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RESEARCH ARTICLE

INFLUENCE OF STATIONARY MAGNETIC FIELDS ON THE GERMINATION AND VIGOR OF SUNFLOWER SEEDS

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ABSTRACT

This study was conducted at the seed quality analysis laboratory of the Faculty of Agricultural Sciences, National University of Assunção. Sunflower seeds (*Helianthus annus*) L. were exposed to stationary magnetic fields with different intensities and exposure times aiming to evaluate the influence of static magnetic fields on seed germination and vigor. The variables analyzed were germination, shoot length and root length. The results showed a positive effect on shoot length when seeds were magnetized. The results of the magnetic treatment at an intensity of 40 mT and 72 hours of exposure were superiorto the control in relation to the variables shoot and root length. We can conclude thatmagnetism at an intensity of 40 mT for 72 hours promotes the growth of sunflower seedlings.

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INTRODUCTION

Sunflower is an annual herbaceous plant from the Asteraceae family native to the Americas, specifically Central and North America. It is cultivated worldwide (Shosteck, 1974). Its seeds are used to produce edible oil, especially during winter because seeds withstand low temperatures without freezing and are easy to maintain. They are also used for consumption in toasts, such as peanuts. The flowers are ornamental and used as food for birds (Dietze, 2010). The evaluation of the physiological potential of seeds is essential as a basis for the processes of production, distribution and marketing of seed lots (Martins *et al.,* 2014). Thus, producers and seed testing laboratories should use tests that provide reproducible and reliable results, safely indicating the quality of a seed lot especially with regard to vigor (Frigeri, 2007). It is relevant to note that a seed lotfrom the same species comprises a defined, identified and homogeneous amount of seeds with similar physical and physiological attributes. The uniformity and seedling emergence speed are important components of seed vigor.

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In order to validate these elements, the length of seedlings is estimated. It is then possible to classify seedlings into strong and not strong (Bazáñez and Farras, 2005). Staselis and Duchovskis (2004) reported that the use of low frequency magnetic fields during the germination process may suppress the adverse effects caused by high temperature and humidity conditions. Biochemical studies conducted with seeds after a magnetic treatment showed an increase in the α-amylase activity, thus indicating an increase in the production of the plant hormone gibberellic acid and the activity of the hydrolytic enzyme acid phosphatase. The response of seeds to magnetic fields with a varied intensity demonstrates the possibility of electromagnetic controls in the growth process (Kalinin *et al.,* 2005). Galland and Pazur (2005) emphasize that, regarding densities used for stimulating plants, the effect of magnetic fields and high density ranges from 100 mT to 250 mT in most cases. Among the magnetic treatments applied to seeds, some require the use of electrical current sources (active) and some do not require a power source (passive). The effects of stationary fields applied by permanent magnets are the most perceivable and adaptable to field conditions than the effects of active sources (Carbonell *et al.,* 2005). In most investigated cases, the variables often used to verify possible effects on the quality of seeds are percentage of germination and shoot and root length (Aladjadjiyan, 2002). In this context, the aim of this study was to evaluate the influence of stationary magnetic fields on sunflower seed germination and vigor.

MATERIALS AND METHODS

The experiment was conducted at the seed quality analysis laboratory of the Faculty of Agricultural Sciences, National University of Assunção.*Helianthus annus* (L) seeds were used. They were subjected to two stationary magnetic fields with two intensities (30 and 40 mT) and five periods (12, 24, 36, 48 and 72 hours).

Table 1. Treatments using *Helianthus annus* (L.) seeds subjected to 2 stationary magnetic field intensities for fivetime periods and seeds without being exposed to magnetic fields

T1	Control, seeds not exposed to magnetic fields
T2	12 hours of exposure to 30 mT magnetic fields
T3	24 hours of exposure to 30 mT magnetic fields
T4	36 hours of exposure to 30 mT magnetic fields
T5	48 hours of exposure to 30 mT magnetic fields
T6	72 hours of exposure to 30 mT magnetic fields
T7	12 hours of exposure to 30 mT magnetic fields
T8	24 hours of exposure to 30 mT magnetic fields
T9	36 hours of exposure to 30 mT magnetic fields
T10	48 hours of exposure to 30 mT magnetic fields
T11	72 hours of exposure to 30 mT magnetic fields

