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Influence of different intensities of magnetic field on germination, vegetative growth and some physiological aspects of salinity-stressed cucumber

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ABSTRACT

Two experiments were designed to investigate the effect of different static magnetic fields and 10% seawater stress on seed germination of cucumber (*Cucumis sativus* L. var. Beit Alpha), seedling vigour, vegetative growth and some biochemical aspects. Salinity stress reduced seeds germination, seedlings fresh mass and seedlings vigour by about 30%, 54%, and 70 % respectively. Moreover, salinity significantly reduced the depletion in seedling dry mass in comparison with control. The magnetic fields of 50 mT for ½ h and 100 mT for 30 s improved seed germination, seedlings fresh mass and seedlings vigour under salinity stress by about 30%, 50% and 150%, respectively in comparison with salinity treatment alone. Conversely, the dual treatment of 200 mT for 1/2 h and salinity stress had more reduction effect on cucumber than salinity alone. In general, the magnetic fields of 50 mT 30 s, 100 mT 1/2 h and 200 mT 30 s had a non significant effect on seed germination. Except for 50 mT 30 s intensity which had a promotive effect, the effect of all used magnetic fields on shoot biomass and chlorophylls content were comparable with those for seedlings fresh mass. The positive effect of magnetic fields seemed to be attributed to the enhancement in total amylase activity, soluble sugars, RNA, K^+/Na^+ ratio and chlorophylls level. On the contrary, magnetic treatments decreased peroxidase activity, total proteins and electrolytes leakage under salinity stress conditions. However, all magnetic intensities increased Fe content, in spite of being independent of magnetic intensity or exposure period.

Keywords: Cucumber, Enzymes, Ferromagnetism, Germination, Growth, Leakage, Protein, RNA, Salinity.

INTRODUCTION

Salinity is one of the major environmental factors limiting worldwide productivity and distribution of crops in agriculture (Parida and Das, 2005). The United Nations Environment Program estimates that approximately 20% of agricultural land and 50% of cropland in the world is salt-stressed (Flowers and Yeo, 1995). Salinity is inimical to plant growth through specific ion toxicities, osmotic effects and induced nutrient deficiencies (Shannon, 1998). Na^+ is the primary cause of ion specific damage resulting in a range of disorders in enzyme activation, protein synthesis and plasma membrane stability (Tester and Davenport, 2003; Mansour 2013). Over the course of evolution, plants have developed a variety of molecular mechanisms to cope with salt stress involving changes in many biochemical pathways to protect major processes such as photosynthesis and respiration (Parida and Das, 2005; Fan *et al.*, 2013).

Salt stress could be partially overcome through plant breeding or by producing transgenic plants, but the progress to develop such salt resistant plants is very slow due to the complex nature of salt tolerance (multigenic control). Consequently, plant breeding and biotechnological methods applied to improve many crops were not much successful, even after gene improvement (Dionisiosese and Tobita, 2000; Iqbal and Ashraf, 2013). Thus, the use of some other low cost and low risk methods like seed priming (Aldesuquy and Ibrahim, 2001; Iqbal and Ashraf, 2013) and seed magnetization could be attractive solutions to overcome the salinity problem (Abou el-yazied *et al.*, 2011; Radhakrishnan and Kumari, 2012). The negative impact of using saline water has led the agricultural scientists to explore the influence of physical factors such as the magnetic fields on plants (Tanvir *et al.*, 2012; Bilalis *et al.*, 2013). Exposure of seeds to magnetic fields is safe and affordable potential physical pre-sowing treatments to enhance post-germination plant development and crop stand (Vashisth and Nagarajan, 2010). Amazing biochemical and biophysical changes are associated with magnetic treatments which led to higher germination, growth rate and yield in plants grown in optimum conditions (Podleśny *et al.*, 2004; Bhardwaj *et al.*, 2012; Tanvir *et al.*, 2012; Dhawi, 2014). The fast germination and seedlings growth of magnetic-field-treated seeds was attributed to the increase in enzymes activity (e.g. α- amylase) and seed coat membrane integrity (Vashisth and Nagarajan, 2010), and the reduction in peroxidase activity, rate of lipid peroxidation and electrolyte leakages of membranes (Payez *et al.* 2013). In this respect, Radhakrishnan and Kumari (2012) found that the exposure of soybean seeds to 1500 nT for 20 days (5 h per day) improved soybean productivity through the enhancement of protein, enzyme activities and mineral accumulation. However, some results showed the negative impact of magnetic fields on plants and attributed this to the accumulation of reactive oxygen species (Monselise *et al.*, 2003; Jouni *et al.*, 2012). Cucumber (*Cucumis sativus* L.) is a salinity sensitive and popular vegetable crop (Chartzoulakis, 1992). Although the biochemical and biophysical changes associated with magneto priming in germinating cucumber seeds were studied by Bhardwaj *et al.* (2012) no information is available about the effect of seed magnetization on cucumber vegetative growth neither on growth nor physiology under salt stress. Therefore, the present study aims at elucidating the amelioration of cucumber tolerance to salinity by using magnetic field.

