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STATIONARY MAGNETIC FIELD STIMULATES RICE ROOTS GROWTH

M. FLOREZ [1], J. ALVAREZ[1], E. MARTINEZ[1*], V. CARBONELL[1]

[1]Departamento de Ingeniería Agroforestal. Unidad de Física y Mecánica. E.T.S. Ingeniería Agronómica, Alimentaria y de Biosistemas.

Ciudad Universitaria s/n, 28040 Madrid, Spain
E-mails: mercedes.florez@upm.es; jose.alvarez.sanchez@upm.es; elvira.martinez@upm.es; victoria.carbonell@upm.es

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Abstract. Magnetic field is an environmental factor playing an important role in living organisms, although its effect is not well known. An increase of roots and stem length was observed in seeds subjected to a stationary magnetic field. Some authors have explained the close relation of the magnetic field to cell metabolism of plants.

This paper is a survey of magnetic fields effects on rice seedling exposed to magnetic field of two induction values, both stronger than the geomagnetic field, for various length of time.

Root length was measured on the 3rd, 7th and 10th day after seeding. Magnetically treated seedlings grew longer and heavier than untreated ones. On the 3rd day the length of roots of seedlings chronically exposed to 125 and 250 mT were significantly longer (20.67 and 30.61 mm respectively) than control (9.05 mm). On the 7th day, significant differences were observed for doses D6 (chronically exposed to 125 mT) and D11 (exposed to 250 mT for 24 h) related to controls. On the 10th day, exposed roots were longer and heavier than control roots, but not significantly. In addition, secondary roots of plants chronically exposed to magnetic field were more developed than untreated ones.

Key words: magnetic stationary field, rice, seeds, roots growth, stimulation.

1. INTRODUCTION

Nowadays a lot of research is trying to develop sustainable agricultural techniques and eco-friendly environment. Many of these techniques to improve crops introduce the magnetic treatment of seeds as a priming method.

Effects of magnetic fields on seeds and plants has been widely studied and although different theories have been proposed, there have been no conclusive results.

The first known studies on the effect of the magnetic field on plants were made by Savostín in 1930 [1], and since then the focus has been on changes in seed germination [2], seedling growth [3,4], assimilation and absorption of nutrients [5], early germination [6,7], the effect on dormancy, changes in enzymatic and photosynthetic activity, and among aspects [8,9]. Among the earliest few studies on the effect of magnetic fields on roots, there are those focused on the growth of primary roots [10-16].

Since 2000 many authors published articles on the effect of stationary magnetic fields on the growth of plant roots. It has been determined that exposure to the magnetic field increased the entrance of amino acids in the Vicia faba L. roots, alters the movement of ions through the plasma membrane [17] and inducts curvature of primary roots in radish seedlings. The roots presented geomagnetism, this being negative, thus they responded significantly to the south magnetic pole [18]. Magnetic treatment of sunflower seeds produced a statistically higher increase in seedling dry weight, root length, surface area and root volume during the first month of growth.

2. METHODS

To study the effect of stationary magnetic fields on root growth, tests were performed under laboratory conditions.

2.1. THE SEEDS

Seeds were supplied by the Spanish Office of Plant Varieties, which guarantees homogeneity and viability of seeds as well as the significance of results without need of using large samples of plant material.

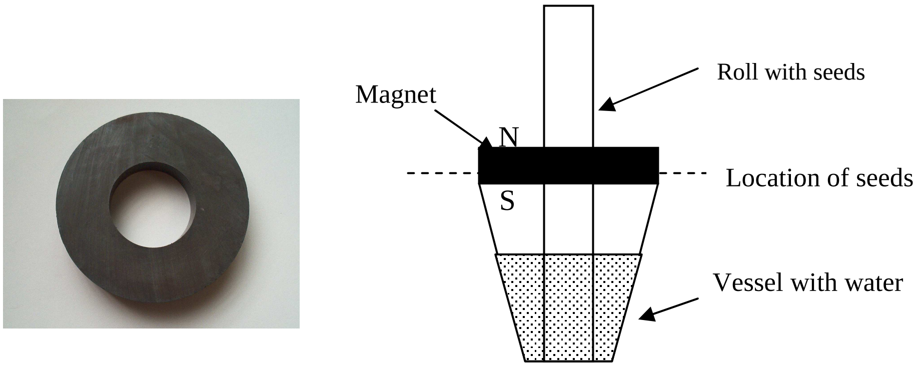
Germination test scoring was performed according to the rules issued by the International Seeds Testing Association [19].

