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Effect of magnetically induced structural changes in water and cotton seed on germination behavior

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Abstract

Planting quality seed is a guarantee for optimum plant population and high yield. Cotton crop being grown and processed in hot environments is facing germination problems and climate change will aggravate it day by day. Magnetic treatment of water and seed is a safer option to enhance the seed germination. Water and seed stimulation magnetic devices were used for water and seed were used in this study to check their effect on seed germination with water passing (WP) 0WP, 3WP and 6WP and seed passing (SP) 0SP, 2SP, 4SP and 6SP and their interaction effect. Results revealed that individually both devices have positive effect on seed germination enhancement (18.67% in 3WP and 21.3% in 2SP). The interaction of both treatments (i.e. application of treated water on treated seeds) gave germination enhancement but its pattern was not linear and needs further detailed studies for its understanding and application.

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Introduction

Magnetic field application on water had stimulatory effect with respect to increase in seed germination and have also been widely used for enhancement of growth and yield of seedlings (Ijaz *et al.,* 2012). It is believed that with the use of magnetic field on seed and water, some physiological-biochemical changes occurs due to re-arrangement of influenced molecule. Thus breathing and photosynthesis of the seed intensifies, water assimilation becomes faster which ultimately enhance viability of seeds (Putincev and Platonova, 1997). Chemical substances used for seed invigoration were found detrimental at later stages of plant development and seedling growth and also considered unfavorable to the environment (Jamil *et al.*, 2012). Therefore, pre-sowing treatment of magnetic field gives safe, inexpensive and most harmless option (Podlesny, 2004). It has been noted that exposure of magnetic field enhance ions concentration, free radicals and physical changes which favors better seed germination (Haq *et al.*, 2012). Magnetic field pre-treatment to seed causes increase seed germination rate, initial plant growth and yield (Majd *et al.*, 2009). Generally, the magnetically treated lentil seeds showed better growth and grew taller with improved root seedlings than untreated controls (Shabrangi and Majd, 2009). The behavior of seeds passed through magnetic device (direct effect) is different from the normal seeds sown with magnetic water irrigation (indirect effect). This direct and indirect stimulation through magnetic field have been found to bring a positive effect on germination and growth (Alexander and Doijode, 1995; Carbonell *et al.*, 2000), of plants like wheat, maize, rice, sunflower, barley, onion, corn and tomato (Dagoberto *et al.*, 2000; Aladjadjiyan, 2002; Harichand *et al.*, 2002; Martinez *et al.*, 2002; Moon and Chung, 2002; Fischer *et al.*, 2004; Florez *et al.*, 2007) increasing shoot and root length and dry biomass of seedlings and crop yield (Pietruszewski, 1993). Moreover, the exposure strength and time also varies for stimulation. Likely, the influence of magnetic field on pea seeds was found to enhance germination rate in different regimes than control and 60 mT and 180 mT for 5 min treatments resulted in better emergence index of germinating seed (Iqbal *et al.*, 2012). The interaction between magnetic exposure strength and duration would change the expected seed germination and growth. In case of lentil (*Lens culinaris*), increased growth under magnetic force of 0.18T and 0.24T for 20 min found shows a resonance-like element called as ''Interaction'' (Shabrangi and Majd, 2009; Kavi, 1983).

Cotton (*Gossypium hirsutum* L.) is the most important cash crop (Federal Bureau of Statistics, 2011). In cotton-wheat cropping system, the sowing of cotton is delayed due to late harvesting of wheat crop causing difficulties in germination of cotton crop (Fujisaka *et al.*, 1994). Efficient seed germination leads towards better growth, crop establishment and yield. Pulsed electromagnetic fields have some positive effects on germination and early growth stages of cotton seedlings (Bilalis *et al.*, 2012). Pre-treated cotton seeds with magnetic field causes increase in yield of 6.3% and fiber length of 9.4% (Leelapriya *et al.*, 2003). Furthermore, results indicated that pre-sowing application of magnetic field enhanced the transpiration rate, photosynthetic rate, stomatal conductance, root growth, shoot growth and N, P, K, Ca and Mg percentage in early stages of cotton plants and considered this technique organic friendly and highly desirable in modern agriculture (Bilalis *et al.*, 2013).

