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Rationalization of Water Use and Fertilization of Globe Artichoke Using Magnetic Water Irrigation

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ABSTRACT

Two field experiments were carried out during the two growing seasons of 2019/2020 and 2020/2021 at the El Kanater Hort. Res. Station, El Kaloubia governorate Egypt, to study the effect of irrigation with normal water, magnetized water at 100, 75% of potential evapotranspiration, under different levels of N, P and K of the recommended doses fertilization and their combined interactions on productivity and water use efficiency of globe artichoke. The experiment design was a split plot with three replicates and the main plots were allocated to irrigation water treatments whereas the sub-plots were concerned with NPK fertilizer levels. The results indicate that irrigation with 75 or 100% ETc magnetic water produced the maximum vegetative growth, early and total yield / plant and ton/fed, head dry matter percent, inulin content, water use efficiency and head NPK percentages. The optimal NPK fertilizer rate for artichoke plants is 75% and irrigation with magnetized water at 75% ETc mixed with NPK fertilizers at 75% of recommended rates produced the best interaction of yield characters and its constituent. The highest water use efficiency (7.51 kg $m^{-3}$and 7.40 kg m^{-3})) was obtained by 75% ETc magnetized mixed by100 or 75 % NPK as well as ETc 75% magnetized water combined with 75% of recommended NPK (9.21 kg m^{-3}) in the first and second season respectively, It might be concluded that irrigated artichoke plants with 75% ETc magnetized water and fertilize with 75% of recommended NPK resulted in a 25% reduction in irrigation water and NPK fertilization.

Keywords: Globe artichoke, magnetic water, and productivity.

INTRODUCTION

The globe artichoke (*Cynara scolymus* L.) widely cultivated across the Mediterranean region (Denisow-Pietrzyk *et al.*,2019) whereas its different plant parts considered potential sources of valuable phytoconstituents, polysaccharides, and polyphenols. These chemicals contribute to its nutrition, industry, and bioactivities, including hepatic-and cardiovascular protection and inflammation disorders (Zayed *et al.*, 2020) and considered one of the most significant sources of cynarine, phenolic antioxidants in nature, presents a good anti-proliferative potential effect on cancer cells (Noriega-Rodríguez *et al.*, 2020). According to the Economic Affairs Sector, Part "1", Winter Crops, 2019/2020 season, published by the Ministry of Agriculture and Land Reclamation. Regarding total production and harvested area, Egypt came in second place in the globe, producing 308,884 tons from 38.400 fed. There is an increasing need to promote artichoke production to meet expanding demands for both domestic consumption and export due to consumer awareness of functional foods with positive health effects.

In response to population growth, irrigated agriculture has a greater need for water, and in this situation, it is important to take water availability into consideration (Abedinpour and Rohani, 2017). As a result, water waste needs to be decrease in response to water scarcity, and more technologies that increase water use-efficiency should be used, especially in areas where water is expensive and scarce. Utilizing magnetically treated water, which benefits soil and plants, is one of the innovative technologies as a water-saving solution (Surendran *et al.*, 2016). Water molecules naturally form hydrogen bonds with up to four additional water molecules, but magnetic treatment releases the water molecules, making the water more cohesive (Khoshravesh *et al.*, 2011). Magnetic water treatment can alter the water architecture, diminishing surface tension, promoting mineral solubilization, and maintaining enough water supply (Pang and Deng, 2008). It can impact the availability of nutrients in the soil (Mostafazadeh-Fard *et al.*, 2011), Plants that irrigated with magnetized water improved in several ways, including increased germination rate, root and shoot system growth, inflorescence and fruiting development, fruit quantity, yield, and quality, as well as decreased irrigation water conductivity, salt solubility, and pH (Grewal and Maheshwari, 2011) and (Sadeghipour and Aghaei ,2013). Also, the magnetic field has an important role in increase the percentage of dissolved oxygen in water which increasing the speed of chemical reactions and it has a beneficial impact on the surface tension of the water (the contact angle), that is a useful predictor of plant growth when the contact angle decreases by ((23%) because the plant's absorption rate improves by the capillary property, in addition, the amount of nutrients (NO_2, NO_3, and NH_3) readily obtainable in irrigation water is regulated by the magnetization of the water. This modification impacted plant development, furthermore, the concentration of soluble ions like Ca^{+2}, Mg^{+2}, Cl^- and $SO4^{-2}$ were reduced (Kareem *et al.*, 2019). Irrigation with magnetized water had a high-water efficiency and a higher moisture content, water availability, and soil field capacity in sandy soil (Hamza *et al.*, 2021).

One of the most essential components required for plant development and productivity is plant nutrition, which uses the right quantity of chemical fertilizers (Bisht and Chauhan, 2020). Strong links between the amount of NPK in the soil, the production and productivity of artichokes (Saleh *et al.*, 2016) and

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applied doses of nutrients, may affect crop productivity and quality (Ali *et al.,* 2021). Employing magnetic water saving irrigation water in lettuce and potato (Abdel-Aziz *et al*,.2017), increased water productivity for tomatoes, eggplant, and beans (Abdel Kareem, 2018), and mitigated the adverse effects of drought in the *Moringa* species (Hasan *et al*.,2018).

Recently many studies have examined the effect of magnetic fields on plant development while magnetic field with fertilizing NPK on globe artichoke plants have received little attention, therefore, this study investigate the influence of magnetic water irrigation on growth, yield, and productivity at different NPK fertilization levels.

MATERIALS AND METHODS

The experiment was conducted at El-Kanater Research Station, El-Kaluobia governorate, during the two consecutive seasons 2019/2020 and 2020/2021 to study the effect of irrigation with normal and magnetized water at 100% and 75% of potential evapotranspiration (ETc) under three levels of N, P and K fertilizers on globe artichoke (c.v Herous) growth, yield, quality as well as water use efficiency.

The used experimental treatments were: -

1-Water treatments: At two levels of potential evapotranspiration (ETc)100 and 75 % two types of water were used: magnetized water and normal irrigation water.

2-NPK fertilization: Three levels of NPK fertilizers, viz. 100% (control), 75 and 50 of the recommended doses (150 kg Nitrogen as ammonium nitrate (33.5 %N), 94 L phosphorus as phosphoric acid (10 %) and100 Kg potassium as potassium sulphate (48 %K2O) /fed were used according to the suitable recommendation of the Ministry of Agriculture and Land Reclamation for globe artichoke crop.

The of the experiment was split plot design with three replicates. Each replicate included twelve treatments which were the combinations among four irrigation water treatments and three levels of NPK fertilizers. The main plots were dedicated to irrigation water treatments, while the sub-plots were concerned with NPK fertilizer levels. All plots received organic manure by rate of 30 m^3/fed during soil preparation. The globe artichoke stumps were planted on August 15th and September 1st, respectively, in the two seasons. Each experimental plot contained five rows of 5 m length and 1 m width, with a plot size of 25 m^2. Plants were fertilized 45 days intervals in five doses during the cycle of plant through the drip irrigation system. All agricultural procedures, such as weeding, pest and disease management were used. Tables (1–2) describe the physical and chemical analyses of the experimental soil:

Table 1. Physical properties and chemical analyses of soil.

Physiochemical of properties the soil					Chemical properties		Available macronutrients (mg kg 1)		
Sand	**Silt**	**Clay**	**Texture (Class)**	**pH (1:2.5)**	**OM (g kg 1)**	**Total $CaCO_3$ (g kg 1)**	**N**	**P**	**K**
19.31%	25.21%	55.48%	Clay	7.67	9.6	40.9	53.62	5.72	439.5
					Soluble ions (mmolc L-1)				
ECe (dSm-1)	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO_3^-	CO_3^{2-}	SO_4^{2-}	SAR
5.1	27.65	13.86	9.23	1.4	21.71	4.29	---	26.14	2.19
Irrigation water					Soluble ions (mmolc L-1)				
		pH	ECe (dSm-1)	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO_3^-
		7.61	0.82	2.94	1.85	3.28	0.17	4.55	0.49
		CO_3^{2-}	SO_4^{2-}	SAR					
		---	3.2	2.19					

Table 2. Field capacity wilting point, available water, and bulk density of soil at various depths.

Depths	Field capacity (F.C.) %	Wilting point (WP) %	Available water (AW) %	Bulk density (BD) g/cm3
0-15	37.5	18	19.5	1.25
15-30	36.4	17.4	19	1.28
30-45	34.5	16.6	17.9	1.3
45-60	31.3	16.1	15.2	1.33

Crop-soil-water relation

Reference crop evapotranspiration (ET_o)

ET_o values were calculated based on local meteorological data of the experimental site (Table 3) and according to the Penman-Monteith equation FAO (1998). Calculations were performed using the CROPWAT model FAO (1992).

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where:

ET_o: reference evapotranspiration (mm day^{-1}), R_n: net radiation at the crop surface (MJ m^{-2} day^{-1}),G: soil heat flux density (MJ m^{-2} day^{-1}), T: mean daily air temperature at 2 m height (°C), u_2:wind speed at 2 m height (m s^{-1}), e_s: saturation vapor pressure (kPa), e_a: actual vapor pressure (kP) e_s-e_a: vapor pressure deficit (kPa), Δ: slope of the vapor pressure-temperature curve (kPa °C^{-1}), γ: psychrometric constant (kPa °C^{-1}).

Crop evapotranspiration (ETc)

The ETc values were calculated according to the following equation given by FAO (1977):

$$ETc = ETo \times Kc$$

Where: ETc: crop evapotranspiration (mm day 1), ET_o: reference crop evapotranspiration (mm day 1)

Kc: crop coefficient: Current KC values published for globe artichoke are given based on three growth stages: initial, KCi=0.5; middle KCm=1.0; and late development KCe=0.95, Allen *et al.* (1998), the maximum KC=1.0 occurs when the canopy cover for the annual system reaches over 90% Smith, (1992).

Amount of applied irrigation water (AIW):

The amounts of applied irrigation water were calculated according to the equation given by Vermeiren and Jopling (1984) as

$$AIW = \frac{ETc \times Kr \times I}{Ea\,(1 - LR)} \text{ - Raineff}$$

Where:

AIW: depth of applied irrigation water (mm), Etc.: crop evapotranspiration (mm day 1).

Kr: reduction factor that depends on ground cover, I: irrigation interval (days)

Ea: irrigation application efficiency for the drip irrigation system (≈ 90% at the site location).

