnormal seedlings and dead seeds) was conducted in 2018, 2019, 2020, 2021 and 2022 years at the Laboratory for Seed and Planting Material Testing of the Institute for Plant Protection and the Environment in Belgrade. The germination testing of three cucumber seed hybrids considered was performed using a standard laboratory method according to the Rules on the Quality of Seeds of Agricultural Plants *("Official Gazette of SFRY", no. 47/87*), which are in accordance with the ISTA Rules (*ISTA, 2018*).

The experimental data obtained were processed using the statistical package STATISTICA 8.0 for Windows. Differences between the treatments were determined using the analysis of variance (ANOVA), whereas the least significant difference (LSD) test was used for individual comparisons. Grouping information using Tukey method and 95.0% confidence. The variability for each feature is expressed using the coefficient of variation (CV, %). Correlations between the parameters observed were determined using the Pearson correlation coefficient (r).

RESULTS AND DISCUSSION

ANOVA results on the influence of factors: year (Y), hybrid (H) and their interactions (Y × H) had a significant effect ($p<0.01$) on germination energy, total germination, abnormal seedlings and dead seeds (Table 1). Similar results of significant influence of year, variety/hybrid and their interaction on quality indicators of alfalfa, tomato and cabbage seeds were noted earlier (*Stanisavljević et al., 2018; Poštić et al., 2020; Poštić et al., 2022*).

Observed by year, the average germination energy values of the tested cucumber hybrids decline and are the lowest in the fifth year (89%), as expected (Table 2). Tested cucumber hybrids lose germination energy more slowly than tomato and cabbage seeds, according to earlier research (*Poštić et al., 2020; Poštić et al., 2022*).

A significantly lower germination energy was recorded in the Edona F1 hybrid in all examined years, compared to the other two hybrids. Also, the Edona F1 hybrid recorded the fastest decline of this indicator, which is confirmed by the highest CV of 6.46 %. According to *Almeida et al.* (2010), the germination energy test can be used as an indication of vigor, because as seed deterioration progresses, the germination speed is reduced. The achieved values of seed germination (Table 3) by years and hybrids have the same tendency as the obtained values of germination energy.

A significant decrease in seed germination was recorded only in the Edona F1 hybrid only in the third year (2020) of the test, in the other two hybrids no significant decrease in the value of seed germination per year was noted. Based on these results, we can state that cucumber hybrids lose viability more slowly, compared to earlier studies of the germination of tomato and cabbage seeds (*Poštić et al., 2020; Poštić et al., 2022*).

The number of abnormal seedlings in Centauro F1 and Solatio F1 hybrids did not decrease significantly with age, which indicates that the seeds of these two hybrids have high viability. Soares et al. (2019) reported similar results of a low percentage of abnormal seedlings examining four lots of cucumber seeds.

The same trend in the value of the number of dead seeds in the tested cucumber hybrids was recorded, as well as in the number of abnormal seedlings.

The percentage of dead seeds with seed aging increases significantly only in the Edona F1 hybrid and only in the third year (2020). In the Edona F1 hybrid, the interval of variation in the percentage of dead seeds was in a narrow interval from 0 % in 2018 to 6 % in 2022.

Hybrids Centauro F1 and Solatio F1 had no significant increase in the percentage of dead seeds was recorded, which is the opposite of earlier reports in the research on the aging of tomato and cabbage seeds (*Poštić et al., 2020; Soares et al., 2019;Poštić et al., 2022*).

Taking into consideration 15 pairs (five years, three hybrids), the strongest positive correlation was established between germination energy and seed germination ($r = 0.95635$, $p<0.001$) and between abnormal seedlings and dead seeds ($r = 0.92301$, $p<0.001$). As expected, a negative and highly significant ($p \leq 0.001$) correlation was established between germination energy and: abnormal seedlings ($r = -0.94535$) and dead seeds ($r = -0.93255$). Likewise, a strongest negative ($p \leq 0.001$) correlation was found between seed germination and: abnormal seedlings ($r = -0.97497$) and dead seeds ($r = -0.98545$) Table 4. These results agreement with the results (*Stanisavljević et al., 2017; Soares et al., 2019;Poštić et al., 2020; Poštić et al., 2022*).

Table 1. F-values for observed factors

Factors	Germination energy	Total germination	Abnormal seedlings	Dead seeds
Year (Y)	235.96**	135.96**	58.72**	70.07**
Hybrid (H)	942.76**	339.09**	175.44**	139.00**
Y × H	54.76**	61.98**	38.64**	19.39**

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

Table 2. Effect of year and hybrids on cucumber germi. energy (%)

Hybrid (H)	Year (Y)					Average (H)	CV (%)
	2018	2019	2020	2021	2022		
Centauro F1	99aA	98aA	97aAB	97aAB	96aB	97	1.17
Edona F1	94bA	93bA	90cB	86cC	80cD	89	6.46
Solatio F1	97aA	96aA	94bB	93bB	92bB	94	2.20
Average (Y)	97	96	94	92	89	93	
CV (%)	2.60	2.63	3.75	6.05	9.32		

Table 3. Effect of year and hybrids on cucumber seed germi. (%)

Hybrid (H)	Year (Y)					Average (H)	CV (%)
	2018	2019	2020	2021	2022		
Centauro F1	100aA	100aA	99aA	98aA	98aA	99	1.01
Edona F1	99aA	98aA	95bB	90bC	88bC	94	5.16
Solatio F1	99aA	99aA	98aA	98aA	97aA	98	0.85
Average (Y)	99	99	97	95	94	97	
CV (%)	0.58	1.01	2.14	4.85	5.84		

* Small letters show the difference a, b, for the column, capital letters show the difference A, B, for the line; Grouping Information Using Tukey Method and 95.0% confidence;

Table 4. The correlation coefficients between the observed traits (n=15)

Traits	Germination energy	Seed germination	Abnormal seedlings	Dead seeds
Germination energy	-	0.95635***	- 0.94535***	- 0.93255***
Seed germination		-	- 0.97497***	- 0.98545***
Abnormal seedlings			-	0.92301***
Dead seeds				-

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

CONCLUSION

Based on five years of research, we can conclude the following:

- Year (Y), hybrid (H) and their interactions (Y × H) had a significant effect ($p<0.01$) on germination energy, seed germination, abnormal seedlings and dead seeds.
- Centauro F1 and Solatio F1 hybrids have a higher degree of vigor seeds and as such their germination energy and seed germination rate decrease more slowly, compared to the Edona F1 hybrid.
- The Edona F1 hybrid had a significantly higher percentage of abnormal seedlings in the fourth year research, and a significantly higher number of dead seeds in the third year.
- Obtained results showed that indicators of cucumber seed quality, germination energy and seed germination in the investigated cucumber hybrids decrease more slowly during aging, which indicates that cucumber hybrids retain viability for many years during aging.
- In future research on cucumber seeds, it should be assessed how age affects the growth of stem cells and the length of the seedling's primary root.

Key words: *cucumber, hybrid, germination*

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