In the experimental design four replicates (n = 4) with 25 seeds were used. Each group of 100 seeds was subjected to magnetic treatment, and analogous groups of 100 seeds without magnetic treatment were used as control.

Seeds were stuck to filter paper with non-toxic stick glue, with the vertical longitudinal axes. Each filter paper with seeds was rolled up and placed in a vessel containing distilled water, and no other substance was added. Four hours later, the moistened seeds were exposed to magnetic treatment.

2.2. THE MAGNETIC TREATMENT

Applied magnetic doses, that is, the value of the magnetic induction B and the time of application t varied. Ring magnets as shown in Fig. 1a were used to generate a magnetic field. Magnetic induction values in the center of the magnet, provided by the manufacturer, are 125 mT and 250 mT. Magnets were placed on top of vessels and rolls with seeds were placed in the hole of the magnet to generate each dose (Fig. 1b), during the time established. Control C ran simultaneously with exposure to doses D1-D12.



(a) (b)

Fig. 1 - (a) Ring magnets. (b) Magnets on vessels and roll with seeds.

Geometric characteristics of magnets were 75 mm external diameter, 30 mm internal diameter, 10 mm high for B1 and 15 mm high for B2. Doses D1–D12 applied were obtained by exposing the seeds to B1=125 mT and B2=250 mT for different times, as follows:

Exposure to B1=125 mT: 1 min (D1), 10 min (D2), 20 min (D3), 1h (D4), 24 h (D5) and chronic exposure (D6).

Exposure to B2=250 mT: 1 min (D7), 10 min (D8), 20 min (D9), 1h (D10), 24 h (D11) and chronic exposure (D12).

Four magnets of the same material and dimensions, but without magnetic induction, were used as control and the four control rolls with 25 seeds each one were placed inside. All the vessels with seeds were labeled and randomly distributed for the growth test.

Labels were not related to the dose applied so that both counting of germinated seeds and subsequent measurements was blind.

The objective of the test was to evaluate the effect on length and weight of rice seedlings, and specifically root growth of the stationary magnetic field. Three days after sowing, rolls of filter paper were unrolled and length of seedlings was measured; afterwards, they were re-rolled and placed in vessels in order to re-measure the length of roots on the 7th and 10th days. On the 10th day the experiment finished, and length and weight of seedlings were measured before discarding.

2.3. STATISTICAL ANALYSIS

Windows SPSS 11.0 software was used for statistical analysis of growth data. Analysis of variance was applied to detect differences between the average parameters. Levene test was used to check variance normality of data and the Kolmogorov-Smirnov test to check significant differences between the two datasets. Multiple comparison Tukey test and Dunnet test were performed to detect treated and control plant parameter differences.

3. RESULTS

Length of roots of seedlings was measured on days 3rd, 7th and 10th after sowing; in addition, the 10th day weight of seedlings was also measured. Figure 2 shows that the root length measured on the 3rd day was greater than the control root length for doses D2, D6, D11 and D12; the greatest differences were obtained for the seedlings chronically exposed to the magnetic field.

Roots of treated seedlings were also longer than those of untreated seedlings on the 7th day but significant differences were obtained only for doses D6 and D11 (Fig. 3). On 10th day, roots of the seedlings exposed to both magnetic inductions were longer than those untreated ones, but no significant differences were obtained with respect to the control (Fig. 4) and similar results were observed for the weight of treated seedlings, as they were heavier than control seedlings. Figure 5 shows a greater development of secondary roots of rice seedlings chronically exposed to a magnetic field of 250 mT than that of the control.

