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Comparison of the Effects in the Germination and Growth of Corn Seeds (Zea Mays L.) by Exposure to Magnetic, Electrical and Electromagnetic Fields

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At the moment of obtaining good agricultural yields, as in the specific case of corn (Zea mays L.), the action of various factors, such as the surrounding environment, can cause a decrease of the germinative power of seeds.
To improve the germinative power of the corn seeds, it has been searched for new methods and technologies. In this regard, our study focuses on the comparison of the effects on seeds when exposed to magnetic fields of high and low intensities, and to electric and electromagnetic fields. For a time of 15 days the seeds were exposed by different fields. The studied variables were: the germination percentage, growth dynamics of coleoptiles, and accumulation of fresh mass, dry biomass and contents of chlorophyll a, chlorophyll b, and total chlorophyll. The best results were obtained for the seeds treated with electromagnetic fields doubling the value of most of the indicators under study.

1. Introduction

For a small, medium or large producer to obtain high quality seeds has been always the main determining factor in the moment of expectation of good agricultural yields. In some circumstances, this is seriously affected by the action of various factors. In the specific case of corn (Zea mays L.), the decrease of germinative power of seeds can be associated with different factors of the product and the surrounding environment. For this reason, the search for new methods or technologies for improving of the germinative power of corn seeds has an essential importance, supported by the fact that this type of seeds will be susceptible to a loss of seed vigour during prolonged storage. It is subject to their physical and chemical characteristics as has been verified by many authors (Ijaz et al., 2012).
In a situation like this, a farmer finds seeds with germinative limited power, which leads to a sudden increase or decrease of the volume of seeds per unit area. This initiated a large interest for searching new tools that allow to stimulate the germination, in embryos of seeds with low viability. One technology, that has emerged in order to stimulate the response of post-germination of the plants, is exactly the magnetic treatment of seeds (Pietruszewski, 2014).
The successful research in this area for the specific use of this technique has been unstable during the time, because the mechanisms of interaction of these agents with biological materials are not fully understood (Podlesny, 2004). So far, studies have mainly focused on the effects of magnetic field on biological materials, however there is a poor evidence of effects of electrical and electromagnetic fields.
Earlier work of Sawostin from 1930 (Hayden-Griffin, 1971) concentrated on the effects of magnetic fields in plant tissues. He studied the effect of magnetic field of 700 mT on biophysical and physiological parameters on cellular level in Nitella flexilis. In the area of Agricultural Sciences, since the early twentieth century, researches have been conducting experimental works with an aim to understand the effects of the magnetic

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field in the growth and development of plants - mainly through a seed treatment (Afzal et al. 2012). Among the main advantages of application of the magnetic field on seeds this method has a greater facility of manipulation with a minimal risk to damage, when compared to manipulations with tissues of leafs, roots or stems. Furthermore, one of the main reasons why the seed treatment with magnetic fields has spread worldwide lies in the positive impact that has on a recovery of seeds exhibiting a poor quality for certain vegetable species (Rico et al., 2014).
The knowledge of experimental route of employing factors that modify the stimulatory action of magnetic fields has allowed a proper use of this technique for benefits of mankind (Pietruszewski et al., 2007).
The use of magnetic and electromagnetic inductions represents non-invasive and non-destructive technologies that could produce changes in environmental conditions (Abina et al., 2013).
Due to all that have been mentioned above, the key purpose of this study is to compare results obtained after the seeds were exposured by different intensities of magnetic fields (MF), electromagnetic fields (EMF) and electric fields (EF) on the germination, growth and development of coleoptiles of the studied variety of corn.
The obtained results show that the method can be used on a larger scale for a possible application with an aim to increase the germinative power of seeds of this variety.

2. Materials and methods

2.1 Seeds

Perfomed experiments used lots of corn seeds (Zea mays L.) ICA-V-508 with a germination rate around 92%, supplied by the company Semicol.

2.2 Seed treatment

Seeds were exposed by different fields for 15 d up to the beginning of the vegetative period (day 12) and compared with unexposed seeds. Sowing was carried out in alveoli of 100 cm^3 using as a substrate the coconut fibre. The substrate was moistened and disinfected in an advance. A completely randomized design was used with the factorial arrangement of three replicates per a treatment and 50 seeds per a replicate.

