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INFLUENCE OF PRESOWING LASER RADIATION ON SPRING WHEAT CHARACTERS*

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A b s t r a c t. The objective of the research was to determine the effect of two methods (D and R) and 6 doses of laser treatment on 10 genotypes of spring wheat in the conditions of 2-factor field experiment. The method of randomised blocks with the use of point sowing was applied. During the vegetation the phases of development were observed in both the control plants and the plants exposed to different doses of laser rays. The fully mature plants were harvested. The plants chosen randomly from each individual field were evaluated in terms of 11 morphological characters determining the yield of a grain crop: plant height, total and productive tillering, ear length and ear density, number of spikletes, plant yield (number and weight of grain), ear yield and 1000 grain weight. The obtained results were analysed statistically. The variance analysis showed significant differences among cultivars, and the dose interaction with such morphological characters as the ear length and its density.

The Duncan test was applied in order to determine homogeneous groups. The method of exposure to the laser light D ($4x10^{-3}$ J/cm^2) significantly increased the ear length of the treated plants vs. the ear length of the control plants, whereas the method R ($4x10^{-5}$ J/cm^2) significantly shortened the length of an ear. The D method largely lowered the value of ear density whereas the R method increased the ear density of the exposed plants vs. the same character of the control plants. The reaction of cultivars for both characters, ear length and ear density, was differentiated.

K e y w o r d s: wheat, laser, plant yield, plant characters

INTRODUCTION

Research on the results of pre-sowing biostimulation of plant materials has been carried out for 20 years abroad and for approximately 10 years in Poland. Although the results of the research are not consistent the majority of the authors claim that laser light brings positive results such as faster growth and development of the plant root system, better adaptation to negative environmental conditions, higher resistance to diseases, increase in yield volume and its improved quality [3-5,8].

The results of the laser treatment performed on seeds are diverse depending on species and cultivars. The seeds of vegetables: cucumbers, tomatoes, lettuce, are more sensitive and susceptible to laser stimulation [10,12] than cereals and sugar beet [4,11].

The majority of research on the stimulating influence of laser radiation was carried out on vegetable plants, and less information is available on the impact of the stimulation on cereals. The research carried out on cereals indicated an increase in general and productive tillering after the use of laser. In addition, as a result of laser

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irradiation, the assimilating surface of the leaves increased [1-3,8,9,11].

Other authors, which are in minority, [13] claim that pre-sowing laser irradiation has no stimulating effect on the morphological characters especially for cereals.

Only a limited scope of research has been made so far on the influence of laser radiation on spring wheat. This work therefore comprises trials connected with the application of laser He-Ne to pre-sowing bio-stimulation of seeds, and the study of the influence of laser radiation on the yield structure elements of some chosen cultivars of spring wheat.

MATERIALS

The material for the studies consisted of 10 spring wheat cultivars (Alkora, Banti, Eta, Henika, Hera, Igna, Ismena, Jota, Omega and Sigma).

The genotypes tested in this study are the latest, hight-yielding Polish cultivars of good technological quality. These cultivars were irradiated before sowing with 6 doses of laser radiation. Two methods D and R were used [6,7].

Dose D_I - 4 x 10^{-3} J/cm^2, dose D_{II} - double dose D_I and dose D_{III} - triple dose D_I , dose R_I - 4 x 10^{-5} J/cm^2, dose R_{II} - double dose R_I and dose R_{III} - triple dose R_I, with the use of He - Ne laser, equipped with the device for pre-sowing biostimulation of seeds was used in the experiment [6,7].

A field experiment was performed 3 days after the laser treating, in randomised blocks in three replications at Swojec near Wrocław in 1996. The analysed objects were the control plants and the plants treated with different laser radiation doses.

The sowing was punctual. The following morphological characters were measured : plant height, total and productive tillering, ear length and ear density, number of spikeletes, number and weight of grain per plant, number and weight of grain per ear and 1000 grain weight.

The issues were analysed statistically in order to determine the significance of differences between the cultivars, doses and interaction. With respect to the features in which significant differences occurred the Duncan test was applied in order to determine homogeneous groups.

