International Journal of
Agricultural Research

ISSN 1816-4897

Academic
Journals Inc.

www.academicjournals.com

International Journal of Agricultural Research 3 (6): 433-438, 2008
ISSN 1816-4897

Effect of Infra-Red Laser on Wheat (*Triticum aestivum*) Germination

[1]Abdelghafar M. Abu-Elsaoud, [2]Sultan T. Tuleukhanov and [3]Dina Z. Abdel-Kader
[1]Department of Botany, Faculty of Science, Suez Canal University,
Port-Said, Egypt
[2]Department of Human and Animal Physiology and Biophysics, Faculty of Biology,
Al-Faraby University, Kazakhstan
[3]Department of Botany, Faculty of Science, Suez Canal University, Egypt

Abstract: In this research, the influence of infra-red laser on four wheat cultivars from Kazakhstan and Egypt were carried out in order to enhance their germination percentage. Seeds were *in vitro* irradiated to IR laser for 0, 1, 3, 10, 30, 60, 180, 600, 1200 and 1800 sec. Seeds pre-sowing irradiation with monochromatic infra-red (IR) laser have increased the germination percentage of the four wheat cultivars. Maximum germination percentages noticed were mainly after IR-seed pre-sowing irradiation with 1, 60 and 1200 sec. Generally, IR laser enhanced the germination percentage of wheat cultivars after 3 days to reach a maximum of 93.3%$_3$ in cultivar akcay after irradiation for 1200 sec. An IR-irradiation of 30 sec caused a general inhibition in germination in the four studied cultivars with minimum germination percentage of 6.7%$_3$ recorded in sakha-168. Germination percentage at 5 and 7 days showed a similar behavior with maximum germination percentage recorded mainly at 30 sec of infra-red seed irradiation. So, seed pre-sowing irradiation with IR laser one-shot for 1 sec is recommended to be enough to enhance the germination percentage of experimented wheat studied.

Key words: Infra-red laser, wheat (*Triticum aestivum*), seed irradiation, germination percentage

INTRODUCTION

Irradiation of seeds by laser influences modifies the development and yield of cultivated plants. In recent years, increases in the importance of the physical factors of the treatment of pre-sowing seeds in connection with tendencies in cultivation technology, tend towards the propagation of plant production methods which are friendly to the environment. In the national and foreign bibliography there are many papers proving the favourable effect of laser light on the size of yield and sometimes also, on quality (Podleoeny *et al*., 2001). Among them is a lack of any detailed particular research results showing changes in the irradiated seeds and plants grown from these seeds. Particularly, low intensity laser irradiation in the visible and near infra-red ranges have been intensively used in the past two decades in various biological aspects including biotechnology (Salyaev *et al*., 2005; Hamblin and Demidova, 2006). However, there is no explanation for the effect of monochromatic coherent irradiation on biological objects because of difficulties in the analysis of light-energy transformation in cells and integrated response of complex multilevel living systems to laser irradiation since the study of Salyaev *et al*. (2007). The laser light may spread in a living tissue in a wave-guide mode, undergo considerable diffraction on heterogeneities and generate interference pattern inside the tissue, which promotes concentrations of irradiations, local heating of cellular structures and subsequent stimulation

Corresponding Author: Abdelghafar M. Abu-Elsaoud, Department of Botany, Faculty of Science, Suez Canal University, Port-Said, Egypt

of a number of important metabolic processes (Salyaev *et al*., 2007). Earlier, it was shown that low intensity laser irradiation stimulated morphogenetic variations and induced callus formation in tissue culture of wheat and wild grasses (Salayaev *et al*., 2001).

However, there is no explanation for the effect of monochromatic coherent irradiation on biological objects because of difficulties in the analysis of light-energy transformation in cells and integrated response of complex multilevel living systems to laser irradiation since the study of Salyaev *et al*. (2007). The laser light may spread in a living tissue in a wave-guide mode, undergo considerable diffraction on heterogeneities and generate interference pattern inside the tissue, which promotes concentrations of irradiations, local heating of cellular structures and subsequent stimulation of a number of important metabolic processes (Salyaev *et al*., 2007). Earlier, it was shown that low intensity laser irradiation stimulated varies morphogenetic processes and induced callus formation in tissue cultures of wheat and wild grasses (Salayaev *et al*., 2001).

