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Research Article

Effect of magnetic field on germination of two *Calendula officinalis* L. cultivars

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ABSTRACT:

The main objective of this study is to determine the effects of magnetic treatment, in addition to the geomagnetic field, on germination of two *Calendula officinalis* L. cultivars, “Antares flashback” and “Gold star”. Groups of 50 seeds were exposed to 1505.2 and 2260.8 mT magnetic field generated by 1 mA electrical flow in 60 and 90 round coils for 6 and 24 hours. The selected germination parameters were germination rate and percentage, radicle and plumule length, seed vigor.

Keywords: Germination, Magnetic field, “Antares flashback” , “Gold star”.

Introduction:

Pot marigold (*Calendula officinalis*), is an herbaceous plant in *Calendula* genus of Asteraceae family. It is an aromatic perennial and medical plant. The cosmetic and therapeutic applicability of Calendula is well established especially when concerned with skin-related disorders (Mishra *et al.,* 2011). The flowers of *Calendula* contain flavonol glycosides, triterpene oligoglycosides, oleanane-type triterpene glycosides, saponins, and asesquiterpene glucoside (Ukiya, 2006). Seed priming stimulates many of the metabolic processes involved with the early phases of germination and it has been noted that seedlings from primed seeds emerge faster, grow more vigorously and perform better in adverse conditions (Neto *et al.,* 2000).

The normal process of germination and plant growth occurred by genetic and environmental factors. In agriculture proper preparation of seeds before sowing named priming, which applies to chemicals (seed dressing, growth regulators), scarification, seed stratification and physical factors (fixed and variable magnetic and electrical fields, microwave, ionizing and laser radiation), which usually affects positively germination and plant growth and the height of the yields obtained (Muszyñski and Gadyszewska, 2008; Yi-Ping Chen et al., 2005).

Four types of fields were applied in the aim of studying the impact of magnetic fields on plants, their germination and growth: weak static fields, homogeneous magnetic fields (up to about 100 ìT), with consideration to geomagnetic fields, strong homogeneous magnetic fields (of the order of mT to 1 T), strong inhomogeneous magnetic fields and low frequency magnetic fields (ELF) of mT order (Galland and Talon, 2005). The seeds of many crops were subjected to the activity of physical stimulating factors. Onion seeds were stimulated with variable magnetic fields at a frequency of 50 Hz, the greatest yield growths and greatest chive lengths were obtained at a stimulation time of 15 s. For cabbage seeds and radish stimulated with variable magnetic fields at induction of B= 30, 60, and 100 mT for stimulation times from 4 to 60 s, a positive effect on germination rate and yields was obtained for induction of 30 mT (Kornarzyñski et al., 2004 nad 2005). Also, researches carried out over the years concerning the possibility of the application of magnetically treated water in agriculture has generally been concerned with determining of its usefulness for improving seed germination and plant growth (Morejon et al.,2007). Magnetic field pre-treatment had also a positive effect on cucumber, such as stimulating seedling growth and development (yinal, 2005). An increased rate of germination of cereal seeds exposed to magnetic field has been obtained; greater albumin, gluten and starch contents in wheat seeds exposed to magnetic fields were obtained (pittman, 1963) A possible mechanism associated with magnetism to accelerate tomato ripening was proposed (Boe, 1963). In previous studies, scientists found that 125 mT and 250 mT magnetic treatment produces a biostimulation on the initial growth stages and an increase of the rate of germination of several seeds such as rice, wheat, and barley (Carbonel, 2000; Martinez, 2000; Martinez 2002, florez,2004, florez,2007). A positive response in grass seeds has been observed; exposure to magnetic field provided earlier germination, increased the number of germinated seeds, reduced the germination rate, and increased root length for *Festuca arundinacea* Schreb. and *Lolium perenne* L. seeds (carbonel,2008). Recently, the 125 mT and 250 mT magnetic field exposure to pea and lentil seeds has been studied; the growth parameters (total and stem weight, total and stem length) measured on days 7 and 14 were increased; consequently, seedlings from seeds magnetically treated grew taller and heavier than control ones. Increased root development was also observed (Martinez,2009).