The aim of present study was to determine the direct and indirect effects of magnetic devices developed by Magnetic Technologies L.L.C., Russia on cotton seed germination of local varieties under local conditions.

Materials and methods

The study was carried out at Seed Preservation Laboratory, Plant Genetic Resources Institute (PGRI), NARC, Islamabad. The experiment was laid out in completely randomized design (CRD) with 12 treatments using three replications. The study was conducted to check the performance of two magnetic devices one each for seed and water (Magnetic Technologies L.L.C) on the invigoration of the cotton seed with low viability.

Table of completely randomized design with 12 treatments using three replications.

Treatment code	Explanation of treatment code
0SP- 0WP	0 seed passing + soaking with only distilled water (control)
2SP- 0WP	2 seed passing through magnetic device+*soaking with only distilled water (direct effect)
4SP- 0WP	4 seed passing + soaking with distilled water (direct effect)
6SP- 0WP	6 seed passing + soaking with distilled water (direct effect)
0SP- 3WP	0 seed passing + soaking with 3 water passing (indirect effect)
2SP- 3WP	2 seed passing + soaking with 3 water passing (interaction)
4SP- 3WP	4 seed passing + soaking with 3 water passing (interaction)
6SP- 3WP	6 seed passing + soaking with 3 water passing (interaction)
0SP- 6WP	0 seed passing + soaking with 6 water passing (indirect effect)
2SP- 6WP	2 seed passing + soaking with 6 water passing (interaction)
4SP- 6WP	4 seed passing + soaking with 6 water passing (interaction)
6SP- 6WP	6 seed passing + soaking with 6 water passing (interaction)

*Passed through the magnetic device.

Seed Source

The cotton germplasm cv. 3701 was obtained from Pak-China project, National Agricultural Research Center, Islamabad, Pakistan. Healthy seeds with uniform size having viability of 28-30% were used in the experiment.

Seed Treatment

The funnel shaped magnetic device was (Ijaz *et al.,* 2012) used and seeds were passed through it slowly with uniform speed. The numbers of seed passing were 0, 2, 4 and 6 times. The seeds were sown immediately after passing through magnetic device.

Water Treatment

The magnetic device for water treatment was also funnel shaped (U050 mg, 0.5 inch, output 4-6 m^3/hr, production by Magnetic Technologies L.C.C., Russia, branch United Arab Emirates) of small size (Ijaz *et al.,* 2012). The numbers of water passing were 0, 3 and 6 times. This magnetized water was used to moist the paper towel before sowing seed.

Seed Germination Test

The seeds were sown following the seed germination between paper (BP) method. In each replication, twenty five magnetically treated and untreated seeds were sown on paper towel (22 × 23 mm; Victory brand, Shinbashi Paper Company, Shizuoka, Japan). The paper towel was moistened either with distilled water (control) or magnetized water (magnetically treated and untreated seeds). Germination test was performed according to International Seed Testing Association (ISTA, 1993; AOSA, 1983). Paper towel sheets were rolled and placed in plastic beaker, covered with polythene bag. The beakers were, then, placed in an incubator at 25±2°C under light conditions of 16 h. Total numbers of seeds germinated were counted on daily basis and percentage was calculated at 7th day. Data was recorded for shoot length (cm), root length (cm), shoot and root dry weight (g) and seed germination index (SGI) was calculated as described in Association of Official Seed Analysts (1983) by the following formula:

$$SGI = \frac{\text{No. of germinated seedlings}}{\text{Days of first count}} + \cdots + \frac{\text{No. of germinated seedlings}}{\text{Days of final count}}$$

Root length and shoot length was also measured at 7^{th} day of sowing. The fresh seedlings were placed in oven at 75°C for 48 h and dry weight of seedlings was measured and expressed in grams per seedling.

Statistical analysis

Analysis of variance was carried out as outlined by Steel and Torrie (1997).

Results

Germination percentage

Maximum seed germination was found for seed magnetic treatment with direct effect on showing 21% increase as compared to soaking with magnetic water device producing 18% increase in germination over control. The germination with water passings (WP) ranged from 28 to 46%, the highest value associated with 3WP having 18% increases over control (Fig. 1A), while the germination enhancement ranged between 28 to 49% with seed passing (SP) treatment, a variable result was found with direct magnetic device exposure in terms of number of passing seed experienced. With 4 SP, the germination increase was 8% and in 6 SP, it was 18% over the control (Fig. 1B). Thus, highest increase in germination with seed passings was 21% compared to control.

