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Photobiostimulation of germination and early growth of wheat seeds (*Triticum aestivum L*) by a 980 nm semiconductor laser

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Sumario. El efecto de la exposición de semillas de trigo (*Triticum aestivum* L) a la radiación láser IR con $\lambda = 980\ nm$ en la germinación y el crecimiento temprano se estudiaron bajo condiciones de laboratorio. Las semillas fueron expuestas a una de dos intensidades de la luz láser: 15 mWcm^{-2} or 30 mWcm^{-2} por diferentes periodos de tiempo: 30, 60 o 120 s. Las semillas expuestas a una intensidad de la luz láser de 15mWcm^{-2} por un tiempo de radiación de 30 s mostraron un incremento en el porcentaje de semillas germinadas normalmente mientras que el porcentaje de semillas germinadas anormalmente decremento. Al mismo tiempo se presentó un efecto de estimulación en el crecimiento del tallo y en el crecimiento de las raíces del 10% con respecto al control. Para el tratamiento antes mencionado y el control existe una diferencia significativa de $\rho < 0.001$.

Abstract. The effect of the exposure of wheat (*Triticum aestivum L*) seeds to a IR laser radiation with $\lambda = 980$nm produced by a semiconductor laser on germination and early growth had been studied under laboratory conditions. Seeds were irradiated to one of two laser intensities 15 mWcm^{-2} or 30 mWcm^{-2} for different periods of time 30, 60 or 120 s. Seeds exposed to a light intensity of 15mWcm^{-2} and an exposition time of 30 s. showed an increase on the percentage of seeds germinated normally while the percentage of seeds germinated abnormally decreased. At the same time there is a stimulation effect on the growth of the stem and on the growth of the root of 10% on wheat seedlings over control seedlings. Significant differences ($\rho < 0.001$) were observed between the control and the above treatment.

Keywords. Laser radiation. Surface irradiation efects 61.80.Ba, Aplications of Laser 42.62-b

1 Introduction[*]

Important features in seeds are their ability to germinate and to grow[1]. The initial stages of germination and growth of seeds determine the further development of plants and their final yield. To improve the initial stages of seeds different chemical and physical methods are used. The aim of these methods is the appropriate preparation of the sowing material to improve seed sprouting, growth and vigor[2]. More active and vigorous plants develop better and are better suited to endure unfavorable habitats, at the same time they are also less susceptible to disease.

The laser radiation has been used by different researches[1-6, 8-19] as a physical method to improve the ger-

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mination, the growth and the vigor of seeds. Podlesny et al.[8] reported that the use of a He-Ne laser with $\lambda = 632.8$ nm modifies the initial phases of development of white lupine and faba bean seeds. Wilczek et al.[10] treated *Trifolium pretense L* and *Medicago sativa L* seeds with a He-Ne laser with λ = 632.8 nm. The results they obtained show that the percentage of seeds germinating abnormally, the percentage of hard seeds and the percentage of seeds infected with fungal diseases decreases with respect to control. Szyrmer et al.[11] reported that the laser treatment of *Phaseolus vulgaris L* seeds can modify the course of the metabolic processes as well as their photosynthetic activity. Laszkiewicz et al.[12] observed that seeds treated with laser radiation have better energy and ability to germinate. Drozd et al.[13] reported that the laser treatment of wheat seeds stimulates the early growth and development of the coleoptiles. Dziamba et al.[15] used laser radiation to improve and balance seedling emergence of *Hordeum vulgare L* seeds.

In most of the reviewed articles[3,5,16-19] the researchers used He-Ne and argon lasers to treat seeds (lasers in the visible spectrum), but not only these kind of lasers can be used. Infrared laser can be used to produce stimulation effects

Due the above the principal objective of our work is to determine the optimal parameters of the IR laser radiation with λ = 980nm produced by a semiconductor diode to stimulate the germination and growth of wheat seeds (*Triticum aestivum* L).

2 Materials and methods

Wheat seeds (*Triticum aestivum L*) were supplied by the National Institute of Forest, Agriculture and Livestock Researches of Mexico (INIFAP). Wheat variety was Triunfo, developed by the institute above mentioned and the International Maize and Wheat Improvement Center (CIMMYT).

