EFFECT OF PRE-SOWING MAGNETIC FIELD TREATMENT TO GARDEN PEA (PISUM SATIVUM L.) SEED ON GERMINATION AND SEEDLING GROWTH

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Abstract

The seeds of garden pea (Pisum sativum L. cv. climax) were exposed to full-wave rectified sinusoidal non-uniform magnetic fields of strength 60 mT, 120 mT and 180 mT for 5, 10 and 15 min prior to sowing. The magnetically treated seeds were sown according to the protocol of International Seed Testing Association (ISTA). Magnetically treated seed showed significant increase in germination. The emergence index, final emergence index and vigor index increased by 86.43%, 13.21% and 204.60%, respectively. It was found that exposure of 5 min for magnetic field strengths of 60 mT and 180 mT significantly enhanced the germination parameters of the pea and these treatments can be used practically to accelerate the germination in garden pea.

Introduction

Proper seed germination is vital for better crop yield. Various natural factors affect seed germination processes crops e.g., heavy metals present in soil restrain the enzyme activities as well as oxidative pathways of seeds metabolism, which affect the germination and subsequently the seedling growth. In addition to light and dark periods as well as temperature and salty soil has also a negative impact on seed germination (Achakzai et al., 2010; Muhammad & Hussain, 2010; Mohammadi et al., 2010; Hamid et al., 2010; Ashraf & Ashraf, 2012; Chutipaijit et al., 2012; Kausar et al., 2012). Chemical and physical pre-sowing seed treatments are being used for better seed germination (Dao-liang et al., 2009; Khawar et al., 2010; Perveen et al., 2011; Zia ul Haq et al., 2012a). Chemical concerts were found to be effective for enhancing the seed germination and seedling growth, but are unfavorable to the environment. So far, for the last few years, there are growing concerns of eco-friendly agricultural practices. Of course, physical pre-sowing seed treatments are safer as compared to chemical ones (Jamil et al., 2012). In this regard, Magnetic Field (MF) pre-sowing seed treatment is secure and inexpensive physical method to enhance the seed germination and seedling growth (Podlesny, 2004), because, it enhances the concentration of ions, free radicals and electrical charges physically without any degradation/alteration in the chemical profile of seed and resulantly makes the membranes permeable. Free movement of ions activates the metabolic pathways by enhancing the biochemical and physiological feedback (Zia ul Haq et al., 2012b). According to a few reports the magnetic field strength, exposure time and modulation are important in this consideration (Iqbal et al., 2012a; Tkalec et al., 2009). Researchers world wide have reported that wheat, maize, sunflower, barley, corn, beans, tomato, fruit seeds treated with magnetic field show high performance of plant growth, height, yield, seed weight per spike as well as shoot and root length and total fresh and dry weights (Aladjadjiyan, 2002; Dagoberto et al., 2000; Harichand et al., 2002; Martinez et al., 2002; Moon and Chung, 2002; Socorro & Carbonell, 2008; Fischer et al., 2004; Florez et al., 2007).

In this work, we have evaluated the effect of magnetic field pre-sowing seed treatment on mean emergence time, final emergence percentage, vigor index and emergence index of garden pea seeds.

Material and Methods

Seed samples: The seeds of Pisum sativum L. were provided by the Ayub Agricultural Research Institute, Faisalabad, Pakistan. The seeds were exposed to magnetic field in the Department of Physics and sown in Vegetable Seed Laboratory, Institute of Horticultural Sciences, University of Agriculture, Faisalabad.

Magnetic field generation: The pre-sowing magnetic treatments were administered using an electromagnet consisting of two pairs of cylindrical coils, each formed by 4,000 turns of 0.40 mm enameled copper wire. Each pair of coils was wound 11 cm apart on an iron bar (dimensions 40 × 3.5 cm). The two bars were placed one above the other and their ends held by metallic supports. The coils were connected in series and fed through a power source of 220V and 50 Hz using a variac transformer. A 50 Hz full wave rectified sinusoidal voltage was fed to the coils. When electric current passed through the coils, a non-uniform and dynamic magnetic field was generated in the air space between the two bars. Magnetic field treatment was applied according to Iqbal et al., (2012a) with some modification. Figure 1 shows the placement of glass plate in seed stimulator (full-wave rectified sinusoidal non-uniform magnetic fields).

