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Effect of irrigation using saline and magnetized water on some botanical characteristics of cowpea plant (*Vigna unguiculata* L. Walp)

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Abstract

A two-year pot experiments were conducted at the farm of Agricultural Botany Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, during the summer seasons of 2021 and 2022. The aim of the present investigation is to study the effect of irrigation using saline and magnetic (*i.e*., a technique for mitigation the harmful effects of saline water) water on some morphological, physiological and productivity characteristics of two cultivars of cowpea plant (Cream 7 and Kafr El-Shekh). Irrigation water treatments were done using salinity levels at 4000, 5000 and 6000 mgl^{-1} as well as the magnetic treatment of saline irrigation water at the same concentrations compared to the control (tap water) .The results showed that irrigation with saline water at 4000, 5000 and 6000 mgl^{-1}) as well as magnetic water were decreased the morphological, physiological and productivity characteristics during the two study seasons compared to the control. Results also showed that the use of increasing saline water levels led to a significant decrease in all morphological characteristics *i.e*., plant length (cm), number of leaves plant^{-1} leaf area (cm^2) plant^{-1}, branches number plant^{-1}, roots dry weight, stems and leaves dry weights (g). The same results also, showed a decrease in the physiological characteristics *i.e*., chlorophyll A, B, total chlorophyll and total carotenoids (mg g^{-1} F.W) as well as the nitrogen (N), phosphorus (P) and potassium (K) contents. A reverse trend was observed in sodium (Na) and chloride (Cl) in the leaves content. Also, there was a noticeable decrease in yield characteristics *i.e*., number of pods plant^{-1}, pods dry weight plant^{-1} (g), weight of 100 seeds (g), number of seeds plant^{-1}, dry weight of seeds plant^{-1} (g)) compared to the control during the two growing seasons. Data indicated that salinity at 6000 and 5000 followed by 4000 mg l^{-1} respectively, had the most effects on the occurrence of a clear decrease in the studied characteristics compared to the control with the two cultivars during the two seasons. On the other side, using magnetized water of the salinity at 4000, 5000 and 6000 mg l^{-1}, results showed remarkable positive effects for all previous morphological, physiological and productivity characteristics compared to using of saline water with the two cultivars especially Kafr El-Shekh cultivar during the two growing seasons. Finally, the study confirms that the using of magnetic treatment of saline water until a concentration of 6000 mg l^{-1} has reduced the harmful effects of salt stress on the morphological, physiological and yield characteristics of the cowpea plant especially Kafr El-Shekh cultivar.

Keywords: cowpea, *Vigna unguiculata*, magnetic water, salinity, morphology, physiology, yield.

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1. Introduction

Cowpea (*Vigna unguiculata* L. Walp) affiliated to the family Leguminosae (Fabaceae), tribe Phaseoleae, genus Vigna, section Catiang and Species *Vigna unguiculata* (Verdcourt, 1970). Cowpea an annual crop is one of the most important and extensively cultivated legumes in the world, particularly in Africa, Latin America, and some parts of Asia and United States (Xiong *et al*., 2016). Cowpea is where its grain and leaves are sources of precious food, due to their high contents of proteins, minerals, and vitamins. Cowpea grains complement the grains of cereals as foods for people by enhancing the quantities and qualities of proteins and vitamins. For example, cowpea grains have substantial levels of folic acid, which is a critical vitamin for all people and especially pregnant women since it prevents the occurrence of neural tube defects such as spina bifida in infants. Fresh and dry grains of early season cowpea cultivars and fresh pods and leaves are often an important source of food during the "hungry period" occurring two months prior to the main cereal harvest in the Sahelian and savannah zones (Dancette and Hall, 1979). Salinity stress one of the main environmental issues that might have a direct or indirect impact on crop yield. Many crop plants are sensitive to saline stress and are unable to with stand low salinity levels. One of the main causes of dissolved saline accumulation in the soil, which prevents plant growth and physiological processes by reducing metabolism and root-shoot length is irrigation with poor-quality water. By inhibiting plant metabolism, salinity decreases plants' ability to benefit from water and reduces their growth and productivity (Munns, 2002). Plants that grow under saline conditions (soil salinity or irrigation water salinity) are exposed to stress mainly in three ways: by lowering the soil's water potential, which results in a water deficit, by Na^+ and CL^- ions' phytotoxicity, and by reduced nutrient uptake and/or shoot transport (Marschner, 1995). Hence, it was necessary to use innovative and serious solutions to the problem of soil and water salinity, especially if these solutions or technologies are non-polluting and environmentally friendly. One of these techniques is the use of magnetized water. Magnetized water is water that has been subjected to a magnetic field or has passed through a magnetic device. However, in a magnetic treatment device, as the water passes through the magnetic field, all super-molecules vibrate, this intensifies the internal vibration of these super-molecules to the breaking point, and these super-molecules fracture and release their encaged particles. Magnet water treatment does not alter the chemical properties of the water; it regulates the structure of liquid water, so there is no effect on super-molecules in normal water. In order to generate smaller clusters of water molecules than in regular water, magnetic water treatment decreases the hydrogen-oxygen bond angle within the water molecule, this improved water absorption into the cell (Verma, 2011). So, the main aim of this investigation was to study the effect of using magnetic treatment technology for saline water for mitigating the harmful effects of saline water (salt stress) on morphological, physiological and productivity characteristics of two cultivars of cowpea plant (Cream 7 and Kafr El-Shekh cultivars).

