EFFECTS OF MAGNETIC FIELD ON PRE-TREAMENT OF SEEDLINGS AND GERMINATION

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ABSTRACT

Magnetic field studies have been a very important tool for exploring the electronic structure of condensed matter systems. Although applied magnetic fields in many cases have a relatively small effect on the overall electronic structure, they enable experimental techniques that can reveal properties of the underlying electronic structure that would be otherwise inaccessible. In other cases, magnetic field effects can be strong enough to drastically change the nature of the electronic state itself. Currently, cost of magnetic field generating equipment and modest increases in plant growth parameters observed in this study are limitations for the adoption of this technology for commercial plant production. In the future, further research may allow development of optimal magnetic field treatments for each plant species as well as more cost efficient magnetic field generating equipment.

Keywords: *Pre-treatment, Magnetic field, Seedling, Germination*

INTRODUCTION

Magnetic fields are central to the operation of many devices crucial for the functioning of a modern society. For example, electric motors and generators of electrical power take advantage, respectively, of the force exerted by a magnetic field on a wire that carries an electric current and of the complementary process whereby electrons in a wire moving across a magnetic field will feel a force that can drive a current along the wire. Other devices, such as read-out heads in magnetic disk memories, depend on magnetic-field-induced changes in the electrical resistance of certain materials, which are used to sense the orientations of the microscopic magnetic domains that encode digital information on the disk. In view of negative impact of chemical treatment, the modern agriculturists are in research of technologies, based on eco-friendly physical treatment for enhancing the crops productively and magnetic field pre-sowing seed treatment proved to be attractive in this regard (Martinez, *et. al.*, 2014). The applications of pre-treatment of seedling have shown promising potentials in different areas particularly in agriculture (Nyakane, *et. al.*, 2019). Pre-treatment of seedling with magnetic field is gaining more application with significant advantages such as improvements of Magnetic treatment improves first stages of growth in higher plants and increases stress enzyme like APX in seedling which grown from pre-treated seeds (Sunita and Lokesh, 2017). Da silva and Dobranszki, (2016) observed that plant responses to the static magnetic field (SMF) have been observed in a wide range of species, and were well summarized in the review of their papers.

The gain in seed yield resulting from the pre-sowing treatment of seeds with a magnetic field for both broad bean and pea was due to the higher number of pods per plant and fewer plant losses in the unit area in the growing season. No significant differences were found in the course of most developmental phases of those plants grown from the treated and non- treated seeds. However, a few days acceleration was reported concerning the maturity of plants obtained from those seeds pre-treated magnetically in comparison to the control. De Souza et al. (2006) observed the effects of pre-sowing magnetic treatments on growth and yield of tomato exposed to full-wave rectified sinusoidal non- uniform magnetic fields (MFs) induced by an electromagnet at 100mT (rms) for 10 min and at 170mT (rms) for 3 min. In the vegetative stage, the treatments led to a significant increase in leaf area, leaf dry weight, and specific leaf area (SLA) per plant. Also, the leaf, stem, and root relative growth rates of plants derived from magnetically treated seeds were greater than those shown by the control plants. In the generative stage, leaf area per plant and relative growth rates of fruits from plants from magnetically exposed seeds were greater than those of the control plant fruitsMagnetic seed treatment is one of the physical pre-sowing seed treatments especially worth our attention since its impact on the seeds can change the processes taking place in the seed and stimulate plant development. Sunita *et. al.* 2017 ascertain the adverse effect of salinity on germination and seedling vigour can be alleviated by magnetoprimig with SMF of 200mT for 1 h and it can also be used to increase water uptake and higher activity of hydrolytic enzymes (α amylase and protease)

Carbonell et al. (2008) evaluated the seeds of rice (*Oryza sativa L.*) exposed to 150 and 250mT magnetic fields both chronically and for 20 min after seedling emergence. Chronic exposure to a 150mT magnetic field increased ($p<0.05$) both the rate and percentage of germination relative to non exposed seeds (18% at 48h). Significant differences were also obtained for seeds exposed to 250mT magnetic field for 20min (12% at 48h). Additionally, seeds were moistened with water magnetically treated by static and dynamic methods. Dynamic and static treatment of water improved the germination of seeds related to the control, but significant differences ($p<0.05$) were only obtained for the dynamic method (16% at 48h).

