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THE EFFECT OF LASER RADIATION ON SPRING WHEAT PROPERTIES

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A b s t r a c t. The objective of the study was to determine the effect of three different doses of laser radiation on the morphological features determining the yield of spring wheat. The field experiment was set up according to the randomized blocks method in Swojec near Wrocław, in 1991. The object of the analyses were control seeds and wheat seeds treated with three doses of laser radiation. Biometric measurements of nine features were performed on plants random sampled from every plot. It was found that among the morphological features of the spring wheat cultivars under study the effect of laser radiation proved to be significant with relation to total and productive tillering, length of ear, weight of grains per ear, and weight of 1 000 grains. In the case of the weight of 1 000 grains, significant interaction occurred between the cultivars and between the three doses of laser radiation. In the case of the very important feature of the yield structure - the weight of grains per ear, dose II ($97.2 \cdot 10^{-3}$ J/cm^2) proved to be a factor significantly increasing the value of that parameter as compared to the control and to the other laser radiation doses.

K e y w o r d s: laser radiation, spring wheat, yield

INTRODUCTION

Laser radiation is a mugenic factor which can stimulate plant growth and development [1,2,4,6]. Laser light is used for presowing irradiation of seeds, since it has been observed that laser radiation has a positive effect on the germination energy and accelerates the growth of germs, which results in faster plant development and, consequently, earlier harvest. Also, better growth and development of the plant root system has been demonstrated, as well as an increase in the assimilative surface area [6,7]. Plants grown from irradiated seeds were characterized by better adaptation to the unfavourable conditions in their environment, were more resistant to diseases and drought, and displayed increased winter hardiness. Some authors [2,4] showed also that laser irradiation of seeds had an effect on the yield determining properties in cereal plants. In their studies the authors observed an increase in productive tillering, in the weight of grains per ear, in the weight and number of grains per plant, and in the ear length. Also, a favourable effect of laser radiation was observed on the quality of crops, since it increased the accumulation of metabolites, especially sugars and protein. The stimulating effects of laser radiation depend on the radiation dose, and also on the species and cultivar of the plants subjected to it. The highest sensitivity and susceptibility to laser radiation is displayed by vegetables, and lower by cereals [3,7].

The objective of the study was to investigate the effect of various doses of laser radiation on the yield-determining features of several cultivars of spring wheat.

MATERIAL AND METHODS

The grain of five Polish varieties of spring wheat - Alkora, Eta, Hera, Omega and Sigma, was irradiated, before sowing, with three different doses of ruby laser radiation (power rated at $30 \cdot 10^{-3}$ W): dose I - $9.2 \cdot 10^{-3}$ J/cm^2, dose II - $97.2 \cdot 10^{-3}$ J/cm^2, dose III - $388.8 \cdot 10^{-3}$ J/cm^2. Irradiated seeds

and control cultivars were sown in Swojec near Wrocław in 1991. The field experiment was set up according to the method of randomized blocks, in three replications, using single-seed sowing with 20 x 10 cm spacing. The object of analyses were control plants and plants grown from seeds treated with three doses of laser radiation. The plants were harvested at full ripeness, and random selected single plants were used to perform biometric measurements of features affecting the structure of cereal crop yield, such as: 1 - plant height (cm), 2 - total tillering, 3 - productive tillering, 4 - ear length (mm), 5 - ear firmness, 6 - weight of grain per plant (g), 7 - number of grains per ear, 8 - weight of grains per ear (g), 9 - weight of 1 000 grains (g). The results obtained were processed statistically in order to determine the significance of differences between the cultivars, the doses of laser radiation, and to determine where there is any interaction between the cultivars and the doses applied. With respect to features in which significant differentiation occurred, the Duncan test was applied in order to determine homogeneous groups.

RESULTS

Variance analysis of the results obtained has shown that in the case of plant height (Table 1), significant differences were observed only between the cultivars. No significant effects of the laser radiation doses were observed, nor any interaction between the doses applied and the cultivars. In the case of total tillering and productive tillering, significant differences occurred for both the cultivars and the laser radiation doses, like in the case of the ear length, where no interaction between laser radiation doses and cultivares occurred, either. The ear firmness was the feature for which significant differentiation occurred only with relation to the cultivars, and similar variance analysis was obtained for the weight of grains per plant. For the number of grain per ear, the variance analysis showed a lack of differentiation with respect to the cultivars as well as the radiation doses, plus no interaction, while for the weight of grains per ear a significant differentiation was found with relation to both the cultivars and the laser radiation doses. The weight of 1 000 grains was the only feature for which significant differentiation occurred for both the cultivars and the laser radiation doses, as well as significant interaction between the cultivars and the radiation doses. The Duncan test showed that, for both the total and the productive tillering, dose I resulted in obtaining higher values than was the case with doses II and III. Also for the ear length, doses II and III caused a decrease in the values of the feature as compared to the control and to the seeds treated with dose I. For the weight of grains per ear, dose II of laser radiation caused an increase in the values of the property, while the control, and doses I and III, formed another homogeneous group of a lower value. The weight of 1 000 grains was the highest after the application

Table 1. Variance analysis for the morphological features under study

Variation	Sum of squares	Degrees of freedom	Mean square	F	α
			Plant height		
General	1107.00	59	18.77		
Error	328.50	38	8.65		
Blocks	7.80	2	3.90		
Cultivars	710.10	4	177.53	20.53	0.00*
Laser doses	14.55	3	4.85	0.56	0.64
Interaction: cultivars x laser doses	46.45	12	3.87	0.45	0.93

