



Research Article

Effect of Pre-Sowing Static Magnetic Seed Treatment on Germination and Root Characters in Chickpea (*Cicer arietinum* L.)

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ABSTRACT

Static magnetic fields of strength from 0 to 250 mT in steps of 50 mT for 1, 2 and 3 h were applied to seeds of chickpea (*Cicer arietinum* var. Pusa 256). Magnetic field strength of 100mT for 1h exposure was the best in terms of germination of seeds, seedling root and shoot length and dry weight. The enhancement varied with magnetic field strength and duration of exposure and did not show any particular trend. In green house experiment, exposure of seeds to this strength showed improved root and shoot growth parameters for seedlings over control. Dynamics of root characters like, total root length, root surface area and root volume showed consistent improvement in the treated plants over the unexposed seeds. Periodic measurements at 10 days interval in root and shoot weight and the length of the longest root, and total root length, surface area and volume also showed similar trends. Results suggest that use of magnetically treated seeds could be effective in alleviating water stress in chickpea.

Key words: Magnetic field, Germination, Seedling vigour, Roots, Growth parameters, Chickpea

Introduction

Exposure of seeds to electromagnetic fields is one of the safest and potential physical pre-sowing treatments to enhance the post-germination development and crop stand (Florez *et al.*, 2007). Magnetic field is especially worth our attention since its impact on the seeds can change the processes taking place in the seed and stimulate plant development. Pittman (1965) reported that speed of germination and seedling growth of corn (*Zea mays* L.) and beans (*Phaseolus vulgaris* L.) were affected by pre-germination exposure of the dry seed to an introduced magnetic field. Pittman and Ormrod (1970) reported that seeds of winter wheat,

magnetically treated before germination, respired more slowly, released less heat energy and grew faster than untreated seed. They also reported that these seedlings absorbed more moisture and contained more reducing sugar than untreated seed.

Pre-germination exposure to static magnetic field of wheat seeds (cv. Sonalika) increased the rate of germination, shoot length, maximum root length and total root length significantly (Bhatnagar and Deb, 1977). Similar effect has been reported in flax, buckwheat, sunflower and field pea (Gubbels, 1982) and ragi (Kavi, 1983). More branches and height in tomato plants (Dayal and Singh, 1986), healthier primary roots in maize (Kato, 1988), better germination and shoot length also in maize (Anna, 2002) and enhanced germination and seedling emergence in broad

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bean and pea cultivars (Podlesny *et al.*, 2004; 2005) are some of the examples to show the positive effect of magnetic seed treatment. However, limited research has been conducted on similar effect on chickpea which is planted during post-rainy season, surviving mostly on progressively declining soil moisture. This study was planned to standardize the field strength and duration for maximum enhancement of germination and to investigate the effect of magnetic fields on root and shoot growth dynamics of *desi* chickpea (Pusa 256).

Materials and Methods

The breeder seeds of chickpea (var. Pusa-256) were obtained from Division of Genetics, Indian Agricultural Research Institute, New Delhi. The moisture content of the seed was 9.3%. Seeds without visible defects, insect damage and malformation were selected and stored in the desiccators having anhydrous calcium chloride.

An electromagnetic field generator “Testron EM-20” with variable static magnetic field (SMF) strength (50 to 500 mT) with a gap of 5 cm between pole pieces was fabricated. A D.C. power supply (80V/10A) with continuously variable output current was used for the electromagnet. A digital gauss meter model DGM-30 operating on the principle of Hall Effect monitored the field strength produced in the pole gap. The probe is made of Indium arsenide crystal and is encapsulated to a non-magnetic sheet of 5 mm x 4 mm x 1 mm and could measure 0-2 Tesla with full-scale range in increments of 5 mT. Seeds were exposed to the SMF of 0 to 250 mT in a cylindrical plastic sample holder for durations ranging 1-3 h. By regulating the current in the coils, desired strength of SMF was monitored, which was measured by a Gauss meter. The strength and duration was standardized for maximum enhancement of germination and vigour of seeds. The germination was determined by using paper methods (ISTA, 1985). Hundred seeds in 4 replications (25 in each) were placed between two layers of moist germination papers. The papers were rolled carefully ensuring minimum pressure on the seeds. These were wrapped in a sheet of wax paper to reduce

evaporation and placed in an incubator at 20°C in upright position. After 8 days, the germinated seeds were evaluated for normal and abnormal seedling, fresh un-germinated and dead seeds. Germination percentage is given on the basis of normal seedlings only. Ten normal seedlings from each replicates were taken at random and the shoot and root lengths were recorded. Seedlings were oven-dried overnight at 90°C and the weight of 10 seedlings per replicate was taken. Seedling vigour was calculated (Abdul-Baki and Anderson, 1973) as:

Vigour index I = Germination % x Seedling length (Root + Shoot)

Vigour index II = Germination % x Seedling dry weight (Root + Shoot)

Eighty chickpea seeds in 4 replications (20 in each) were placed in moistened filter paper in petri dish and kept in an incubator at 20°C. Daily germination count was taken till no more seed germinated. The speed of germination (X) was calculated as

$$X = \frac{(\text{Number of seeds germinated/Day of the first count}) + \dots + (\text{Number of seeds germinated/Day of the final count})}{n}$$

Root and shoot growth dynamics

Magnetically exposed and unexposed seeds were grown in sand and peat media maintained at 20% water content on dry weight basis representing -0.1 MPa matric potential. Periodic samplings were done by washing the roots in gentle stream of water at 10, 20, 30 & 40 days intervals. There were 5 replications for each sampling. The roots were air-dried and scanned using root scanner (LA 1600). The root characters (total root length, surface area, thickness and volume) were determined by win Rhizo computer programme (Regent Instruments Inc., Canada). Shoots (leaves+ stem parts) were dried in a hot-air oven at 80 °C to get the dry weights. Roots were also dried to get its dry weight. Statistical analysis of the parameters was performed by completely randomized design method in the statistical package SPSS (version 10).

Results and Discussion

In comparison to untreated control, SMF-treated seeds showed improvements in germination (2-8%), speed of germination (7-27%), shoot length (29-60%), root length (3-33%), total seedling length (8-38%) and seedling dry weight (5-46%) (Figs. 1&2). There was also increase in vigour index I and II by 13-48 and 8-58%, respectively. Among the 5 SMFs, 100 mT (1 h) was found the most effective in augmenting of the parameters. In general, 1-3 h exposure significantly increased germination characteristics irrespective of the field strength (Fig.1a). However, among various combinations, 100 mT strength with 1 h duration resulted maximum germination (7% more than control). Speed of germination also improved over control and was maximum in 50 mT (3h), 100 mT (1h) and 150 mT (1h) (Fig.1b). Seedling shoot length has less variation, but was higher than the control (Fig.1c). Root length of the seedlings improved by SMF treatment, except 50 mT (3 h), 200 mT (2 h) and 250 mT (3 h) (Fig.1d). Seedling total length (Fig. 2e) dry weight was highest for 100 mT (1 h) treatment (Fig.2f) while seedling vigour was significantly higher in all of the treatments (Fig.2g-h). Overall results showed that the exposure of the seeds of desi chickpea var. Pusa 256 to 100 mT for 1 h was the best among different combinations of magnetic field and exposure time. Hence, this treatment was used subsequently to see effect on root and shoot growth parameters.

Root characters of the seedlings grown under greenhouse condition at 20% soil moisture were periodically monitored Fig.3 (a-c). Total root length significant increased on 30 and 40 DAS by 49 and 39%, respectively which were 23 to 49% increase over the control. Root surface and volume increased by 44.9 and 44.2% on 40 DAS.

Significant increase in length of the longest root (43.5 and 39% on 30 and 40 DAS, respectively) was observed (4a). Increase in root and shoot weight of treated plants was recorded which varied from 14.5 to 41% and 10 to 30% respectively (4b-c). This clearly shows that

seedlings from SMF-treated seeds had consistent increase in the root parameters.

