SEED GERMINATION SURVEY OF ROMANIAN TOMATO AND PEPPER VARIETIES

Mihaela IORDĂCHESCU [1], Anca Amalia UDRIȘTE[1*], V. POPA[1], Liliana BĂDULESCU[1]
[1]Research center for studies of food quality and agricultural products, USAMV, Bucharest, ROMANIA
[*]Corresponding author, e-mail: amalia.udriste@qlab.usamv.ro

Abstract. *Nowadays, people are more and more concerned with healthy food, and they are looking for ecological labeled products, hence the need for novel crop varieties with increased stress resistance in addition to other desirable organoleptic traits. Local Romanian varieties that are already proved to be adapted to local conditions can be used to develop new organic varieties with superior traits. Indicators of seed germination process, such as germination capacity, time, rate, and synchrony are taken into consideration by the plant breeders for the creation of a new crop variety. In the present study, nine Romanian tomato (Solanum lycopersicum L.) varieties (Kristinica, Florina 44, Andrada, Buzău 1600, Buzău 47, Argeș 11, Argeș 20, Ștefănești 24 and Ștefănești 22) and seven pepper (Capsicum annuum L.) varieties (Decebal, Vladimir, Galben Superior, Splendens, Cosmin, Roial and Cantemir) were compared during seed germination process. Seeds were sown on glass Petri dishes on filter paper disks soaked with distilled water. Each variety was replicated three times, and each replicate counted 30 seeds. Seeds were considered germinated when the radicle reached a length of at least 2 mm. The germination process was considered finished when no new seed germinated for three days in a row. Several indicators such as percentage of germination, mean germination time, mean germination rate, homogeneity and synchrony, as well as the seed size, were calculated. Differences among varieties were assessed by ANOVA. Significant differences were observed among the varieties in the end of the survey for all indicators assessed. These differences in the germination indicators can be correlated in future studies with genotype variation among the varieties and can be used as a basis for genotype-assisted breeding programs, by selecting for a desirable trait, such as synchronous germination, or short germination time, or against undesirable trait, such as low percentage of germination.*

Keywords*: Capsicum, germination, Romanian varieties, Solanum*

INTRODUCTION

Healthy food is one of the main concerns of today's society, so people are turning to ecological labeled products for consume (OLATUNJI and AFALOYAN, 2018; COE et al., 2019). Therefore, researchers are looking to develop novel organic varieties with superior traits, such as increased stressed resistance and desirable organoleptic traits (BEBELI and MAZZUCATO, 2008). However, in present varieties, many times such traits come with the cost of less desirable seed germination traits such as percentage of germination (FOOLAD and PANTHEE, 2012). Breeders can use the correlation of the differences in germination indicators with the results of genotyping studies, and select plants with multiple desirable traits in genotype-assisted breeding programs (KIM et al., 2016).

Seed germination is an important plant physiological process that incorporates seed imbibition, activation, intra-seminal growth and embryo protrusion (DELIAN et al., 2010). The germination process can be characterized by several indicators such as germination capacity, time, rate, homogeneity, uncertainty and synchrony of germination (RANAL and SANTANA, 2006). Germination capacity is usually expressed as percentage and it is based on a binary answer (germinated/non germinated). The only stage of germination that can be timed fairly precise is its termination, and a seed is considered germinated from the physiological point of view when the radicle has pierced the tegument (BEWLY and BLACK, 1994). Mean germination time represents the time spent by the seeds to germinate. The speed of germination

is calculated as the mean germination rate, and it is expressed as the reciprocal of mean germination time (RANAL et al., 2009). Homogeneity of germination measures the seed variability in relation to the mean germination time, and germination synchrony and uncertainty are two indicators of germination synchrony (RANAL AND SANTANA, 2006).

This survey is endeavoring to assess the differences among nine tomato varieties and seven pepper varieties at the seed level (seed size) and during germination process.

MATERIALS AND METHODS

Plant materials

Tomato seeds from varieties Argeș 11, Argeș 20, Ștefănești 24 and Ștefănești 22 were received from I.N.C.D.B.H. Ștefănești-Argeș and tomato seeds from varieties Kristinica, Florina 44, Andrada, Buzău 1600, and Buzău 47 as well as pepper seeds from varieties Decebal, Vladimir, Galben Superior, Splendens, Cosmin, Roial, and Cantemir were received from S.C.D.L. Buzău.