RESULTS

The data collected in the meteorological station in Swojec-Wrocław are presented in Table 1. The temperatures in the vegetation period were lower than the average multiannual temperature by 0.5°C. March and July were the coldest months in comparison with the multiannual temperatures. The high level of rain precipitation in the vegetation period, especially in June and July might be the reasons for cereal lying, delayed ripeness, development of diseases and for making the harvest of spring wheat plants difficult.

Table 1. Mean temperature of air and rainfall in growing season 1996: (a) of spring wheat and (b) of many years 1968-1995

Month	Mean temperature (°C)		Difference	Rainfall (mm)		Difference
	a	b		a	b	
III	- 0.2	3.2	- 3.4	24.1	26.9	- 2.8
IV	8.2	8.0	0.2	28.5	37.3	- 8.8
V	13.8	13.5	0.3	60.1	53.5	6.6
VI	17.3	16.5	0.8	260.0	73.3	186.7
VII	16.8	18.3	- 1.5	104.6	71.6	33.0
VIII	18.4	17.8	0.6	72.5	72.2	0.3
Mean temperature in growing season	12.4	12.9	- 0.5	-	-	
Sum				549.8	334.8	215.0

The applied analysis of variations characteristic for two-factor experiment carried out with the random block method showed that the examined cultivars, after application of the two irradiation methods (D and R), differed significantly with relation to all eleven morphological characters, i.e., plant height, general tillering and productive tillering, ear length, ear density, a number of spikeletes in the ear, the plant yield and the ear yield expressed as the number and weight of grain as well as 1000 grain weight.

The essential influence of the used doses of D and R methods was observed in the occurrence of cultivars and dose interactions with ear length. The plants which grew from the grains and irradiated with laser light before sowing following the D method had much longer ears than those of the control plants. However, the application of the R method caused significant shortening of ears (Table 2).

The comparison of cultivars for control and doses of laser radiation (Table 3) showed that the D method caused a significant increase in ear length for the following cultivars: Henika, Igna, Jota, Ismena, Omega and Sigma.

The application of the R method caused a significant shortening of ear length for the following cultivars: Alkora, Banti, Eta, Hera, and Sigma (Table 3).

The comparison of two methods for ear density (Table 4) indicates significant decrease in the value after application of the D method and a significant increase of ear density after application of the R method. Reaction of individual cultivars is diverse (Table 5).

The following cultivars: Alkora, Henika, Jota, Ismena, Omega and Sigma reacted to the applied D method by a significant increase in ear density, whereas the cultivars: Alkora, Banti, Eta, Hera and Sigma reacted, to the applied R method with an increase in the value of ear density in contrast to the control plants.

DISCUSSION

In the research concerning the efficiency of irradiation of wheat grains with laser, the positive influence on the increase in plant yield was confirmed in a number of studies [1-3,10,12].

According to Innyushin [4] laser irradiation accelerates plant development and increases the growth in the green substance of plants. Moreover, the author proved, that in the case of cereals, irradiated with laser light before sowing, significantly higher general and productive tillering is observed in comparison with control plants.

Based on other papers [11,12] Drozd [1,2] used three various doses of laser light (ruby laser) in research on five cultivars of spring wheat: Alkora, Eta, Hera, Omega and Sigma. As a result of irradiation, a significant increase in the number of spikeletes in the ear for the Hera cultivar was observed as well as increase in the productive tillering. The influence of laser radiation was observed on the plant height [8, 12]. Opalko *et al.* [8] also confirmed clear stimulation of features characteristic of plant productivity: grain weight per ear, number of grain per ear, grain number and weight per plant, 1000 grain weight, ear density.

The increase in the value of the enumerated features caused an increase in cereal plant yield.