The IR semiconductor laser was characterized before apply laser radiation to the wheat seeds. The power of the semiconductor laser was measured using a pyroelectric power probe model RjP735 connected to an electrically calibrated pyroelectric radiometer model Rs5900 from the company Laser Probe, USA. The radiation pattern was measured with a photodiode system designed at our laboratory. Due the light of the semiconductor laser presented a gauss distribution, only the central area with variations of power of 10% with respect to the maximum power was considered for applications for seeds.

Six laser treatments were defined to treat the wheat seeds. The treatments were:

- Exposition of wheat seeds to a power density of $15 mWcm^{-2}$ for three different exposition times: 30s (T1), 60s (T2), 120s (T3).
- Exposition of wheat seeds to a power density of $30 mWcm^{-2}$ for three different exposition times: 30s (T4), 60s (T5), 120s (T6).

Once defined the laser treatments, groups of 400 seeds were treated with each laser treatment. Analogous groups were used as control (non-treated seeds). Each group of 400 seeds was divided in 16 repetitions with 25 seeds in each one. Repetitions were labeled and randomly located into the germination chamber.

Table I

Influence of laser treatment on seed germination.

Treatments	% of seeds		
	germinated normally	germinated abnormally	non-germinated seeds
Control	83	14	3
T1	91***	5***	4
T2	90***	6***	4
T3	87*	5***	8**
T4	86	11	3
T5	86	10*	4
T6	87*	10*	3

* Significant differences: $\rho < 0.05$. ** Significant differences: $\rho < 0.01$. *** Significant differences: $\rho < 0.001$.

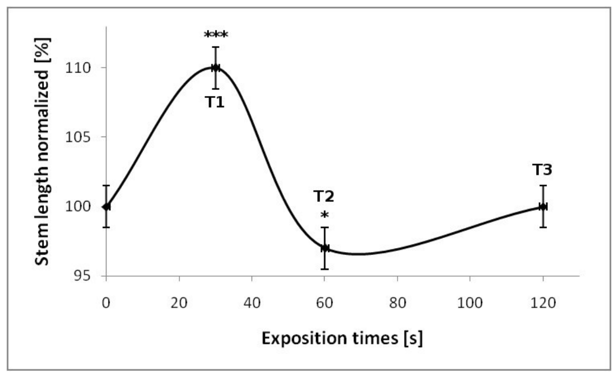

Figure 1. Stem length of wheat seedlings from seeds exposed to a power density of $15 mW cm^{-2}$ and three different exposition times: 30s, 60s and 120 s. The graph includes the standard error of the mean.

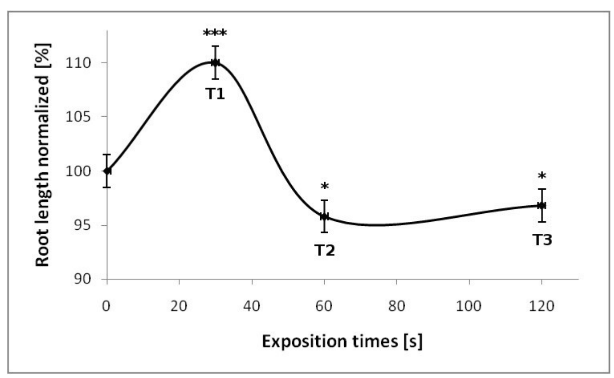

Figure 2. Root length of wheat seedlings from seeds exposed to a power density of $15 mW cm^{-2}$ and three different exposition times: 30, 60 and 120 s. The graph includes the standard error of the mean.

The germination and the growth tests were carried out under laboratory conditions. The temperature of the germination and growth tests was of 20°C and the humidity was 90%. During all the experimental period only distilled water was used to evaluate only the effects of laser treatments. No other substances were added to distilled water and to seeds.

For the germination tests the number of seeds that had germinated was counted after 4 and 10 days. After the tenth day the percentages of seeds germinated normally and abnormally as well as the percentage of seeds that had not germinated at all were calculated.

The growth of wheat seedlings was evaluated in terms of the following magnitudes: the stem length and the root length. The growth data were normalized using the control data.

Germination and growth data were analyzed statistically. For the germination data a Student t-test was done to find the significant differences between each laser treatment and control. For the growth data, they were subjected to an analysis of variance (ANOVA) to detect differences between mean parameters. The mean parameters later were compared using the Tukey test (multiple comparisons) to detect differences between the control and treated plants.