2.3 Germination test, coleoptile growth, fresh mass accumulation and biomass

During the germination process, the planting trays were placed in a growth chamber with a semicontrolled light intensity of 3,000 lux with light cycles of 12 h at the temperature of 23 °C.
The rate of germination was evaluated in the third, sixth and ninth day after the coleoptile has emerged. Measuring the growth of coleoptiles within a precision of 1 mm was done in the third day from the moment on sowing, as well as the accumulation of fresh mass and biomass in the fifteenth day.

2.4 The Chlorophyll content

The absorbance measurement was performed to determine the chlorophyll content. For this, 1 g of fresh leaves of Zea mays L. from each of treatments was placed separately. Leaves were cut into small pieces and sand together with 15 mL of acetone were added to facilitate maceration and extraction of pigments.
10 mL of acetone was added to the remaining pulp and macerated again, then later filtered. The filtered solution was carried to a 25 mL volumetric flask and acetone was added up to the mark. The absorbance measurements were read on visible range spectrophotometers (Selecta V-1100) at wavelengths 645, 652 and 663 nm. Chlorophyll content was determined using the modified method of Jeffrey and Humphrey (1975).

2.5 Statistical Analysis

An analysis of variance of simple classification of completely randomized factorial arrangement was made, taking as variables the types of induced fields and the exposure time. All statistical analyses were performed using Statistica for Windows package StatSoft v4.2.

3. Results and discussion

In the next section, we have evaluated the morphology parameters of plants, and presented the effects caused by each treatment.

3.1 Germination percentage

As presented in Figure 1, the seeds treated with the electromagnetic field under semi-controlled conditions overcame up to (almost) 50% the germination of unexposed seeds in seven day since sowing. In a comparison, those seeds subjected to other treatments show a smaller value of germination percentage than previously reported. For the eighth and ninth days, at the same conditions, a higher germination percentage of seeds exposed to the electromagnetic field was observed. This behavior apparently due to the elimination of seminal dormancy of embryos in a dormant state.

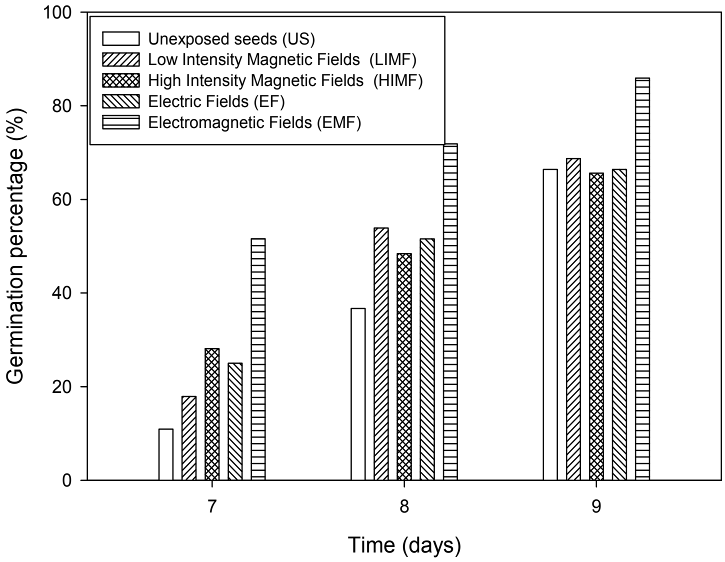

Figure 1: Power germination of seeds of Zea mays L. subjected to magnetic fields of low and high intensities, electric fields and electromagnetic fields.

3.2 Growth of coleoptiles

The coleoptile in Zea mays L. corresponds to the first sprout coming out of the caryopsis, originating from embryonic plumula. It was observed that the growth rate of the coleoptiles was much more pronounced in those caryopses treated by electromagnetic fields with a more prominent sigmoidal curve. The other treatments support a behaviour very similar to the demonstrated by the witness coleoptiles (see Figure 2).

