JJBS

Volume 3, Number 4, December 2010
ISSN 1995-6673
Pages 175- 184

Jordan Journal of Biological Sciences

Impact of Magnetic Application on the Parameters Related to Growth of Chickpea (*Cicer arietinum* L.)

Nawroz Abdul-Razzak Tahir* and Hero Fatih Hama Karim

University of Sulaimanyah, College of Agriculture, Bakrajo, Sulaimanyah, Iraq

.

Abstract

The morphological data were used in this study for the evaluation of five chickpea (*Cicer arietinum* L.) varieties at the University of Sulaimanyah, College of Agriculture in 2010. Seeds of different varieties of chickpea were exposed in batches to static magnetic fields (1500 gauss of magnetic force) for 30, 50 and 70 min. Then, the magnetic seed were placed between two layers of moist germination paper in petri dish. They were placed in the germination incubator at 20°C in an upright position. After 8 days, different plant growth parameters were tested such as germination percentage, root length, shoot length, root fresh weight, shoot fresh weight, root dry weight and shoot dry weight, based on normal seedlings. The results showed that magnetic field application enhanced seed performance in terms of laboratory germination: seedling length and seedling fresh and dry weight compared to unexposed control. However, the response varied with duration of exposure. Among the various duration exposures, 50 and 70 min. exposures gave best results. A pot experiment was carried out in a greenhouse was aimed at finding the effect of a constant magnetic field on the root and shoot system, as well as on yield of spring chickpea. Seeds are grown in plastic cups for 4 months and irrigated with magnetized water which prepared by using static magnetic field. Six to fourteen plants were tagged for morphological data collection. The results showed that magnetized seeds irrigated with magnetized water have enhanced seed performance in terms of plant height, number of brancha, number of leaves, number of leaflets root and shoot fresh weight, root and shoot dry weight, the total photosynthetic pigments (chlorophyll a, b, and carotenoids) and yield in some varieties.

الملخص

اجري البحث فى قسم المحاصيل الحقلية-كلية الزراعة- جامعة السليمانية لعام 2010 على خمسة أصناف من الحمص (Cicer arietinum L) للمعرفة تاثير المعالجة المغناطيسية لماء الرى والبذور على بعض صفات النمو المتعلقة بالبادرة و النبات الحمص.

استخدمت الاجهزة المغناطيسية بقطر 1 بوصة. اجريت عملية مغنطة البذور والماء بقوة 1500 كاوس للفترات 30 و 50 و 70 دقيقة. ووضعت البذور الممغنطة بين طبقتين من ورق رطبة داخل اطباق بترى. ووضعت الاطباق في حاضنة الإنبات عند 20 درجة مئوية. بعد 8 أيام ، تم قياس البادرات الطبيعية على أساس: نسبة الإنبات، طول الجذور ، طول الساق ، الوزن الطرى للجذر ، الوزن الطرى للمجموع خضرى، الوزن الجاف للجذر والوزن الجاف للمجموع خضرى. و أوضحت النتائج أن تطبيق المجال المغناطيسي ادت الى تحسن البذور من حيث المعاير المختبرية: طول البادرات، وزن الطرى والجاف للبادرات بشكل ملحوظ مقارنة مع البذور التي لم تتعرض للمعالجة المغناطيسية فى بعض الاصناف. ومع ذلك ، فسجلت استجابات مختلفه باختلاف مدة التعرض للمعالجة المغناطيسية. وكانت افضل النتائج عن المعاملة معالجة البذور مغناطيسياً لمدة 50 و 70 دقيقة (كل على حدة).

وتم اثناء البحث، زراعة بذور الحمص في البيوت الزجاجية داخل التربة وذلك لايجاد تأثير المعالجة المغناطيسية على النمو الجذرى والخضرى وانتاج الحمص. حيث زرعت البذور (بذور الممغنطة و بذور غير الممغنطة) في أكواب بلاستيكية لمدة 4 أشهر وسقيت النباتات مع الماء الممغنط (للبذور الممغنطة) والماء الحنفية (للبذور غير الممغنطة). وأستخدمت 6-14 نباتاَ لجمع البيانات المورفولوجية. وأظهرت النتائج حصول زيادة معنوية في معدل ارتفاع النبات ، عدد الفروع، عدد الوريقات، عدد الاوراق، الوزن الطرى و الجاف للجذر، الوزن الطري والجاف للمجموع خضرى، صبغات التمثيل الضوئي (الكلوروفيل أ ، ب والكاروتينات) ، والانتاج البذور في بعض الأصناف من الحمص عند المعالجة المغناطيسية المزدوجة لماء الرى والبذور مقارنة مع البذور والماء غير الممغنطة.