3 Results

Table I shows the percentage of seeds germinated normally and abnormally as well as the percentage of non-germinated seeds after laser treatment. From this table it is possible to observe that there are two important increase on the percentage of seeds germinated normally for treatments T1 and T2 while there are two important decreases on the percentage of seeds germinated abnormally for the same treatments. For treatments T1 and T2 the increases registered on the percentage of seeds germinated normally were 8% and 7% respectively while the decreases registered on the percentage of seeds germinated abnormally were 9% and 8% respectively. These treatments presented a statistical significant value of ρ<0.001 for the percentages of seeds germinated normally and abnormally.

For the percentage of non-germinated seeds there were not important increases or decreases on this variable.

Figure 1 shows the stem length for wheat seeds treated with a power density of 15mW cm^{-2} and three different exposition times: 30s (T1), 60s (T2), 120s (T3). The control is represented with the value of 0s. An important increase on the stem length for wheat seedlings was obtained for an exposition time of 30s (T1). The increase registered had a value of 10% over the control level. The statistical significance had a value of $\rho < 0.001$. The other treatments did not show significant differences.

Figure 2 shows the root length for wheat seeds treated with a power density of 15mW cm^{-2} and three different exposition times: 30s (T1), 60s (T2), 120s (T3). As mentioned above the control is represented with the value of 0s. From this figure it is possible to observe that for this power density the highest increase was registered for an exposition time of 30s (T1). The increase registered over the control level was 10%. The statistical significance for this treatment had a value of $\rho < 0.001$. The exposition times of 60s (T2) and 120s (T3) produced decreases on the root length that were not statistically significant.

Figures 3 and 4 show the stem length and the root length respectively for wheat seeds treated with a power density of 30mW cm^{-2} and three different exposition times: 30s (T4), 60s (T5), 120s (T6). As mentioned above the control is represented with the value of 0s. From these figures it is possible to observe that the laser treatment of wheat seeds for this power density did not modify significantly the growth of the stem and of the roots.

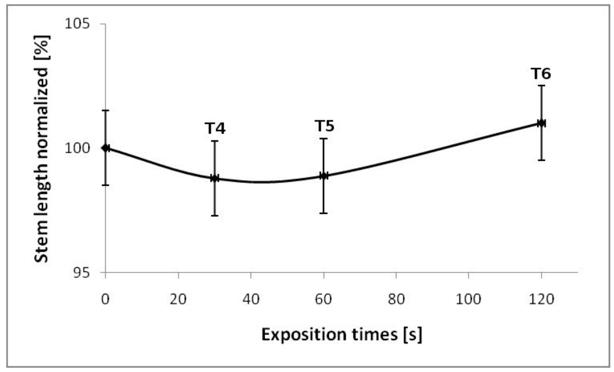

Figure 3. Stem length of wheat seedlings from seeds exposed to a power density of 30mWcm^{-2} and tree different exposition times: 30, 60 and 120 s. The graph includes the standard error of the mean.

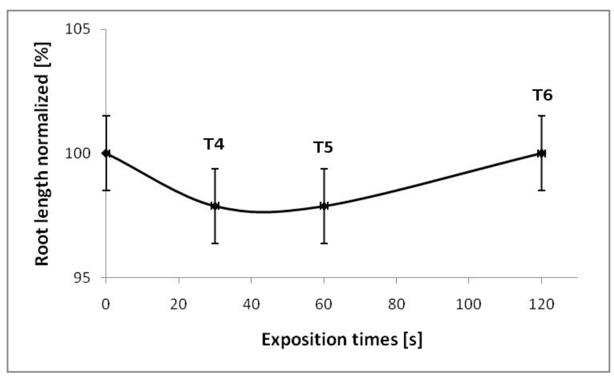

Figure 4. Root length of wheat seedlings from seeds exposed to a power density of 30 mWcm^{-2} and tree different exposition times: 30, 60 and 120 s. The graph includes the standard error of the mean.

4 Conclusions

The laser radiation produced by a semiconductor laser, with a wavelength of 980nm, modifies the germination and velocity of growth of wheat seeds when they are treated before sowing with the laser radiation.

The power density of laser radiation and the exposition time for a definite wavelength are the important parameters that can activate or inhibit the germination and the velocity of growth of wheat seeds. When the power density and the exposition time to laser radiation are optimal it is possible to improve the initial stages of growth of wheat seeds (germination and growth).

