Young plantlets of maize (obtained from caryopsides with uniform genophond let to germinate and growth within an Angelantoni scientifica climatic room) have been cultivated in the presence of static magnetic field in order to observe the dynamics of plant length. Average values and standard deviations have been daily evaluated. Stimulatory effect of the magnetic field ranging between 50 mT and 250 mT was noticed with a saturation tendency at the 5th, 7th and 9th day. Linear correlations were found to describe the average length dependence on the magnetic energy. After 11 days the total fresh substance mass was weighted as well as the dry substance mass. Logarithmic dependence of the dry substance mass on the magnetic energy was evidenced. The application of t-test revealed the effect of certain non-homogeneity of the magnetic sources.

Key words: Zea mays, permanent magnets, growth stimulation.

1. INTRODUCTION

The biological effects of static magnetic field exposure represented an interesting research theme in the bioelectromagnetism field. After exposure to static magnetic field E.coli (K-12 lon mutant) cells lost capacity for division and grow as filaments, unable to form the colonies on the solid media (1). It was demonstrated that a magnetic field can actually enhance the efficiency of DNA repair in E.coli (2) but exposure of cultured mammalian cells to electric, magnetic, or combined electric and magnetic fields did not affect the rate of repair of DNA single strand breaks induced by hydrogen peroxide (3). Various bacterial strains that have been exposed to a homogeneous magnetic field of 1 Tesla, presented no mutagenic or lethal effects, the activity of the bacterial enzyme beta-galactosidase

being also found as independent of the applied magnetic field (4). The growth of wheat plantlets in a static magnetic field was stimulated (5) for different exposure protocols.

In the next, the influence of the magnetic exposure on the maize length and substance accumulation was investigated.

2. MATERIAL AND METHOD

Caryopsides of Zea mays harvested from a single plant, in order to minimize the genophond variation have been chosen to compose the samples (25 seeds let to germinate on watered paper support in a Petri dish constituted a sample). Round permanent magnets having a 50 mT magnetic induction in their center were placed under the Petri dishes containing each 25 maize seeds. Five samples have been arranged using one, two, three, four and respectively five magnets under each dish. After germination the growth was conducted within a Angelantoniscientifica climatic room in well controlled conditions of temperature (24°C) and illumination (16 h:8 h light:dark). Magnetic exposure was carried out continuously during 11 days.

Plant individual length was measured with 0.1 cm precision while the sample weight was measured with 10-5 g accuracy. Plant drying was carried out at 100°C in a vacuum oven.

Statistic analysis was accomplished by means of average values, standard deviations and t-test (two tails, pair type) with the significance criterion of 0.05.

3. RESULTS AND DISCUSSION

In the graphical representations from figures 1-5 the average values of plant lengths are represented for the 3th, 5th, 7th, 9th and 11th day of growth. The magnetic exposure can be quantified by means of the total energy dose (as a function of the magnetic permeability, the magnetic induction and the time):

\[ D = \frac{\Delta D}{\Delta t} t, \text{ where } \Delta D = \mu_0 \frac{B^2}{2} \]

The stimulatory effect noticed for all exposed samples (corresponding to the total magnetic induction values of B, 2B, 3B, 4B and 5B with B=50 mT). The length average values are enhanced almost proportionally to the magnetic induction - linear regression curves with correlation coefficients \( R^2 \) ranging between 0.61 and 0.93 have been found.
Magnetic field influence on some plant growth

\[ y = 0.2533x + 2.159 \]
\[ R^2 = 0.6648 \]

Fig. 1 – Average length after 3 days of growth
(1,...,6 meaning magnetic induction equal to 0, B, 2B,..., 5B).

\[ y = 0.336x + 3.1431 \]
\[ R^2 = 0.9302 \]

Fig. 2 – Average length after 5 days of growth
(1,..., 6 meaning magnetic induction equal to 0, B, 2B,..., 5B).

\[ y = 0.1696x + 4.311 \]
\[ R^2 = 0.6188 \]

Fig. 3 – Average length after 7 days of growth
(1,...,6 meaning magnetic induction equal to 0, B, 2B,..., 5B).
Fig. 4 – Average length after 9 days of growth (1,...,6 meaning magnetic induction equal to 0, B, 2B,..., 5B).

