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Effects of Short-term Magnetic Field on Germination and Growth of Plants

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ABSTRACT

The Numerous studies have been carried out to investigate the effect of short-term magnetic field exposure on plants, where seedlings (4–5 days old) were continuously exposed and grown under short exposure condition. Here, we have used a novel 'short-term magnetic field exposure experimental method' where imbibed seedlings were exposed to higher gauss values ranging from 300 gauss to 0.2 Tesla for a short interval time of 10 minutes. Changing patterns in peas and chick-peas germination and growth, along with various photo-synthetic and biochemical parameters were studied. Results revealed the significant inhibition of germination and growth in short-term magnetic field exposure treated seeds over control. Photosynthesis parameters such as chlorophyll content were found to be affected significantly in 5 days old seedlings exposed to short-term magnetic field exposure treatment. In order to investigate the cause of observed inhibition, we examined the α-amylase activity and antioxidative enzyme activities. α-amylase activity was found to be inhibited, along with the reduction of sugars necessary for germination and earlier growth in shortterm magnetic field exposure. In addition, the health status was measured by leaf color, spots and the stem curvature and the death rate. The result showed the magnetism had a significant positive effect on plant growth. Plant seeds under the influence of magnetic field had higher germination rate and these plants grew taller, larger and healthier.

Keywords: Hall-probe Instrument, Pisum-sativum, Cicer-arietinum, Chlorophyll content, Photosynthesis, Short-term magnetic field

INTRODUCTION

Plants have adapted themselves to the ever existing force of gravity (1 *g*) on earth for eons of years. Any change in the magnitude of gravity as result in magnetism therefore affects the plant growth and development. In recent years, gravity as well as magnetism driven changes in plant productivity has remained an exciting research area in the mainstream of plant physiology research. To understand the role of changing magnetism on plant behavior various systems have been developed. In most of the earlier reports, three to five days old seedlings were exposed to higher *gauss* values up to 3000 *gauss* for longer durations and effects were studied. For instance, suppression in elongation of both epicotyls and roots as well as inhibition in lateral root growth was observed in peas centrifuged at 140 *gauss*, 370 *gauss* and 1050 *gauss* for five days continuously. The decrease in percentage germination and growth was observed in wheat exposed to basipetal magnetic field for three days at 25 ºC in the dark. Stem elongation in 5 mm *Arabidopsis thaliana* inflorescence stems was suppressed, while dry weight of the inflorescence stems increased, when exposed to 300 *gauss* for 24 hrs in dark at 25 ◦ C. Such approach does not provide any information about the magnetic field effect on germination. Moreover, the duration of field exposure were considerably high ranging from 12 hrs to 21 days. Many studies have reported a reduction in percentage germination under field exposure environment, which has been maintained for a longer duration, but none have explained the possible cause for such reduction. Also, the influence of higher *gauss* values on important aspects of photosynthesis process such as chlorophyll pigment content, net photosynthetic rate, efficiency of photosystem PSII etc. have not been reported.

This showed that the growth and yield of lettuce could be improved by treatment of its seeds before they were grown, using rectified sinusoidal non-uniform electromagnetic fields. It was observed that magnetism has effects on lettuce at the nursery, vegetative, and maturity stages, including a significant increase in root length and shoot height, a greater growth rate, and a significant increase in plant height, leaf area, and fresh mass. Positive biological effects of magnetism on sunflower and wheat seedlings weights were reported. Further data show that the magnetic field induced by the voltage of a specific waveform enhanced or inhibited mung bean growth, depending on the frequencies, which suggests that the magnetic field on plant growth may be sensitive to the waveform and frequency of the source electrical voltage. The effect of static magnetic field on plant growth has also been studied. We have found that static magnetic field accelerated germination and early growth of wheat and bean seeds, obtained similar results with chickpeas; furthermore, they found that the responses of the plant to static magnetic field varied with field strength and duration of exposure with no particular trend. However, as indicated by a literature review, weak magnetic field exhibited negative effects on plant growth, such as inhibition of primary root growth, in some cases. For instance, exposure to magnetic field inhibited early growth of radish seedlings with decrease in the weight and leaf area. An interesting result is that the biological effect of a magnetic field is different between the south and north poles, as illustrated by a study, which showed that radish seedlings had a significant tropic response to the south pole of the magnet, but insignificant response to the North Pole. It is theorized that the south pole of the magnet enhances plant and bacterial growth by conferring energy, whereas the north pole retards their growth. Thus, it is possible to utilize the magnetic north pole against infections or tumor growths. Morphological anomalies in pollen tubes of a particular plant exposed to magnetism were observed, which raises an important question of whether magnetism can cause gene mutation and cancer. This issue is still controversial and demands more research evidence before any conclusion can be drawn.