Keywords: Chickpea, Magnetic field, growth parameter.

1. Introduction

Chickpea (*Cicer arietinum* L.), is the third most important cool season food legume in the world after dry beans and peas (FAOSTAT, 2006). Chickpea is a diploid with 2n = 2x = 16 (Arumuganathan and Earle, 1991) having a genome size of approximately 931 Mbp. Chickpea is a self-pollinated crop. Cross-pollination is rare; only 0-1 % is reported (Singh, 1987).

The genus *Cicer* belongs to the family Leguminosae, subfamily Papilionoideae, tribe *Cicereae* Alef and comprises 43 species, nine of which being annual including chickpea (*Cicer arietinum* L.), while the rest are perennial (Van der Maesen, 1987). Chickpea is currently

* Corresponding author. nawrozbiology@gmail.com.

cultivated in over 40 countries worldwide and grown on 11 million hectares producing around 9 million ton in 2005 growing season (FAOSTAT, 2006). Two main types of chickpea cultivars are grown globally– *kabuli* and *desi,* representing two diverse gene pools. The *kabuli* types are generally grown in the Mediterranean region including Southern Europe, Western Asia and Northern Africa and the *desi* types are grown mainly in Ethiopia and Indian subcontinent (Pundir *et al.,* 1985). Chickpea are grown usually as a rained cool-weather crop or as a dry climate crop in semi-arid regions.

Pre-sowing seed treatment including chemical and physical treatments like electrical, microwave and irradiation are known to improve seed performance. Physical methods are not only cost effective; they also significantly improve the yield without adversely affecting the environment. They influence the physiological and biochemical process in the seeds, and thereby contribute to greater vigor and improved crop stand. Therefore, physical pre-sowing seed treatment for enhancing the seed performance, if standardized, can lead to commercial application. Alexander and Doijode (1995) noted that aged onion (Allium cepa) and rice (Oryza sativa) seeds exposed to a weak electromagnetic field for 12 h increased the germination shoot and root length of seedlings. Celestino et al. (2000) reported enhanced germination and growth of Cork oak (Quercus suber) seedlings when exposed to chronic magnetic field. Harichand et al. (2002) reported that exposure of magnetic field (10 mT; 40 h) increased plant height, seed weight per spike and yield of wheat. Aladjadjiyan (2002) observed that the magnetic field stimulated the shoot development of maize and led to an increase in germinating energy, fresh weight and shoot length. Growth of the germinated Vicia faba seedlings was enhanced by the application of power frequency magnetic fields (100 mT) that were supported by increased mitotic index and 3H-thymidine uptake (Rajendra et al., 2005). In broad bean (Phaseolus lunatus) and pea (Pisum sativum*)* cultivars the magnetic stimulation of seeds improved the sprouting and emergence of seed and resulted in higher pod number and seed yield (Podlesny et al., 2005). Harichand et al. (2002) reported that exposure of magnetic field (10 mT; 40 h) increased plant height, seed weight per spike and yield of wheat (Triticum aestivum).

Magnetic treatment of water irrigation is an acknowledged technique for achieving high water use efficiencies due to its effect on some physical and chemical properties of water and soil (Noran *et al.,* 1996). These changes result in an increased ability of soil to get rid of salt and consequently better assimilation of nutrients and fertilizers in plant during the vegetative growth period. Magnetizing methods among different physical and chemical methods of natural water treatment attract a special attention due to their ecological purity, safety, and simplicity. Magnetically treated water (MTW) is the water that is subjected to treatment by a magnetic field. The use of MTW is common in various branches of industry as a precaution against accumulation of scale in the water supply system, cooling tower, thermal and solar heating installation (Lin and Yotvat, 1989). The major objective of this study is to: evaluate the effect of magnetic application on some growth parameters of some chickpea varieties.

2. Materials and Methods

2.1. Plant material

The plant material comprised of five varieties of chickpea including Rania, Chamchamal, Sangaw, FLIP98-133C (screened for their very sensitivity to *Ascochyta rabiei*) and FLIP83-48C (screened for their resistance to *Ascochyta rabiei*). All of the above material was obtained from Sulaimanyah Agricultural Research Center, Sulaimanyah, Iraq. Healthy seeds with identical dimensions were selected by visual observation.