2. Materials and methods

2.1 Soil and water samples

A two pot experiments were conducted at the experimental farm, Agricultural Botany Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, during the two summer seasons of 2021 and 2022. The aim of the present work was to study the effect of magnetized water in alleviating saline stress on some morphological, physiological and productivity trails of cowpea plant. Seeds of two cowpea (*Vigna unguiculata* L.) cultivars *i.e*., Kafr El-Shekh and cream7 were obtained from Agricultural Research Station, Sakha, Kafr El-Shekh, Egypt. Sodium chloride saline (NaCl) was obtained from El-Gomhouria Chemicals Company, Assiut, Egypt, and Delta water device were gotten from Delta Water Company, Alexandria, Egypt. The design of the experiment was factorial included 14 treatments, each treatment was 3 replicates (4 pots for each replicate) in a split-plot design, the main were assigned to the 2 cowpea cultivars and the sub were assigned to applied irrigation treatments with saline and magnetic water at different used concentrations. The seeds were surface sterilized with less than 5% sodium hypochlorite solution for 1-5 minutes, then washed once or twice with distilled water. Seeds were sown on 16th June for 2021and 2022 in 30 cm diameter pots filled with 6 kg of clay loam, then seeds were sowed (10 seeds/pot). After emergences of seedlings, were thinned into three plants per pot (twice, the first after 10 days and the second time after 20 days of sowing). All agricultural practices starting with planting seeds, fertilizing, removing weeds, and controlling diseases as well as insects were done according to the instructions by Egyptian Ministry of Agriculture. The plastic pots were left on the plantation under natural light conditions. Soil samples were randomly taken from the plots before planting. Each three samples were homogenized to make up one sample. Some physical and chemical properties of the soil of the experimental farm (Experimental Farm of the Faculty of Agriculture, Al-Azhar University, Assiut governorate, Egypt), during the two growing successive seasons of 2021 and 2022 were obtained. The soil samples were analyzed at the Central Laboratory for Soil, Water and Plant Analysis, Faculty of Agriculture, Assiut University, Egypt to determine the physical and chemical contents according to standard method described by Jackson (1967) (Tables 1 and 2).

Table (1): Physical and chemical analysis properties of the used in the experimental soil before and after planting during the two successive seasons of 2021 and 2022.

Particle size distribution			Soluble cations and anions in soil paste extract (meq/L)				
Physical properties	Seasons		Chemical properties	Seasons			
	2021	2022		2021		2022	
Sand (%)	21.03	22.15		before	after	before	after
Silt (%)	33.62	31.07	EC (dsm^{-1})	3.63	4.75	3.33	4.68
Clay (%)	45.35	46.78	PH	7.98	7.91	7.93	8.01
Texture class	Clay	Clay	Cl^-	14.21	27.43	13.53	26.82
Field capacity (%)	41	42	$CO3^-$	0.00	0.00	0.00	0.00
Bulk density (g/cm^3)	1.20	1.20	$SO4^{--}$	12.27	27.01	11.20	27.05
Available N (mg/100 kg soil)	26.73	25.52	$HCO3^-$	6.64	6.75	6.61	6.62
Available P (mg/100 kg soil)	9.13	8.88	Na^+	11.33	26.13	11.10	27.07
Available K (mg/100 kg soil)	25.82	24.97	Ca^{++}	7.46	11.13	6.72	11.70
			K^+	0.37	0.55	0.34	0.46

Table (2): Chemical properties of irrigation water (tap water) during 2021 and 2022 seasons.

Seasons	EC (ppm)	pH	Soluble cations (meq/l)				Soluble anions (meq/l)			
			Ca^{++}	Mg^{++}	K^+	Na^+	CO_3^{-2}	HCO_3^-	$SO4^{-2}$	Cl^-
2021	240.40	7.63	1.13	0.76	0.29	1.23	0.00	2.30	0.39	0.96
2022	246.44	7.73	1.10	0.85	0.30	1.16	0.00	2.34	0.36	0.87

2.2 Collecting samples and recording data

2.2.1 Morphological characteristics

Three replicates were taken randomly from each treatment at 60 days after sowing (DAS) during two consecutive seasons of 2021-2022. Plants are separated into organs (root, stem, and leaves) and then dried in an oven at 70°C for 48 h until a constant dry weight was reached and the following morphological characteristics were recorded: i.e., plant length (cm), number of leaves plant^{-1}, leaf area (cm^2) plant^{-1}, number of branches plant^{-1}, root dry weight (g) plant^{-1}, Stem dry weight (g) plant^{-1} and Leaves dry weight (g) plant^{-1}. Leaf area (cm^2) plant^{-1} was measured by the method described by Gao *et al*. (2011).

2.2.2 Physiological characteristics

2.2.2.1 Chlorophyll content (mg g-1 F.W)

Chlorophyll a, b and total chlorophyll as well as total carotenoids in fresh leaves were determined according to Mornai (1982).

2.2.2.2 Minerals content (%)

Nitrogen (N) content was determined by Kjeldahl method according to AOAC (1995). Phosphorous (P) content was determined by ascorbic acid using the colorimetric method described by John (1970). Potassium (K) and sodium (Na) content were measured using the flame photometer method as described by Person (1976). Chloride (Cl) content was assessed according to the method described by Jackson (1973).

2.2.3 Yield and its components

At the harvest stage i.e., at 97 DAS (after the ripening of pods), the following characteristics were recorded number of pods plant^{-1}, dry weight of pods plant^{-1} (g), weight of 100 seed (g) and No. of seeds plant^{-1} as well as dry weight of seeds plant^{-1} (g).

2.2.4 Statistical analysis

Collected data were subjected to two-way ANOVA (Cultivars x Salinity levels) using statistical software package "Statistix 8.1" (Gomez and Gomez, 1984). The treatments' means were compared using Fisher's Least significant difference (LSD) test at the significance level of 5% ($p \leq 0.05$).

