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THE INFLUENCE OF NEAR INFRARED STIMULATION
ON THE GERMINATION ENERGY AND GERMINATION CAPACITY
OF SELECTED PARSLEY VARIETIES

ABSTRACT

A variety of different physical methods are used increasingly frequently to improve the quality of the seeds material. Numerous publications confirm the positive effect of, for example, the magnetic field with a frequency of 50 Hz on the germination of seeds. However, there are no significant reports regarding the impact of NIR radiation on the growth and development of plants. To fill this gap the influence of three doses of near-infrared seeds stimulation was tested under laboratory conditions. The power density was 6.9mW/cm². The used seeds encompassed four parsley varieties: Konika, Osborne, Alba and Hanácká. Both the influence of the used variety as well as the radiation dose on parsley germination were tested. The obtained results indicate that the stimulation affects the selected parsley varieties.

Key words: biostimulation, germination energy, near infrared (NIR), parsley, seeds

INTRODUCTION

The aim of this publication was to investigate the impact of the near infrared radiation (NIR) on parsley seeds and to its influence on the growth and development of this plant.

The main objective was to increase the germination capacity of parsley seeds. Root parsley is a staple flavouring plant grown in Poland. However, harvesting parsley crop is not easy due to several factors. First of all parsley seeds have low germination capacity. Besides, they have high requirements for germination places, the floor should be

middle-concise, rich, not crusted over, mould, and also it should have high water capacity and pH close to neutral. Parsley is very sensitive to rainfall, both deficit and overflow of water have a negative impact on its growth. Another factor is soil fertilization which is also necessary for parsley to grow.

The need for quality food is becoming an enormous challenge for the modern world. The quality of products available on the market is plummeting, however, simultaneously their prices are rising. The reason for this is the massive use of chemicals in the production process. Although these chemical agents are highly effective, they also pose a biohazard, because they penetrate food (Anisimov and Chaikina, 2014; Grabowska *et al.*, 2014; Grémiaux *et al.*, 2016; Khan *et al.*, 2009; Michalak *et al.*, 2018; Vasilenko, 2016; Wiatrak *et al.*, 2016).

The above mentioned threats resulted in greater consumer awareness and emphasised the necessity to conduct research on improving the quality of food. These investigations were connected with a significant increase in the interest in the use of physical stimulus factors to improve the quality of the plants. Physical stimulation influences the physiological and biochemical changes of plant seeds. However, it is important that this method does not penetrate into the soil substrate, and therefore it is not harmful for the environment (Aladjadjiyan, 2012; Bae *et al.*, 2015; Godlewska *et al.*, 2016; Michalak *et al.*, 2015; Podleśny, 2004; Saberi and Tamian, 2014; Tadeusiewicz, 2008). In the literature there are also descriptions of experiments in which the influence of near-infrared radiation (NIR) on the germination energy and the germination capacity of seeds, including parsley, were investigated (Grabowska and Mech, 2015a, 2015b; Gruszecki, 2005).

In general, NIR radiation works at the quantum level (by affecting the atomic and molecular levels), however, it also affects the level of plant cells and tissues. It has been known for a long time that the use of near-infrared radiation improves seed germination (although the mechanism of this process is not fully understood yet) (Michalak *et al.*, 2018). The British patent GB 2.303.533 indicates the possibility of stimulating seeds by means of near-infrared radiation, also when it is connected to red light (Vasilenko, 2016). It was shown in the literature that usually the stimulation of seeds by radiation in the wavelength range from 800 to 1000 nm improved the germination of various garden plants (Grabowska *et al.*, 2015, 2014, 2013; Johnson *et al.*, 1996; Niemczyk, 2017; Vasilenko and Popova, 1996). Moreover, the germination capacity of the seedlings increased when NIR light was applied.

The examination of the influence of near-infrared radiation on the parsley seeds of the selected varieties was the goal of the experiment presented in this publication. For this purpose, seed irradiation was performed with a halogen lamp with an NIR filter, and then the seeds were transferred to a phytotron. Four parsley varieties – Konika, Osborne, Alba and Hanácká were used in the experiment. It can be said that the experiment had a bifactor nature. The influence of the used variety and also the dose of radiation on parsley germination was also analysed. First 100 seeds were plated on blotting paper in a Petri dish. Then, the Petri dishes with seeds were placed in the phytotron until germination started. The tests were performed

three times. The temperature and humidity in the phytotron remained at the same level. Subsequently, 10 days after sowing the germination energy of all samples was checked and 21 days after sowing – germination ability. The obtained results indicate that stimulation affects the selected parsley varieties. During the research, tests were also carried out to determine the structure of parsley shoots after stimulation and their properties were compared with a control sample that was not stimulated. The results of these studies will be subject of another publication.

