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Evaluation of Artichoke (*Cynara scolymus* L.) Plant Quality under Irrigation by Magnetized Water

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Abstract

The magnetic fields are one of the effective environmental factors on biological phenomena in living organisms especially plants. Artichoke (*Cynara scolymus* L.) is a medicinal plant that plays a good role in blood cholesterol reduction and liver disorders, this study has performed to investigate the effectiveness of magnetic water on growth, fresh and dry weight of leaf and root, efficiency of the water consuming and some chemical compounds of Artichoke plant in 2012. Experimental treatments include of four levels of electromagnetic field intensity (Zero, 3000, 6000 and 10000 Gauss) as a complete randomized design with four replications. Analysis of variance of data revealed that plant growth, shoot weight, root weight and efficiency of water consuming and chemical compounds were significantly influenced by irrigation with magnified water. The highest Phenol and Antioxidant activity of plant extract was observed in samples which were irrigated with water in which magnified with 6000G magnetic field with 3.99 mg/g and 66.74%, respectively. Contrast to that the highest amount of chlorogenic acid (0.20 mg/g) was observed in samples which were irrigated using top water. Based on the obtained results Therefore, it is concluded this level (6000G) of intensity has better effectiveness in comparison to other level on quality of Irrigation water and could increase quality Artichoke plant.

1. Introduction

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 the soil to get rid of salt and consequently better assimilation of nutrients and fertilizers in plant during the vegetative growth period. Magnetified water was shown to have 3 main effects: 1) increasing the leaching of excess soluble salts, 2) lowering soil alkalinity and 3) dissolving slightly soluble salts such as carbonates, phosphates and sulfates (Hilal & Hillal., 2000). According to the data obtained from Russia, Australia, Poland, Turkey, Portugal, England, United States, China and Japan (Cakmak *et al*., 2009), decrease of soil alkalinity, increase in mobile forms of fertilizers, increase in crop yields, and earlier vegetation periods can be achieved by magnetified water treatment. The attempts to increase food and energy production for satisfying growing needs led to intensive development of plant production through the use of chemical additives, which in its turn caused more and more pollution of soil, water and air (Aladjadjiyan., 2012).Irrigation of common bean plants with magnetic water increased significantly the growth characteristics, potassium, GA3, kinetin, nucleic acids (RNA and DNA), photosynthetic pigments (chlorophyll a & b and carotenoids), photosynthetic activity and translocation efficiency of photo-assimilates as compared with control plants (Moussa., 2011). 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. Magnetic fields have been reported to exert a positive effect on the germination of seeds (Alexander & Doijode., 1995; Carbonell *et al*., 2000), on plant growth and development (De Souza *et al*., 1991; Martínez *et al*., 2000), on tree growth (Ruzic *et al*., 1998), on the ripening of fruits and on crop yield (Pie-

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truszewski., 1999). Lin and Yotvat (*1990*) reported an increase in water productivity in both crop and livestock production with magnetically treated water. Some studies have shown that there is an increase in number of flowers, earliness and total fruit yield of strawberry and tomatoes by the application of magnetic fields (Esitken & Turan., 2004; Danilov *et al*., 1994). Magnetic fields can also influence the root growth of various plant species (Belyavskaya., 2004; Muraji *et al*., 1992 and 1998; Turker et al., 2007). Muraji *et al* (1992) demonstrated an enhancement in root growth of maize (Zea mays) by exposing the maize seedling to 5 mT magnetic fields at alternating frequencies of 40–160 Hz. However, there was a reduction in primary root growth of maize plants grown in a magnetic field alternating at 240–320 Hz. Highest growth rate of maize roots was achieved in a magnetic field of 5 mT at 10 Hz (Muraji *et al*., 1998). Turker *et al* (2007) reported an inhibitory effect of static magnetic field on root dry weight of maize plants, but there was a beneficial effect of magnetic field on root dry weight of sunflower plants. On the other hand, it has been recorded that MF affected various characteristics of plants like germination of seeds, seedlings growth and reproduction including the growth of meristematic cells and chlorophyll development (Namba *et al*., 1995; Atak *et al*., 1997 ; Reina *et al*., 2001). Several studies have shown that strong magnetic fields change cell membrane characteristics, cell metabolism, cell reproduction and various other cellular functions like mRNA quantity, gene expression, protein biosynthesis and enzyme activities. Also, it has been reported that magnetic fields affect plant growth characteristics at the organ and tissue level in seeds, young seedlings and plants (Wadas., 1992 ; Atak *et al*., 2003; Pietruszewski., 2007; Hernandez *et al*., 2007). Artichoke is an herbaceous perennial plant (*Cynara scolymus* L.) belonging to the Compositae family (Asteraceae) cultivated in the Mediterranean area (Gebhardt., 2001) A major class of polyphenols is the caffeic acid derivatives (Tapiero *et al*., 2002) and in edible vegetables they mainly occur as esters with quinic acid; the leaves of *Cynara scolymus* L. are very rich (Chen & Ho., 1997; Schutz *et al*., 2004) in mono and dicaffeoylquinic compounds (Llorach *et al*., 2002; Wang *et al*., 2003). In primarily cultured rat hepatocytes artichoke extracts inhibited cholesterol biosynthesis, likely due to an indirect inhibition of HMG-CoA reductase activity (Gebhardt., 1998). However, in Iran the available studies and application of this technology in agriculture is very limited. Therefore, the present work aim to study the effect of irrigation with magnetified water on growth, use efficiently and some chemical constitute of Artichoke under greenhouse conditions.