LR: leaching requirements: the extra amount of applied water needed for salt leaching, calculated according to FAO (1985) as follows:

$$LR = \frac{ECiw}{ECe}$$

Where:

ECiw: salinity of irrigation water (dS m^{-1}) and ECe: average soil salinity tolerated by the crop as measured by soil saturated extract (dS m^{-1}). Under the current experimental conditions, no additional water was added for leaching to avoid any effect on stress treatments.

Raineff = Rain × 0.65.

Table 3. Meteorological data in 2019/2020 and 2020/2021 seasons

Months	T.max	T.min	W.S	R.H.	S.S	R.F	mm/day	mm/month
							Eto	
2019/2020								
August	38.9	22.7	2.6	39.8	13	0	7.46	74.6
September	35.8	20.5	2.8	47.9	12.3	0	6.47	194.1
October	32.3	18.6	2.7	53.8	11.2	16.8	5.2	161.2
November	28.4	14.8	2.4	52	10.6	0.11	4.07	122.1
December	20.9	9.5	2.9	63.6	10	25.9	2.84	88
January	19.5	8.4	2.9	65.5	12.4	20.6	2.75	85.3
February	19.8	8.3	2.7	65	11.8	18	3.17	88.8
March	21	8.7	2.8	63.1	11.1	82.1	3.82	118.4
April	22.2	9.4	2.8	61.2	10.3	103	4.34	99.8
Seasonal (mm)								1032
2020/2021								
August	38.9	22	2.8	45.3	13.1	0	8.32	83.2
September	38.2	21.8	3.2	50.6	12.2	0	7.66	229.8
October	33.3	19.1	3	57.3	11.3	0.7	5.69	176.4
November	24.6	13.6	2.4	63.4	10.5	10.9	3.33	99.9
December	22.6	10.5	2.3	60.6	10.1	0.6	2.74	84.9
January	21.5	8.3	2.6	59.1	10.4	1.9	2.99	92.7
February	21.8	8.3	2.4	61.5	11	20	3.28	91.8
March	23.3	9.2	2.7	62.4	11.5	95	4.16	129
April	29.4	11.7	3.2	50.2	11.8	4	6.28	125.6
Seasonal (mm)								1113

Where: T. max., T. min. = maximum and minimum temperatures °C; W.S = wind speed (m/ sec); R.H. = relative humidity (%); S. S= actual sunshine (hour), RF = rainfall and Penman- Monteith formulae (mm / month). Data obtained from the Agro Meteorological Unit at SWERI, ARC.

Water productivity (WP)

Applied irrigation water used to describe the relationship between production and the amount of water applied. It was determined according to (Zhang, 2003). The following equation used as follow:

$$WP = \frac{\text{Flower head yield (kg/fed.)}}{\text{Total seasonal applied water (m}^3\text{/fed.)}}$$

The main irrigation water line connected to a magnetic device that fixed and positioned at the north and south poles. It provides details by: Density of 14500 Gauss, 1inch diameter, 12 m3 per hour flow rate, and thread connection. the following materials Equipment weight: 6 kg 80°C., seven bar of pressure. The Delta Water Company provided the gadget, Alexandria Egypt.

Data recorded

Vegetative growth

At the start of the flowering period (100 and 120 days from planting in the first and second season respectively), five plants were chosen randomly from each plot to recorded plant height and measure chlorophyll content (SPAD).

Yield and its components

Early yield

The first three harvests collected to count the head early yield/ plant and random samples of five flower heads from each plot collected to determine flower head weight (g), diameter (cm), and receptacle weight (g).

Total yield

From the beginning of the harvest season to the end of May, total yield calculated as the number of heads per plant and per fed. and random samples of five flower heads from each plot obtained to measure quality attributes such as flower head weight(g), diameter(cm), as well as receptacle weight(g).

Chemical analyses

Dry matter %

Samples of fresh receptacles (100g) taken from each experimental plot, dried at 70°C for 48 h in a ventilated oven until constant weight achieved and the dry matter % calculated.

Inulin content in heads

Inulin content (mg/100 g dry weight) was determined in dried portion of edible parts according to the method described by (Winton and Winton 1958).

Minerals content in heads

Samples of dried receptacles of artichoke ground and digested by H_2SO_4+ H_2O_2 then diluted with 100 mL distilled water. Mineral contents, i.e., nitrogen, potassium, and phosphorus % were determined according to (AOAC 2005). Nitrogen percentage was determined by Kjeldahl method, phosphorus percentage using spectrophotometrically method. Also, potassium percentage was determined by flame photometer according to (Page *et al.,* 1982).

Statistical Analysis

The statistical analyses of obtained data were conducted using the Info Stat modelling program. The comparisons between the means of various treatments conducted in accordance with (Snedecor and Cochran 1982).

RESULTS AND DISCUSSION

Growth parameters

Plant height

Data in Table 3 show that in both seasons, plants that were irrigated with magnetic water at 100% ETc had the highest plant height values. Similar studies by (Seron et al., 2019, Samarah et al., 2020 and Alattar et al., 2020) found positive effect of magnetic irrigation water on improving plant height of eggplant, tomato, and pepper respectively. Fertilizing globe artichoke plants with 75% of the recommended NPK provided the highest values of plant height in both seasons. Similar findings from Selim (2019) demonstrated that adding 75% NPK significantly enhanced the height of potato plants and (Elsharkawy *et al.*, 2021) who found that treated artichoke with 75% of requisite P and K increased the plant height. On the contrary, (Petropoulos *et al.* 2022) found that the maximum plant height was produced with adding 100% of recommended potassium for globe artichoke plants.

The interactions among the two factors indicated that irrigated plants at 75 % ETc of magnetic water and addition 75 % of recommended NPK fertilizers gave the highest plant height values in the first season, in addition irrigated plants by100 % ETc magnetic water and 75 % or 50% of recommended NPK fertilizers demonstrated the highest value of plant height, in the second season Table 3. Magnetized water that is easily absorbed by root cells as water becomes an excellent transporter of nutrients works that activate the role of nitrogen in protein synthesis and cytokinin, which impacts cell division and growth and reflects on the rise in plant height. The interaction treatments of magnetized water and N-fertilizer rates resulted in a highly significant increase in marjoram plant height (Khater, 2019 and Mostafa, 2020). Combining magnetic water with the application of inorganic and/or organic soil additives enhanced snapdragon growth and inflorescence production (Al-Mana *et al.,* 2021).

Table 3. Effect of irrigation water treatments and NPK rates on plant height and chlorophyll of globe artichoke during 2019/2020 and 2020/2021 seasons.

Treatments	Plant height(cm)				Chlorophyll (SPAD)			
	N. P. K levels							
	100%	75%	50%	Means	100%	75%	50%	Means
				Season 1				
Normal irrigation 100%Etc.	85.56 h	90.34 f	78.53 j	84.81 D	55.53 c	55.23d	53.33 i	54.70 AB
Normal irrigation75% Etc.	93.54 e	96.70 c	90.32 f	93.52 B	54.20 fg	53.93 gh	53.77 h	53.97 B
Magnetic irrigation 100%Etc.	95.73 d	96.66 c	97.44 b	96.61 A	56.23 a	55.93 b	54.23 f	55.47 A
Magnetic irrigation 75% Etc.	87.72 g	97.51 a	85.05 i	90.09 C	55.33 cd	56.33 a	54.57 e	55.41 A
Means	90.64 B	95.30 A	87.83 C		55.33 A	55.36 A	53.97 B	
				Season 2				
Normal irrigation 100%Etc.	103.7 j	104.4 i	103.2 k	103.7 D	58.53 b	57.77 d	58.03 cd	58.11 A
Normal irrigation 75% Etc.	107.6 g	114.4 d	104.5 h	108.8 C	57.27 e	56.63 f	54.70 g	56.20 B
Magnetic irrigation 100%Etc.	112.5 e	115.7 ab	115.8 a	114.7 A	59.43 a	58.43 b	56.63 f	58.17 A
Magnetic irrigation 75% Etc.	114.8 c	115.7 b	111.9 f	114.1 B	59.37 a	58.30 bc	57.03 e	58.23 A
Means	109.6 B	112.5 A	108.8 C		58.65 A	57.78 AB	56.60 B	

Values within the column or rows followed by the same capital or small letter/s do not significantly differ from each other according to Duncan' s multiple range test at 5% level.

Chlorophyll content:

Table 3 show that artichoke plants irrigated with 75 or 100 % ETc magnetic water and100 % ETc normal water had the highest chlorophyll values in both seasons. In this regard Saleh (2003) reported that the content of chlorophyll of artichoke leaf did not vary at application rates more than 50% of pan evaporation however, increasing water rates tend to increase it, while the greatest irrigation rate of 125 % of pan evaporation tended to decrease it. Selim *et al.*, (2009) linked the elevation in photosynthetic pigments to an increase in gibberellic acid content via plants due to magnetic treatment. Similarly, irrigation plants with magnetic water resulted in considerable increases in chlorophyll content Elsayed (2014) on bean; El-Kholy *et al.* (2020) on rosemary and Ismail *et al.,* (2020) on rocket plant. Fertilizing with either 75 or 100 % of recommended NPK achieved the highest chlorophyll content in the two growing. Plants irrigated with 100 % ETc magnetic water and applied 100 % of recommended NPK and 75 % ETc magnetic irrigation combined with 75 % of recommended NPK in the first season. In addition, both 75 and 100% ETc magnetic with 100 % of recommended NPK treatments had the highest value of chlorophyll interaction in the second season. Magnetic field enhances ion mobility and improves ion absorption, leading to a change in enzyme activity and, consequently, photosynthetic activation (Dhawi and Al Khayri, 2009). Similar results were obtained by Selim, (2019) who revealed that utilizing magnetized water combined with 75 % NPK significantly increased total chlorophyll in potato.

Early yield

Artichoke plants irrigated with 75 % ETc normal water and both75 and 100 % ETc magnetic water achieved the maximum number of heads of early yield in both seasons compared with control (100 % ETc water) Table 4. According to (Macau *et al.*, 2000), the cultivar Blanca de Tuleda's early production was unaffected by the amount of irrigation supplied. However, magnetic irrigation treatment significantly affected strawberry early yield (Esitken and Turan, 2004) also, Saleh, (2003) found that irrigation artichoke based on 75-100 % pan evaporation resulted in the highest early bud production.

Fertilizing with 100, 75 and 50% of recommended NPK had no significant differences in early yield as head number in both seasons (Table 4). However, balanced NPK fertilization is the most principal factor impacting early yield (Elia and Conversa, 2007). Furthermore, (Ierna *et al.* 2006) revealed that regulation of phosphate and nitrogen supplies is successful method for improving yield of globe artichoke.

