EVALUATION OF THE QUALITY OF TOMATO SEED POPULATIONS FROM THE ORGANIC PRODUCTION SYSTEM DURING AGING

OCENA KVALITETA SEMENA POPULACIJA PARADAJZA IZ ORGANSKE PROIZVODNJE TOKOM STARENJA

Dobrilov POŠTIĆ*, Raithor STRBANOVIĆ*, Zoran BROČIĆ**, Aleksandra STANOJKOVIĆ-SEBIĆ***, Nenad DURIĆ****, Snežana TOŠKOVIĆ*****. Rade STANISAVLJEVIĆ*

*Institut za zaštitu bilja i životnu sredinu, Beograd, Teodora Dražera 9
**Poljoprivredni fakultet, Beograd, Nemanjina 6
***Institut za zemljište, Beograd, Teodora Dražera 7
****Fakultet za biofarming, Beograd, Bulevar maršala Tita (76 m a.s.l.)
*****Akademija strukovnih studija, Šabac, Vojvode Putnika 56
e-mail: pdobrilov@yahoo.com

ABSTRACT

A total of six tomato seed populations, collected in the autumn of 2016 at different locations in Serbia (West (3), South (1), North (1) and East (1)), were enrolled in this study. Seeds of the tomato populations considered were produced in the organic growing system in the area of Zavoci (76 m a.s.l., chernozem), Stara Pazova, Northern Serbia (44° 47′ 19.6″ N, 20° 27′ 56.2″ E) in 2017. Analyses of the germination parameters of the tomato seed populations examined (namely the germination energy, total germination, abnormal seedlings and dead seeds of the tomato seeds considered) indicated significant (p < 0.01) differences according to the production year (A) and the tomato seed population (B). The interaction interactions (p < 0.01) of these factors (A × B) proved significant only relative to dead seeds. A highly significant positive correlation was found between the germination energy and the total germination of the seeds considered (r = 0.8711, p < 0.001), as well as between the amounts of their abnormal seedlings and dead seeds (r = 0.92297, p < 0.001). The germination energy and the total germination of the tomato seeds considered were found to decrease with the increasing seed age, in contrast to the numbers of their abnormal seedlings and dead seeds which continued to increase with seed aging.

Key words: tomato, germination, seeds, population/variety.

REZIME

Seme šest populacija/sorti paradajza prikupljeno je u jesen 2016. sa različitih lokaliteta iz Srbije: zapadne (3 populacije), južne (1), severne (1) i istočne (1). Proizvodnja semena populacija paradajza u organskom sistemu gajenja izvedena je 2017. godine na lokaciji zapadne Srbije u Staroj Pazovi, potes Zovice (76 m n.m.) 44° 47′ 19.6″ N, 20° 27′ 56.2″ E. Cilj istraživanja je bio da se izvrši ocena uticaja godine i populacije na pokazatelje kvaliteta semena paradajza tokom 2017., 2018. i 2019.. Seme je čuvano u skladištu upakovano u pvc-kesama na temperaturi ispod 15°C, RH 50%.

Analiza energije klijanja, ukupne klijavosti, neneormalnih klijanaca i mrtvog semena paradajza pokazala je visoko značajne razlike (p<0.01) pod uticajem faktora godina (A) i populacija semena (B). Vrlo značajna interakcija (p<0.01) ispitivanih faktora u pogledu mrtvog semena paradajza dobijena je samo kod međusobnog uticaja faktora A × B. Zabeležena je visoko značajna korelacija (p≤0.001) između energije klijanja i ukupne klijavosti, i između broja neneormalnih klijanaca i mrtvog semena. Energija klijanja i ukupna klijavost sa povećanjem starosti semena opadaju, dok broj neneormalnih klijanaca i mrtvog semena raste. Rezultati ovog rada treba da daju doprinos u shvatanju značaja autohtona populacija/sorti semena paradajza, već i autohtona sorti semena ostalog povrća; odnosno da ukažu na značaj očuvanja genetičkih resursa za organsku poljoprivredu.