3. Results and Discussion

3.1 The effect of irrigation with saline water and magnetically treated saline water on morphological characteristics

Data in Tables (3 and 4) clearly show the effect of irrigation with tap water, saline water concentrations at (4000, 5000 and 6000 mgl^{-1}) and magnetically treated saline water at the same concentrations on vegetative growth characteristics of cowpea plant at 60 DAS i.e., plant length (cm), number of leaves plant^{-1}, Leaf area (cm^2) plant^{-1}, No. of branches plant^{-1} as well as root, stem and leaves dry weights (g) plant^{-1} for the two cultivars (Cream 7 and Kafr-Elshekh) during 2021 and 2022 seasons. The results show that the Kafr El-Shekh cultivar was significantly superior to all morphological characteristics compared to the cream7 cultivar, this difference between the cultivars is due to the genetic variations among cultivars and their capability for utilizing the environmental sources especially light, CO_2, water, and nutrients, this agrees with what was reached by El-Hefny (2010). Also, the results indicated that all salinity stress levels decreased the studied growth characteristics of two cowpea cultivars (Cream 7 and Kafr-Elshekh), where the lowest values were obtained at a concentration of 6000 (SW3) followed by 5000 (SW2) and then 4000 mg l^{-1} (SW1), respectively, when compared with untreated plant *i.e*., irrigated with tap water (control). The reduction in morphological characteristics may be due to the inhibition of cell division and reduced rate of cell elongation exerted by the high salinity levels, as the water content decreases with increasing salinity, it resulted in a gradual decrease in the plant growth. These results are in line with those obtained by El-Hefny (2010) and Lekshmi and Jayadev (2017). Filipović *et al*. (2020) found that compared to the control plants, irrigation with saline water statistically significantly reduced plant height for 4 cm (NaCl 50) and 5.6 cm (NaCl 100), which is a reduction of 6.3 and 8.8%, respectively.

Table (3): Morphological characteristics of cowpea cultivars as affected by salinity and magnetic water irrigation treatments at 60 days after sowing during 2021 and 2022 seasons.

Treatment		Trait	Plant length (cm)		No. of leaves plant^{-1}		Leaf area (cm²) plant^{-1}		No. of branches plant^{-1}	
		Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivars										
Cream 7			29.00	29.64	23.38	25.10	17.46	18.48	11.52	8.43
Kafr-Elshekh			37.05	39.76	25.57	27.00	30.80	31.83	14.10	14.29
L.S.D. at 5 %			0.86	1.20	1.15	1.14	0.77	0.67	0.92	0.65
Irrigation treatments										
Control (tap water)		0.0 mg l^{-1}	38.42	51.00	27.17	28.67	26.41	27.15	13.50	12.50
Salinity water		4000 mg l^{-1}	33.08	33.61	25.17	28.00	24.63	25.23	13.00	11.33
		5000 mg l^{-1}	31.15	29.87	23.67	25.33	22.93	24.16	12.33	10.83
		6000 mg l^{-1}	27.17	28.65	21.33	21.50	21.91	23.59	11.33	10.67
Magnetized water		4000 mg l^{-1}	37.02	36.16	27.33	29.00	25.92	26.38	14.17	12.00
		5000 mg l^{-1}	35.00	33.25	24.50	24.33	24.14	25.27	13.00	11.17
		6000 mg l^{-1}	29.33	30.39	22.17	25.50	22.98	24.30	12.33	11.00
L.S.D. at 5 %			1.61	2.25	2.15	2.14	1.44	1.26	1.71	1.22
Interaction between cultivars, saline and magnetic water irrigation treatments										
Cream 7	Control (tap water)	0.0 mg l^{-1}	30.33	45.00	25.33	27.67	18.52	19.20	12.33	10.33
	Salinity water	4000 mg l^{-1}	29.17	28.62	24.33	26.33	18.26	18.66	11.67	8.33
		5000 mg l^{-1}	27.63	24.67	23.00	24.33	16.58	17.58	11.00	7.67
		6000 mg l^{-1}	24.50	23.30	20.67	21.00	15.59	17.50	9.67	7.67
	Magnetized water	4000 mg l^{-1}	31.20	31.72	25.33	27.33	19.08	19.89	13.33	9.00
		5000 mg l^{-1}	31.17	29.17	23.67	25.00	17.76	18.57	11.67	8.00
		6000 mg l^{-1}	29.00	25.03	21.33	24.00	16.46	17.96	11.00	8.00
Kafr-Elshekh	Control (tap water)	0.0 mg l^{-1}	46.50	57.00	29.00	29.67	34.30	35.10	14.67	14.67
	Salinity water	4000 mg l^{-1}	37.00	38.60	26.00	29.67	31.01	31.80	14.33	14.33
		5000 mg l^{-1}	34.67	35.07	24.33	26.33	29.27	30.73	13.67	14.00
		6000 mg l^{-1}	29.83	34.00	22.00	22.00	28.24	29.68	13.00	13.67
	Magnetized water	4000 mg l^{-1}	42.83	40.59	29.33	30.67	32.75	32.87	15.00	15.00
		5000 mg l^{-1}	38.83	37.33	25.33	23.67	30.52	31.97	14.33	14.33
		6000 mg l^{-1}	29.67	35.75	23.00	27.00	29.50	30.63	13.67	14.00
L.S.D. at 5 %			2.27	3.18	3.05	3.03	2.04	1.78	2.42	1.73