Table 1. Continued

Variation	Sum of squares	Degrees of freedom	Mean square	F	α
		Total tillering			
General	119.10	59	2.02		
Error	40.03	38	1.11		
Blocks	15.77	2	7.89		
Cultivars	39.47	4	9.87	8.92	0.00*
Laser doses	13.36	3	4.45	4.03	0.01*
Interaction: cultivars x laser doses	8.48	12	0.71	0.64	0.79
		Productive tillering			
General	88.18	59	1.49		
Error	30.13	38	0.79		
Blocks	9.76	2	4.88		
Cultivars	29.14	4	7.29	9.19	0.00*
Laser doses	10.91	3	3.64	4.59	0.00*
Interaction: cultivars x laser doses	8.24	12	0.69	0.87	0.59
		Ear length			
General	1 529.00	59	25.91		
Error	368.20	38	9.69		
Blocks	432.40	2	216.22		
Cultivars	435.90	4	108.98	11.25	0.00*
Laser doses	137.70	3	45.91	4.74	0.00*
Interaction: cultivars x laser doses	154.60	12	12.88	1.33	0.24
		Ear firmenss			
General	96.43	59	1.63		
Error	17.9	38	0.47		
Blocks	12.87	2	6.44		
Cultivars	56.91	4	14.23	30.05	0.00*
Laser doses	54.27	3	18.09	38.00	0.76
Interaction: cultivars x laser doses	8.11	12	0.68	1.43	0.19
		Weight of grains per plant			
General	523.60	59	8.87		
Error	223.70	38	5.89		
Blocks	49.35	2	24.67		
Cultivars	172.50	4	43.11	7.32	0.00*
Laser doses	28.09	3	9.36	1.59	0.21
Interaction: cultivars x laser doses	49.95	12	4.16	0.71	0.74
		Number of grain per ear			
General	1 800.00	59	30.51		
Error	927.50	38	24.41		
Blocks	74.53	2	37.27		
Cultivars	247.40	4	61.85	2.53	0.06
Laser doses	204.70	3	68.24	2.80	0.05
Interaction: cultivars x laser doses	346.00	12	28.84	1.18	0.33

Table 1. Continued

Variation	Sum of squares	Degrees of freedom	Mean square	F	α
		Weight of grains per ear			
General	3 270	59	0.055		
Error	1 340	38	0.035		
Blocks	0.041	2	0.020		
Cultivars	0.412	4	0.103	2.92	0.03*
Laser doses	0.879	3	0.293	8.31	0.00*
Interaction: cultivars x laser doses	0.599	12	0.049	1.41	0.20
		Weight of 1 000 grains			
General	463.20	59	7.85		
Error	169.30	38	4.46		
Blocks	1.49	2	0.75		
Cultivars	87.86	4	21.96	4.93	0.00*
Laser doses	94.04	3	31.35	7.03	0.00*
Interaction: cultivars x laser doses	110.50	12	9.21	2.07	0.04*

*Significant at P=0.05

of dose II, while it was significantly lower for doses I and III. Significant interaction substantiated these relationships, especially in the case of the Alkora and Eta varieties.

DISCUSSION

Publications dealing with the problem of the stimulating effect of laser radiation on the growth and development of cereal plants are relatively scarce. Most of the studies on this particular application of lasers were conducted on vegetable plants which turned out to be more sensitive to He-Ne radiation than other species of crop plants. A relatively large number of publications can be found in the Russian literature, where studies of this kind were conducted on a larger scale, but none of those provides information on the optimum time of irradiation. It has only been stated that the best results are obtained with the application of pulsating He-Ne light (red-blue) [4,6,7]. In studies on the effectiveness of laser irradiation of wheat grain, only in a few of them a positive effect was observed on the early emergence, growth, and crop yield of the plants [2,4]. According to Inyushin and Vasilienko [2,5], laser radiation causes an increase in the total and productive tillering of plants. This is supported by other authors [1,4,6], as well as by the authors' own studies. An effect of laser radiation on the height of plants was also observed [4,6], but this has not found confirmation in these studies, as none of the laser radiation doses applied caused any significant differentiation in this property.

Opalko *et al.* [4] reported stimulation of the properties characterizing the productivity of plants - the weight and number of grains per ear, the yield of grains per plant, and the weight of 1 000 grains. In the authors' own studies discussed here, the application of dose II caused an increase in the weight of grain per ear and in the weight of 1 000 grains. The studies by Zubal [7], however, showed a lack of stimulating effect of laser radiation on the morphological features of wheats, which can be explained by the weather conditions in the course of the vegetation period. Inyushin [2] observed an increase in the yield of wheats of up to 20 %, and Vasilienko reports that irradiating wheat seeds three times caused a yield increase of up to 45 %. It seems that more

substantial information of the effect of laser radiation on wheats can be obtained after conducting experiments over several vegetation seasons, so as to eliminate the effect of the weather factor which may affect the results obtained.

CONCLUSIONS

1. Out of the nine morphological features of the spring wheat cultivars under study, laser radiation proved to have a significant effect on the total and productive tillering, on the length of the ear, and on the weight of 1 000 grains.

2. In the case of the important feature affecting the yield structure - the weight of grains per ear, dose II ($97.2 \cdot 10^{-3}$ J/cm^2) proved to be a factor increasing the value of that parameter with relation to the control and to the other laser radiation doses.

3. The weight of 1 000 grains was that property for which significant interaction was observed between the cultivars and the three laser radiation doses applied in the study.

4. Dose II, proved to be a factor significantly increasing the value of the weight of 1 000 grains with relation to the control and to the other laser radiation doses, especially in the case of the Alkora and Eta varieties.

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