2.2. Magnetic treatment

2.2.1. Germination characteristic

This research was carried out in the 2009-2010 at College of Agriculture, University of Sulaimanyah to determine the impact of magnetic application on five chickpea varieties. A complete randomized design with three replications was used. Chickpea seeds were placed in magnetron (one inch of diameter and 1500 gauss of magnetic force as shown in Fig. 1) in a cylindrical shaped sample holder. One hundred visibly mature, healthy seeds were treated by magnetic field for various durations ranging from 30 min (T30), 50 min (T50) and 70 min (T70). Seed germination was achieved in three replications each with 15 seeds placed on two layers of moist filter paper in Petri dishes (imbibed with 12 ml of magnetized water). They were placed in the germination incubator at 20 °C in an upright position. After 8 days, germinated seeds were grouped as normal, abnormal seedling, fresh ungerminated and dead seeds. Germination percentage was calculated based on normal seedlings. The seedlings from each replicate were randomly taken for measuring shoot and root length (using a ruler), and shoot and root fresh weight. Subsequently, they were dried in an oven at 90 °C for 48h and the dry weight of these seedlings was measured.

2.2.2. Greenhouse experiment

This research was carried out in 2010 (15.01.2010-18.05.2010) at the College of Agriculture, University of Sulaimanyah so as to determine the impact of magnetic application on five chickpea varieties grown under greenhouse conditions. A complete randomized design with ten replications was used. Two groups of chickpea (*Cicer arietinum L.*) seeds (magnetized group and control group for each variety) are selected with twenty seeds for each variety. Two seeds were sown (in 15.01.2010) in a plastic cup (25 cm height, 7 cm diameter) in 3 cm depth of soil containing mix (2 soil: 1 peat moss). Group (1) contained ten plastic cups (2 seeds/plastic cup) containing magnetized seed and irrigated with magnetized water, while group (2) contained ten plastic cups (2 seeds/plastic cup) containing unmagnetized seeds and irrigated with tap water. Irrigation was provided as and when required. The plastic cups were maintained in greenhouse under natural light. After four days the seedlings started to emerge over the soil level.

2.3. Quantitative morphological traits

Growth and developmental characteristics, including, plant height, number of primary branches, leaves, leaflets, roots, fresh and dry weight of root and shoot, total pigment (Carotene + Chlorophylls a and b) of 28 days old plants were measured:

1. Plant height: Height of plants (cm) from ground to the highest part of the plant by using a ruler.
2. Number of primary branches: Actual counts of primary branches on the main stem per plants.
3. Number of leaves and leaflets: Actual counts of number of leaves and leaflets per plant.
4. Root biomass: Weight (g) of fresh and dry root per plant.
5. Shoot biomass: Weight (g) of fresh and dry shoot per plant
6. Total pigments (Carotene + Chlorophylls a and b)
7. Grain yield: Dried weight (g) of seed per plant at 12% moisture content.

2.4. Chlorophyll and carotene assay

Photosynthetic pigments were extracted according to Mochizuki method (Mochizuki *et al.,* 2001). One gram of fresh leaves of 28 days old plants (mixture of small specimens picked up from all the 14 plants) were ground in liquid nitrogen, using a mortar and pestle. Ten milliliter of 80% acetone was added to a 15 ml Falcon tube, and mixed in dark for 15 min (note: chlorophylls degrade under light). The mixture was filtered through two Whatman filter papers. The absorbance (A) of chlorophyll and carotene content was measured, with three replications, at three-wave lengths 470, 646 and 663 using spectrophotometry. The chlorophyll and carotene concentrations are calculated as follows:

Chlorophyll a (mg/g) = $[12.21\times A663 - 2.81 \times A646] \times V/1000\times W$

Chlorophyll b (mg/g) = $[20.13 \times A646 - 5.03 \times A663] \times V/1000\times W$

Carotenoids (mg/g) = $[1000 \times A470 – 3.27 \times (Chl\ a) – [104 \times (Chl\ b)/227] \times V/1000\times W$

Total pigments = chlorophyll a + chlorophyll b + carotenoids

Where V = volume of the extract (ml); W = Weight of fresh leaves (g).

Figure 1: Showing Magnetron apparatus.

2.5. Statistical analysis

Statistical analyses were conducted using SPSS for windows (version 18). The variance analyses (ANOVA) was used to test the main effects of magnetic field. The Duncan's test was done to find the significant differences between each magnetic treatment and control at level 5% (Levesque, 2007).

3. Results and Discussion

3.1. Seedling growth (laboratory experiment)

Concerning the germination percentage, exposure of chickpea seeds to different time of magnetic field did not show significant difference between the control and others treatments for all varieties (Table 1). Other developmental growth parameters including: root length of 8 days seedlings, showed significant differences among the treatments: Control, T30, T50 and T70 for Chamchamal, Sangaw and FLIP98-133C, while Rania and FLIP83-48C revealed non-significant difference among the treatments: Control, T30, T50 and T70 (Table 1). From these results, it was found that the average length of root of Chamchamal, Sangaw and FLIP98-133C was more than the average length of control. The improvement root length over untreated seeds (control seeds) was 40-45% for the varieties Chamchamal and Sangaw.