MATERIALS AND METHODS

Biological material

The experimental material were four varieties of parsley seeds: Konika, Osborne, Alba and Hanácká. Root parsley is one of the basic, flavouring crops, commonly grown in Poland. It has been known in Poland for a long time, but its crop is not always successful. Failures in the production are due to several factors (Gruszecki, 2005). The seeds used in the experiment came from “MoravoSeed” and “Nohel-Garden” companies (Fig.1A).

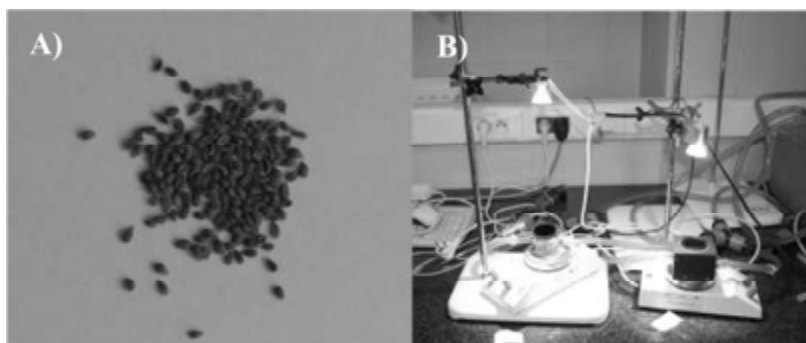


Fig. 1 A) Seeds of parsley B) Appliance for irradiation

Near-infrared procedure

The samples were exposed to halogen lamp radiation of a halogen lamp (Fig. 1B) equipped with a 700–2,000 nm filter. The light was focused on a flat glass tube in which the samples were kept in a dark glass cell. The power density of the incident light was 6.9 mW/cm². It was measured by a fito-phytometer, OPTEL (Fig. 2). The irradiation temperature was kept constant at 21±1°C by means of an additional water-cooling system (Walski *et al.*, 2014) (Fig. 3).

Research material consisted of four groups: without stimulation (control group), 15 min, 30 min and 60 min. When irradiation was switched off the samples were put into a phytotron for 20 min.



Fig. 2. Fito-photometer - device used to check power density



Fig. 3. Thermostat

Seeds storage

One hundred seeds were plated on blotting paper in the Petri dish (Fig. 4A). Then, the Petri dishes with seeds were located in the phytotron (Sanyo Versatile Environmental Test Chamber MCC-351H) until germination. Temperature and humidity were controlled throughout the entire process (Fig. 4B).

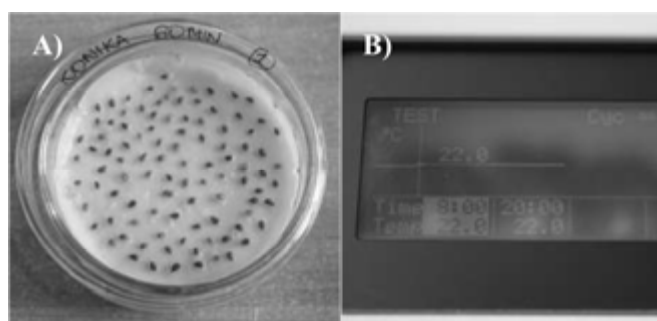


Fig. 4. A) Seeds plated in Petri dish, B) Temperature in phytotron

RESULTS AND DISCUSSION

The following parameters were calculated after stimulation: germination energy (10 days after sowing) and germination ability (21 days after sowing).

Germination energy (GE)

Germination energy is used to determine the viability of seeds. It is the percentage of the number of seeds germinated normally at the shortest possible time (Drozd *et al.*, 2004). On the 10th day after sowing, the germination energy of individual seed varieties was calculated for each of the applied radiation doses and also for each repetition (Table 1). Figures 5-8 show the seeds on selected Petri dishes 10 days after sowing.

