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Composition and Behavior of Sunflower Seeds (*Helianthus annuus* L.) From Plants Treated with Magnetic Fields for Energy Potential Use of Biomass

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Undoubtedly, with the different effects of climate change, the companies producing biofuels have turned their attention to the woody and herbaceous species, for their energy use. Although these processes are based on the different agroindustry chains that are developed at local, regional, national or international level, depending on the type of soil, vegetation and predominant climate presented in each of them. For this reason, the industry transformation sector must go hand in hand with the primary sector, ensuring a large amount of volume in the production of biomass with characteristics desired by the processors of plants for the use of bioenergy improving the production techniques. Having said that, this research evaluated the composition and initial behavior in a second generation of the sunflower seeds (*Helianthus annuss* L.) of plants that were treated during their germination phase with induced magnetic fields. The magnetic field strengths of 14μT and 422μT to which the mother plants were subjected were generated with coils of 300 and 1200 turns, handling an exposure time of 60 min, 180 min, 300 min and 15 days (permanent). Subsequently evaluating seeds in relation to variables such as germination and initial seedling growth (% of germination, fresh biomass and dry biomass, leaf area, chlorophyll, in addition, to development indicators); in the same way, the watery activity, the protein nitrogen content, the ethereal extract or crude fat content, the ash content and the crude fiber were determined on the seeds of the first generation. On the other hand, the experimental design was subject to the initial conditions of culture of the mother plants being a factorial design in relation two components "field intensity x time of magnetic induction". The best results were evidenced in those plants coming from seeds of mother plants treated with fields with lower intensity and with a longer exposure time.

1. Introduction

The existing energy sources surround our environment in a habitual way producing invisible forces to the human eye, said energy packages are transported by the space producing magnetic and electric field waves giving origin to natural phenomena; among them the biological effect on seeds of cultivated plants. In fact, living beings are used to living with them. This has allowed in recent decades have been the subject of numerous studies; among them, there are those focused on establishing their influence on germination, growth and development of species of agro-industrial interest. This is how the theoretical references show a possible stimulating effect of the induced fields on the morpho-physiological development processes of the treated plants, from germination to harvest. However, the high number of factors that intervene in the interaction electromagnetic field-living being complicates the establishment of mechanisms of action, existing to date only hypotheses (Suárez et al., 2016 and Ortiz et al., 2015).
In this context, studying energy alternatives that are friendly to the environment, which favor the improvement of the productive potential of energy crops, has been the focus of this study. It is worth noting that this

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research allowed to minimize the use of agro-inputs and increase the physiological variables per unit of area, highlighting the production in biomass and chlorophylls.

2. Materials and methods

2.1 Characteristics of vegetable material.

For experimental development, second-generation sunflower seeds (*Helianthus annuss* L.) were used; that is, of plants that originated from seeds treated with electromagnetic fields. Their culture conditions coincide with those established by Suárez et al., 2017.

2.2 Application of magnetic fields in sunflower seedlings (Helianthus annuus L.)

The seeds evaluated were not treated with magnetic fields, since it is intended to evaluate the residual effect of the treatment carried out on the mother plant with this type of induced field. It is then that the seeds that gave rise to the mother plants were subjected to intensities of the magnetic field of 14 μT and 422 μT generated with coils of 300 and 1200 turns, managing an exposure time of 60 min, 180 min, 300 min and 15 days (permanent).

2.3 Evaluation of the germination process of the seeds of *Helianthus annuus* L.

The interpretation of the percentage of germination was given by the relationship that exists between the number of seed sown and the germinated seeds. To determine this, the following equation was used (Rosso et al., 2015):

$$\text{Percentage of germination } = \frac{\#\text{ germinated seeds}}{\#\text{ Seed sown}} * 100 \qquad (1)$$

2.4 Measurement of parameters of growth and development

During the initial production of sunflower, the following morpho-physiological characteristics were measured:

a) Number of roots established through by direct counting, considering main root and secondary roots;

b) Volume of roots through the volume of water displaced in a graduated test tube type A, when introducing the roots up to the neck (point of union between the stem and the main root);

c) Fresh mass (g) determined in the analytical balance; this measurement was carried out within fifteen (15) days after the beginning of germination and thirty days after the first measurement;

d) Dry mass (g) was determined according to the procedure (Cortés-Castillo et al., 2010);

e) Leaf area (cm^2) was determined by the method cited by Suárez et al. (2017);

f) Nitrogen content that is expressed as Total Nitrogen or Gross Protein (N x 5.7) in seeds by the Kjeldahl method. For this, equation 2 was used:

$$\text{mg N} = N \times V \times 14 \qquad (2)$$

Where:

N = Acid normality assessment
V = Acid volume consumed
14 = Nitrogen weight of nitrogen