The results revealed that shoot length was increased in treatment T50 for Rania, Chamchamal and Sangaw (Table 1). There was no significant difference among the treatments: Control, T30, T50 and T70 for FLIP83-48C. On the other hand, the treatment T70 shared the maximum shoot length for FLIP98-133C. The improvement over control (untreated seeds) was 73 and 26 % for the varieties: Chamchamal and Sangaw respectively (Table 1). For root fresh weight, significant positive value was observed among the treatments: Control, T30, T50 and T70 in all varieties except FLIP83-48C. The value of improvement, when compared with the control (untreated seeds), varied between 40 to 80% (Table 1).

The parameter, shoot fresh weight, showed the significant positive value for the varieties: Chamchamal and FLIP98-133C, when compared with the control (untreated seeds). The percentage of improvement was 50-90% (Table 1). Root dry weight was significantly higher than the control in most of the treatments for all varieties except Rania. The percentage of improvement was 40-50% when compared to the control (Table 2). The average seedling shoot dry weights are tending to increase in treatments: T30, T50 and T70 for Chamchamal, T50 for Sangaw and T70 for FLIP98-133C (Table 2).

Table 1: Effect of seed pretreatment by magnetic field and its duration on germination characteristic: germination percentage, root length, shoot length, root fresh weight and shoot fresh weight.

Treatments	Rania	Chamchamal	Sangaw	FLIP98-133C	FLIP83-48C
Germination percentage (%)					
Control	90.33a	93.33a	95.55a	73.33a	93.33a
T30	92.33a	93.33a	93.33a	73.33a	93.33a
T50	95.55a	93.33a	95.55a	86.66a	93.33a
T70	93.33a	95.55a	95.55a	82.22a	91.11a
Root length (cm)/plant					
Control	4.18a	4.45b	4.84b	3.59a	1.81a
T30	4.26a	5.54ab	4.98b	2.81b	1.57a
T50	4.13a	6.18a	5.58ab	2.88b	1.94a
T70	4.65a	6.48a	6.54a	3.64a	1.78a
Shoot length (cm)/plant					
Control	2.26ab	2.10b	2.61b	1.84b	1.22a
T30	2.04b	3.28a	2.63b	1.62b	1.11a
T50	2.64a	3.92a	3.41a	1.84b	1.18a
T70	2.37ab	3.65a	3.29a	2.75a	1.19a
Root fresh weight (mg)/plant					
Control	114.23b	70.12b	132.26b	92.56b	68.21a
T30	116.9b	85.53b	154.1ab	88.9b	61.23a
T50	131.26a	134a	176.76a	102.5b	63.13a
T70	136.26a	135.7a	187.8a	129.33a	56.9a
Shoot fresh weight (mg)/plant					
Control	62.96ab	46.43c	70.13b	41.53b	32.55a
T30	58.36b	77.3b	74.05b	36.26b	39.66a
T50	75.36a	98.03a	120.03a	45.16b	34.4a
T70	61.1ab	88.33ab	89.26b	60.06a	36.23a

*Means designated with the same letter (s) do not differ significantly from each other according to Duncan's multiple range tests, $p \leq 0.05$.

Table 2: Effect of seed pretreatment by magnetic treatment and its duration on germination characteristic: root dry weight and shoot dry weight.

Treatments	Rania	Chamchamal	Sangaw	FLIP98-133C	FLIP83-48C
Root dry weight (mg)/plant					
Control	14.45a	11.31b	11.88b	10.54b	5.78ab
T30	14.253a	14.14a	13.97ab	11.05b	4.95b
T50	14.98a	14.92a	15.44a	11.83ab	6.29a
T70	14.60a	14.92a	14.54a	14.13a	5.84ab
Shoot dry weight (mg)/plant					
Control	8.14ab	7.33b	8.41b	5.69b	4.24a
T30	8.19ab	10.35a	9.37b	5.73b	4.39a
T50	8.8a	11.79a	11.99a	5.93b	4.36a
T70	7.85b	10.02a	9.86b	7.54a	4.70a

*Means designated with the same letter (s) do not differ significantly from each other according to Duncan's multiple range tests, $p \leq 0.05$.