2. Material and Methods

This research was carried out in the 2012 at gorgan University of Agricultural and Natural Resources. The study was conducted under greenhouse conditions. There was one factor in the study: type of irrigation water. The following three types of, magnetified water with densities (3000, 6000 and 10000 Guass) and potable water with four replications were selected for the study. Seeds were planted into round plastic pots (of 25 cm diameter and 35 cm hight) filled with mix of 54% sand, 25% silt and 21% clay (EC= 3.11 ds/m, PH= 7.9). The parameters like, plant height, fresh and oven dry weight and water productivity of Artichoke plants were determined. Biochemical compounds (Phenol and Antioxidant activity) of leaves were determined spectrophotometrically. Cholrogenic acid was determined with HPLC. Pots were irrigated with the tap water after magnetization through passing in magnetic device (HY5030E nutrient source DC, input 220 V, 3 Amperoutputtensity and teslameter device UT201 company Hengtong).

2.1. Extract Preparation

The leaf samples were collected from the experimental plants. Well drained (at room temperature) samples were finely powdered and each sample (0.5 g) was extracted by percolation method using pure methanol (5 mL) for 24h to have a complete solvent removal extract.

2.2. Total Phenolics Content

Total phenolics were assayed using the Folin–Ciocalteau reagent (McDonalad *et al*., 2001). The extract of sample was added to 0.5 ml of distilled water and was mixed with 5 ml of the Folin–Ciocalteu reagent and aqueous Na_2CO_3 (4 mL, 1M). The mixture was allowed to stand for 15 min and the phenols were determined by Spectrophotometric at 760 nm. Total phenolic content of plant parts was expressed as milligrams of gallic acid equivalents per gram of dry weight (mg $GAEg^{-1}$ DW) through the calibration curve with gallic acid. All samples were analyzed in three replications.

2.3. DPPH Radical Scavenging Assay

DPPH was used for determination of free radical-scavenging activity of the extracts (Koleva *et al*., 2002). Then 1 ml of each extract, were added 1 mL

DPPH (diphenylpicrylhydrazyl). After 15 min at room temperature, absorbance was measured at 517 nm and during using methanol as blank. The antioxidant capacity was expressed as a percentage of inhibition of DPPH radical (% inhibition of DPPH radical) calculated according to the following equation: % inhibition of DPPH radical = $[(A_C - A_A / A_C]$ x 100, where A_C: absorbance of the control at time = 0 min; and A_A: absorbance of the antioxidant at time = 15 min.

2.4. Analysis of Chlorogenic Acid by Analytical HPLC
The contents of chlorogenic acid were determinated using HPLC method. Standards were dissolved in methanol the extract solutions were filtered through 0.45 µm filter (Whatmen type). The HPLC analysis was carried out on a Merck Hitachi apparatus model LaChrom L-7100 connected to a computer analytical program HSM and an RP C18 micro bondapak column (250 x 4.6mm, 5 µm) was set at 40 ^{0}C. Mobile phase included filtered H_3PO_4 (Phosphoric acid 0.5%), acetonitrile and dionised water. The flow rate was kept at 1 mL per min. UV detector at 280 nm was used for (chlorogenic acid: 9 min).

