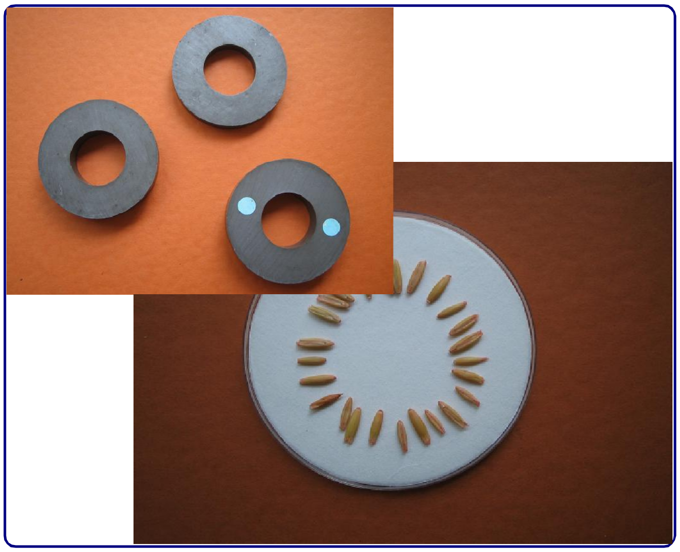
# MEAN GERMINATION TIME AND GERMINATION RATE OF OAT SEEDS SUBJECTED TO STATIONARY MAGNETIC FIELD



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**RESUMEN**

El objetivo de este estudio es determinar y cuantificar el efecto de campos magnéticos estacionarios en la germinación de semillas de avena (*Avena sativa,* L. var. cobeña). Para ello, las semillas fueron expuestas a un campo magnético 125 mT o 250 mT durante distintos periodos de tiempo: 20 minutos (E1, E5), 1 hora (E2, E6), 24 horas (E3, E7) ó de forma crónica (E4, E8) durante todo el proceso de germinación. Se realizaron tests de germinación en condiciones de laboratorio, empleándose imanes cilíndricos para generar el campo magnético. Para obtener el tratamiento magnético las Placas Petri con las semillas se dispusieron sobre imanes durante el tiempo correspondiente a cada tratamiento. Grupos de semillas sin exposición a campo magnético fueron empleadas como control. Los parámetros utilizados para el análisis de velocidad germinativa fueron el número de semillas germinadas (G), el tiempo medio de germinación (TMG) y el tiempo necesario para que germine respectivamente el 1, 10, 25, 50 y 75 % del número N de semillas utilizadas en cada tratamiento ($T_1$, $T_{10}$, $T_{25}$, $T_{50}$ y $T_{75}$). Estos, parámetros fueron proporcionados por el software Seedcalculator, así como las correspondientes curvas de germinación.

En general, los resultados obtenidos muestran que el tiempo requerido para obtener los distintos porcentajes de germinación fue menor en las semillas expuestas a campo magnético (tratamientos E1 a E8), destacando la reducción obtenida para el tratamiento E1, exposición a 125 mT durante 20 minutos. El TMG obtenido para las semillas sometidas al tratamiento magnético E1 resultó significativamente menor (11.48%) que el TMG del control. Los parámetros $T_1$, $T_{10}$ y $T_{25}$ también fueron menores para las semillas sometidas a tratamiento, obteniendo reducciones del 46.62%, 24.02% y 13.46% respectivamente. La reducción en los parámetros de germinación implica que la velocidad de germinación es mayor. Dado que los parámetros $T_1$ y $T_{10}$ están relacionados con el inicio de la germinación, este estudio refleja un adelanto en la germinación y disminución del periodo de latencia en la mayoría de los tratamientos magnéticos aplicados. Estudios previos realizados por los autores sobre la influencia de campos magnéticos estacionarios reflejaron incrementos en el porcentaje y la velocidad de germinación de semillas de cereales y leguminosas y un mayor crecimiento de plantas sometidas a tratamiento magnético. Se puede concluir que el tratamiento magnético aplicado incrementa la velocidad de germinación de las semillas de avena.

