Analyzing the index and speed of the germination of *Paulownia tomentosa* seeds while being exposed to laser

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Abstract. The purpose of this study was to track the reaction to extreme conditions by germination of *Paulownia* seeds by exposing them to the electromagnetic radiation of red and green laser. Plants have different response to light of different colors. The lots of 100 *Paulownia* seeds were placed on the red and green laser beam trajectory lasted 5, 10, 15, 20, 25, 30 minutes. After that they were germinated. The entire germination process was followed both as a daily evolution over the 14 days set as well through the perspective of the two *Paulownia* seed germination indicators. The most beneficial in both cases is the different ways of exposure in only 5 minutes. It confirms that the laser beam can be utilized as a bio-stimulator.

Key Words: SG-speed germination, IG-germination index, green laser, red laser, Paulowniaceae, empress tree, princess tree.

Introduction. Organisms generally live in a complex living environment under the influence of physical agents (terms). In the last couple of years there have been increasingly extreme climate changes. One of the essentials of life is the ability to adapt to the changes that are constantly occurring. Live organism can survive in many places and many conditions. The first needs for life are a liquid medium, organic matter and an energy source.

Electromagnetic radiation as a source of energy can contribute to the energy exchange required by plants (Cook 2002).

The laser discovery was very important by its application in various fields such as medicine, biology, chemistry, physics and agriculture. Among its applications in agriculture we can mention its use as a bio-stimulator device. The action of the laser, of low intensity, causes biostimulation when used on seeds, seedlings and plants (Aladjadjiyan 2007; Chen et al 2005; Dziwulska 2006; Govil et al 1985; Hernandez et al 2007, 2008; Perveen et al 2010).

Plants have different responses to light of different colors. Scientific research and experiments have been conducted to link the illumination of various areas of the electromagnetic radiation spectrum and plant growth. Generally, it has been observed that red light causes the plants to grow in height. Green light leads to a high growth. After knowing the illumination with artificial light sources, the plant growers began to use this knowledge (Floroiu 2013).

The wavelength of 555 nm with the radiant flux value of 1W is perceived much more intense than the 500 nm wavelength radiation with the same value of 1 watt of the radiant flux. By the equivalent of watt lumens, using the light efficiency curve, the optimum values are between 450 nm and 650 nm (Şteţiu 1987).

Material and Method

Plant material used. As biological material, we used the *Paulownia tomentosa* seeds (Figure 1).

Figure 1. *Paulownia tomentosa* seed (https://www.flickr.com/photos/scorp24/8743066545).

Method for determination of germination. Germination is all morphological and physiological processes of transforming an embryo into seed, from sleep to active growth state (Peterfi & Sălăgeanu 1972; Baskin & Baskin 2001; Bonner & Karrfalt 2008; Sadeghi et al 2011). The process of germination in these case was determined by two indicators, considered the representative and were calculated to evaluate their efficiency in data interpretation (Anjum & Bajwa 2005; Ranal & Santana 2006).

The two selected indicators are: germination index (IG) (Marcu et al 2013) and germination speed (VG) (Cihapusio et al 1997; Marcu 2013).

Laser beam exposure of plant material. Germination indicators, when the plant material is exposed to the laser beam, were determined following the specific procedures, in two steps. The first stage, held at the National Institute of Research and Development of Isotopic and Molecular Technologies Cluj-Napoca, in the Department of Molecular and Biomolecular Physics. The second stage in the University of Agriculture and Veterinary Medicine, Cluj-Napoca, Faculty of Horticulture in biophysics laboratory. It was aimed the stimulation batches of 100 *P. tomentosa* seeds, by two similar methods, but the difference was the power and wavelength of the laser beam, because the wavelengths in the visible spectrum are different.

The way the human eye perceives light is different, and by extension the living material. For these reasons, the green laser variants with λ = 532nm and the red laser with wavelength λ = 632.8 nm were chosen. The red beam device is HeliumNeon type LASOS, with a wavelength beam λ = 632.8nm, excellent quality, with a wide variety of red spectra.

The lots of 100 *P. tomentosa* seeds were placed on the red laser beam trajectory, 0.6 mW power, the exposure diameter of 7 cm with the area $(\pi r^2) = 0{,}0038 m^2$ (Figure 2).