Irrigated plants with both 100 % ETc magnetized water combined with 50 % of needed NPK rates and 75 % ETc magnetic water combined with 75 % or 100 % of NPK had the optimum interaction of early yield as head number/ plant in the first season Table 4. Furthermore, either interaction between 100% ETc magnetized water and75 or 50% of needed NPK or between 75% ETc magnetized water and 100 % of needed NPK produced the highest early yield in the second season. These results are in agree with those obtained with Similarly, (Abd El–Latif *et al.,* 2015) revealed that utilizing magnetized water combined with 75 % NPK significantly increased strawberry yield. Anwar *et al.,* (2017) found that irrigation with 100 % ETc normal water combined with 100% of recommended dosage of K were the most favorable interaction for increasing early flower heads number / plant of artichoke. Also, (Doklega ,2017) found that the best interaction of potato yield plants was achieved when irrigated with magnetized water and 75% of the suggested NPK, with no significant differences when 100% of the required NPK was used.

Total yield

Artichoke plants irrigated with75 % ETc magnetized water produced the highest head of total yield in both seasons (Table 4) and100 ETc magnetized water gave the highest number of total head in the second season. Artichokes need regular irrigation throughout the growth season, especially when the buds are forming because otherwise, they would produce weak, low-quality buds (Schrader and Mayberry, 1997). Using magnetic water promotes the uniformity and distribution of irrigation water, improves plant absorption nutrients, and increased some vegetables yield (Tartoura *et al.,* 2020) on Jerusalem artichoke and (Samarah *et al.,* 2021) on tomato.

Table 4. Effect of irrigation water treatments and NPK rates on number of early and total yield of globe artichoke during 2019/2020 and 2020/2021 seasons.

Treatments	No. early yield				No. total yield			
	N. P. K levels							
	100%	75%	50%	Means	100%	75%	50%	Means
Season 1								
Normal irrigation 100%Etc.	2.14 g	2.07 g	1.85 h	2.02 B	10.10 e	11.57 c	8.400 h	10.02 C
Normal irrigation 75% Etc.	3.02 d	3.16 c	2.56 e	2.91 A	11.57 c	12.90 a	9.33 g	11.27 B
Magnetic irrigation 100%Etc.	2.14 g	3.22 bc	3.36 a	2.91 A	11.83 b	11.57 c	10.93 d	11.44 B
Magnetic irrigation 75% Etc.	3.32 ab	3.37 a	2.39 f	3.03 A	13.00 a	12.97 a	9.67 f	11.88 A
Means	2.66 A	2.96 A	2.54 A		11.63 A	12.25 A	9.58 B	
Season 2								
Normal irrigation 100%Etc.	1.72 g	2.11 e	1.66 g	1.46 B	14.07 b	12.90 cd	10.57 f	12.51 B
Normal irrigation 75% Etc.	2.38 d	2.49 d	1.88 f	2.86 A	11.93 e	13.27 c	11.60 e	12.27 B
Magnetic irrigation 100%Etc.	2.79 b	3.24 a	3.17 a	2.80 A	12.83 cd	14.83 a	12.80 cd	13.49 A
Magnetic irrigation 75% Etc.	3.25 a	2.77 bc	2.66 c	2.91 A	14.90 a	15.27 a	12.43 d	14.20 A
Means	2.55 A	2.63 A	2.34 A		13.43 AB	14.07 A	11.85 B	

Values within the column or rows followed by the same capital or small letter/s do not significantly differ from each other according to Duncan' s multiple range test at 5% level.

Data in Table 4 show that fertilizing 75 and 100 % of required NPK doses resulted in the highest no. of heads of total yield in the two tested seasons. Similar results were obtained with, (Negro *et al.,* 2016) revealed that increasing nitrogen doses resulted in increased plant vigor and enhancement head yield production of artichoke. balancing nitrogen and phosphorus supply are successful strategies to increase crop yields and more sustainable addition with nitrogen. Also, applying 75 or 100 % of the required potassium level did not significantly impact the total artichoke yield (Petropoulos *et al.*, 2022).

The superior interaction of no. of heads of total yield achieved with irrigated 100% ETc magnetized water combined 50% of recommended NPK in both seasons (Table 4). In addition, irrigation with 75% ETc magnetized water combined 75% of recommended NPK produced the highest interaction in both seasons. With the use of magnetic treatment, minerals are more easily dissolved, allowing plants to develop with sufficient nutrients and consuming less water overall (Zlotopolski, 2017.) Our results are consistent with those of Selim (2019), who found that magnetic irrigation can reduce the need for NPK fertilizer by more than 25% and all fertilizer levels led to highly substantial increases in tuber yield under magnetic irrigation treatment.

Head quality of early yield

The results in Table (5) show that irrigated artichoke plants with 75% ETc magnetized water shows that produced the highest head weight of early yield in both seasons. Irrigated artichoke plants with all water treatments had the largest head diameter of early yield in the first season; however, in the second season, irrigation with100% ETc normal water and 75% ETc magnetized water produced the largest early head diameter. Also, Table 5 show that irrigation with100 %t ETc magnetized water achieved the best values of receptacle weight of early yield in both seasons. Alattar *et al*., (2020) found that pepper fruit quality was significantly influenced by magnetized water. The Magnetized treatment resulted in significantly increased potato diameter and thickness compared to unmagnetized water (Mostafa, 2020). Significant increases in plant stem diameter resulted when irrigating plants with magnetically treated water compared to control plants (Samarah *et al.*, 2021) on tomato.

Fertilizing with 75 % of preferred NPK gave the highest head weight of early yield with no substantial differences with 100% NPK in the first season. While 100% NPK produced the maximum head weight of early yield in the second season. In this respect, no significant difference in the early bud weight among the nitrogen treatments (Hussin, 2003). Fertilized with each level of recommended NPK had no significant effect on head diameter of early yield. However, in both season plants fertilized with 100 and 75 % of needed NPK had the highest weight values of early edible part Table 5. The same findings were reported by Nigro et al., (2016), who discovered little variations with the various nitrogen fertilizer rates for the average weight of the globe artichoke heads.

Table 5. Effect of irrigation water treatments and NPK rates on quality characteristics of early yield of globe artichoke during 2019/2020 and 020/2021 seasons.

Characters	Average of head weight (g)				Average of head diameter (cm)				Receptacle weight (g)			
Treatments	N. P. K levels											
	100%	75%	50%	Means	100%	75%	50%	Means	100%	75%	50%	Means
Season 1												
Normal irrigation 100%Etc.	283.00 c	298.50 a	281.40 c	287.60 A	7.83 cde	8.07bc	8.17 b	8.02 A	59.07 c	49.69 h	56.26 f	55.01 C
Normal irrigation 75% Etc.	279.80 cd	279.80 cd	265.40 f	275.00 B	8.20 b	7.13 g	8.10 bc	7.81 A	56.66 e	57.80 d	48.65 i	54.37 C
Magnetic irrigation 100%Etc.	282.50 c	299.40 a	274.90 e	285.60 AB	7.83 cde	7.73 def	7.60 ef	7.72 A	59.21 c	60.04 a	59.73b	59.66 A
Magnetic irrigation 75% Etc.	299.30 a	291.70 b	276.00 de	289.00 A	8.97 a	7.50 f	7.97bcd	8.14 A	54.62 g	60.07 a	56.50 e	57.07 B
Means	286.10AB	292.40 A	274.40 B		8.21 A	7.61A	7.96 A		57.39 A	56.90 A	55.28B	
Season2												
Normal irrigation 100%Etc.	273.30 a	264.50 d	256.60 f	264.80 C	8.10 de	8.23 cd	8.27 c	8.20 A	83.24 c	69.99 g	68.64 h	73.96 C
Normal irrigation 75% Etc.	265.90 c	264.80 d	257.10 e	262.60 D	8.20 cd	7.47 g	8.47 b	8.04 AB	63.53 j	71.58 f	67.69 i	67.60 D
Magnetic irrigation 100%Etc.	273.50 a	273.40 a	255.00 g	267.30 B	7.83 f	8.13 cd	7.60 g	7.86 B	85.01 a	84.88 a	83.86 b	84.58 A
Magnetic irrigation 75% Etc.	273.60 a	272.60 b	266.00 c	270.70 A	9.07 a	7.83 f	7.97 ef	8.29 A	81.52 d	83.79 b	80.48 e	81.93 B
Means	271.60 A	268.80 B	258.70 C		8.30 A	7.92 A	8.08A		78.32 A	7.56 A	75.17B	

Values within the column or rows followed by the same capital or small letter/s do not significantly differ from each other according to Duncan' s multiple range test at 5% level.

The best interaction of head weight of early yield was recorded with irrigated 100% ETc magnetic water plus 75% of recommended NPK and applied 75% ETc magnetic water plus 100% of recommended NPK in both seasons Table 5 Also, the superior interaction of head diameter of early yield was recorded with irrigated artichoke plants with 75% ETc magnetized water plus 100% NPK in both seasons. Furthermore, the best interaction of early receptacle weight was observed with 100% ETc magnetized water plus 75% of recommended NPK in both seasons. Magnetic irrigation water under 75 or 100% NPK of recommended levels gave the best results for tomato growth and yield reducing the applied rate of N and K fertilizers (Helaly, 2018). Also, magnetic treatment increased water that is readily available and enhanced the solubility and uptake of nitrogen, phosphate, and potassium, which raised maize crop production (Hamza *et al.,* 2021).

Head quality of total yield

Data in Table 6 indicate that irrigation of artichoke plants with 75% ETc magnetized water produced the highest head weight of total yield in both seasons and irrigation with100% ETc magnetized water showed the largest head diameter with no significant differences with 75 % ETc magnetized water in the first season, however in the second season, irrigation with 75 % ETc magnetized water produced the highest head diameter with no significant differences with100% ETc magnetized water. These results are in harmony with Seron *et al.* (2019) who revealed that irrigation with the 75% ETc provided fruit yield values equal to 100% ETc on eggplant. Also, irrigated artichoke plants with 100% ETc magnetized water produced the highest receptacle weight of total yield in both seasons Table 6. These increase in head quality may be due to the greater availability of nutrients and the hormonal activities resulted from using magnetic water which may induce the biosynthesis of bioactive compounds. Many beneficial impacts of magnetizing irrigation water on yield and its components (number of tuber and tuber weight/ plant) of potato plants were achieved by (Hozayn *et al.*, 2016 and Moussa and Hozayn, 2018).