Electromagnetic treatments: The magnetic field exposure time and strength were applied to the pea seed as follows:

<table>
<thead>
<tr>
<th>Magnetic field strength (mT)</th>
<th>5 min</th>
<th>10 min</th>
<th>15 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 mT</td>
<td>T1</td>
<td>T2</td>
<td>T3</td>
</tr>
<tr>
<td>120 mT</td>
<td>T4</td>
<td>T5</td>
<td>T6</td>
</tr>
<tr>
<td>180 mT</td>
<td>T7</td>
<td>T8</td>
<td>T9</td>
</tr>
</tbody>
</table>
Non-exposed seeds were used as control (T0). The dry, mature and healthy seeds were kept in Petri plates (dimensions 3×10 cm) between the poles of electromagnet having non-uniform magnetic strength for the required duration. The strength of the magnetic field was varied by changing the current in the coil of electromagnet. A magnetic flux meter was used to measure the strength of the magnetic field between the poles. All treatments in the experiments were run simultaneously under similar conditions. After appropriate treatment for specific period and magnetic field strength the seeds were washed with fungicide solution to save from fungus and then were placed on a filter paper in a circular glass Petri plate (15 cm diameter) and kept in germination incubator. 10 mL of distilled water were applied to each Petri plate daily. Seed germination was measured following the method of Anon., (2004). The number of germinated seeds was noted after germination. This process was repeated for 7 days. For the emergence test, 60 seeds per treatment were used in four replications and cultured in plastic bowls (25 cm diameter, 4 cm depth) containing sandy soil. Entire experiment was performed under the same laboratory conditions. The various germination parameters viz., mean emergence time, final emergence percentage, vigor index and emergence index were calculated following De Souza et al., (2006).

Statistical analysis: The data were analysed using SPSS-16 software. For the laboratory experiment, two factor analysis of variance (ANOVA) was performed on a factorial experiment keeping the magnetic field as the first factor and exposure time as the second one. The significant levels (p<0.05) of difference for all measured trials; magnetic field, exposure time and interactions were estimated.

Results and Discussion

After sowing, fast and more uniform germination of pea seed treated with magnetic field was observed as compared to control. Pre-sowing magnetic field treatment significantly enhanced the germination parameters such as vigor index, final emergence percentage and emergence index. No significant change was observed in mean emergence time. The T1 and T7 treatments showed better response in terms of emergence index. The treatment T9 showed the lowest value as compared to the control and T6 and T8 did not affect the emergence index (Fig. 2).

![Fig. 2. Effect of different magnetic field strength and exposure duration of pea seed on emergence index. The same letters on bars show non-significant difference (p<0.05).](image)

No significant effect of magnetic field treatment was found on mean emergence time. Electromagnetically treated seeds showed a negative response as compared to untreated seeds (Fig. 3). The vigor index response was improved to a great extent; the dose T7 showed the highest value followed by T2 (Fig. 6). Final emergence percentage was observed positive for various magnetic field strengths. The effect of T1, T2, T3, T4 and T7 was found similar but higher than the other treatments including control (Fig. 4).