The seeds were exposed to stationary magnetic fields created by two ceramic cylindrical magnets with intensities of 30 mT and 40 mT. The magnets were 8 cm in diameter and 2 cm wide. A base and a top were set, separated by polystyrene columns, leaving a space between them.The seeds were placed in plastic tubes with 3 cm in diameter in accordance with the periods and the intensity necessary for each treatment. For the analysis of germination, 50 seeds were used per replication. They were sown on a plastic tray (30 cm length x 15 cm width x 10 cm depth). Washed sand, previously sterilized and moistened with distilled water, was used as substrate. Subsequently, it was then kept in a BOD chamber at 25°C for ten days (ISTA, 2003). To evaluate shoot and root length of seedlings, 20 seeds were sown in three sheets of germitex paper moistened with distilled water equivalent to 2.5 times its dry weight under the same conditions the germination test was conducted. The average length was determined using 10 normal seedlings per treatment. The shoots and roots of seedlings were measured with a ruler and the results were expressed in millimeters. The experiments were completely randomized, comprising four replications in a 5x2 factorial design. Data were subjected to analysis of variance and means were compared by Tukey test ($p<0, 05$).

RESULTS AND DISCUSSION

Table 2 shows that the sunflower seeds, under different exposure times and magnetic field intensities, indicate no statistically significant differences between treatments regarding germination. Therefore, according to shoot length results, there were no differences among all treatments. In relation to roots, the only difference was in the control treatment, with 72 hours of exposure at a 40 mT intensity. Aladjadjiyan (2002) found that the application of a 150 mT magnetic field to corn seeds related to10, 15, 20 and 30-minuteincrements increased germination, and the most notable results were at 10 minutes of exposure.

Table 2. Germination, shoot and root length of sunflower seeds (*Helianthus annuus*) in relation to different exposure times and stationary magnetic field intensities

Treatments	Germination (%)	Shootlength (cm)	Radiclelength (cm)
1	89 A*	7,69 G	3,79 B
2	89 A	7,86 FG	3,96 AB
3	89 A	8,00 EF	4,01 AB
4	91 A	8,70 DEF	4,02 AB
5	89 A	9,01 CDE	4,03 AB
6	89 A	9,42 BCD	4,11 AB
7	91 A	9,55 BCD	4,13 AB
8	90 A	9,78 ABC	4,16 AB
9	91 A	10,29 AB	4,18 AB
10	90 A	10,40 AB	4,22 AB
11	90 A	10,64 A	4,24 A
CV	6,05 %	10,81 %	10,45 %

*Means with the same letter do not differ significantly ($p <= 0,05$).

Similar results were obtained by Aladjadjiyan & Ylieva (2003) when tobacco seeds were exposed to the same magnetic field intensity and the same exposure time. Importantly, the results of this study do not coincide with those found by Carbonell et al. (2005), where applications of stationary magnetic fields at 125 mT and 250 mT resulted in an increase in the seed germination of *Helianthus annuus*. This effect was pronounced when the treatment was performed during 24 hours. Studies with *Leucaenaleucocephala* seeds treated with different levels of magnetic fields show that the intensity of 125 mT, during 60 minutes of exposure, resulted in a greater root length in seedlings and a direct increase in protein levels (Hincapie, 2010). According to Vazquez (1997), in his study on *Phaseolus vulgaris* seeds treated with magnetic intensities of 125 mT and 250 mT for 10, 30 and 60 minutes, the variations in the characteristics of plants were an increase in biomass and in number of roots possibly related to the procedure performed using magnetic fields. Reports on corn seeds showed that the exposure to magnetic induction levels of 125 mT and 250 mT, applied with permanent magnets for different exposure times, resulted in an increase in seedling height and weight (Flórez *et al.,* 2007). Martinez *et al.* (2009) reported similar results for *Triticumaestivum* seedlings exposed to magnetic field intensities of 125 mT and 250 mT for 1, 10, 20, 60 minutes and 24 hours, causing an increase in seedling length and weight and obtaining significant differences. Hernandez (2010) observed an increase in vigor by applying a magnetic field to corn seeds with permanent magnets. According to Martinez et al. (2009), tomato seeds (*Lycopersiconescultelum* L.) also increased seedling growth after constantly subjected to magnetic fields for 36 hours.

Conclusion

Magnetism does not adversely affect sunflower seed germination. At the intensity of 40 mT, it promotes the growth of shoots and primary roots of sunflower seedlings with an exposure of 72 hours to magnetic fields.

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