

THE INFLUENCE OF DIRECT CURRENT DISCHARGES ON VEGETAL ORGANISMS EXPOSED DURING EARLY ONTOGENETIC STAGES

Iuliana Motrescu¹, C. Astefanoaei², C. Nadejde², D. E. Creanga², G. Stoian³

¹"Ion Ionescu de la Brad" University, Biophysics Department, M. Sadoveanu Street, 700490, Iasi

²"Al. I. Cuza" University, Faculty of Physics, 11A Blvd. Carol I, 700506, Iasi, Romania

³National Institute of Research & Development for Technical Physics, 47 Mangeron Blvd, 700050, Iasi

Abstract

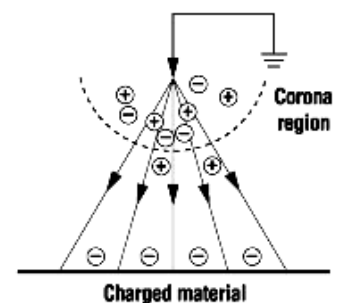
The impact of direct current pulses on vegetation was studied in the frame of laboratory experiment, based on sunflower response to electromagnetic stress. The direct current device delivers short pulses (40 ms) of relative high amplitude (15 kV) between a point electrode and a plate one. Plant seedlings during their early ontogenetic stages were exposed to various numbers of electric pulses for five consecutive days. The influence on the photosynthesis was studied by measuring the fresh substance mass, the dry substance and the water accumulation at the end of the experiment. The chlorophyll ratio was assayed, since the ratio chl_a/chl_b may be taken as an indirect indicator of photosynthesis efficiency.

Key words: direct current pulses, sunflower plantlets, chlorophyll ratio

1. Introduction

Electromagnetic stress seems to be more and more an actual threatening for the ground biosphere in the modern era. The Earth natural magnetic fields, as well as atmospheric electric discharges between cloud dipoles, are concurred by the emissions of Radio, TV and radar stations, and by corona discharges, generated because of imperfect electric insulation of high voltage energy transmission lines. Since both magnetic fields and electric discharges are often acting upon the agricultural crops (grains and trees cultures), the study presented bellow is focused on the response of young sunflower plants to these overlapped stimuli.

Physical background: If high voltage applied between two electrodes in dielectric medium, the only current flowing is very small, due to few ions always present due to ionizing radiation. If the voltage is increased above ionization threshold, some present ions are accelerated to speeds, where each collision with neutral molecule result in its



ionization. As result, an avalanche of ionizations occurs and whole medium becomes ionized. This high field density is difficult to achieve if electrodes are equally sized and far apart. However, if one of the electrodes is very small, thin or sharp (such as wire), field density near its surface is very high and ionization can occur at moderate voltages, while second electrode (collector) has no sharp edges and no ions are generated there. What happens then is the effect called corona discharge.

2. Method and samples

Electrical device: Laboratory electrical device, designed and assembled to generate electrical pulses with controlled physical parameters, was utilized to obtain corona discharge. Between the plate electrode and the pointed one, a dielectric sheet is placed. Positive polarity was stated, while triangular pulses amplitude was chosen of 15 kV.

Electrical exposure: Plant samples, i.e. Petri dishes with 50 sunflower plantlets each, freshly germinated from seeds with uniform genophond – as provided by single plant, were placed one by one between the two electrodes, in order to apply corona pulses: 5, 10 and respectively, 20 pulses applied with 20 seconds pauses. The plant exposure was carried out every two days until plants were aged of 14 days. Pointed electrode was brought practically in contact with one plantlet top, the electrical discharge propagating through all the other plantlets in the exposed sample.

Biomass and chlorophyll analysis: Fresh substance mass and dry mass of the plantlets, grown for 14 days under the impact of direct current discharge, were weighted using a semianalytical balance with 10^{-4} g accuracy. Plantlet drying was carried out at 100°C , in adequate electric oven. Water accumulation was estimated as the difference between the fresh and respectively dry mass values. The contents of chlorophyll a, chlorophyll b and carotene like pigments in green tissue extracts in acetone 85% was assayed using Meyer-Berthenrath method [3] by means of light extinctions at two wavelengths (645 nm and 663 nm); Shimadzu spectral device was used.

