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ORIGINAL PAPER

The influence of modulated red laser light on seedlings of some annual ornamental species (*Dianthus caryophyllus* and P*etunia hybrida*)

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Abstract

The modulation of the laser light by an audio field leads to a complex source that stimulates the vegetative growth and flower development , in a relaxing and unstresfull mode. Red light laser in the spectral range of 660 nm – 680 nm is a very important source, considering the strong absorption bands of chlorophylls "a" and "b" in this type of plants. The development of an experimental device using the high power of a red light laser diode of 200mW output power, modulated simultaneously by the audio field, with an aimed arm, a support and the electronic source. This experimental device is not expensive and can be used in all green-houses without special environmental conditions.

The S1- seedlings of Dianthus caryophyllus L. -cv. Feuerkőning, Fam. *Caryophyllaceae and S2 – seedlings of Petunia hybrida Vilm.* Fam. *Solanaceae, line L7, used in breeding at SCDLBuzau, were tested in our experiments, each of them in 3 variants for three exposure times (5, 7 and 10 min), corresponding to the laser doses (0.7, 1.0 and 1.4 J/cm2).*

Key-words: red laser light diode, light stimulation of plant, light and audio field simultaneously modulated, light treatment of plants

Introduction

Light is to plants both a source of energy and information. It is a source of energy for photosynthesis and a source of information for photoperiodism (night / day), phototropism (light direction) and photomorphogenesis (quantity and quality of light)[1].

Use of laser radiation on seeds results in a series of positive effects: stimulation of plant growth during all stages of vegetation, reducing germination time, increasing the number of flowers per plant, qualitative and quantitative increase of production, etc.[2,3,4].

Laser radiation interaction with biological environment has specific features due to laser radiation characteristics, involving physical and biological aspects [5].

In experiments conducted with continuous laser light and laser light modulated at audio frequencies [6], it was found that when laser radiation are used, doses of up to 2 J/cm2 are sufficient for plant irradiation, with positive effects on plants.

The purpose of this experiment was to determine the effect of audio modulated laser radiation on two annual ornamental species - *Dianthus caryophyllus L. Fam. Caryophyllaceae* and *Petunia hybrida* Vilm*. Fam. Solanaceae.*

Material and method

Biologic material. As biologic material the two annual ornamental species chosen for experimenting were P*etunia hybrida*, Fam. *Solanaceae* and *Dianthus caryophyllus,* Fam. *Caryophyllaceae,* because they have a great decorative value, thus being highly appreciated by farmers and by hobbyists.

Petunia hybrida Vilm*. line L7,* used by SCDL Buzau in breeding, was selected for testing. The P*etunia hybrida* plants are annual, glandulous hairy, herbaceous, sufrutescente. Growth is high, erect, with funnel-shaped flowers, simple, rich and persistent bloom. It blooms from July to fall first frost.

Dianthus caryophyllus L. – CHABAUD series, *-cv. Feuerkőning,* – is characterized as being decorative by abundant red flowers with sweet fragrance, long period of flowering (from June until late fall).

Experimental scheme. Three different experiments were established with various doses of radiation, comparing to untreated control. Time source of radiation exposure and height varied in correlation with plant height.

Petunia hybrida and *Dianthus caryophyllus* seedlings were supplementary treated with red laser radiation and audio field synchronously modulated in the following experimental variants:

- 3 **variants** corresponding to the three different exposure times: **5, 7 and 10 minutes** for which the irradiation dozes are respectively : 0.69 J/cm^2, 0.96 J/cm^2, 1.38 J/cm^2

- Every variant has 10 repetitions (1 repetition= one 7 cm diameter pot having 2-4 seedlings).

- During the experiments, the treatment was applied three times for each variant, at 7-10 days intervals, beginning when the seedlings had 3-5 leaves and 5-7 cm in height.

For each variant 10 repetitions were used (1 repetition = 2-4 seedlings in a 7cm Ø pot).

All experimental variants were placed in the same environmental conditions (acclimatized chamber), 27^{0}C, relative humidity of 65% and photoperiod of 18 hours illumination/6 hours dark.