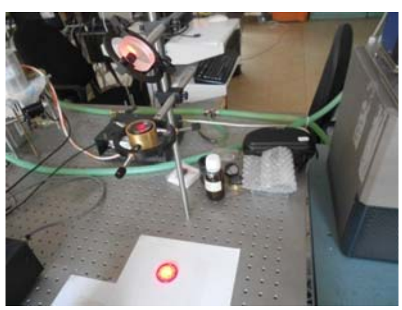

Figure 2. *Paulownia tomentosa* seeds exposed red laser beam (original).

The green beam that has a wavelenght of λ = 532 nm is LASER QUATUM GEM, the most widely used green laser (Figure 3). It has power between 2 W and 6 W, with excellent beam parameters, sophisticated software, and control interface. Includes Remote App technology, allowing for a complete interface, being designed for demanding applications from a few mW for bio-imaging, a few hundred mW for Raman spectroscopy, fluorescence imaging, optical tweezing, to W for holography, going to higher powers for

Ti Sapphire Oscillatory Pumping. In the same way the lots of 100 *P. tomentosa* seeds were placed on the green laser beam trajectory, with a power of 2 W the exposure diameter of 7 cm, with the area $(\pi r^2) = 0,0038 m^2$.

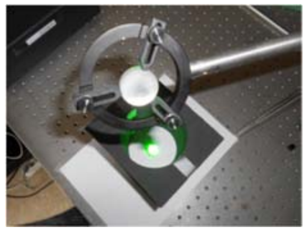

Figure 3. Exposing *Paulownia tomentosa* seeds to green laser beam (original).

Exposure time. Multiple exposure ranges were chosen: 5 minutes, 10 minutes, 15 minutes, 20 minutes, 25 minutes, 30 minutes in the both laser beam. We considered the control group that was not exposed to the laser beam.

Subsequently, the seed lots were seeded in Lidhart special pots in the Biophysics Laboratory, ensuring optimal conditions of brightness, temperature between 23 and 26°C.

The experimental varants were organized in four repetitions.

Statistical analysis. Experimental data were subjected to one-way analysis of variance (one-way ANOVA) at a 5% level of probability and Duncan test, to determine the differences in average of two tested parameters between exposed and non-exposed seeds.

Results and Discussion. The entire germination process was followed both as a daily evolution over the 14 days set as well as through the perspective of the two *P. tomentosa* seed germination indicators.

The present study demonstrated in detail the evolution every day, every lot of 100 seeds being exposed to laser lasting 5, 10, 20, 25, 30 minutes.

Green laser exposure (Figure 4):

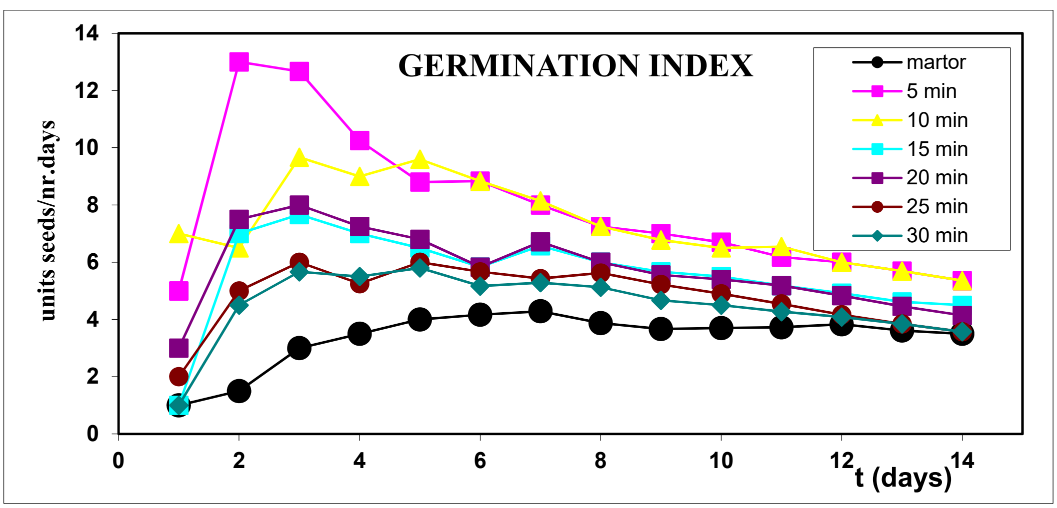

Figure 4. Germination index of *Paulownia tomentosa* seeds under influence of green laser beam, six exposure time, on fourtheen days.