Fertilizing artichoke plants with 75% of recommended NPK had the highest head weight of total yield with no significant differences with 100% NPK in both growing seasons, however, 100, 75, or 50% of recommended dosages NPK fertilizer had no significant effect on total head diameter in both seasons Table 6. Fertilizing with the lowest rate of NPK (50%) produced the highest values of receptacle weight of total yield in the first season followed by the other two treatments Table 6. However, in the second season there were no significant differences among the three treatments. Semi related results obtained by Petropoulos *et al.* (2022) who found that soil treatment of 75% recommended potassium fertilizer increased quality measures of globe artichoke plants.

The best interaction of head weight of total yield was recorded with irrigated artichoke plants with75% ETc magnetized water combined 75% or 100% of recommended NPK in both seasons. Besides, interaction between 75% ETc magnetized water plus 100% NPK and 100 % ETc magnetized water plus 75 % of recommended NPK in both seasons had the superior interaction of diameter total head Table 6. Moreover, the highest interaction of receptacle weight of total yield was produced with irrigation with 100% ETc magnetized water plus 75% or 100 % NPK in both seasons Table 6.

Table 6. Effect of irrigation water treatments and NPK rates on quality characteristics of total yield of globe artichoke during 2019/2020 and 020/2021 seasons.

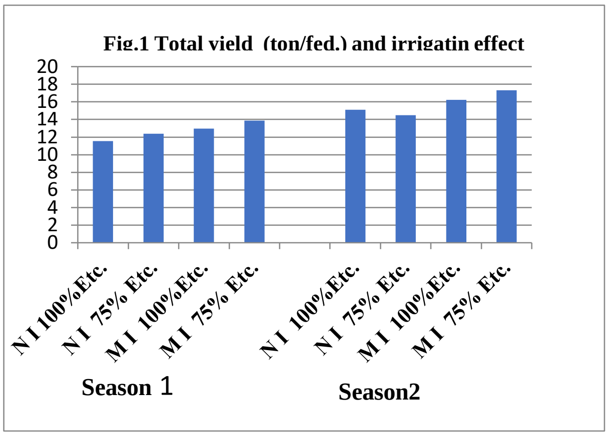
Characters	Average of head weight (g)				Average of head diameter (cm)				Receptacle weight (g)			
Treatments	N. P. K levels											
	100%	75%	50%	Means	100%	75%	50%	Means	100%	75%	50%	Means
					Season 1							
Normal irrigation 100%Etc.	283.00 b	298. 50 a	281.40 b	287.60 A	8.03 ef	7.30 g	9.10 b	8.14 B	78.73 e	83.13 d	88.77 b	83.54 B
Normal irrigation 75% Etc.	279.80 bc	279.80 bc	265.40 e	275.00 B	8.23 de	8.50 cd	8.23 de	8.32 B	66.47 i	57.57 j	71.90 g	65.31 D
Magnetic irrigation 100%Etc.	282.50 b	299.40 a	274.90 d	285.60AB	8.80 bc	9.70 a	9.07 b	9.19 A	89.83 a	90.10 a	86.13 c	88.69 A
Magnetic irrigation 75% Etc.	299.30 a	295.60 a	276.00cd	290.30 A	9.50 a	8.57 cd	7.73 f	8.60 AB	68.47 h	71.90 g	72.83 f	71.07 C
Means	286.10 AB	293.30 A	274.4 B		8.64 A	8.52 A	8.53 A		75.88 B	75.67 B	79.91 A	
					Season2							
Normal irrigation 100%Etc.	308.90 c	307.70 d	286.00 j	300.90 B	8.90 c	9.17 b	8.87 c	8.99 C	150.90 d	151.00d	132.30e	144.70 B
Normal irrigation 75% Etc.	297.10 g	300.70 f	288.40 i	295.40 C	8.93 c	9.20 b	9.27 b	9.13 BC	133.10 e	156.40c	157.10c	153.90 B
Magnetic irrigation 100%Etc.	309.50 bc	306.40 e	286.30 j	300.80 B	9.27 b	9.43 a	9.20 b	9.30 AB	175.80a	171.40a	166.00 b	166.10 A
Magnetic irrigation 75% Etc.	310.20 ab	311.10 a	290.50 h	303.90 A	9.47 a	9.45 a	9.27 b	9.39 A	134.20 e	146.80d	158.00 c	146.40 B
Means	306.40 A	306.50 A	287.80 B		9.14 A	9.31 A	9.15 A		148.50A	156.40A	53.40 A	

Values within the column or rows followed by the same capital or small letter/s do not significantly differ from each other according to Duncan' s multiple range test at 5% level.

Total head yield Kg/ fed.

Irrigation by magnetic water at 75% ETc produced the highest total yield ton /fed. in both seasons Fig. 1. Similarly, Irrigation using magnetic water increased soil moisture by up to 75 % when compared to nonmagnetic water, according to (Mostafazadeh-Fard *et al.*, 2011), they suggested that magnetized water be applied for irrigation to save irrigation water. These findings are coincided with those of (Moussa, 2011) who reveal that magnetic water can promote photosynthesis process and photo-assimilate translocation efficiency in common bean plants. Cowpea yield/plant was raised by 9.1% by Sadeghipour and Aghaei (2013) using magnetic water irrigation. Adeniran et al., (2020) demonstrate that Lagos Spinach crop growth and yield were improved by the magnetic treatment of irrigation water. Fertilizing with 75 % of recommended NPK produced the highest values of total yield ton /fed of heads in the two tested seasons following by 100 % of NPK (Fig 2).

The best interaction of total yield ton /fed. produced with irrigated artichoke plants with each magnetized water at 75% ETc. combined 100% and75% of recommended NPK fertilizers in the1st season. However, in the second season irrigation by ETc75% magnetic water plus 75% of recommended NPK showed the highest interaction followed by irrigation 75% ETc magnetic water plus 100% of recommended NPK Fig 3. Treatment of water with a magnetic field resulted in restructured water that may breakdown and transport NPK compounds and increasing its solubility. Increasing artichoke yield may be due to magnetic water's stimulatory effect on photosynthetic pigment and growth stimulants as well as applying magnetic water to soil, the pH of the soil may be modified, increasing the solubility of micronutrients around globe artichoke roots, magnetic water may have a more stimulating effect on pigments, photosynthetic rate, and protein synthesis (Mostafa, 2020).



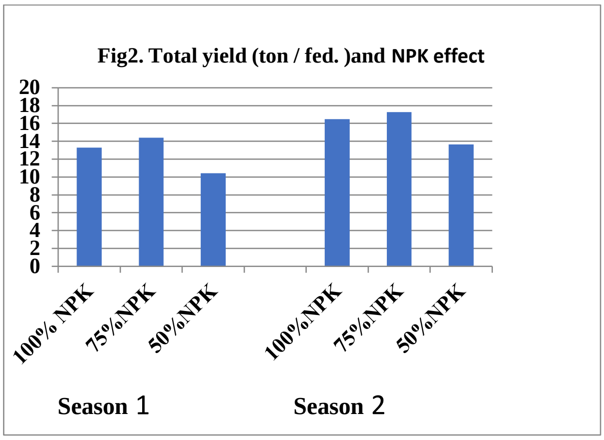


Fig. 1 and 2. irrigation water treatments and NPK levels effects on total yield (ton / fed.) of globe artichoke during 2019/2020 and 2020/2021 seasons.
Where: NI= normal irrigation and MI = magnetic irrigation.

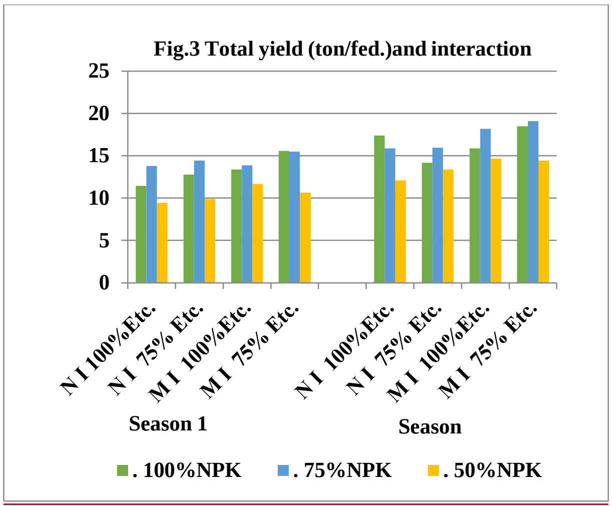


Fig 3. Interaction between irrigation water treatments and NPK levels effect on total yield (ton/fed.) of globe artichoke during the 2019/2020 and 020/2021 seasons.
Where: NI= normal irrigation and MI = magnetic irrigation

Chemical components

Dry matter (%).

Results in Table (7) show that irrigation with each 100 and 75 % ETc normal water and 75 % magnetic water produced the highest values of dry matter % in the first season while in the second season irrigated 100%ETc normal water had the highest value. The positive effect of the magnetic water on dry matter was reported by (Shahin *et al.*, 2016) on cucumber and (Abdel-Aziz *et al., 2017*) on lettuce and potato crops.

Fertilizing with 75 and 50 % of recommended doses leads to the significant increase in dry matter percentage in both seasons Table 7. Similarly, (Saleh *et al.*, 2016) found that adding nitrogen and potassium to globe artichoke achieved the highest value of dry matter percentage. The metabolic function of many molecules, including proteins, enzymes, nucleic acids, and chlorophyll, depends on nitrogen. N is essential for cell division and accelerates photosynthesis, increasing the synthesis of organic matter in plant tissues. K is important for crop quality production. It increases fruit size and promotes root growth. It is essential for the movement of sugars and the synthesis of carbs (Marschner, 1995). and its main responsibilities include osmotic balance, maintaining electrochemical balances within cells and their compartments, and controlling enzyme activity.

Data in Table 7clearly show that the best interactions of dry matter % were produced from either irrigation 100 % ETc normal water or 75 % ETc magnetic water combining fertilizing with 75% of recommended NPK in both seasons. In addition, the same irrigation treatments combined with 50% of recommended NPK had the highest dry matter % in the first season. These findings are consistent with those of Helaly, (2018) who revealed that the highest dry matter in tomato plants produced from grown in magnetic water with either 75 or 100 percent N and K fertilizer no significant differences with 50% of recommended N and K.

Table 7. Effect of irrigation water treatments and NPK rates on inulin content and dry matter of total yield heads of globe artichoke during 2019/2020 and 2020/2021 seasons.

