Study of 125 mT magnetic treatment on the germination and initial growth of triticale seeds

J. Alvarez, M.V. Carbonell, M. Flórez, E. Martínez, A. Campos

Abstract. *The effects of magnetic treatments on germination and the initial growth stages of triticale seeds have been studied. Germination and growth tests were carried out under laboratory conditions by exposing triticale seeds to 125 mT for different times (1, 10 and 20 min, 1 and 24 hour). The rate of germination was assessed by determining the mean germination time (MGT) and time required to germinate 1, 10, 25, 50, 75 and 90 percent of seeds. Parameters T_{10} – T_{90} and mean germination time were reduced for all treatments applied. Plants exposed to magnetic fields grew higher than control. Results suggest that stationary magnetic fields have a stimulating effect on the first stages of growth of triticale plants*

***Keywords**. Triticale, magnetic field, germination rate, early growth*

INTRODUCTION

The main objective of this study is to determine the effects of magnetic treatment on the germination and initial growth of triticale seeds. Magnetic field has been used widely as treatment to improve germination, seedling growth and yield. In general, the enhancement of growth due to magnetic field exposure appears to have been confirmed by many scientists. Some have tried to determine effects related with seed germination, such as changes in biochemical activity, curvature, magnetotropism and germination rate. Cakmak *et al.* (2010) observed that the application of magnetic field doses of 4 mT and 7 mT promoted germination ratios of bean and wheat seeds. De Souza, *et a*l. 2010 concluded that pre-sowing magnetic treatments have the potential to enhance tomato seed germination and early seedling growth. Best results were obtained by the combinations 160 mT for 1 min and 200 mT for 1 min. In soil, exposure of seeds to these two magnetic fields significantly increased emergence index, percent emergence, shoot and shoot length, shoot and root dry weights and leaf area of 28-day-old seedlings under greenhouse conditions compared to control seedlings.

MATERIALS AND METHODS

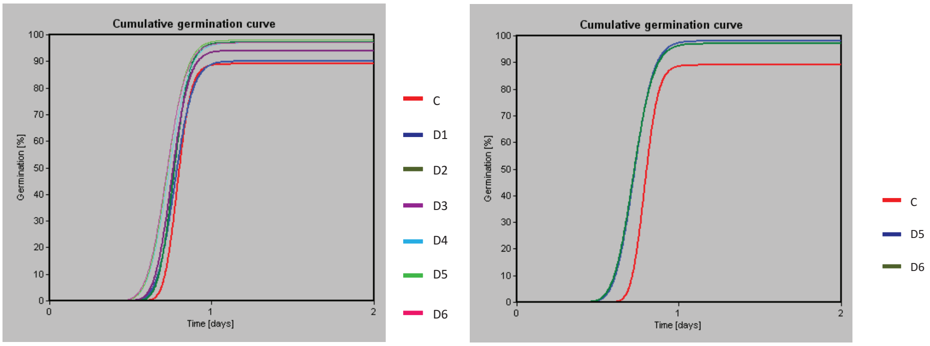
Germination and growth tests of triticale were carried out under laboratory conditions with natural light and temperature between 18-22 ºC, according to guidelines issued by the International Seed Testing Association (ISTA, 2004). Triticale (*X Triticosecale* Wittmack) is a wheat and rye hybrid. Seeds were supplied by the Spanish Office of Vegetable Varieties, which guarantees high seed viability and homogeneity and thus significant results with smaller samples. The static magnetic field was generated by permanent ring magnets, with strengths of 125 mT, internal and external diameters of 3 and 7.5 cm, and height of 1 cm. Ring analogous to the magnets, of the same material but without magnetic induction, were used as blind (Control). Magnetic doses were obtained by exposing the seeds to each magnetic field for different times. The experimental design involves four replicates (n=4) with 25 seeds. Thus, groups of 100 seeds were subjected to each magnetic treatment, and an analogous group was used as control. Germination was tested by placing 25 seeds per Petri dish around a circular line, on filter papers soaked with 12 ml of distilled water. Petri dishes were placed on top of a magnet for time corresponding to their treatment. Petri dishes were labeled and randomly located. Experimental groups P1-P5 and control C ran simultaneously. Number of germinated seeds was recorded, to determine the time necessary to achieve the final maximum percentage of germinated seeds (Gmax). Seeds were considered germinated when their radicle measured at least 1 mm. The rate of germination was assessed by determining the mean germination time (MGT) and time required to germinate 1- 90 percent of seeds (parameters T_1, T_{10}, T_{25}, T_{50}, T_{75} and T_{90}). Statistical analysis of variance and mean comparisons was performed using the Seedcalculator software specifically developed for seed germination data analysis by Plant Research International. Software provides germination curves for each treatment, a comparison of the results of all the treatments and a comparison with the result of the control.

