

PLANT GROWTH UNDER STATIC MAGNETIC FIELD INFLUENCE*

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Already germinated seeds of *Zea mays* were cultivated in the presence of static magnetic field in order to observe several biochemical changes and stimulation effect on plantlets growth. Magnetic treatment involved the application of five different values of magnetic induction of static magnetic field, ranging between 50 mT and 250 mT, during 14 days. In order to investigate the biochemical changes of chlorophylls, total carotenoids and nucleic acids, spectrophotometrical measurements have been carried out. The influence of the static magnetic field intensity was discussed and statistic significance analysis was assessed for the differences between the average values of samples and controls.

Key words: static magnetic field, *Zea mays*, photosynthesis pigments, nucleic acids, growth stimulation.

1. INTRODUCTION

Over many years, the effects of static magnetic fields on plant life have been the subject of different research studies. Recently, many authors have reported the effects of static magnetic fields on the metabolism and growth of different plant species [1–2]. Numerous experiments have been conducted on the effects of magnetic fields or water exposed to permanent magnets on plant growth regarding: ripening of fruits and vegetables; increase in the farm crop; bacteria; virus; behavioral peculiarities of animals, birds, aquatic species, etc. Exposure of seeds to magnetic field for a short time was found to help in accelerated sprouting and growth of the seedlings [3]. Such plants also showed deeper roots as well as more vigorous growth compared to those, which have grown out of the untreated seeds. Magnetic field treatment of seeds leads to acceleration of plants growth, proteins biosynthesis and root development [4–6]. The scientific reports of numerous authors showed that the magnetic field exposure

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increases germination of non-standard seeds and improves their quality. Also, strong influence on the fast initial growth stages of the plants after the germination is well known [7–8]. The growth of wheat plantlets in a static magnetic field was stimulated [9] by means of different exposure protocols.

Having in mind the possible application of the magnetic field treatment in agricultural practice we investigated the static magnetic influence on the early stages of the development upon the *Zea mays* plantlets.

2. MATERIALS AND METHODS

Agricultural species (*Zea mays*) with major role in people life was taken for the experimental study. *Zea mays* seeds from a single genitor plant (50 seeds) were let to germinate on deionized watered paper support in a Petri dish. After germination the young *Zea mays* plantlets arranged in Petri dishes exposed to round permanent magnets of about 50 mT each, while the control sample was let to develop in absence of the external magnetic field. All samples were kept in well controlled laboratory conditions of temperature ($24 \pm 0.5^\circ\text{C}$) and illumination (10 h: 14 h light/dark circle). Five sample types were arranged using 1 to 5 permanent magnets under each Petri dish. This way, magnetic exposure, magnetic field ranging between 50 and 250 mT, was carried out continuously during 14 days five different magnetic field energy densities being supplied (between 995 and 24880 J/m³). Magnetic induction was measured using TSH type teslameter with Hall probe, having 10^{-4} T accuracy. All plant groups were supplied daily only with deionized water during the experiment, 15ml water per each dish. After 14 days spectrophotometrical measurements have been carried out. The content of chlorophyll **a**, chlorophyll **b**, total carotenoid pigments and average nucleic acid was assayed using Meyer-Berthenrath's method [10] modified by M. Stirban [11] and respectively Spirin's method [12]. The spectral device was a Perkin-Elmer UV-VIS provided with quartz cells. Green tissue harvested, from each exposed and control sample (mixture of small specimens picked up from all the 50 plantlets), was weighted, crushed and mixed with the same volumes, of 85% acetone in deionized water for the assimilatory pigments extraction and 6% perchloric acid for nucleic acid extraction, being further quantitatively transferred into quoted glass tubes. The levels of chlorophyll **a**, chlorophyll **b**, total carotenoids like pigments and the average level nucleic acid were calculated with quantitative formulas following [11–12]. Three repetitions of each spectrophotometric assay have been accomplished. Plant individual length was measured with 0.1 cm precision while the sample weight was measured with 10^{-5} g accuracy. Plant tissue drying was carried out at 100°C in a vacuum oven. The box plot representation technique was used to compare the lengths values distribution for data series [13]. Statistic analysis was accomplished by

means of average values, standard deviations and *t*-test (two tails, pair type) considering the significance criterion of 0.05.

3. RESULTS AND DISCUSSIONS

Quantitative insight in the molecular mechanisms involved in the complex phenomena of plant growth was carried out by means of spectrophotometrical assays. The data provided by the assimilatory pigments levels offered the main information upon the photosynthesis complex processes since they are able to reveal the response of the Light Harvesting Complex II (located in the chloroplast membranes) to the external constraints. In Fig. 1 is evidenced a slight increase (of about 4.24%) of chlorophyll **a** level (the main photosynthesis pigment, directly involved in the solar energy conversion into chemical energy) for the plants exposed to the lowest magnetic field (50 mT).