Pre-sowing magnetic field treatment effect on germination and other characteristics have been reported earlier in other crops (Pittman, 1965; Gubbels, 1982; Anna, 2002; Fischer *et al.*, 2004; Florez *et al.*, 2007; Vashisth and Nagarajan, 2008a). In *kabuli* type chickpea, Vashisth and Nagarajan (2008b) reported enhanced performance in terms of laboratory germination characters and improved root and shoot growth of 1 month old plants in the field. They reported highest response when the seeds were exposed to a magnetic field of 100 mT for 1 h. Accumulation of dry weight of 10 days old seedling of maize increased logarithmically with duration of SMF induction to seeds (Florez *et al.*, 2007). However, unlike to the study, we have gone up to 3 h exposure, and also dry seeds were exposed to magnetic field. Fischer *et al.* (2004) reported that sunflower seedlings exposed to magnetic field showed small but significant increases in shoot and root fresh weights, whereas dry weight and germination remained unaffected. Our study indicated that certain combinations of strength and duration could be highly effective (Fig.1a-d). In particular, “windows” of optimal effectiveness have been seen for certain combinations, this nonlinear dose-response effect was related to ion cyclotron resonance (ICR) of small ions (Liboff, 1985; Liboff *et al.*, 1987). This may be one of the reasons for getting varied response with different combinations of magnetic field strength and exposure time. This observation suggests that there may be a resonance like phenomena which increases the internal energy of the seeds and that occurs at a particular combination of magnetic field and exposure time. In *ragi* seeds, exposure to magnetic field changed its internal potential energy which could be used to get higher yields by suitably selecting the field strength and exposure time (Kavi, 1983). In *desi* chickpea, our results showed that an exposure of 100 mT for 1 h was the best in enhancing seedling characters which matched with that reported for *kabuli* type chickpea earlier (Vashisth and Nagarajan, 2008b).

