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Static Magnetic Field Influence on Elements Composition in Date Palm (*Phoenix dactylifera* L.)

[1]Faten Dhawi, [2]Jameel M. Al-Khayri and [3]Essam Hassan

[1]Department of Botany and Microorganism, Girls Science College, King Faisal University, Dammam 31113, Saudi Arabia.
[2]Date Palm Research Center; Department of Agricultural Biotechnology, College of Agricultural and Food Sciences, King Faisal University, P.O. BOX 420, Al-Hassa 31982, Saudi Arabia.
[3]Electrical Engineering Department, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia.

Abstract: Living cells possess electric charges exerted by ions or free radicals, which act as endogenous magnets. These endogenous magnets can be affected by exogenous magnetic field, which can orient unpaired electrons. Treatments with magnetic field are assumed to enhance seed vigor by influencing the biochemical processes that involve free radicals, and by stimulating activity of proteins and enzymes. Numerous studies suggested that magnetic field increases ions uptake and consequently improves nutrition value which could be a good alternative for chemical treatments. Seedlings of date palm *(Phoenix dactylifera* L.) were treated with varying doses of static magnetic field (SMF) in order to evaluate the effect on elements uptake. The SMF source is a magnetic circuit set to produce three levels of magnetic field intensities (10, 50 and 100 mT). Seedlings were exposed to these magnetic fields for different periods: 0, 30, 60, 180, 240 and 360 min. Leaf samples were subjected to chemical analysis for elements (Mg, Ca, Na, P, K, Fe, Mn and Zn) using inductive couple plasma (ICP) spectroscopy. The results revealed that concentrations of Ca, Mg, Mn, Fe, Na, K, and Zn increased, while P concentration decreased with raising SMF intensities and durations of exposure. Static magnetic field has a potential to enhance growth due to the positive effect on the plant major elements such as Ca and Mg, but negative electrical charges on the plants inhibited the uptake of anions such as P. Increasing ions may elevate the nutrition value of date palm plants.

Key words:

INTRODUCTION

The exact mechanism of the effect of static magnetic field (SMF) on living organisms is still unclear. Plants cells affected by magnetic field can response in unpredictable way according to many factors including species, intensity of magnetic field (MF)and exposure period[1,2]. It has been reported that external magnetic fields influence both the activation of ions and polarization of dipoles in living cells[3]. Response of the cells under time varying magnetic fields is contingent not only on the wavelength and amplitude but also on how well the exogenous MF matched the phase of the cell's own oscillators; matched versus unmatched phase gives opposite results[4].

The forces induced by magnetic fields may be large enough to affect any process that can change the rate of movement of electrons significantly[5]. Studies on the meristematic cells of plants have shown that MF effects normal metabolisms and has impact on cellular division[6]. An optimal external electromagnetic field could accelerate the activation of plant growth, especially seed germination[7,8,9,10].

Nutrition value could be enhanced by MF treatment. Sharaf El-Deen[11]. noticed that MF increased amino acids, Ca and K content in mushroom (*Agaricus bispours*). In addition, magnetic field pretreatment of seeds was reported to increased lipid oxidation and ascorbic acid contents in cucumber (*Cucumis sativus*) [12]. the sugar content in sugar beet roots (*Beta vulgaris*) and gluten in wheat (*Triticum aestivum*)[13, 14].

Magnetic field may play an important role in cation uptake capacity and has a positive effect on immobile plant nutrient uptake[15]. Therefore, MF could be a substitution of chemical additives, which can reduce toxins in raw materials and thus raise the food safety. There were few studies linking magnetic field with elements accumulation in plants of strawberry (*Fragaria x ananassa*)[15]. and wheat[16]. However, literatures related to the effect of magnetic field on

Corresponding Author: Faten Dhawi, Department of Botany and Microorganism, Girls Science College, King Faisal University, Dammam 31113, Saudi Arabia.
Emal: faten.dhawi@live.com,

ions accumulation in date palm were not encountered. The objective of this study was to evaluate ions accumulation in date palm in response to various intensities and durations of static magnetic field.

MATERIALS AND METHODS

Plant material: Seeds of date palm (cv. Khalas) were sterilized with 1% sodium hypochlorite for 5 min, soaked in water for 24 h at 37°C then germinated over moist filter paper at temperature of 37°C. At age of 15 days, seedlings were placed in 9 cm Petri dishes and subjected to SMF treatment.