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MATERIAL AND METHODS

Seeds material

Seeds of cucumber (*Cucumis sativus* L. var. Beit Alpha) were obtained from Al-Qunfudah office of vegetable seeds, Saudi Arabia kingdom. A germination test was carried out to check the viability of the seeds. The germination percentage and the seeds moisture content were about 85% and 9.0%, respectively.

Magnetic field treatments

Seeds were surface sterilized with 2.5 g L^{-1} sodium hypochlorite solution for 5 min and rinsed with sterile distilled water. The sterilized seeds were soaked in distilled water for 8 h and kept in a cylinder of filter paper (1.5× 4 cm). Then the seeds were exposed to different magnetic fields in Physics Dept. at Al-Qunfudah University College using Dia, Para and Ferromagnetism apparatus (Fig.1). The seeds were exposed to three levels of magnetic intensity (50 mT, 100 mT and 200 mT)at two periods of exposure (30 seconds and 1/2 hour)so that 7 groups were conducted:0.0mT (control), 50 mT 30 s, 50 mT ½ h, 100 mT 30 s, 100 mT ½ h., 200 mT 30 s, 200 mT ½ h. For each group, two different treatments were performed; one was left as control and the other for stress test using 10% seawater, either for germination or vegetative growth experiment.

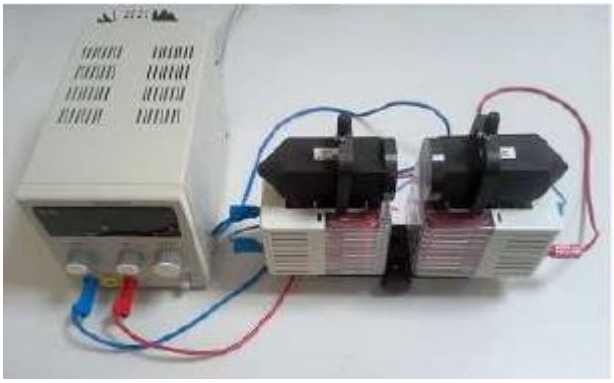

Figure (1): Dia, Para and Ferromagnetism apparatus.

Germination experiment

The seeds of each group were sown in plastic boxes (20 seeds/box; 12 × 20 cm) lined with filter papers. Then each group was allocated into two treatments: control treatment moistened with 20 cm^3distilled water and salt stress treatment moistened with 20 $cm^3$10% seawater (EC = 6.5dS m^{-1}). All boxes were covered and incubated in dark at 25°C in Wise incubator for 5 days. Samples were taken for seedlings mass, root length, hypocotyls length and biochemical analyses at the end of the 5th day.

Estimation of germination percentage (Germination %)

Number of germinating seeds was recorded on 1st, 2nd, 3rd and 5th days in three replicates (three boxes) for each treatment and used for the estimation of germination percentage.

Determination of seedlings biomass and vigour

Ten normal seedlings from each replicate were taken at random, and shoot and root lengths were measured. For biomass, each 10 seedlings was weighed and dried overnight in an oven set at 80°C and the seedling vigour was calculated by the formula of ABDUL-BAKI and Anderson (1973):

Vigour index = Germination % × Seedling length (Root + Shoot).

Extraction and assay of total amylase activity

Fresh seedlings were ground in cold tris-maleate buffer (0.05M; pH 7.0) with the aid of mortar and pestle. The homogenate was centrifuged for 20 min at5000gand the supernatant was used to assay total amylase activity by the method adopted by de MORAIS and Takaki (1998). The reaction mixture contained 1.0 cm^3 enzyme extract and 1.0 cm^3 starch solution (150 mg soluble starch, 600 mg KH_2PO_4 and 200µ mol $CaCl_2$ in 100 cm^3 distilled water) and the reaction was carried out for 5 min at 30 °C. The reaction was stopped by adding 1 cm^3 iodine reagent (3 mg KI + 0.3 mg I_2 in 0.05N HCl). For reading, the mixture was diluted up to 13 cm^3 and the absorbance was read at 620 nm using spectrophotometer (APEL, PD-303 UV). One unit of enzyme was considered as the quantity that causes alteration of 0.1 in absorbance.

Extraction and assay of guaiacol peroxidase activity

A known leaf fresh weight was macerated in phosphate buffer (0.1M; pH 7) with a pre-cooled mortar and pestle. The homogenate was centrifuged at 5ºC at 8000 g for 25 min. The supernatant was used as a source for peroxidase enzyme within 2-4 h. Peroxidase (EC 1.11.1.7) activity was determined by the guaiacol oxidation method as described by Sadasivam and Manickam (1996).

Determination of total RNA:

Fresh plant materials (20-50 mg) was homogenized in lysis buffer and centrifuged at 10000 g for 10 min. Chloroform was added, and after centrifugation the supernatant was transferred into a micro centrifuge tube. RNA in the samples was purified by silica-gel column (SGC)-based isolation technology. Isopropanol was added to the prepared lysate and the mixture was transferred directly into spin column. Then the spin column was placed into an RNase-free centrifuge tube and centrifuged at 10,000 g for 1 min to elute the RNA. Total RNA concentration was determined by a UV spectrophotometer at 260 nm and the sample purity was assessed by using the 260 nm:280 nm calculation(Manchester 1996).