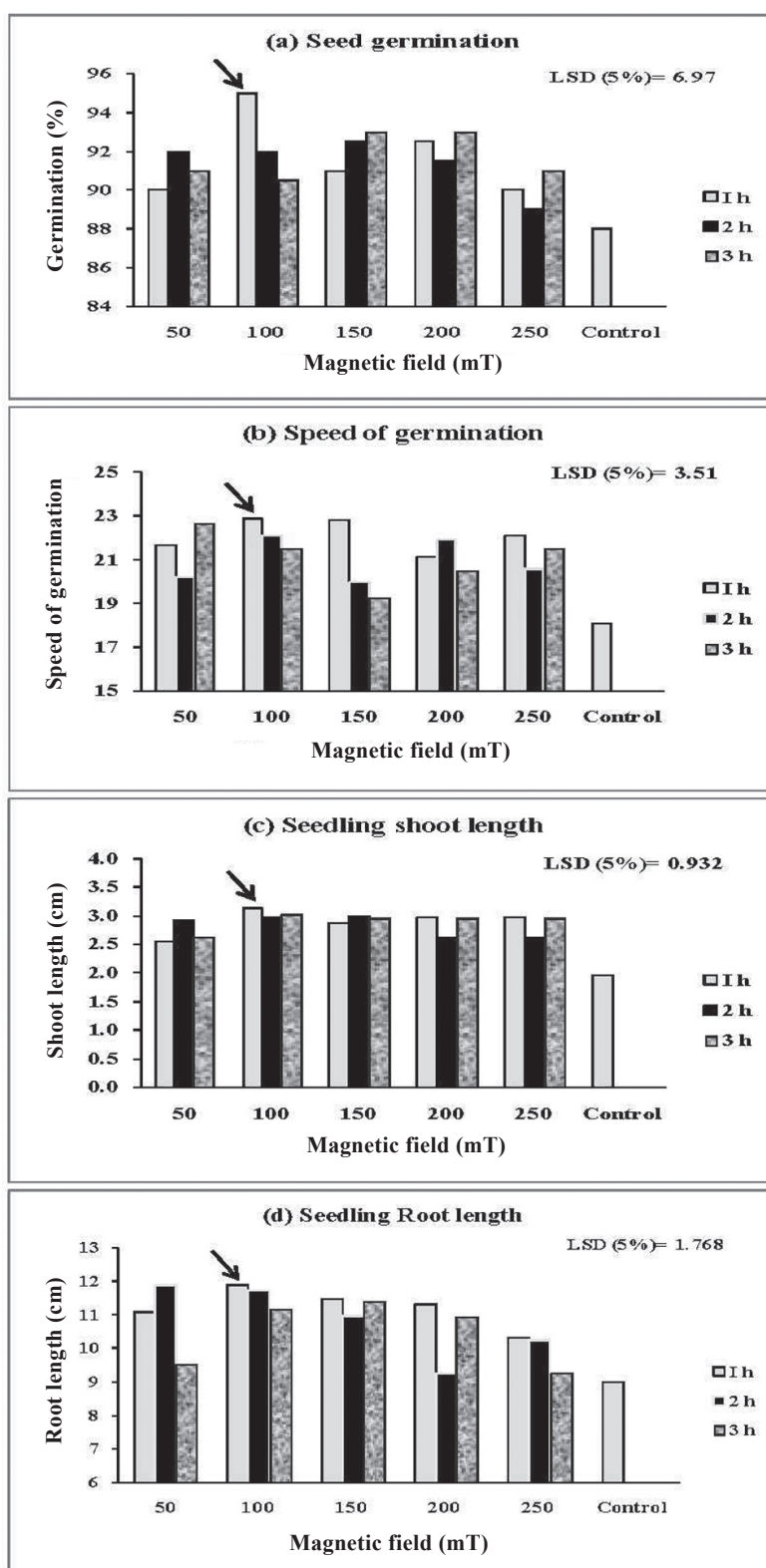


Fig. 1. (a-d) Effect of different doses and duration of magnetic field exposure to chickpea seeds (var. Pusa-256) on (a) percent germination, (b) speed of germination, (c) shoot length of 8 day old seedling, (d) root length of 8 day old seedling. Arrow sign indicates the treatment at which maximum enhancement observed