Effect of pulsed nitrogen laser radiation (337.1 nm) on morphological characteristics and biochemical contents in seedlings from treated greengram (*Vigna radiata* L.) seeds previously studied, by germinating and growing in petri dishes for a week (Sudha *et al*., 1985). They found that shoot and root lengths and fresh and dry weights of the seedlings were maximum with the 30 min exposure, while protein was maximum with 20 min, RNA and DNA contents with 5 min exposure time. Whereas, chlorophyll content was not affected by the irradiation. Wilczek *et al*. (2004) carried out Laboratory experiments on the germination of tetraploid red clover seeds (var. Bona). Laser treatment significantly decreased the share of hard seeds and did not influence the percentage. Seed dressings significantly decreased seed infection with disease when compared to the control and objects with laser treatment. They concluded that laser treatment should not be applied in the case of massive seed infection with fungi of the *Alternaria* type since a significant increase was noted after laser irradiation with power of 3×3, 3×5 and 6 mW $cm^{-2}\times5$.

Seed embryos of *Isatis indogotica* were exposed to He-Ne laser irradiation (5.23 mW mm^{-2}, radiated for 5 min) to determine whether or not He-Ne laser caused changes to thermodynamic parameters of seeds and had a long-term physiochemical effects (Chen *et al*., 2005). A microwave (180 mW mm^{-2}) was also employed in place of laser to pretreated seeds for 8 sec as a parallel experiment with the laser pretreatment in order to identify the temperature effects of laser. They found that the thermodynamic parameters of seeds pretreated with He-Ne laser and microwave were similar during 40 h germination at 25°C, while they changed significantly compared with that of the control. Similarly, the physiological characters of the seedlings, e.g., stomatal conductance, water utilization efficiency, net photosynthetic rate and chlorophyll concentration and the biochemical characters of the seedlings, e.g., the concentration of soluble saccharides, soluble protein and the activities of α-amylase, GPT and GOT were increased significantly by the laser pretreated. Meanwhile, the biomass and leaf area of the seedlings were significantly improved. These changes suggested that the pretreatment with He-Ne laser had not only a short-term biological effect, which enhanced inner energy of seeds, but also a long-term effect, which contributed to the acceleration of the growth and development of seedlings.

The mid-infrared (mid-IR) should be a fruitful area for medical research and instrumentation since this is the region where the most identifiable molecular molecules absorb and radiate. Due to the unique specificity of a biological molecule's spectrum in the mid-IR, semiconductor lasers in the mid-IR have a unique advantage over ultraviolet and visible or near-IR lasers. Small room-temperature laser diodes can be used in small hand-held, portable and hopefully inexpensive, medical devices for rapid measurement, possibly in patient-operated home-care devices. Since, the mid-IR radiation can be connected with otherwise invisible chemical processes, it becomes possible to watch the biochemical processes of life reveal themselves. Until recently, work in this region had been handicapped by lack of sources, detectors and optical materials, but this is changing, as this conference shows and important new directions lie ahead (Waynant *et al*., 2001). So, the present work was aimed to evaluate the effect infra-red laser of wavelength 632.8 nm on wheat germination percentage in order to be used in agriculture in enhancement of wheat germination percentage.

MATERIALS AND METHODS

Plant Materials

Triticum aestivum seeds were obtained from the Botanical institute (Kazakhstan) and the National Agricultural Center, Egypt. Four wheat cultivars were selected, three from Kazakhstan namely; *Triticum aestivum* L. cv. Akcay, *Triticum aestivum* L. cv. Kazakhstanskaya-10 and *Triticum aestivum* L. cv. Eretrospermum-350, in addition to one Egyptian cultivars namely; *Triticum aestivum* L. cv. Sakha-168.