Determination of crude protein content

Determination of total protein was performed according to A.O.A.C method (1995). The dry powdered seedlings were digested in concentrated

H_2SO_4 in Kjeldatherm Gerhard instrument. After this, distillation and titration for total N- determination was carried with automatic Vapadest 50s Gerhard instrument. Crude protein = 6.25 × total-N.

Measurements of K, Na and Fe ions content

A known seedlings dry weight was digested in boiling concentrated HNO_3 and made up to known volume with de ionized water. K^+ and Na^+ concentrations were measured by flame photometer (Perkin Elmer, model 2100, Germany). Fe^{3+} level was measured using the atomic absorption spectrophotometer Perkin-Elmer 2380 (Rorison *et al.* 1993).

Determination of soluble sugars content

A known dry weight was submerged in 80% ethanol overnight with periodic shaking, then filtered through Whatman No. 1 filter paper. Total soluble sugars in this filtrate were determined spectrophotometrically by the anthrone method (*Riazi et al*. 1985).

Vegetative growth experiment

Growth conditions

Four seeds from each group were sown in plastic pots (15 cm width × 20 cm height) containing 2.75 kg sandy soil amended with peatmos (2 sandy soil:1 peatmos). This soil was taken from an agricultural field at Al-Qunfudah Governorate. All pots were irrigated with tap water (EC = 0.2 dS/m) for two weeks, then the plants were thinned to one plant per pot and each one received 1 g $Ca(NO3)_2$ and 1 g K_2HPO4 as inorganic fertilizers. After that, the plants were continued in irrigation with tap water for another week. Then, the pots of each group were allocated into two treatments: control (tap water) and salt stress (10% seawater). These fourteen treatments were replicated 8 times to give a total of 112 pots. The plants were grown in a greenhouse for the following three weeks at the Al-Qunfudah College and the plants were subjected to natural day/night conditions. Minimum/maximum temperature and average photoperiod (day/night) were 20/35 ºC and 11.5/12.5 h, respectively during the study. Irrigation to field capacity for control and salinity treatments was carried out when soil moisture content had fallen to 60% of its initial value. At the end of the experiment (6 weeks from sowing), samples were taken for growth, photosynthetic pigments and electrolyte leakage analyses.

Determination of photosynthetic pigments

Chlorophyll a, chlorophyll b and carotenoids of leaf samples were extracted rapidly in ammoniacal acetone and their concentrations were determined spectrophotometrically by the method of Lichtenthaler (1987).

Measurement of electrolyte leakage (EL)

Based on the method described by Bajji *et al.* (2001), leaf discs were washed quickly with deionised water and placed in 10 ml of deionised water. An initial electrical conductivity (ECi) was measured using a conductivity meter (METTLER-TOLEDO). The tubes containing the leaf discs were returned into the dark at 25 °C and subsequent measurements were done after 4 h (ECf). After this, the samples were autoclaved, cooled at 25 °C and the total electrical conductivity (ECt) was measured. The electrolyte leakage was calculated from the formula:

$$[(ECf – Eci) / (ECt – Eci)] \times 100.$$

Statistical analysis

The experiments had completely random and factorial designs. The data are means from 3 to 6 replicates. The results were subjected to an analysis of variance using the general linear model and one-way ANOVA. The significant differences between means (least significant difference a posteriori test) at $P < 0.05$ were calculated with SPSS 15 (SPSS Inc., Chicago, IL, USA).

RESULTS

Changes in seeds germination

After one day, salinity stress (10% seawater) reduced seeds germination percentage by about 70% of control value (Table 1). This reduction was continued to be about 40%, 30% and 30% after 2nd, 3rd and 5th days, respectively. The influence of magnetic field on seeds germination appeared to be a function of intensity and exposure duration. Of all used magnetic intensities, 50 m T ½ h, and 100 mT30 s were the only ones which had a marked promotive effect on seeds germination in control and stress conditions. After 1st day, these treatments caused a 2-fold and 3-fold increase in germinating seeds in control and salinity stress conditions, respectively. The positive effect of these magnetic treatments was continued under the stress condition until the 5th day of germination, but with a low level. On the other hand, seeds magnetization with a high magnetic intensity, 200 mT for 30 s or 1/2 h, non significantly affected the germination percent in optimum conditions and reduced seeds germination under salinity stress conditions in comparison with the untreated seeds. The combination treatment (200 mT + salinity stress) added more reduction in germination percentage than salinity stress alone. On many occasions, the other magnetic treatments (50 mT30 s and 100 mT 1/2h) had no significant effect on seeds germination.

Changes in seedlings biomass and vigour

Salinity stress lowered seedling fresh mass to 56% of control value (Fig. 2a). Regarding the effect of magnetic field, 50 mT for 1/2h and 100 mT for 30s improved seedling fresh mass by 20% and 50% under control and stress conditions, respectively. Seedling dry mass was about 30% higher under salinity stress than control conditions (Fig. 2b). The magnetic treatments 50 mT 1/2h and 100 mT 30s decreased seedlings dry mass by about 20% and 15% under control and stress conditions respectively. On some occasions, the effect of 50 mT 30s and 100 mT 1/2h treatments was comparable with

Table (1): Interactive effect of magnetic field and salinity stress on germination percentage in cucumber. Values are mean ± SE (n=3).Values within the same column followed by the same letter(s) are not significantly different at P > 0.05. SW, seawater.