Kasperowitch [5] obtained an increased spring wheat yield after the application of presowing laser biostimulation of grain by 4–21 g/ha in comparison with the plants. Dziamba and Koper [3] examined one cultivar of spring

T a b l e 2. Effect of laser biostymulation upon the ear length (mm). Homogeneous groups

Method D			Method R		
dose	D_{III}	- 110.4	control		- 101.5
dose	D_{I}	- 110.2	dose	R_{III}	- 98.6
dose	D_{II}	- 108.9	dose	R_{II}	- 95.8
control		- 101.5	dose	R_{I}	- 95.5
	LSD = 3.9			LSD = 3.5	

T a b l e 3. Influence of different doses of laser radiation on the ear length (mm) in various wheat cultivars. Homogeneous groups

Method D			Method R		
			Alkora		
dose	D_{III}	- 126.7	control		- 113.7
dose	D_{II}	- 115.7	dose	R_{II}	- 104.3
control		- 113.7	dose	R_{III}	- 104.0
dose	D_{I}	- 111.8	dose	R_{I}	- 103.7
			Banti		
dose	D_{III}	- 109.0	control		- 108.3
control		- 108.3	dose	R_{III}	- 100.3
dose	D_{II}	- 106.0	dose	R_{II}	- 90.3
dose	D_{I}	- 104.3	dose	R_{I}	- 90.0
			Eta		
control		- 112.3	control		- 112.3
dose	D_{III}	- 111.3	dose	RI	- 99.0
dose	D_{I}	- 110.3	dose	RII	- 96.0
dose	D_{II}	- 108.0	dose	RIII	- 95.3
			Henika		
dose	D_{III}	- 131.0	dose	R_{II}	- 115.3
dose	D_{I}	- 126.7	dose	R_{I}	- 113.3
dose	D_{II}	- 123.0	dose	R_{III}	- 112.7
control		- 111.0	control		- 111.0
			Hera		
dose	D_{I}	- 110.7	control		- 109.7
dose	D_{II}	- 110.3	dose	R_{III}	- 100.7
control		- 109.7	dose	R_{I}	- 98.0
dose	D_{III}	- 106.3	dose	R_{II}	- 94.7
			Igna		
dose	D_{II}	- 109.3	dose	R_{III}	- 98.0
dose	D_{I}	- 107.7	dose	R_{I}	- 97.3
dose	D_{III}	- 106.3	control		- 95.0
control		- 95.0	dose	R_{II}	- 90.7
			Ismena		
dose	D_{III}	- 97.7	dose	R_{III}	- 92.3
dose	D_{II}	- 95.3	dose	R_{I}	- 92.0
dose	D_{I}	- 92.3	control		- 89.3
control		- 81.7	dose	R_{II}	- 88.3
			Jota		
dose	D_{I}	- 111.9	dose	R_{II}	- 94.3
dose	D_{II}	- 105.0	dose	R_{III}	- 94.3
dose	D_{III}	- 100.7	control		- 81.7
control		- 89.3	dose	R_{I}	- 81.7

Table 3. Continuation

Method D			Method R		
			Omega		
dose	D_{I}	- 106.3	dose	R_{III}	- 89.0
dose	D_{III}	- 103.0	control		- 88.7
dose	D_{II}	- 102.7	dose	R_{II}	- 87.7
control		- 88.7	dose	R_{I}	- 86.3
			Sigma		
dose	D_{I}	- 121.0	control		- 105.0
dose	D_{III}	- 114.3	dose	R_{III}	- 99.3
dose	D_{II}	- 113.7	dose	R_{II}	- 96.0
control		- 105.0	dose	R_{I}	- 93.7

Table 4. Laser radiation (at different doses) and the ear density. Homogeneous groups

Method D			Method R		
control		- 17.5	dose	R_{I}	- 19.3
dose	D_{III}	- 16.3	dose	R_{II}	- 19.0
dose	D_{II}	- 15.9	dose	R_{III}	- 18.8
dose	D_{I}	- 15.8	control		- 17.5
LSD = 1.3			LSD = 1.2		

Table 5. Pre-sowing laser biostymulation and the ear density in different wheat cultivars. Homogeneous groups