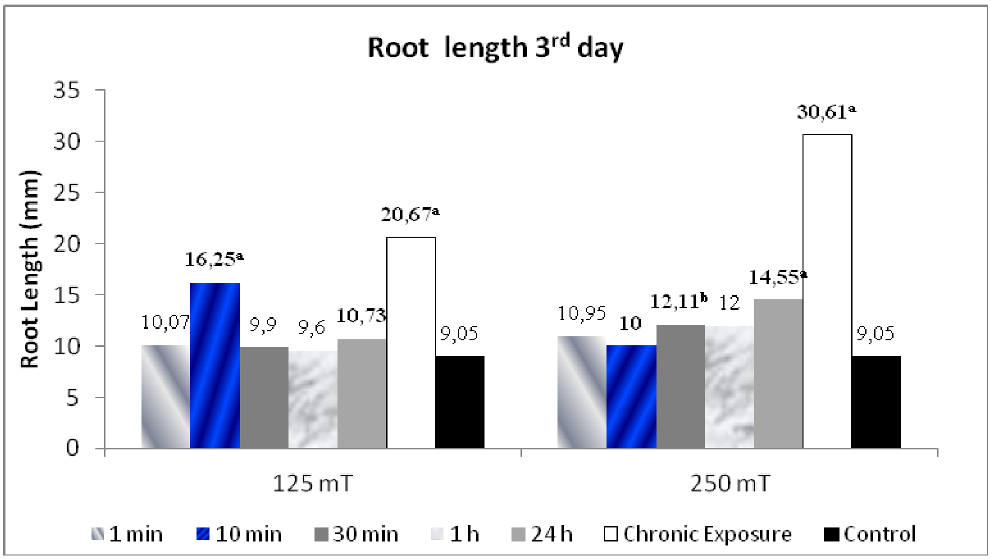


Fig. 2 - Root length measured on the 3rd day. Upper letters indicate significant differences related to control: a(p<0.001), b(<0.05).

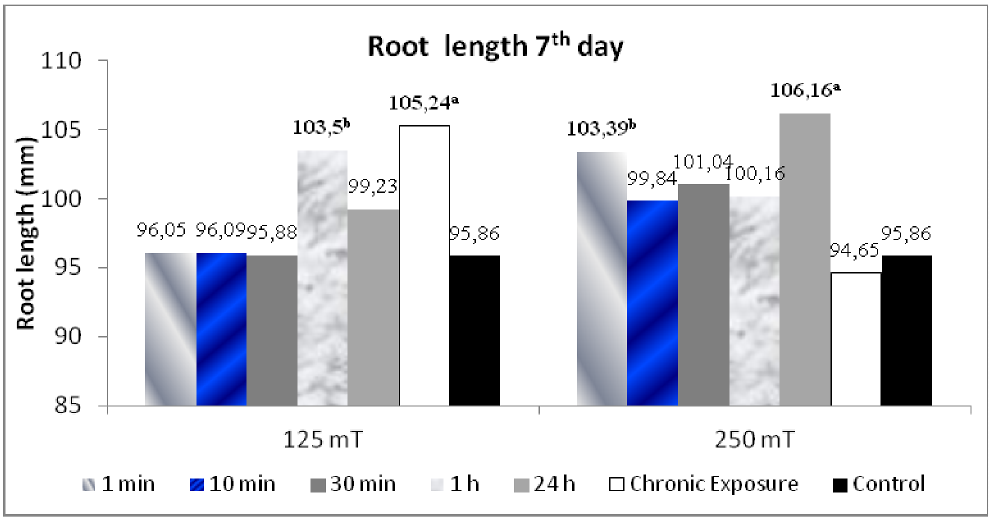


Fig. 3 - Root length measured on the 7th day. Upper letters indicate significant differences related to control: a(p<0.001), b(<0.05).