Treatments		Germination percentage			
Salinity Level	Magnetic field	1 day	2 days	3 days	5 days
0.0	0.00	30±1.73c	80±2.30ab	85±2.89ab	85±1.80ab
0.0	050 mT 30 s	35±2.31c	75±1.73bc	85±2.31ab	85±2.11ab
0.0	050 mT½ h	65±2.88a	85±2.80a	90±3.46a	90±2.89a
0.0	100 mT 30 s	64±2.89a	85±2.31a	87±1.73a	88±2.92a
0.0	100 mT½ h	50±2.21b	84±2.89a	86±2.46ab	86± 2.21ab
0.0	200 mT 30 s	32±2.89c	70±1.74c	85±2.62ab	85±2.42ab
0.0	200 mT½ h	34±2.30c	73±3.45bc	84±2.23ab	84±1.73ab
10% SW	0.00	10±1.58d	50±2.17e	60±2.75d	60±1.72d
10% SW	050 mT 30 s	10±2.17d	60±1.73d	75±2.31c	75±2.10c
10% SW	050 mT½ h	35±2.30c	70±2.88cd	80±2.78bc	80b±2.32c
10% SW	100 mT 30 s	30±2.73c	65±2.31d	75±2.65c	75±1.97c
10% SW	100 mT½ h	30±1.74c	55±1.73e	60±2.81d	60±2.32d
10% SW	200 mT 30 s	14±2.15d	35±1.74f	50±1.87e	50±1.82e
10% SW	200 mT½ h	15±2.21d	36±2.32f	49±2.18e	49±2.10e

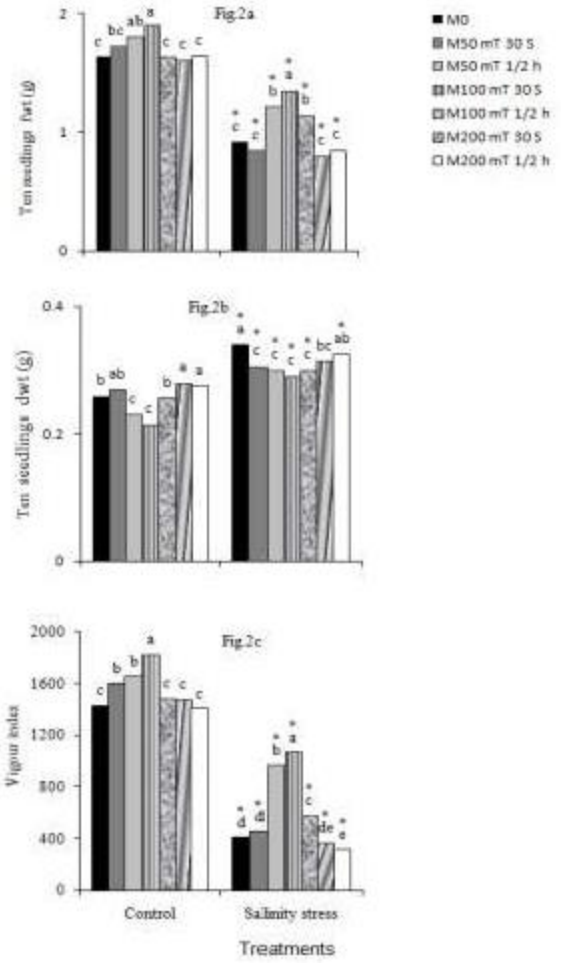

Figure (2): Interactive effect of magnetic fields and salinity stress on growth parameters of cucumber seedlings. Values are mean of three replicates. Values in a group with the same letter (S) are not significantly different as p< 0.05. An asterisk (*) indicates a significant difference with the corresponding control. Abbreviation: M, magnetic field.

those of 50 mT 1/2h treatment. Over all conditions, the magnetic field of 200mT intensity had a non significant effect on seedlings fresh and dry mass (Fig. 2a &2b).

Application of salinity stress reduced seedling vigour index to about 30% of control value (fig. 2c). The two magnetic treatments 50mT 1/2h and 100mT30 s enhanced the vigour index by about 30% and 150% in control and salinity stress conditions, respectively. Sometimes, the effect of 50 mT30 s and 100mT1/2h treatments was similar to those of 50 m T 1/2 h treatment. The magnetic field of 200mT intensity for 1/2 h had a negative impact on the vigour index in relation with the untreated seedlings (Fig. 2c).