Monitoring was performed by studying the growth capacity of seedlings, determining the height, number of leaves and development of flower stems.

Experimental device. Laser radiation has special features: it is monochromatic, coherent and polarized. In these experiments a laser diode was used, emitting on red with 3-4 nm width, some mm coherent length and 99:1 polarizing order. The output power is 180 mW.

The device (**Fig.1**) generating the necessary fields to be applied on plants includes a laser diode able to generate 660 nm, 200 mW beams, an audio system (radio, CD, tape) and adequate electronics.

The laser diode is supplied by a constant current source or, alternatively, it uses a constant but low current and a variable superposed current what is modulated by audio signal.

The cw operation of laser diode was fixed as:

- Voltage: 5.35 volts
- Current: 300 mA
- Laser power: about 180 mW.

The modulated operation was carried out using audio signal generated by the radio.

It was amplified and superposed on the cw current of 50 mA, which is the threshold of laser effect. The amplitude of modulated voltage is superposed so that the corresponding current does not exceed 300 mA.

The divergence of laser beam is about 0.1 miliradians. A divergent lens increases the divergence so that the diameter of the beam to be 20 centimeters at one meter distance. That was necessary to illuminate a specified surface of a plant.

The experiments were done using classical music with intensity levels agreeable for people, too.

The Laser head is inside a cylinder on a mobile arm. The **Clamping system** type **"mobile arm"** allows the adjustment the distance between the laser diode system and the exposure area. The exposed surface is chosen according to the size of plants to be irradiated and can be adjusted using the mobile arm.

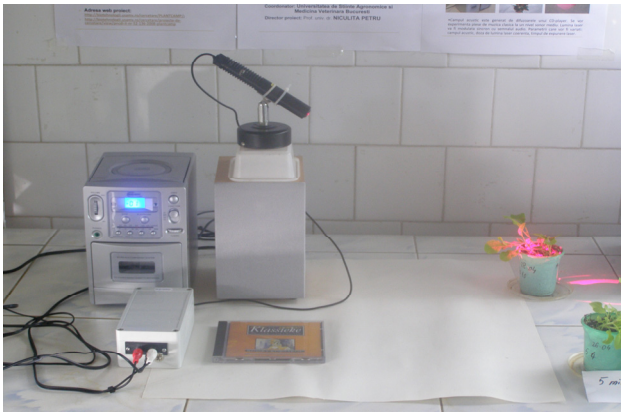

Fig. 1. Experimental device and illuminated plants

Results and discussions

Table 1 presents the results regarding the growth and development capacity of *Petunia* plants after the treatment with red laser irradiation and audio filed simultaneously modulated.

Table 2 presents the irradiation doses corresponding to different exposure times and different distances between the illuminated surface and the illumination source. All these values were obtained for specific surfaces in which the illumination is homogeneous (**Fig.1**). Also these values were obtained for different distances between the laser head and the illuminated surface, because the laser head has an optical system which expands the light over all surfaces.

Table 1. Growth and development capacity after irradiation in *Petunia hybrida* L7 compared to the control (for each variant and repetition).

Var.	Repetition average	Height average (cm)	No. of leaves average/plant	No of flowers average /plant
V1	R1- R10	22.7	17	1
V2	R1- R10	17	14	0
V3	R1- R10	16	13	0
VM	R1- R10	13	12	0

Variants:
V1= 5 minutes of exposure time and dose of 0.88J/cm^2;
V2= 7 minutes of exposure time and dose of 1.23 J/cm^2;
V3= 10 minutes of exposure time and dose of 1.75 J/cm^2;
VM **= control (**untreated).

Exposure time range for which the doses were calculated varies from 1 minute to 2 hours, and the distance range between the laser head and illuminated surface is between 15 cm to 50 cm, which corresponds to 23 cm^2 and 142 cm^2, respectively. In our experiments the distance of 35 cm was used, which corresponds to an illuminated surface of 78.5 cm^2. **Graph. 1** shows the morphological results for the three variants, 10 repetitions for each of them and three exposure times corresponding to three irradiation doses.