Dergam and Abdulrazzak (2022) note that the use of water with high salinity (6 ds/m) led to a significant decrease in both the wet weight of the product and the height of the plant. The reason for this decrease is the negative impact of salts on plant growth, as well as the shortage of water absorbed as a result of osmotic stress (Jasim *et al*., 2015). At the same time, the irrigation with magnetically treated saline water concentration at 4000 mg l^{-1} (MT1) led to a significant increase in the aforementioned morphological characteristics compared to untreated plant (control). The exception was only in the case of leaves number trait, where this trait was superior to the control plant. These results are in line with those obtained by previous studies (Abd El-Qodos and Hozayn, 2010a,b) that suggested that stimulation growth of lentil, flax, chick-pea and wheat under magnetic water treatment may be due to formation of new protein bands. In this regard, Hozayn *et al*. (2015) showed that magnetic treatment induces mitosis meristematic cells and cell metabolism of pea, lentil, flax and onion, resulting in reducing the harmful effect of salinity. The same results were obtained during the two growing seasons. Alattar *et al*. (2021) showed that the magnetized water increased the dry weight of corn plants as compared with plants in the non-magnetized group. Regarding the interaction between cultivars and irrigation with magnetically treated water with different salinity levels, The results indicated that the highest values for all vegetative growth characteristics of cowpea plant were obtained with Kafr El Shekh cultivar and magnetically treated saline water at a concentration of 4000 mgl^{-1} (MT1) compared to untreated plant (control) and other applied treatments, these results were true during the tow experimental seasons. these results are in line with those obtained by Mostafa (2020) found that Irrigation of potato plants with magnetically treated water led to an increase in plant height as well as the number of leaves compared to other plants compared to the case of the non-magnetic water.

Table (4): Dry weight characteristics of cowpea cultivars as affected by salinity and magnetic water irrigation treatments at 60 days after sowing during 2021 and 2022 seasons.

Treatment		Traits	Root dry weight (g plant^{-1})		Stem dry weight (g plant^{-1})		Leaves dry weight (g plant^{-1})	
		Season	1st	2nd	1st	2nd	1st	2nd
Cultivars								
Cream7			0.66	0.65	1.52	1.57	1.84	1.87
Kafr-Elshekh			0.91	0.99	1.73	1.83	1.95	2.14
L.S.D. at 5%			0.02	0.02	0.02	0.01	0.01	0.02
Irrigation treatments								
Control (tap water)		0.0 mg l^{-1}	0.84	0.91	1.69	1.74	2.00	2.04
Salinity water		4000 mg l^{-1}	0.78	0.80	1.61	1.70	1.88	2.01
		5000 mg l^{-1}	0.75	0.79	1.60	1.68	1.86	1.99
		6000 mg l^{-1}	0.73	0.76	1.58	1.66	1.84	1.97
Magnetized water		4000 mg l^{-1}	0.84	0.85	1.65	1.73	1.91	2.04
		5000 mg l^{-1}	0.79	0.82	1.63	1.69	1.89	2.00
		6000 mg l^{-1}	0.77	0.79	1.62	1.69	1.88	1.99
L.S.D. at 5 %			0.03	0.03	0.03	0.03	0.03	0.03
Interaction between cultivars, saline and magnetic water irrigation treatments								
Cream 7	Control (tap water)	0.0 mg l^{-1}	0.73	0.77	1.57	1.61	1.88	1.92
	Salinity water	4000 mg l^{-1}	0.65	0.62	1.51	1.56	1.83	1.86
		5000 mg l^{-1}	0.61	0.61	1.50	1.55	1.81	1.85
		6000 mg l^{-1}	0.59	0.59	1.48	1.54	1.79	1.84
	Magnetized water	4000 mg l^{-1}	0.72	0.66	1.55	1.61	1.87	1.92
		5000 mg l^{-1}	0.65	0.64	1.53	1.56	1.85	1.87
		6000 mg l^{-1}	0.63	0.63	1.52	1.57	1.84	1.86
Kafr-Elshekh	Control (tap water)	0.0 mg l^{-1}	0.95	1.05	1.80	1.87	2.11	2.16
	Salinity water	4000 mg l^{-1}	0.91	0.98	1.71	1.84	1.92	2.15
		5000 mg l^{-1}	0.89	0.96	1.69	1.81	1.90	2.12
		6000 mgl^{-1}	0.87	0.93	1.68	1.79	1.88	2.10
	Magnetized water	4000 mg l^{-1}	0.95	1.04	1.75	1.85	1.96	2.16
		5000 mg l^{-1}	0.92	0.99	1.73	1.82	1.93	2.14
		6000 mg l^{-1}	0.90	0.95	1.72	1.81	1.92	2.13
L.S.D. at 5 %			0.05	0.04	0.04	0.04	0.04	0.04

3.2 The effect of irrigation with saline water and magnetically treated saline water on physiological characteristics

3.2.1 Chlorophyll content mg g^{-1} F.W

Data presented in Table (5) show the effect of irrigation with tap water, saline water at (4000, 5000, and 6000 mg l^{-1}) and magnetically treated saline water at same concentrations on chlorophylls content mg g^{-1} F.W of cowpea leaf (chlorophyll A, chlorophyll B, total chlorophyll and total carotenoids) cultivars Cream7 and Kafr-Elshekh at 60 DAS during 2021 and 2022 seasons. The results showed the superiority of Kafr El-Shekh cultivar on the content of the determined photosynthetic pigments compared to cream7 cultivar, the differences between the cultivars are due to the genetic differences between the cultivars and their ability to benefit from environmental resources, especially light, carbon dioxide, water and nutrients. This is consistent with the conclusions presented by Zaki *et al*. (2009).

Table (5): Photosynthetic pigments content of cowpea cultivars as affected by salinity and magnetic water irrigation treatments at 60 days after sowing during 2021 and 2022 seasons.