Seed germination measurements

Seeds were sterilized with 70% ethanol for 3 minutes, followed by rinsing with double distilled H_2O for 5 minutes. Seeds were placed on filter paper soaked with distilled water in glass Petri dishes with 20 cm in diameter. Prior to the experiment, the glass Petri dishes were sterilized with an 80% ethanol solution. Throughout the experiment, the vessels used for germination were kept at room temperature (21-22°C daytime/18-19°C nighttime) and natural light conditions. For each variety were used three replications, with 30 seeds in each replication (Fig. 1). Physiological indicators associated with seed germination were calculated following the procedure described by RANAL et al. (2009).

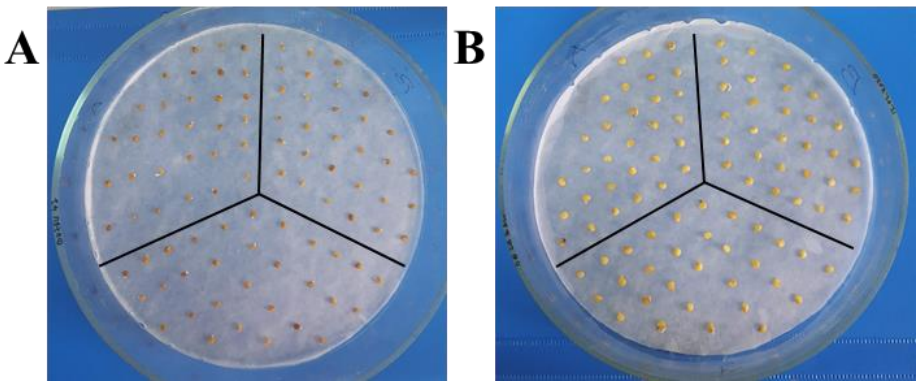

Figure 1. Glass Petri dishes with three replications, 30 seeds/replication. A. Tomato. B. Pepper

Seed size measurements

The seed samples were analyzed as such, without modification. The images were acquired with Leica S8 APO stereomicroscope, equipped with Leica DFC 295 camera. The measurements were taken using the LAS Core software. The length and width of the seed as well as the length and width of the opening where the radicle pierces the tegument were measured (Fig. 2).

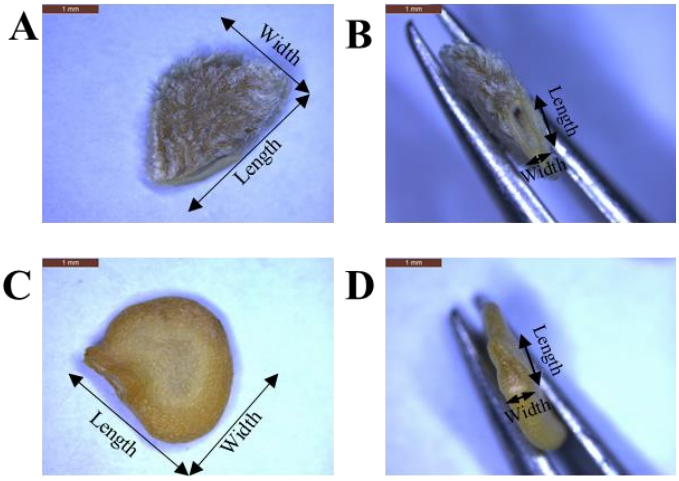

Figure 2. A. Tomato seed; B. Tomato seed opening; C. Pepper seed; D. Pepper seed opening. Dark bar in the upper left corner represents 1 mm.

RESULTS AND DISCUSSIONS

Tomato seed germination

Nine tomato varieties were compared for several physiological indicators of seed germination: percentage of germination, mean germination time, homogeneity, mean germination rate, uncertainty of germination and germination synchrony (Fig. 3).

In the case of percentage of germination, the highest percentage rate was observed for the Buzău 47 variety (92.22%) whereas the Ștefănești 24 variety displayed the lowest percentage of germination (31.11%). Ștefănești 24 percentage of germination was significantly lower than all other varieties at $P<0.01$.

Mean germination time varied considerably among the varieties studied, with a shortest time of germination for Florina 44 (4 days), and the longest germination time for Ștefănești 24 (11 days). There were no significant differenced at $P<0.05$ between varieties Kristinica and Andrada (~ 8 days), Florina 44 and Buzău 47 (4-5 days), Andrada and Ștefănești 22 (7 days), and among Buzău 1600, Buzău 24, Argeș 11, Argeș 20 (5-6 days).

In the case of homogeneity, expressed by the coeficient of variation of the germination, there were no significant differences among the varieties studied at $P<0.05$.

Mean germination rate varied significantly among the tomato varieties. The highest germination rate was observed for the Florina 44 (0.24 day^{-1}), whereas the lowest germination rate was observed for Ștefănești 24 (0.09 day^{-1}). No significant differences were observed at $P<0.05$ among Kristinica, Andrada, and Ștefănești 22 or among Buzău 1600, Buzău 24, Argeș 11, and Argeș 20.

