Scientific Papers. Series B, Horticulture. Vol. LXII, 2018
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

STUDY OF THE EFFECT OF ULTRASOUND ON VEGETABLE CROPS IN DIFFERENT EXPOSURES

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Abstract

The paper examines the impact of ultrasound on seeds of vegetable crops of the Apiaceae family in different exposition. The results of these studies show that seed treatment with ultrasound influences seed quality sowing. Ultrasonic treatment of the appropriate duration increases not only germination energy but also laboratory germination. It should be borne in mind that ultrasound stimulation with a certain duration, depending on the culture, may also have a negative effect.

Key words*: ultrasound, vegetable crops, quality sowing.*

INTRODUCTION

Vegetable production is one of the main sub-sectors of agriculture and an important share of plant growing. Root vegetables - carrot, parsley and celery are crops of great economic importance due to their high nutritional and biological value.

Carrots (*Daucus carota*), which are the main root crop, are used both for fresh and canned consumption. Besides food, carrots are used in pharmacy and perfumery industry. For rhythmic supply to the market and canning industry, carrots can be sown from early spring to early summer and early winter. Traditional sowing times are the end of February - early March, the first half of June and the first half of December.

Parsley and celery are used as a spice and are important for improving the palatability and digestibility of the food. This is due to the essential oils contained in them. With the content of nutrients and especially of essential oils, celery takes one of the first places among vegetable cultures used as seasonings. With the content of nutrients and especially of essential oils, celery takes one of the first places among vegetable cultures used as seasonings.

Celery is the only vegetable crop that grows through seedlings. Due to its long vegetation period, the nursery cultivation method and the large requirements for agrotechnical factors, the production of celery is considerably more labor intensive than other root crops (Cholakov, 2009). The areas occupied with celery in 2014 are 5 ha and the production is 57 t.

The purpose of this study is to investigate the possibility of pre-treatment of seeds with ultrasound to increase germination and seed germination. Carrot, parsley and celery are two-year-old vegetable crops of the *Apiaceae* family. Carrot refers to the genus *Daucus*, parsley to the genus *Petroselinum*, and celery to the genus *Apium*.

Various methods of pre-seed treatment have been developed, such as pre-soaking the seeds in water, rooting, heat treatment, impact with physical agents, etc., aiming at improving their seed qualities (Esfandiar F. et al., 2012).

In the system of organic farming, the use of certain physical factors on the biological development of crops is a modern method of achieving high yields. The use of physical factors is preferable to chemical treatments that can lead to plant contamination (Kwiatkowska B. et al., 2011).

The positive influence of ultrasound on seed sowing properties has been found in other crops such as rice (Liu Y. et al., 2003), wheat (Yaldagard M. et al., 2007), dill (Esfandiar Fateh, 2012; Zhao Yan et al., 2012), sunflower (Machikowa et al., 2013) and others.

The first scientific studies on the influence of ultrasound on plant development date back to

the 30-40 years of the last century. Experiments conducted in the Soviet Union show that ultrasonic oscillations have a beneficial effect on germination and subsequent plant development (Istomina O., Ostrovskiy E., 1936; Davidov G.K., 1940).
The use of ultrasound to accelerate germination of seeds is effective only when they are placed in a liquid medium, since this method of treatment allows the absorption of water from the seed that causes germination (Gordon, 1963; Yaldagard et al., 2008).

MATERIALS AND METHODS

The survey was conducted in the period 2016-2017 years in the Department of Mechanization and Department of Horticulture at the University of Plovdiv.
The subject of the study was the carrot, parsley and celery seeds. An ultrasonic bath is used to perform the study (Figure 1).

Figure 1. BRAND CT-405

The bathtub uses the principle of intense sound pressure, created by an ultrasound source, was born in a limited volume of liquid - a plurality of microscopic bubbles are formed that shrink and expand in sync with the frequency at which they hit the surface of the objects placed in the liquid.
Three exposures of ultrasound treatment were tested at 3, 6 and 12 minutes at a frequency of 43-45 kHz. To perform the ultrasound treatment, the seeds were placed in distilled water.