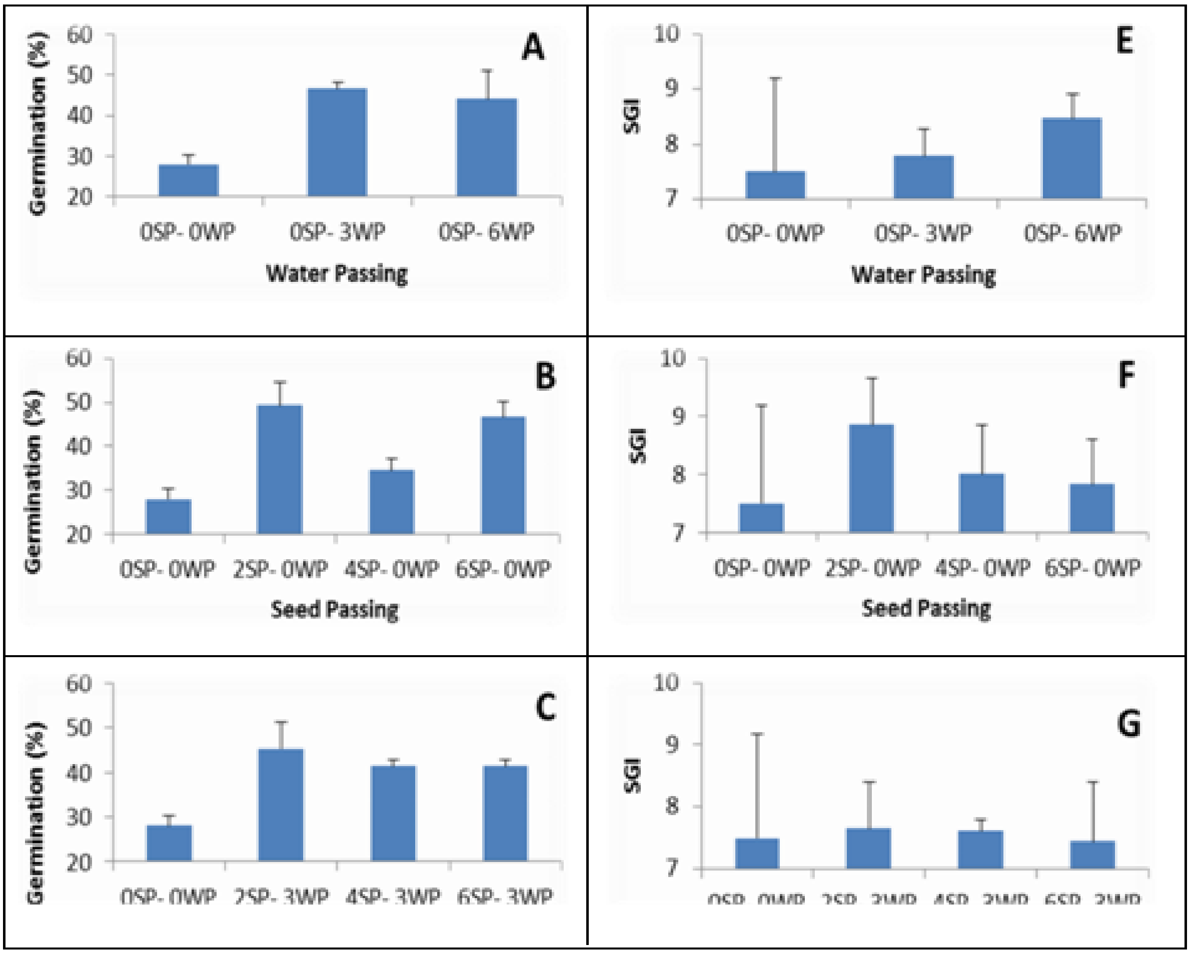

Fig. 1. Germination response of direct and indirect effects of magnetic devices on cotton seeds exposed to magnetized water (A), seed passing through magnetized device (B), direct magnetic effect interaction with 3WP (C) and with 6WP (D), and seed germination index (SGI) response of cotton seeds exposed to magnetized water (E), seed passing (F), interaction with 3WP (G) and interaction with 6WP (H).