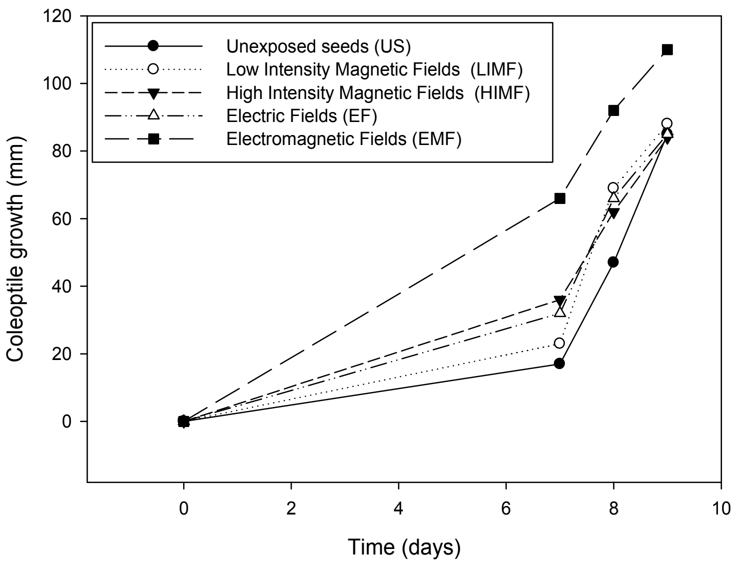

Figure 2: Dynamics of growth of coleoptiles of Zea mays L. for each study treatment

3.3 Accumulation of fresh mass and biomass (g)

As is reflected in Figure 3 (a, b) an increase in the formation of fresh mass can result in a dry biomass accumulation. This can be related to the Figure 2. After the analysis of Figure 3 (b) it can be seen the best results for those seedlings from seeds that were treated with electromagnetic fields followed by the seeds were treated with high magnetic fields.

Everything seems to indicate that the main source of difference between these two treatments takes root in the quantity and destination of asimilatos produced in the photosynthetic process.

The plants that produce apparently major quantity of asimilatos were treated with electromagnetic fields as reflected in Figure 3 (a).