Table 1

Germination energy of all extracted varieties of parsley seeds

Time [min]	KONIKA [%]			OSBORNE [%]			ALBA [%]			HANÁCKÁ [%]		
	1	2	3	1	2	3	1	2	3	1	2	3
0	82	82	78	92	84	90	63	55	70	56	59	50
15	83	73	72	86	86	80	64	41	68	52	60	69
30	75	74	85	85	90	89	64	66	58	58	61	64
60	75	79	93	85	79	2	58	64	70	55	51	69

Stimulation with near-infrared radiation does not affect the GE of Konika parsley seeds (Fig. 5), and in some cases even a slight decrease in germination energy can be observed. In the case of the Osborne variety (Fig. 6), near-infrared stimulation did not affect the GE of seeds. In the case of the germination energy evaluation for sample 3, which was stimulated for 60 minutes, a very low level of this parameter was observed due to the drying of the plate. The NIR stimulation did not affect the GE of Alba (Fig. 7) and Hanácká parsley seeds (Fig. 8), either.

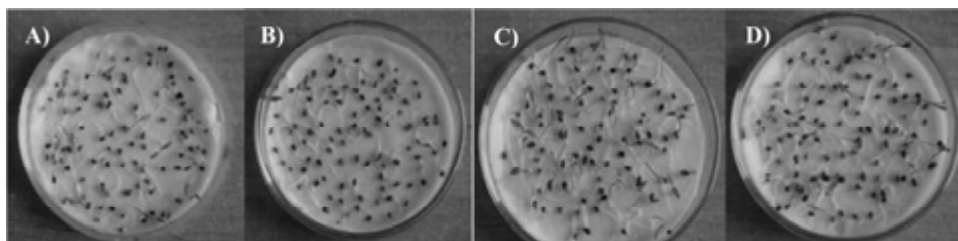


Fig. 5. Sample dishes with Konika seeds 10 days after sowing
A) Control sample, B) 15 min stimulation, C) 30 min stimulation, D) 60 min stimulation

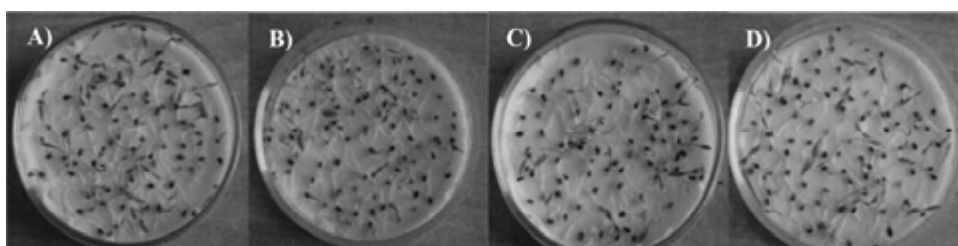


Fig. 6. Sample dishes with Osborne seeds 10 days after sowing
A) Control sample, B) 15 min stimulation, C) 30 min stimulation, D) 60 min stimulation

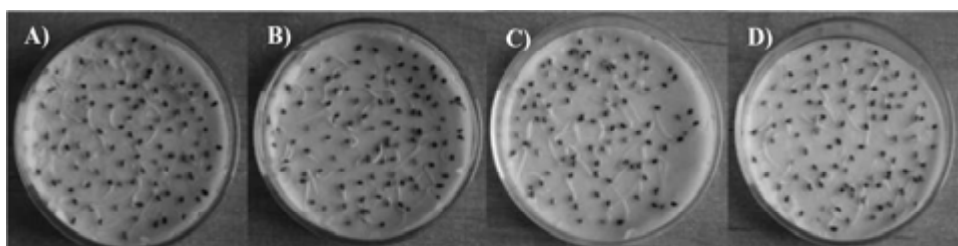


Fig. 7. Sample dishes with Alba seeds 10 days after sowing
A) Control sample, B) 15 min stimulation, C) 30 min stimulation, D) 60 min stimulation

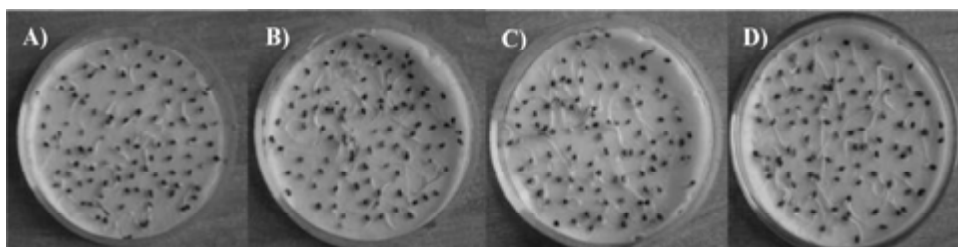


Fig. 8. Sample dishes with Hanácká seeds 10 day after sowing
A) Control sample, B) 15 min stimulation, C) 30 min stimulation, D) 60 min stimulation