Statistical analysis: Five repetitions of every measurement were accomplished in identical conditions; statistical analysis was performed by means of t-test, considering the significance threshold of 0.05.

3. Results and discussions

In Fig. 1 the average values and standard deviations of the biomass measurements are represented. Slight (but significant, $p < 0.05$) stimulatory influence, of 10 direct current pulses on the vegetal mass, was noticed, followed by inhibitory influence of double number of pulses (statistical non significant).

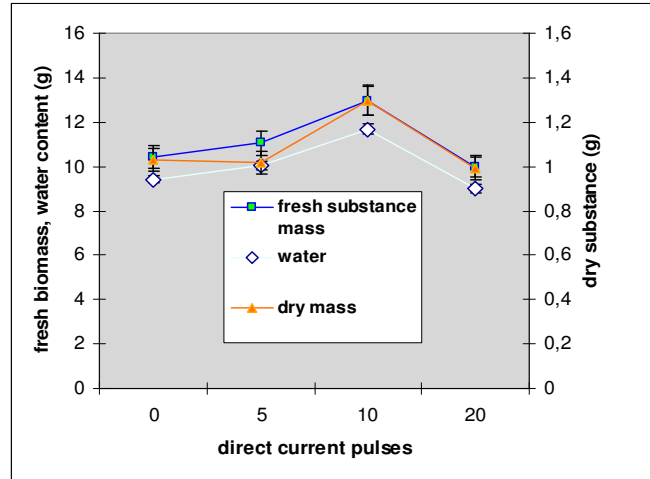


Fig. 1. Fresh substance mass, dry mass and water accumulation in the plantlets exposed to direct current pulses

The sum of pigment content was found non significantly changed, while the chlorophyll ratio was diminished in the exposed samples, in comparison to the control ($p < 0.05$). This biochemical parameter is known to provide indirect information on the activity of the enzyme complex LHC II (light harvesting complex II) from the plant chloroplasts.

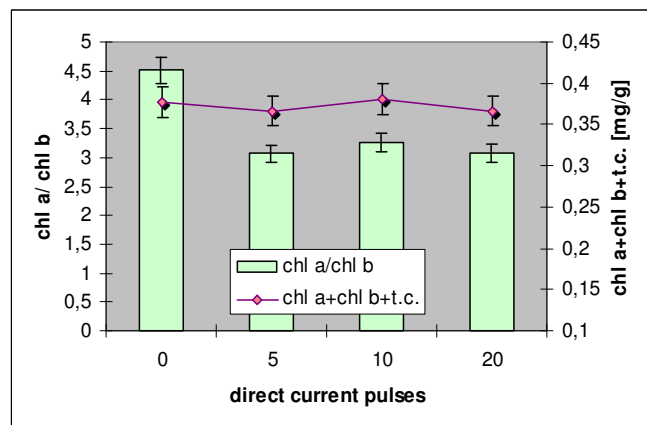


Fig.2. The chlorophyll ratio and the pigment sum in the plantlets exposed to direct current pulses.

From the results presented above the sensitivity of this enzyme complex to external constraints is proved. More, the chlorophyll ratio is an indirect indicator of the photosynthesis

efficiency, so the results in Fig. 2 evidenced the negative influence of the direct current pulses on the young plants photosynthesis: it is necessary to take into account both direct and indirect effects of electrons and ions from the corona pulses. Rapid electrons may interact directly with the vegetal cells, causing ionizing phenomena and molecular dissociation, similarly with ionizing radiation. All these may perturb cell membrane stability, biochemical reaction rates and biochemical composition of cell plasma. Water radiolysis may occur, hydrogen and oxydril radical higher levels being able to trigger peroxide cascades within cell structures, leading to indirect perturbation of biochemical balance.

4. Conclusion

The simulation of the plant exposure to atmosphere electric discharges by means of laboratory generator was accomplished aiming to evidence putative biological effects. The slight stimulatory influence on the plant biomass of repeated application of 10 pulses was revealed. Negative influence on the photosynthesis efficiency for all numbers of pulses was evidenced. The main issue of this study seems to be related to the electromagnetic pollution generated by atmospheric electrical discharges from either natural or artificial sources.

References:

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