IR-Laser Treatments

Four wheat (*Triticum aestivum*) cultivars were selected and used to study the effect of infra red laser seed irradiation. Seeds were firstly surface sterilized using 70% ethyl alcohol. Seeds were treated with infra red laser for 0, 1, 3, 10, 30, 60, 180, 600, 1200 and 1800 sec. IR-laser irradiation were carried out using MSHN5-A-B450MM with wavelength 632.8 nm, power intensity 5.23 mW mm^{-2} and beam diameter 1.5 mm. The irradiated seeds were immediately cultivated on petri dishes (30 seeds per each petri-dish) filled with special hydrogel for cultivation which permit continuous water nourishment to cultivated plants. Hydrogel that is cross-linked sodium polyacrylate has excellent water absorbing capabilities (over 200 mL of water per g of hydrogel) which promote and enhance plant growth (Akihiro and Yuichi, 2005). The growth conditions were 12/12 h light/dark, 25/19°C day/night. Study was conducted in November-2007, at laboratories of Department of Biophysics, Faculty of Biology, Kazakh National University (Al-Faraby), Almaty, Kazakhstan.

Germination (%)

Germination percentage of control and irradiated wheat were recorded after 3, 5 and 7 days of cultivation with three replications.

Statistical Analyses

Statistical analyses were carried out using SPSS statistical software Ver. 9 and Microsoft Excel 2003.

RESULTS

Data of germination and germination percentage after three days of cultivation on polyacrylate hydrogel (germination $\%_3$), were shown in Table 1 in both experiments this is best expressed in the penta-fold irradiation and the irradiation with exposure of 1 min.

Generally, IR laser enhanced the germination percentage of wheat cultivars after 3 days to reach a maximum of $93.3\%_3$ in cultivar akcay after irradiation by IR laser for 20 min. Irradiated wheat cultivars at 3 days germination showed a general increase in germination percentage in respect to the control. An IR-irradiation of 30 sec caused a general inhibition in germination in the four studied cultivars with minimum germination percentage of $6.7\%_3$ recorded in sakha-168.

Statistical analysis showed that there is a highly significant difference among cultivars in germination percentage after 3 days ($F = 7.792$, $p = 0.011$). On the other hand, there were a very high significant difference among infra-red laser irradiations ($F = 4.452$, $p = 0.000$) (Table 2).

Table 1: Effect of Infra-Red (IR) seed irradiation on germination percentage ($\%_3$)

IR irradiation time (sec)	Cultivars Akcay	Kaz-10	Eret-350	Sakha-168	Variance
0	60.0±1.14	36.7±0.70	43.3±0.82	46.7±0.89	96.30
1	56.7±1.07	23.3±0.44	66.7±1.26	43.3±0.82	350.93
3	30.0±0.57	23.3±0.44	20.0±0.38	13.3±0.25	48.15
10	10.0±0.19	20.0±0.38	33.3±0.63	33.3±0.63	128.70
30	13.3±0.25	13.3±0.25	10.0±0.19	6.7±0.13	10.19
60	36.7±0.70	23.3±0.44	66.7±1.26	23.3±0.44	417.59
180	70.0±1.33	60.0±1.44	40.0±0.76	53.3±1.01	158.33
600	90.0±1.71	63.3±1.20	73.3±1.39	56.7±1.07	210.19
1200	93.3±1.77	50.0±0.95	73.3±1.39	43.3±0.82	522.22
1800	30.0±0.57	23.3±0.44	66.7±1.26	3.3±0.06	699.07
Variance	881.60	319.63	537.78	380.37	
Two-way ANOVA					
		F-ratio	p-value		
Among cultivars		7.79	0.011**		
Among IR treatments		4.45	0.000***		

Values are shown in Mean±SE, *Significant at p<0.05, **Highly significant at p<0.01, ***Very high significant at p>0.001

Table 2: Effect of Infra-Red (IR) seed irradiation on germination percentage ($\%_5$)