Method D			Method R		
			Alkora		
dose	D_{II}	- 15.8	dose	R_{I}	- 18.0
dose	D_{III}	- 15.3	dose	R_{II}	- 17.3
dose	D_{I}	- 14.7	dose	R_{III}	- 17.3
control		- 13.7	control		- 13.7
			Banti		
dose	D_{III}	- 16.3	dose	R_{II}	- 20.6
dose	D_{I}	- 16.1	dose	R_{I}	- 20.0
dose	D_{II}	- 15.9	dose	R_{III}	- 18.3
control		- 15.5	control		- 15.5
			Eta		
dose	D_{III}	- 17.0	dose	R_{III}	- 20.0
dose	D_{I}	- 16.3	dose	R_{II}	- 20.0
control		- 16.0	dose	R_{I}	- 18.6
dose	D_{II}	- 15.5	control		- 16.0
			Henika		
control		- 16.0	dose	R_{I}	- 16.7
dose	D_{III}	- 14.7	control		- 16.0
dose	D_{I}	- 14.3	dose	R_{III}	- 16.0
dose	D_{II}	- 14.2	dose	R_{II}	- 15.8

T a b l e 5. Continuation

Method D			Method R		
			Hera		
control		- 16.8	dose	R_{II}	- 19.8
dose	D_{III}	- 16.8	dose	R_{I}	- 19.1
dose	D_{I}	- 16.4	dose	R_{III}	- 18.3
dose	D_{II}	- 15.7	control		- 15.7
			Igna		
control		- 19.4	control		- 19.4
dose	D_{III}	- 19.2	dose	R_{II}	- 19.2
dose	D_{I}	- 19.1	dose	R_{I}	- 19.1
dose	D_{II}	- 19.1	dose	R_{III}	- 19.1
			Ismena		
control		- 21.3	control		- 21.9
dose	D_{III}	- 18.0	dose	R_{II}	- 21.9
dose	D_{I}	- 17.7	dose	R_{III}	- 21.9
dose	D_{II}	- 17.5	dose	R_{I}	- 21.5
			Jota		
control		- 21.9	dose	R_{I}	- 21.7
dose	D_{III}	- 17.5	control		- 21.3
dose	D_{I}	- 16.4	dose	R_{II}	- 19.3
dose	D_{II}	- 15.4	dose	R_{III}	- 19.0
			Omega		
control		- 19.5	control		- 20.7
dose	D_{III}	- 16.3	dose	R_{II}	- 20.3
dose	D_{I}	- 16.3	dose	R_{III}	- 19.8
dose	D_{II}	- 15.9	dose	R_{I}	- 19.5
			Sigma		
control		- 15.8	dose	R_{III}	- 17.6
dose	D_{II}	- 16.2	dose	R_{II}	- 17.0
dose	D_{III}	- 15.1	dose	R_{I}	- 17.0
dose	D_{I}	- 14.1	control		- 15.8
LSD = 0.7			LSD = 1.3		

wheat for which He-Ne laser irradiation was applied once, three, five and seven times. The best results were observed for irradiation applied three times. The yield increase ranged from 4 to 17%, 1000 grain weight increased by 4–9% and grain weight per ear increased by 7–37%.

Rybiński *et al.* [9] irradiated barley grain with laser and compared the effect of that operation with the influence of chemical mutagenic substances. Small doses of laser irradiation caused stimulation whereas high doses caused negative changes-reduction of shoot length, plant roots and chlorophyl mutations. According to the authors only small doses of laser irradiation caused positive effects, which may be important for plant production.

There is however no stimulating effect of laser on morphological characters of wheat, which is confirmed with the data obtained by Zubal [13].

The research illustrated in this work on the reaction of ten spring wheat cultivars to different doses of laser light has shown significant effect only for ear length and ear density. The obtained results might have been influenced by the weather conditions in the year of the field experiment. The very high degree of precipitation and lower than the average temperature in the vegetation period might have interfered with the growth and development of the analysed genotypes of spring wheat.

CONCLUSIONS

1. The pre-sowing application of laser light had a significant effect on two morphological characters determining the cereal yield: length and density of ear.

2. The irradiation D method lengthened the ear and decreased the ear density, whereas R method, on the contrary, shortened the length of the ear and increased its density significantly.

3. Reactions of the ten analysed cultivars of spring wheat to both applied methods of irradiation were diverse.

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