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The Response of Saline Irrigation Water to Magnetization and Its Effect on Soil Properties and Cowpea Productivity in Newly Reclaimed Lands in North Sinai

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THE FIELD experiment was carried out in three locations at North Sinia Governorate, Egypt, during two successive summer seasons 2018 and 2019, to study the Effect of the three saline water levels (3.14, 6.25 and 9.37 dSm^{-1}) treated with or without magnetic field on some soil chemical properties and cowpea productivity and quality. In both seasons, each experiment was conducted in a randomized complete blocks design (RCBD) with six replicates. The obtained results showed that using irrigation water with high salinity levels decreased salinity of soil and soil pH for irrigation water treated with magnetic compared with untreated. Available macro and micronutrients in soil as affected with magnetic irrigation water were higher than untreated water. Growth parameters, yield components (number of pods and weight of pods and seed yield fed^{-1}) and some chemical constituents (macro-micronutrients in shoot and seeds contents, total chlorophyll content, proline, protein and carbohydrates) were higher with magnetic treated irrigation water as compared to control. Magnetized Irrigation water salinity of 3.14 and 6.25 dSm^{-1} effects with magnetic water were higher than untreated showed a uniform impact in soil properties and cowpea growth inhibition and its productivity under high salinity stress condition. The use of magnetized water has a role in reducing EC as there has been a decrease in the value of EC compared to un-magnetized water at Galbana, Romana and Rabaa), respectively. Using irrigation water salinity treated with magnetic to soil increased of leaching soluble salts.

Keywords: Magnetized, Irrigation water, Salinity, Cowpea, Productivity.

Introduction

In Egypt, there are quantities of groundwater salinity. Hence, the exploitation of this resource is limited (Ahmed et al., 2002). The irrigation water salinity amount that could be used annually from the Egyptian aquifers is estimated at 11.565 billion m^3 per year (Abo-Soliman and Halim, 2012). Salinity problems increase with increasing salt concentration in irrigation water. Water scarcity is a limiting factor for crop production in arid and semi-arid regions (Abdel-Aziz and Sadik, 2017). Salinity decreased significantly after leaching with different magnetized irrigation water compared to different normal water in all soil depths. Thus is the increase of removed soluble salts by leaching with the magnetized water compared with the normal water. The removal of soluble soil salts by leaching with magnetized water is an important role of improvement and reclamation of salt-affected soils (Maheshwari and Grewal, 2009). Weakening of hydrogen bonds within groups due to magnetic fields, and reconfiguration of larger groups into smaller units with stronger hydrogen bonds (Wang et al., 2013). Water is necessary in the response of biological materials to magnetic fields. In the fact, Water refers to the medium in which biochemical reactions occur, magnetic fields may change cellular metabolism using water as receptor of the magnetic fields. Magnetically treated water have effect on activation energy, viscosity, conductivity, hydrogen bond formation, water molecule size, surface tension, evaporation, dissolved oxygen, salt mobility and uniformity of its structure (Inaba et al., 2004). Magnetized water increased NaCl diffusion by 50% while KCl reached 20%. It has lowered the diffusion of KH_2PO_4, super phosphate and $ZnSO_4$ (Hilal, 2013).

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Water is exposed to the magnetic field through this process magnetic occurrence changes in water at molecular, atomic and electronic structure (Silva and Dobranszki, 2014, Hozayn and Abdul, 2010)). Magnetized water molecules are restructuring into smaller clusters and made of six symmetrically organized molecules. Cluster of the magnetized water into inside the cells through the membranes and become the magnetized water bio-friendly for plants (Ali and Sammaneh, 2014). The soil treated with magnetic system increasing of the available of nitrogen, phosphorus and potassium compared to a control (Meysam and Ebrahim, 2017). Tai et al. (2008) found that soil treated with magnetic water causing decreased soil pH from pH 9.2 to 8.5. Irrigation water with magnetic field led to changes in the properties of molecules causing decrease in surface tension, reduced viscosity, increased dissolvability, increased permeability and improved oxygen so mineral elements available to plants, hence magnetic water bears different chemical and physical properties than the normal water (Nasher, 2008).

Cai et al. (2009) found that magnetized has strong effects on reducing the surface tension and increasing of viscosity, water is more stabilized with magnetic treated with minimal molecular energy while greater in activation energy. Significant response in the soil chemical properties (pH, EC, Na^+, Cl^-, SAR, available nitrogen, phosphorus and potassium contents) because of irrigation with the magnetized saline water compared to the normal water (Abd-Elrahman and Osama, 2017). Also, irrigation with magnetic treated water considered as a one of valuable modern technologies that improve crop production and alleviate salinity of soil and water (Fanous et al., 2017). Magnetized water technology may refer to technique can improve of both crops yield and save irrigation water (Abdel-Aziz et al., 2017).

In Egypt, area planted of cowpea according to Agricultural Economic Bulletin, in 2013 was about 14830 feddan with production 17248 tons and an average yield of 1.163 ton/feddan (Bashandy and El-Shaieny, 2016).

Cowpea is source of vitamins, minerals, carbohydrates and dietary fibers (Gonçalves et al., 2016). Cowpea using as a forage it is a source of protein and is quite digestible for ruminants (Anele et al., 2011). The present work aimed to study the effect of magnetic irrigation water on reducing the negative effects of saline irrigation water and improving soil and cowpea productivity under the conditions of newly reclaimed lands at North Sinia.

Materials and Methods

Experimental sites

Field experiments were carried out during two summer seasons 2018 and 2019 in the three locations at North Sinia governorate, Egypt. Galbana, Romana and Rabaa wells water are used to irrigate cultivated land in these locations. The soils of these locations are characterized as saline soil, low content of organic matter and available macro and micronutrients (Table 1).