2.4.1 Statistical Analysis
Statistical analyses were conducted using SAS program Version 9.2. 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%.

4. Results

4.1. Artichoke Growth
Data presented in Table (1) show that irrigation of artichoke plant with electro magnetified water significantly increased tested growth parameters as compared to plants which irrigated with tap water.
From Figs 1,2 it can be fined that plant height and the fresh weight of leaf and root weight increased when plants were treated with magnetic water in any densityexcept in the 3000G. In most cases when the plants were irrigated with on the water in which magnetified under 6000G, plant height, as well as the fresh weight of root and leaf were increased 37.25 cm, 15.11g and 16.11g respective). The improvement of measured parameter compared to control was: 10.73, 19.45 and 30.55 % for plant height, leaf and root fresh weight (g/plant), respectively.

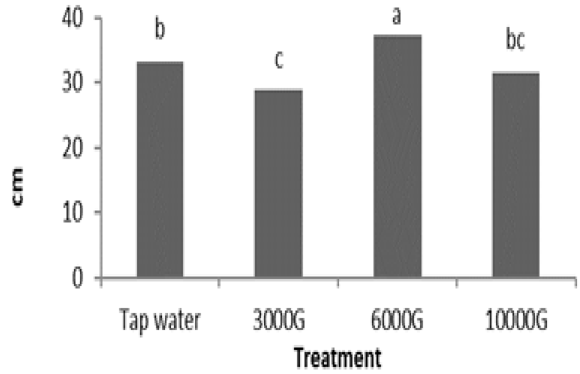

Fig. 1 Indices of plant height, irrigated using magnetified water.
Means with similar letter are not significant at the 5% probability level.

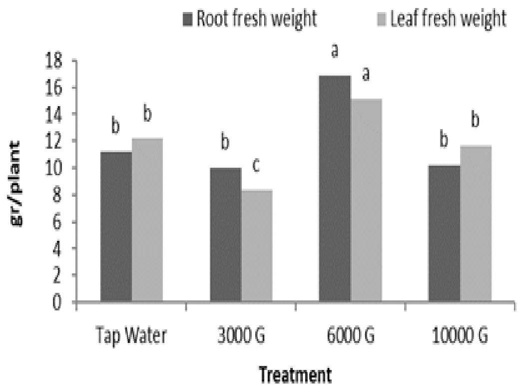

Fig. 2 Variation of leaf and root fresh weight, treated by magnetic water. Means with similar letter are not significant at the 5% probability level.

Table 1 Analysis of variance effect of magnetic water treatment on growth characteristic

Different source	df	Plant height	Fresh Weight	Dry weight	Root fresh weight	Root dry weight	Water utiliyationefficiency
Magnetic density	3	50/61**	30/69**	0/29**	42/4**	3/14*	0/45**
Error	9	6/12	1/81	0/02	1/44	0/86	0/04
CV		7/57	11/39	14/06	9/95	36/55	14/07

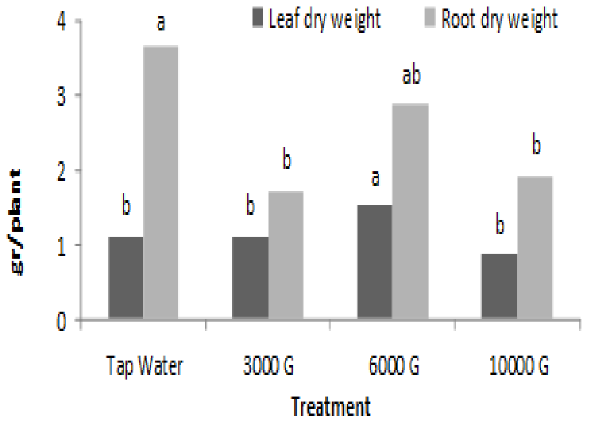

Fig. 3 Variation of leaf and root dry weight, treated by magnetic water. Means with similar letter are not significant at the 5% probability level.

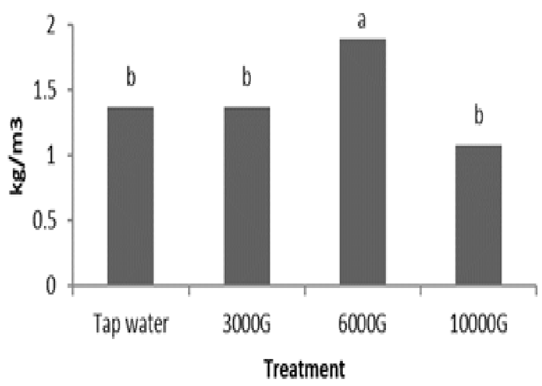

Fig. 4 Indices of water utilization efficiency, treated by magnetic water Means with similar letter are not significant at the 5% probability level.