Exposure to static magnetic field: The SMF was applied at Electrical Engineering Department in King Fahd University of Petroleum and Minerals (KFUPM) using, a static magnetic circuit with induction at three levels (10, 50 and 100 mT) for 0, 30, 60, 180, 240, and 360 min. The magnetic circuit consisted of two coils each of 480 turns per coil wound on carbon steel and loaded by variable currents to achieve variable magnetic field intensities. The pole pieces cross section is made with 10 cm internal diameter to enable placing the 9 cm petri dish horizontally.

After treatment, each seedling was planted in 20-cm plastic pots containing potting mix (1 soil: 1 peat moss: 1 vermiculate) and maintained in greenhouse under natural light at temperature of 30°C - 41°C with 50% of relative humidity.

Analyzing and measuring elements: Elements were measured using Inductive Couple Plasma Spectroscopy -Optical Emission Spectrometry (ICP-OES) (Varian-liberty- 730-ES simultaneous ICP-OES series II, USA). Leaves were oven dried at 70ºC for 24 h using (Duo-Vac oven Lab Line, 3620 Vacuum Oven, USA). Microwave-assisted digestion system was used to extract elements from leaf samples in a closed microwave system[17,18]. Dried sample digested by accurately weighing 0.25 g of sample into Teflon® PFA lined microwave digestion vessels and adding 3 ml of 10 M HNO_3 (Merck Tracepur) and 1 ml of H_2O. Microwave digestion applied at power of 600 W and pressure of 350 PSI, in two stages: first, at 120 ºC for 3 min and second at 200 ºC for 10 min. Following digestion, the solutions were allowed to cool, transferred to 25 ml volumetric flasks, and diluted to volume with >18 cm^3 deionized water.

Experimental design and Statistical analysis: The experiment was designed with 7 replications per treatment. Total of 126 seedlings were used for this experiment. The experiment was setup as a factorial design 3×6. Two factors were involving magnetic field intensity at three levels (10, 50 and 100 mT) and exposure duration at 6 levels including control samples (0, 30, 60, 180, 240 and 360 min).

Data were subjected to analysis of variance (ANOVA). Least significant difference (LSD) test applied to compare the elements results of the groups exposed to magnetic field with the control. For the statistical evaluation of the results, significance was defined by a probability level of $p<0.05$.

RESULTS AND DISCUSSION

The current study shows that elements composition are significantly affected by the intensity of the SMF and the duration of exposure as indicated by the significant two-way interaction based on ANOVA (Table 1). Major elements were affected by SMF intensities and duration (Figure1 *A*, *B*, *C)*. Amount of Ca and Mg increased significantly; while P^+ amount decreased significantly; this trend grew gradually from 10 mT to 100 mT treatments.

Minor elements were also affected by SMF and increased significantly also; Mn, Fe and Zn average increased with increasing dose 10- 100 mT and durations (30- 360 min) (Figure2 *A*, *B*, *C*). Potassium $(K^)$ and sodium (Na) pump were also affected significantly by SMF 10 -100 mT (Figure 3 *A*, *B*, *C*).

Discussion: The earth magnetic field influences the movement and absorption of elements[19]. Liboff[20]. suggested that magnetic fields can interact in a resonant manner with endogenous AC electric fields in biological systems. Static magnetic fields have been reported to affect the diffusion of biological particles in solutions by inducing Lorentz force or Maxwell stress. Lorentz force would influence the diffusion of charged particles such as various ions including plasma proteins [21]. The orientation of ferromagnetic particles and the modulation of radical-pair reactions have been proposed as mechanisms for the observed effects of MF[22]. Magnetic treatments are assumed to enhance plants seed vigor by influencing the biochemical processes that involve free radicals, and by stimulating the activity of proteins and enzymes[23,24]. have emphasized that 50-60 Hz and 10-100 mT magnetic fields has caused some changes on the permeability of plasma membrane at *Vicia faba* tip cell.

A study on tomato plants showed that the application of MF to irrigation water increased nutrient element contents of plants[25]. Ions up take increased flowing MF treatment, Marschner[26]. suggested that owing to plant cells having negative electrical charge, they take up ions with a positive electrical charge.

Table 1: Analysis of variance of elements accumulation under static magnetic field impact.