IR irradiation time (sec)	Cultivars Akcay	Kaz-10	Eret-350	Sakha-168	Variance
0	90.0±2.26	60.0±1.51	70.0±1.76	70.0±1.76	158.3
1	93.3±2.35	60.0±1.51	86.7±2.18	46.7±1.17	485.2
3	50.0±1.26	63.3±1.59	33.3±0.84	36.7±0.92	188.0
10	53.3±1.34	33.3±0.84	43.3±1.09	50.0±1.26	77.8
30	16.7±0.42	20.0±0.50	16.7±0.42	13.3±0.34	7.4
60	60.0±1.51	36.7±0.92	70.0±1.76	33.3±0.84	318.5
180	80.0±2.01	90.0±2.26	93.3±2.35	60.0±1.51	225.0
600	93.3±2.35	83.3±2.10	86.7±2.18	76.7±1.93	48.1
1200	96.7±2.43	80.0±2.01	93.3±2.35	66.7±1.68	188.0
1800	53.3±1.34	60.0±1.51	93.3±2.35	6.7±0.17	1274.1
Variance	686.9	521.5	785.7	557.5	
Two-way ANOVA					
		F-ratio	p-value		
Among cultivars		9.66	0.000***		
Among IR treatments		5.74	0.003**		

Values are shown in Mean±SE, *Significant at p<0.05, **Highly significant at p<0.01, ***Very high significant at p>0.001

After 5 days of *in vitro* seed cultivation, the germination percentage of akcay cultivar reached a maximum of 96.7$\%_5$ after irradiation by IR laser for 20 min. However, an IR-irradiation of 30 sec caused a general inhibition in germination in the four studied cultivars with minimum germination percentage of 6.7$\%_5$ recorded in sakha-168. Statistical analyses showed that there is a very high significant difference among cultivars in germination percentage after 5 days ($F = 9.66$, $p = 0.000$). Moreover, there were a very high significant difference among infra-red laser irradiations ($F = 5.74$, $p = 0.003$).

After 7 days of *in vitro* seed cultivation on polyacrylate hydrogel, IR laser enhanced the germination percentage of wheat cultivars to reach a maximum of 100$\%_7$ in cultivars akcay, kazakhstanskaya-10 and eretrospermum-350 after irradiation for 3 min (Table 3). Irradiated wheat cultivars at 7 days germination showed a general increase in germination percentage in respect to the control. An IR-irradiation of 30 sec caused a general inhibition in germination in the four studied cultivars with minimum germination percentage of 16.7$\%_7$ recorded in sakha-168. Statistical analyses showed that there is a very high significant difference among cultivars in germination percentage after 7 days ($F = 8.41$, $p = 0.000$). Moreover, there were a very high significant difference among infra-red laser irradiations ($F = 5.74$, $p = 0.004$).

Table 3: Effect of Infra-Red (IR) seed irradiation on germination percentage (%$_7$)

IR irradiation time (sec)	Cultivars Akcay	Kaz-10	Eret-350	Sakha-168	Variance
0	93.3±4.78	96.7±4.17	100.0±2.96	73.3±3.76	143.5
1	86.7±4.44	96.7±4.17	93.3±4.78	66.7±3.42	180.6
3	76.7±3.93	80.0±4.10	46.7±2.39	53.3±2.73	276.9
10	80.0±4.10	66.7±3.42	60.0±3.07	83.3±4.27	121.3
30	23.3±1.20	43.3±2.22	30.0±1.54	23.3±1.20	88.9
60	90.0±4.61	73.3±3.76	93.3±4.78	53.3±2.73	336.1
180	100.0±2.96	100.0±2.96	100.0±2.96	80.0±4.10	143.5
600	96.7±4.17	90.0±4.61	93.3±4.78	93.3±4.78	7.4
1200	100.0±2.96	93.3±4.78	100.0±2.96	76.7±3.93	140.7
1800	80.0±4.10	93.3±4.78	96.7±4.17	16.7±0.85	1396.3
Variance	533.3	347.7	667.2	647.4	
Two-way ANOVA					
		F-ratio	p-value		
Among cultivars		8.41	0.000***		
Among IR treatments		5.74	0.004**		