Characteristics of the experimental soil

Surface soil samples (0 – 30 cm) Collected from each location before seed sowing, air-dried, ground and passed through 2 mm sieve and kept for analysis. Particle size distribution was determined according to the FAO (1970). Chemical parameters were: Electrical conductivity (EC), soil reaction (pH), organic matter (OM), cations, anions and total calcium carbonate contents were determined according to Page et al. (1982). Nitrogen in soil was determined by (Bremner and Mulvaney 1982), the amount of available phosphorus in soil was described by Olsen et al. (1954) and the concentration of P was measured colorimetrically using the ascorbic acid method (Olsen and Watanabe 1965) and the concentration of K was measured by flame photometer (Black, 1965). The amounts of available Iron, Manganese and Zinc were determined by extracting the soil with DTPA solution according to (Lindsay and Norverll, 1978). The results obtained are shown recorded in Table (1).

Water of irrigation

Water of each well was used for irrigation, whether directly (before magnetization or after magnetization). Irrigation water chemical composition (Table 2) was determined according to Chapman and Pratt (1961). Model system of magnetic water was Delta water system. The diameter of magnetic device was 2 inches. The magnetic field produces a force of about 1.5 Tesla and out pot of 25 m^3/hr from the magnetized water flow rate. The model was made from stainless Steel material.

Experimental layout

Each experiment was carried out in a randomized complete blocks design (RCBD) with six replicates. The plot area was 50 m^2 (5 x 10 m) which divided into rows with 60 cm. during land preparation, 10 ton compost/fed was applied to the soil and mixed before 20 days from seed sowing. Seeds of cowpea (*Vigna unguiculata* L.) c.v. Kafr El-Sheikh 1, were inoculated with bio-fertilizer of symbiotic N- fixing bacterial: *Rhyzobium leguminosarum* salt- tolerant strain which was supplied from Department of Microbiology. Arabic gum solution was used as sticking agent (coating agent) for Cowpea seeds. Seed sowing was carried out 20th May, 2018 and 2019 where 25kg seeds/fed were used. Three coated seeds were sown in a hole at 4 cm depth. The distance between each two holes was 20 cm. After 30 day from sowing, seedling in each hole was thinned to one plant per hole.

TABLE 1. The main chemical and physical properties of the three experimental locations for the two seasons, 2018 and 2019

Well	Coarse sand (%)	Fin sand (%)	Silt (%)	Clay (%)	Texture	O.M (g kg^{-1})	SAR	$CaCO_3$ (g kg^{-1})
Galbana	6.88	62.30	10.44	20.38	Sandy clay loam	5.6	10.12	95.5
Romana	5.90	65.23	13.10	15.77	Sandy loam	5.5	8.17	106.3
Rabaa	6.32	64.89	12.85	15.94	Sandy loam	5.8	7.79	123.0

	pH (1:2.5)	EC (dS m^{-1})	Cations (cmol$_c$ kg soil)				Anions (cmol$_c$ kg soil)		
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO^{-}_3	Cl^{-}	SO^{--}_4
Galbana	8.04	5.68	8.22	14.00	33.70	0.88	4.99	27.53	24.28
Romana	8.05	5.12	9.30	13.28	27.81	0.81	3.69	18.93	28.58
Rabaa	8.02	5.33	10.85	14.32	27.28	0.85	4.35	22.35	26.60

Available	Macronutrients (mg/kg)			Available Micronutrients (mg kg^{-1})		
	N	P	K	Fe	Mn	Zn
Galbana	35.77	5.22	185.00	3.10	1.29	0.58
Romana	37.25	4.20	180.32	2.49	1.04	0.55
Rabaa	33.95	3.98	183.00	1.87	1.08	0.56

TABLE 2. Water chemical composition of the three wells before and after magnetization, (average two experimental seasons)

Water characteristic		Well					
		Galbana		Romana		Rabaa	
pH (1:2.5)		8.08	8.05	8.15	8.09	8.22	8.17
EC (dS m^{-1})		3.13	3.04	6.23	6.14	9.37	9.25
Cations (cmol$_c$ l^{-1})	Ca^{++}	3.34	4.20	4.32	7.55	5.98	9.30
	Mg^{++}	9.40	7.93	17.29	15.56	22.13	20.90
	Na^{+}	17.36	16.95	39.71	37.21	64.80	61.42
	K^{+}	1.20	1.32	0.98	1.08	0.79	0.88
Anions (cmol$_c$ l^{-1})	HCO^{-}_3	3.18	3.09	5.20	4.66	6.10	5.97
	Cl^{-}	12.85	10.56	26.30	22.90	45.88	48.37
	SO^{--}_4	15.27	16.75	30.80	33.84	41.72	38.66
Soluble nutrients (mg L^{-1})	NO_3-N	22.36	25.14	17.69	19.88	12.69	15.63
	NH_4-N	9.63	12.36	7.63	10.33	5.49	9.55
	P	3.85	4.10	3.12	3.75	2.98	3.22
	K	8.89	10.20	7.36	9.62	7.10	8.92
	Fe	1.20	1.38	1.12	1.27	1.03	1.14
	Mn	0.97	1.04	0.88	1.02	0.85	0.96
	Zn	0.46	0.55	0.40	0.52	0.37	0.48

Plant harvesting

At harvesting stage in the first week of October, ten take plants were collected from each plot to measure the foliage parameters: plant high (cm), No. of branch/plant, No. of pods/plant, No. of seeds/pod and 100-seed weight (gm). A lot of plants for each plot were harvested to measured, pods yield (ton/fed), dry shoot (ton/fed) and seeds yield (ton/fed). The shoots and seeds of cowpea were subjected to washing by tap water followed by distilled water and oven- dried at 70c^0 for 48 hrs., then ground using stainless steel mill. The plant powder was kept for analysis (Chapman and Pratt, 1961).

Soil and plant analysis

Soil analysis

After plant harvesting, samples of surface soil (0-30 cm) were taken from each experimental plot, air dried, ground, passed through 2 mm sieve and kept for analysis. The main chemical properties were determined as perversely methods (Page et al*.,* 1982).

Plant analysis

Elements were determined by digestion extract, digestion solution of $H_2SO_4 + HClO_4$ acids (Ryan et al., 1996). The concentration of N, P, K, Fe, Mn, and Zn were measured by atomic spectrophotometer (Model, Sepectronic 21 D) (Cottenie et al*.*, 1982). The chlorophyll content was measured using fresh leaves of plant with the chlorophyll- meter Spad 502 at 09:00 (Wood et al., 1992). The proline concentration in plant leaves was determined by method showed by Bates et al. (1973). The percentage of Carbohydrates was determined in grains (DuBois et al*.,* 1956).