The aim of the present study was to determine the effects of exposure of two *Calendula* cultivars seeds to magnetic field on seed germination and seedlings early growth under laboratory conditions.

MATERIALS AND METHODS:

The extremely low frequency magnetic field treatment was applied using a Helmholtz coils system. This consisted of two coils, each formed by 1,000 turns of 1 mm cooper wire, with a mean diameter of 260mm and a thickness of 25mm. The coils were mounted coaxially and placed at a mean distance of 130mm each other. The coils were fed through a power terminal of 50Hz sinusoidal voltage and current intensity adjusted at 1.76A. Thus, when a 50Hz sinusoidal electric current passed through the coils, a vertical sinusoidal magnetic field of 10mT was generated in the centre of the coils system. For higher amount of magnetic field we increase voltage and intensity. The seed exposure was done by placing dishes in the centre of the coils system. Exposure time duration was controlled by automatic timer coupled to the magnetic generator supply. The measurements of the magnetic field induction evidenced that within the centre of the Helmholtz coils system no significant variations of the value of 10mT could be detected for a 100mm diameter area, as measured with a Tesla meter provided with Hall probe. Magnetic exposure intensity was expressed as magneticnergy dose, D= w. t, where w [J /m3] is the energy de $w = \frac{B^2}{2\mu_0}$ magnetic field while t[s] is the exposure time duration. The magnetic field energy density was assessed to 39.8×10^{-6}J/cm^3 as resulted by applying the formula where B[T] is the magnetic field induction and μ_0 is the magnetic permeability of free space. Thus, the magnetic dose used during the exposure ranged between 0.143 J·s/cm3 and 0.573 J·s/cm3 (Racuciu, 2012). We exposed groups of 50 seeds to varied magnetic field strengths of 1505.2 and 2260.8 mT magnetic field generated by 1 mA electrical flow in 60 and 90 round coils for 6 and 24 hours. The germination percentage (Maguire, 1962), mean germination rate (Maguire, 1962) , radicle and plumule length, and seed(Plantlet) vigor (Maguire, 1962), were recorded and exposed to Jump computer package, where a significance test based on ANOVA was done. Further analysis involved comparing varied field strengths and exposure periods.

RESULTS AND DISCUSSION:

Analysis of data results in table 1. For germination related traits.

Table 1. Mean square of germination studied traits

	df	Germination rate	Germination percentage	Radicle length	Plumule Length	Plantlet vigor
Magnetic field	2	10.804	54.393	0.886	2.669	1.500
Magnetic field * cultivar	2	2.647	23.307	0.381	1.132	0.245
Err	24	54.11	461.307	15.027	26.33	8.790

- Germination percentage:

Analysis of variance for seed germination percentage showed that there was a significant difference (P≤1%) between magnetic field treatments. 24 hours of 2260.8 mT on “Antares flashback” cultivar had the highest and control in similar cultivar had the lowest germination percentage (table 1). It shows that higher level og magnetic field and longer time of application may increase seed germination. Florez and et al., (2004) studied on rice had similar results. The better germination percentage may be occurred because of an increase in availability of Ca and Mg which are co factors to seed germination (Moore, 1966). magnetic field has higher effects on germination of temperature sensitive seeds (Rochalska, 2005). Kobayashi (2004) showed that magnetic field could activate metabolic and Enzymatic reactions during seed germination process. Studies on sunflower seeds showed higher amount of alpha amylase, dehydrogenises and protease under magnetic field treatment in compare to control. The amount of enzymes increased by increase in field intensity (Vashisth, 2010).