Changes in total soluble sugars and enzymes activity

Application of salinity stress reduced total soluble sugars content in cucumber seedlings to 35% of control value (Fig.3a).It can be seen from fig.3a that the magnetic treatments 50mT 1/2h, 100 mT30 s and 100 m T 1/2 h significantly increased total soluble sugars in the seedlings grown in control and stress conditions. The magnetic treatments (50 mT30 s and 200 mT30 s) had a non significant effect on sugars content. The treatment 200 m T 1/2 h added more reduction in sugars content in cucumber seedlings under salinity stress conditions. Total amylases activity in the seedlings was reduced to 25% of control value in response to salinity stress. (Fig.3b). In general, the effects of magnetic intensity and exposure duration on amylases activity were similar to those of total soluble sugars. There was about 3-fold increase in peroxidase activity in cucumber seedlings in response to salinity stress (Fig.3c).

Most magnetic treatments significantly increased the peroxidase activity in comparison with control seedlings. However, the combination treatments (Salinity + Magnetic fields) induced a lower increase in peroxidase activity in comparison with salinity stress alone.

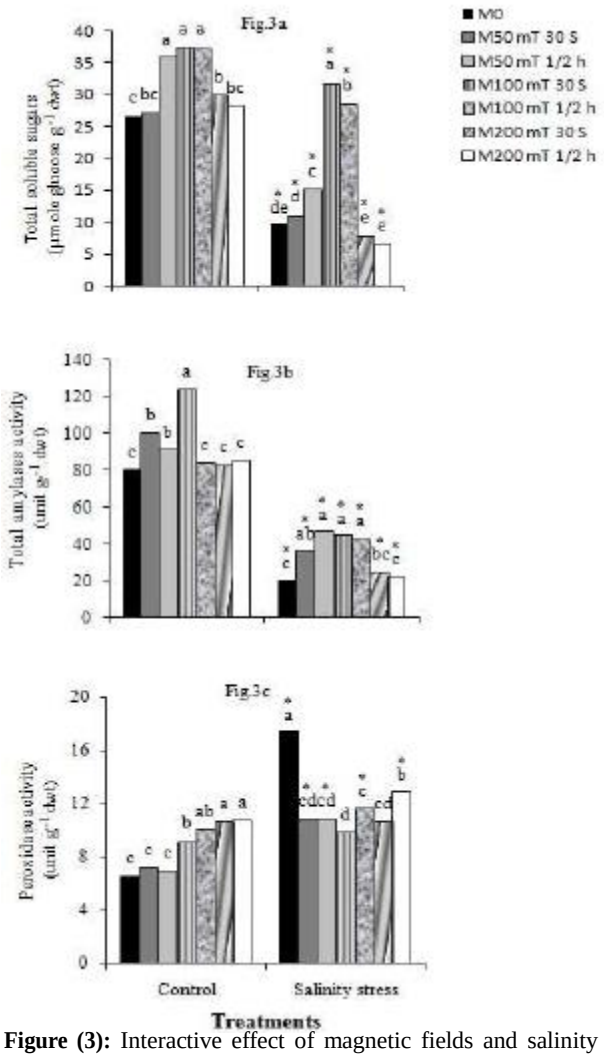

Figure (3): Interactive effect of magnetic fields and salinity stress on total soluble sugars content and enzymes activity of cucumber seedlings. Values are mean of three replicates. Values in a group with the same letter (S) are not significantly different as $p< 0.05$. An asterisk (*) indicates a significant difference with the corresponding control. Abbreviation: M, magnetic field.

Changes in total RNA and proteins

Salinity stress reduced RNA content in cucumber seedlings to about 50% of control level (Fig.4a).In control and stress conditions, the magnetic intensities 50 m T and 100 m T significantly increased RNA content in cucumber seedlings. The highest increase was observed in response to 50 m T 1/2h and 100 mT30 s treatments. Conversely, the 200 m T for 30 s and 1/2 h treatments reduced this important biochemical substance by about 30% and 40% in control and stress conditions, respectively.

Cucumber seedlings grown under salinity stress had higher total protein content than those grown under control conditions (Fig.4b). It may be unexpected that all magnetic treatments lowered the protein content in the used seedlings in comparison with the untreated ones. Among all magnetic treatments, the highest value of proteins was observed in response to 50 m T 1/2 h and 100 mT30 s treatments.

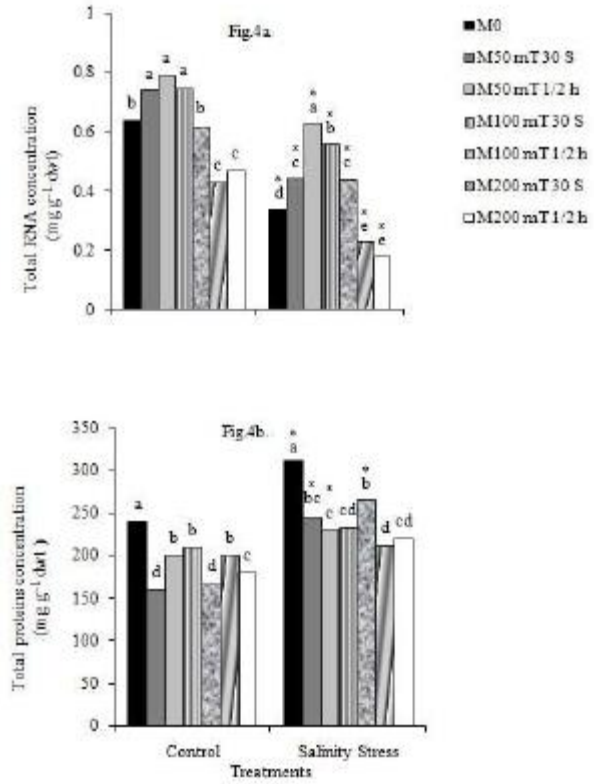

Figure (4): Interactive effect of magnetic fields and salinity stress on RNA and total proteins of cucumber seedlings. Values are mean of three replicates. Values in a group with the same letter (S) are not significantly different as $p< 0.05$. An asterisk (*) indicates a significant difference with the corresponding control. Abbreviation: M, magnetic field.