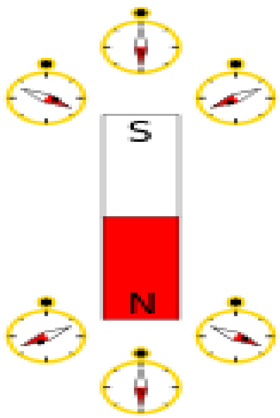

Fig 1: *Magnetic near pole*

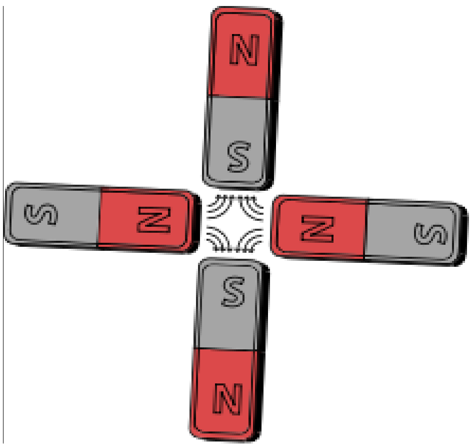

Fig 2: *Magnetic quadrupoke moment*

Using a magnetic time exposure for 30-60min led to a higher generation of Reactive Oxygen Specie and garden to decrease the biosynthesis of chlorophyll, carotenoid, phenolic and flavonoid compounds (Bilalis, *et. al.* 2012)

Exposure of seeds to these magnetic fields improved seed coat membrane integrity as it reduced the cellular leakage electrical conductivity. In the field, seeds exposed to these treatments showed increased field emergence and significantly increased seedling dry weights of one-month-old plants.

After surveying various methods used to improve the quantitative and qualitative attributes of agronomic and botanical production in greenhouse or field conditions. Nyakane *et. al.,* (2019a) recorded that the biological effects of magnetic field treatments depends on the strength and exposure period of plant.

However, agronomic attributes (plant height and chlorophyll content) and mineral composition (stem-N) were optimized when approximately equal proportions of Ca and Mg were applied in combination with exposure to an MF (Nyakane, *et. al.* 2019b).

Shawanroy, (2012) stated that, magnetic field alters the membrane structure of the plant cells so that the plants absorbs more water and nutrients. In addition, the vast majority of biological substances are proteins that contain metal ions, such as hemoglobin, cytochrome or ferritin, which can be paramagnetic (Hozayn and Qados, 2010; Azita and Ahmad, 2009).

Recent studies demonstrated that electric and magnetic field exposure enhanced seed germination of corn (Aladjadjiyan, 2002), cotton (Phirke et al., 1996), wheat (Martinez et al., 2002; Phirke et al., 1996), soybean (Camps-Raga et al., 2009), rice (Carbonell et al., 2000), barley (Lynikiene and Pozeliene, 2003), and ornamental grasses (García et al., 2008), and increased rooting on vegetative cuttings of grapes (Dardeniz et al., 2006).