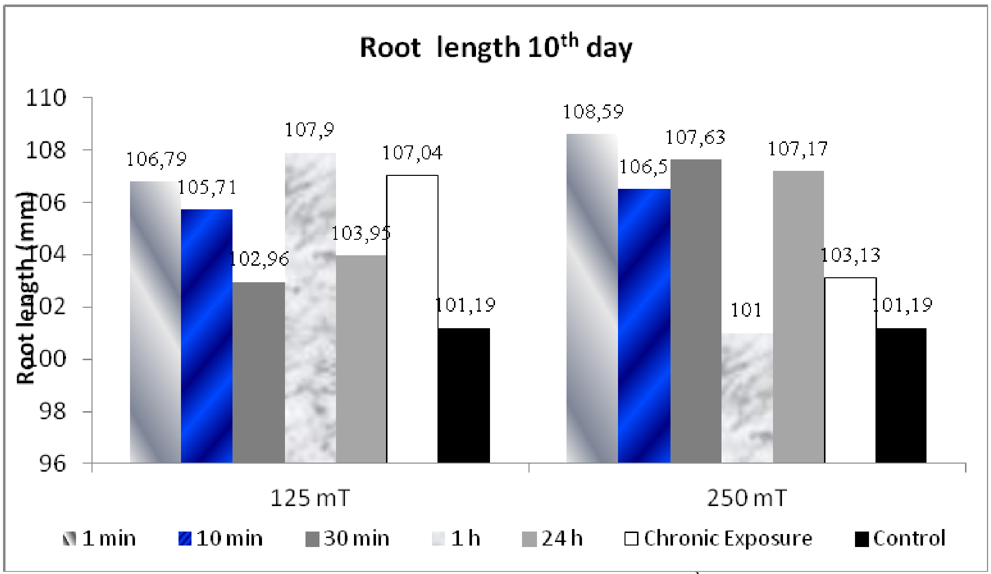


Fig. 4 - Root length measured on the 10th day.

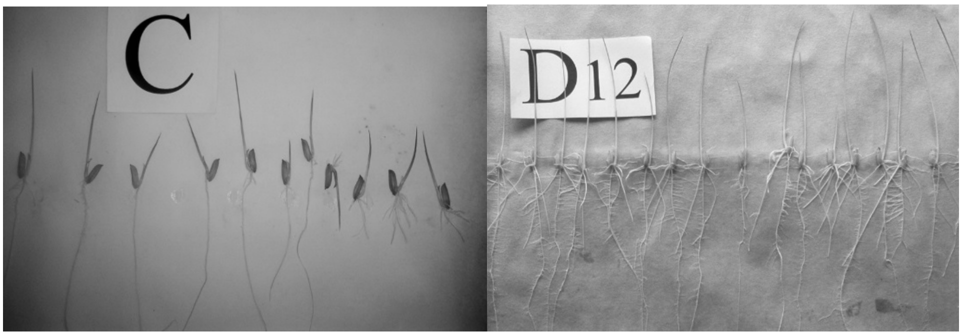


Fig. 5 - Secondary roots of rice control seedlings and chronically exposed.

In summary, roots of magnetically treated rice seedlings were longer and heavier than the control seedlings; these differences were significant for chronic exposure.

4. DISCUSSION

Magnetically treated rice roots grew longer and heavier than the untreated ones; these differences were significant for 24 h (D5, D11) and chronic exposure. The stimulatory effect of the different magnetic doses, reported in this paper, is in agreement with that obtained by other researchers: the pretreatment of rice and onion seeds increased germination of seeds as well as the vigor of the low viability seedlings [20]; seeds exposed to magnetic fields absorbed more moisture and contained higher albumin, gluten and starch content [21]. Cotton seed pretreatment increased production as well as fiber length [22].

Mechanisms of action of magnetic fields in plants and other living systems are, for now, not very well known although many theories have been proposed. One of the most widespread theories is that changes occur both at the biochemical level, and/or alteration of enzymatic activity [23]. In a study carried of exposure of lettuce seeds to a stationary magnetic field of 1-10 mT, a greater water uptake of seeds was observed, and they reported as the cause of the higher germination rate of these seeds [24]. In the same way, Zanini observed alterations on water uptake mechanism din palm oil kernel by application of a magnetic field and proposes that applied magnetic fields seem to target the signaling system of plant cells involving Ca^{2+} ion [25]. The influx of Ca^{+2} through the plasma membrane as the main mechanism responsible for the effects, has been reported and it can be associated with the activation of voltage-dependent calcium channels embedded in the plasma membrane by the stationary magnetic field [26]. Other authors paid attention to the potential role of the cryptochrome as a plant magnetosensor. Other explanations have been proposed based on movements of paramagnetism, diamagnetism and ferromagnetism substances and molecular and cellular changes [27-29] and other mechanism of action [30]

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