TECHNICAL SCIENCES
Abbrev.: Tech. Sc., Pap. And Rep., No 9, Y. 2006

PRE-SOWING LASER BIOSTIMULATION OF CEREAL GRAINS

Bożena Gładyszewska
Department of Physics, Agricultural University, Lublin

K e y w o r d s: biostimulation, He-Ne laser, rye, wheat.

A b s t r a c t

The paper presents the results of studies on the effect of pre-sowing laser biostimulation on the germination process of rye cv. "Dańkowskie Złote" and wheat cv. "Salwa" grain harvested in 2003, 2004 and 2005. The germination capacity, germination rate and the Pieper coefficient were determined. The research was conducted at two germination temperatures, 15°C and 20°C. The seeds were subjected to pre-sowing biostimulation with an He-Ne laser with a power density of P = 4 mW/cm^2.

PRZEDSIEWNA STYMULACJA LASEROWA ZIARNIAKÓW ŻYTA I PSZENICY

Bożena Gładyszewska
Katedra Fizyki AR, Lublin

S ł o w a k l u c z o w e: stymulacja, laser He-Ne, żyto, pszenica.

S t r e s z c z e n i e

Przedstawiono wyniki badań nad wpływem przedsiewnej stymulacji laserowej ziarniaków żyta odmiany „Dańkowskie Złote" i pszenicy odmiany „Salwa" (pochodzących ze zbioru w latach 2003, 2004 i 2005) na proces ich kiełkowania. Wyznaczono zdolność i szybkość kiełkowania oraz czas Piepera. Badania przeprowadzono w dwóch temperaturach kiełkowania: 15 i 20°C. Nasiona były przedsiewnie naświetlone światłem lasera He-Ne o powierzchniowej gęstości mocy wynoszącej P = 4 mW/cm^2.

Introduction and aim of the study

The appropriate preparation of cereal seeds prior to sowing may ensure a higher yield of better quality. This may be achieved, among others, by exposing kernels to helium-neon laser light. Laser biostimulation is a physical phenomenon based on the absorption of light energy by grains, which is then transformed into chemical energy and used by the plant at later stages of growth. The energy supply increases the energy potential of seeds, which in turn impacts the physiological processes in germinating seeds, thus accelerating maturity, increasing resistance to disease as well as raising the biological and processing quality of the yield (Dziamba, Koper 1992, Lipski 1996, Podleśny, Koper 1996). Studies on the effects of pre-sowing laser biostimulation on seeds have been performed throughout the world over a few dozen years. The best effects of laser treatment on seed germination and yield were achieved with vegetable plants, and slightly worse with cereal plants and root crops (Daniel 2005, Daniel 2005, Drozd et al. 1994, Gładyszewska 1998, Gładyszewska et al. 1998). It was found that exposure to laser light positively impacted germination and growth in many varieties of cereal plants (wheat, rye, white lupine, maize), root crops (sugar beet) and vegetables (tomatoes, cucumbers) (Dziwulska, Koper 2003, Drozd, Szajsner 1997, Gładyszewska, Koper 1997, Koper et al. 2000, Lipski et al. 1996, Podleśny, Koper 1996, Podleśny, Koper 1997 1996, Podleśny, Koper 1998, Sheppard, Chubey 1990). The objective of this study was to verify whether pre-sowing He-Ne laser biostimulation affected the germination kinetics of wheat and rye grains harvested in 2003, 2004 and 2005.

Materials and methods

The experimental materials comprised seeds of wheat cv. “Salwa” and rye cv. “Dańkowskie Złote”. Air-dried seeds were subjected to laser biostimulation one day prior to sowing. One of three available technologies was applied for this purpose, i.e. the divergent laser beam method (Dygdała, Koper 1993). Figure 1 presents the stand for pre-sowing laser biostimulation of seeds with a divergent beam.

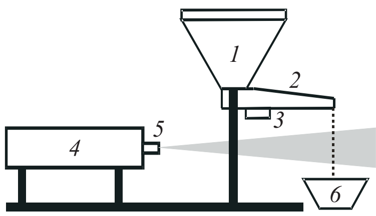

Fig. 1. A stand for pre-sowing laser treatment of seeds: *1* – charging hopper with metering device, *2* – chute, *3* – vibrator, *4* – laser, *5* – microscope lens, *6* – seed dish

The seeds intended for laser treatment were placed in the charging hopper –1. Then they were moved to the chute –2 through a regulated slot. Under the influence of a vibrating device –3 located under the chute, the seeds fell into the seed dish –6 slowly and steadily. The seeds were subjected to a divergent laser beam during their free fall. An He-Ne laser beam –4 with a density power of $P = 4$ mW/cm^2 was applied for the biostimulation.