Statistical analysis

The obtained data were subjected to statistical analysis (Snedecor and Cochran (1990). And the least significant differences at probability 5% (LSD at 0.05) was used to compare the treatment means. A combined analysis was used between three locations.

Results and Discussion

Effect of magnetized water on some soil properties

Soil pH

Table 3 showed that mean values of pH in soil treated with magnetized or un-magnetized water at locations whi ch irrigated from three wells: (Galbana, Romana and Rabaa), respectively. The pH in soil was decrease significantly as a result magnetized treatment in each of Galbana and Romana. The soils of all experimental plots are characterized by slightly too moderately alkaline conditions with pH values always ranging from 7.81 to 8.05. The relative decreases of mean values of soil pH were 1.1, 1.7 and 1.2 % for soil treated with magnetic water from Galbana, Romana and Rabaa respectively, 0.62, 0.75 and 0.62 % in soil and were treated with un-magnetized water, respectively compared to initial soil pH. The soil pH in all locations was reducing as affected with different saline irrigation water treated magnetically as compared to untreated. These results is agreement with Abd El-Rahman et al. (2019) found that decreasing in soil pH related to effect of magnetized of water on organic matter of the soil where it releases organic acids in the rhizosphere. Meysam and Abobatta (2019) found that magnetic water enhanced water use efficiency and soil pH has reduced. Meysam and Ebrahim (2017) found also that soil pH has decreased as affected the irrigation water salinity treated magnetically. The pH decreased of the saline soils due to that the salts compress the electrical double layer of soil colloids, then released ions of H^+ in the soil solution. In addition, leaching salts from profile of soil and adsorb ions of H^+ instead of the other cations on clay and organic fractions, may lead to reduce of soils pH (Abd-Elrahman and Osama, 2017).

Soil salinity

Table 3 showed that the EC values of soils irrigated with different irrigation waters were decreased as magnetically affected. Magnetized of water is an important in decreasing soil salinity than un-magnetized water. The decrease in salinity of soil treated with magnetized water because of changes in hydrogen bonding and increased mobility of ions. Also, Fig (1) shows that mean values of EC in soil treated with magnetized or un-magnetized water at locations which irrigated from three wells: (Galbana, Romana and Rabaa), respectively. The use of magnetized water has a role in reducing EC as there has been a decrease in the value of EC compared to un-magnetized water at Galbana, Romana and Rabaa), respectively. EC in soil treated with magnetized water at Romana was 3.25 dSm^{-1}while un-magnetized water was 4.21 dSm^{-1} and accordingly, soil salinity at Romana was the highest response to the decrease as a result of magnetization. In addition, Fig (2) shows that Values of E.C were in soil treated with magnetized water through months at three wells. Values of E.C were reduce gradually from May until October because number of irrigation which helps soil in leaching soluble salts. Also, using irrigation water salinity treated with magnetic to soil increased of leaching soluble salts, decreased EC of soil at three locations of soil which were irrigated from Galbana, Romana and Rabaa. The reduce in soil salinity may be explained as thus, that water treated by magnetic power contains fine colloidal molecules and electrolytic substances, which response to magnetic treated, through increasing ability to sediment that results in a decreased EC. The reduce in soil salinity may be explained as thus, that water treated by magnetic power contains fine colloidal molecules and electrolytic substances, which response to magnetic treated, through increasing ability to sediment that results in a decreased EC. The Changes in properties of water such as polarity, hydrogen bonding, surface tension, pH,

TABLE 3. Mean values of pH, EC and available macronutrients contents in soil treated with magnetized water or un-magnetized water at the two seasons

Months	Galbana		Romana		Rabaa	
	Magnetized	un-magnetized	Magnetized	un-magnetized	Magnetized	un-magnetized
			pH (1:2.5)			
May	8.02	8.04	8.01	8.05	8.01	8.02
Jun	8.01	8.03	7.97	8.03	7.99	8.00
July	7.95	8.01	7.94	8.0	7.92	7.98
August	7.92	7.98	7.91	7.99	7.92	7.96
September	7.91	7.96	7.83	7.97	7.85	7.93
October	7.86	7.93	7.81	7.92	7.82	7.90
Mean	7.95	7.99	7.91	7.99	7.92A	7.97
			EC (dS m^{-1})			
May	4.45aA	5.58aA	4.22aB	5.10aA	4.30aB	5.33abA
Jun	4.32aB	5.32aA	3.88aB	5.50aA	3.91abB	5.23abcA
July	3.26abB	4.89abA	3.40bB	4.50bA	3.55abcB	5.05abcA
August	3.10abB	4.36bcA	2.92cB	3.86cA	3.20bcdA	5.87aA
September	2.89bA	3.71cdA	2.75cB	3.21dA	2.98cdA	4.37bcA
October	2.55bB	3.44dA	2.30dB	3.10dA	2.62dB	3.88cA
Mean	3.43B	4.55A	3.25B	4.21A	3.43B	4.96A
			Available N (mg kg^{-1})			
May	38.95bA	37.52bA	39.10aA	37.49aA	37.95bA	34.90cA
Jun	42.36abA	39.26abA	41.96aA	42.18aA	40.73abA	36.14bcA
July	45.10abA	41.25abA	42.95aA	39.55aA	42.55abA	39.12abcA
August	45.85aA	41.88abA	44.39aA	41.75aA	45.10aA	41.52abcA
September	47.32aA	42.36abB	45.85aA	43.68aA	46.24aA	43.61abA
October	47.82aA	44.17aA	46.10aA	44.85aA	46.88aA	44.52aA
Mean	44.57A	41.07B	43.39A	41.58A	43.24A	39.97B
			Available P (mg kg^{-1})			
May	5.88aA	4.78bA	4.83fA	4.35dB	4.33dA	4.08dA
Jun	6.03aA	5.78aB	5.05eA	4.39dB	4.86cA	4.22dB
July	6.09aA	5.89aB	5.12dA	4.67cB	5.08bcA	4.48cB
August	6.15aA	6.02aA	5.23cA	4.82bcB	5.22bcA	4.75bB
September	5.23aA	6.07aA	5.36bA	4.90abB	5.25abA	4.88abA
October	6.55aA	6.13aB	5.48aA	5.04aB	5.59aA	5.06aB
Mean	5.99A	5.78A	5.18A	4.70B	5.05A	4.58B
			Available K (mg kg^{-1})			
May	193.0cA	188.0dA	188.0dA	184.0dA	191.0cA	187.0dB
Jun	194.0cA	190.0dA	193.0cdA	189.0cdA	195.0cA	194.0cA
July	198.0bcA	193.0cdA	198.0bcdA	192.0cB	199.0bcA	198.0bcA
August	203.0abcA	197.0bcB	203.0abcA	196.0bcB	205.0abcA	201.0abcA
September	206.0abA	201.0abA	208.0abA	203.0abA	214.0abA	203.0abA
October	212.0aA	206.0aA	213.0aA	208.0aA	218.0aA	207.0aA
Mean	201.0A	195.83A	200.50A	195.33A	203.67A	198.33A