The germination index reaches the maximum value for the 5-minute exposure on the second day. The first two days giving most seed germinating units. The germination index has a similar linearity for the five samples tested under the 532 nm wavelength laser radiation.

The best germination index is the one with 110.73 seed units/no. of days, exposure time, 5 minutes, followed by a gradual decline correlated with degrees of five minutes, as follows: 102.8 seed units seeds/no. of days at 10 minutes, 85.00 seed units/no. of days at 15 minutes, 80.67 seed units/no. of days at 20 minutes, 67.22 seed units/no. of days at 25 minutes, 62.98 units seeds/no. of days at 30 minutes, these values being superior to the control version of 47.37 seed units/no. of days (Figure 5).

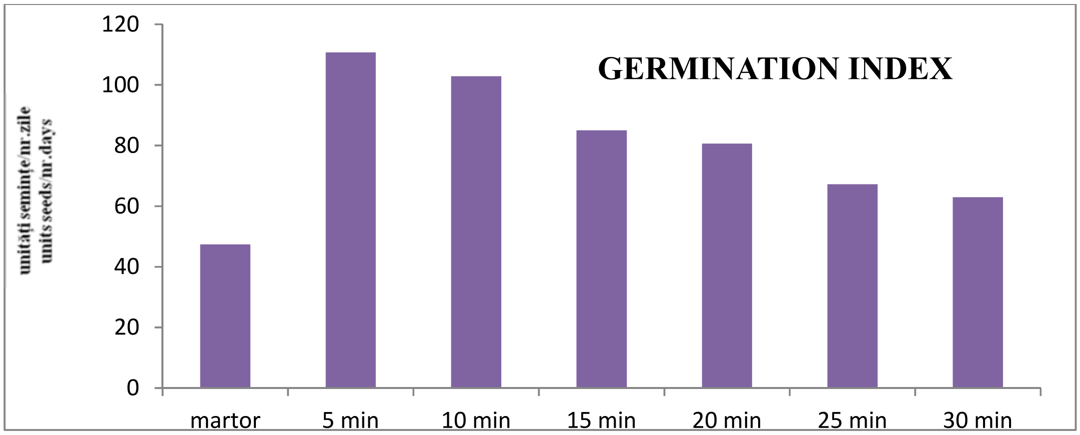

Figure 5. Germination index of *Paulownia tomentosa* seeds under influence of green laser beam, six exposure time.

With regard to the seed germination rate of *P. tomentosa*, during the monitoring of the green laser radiation experiment, it confirms the rapid dynamics in the first three days for all exposure times, relative to the blank sample (Figure 5).

Treated seeds show rapid germination, with clear influences on germination indicators. The remainder of the period is characterized by a slow germination rate, the speeds running in parallel, superimposed (Figure 6).