Therefore, the aim of the present study was to analyze the effect on the germination and various physiological parameters, when seeds were exposed to short-term magnetic field. Various physiological and biochemical parameters such as germination, growth, chlorophyll content, photosynthesis, chlorophyll fluorescence as well as antioxidative response were studied. As per our knowledge such kind of work has not been carried so far.

METHODOLOGY

Seeds Selection and Short-term magnetic field exposure Treatment Pea seeds ***(Pisum sativum)*** and chick peas ***(Cicer arietinum)*** were procured from the local market of Parner city (MH). They were treated with 0.5 % systemic fungicide (Uthane M-45, United Phosphorus Limited), washed thoroughly and imbibed in distilled water (D.W) for 24 hours. After imbi-bition these seeds were subjected to short-term magnetic field treatment viz.1000 gauss 1500 gauss, 2000 gauss for 10 min each at 25 ◦ C, using a Hall probe Method. Light intensity was maintained as 15 μE $m^{-2}s^{-1}$. All the measurements were carried out on 5th day post sowing with emerged out shoots.

Estimation of Embryo Viability

Immediately after 10 min of short-term field treatment, control and treated seeds were stained with 1 % tetrazolium solution to check the embryo viability.

Seed Germination, Growth and Vigor Index Measurement:

Percentage germination, root length, shoot length, fresh weight of shoot and root were measured for both control and short-term magnetic field treated samples on fifth day from sowing. Vigor index of the seedlings was calculated by using the relation,

Vigor Index = Average total height of seedlings
x % seed germination

Enzyme Extraction and Assays

Five days post short-term magnetic field exposure, control and short-term field treated seeds without leaf blades were homogenized in ice cold 0.05 M phosphate buffer (pH 6.8) containing EDTA (0.5 mM). Each homogenate was centrifuged at 10,000 x *g* for 10 min at 4 ◦C. The supernatant was used for enzyme assays.

a-Amylase activity, catalase activity (CAT) and guaiacol peroxidase (GPX) activity were determined as described by Sadasivam and Manickam with some minor modifications. One unit of Amylase activity was defined as the amount of enzyme required for liberating 1 mg of maltose per min at 37 ◦ C. Catalase activity was measured by the decrease in H_2O_2 concentration in a reaction mixture containing 0.05 M phosphate buffer (pH 7.0), enzyme extract & H_2O_2 at 430 nm. Guaiacol Peroxidase activity was determined as the rate of oxidation of guaiacol to tetraguaiacol that is being monitored by recording the absorbance change at 436 nm for one min. Protein concentration was determined according to using bovine serum albumin standard.

Biochemical Quantification of Non Structural Carbohydrate Reserve:

Starch content and total reducing sugars were estimated from caryopses of five-days old seedlings raised from short-term magnetic field and control as described by Sadasivam and Manickam

Estimation of Chlorophyll Content

Chlorophyll was extracted from shoots of five days old seedlings raised from control and short-term magnetic field exposed seeds according to the method of Absorption spectra of total chlorophyll were recorded by using UV-Visible spectrometer. Chlorophyll a, b and total chlorophyll contents were calculated using Arnon's formula.

Photosynthesis and Chlorophyll Fluorescence Parameter

Photosynthesis parameters were recorded with the help of TPS-2, a portable photosynthesis system (PP systems, USA). Shoots of five days old peas seedlings were placed in the leaf cuvette (PLC4-B type, area 2.5 cm^2) and pho-tosynthesis rate (P_N), transpiration rate (Evap), stomatal conductance (G_S) and intracellular CO_2 concentration (C_{int}) were measured at PAR intensity of 600 μmol $m^{-2}s^{-1}$.