Values are shown in Mean±SE, *Significant at p<0.05, **Highly significant at p<0.01, ***Very high significant at p>0.001

DISCUSSION

The effects of laser irradiation on organism are chiefly of light effect, electromagnetism effect, temperature effect and pressure effect. However, the low power laser, especially the laser of visible wavelength, is supposed to emit little heat and pressure effect. Therefore, some researchers hold that the influence mechanism of laser irradiation is most likely attributed to its light effect and electromagnetism effect (Chen *et al*., 2005).

Present research results showed that IR-laser successfully enhanced germination percentage of studied wheat cultivars both Egyptian and Kazakh wheat. Kazakhstan cultivar Akcay gave the maximum germination percentage of 93.3, 96.7 and 100% after 3, 5 and 7 days of germination after laser irradiation for 20, 20 and 3 min, respectively. Moreover, cultivars Eretrospermum-350 and kazakhstanskaya-10 recorded maximum germination percentage of 100% after 3 min IR laser irradiation.

An IR-irradiation of 30 sec caused a general inhibition in germination in the four studied cultivars with minimum germination percentage of 6.7%$_3$ recorded in sakha-168. Germination percentage at 5 and 7 days showed a similar behavior with maximum germination percentage recorded mainly at 30 sec of infra-red seed irradiation.

Chen *et al*. (2005) found that enthalpy change (DH) during the germination process of seeds pretreated with laser was notably higher than that of the control. Change of enthalpy (DH), sometimes referred to as heat content, is related to internal energy.

Seeds pretreated with laser have to absorb more energy from the surrounding than that of the control in the course of the individual development because laser broke the kinetic equilibrium of germination seeds and enhanced the internal energy of seeds. It was reported that as an open system, the living organism must exchange energy with surrounding system to keep its high order state of system when this order is broken (Chen *et al*., 2005). Consequently, the biochemistry and physiology metabolisms of the plants pretreated with laser were accelerated.

REFERENCES

Akihiro, O. and M. Yuichi, 2005. Plant culture by hydrogels. Biol. Ind., 22: 78-83.

Chen, Y.P., M. Yue and X.L. Wang, 2005. Influence of He-Ne laser irradiation on seeds thermodynamic parameters and seedlings growth of *Isatis indogotica*. Plant Sci. 168: 601-606.

Hamblin, M.R. and T.N. Demidova, 2006. Mechanisms of low level light therapy. Proc. SPIE, 6140: 614001-614001.

Podleoeny, J., L. Misiak and R. Koper, 2001. Concentration of free radicals in faba bean seeds after the pre-sowing treatment of the seeds with laser light. Int. Agrophys., 15: 185-189.

Salyaev, R.K., L.V. Dudareva, S.V. Lankevich and V.M. Sumtsova, 2001. Effect of low-intensity coherent radiation on callusogenesis in wild grasses. Dokl. Biochem. Biophys., 379: 279-280.

Salyaev, R.K., L. Dudareva, S. Lankevich, S. Makarenko, V. Sumtsova and E. Rudikovska, 2005. Influence of low-intensity laser radiation on lipid peroxidation in wheat callus cultures. AWN, 51: 122-124.

Salyaev, R.K., L. Dudareva, S. Lankevich, S. Makarenko, V. Sumtsova and E. Rudikovska, 2007. Effect of low-intensity laser irradiation on the chemical composition and structure of lipids in wheat tissue culture. Doklad. Biol. Sci., 412: 87-88.

Sudha, R.G., D.C. Agrawal, K.P. Rai and S.N. Thakur, 1985. Growth responses of *Vigna radiata* seeds to laser irradiation in the UV-A region. Physiol. Plant., 63: 133-134.

Waynant, R.W., I.K. Ilev and I. Gannot, 2001. Mid-infrared laser applications in medicine and biology. Philos. Transact. A Math. Phys. Eng. Sci., 359: 635-644.

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