![Fig. 3. Effect of different magnetic field strength and exposure duration of pea seed on mean emergence time. The same letters on bars present statistically similar effects (p<0.05).](image)

The percent improvement of germination rate over untreated seeds has been found to be 75.11% to 86.43% for the emergence index, 1.89% to 13.21% for final emergence percentage and 12% to 204.60% for vigor.
EFFECT OF PRE-SOWING MAGNETIC TREATMENT OF *PISUM SATIVUM*

index, while no significant effects were observed on mean emergence time. Over all, percent enhancement in germination rate was not consistent in all estimated parameters. The treatment of 60 mT was found superior for emergence index and final emergence percentage, while 180 mT was found relatively better for vigor index (Fig. 5). Seed stimulation with magnetic field had a profound effect on later stages of growth and development of pea. For example, the T2 exposure dose had a more pronounced effect on seedling height, while T9 showed the minimum response. All treatments affected the seedling length in the following decreasing order; T2 > T7 > T4 = T1 = T6 > T9 > T0. The height of all seedlings raised from treated seeds varied from 14-20.5 cm, which was considerably higher than that of control (9 cm) (Fig. 6).

In case of percent enhancement of germination rate, dose T1 was found more effective for enhancing the emergence index followed by T7, while T1, T2, T3 and T4 were found superior in improving the final emergence percentage. The highest percent increase in vigor index was found in dose T7 (204.60%). Magnetic field exposure time of 5 to 10 min significantly enhanced the germination parameters. However, exposure of 5 min was more effective as compared to longer time intervals (Figs. 2-5).

The interaction of magnetic field strength and exposure time are presented in Table 1. Among most of the field strengths, the enhancement of germination rate was noted significantly higher for 5 min duration. The speed of germination was significantly superior to control of 5 min exposure, either MF applied at 60 mT or 180 mT. Of all the magnetic field strengths applied, enhancement of emergence index was higher for T1 and T7. As the magnetic field strength exposure increased from 5 to 15 min, a continuous decrease in emergence index was observed. For treatment T3, the percent increment in emergence index was 75.11%, while for T9 the response was -23.99%. Similarly, percent decrease in emergence index was -15.09% and -32.07% for T6 and T9.

![Fig. 4. Effect of different magnetic field strength and exposure duration of pea seed on final emergence percentage. The same letters on bars present statistically similar effects (p<0.05).](image1)

![Fig. 5. Effect of different magnetic field strength and exposure duration of pea seed on vigor index. The same letters on bars present statistically similar effects (p<0.05).](image2)

![Fig. 6. Showing the comparative effect of magnetic field treatment on the height of pea plant: T0 (control), T1, T4, T7 (60, 120 and 180 mT for 5 min), T2, T5, T8 (60, 120 and 180 mT for 10 min) and T3, T6, T9 (60, 120 and 180 mT for 15 min), respectively.](image3)
The vigor index also showed highest response for 5 min (T7). The emergence index, final emergence percentage and vigor index generally showed better response at lower magnetic field strength ranging from 5 to 15 min exposure or at higher magnetic field strength for shorter time (5 min). The percent increase observed in emergence index were 86.43, 76.46 and 75.11 for 5, 10 and 15 min, respectively, while at 180 mT for 5 min was 82.30% and then there was a sudden decrease for 10 min (13.39%) and 15 min (-23.99 %). Similarly, the maximum response (59.66%) of emergence index was found at T4 treatment and then there was a consistent decrease as time of exposure increased. Treatment for shorter time exposure showed similar results for final emergence percentage, however, by increasing the field strength and exposure time, the response decreased significantly. However, the positive effect of magnetic field treatment was observed, when seeds were treated for shorter time at higher magnetic strength or at lower strength for longer as well as shorter time intervals.

Table 1. Percent effect (positive/negative) on emergence index (EI), mean emergence time (MET), final emergence percentage (FEP) and vigor index (VI) of pea seed, CP (Calculated Parameters) and T (Time of exposure).