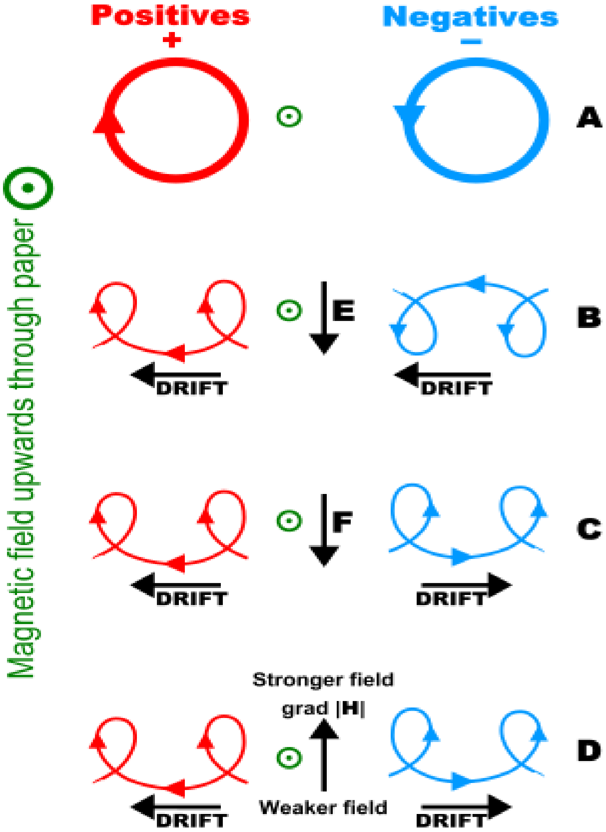

Fig 3: *Charged particle drifts* in a magnetic field with (A) no net force, (B) an electric field, **E**, (C) a charge independent force, **F** (e.g. gravity), and (D) in a homogeneous magnetic field, grad **H**.

Rajendra et al. (2005) have observed significant increase in mitotic index as well as 3H-thymidine incorporation into DNA in seeds of *Vicia faba* exposed to 100 μT power frequency electromagnetic field. These are clear indications of enhancement of growth of germinated seedlings exposed to magnetic field. In the same conditions, seedlings of sunflower showed higher seedling dry weight, root length, root surface area and root volume. Moreover, in germinating seeds, enzyme activities of α-amylase, dehydrogenase and protease were significantly higher in treated seeds than controls (Vashisth and Nagarajan, 2010).

Magnetic field on germination

Magnetic field studies have been a very important tool for exploring the electronic structure of condensed matter systems. Although applied magnetic fields in many cases have a relatively small effect on the overall electronic structure, they enable experimental techniques that can reveal properties of the underlying electronic structure that would be otherwise inaccessible. In other cases, magnetic field effects can be strong enough to drastically change the nature of the electronic state itself. In either situation, access to higher magnetic fields is important to allow the study of new materials and new phenomena. The application of magnetic field on germination is a suitable, cheap and easy seed invigoration method for improving germination and seedling vigour indices of poor quality seed (Ma, *et. al.* 2016).

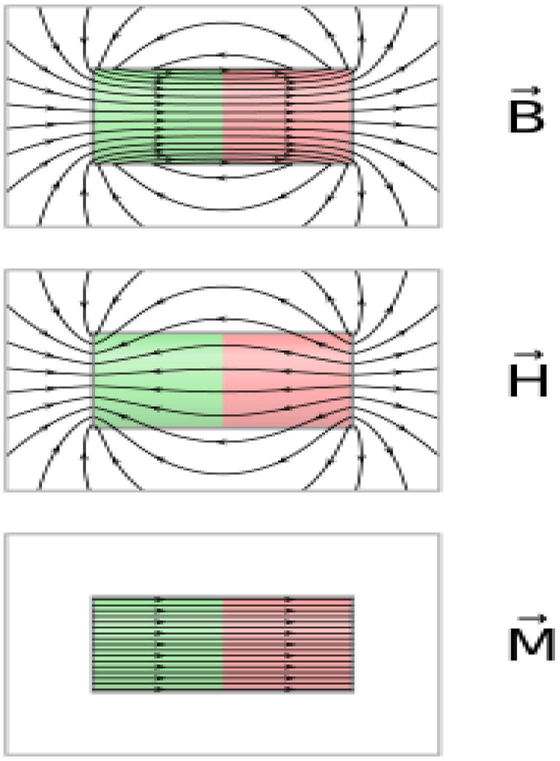

Fig 4: Comparison of **B**, **H** and **M** inside and outside a cylindrical bar magnet

Pre-sowing treatment of corn seeds with pulsed EMFs for 0, 15, 30, and 45 min improved germination percentage, vigor, chlorophyll content, leaf area, plant fresh and dry weight, and finally yields. Seeds that have been exposed to MF for 30 and 45 min have been found to perform the best results with economic impact on producer's income in a context of a modern, organic, and sustainable agriculture (Bilalis et al., 2012).