Changes in K, Na and Fe ions content

Salinity stress decreased K^+ concentration in cucumber seedlings by 22% of control value (Fig. 5a). On the other hand, this stress treatment led to a 3-fold increase in Na^+ content (Fig.5b). Consequently, the K^+/Na^+ ratio was markedly reduced (70% decrease) in response to the salinity stress (Fig.5c). In general, magnetic treatments appeared to decrease K^+ and Na^+ levels in control condition and increased it in the stress treatment. However, the K^+/Na^+ ratio was either not changed (most magnetic fields) or increased (100 mT1/2h) due to magnetic fields application.

Application of salinity stress increased Fe content by 30% in comparison with control (Fig. 5d). It may be interesting that all magnetic treatments increased Fe content in cucumber seedlings grown in control and stress conditions. However, this increase was independent of magnetic intensity and exposure period.

Changes in shoot dry mass

It can be seen from table 2 that irrigation of cucumber plants with 10% seawater reduced shoot dry mass to 46% of control value. The statistical interaction (magnetic intensity × exposure period) was significant.

Over all conditions, the three treatments 50 mT30 s, 50 m T ½ h and 100 mT30 s enhanced shoot dry mass. These magnetic treatments increased shoot dry mass by about 25% and 30% in control and stress conditions, respectively. On the other hand, the magnetic treatment 200 m T 1/2h significantly decreased shoots dry mass in comparison with the untreated plants. The effect of the other magnetic treatments (100 m T ½ h and 200 mT30 s) on this parameter was not significant. It is worth mentioning that the magnetic treatment 50 mT30 s had a promotive effect on vegetative growth which was rarely observed during the germination stage.

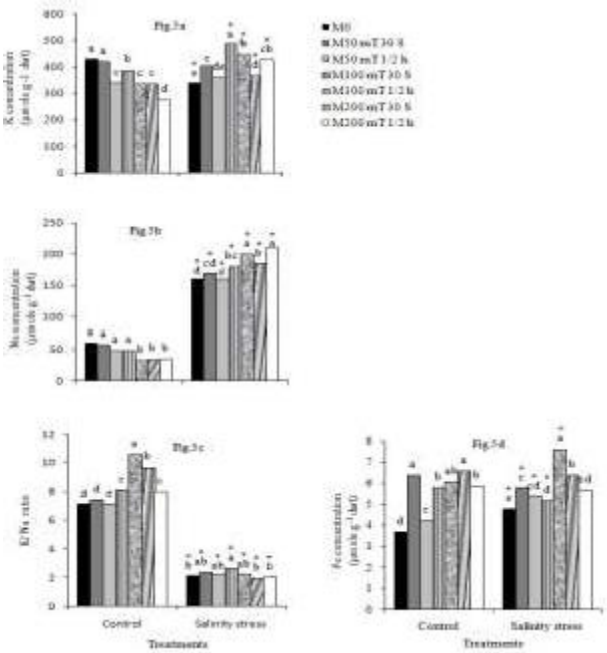

Figure (5): Interactive effect of magnetic fields and salinity stress on some ions concentration of cucumber seedlings. values are mean of three replicates. Values in a group with the same letter (S) are not significantly different as $p< 0.05$. An asterisk (*) indicates a significant difference with the corresponding control. Abbreviation: M, magnetic field.

Changes in photosynthetic pigments

Salinity stress reduced total chlorophylls and chlorophylls/ carotenoids ratio in cucumber leaves to 60% and 75% of control levels, respectively (Table 2). Photosynthetic pigments content varied considerably with respect to the magnetic field intensity and exposure duration. Most magnetic treatments enhanced total chlorophylls content in control and stress conditions. Total chlorophylls level was much higher in response to 100 mT30 s than the other magnetic treatments. Conversely, the application of 200 m T 1/2h magnetic field appeared to have a negative impact on chlorophyll content. This magnetic treatment reduced chlorophylls content by about 15% and 20% in control and stress conditions, respectively. Also, the effect of magnetic field on chlorophylls/ carotenoids ratio appeared to depend on the magnetic intensity and the exposure period. The magnetic treatments of 50 mT for 1/2h exposure and 100 m T for 30 s exposure had an enhancement effect on chlorophylls/ carotenoids ratio, whereas the magnetic treatment of 200 m T for 1/2hexposure period had a negative impact on this ratio.