The interaction between SP and WP treatments showed positive trend for germination percentage in all treatment combinations. Increase in germination was recorded upto 45% under 2SP-3WP (Fig. 1C). Whereas, 4SP-3WP and 6SP-3WP had same germination value of 41% which is less than the highest value (45%). On the other hand, 6WP also have some positive results for germination percentage enhancement. The highest germination (42%) attained for 2SP-6WP which is quite less than the interaction of 3WP-2SP (Fig. 1D).

Seed Germination Index (SGI)

It was observed that effects of magnetized water with 6WP had the highest SGI of 8.46 (Fig. 1E) as compared to 7.79 and 7.50 under 3WP and 0WP, respectively. Increase in SGI correlated positively with increased exposure to the direct magnetic effect (Fig. 1E). However, these results do not correlate with germination percentage (Fig. 1A). Whereas in the direct effect of magnetic device on seed samples, a sharp increase resulted under 2SP treatment with a SGI value of 8.86 which although higher than control, gradually decreased at 4 & 6SP as well (Fig. 1F).

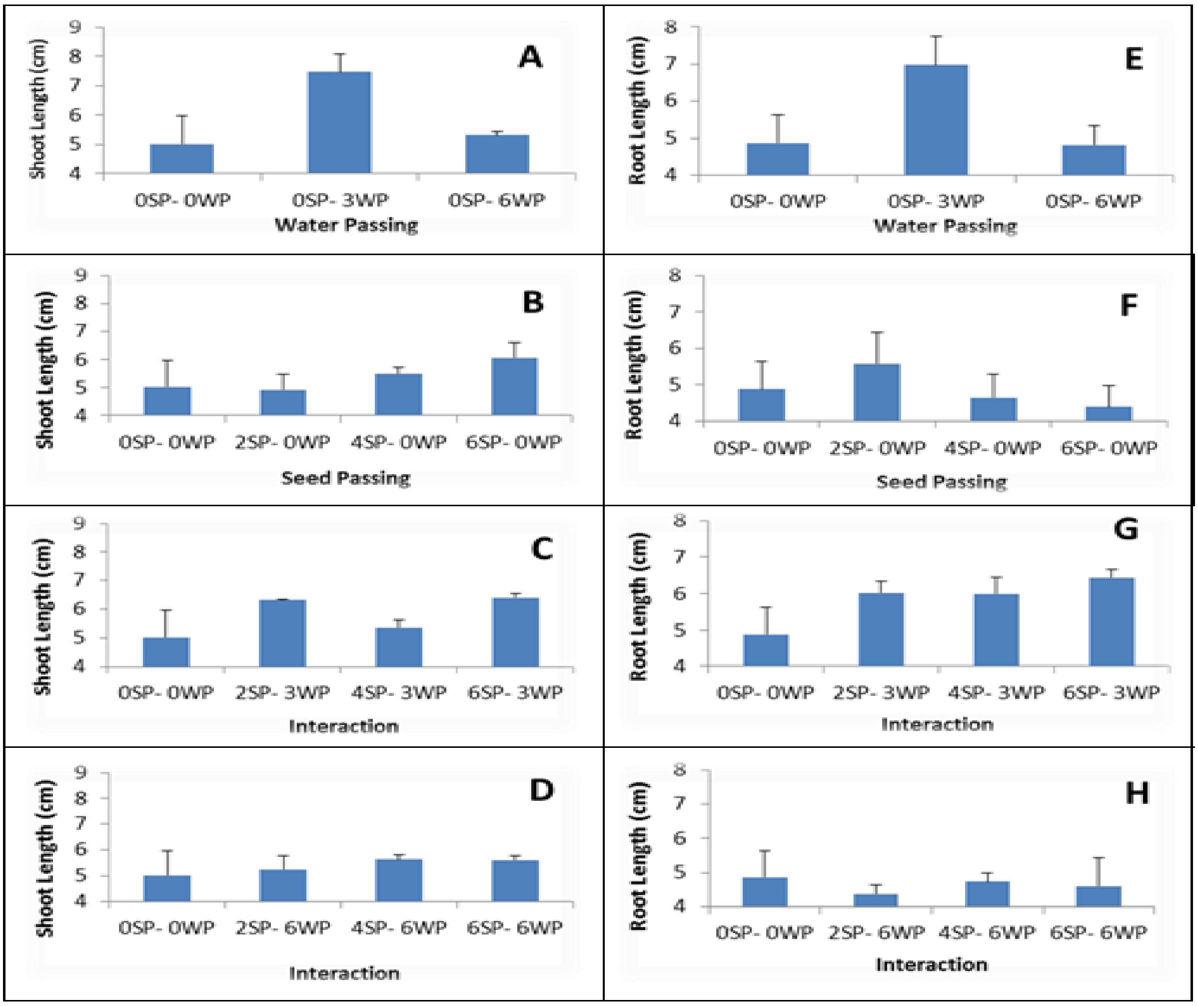