**PALABRAS CLAVES**

Velocidad de germinación, semillas de avena, A*vena sativa*, tratamiento magnético, precocidad

**ABSTRACT**

*The objective of the present study is to determine and quantify the effect produced by stationary magnetic fields on oat seed germination (Avena sativa, L. var. “cobeña”). For this purpose, seeds were exposed to a magnetic field 125 mT of 250 mT during different periods of time: 20 minutes (E1, E5), 1 hour (E2, E6), 24 hours (E3, E7), or in a conic form (E4, E8) during the whole germination process.*

*Germination tests were carried out under laboratory conditions with cylindrical magnets to obtain the magnetic field. For magnetic treatment seed on Petri dishes were placed on magnets during time necessary for each treatment. Seeds without exposition to the magnetic field were used as control group. Parameters used for germination speed analysis were: number of germinated seeds (G), mean germination time (MGT) and necessary time for germination of 1, 10, 25, 50 and 75% of N number of speeds used for each treatment ($T_1$, $T_{10}$, $T_{25}$, $T_{50}$, and $T_{75}$). These parameters were supplied through the software Seedcalculator, as well as the corresponding germination curves.*

*In general, from the results obtained it can be said that the time required to obtain different germination percentages was lower for seeds exposed to the magnetic field (treatments E1 and E8). Reduction in time for E1 treatment stands up with 20 a minutes-exposition-time to 125 mT. MGT obtained for seeds with magnetic treatment E1 was significantly lower (11.48%) than the control group. Parameters $T_1$, $T_{10}$, $T_{25}$ were also lower for seeds submitted to treatment, obtaining reductions of 46.62 %, 24.02 % and 13.46 % respectively. Reduction in germination parameters indicates that germination speed is higher. Because parameters T1 and $T_{10}$ are related to the beginning of germination, this study represents a progress in germination and a reduction in the induction phase in most of the magnetic treatments applied. Previous studies done by authors about the influence of stationary magnetic fields have shown increases in percentages and germination speeds for pulses and cereals and greater growth for plant submitted to magnetic field. It can be concluded that the application of magnetic fields increases speed germination time for oat seeds.*

**KEYWORDS**

Speed germination time, oat seeds, Avena sativa, magnetic treatment, earliness.

## 1. INTRODUCTION

The effects on the onset and germination rate of oat seeds exposed to both magnetic field strengths (125 or 250 mT) for different periods of time have been explored

2000.), a biostimulation on the initial growth stages of barley (Martinez *et al., 2002)* and wheat (Martínez et al., 2002)., and early sprouting and first stages of growth of treated rice plants (Flórez *et al., 2004)*. Results obtained showed increases in germination rate and plant weight and length greater when seeds were subjected to magnetic treatment than respectively controls. In the study realized with wheat seeds, increased plant height was observed when the magnetic dose was increased; then the stimulatory effect could be related to the amount of energy supplied to the plant tissues by the magnetic field.

The science of applying electromagnetic fields to biological systems known as magnetobiology has made rapid strides in the past few years. The influence of magnetic fields on the behaviour of living systems has been studied for long but the mechanism of action between magnetic field and plants is as yet poorly understood. Beneficial effects of magnetic field of different strength on the crop and yield have reported, an increase of crops of different species subjected to magnetic field has been found. The enhancement of growth of agricultural species under specific magnetic conditions appears to have been confirmed by many scientists. (Aladjadjiyan, 2002) detected that exposure to a 150 mT magnetic field stimulated shoot development and led to increase of the germination, fresh weight and shoot length of maize plants. (Yano et al., 2001*).* observed the induction of primary root curvature in radish seedlings in a static magnetic field; the roots responded tropically to the static magnetic field, with the tropism appearing to be negative, these roots responded significantly to the south pole of the magnet. Recently, (Yinan *et al., 2005).* published that the magnetic field pretreatment had a positive effect on cucumber seedlings, such as stimulating seedling growth and development.