Treatment		Trait	Chlorophyll A (mg g^{-1} F. W.)		Chlorophyll B (mg g^{-1} F. W.)		Total chlorophyll (mg g^{-1} F. W.)		Total carotenoids (mg g^{-1} F. W.)	
		Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivars										
Cream7			1.32	1.37	0.64	0.67	1.96	2.04	1.61	1.65
Kafr-Elshekh			1.39	1.43	0.68	0.72	2.07	2.15	1.66	1.71
L.S.D. at 5 %			0.02	0.02	0.01	0.02	0.02	0.03	0.02	0.02
Irrigation treatments										
Control (tap water)		0.0 mgl^{-1}	1.51	1.53	0.76	0.79	2.27	2.32	1.73	1.77
Salinity water		4000 mgl^{-1}	1.41	1.44	0.69	0.72	2.10	2.16	1.66	1.69
		5000 mgl^{-1}	1.30	1.34	0.62	0.66	1.92	2.01	1.56	1.60
		6000 mgl^{-1}	1.21	1.26	0.53	0.57	1.74	1.84	1.50	1.54
Magnetized water		4000 mgl^{-1}	1.49	1.52	0.74	0.79	2.23	2.30	1.73	1.78
		5000 mgl^{-1}	1.33	1.39	0.68	0.73	2.02	2.12	1.69	1.73
		6000 mgl^{-1}	1.24	1.33	0.59	0.63	1.83	1.96	1.60	1.64
L.S.D. at 5 %			0.03	0.03	0.03	0.03	0.03	0.05	0.03	0.03
Interaction between cultivars, saline and magnetic water irrigation treatments										
Cream 7	Control (tap water)	0.0 mgl^{-1}	1.48	1.50	0.73	0.77	2.21	2.27	1.70	1.74
	Salinity water	4000 mgl^{-1}	1.38	1.41	0.66	0.69	2.04	2.10	1.63	1.66
		5000 mgl^{-1}	1.27	1.32	0.60	0.63	1.87	1.95	1.53	1.57
		6000 mgl^{-1}	1.19	1.23	0.50	0.54	1.69	1.78	1.47	1.51
	Magnetized water	4000 mgl^{-1}	1.46	1.49	0.72	0.76	2.17	2.24	1.71	1.75
		5000 mgl^{-1}	1.30	1.36	0.66	0.71	1.96	2.06	1.67	1.70
		6000 mgl^{-1}	1.21	1.30	0.57	0.60	1.77	1.90	1.57	1.61
Kafr-Elshekh	Control (tap water)	0.0 mgl^{-1}	1.54	1.56	0.78	0.82	2.32	2.37	1.75	1.80
	Salinity water	4000 mgl^{-1}	1.44	1.46	0.71	0.74	2.15	2.21	1.68	1.72
		5000 mgl^{-1}	1.33	1.37	0.64	0.68	1.97	2.06	1.58	1.62
		6000 mgl^{-1}	1.24	1.29	0.55	0.59	1.79	1.89	1.52	1.57
	Magnetized water	4000 mgl^{-1}	1.52	1.55	0.76	0.81	2.28	2.35	1.76	1.81
		5000 mgl^{-1}	1.36	1.42	0.70	0.75	2.07	2.17	1.72	1.76
		6000 mgl^{-1}	1.27	1.36	0.61	0.65	1.88	2.01	1.62	1.66
L.S.D. at 5 %			0.05	0.04	0.04	0.05	0.04	0.07	0.05	0.04

Also, this study indicated that the lowest values were obtained at a concentration of 6000 (SW3), followed by 5000 (SW2) and then 4000 mg l^{-1} (SW1), respectively, when compared to untreated plant (control). Mergeb (2021) The results show that Chlorophyll ‘a' content decreased as concentration of NaCl salt increased, reaching its lowest level, in terms of was reduced from 0.65 in non-salinized plants to 0.61 in plants treated with 300 mM NaCl of faba bean. it can be said that the effect of salts had negative effects on these properties because salinity leads to a gradual decrease in the water content of cells, which leads to descendent growth. Maintaining adequate water content is crucial for several plant processes, including photosynthesis. Salinity hinders the de novo synthesis of proteins and the components of chlorophyll (Ahanger *et al*., 2014). These findings corroborated those of Abeer *et al*. (2015) who discovered that subjecting cowpea plants to saline stress reduced the amount of chlorophyll a,b and carotenoids in cowpea leaves. Al-huraby and Bafeel (2022) found that all different concentrations of NaCl significantly decreased the chlorophyll (a and b) and carotenoids content as compared to the control plants. At the same time, the irrigation with all levels of magnetically treated saline water, especially a concentration of 4000 ppm (MT1) led to a significant increase in content of all pigments’ photosynthesis of two cowpea cultivars (Cream 7 and Kafr-Elshekh) plants, in addition to reducing the harmful effect of salinity compared to untreated plants (control). Except was only for trait of total carotenoids in the second growing season, which gave a better significant increase than the control plants. So it can be said that the effect of magnetic treatment of saline irrigation water has a clear positive effect on plant growth in general, enhancement of photosynthetic pigments as a result of magnetic water treatment was reported and explained due to increasing growth promoters indole acetic acid (IAA) (Hozayn and Abdul El-Qodos, 2010a,b), stimulate mitosis meristematic cells and cell metabolism (Hozayn *et al*., 2015), increase in cytokinin synthesis (Atak *et al*., 2003). Mostafa (2020) found that the irrigation of potato plants with magnetically treated water led to an increase in the chlorophyll ratio compared to other plants. Regarding the interaction between the magnetically treated water with the different levels of salinity on the two plant cultivars resulted in a clear superiority of (Kafr-Elshekh) cultivar over (Cream 7) cultivar and magnetically treated saline water at a concentration of 4000 mg l^{-1} (MT1) compared to untreated plant (control) in the content of the photosynthetic pigments (chlorophyll A, B, and total carotenoids) in the cowpea leaf tissues. These results were similar during the two growing seasons. Recently, Hozayn *et al*. (2015 and 2016a) obtained similar results on wheat and canola irrigated with magnetic water.

