"The Influence of Electromagnetic Radiations on the Cellular Metabolism of Some Species of Vegetables"

General considerations

In the current context, of the exponential growth of the population, of the increased greenhouse effect, of the land and water pollution, of the exhausting of nutrition resources, it is necessary to find solutions for the nutrition safety, which can cover the nutrition deficit of the world's population, using minimum financial resources.

The highest goal for the systems of plant production is to develop innovative and efficient technologies, which reduce the production costs, ensure maximum of productivity, preserving the natural resources and protecting the environment.

Although the research regarding the influence of LEDs on the growth and development of plants are spread around the world, there are still a lot of aspects to discuss in regard to the influence of LEDs on the quality of the plants, and the studies about the LEDs influence on the hydroponic cultures are extremely rare.

Original research

In the present paper, I have studied the effects of electromagnetic radiations produced by LED diodes from the spectral domain 350 nm -750 nm onto the cellular metabolism of some species of vegetables.

The purpose of this paper was to make more efficient the production of vegetables widely used, in bio conditions, with little energy.

The objectives of the study were:

The influence of artificial lighting using LEDs on the germination and growth of the tomato, cucumber and lettuce plants

The influence of spectral quality of light on each species chosen in different stages of vegetation

The influence of the electromagnetic radiation on the cellular metabolism in general and on the enzymes' activity in particular

MATERIAL AND METHOD

The biological material used in the research was 3 species of vegetables:

- Tomato species Lycopersicon esculentum L.
- Cucumber species (Cucumis sativus L.)
- Species Lactuca sativa L. fam Compositae (Asteraceae).

Tomato species Lycopersicon esculentum L.- the type used: hybrid Cindel F1

Cucumber species (Cucumis sativuc L.) – the type used: hybrid Pyralis F1

Lactuca sativa L. with the varieties: Lollo Bionda, Lollo Rossa, Murai RZ, Markies.

The extremely rich variety of organic substances and minerals that vegetables contain gives this demanded category of products an effective nutritional value. Still, the content of vitamins and mineral salts of vegetables is very important, because they ensure the physiological balance of the human body, which gives these products a therapeutic value. The vegetables chosen for this study are among those widely used.

Experimental conditions: the study was performed, in conditions of controlled environment, ensuring a constant temperature and humidity; in Hortinvest greenhouses, in one of the cells with installations for hydroponic cultures.

In both locations, the photoperiod was 16 hours during day time and 8 hours dark\night.

The lighting sources used for the experiments were: fluorescent tubes, producing white light (Ne), LED panels with polycolors light.

Experimental variants: In all experiences, the control variant V1 was the biological material lighted with white light (neon). The other variants resulted from combing in different ratios the radiations emitted by LEDs with ***λ 660 nm*** red, 450 nm blue, 520 nm green.

Working methods: determination of seed germination according to ISTA norms, 2006;

The variation of morphological parameters was determined by biometrical measurements.

The biochemical analyses were conducted in the Enzimology Lab through the methods described in chapter 4 of the paper.

The statistical interpretation of the data was made through Anova method and Microsoft Excel Program.

RESULTS AND DISCUSSIONS:

1. The analysis of the influence of the electromagnetic radiation on germination, following which we established the wavelengths that are more favorable to increasing the germination percentage and to shortening of the germination period

The analysis of the germination of the tomato seeds at the end of the trials underlined some aspects that we took into consideration when choosing the LED variants for which we continue the experiments.

- The highest percentage of germination was that of the seeds exposed to LEDs red 75% and blue 25%, which germinated 122,5% compared to the control variant
- The seeds exposed to the green light had the lowest percentage of germination (81%) for the variants with 50% green light, with only 3% above the limit recorded at 10 days, as compared to the control variant.

Based on the experimental results of the analysis of the germination of the cucumber seeds we can make the following observations:

- The highest percentage of germination at 4 days was that of the V2 variant (red LEDs 100%), for which the germination was 60%, higher than the control variant (53%) with 7%. To be noted is the fact that for V3 variant (red LEDs 75% and blue 25%) it has been obtained a good result (109,3%) compared to the control variant (V1 neon), which was taken as a reference (100% germination)
- The seeds exposed to blue and green LEDs germinated in a lower percentage than the control variant.