Changes in electrolyte leakage:

Salinity stress caused a twofold increase in the electrolyte leakage of cucumber leaves in relation with control (Table 2). It is interesting that most magnetic field treatments (except for 200 m T for 1/2 h) obviously reduced the electrolyte leakage in control and stress conditions and the effect was more pronounced with 100 m T intensity. This reduction was higher under control than under salinity stress conditions. Application of 100 m T (for 30 s or 1/2 h exposure periods) reduced the membranes permeability by about 45% in optimum conditions and 30% under salinity stress conditions. On the other hand, the application of magnetic field of 200 m T intensity for 1/2 h nonsignificantly affected the electrolyte leakage of cucumber leaves under control or stress conditions.

Table (2): Interactive effect of magnetic fields and salinity stress on shoot dry mass, photosynthetic pigments and electrolyte leakage of cucumber plants. Values are mean ± SE (n= 5 for shoot mass and n =3 for the other parameters). Values within the same column followed by the same letter(s) are not significantly different at $P > 0.05$. SW, seawater.

Treatments		Shoot dry mass	Total chlorophylls	Chlorophylls/carotenoids	Electrolyte leakage
Salinity Level	Magnetic Field	(g/ plant)	($mg.g^{-1}dwt$)	ratio	(%)
0.0	0.00	1.44±0.09b	38.6±0.91c	8.81±0.24b	21.2±0.46f
0.0	050 mT 30 s	1.69±0.07a	41.9±1.18b	8.63±0.35b	15.9±0.79g
0.0	050 mT½ h	1.86±0.12a	42.7±1.54b	10.16±0.42a	14.4±0.57g
0.0	100 mT 30 s	1.80±0.05a	45.9±0.89a	9.11±0.13b	11.7±0.62h
0.0	100 mT½ h	1.42±0.13b	39.0±0.97c	7.71±0.18c	11.0±0.58h
0.0	200 mT 30 s	1.49±0.16b	36.9±1.15c	8.38±0.16b	15.6±0.57g
0.0	200 mT½ h	1.19±0.14c	32.1±0.93d	7.82±0.12c	22.7±0.69f
10% SW	0.00	0.66±0.05e	23.8±0.66f	6.76±0.21d	43.8±1.15a
10% SW	050 mT 30 s	0.85±0.06d	25.2±1.15f	6.81±0.43d	40.7±1.44b
10% SW	050 mT½ h	0.95±0.04d	29.6±0.53e	7.04±0.34cd	35.1±1.15c
10% SW	100 mT 30 s	0.93±0.05d	33.6±0.69d	7.11±0.14cd	32.0±1.15d
10% SW	100 mT½ h	0.69±0.06e	29.5±0.74e	6.84±0.17d	27.9±1.13e
10% SW	200 mT 30 s	0.65±0.07e	28.3±0.67e	6.48±0.15de	37.3±1.17c
10% SW	200 mT½ h	0.44±0.08f	19.5±0.61g	5.90±0.18e	42.0±1.61ab

DISCUSSION

Cucumber Seed germination and seedlings growth were strongly inhibited by 10% seawater stress. This depressive effect of salinity is apparently due to increased Na^+ and decreased K^+ with a correspondingly lower K^+/Na^+ ratio, as the cellular ionic imbalance results in osmotic damage and disorders in enzyme activation and protein synthesis (Tester and Davenport, 2003; Munns and Tester, 2008). The observed increase in Fe concentration in the salt–stressed seedlings was compatible with the increase in peroxidase activity which may indicate that this metal ion is a peroxidise cofactor in cucumber like other plants (Singh *et al*., 2010). Other studies found that salinity stress decreased Fe in the tested plants (Huang *et al*., 2010; Heidari and Sarani, 2012). The difference between these results and the present finding might result from the presence of Fe in seawater and/or the short term performance of the experiment. The recorded decrease in total amylase activity which was associated with a reduction in total soluble sugars in response to salinity stress could at least partially explain the depression in germination rate and seedlings biomass. These results are compatible with those of Ashraf *et al*. (2002) who observed the decrease in α-amylase and protease activity, and sugars content with increasing salinity level during cotton germination. The present data about the decrease of total RNA with an increase in seedling total protein in response to salinity stress might point to low protein mobilization and DNA transcription as stated by Ashraf *et al*. (2002) and Du *et al*. (2010).

The present results indicated a beneficial effect of some magnetic doses, 50 mT for 1/2h and 100 mT for 30 s, on seeds germination and seedlings vigour in control and salinity stress conditions. These findings are in accordance with Bhardwaj *et al*. (2012) who reported that pre-germination treatment with 200 mT for 1h improve cucumber seeds germination and water uptake in control conditions. Also Abou el-yazied *et al*. (2011) found that tomato seeds exposed to 100 mT for 15 min had a higher germination percentage and germination rate under saline conditions than untreated seeds. The stimulatory effect of 50 mT for 1/2 hour and 100 mT for 30 seconds is due to increased K^+, Fe, total soluble sugars, amylase activity and total RNA concentration. This increase in solutes concentration is necessary for osmotic adjustment (Munns and Tester, 2008) and RNA is essential for gene expression and protein de novo synthesis (Du *et al*., 2010). Nonetheless, the decrease in protein level by these magnetic treatments during cucumber seeds germination might result from an increased rate of mobilization rather than de novo synthesis.