## 2. METHODOLOGY

The oat seeds were supplied by the Spanish Institute of Seeds and Greenhouse Plants which guarantees high seed viability and homogeneity. The experiments were carried out under laboratory conditions, with natural light and average room temperature 20±2ºC. Germination test was performed according to the guidelines issued by the International Seed Testing Association (ISTA, 2004) with slight modifications. The seeds were germinated by placing 200 seeds in 4 replicated Petri dishes, and soaking each filter paper with 12 ml of distilled water. Magnetic treatment was provided as doses, depending on the exposure time and the magnetic induction. The magnetic fields were generated by ring magnets with magnetic induction values $B_1$=125 mT and $B_2$=250 mT. Analogous rings without magnetic induction were used as blind. The seeds were placed around a circular line, and then all the seeds were subjected to the same magnetic field strength. To obtain each magnetic dose, the magnet was placed below Petri dish for the following times: 20 min, 1 h, 24 h, and chronic exposure, as showed in table 1. When the corresponding exposure time was finished, the magnet was changed for a blind ring. Petri dishes of control group were located on blind rings for all the experimental time.

*Tabla 1. Magnetic Treatment applied for 125 mT (E1-E4), 250 mT (E5-E8) and control (C).*

| Exposure Time | Magnetic Treatment (E) | |
|---|---|---|
| | $B_1$=125 mT | $B_2$=250 mT |
| 0 | Control C | |
| 20 minutes | E1 | E5 |
| 1 hour | E2 | E6 |
| 24 hours | E3 | E7 |
| Chronic Exposure | E4 | E8 |

For each treatment, the number of germinated seeds was scored three times per day and the rate of germination

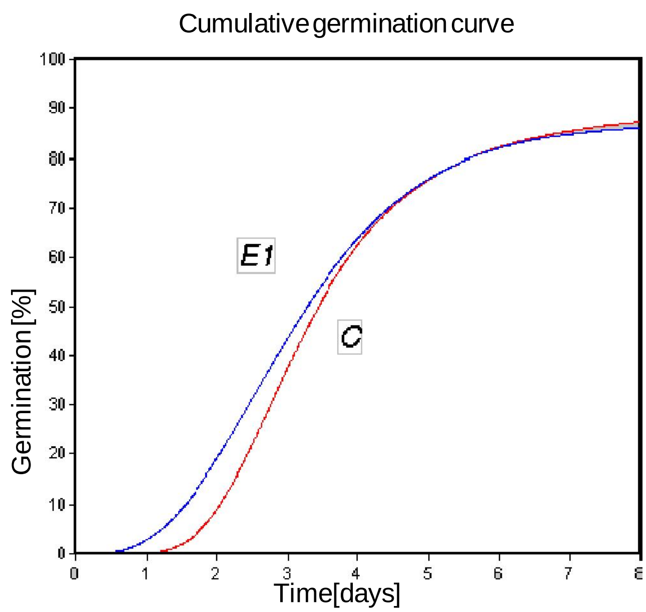


*Figure 1: Percentage of oat germinated seeds function of time, expressed in days, for E1 (seeds exposed to 125 mT for twenty minutes) and C (control, not exposed seeds)*

was assesses by determining the following parameters: G (number of germinated seeds), MGT (mean germination time), $T_1$, $T_{10}$, $T_{25}$, $T_{50}$, and $T_{75}$ (time needed to obtain 1, 10, 25, 50 and 75 % of germinated seeds). Germination curves were plotted for each treatment. Statistical analysis was performed using the Seedcalculator software, specifically developed by Plant Research International (Wageningen, The Netherlands)
for seed germination data analysis. Results were compared by the Student's-t test and the p-value was calculated to establish the significant differences between each treatment and control.

## 3. RESULTS AND DISCUSSION

The germination parameters determined for each treatment, expressed as mean of the 4 replicates and their standard error are provided in Table 2. The results indicate that germination was intensely affected by the magnetic treatment, with greatest effects noted for 20 minutes of exposure (doses E1 and E5). The onset of germination, evaluated by parameters $T_1$ and $T_{10}$ were significantly lower than the corresponding values of the control, for most of doses. In general, parameters for treated seeds were below control value when seeds were exposed to magnetic field (treatments E1 to E8).

The Figure 1 shows the curves of germination for control (C) and seeds exposed to 125 mT for 20 minutes (E1). The control seeds present a beginning of the germination slower than the treated seeds. A great germination rate in E1 group *vs*. control group is also observed.