Capital letters are for comparison between un-magnetized and magnetized.
Small letters are for comparison between months.

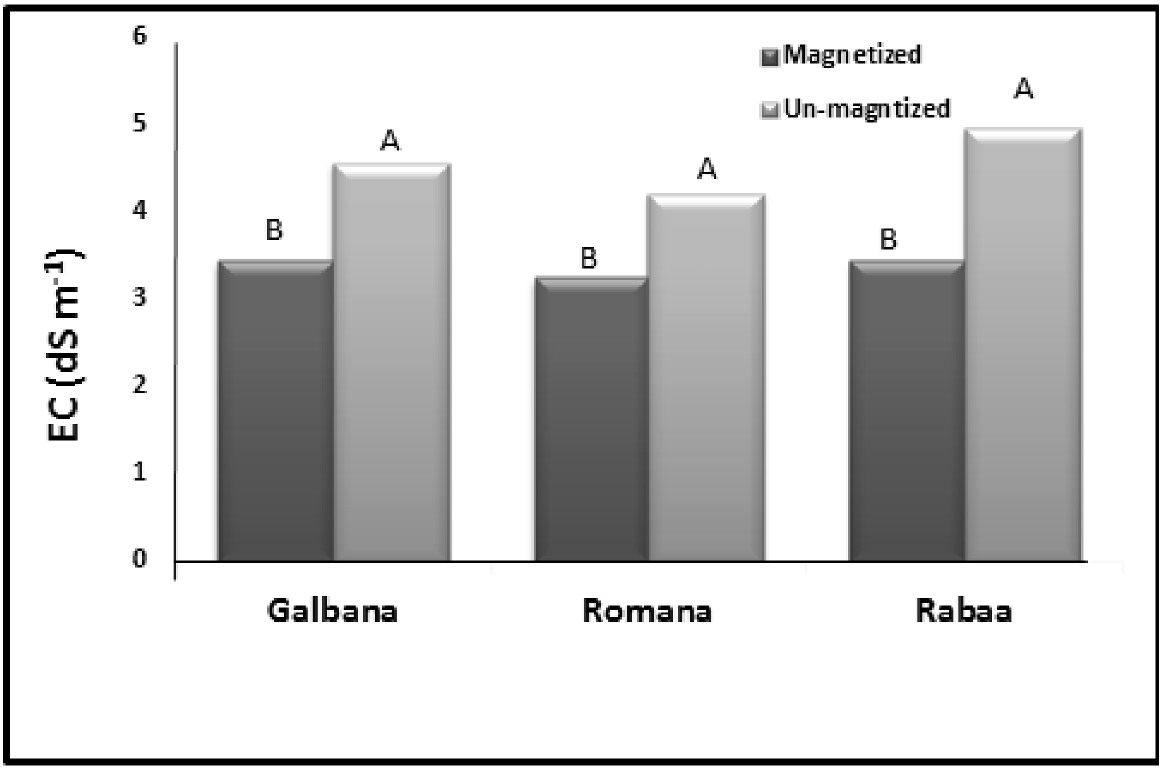

Fig. 1 Mean values of EC in soil treated with magnetized or un-magnetized water at two seasons
* Error bars represent standard deviation values SD= 0.104 and 0.376 for magnetized or un-magnetized water