Ključne reči: paradajz, klijavost semena, populacija/sorta.

INTRODUCTION

Seeds are one of the basic preconditions of successful agricultural production and regular yields of high quality. Therefore, the identification and testing of seed quality, i.e. vigor, is of paramount importance to crop production (Poštić et al., 2019). Vigor or biological viability is used to describe the physiological properties of seeds responsible for their ability to germinate rapidly in the soil (Tabaković et al., 2013). There is a deficit in organic seeds both in Serbia and worldwide, which is being increasingly compensated for by conventional non-treated seeds. However, the EU experts have announced that organic production will not be able to use untreated seeds from conventional production as of 2021. Over the past twenty years, the global organic production has rapidly expanded due to growing concerns about human health and a great demand for "healthy" food (Postic et al., 2018). Organic farming and organic tomato production have recently been receiving increased attention in Serbia. However, there are no accurate data on the organic production of tomatoes in Serbia to date.

Nowadays, a 0.9 % share of the total agricultural land in the world is devoted to organic agriculture. However, the largest share of 6.2 % of the agricultural land devoted to organic farming is recorded in Europe. As many as eight EU countries have an average of more than 10 % of their agricultural land devoted to organic farming. However, only a 0.4 % share of the total agricultural land is devoted to organic farming in Serbia. A total of 13,423 ha were devoted to organic production in Serbia in 2017, or 0.4 % of the total Serbian arable land, with 6,022
registered organic producers (FiBL, 2020). Tomatoes are one of the most common and economically significant vegetable crops in Serbia, grown in the open field or in protected areas. The conventional production of tomatoes in Serbia approximates to 180,000 t, covering a land area of 20,000 ha. Owing to the lack of organic seeds in the market, domestic producers use seeds from their own production and/or local seed populations adapted to the agroecological conditions in Serbia (Ugrenović et al., 2013).

A continuous decrease in the number of well-established local seed populations in Serbia poses a great threat to the local biodiversity and genetic resources. In the face of increasing production issues caused by climate change, it is necessary to collect and preserve as many well-established local seed populations and plant varieties as possible because they carry many genes for resistance to various adverse environmental conditions and plant diseases (pathogens). The purpose of this study is to evaluate the effects of production year and seed population on the most significant indicators of the quality of organic tomato seeds. The results obtained emphasize the overriding importance of domestic seed populations and plant varieties of tomatoes and other vegetable crops for organic agriculture.

**MATERIAL AND METHOD**

Production of tomato seeds in the organic farming system. A total of six tomato seed populations, collected in the autumn of 2016 at different locations in Serbia (West (3), South (1), North (1) and East (1)), were enrolled in this study. Seeds of the tomato populations considered were produced in the organic growing system in the area of Zaovice (76 m a.s.l., chernozem), Stara Pazova, Northern Serbia (44°47'19.6"N, 20°27'56.2"E) in 2017. The soil properties are shown in Table 1.

Seed sowing was performed using containers in early April, whereas planting in the open field was carried out in mid-May (at a distance of 0.4 × 0.7 m and in a plot area of 10 m²). Crop management was conducted according to the commonly accepted recommendations for growing tomatoes in the organic production system. Tomatoes were harvested at full physiological maturity during August and September, followed by seed extraction and 24-hour seed fermentation. Seed drying was performed in the shade at room temperature. The seeds were stored in PVC bags at a temperature below 15°C, RH 50%.

| Depth (cm) | Type of soil | CaCO3 % | PH | Humus | mg/100g soil |
|-----------|--------------|---------|----|-------|--------------|
| 0-30      | Chernozem   | 6.32    | -  | 7.70  | 5.86         |

The germination testing of six seed populations considered was performed using a standard laboratory method involving filter paper moistened with a 0.2 % aqueous KNO₃ solution at 4 × 100 seeds. The seeds were incubated for 14 days at a temperature of 20-30°C and a relative air humidity of 95 %. The germination energy after 5 days of incubation, the total germination and the numbers of abnormal seedlings and dead seeds after 14 days of incubation of the tomato seeds considered were determined 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, 2002-2018). The results obtained are consistent with the results of Stanisavljević et al., (2018). The impact interactions (p < 0.01) of these factors (A × B) proved significant only relative to dead seeds.