Fig. 2. Shoot length (cm) response of direct and indirect effects of magnetic devices on cotton seeds exposed to magnetized water (A), seed passing through magnetized device (B), direct magnetic effect interaction with 3WP (C) and with 6WP (D), and Root length (cm) response of cotton seeds exposed to magnetized water (E), seed passing (F), interaction with 3WP (G) and interaction with 6WP (H).

The interaction between different SP with 3WP showed a slight change in each passing (Fig. 1G). Whereas the seed sown on 6WP interaction with 2 & 6SP resulted in an alternative behavior of germination index (Fig. 1H). The positive interaction in 6SPwith 6WP yielded the highest SGI value of 8.09 among all the treatments of interactions.

Shoot length (cm)

A sharp increase with indirect effect on shoot length (7.47 cm) with 3WP as compared to 0WP control (5.0 cm) and 6WP (5.3 cm) was observed (Fig. 2A). The influence of the magnetic device was stronger under 3WP treatment. The shoot length at 6SP scored greater value than all other seed passing treatments (Fig. 2B). The interaction between different SP treatments with 3WP showed an increase in shoot length with a cyclic behavior (Fig. 2C). The sharp increase was observed in 2SP-3WP and 6SP-3WP treatments as compared to the control. The least increase was observed at 4SP-3WP interaction but that was greater than control.

Whereas, the increasing level of SP interacting with 6WP exhibited an increase in shoot length in a positive correlation with each passing (Fig. 2D).