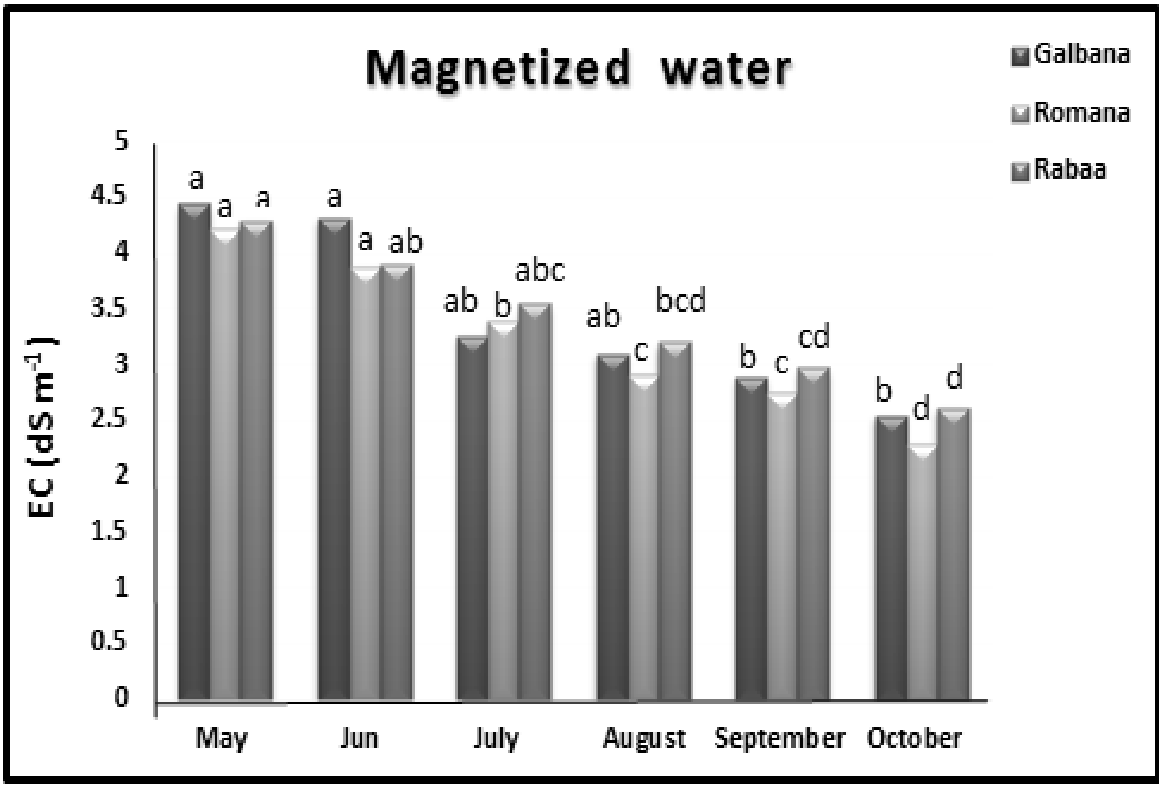

Fig. 2. values of EC in soil treated with magnetized water through months
* Error bars represent standard deviation values SD= 0.117, 0.246, 0.145, 0.142, 0.116 and 0.168 Galbana, Romana and Rabaa

conductivity, refractive index and soluble salts are due to magnetic field effect (Chang and Weng, 2008). Meysam and Ebrahim (2017) found that magnetized water was not significant in the soil EC compared with the control. The relative decreases of mean values of soil salinity were 39.61, 36.52 and 35.65 % for soils treated with irrigation water different salinity (Galbana, Romana and Rabaa), respectively as affected magnetically as those of the initial soil. The relative decreases of mean values of soil salinity were 19.89, 17.77 and 6.94 % for soil treated with different saline normal water (un-magnetized water) compared with initial soil. Results are in agreement with those showed by Ashwini and Manjunatha (2018) who reported that salinity irrigation water has decrease from 7.20 to 1.15 dSm^{-1} under non-treated compared with a decrease from 7.3 to 1.08 dSm^{-1} as affected by magnetized irrigation water treatment. Mohammed and Baseem (2013) indicated that magnetizing irrigation water plays in removing salts from the soil. Grewal and Maheshwari (2011) showed that magnetic water has some different physical and chemical characteristics than non-magnetic water in regards to surface tension, pH, hydrogen bonding, conductivity, polarity and solubility of salts.

Available macronutrients contents in soil

Table 3 showed that irrigation water of different salinity treated with magnetic increased amounts could be due to available nitrogen, phosphorus and potassium content in soils compared with those irrigated by un-magnetized water. Increasing of available nitrogen, phosphorus and potassium in soil as treated with magnetic irrigation water reduce of soil alkalinity and increase in mobility of elements. These results are found by Meysam and Ebrahim (2017) who indicated that the available soil nitrogen, phosphorus and potassium significantly increased with magnetic treated of different irrigation water compared to normal water. Corresponding, the relative increases of mean available N values were -24.60 %, -16.48 % and -27.36 % respectively in soils treated with magnetically irrigation water, while those of soils without magnetic water were -14.81, -11.15 and -17.73 % for Galbana, Romana and Rabaa, respectively. The relative increases of mean values were -14.75- 23.33 and -26.88 % for P in soil treated with different saline irrigation water treated with magnetic for Galbana, Romana and Rabaa, respectively, while, the mean values -10.72, -11.90 and -15.08 % in P in soil irrigated with different saline water without magnetic for Galbana, Romana and Rabaa, respectively. The relative increases of mean available K values were -8.65, -11.19 and -11.30 % in soil treated with magnetic irrigation water different salinity respectively, while the mean values in soil treated with irrigation water different salinity without magnetic were -5.85, -8.32 and -8.38 % for K in soil respectively. These results are related to soil treated with different saline irrigation water and magnetic treated of water as they affect the absorption of nitrogen, Phosphorus and potassium from the nitrogen, Phosphorus and potassium absorbed soils on the colloidal compound, thus increasing its availability in the soil. These results agree with found by Hilal et al. (2013) who suggested that magnetic treatment of irrigation water led to a decrease in soil pH, salt ions accelerating coagulation and salt crystallization, increasing the efficiency of fertilizers and increasing nutrient (NPK) mobility in soil (Abd-Elrahman and Shalaby 2017).

Available micronutrients contents in soil

Table 4 showed that the increase in the amount of available micronutrients (Iron, manganese and zinc) were achieved as a result of treated with irrigation water of 3.13, 6.23 and 9.37 dS m^{-1} in the different locations with or without magnetic water. The results showed that there is a significant difference in the values of iron, manganese and zinc available in the soil irrigated with magnetic water compared to the normal water irrigated (un-magnetized).

The maximum effects on Iron, manganese and zinc contents were related to magnetic water, which might be due to their solubility in the soil solution. The available contents of Iron, manganese and zinc in soil were significantly increased with magnetized water than with non-magnetic. The response of irrigation water with or without magnetic treatment on available micronutrients (Fe, Mn and Zn $mgkg^{-1}$ soil) were significant. Moon and Chung (2000) who indicated that magnetized water has role in dissolving minerals in soil, dissolve oxygen and increasing rate of activity of chemical reactions. using irrigation water salinity treated with magnetic water to soil increased leaching soluble salts, decreased soil pH and increasing nutrients (Fe, Mn and Zn) mobility in soil (Hilal et al., 2013). Hilal et al. (2002) found that the mobility of nutrient in root zone according to element magnetic susceptibility. Induced magnetic increase of nutrient extraction from soil was the greatest for Fe, Mn and Zn.