**RESULTS AND DISCUSSION**

Analyses of the germination parameters of the tomato seed populations examined (namely the germination energy, total germination, abnormal seedlings and dead seeds of the tomato seeds considered) indicated significant differences (p < 0.01) according to the production year (A) and the tomato seed population (B). The results obtained in the present study are consistent with the results of Stanisavljević et al., (2018). The impact interactions (p < 0.01) of these factors (A × B) proved significant at 0.01; * - significant at 0.05; ns - not significant.

The germination energy of the tomato seed populations considered ranged from 72 % to 92 % (Table 4). As expected, the highest average germination energy of 89 % was determined in 2017, followed by 85 % in 2018 and 79 % in 2019. After harvest (2017), the decreases in the germination energy of the tomato seed populations considered ranged on average from 4 % in 2018 to 10 % in 2019. The results obtained are consistent with the results of Poštić et al. (2011). The total germination of the tomato seed populations considered ranged from 81 % to 98 % (Table 5). As expected, the highest average total germination of 94 % was determined in 2017, followed by 88 % in 2018 and 84 % in 2019. After harvest (2017), the decreases in the overall germination of the tomato seed populations considered ranged on average from 6 % in 2018 to 10 % in 2019. The results obtained are consistent with the results of Poštić et al., (2011). Lower variability was found in the germination energy (Table 4) and the total germination (Table 5) of the tomato seeds considered, ranging from 3.15 % to 11.43 %. The number of abnormal seedlings of the tomato seeds considered was found to increase with the increasing age.
of tomato seeds, ranging from 0 % in the first year to 9 % in the third year (Table 6). The smallest average number of abnormal seedlings of 3.33 % was observed in the Jabučar East population (Negotin), whereas the largest number of abnormal seedlings of 7.33 % was observed in the Jabučar West population (Šabac).

The number of dead seeds of the tomato seeds considered increased with seed aging, ranging from 2 % in the first year to 10 % in the third year (Table 7). High variability was found for abnormal sprouts (Table 6) and dead seeds (Table 7), ranging from 13.32 % to 91.65 %.

The coefficients of correlation (r) computed express the interdependence between the seed quality parameters observed (Table 6). As expected, a highly significant positive correlation was found between the germination energy and the total germination of the tomato seeds considered (r = 0.8711, p < 0.001), as well as between the numbers of their abnormal seedlings and dead seeds (r = 0.92297, p < 0.001). The results obtained are consistent with the results of Stanisavljević et al., (2017).

Table 4. Effects of the production year and seed population on the germination energy (%)

| Population (B) / Origin       | Year (A) | Average | CV (%) |
|-------------------------------|----------|---------|--------|
| Jabučar / West (Badovinci)   | 2017     | 90aA    | 86aB   | 72cC   | 82.7 | 11.433 |
| Jabučar / West (Šabac)       | 2018     | 84bA    | 80cB   | 75aC   | 79.7 | 5.660  |
| Jabučar / West (Šabac)       | 2019     | 91aA    | 85aB   | 81aC   | 85.7 | 5.875  |
| Jabučar / South (Pirot)      | 2017     | 92aA    | 88aB   | 83aC   | 87.7 | 5.144  |
| Sant pjer / North (Sombor)   | 2018     | 84bA    | 83aB   | 79bB   | 82.0 | 3.227  |
| Jabučar / East (Negotin)     | 2019     | 90aA    | 87aB   | 82aC   | 86.3 | 4.681  |
| Average (A)                  | 2017     | 98.5    | 91.7   | 91.7   | 90.3 | 88.6   |