In the case of uncertainty of germination, the highest value was observed for Andrada variety (2.54 bit) and the lowest value for the Florina 44 variety (1.28). Significant differences at $P<0.01$ were observed between Kristinica and Florina 44, Florina 44 and Andrada, and Florina 44 and Ștefănești 22. Significant differences at $P<0.05$ were observed between Kristinica and Buzău 47, Florina and Buzău 1600, Florina and Argeș 11, Andrada and Buzău 47.

The highest synchrony value was detected for the Florina 44 variety (0,51) whereas the lowest value was detected for the Andrada variety (0.15). Significant differences at $P<0.01$ were

observed between the varieties Kristinica and Forina 44, Florina 44 and Andrada, Florina 44 and Argeș11, Florina 44 and Argeș 20, Florina 44 and Ștefănelti 24, and Florina 44 and Ștefănești 22.

Significant differences at P<0.05 were observed between the varieties: Florina 44 and Buzău 1600; Andrada and Buzău 47.

Figure 3. Seed germination indicators for the nine tomato varieties studied: Kristinica, Florina 44, Andrada, Buzău 1600, Buzău 47, Argeș11, Argeș 20, Ștefănești 24, Ștefănești 22. Error bars represent standard error of the mean.

Pepper seed germination

Seven pepper varieties were used compared for several physiological indicators of seed germination: percentage of germination, mean germination time, homogeneity, mean germination rate, uncertainty of germination and germination synchrony (Fig. 4).

In the case of percentage of germination, the highest percentage rate was observed for the Roial variety (95.56%) and the lowest percentage of germination was observed for the Vladimir variety (10.00%). Significant differences at P<0.01 were observed between the variety Decebal and all the other pepper varieties, with the exception of Splendens, where the difference was significant at P<0.05. Vladimir variety's percentage of germination was significantly lower than all other

varieties at P<0.01. Decebal variety's percentage of germination was significantly lower than that of Cosmin, Roial and Cantemir at P<0.01.

Mean germination time varied considerably among the varieties studied, with a shortest time of germination for Roial (~5 days), and the longest germination time for Vladimir (~13 days). No significant differences were observed among Decebal, Splendens, Cosmin; and Cantemir (~9-11 days), Vladimir and Galben Superior (~12-13 days), Galben Superior, Splendens Cosmin (~10-12 days), and Cosmin and Cantemir (~9 days).

In the case of homogeneity, expressed by the coeficient of variation of the germination, the highest value was observed for the Decebal variety (42.41%) and the lowest value for the Valdimir variety (10.27%). Decebal variety had a significantly higher value than all other varieties at P<0.01. Vladimir variety's homogeneity was significantly lower than that of Roial and Cantemir at P<0.05. Cosmin and Roial varieties'values differed significantly at P<0.05.

Figure 4. Seed germination indicators for the seven pepper varieties studied: Decebal, Vladimir, Galben Superior, Splendens, Cosmin, Roial, Cantemir. Error bars represent standard error on the mean.

The highest mean germination rate was observed for the Roial variety (0.18 day^{-1}), whereas the lowest germination rate was observed for Vladimir variety (0.08 day^{-1}). Roial variety mean germination rate was significantly higher at P<0.01 than all the other varieties. Vladimir variety's value was significantly lower at P<0.01 than that of Roial and Cantemir varieties. Significant differences at P<0.05 were observed between Decebal and Vladimir varieties as well as between Galben Superior and Cantemir varieties.

In the case of uncertainty of germination, the highest value was observed for Galben Superior variety (2.86 bit) and the lowest value for the Vladimir variety (1.31). Vladimir variety's value was significantly lower at P<0.01 than that of the Decebal, Galben Superior, Splendens; and Cantemir varieties. Significant differences at P<0.05 were observed between Vladimir and Roial varieties and Galben Superior and Cosmin varieties.

The highest synchrony value was detected for the Cosmin variety (0.29) whereas the lowest value was detected for the Vladimir and Decebal varieties (0.10). Cosmin, Roial and Cantemir had significantly higher values at P<0.01 than Decebal, Vladimir and Galben Superior varieties. Splendens synchrony value was significantly higher than that of Decebal and Vladimir at P<0.05, and significany lower than that of Cosmin at P<0.01. Significant difference at P<0.0s was observed between the varieties Cosmin and Cantemir.

Tomato seed size

Seed length, seed width, seed opening length and seed opening with were measured for the nine tomato varieties under study (Fig. 5).