Before recording chlorophyll fluorescence, shoots were dark adapted for 15 minutes. The chlorophyll fluorescence transient was induced by applying a pulse of saturating red light (peak at 650 nm, maximum intensity > 3000 μmol m^{-2} s^{-1}) at the sample surface. The LEDs are focused via lenses onto the leaf surface to provide even illumination over the area of leaf exposed by the leaf clip (4 mm diameter). Fluorescence parameters defining the photochemistry of PSII such as maximum quantum efficiency of PSII photochemistry (Fv/Fm), performance index on the basis of absorption (PI) and maximal photochemical efficiency of PSII (Fv/Fo) were measured using Handy PEA (Hansatech Instruments Ltd, England).

Statistical Analysis

Each experiment was done in triplicates. For each measurement, the mean values and the standard error of the means (SE) were calculated. The significance of differences between control and treatment was analyzed by the Student's t-test.

RESULT AND DISCUSSION

In the present study we have analyzed the post effects of short-term magnetic field exposure on peas and chick peas germination and growth parameters. The results provide physiological and biochemical evidences suggesting that seeds are able to perceive magnetic field stress within short duration interval of 10 min, can memorize and respond to it upto five days.

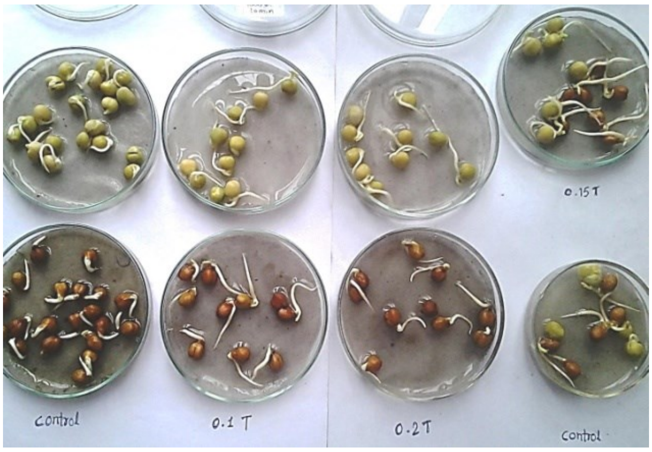


Fig 1: The unhealthy changes in control and experimental groups at the end of the fourth week.

Embryo Viability, Caryopses Germination, Growth and Vigour Index.

Embryo viability test was performed to rule out the pos-sibility of physical damage to the seeds exposed to field values.Result showed that seeds were 100 % viable even after exposure to field value and have ability to grow. Fig.1 shows the growth of five days seedlings raised from control and short-term magnetic field exposed seeds. No germination was observed in 2500 gauss.Any change in the magnitude of field is thus expected to affect seed physiology. In the preliminary experiments it was found that germination and growth was resistant to the inhibitory effect of short-term magnetic field up to 400 *gauss*. This could be due to the relatively harder seed coat which might be shielding the effective magnetic force experienced by the embryo. It is only after 500 *gauss*, that the inhibitory effects on germination and growth related parameters were observed.

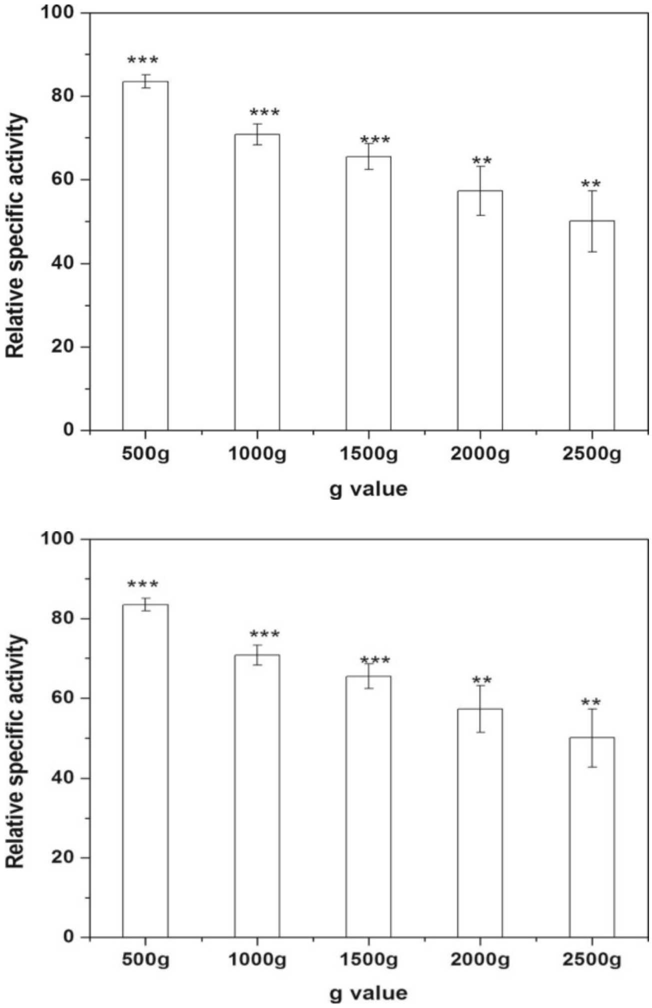
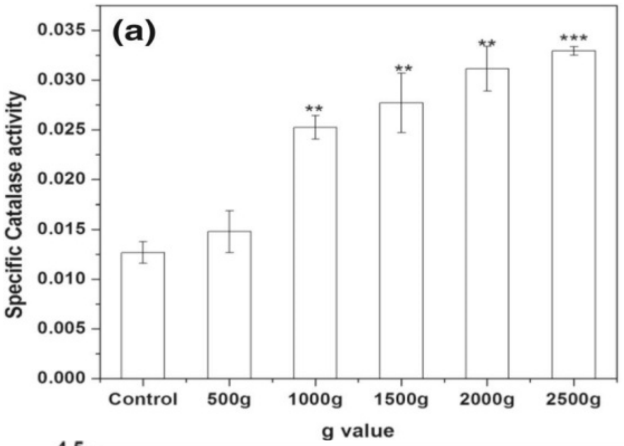