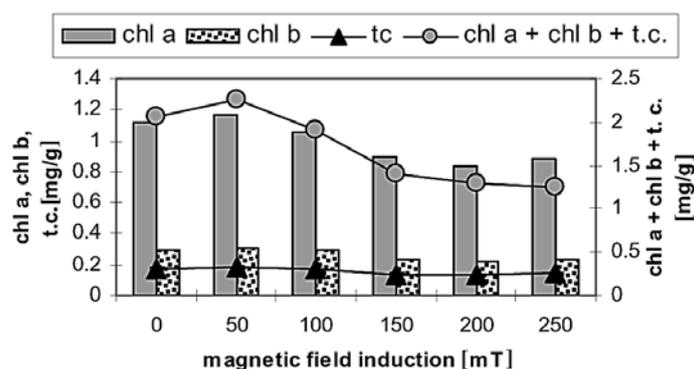


Fig. 1 – Assimilatory pigments level in *Zea mays* plantlets exposed to magnetic field (chl a, chl b – the levels of chlorophyll a – respectively chlorophyll b; t.c. – the level of total carotenoid pigments).

But, for the static magnetic field induction ranging between 100 and 250 mT an inhibitory effect on chlorophyll **a** level may be remarked. The changes in the secondary pigments (chlorophyll **b** and total carotenoid pigments) comparatively to the control are presented in Fig. 1, revealing similar variation. Consequently, the total assimilatory pigments content had parallel variation in dependence to magnetic field induction as observed for each assimilatory pigment level (Fig.1). Student *t*-test (two tailed, pair type) was applied to evaluate reliability of modifications induced by magnetic exposure in assimilatory pigments level for exposed samples in comparison to the control. Statistical analysis results are presented in Table I: all modifications induced by static magnetic field exposure have statistical significance in comparison with the threshold of 0.05. Between all assimilatory pigments levels very good linear

correlations were established (with correlation coefficients R^2 ranging between 0.9891 and 0.9939). Concluding on these results, all analyzed assimilatory pigments had similar variations *versus* static magnetic field induction. The chlorophylls ratio (chlorophyll **a**/chlorophyll **b**) is known as an indirect indicator of the energetic activity of LHC II system (Light Harvesting Complex II) that is controlling the first stage of solar energy conversion into its chemical form. The chlorophyll ratio (Fig. 2) for magnetically exposed samples presents small variations in comparison with control value suggesting magnetic sensitivity of photosynthesis efficiency. A slight increase (of about 3%), statistically significant with $p = 0.036$, for chlorophylls ratio value was obtained for low magnetic field induction (50 mT) while for 100 mT magnetic field exposure a diminished value for chlorophylls ratio was revealed (of about 4%) with $p = 0.044$. For the other magnetic field induction no statistically significant change was revealed.

Table 1

Results of statistical analysis of assimilatory pigments level in plantlets after magnetic exposure

Exposure static magnetic field induction [mT]							
	0	50	100	150	200	250	pigment
Standard deviation [mg/g]	0.01196	0.01662	0.01124	0.02139	0.06143	0.01020	Chl a
	0.01574	0.01488	0.01451	0.02079	0.00624	0.00250	Chl b
	0.00493	0.01763	0.01140	0.03395	0.03686	0.04101	t.c.
P (<i>t</i> -test)		0.01337	0.00325	0.01018	0.04493	0.01923	Chl a
		0.01314	0.04613	0.02136	0.03370	0.04476	Chl b
		0.04422	0.01427	0.01197	0.04131	0.04210	t.c.

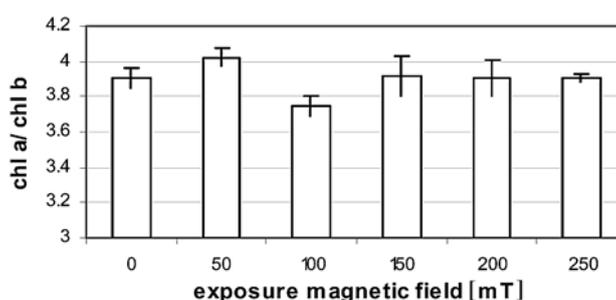


Fig. 2 – Static magnetic field effect on the chlorophylls ratio in *Zea mays* plantlets.

The average content of nucleic acids in *Zea mays* young plantlets after the magnetic exposure is presented in Fig. 3. One can see that for low magnetic field energy density the average nucleic acid level is enhanced in comparison to the control sample, while for the increasing magnetic field energy density an

inhibitory effect for average nucleic acid level was noticed. In Fig. 4-left the linear approach of the correlation between the plant fresh substance mass per number of plantlets for every sample and the average plants length was represented, outlying the clear stimulatory effect of the magnetic exposure at the individual level.