The objective of growth test was to evaluate length and weight of triticale plants subjected to magnetic field during the first stages of development (2nd, 4th and 6th days after seeding). Treated seeds with their long axes vertical were glued to filter paper with a non toxic adhesive. Each filter paper with seeds was rolled and placed in a vessel containing distilled water. Rolls with 25 seeds were numerically labeled and placed randomly during the test. No other substance was added to the water during the experimental period. Growth was measured at 2, 4 and 6 days after seeding. Data statistics were analysed with SPSS 11.0 for Windows software (v.18). Means were compared using Tukey and Dunnet test.

RESULTS AND DISCUSSION

Germination test. The number of germinated seeds (G_{max}), from 80 to 99 %, corroborates the high quality of seeds. Parameters T_{10} – T_{90} and the mean germination time (MGT) were reduced for all the applied magnetic doses. While the MGT of control seeds was 18.96 ± 0.24 h, this parameter was significantly reduced for doses D6 (17.28±0.24 h), D5 (17.52±0.24 h) and D4 (17.76±0.24 h). The time required to germinate 1%, parameter T_1, of seeds exposed to a magnetic field was less than control. As T_1 is closely related to the onset of germination, these results indicate that triticale seeds exposed to a magnetic field sprouted earlier. The time required for germination recorded for each treatment was, in general, less than the corresponding control values; thus the rate of germination of treated seeds was higher than that of the untreated seeds (C).

Figure 1 shows the germination curves for treated seeds and control. Figure 1a show all magnetic treatments, it is remarkable that all curves are at left and above side of control cureve; figure 1b show the most significant different between D5 and D6 treatments compared to control.



(a) (b)

Figure1. (a) Germination curves of triticale seeds exposed to 125 mT magnetic field (D1 - D6) and control (C). (b) Germination curves of triticale seeds exposed to 125 mT magnetic field for 24 hours and chronic (D5 and D6) vs. control (C).

Growth test. Figure 2 shows the mean root length of triticale seedlings measured on the 2^{nd}, 4^{th} and 6^{th} day after seeding for all doses, compared with control, and weigth on 6^{th} day. On the 2nd day, greatest differences in mean total length were observed in doses D6 (9.55±0.28 mm), D5 (8.44±0.33 mm) and D4 (8.01±0.32 mm), compared with control (4.61±0.27 mm) Results of mean total length measured on the 2^{th} day shown similar differences. Results of root length measured on the 4th day shown that while the mean of control was 26.29±1.14 mm, the greatest length of seedlings was obtained for doses chronic treatment D6 (48.00±1.18 mm), exposure for 24 hours D5 (40,39±1.14 mm) and exposure for one hour D4 (37.98±1.43mm). Results measured on the 6th day after seeding shown that plants subjected to all doses were higher than control plants; the greatest increases were obtained for D6 (50.42±1.45 mm), D5 (51,47±1.37 mm) and D4 (48.63±1.29 mm) compared with control (39.71±1.24 mm). Consequently, all plants exposed to magnetic fields prior sowing grew higher than control. Figure 2 (d) shows the fresh weight of seedling on the 6th day, extremely significant differences were obtained for D6, D5 and D4, and significant differences for D2.