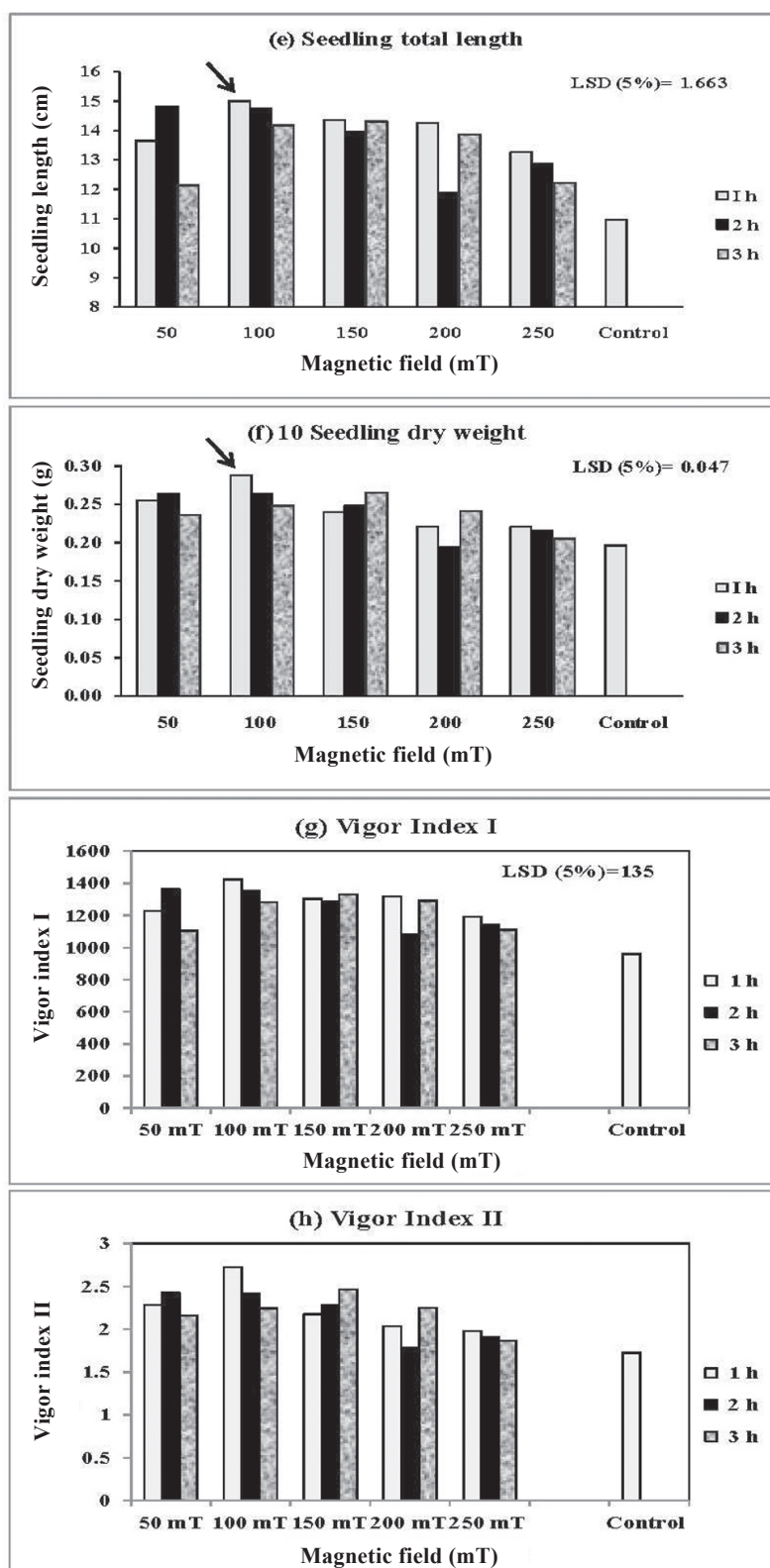


Fig. 2. (e-h) Effect of different doses and duration of magnetic field exposure of chickpea seeds (var. Pusa-256) on (e) total seedling length, (f) 10 seedling dry weight, (g) vigour index I, (h) vigour index II. Arrow sign indicates the treatment at which maximum enhancement observed

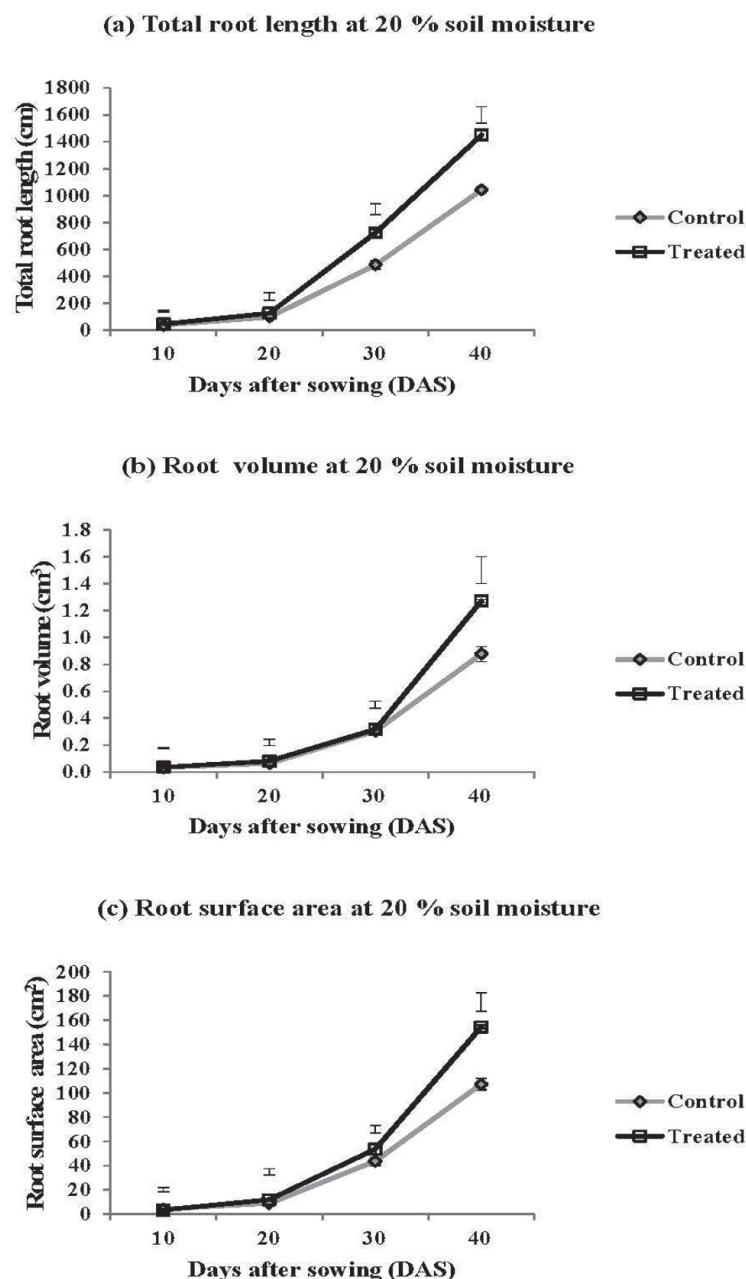


Fig. 3. Changes in (a) total root length, (b) root volume and (c) root surface area of plants from magnetically exposed and unexposed seeds of chickpea var. Pusa 256 grown in sand culture with 20% moisture