Experimental conditions of seed germination

Each tested group was represented by 500 seeds, which were sown on absorbent paper in Petri dishes (5 samples each of 100 seeds). Prior to sowing, the dishes and absorbent paper were sterilized at 150°C and then cooled to 20°C. The temperature in the thermostatic oven in which the seeds germinated was stabilized exact to ±1°C, while the humidity levels of the absorbent paper were maintained through doses of distilled water. The experiment was conducted at 15°C and 20°C. A seed recognized as germinated was one with a germ at least 2 mm long. The counting was performed every few hours. Seeds obtained during the years 2003 and 2004 were tested in 2004, while the seed material from 2005 was tested the same year.

Results and discussion

The results of tests performed at two different germination temperatures, $T = 15$°C and $T = 20$°C, were analyzed in accordance with the Polish Standard PN-94/R-65950. The germination capacity Z_k and the germination rate S_k as well as the mean germination time of a single seed t_p in the control group and in the laser-stimulated group were determined for each of the tested variants. The results are presented in Figures 2 and 3.

The analysis of the experimental results indicates that wheat seeds harvested in 2004 and subjected to laser treatment prior to germination at $T = 15$°C had the highest germination capacity ($Z_k = 97.8\%$). No significant impact of laser treatment, temperature or year of harvest on the germination capacity Z_k was observed in the tested wheat groups.

The wheat germination rate S_k was slightly lower in the group of laser--exposed seeds germinating at $T = 15$°C. This also pertains to cereal grains from the 2003 and 2005 harvests germinating at $T = 20$°C. However, a significant effect of biostimulation on the germination rate was noted in the group of seeds harvested in 2004 ($T = 20$°C). Compared to the control group, this increase was noticeable and amounted to 19.1%. The laser treatment resulted in a slight

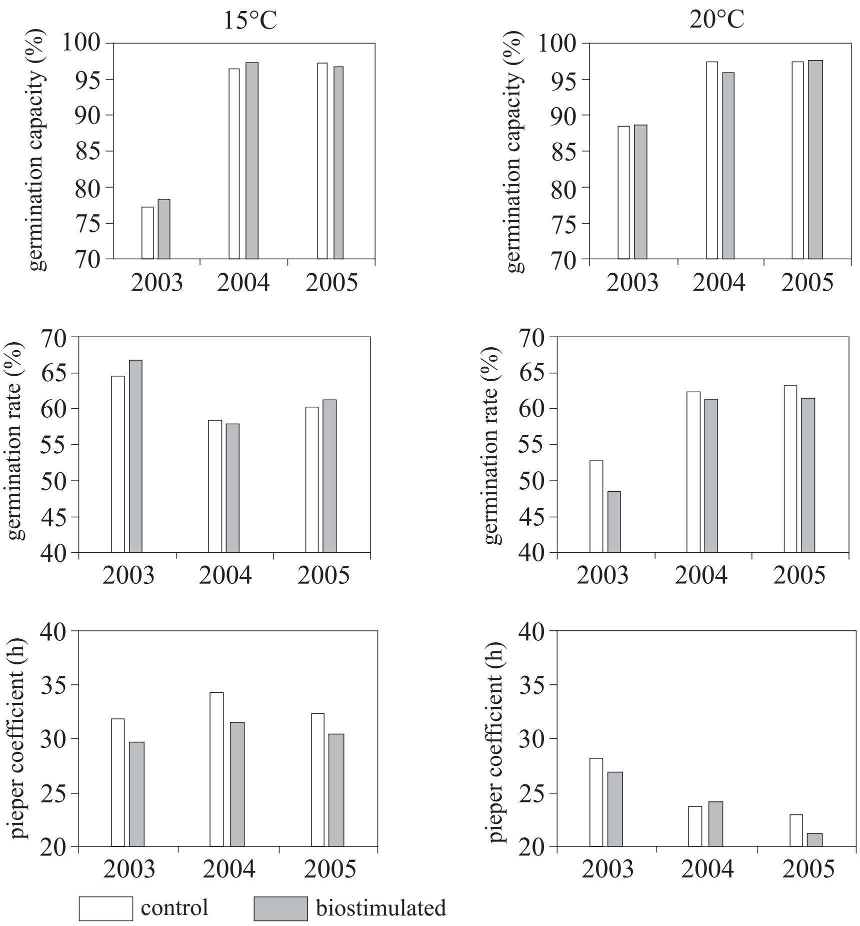

Fig. 2. Germination capacity Z_k, germination rate S_k and Pieper coefficient t_p (mean time of single seed germination) of rye seeds germinating at 15°C and 20°C, harvested in 2003, 2004 and 2005