For the control untreated seeds of the crops set to germinate in Petri dishes. Depending on the duration of seed treatment, the following options were tested:
Carrot:
1. Control;
2. Exposure 3 min.;
3. Exposure 6 min.;
4. Exposure 12 min.;
Parsley:
1. Control;
2. Exposure 3 min.;
3. Exposure 6 min.;
4. Exposure 12 min.;
Celery:
1. Control;
2. Exposure 3 min.;
3. Exposure 6 min.;
4. Exposure 12 min.;
The experiment was set in 3 replicates and the number of seeded counts in each iteration was 100. After the treatment, the seeds were placed in a thermostat at 24°C, with the number of seed germinated daily. The counting continued until the 14th day for carrot, 21 for celery and 28 for parsley.
Two parameters were determined to determine the viability of seeds and their germination, namely laboratory germination (%) and germination (%). As a result of day-to-day readings, the speed and cooperativity of seed germination were determined.
Laboratory germination, showing normally germinated pure seeds under optimum conditions for a specified period of time, is determined by counting the number of germinated seeds according to the accepted BDS standards (601 84) as follows:
1) On the 14th day for carrot;
2) On the 28th day for parsley;
3) On the 21st day for celery.
The germinating energy, expressing the percentage of normally germinated seeds under optimum conditions, but for a shorter period of time, was reported to:
1) 7th day for carrots (under BDS);
2) 10th for parsley (under BDS);
3) 10th for celery (under USSR).

RESULTS AND DISCUSSIONS

1. Germination energy (%)

Research results show that seed treatment with ultrasound has a positive effect on the germination energy indicator and is best shown in carrots.

From the results presented in Figure 2, it is seen that as the exposure increases, the percentage of germination energy also increases. Depending on the duration of the ultrasound seed treatment, the germination energy increased from 30% as measured by the control to 43% in the 3 minutes version. Prolonged treatment has a stimulating effect since the value of the test item increases regularly and reaches 65% in the 6 minutes variant and up to 100% in the 12 minutes exposure. The excess over the control was 116.7% and 233.3%, respectively.

Under the influence of ultrasound stimulation, the terminable energy recorded in parsley (Figure 3) increased, although slightly, from 20% (control readings) to 26% in the 6 minutes exposure scenario, and increased to 28% in the exposure duration variant 3 min. The excess over the control in these variants is 30% and 40%, respectively.

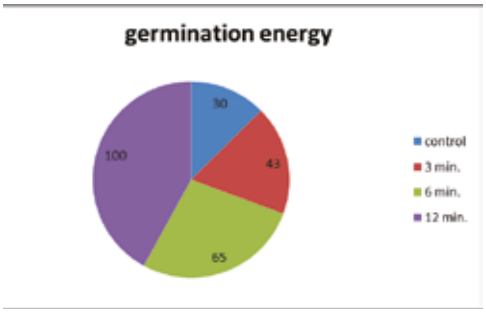

Figure 2. Germinating energy (%) of carrot seed, average for the period 2016-2017

Treatment of 12 minutes ultrasound parsley seeds has a rather negative effect as no germinating seed is reported at this exposure, and germinating energy is 0%, respectively.

The treatment of celery seeds with ultrasound (Figure 4) affects the germination energy only when its duration is 12 minutes. The reported sparkling energy in this variant is 14%. For all other variants, including the control, the germinating energy reading is 0%.

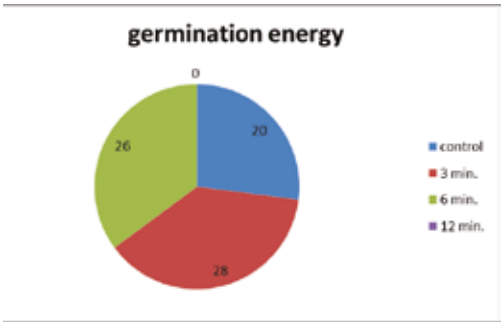

Figure 3. Germination energy (%) of parsley seeds averaged over the period 2016-2017

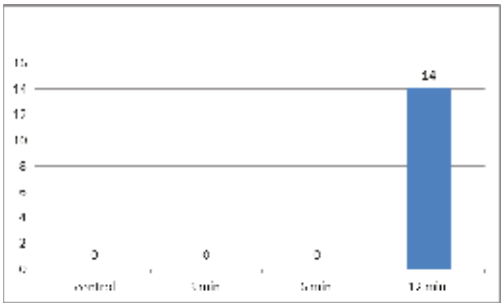

Figure 4. Germination energy (%) of celery seeds, averaged over the period 2016-2017

2. Cultivation (%)

Germination is a very important indicator of a biological aspect that provides information on the viability of the seeds, their suitability and the determination of the seed norm (Murtazov, 1984). And with this main indicator, the trend established in carrots to enhance the effect of seed treatment with increasing duration is retained (Figure 5).