Germination capacity (GC)

The term germination capacity is used to determine the percentage of seeds producing seedlings classified as normal under appropriate conditions in a defined period of time (Drozd *et al.*, 2004). Seeds stimulation by the near-infrared apparently influenced on the increase in germination capacity (Table 2) in seeds which were stimulated for 60min.

Germination capacity of all extracted varieties of parsley seeds

Table 2

Time [min]	KONIKA [%]			OSBORNE [%]			ALBA [%]			HANÁČKÁ [%]		
	1	2	3	1	2	3	1	2	3	1	2	3
0	83	84	82	94	98	90	77	68	74	66	70	58
15	85	81	75	89	89	81	72	82	79	62	73	72
30	78	82	88	92	90	94	82	88	76	63	61	77
60	85	86	95	86	83	84	81	83	85	64	72	75

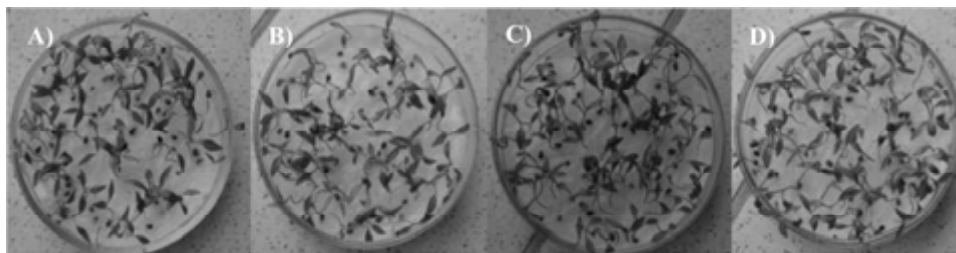


Fig. 9. Sample dishes with Konika seeds 21 days after sowing
A) Control sample, B) 15 min stimulation, C) 30 min stimulation, D) 60 min stimulation

After the stimulation of the Osborne parsley seeds stimulated 15 and 60min by near-infrared radiation, a decrease in the GC of these seeds becomes visible. NIR stimulation increased the GC of Alba parsley seeds, the biggest changes were observed in the case of 60min stimulation. Likewise, NIR stimulation increased the GC of Hanáčká parsley seeds of varieties and again the biggest changes occurred in the case of 60min stimulation.

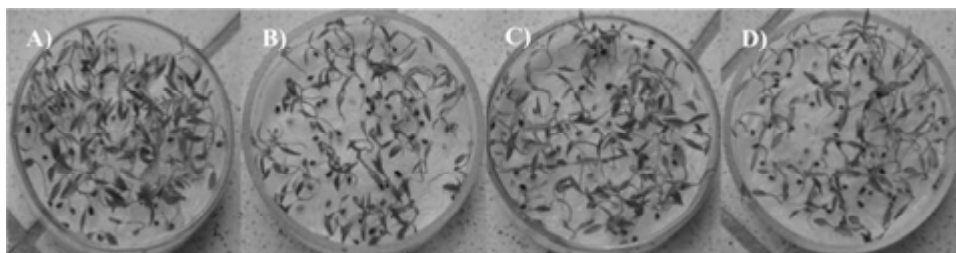


Fig. 10. Sample dishes with Osborne seeds 21 days after sowing
A) Control sample, B) 15 min stimulation, C) 30 min stimulation, D) 60 min stimulation

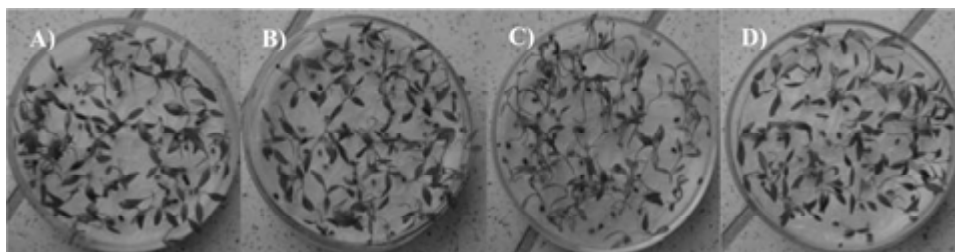


Fig. 11. Sample dishes with Alba seeds 21 days after sowing
A) Control sample, B) 15 min stimulation, C) 30 min stimulation, D) 60 min stimulation