3.2.2 Minerals content

Data in Table (6) indicate the effect of irrigation with tap water, saline water concentrations at 4000, 5000 and 6000 mg l^{-1} as well as magnetically treated saline water at the same concentrations on minerals content % of cowpea cultivars (Cream 7 and Kafr-Elshekh) such as N, P, K, Na, and Cl at 60 DAS during 2021 and 2022 seasons. The results showed that Kafr-Elshekh cultivar was significantly superior in (N, P and K) content compared to Cream 7, while Cream 7 gave the highest values in (Na and Cl) content compared to Kafr-Elshekh cultivar during the two growing seasons.

Table (6): Minerals content (%) of cowpea cultivars as affected by salinity and magnetic water irrigation treatments at 60 days after sowing during 2021 and 2022 seasons.

Treatment		Traits	N		P		K		Na		Cl	
		Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivars												
Cream 7			1.51	1.42	0.38	0.36	1.43	1.30	0.61	0.56	0.84	0.80
Kafr-Elshekh			2.37	2.12	0.42	0.47	1.70	1.61	0.52	0.46	0.66	0.72
L.S.D. at 5 %			0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
Irrigation treatments												
Control (tap water)		0.0 mg l^{-1}	2.98	2.92	0.56	0.55	2.70	2.68	0.19	0.17	0.33	0.32
Salinity water		4000 mg l^{-1}	2.27	1.91	0.40	0.40	1.61	1.49	0.56	0.48	0.75	0.72
		5000 mg l^{-1}	1.61	1.48	0.35	0.35	1.38	1.24	0.63	0.56	0.82	0.81
		6000 mg l^{-1}	1.35	1.27	0.31	0.30	1.04	0.92	0.74	0.67	0.96	1.01
Magnetized water		4000 mg l^{-1}	2.33	1.98	0.44	0.47	1.68	1.56	0.54	0.47	0.70	0.70
		5000 mg l^{-1}	1.66	1.55	0.39	0.44	1.45	1.30	0.59	0.55	0.79	0.78
		6000 mg l^{-1}	1.40	1.31	0.35	0.37	1.10	0.98	0.71	0.66	0.91	0.96
L.S.D. at 5 %			0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03
Interaction between cultivars, saline and magnetic water irrigation treatments												
Cream 7	Control (tap water)	0.0 mg l^{-1}	2.93	2.89	0.53	0.51	2.64	2.62	0.20	0.17	0.34	0.33
	Salinity water	4000 mg l^{-1}	1.63	1.46	0.35	0.35	1.38	1.33	0.63	0.55	0.86	0.84
		5000 mg l^{-1}	1.15	1.04	0.34	0.31	1.14	0.97	0.69	0.63	0.94	0.89
		6000 mg l^{-1}	0.96	0.96	0.30	0.25	1.02	0.81	0.77	0.71	1.47	0.95
	Magnetized water	4000 mg l^{-1}	1.68	1.51	0.41	0.42	1.49	1.43	0.59	0.51	0.81	0.82
		5000 mg l^{-1}	1.18	1.11	0.38	0.37	1.24	1.04	0.65	0.62	0.90	0.85
		6000 mg l^{-1}	1.03	0.99	0.35	0.27	1.12	0.89	0.73	0.70	1.00	0.90
Kafr-Elshekh	Control (tap water)	0.0 mg l^{-1}	3.03	2.95	0.60	0.59	2.76	2.74	0.18	0.16	0.32	0.31
	Salinity water	4000 mg l^{-1}	2.91	2.37	0.45	0.45	1.85	1.66	0.49	0.42	0.64	0.61
		5000 mg l^{-1}	2.07	1.91	0.37	0.38	1.62	1.51	0.56	0.50	0.71	0.73
		6000 mg l^{-1}	1.73	1.58	0.32	0.36	1.06	1.03	0.70	0.63	0.86	1.07
	Magnetized water	4000 mg l^{-1}	2.97	2.45	0.47	0.52	1.87	1.69	0.48	0.40	0.59	0.58
		5000 mg l^{-1}	2.13	1.99	0.40	0.50	1.66	1.57	0.52	0.48	0.68	0.71
		6000 mg l^{-1}	1.77	1.63	0.35	0.47	1.08	1.07	0.68	0.61	0.82	1.01
L.S.D. at 5 %			0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.04	0.04