Periodic observations of root parameters showed significant increase in plants raised from SMF treated seeds from 30 DAS. This is because desi chickpea is hardy and has better inherent root system. Therefore, the improvement due to SMF was not observed initially. Similar trends were observed for other characters like longest root length, root and shoot dry weights. In

chickpea var. Pusa 1053, Vashisth and Nagarajan (2008a) have reported doubling of total root length, surface area and volume in 1 month old plants grown from seeds treated with 100 mT magnetic field for 1 h. They also reported significant increase in longest root length, root and shoot dry weights of the plants. Rajendra *et al.* (2005) observed a significant increase in

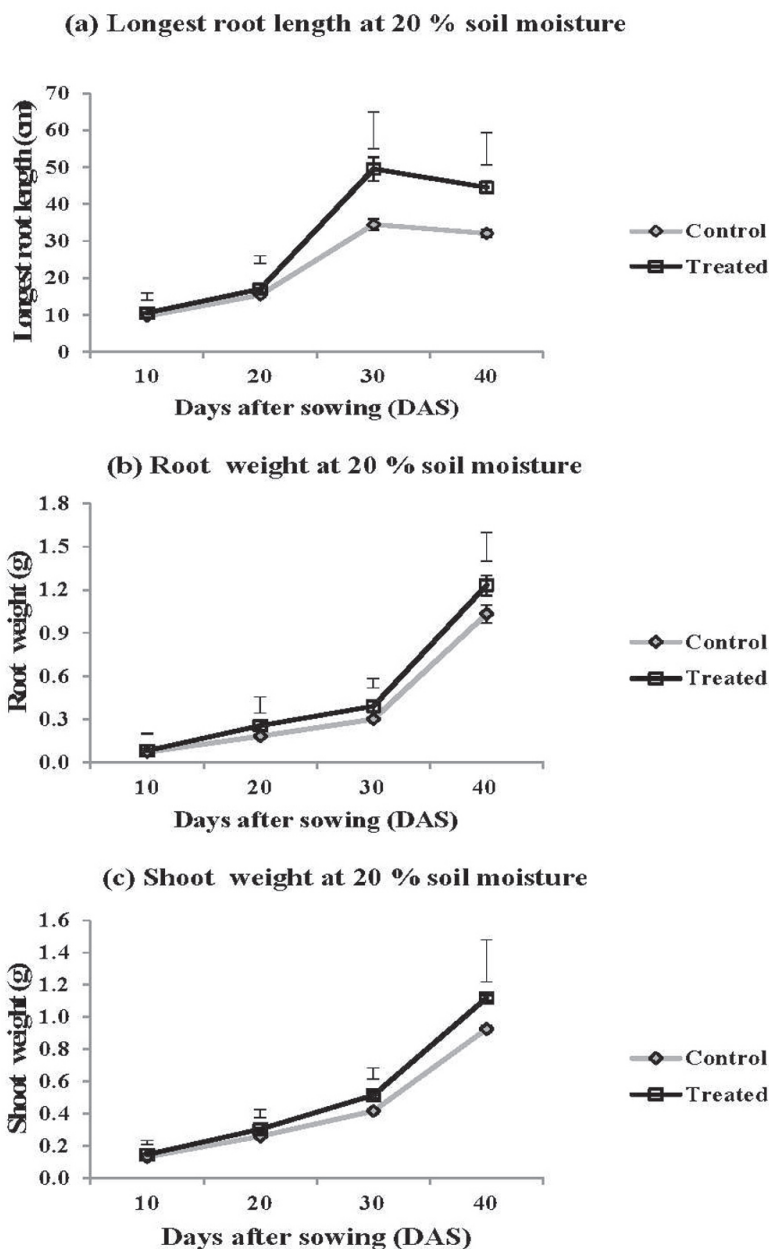


Fig. 4. Changes in (a) longest root length, (b) root weight and (c) shoot dry weight of plants from magnetically exposed and unexposed seeds of chickpea var. Pusa 256 grown in sand culture with 20% moisture

mitotic index as well as ^3H -thymidine incorporation into DNA in seeds of *Vicia faba* exposed to 100 μT power frequency magnetic fields. A similar mechanism may be operating in chickpea, where in increased cell number of SMF treated plants during initial sampling period might have led to greater expansion of these cells in the subsequent samplings. This would have resulted in higher growth rates of root and shoot

parameters in plants from the treated seeds. Serraj *et al.* (2004) also suggested that deep and prolific root systems are associated with enhanced drought tolerance in chickpea.

Conclusions

Significant increase in seedlings vigour and improved root characters through magnetic

treatment have practical importance in chickpea which is a rainfed crop and generally grows under receding stored soil moisture. The improved functional root parameters suggested that the magnetically treated desi chickpea seeds could be exploited to help the plants to extract moisture from deeper layers.