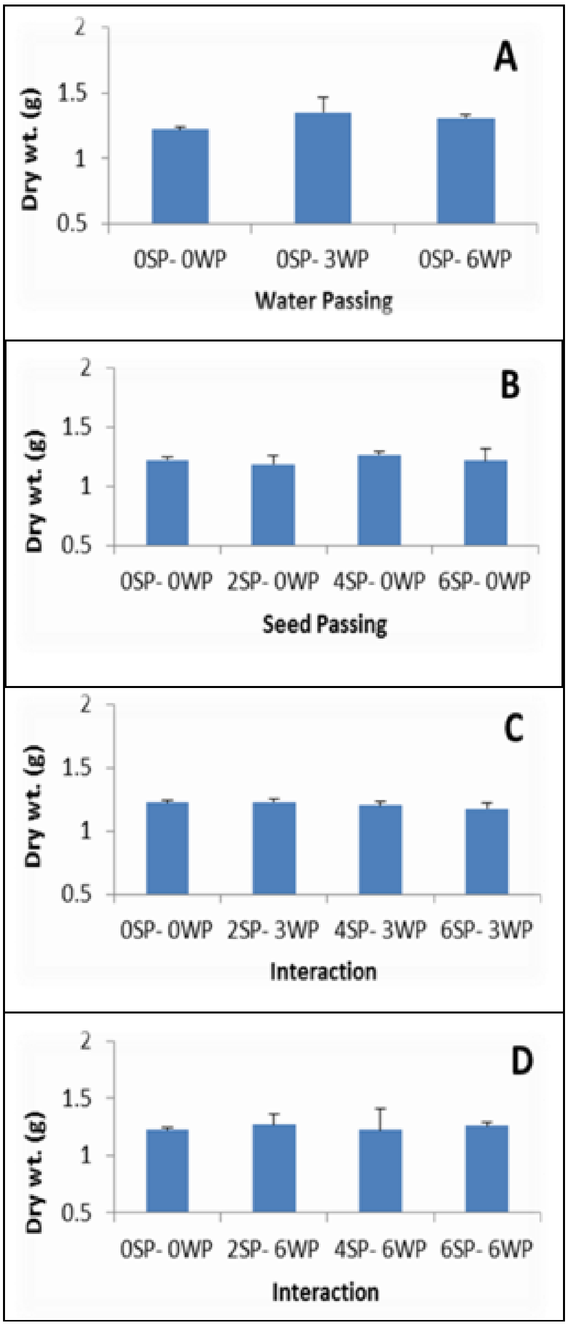

Fig. 3. Seedling dry weight (g) response of direct and indirect effects of magnetic devices on cotton exposed to magnetized water (A), seed passing through magnetized device (B), direct magnetic effect interaction with 3WP (C) and with 6WP (D).

Root length (cm)

The control (4.88) and 6WP (4.83) treatments showed much less progress in root length than 3WP (Fig. 2E). In case of SP for magnetization, the longest root length was found in 2SP (Fig. 2F). All other treatments of seed passing showed diminished length of roots. All the interactions of 3WP with SP treatments showed increase in root length with a positive correlation (Fig. 2G). The highest value is of 6SP-3WP interaction gave length of 6.43 cm, whereas: with 3WP interaction with SP treatments the control was of highest length of root (4.88 cm) (Fig. 2H). The observation of root length in Fig. 2F confirms that seed passing is not the powerful component, but rather water passing with 3WP. The decrease in root length may depict unsuitability of this interaction each other.

Dry Weight (g)

Dry weight of seedling was also observed under different seed and water passing through the magnetic device (Fig. 3). The highest dry weight was observed when water passed through the magnetic device three times (1.35 g) compared to the control (1.21 g). Whereas in seed passing treatments the dry weight remained at par with each other (Fig. 3B). Similar trend was observed in the interaction of different seed passing treatments with water passing treatments (Fig. 3C, 3D) and showed inconsistent behavior.

Discussion

Germination of cotton seeds indirectly affected by magnetized water passing was found to increase considerably in 3WP and 6WP as compared to control. Enhancement of germination rate with 3WP was found more effective in increasing germination percentage of the seeds (Fig. 1A). Vashisth and Nagarajan, in 2010 and 2008 found that direct effect of magnetic fields increase the speed of germination in sunflower (2010) and in chickpea (2008). In our study the rate of germination of pre-treated magnetized seeds (direct effect) was higher than untreated seed. Similarly, improvement in germination was reported at early stages of cotton seedlings development that performed better than control treatments (Bilalis *et al.*, 2012). The highest positive direct and indirect treatment interaction of 2SP-3WP increased the germination up to 17% than control.

The overall germination response indicated that maximum exposure to the magnetic field have no positive correlation; therefore the direct effect in 2SP and indirect effect in 3WP alone or in combination may have better enhancement of cotton seed germination although its combination gave results at par to 3WP alone, it will be waste of time and resources to practice extra procedures.

The effect of magnetic exposure on speed of germination index (SGI) stimulated with the increase in water passing (Fig. 1), demonstrating a positive correlation and a plus point to use higher indirect effect i.e. 6WP to achieve improved SGI over 3WP. Although, SGI was higher than control at all the SP treatments. Only the increase in 2SP correlated with seed germination data. The speed of germination under the interaction of 3WP as well as 6SP with different SP treatments showed uneven behavior. Similarly, 2SP-6WP and 6SP-6WP interactions were higher than control at both the germination as evident from Fig- 1D and its speed index followed its same cyclic behavior (Fig. 1D, 1H); that needs further elaboration by broader experimentation.

The indirect magnetic field stimulatory effect was positive on shoot length as well as root length of cotton seed treated with 3WP magnetized water passing treatments (Fig. 2). It was observed that, after treating the seeds with the specified exposure, a faster sprouting of the treated seeds occurs, however, increasing exposure remained totally non-responsive. It has also been reported that shoot growth increased under magnetic field (0.15T strength) on maize samples compared with the control (Aladjadjiyan, 2002; Bilalis *et al*., 2013). In the direct effect of magnetic stimulation to seed, shoot length responded to higher SP treatments while root responded to only lower level of 2SP. Here the behavior of shoot and root was different (Fig. 2B, 2F) from indirect effect (Fig. 2A, 2E).