Fig 2: Effect of short-term magnetic field on relative *a*-amylase activity in seeds (U g^{-1} of seed). Percent relative activity was calculated with respect to control Chlorophyll Content.

After germination, degreening, a major event occurs in seedlings, where etioplasts get converted to chloroplast. At this stage, chlorophyll is synthesized with a greater rate.



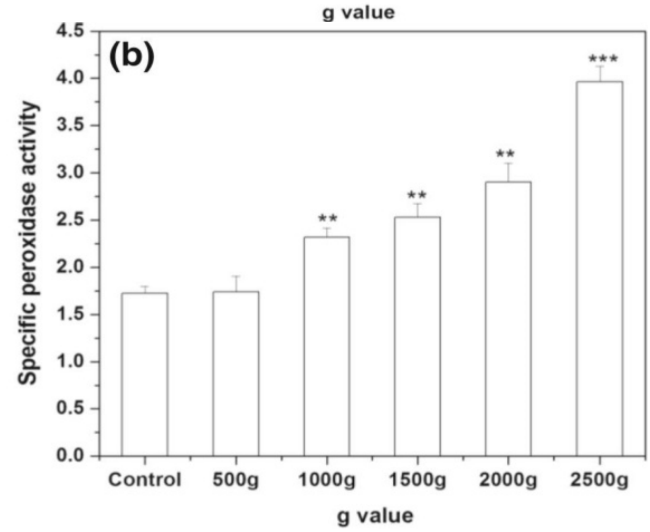


Fig. 3 a. Effect of short-term magnetic field exposure on Catalase specific activity (U g^{-1} of seed) in pea seeds. **b** Effect of short-term magnetic exposure on Guaiacol peroxidase specific activity (U g^{-1} of seed) in chick pea seeds.

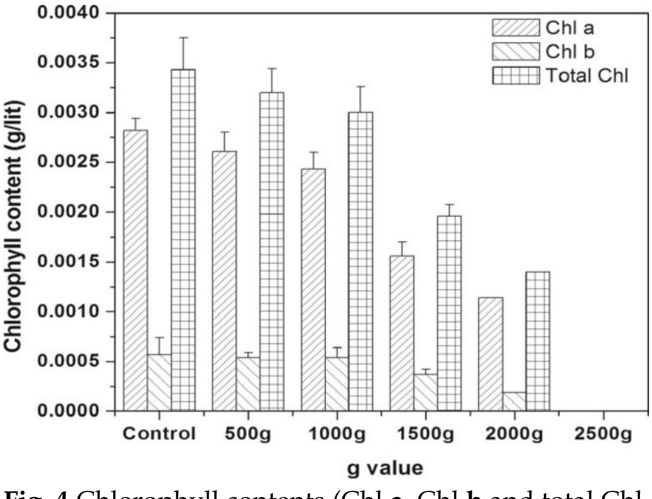


Fig. 4 Chlorophyll contents (Chl **a**, Chl **b** and total Chl, g/ltr) in shoots of 5 days old seedlings raised from control and short-term magnetic field exposed seeds.