The biggest seed length was noted for the Ștefănești 24 variety (4.020 mm) and the smallest seed length was noted for the Florina 44 variety (2.615 mm). Ștefănești 24 seeeds were significantly bigger than Florina and Andrada seeds at P<0.01, and bigger than Kristinica, Argeș 11 and Argeș 20 seeds at P<0.05. Florina 44 seeds were significantly smaller than Buzău 1600, Buzău 47, Ștefănești 24 and Ștefănești 22 seeds at P<0.01, and significantly smaller than

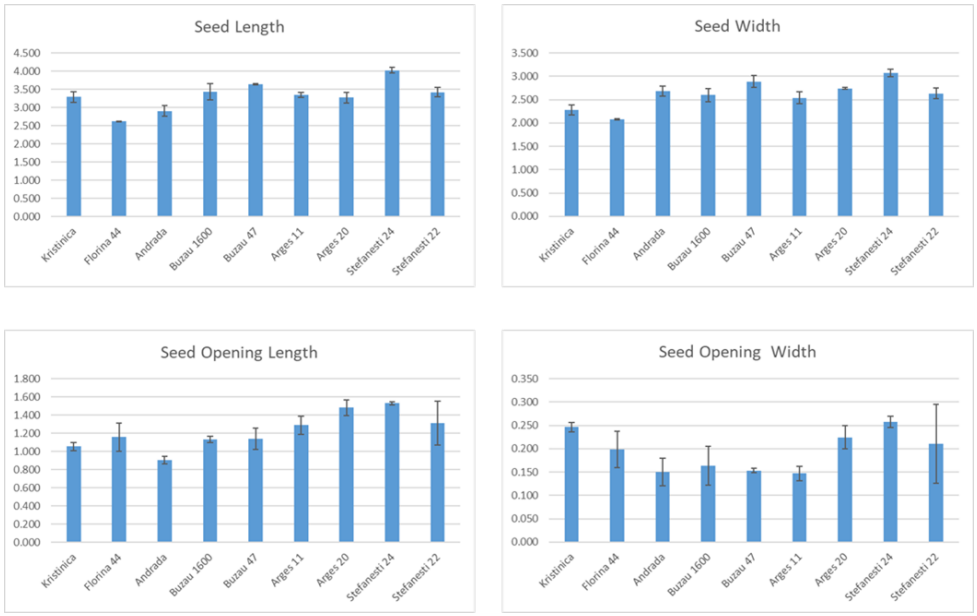

Figure 5.Tomato seed size indicators for the nine tomato varieties studied: Kristinica, Florina 44, Andrada, Buzău 1600, Buzău 47, Argeș 11, Argeș 20, Ștefănești 24, Ștefănești 22. Error bars represent standard error on the mean.

Kristinica, Argeș 11 and Argeș 20 seeds at P<0.05. Andrada seeds were significantly smaller than Buzău 47 seeds at p<0.05.

The biggest seed width was observed for the Ștefănești 24 (3.072 mm) variety and the smallest seed width was observed for the Florina 44 variety (2.083 mm). Ștefănești 24 seed width was significantly higher than Kristinica and Florina 44 seed width at P<0.01, and significantly higher than Argeș 11 seed width at P<0.05. Florina 44 seed width was significantly lower than Buzău 47, Argeș 20 and Ștefănești 24 seed width at P<0.01 and significantly lower than Andrada and Ștefănești 22 seed width at P<0.05.

In the case of seed opening length, Andrada seed opening length was significantly smaller than Argeș 20 and Ștefănești 24 seed opening lengths at P<0.05.

No significant differences were observed among the nine tomato varieties for the seed opening width.

Pepper seed size

Seed length, seed width, seed opening length and seed opening with were measured for the seven pepper varieties under study (Fig. 6).

The highest value for the seed length was observed for the Decebal variety (4.459 mm) and the lowest value was observed for the Vladimir variety (3.840 mm). Decebal seeds were significantly longer than Vladimir and Cosmin seeds at P<0.05.

The highest value for seed width was noted for the Splendens variety (3.661 mm) and the lowest value was noted for the Vladimir variety (2.851 mm). Splendens seeds were significantly wider than Vladimir and Roial seeds at P<0.01, and wider than Cosmin seeds at P<0.05. Vladimir seeds were narrower than Decebal, Galben Duperior, Splendens, and Cantemir at P<0.01, and narrower than Cosmin seeds at P<0.05. Cantemir seeds were wider than Roial seeds at P<0.05.