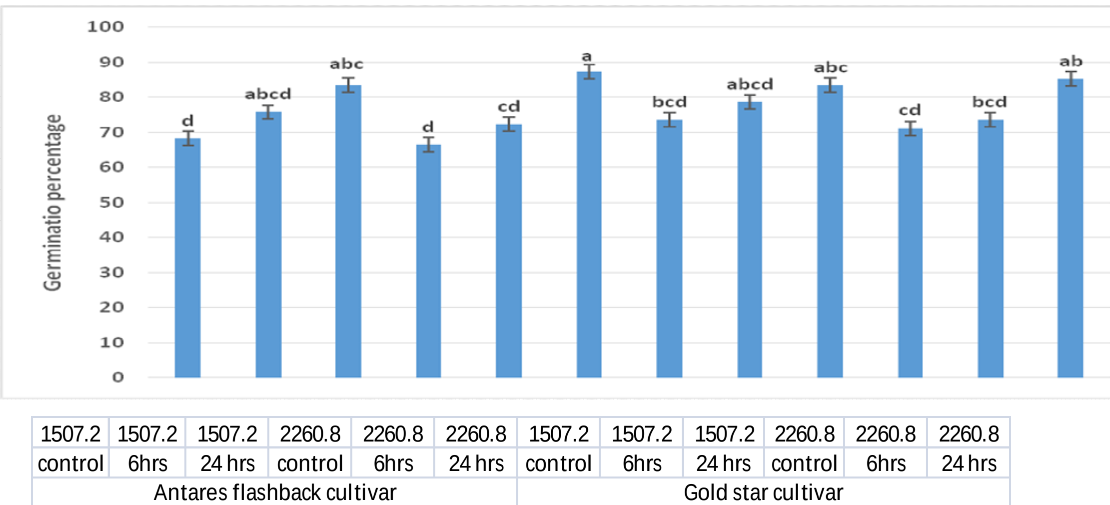
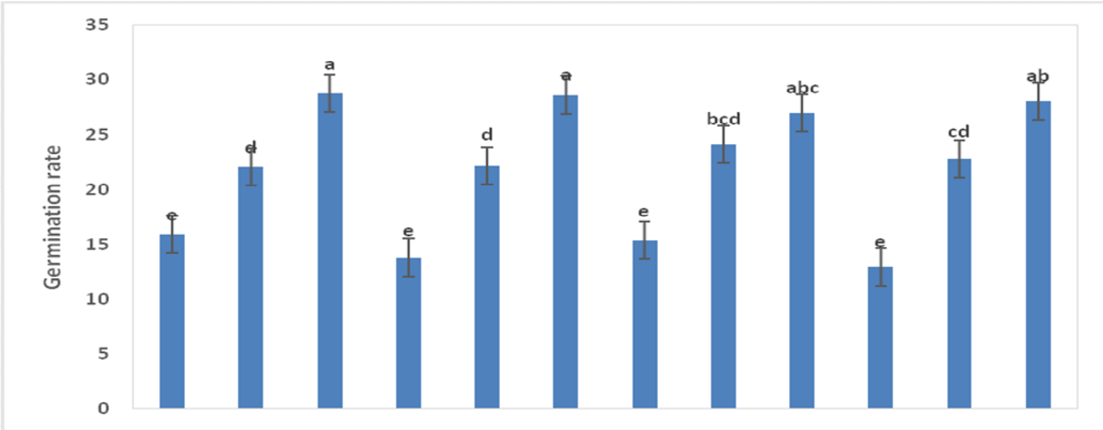


Figure 1, germination percentage of treatments in both studied pot marigold cultivars. Columns with different letters have significant differences (P≤5%)

- Germination Rate:

Comparison of germination rates between treatments shows significant differences between magnetic field treatments (P≤1%). Longer seeds treated by magnetic field, faster they germinate. But the intensity of field had no significant effects on germination rate. Differences between cultivars were not significant.

(Table 2).