Fig. 5 – Average length after 11 days of growth (1,...,6 meaning magnetic induction equal to 0, B, 2B,..., 5B).

Fig. 6 – Comparative picture of the correlation between the plant length and the magnetic induction.
Fig. 7 – The growth dynamics for different magnetic induction values.

Fig. 8 – The fresh substance mass and the water accumulation (1,...,6 meaning magnetic induction equal to 0, B, 2B,.., 5B).

Fig. 9 – The correlation between plant length and total fresh substance mass at the 11th day.
The rather high standard deviation values that affected the correlation coefficient may be generated by the non-homogeneity of the magnetic exposure since the magnetic induction is slightly decreased from the center of the round magnet (the center of the plantlets arrangement within a Petri dish) and the its contour. Consequently, the comparison between the control (non-exposed) sample and the magnetic exposed samples, carried out by means of the t-test revealed statistically significant differences only for some situations (Table I).

<table>
<thead>
<tr>
<th>B</th>
<th>2B</th>
<th>3B</th>
<th>4B</th>
<th>5B</th>
<th>Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.249637</td>
<td>0.090091*</td>
<td>5.26822E-06*</td>
<td>0.001178*</td>
<td>8.42381E-05*</td>
<td>3</td>
</tr>
<tr>
<td>0.112455</td>
<td>0.013504*</td>
<td>0.00029075*</td>
<td>0.000117*</td>
<td>1.5737E-06*</td>
<td>5</td>
</tr>
<tr>
<td>0.177984</td>
<td>0.398944</td>
<td>0.130695183</td>
<td>0.11205</td>
<td>0.170404745</td>
<td>7</td>
</tr>
<tr>
<td>0.604081</td>
<td>0.371439</td>
<td>0.165732033</td>
<td>0.168299</td>
<td>0.160889381</td>
<td>9</td>
</tr>
<tr>
<td>0.166994</td>
<td>0.320937</td>
<td>0.175715493</td>
<td>0.047496*</td>
<td>0.001776743*</td>
<td>11</td>
</tr>
</tbody>
</table>

*-statistically significant according to the threshold of 0.05.

In Figure 6 a comparative representation of the experimental data is given. The influence of the magnetic induction increasing was leading to a saturation tendency for the last three samples (3B, 4B and 5B) at the 5th, 7th, and 9th days. The control does not appear to be higher than the exposed samples in all situations as reflected also in the graph from figure 7, where the curves corresponding to the growth dynamics of every sample are not parallel.

In Figure 8 the fresh mass of the plants from every sample is represented together with the dry mass and the water content corresponding to the 11th day of growth. A certain diminution was noticed in the fresh substance mass as well as in the water content for the magnetic induction of 2B. The dry substance mass was found to correlate logarithmically on the magnetic induction. In Figure 9 the linear approach of the correlation between the average length and the mass per length was represented, outlying the clear stimulatory effect of the magnetic exposure at the individual level.

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 can not be extrapolated for other ranges of values; however they can have their relevance if one consider the non-homogeneity of the environmental magnetic field as well as the variations generated by the artificial sources of magnetism.

Further experiments and investigation techniques are intended in order to get a deeper insight in the plant magnetosensitivity and putative biotechnological tools could be designed on the basis of the magnetic exposure.
4. CONCLUSIONS

Young plants of maize (a significant cereal for many human communities and aliment industries) are able to respond to the magnetic field ranging between 50 and 250 mT. Plant lengths are higher for all exposed samples as it was record for the first 11 days of growth. The relatively high standard deviations may be taken as an indication upon the plantlet sensitivity to the non-homogeneity of the magnetic exposure since genophond non-uniformity was minimized. The accumulation of dry substance mass was enhanced logarithmically to the increase of the magnetic induction.

REFERENCES