<table>
<thead>
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<th>CP</th>
<th>T(min)</th>
<th>MF(mT)</th>
<th>Percent effect (+/-)</th>
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<th>T(min)</th>
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<th>Percent effect (+/-)</th>
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</table>

Discussion

Treatments of different magnetic fields generally enhanced the germination rate of pea seed (Figs. 2-5). Similar results have also been reported by various researchers for seeds of different crops. For example, a considerable improvement in germination characteristics such as seedling vigor, shoot and root growth was observed in maize and chickpea seeds when treated magnetically (Aladjadjiyan, 2002; Fischer et al., 2004; Florez et al., 2007; Vashisth & Nagarajan, 2007 & 2008). Fischer et al., (2004) observed higher germination and growth of sunflower seed as compared to untreated seeds. Florez et al., (2004 & 2007) reported enhanced germination in rice when exposed to 125 mT/250 mT magnetic fields for specific time intervals, which indicates that the better results are dependent to specific magnetic field strength and exposure duration. It is well understood from the literature that the best outcome of seed germination is possible when optimal exposure doses are applied. It has been widely reported that different doses of magnetic field treatment stimulate seed germination and seedling growth for shorter exposure time, while that of higher doses for longer time having no significant improvement in germination rate (Zia ul Haq et al., 2012b; Florez et al., 2007). The longer time exposure might be detrimental, because throughout the study not a single result was found better for longer exposure of seed. The results for emergence index, final emergence percentage and vigor index pointed out that specific combination of magnetic field strength and exposure duration such as T1 and T7 are exceedingly efficient in enhancing the germination rate (Table 1). This observation indicates that seed germination takes place at appropriate magnetic field exposure duration and strength (Iqbal et al., 2012a), which was also reported by Jamil et
al., (2012) that the higher crops yield can be obtained by applying the magnetic field strength for specific time intervals. The mechanism of seed germination stimulation might be attributed to changes in biochemical, physiological processes as well as acceleration in metabolism and that of enzymes accelerated activities (Podlesny et al., 2003). It is considered that the magnetic field influence the structure of cell membranes and in this way increase their permeability and ion transport in the ion channels, which as a result affects the metabolic pathways. The enzymes which are necessary for seed germination at particular stages of germination were found higher in magnetically treated seeds during germination (Aksyonov et al., 2000; Jamil et al., 2012).

According to Iqbal et al. (2012a) magnetic field affects the biological objects by non-conventional spins, free radicals, liquids crystals or mobile electron charges. Chemically, these free radicals are very active particles, which enter into fast reactions with oxygen and in this way they cause changes in the biochemical and physiological processes in seed germination. Garcia & Arza (2001) reported an increase in water uptake rate due to magnetic field treatment, which may be responsible for increased germination speed in pea seeds.

Results of pea seed germination in present study were found parallel to those of Yinan et al., (2005) for wheat crop and cucumber. Similarly, the effect of magnetic field doses (strength and exposure time) tested in the present study are in agreement with those of other workers (Aladjadjiyan, 2002; Dagoberto et al., 2000; Harichand et al., 2002; Martinez et al., 2002; Moon & Chung, 2002; Socorro and Carbonell, 2008; Fischer et al., 2004; De Souza et al., 2006; Florez et al., 2007). From the results it is concluded that positive effect can be achieved of seed germination at specific doses of magnetic field for specific exposure duration. Different magnetic field strength treatments increased the germination rate, when the seed were treated particularly for shorter time and high magnetic field strength or longer exposure duration for low magnetic field strength. Furthermore, the optimization of the magnetic field doses (strength and exposure time) can be performed using response surface methodology. Iqbal et al., (2012b) has reported the use of response surface methodology in pre-sowing magnetic field treatment for chili seed and pointed out the actual magnetic field doses to enhance the germination, biochemical, physiological and enzymatic attributes in chili can be achieved using response surface methodology.

Conclusion

Exposure of pea seed to magnetic fields significantly enhanced the germination rate such as emergence index, final emergence percentage and vigor index as compared to control seeds. The results showed that the germination rate was more uniform comparatively in shorter period under the effect of magnetic field as compared to control. Of the various combinations of field strengths and exposure time, 60 mT and 180 mT for 5 min treatments yielded the better results. This improved germination rate suggests that magnetically treated pea seeds can be used practically in agriculture, where the environmental factors are limiting for the germination of seeds.

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References


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