Factor	df	MS	F	p
Calcium				
Intensity	2	20045905.3	864.443314	0.0001
Time	5	11234585.2	484.471113	0.0001
Intensity X Time	10	1046908.12	45.146	0.0001
Error	108	23189.381		
Magnesium				
Intensity	2	1320459	112.53	0.0001
Time	5	464099	39.55	0.0001
Intensity X Time	10	56715	4.83	0.0001
Error	108	11734		
Manganese				
Intensity	2	4281.7	529.78	0.0001
Time (min)	5	2465.8	305.10	0.0001
Intensity X Time	10	315.7	39.06	0.0001
Error	108	8.1		
Phosphorus				
Intensity	2	3095806.1	235.36	0.0001
Time	5	2885509	219.4	0.0001
Intensity X Time	10	144650.3	10.99	0.0001
Error	108	13153.18		
Potassium				
Intensity	2	1055673	77.4	0.0001
Time	5	479076.508	35	0.0001
Intensity X Time	10	112829.4	8.3	0.0001
Error	108	13642.6		
Sodium				
Intensity	2	7534921	1036.04	0.0001
Time (min)	5	1914055	263.18	0.0001
Intensity X Time	10	379501	52.18	0.0001
Error	108	7273		
Iron				
Intensity	2	2478.5	342.05	0.0001
Time	5	1240.8	171.24	0.0001
Intensity X Time	10	179.9	24.82	0.0001
Error	108	7.2		
Zinc				
Intensity	2	950.2	143.9	0.0001
Time	5	637.9	96.61	0.0001
Intensity X Time	10	93.6	14.18	0.0001
Error	108	6.6		

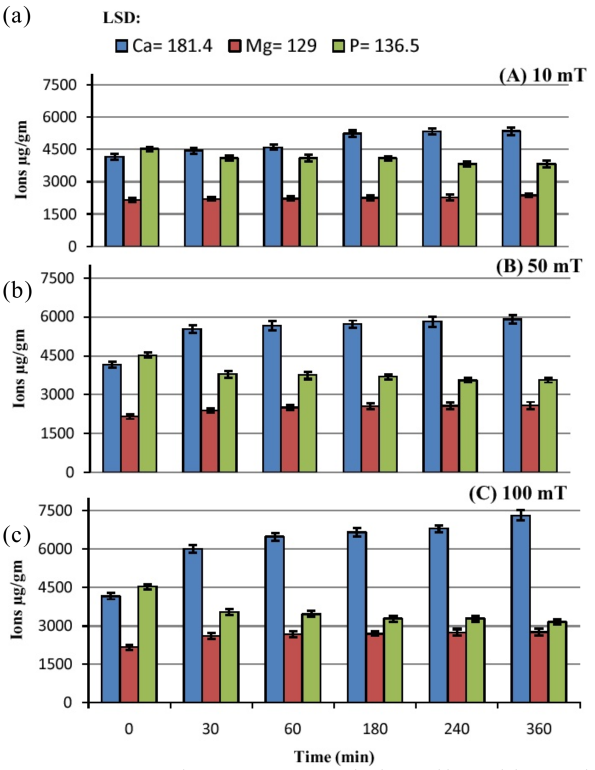

Fig. 1: Macro elements accumulation affected by static magnetic field. Accumulation of Ca, Mg and P for different exposure (A: 10 mT, B: 50 mT, C: 100 mT) and durations (30, 60, 180, 180, 240, 360 min). Means ± SD, *n* = 7.