Characters	Dry matter (%)				Inulin (mg/100gm dry weight)			
Treatments	N. P. K levels							
	100%	75%	50%	Mean	100%	75%	50%	mean
				Season 1				
Normal irrigation 100%Etc.	19.74 e	25.12 a	25.24 a	23.37 A	4.63 e	3.84 h	3.89 h	4.12 B
Normal irrigation 75% Etc.	23.47 bc	24.03 b	23.25 c	23.58 A	4.11 f	4.71 d	3.65 i	4.16 B
Magnetic irrigation 100%Etc.	18.27 f	20.53 d	18.79 f	19.20 B	4.79 c	4.16 f	5.26 a	4.74 A
Magnetic irrigation 75% Etc.	18.08 f	25.13 a	24.82 a	22.68 A	5.31 a	5.08 b	4.01 g	4.80 A
Means	19.89 B	23.70 A	23.02 A		4.71 A	4.45 AB	4.20 B	
				Season 2				
Normal irrigation 100%Etc.	17.84 c	18.55 a	16.20 f	17.53 A	3.46 h	4.32 g	3.02 i	3.60 C
Normal irrigation 75% Etc.	17.47 d	15.68 h	16.79 e	16.65 B	4.95 d	4.54 f	4.56 f	4.68 B
Magnetic irrigation 100%Etc.	15.88 g	15.61 i	17.51 d	16.33 C	5.86 a	4.70 e	5.80 a	5.45 A
Magnetic irrigation 75% Etc.	15.69 h	18.56 a	18.50 b	17.58 B	5.68 b	5.18 c	4.98 d	5.28 A
Means	16.72 B	17.10 A	17.25 A		4.99 A	4.69 AB	4.59 B	

Values within the column or rows followed by the same capital or small letter/s do not significantly differ from each other according to Duncan' s multiple range test at 5% level

Inulin content (mg/100g dry weight).

Results in Table 7 show that irrigated artichoke plants with 75 and 100% ETc magnetized water at produced the highest inulin content in edible part of heads in both seasons. Results are in harmony with those obtained by (Aduldecha *et al.,* 2016) reported that inulin production was significantly reduced by low soil moisture content, and the decline was particularly noticeable under extreme drought stress, also, (Tartoura *et al.,* 2020) found that irrigation with magnetized water gave the highest values of inulin compared with control non-magnetized water treatment on Jerusalem artichoke plants. Fertilizing with 100 NPK produced the highest values of inulin content in total heads with no significant differences with fertilizing with 75% of recommended dose in both seasons Table 7. K is essential for sugar translocation and the synthesis of carbohydrates because potassium ion is known to be one of the three largest constituents in sieve tube sap (Moussa, 2011). Increasing rates of potassium and phosphorus fertilizers had positive effect on the inulin content of artichoke heads (Elsharkawy *et al.,*2021). Related results were obtained by (Petropoulos *et al.,* 2022) who indicate that applied 75% of recommended dose K significantly increased the inulin content. The best interaction of inulin content recorded when irrigated artichoke plants with 100% ETc magnetized water plus 50% of recommended NPK in both seasons Table 7. Similarly, (Tartoura *et al.,* 2020) suggested that irrigating with magnetic water and treating plants with 50 % organic + 50 % N and K increased the inulin content in Jerusalem artichoke tubers.

NPK content of heads

Results in Table 8 show that irrigation with normal water at 100 % ETc and magnetic water at 75% ETc had the highest nitrogen content in the two seasons Furthermore, irrigation with all water treatments had the highest phosphorus content in the first season in addition, irrigation with magnetic water at 100% ETc had the highest value with no significant differences with magnetic water at 75% ETc in the second season. According to (Noran *et al.*, 1996), magnetic water influences the solubility of phosphorus salts and magnetic irrigation has an effect on the mobility of potassium, phosphorus, and nitrogen salts in the soil. More nutrients are produced by plants that have been treated with magnetized water (Vladimir, 2017). Data in Table 8 indicate that there were no significant differences in nitrogen and phosphorus between the three levels of NPK fertilizers in the first season however, in the second season the 75% of recommended NPK had the highest head N and P content. In this respect, (Doklega, 2017) found that no significant differences between the fertilizing with 75 or 100 %of recommended NPK on N and P in potato plants. Irrigation with magnetic water at 75%ETc combined with 75% of recommended NPK had the best interaction value of nitrogen content in both seasons. Also, the best interaction of phosphorus content values was produced from irrigation with magnetic water at 100 % ETc combined with 100% from recommended NPK and irrigation with magnetic water at 75 % ETc combined with 75% from recommended NPK in the first and second seasons, respectively (Table 8). These results might be explained by the fact that water passes through a magnetic field, which increases both the number of water molecules per unit of volume and the capacity of water molecules to absorb nutrients. In this connection, (Ratushnyak *et al.,* 2008) demonstrated that the magnetic treatment enhanced the amount of soil microorganisms, such as bacteria that fix nitrogen, that may enhance the availability of nutrients in the soil for plant absorption. The findings agree with those of (Doklega, 2017), who observed that the interaction of magnetic irrigation with 75and 100 % of NPK doses led to significantly greater levels of phosphorus and nitrogen in potato tubers.

Table 8. Effect of irrigation water treatments and NPK rates on N and P percentage of heads of globe artichoke during 2019/2020 and 2020/2021 seasons.

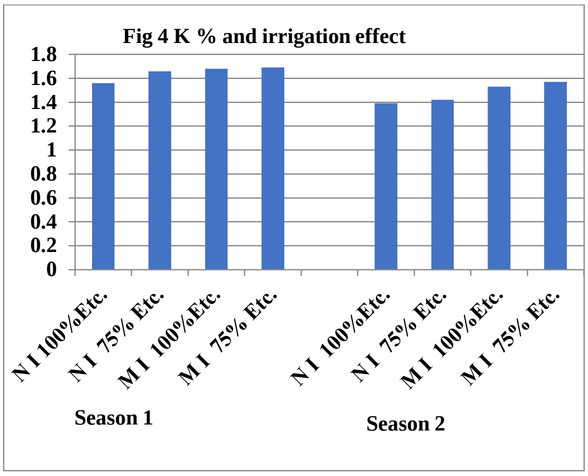
Treatments	Nitrogen (N %)				Phosphorous (P %)			
	N. P. K levels							
	100%	75%	50%	Mean	100%	75%	50%	mean
	Season 1							
Normal irrigation 100%Etc.	2.51 b	2.53 b	2.43 bc	2.49 A	0.597 bc	0.620 b	0.417 g	0.545 A
Normal irrigation 75% Etc.	1.83 f	2.24 d	2.32 cd	2.13 C	0.447 f	0.543 d	0.553 d	0.514 A
Magnetic irrigation 100%Etc.	2.34 cd	2.42 bc	2.03 e	2.27 B	0.650 a	0.570 cd	0.467 f	0.562 A
Magnetic irrigation 75% Etc.	2.33 cd	2.83 a	2.42 c	2.53 A	0.470 f	0.593 bc	0.513 e	0.526 A
Means	2.25 A	2.51 A	2.30 A		0.541 A	0.582 A	0.488 A	
	Season 2							
Normal irrigation 100%Etc.	2.57 cd	2.81 b	2.13 g	2.50 AB	0.437 e	0.553 c	0.337 f	0.442 B
Normal irrigation 75% Etc.	2.26 f	2.64 c	2.13 g	2.35 B	0.603 b	0.517cd	0.237 g	0.452 B
Magnetic irrigation 100%Etc.	2.34 f	2.74 b	2.45 e	2.51AB	0.653 a	0.640 ab	0.550 c	0.614A
Magnetic irrigation 75% Etc.	2.54 d	2.98 a	2.55 d	2.69 A	0.403 e	0.647 a	0.480 d	0.510AB
Means	2.43 B	2.79 A	2.32 B		0.524 AB	0.589 A	0.401B	

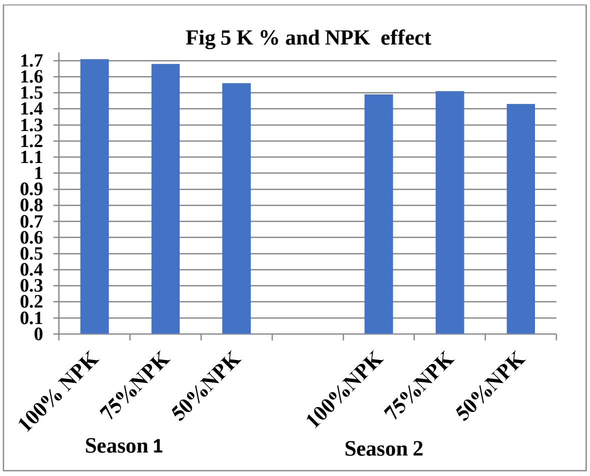
Values within the column or rows followed by the same capital or small letter/s do not significantly differ from each other according to Duncan's multiple range test at 5% level

Fig (4) shows that irrigation with75 % ETc normal water produced the highest potassium content in the first season with no significant differences with 100% ETc magnetic water while in the second season 75 and 100% ETc magnetic water had the highest potassium content.

Magnetic water improved absorption of vital elements such as potassium (K^+) (Marei, *et al.,* 2014) on pepper. Also, nitrogen, phosphorus, and potassium content of cucumber shoots were improved by magnetic water irrigation Shahin *et al.* (2016). Fig 5 show that the highest potassium content was produced from fertilizer with 100 and 75 % of the recommended doses of NPK in the first season while in the second season all doses of NPK had not significant effect on potassium head content.

The best interaction of potassium content was achieved from irrigation with 75%ETc magnetic water and adding 75 % of recommended NPK doses Fig (6). The results are in harmony with obtained by Helaly (2018) found that application rate of K fertilizers of tomato plants was decreased from 25% to 50% by irrigation with magnetic water. Similar results were obtained with (Selim, 2019) who found that fertilizing 100% of NP K combined magnetic water achieved the highest value of potassium content in potato.





Where: NI= normal irrigation and MI = magnetic irrigation.