The laser treatments of wheat seeds T1 and T2 caused an increase on the percentage of seeds germinated normally and a decrease on the percentages of seeds germinated abnormally. At the same for the treatment T1 there is a stimulation effect on the growth of the stem and the root of the seedlings.

References

1. Wilczek M., Koper R. Cwintal M., Kornillowicz-Kowalska T., "Germination capacity and the health status of red clover seeds following laser treatment.", Int. Agrophys, Vol. 18(3), 289-293 (2004).

2. Podlesny J., Podlesna, A., "Morphological changes and yield of selected species of leguminous plants under the influence of seed treatment with laser light.", Int. Agrophys. Vol. 18 (3), 253-260 (2004).

3. Aladjadjian A., "The use of physical methods for plant growing stimulation in Bulgaria." Journal of Central European Agriculture, Vol. 8:3, 369-380 (2007).

4. Rybinska W., Garczyński S., "Influence of laser light on leaf area and parameters of photosynthetic activity in DH lines of spring barley (Hordeum vulgare L.)." Int. Agrophys, Vol. 18(3), 261-267 (2004).

5. Chen Y., Liu Y., Wang X., Ren Z., Yue M., "Effect of microwave and He-Ne laser on enzyme activity and biophoton emission of *Isatis indigotica* fort." Vol. 47:7, 849-855 (2005).

6. Chirkova, T.V., "Physiological mechanism of stability in plants.", St. Petersburg, S.-Peterb. U. (2002).

7. Karu T. I., "The science of low power therapy.", London: Harwood (1998).

8. Podlesny J., Podlesna, A., "Morphological changes and yield of selected species of leguminous plants under the influence of seed treatment with laser light.", Int. Agrophys. Vol. 18 (3), 253-260 (2004).

9. Podlesny J., "Effect of laser irradiation on the biochemical changes in seeds and the accumulation of dry matter in the faba bean." Int. Agrophys, Vol. 16, 209-213 (2002).

10. Wilczek M., Koper R., Cwintal M., Kornillowicz-Kowalska T., "Germination capacity and the health status of alfalfa seeds after laser treatment.", Int. Agrophys, Vol. 19(1), 85-89 (2005).

11. Szyrmer J., Klimont K., "The influence of laser biostimulation on the quality of French bean (*Phaseolus vulgaris L*) seeds.", Biul. IHAR, 210, 165-168 (1999).

12. Laszkiewicz E., "Application of laser irradiation to improve sowing quality of durum wheat seeds.", Proc. 1st. Int. Sci. Conf. Agrolaser, Lublin, 26-28.09, 45-50 (2001).

13. Drozd D.T., Szajsner H., Turzyniecka-Malysz H., "Application of laser irradiation to increase of wheat sowing value-years 1993-1997.", Proc. 1st. Int. Sci. Conf. Agrolaser, Lublin, 26-28.09, 13-17 (2001).

14. Drozd D.T., Szajsner H., "Influence of presowing laser radiation on spring wheat characters.", Int. Agrophys. Vol. 13, 79-85 (1999).

15. Dziamba S., Dziamba M., "Influence of pre-sowing light radiation of seeds on yielding and elements of yield structure in spring barley.", Proc. 1st. Int. Sci. Conf. Agrolaser, Lublin, 26-28.09, 19-24 (2001).

16. Malov A.N., Vygovskii Yu. Nu., "The physics of laser Biostimulation, Moscow, MILTA (2002).

17. Petkova V., Cholakov D., "Physiological behavior of tomato and cucumber plants caused by day or night Helium-Neon laser irradiation of their seeds.", Acta Hort. (ISHS), 579, 281-284 (2002).

18. Salyaev R. K., Dudareva, L. V., Lankevich, S. V., Makarenko S. P., Sumtsova, V. M., Rudikovskaya E. G., "The effect of Low-intensity laser irradiation on the chemical composition and structure of lipids in wheat tissue culture.", Dokl. Akad. Nauk., 412, 87-88 (2007).

19. Salyaev R. K., Dudareva, L. V., Lankevich, S. V., Sumtsova, V. M., "The effect of Low-intensity coherent radiation on morphogenetic processes in wheat callus culture.", Dokl. Akad. Nauk., 376, 113-114 (2001).

20. ISTA, International Rules for Seed Testing. International Seed Testing Assoc. Zurich, Switzerland (2008).