The results also indicated that the content of (N, P and K) in cowpea plant was significantly decreased with gradually increasing of salinity level up to 6000 mg l^{-1} compared to control plant. On the other hand, the content of (Na and Cl) increased with increasing salinity up to 6000 mg l^{-1}, probably due to competition between Na^+ and other minerals including K^+, Mg^{+2} and Ca^{+2}, salt stress leads to nutrient deficit. These findings are in line with those of Shereen *et al.* (2009) who discovered that under saline stress, rice plants' shoot ions showed an increase in Na^+ accumulation along with a drop in K^+ concentration. Ma *et al.*, (2022) found that the saline-alkaline stress resulted in a considerable decrease in shoot total nitrogen and $NO3^{--}$ nitrogen of nipponbare seedlings irrigated with non-magnetized water. Selim *et al*. (2022) shows that as seawater levels rose, macro and micro minerals in wheat plants and grains declined with the exception of Na and Cl, which increased. With a 12.5 dS m^{-1} seawater level, the concentrations of the elements N, P, and K, in the wheat plant shoots declined by approximately 19%, 27%, and 13%, respectively, compared to the control. At the same time, irrigation with magnetically treated saline water up to a concentration of 4000 mg l^{-1} (MT1) led to a significant increase in the content of N, P and K in the two cultivars (Cream 7 and Kafr-Elshekh) plants, in addition to reducing the harmful effect of salinity. This level (MT1) led to a significant decrease in the content of (Na and Cl) in cowpea leaves when compared with other levels of magnetically treated saline water (MT3 and MT2) compared to untreated plant (control) in both seasons. These findings are in line with those of Hozayn *et al*. (2016b) revealed that, irrigated potato plants with magnetic water increased macro-elements (N, P, K, Ca and Mg), the increment ranged between 2.40 to 28.57% and from 2.19 to 33.92% compared with irrigation with normal water. Hozayn *et al.* (2019a) reported that Magnetic water leads to an increase in all elements' content except sodium. This is because Na is a paramagnetic element, i.e., having a small positive susceptibility to magnetic fields, while other elements are diamagnetic which are slightly repelled by a magnetic field. Regarding The interaction between the magnetically treated water with the different levels of salinity on the two plant cultivars resulted in a clear superiority of (Kafr el-shekh) cultivar over (Cream 7) cultivar and magnetically treated saline water at a concentration of 4000 ppm (MT1) in content (N, P, and K) compared to untreated plants (control), while, the highest values were obtained for the content of (Na, Cl) in the cream7 cultivar with saline water at a concentration of 6000 ppm (SW3). these results were similar during the two growing seasons. The application of magnetized water improved the availability of minerals in the soil (Kronenberg, 2005), by making salts and minerals needed for cell division and elongation during plant growth more soluble. With the exception of sodium, magnetic water increased the content of all elements, according to Hozayn *et al.* (2019a). Selim *et al*. (2022) showed that when examining all seawater levels, the magnetic treatment caused significant increases in concentration of all the minerals, except Na and Cl, in all areas of wheat plants. In comparison to the non-magnetic treatment, the N, P, and K concentrations in grains increased by roughly 50%, 24% and 25%, respectively, while the Na and Cl concentrations in the shoot decreased by approximately 20% and 25%, at a seawater level of 12.5 dS m^{-1}. This is due to the fact that Na is a paramagnetic element, meaning it has a slight positive susceptibility to magnetic fields, as opposed to other elements, which are diamagnetic and are only weakly attracted to magnetic fields. These outcomes are consistent with Estken and Turan (2004). Hajer *et al.* (2006) when potato plants were irrigated with magnetic water, N%, P%, and K% levels in the leaves increased dramatically. Ma *et al.* (2022) found that the saline-alkaline stress resulted in a considerable decrease in shoot total nitrogen and NO_3^{-} nitrogen of nipponbare seedlings irrigated with non-magnetized water, whereas with exposure to magnetized water, there was a significant increase in shoot total nitrogen of nipponbare seedlings under both normal and saline-alkaline stress conditions.

3.3 The effect of irrigation with saline water and magnetically treated saline water on yield and it`s components of cowpea plant

Yield of cowpea plant cultivars (Cream 7 and Kafr-Elshekh) and its component characteristics *i.e*., number of pods plant^{-1}, dry weight of pods plant^{-1} (g), weight of 100 seed (g), number of seeds plant^{-1} and dry weight of seeds plant^{-1} (g) were affected by irrigation with tap water, saline water concentrations at 4000, 5000 and 6000 mg l^{-1} as well as magnetically treated saline water at concentrations 4000, 5000 and 6000 mg l^{-1} at 97 DAS during the two growing seasons of 2021 and 2022. Regarding for cultivars there was significant superiority of Kafr-Elshekh over Cream 7 in the studied yield traits. At the same time, the results indicated that the yield traits of cowpea plant decreased significantly with increasing salinity level up to 6000 mg l^{-1} compared to control plant as shown in Table (7) during the two growing seasons. The highest salinity level was shown to produce the lowest total pod yield values. These results are consistent with Selim *et al*. (2022) showed that all yield features of wheat plants such as spike weight (g plant^{-1}), grains number/spike, grain weight (g plant^{-1}), and weight of 100 grains (g), dropped significantly with increasing seawater levels during both seasons, the reduction in grain weight was 91% and 68%, respectively, at the elevated seawater of 12.5 dS m^{-1} in contrast to the control. As a direct result for decreasing rate of photosynthesis and other metabolic processes, which also affected the pace of carbohydrate metabolism. However, other studies indicated that this impact might be brought on by a decline in photosynthesis and protein synthesis disruption of growth regulators or enzyme function (Debuba *et al*., 2006; Thapon *et al*., 2008). Filipović *et al*. (2020) found that when irrigating bean plants with saline water (50 + 100 mmol NaCl) a decrease was given in the number of seeds per plant, the weight of seeds and the weight of pods per plant. This agrees with what was reached by El-Hefny (2010). The results obtained also indicated irrigation with magnetically treated saline water up to 4000 mg l^{-1} (MT1) led to a significant increase in all yield traits of two cultivars (Cream 7 and Kafr-Elshekh) compared to untreated plant (control) in both seasons. This result was in agreement with that obtained by Sadeghipour (2016) showed that magnetic water increased seed yield, yield components. The present study revealed that irrigation with magnetized water raised seed yield of cowpea by 38% as compared to ordinary water. Also, Selim *et al*. (2022) reported that The irrigation with magnetic water; increased yield attributes such as spike weight (g plant−1), grains number/spike, grain weight (g plant−1), and weight of 100 grains (g), by roughly 30%, 58%, 688%, and 37%, respectively, at a seawater stress level of 10 dS m^{-1} compared to controls. Surendran (2016) showed that magnetic treatment of irrigation water types led to an improvement in the yield parameters of cowpea. In the field experiment with brinjal also the magnetic treatment of normal and saline water improved the yield by 25.8 and 17.0% over the control.