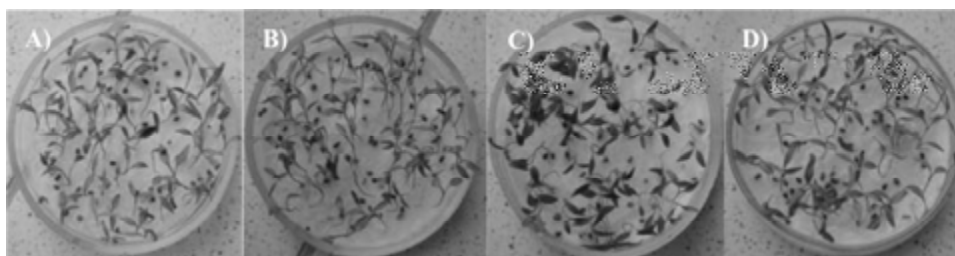


Fig. 12. Sample dishes with Hanácká seeds 21 days after sowing
A) Control sample, B) 15 min stimulation, C) 30 min stimulation, D) 60 min stimulation

CONCLUSIONS

Near-infrared stimulation did not affect the germination energy of all tested varieties of parsley seeds. On the box plot chart (below) one can observe that germination capacity clearly increased for Konika and Alba varieties. This is much less visible for the Hanácká variety (large dispersion value). However, for the Osborne variety, germination is completely random with respect to exposure time. We believe that we should repeat this experiment with a larger group of studied plants and also include other stimulants (e.g. stimulation with variable and constant magnetic field).

Our results were analysed by the Kruskal-Wallis (K-W) test for many independent groups. This is a nonparametric test which compares more than two groups with each one another. It is analogous to the variance analysis. This test does not require the fulfilment of the assumption of the normality of the obtained results. The idea of this test is the measurement of the location summary one-point statistics in all analysed groups. The whole sample is ranked (all groups are combined) and then the Kruskal-Wallis test statistic is constructed. This statistic is a measure of the deviation of sample ranks from the average value of all ranks. The distribution of statistics is derived with the less restrictive assumption that we compare at least three groups, all of which have a population of at least 3.