* Means in the columns followed by the same letter are not significantly different according to the Fisher’s protected LSD values (P = 0.05)

Table 5. Effects of the production year and seed population on the total germination (%)

| Population (B)/Origin    | Year (A) | Average | CV (%) |
|--------------------------|----------|---------|--------|
| Jabučar / West (Badovinci) | 2017     | 96aA    | 89abB  | 85aC   | 90.0 | 6.186  |
| Jabučar / West (Šabac)   | 2018     | 86cA    | 85cA   | 81bB   | 84.0 | 3.150  |
| Jabučar / South (Pirot)  | 2019     | 96aA    | 88bB   | 84aC   | 89.3 | 6.840  |
| Sant pjer / North (Sombor) | 2017    | 90bA    | 86cB   | 82bC   | 86.0 | 4.651  |
| Jabučar / East (Negotin) | 2018     | 98aA    | 91aB   | 86aC   | 91.7 | 6.576  |
| Average (A)              | 2019     | 93.7    | 88.2   | 83.8   | 88.6 |        |

* Means in the columns followed by the same letter are not significantly different according to the Fisher’s protected LSD values (P = 0.05)

Table 6. Effects of the production year and seed population on the number of abnormal seedlings (%)

| Population (B)/Origin      | Year (A) | Average | CV (%) |
|----------------------------|----------|---------|--------|
| Jabučar / West (Badovinci) | 2017     | 2bC     | 4abB   | 6abA   | 4.00 | 50.00  |
| Jabučar / West (Šabac)     | 2018     | 6aB     | 7aB    | 9aA    | 7.33 | 20.830 |
| Jabučar / West (Šabac)     | 2019     | 1bC     | 5aB    | 7aA    | 4.33 | 70.501 |
| Jabučar / South (Pirot)    | 2017     | 2bB     | 5aA    | 6abA   | 4.33 | 48.038 |
| Sant pjer / North (Sombor) | 2018     | 4aC     | 6aB    | 9aA    | 6.33 | 39.736 |
| Jabučar / East (Negotin)   | 2019     | 0bC     | 4abB   | 6abA   | 3.33 | 91.652 |
| Average (A)                | 2017     | 2.50    | 5.17   | 7.33   | 5.00 |        |

* Means in the columns followed by the same letter are not significantly different according to the Fisher’s protected LSD values (P=0.05)

Table 7. Effects of the production year and seed population on the number of dead seeds (%)

| Population (B)/Origin      | Year (A) | Average | CV (%) |
|----------------------------|----------|---------|--------|
| Jabučar / West (Badovinci)| 2017     | 2bC     | 7aB    | 9aA    | 6.0  | 60.93  |
| Jabučar / West (Šabac)     | 2018     | 8aB     | 8aB    | 10aA   | 8.67 | 13.323 |
| Jabučar / West (Šabac)     | 2019     | 3bC     | 7aB    | 9aA    | 6.33 | 48.238 |
| Sant pjer / North (Sombor) | 2017     | 2bC     | 5bB    | 9aA    | 5.33 | 65.848 |
| Jabučar / East (Negotin)   | 2018     | 6aB     | 8aA    | 9aA    | 7.67 | 19.924 |
| Average (A)                | 2019     | 2bC     | 5bB    | 8aA    | 5.00 | 60.00  |

* Means in the columns followed by the same letter are not significantly different according to the Fisher’s protected LSD values (P = 0.05)
Table 8. The correlation coefficient for the traits observed (n = 16)

| Traits          | Germinat. energy | Total germinat. | Abnormal seedlings | Dead seeds |
|-----------------|------------------|-----------------|--------------------|------------|
| Germinat. energy | -                | 0.8711***       | -0.82930***       | -0.87727***|
| Total germinat. | -                | -               | -0.97903***       | -0.98202***|
| Abnormal seedlings | -              | -               | -                  | 0.92297***|
| Dead seeds      | -                | -               | -                  | -          |

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

The strongest negative correlation was found between the germination energy of the tomato seeds considered and the numbers of their abnormal seedlings (r = -0.82930, p < 0.001) and dead seeds (r = -0.87727, p < 0.001), as well as between the total germination of the tomato seeds considered and the numbers of their abnormal seedlings (r = -0.97903, p < 0.001) and dead seeds (r = -0.98202, p < 0.001).