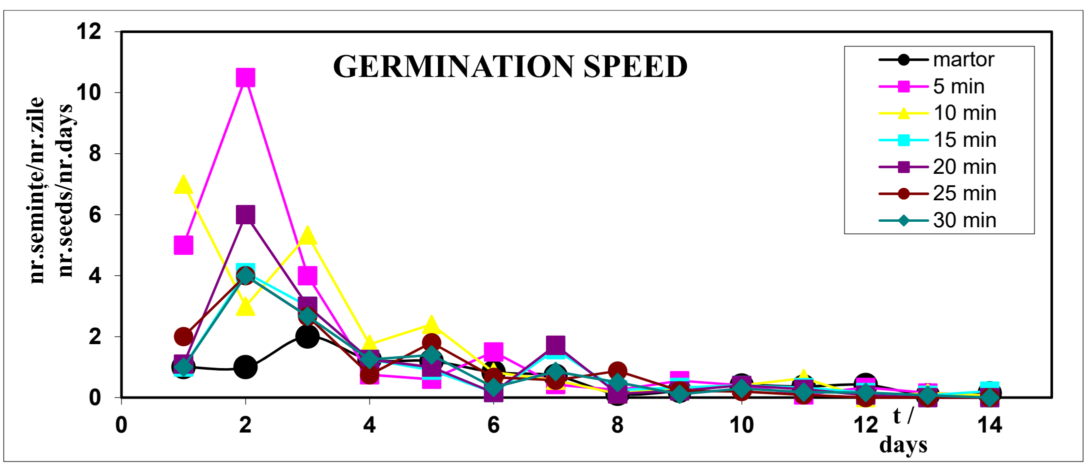

Figure 6. Germination speed of *Paulownia tomentosa* seeds under influence of green laser beam, six exposure time, on fourteen days.

From the point of view of the obtained values, there is a tendency of proportionality between the germination rate and the germination index, which is preserved. The lowest germination rate of the experimental lots is 12.84 no. seeds/no. days at the 30 minute sample. The speeds begin to increase to 13.84 no. seed/no. days at 25 minutes, 15.33 no. seed/no. days at 20 minutes, 17.53 no. seeds/no. days at 15 minutes, 22.61 no. seed/number of days at 10 minutes, reaching the maximum germination rate at 24.63 no. seed/number of days for sample exposed for 5 minutes (Figures 7 & 8).

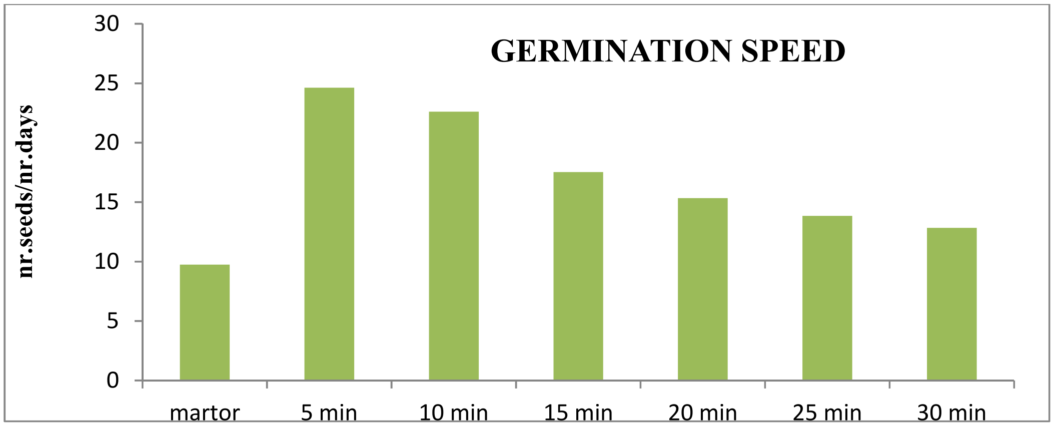

Figure 7. Germination speed of *Paulownia tomentosa* seeds under influence of green laser beam, six exposure time.

Red laser exposure:

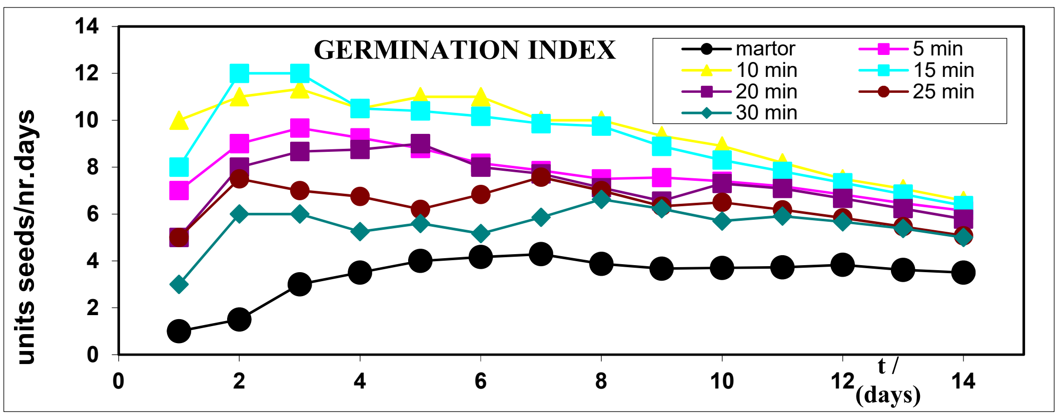

Figure 8. Germination index of *Paulownia tomentosa* seeds under influence of red laser beam, six exposure time, on fourtheen days.