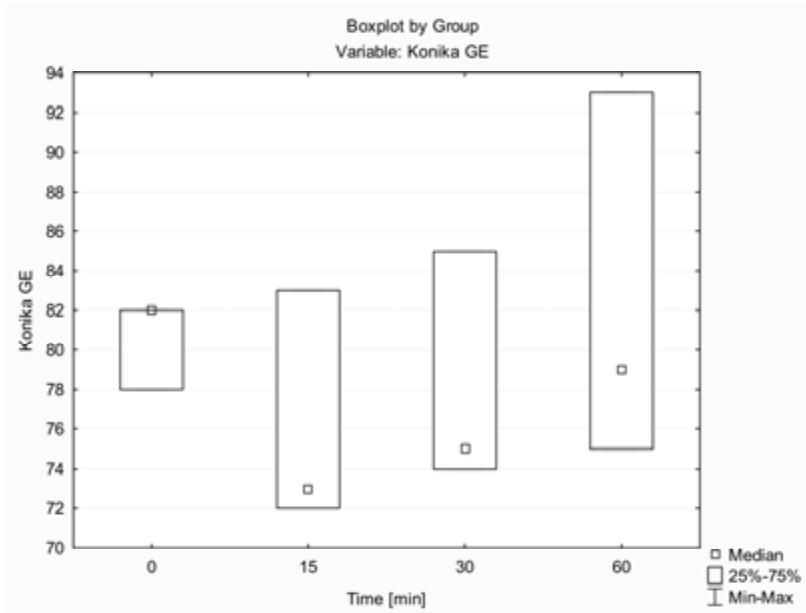


Fig. 13 Boxplot for Konika, Germination energy

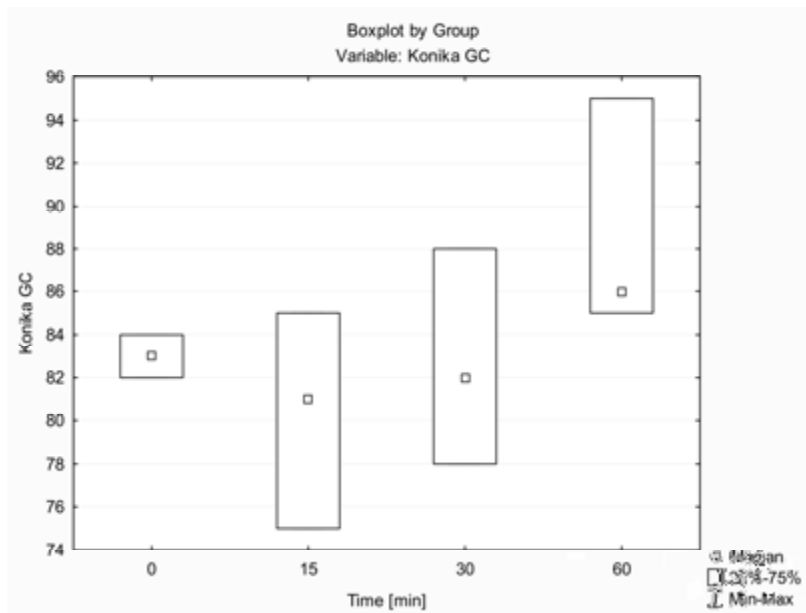


Fig. 14 Boxplot for Konika, Germination capacity

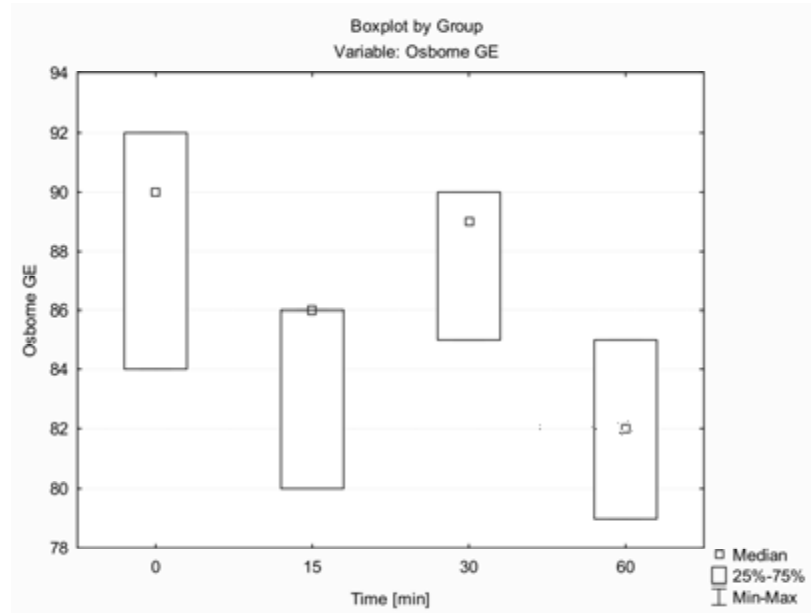


Fig. 15 Boxplot for Osborne, Germination energy

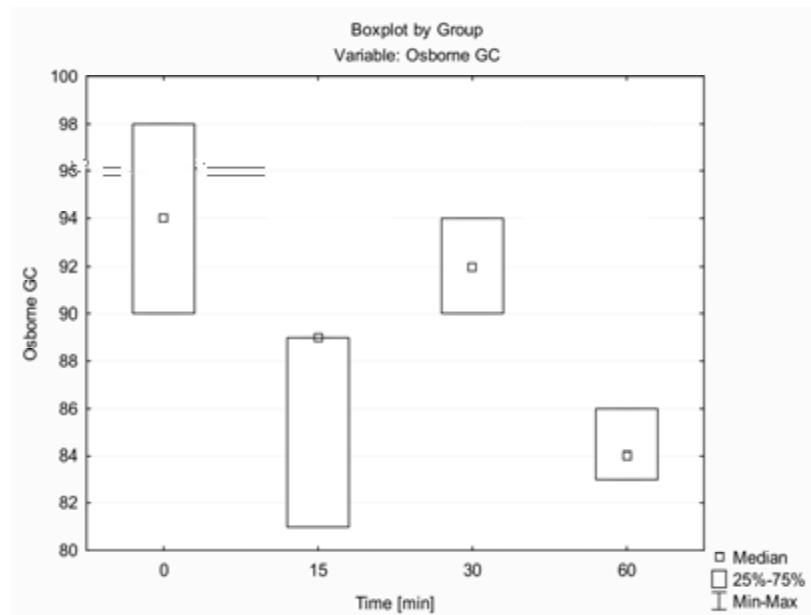


Fig. 16 Boxplot for Osborne, Germination capacity

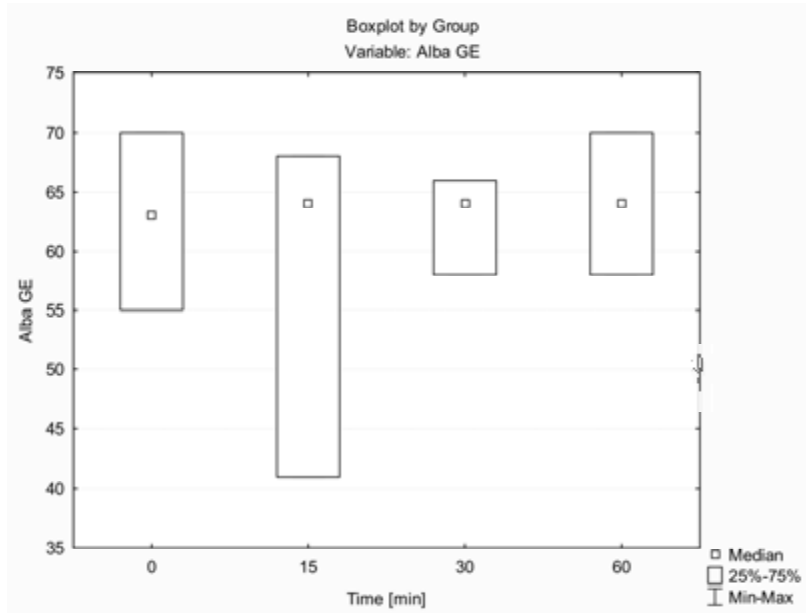


Fig. 17 Boxplot for Alba, Germination energy

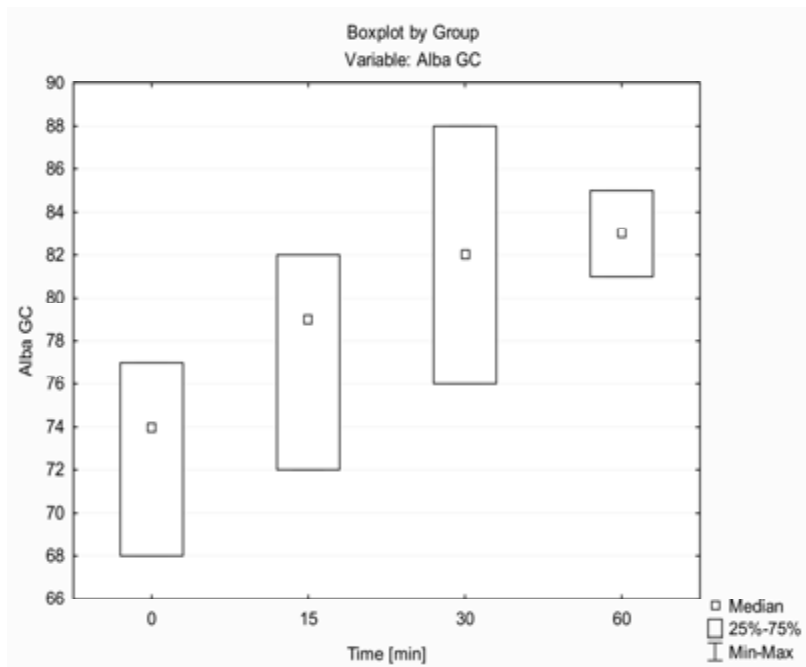


Fig. 18 Boxplot for Alba, Germination capacity

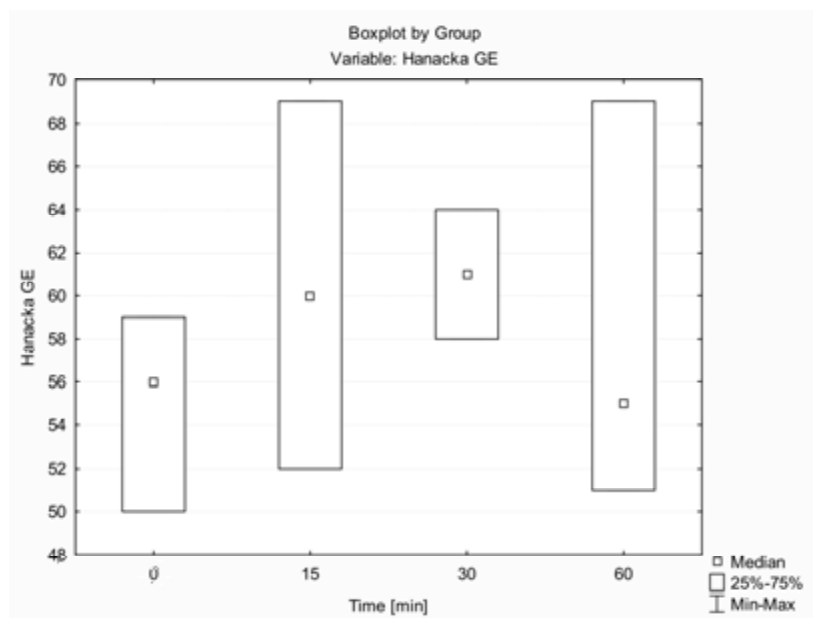


Fig. 19 Boxplot for Hanácká, Germination energy

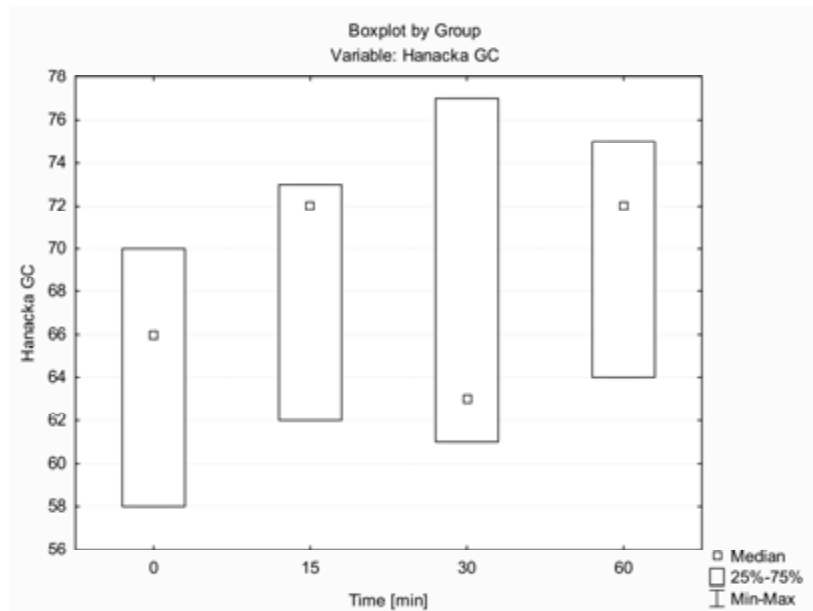


Fig. 20 Boxplot for Hanácká, Germination capacity

In the K-W test, the significance of the effect of NIR exposure time on germination energy was analysed (Figs. 14, 16, 18 and 20), as well as the capacity

(Figures 15, 17, 19, 21), the significance level was 0.05. The results of the test are presented in the following charts (median - first and third quartile - minimum and maximum). Explanation of the abbreviations used: GE - germination energy; GC - germination capacity.

The results of statistical tests confirm our earlier observations. We can see that NIR stimulation gives different results depending on the parsley varieties and the exposure amount. We cannot generally say that this stimulation affects the parsley seeds in one way. However, in most cases, the beneficial effect of NIR on the seeds of selected parsley varieties can be noticed. The germination capacity of Konika and Alba varieties after biostimulation increases (statistically significant). This is also evident for the Hanácká variety, but definitely less clearly (there is a large variation of this value). However, for the Osborne variety, GC is completely random compared to the time of exposure. In the case of germination energy, such effective results cannot be observed (no statistically significant differences between the examined groups). On basis of the results we can find some effect of near-infrared stimulation for GE, however, it is not possible to form unambiguous cognitive conclusions. In some cases, you can even observe the progress of changing this parameter as the exposure time increases (e.g. the Konika variety).

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