Table (7): Yield components of cowpea cultivars as affected by salinity and magnetic water irrigation treatments at 97 days after sowing during 2021 and 2022 seasons.

Treatment		Trait	Number of pods plant^{-1}		Dry weight of pods (g) plant^{-1}		Weight of 100 seed (g)		Number of seeds plant^{-1}		Dry weight of seeds (g) plant^{-1}	
		Season	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cultivars												
Cream 7			9.57	9.86	8.49	9.20	11.63	11.64	54.81	61.67	6.60	7.17
Kafr-Elshekh			10.91	10.48	10.31	10.21	12.13	12.47	66.43	65.91	8.03	8.13
L.S.D. at 5 %			0.46	0.52	0.67	0.76	0.72	0.75	4.15	4.20	0.53	0.53
Irrigation treatments												
Control (tap water)		0.0 mg l^{-1}	13.67	13.67	15.81	16.29	13.37	12.90	100.17	106.83	12.51	13.02
Salinity water		4000 mg l^{-1}	10.00	9.67	9.49	9.09	12.41	12.47	62.17	65.17	7.36	7.46
		5000 mg l^{-1}	8.50	8.67	6.80	7.28	11.53	11.62	41.00	49.33	5.05	5.71
		6000 mg l^{-1}	8.17	7.83	5.56	5.61	10.76	11.20	35.50	34.00	4.26	4.32
Magnetized water		4000 mg l^{-1}	11.83	12.33	12.00	13.70	12.59	12.63	81.50	87.17	9.04	10.41
		5000 mg l^{-1}	10.33	10.17	9.21	8.71	11.63	11.90	59.50	59.83	7.62	7.27
		6000 mg l^{-1}	9.17	8.83	6.92	7.26	10.89	11.69	44.50	44.17	5.41	5.39
L.S.D. at 5 %			0.87	0.97	1.26	1.43	1.34	1.39	7.76	7.86	1.00	1.00
Interaction between cultivars, saline and magnetic water irrigation treatments												
Cream 7	Control (tap water)	0.0 mg l^{-1}	12.33	13.33	14.20	14.84	12.88	12.47	87.67	99.67	10.81	11.97
	Salinity water	4000 mg l^{-1}	9.33	9.33	8.31	8.31	12.25	12.10	53.67	63.67	6.31	6.86
		5000 mg l^{-1}	8.33	8.67	6.22	6.96	11.17	10.97	40.67	52.33	4.52	5.70
		6000 mg l^{-1}	8.00	8.33	5.05	5.45	10.73	10.83	33.67	34.33	3.97	4.16
	Magnetized water	4000 mg l^{-1}	10.33	11.67	10.84	13.83	12.40	12.34	72.00	83.33	8.28	10.36
		5000 mg l^{-1}	9.67	9.00	8.23	8.03	11.23	11.48	53.67	56.00	7.02	6.33
		6000 mg l^{-1}	9.00	8.00	6.57	6.97	10.78	11.29	42.33	42.33	5.32	4.84
Kafr-Elshekh	Control (tap water)	0.0 mg l^{-1}	15.00	14.00	17.42	17.73	13.86	13.32	112.67	114.00	14.20	14.08
	Salinity water	4000 mg l^{-1}	10.67	10.00	10.67	9.86	12.56	12.84	70.67	66.67	8.40	8.06
		5000 mg l^{-1}	8.67	8.67	7.38	7.61	11.89	12.26	41.33	46.33	5.58	5.71
		6000 mg l^{-1}	8.33	7.33	6.08	5.76	10.79	11.57	37.33	33.67	4.55	4.48
	Magnetized water	4000 mg l^{-1}	13.33	13.00	13.16	13.56	12.78	12.92	91.00	91.00	9.80	10.46
		5000 mg l^{-1}	11.00	11.00	10.18	9.39	12.02	12.32	65.33	63.67	8.21	8.20
		6000 mg l^{-1}	9.33	9.00	7.27	7.55	11.00	12.08	46.67	46.00	5.49	5.94
L.S.D. at 5 %			1.23	1.37	1.79	2.02	1.90	1.97	10.97	11.11	1.41	1.41

Regarding the interaction between the magnetically treated water with the different levels of salinity on the two plant cultivars resulted in a clear superiority of (Kafr-Elshekh) cultivar over (Cream 7) and magnetically treated saline water at a concentration of 4000 mg l^{-1} (MT1) in studied yield traits compared to untreated plant (control) during the two growing seasons. It makes sense for increasing chickpea yield and its constituent parts after magnetic treatment given the rising value of vegetative growth criteria and pigments (Hozayn *et al*., 2017). The findings concur with those of Hozayn and Abdul Qados (2010a) who found that magnetic water greatly enhanced chickpea plant seeds when compared to control plants. El Sayed (2014) showed the beneficial effects of magnetic water on the weight of 100 broad bean seeds when compared to the control treatment.

4. Conclusion

Results obtained in the present study recommended using of the magnetic treatment technique for saline water up to a concentration of 6000 mg l^{-1} for reducing the negative effects of using irrigation with saline water on growth characteristics as well as the yield of cowpea plant, especially Kafr-Elshekh cultivar under the same study conditions.

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