decrease in the Pieper coefficient t_p for wheat seeds from the 2003-2005 harvests, germinating at $T = 15°C$, while the mean time of single seed germination was longer by around 2 hours at $T = 20°C$. In the control groups of seeds germinating at $T = 15°C$ the mean time of single seed germination (Pieper coefficient t_p) was shorter by about 10 hours, compared with the same groups of seeds germinating at $T = 20°C$.

Rye kernels from the 2004 and 2005 harvests had the germination capacity Z_k comparable to that of wheat Z_k, whereas rye seeds harvested in 2003 had lower germination capacity, i.e. $Z_k = 77.2\%$ for the control group and $Z_k = 78.2\%$ for the biostimulated group. Germination took place at $T = 15°C$. Laser treatment also increased the germination rate S_k of rye grains harvested in 2003 and 2005, germinating at $T = 15°C$, and decreased the germination rate S_k of kernels from

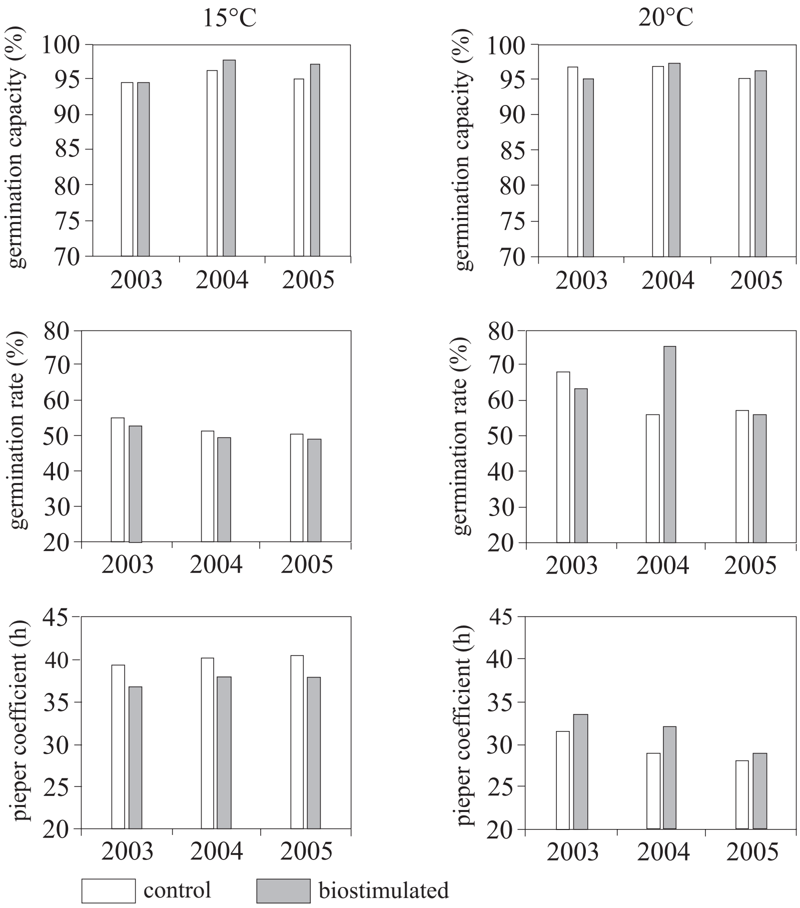

Fig. 3. Germination capacity Z_k, germination rate S_k and Pieper coefficient t_p (mean time of single seed germination) of wheat seeds germinating at 15°C and 20°C, harvested in 2003, 2004 and 2005

the 2004 harvest, while at $T = 20°C$ the germination rate decreased by 1% to 4% compared to the control in all grain groups. The mean time of single seed germination (Pieper coefficient t_p) was shorter by approximately 3 hours in all biostimulated rye seed groups that germinated at $T = 15°C$ and $T = 20°C$. Only the kernels obtained in 2004, germinating at $T = 20°C$, had an insignificantly higher Pieper coefficient than those of the control group.