Researchers carried out an experiment study on water absorption by lettuce seeds previously treated in a stationary magnetic field of 1 to 10 mT. They reported an increase in water uptake rate due to the applied magnetic field, which may explain the increase in the germination seed of treated lettuce seeds (Calatayud *et al.,* 2003). Lentil seedlings from magnetically pretreated seeds grew better than the untreated, and also biomass and root growth were significantly increased (Ahmad *et al.,* 2009). Biomass increase needs metabolic changes particularly increasing protein synthesis (Lebedev and Litvinenko, 1977). The mechanism of stimulating effect of magnetic field-treatment on seed germination and seedling growth was unknown. Although most seemed to involve changes in intracellular levels of Ca^{+2} and in other ionic current density across cellular membrane (Florez *et al.,* 2004) which caused alteration in osmotic pressure and changes in capacity of cellular tissues to absorb water (Calatayud *et al.,* 2003). Magnetic fields can remove bounded of Ca^{+2} from cell membrane which is essential for the stability of membranes. Consequently, their loss will increase temporary pore formation under the mechanical stresses from pressure differences within cell and abrasion by its moving content. The magnetic field could increase an inner energy which is distributed among the atoms causing accelerated metabolism (Campbell, 1977).

In conclusion, the magnetic field pre-treatment for 50 or 70 min enhanced root length, shoot length, root fresh weight, shoot fresh weight, root dry weight and shoot dry weight compared with the control. Seed germination percentage did not show any significant differences between the treatments times for all varieties.

3.2. Greenhouse experiment

Cumulative plant growth data (plant height, number of branch, number of leaves, number of leaflets and total pigments) were measured. The most significant different growth was observed in plants grown from magnetized seeds and water for the treatments T50 and T70 (Tables 3 and 4). Growth data were measured onthe 28^{th} days after seeding. The greatest plant height was observed in plants grown up from seeds magnetized for 50 (T50) and 70 min (T70) and irrigated with magnetized water for all varieties of chickpea except Rania (Table 3). This result was in agreement with that obtained by Algozari and Yao (2006) in the increasing of plant height as a result of magnetizing of seeds and water. They reported that the magnetic application lead to easy breakthrough of water for the cell membrane of plants. The easy breakthrough of water leads to better absorption of water and mineral by plant roots (Barefoot and Reich, 1992). Kronenberg *et al.* (2005) showed that the magnetic application lead to an increase in the availability of minerals in soil through the increasing of solubility of salts and minerals. The increasing of solubility of salts and minerals lead to the increasing of macro and micro elements from soil and division and elongation of cell during the plant growth. However, it was found that the pretreatment of seeds for 50 (T50) and 70 min (T70) by magnetic field and irrigation by magnetized water had more growth in branch compared with the control plants in all varieties except FLIP98-133C and FLIP83-48C (Table 3). Also these data allow us to find significant differences among the treatments: Control, T30, T50 and T70 for the number of leaves and leaflets of chickpea plants (Tables 3). Total pigments content (Chlorophylls a, b and Carotene) increased significantly (20-25%) for Chamchamal, FLIP98-133C and FLIP83-48C with respect to control groups at T30 and T50. On the other hand, Rania did not show significance difference between the control and the magnetic treatments: T30, T50 and T70 (Table 3). Total fresh weight (biomass) of plants was measured on the 28^{th} days after planting (Table 4). Shoot fresh weight, root fresh weight, root dry weight and shoot dry weight were significantly affected by magnetic application compared with the control. Significant genotypic variability was detected in all genotypes except Rania for shoot fresh weight (Table 4). Comparatively higher shoot fresh weight was obtained at magnetic treatment T70. The greatest increase (improved value) in shoot fresh weight was recorded with Chamchamal at T70. Analysis of variance for root fresh weight traits computed from the chickpea, treated or non-treated by magnetic

Table 3: Effect of magnetized seed and water on plant height, number of branch, number of leaves, number of leaflets and total pigments (Chlorophyll a + Chlorophyll b + Carotene) of chickpea grown in soil under greenhouse condition.

Treatments	Rania	Chamchamal	Sangaw	FLIP98-133C	FLIP83-48C
Plant height (cm)/plant					
Control	17.35a	15.44b	14.93b	13.80b	13.40b
T30	16.52a	16.58ab	15.42b	15.26ab	14.97ab
T50	16.37a	17.52a	16.99ab	15.69a	16.58a
T70	17.85a	17.97a	18.13a	14.34ab	15.61ab
Number of branch/plant					
Control	3.13b	3.13b	4.1b	4.4a	3.83a
T30	3.7ab	3.73a	4.13b	4.26a	3.96a
T50	3.43ab	3.86a	4.33ab	4.36a	4.3a
T70	3.9a	3.76a	4.66a	4.56a	4.23a
Number of leaves/plant					
Control	12.5ab	11.7b	16.83b	15.76b	14.43b
T30	11.73b	11.6b	17.06b	16.2b	15.8ab
T50	14a	14.86a	19.73a	19.06a	17.7a
T70	13.93a	15.23a	20.73a	18.86a	16.33ab
Number of leaflets/plant					
Control	79.26b	88.26bc	102.93b	82.36b	75.9c
T30	79.7b	77.46c	101.46b	82.6b	88.96bc
T50	89.33ab	98.96ab	114.86ab	111.83a	105.96a
T70	96.1a	109.16a	122.8a	103.16a	96.96ab
Total pigments (Chlorophyll a, b + Carotene) (mg/g fresh weight)/plant					
Control	0.253a	0.199bc	0.220a	0.201d	0.165b
T30	0.258a	0.189c	0.218a	0.235b	0.202a
T50	0.241a	0.240a	0.211a	0.236a	0.167b
T70	0.251a	0.201b	0.201b	0.219c	0.161c