In interaction, it seems that 3WP influenced the increase partially for shoot length and in all cases of root length, whereas, the root length increase in 6SP-3WP (Fig. 2G) was contrary to its results in direct effect of 6SP (Fig. 2F) or interaction (Fig. 2H). Bilalis *et al.* (2012) have shown that electromagnetic field enhances root length almost twice as compared to control plant.

On the other hand, the interaction was quite opposite in seed passing with 6WP treatments showing a complex response of root length. There was no conclusive influence of magnetic stimulation either direct, indirect on plant biomass. We here report first time categorically the direct and indirect effect of magnetic influence on seed germination that, germination enhances with either direct or indirect application of magnetic influence, however the effect is not additive in combination. Though germination enhanced, high variability as well as response in germination behavior was recorded.

Conclusion

It was concluded that direct effects of magnetic devices on seed and indirect effect mediated via water showed positive enhancement behavior of germination under 2SP and 3WP treatments respectively. The cotton seed germination was more enhanced by direct exposure to magnetism than indirectly mediated through exposure to magnetized water. Similarly, in 3WP plant growth was accompanied with significant increase in shoot length and root length. Furthermore, the interaction treatments (WP with SP) expressed a disoriented behavior. The magnetic stimulation devices for water and seed should not be used simultaneously. It warrants a large scale study with contrasting genotypes to arrive at applicable conclusion. The improved germination suggests that magnetic devices do hold the potential for invigoration of seed viability, however, at this stage it cannot be applied in practical agriculture prior to detailed studies under field conditions.

References

AOSA. 1983. Association of Official Seed Analysts. *Seed vigour testing hand book*. Contribution No. 32 to the Handbook of seed testing.

Alexander MP, Doijode SD. 1995.

Electromagnetic field, a novel tool to increase germination and seedling vigour of conserved onion (*Allium cepa* L.) and rice (*Oryza sativa* L.) seeds with low viability. Plant Genetic Resources Newsletter, **104,** 1-5.

Aladjadjiyan A. 2002. Study of the influence of magnetic field on some biological Characteristics of *Zea mays*. Journal of Central European Agriculture **3**: 89-94.

Bilalis DJ, Katsenios N, Efthimiadou A, Karkanis A, Efthimiadis P. 2012. Investigation of pulsed electromagnetic field as a novel organic pre-sowing method on germination and initial growth stages of cotton. Electromagnetic Biology and Medicine **31(2),** 143-150.
http://dx.doi.org/10.3109/15368378.2011.624660

Bilalis DJ, Katsenios N, Efthimiadou A, Karkanis A, Khah EM, Mitsis T. 2013. Magnetic field pre-sowing treatment as an organic friendly technique to promote plant growth and chemical elements accumulation in early stages of cotton. Australian Journal of Crop Science **7(1),** 46-50.

Carbonell MV, Martinez E. Amaya JM. 2000. Stimulation of germination in rice (*Oryza sativa* L.) by a static magnetic field. Electromagnetic Biology and Medicine **19(1),** 121–128.
http://dx.doi.org/10.1081/JBC-100100303

Dagoberto GF, Angel DST, Lilita SP. 2002. Effect of magnetic treatment of onion (*Allium cepa*) seeds on the germination and growth of seedlings. Alimentaria **39,** 181-186.

Fujisaka S, Harrington LW, Hobbs PR. 1994. Rice-wheat in South Asia: Cropping systems and long term priorities established through diagnostic research. Agricultural Systems **46,** 169-187.

Fischer G, Tausz M, Kock M, Grill D. 2004. Effect of weak 16 2/3 HZ magnetic fields on growth parameters of young sunflower and wheat seedlings. Bio Electro Magnetics **25,** 638-41.
http://dx.doi.org/10.1002/bem.20058

Florez M, Carbonell MV, Martinez E. 2007. Exposure of maize seeds to stationary magnetic fields: effects on germination and early growth. Environmental and Experimental Botany **59,** 68-75.
http://dx.doi.org/10.1016/j.envexpbot.2005.10.006

Federal Bureau of Statistics. 2011. Economic Survey of Pakistan (2011-12). Government of Pakistan.