4.2. Chemical constituents

The content of total phenol and antioxidant activity of leaves in a period of 120 days after sowing showed a big variation response to magnetic water (table 2).

Table 2 Analysis of variance effect of magnetic water treatment on chemical characteristic

Different source	df	Phenol (mg/g)	Antioxidant activity (%)	Chlorogenic acid (mg/g)
Treatment	3	$2/762^{*}$	$268/05^{**}$	$0/01^{**}$
Error	9	0/822	17/55	0/0001
CV		32/93	7/02	7/67

Means comparison showed significant difference of phenols and antioxidant activity affected by water magnetic density and compared to tab water a clear increase was observed. Mean comparison of data showed an increase of 3/99 mg/g and 66/74% in phenol and antioxidant activity, respectively when irrigated by the water magnetified by 6000G magnetic field. Surprisingly minimum amount of total phenol as well as antioxidant activity were observed in samples which were irrigated with water that magnetified by 3000G treatment in which did not have significant difference with the samples were irrigated with tab water (Fig. 5-6).

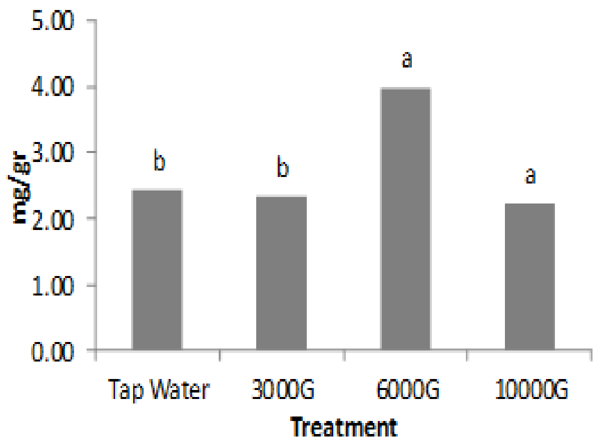

Fig. 6 the variation of phenolic compounds under different irrigation regimes
Means with similar letter are not significant at the 5% probability level.

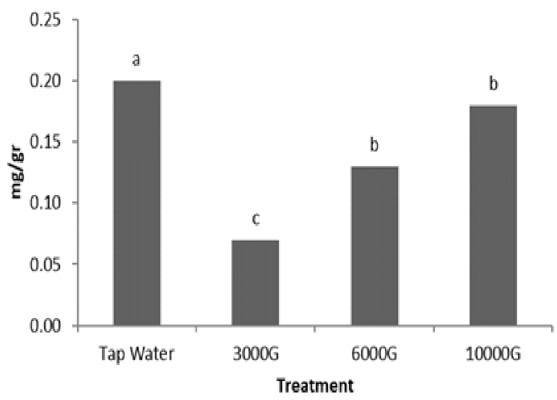

Fig. 7 Chlorogenic acid content of samples irrigated by magnetic water
Means with similar letter are not significant at the 5% probability level.

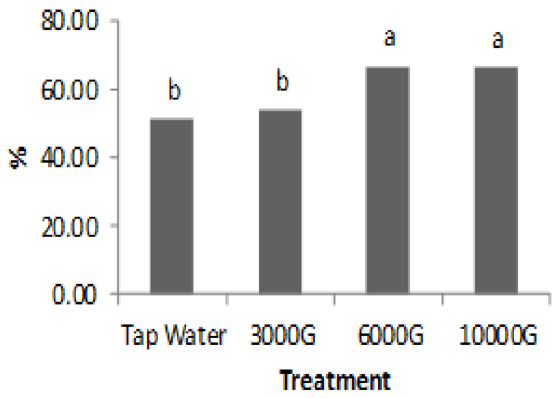

Fig. 5 Indices of antioxidant activity, treated by magnetic water Means with similar letter are not significant at the 5% probability level.

4.3. Chlorogenic Acid

The statistical analysis of data indicates that chlorogenic acid content was significantly affected by the irrigation treatments. Data presented in Table (2) show that, although the content of chlorogenic acid was gradually increased by increasing in magnetic density, but the content of this compounds in the samples which were irrigated by tab water was higher than that of them even 10000G (Fig. 7).