Fig 4 and 5. irrigation water treatments and NPK levels effects on K content of head globe artichoke during 2019/2020 and 2020/2021 seasons

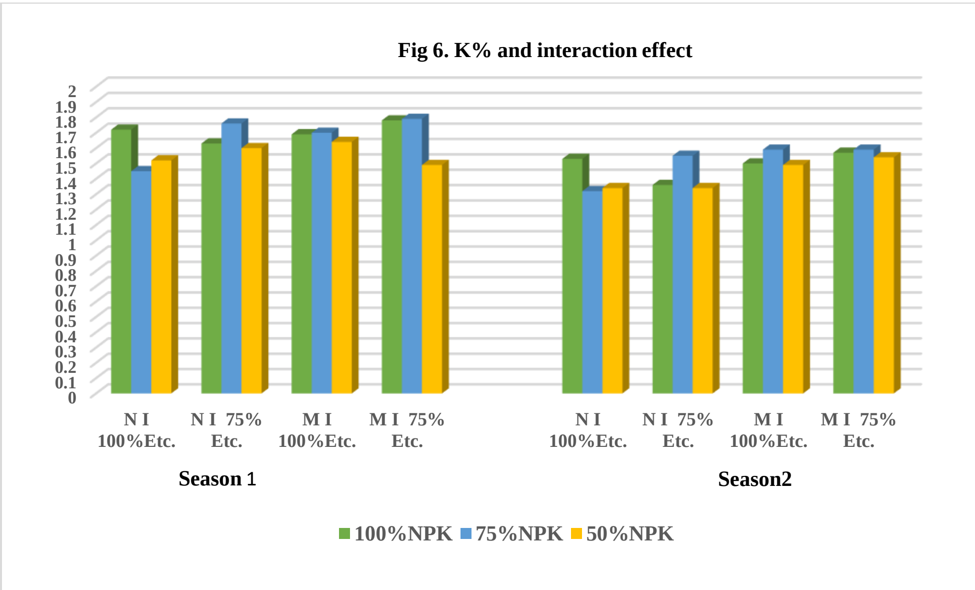


Fig 6. interaction effect of between irrigation water treatments and NPK levels on K content of head globe artichoke during 2019/2020 and 2020/2021 seasons.

Where: NI= normal irrigation and MI = magnetic irrigation.

Crop-water relations

Amount of applied irrigation water (IWA m^3/fed).

The amounts of irrigation water applied (m^3 fed^{-1}) were measured for all treatments, results presented in Table (9) clearly show that the values of water applied increased under ETc 100 % treatment compared with ETc 75 % of potential evapotranspiration (ETc). The highest values were (2764 and 2957 m^3/fed) due to (ETc 100 %) treatment, where the lowest values were obtained under (ETc 75 %) treatment as (2073 and 2218 m^3/fed) in the two growing seasons, respectively. Also, results reveal that (ETc 75 %) irrigation treatments could save about 25% of the applied water, compared with (ETc 100 %) in both growing seasons. Artichoke is a high-water requirement plant, in part due to its large foliage biomass and long production cycle (up to 7 month). During the transplanting and vegetative stage, drought stress can negatively affect survival management, slow growth, and consequently decrease head yield.

Controlling the soil's moisture during the reproductive st age is essential for creating highquality heads, especially when fl owering buds are growing (Ryder et al.,1983). According to Litrico et al. (1998), irrigation that was applied at 100% ETc resulted in the best yield response.Monthly applied irrigation water (m^3/fed). Furthermore, (Shinohara *et al.*,2011) found that under 700 mm (2940 m3/fed) of water inputs (for a bare soil system) were sufficient to produce artichokes with high marketable yields, superior size, and nutritionally superior heads.

Monthly water consumption started low when plants were small and increased gradually with increased plant growth reaching a maximum in March, due increased demand for water by plants (Table 9). The March values for the treatments averaged (472 and 515) and (354 and 386) m^3/fed. for 100 % ETc and 75 % ETc in both seasons, respectively.

The monthly water consumption took a rather similar trend. This result reveals that the monthly water consumptive use starts small because plant seedlings need less water at their initial growth stage. Therefore, soil moisture losses are mainly by evaporation from soil surface at that time. With the advance of plant age, transpiration increased, and consequently monthly consumptive use increased as plant foliage developed.

Soil moisture depletion in the advanced growth phase is due to evapotranspiration (ET); and daily water consumptive use reaches its peak in the late of the growing season which is considered the critical period and causes the highest amounts of water demands of irrigated artichoke plants (FAO 1992) then, ET decreases at the end of the growing season. The water content in artichoke plants changes depending on soil moisture and air humidity, the season of the year and time of the day as well as plant age (Saleh, 2003). Many studies around the world indicated that the marketable yield of artichoke significantly increased when applying irrigation regime of 100 ETc compared to the treatments of 50 % and 75% ETc (Hernández-Pérez *et al.*, 2013).

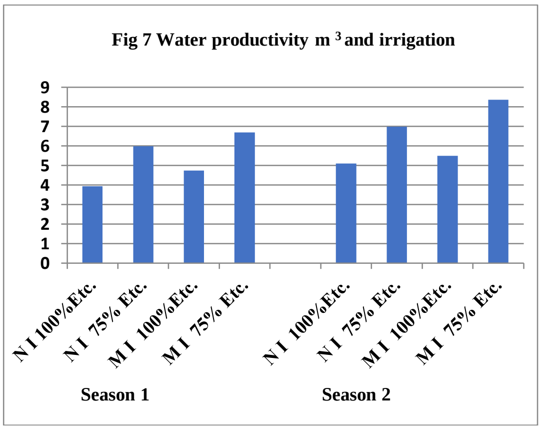
Table 9. Effect of irrigation water treatments on the amounts of applied irrigation water for the 2019/2020 and 2020/2021 growing seasons.

Month	ETc 100 %		ETc 75 %		Runoff (R× 0.65)	
	m^3/ fed./ day	m^3/fed. /month	m^3/ fed. /day	m^3/fed. /month	m^3/ fed. /day	m^3/fed. /month
	Season 1					
August	6.3	63	4.7	47	-	-
September	8.2	245	6.1	183	-	-
October	8.5	263	6.4	197	1.5	45.9
November	10.0	299	8.5	256	0.0	0.3
December	10.6	329	8.0	247	2.3	70.7
January	10.7	331	8.0	248	1.8	56.2
February	13.3	373	10.0	280	1.8	49.1
March	15.2	472	11.4	354	7.2	224.1
April	17.3	346	13.0	260	9.4	281.2
Total		2764		2073		728
	Season 2					
August	7.0	70	5.2	52	-	-
September	9.7	290	7.2	217	-	-
October	9.3	288	7.0	216	0.1	1.9
November	8.2	245	6.1	184	1.5	29.8
December	10.2	317	7.7	238	0.1	1.6
January	11.2	346	8.4	260	0.2	5.2
February	13.8	386	10.3	289	2.0	54.6
March	16.6	515	12.4	386	8.4	259.4
April	25.1	501	18.8	376	0.4	10.9
Total		2957		2218		363.4

Water productivity (WP) kg/m^3:

It appears from Fig 7 that this trait was markedly profitable under 75 % ETc magnetized water, as it registered 6.69 Kg yield /m^3 water of irrigation in the first season and 8.36 Kg yield /m^3 water of irrigation in the second season, respectively. Whereas the high normal irrigation treatment (100 % Etc) produced the least of water productivity values (3.94 and 5.11) Kg yield /m^3 irrigation water in both seasons, respectively. This means that artichoke plant favors medium watering and high production prefers medium soil moisture than high watering (Schrader and Mayberry, 1997). There was a considerable improvement in the water productivity by applying magnetic water treatment as reported by (Marei, *et al.*, 2014) and Abdel Kareem, 2018). Magnetic treatment is a technique used to achieve high water use efficiency since it has an effect on many physical and chemical properties of soil and water (Maheshwari and Grewal 2009) and save about 15% -30% of irrigation water (Fayed *et al.*, 2021).

Fig 8 indicates that fertilization with 100, 75, and 50 percent doses of NPK resulted in average water productivity of 6.75, 7.11, and 5.62 kg/m^3 in the first season, while they were 5.54, 5.96, and 4.54 kg/m^3 in the second season respectively, Fig 8 also clear that 25% of NPK levels can be conserved. The highest interaction of water uses efficiency (7.51 kg m^{-3}) resulted from irrigation with 75% ETc magnetized water combined with 100% dose of NPK with no significant differences when irrigation with magnetized water combined with 75% of the recommended fertilization dose of NPK (7.40 kg m^{-3}) in the first season Fig 9. In addition, irrigation with 75% ETc magnetized water combined with 75% dose of NPK produced the highest value (9.21 kg m^{-3}) in the second season. These findings indicate the potential to reduce the rate of chemical fertilization and water amount by around 25% when using magnetized water for irrigation without having any negative effects on the artichoke crop and its constituent parts. Magnetic water treatment has positive effect on lettuce and potato crops resulted in saving irrigation water about 20- 30% (Abdel-Aziz *et al.*, 2017). Fertilizers use efficiency increased and high soil moisture was detected; this could be because the magnetized water molecules are loosened, making the water more cohesive due to the hydrogen bonding force (Khoshravesh *et al.*, 2011). This prevented water from leaching to deeper depths because water molecules were instantly linked to soil particles (Ismail *et al.*, 2020).



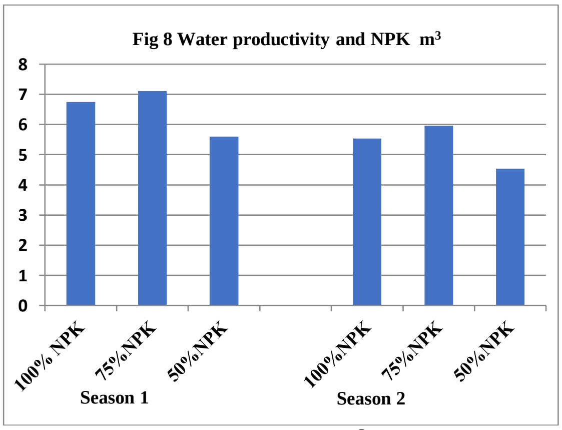


Fig. 7and 8. irrigation water treatments and NPK levels effects on water productivity (WP) kgm^3 globe artichoke during 2019/2020 and 2020/2021 seasons

Where: NI= normal irrigation and MI = magnetic irrigation.

However, results in Fig 9 indicate that, decreasing NPK fertilization rates (75%) of recommended doses combined with 75% magnetized water led to an increase in water productivity values (9.21 kg m^{-3}) in the second season. To save irrigation water, it is recommended to use magnetized water for irrigation (Mostafazadeh *et al.*, 2011) and (Abd El-Latif *et al.*, 2015) indicate that magnetic water application and 100, 75 and 50 % dose of NPK increased water use efficiency compared to non-magnetized water.