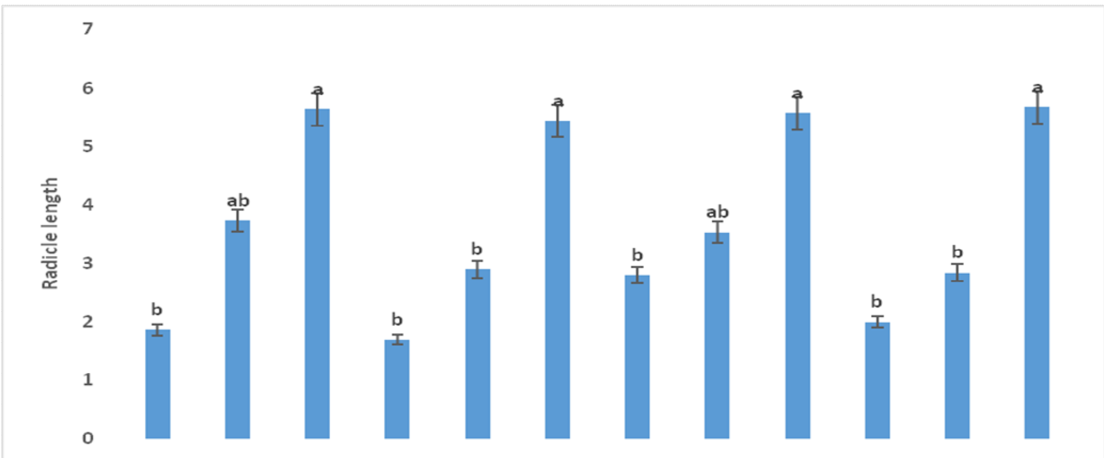
1507.2 control	1507.2 6hrs	1507.2 24 hrs	2260.8 control	2260.8 6hrs	2260.8 24 hrs	1507.2 control	1507.2 6hrs	1507.2 24 hrs	2260.8 control	2260.8 6hrs	2260.8 24 hrs
Antares flashback cultivar						Gold star cultivar					

Figure 2, germination rate of treatments in both studied pot marigold cultivars. Columns with different letters have significant differences (P≤5%)

- Radicle and Plumule length

Analysis of data showed significant effects of both intensity and time of magnetic field treatments on radicle length and stemlet height (P≤1%). Highest length of rootlet growth occurred in 2260.8 and 24 hrs of treatment (fig. 3). There were no significant differences between cultivars for rootlet length. Highest Plumule height occurred in 2660.8 mT for 24 hrs in Gold star cultivar. Lowest stemlet growth related to antares flashback cultivar with no treatments (fig. 4).

The increase in length of rootlet and height of plumule maybe occurred because of cell elongation or osmotic pressure (Negishi, 1999). Increasion of Ca and mitochondria in plant cells under treatment results in higher metabolism and supports growth.



1507.2 control	1507.2 6hrs	1507.2 24 hrs	2260.8 control	2260.8 6hrs	2260.8 24 hrs	1507.2 control	1507.2 6hrs	1507.2 24 hrs	2260.8 control	2260.8 6hrs	2260.8 24 hrs
Antares flashback cultivar						Gold star cultivar					

Figure 3, Radicle length of treatments in both studied pot marigold cultivars. Columns with different letters have significant differences (P≤5%)