Therefore, inhibition at the stage of germination can have adverse effect on the greening process of plants. Moreover, oxidative stress is responsible for the inhibition of chlorophyll biosynthesis.

We therefore investigated the chlorophyll concentration in short-term magnetic field treated seedlings with control. Major photosynthetic pigments, chl-a and chl-b, were significantly decreased in seedlings raised from short-term magnetic field exposed. Decrease in chlorophyll content was 7 %, 14 %, 45 % and 60 % in 500 *gauss*, 1000 *gauss*, 1500 *gauss* and 2000 *gauss*, respectively as compared to the control.

CONCLUSION

Present study has shown for the first time that imbibed seeds could sense and respond to magnetic field exposure given for a very short period of 10 min, without any physical damage. Further, they can retain this memory even while growing less than 1 *gauss* conditions post short-term hyper-gravity treatment. In conclusion, short-term magnetic exposure of 10 min might disrupt the *a*-amylase activity of germinating peas, which probably restricts the supply of sugars necessary for the embryo growth and development. Further, short-term magnetic field exposure reduced chlorophyll content and thus, the photosynthetic activity of growing peas seedlings. This can be related to the enhanced antioxidative enzyme activity in short-term magnetic field exposed seeds. Though such high *gauss* values used in the experiments do not exist in nature, situations may occur where hydrostatic forces of this order may exist. Moreover, without any special modification in the instrument design of centrifuge, it is possible to study the effect of short-term magnetic field on plants. This method in itself provides a simple and novel approach to study magnetic field effects on plants. As per our knowledge, this kind of study has not been reported previously.

Conflicts of interest: The authors stated that no conflicts of interest.

REFERENCES

1. Belyavskaya NA. Biological effects due to weak magnetic field on plants. *Adv Space Res*.,2004; 34: 1566-74.
2. Dattilo AM, Bracchini L, Loiselle SA, Ovidi E, Tiezzi A, Rossi C. Morphological anomalies in pollen tubes of Actinidia deliciosa (kiwi) exposed to 50 Hz magnetic field. *Bioelectromagnetics*. 2005; 26: 153-6.
3. De Souza A, Sueiro L, González L.M, Licea L, Porras EP, Gilart F. Improvement of the growth and yield of lettuce plants by non-uniform magnetic fields. *Electromagn Biol Med*.,2008; 27:173-84.
4. Fischer G, Tausz M, Kock M, Grill D. Effects of weak 16 3/2 Hz magnetic fields on growth parameters of young sunflower and wheat seedlings. *Bioelectromagnetic*s, 2004; 25:638-41.
5. Huang HH, Wang SR. The effects of inverter magnetic fields on early seed germination of mung beans. *Bioelectromagnetics*. 2008; 29:649-57.
6. Vashisth A, Nagarajan S. Exposure of seeds to static magnetic field enhances germination and early growth characteristics in chickpea (Cicer arietinum L.). *Bioelectromagnetics* 2008; 29: 571-8.
7. Aarti, D., Tanaka, R., Ito, H., Tanaka, A.: High light inhibits chloro-phyll biosynthesis at the level of 5-aminolevulinate synthesis during de-etiolation in cucumber (*Cucumis sativus*) cotyledons. Photochem. Photobiol. 2007; **83**, 171–176.
8. Arnon, D.I.: Copper enzymes in isolated chloroplasts Polyphenoloxi-dase in Beta vulgaris. *Plant Physiol*. 1989; **24**(1), 1–15.
9. Barjaktarovi´c Z, Nordheim A, Lamkemeyer T. Fladerer C, Madlung J, Hampp R. Time-course of changes in protein amounts of specific proteins upon exposure to hyper-*g*, 2-D clinorotation and random positioning of Arabidopsis cell cultures. *J. Exp. Bot*. 2007; **58**(15–16), 4357–4363.
10. Beck E, Ziegler P. Biosynthesis and degradation of starch in higher plants. *Annu. Rev. Plant Physiol. Plant Mol. Biol*.1989; **40**, 95–117.
11. Jagtap SS, Vidyasagar PB. Effects of high gravity (g) values on growth and chlorophyll content in wheat. *Int. J. Int. Biol.* BBB10 special issue, 2010; **9**(3), 127–129.