With the above calculation you can infer the % of proteins as (see equation 3):

$$\%\text{ Proteins} = P_2/P_0 \times 100 \times F \qquad (3)$$

Where:

P_2: Nitrogen (mg).
P_0: Weight of the sample (mg).
F: Protein factor (5.7 in vegetables)

g) Ethereal Extract or Gross Fat through Soxhlet extraction with n-Hexane and gravimetry for quantification;

h) Ash by gravimetry after submitting the sample at 600 °C in Muffle

2.5 Context of the experimental design

The initial experiment (the one used to obtain the mother plants) was developed under a bifactorial design (induced field strength x field induction time) based on the assembly of 8 germination trays with 200 seeds per treatment; and its subsequent effect on 200 plants for each treatment, exposed to two magnetic field strengths (A1 = 14 µT and A2 = 422 µT) and four exposure times (B1 = 60 min, B2 = 180 min, B3 = 300 min and B4 = 15 days); applied to the seeds under study (*Helianthus annuus* L.). Similar cultivation conditions were generated for control seeds (without induction of magnetic field).
Table 1 shows the interaction generated between the different treatments:

Table 1. Interaction between the factors under study

Interactions		**Exhibithion time**				**Control**
		15 days (permanent)	**300 min**	**180 min**	**60 min**	
Intensity of the Field	**422 µT**	L1	L2	L3	L4	C
	14 µT	L8	L7	L6	L5	

2.6 Statistical analysis

A single analysis of variance (ANOVA) between the averages of the samples by treatment at a significance level of 95 % (α = 0.05) was carried out to establish whether any differences exist for the variables under evaluation (Suárez, 2011). If there was no significant difference between the samples, a multiple range test was performed using the statistical package Statgraphics Centurion.

3. Results and discussion

3.1 Percentage of germination

Analyzing the percentage of germination in a second generation of seeds allowed to demonstrate the residual effect that has the application of magnetic field. Everything seems to indicate then that the stimulating effect that occurs on the germination process reported by Suárez et al., 2017 in this crop remains very similar to the first generation or failing improved to day 15. Table 2 for its part evidence that optimal results were presented for the seeds at lower intensity of the field (14 µT), exceeding in all cases those treated with greater intensity (422 µT) in the first generation and the control.

Table 2. Interaction between the factors under study

Treatment	% of germination
L1	20
L2	20
L3	63
L4	60
L5	78
L6	90
L7	75
L8	90
Control	70

Results similar to those described above obtained Fung Y. B. et al. (2010) in his work entitled "Effect of the application of a magnetic field on the germination in vitro of seeds of *Rosmarinus officinalis* L." and Hincapie E. A. et al. (2010) in "Effect of the magnetic field on the germination of *Leucaena leucocephala*". Both groups of authors in different cultures and under different culture techniques could conclude that the magnetic and/or electromagnetic fields positively affect the germination process, adding that at lower intensities a greater incidence on this variable can be observed.

3.2 Number and volume of roots

In correspondence with the percentages of germination, it can be observed in table 3 that the data obtained for the number of roots and their corresponding volume showed the highest values for those plants that were treated with the lowest intensities of the field. Plants from the lower intensity not only have a greater number of roots, but they have a greater volume, which could be related to an extraordinary capacity of these to fix to the substrate and absorb nutrients from the soil matrix.

Table 3. Characterization of the root

Treatment	No. Roots	Vol. Of Roots
L1	35	0.2
L2	34	0.6
L3	36	0.4
L4	54	0.6
L5	75	0.8
L6	48	0.8
L7	46	0.6
L8	70	0.6
Control	46	0.5

3.3 Fresh mass and dry mass

Figure 1 shows the results for the indicators fresh mass and dry mass per treatment, clearly showing that the lowest intensities are those that achieved the best values. This is the treatment L5 that despite not having been the highest fresh mass possessed, if it was most the dry mass accumulated.