The negative effect of high doses of magnetic treatment, 200 m T, on cucumber germination and seedling vigour appeared to be due to elevated Na^+ level, and reduced soluble sugars and RNA concentration as well as decreased amylase activity. On the other hand, Levitt (1980) attributed the inhibitory effect of magnetic field to mechanical compression of membrane materials, influence on the diffusion of charged particles and changes in rate and pattern of translocation and accumulation of magnetically susceptible microelements. In this regard, Rãcuciu *et al*.(2008) found that high magnetic doses, 150 -250 mT, had an inhibitory effect on dry mass, chlorophylls, RNA and DNA level in young maize plants, however, the low magnetic dose (50 mT)was of stimulatory effects on most of these parameters.

In this study, the devastating effect of salinity stress on shoot biomass of cucumber plants could be attributed to the observed reduction in chlorophylls content which was accompanied with an increase in electrolyte leakage and cellular ionic imbalance (Tester and Davenport, 2003; Munns and Tester, 2008). The positive effect of magnetic field with the intensities 50 mT for 30s and 1/2h and 100 mT for 30s on shoot biomass in control and salinity stress conditions appeared to be due to the enhancement of total chlorophylls content and reduction of the electrolyte leakage. In this accord, Payez *et al.* (2013) reported that magnetic fields application reduced the electrolyte leakage and accordingly increased the membranes stability of plants grown in optimum conditions. Moreover, the beneficial effect of magnetic field on vegetative growth of plants was well indicated under water deficit conditions (Al-khazan *et al*., 2011; Selim and El-nady, 2011). Nevertheless, the negative effect of the magnetic treatment 200 mT for 1/2h on shoot biomass and chlorophylls content under stress conditions was compatible with the results obtained in the germination experiment which was related, at least partially, to the observed reduction in RNA content and amylases activity.

CONCLUSION

The results obtained in the germination and vegetative growth experiments confirmed that the effect of magnetic field on cucumber depends on magnetic intensity and exposure period. The optimum doses to mitigate the adverse effect of salinity stress in germination and vegetative stages are 50 mT for 1/2h and 100 mT for 30 sec. The promotive effect of these magnetic treatments seemed to be due to the enhancement in total RNA, soluble sugars, amylase activity and total chlorophylls, and reduction in the electrolyte leakage. The enhancement effect of 50 m T for 30 seconds appeared in the vegetative stage only. High magnetic doses e.g. 200 mT for 1/2h had a negative impact on cucumber. However, interactive effect of magnetic field and salinity stress on cucumber needs further investigations on the molecular level to elucidate the mechanistic strategy of the regulatory gene(s).

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تأثير المجال المغناطيسي المختلف الشدة على الإنبات. النمو الخضري وبعض السمات الفسيولوجية فى نباتات الخيار الجهدة ملحيا

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اجريت تجربتان لدراسة تأثير المجال المغناطيسي المختلف الشدة والإجهاد الملحي (10% ماء بحر) على معدل الإنبات والمنو الخضري وبعض السيمات الفسيولوجية فى نبات الخيار،لقد ادي الإجهاد الملحى الى نقص واضح فى معدل الإنبات والوزن الطازج ودليل حيوية البذور وأدت معاملة البذور بالمجال المغنديسي ذي الشدة 50 مللى تسلة لمدة 30 دقيقة و 100 مللى تسلة لمدة 30 ثانية الى تحسن معدل الانبات والوزن الطازج ودليل الحيوية للبذور كبيرة فى فى البذور المجهدة ملحيا. وعلى العكس فقد كان للمعاملة بمجال مغناطيسي ذي الشدة 200 مللى تسلة لمدة 30 دقيقة تاثيرا سلبيا على انبات البذور المجهدة ملحيا عند مقارنه بتأثير الإجهاد الملحي فقط وبصفة عامة لم يكن للمجال المغناطيسي ذي الشدة 50 مللى تسلة لمدة 50 ثانية و100 مللى تسلة لمدة 30 دقيقة و 200 مللى تسلة لمدة 30 ثانية تأثير معنوي على انبات بذور الخيار. بإستثناء المعاملة بشدة 50 مللى تسلة لمدة 50 ثانية_ والتى ادت الى تحسن ملحوظ فى الوزن الطازج للمجموع الخضري ومحتوى الأوراق من الكلوروفيل – وكان تاثير مستويات الأخري من شدة المجال المغناطيسي على النمو الخضري لنباتات الخيار مثلما لوحظ فى مرحلة الإنبات، ولقد اتضح التأثير الأيجابي للمجال المغناطيسينتج من التحسن فى نشاط انزيم الاميليز وتركيز السكريات الذائبة الكلية و RNA و نسبة ايونات البوتاسيوم الى ايونات الصوديوم على العكس من ذالك فقد ادت المعاملة بتلك المجالات المغناطيسية الى تقليل نشاط إنزيم البيروكسيديز وتركيز البروتين ونفاذية الأغشية الخلوية للمواد الإلكترولتية وفى ظروف الإجهاد المحلى.