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References

- Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean by multiple criteria. *Crop Sci.* **10**: 31-34.
- Anna, A. 2002. Study of the influence of magnetic field on some biological characteristics of *Zea mais*. *J. Central Euro. Agric.* **3**: 89-94.
- Bhatnagar, D. and Deb, A.R. 1977. Some aspects of pregermination exposure of wheat seeds to magnetic fields. Seed germination and early growth. *Seed Res.* **5**: 129-137.
- Dayal, S. and Singh, S.P. 1986. Effect of seed exposure to magnetic field on the height of tomato plants. *Indian J. Agric Sci.* **56**: 483-486.
- Fischer, G., Tausz, M., Kock, M. and Grill, D. 2004. Effects of weak 16(2/3) Hz magnetic fields on growth parameters of young sunflower and wheat seedlings. *Bioelectromagnetics* **25**: 638-641.
- Food and Agriculture Organization of the United Nations (FAOSTAT), 2004. Available at <http://faostat.fao.org/>
- Florez, M., Carbonell, M.V. and Martinez, E. 2007. Exposure of maize seeds to stationary magnetic fields: Effects on germination and early growth. *Environ. Expt. Botany.* **59**: 68-75.
- Gubbels, G.H. 1982. Seedling growth and yield response of flax, buckwheat, sunflower and field pea after preseedling magnetic treatment. *Can. J. Plant Sci.* **62**: 61-64.
- ISTA, 1985. International seed testing association. *Seed Sci. Technol.* **13**: 299-513.
- Kato, R. 1988. Effect of a magnetic field on the growth of primary roots of *Zea mays*. *Plant Cell Physiol.* **29**: 1215-1219.
- Kavi, P.S. 1983. The effect of non-homogeneous, gradient magnetic field on the magnetic susceptibility values of in sit ragi (*Eleusine coracana Gaertn*) seed material. *Mysore J. agric. Sci.* **17**: 121-123.
- Liboff, A.R. 1985. Cyclotron resonance in membrane transport. *NATO ASI Ser. A* **97**: 281-296.
- Liboff, A.R., Smith S.D. and McLeod B.R. 1987. Experimental evidence for ion cyclotron resonance mediation of membrane transport. In: Mechanistic Approaches to Interactions of Electric and Electromagnetic Fields with Living Systems (Blank, M. and Findl, E., Eds.), Plenum Press, New York. pp. 109-132.
- Pittman, U.J. 1965. Magnetism and plant growth III. Effect on germination and early growth of corn and beans. *Can. J. Plant Sci.* **45**: 549-554.
- Pittman, U.J. and Ormrod, D.P. 1970. Physiological and chemical features of magnetically treated winter wheat seeds and resultant seedlings. *Can. J. Plant Sci.* **50**: 211-217.
- Podlesny, J., Pietruszewski, S. and Podlesna, A. 2004. Efficiency of the magnetic treatment of broad bean seeds cultivated under experimental plot conditions. *Int. Agrophysics.* **18**: 65-71.
- Podlesny, J., Pietruszewski, S. and Podlesna, A. 2005. Influence of magnetic stimulation of seeds on the formation of morphological features and yielding of the pea. *Int. Agrophysics.* **19**: 1-8.
- Rajendra, P., Nayak, H.S., Sashidhar, R.B., Subramanyam, C., Devendarnath, D., Gunasekaran, B., Aradhya, R.S.S. and Bhaskaran, A. 2005. Effects of power frequency electromagnetic fields on growth of germinating *vicia faba L.*, the broad bean. *Eletromagnetic Biol. Medicine* **24**: 39-54.
- Serraj, R., Krishnamurthy, L., Kashiwagi, J., Kumar, J., Chandra, S. and Crouch, J.H. 2004. Variation in root traits of chickpea (*Cicer arietinum*) grown under terminal drought. *Field Crop Res.* **88**: 115-117.
- Vashisth A. and Nagarajan S. 2008a. Effect of magnetic field on seed performance of diverse crop species. *Indian J. Agric. Sci.* **78**: 708-711.
- Vashisth A. and Nagarajan S. 2008b. Exposure of seeds to static magnetic field enhances germination and early growth characteristics in chickpea (*Cicer arietinum L.*). *Bioelectromagnetics* **29**: 571-578.