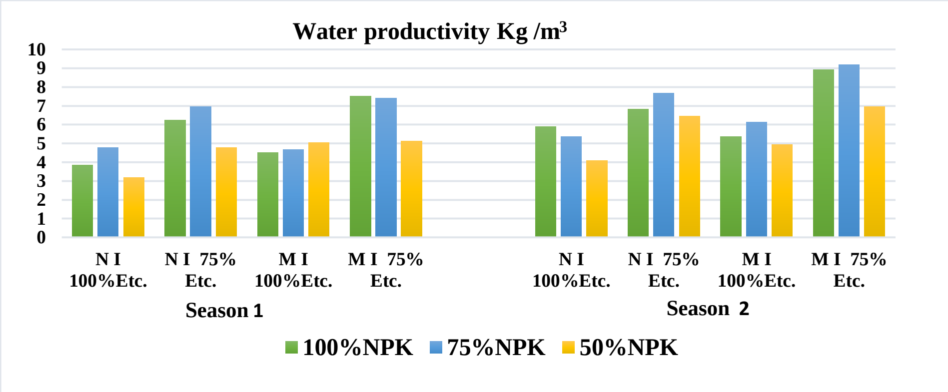


Fig 9. Interaction effect of between irrigation water treatments and NPK levels on water productivity of globe artichoke during 2019/2020 and 2020/2021 seasons.

Where: NI= normal irrigation and MI = magnetic irrigation.

CONCLUSION

The current study recommended that irrigation of globe artichoke plants (cv. Herous) with magnetic water at 75% of evapotranspiration and fertilization with 75% of recommended NPK, promoted growth, increased head early and total production, improved biochemical characteristics, and increased water management efficiency which would result in saving 25% of irrigation water and NPK fertilization.

REFERENCES

Abdel-Aziz, A., Arafa, Y.A., and Sadik, A. 2017. Maximizing water use efficiency for some plants by treated magnetic water technique under east owainat conditions Egypt. J. Soil Sci. 57: (3) 353 – 369.

Abdel Kareem, N. S. 2018. Evaluation of Magnetizing Irrigation Water Impacts on the Enhancement of Yield and Water Productivity for Some Crops Journal of Agricultural Science and Technology A 8:274-286.

Abd El-Latif, A.A., Abdelshafy, A.A., and Eid T.A. 2015. Minimizing strawberry mineral fertilization and enhancing water use efficiency by using magnetized irrigation water. J. Plant Production, Mansoura Univ., 6 (9): 1581–1593.

Adeniran, K. A., Kareem, K, Y., Yusuf, K. O., and Afolayan, S. O. 2020. Effects of electromagnetic treatment of irrigation water on growth and yield of Lagos Spinach (*Celosia argentae* L.*)* Agricultural Engineering International 22 (2):32- 40.

Aduldecha, C., Kaewpradit, W., Vorasoot, N., Puangbut, D., Jogloy, S., and Patanothai, A. 2016. Effects of water regimes on inulin content and inulin yield of Jerusalem artichoke genotypes with different levels of drought tolerance. Turkish Journal of Agriculture and Forestry 40, 335–343.

Alattar, E, Elwasife, K., and Radwan, E. 2020. Effects of treated water with neodymium magnets (NdFeB) on growth characteristics of pepper (*Capsicum annuum*). AIMS Biophys 4 (7): 267–290.

Ali, M.M.E., Petropoulo, S.A., Selim, D.A.F.H., Elbagory, M., Othman, M.M., Omara, A.E.D., and Mohamed, M.H. 2021. Plant growth, yield, and quality of potato crop in relation to potassium fertilization. Agronomy, 11, (675) 1-16.

Allen, R.G., Pereira, L.S., Raes, D., and Smith, M. 1998. Crop evapotranspiration: guidelines for computing crop water requirements. In: Proceedings of the Irrigation 265 and Drainage Paper No. 56. Food and

Agricultural Organization, United Nations, Rome, Italy.

Anwar, R. S. M., Mahmoud, M. A., and Naglaa, H. H. 2017. Effect of Irrigation and Potassium Fertilizer on Vegetative Growth, Yield and Quality of Globe Artichoke Plants under Sandy Soil Conditions J. Plant Production, Mansoura Univ., 8(11): 1267 – 1276.

AOAC (Association of Official Analytical Chemists-International), 2005. Official Methods of Analysis. 18th edn., eds.: W. Hortwitz, G. W. Latimer, AOAC-Int. Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland, USA AOAC (Association of Official Analytical Chemists-International), 2005. Official Methods of Analysis. 18th edn., eds.: W. Hortwitz, G. W. Latimer, AOAC-Int. Suite 500, 481 North Frederick Avenue, Gaithersburg, Maryland, USA.

Abedinpour M., and Rohani, E. 2017. Effects of magnetized water application on soil and maize growth indices under different amounts of salt in the water. Journal of Water Reuse and Desalination 7(3):319-325.

Bisht, N., and Chauhan, P.S. 2020. Excessive and Disproportionate Use of Chemicals Cause Soil Contamination and Nutritional Stress 12: 1-10.

Denisow Pietrzyk, M., Pietrzyk, Ł., and Denisow B. 2019. Asteraceae species as potential environmental factors of allergy. Environmental Science and Pollution Research International, 26: (7) 6290-6300.

Dhawi, F., and Al Khayri, J.M. 2009. Magnetic fields induce changes in photosynthetic pigments content in date palm (*Phoenix dactylifera* L.) seedlings. Open Agr. J. (3): 1–5.

Doklega, S. M. A. 2017. Impact of Magnetized Water Irrigation, Soil Mineral Fertilization and Foliar Spraying with Nanomaterial on Potato Plants J. Plant Production, Mansoura Univ., 8 (11): 1113 - 1120.

Elia, A., and Conversa, G. 2007. Mineral Nutrition Aspects in Artichoke Growing Acta Hon 630. ISHS. 239-249.

El-Kholy, S.A., Mazrou, M.M., Afify, M.M., Nadia, A.M. El-Said, H., and Zedan M.Z. 2020. Effect of irrigation with magnetic water on vegetative growth, chemical contents and essential oil in rosemary grown in different levels of salinity. Menoufia J. Plant Prod., 5 (6):143 – 157.

El-sayed, H. 2014. Impact of magnetized water irrigation for improving the growth, chemical composition, and yield production of broad bean (*Vicia faba* L.) plant. American J. Exp. Agric., 4(4): 476-496.

Elsharkawy, G.A., Ibrahim, H.A.H., Salah, A.H., Akrami, M., Ali, H.M., and Abd-Elkader, D.Y. 2021. Early and Total Yield Enhancement of the Globe Artichoke Using an Ecofriendly Seaweed Extract-Based Bio stimulant. Agronomy. 11, (1819):1-17.

Esitken, A. and Turan, M. 2004 Alternating Magnetic Field Effects on Yield and Plant Nutrient Element Composition of Strawberry (*Fragaria* x *ananassa* cv. Camarosa) Acta Agric. Scand., Sect. B, Soil and Plant Sci. 54: 135-139,

FAO 1977. Guidelines for predicting crop water requirements. In Irrigation and Drainage Paper, 24. By Dorenbos, J., and Pruitt, W.O., Eds.; Food and Agricultural Organization: Rome, Italy

FAO 1985. Water quality for agriculture. In FAO Irrigation and Drainage Paper, 29 Food and Agricultural Organization: Rome, Italy.

FAO 1998 Crop evapotranspiration: Guidelines for computing crop water requirements. In: FAO Irrigation and Drainage Paper, 56. By Richard, A., P. Luis, R. Dirk, and S. Martin (eds.). Food and Agricultural Organization: Rome, Italy.

FAO 1992 CROPWAT: A computer program for irrigation planning and management. In: FAO Irrigation and Drainage Paper, 46. By Martin, S., Ed.; Food and Agricultural Organization: Rome, Italy.

Fayed, M. H., Ghanem, H. G., Sheta M. H., and Ali A. A. 2021. Effect of magnetized water on water use efficiency of spinach under north Sinai conditions. Misr Journal of Agricultural Engineering 38 (2): 137 – 154.

Grewal, H.S., and Maheshwari, B.L. 2011. Magnetic treatment of irrigation water and snow pea and Chickpea seeds enhances early growth and nutrient contents of seedlings. Bio electromagnetics, 3 (2): 58-65.

Hamza, A. H., Sherif, M. A., Abdelmoez, W., and Abd El-Azeim, M. M. 2021. Impacts of Magnetic Field Treatment on Water Quality for Irrigation, Soil Properties and Maize Yield J. Mod. Res. (3): 51-61.

Hasan, M. M., Alharby, H. F., Hajar, A. S., Hakeem A. S. and Alzahrani, Y. 2018 Effects of magnetized water on phenolic compounds, lipid peroxidation and antioxidant activity of moringa species under drought stress. The Journal of Animal and Plant Sciences. 28(3):803-810.

Helaly, A. A. 2018. Impact of Irrigation with Magnetized Water under Different Levels of Nitrogen and Potassium Fertilizers on Growth and Productivity of Tomato (*Solanum lycopersicon* L.). Middle East J. Agric. Res., 7(4): 1874-1884,

Hozayn, M., Salama, A. M., Abd El-Monem, A.A., and Hesham, A. F. 2016. The impact of magnetized water on the anatomical structure, yield, and quality of potato (*Solanum tuberosum* L.) grown under newly reclaimed sandy soil. RJPBCS., 7(3):1059-1072.

Ierna A. G. Mauromicale and Licandro P. 2006 Yield and Harvest Time of Globe Artichoke in Relation to Nitrogen and Phosphorus Fertilization Acta Hort. 700, ISHSp. 115-120.

Ismail, W. H., Mutwali, E. M., Salih, E. A., and Tay Elmoula, E. T. 2020. Effect of Magnetized Water on Seed Germination, Growth, and yield of Rocket Plant (*Eruca sativa* Mill). SSRG International Journal of Agriculture & Environmental Science (SSRG-IJAES) (7): 34-38.

Kareem, O. H., Al-Obaidy, A. H. M.J., and Al-Anbari, R. H. 2019 Improving the Properties of Main Drainage Water by Using of Magnetic Field Technique Engineering and Technology Journal 37 (6): 195-200.

Khater, R. M. 2019. Effect of Irrigation with Magnetic Water and Nitrogen Fertilizers Source on the Vegetative Growth, Essential Oil Ingredients and Productivity of *Origanum Majorana* Journal of Architecture and Construction. 3 (2): 27-40.

Khoshravesh M., Mostafazadeh-Fard B., Mousavi S.F., and Kiani A.R. (2011). Effects of magnetized water on the distribution pattern of soil water with respect to time in trickle irrigation. Soil use and management 27(4):515-522.

Litrico, P.G., C. Santonoceto, and Anastasi, U. 1998. Effects of changes of seasonal irrigation volume on yield of globe artichoke Cynara scolymus L. grown from seed. Agricoltura-Ricerca Italy 20: 53-60. 39 (2): 67-74.