The best germination index is 132,40 units of seed/no. Of the 10 minute exposure sample, followed by a gradual decrease, correlated with the five minute grading, as follows: 128,22 units of seed/no 15 minutes per day, 101.89 seed units/number of days at 20 minutes, 89.24 seed units/number of days at 25 minutes, 77.38 seed units/number of days at 30 minutes (Figure 9).

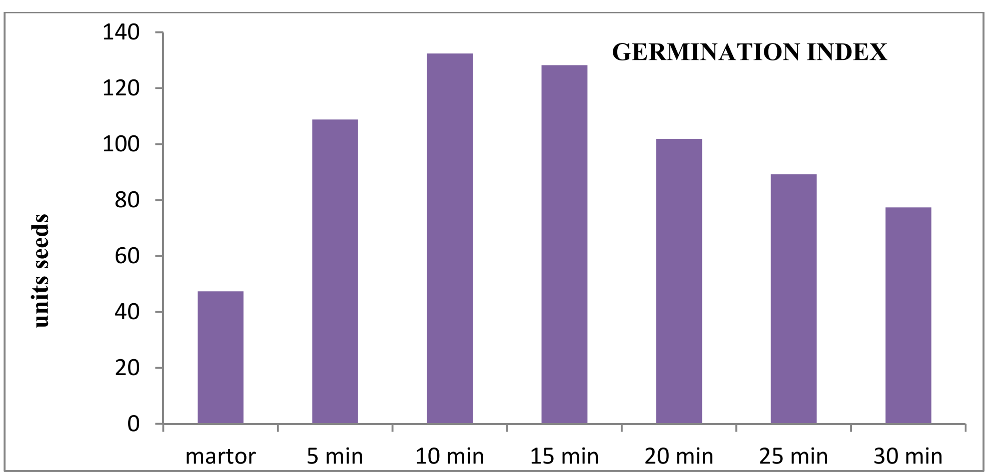

Figure 9. Germination index of *Paulownia tomentosa* seeds under influence of red laser beam, six exposure time.

We have 108.82 seed units/number of days at 5 minutes. These values are superior to the control variant of 47.37 seed units/number days (Figure 9)..

As it regards the seed germination rate of *P. tomentosa* species during the 632 nm wavelength laser radiation monitoring, it confirms rapid dynamic over the first two days for all exposure times, relative to the control sample.

Influences are not so clear on the germination indicators in the rest of the days. The rate of germination being progressively decreasing, being not so significant as compared to the germination index (Figure 10).