CONCLUSION

Production year, seed population and plant variety exerted strong effects on the quality of organic tomato seeds (namely the germination energy, total germination, abnormal seedlings and dead seeds of the tomato seeds considered). The tomato seed populations examined exhibited lower variability in the germination energy and the total germination with seed aging. However, high variability was observed in the numbers of their abnormal seedlings and dead seeds. A highly significant positive correlation was found between the germination energy and total germination of the tomato seeds considered (r = 0.8711, p < 0.001), as well as between the numbers of their abnormal seedlings and dead seeds (r = 0.92297, p < 0.001). The germination energy and the total germination of the tomato seeds considered were found to decrease with the increasing seed age, in contrast to the numbers of their abnormal seedlings and dead seeds which continued to increase with seed aging.

ACKNOWLEDGEMENT: This research was financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia (Project TR 31018).

REFERENCES

FiBL (2020): Data on organic agriculture 2007-2017. The Organic-World.net website mainained by the Research Institute of Organic Agriculture (FiBL), Frick, Switzerland. Data available at http://www.organic-world.net/statistics/ International Seed Testing Association. International Rules for Seed Testing, edition 2002-2018. ISTA Basserdorf, CH.

Poštić, D., Momirović, N., Z., Bročić, Ž., Doljanović, N., Trkulja, N., Dolovac, Z., Ivanović (2011): Ocena kvaliteta semena hibrida paradajza (Lycopersicon esculentum L.), XVI Savetovanje o biotehnologiji, 4-5 Marta 2011. Čačak, 16, (18), 183-187.

Poštić, D., R. Štrbanović, A. Stanojković-Sebić, M. Tabaković, N. Đurić, S. Jovanović, Stanisavljević, R. (2018). Yield different populations pumpkin (Cucurbita maxima Duch.) in organic system production. Journal on Processing and Energy in Agriculture, 22 (1), 31-33.

Poštić, D., Štrbanović, R., Stanojković-Sebić, A., Tabaković, M., Milivojević, M., Jovanović, S., Stanisavljević, R. (2019). Increasing the Pepper Seed Quality Using Mycorrhiza Fungi. Journal on Processing and Energy in Agriculture, 23; 2; 66-68.

Rules of the quality of seeds of agricultural plants ("Official Gazette of SRFY ", no . 47/87)

Republic of Serbia.

STATISTICA (Data Analysis Software System), v.8.0 (2006). Stat-Soft, Inc, USA (www.statsoft.com).

Stanisavljević, R., Milenković, J., Štrbanović, R., Poštić, D., Velijević, N., Jovanović, S., & Tabaković, M. (2017). Variabilnost kvaliteta semena italijanskog ljulja i engleskog ljulja proizvedenih u dva regiona. Journal on Processing and Energy in Agriculture, 21(2), 124-126.

Stanisavljević, R., Poštić, D., Milenković, J., Đokić, D., Tabaković, M., Jovanović, S., & Štrbanović, R. (2018): Possibilities for improving the seed quality by application of temperature treatment before sowing. Journal on Processing and Energy in Agriculture, 22, (2) 76-79.

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.

Ugrenović, V., Filipović, V., Popović, V., Glamočlija, D. (2015). Indeks pleva-pokazatelj produktivnosti i kvaliteta plevićastih pšenica. Selekcija i semenarstvo, Vol. XXI (2): 31-37.

Received: 24.02.2020. Accepted: 21.04.2020.