Growth characters

Table 5 revealed that irrigation water different of salinity whether magnetic water increased growth characteristics i.e. plant height (cm), No. of branches/plant, No. of pods /plant and No. of seeds /pods as compared with un-magnetized**.** Magnetized water increased all plant parameters and this is reflected in biomass increase. Increasing may be related to the increased movement of ions and their absorption to the effect of the treated magnetic water leading to biochemical changes or enzymatic activities. The effect of magnetized water on plant height (cm) was significant compared with un-magnetized water at 6.23 dSm^{-1} while the No. of branches/plant, No. of pods / plant No. of seeds/pods were not significant. These results are consistent with those reported by Amer *et al*. (2014) who found that irrigation water treated with magnetic on soybean plant, increased the growth parameters i.e. No of pods/plant, No of branch/plant and plant height as compared to untreated plants. The results are due to the role of the magnetic field and its effect on cellular processes such as gene transcription for its role in changing cellular processes (Hozayn and Abdul Qados, 2010).

TABLE 4. Mean values of available micronutrients contents in soil treated with magnetized or un-Magnetized at the two seasons

Months	Galbana		Romana		Rabaa	
	Magnetized	un-magnetized	Magnetized	un-magnetized	Magnetized	un-magnetized
			Fe ($mgkg^{-1}$)			
May	3.55eA	3.30aA	2.65eA	2.53dA	1.98dA	1.90cA
Jun	3.76dA	3.81aA	2.80dA	2.66cB	2.04cdA	1.96bcA
July	3.85cA	3.66aB	2.88cdA	2.73bcB	2.08cA	1.98abcA
August	3.92bcA	3.75aB	2.93bcA	2.80abA	2.33bA	2.06abcB
September	3.95abA	3.84aB	2.97abA	2.82abB	2.48aA	2.09abB
October	4.03aA	3.89aB	3.02aA	2.87aB	2.52aA	2.13aB
Mean	3.84A	3.71A	2.88A	2.74B	2.24A	2.02B
			Mn ($mgkg^{-1}$)			
May	1.35dA	1.24dB	1.09eA	1.04cA	1.14eA	1.08cA
Jun	1.70cA	1.29dB	1.22dA	1.07cB	1.23dA	1.12cB
July	1.89bA	1.39cB	1.34cA	1.19bA	1.38cA	1.18cB
August	2.01bA	1.55bB	1.59bA	1.23bB	1.43cA	1.29bB
September	2.06abA	1.69aB	1.63bA	1.36aB	1.62bA	1.38abB
October	2.19aA	1.76aB	1.72aA	1.44aB	1.74aA	1.47aB
Mean	1.87A	1.49B	1.43A	1.22B	1.42A	1.25B
			Zn ($mgkg^{-1}$)			
May	0.61dA	0.58cA	0.59dA	0.55dA	0.6dA	0.56dA
Jun	0.65cdA	0.62bcA	0.63dA	0.58cdA	0.65cdA	0.58cdA
July	0.69cA	0.65bcA	0.66cdA	0.62cA	0.71bcA	0.62bcdB
August	0.76bA	0.69abA	0.72bcA	0.68bA	0.77abA	0.66abcB
September	0.78abA	0.72abB	0.79abA	0.72bA	0.79aA	0.68abA
October	0.83aA	0.78aA	0.85aA	0.79aA	0.84aA	0.73aB
Mean	0.72A	0.67A	0.71A	0.66A	0.73A	0.64B

Capital letters are for comparison between un-magnetized and magnetized.
Small letters are for comparison between months.

TABLE 5. Plant growth characters as affected by irrigation

Salinity of water irrigation (dSm^{-1})	Plant height (cm)	No. of branches / plant	No. of pods/plant	No. of seeds /pod
		Un-magnetized water		
3.13	79.58aA	8.23aA	12.36aB	6.34aB
6.23	60.31bA	6.12bA	9.24bB	4.52abB
9.37	45.63bA	4.89bA	6.17cA	4.0bA
		Magnetized water		
3.13	86.21aA	9.21aA	16.34aA	9.85aA
6.23	76.34aA	6.89abA	13.0bA	8.34aA
9.37	51.69bA	5.23bA	8.33cA	5.99bA

Small letters are for un-magnetized and magnetized.
Capital letters are for comparison between un-magnetized and magnetized in each salinity.

Yield components of cowpea

Table 6 showed that there is a marked increase of 100 seeds (g) for planted treated with irrigation water at 6.23 and 9.37 dSm^{-1} and magnetic as compared un-magnetized water. There were increases of the weight 100 seeds (g), seeds yield (ton/fed) and pods yield (ton/fed) with decreasing salinity irrigation water as affected with magnetizing water. While weight of dry shoot (ton/fed) had not significant different between salinity and magnetic treatments. These results due to the irrigated with water treated with magnetic led to increase of seeds yield as effect on chlorophyll contents has role in photosynthesis. The results are a result of the effect of magnetized water on the absorption of nitrogen, phosphorus and potassium from the soil and the work to increase its availability to the plant, thus resulting in improved plant growth and increased productivity.

Belyavskaya (2001) suggested that the magnetized water has a role in the metabolism of cells, as it stimulates them. Omid (2016) reported that plant growth increased significantly with magnetized water by 23% compared to control. The effect of magnetized water resulted in plant height and increased availability of nutrients. Moussa (2011) found that the used magnetic water can increase parameters with the bean yield. Yadollahpour et al. (2014) indicated that magnetic treated of irrigation water were significant in yield. The magnetized salt water increased the seeds and pods with peas as a result of its effect on biochemical changes compared to normal water. Amer et al. (2014) found that irrigation of soybean plant by magnetic water significantly increased the seed weight, no of pods/ plant, no of branch/plant, seeds weight/plant, and weight of pods/plant as compared to untreated plants.

Macronutrients concentration in seeds and shoot

Tables 7 showed that the irrigation water treated with magnetic field had an increased concentration of nitrogen, phosphorous and potassium content in the seeds and leaves cowpea, an increase in the concentration of nitrogen, phosphorus and potassium in the seeds, and a decrease in the salt of irrigation water. High concentrations of nitrogen, phosphorus and potassium in seeds and shoot of plants grown in soil treated with salinity irrigation water (3.13 dSm^{-1}) are affected by magnetized water more than un-magnetized water. The effect of magnetized water on phosphorous concentration was significant in shoot plants. The effect of irrigation water salinity was significant, and there was nitrogen, phosphorus and potassium concentration in shoot cowpea, with an increase in the salinity of irrigation water. Concerning, the interaction between the magnetized water and the saline irrigation water, the concentration of nitrogen, phosphorus and potassium was not significant in the seeds, while the N concentration in shoot was significant.