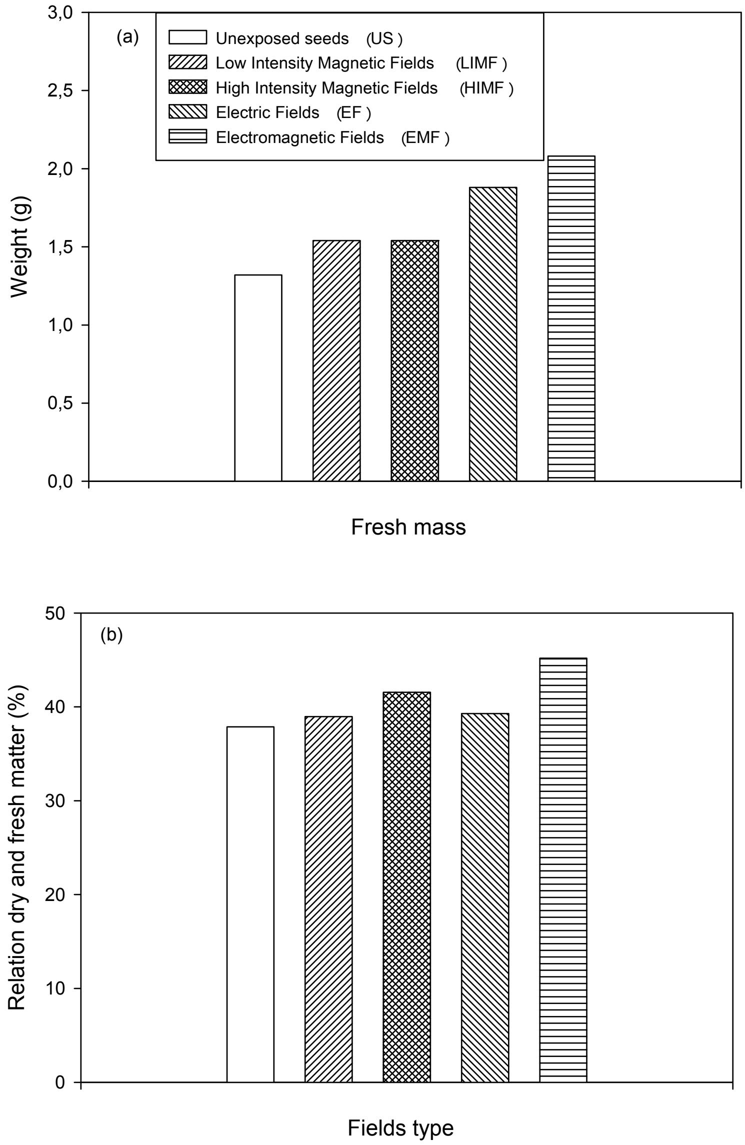

Figure 3: (a) Accumulation of fresh mass (g.) and (b) relation fresh and dry matter (%.) in the plants of Zea mays L. by treatments under study.

3.4 The Chlorophyll content

As shown in Figure 4, the levels (mg) of chlorophylls a, b and total, present in the plants treated with electromagnetic fields exceed almost twice those used in other treatments. A significant increase (as shown in the above figure) has to be translated in a major photosynthetic efficiency, that is possible to connect to a higher growth rate (see Figure 2) and a greater accumulation of fresh mass (see Figure 3).

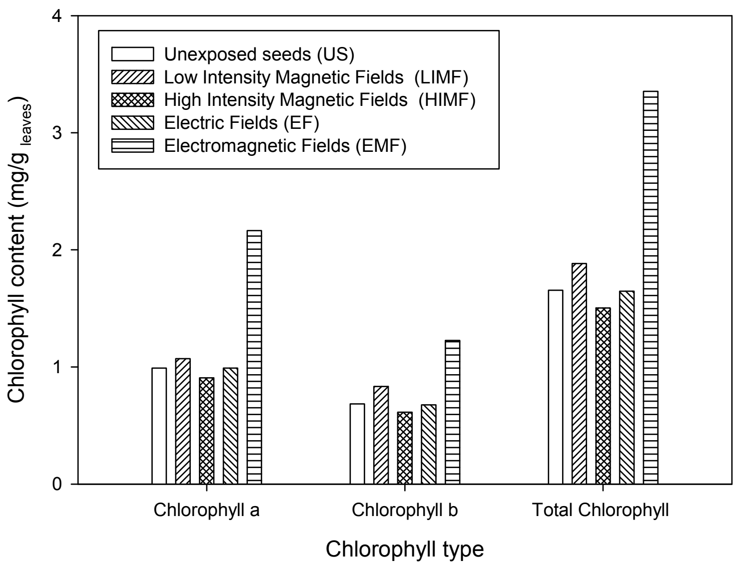

Figure 4: Chlorophyll content. a, b and total, on leaves Zea mays L. obtained by the modified method of Jeffrey and Humphrey (1975)

4. Conclusions

When one tries to raise the performance of the cultures, it is possible to resort to improving the methods of sowing, by means of the application of treatments before the seeds. The pre-sowing treatments were used implied the exhibition of a material to magnetic, electrical and electromagnetic fields. By applying electromagnetic fields was evident improvement in germination rates, growth of coleoptiles and thus the decrease in the time of dormancy.

It is important to mention that different studies have allowed to observe the effect of magnetic fields with intensities superior to the earth's magnetic field, on the living organisms and biological material, likewise other studies could have verified that the biological organisms for the most part are diamagnetic and therefore the effects. It is important to highlight that the above mentioned effects on the seeds are associated with factors as the dampness of the treated seeds and the regime of applied treatment.

Several authors have demonstrated that the stimulatory effect has been due to mechanisms such as the increases of the enzyme activity, more efficient processes of cellular division and changes produced in the permeability of the membranes (Maffei, 2014), nevertheless to extend the information of these affirmations it will become necessary to realize the second stage where the vegetative period will be evaluated in the phase of exponential growth up to coming to the flowering phase.

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