According to the determinations made during 2012 – 2013 on lettuce seeds from varieties Murai RZ, Lollo Bionda and Lollo Rossa the following conclusions have been reached:

- ✓ The highest percentage of germination at 4 days was noticed at the variant exposed to red LEDs 75% and 25% blue, at all three varieties of lettuce studied.
- ✓ Good result have been obtained also with the variants in which the seeds were exposed to blue LEDs 50% and red 50%, which germinated over 100% compared to the control variant
- ✓ The seeds irradiated with blue and green LEDs germinated in a lower percentage than the control variant with fluorescent light (Ne).
- ✓ The best results were obtained for the interval 50 -75% red LEDs and 25 – 50% blue LEDs, therefore I consider that the following determinations should be made in this irradiating interval, in a ratio of 1:1 red and blue

2. The study of the light influence on the morphoanatomic parameters of the tomato, cucumber and lettuce seedlings

From the experiments made for the tomato plants, we emphasize: As to the influence of light on the dynamics of leaf formation, V3 variant (50% R+ 50% B) had the best results during the three repetitions, the total number of leaves at the end of the experiments being 8, 37, 21% higher than the control variant. As to the height evolution of the plants exposed to different light conditions, V3 variant (50% R+ 50% B) stimulated best the tomato plants, the seedling produced having 31 cm on the average of the three experiments. As to the morphological characteristics of cucumber plants resulted in the experiments, the V3 LED variant (50% R+ 50% B) influenced significantly positive the growth of the cucumber plants. As to the growth of lettuce plants under different light conditions, the LED lighting variants influenced significantly different all the studied variants, as follows:

Lollo Bionda type had a very good growing rate at variant LED 70% red + 30% blue

Murai RZ type was mostly influenced by LED 70% red + 30% blue

Lollo Rossa type behaved similarly, being influenced significantly positive at variant 70% red + 30% blue

The evaluation of the development of tomato seedling in greenhouses emphasized that LED lighting, applied in the seedling stage determined a better development of plants compared to the seedling exposed to fluorescent light (neon). There were also differences in plant development between the two variants of LED lighting, so that variant 50% R+ 50% B influenced the most the morphological parameters of the tomato plants.

The evaluation of the development of the lettuce plants in greenhouse on hydroponic cultures in different light conditions emphasized distinct dynamics in the evolution of the morphological parameters. Thus, the best evolution in the dynamics of leaf formation, plant weight and total number of leaves was recorded in V2 variant (70% red + 30% blue). The root length, the height of the plant and the head diameter had the highest values for the variant 50% red + 50% blue. These evolutions were different in terms of both lighting conditions and the variety of the studied species.

3. The analysis of the effects of the electromagnetic radiation on the biochemical content in the studied plants. The comparative analysis of the dry mass content of the tomato plants shows a 10.2% increase at the variant 50R+50B, compared to the control variant. The highest increase in dry mass was recorded in V3 variant (50R+ 50B), with a 8,8% percentage. The lowest content of dry mass was found in the variants under LEDs 70%R – 30%B (7,6%).

The lighting of tomato crops with polychromatic light according to the characteristics of V3 LED 2 50R+50B and V2 LED 1 R70 – R30 determined a decrease in the content of glucides of about 10% - 20% compared to the control variant. The high content of glucides in the tomato plants exposed to fluorescent light (Ne) shows the extreme maturation of the plants – that is the aging of the seedling.

The high content of invertase in plants indicates the fact that these are not fully maturated (they are raw). The results show that the plants grown under fluorescent light (Ne) have the highest content of invertase, meaning 0, 814 μmol\ day\min\g, compared to plants grown under LED light. The protein accumulation is maximum in the growth periods of the plants when energy is essential to all the processes that take place in plants, especially to photosynthesis.

Thus, the proteic concentration in the tomato plants lighted by LED 250R + 50B is, on average, 1,23 higher compared to the plants under neon and 1,13 higher compared to the plants under LED1. 1 R70- R30. As such, we can say that the higher percentage of red light influences positively the accumulation of organic substances, meaning proteins and pigments.

Peroxidase is an enzyme which catalyses the degradation of some peroxides, which are toxic compounds, present in plants as a defence reaction against the action of some factors of biotic and abiotic stress. For the tomato plants lighted by LED1 we obtained the lowest values of

the peroxidase activity, and the highest value was obtained for the plants under fluorescent lamps. These results emphasize the stress produced by the fluorescent light neon compared to the light emitted by LEDs.

For the cucumber plants, we have the following results: the plants developed under LED light have the highest content of invertase, meaning 0,146 μmol\day\min\g, compared to the plants developed under fluorescent light, which have a content of invertase of only 0,035 μmol\day\min\g. These values show that, although the seedling developed under LED light is good for transplantation, in the plants there are still transformations that lead to a afterward development which is very good compared to that of the plants in the control variant neon light, which are almost at the end of their development, being aged.

The results clearly confirm the specialized literature by the fact that blue LEDs are far more efficient for the synthesis of the biochemical compounds. For all the species there has been noted an increase in the content of nutrients (vitamin C and carbohydrates) when using LEDs with 40% blue light and 60% red light.

In addition, the combination of blue and red LEDs is an efficient source for photosynthesis, if we take into consideration the higher content of chlorophyll in the plants grown under LED light, compared to those grown under neon light. Irrespective of the LED light variant to which the plants were exposed, at harvest they had similar characteristics, similar size, vigor and a fresh and pleasant appearance.