These data are consistent with those mentioned by Grewal and Maheshwari (2011) who found that magnetic of irrigation water significantly increased in N, P, K contents in snow pea. Using magnetic water causes changes in the characteristics of the molecules resulting in reduce surface tension, reduced viscosity, increased dissolvability, increased permeability and improved oxygen content hence became elements more available to plants, so magnetic water has different chemical and physical properties than untreated water (Waleed, 2019). Magnetized water has a role in the effect on leaching nutrients and their absorption by root and translocation to Faba bean seeds, which caused more content of macro nutrients of the seeds (Hozayn et al., 2016). Abulrahman and Halimah (2018) showed that the magnetized water increases the absorption of elements compared to normal water.

TABLE 6. The effect of salinity of irrigation water treated with magnetized or un-magnetized on the average values of cowpea yield components in two seasons

Salinity of water irrigation (dSm^{-1})	Weight of 100 seeds (g)	Weight of seeds yield (ton/fed)	Weight of pods yield (ton/fed)	Weight of dry shoot (ton/fed)
		Un-magnetized water		
3.13	15.62aA	1.07aB	1.35aA	2.18aA
6.23	10.36aA	0.89bB	1.05abB	1.75aA
9.37	9.37aA	0.56cB	0.89bB	1.10aB
		Magnetized water		
3.13	22.59aA	1.29aA	1.87aA	3.48aA
6.23	17.63bA	1.10bA	1.43bA	2.17aA
9.37	13.52bA	0.97cA	1.13cA	1.49aA

Small letters are for un-magnetized and magnetized.
Capital letters are for comparison between un-magnetized and magnetized in each salinity.

TABLE 7. Effect of salinity of irrigation water treated with magnetized or un-magnetized water on mean values macronutrients concentration in seeds and shoots of cowpea for two the seasons

Salinity of water irrigation (dSm^{-1})	Seeds			Shoots		
	N (%)	P (%)	K (%)	N (%)	P (%)	K (%)
			Un-magnetized water			
3.13	3.10aA	0.46aA	2.46aA	2.95aA	0.39aB	2.58aA
6.23	2.62aA	0.35abB	2.20aA	2.46bB	0.27bB	2.50aA
9.37	2.17aA	0.29bA	1.79aA	2.16cB	0.23bA	2.19bA
			Magnetized water			
3.13	3.16aA	0.55aA	2.75aA	3.18aA	0.46aA	2.69aA
6.23	3.15aA	0.47aA	2.46aA	2.85bA	0.37bA	2.55abA
9.37	2.46aA	0.36bA	2.13aA	2.44cA	0.29cA	2.30bA

Small letters are for un-magnetized and magnetized.
Capital letters are for comparison between un-magnetized and magnetized in each salinity.

Micronutrients concentrations in seeds and shoot of cowpea plant

Tables 8 showed that the use of magnetized water with the salinity of different irrigation water has an effect on the concentration of micronutrients (iron, manganese and zinc mg / kg) in the seeds and shoot cowpea plants were increasing with reduced salinity of irrigation water. The use of magnetized water significantly increased the iron, manganese content of cowpea seeds. The application of irrigation water different salinity levels led to significant increases of iron, manganese and zinc content of the seeds with decreases of water salinity. The used of magnetic water and the irrigation water salinity level had significant for increasing Mn concentration in shoot cowpea plant at 6.23 dSm^{-1} irrigation water salinity, while Fe and Zn concentrations in shoot were not significantly affected. The maximum iron, manganese and zinc content in seeds and shoot of planted treated with saline irrigation water as magnetic water than those of normal not magnetic water. These findings are in a context consistent with Grewal and Maheshwari (2011) who noticed that the treatment with magnetized water for irrigation water was significant increase in Zn, Fe and Mn contents in snow pea. Hozayn et al. (2016) showed that micronutrients contents in seeds were significantly with magnetized irrigation compared with un-magnetized water irrigation. That effect is due to the magnetic effect on leaching nutrients and their absorption by root and translocation to Faba bean seeds, which caused more content of micro elements of the seeds.

Biochemical characteristics of cowpea plant

Table 9 showed that the use of irrigation water with different salinity levels affected by the magnetic field system and effect on protein (%) content in seeds of cowpea which was not significant. Moreover, the protein contents of cowpea plant seeds that were irrigated with magnetized water increased more than un-magnetized, and thus increased plant growth. The used of magnetic water led to increase protein content in seeds due to responsible for the simulation of protein compared with untreated. Those results are in line with Babaloo et al. (2018) who found that the increasing of protein contents in Plants irrigated with magnetized water was accompanied with increasing growth promoters (IAA). Chlorophyll content was significant increases of plants as affected with magnetic irrigation and significant decreased of chlorophyll as affected with increasing irrigation water salinity. Chlorophyll content was high at salinity 3.13 and 6.23 dSm^{-1} with magnetized water. This was an increase in the total chlorophyll content in plants as a result of its being affected by magnetized water compared to its content in irrigation with un-magnetized water. Those results are in context with Atak et al. (2003) suggested that magnetized water increases the photosynthetic pigment and is due to the plant's response to cytokinin synthesis. Cytokinin has an active role on chloroplast, shoot formation, axillary bud growth and Stimulation of genes in attracting nutrients in chloroplast development. The effect of magnetized water on cellular processes such as gene transcription which has an important role in cellular processes (Omid, 2016).