*Means designated with the same letter (s) do not differ significantly from each other according to Duncan's multiple range tests, $p \leq 0.05$.

Table 4: Effect of magnetized seed and water on shoot fresh weight, root fresh weight, shoot dry weight, root dry weight and seed yield/plant of chickpea grown in soil under greenhouse condition.

Treatments	Rania	Chamchamal	Sangaw	FLIP98-133C	FLIP83-48C
Shoot fresh weight (g)/plant					
Control	2.79a	1.63b	3.17b	2.07c	2.36c
T30	2.68a	1.5c	3.4a	2.19b	2.5b
T50	2.87a	2.75a	2.95c	2.23ab	3a
T70	2.67a	2.83a	3.03bc	2.29a	3.03a
Root fresh weight (g)/plant					
Control	4.83b	3.55c	5.11b	3.45d	4c
T30	4.66b	3.20c	5.33b	4.2c	5.23ab
T50	6.86a	4.2b	5.05b	4.48b	5.35a
T70	5.55b	4.83a	5.73a	5.46a	4.86b
Shoot dry weight (g)/plant					
Control	0.359c	0.18d	0.57b	0.43b	0.43a
T30	0.425b	0.31c	0.601b	0.44b	0.46a
T50	0.453a	0.44b	0.605b	0.47a	0.46a
T70	0.445ab	0.48a	0.79a	0.44b	0.47a
Root dry weight (g)/plant					
Control	0.51c	0.31b	0.46b	0.27d	0.259c
T30	0.515bc	0.25c	0.47b	0.32c	0.40a
T50	0.525b	0.32b	0.50b	0.44a	0.36b
T70	0.67a	0.42a	0.589a	0.42b	0.38b
Seed yield (g)/plant					
Control	3.05c	3.01c	3.41b	2.61b	2.28d
T30	3.27b	3.2b	3.28b	2.76b	2.93c
T50	4.00a	3.76a	4.18a	3.36a	3.1b
T70	3.98a	3.65a	4.15a	3.33a	3.22a

*Means designated with the same letter (s) do not differ significantly from each other according to Duncan's multiple range tests, $p \leq 0.05$.

field, showed significance differences. The highest increased in root fresh weight was recorded by FLIP98-133C at T70 compared with the control (Table 4). Significant genotypic variability was detected in all genotypes except FLIP83-48C for shoot dry weight. The greatest increase (improved value) in shoot dry weight was recorded by Chamchamal at T70 compared with the control (Table 4). Analysis of variance for root dry weight traits computed from the chickpea treated or non-treated by magnetic field, showed significance differences. The highest increase in root dry weight was recorded by FLIP98-133C at T70 compared with the control (Table 4). The current study showed that seeds yield per plant was significantly affected by the duration of exposure to magnetic field as indicated by the significant one-way based on ANOVA ($p < 0.05$) (Table 4). Rania (T50), Chamchamal (T50), Sangaw (T50), FLIP98-133C (T50) and FLIP83-48C (T70) showed an increase of 31, 25, 23, 29 and 41% respectively of seeds yield compared with the control (Table 4). The increasing of seed yield as a result of increased plant growth and the effectiveness of the shoots in the photosynthesis process (Kronenberg et al., 2005).

The results obtained in this growth test allow us to conclude that magnetic treatment improves the stages of growth in higher plants. In general the seedlings from seeds magnetically pretreated grew taller and heavier than untreated controls. These seedlings showed greatly improved root characteristics. The stimulatory effect of the application of different magnetic times on the growth data reported in this study was in agreement with that obtained by other researchers. Florez *et al.* (2007) observed an increase in the initial growth stages and an early sprouting of maize and rice seeds exposed to 125 and 250mT stationary magnetic field. Martinez *et al.* (2002) observed similar effects on wheat and barley seeds magnetically treated. The mechanisms are not well known yet, but several theories have been proposed, including biochemical changes or altered enzyme activities by Phirke *et al.* (1996). Chickpea seedlings from magnetically pretreated seeds grew more than the untreated, and also biomass and root growth were significantly increased.