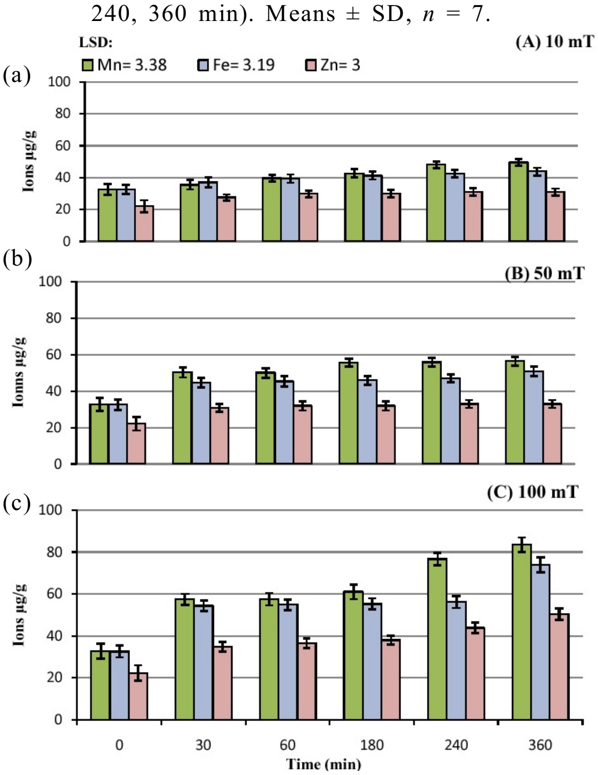

Fig. 2: Micro elements accumulation affected by static magnetic field. Accumulation of Mn, Fe and Zn for different exposure (*A*: 10 mT, *B*: 50 mT, *C*: 100 mT) and durations (30, 60, 180, 180, 240, 360 min). Means ± SD, *n* = 7.

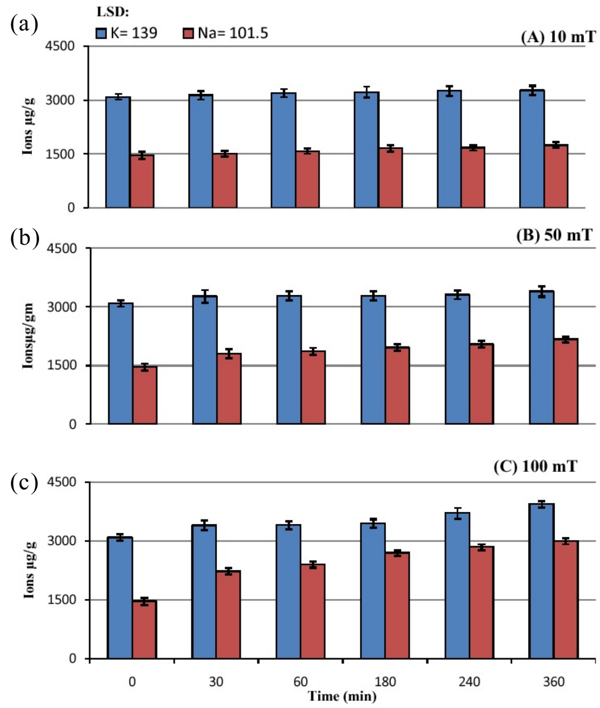

Fig. 3: Sodium and potassium pump accumulation affected by static magnetic field. Accumulation of K and Na for different exposure (*A*: 10 mT, *B*: 50 mT, *C*: 100 mT) and durations (30, 60, 180, 180, 240, 360 min). Means ± SD, *n* = 7.

In the present study, ions content increased significantly with time extending analogues to Wojcik [16]. study who found that MF increased ions if time of exposure was longer. Levels of calcium increased following exposure to SMF. In fact, it has been reported that changes in electrical conductivity of $CaCl_2$ solution are caused by exposure to static magnetic fields[27]. Being a second messenger, Ca is involved in regulation at all stages of plant growth and development, including growth and differentiation, photo morphogenesis and embryogenesis, the self-incompatibility responses in pollen-pistil interactions and movement of stomatal cells[28]. Cytochemical studies indicate that cells of plant roots exposed to weak magnetic field show calcium over-saturation in all organelles and in cytoplasm unlike the control ones[2]. Magnetic fields could enhance release of free radicals [29]. and cause stress whereas calcium ions participate in many plant growth processes and responses to stress [30]. thus explained Ca high average[31]. showed that a static MF exerts the strong and reproducible effect of reducing apoptosis in several cell systems. This effect is mediated by the MF's ability to increase Ca influxes. Moreover, Mg, K , Fe, Mn, Zn and Na were also affected under SMF and increased significantly while P decreased with raising intensity and time of exposure. Analogues with Esitken and Turan[15]. study which indicated that increasing MF strength from control to 0.384 T increased contents of N, K, Ca, Mg, Fe, Mn, Na and Zn but reduced P and S content the leaves of strawberry. In addition, results may vary according to plant organs, Wojcik[16]. study indicated that MF increased contents of (Mg, Fe and Cu) in buckwheat (*Hruszowska sp*.) grain and (P, Ca, K and Zn) in straw.

In conclusion, ions accumulation was affected by magnetic field in date palm plants. Magnetic field may play an important role in cations uptake capacity and has a positive effect on immobile plant nutrient uptake which raise the products nutrition value of date palm. The SMF treatment could be a promising technique for agricultural improvements but extensive research is still required.

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