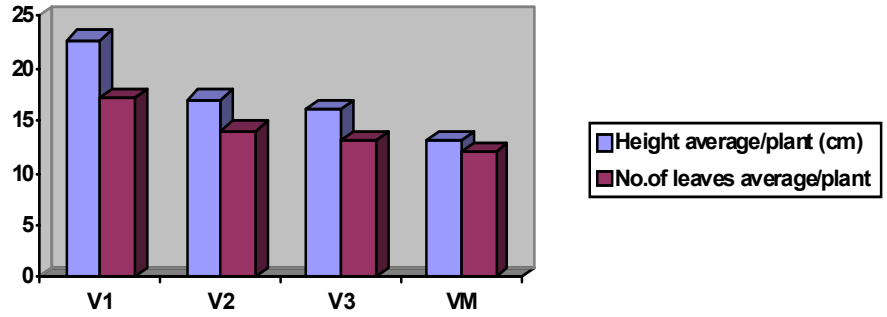

Fig. 1. Plant average height and average no. of leaves /plant determined for *Petunia hybrida* line L7

Table 2. Doses vs. exposure time for different distances between the illuminated surface and the red laser diode

T(min)	Doze (J/cm2)							
	L= 15 cm	L=20 cm	L=25 cm	L=30 cm	L=35 cm	L=40 cm	L= 45 cm	L=50 cm
1	0.47	0.32	0.23	0.18	0.14	0.11	0.09	0.08
2	0.93	0.64	0.46	0.35	0.28	0.22	0.18	0.15
3	1.40	0.96	0.69	0.53	0.41	0.33	0.27	0.23
4	1.87	1.27	0.92	0.70	0.55	0.44	0.36	0.31
5	2.33	1.59	1.16	0.88	0.69	0.55	0.46	0.38
10	4.67	3.19	2.31	1.75	1.38	1.11	0.91	0.76
15	7.00	4.78	3.47	2.63	2.06	1.66	1.37	1.14
20	9.34	6.37	4.62	3.51	2.75	2.22	1.82	1.53
25	11.67	7.96	5.78	4.38	3.44	2.77	2.28	1.91
30	14.01	9.56	6.94	5.26	4.13	3.32	2.73	2.29
35	16.34	11.15	8.09	6.14	4.82	3.88	3.19	2.67

These results illustrate the growth and development in treated plants, the morphological characters being counted after 14 days from the third treatment. From this graph it can be noticed that good results were obtained for the smallest dose (0.69 J/cm^2). This means that for a good development of these plants little irradiation with red light is necessary, because the productivity is high. If the dose increases, it can be observed that the plants do not have a good development. On the contrary, they stop growing. Also, a stimulated behavior is observed for all treated variants comparing to the control. **Fig. 2** shows plants treated for 5, 7 and 10 minutes.

Fig. 2. Three exposure time ranges (5, 7, 10 minutes) selected for treated petunia seedlings

Fig. 2. Shows that the plants which were irradiated only for 5 minutes have a good development, with more leaves and they are more vigorous than the one irradiated for 10 minutes.

Fig. 3 shows more plants from the treated variants, compared to control of non-irradiated petunia and dianthus plants. It can be observed that the plants in the control variant are smaller in size in comparison with the irradiated seedlings.

A.)  B.) 

Fig. 3 More irradiated seedlings compared to the control of non-irradiated petunia(A) and dianthus (B) plants after 2 month of cultivation.

Conclusions

a) For *Petunia* plants the most effective dose of radiation was found to be 0.88J/cm2, corresponding to the suitable variant V1, because they have significant positive differences in terms of growth rate, number of formed shoots and number of leaves formed. Influence of laser radiation is therefore beneficial for all studied and determined characteristics.

b) The maximum dose of 1.75 J/cm2 selected in V3 does not increases the number of shoots and flowers, and also it has negative or no influence on the plant height.

c) The present research will continue to consolidate the results and to identify new treatment options with laser radiation, having an ecological, unstressful and stimulating effect on plant growth and development. We consider that the petunias treated with laser radiation and audio field simultaneously modulated proved to be the species that reacted fastest and most powerful to radiation. The speed and magnitude of plant response was remarkable.

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