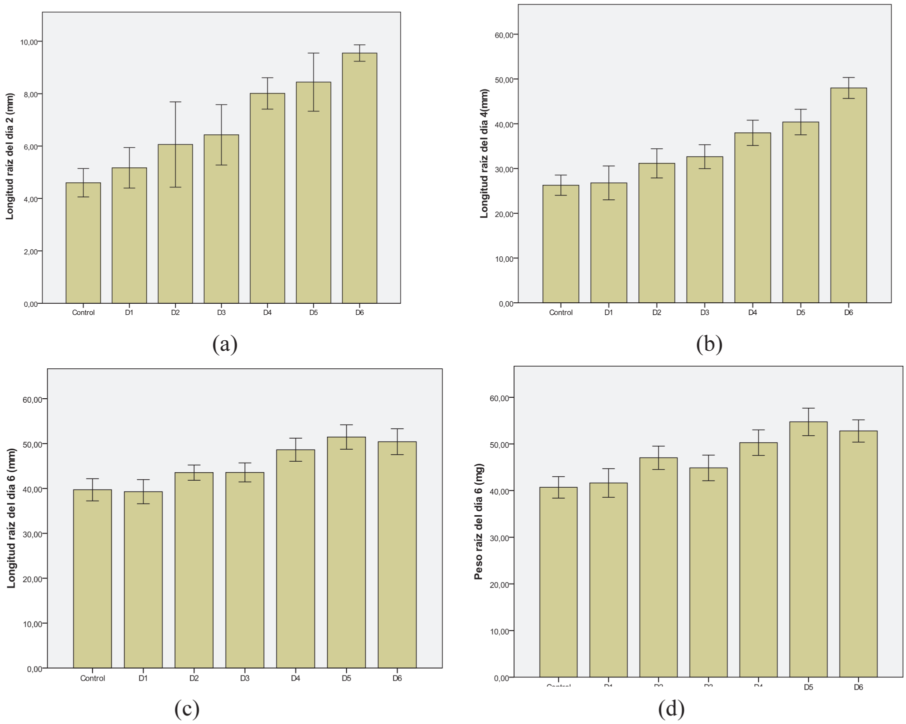


Fig. 2. (a) Mean root length of triticale plants from seeds exposed to 125, measured on 2nd day, including the 95% confidence intervals, (b) 4th day, (c) 6th day, (d) Root weight measured on 6th day.

Our results are in agreement with the germination data of maize seeds obtained by Aladjadjiyan (2002), who found an increase in germination and shoot development in seeds exposed to 150 mT magnetic field for 10, 15, 20 and 30 minutes. Podlesni et al. (2004) found magnetic treatment of 30 mT and 85 mT on two broad bean cultivars affected positively the germination and emergence. Soltani et al. (2006 a, b) found the effect of a magnetic field on Asparagus officinalis and Ocimum basilicum seed germination and seedling growth to be positive. Vashisth et al. (2008) observed that magnetic field application enhanced chickpea seed germination speed, seedling length and seedling dry weight. Pietruszewski et al. (2010) observed accelerated germination after magnetic stimulation of wheat seeds. They worked with 30, 45 and 60 mT magnetic field strengths.

Shine et al. (2011) found that exposure to magnetic fields improved parameters like water uptake, leaf photosynthetic efficiency and leaf protein content.

In previous studies author found an increase in the rate of germination of seeds and a stimulation of growth of seedlings. They found a positive growth response to a 125 mT and 250 mT magnetic field in rice, wheat and barley seeds (Flórez 2004; Martínez et al. 2000, 2002). An increase of the initial growth stages and an early sprouting of maize seeds exposed to a stationary magnetic field was also observed by Flórez *et al.* (2007), grass seeds and pea plants by Carbonell *et al*. (2008, 2011). Recently they have also obtained an early germination in *Salvia officinalis* L. and *Calendula officinalis* L. (Flórez *et al*. 2012).

CONCLUSIONS

Results obtained in this study allow us to conclude that magnetic treatment improves germination rate of triticale seeds. In general, most of the parameters recorded for all the doses applied to triticale seeds were better than control values. Thus, the rate of germination of treated triticale seeds was higher than the untreated seed (C) rate. Furthermore, seedlings from magnetically treated seeds grew taller than control.

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Докладът е рецензиран.