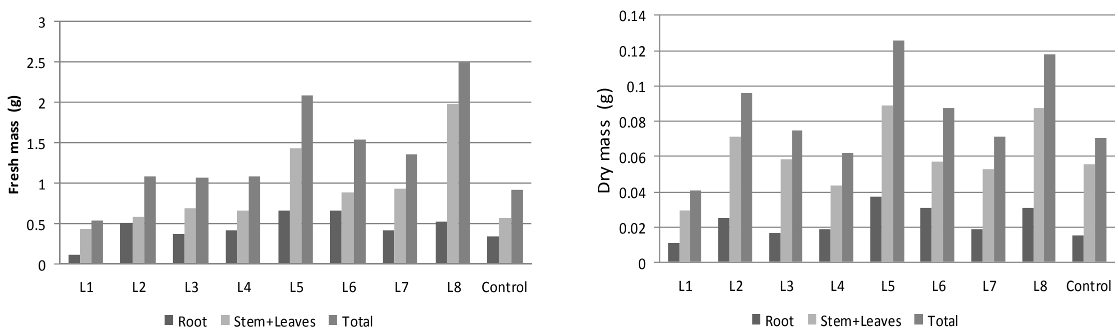

Figure 1. Content in fresh mass and dry mass of the plant

One of the possible explanations of the positive effect observed in the magnetic treatment is in the paramagnetic properties of the atoms in the cells and pigments of the plants; that is, the chloroplasts. In an external magnetic field, the magnetic moments of these atoms are aligned with the direction of the field, causing the magnetic properties of the molecules to determine their ability to absorb the energy of the magnetic field, to transform it into another type of energy and transfer it to other structures in the cells of the plant; thus, generating its activation. The magnetic effects in plants can be explained with the resonance structure of the ion cyclotron and the models of even radicals, two mechanisms that also play an important role in the magneto-perception of other organisms (Galland and Pazur, 2005 cited by Zuñiga et al., 2016).

3.4 Leaf area (cm^2)

Figure 2 reflects the average leaf area per plant within each treatment, highlighting the treatment plants 5, because it is above the control and the rest of the treatments. It should be noted that a greater foliar area in this case is directly related to the growth and development of the rest of the organs of the plant. It is at the level of the leaves where it is captured, mainly solar energy through photosynthesis to convert it into chemically usable energy.

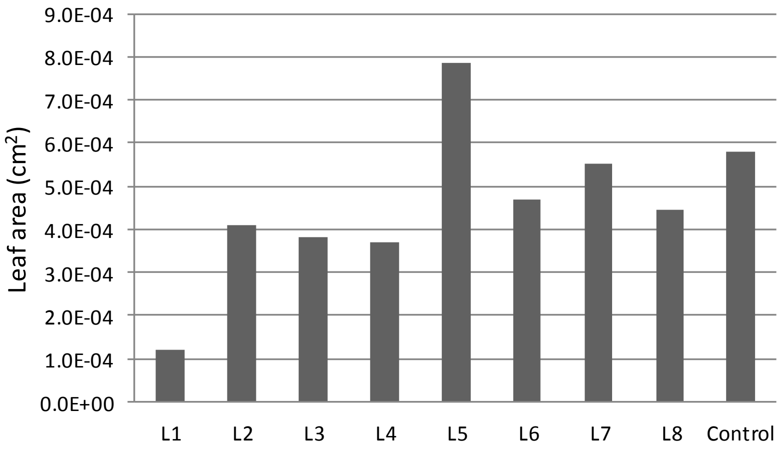

Figure 2. Foliar area at 15 days after germination

In this sense, Savin (1981) and Kuzin (1993), cited by García - Fernández et al. (2013) have indicated that they obtained with the use of the induced fields a better organization of parenchyma palisaded at leaf level, a better stomata disposition and a higher capacity in the stoma opening and closing mechanism, which according to them reflected in a stimulation in the synthesis of the abscisic acid in the root, which is transported via xylem to the leaves, inducing changes in the permeability of the membranes of the protective cells, which release solutes (K^+, Ca^{2+}) into the cytoplasm of accompanying cells, and with it, the diminution of the potential of turgor that causes the stomata to close partially, avoiding the loss of water by transpiration.

3.5 Proximate bromatological analysis of the seeds

The bromatological analysis of the seeds used in the process showed that its composition was quite homogeneous as seen in table 4, regardless of the treatment used. It should be noted that, as was evidenced in the rest of the indicators analyzed, the lower intensity in most cases exceeded the reference values (control).

Table 4. Proximate bromatological of sunflower seeds

Treatment	Nitrogen (mg)	% Proteins	Ethereal Extract (g)	Ashes (g)
L1	28.00	0.638	0.127	4.449
L2	7.00	0.160	0.073	4.776
L3	44.80	1.021	0.085	4.763
L4	14.00	0.319	0.027	4.583
L5	68.60	1.564	0.192	4.510
L6	54.60	1.245	0.984	4.050
L7	40.60	0.926	0.222	4.426
L8	35.00	0.798	0.254	4.390
Control	29.40	0.670	0.285	4.309

4. Conclusions

The best results obtained on the response variables analyzed were found for L5 (60 minutes exposure to 14 μT) which shows the stimulation in the different growth and development processes of the plant at low intensities of the magnetic field in short exposure time.

Likewise, an optimal mitigation of the detriments that cause adverse factors when using the magnetic fields was observed if the results are compared with the control, which opens a door to its widespread use in agriculture.
Finally, although more research is needed at the local and national levels that give full explanation about the magnetic field-soil-plant interaction, current knowledge allows to empower this technique as an alternative with high potential to improve agricultural production.

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