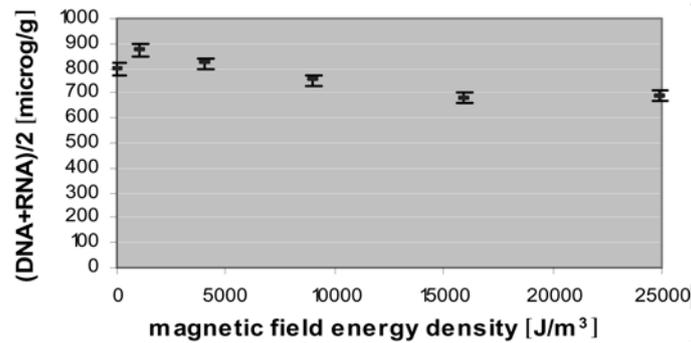


Fig. 3 – The average level of DNA and RNA for the plantlets exposed to static magnetic field influence.

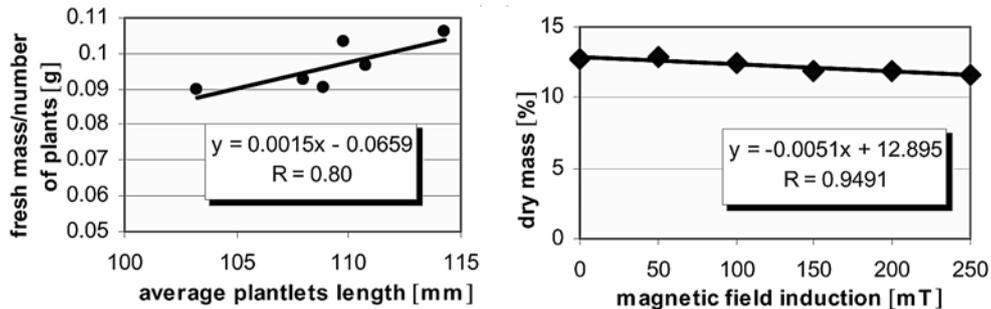


Fig. 4 – The correlation between fresh substance mass per individual plant and average plant length – left, and dry mass accumulation on plants under magnetic field exposure – right.

The dry substance mass was found slightly linearly decreasing on the magnetic induction (Fig. 4-right). For the comparative study of stem lengths we have applied box-plot graphical method. In Fig. 5 is presented the box-plot graphic for control and magnetic exposure samples. The average values of plants length are enhanced proportionally to the magnetic induction – a linear regression curve with correlation coefficients R about 0.9175 was found.

These results may be interpreted taking into account the magnetosensitivity as ubiquitous feature of the organisms living in the magnetic field of the Earth. The results obtained for the relatively low values of the magnetic induction used in this experiment are not to be necessarily extrapolated for other ranges of values; however they might have their relevance if the non-homogeneity of the

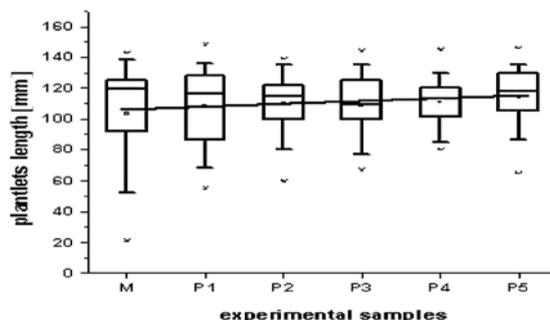


Fig. 5 – Box-plot representation for the magnetic field exposed plants length. M-control, P₁ – P₆ – magnetic exposed samples (magnetic field induction ranging between 50 (P₁) and 250 mT (P₅)).

environmental magnetic field is considered as well as the variations generated by the artificial sources of magnetism. Some general considerations related to the sources of variability in the measured data need to be done. One of the sources of variability in this experiment is given by the magnetic exposure since the permanent magnets are characterized by inhomogeneous field distribution. The large number of plantlets in every experimental sample and the three repetitions of the all experimental measurements should diminish the influence of this variability source. In the case of spectrophotometric assays the biological material was taken from entire green tissue obtain by mixing up the green tissue from the all plants grown at different distances along the magnet radius in order to minimize the variability generated by the magnetic exposure. Finally the statistic significance evidenced of the differences between the average values corresponding to control and exposed samples allow saying that young maize plants did responded to magnetic exposure within the experimental arrangement presented above.

4. CONCLUSIONS

The magnetic exposure to low static magnetic field (50 mT) revealed the stimulatory influence on the plants in their early ontogenetic stages: significant enhancement of the fresh tissue mass, assimilatory pigments level as well the chlorophyll ratio, average nucleic acids level, increase of the average plants length (exception: the dry substance mass accumulation). For enhanced magnetic field induction (ranging between 100 and 250 mT) an inhibitory effect for all measured parameters was obtained. The cultivation of plants under low magnetic field could be the background of crop improving in the frame of future agricultural techniques.

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