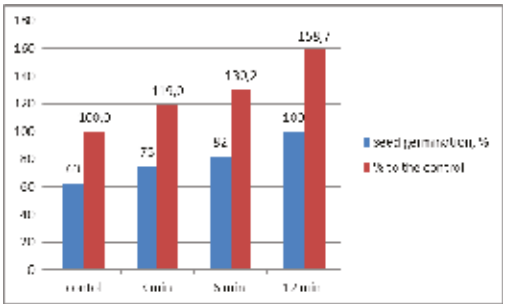

Figure 5. Laboratory germination (%) of carrot seed, averaged over the period 2016-2017

One hundred percent germination was reported in the 12 minutes exposure scenario, and it

should be noted that these values were recorded as early as the 7th day when germinating energy was determined. The excess over the control for this variant is 58.7%.
In the two other exposures, the reported values were 75% for variant 2 (3 minutes) at 19% over the control and 82% germination in variant 3 (6 minutes) with the control over 30.2%. The germination rate at the control was 63% lower than the other variants.
Attention is paid to the results presented in Figure 6 providing information on the speed and cope of seed germination in carrots.

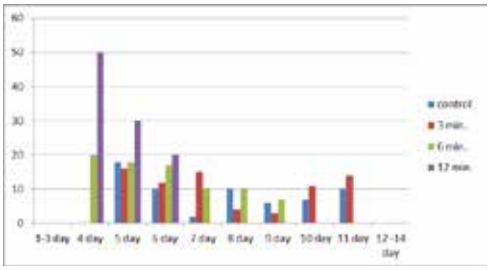

Figure 6. Germination of carrot seeds by day

It is seen that under the influence of ultrasound treatment with a duration of 6 and 12 minutes seed germination begins on the 4th day after the treatment, which is a day earlier than the control.
Attention is paid to the results reported in the 12 minutes variant, in which seed germination is most common. Within 3 consecutive days, the number of germinated seeds in this variation reaches 100.
By comparison, the control for the same period of time is the number of sprouts 30. In the 6 minutes variant, seed germination ends on day 9, and for the other two options, including the control - on the 11th day.

In Figure 7 shows the results for laboratory germination of parsley seeds. The highest percentage of laboratory germination was reported in a 6 min. exposition, with a 33.3% increase over the control.

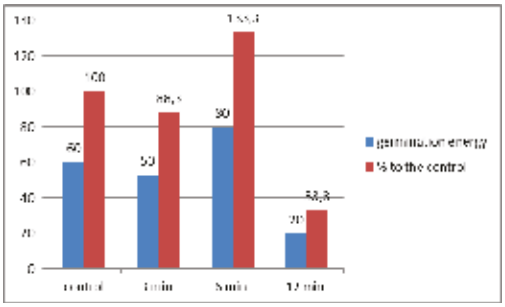

Figure 7. Laboratory germination (%) of parsley seeds averaged over the period 2016-2017

Laboratory germination reported at the control was 60%. For the other two exposures, the reported test value is lower than that of the control. While in the 3 minutes variant the difference is only 7% in favour of the control, in the 12 minutes seed treatment variant, the difference in untreated seed (control) is drastic and reaches 40%.
Obviously, this indicator can be said to be negatively affected by the prolonged treatment of the seeds with ultrasound - 12 min.
The results presented in Figure 8 are quite different, so it is difficult to establish any tendency or regularity. However, seed germination may vary from day 7 to day 11, with the 3 minutes exposure being at its earliest, and at 12 minutes exposure at the latest. The control sprout starts on the 9th and ends on the 14th. For all other variations, this process ends until the 19th day.