Harichand KS, Narula V, Raj D, Singh G. 2002. Effect of magnetic fields on germination, vigour and seed yield of wheat. Seed Research **30,** 289-293.

Haq Z, Jamil Y, Irum S, Randhawa MA, Iqbal M, Amin N. 2012. Enhancement in the germination, seedling growth and yield of radish (*Raphanus sativus*) using seed pre-sowing magnetic field treatment. Polish Journal of Environmental Studies **21,** 369–374.

ISTA. 1993. International Seed Testing Association. International rules for seed testing. Seed Sci. Technol. 21 Supplement.

Ijaz B, Jatoi SA, Ahmad D, Masood MS, Siddiqui SU. 2012. Changes in germination behavior of wheat seeds exposed to magnetic field and magnetically structured water. African Journal of Biotechnology **11,** 3575 – 3582.
http://dx.doi.org/10.5897/AJB11.2927

Iqbal M, Muhammad D, Haq Z, Jamil Y, Ahmad MR. 2012. Effect of pre-sowing magnetic field treatment to garden pea (*Pisum sativum* L.) seed on germination and seedling growth. Pakistan Journal of Botany **44(6),** 1851-1856.

Jamil Y, Haq Z, Iqbal M, Jamil T, Amin N. 2012. Enhancement in growth and yield of mushroom (*Pleurotus ostreatus*) using magnetic field treatment. International Agrophysics **26,** 375–380.
http://dx.doi.org/10.2478/v10247-012-0052-4

Kavi PS. 1983. The effect of non-homogeneous gradient magnetic field susceptibility values in-situ ragi seed material. Mysore Journal of Agricultural Sciences **17,** 121-123.

Leelapriya T, Dhilip KS, Narayan PVS. 2003. Effect of Weak Sinusoidal Magnetic Field on Germination and Yield of Cotton (*Gossypium* spp.). Electromagnetic Biology and Medicine **22,** 117–125. http://dx.doi.org/10.1081/JBC-120024621

Moon JD, Chung HS. 2000. Acceleration of germination of tomato seed by applying AC electric and magnetic fields. Journal of Electrostatics **48,** 103-114.
http://dx.doi.org/10.1016/S0304-3886(99)00054.6

Martinez E, Carbonell MV, Florez M. 2002. Magnetic Bio-stimulation of initial growth stages of wheat (*Triticum aestivum*, L.). Electromagnetic Biology and Medicine **21,** 43-53.
http://dx.doi.org/10.1081/JBC-120003110

Majd A, Shabrangi A, Bahar M, Abdi S. 2009. Effect of AC and DC Magnetic Fields on Seed Germination and Early Vegetative Growth in Brassica Napus L. *Prog. Electromagnetic.* Res. Symposium RS Proceedings, Moscow, Russia, 710-714.

Putincev AF, Platonova NA. 1997. Treatment of seed in electromagnetic field (in Russian). Agriculture **4,** 45.

Podlesny J, Pietruszewski S, Podlesna A. 2004. Efficiency of the magnetic treatment of broad bean seeds cultivated under experimental plot conditions. International Agrophysics **18,** 65-71.

Steel RGD, Torrie JW, Dickey M. 1997. Principles and Procedures of Statistics. A Biometrical Approach. McGraw-Hill Book Company In. New York. 666 p.

Shabrangi A, Majd A. 2009. Effect of Magnetic Fields on Growth and Antioxidant Systems in Agricultural Plants. Prog. Electromagnetic. Res. Symposium, Proceedings, Beijing, China, 1142-1147.

Vashisth A, Nagarajan S. 2008. Exposure of seeds to static magnetic field enhances germination and early growth charateristics in Chickpea (*Cicer arietinum* L.). Bioelectromagnetics **29(7),** 571–578. http://dx.doi.org/10.1002/bem.20426.

Vashisth A, Nagarajan S. 2010. Effect on germination and early growth characteristics in sunflower (*Helianthus annuus*) seeds exposed to static magnetic field. Journal of plant physiology **167,** 149–156.
http://dx.doi.org/10.1016/j.jplph.2009.08.011