Conclusions

The analysis of the obtained results enabled to formulate the following conclusions:

1. The highest germination capacity $Z_k = 97.8\%$ was observed in wheat kernels from the 2004 harvest subjected to laser biostimulation and germinating at $T = 15°C$.

2. He-Ne laser pre-sowing biostimulation with a power density of P = 4mW/cm^2 resulted in an increase (by 19.1%) in the germination rate Sk of wheat seeds harvested in 2004, germinating at T = 20°C, as compared to the control group.

3. The mean time of single seed germination (Pieper coefficient t_p) in wheat and rye from the 2003, 2004 and 2005 harvests, germinating at 15°C, was shorter in comparison with the control group.

4. Due to the inconclusive results concerning the impact of a laser beam with a power density of P = 4 mW/cm^2 on the cereals tested in this experiment, further research is necessary to determine the optimal does of radiation that could positively affect the germination kinetics of the analyzed cultivars of wheat and rye.

References

Daniel A. 2005. *Wpływ przedsiewnej stymulacji nasion pszenicy na proces kiełkowania*. Lublin (praca magisterska).

Daniel W. 2005. *Wpływ przedsiewnej laserowej stymulacji nasion żyta na ich żywotność*. Lublin (praca magisterska).

Dziwulska A., Koper R. 2003. *Wpływ przedsiewnej biostymulacji laserowej na kiełkowanie nasion lucerny siewnej*. Acta Agrophysica, 82: 33-39.

Dygdała Z., Koper R. 1993. *Urządzenie do przedsiewnej biostymulacji nasion światłem laserowym*. Patent UPRP, nr 162598.

Drozd D., Szajsner H. 1997. *Laboratoryjna ocena wczesnych faz rozwojowych pszenicy jarej poddanej działaniu promieniowania laserowego*. Biuletyn IHAR, 204: 187-190.

Drozd D., Szajsner H., Koper R. 1994. *Wpływ biostymulacji laserowej na zdolność kiełkowania pszenicy jarej*. Annales UMCS, Lublin, 29: 217-223.

Dziamba S., Koper R. 1992. *Wpływ naświetlania laserem nasion na plon ziarna pszenicy jarej*. Fragmenta Agronomica, 1/33: 88-92.

Gładyszewska B. 1998. *Ocena wpływu przedsiewnej laserowej biostymulacji nasion pomidorów na proces ich kiełkowania*. Lublin (praca doktorska).

Gładyszewska B., Koper R. 1997. *Effects of the pre-sowing laser biostimulation of seeds of some cultivanted plants*. COST 814-Crops development for the cool and wet regions of Europe. Europea Commision, 225-230.

Gładyszewska B., Koper R., Kornarzyński K. 1998. *Technologia i efekty przedsiewnej laserowej biostymulacji nasion ogórków*. Zeszyty Problemowe Postepów Nauk Rolniczych, 454: 213-219.

Koper R., Mikos-Bielak M., Próchniak T., Podleśny J. 2000. *Wpływ przedsiewnej biostymulacji laserowej nasion łubinu białego na właściwości chemiczne plonów*. Inżynieria Rolnicza, 4(15): 43-52.

Lipski S., Koper R., Kornas-Czuczwar. 1996. *Ocena wpływu stymulacji nasion światłem laserowym na rozwój i plonowanie kukurydzy*. Zeszyty Problemowe Postępów Nauk Rolniczych, 444: 219-224.

Podleśny J., Koper R. 1996. *Wpływ przedsiewnej biostymulacji laserowej nasion wybranych roślin strączkowych na plony i skład chemiczny*. Zeszyty Problemowe Postępów Nauk Rolniczych, 444: 253-261.

Podleśny J., Koper R. 1998. *Efektywność stosowania przedsiewnej obróbki nasion łubinu białego światłem laserowym*. Zeszyty Problemowe Postępów Nauk Rolniczych, 454, 255-262.

Sheppard S.C., Chubey B.B. 1990. *Radiation hornesis of field – seeded broccoli, parsnip and cauliflawer*. Canadien Journal.of Plant Science, 70(1): 369-373.

Translated linguistically by Aleksandra Poprawska Accepted for print 2006.09.22