Magnetic field is known as an environmental factor which affects gene expression. Therefore, augmentation of biological reactions like protein synthesis, biomass would increase too. Moreover, transcriptional factors are under effect of magnetic field stimulation (Xi and Ling, 1994). The effects of magnetic fields are superimposed on endogenous rhythms in some situations leading to inhibition, and in others to stimulation, while sometimes no effects had been reported. Moreover, magnetic fields have the ability to change water properties, thus magnetized water increased rice chlorophyll content (Tian *et al.,* 1989). Similary, Racuciu *et al.* (2008) reported that long magnetic field exposure has the ability to increase assimilatory pigments. This fact was confirmed by several studies for different plants where magnetic field treatment increased the chlorophyll content in sugar beet (*Beta vulgaris* L.) leaves (Rochalska, 2005). Additionally, studies by Atak *et al.* (2007) involving magnetic field impact on soybean (*Glycine max* L.) confirmed that magnetic field significantly increased chlorophyll a, chlorophyll b and total chlorophyll contents. Whereas, magnetic field short exposure is accompanied with increases in chlorophyll a, chlorophyll b and total chlorophyll contents (Atak *et al*., 2000). The reduction of pigments explained by Commoner *et al.* (1956), that chemical with unpaired electrons possess a magnetic moment plays an important role in electron transfer and kinetics of chemical reactions. The electrons with magnetic moments can be oriented in the external magnetic field. As a result of the interaction between the external magnetic field and the magnetic moment of unpaired electrons, the energy is absorbed. Chloroplasts have magnetic moments and could be affected by the absorbed energy at a high dose of magnetic field which can disturb the pigments synthesis. Other possible explanations for the decline in pigments content are that carotenoids may be consumed in radical scavenging reactions (Strzalka *et al.,* 2003), or free radicals inhibited the pigments synthesis through affecting photosynthesis enzymes.

In conclusion, magnetic field could be used as a stimulator for growth related reactions. Photosynthetic pigments content have shown a significant increase in response to magnetic fields at low dose. Short exposure to alternating magnetic field had a positive impact, whereas long exposure had a negative effect on pigments content similar to magnetic field effect on proline (Dhawi Al-Khayri, 2008). Using magnetic field treatment could be a promising technique for agricultural improvements but extensive research is required, using different levels of magnetic field doses to determine the optimum dose. We can conclude that exposure of dry chickpea seeds to static magnetic field for different durations significantly increased laboratory germination characteristics. On the other hand, the exposure of seed to magnetic field and irrigation with magnetized water revealed the stimulatory influence on the following growth characters: significant enhancement of the fresh tissue mass, assimilated total pigments level, increase of the average plants height, number of branch, number of leaf and leaflet in some varieties of chickpea.

In conclusion, the exposure of seed to magnetic field and irrigation with magnetized water revealed the stimulatory influence on the plants: significant enhancement of the fresh tissue mass, assimilatory total pigments level, increase of the average plants height, number of branch, number of leaves and leaflets in some varieties of chickpea. We recommend the following:

1. Studying the effect of magnetic field on the flowering.
2. Evaluation of expression of genes, total proteins and metabolic compounds related to the growth.
3. Studying the effect of magnetic field on the resistance to biotic (*Ascochyta rabiei*) and abiotic stress (Drought).

References

Ahmad M and Azita S. 2009. Effect of seed pretreatment by magnetic fields on seed germination and ontogeny growth of agricultural plants. Progress in electromagnetics research symposium, Beijing, China, March 23-27, 2009.

Aladjadjiyan A. 2002. Study of the influence of magnetic field on some biological characteristics of Zea mays. J. Central Euro. Agric. **3(2)**: 89-94.

Alexander MP and 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 Genet. Res. News. **104**: 1-5.

Algozari H Yao A. 2006. Effect of the magnetizing of water and fertilizers on the some chemical parameters of soil and growth of maize (MSc thesis). Baghdad (Iraq): University of Baghdad.

Arumuganathan K and Earle ED. 1991. Nuclear DNA content of some important Plant species. Plant Mol. Biol. Reptr. 9: 208-218.

Atak C Celik O Olgun A Alikamanolu S and Rzakoulieva A. 2007. Effect of magnetic field on peroxidase activities of soybean tissue culture. Biotechnol. **21**: 166-71.

Atak C Danilov V Yurttafl B Yalçin S Mutlu D and Rzakoulieva A. 2000. Effect of magnetic field on Paulownia seeds. Com. J.I.N.R. Dubna. 1-14.