TABLE 8. Effect of salinity of irrigation water treated with magnetized or un-magnetized water on mean values micronutrients concentration in seeds and shoots of cowpea for two the seasons

Salinity of water irrigation (dSm^{-1})	Seeds			Shoots		
	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
			Un-magnetized water			
3.13	65.28aB	41.28aB	37.36aA	59.34aA	37.23aA	23.14aA
6.23	51.41bB	37.14aA	25.48bA	42.85bA	27.63bB	17.98abA
9.37	38.10cA	28.49bA	19.94bA	30.79cA	24.13bA	13.16bA
			Magnetized water			
3.13	78.90aA	55.34aA	33.19aA	66.32aA	45.32aA	33.21aA
6.23	63.48bA	44.28bA	25.34aA	50.11bA	38.20bA	23.14abA
9.37	44.0cA	35.96bA	20.49aA	36.85cA	27.13cA	16.32bA

Small letters are for un-magnetized and magnetized.

Capital letters are for comparison between un-magnetized and magnetized in each salinity.

TABLE 9. Effect of salinity of irrigation water treated with magnetized or un-magnetized water on mean values biochemical characteristics in cowpea plant for the two seasons

Salinity of water irrigation (dS m^{-1})	Protein (%)	Total chlorophyll (mg/g fw)	Proline (mg/g dw)	Carbohydrate (%)
		Un-magnetized water		
3.13	19.38aA	32.98aB	22.87cA	19.64aB
6.23	16.38aA	22.12bB	42.10bA	14.51aB
9.37	13.55aA	13.30cA	55.53aA	12.73aB
		Magnetized water		
3.13	21.81aA	37.55aA	18.30cA	32.85aA
6.23	19.69aA	28.49bA	37.29bB	25.11bA
9.37	15.38aA	17.80cA	42.17aB	16.80cA

Small letters are for un-magnetized and magnetized.

Capital letters are for comparison between un-magnetized and magnetized in each salinity.

On the other hand, the effect of salinity of irrigation water at different rates was significant increase of proline content in plants cowpea with increasing of irrigation water salinity, while the magnetic water was significant decrease of salinity led to decrease of proline content in plant cowpea. From the results, it was observed that there was a positive relationship between the effect of salinity levels in irrigation water and proline accumulation in plants. This study is in agreement with El-Sayed (2015) found that the magnetic water irrigation significant decrease in proline content with decrease salinity at leaves, stems, and roots of bean compared with control. Increasing the proline content of beans irrigated with magnetized water more than irrigated with tap water helps to increase plant growth. Improving the quantity and quality of cowpeas is due to the use of magnetized water. Magnetic field stimulated the proline content in shoot and led to the increase of the length shoot, fresh and dry weight yield of cowpea. Tarek et al. (2019) indicated that the proline content in plant reduce with low irrigation water. The magnetized water decreased the salinity of the water and thus the proline content in the plants.

Concerning, the effect of irrigation water different salinity levels was increased of carbohydrate content with decreasing saline irrigation water. The magnetic water used led to significant for increase carbohydrate content in cowpea plant. Carbohydrate content had significant different with salinity 6.23 and 9.37 dSm^{-1} with magnetized water compered to un-magnetized water. This may indicate result of bioenergetics causing cell pumping and enzymatic stimulation. These data are in agreement with El-Sayed (2015) indicated that the used of magnetic water led to increasing significantly in carbohydrates because of relationship between stomata conductance and photosynthesis, hence increasing in photosynthesis. Hameda (2014) who found that irrigated with magnetized water increased carbohydrates compared to tap water due to the relationship between stomatal conduction and photosynthesis.

Conclusion

Irrigation water at different salinity levels treated with magnetic field resulted in remarkable increases in the available macro and micronutrients contents in soil and shoot and seeds cowpea plants, yield, yield components, and quality production of cowpea compared with untreated. The current results indicated that irrigation with magnetized water can be considered as one of the most valuable, safe, practical technologies that can in improve the soil and cowpea yield. However, the use of magnetically treated water potentials in agriculture needs to be studied on different crops and situations especially under field conditions.

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There is no conflict of interest because the researcher is one author

Author's Contribution

Dalal. H. Sary designed the study and designed the experimentation and followed up the field-work. She is managed the laboratory analyses of the study, literature survey, performed the statistical analysis and drafted the manuscript. Author read and approved the final manuscript.

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استجابة مياه الري المالحة للمغنطة وتأثيرها على خواص التربة وإنتاجية اللوبيا في الأراضي المستصلحة حديثا بشمال سيناء

دلال حريمس سارى
قسم بحوث الأراضي الرملية والجيرية. معهد بحوث الأراضي والمياه والبيئة. مركز البحوث الزراعية

اجريت تجربة حقلية فى ثلاث مواقع بمحافظة شمال سيناء – مصر ، خلال موسمين صيفين متتالين ٢٠١٨ و ٢٠١٩ ، لدراسة تاثير مستويات ملوحة مياه الرى (٣,١٤ ، ٦,٢٥ و ٩,٣٧ ملليموز/سم) المعاملة بالتقنية المغناطيسية والغير معاملة على بعض خواص التربة الكميائية وانتاجية وجوده محصول اللوبيا . اجريت التجربة فى تصميم قطاعات كاملة العشوائية فى ستة مكررات. أوضحت النتائج المتحصل عليها أن استخدام مياة ري ذات ملوحة عالية يقلل من ملوحة التربة و حموضة التربة المروية بالمياه المعالجة بالمغناطيسية مقارنة بالمياه غير المعالجة. ادى استخدام الرى المعامل بالتقنية المغناطيسية الى زيادة المغذيات الكبرى والصغرى المتوفرة في التربة عن غير المعالجة. لوحظ ان استخدام الرى المعامل بالتقنية المغناطيسية ادى الى زياده فى قياسات النمو ومكونات المحصول (عدد ووزن القرون والانتاجية فدان $^{-١}$) وبعض المكونات الكيميائية (المغذيات الكبرى والصغرى فى الاوراق و البذور، ومحتوى الكلوروفيل الكلي والبرولين والبروتين والكربوهيدرات مقارنة بغير معاملة . بشكل عام ، يمكن أن نستنتج أن ملوحة مياه الري ٣,١٤ و ٦,٢٥ ملليموز/سم المعالجة بالمياه المغناطيسية أكثر من غير المعالجة أظهرت تأثيرًا موحدًا في خواص التربة وتثبيط نمو اللوبيا وإنتاجيتها تحت ظروف إجهاد الملوحة العالية.