Macua, J.L., I. Lahoz and J. Garnica. 2000. The influence of amount of irrigation water quantities on yield and quality of me artichoke cv. Blanca de Tudela. IV International Congress on Artichoke 2000. Valenzana, Italy. p43

Maheshwari, B.L., and Grewal, H.S. 2009. Magnetic treatment of irrigation water: Its effects on vegetable crop yield and water productivity. Agricultural Water Management, 96(8): 1229- 1236.

Marei, A. Rdaydeh, D., Karajeh, D., and Abu-Khalaf, N. 2014. Effect of Using Magnetic Brackish Water on Irrigated Bell Pepper Crop (*Capsicum annuum* L.) Characteristics in Lower Jordan Valley/West Bank. Journal of Agricultural Science and Technology A 4: (1) 830-838.

Marschner, H. 1995. Mineral nutrition of higher plants. Academic press, London, 4 th printing (1999): 889.

Mostafa H. 2020. Influence of magnetized irrigation water on the fertigation process and potato productivity Research in Agricultural Engineering, 66, (2): 43 –51.

Mostafazadeh-Fard B., Khoshravesh M., Mousavi S., and Kiani A. 2011 Effects of magnetized water and irrigation water salinity on soil moisture distribution in trickle irrigation. Journal of Irrigation and Drainage Engineering 137 (6): 398-402.

Moussa, H. R. 2011. The Impact of Magnetic Water Application for Improving Common Bean (*Phaseolus vulgaris* L.) Production. New York Science Journal, 4(6):15-20.

Moussa, Z., and Hozayn M. 2018. Using of magnetic water technology for the management of brown rot disease of potato. J. Plant Prot. and Path., Mansoura Univ., 9 (3): 175 – 180

Negro, D., Montesano, V., Sonnante, G., Rubino P., De Lisi, A., and Sarli, G. 2016. Fertilization strategies on cultivars of globe artichoke: Effects on yield and quality performance, Journal of plant nutrition, 39(2): 279-287.

Noran, R., and Shani, R. Lin, I. 1996. The effect of irrigation with magnetically treated water on the translocation of minerals in the soil. Magn. Electr. 9 (7):109-122.

Page, A.L., Miller, R.H., and Keeny, D.R. 1982. Methods of Soil Analysis, Part II. Chemical and Microbiological Properties. (2nd Ed), Am. Soc. Agron. Monograph No. 9, Madison, Wisconsin, USA.

Pang XF, Deng B (2008) Investigation of changes in properties of water under the action of a magnetic field. Sci China Phys Mech 51: 1621–1632.

Petropoulos, S.A., Spyridon, R. S., Nada, B., Reda, M. Y. Z., and Mustafa, H. M. M. 2022. The Response of Globe Artichoke Plants to Potassium Fertilization Combined with the Foliar Spraying of Seaweed Extract Agronomy, 12 (490): 1-21.

Ratushnyak, A.A., Andreeva, M.G., Morozova, O.V., Morozov, G.A. and Trushin, M.V. 2008. Effect of extremely high frequency electromagnetic fields on the microbiological community in rhizosphere of plants. Int. Agrophysics,13 (22): 71-74.

Ryder, E.J., N.E. De Vos and M.A. Bari. 1983. The globe artichoke (Cynara scolymus L.) HortScience. 18(5):646-653.

Noriega-Rodríguez, D., Soto-Maldonado, C., Torres-Alarcón, C., Pastrana-Castro, L., Weinstein-Oppenheimer, C., Zúñiga-Hansen, M. E. 2020 Valorization of Globe Artichoke (Cynara scolymus) Agro-Industrial Discards, Obtaining an Extract with a Selective Effect on Viability of Cancer Cell Lines. Processes 8, (715): 1-14.

Sadeghipour, O., Aghaei, P. 2013. Improving the growth of cowpea (*Vigna unguiculata* L. Walp.) by magnetized water. J. Biodiv. Env. Sci. 3 (1): 37–43.

Saleh, S.A., 2003. Physiological responses of artichoke plants to irrigation and fertilization under special recognition of salinity. Ph.D. Thesis, Chair of Vegetable Science, Center of Life Sciences Weihenstephan, Technische Universität München, Freising, Germany p. 41.

Saleh, S.A., Zaki, M.F., Tantawy, A.S., and Salama, Y.A.M. 2016. Response of artichoke productivity to different proportions of nitrogen and potassium fertilizers. Int. J. ChemTech Res., 9, (3): 25–33.

Samarah, N. H., Hani, M. M.I. B., and Makhadmeh, I.M. 2021. Effect of Magnetic Treatment of Water or Seeds on Germination and Productivity of Tomato Plants under Salinity Stress Horticulturae. 7, (220): 1-11.

Schrader, W.L. and Mayberry K.S. 1997. Artichoke production in California. University of California. Agriculture and Natural Resources. Publication 7221. 4p.

Selim, D.A., Gendy, A.A., Maria, A.M., and Mousa, E.M. 2009. Response of pepper plants (*Capsicum annuum* L.) to magnetic technologies. in: Proceedings of the first Nile Delta Conference on Export Crops (Improvement and Protection of the Egyptian Export Crops), Faculty of Agriculture, Menufiya University. 30–31 March 89-104.

Selim, A. H., and Dalia, S. A. H. 2019. Physio- Biochemical Behavior, Water Use Efficiency and Productivity of Wheat Plants Exposed to Magnetic Field J. Plant Production, Mansoura Univ., 10 (2): 185 – 191.

Seron, C.C., Rezende, R., Lorenzoni, M. Z., Cândido de Souza, Á. H., Gonçalve, A.C. A., and Saath,R. 2019 Irrigation with water deficit applying magnetic water on scarlet eggplant. Revista de Agricultura Neotropical, Cassilândia. 6:(4)21-28.

Shahin, M. M., Mashhour, A. M. A. and Abd-Elhady, E. S. E. 2016 Effect of Magnetized Irrigation Water and Seeds on Some Water Properties, Growth Parameter and Yield Productivity of Cucumber Plants Current Science International 5: (2)152-164.

Shinohara, T Sh. Agehara, Yoo, K. S. and Leskovar D. I 2011. Irrigation and Nitrogen Management of Artichoke: Yield, Head Quality, and Phenolic Content. HORTSCIENCE 46(3):377–386.

Smith, M. 1992. CROPWAT: A computer program for irrigation planning and management", FAO. Irrig. Drain. Pap. No. 46, Rome, Italy

Snedecor, G.W., and Cochran, W.G. 1989. Statistical Methods. 8th Ed, Iowa State Univ., Press, Ames, Iowa, USA.

Surendran U, Sandeep O, and Joseph EJ (2016). The impacts of magnetic treatment of irrigation water on plant, water, and soil characteristics. Agricultural Water Management 178(1):21-29.

Tartoura, E. A. A., El-Gamily, E. E., El-Shall, Z. S. and Manal, M. S. E. 2020. Effect of Organo-Chemical Fertilizers Mixtures under the Condition of Irrigation Intervals with Magnetized Water on Yield and its Components of Jerusalem artichoke J. of Plant Production, Mansoura Univ.,11 (12):1443 – 1452.

Vermeiren, L. and Jopling, G. A. 1984. Localized irrigation: Design, installation, operation, evaluation. In FAO Irrigation and Drainage Paper, 36 Food and Agricultural Organization: Rome, Italy.

Vladimir, Z. 2017. Magnetic Treatment Reduces Water Usage in Irrigation Without Negatively Impacting Yield, Photosynthesis and Nutrient Uptake in Lettuce. International Journal of Applied Agricultural Sciences, 3(5): 117-122.

Winton, A.L., and K.B. Winton, 1958. The analysis of foods. John Wiley and Sons, Inc. London. p: 357.

Zayed A., Serag A., and Farag M. A 2020. Cynara cardunculus L.: Outgoing and potential trends of phytochemical, industrial, nutritive and medicinal merits , Journal of Functional Foods 69, (6): 1-16.

Zhang, H. 2003. Improving water productivity through deficit irrigation: Examples from Syria, the north China Plain and Oregon, USA. In: Water Productivity in Agriculture: Limits and Opportunities for Improvement. CABI publishing p: 332.

Zlotopolski, V. 2017. Magnetic Treatment Reduces Water Usage in Irrigation Without Negatively Impacting Yield, Photosynthesis and Nutrient Uptake in Lettuce. International Journal of Applied Agricultural Sciences 3 (5) :117 -122.

ترشيد أستخدام الماء والتسمد للخرشوف بأستخدام الري الماء الممغنط

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الملخص

أجريت تجربتان حقلبتان في موسمي 2019 /2020 و 2021/2020 في محطه بحوث البساتين بالقناطر الخيريه - محافظه القليوبيه- مصر لدراسه تأثير الري بالماء الممغنط عند مستوي 100و75 %من البخر نتح والتسميد النتروجيني والفسفوري والبوتاسي بمعدل (100و75 و 50%؟ من المعدل الموصي به) والتفاعل بينهم علي المحصول ومكوناته لنبات الخرشوف . كان تصميم التجربه القطاعات المنشقه مرة واحدة في ثلاث مكرارات ووزعت معاملات الري في القطع الرئيسية ومعاملات التسميد في القطع الفرعيه . أشارت النتائج الي أن: 1- الري بالماء الممغنط عند مستوي 200 و 75 % من البخر نتح أدي الي الحصول علي أعلي أرتفاع للنبات والكلوروفيل الكلي والمحصول المبكر والكلي للنبات وباطن للفدان وجودة الرؤوس ونسبه الأنيولين والماده الجافه وكفاءة أستخدام الماء ومحتوي العناصر (النتروجين والفسفور والبوتاسيوم) في كلا الموسمين. 2-كان أفضل معدل للتسميد النتروجيني والفسفوري والبوتاسي هو 75% من الموصي به و أفضل تفاعل لصفات المحصول ومكوناته بين الري بالماء الممغنط عند 75% من البخر نتح والتسميد بمعدل75 % من الموصي به. 3-تم الحصول علي أعلي قيم لكفاءة أستخدام الماء 7.51 و 7.4 كجم/م3 عند الري 75 % من البخر نتح من الماء الممغنط مع كلا من 100 و 75% من التسميد الموصي به . وكذالك ايضا الري بالماء الممغنط عند 75 % من البخر نتح و 75% من التسميد الموصي به(9.21 كجم/م3) في السنه الأولي والثانيه علي التوالي. وتوصي الدراسه بري نباتات الخرشوف بأستخدام الماء الممغنط عند 75 % من البخر نتح والتسميد بمعدل 75% من الموصي به للتسميد النتروجيني والفسفوري والبوتاسي والذي أدي الي أنخفاض معدل الري والتسميد بنسبه 25%.