5. Discussion

Today's, salinity is one of the most important barriers in front of agriculture and human food supplementation. Thus any way or solution which can reduce or remove the side effect of salinity on plants is noticeable. Magnetic water utilization in the saline soil is one of theme.Magnetic water increased significantly fresh and dry weight of leaf, stem, and root of broad bean as compared to tap water (Ahmed El Sayed, 2014).Positive effects of magnetized water ongrowth of root, stem and leaf of cowpea are very important since they appear to induce animproved capacity for nutrients and water uptake, providing greater physical support to thedeveloping shoot (Sadeghipourand-Aghaei, 2013).Monselise *et al.* (2003) who observed that magnetic fields of low frequency induces a stress on higher plants. The stimulatory effect of the application of magnetic water on the growth parameters reported in this study may be attributed to the increase in photosynthetic pigments, endogenous promoters (IAA). Ahmed El Sayed (2014) showed that the irrigation of broad bean plant with magnetic water increased significantly the growth parameters as compared to pots whichirrigated with tap water. Fomicheva *et al*., (1992) and Belyavskaya (2001) reported that magnetic water significantly induces cell metabolism and mitosis meristematic cells of pea, lentil and flax. Above statements further suggest that the magnetic treatment of water probably alters something in water, makes the water more functional within plant system and therefore probably influences the plant growth at cell level. Magnetic treatment of water may affect phyto-hormone production leading to improved cell activity and plant growth (Ahmed Ibrahim, 2013) Reina *et al*. (2001) found significance increase in the rate of water absorption accompanied with an increase in total mass of lettuce with the increase of magnetic force. Moreover, Nasher (2008) found that chick pea plants irrigated with magnetified water were taller than plants irrigated with tap water.The increase in the plant weight with the magnetic treatment of water has been reported to change some of the physical and chemical properties of water, mainly hydrogen bonding, polarity, surface tension, conductivity, pH and solubility of salts (Smikhina, 1981; Amiri and Dadkhah, 2006; Chang and Weng, 2008). The use of magnetically treated irrigation water increased available soil P in celery and snow pea. (Maheshwari and Grewal, 2009). The wash-out produce by magnetified water the soil was observed to have an increase in phosphate mobile forms (Tackashinko,1997). The increase in the use efficiency water may be due to the effect of magnetic field on alteration the key of cellular processes such as gene transcription which play an important role in altering cellular processes and cellular content increase. Moreover, Goodman *et al*. (1995) and Atak *et al* (2003) described the role of MF in changing the characteristics of cell membrane, affecting the cell reproduction and causing some changes in cell metabolism. So the increase in total phenol under this study may be attributed to the role of MT in changing the cell membrane properties. Our results also showed the primitive effect of magnetic water treatment on total phenols and total indole.Ahmed El Sayed (2014) showed that total phenols promotive significantly in broad bean plant irrigated by magnetic water compared to tap water plant (control). A potential link between magnetic fields and its effects on living organisms is the fact that MF causes an oxidative stress, that is, MF can alter energy levels and spin orientation of electrons to increase the activity, concentration, and lifetime of free radicals (Repacholi and Greenebaum, 1999; Sahebjamei *et al*., 2007). Probably one of cases that can antioxidant activity increased effects is of MF on water Living organisms.

Probably one of cause chlorogenic acid decrease in artichoke plant is decrease of salinity effects. results of reduced Na concentration in snow pea pods irrigated with magnetically treated saline water (1000 ppm

NaCl) suggest restricted Na loading into snow pea pods (Maheshwari and Grewal, 2009). Soil salinity was significantly decreased after the leaching with different magnetified irrigation water compared with the different normal water at all soil depths (Ahmed ibrahim and bassem Mohsen, 2012).

In summary, growth parameters, some biochemical components and yield components of experimental plants is concomitantly increased when plants are treated with magnetic water. Biochemical components such as; total phenol and antioxidant activity were also increased significantly in plants treated with magnetic water.Although chlorogenic acid content of control samples was higher than that of treated plants, but it seems that high densities magnified water increases this compounds. Furthermore, environmental stresses could significantly enhance the Chemical constituents. As a result, magnetified stressed plants may be interesting potential sources of polyphenols for economical use.

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