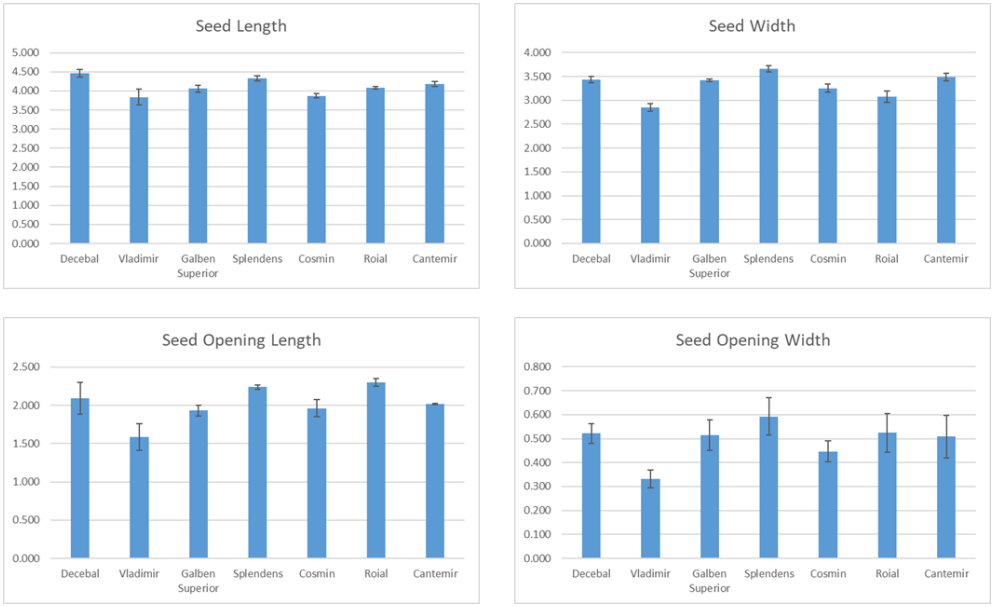

Figure 6. Pepper seed size indicators for the seven pepper varieties studied: Decebal, Vladimir, Galben Superior, Splendens, Cosmin, Roial, Cantemir. Error bars represent standard error on the mean.

The highest value for seed opening length was observed for the Roial variety (2.298 mm), whereas the lowest value was observed for the Vladimir variety (1.583 mm). Vladimir seed opening value was significantly lower than that of Roial value at $P<0.01$ and lower than that of Splendens variety at $P<0.05$.

No significant differences were observed among the sever pepper varieties for the seed opening width.

CONCLUSIONS

Significant differences in the seed germination indicators and seed size measurements were observed among both the tomato and pepper varieties studied.

In the case of tomato, the percentage of germination was above 70% for most varieties with the exception of the Ștefănești 24 variety. This variety stands out among the tomato varieties studied also with the longest mean germination time and lowest mean germination rate. Another variety that stands out is Florina 44, which showed the shortest mean germination time, highest mean germination rate, highest synchrony and lowest uncertainty of germination values. From the seed size measurements these two varieties have also the biggest seeds (Ștefănești 24) and the smallest seeds (Florina 44).

In the case of pepper, Vladimir variety displays the lowest percent of germination, longest mean germination time, lowest homogeneity, lowest mean germination rate, uncertainty and synchrony of germination values. Roial variety also stands out with the highest percent of germination, shortest mean germination time, and highest mean germination rate.

Romanian consumers appreciate Romanian vegetable varieties. Even though Ștefănești 24 tomato variety showed undesirable traits low germination rate and long germination time, the variety is valuable as it produces big, flashy tomato fruits, with superior organoleptic traits. Ștefănești 24 tomato variety showed a very high production capacity among the varieties with indeterminate growth (production of 9,6 kg/plant) (BADULESCU et al., 2017). Also the demand for Vladimir pepper certified seeds increased, so the offer of Vladimir certified seed production by SCDL Buzău for the period 2015-2020 was planned to range from 5 kg/2015 to 8 kg/2020 (GLAMAN et al., 2015). Moreover, unwanted traits can be improved in the field using organic biostimulators, such as bioseed (DRĂGHICI et al., 2012), as well as improved seeding mixtures (FILIPOV et al., 2019).

Nowadays, constant efforts are made to produce novel varieties with various superior traits and improve the existing ones. Several varieties with better yield compared to Galben Superior variety have been reported recently (SBIRCIOG, 2018). This variety was also reported to have a high percentage of edible part (SOARE and VOICU, 2009). Nevertheless, further genotyping studies are needed to correlate the phenotyping traits studied in this survey with DNA sequence differences, in order to select plants with multiple superior traits in genotype-assisted breeding programs, with the final goal of creating novel ecological varieties of tomato and pepper, which will appeal to the consumers.

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