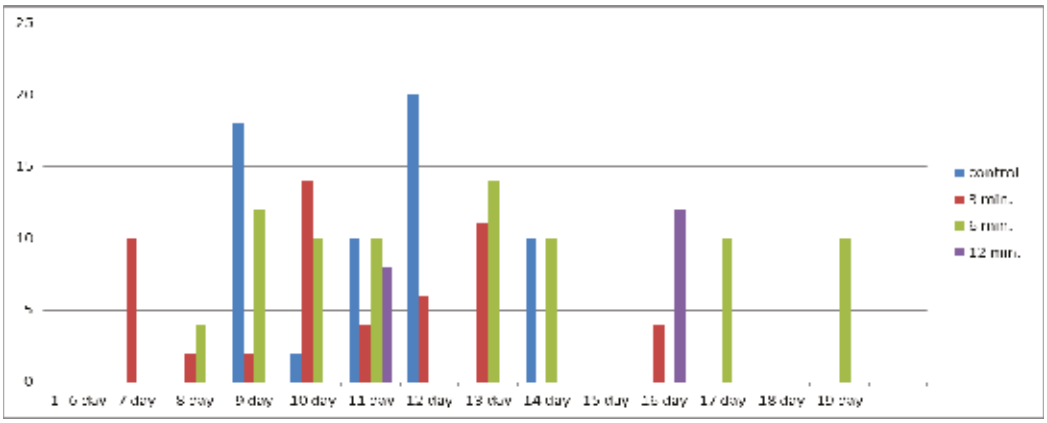

Figure 8. Sprouting seeds of parsley by day for the whole period.

In Figure 9 the results for laboratory germination of celery are presented. Laboratory germination was only reported for 6 minutes and 12 minutes exposures. Under the influence of 6 minutes treatment seed germination reaches 60% at 0% for the control. Significantly lower and at the same time higher than that of the control is laboratory germination in the variant with 12 min. duration - 20%.

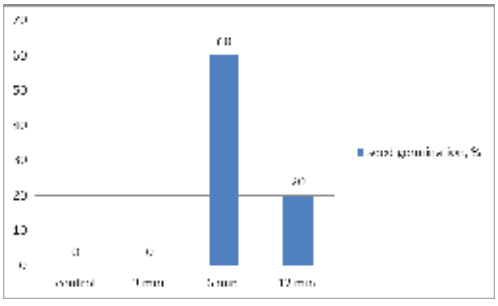

Figure 9. Laboratory germination (%) of celery seeds, average for the period 2016-2017

The germination process begins at day 9 in the variant (Figure 9) with 6 minutes exposure and at day 12 in variant 4 (12 minutes). In the same two variants seed germination ends on day 17 on day one and on day 18 in the second variation. There is also a difference between the variants in the seed germination rate. While in the 6 minutes version the seeds germinate at regular intervals of days (daytime), in variant 4 only two of the readings are found to have sprouted seeds, with the difference between the first and the second being 6 days.

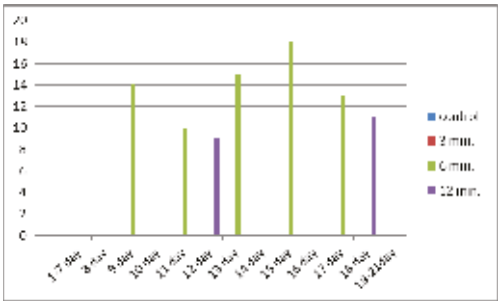

Figure 10. Germination of celery seeds by day for the whole period

CONCLUSIONS

Seed treatment with ultrasound influences seed sowing.

The optimum duration of ultrasound exposure in carrots lasts for 12 minutes, and for parsley and celery - 6 minutes.

This method of seed treatment increases the carrots energy of carrots by up to 233.3% and of parsley by up to 40%. Celery has 14% germinated energy at 0% for the control.

Ultrasonic treatment of the appropriate duration increases not only germinating energy but also laboratory germination. In carrots it reaches 100%, in parsley 80%, and in celery - up to 60%. The excess over the control with 58.7% for carrots and 33.3% for parsley. In celery reported laboratory germination is 0%

It should be borne in mind that ultrasound stimulation with a certain duration, depending on the culture, may also have a negative effect.

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