Barefoot RR and Reich CS. 1992. The calcium factor: The scientific secret of health and youth. South eastern, PA: Triad Marketing, 5th edition.

Calatayud A Iglesias DJ Talón M and Barreno E. 2003. Effect of 2-month ozone exposure in spinach leaves on photosynthesis, antioxidant systems and lipid peroxidation. Plant Physiol. Biochem. **41**: 839-845.

Campbell GS. 1977. **An introduction to environmental biophysics**. Springer-Verlag, NY, USA.

Celestino C Picazo ML and Toribio M. 2000. Influence of chronic exposure to an electromagnetic field on germination and early growth of Quercus suber seeds: Preliminary study. Electro. Magnetobiol. **19(1)**: 115-120.

Commoner B Heise JJ and Townsend J. 1956. Light-induced paramagnetism in chloroplasts. Proc. Natl. Acad. Sci. USA. 42: 710-14.

Dhawi F Al-Khayri JM. 2008. Proline accumulation in response to magnetic fields in date palm (Phoenix dactylifera L.). Open Agri. J. **2**: 80-88.

FAOSTAT-Agriculture 2006. Database.htt://www.fao.org/waicent/statistic.asp.

Florez M, *Carbonell MV and Martinez E. 2007.* Exposure of maize seeds to stationary magnetic fields: Effects on germination and early growth. Environ. Exper. Bot. **59**: 68-75.

Harichand KS Narula V Raj D and Singh G. 2002. Effect of magnetic fields on germination, vigor and seed yield of wheat. Seed Res. **30(2)**: 289-293.

Lebedev IS and Litvinenko LT. 1977. After effect of a permanent magnetic field on photo- chemical activity of chloroplast. Sov. Plant Physiol. **24**: 394-395.

Levesque R. (2007). **SPSS programming and data management: A guide for SPSS and SAS users**, Fourth Edition, SPSS Inc., Chicago.

Lin I and Yotvat J. 1989. Exposure of irrigation water to magnetic field with controlled power and direction: effects on grapefruit. Alon Hanotea. **43**: 669-674.

Kronenberg KJ. 2005. Magneto hydrodynamics: The effect of magnets on fluids. GMX international.

Martines E Carbonell MV and Florez M. 2002. Magnetic biostimulation of initial growth stages of wheat. Electromagn. Biol. Med. **21(1)**: 43-53.

Mochizuki N Brusslan JA Larkin R Nagatani A and Chory J. 2001. Arabidopsis genomes uncoupled 5 (GUN5) mutant reveals the involvement of Mg-chelatase H subunit in plastid-to-nucleus signal transduction. Proc. Natl. Acad. Sci. U.S.A. 98: 2053-2058.

Noran R Shani U and Lin I. 1996. The Effect of irrigation with magnetically treated water on the translocation of minerals in the soil. Magn. Electr. Separ. **7(2)**:109-122.

Phirke PS Kubde AB and Umbarkar, S. P. (1996). The influence of magnetic field on plant growth. Seed Sci. Technol. 24: 375-392.

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. Agrophys. **19**: 1-8.

Pundir RPS Rao NK and Van Maesen LJG. 1985. Distribution of qualitative traits in the world germplasm of chickpea (*Cicer arietinum L.*) Euphytica. **34**: 697-703.

Racuciu M Creanga DE and Galugaru CH. 2008. The influence of extremely low frequency magnetic field on tree seedlings. Rom. J. Phys. **35**: 337-342.

Rajendra P Nayak HS Sashidhar RB Subramanyam C, Devendarnath D, Gunasekaran B, Aradhya RSS and Bhaskaran A. 2005. Effects of power frequency electromagnetic fields on growth of germinating Vicia faba L., the broad bean. Eletromagn. Biol. Med. **24**: 39-54.

Rochalska M. 2005. Influence of frequent magnetic field on chlorophyll content in leaves of sugar beet plants. Nukleonika. **50**: 25-38.

Singh KB. 1987. Chickpea breeding. In: M.C. Saxena and K.B. Singh (eds.). **The Chickpea**. CAB International, UK. pp.127-162.

Strzalka K Kostecka-Guga A and Latowski D. 2003. Carotenoids and environmental stress in plants: significance of carotenoid-mediated modulation of membrane physical properties. Russ. J. Plant Physiol. **50**: 168-173.

Tian WX Kuang YL and Mei ZP. 1989. Effect of magnetic water on seed germination, seedling growth and grain yield of rice. J. Jilin. Agric. Univ. **11**: 11-16.

Xi G Fu ZD and Ling J. 1994. Change of peroxidase activity in wheat seedlings induced by magnetic field and its response under dehydration condition. Acta. Bot. Sinica. **36**: 113-118.