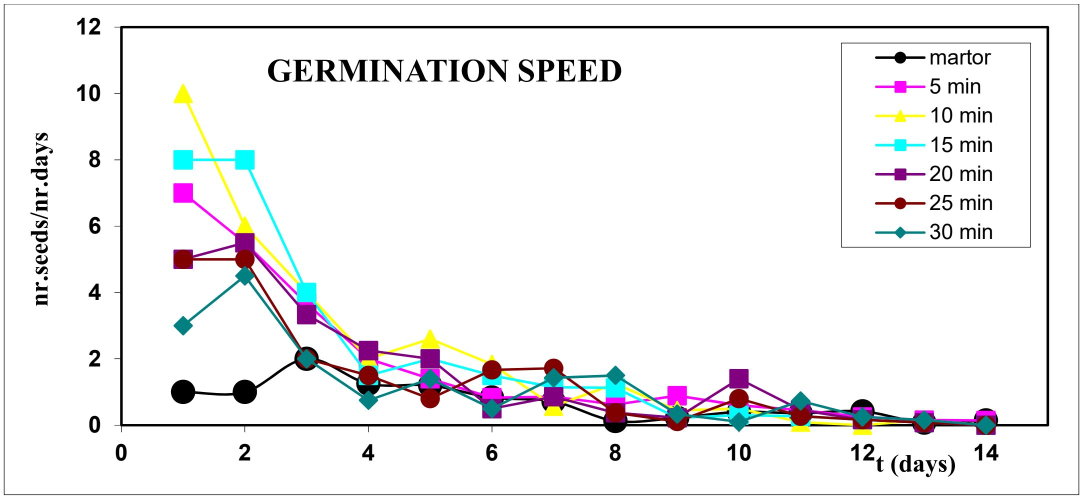

Figure 10. Germination speed of *Paulownia tomentosa* seeds under influence of red laser beam, six exposure time, on fourtheen days.

The values obtained for each sample are shown in Figure 11. The lowest germination speed of the experimental lots is 9.74 no. seed/number of days at the blank sample. Speed starts to rise to 19.48 no. seed/number of days at 25 minutes, 22.14 no. seeds/no. days at 20 minutes, 28.31 no. seed/number of days at 15 minutes, maximum germination rate 29.44 no. seed/no. days 10 minutes and with 24.37 no. seed/number of days for sample exposed for 5 minutes.

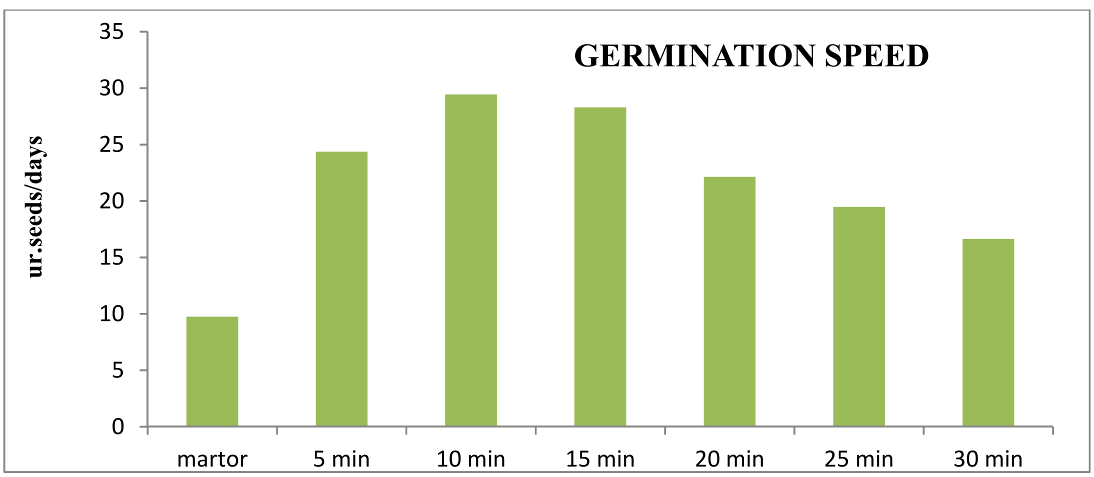

Figure 11. Germination speed of *Paulownia tomentosa* seeds under influence of red laser beam, six exposure time.

Conclusions. After analyzing and interpreting the results, the conclusions on the influence of electromagnetic field on *P. tomentosa* seeds when using green laser and red laser radiation are the following:

The results obtained statistically reflect the stimulating effects of the laser green method action. Influenced by the time factor of the *P. tomentosa* seeds being exposed at the green beam radiation in the germination index, there is a very significant positive difference on the average winess. The Duncan test confirms the importance of the time factor decision with 5, 10, 15, 20, 25, 30 minutes.

Red laser action is beneficial, stimulating, at low exposures of 10 minutes, in terms of the analyzed indicators. Meanwhile the same seeds were exposed at the red beam were also influenced by the time factor and a vhich is the key difference in the germination index. After the Duncan test the best results were at 10 minutes exposure. The most beneficial in both case is the different ways of exposure in only 5 and 10 minutes. It confrm that the laser beam can be utilized as a bio-stimulator.

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