The application of magnetic techniques to improve the germination and growth of plants has been researched for long time. An increased rate of germination cereal seeds exposed to magnetic field has been obtained by Pittman (1963). Pregermination treatment improved the germination and seedling vigour of low viability rice and onion seeds by Alexander. Greater albumin, gluten and starch contents in wheat seeds exposed to magnetic field were obtained has been reported by Pietruszweski . The mechanisms at work when plants and other living systems are exposed to a magnetic field are not as well known yet but several theories have been proposed including biochemical changes or altered enzyme activities (Murphy, 1994 ;Phirke,1996). A possible mechanism associated with magnetism to accelerate tomato ripening was proposed by Boe 1963.

*Table 2 Germination parameters determined for oat seeds exposed to a stationary magnetic field, expressed as mean and their standard error.*

| Magnetic Field | Treatment | G | $T_1$ | $T_{10}$ | $T_{25}$ | $T_{50}$ | $T_{75}$ | MGT |
|---|---|---|---|---|---|---|---|---|
| | | (%) | ($\overline{x}$ ± SE) hour | | | | | |
| | C | 90.00 ±2.71 | 31.92 ±4.56 | 48.96 ±2.88 | 62.40 ±1.68 | 82.32 ±2.40 | 117.84 ±5.52 | 87.84 ±2.40 |
| 125 mT | E1 | 87.00 ±4.12 | 17.04* ±4.80 | 37.20* ±3.12 | 54.00* ±1.44 | 78.48 ±0.72 | 117.36 ±17.28 | 77.76 * ±3.60 |
| | E2 | 93.00 ±1.91 | 24.96* ±5.04 | 42.72 ±6.24 | 56.88 ±6.96 | 78.24 ±8.16 | 112.8 ±11.04 | 85.68 ±6.24 |
| | E3 | 94.00 ±2.58 | 33.12 ±3.12 | 46.32 ±2.40 | 57.12 ±1.92 | 75.84 ±3.08 | 118.08 ±12.00 | 92.40 ±5.04 |
| | E4 | 90.00 ±2.58 | 24.24* ±4.80 | 45.60 ±2.64 | 61.92 ±0.72 | 85.20 ±4.56 | 118.56 ±12.24 | 85.92 ±3.12 |
| 250 mT | E5 | 93.00 ±2.52 | 14.40* ±4.80 | 35.04* ±6.24 | 52.56* ±5.52 | 78.00 ±2.40 | 112.08 ±6.00 | 80.40 ±3.12 |
| | E6 | 93.00 ±2.52 | 14.40* ±4.80 | 35.04* ±6.24 | 52.56* ±5.52 | 78.00 ±2.40 | 112.08 ±6.00 | 80.40 ±3.12 |
| | E7 | 92.00 ±3.27 | 25.20* ±3.84 | 44.64 ±2.16 | 60.24 ±1.92 | 83.76 ±4.80 | 121.68 ±12.48 | 90.24 ±3.60 |
| | E8 | 92.00 ±2.83 | 16.08* ±3.60 | 38.40* ±4.80 | 57.60 ±5.28 | 84.72 ±6.00 | 120.72 ±7.92 | 85.68 ±4.08 |

Legend C (Not exposed seeds, control), E1 (125 mT, 20 min), E2 (125 mT, 1hour), E3 (125 mT, 24 hour), E4 (125 mT, chronic exposure), E5 (250 mT, 20 min), E6 (250 mT, 1 hour), E7 (250 mT, 24 hour), E8 (250 mT, chronic exposure). G: number of germinated seeds (%); $T_1$, $T_{10}$, $T_{25}$, $T_{50}$ and $T_{75}$: time needed to obtain 1, 10, 25, 50 and 75 % of germination; MGT: mean germination time. Asterisks indicate significant differences vs. control: *(p<0.05).

## 4. CONCLUSION

Stationary magnetic field of 125 mT and 250 mT produces an increase on germination rate of oat seeds, which involves a reduction in the parameters registered (time required to obtained 1-75 % of germinated seeds). This effect is greater for treatment E1, exposure to 125 mT for 20 minutes.

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