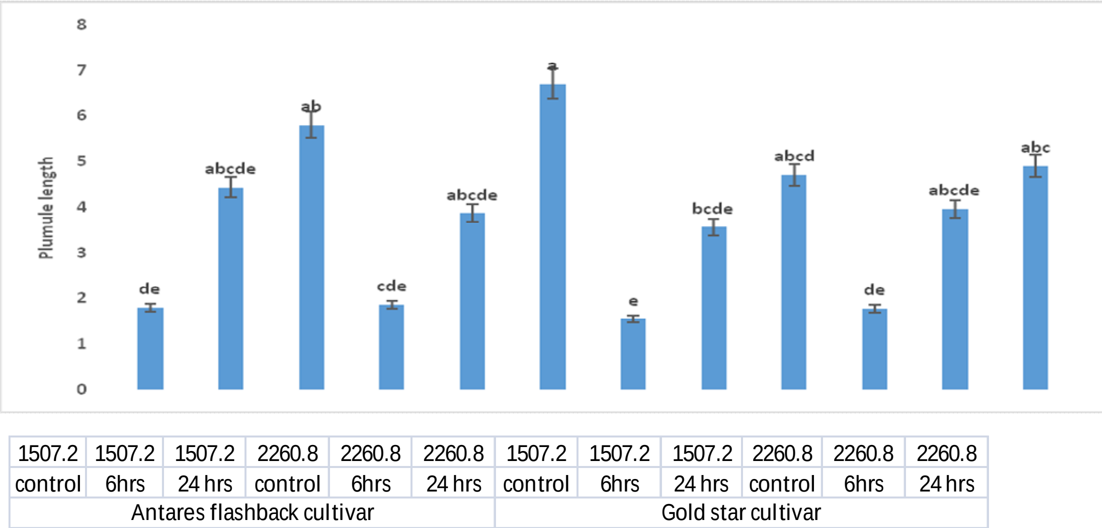
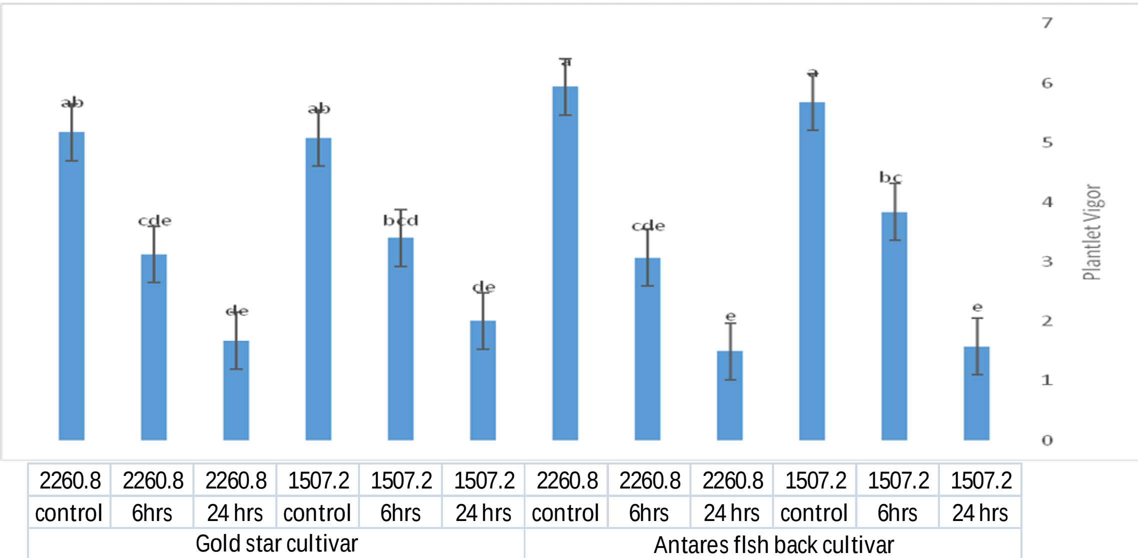


Figure 4, Plumule height of treatments in both studied pot marigold cultivars. Columns with different letters have significant differences (P≤5%)

- Plantlet(seed) vigor

Plantlet vigor highly affected by field treatments. Both 24 hrs treatments of 1507.2 and 2260.8 mT on antares flashback had highest vigor. The plantlet vigor hadan increasing trend by both time and intensity of magnetic field treatments, although there were no significant differences between 6hrs and control.



CONCLUSION:

In conclusion the results of this study showed that magnetic field could significantly increase seed germination and by making enzymes more available it increases the pace of germination occurrence. The plantlets derived from treated seeds with both intensities were more vigorous that those which were not treated or treated inadequately. The results of plantlet vigor suggest that treatment length of treatment is as important as its intensity and 6hrs may not produce good enough plants as 24hrs of treatment did.

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