Moon and Chung (2000) found that the percent germination rates of tomato seed treated with AC electric fields ranging from 4 to 12 kV/cm and AC magnetic flux densities ranging from 3 to 1000 G exposed to 15 to 60 s time were accelerated about 1.1–2.8 times compared with that of the untreated seed. However, an inhibitory effect on germination was shown in the case of the electric field more than 12 kV/cm and the exposure time more than 60 s.

The effect of pre-sowing magnetic treatments was investigated on germination, growth, and yield of okra (*Abelmoschus esculentus* cv. Sapz paid) with an average MF exposure of 99 mT for 3 and 11 min. A significant increase ($P< 0.05$) was observed in germination percentage, number of flowers per plant, leaf area, plant height at maturity, number of fruits per plant, pod mass per plant, and number of seeds per plant. The 99 mT for 11 min exposure showed better results as compared to control (Naz et al., 2012).

Exposure of seeds to physical energy treatments through static magnetic field of strength below 250 mT for one hour and metaphysical energy treatment through BK RYM, (a positive thought energy based treatments) for two and four hours could be a suitable, cheap and easy seed invigoration method for improving germination and seedling vigour indices of poor quality seed. Seed enhancing energy treatments not only increase the growth and vigor parameters of seedlings but also play a significant role in enhancing biochemical properties of seeds (Rashmi, *et. al.*, 2014). However, contrasting results have also been reported. For instance, the mean germination time of rice (*Oryza sativa*) seeds exposed to one of two MF strengths (125 or 250 mT) for different times (1 min, 10 min, 20 min, 1 h, 24 h, or chronic exposure) was significantly reduced compared to controls, indicating that this type of magnetic treatment clearly affects germination and the first stages of growth of rice plants (Florez et al., 2004).

The advantage of using Magnetic gradient is that it can move diamagnetic compounds under weightless or microgravity conditions and serve as directional stimulus during seed germination in low-gravity environment (Fariba, *et. al.* 2013). A magnetic field applied to dormant seeds was found to increase the rate of subsequent seedling growth of barley, corn (*Zea mays*), beans, wheat, certain tree fruits, and other tree species. Moreover, a low frequency magnetic field (16 Hz) can be used as a method of post-harvest seed improvement for different plant species, especially for seeds of temperature sensitive species germinating at low temperatures (Rochalska and Orzeszko-Rywka, 2005). Seed germination rates were frequently improved when seeds were pretreated with a moderate intensity of SMF (Carbonell *et. al.* 2011).

CONCLUSION

Experimentally treated wheat exhibited marginally (but significantly) higher root fresh and dry weights, total fresh weights and higher germination rates. Podlesny et al. (2004, 2005) confirmed the positive effect of the magnetic treatment on the germination and emergence of both broad bean and pea cultivars. The magnetic stimulation of seeds favourably influenced the sprouting and emergence of seed. As a result of the application of this treatment plant emergence was more uniform and took place 2-3 days earlier than the emergence of plant in the control. Pea seedling grown from seeds treated with magnetic field were better formed and the 9 plants grown from them produced a temporarily bigger leaf surface. Magnetic treatment are assumed to enhance plant vigour by influencing the biochemical process that involve free radicals and by stimulating the activity of proteins and enzymes (Radharkrishman and Kumari, 2012). Treatment with MF also improved germination-related parameters like water uptake, speed of germination, seedling length, fresh weight, dry weight, and vigor indices of soybean seeds under laboratory conditions (Shine et al., 2011).

Magnetic field application with a strength from 0 to 250 mT in steps of 50 mT for 1–4 h significantly enhanced speed of germination, seedling length and seedling dry weight compared to unexposed control in chickpea (*Cicer arietinum*). It was also found that magnetically treated chickpea seeds may perform better under rainfed (un-irrigated) conditions where there was a restrictive soil moisture regime (Vashisth and Nagarajan, 2008).

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